WORKING GROUP FOR THE BAY OF BISCAY AND THE IBERIAN WATERS ECOREGION (WGBIE)

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i Executive summary

The ICES Working Group for the Bay of Biscay and the Iberian Waters Ecoregion (WGBIE) assesses the status of 23 stocks that are present in ICES divisions 3.a through Subarea 9, but primarily assess stocks distributed across subareas 7, 8, and 9. The group was tasked with conducting assessments of stock status for 18 stocks using analytical models, surplus production models, or trends and indicators, to provide catch forecasts and a first draft of the ICES advice for 2022. For two *Nephrops* stocks, updates were provided on catch data with the advice release delayed until October 2021 after the completion of the UWTV surveys used for the assessment. All 21 stocks that were scheduled for advice release in June 2021, after the stock information update, had no specific revision to the proposed advice. For most of the stocks, the advice is valid for the year 2022, except for the stocks in categories 3 to 6 where the advice is biennial or triennial.

Analytical assessments using age-structured models were conducted for the northern stock of white anglerfish, the northern and southern stocks of megrim, four-spot megrim in Iberian Waters, and sole in the Bay of Biscay. The northern hake stock and one southern white anglerfish were assessed using models that allow the use of length-structured data (no age data). A surplus-production model, without age or length structure, was used to assess southern black anglerfish, *Nephrops* in FUs 25, 2627, and 31. An analytical age–length structure model was used for the European sea bass in the Bay of Biscay. Length-based and survey trends-based methods were used to assess northern black anglerfish, southern hake, southern sole, and *Nephrops* in FUs 2829. Two *Nephrops* stocks (FUs 2324 and 30) are assessed using a bias-corrected UWTV survey abundance method.

The length-structured assessment for the southern stock of hake was rejected in 2019, resulting in the downgrading of the stock from category 1 to 3 as an interim solution. This decision was also supported by the absence of clear guidelines on how to adjust forecasts for advice when using the decision tree recommended by WKFORBIAS (ICES, 2020) for stocks with strong retrospective patterns. This year, a production model (SPiCT) was explored to derive proxy reference points despite the very wide confidence intervals.

Earlier this year, WKTADSA (Workshop on tools and development of stock assessment models using a4a and stock synthesis) was organized with the participation of external experts from JRC, Wageningen University and Research, NOAA, and ICES. The workshop's main objective was to develop, test, and review the performance of seven WGBIE stocks using alternative analytical assessment models: a4a and stock synthesis (SS). The northern hake and southern white anglerfish have already been assessed using the SS approach since 2017. These two stocks took advantage of the workshop to test and evaluate the performance reviews of the model following revisions of input data and parameters, and analyse convergence issues. The northern white anglerfish and megrim are both in an advanced stage of assessment migration to SS and a4a model, respectively. The remaining stocks are at an earlier stage of developing and exploring these alternative assessment models; SS model for southern hake, northern and southern black anglerfish; a4a models for the two southern megrims. WGBIE agreed that a follow-up online workshop with external experts will be organized before the end of 2021 to speed up the process of preparing for a benchmark.

Five stocks were benchmarked this year. Southern sole was assessed using trends from combined biomass index between commercial Portuguese LPUE and Spanish bottom trawl survey index, and a length-based indicator (LBI). The assessment model was accepted during the WKWEST (ICES, 2021) and the stock was upgraded from category 5 to 3. Four stocks were benchmarked during WKMSYSPiCT (ICES, 2021) which includes southern black anglerfish and three *Nephrops* stocks (FUs 25, 2627, and 31). The production model SPiCT developed for each of these stocks uses the catches in the model and forecast. All these stocks were upgraded from category 3 to 2.

In 2020, the migration of assessment to TAF was initiated by ICES on some specific stocks. For WGBIE, the northern stock of hake and the Bay of Biscay sole stocks were chosen, and are now implementing the TAF-based assessments.

This year WGBIE was informed that the collection of data from the commercial fishery and the research surveys during 2020 were affected by COVID-19 restrictions to varying degrees across member states. These affected the assessment of some stocks at different levels.

The recurrent late data submission to ICES for some stocks has not occurred, despite the COVID-19 disruption. All the data were uploaded to InterCatch ahead of the meeting and did not cause any delay in the assessment process of WGBIE stocks.

In response to the spread of the COVID-19 virus, all ICES assessment and advice physical meetings were suspended and held remotely. The online meetings have revealed to be productive as all the planned Terms of Reference were covered.

The structure of the report is set out with section 1 presenting a summary for each stock, discussing general issues and conclusions. Section 2 provides descriptions of the relevant fishing fleets and surveys used in the assessment of the stocks. Sections 3–18 contain all the single-stock assessments.

ii Expert group information

Expert group name	Working Group for the Bay of Biscay and the Iberian Waters Ecoregion (WGBIE)
Expert group cycle	Annual
Year cycle started	2020
Reporting year in cycle	1/1
Chairs	Cristina Silva, Portugal
	Ching Villanueva, France
Meeting venue and dates	5–12 May 2021, online meeting (23 participants)

1 Introduction

Working Group for the Bay of Biscay and the Iberian Waters Ecoregion

1.1 Summary by stock

The stocks assessed by WGBIE, the Working Group for the Bay of Biscay and the Iberian Waters Ecoregion, are distributed across ICES divisions 3.a through 9.a (Figure 1.1). Figure 1.2 shows the distribution of the *Nephrops* functional units (FUs) also assessed by the working group. A summary of each stock is provided in this introduction. More detailed information can be found in the corresponding stock-specific sections of the report.

Anglerfish (*Lophius piscatorius* and *L. budegassa*) in Subarea 7 and divisions 8.a, 8.b, and 8.d

Both species are caught on the same grounds and by the same fleets and are usually not separated by species in the landings. Anglerfish is an important component of mixed fisheries taking hake, megrim, sole, cod, plaice, and *Nephrops*. France contributes to most of the landings for the combined species in this area and has done so since 1990. Since 2011, the landings of both species combined have been above the average of the time-series. Total Allowable Catch (TAC) for both species combined was set at 20 526 t for 2020. The combined TAC for 2021 was not agreed upon at the time of the WGBIE meeting.

Age determination problems and an increase in the uncertainty in the discard levels have prevented the performance of an analytical assessment since 2007. Since then, the assessments were based on examining commercial LPUEs and survey data (biomass, abundance indices and length distributions from surveys). In 2018, both stocks were benchmarked (WKANGLER; ICES, 2018c) with *Lophius piscatorius* attaining an age-based analytical assessment with reference points and forecast and assessed following the category 1 framework (ICES, 2021a). *L. budegassa*, however, continues with assessing the status of the stock through examination of survey-based trends based on the framework for category 3 stocks (ICES, 2012; 2021a). Both stocks are under the EU multiannual management plan (EU MAP; EU, 2019). However, there is no agreed shared Management Plan with the UK for this stock and ICES provides advice according to the ICES MSY approach for *L. pisctorius* and the precautionary approach for *L. budegassa*.

For *L. piscatorius*, the available data indicate that the biomass has been increasing as a consequence of the good recruitment observed in 2001, 2004, 2010, 2014 and 2018. In 2021, ICES assessed that fishing mortality (F) on the stock is below F_{MSY} having been above for the entire time-series until 2017. The spawning stock size is above MSY $B_{trigger}$, B_{pa}, and B_{lim}. There is evidence of good recruitments in the more recent period with the last year of very good recruitment in 2018. The 2017 recruitment estimate, despite considered as one of the years when the value was good, is highly uncertain because there was no recruitment index available for 2017. Recruitment in the periods 2011–2013 and 2019–2020, although lower than in previous years, is estimated to be above the geometric mean (GM) of the series.

The assessment for *L. budegassa* excludes Division 7.a as they are only found in very small numbers at the very southern edge of this area. The discarding rate is 9% of the total catch. The assessment which uses the combined survey data indicates that the biomass has increased and is now at its highest level of the time-series. The combined surveys show evidence of large recruitment in 2013 dropping to similar levels seen historically, thereafter. However, the recruitment in

2020 increased significantly and is the highest value observed in the whole time-series. Fishing pressure is below F_{MSY} and no reference points for stock size have been defined. The stock is assessed using survey trends based on a category 3 stock approach (ICES, 2021a).

Although the stocks are assessed separately, they are managed together.

The collection of data from the commercial fishery and research surveys during 2020 was affected by COVID-19 restrictions to a varying degree across member states. For these stocks, the data used for the advice did not appear to be negatively affected and the impact on the advice for both stocks are considered to be minimal.

More details on the stocks are provided in section 3 below.

Anglerfish (*L. piscatorius* and *L. budegassa*) in divisions 8.c and 9.a

Both species are caught in mixed bottom-trawl fisheries and artisanal fisheries using mainly fixed nets. The two species are usually landed together for the majority of commercial categories and they are recorded together in ports statistics. Landings for *L. piscatorius* and *L. budegassa* in 2020 were 909 t and 793 t, respectively. The combined TAC was set at 4023 t for 2020 and 3 672 t for 2021. Both stocks are included in the EU MAP (EU, 2019) in Western waters and adjacent waters.

The two species were benchmarked in 2018 (WKANGLER; ICES 2018c) and are assessed separately, using the Surplus Production in Continuous Time (SPiCT) model (Pedersen and Berg, 2017), tuned with commercial LPUE series for *L. budegassa* following a category 3 (ICES, 2021a) approach and a length-based stock synthesis (SS; Methot Jr. and Wetzel, 2013) model following a category 1 (ICES, 2021a) approach for *L. piscatorius*. Early this year, *L. budegassa* was benchmarked again with SPiCT in WKMSYSPiCT (ICES, 2021c) where a thorough evaluation of input data, model settings and diagnostics was performed. Although already assessed with SPiCT, this stock was considered in category 3, and the advice based on the SPiCT model relative trends of biomass and fishing mortality. The stock is now in category 2, with relative reference points and the advice is based on projections performed with the model.

Biomass of *L. piscatorius* decreased during the 1980s and early 1990s but has progressively increased over the last two decades to an estimated 11 625 t in 2020. The biomass has been estimated to be above the biomass reference point MSY $B_{trigger}$ since 2005. For 2020, spawning-stock size is above MSY $B_{trigger}$, B_{pa}, and B_{lim}. Fishing mortality peaked during the late 1980s but has since declined, was below F_{MSY} since 2011. Recruitment has been relatively low in recent years and shows little evidence of strong year-classes since 2001.

Trends in relative biomass of *L. budegassa* indicate a steady decrease from the beginning of the series until 2005. Since then, an increasing trend was observed with the highest estimated biomass of the time-series recorded in 2016. For 2020, biomass is above MSY $B_{trigger}$ and B_{lim}. F remained at high levels between the late 1980s and late 1990s then progressively declined since 2000. In 2019, relative F was estimated to be the lowest value of the time-series and a slight increase was observed for 2020. F of the stock is below F_{MSY}. Although the stocks are assessed separately, they are managed together.

The collection of data from the commercial fishery during 2020 for both stocks was impacted by COVID-19 restrictions to a varying degree across member states. For this stock, the diagnostics for the assessment were deemed acceptable and the impact on the perception of the stock status and advice is considered minimal.

More details on the stocks are provided in section 4 below.

Megrim (*Lepidorhombus whiffiagonis* and *L. boscii*) in divisions 7.b–7.k, 8.a, 8.b, and 8.d

Lepidorhombus spp. in divisions 7.b–7.k, 8.a, 8.b, and 8.d are caught in a mixed demersal fishery with anglerfish, hake and *Nephrops.* Both are targeted species and are also considered valuable bycatch. The two species are landed and recorded together in ports statistics. Information from landings was available for 2017 for *L. boscii* that provided a rough proportion for splitting the two species.

Landings in recent years were relatively stable around 15 000 t where the highest landings in its time-series were observed in the years 1989 (19 233 t), 2010 (16 026 t) and 2013 (16 025 t). Since 2014, landings declined with no constant trend (average of around 12 000 t). In 2020, landings were at 11 141 t, considered as second to the lowest value recorded in the whole time-series next to the 11 048 t observed in 2008. Discarding of smaller megrim is substantial and also includes individuals above the minimum landing size (MLS) of 20 cm. The discards were variable, between 885 t (2020) and 6243 t (2004).

The *L. whiffiagonis* is assessed with a Bayesian catch-at-age model considered as a full analytical assessment since 2016. Catch, landings and discard data have varied without trend over the time-series with the most recent period, with the year 2017 showing a slight increase. Recruitment has fluctuated without trend over the time-series with 2016 and 2017 giving above-average values. Biomass has steadily declined to its lowest level in 2006, increasing since then. From 2009 until 2017, the value was stable to around 57 200 t. Since 2018, a significant increase trend is observed in the SSB with the highest value recorded this year 126 311 t, the highest of the time-series.

Before 2017, *L. boscii* in this area was unassessed. This stock was included in the ICES data call for the first time in 2018 and historical catch data were also requested. The *L. boscii* data on catch, landings, and discards for 2017–2020, were available to the WG and official landings are recorded under the combined species of *Lepidorhombus* spp. Data available from surveys did not provide adequate information to assess the status of the stock.

Sampling in 2020 was negatively affected by the COVID-19 pandemic and France could not estimate four-spot megrim catches for this year. LFDs for landings and discards were also not available from all countries due to the difficulty of accessing samples in 2020. For this reason, the catch data from 2017 to 2019 are deemed to be the most reliable in the time-series and are used to determine recent average catches. The average discarding rate (2017–2019) is 27% of the total catch.

Currently, this stock is classified as a data-limited stock (DLS) in category 5 (ICES, 2021a) as only data on catch since 2017 was available with very limited information from surveys.

The collection of *L. whiffiagonis* data from the commercial fishery and research surveys during 2020 was affected by COVID-19 restrictions to a varying degree across member states. For this stock, the diagnostics for the assessment were deemed acceptable and sensitivity analyses conducted indicated that the impact on the perception of the stock status and advice was minimal. In the case of *L. boscii*, the COVID-19 pandemic affected the sampling in 2020 also negatively but to a higher degree compared to *L. whiffiagonis* as France could not estimate *L. boscii* catches for this year. *L. boscii* LFDs for landings and discards were not available from all countries. Spain provided LFDs for landings and discards while Ireland was only able to submit length distributions for discards. This is the first year that Belgium provided data but only information of landings length distribution and age-at-length.

ICES provides annual advice for *L. whiffiagonis* whereas the advice for *L. boscii* is provided for the first time this year. The TAC is for *L. whiffiagonis* and *L. boscii* combined. 2020 combined TAC was set at 20 526 t. However, the combined TAC of both species for 2021 was not agreed at the time of publication of the advice. Due to Brexit, a provisional TAC value of 4460 t for the first quarter of 2021 can only be provided to the WG.

Although the stocks are assessed separately, they are managed together.

Details of the assessment are presented in section 5 below.

Megrim (*L. whiffiagonis* and *L. boscii*) in divisions 8.c and 9.a

Southern megrims *L. whiffiagonis* and *L. boscii* are caught in mixed fisheries targeting demersal fish including hake, anglerfish, and *Nephrops* and are not separated by species in the landings. The majority of the catches are taken by Spanish trawlers. Landings of both species combined in 2019 were 981 t (of which <30 % correspond to *L. whiffiagonis*). The agreed combined TAC for megrim and four-spot megrim in ICES divisions 8.c and 9.a was 2322 t in 2020 and 2158 t in 2021. Both species are assessed separately, using the Extended Survivor Analysis (XSA) model (Shepherd, 1999). Both megrims are included in the EU MAP (EU, 2019) for Western Waters and adjacent waters.

For *L. whiffiagonis*, the assessment indicates that fishing mortality has increased since 2010 with a sharp decline from 2015. In 2021, F is below F_{MSY}. The SSB values in 2007–2010 were the lowest in the series but since 2011, SSB has increased and is now estimated to be above MSY $B_{trigger}$, B_{pa}, and B_{lim}. After very high recruitment (at age 1) in 2010, SSB decreased to an average value. The recruitment is estimated to be high from 2015 onwards.

For *L. boscii* the assessment indicates that SSB decreased gradually from 1989 to 2001, the lowest value in the series, and has since increased. In 2020, the SSB was estimated to be the highest of the series. In 2021, SSB is above $B_{trigger}$, B_{pa}, and B_{lim}. Recruitment has fluctuated around 46 million fish during all the series. Very weak year-classes are found in 1993, 1998, and 2008 and now in the most recent two years, with 2018 showing the lowest recruitment of the series but needs to be confirmed when more data are made available. Estimates of fishing mortality values show two different periods: an initial period with values around 0.5 from 1989 to 1996 followed by a second period at a lower level, with small ups and downs. The last five years show a fall in fishing mortality, with the lowest value in 2020 estimated to be below F_{MSY}. The last four years show a fall in fishing mortality, with the lowest value in 2019 estimated to be below F_{MSY}.

Management of catches of the two megrim species under a combined species TAC prevents effective control of the single-species exploitation rates and could lead to the overexploitation of either species.

The collection of data from the commercial fishery during 2020 for both stocks was affected by COVID-19 restrictions to a varying degree across member states. For this stock, the diagnostics for the assessment were deemed acceptable and sensitivity analyses conducted indicated that the impact on the perception of the stock status and advice was minimal.

Details of the assessments are presented in section 6 below.

Sole in divisions 8.a and 8.b

Bay of Biscay sole is caught in ICES divisions 8.a and 8.b. The fishery has two main components: one is a French gillnet fishery directed at sole (about two-thirds of total catch) and the other one is a trawl fishery (French otter or twin trawlers and Belgian beam trawlers). This is a category 1 stock (ICES, 2021a) assessed using an age-based Extended Survivor Analysis (XSA) model (Shepherd, 1999). The TAC was set at 3666 t and 3483 t for 2019 and 2020, respectively. Landings have been declining until 2017 (3263 t) but have slightly increased in 2018 (3468 t) and 2019 (3351 t). However, these declined again in 2020 (3221 t) to a value slightly lower than in 2017.

For the ORHAGO (B1706) survey, the trend of the cpue shows an increase since 2008 despite some annual fluctuations which stabilized from 2013 onwards. Compared to last year's assessment, there is only very limited change in the cpue from the ORAGHO (B1706) survey.

Discards are not included in the assessment as discards are considered to be negligible for the ages included in the assessment, which starts at age 2.

Since 1984, fishing mortality has gradually increased, peaking in 2002 and decreased substantially the following two years. After 2005, F was stable at around 0.43 (= F_{pa}). In 2017, F is estimated to be below F_{MSY} but increase since 2018 to be above F_{MSY}. The SSB trend in earlier years increased from 1984 (12 300 t) to a high value in 1993 (16 300 t) showing afterwards a continuous decrease until 2003 (9600 t), the lowest value of the series. An increase was then observed in the next three years (2004–2006), then the value remained constant from 2007–2009 (< 11 000 t). SSB has been increasing and was above MSY $B_{trigger}$ in the period 2004–2011. SSB has been decreasing since 2012. In 2014 and 2015, SSB dropped below MSY B_{pa} then increased again in 2016. In 2020, estimated SSB is below MSY $B_{trigger}$ and B_{pa} (both equal to 10 600 t). The recruitment series is stable between 2004 and 2008, at around 17 or 18 million with the 2009-year-class providing the highest value since the early 1990s. The 2010 and 2011 values are close to the $GM_{1993–2014}$ (21 million). However, values declined again in 2012 and 2013 (13 million). Further decline in recruitment values were observed since 2015, with the lowest value of the series observed in 2020 (about 8 million). This year, fishing pressure on the stock is above FMSY but below Fpa while the spawning-stock size is below MSY $B_{trigger}$ and between B_{pa} and B_{lim}.

In addition to this MAP (EU, 2019), the industry implemented a mesh size restriction of > = 80 mm for the bottom-trawls for the periods from 1 January to 31 May and from 1 October to 31 December. A seasonal closure was also applied during the spawning period, 1 January to 31 March, for the directed fishery for common sole. This closure consists of three periods of seven consecutive days for a total of 21 days of closure.

Since 2015, the French sole fishery in the Bay of Biscay (ICES divisions 8.a and 8.b) has been subjected to additional management measures aimed at reducing F and improving the recruitment level of the stock. Since 2016, these measures have concerned at least a 15-day fishing activity suspension during the first quarter for netters and a reinforcement of the trawl selectivity for at least 8 months of the year (including the first quarter).

The COVID-19 restrictions had a negligible affect on the biological sampling as most of the French catches occurred outside the period of the 2020 French spring lockdown.

Details on the assessment are provided in section 7 below.

Sole in divisions 8.c and 9.a

Portugal and Spain are the main participants in these fisheries with *Solea solea* mainly caught with gillnets and trammelnets. In Portugal, *Solea solea* is caught together with other similar species *Solea senegalensis* and *Pegusa lascaris* though in recent years official catches are reported separated by species. There is some evidence that *Solea* spp. may have been misclassified in the past in Portuguese landings, which means that *Solea solea* official landings might not correspond only to this species but a mix of *Solea solea* with very few *S. senegalensis* and some *P. lascaris*. Total landings of *S. solea* were corrected during the WKWEST benchmark (ICES, 2021b). Total corrected landings for *S. solea* is 399 t and 431 t for 2019 and 2020, respectively.

Until now no assessment was performed for this species. This stock was recently benchmarked during the Workshop on Selected Stocks in the Western Waters in 2010 (WKWEST; ICES, 2021b) and the category of the stock was upgraded to category 3. Now, the advice for *S. solea* only is provided based on trends from the combined biomass index between commercial Portuguese LPUE and Spanish bottom-trawl survey index and length-based indicator (LBI; ICES, 2021a).

Management of all sole species under a combined species TAC prevents the effective control of the single-species exploitation rates and could lead to the overexploitation of either species. *S. solea* accounts for 55% of the catches in the last three years. Fishing pressure on the stock is at/below $F_{MSY\ proxy}$ and no reference points for stock size have been defined for this stock.

The collection of data from the commercial fishery during 2020 was affected by COVID-19 restrictions to a varying degree across member states. For this stock, the diagnostics for the assessment were deemed acceptable and the effect on the perception of the stock status and advice is considered minimal.

Details on the assessment are provided in section 8 below.

Hake in subareas 4, 6, and 7, and divisions 3.a, 8.a, 8.b, and 8.d (Northern stock)

Hake is caught in nearly all fisheries in subareas 7 and 8, and in some fisheries in subareas 4 and 6. In recent years. France accounted for the main part of the catches, followed by Spain than Scotland. Stock landings have been steadily increasing throughout the last decade, from 36 675 t in 2001 to 107 530 t in 2016, the highest value of the time-series. The 2017 landings saw a slight reduction down to 104 670 t. Discards were not available until 2002. From 2003 until 2010, discards were provided as a total in all the divisions and subareas where the northern hake is caught. In 2014, discards were allotted to specific divisions where the highest discarding occurs in divisions 4 and 7. A declining trend in total discards was observed since 2017. However, discarding in divisions 8.a, 8.b, and 8.d became the highest contributor to the 2017 total discards. In 2020, total discards were 3257 t. with a corresponding drop in discarding. Since 2009, landings have been above the agreed TAC until 2015. From 2015 until 2020, landings were below the agreed TAC. In 2020, the TAC was 112 903 t. However, the TAC for 2021 was not agreed at the time of the 2021 WGIBE meeting.

The stock was inter-benchmarked in 2019 (ICES, 2019) with one of the main objectives to assess the inclusion of hake eggs and larvae data collected during the triennial ICES Mackerel/Horse Mackerel Egg Survey (ICES, 2017a) and to account for the whole discard data available in the assessment. The inter-benchmark concluded that the hake egg index needs to be further investigated. Due to considerable information provided by this index, it is now recommended for use as an external indicator for comparison with the assessment results (SSB trends). Data inclusion of discards in the assessment adequately matches the patterns observed in the data and was considered as a suitable basis for assessment of the northern hake stock. As the assessment now accounts for all the catch data available, there is no need to provide catch advice with two types of unwanted catch.

The assessment was carried out according to the Stock Annex, and the group accepted the assessment as appropriate for providing advice. The retrospective pattern improved significantly in 2018 with the revision of the EVHOE survey and the update of the recruitment settings in the SS control file (ICES, 2018f). Although the revision of 2018 discards data had a negligible affect on the stock status estimates this year, it had a negative impact on the retrospective pattern. The patterns are significantly worse than in previous years. The spawning-stock biomass estimate obtained this year is above $B_{trigger}$, B_{pa}, and B_{lim} and the F is above F_{MSY} but below F_{pa}. The highest Mohn's rho index (Mohn, 1999) was obtained for spawning-stock biomass Platform (Windows/Linux) dependent convergence issues were detected.

The recruitment appears to fluctuate without substantial trend over the whole series with 2008 estimated to be the highest of the time-series (772 million), followed by the one in 1985 (650 million) and the one in 1981 as the third-highest (~617 million). From high levels at the start of the series (96 kt in 1980), the SSB decreased steadily to a low level at the end of the 1990s (23 kt in 1998). Since that year, SSB has increased to the highest value of the series in 2016 (307 kt) and decreased afterwards until 2019 (217 kt) then slightly increasing again in the last two years (225 and 239 kt for the years 2020 and 2021, respectively). The fishing mortality is calculated as the average annual F for sizes 15–80 cm. This measure of F is nearly identical with the average F for ages 1–5. Values of F increased from values around 0.5–0.9 in the late 1970s until the early 1980s to values around 1.0 during the 1990s. A declining trend in F was observed from 2000 to 2015. F increased slightly in 2016 (0.27) and 2017 (0.37) but values in 2018 and 2019 F_{MSY} (0.26). The F estimate for 2020 (0.26) is equal to F_{MSY}, with a three-year mean of 0.28.

The EU MAP for stocks in the Western Waters and adjacent has been agreed by the EU for this stock (EU, 2019). This plan is not adopted by Norway and UK; thus, it was not used as the basis of the advice for this shared stock. ICES was requested to provide advice based on the MSY approach and to include the MAP as a catch option.

The stock coordinator noticed some errors in the assessment codes while running the model for WGBIE 2021. These were corrected and used in the provision of the 2022 advice. However, this also led to the revision of the 2021 advice.

The collection of data from the commercial fishery and research surveys during 2020 was affected by COVID-19 restrictions to a varying degree across member states. For this stock, the diagnostics for the assessment were deemed acceptable and the impact on the perception of the stock status and advice is considered minimal.

Details about the assessment of this stock are provided in section 9 below.

Hake in divisions 8.c and 9.a (Southern stock)

Hake in divisions 8.c and 9.a is caught in a mixed fishery by Spanish and Portuguese trawlers and artisanal fleets. Spain accounts for the main part of the landings. Total landings increased in 2018 and 2019 up to 10 183 t and 11 800 t and decreased in 2020 to 8732 t. Total discards in 2018 were 1942 t and decreased to 1061 t in 2019 and 438 t in 2020. Total catches were 12 861 t in 2019 and 9171 t in 2020. The TAC for 2020 is 8752 t which means that total catches exceeded the advised TAC.

The southern hake stock was benchmarked in 2014 (WKSOUTH; ICES 2014) to address the difficulties encountered by the GADGET model (Begley and Howell, 2004; Begley, 2005) in its search for the set of parameters that maximize the likelihood function. The work confirmed that the model fitting procedure is finding a genuine optimum and can thus continue to be used as the assessment model.

The assessment in 2020 was updated using the data until 2019 with no revisions of data from previous years. The model was rejected due to its strong and persistent retrospective pattern which was not possible to solve and the advice produced in 2020 for 2021 was based on trends, following the rules of a category 3 stock. The mean of the standardized indices (SP-NSGFS-WIBTS-Q4 [G2784] and PT-TR) was used as the index of stock development. In 2021, the basis of assessment is the same, but some other methods used for category 3 stocks were explored. All sources of data are under revision and the Stock Synthesis integrated model is being explored for a new benchmark proposed for 2022.

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

Details on the assessment of this stock are in section 10 below.

Nephrops in divisions 8.a and 8.b (FUs 23–24)

There are two functional units (FU) in ICES divisions 8.a and 8.b: FU 23 (Bay of Biscay North) and FU 24 (Bay of Biscay South), see Figure 1.2. *Nephrops* in these FUs are almost exclusively exploited by French trawlers. Landings declined until 2000, from 5281 t in 1988 to 2848 t in 2000. After that year, they increased again to around 3421 t, staying at > 3000 t until 2006. From 2007–2009, landings have been around 2800 t then increased to about 3200 t during the next 2 years. In 2012 and 2013, a reduction in the landings occurred (2290 t in 2012, 2195 t in 2013) followed by an increase to 3425 t in 2015. In 2020, total nominal landings reached 2273 t, close to the historically lowest level of its time-series in 2018 (2125 t). The agreed TAC for 2020 was 3886 t and for 2021, the TAC was fixed at 3984 t.

A French regulation increased the minimum landing size in 2006 and several effort and gear selectivity regulations have also been put in place in recent years. The use of selective devices for trawlers targeting *Nephrops* became compulsory in 2008. All these measures are expected to be contributing in various ways to the change of landings and discard patterns recently observed. In general, discards values after 2000 have been higher than in earlier years, although sampling only occurred on a regular basis from 2003, so information about discards is considerably weaker for the earlier period. Since 2017, the use of a discarding quick-chute system on-board has become compulsory. This measure has a direct impact on the survival rate of discards. The new survival rate of 50% was accepted to be used in the assessment and advice of the stock (WK*Nephrops* 2019, ICES, 2020c).

This stock was benchmarked in WKNEP in 2016 (ICES, 2017b) which has reviewed the methods proposed using an underwater TV survey. The outcome of this process classified the stock as a category 1 stock and the methods developed were considered appropriate for assessing the stock and provision of advice.

No quantitative analytical assessment was carried out during the WG in spring since the survey used for the assessment had not been completed yet. An update of the assessment and the report will be carried out after the WG and the advice will be provided in October 2020.

Details can be found in section 11 below.

Nephrops in Division 8.c (FUs 25 and 31)

There are two functional units in Division 8.c (Figure 1.2): FU 25 (North Galicia) and FU 31 (Cantabrian Sea).

Nephrops are caught in a mixed bottom-trawl fishery in the North and Northwest Iberian Atlantic. Landings from both FUs have declined dramatically in recent years reaching less than 15 t in each FU in 2015, below the TAC in recent years, which has not been restrictive. The TACs were set at 0 t for all of Division 8.c for 2017 to 2020. However, a scientific quota was established for *Nephrops* in each of the FUs in order to undertake an observer programme to collect data to continue to assess the status of the stock. Special quotas of 4.3 t in 2017 reduced to 2 t in 2018–2020 were set for *Nephrops* in FU 25 and 0.7 t in 2019–2020 for *Nephrops* in FU 31 for this programme (*Nephrops* Sentinel fishery), supervised by the Spanish Oceanographic Institute (IEO) for obtaining a *Nephrops* abundance index and complementary data.

A recovery plan for southern hake and Iberian *Nephrops* stocks has been in force since 2006. The aim of the recovery plan is to rebuild the stocks within 10 years, with a reduction of 10% in F relative to the previous year and the TAC set accordingly (EU, 2005). The recovery plan was repealed in 2019.

Until 2020, these stocks were assessed by the analysis of the LPUE series trend according to the ICES data-limited approach, both stocks were considered as category 3.1.4 (ICES, 2015). This year, these two stocks were benchmarked during the WKMSYSPiCT (ICES, 2021c) and both were upgraded to category 2 (ICES, 2021a), with the assessment and advice based on the SPiCT model (Pedersen and Berg, 2017) and derived relative reference points. For both stocks, catch and SP-NGFS-Q4 bottom trawl survey abundance index time-series were used as input data.

In FU 25, F is below F_{MSY} and total biomass is below $B_{trigger}$ and B_{lim} while in FU 31, F is below F_{MSY} and total biomass is below B_{MSY} and $B_{trigger}$ but above B_{lim}.

A single TAC covers the entire ICES Division 8.c. ICES advises that the management area should be consistent with the assessment area.

The collection of data from the commercial fishery and research surveys during 2020 has been impacted by COVID-19 restrictions to a varying degree across member states. For these stocks, the impact of the COVID-19 pandemic on the perception of the stock status and advice is considered minimal.

Additional details are provided in section 12 below.

Nephrops in Division 9.a (FUs 26–27, 28–29, and 30)

There are five functional units in Division 9.a (Figure 1.2): FU 26 (West Galicia), FU 27 (North Portugal), FU 28 (Alentejo, Southwest Portugal), FU 29 (Algarve, South Portugal) and FU 30 (Gulf of Cádiz). To ensure that the stocks in these FUs are exploited sustainably, ICES advises that management should be implemented at the FU level.

Landings in 2019 from the five FUs combined were 357 t in 2019 and 315 t in 2020. The TAC set for the whole of subareas 9 and 10 and Union waters of CECAF 34.1.1 was 386 t and 374 t for 2020 and 2021, respectively.

A recovery plan for southern hake and Iberian *Nephrops* stocks had been in force since 2006. The aim of the recovery plan was to rebuild the stocks within 10 years, with a reduction of 10 % in F relative to the previous year and the TAC set accordingly (EU, 2005). In March 2019, the European Parliament and the Council have published the MAP for the Western Waters and adjacent waters (EU, 2019) which repealed the previous recovery plan. This plan applies to demersal stocks including *Nephrops* in ICES Division 9.a.

FUs 26+27 (West Galicia and North Portugal):

The fishery shares the same characteristics as that in Division 8.c, described above.

The advice for these *Nephrops* stocks is triennial. The last advice given in 2019 was valid for 2020, 2021 and 2022. However, as it is now considered a category 2 stock, new advice according to this category will be given in this year. For *Nephrops* in FUs 26–27, ICES advised that when the precautionary approach is applied, there should be zero catch in each of the years 2020 and 2021.

Landings are reported by Spain and, in minor quantities, by Portugal. Since 2012, quantities have been similar and at very low levels (≤ 7 t). Spanish fleets fish in FU 26 and FU 27, whereas Portuguese artisanal fleets fish with traps in FU 27. Two periods can be distinguished in the landings time-series available from 1975–2020. During 1975–1989, the mean landing was 680 t, fluctuating at approximately between 575 and 800 t. From 1990 onwards, there has been a marked downward trend in landings, being below 50 t from 2005 to 2011. In the last nine years, landings continued to decrease and are below 10 t. Discards rates are considered negligible.

This stock was considered as a category 3.1.4 according to the ICES data-limited approach since 2012 (ICES, 2012) and was assessed by the analysis of the LPUE series trend. *Nephrops* in FUs 26–27 was recently benchmarked during the WKMSYSPiCT (ICES, 2021c). The stochastic production SPiCT model (Pedersen and Berg, 2017) was accepted for assessment and to produce advice. This stock is now upgraded to category 2 and accordingly, assessment has been carried out this year using the SPiCT model.

Additional details can be found in section 13.1 of this report.

FU 28+29 (SW and S Portugal):

Nephrops are taken by a multispecies and mixed bottom-trawl fishery. The trawl fleet comprises two components, one targeting fish operating along the entire coast, and another one targeting crustaceans, operating mainly in the southwest and south, in deep waters. There are two main target species in the crustacean fishery, Norway lobster and deep-water rose shrimp, with different but overlapping depth distributions. In years of high rose shrimp abundance, the fleet directs its effort to this species as a preference.

The advice for this stock is biennial and valid for 2020 and 2021. Based on the ICES approach for DLSs, ICES advised that catches in 2021 for FUs 28 and 29 should be no more than 309 t. To ensure that the stock in FUs 28 and 29 are exploited sustainably, ICES advises that management should be implemented at the FU level.

For the period 1984–1992, the recorded landings from FUs 28 and 29 have fluctuated between 420 and 530 t, with a long-term average of about 480 t followed by a declining period in 1990–1996 down to 132 t. From 1997 to 2005, landings increased to levels observed during the early 1990s, decreasing again in recent years. The landings in 2009–2011 were stable at around 150 t, increasing to 299 t over the years 2014–2018. Landings in 2019 and 2020 were 284 t and 247 t, respectively. There are no discards of *Nephrops* in the fishery.

During 2020, *Nephrops* Portuguese sampling in markets was affected by the COVID-19 pandemic and no sampling was conducted during April, May, July, and August. Raising of the length compositions for the missing months was based on the mean length composition of the last three years (2017–2019) in each of those months.

According to the ICES data-limited approach, this stock is classified in the category 3.2.0 (ICES, 2015) and the advice is based on standardized cpue and effort trends. Standardized effort shows a consistent declining trend until 2010, fluctuating at low levels since. The standardized cpue model, used as an index of biomass, was reviewed during WKMSYSPiCT and presents a slightly increasing trend since 2014 with some fluctuations. Proxy reference points were estimated using the Mean Length Z approach with the standardized effort. The results indicate that the stock is exploited at levels below the F_{MSY} reference point.

This stock was recently benchmarked during the WKMSYSPiCT in early 2021 (ICES, 2021c) where the SPiCT method (Pedersen and Berg, 2017) was implemented to produce advice. However, given the available input data for the stock, the contradicting results produced using different model configurations and the impossibility to distinguish between the two alternative stock statuses, the stochastic production SPiCT model was not accepted to provide assessment and advice for this stock. Thus, the stock remains in category 3.

Additional details can be found in section 13.2 of this report.

FU 30 (Gulf of Cádiz):

Nephrops in the Gulf of Cádiz is caught in a mixed fishery by the trawl fleet. Landings are markedly seasonal with high values from April to September. Landings were reported by Spain and, in minor quantities, by Portugal. Landings increased from 100 t in the mid-1990s to a higher level at the beginning of the 2000s. Landings decreased again until 2008 fluctuating at around 100 t from 2008 to 2012. In 2013–2015, landings dropped to around 20 t, due to a sanction applied by the European Commission for Spain having exceeded the quota in 2012 so that the *Nephrops* fishery was closed with vessels only fishing for *Nephrops* for a few days during summer and winter periods. From 2016, effort and landings have resumed back to levels seen prior to this period, with the inclusion of the unreported landings. Estimates since 2016 are considered the best information available.

According to the ICES data-limited approach, this stock is classified in the category 3.2.0 (ICES, 2015) and the advice is based on the underwater TV survey (UWTV) series trends. No quantitative analytical assessment was carried out during the WG in spring since the survey used for the assessment had not been completed yet. The UWTV survey was not conducted in 2020 due to the COVID-19 disruption which led to the absence of an abundance index estimate for 2020. The advice for 2021 was produced based on the survey trends assuming for 2020 the same abundance estimate of 2019. An update of the assessment and this report will be carried out after the WG and the advice will be provided in October, after the results of the 2021 survey.

Additional details can be found in section 13.3 of this report.

General comments:

The five *Nephrops* FUs (assessed as 3 separate stocks) are managed jointly, with a single TAC set for the whole of subareas 9, 10 and CECAF 34.1.1. This may lead to unbalanced exploitation of the individual stocks. The northernmost stocks (FUs 26–27) are at extremely low levels, whereas the southern ones (FUs 28–29 and FU 30) are in better condition.

The TAC set for the whole Division 9.a was 386 t and 374 t for 2020 and 2021, respectively, of which no more than 6% may be taken in FUs 26 and 27, and no more than 77 t in 2020 and 65 t in 2021 may be taken in FU 30.

The sampling programs coordinated by the IEO (onshore, observers at-sea and biological sampling) were suspended partially in 2020 due to administrative problems and to the COVID-19 disruption affecting the information of FUs 26 and 30.

European sea bass in divisions 8.a and 8.b

Sea bass in the Bay of Biscay are targeted by France (more than 98.8% of international landings) by line fisheries (handlines and longlines) which take place mainly from July to October. Other exploitations such as nets, pelagic trawlers, and mixed bottom-trawl fisheries occur from November to April, the period when prespawning and spawning grounds when sea bass aggregate. Since the late 1990s, total landings were stable with an average at around 2600 t over time. Landings of netters have, however, increased since 2011 due to a decrease of sole quotas from 2011 and a redistribution of effort towards this species combined with good weather conditions in 2014. Recreational fisheries are an important part of the total removals but these are not accurately quantified. Discards are known to take place but are not fully quantified. The available data suggests that discards can be considered negligible (<5%).

The sea bass stock in the Bay of Biscay was benchmarked in 2017 and 2018 (WKBASS and IBPBass; ICES 2018d, 2018e) and included both recreational and commercial landings and is tuned by a commercial landings per unit of effort series. Since 2000, commercial landings have fluctuated without trend and the recreational removals give similar fluctuations and trends given that the values are based on the assumption of constant F relating to recreation survey data collected in 2010.

Sea bass in the Bay of Biscay is not subject to the EU TACs and quotas but is ruled by an EU multiannual plan (MAP; EU, 2019) for the Western waters and adjacent waters since 2019.

The only available tuning index fluctuates without trend with the years 2012 to 2016 showing a decline than an increase in 2017. The SSB fluctuated around 20 000 t. A low SSB was observed just before the 2000s then a high value was observed around the year 2010. Since then, a decreasing trend was observed. SSB is currently above MSY $B_{trigger}$, B_{pa}, and B_{lim}. The recruitment series was variable around ~30 million individuals per year. Recruitment below average was observed for years 2010 and 2015–2016. F, estimated as the average of ages 4–15, has fluctuated without trend over the time-series. Currently, fishing pressure on the stock is below F_{MSY}.

The COVID-19 pandemic has not impacted the data quality for assessment and advice of the stock.

Currently, the assessment of the stock relies on a short data time-series: length composition time-series started in 2000; age-at-length time-series started only in 2008 (with a proper sampling after 2010); recreational data were surveyed for only one year in 2010. In addition, there is no scientific survey for adult sea bass to scale the model to an appropriate level of abundance. There is no survey for recruits either. All these elements introduce uncertainty in the assessment.

Additional details can be found in section 14 below.

European sea bass in divisions 8.c and 9.a

Spanish and Portuguese vessels represent almost all of the total annual landings in divisions 8.c and 9.a. Commercial landings represented 788 t in 2019, a value slightly higher than the previous year, 716 t in 2018. A peak in landings was observed in 1989–1990 and again in 2013, reaching more than 1000 t while the lowest landings have been observed in 1980, 1981, and 1985 and more recently in 2003 (466 t). Discards from observer programmes show that discarding is negligible for this stock. Recreational catches are not quantified but considered not negligible.

No stock assessment is carried out as the stock is considered as category 5.2.0 (ICES, 2021a). Information on abundance and exploitation is not yet available and the update of the landings data does not change the perception of the stock. Advice for this stock is based on the precautionary approach and it was issued in 2019 for the years 2020 and 2021. Landings are more than the advised catch (502 t) and it is uncertain whether the 2020 and 2021 advice will have any impact on the stock given that this is not limited by management as only an MLS applies (EU, 1998).

Additional details can be found in section 15 below.

Plaice in Subarea 8 and Division 9.a

Plaice (*Pleuronectes platessa*) are caught as bycatch by various fleets and gear types covering small-scale artisanal and trawl fisheries. Portugal and France are the main participants in this fishery with Spain playing a minor role. Present fishery statistics are considered to be preliminary as there are concerns about the reliability of data, missing French data in 1999 and the quality of the French data for 2008–2009. Landings may also contain misidentified flounder (*Platichthys flesus*) as they are often confounded at sales auctions in Portugal. The quantity of discarding is uncertain. For these reasons, the landings are unlikely to be a good indicator of total removals and ICES considers that it is not possible to quantify the catches.

This stock is currently ranked as a DLS in category 5.2.0 (ICES, 2012; 2021a) as only landings data are available. This year, the updated time-series of landings and discards including 2019 data do not change the perception of the stock.

Additional details can be found in section 16 below.

Pollack in Subarea 8 and Division 9.a

Pollack is mainly caught by France (77%) and Spain (18%) by several types of gears; nets, lines and trawls. Most of the landings are from gillnets (53%) followed by the line (37%) fisheries. Since the early 2000s, the landings have been relatively stable between around 1500 t and 2200 t. The recreational removals are unquantified but considered non-negligible.

Discards by Spanish netters indicate that the discards are considered negligible. Discards by French netters and liners are about 1.2% and 0.1% of their catches, respectively.

The advice for this stock is biennial and the last advice was released in 2019. Pollack is managed under a TAC that was set at 1944 t for 2020 and at 1851 t for 2021, which means that commercial landings have not exceeded the total allowable catches. The TAC for this stock was set separately for ICES divisions 8.a, 8.b, 8.d, and 8.e. All commercial catches are assumed to be landed. ICES cannot quantify the corresponding total catches because the recreational catches cannot be quantified. ICES cannot assess the stock and exploitation status relative to MSY and precautionary approach reference points because the information needed to define reference points is not available.

This stock was benchmarked during the WKMSYSPiCT in early 2021 (ICES, 2021c). Due to the short time-series of the abundance index and to the contrasting gaps in the input data, it was not possible to fit the information available to provide an acceptable assessment model using SPiCT (Pedersen and Berg, 2017). Hence, the stock remains as a DLS in category 5 (ICES, 2012; 2021a) as the only available information is on catches. The updated time-series of landings and discards including 2020 data do not change the perception of the stock. In 2020, length-based methods for DLSs (ICES, 2015) and the stochastic production model SPiCT (Pedersen and Berg, 2017) were explored. As previously referred, the SPiCT assessment was rejected during the WKMSYSPiCT (ICES, 2021c) held earlier this year.

The COVID-19 pandemic has not affected the quality of data on which the advice is based.

Additional details can be found in section 17 below.

Whiting in Subarea 8 and Division 9.a

Whiting (*Merlangius merlangus*) are caught in mixed demersal fisheries primarily by France and Spain. Present fishery statistics are considered to be preliminary. Total landings have fluctuated around an average of 2000 t since 2010. The 2016 landings (2502 t) are reported to be one of the highest of the time-series. In 2017, landings decreased to 1909 t. This was followed by further declines in succeeding years to a value of 1096 t in 2020, the lowest in its time-series when excluding the year 1999 (French landings data were not submitted). Discards and bycatch are about 27% (mean of 2016–2020). Whiting has never been recorded in Spanish discards and is negligible in Portuguese discards. However, there are indications that discarding occurs in the French fleet, recent available information suggests this is highly variable between fleets and for some considerable.

TAC for this stock is only set in Subarea 8. For Division 9.a the TAC is delegated to the Member States.

This species is at the southern extent of its range in the Bay of Biscay and the Iberian Peninsula. It is not clear whether this is a separate stock from a biological point of view.

The stock is classified as a DLS in category 5.2.0 (ICES, 2012; 2021a) as the only available information is on catches. This year, the updated time-series of landings and discards including 2020 data do not change the perception of the stock. The LBI (ICES, 2018a; b) analysis suggests that F is below proxies of the MSY reference points.

The COVID-19 pandemic affected on-board sampling and discard estimates. Discard and length structure were raised on a six-month basis in order to mitigate low sampling levels.

Additional details can be found in section 18 below.

1.2 Available data

Catch (totals and/or age–length structured) and effort data according to species, country, area and *métier* were requested in the ICES standard data call for WGBIE. A deadline of 5 April 2021 was set in order to prepare the datasets for the WG and progress on the use of InterCatch.

For most of the stocks assessed by WGBIE, InterCatch was used mainly to extract catch, landings, and discards data. The data delivered to accessions via worksheet format was, for some stocks, used as the primary data source and compared to the data submitted on InterCatch.

The main data problems detected by the WG, and for which action is required, is the delay in the submission of data via InterCatch or accessions of catch and associated length and age samples and survey and commercial indices. There were no important delays in data submission to InterCatch. However, the quality of submitted data were affected by the COVID-19 disruption. Most of the countries had no sampling in the second quarter of 2020 or the sampling program was reduced. Specific details on the impact on each stock assessment are provided in the corresponding stock section. Biological sampling levels by country and stock are summarized in Table 1.1 through Table 1.4.

Several stocks assessed by the WG are managed by means of TACs that apply to areas different from those corresponding to individual stocks, notably in Subarea 7, as well as for the *Nephrops* FUs in 8.c and 9.a, or to a combination of species in the cases of anglerfish and megrim. Due to Brexit, for some stocks as the northern stock of hake, megrims in divisions 7.b–7.k, 8.a, 8.b, and 8.d and anglerfish in Subarea 7 and divisions 8.a, 8.b, and 8.d, no TACs for the whole 2021 were set at the time of the Working Group but only for the first quarter. The agreement between the EU and the United Kingdom on quota shares was reached only at the end of June.

1.3 Stock data problems relevant to data collection

WGBIE were made aware of an issue with problems relevant to data collection and quality this year linked to the COVID-19 disruption which has affected the assessment and advice to different degrees. Details of the COVID-19 impact on stocks are provided in their specific sections.

1.4 Use of InterCatch by WGBIE

Progress has been made by the group with regards to the use of InterCatch. Several stocks are partly using InterCatch in this process but as a place to hold all the raw data with the files being processed and raised externally.

This year, northern hake files were exclusively processed within InterCatch, because of the complexity of the data, with the number of countries and *métiers*, raising the data were again very time consuming, cumbersome, and difficult with no one year being repeatable.

1.5 Assessment and forecast auditing process

WGBIE carried out the standard audits of individual assessments and forecasts where available for all stocks assessed. Following a template provided by the ICES secretariat, the choice of assessment model, the model configuration, and the data used in the assessments have been checked against the corresponding settings described in the Stock Annex. Not all audits could be completed by the end of the meeting and the remaining stocks were audited after the meeting. Only minor corrections were raised by the auditors and these were corrected accordingly.

1.6 Stock annexes

All stocks assessed by this WG have a specific Stock Annex which is revised accordingly when needed.

1.7 Benchmark of single-species assessments

In 2021, issues lists were completed for 17 stocks (7 cat. 1, 2 cat. 2, 4 cat. 3, and 4 cat. 5) in preparation for benchmarking and to review future research needs. The WG had reviewed the stocks to be benchmarked using the benchmark prioritization scoring sheet. There are five categories, each with a score of 1 to 5 (5 being high priority), the scores from the five categories are then combined using a weighting. The final selection of stocks to be benchmarked is via a ranked system with all stocks assessed by ICES.

In 2020–2021, four stocks in category 3 were benchmarked with SPiCT in WKMSYSPiCT (ICES, 2021a): the southern black-bellied anglerfish (ank.27.8c9a), *Nephrops* in FU 25 (nep.fu.25), *Nephrops* in FU 31 (nep.fu.31), *Nephrops* in FUs 26 and 27 (nep.fu.2627) and *Nephrops* in FUs 28 and 29 (nep.fu.2829). Only for nep.fu.2829 the application of the SPiCT model was not successful. Besides the wide confidence limits, different configurations have produced contradicting results and no model was accepted. The other stocks were upgraded from category 3 to category 2, with relative reference points and the use of the SPiCT model for assessment and forecasts was accepted.

Also, the sole stock in divisions 8.c and 9.a (sol.27.8c9a) was benchmarked in WKWEST (ICES, 2021b). The stock was classified as category 5 and the advice was based on landings. This classification was reviewed with the new data presented at the WKWEST benchmark and the stock was upgraded to category 3, assessed with Length-Based Indicators and advice based on LPUE trends.

1.7.1 Proposals for future benchmarks

Following a recommendation from WGBIE (ICES, 2020b), an online workshop was held in November 2020 and January 2021, the Workshop on Tools and Development of Stock Assessment Models using a4a and Stock Synthesis (WKTaDSA), chaired by Lisa Readdy and with the participation of external experts from NOAA, ICES, and JRC. This workshop was intended to help the WGBIE stock coordinators in the development and application of Stock Synthesis (Methot and Wetzel, 2013) and a4a (Millar and Jardim, 2019) models to some selected stocks to be proposed for a benchmark. The following stocks were involved in the WKTaDSA (ICES, 2021d):

- For a4a: the northern and southern megrims meg.27.7b–k8ad, meg.27.8c9a, and ldb.27.8c9a;
- For Stock Synthesis: northern and southern stocks of hake (2 stocks), northern and southern stocks of anglerfish (4 stocks): hke.27.3a46-8abd, hke.27.8c9a, mon.27.78abd, ank.27.78abd, mon.27.8c9a, and ank.27.8c9a.

Progress has been made in model development, and this online work will continue to evolve until the benchmarks that will take place, for some of the stocks, during the last months of 2021 and the beginning of 2022. In the table below some information on the last benchmark and needs are summarized. Several benchmarks were proposed depending on the stocks and the assessment model.

Name	Assessment status	Latest Benchmark	Benchmark next year	Planning Year +2	Comments/Issues
Hake in subareas 4, 6, and 7 and divisions 3.a, 8.a,b,d (Northern stock)	Update	WKSouth (ICES, 2014), IBPHake (ICES, 2019)	Yes	–	Revision of biological data and *von* Bertalanffy growth parameters, analysis of convergence issues, the inclusion of North Sea surveys, revision of model setting in general (weighting of different data sources).
Hake in divisions 8.c and 9.a (Southern stock)	Downgraded to category 3	WKSouth (ICES, 2014)	Yes	–	Assessment with Gadget rejected. Strong retrospective pattern, the cause of which is unclear. Revision of biological data. SPiCT model explored. Change of assessment models to SS was initiated in WKTaDSA (ICES, 2021d).
Black Anglerfish in Subarea 7 and divisions 8abde	Survey trends (category 3)	WKAngler (ICES, 2018c)	Yes	–	Other models are being explored. Change of assessment model to SS was initiated in WKTaDSA (ICES, 2021d).
White Anglerfish in Subarea 7 and divisions 8abde	a4a (provisional)	WKAngler (ICES, 2018c)	Yes	–	a4a is an age-based assessment and Lengths are converted to ages outside the model. Change of assessment model to SS was initiated in early 2020 and continued in WKTaDSA (ICES, 2021d).
Black Anglerfish in divisions 8.c and 9.a	SPiCT trends (category 3)	WKAngler (ICES, 2018c); WKMSYSPiCT (ICES, 2021c)	–	–	Other models are being explored. Change of assessment model to SS explored in WKTaDSA (ICES, 2021d).
White Anglerfish in divisions 8.c and 9.a	Update	WKAngler (ICES, 2018c)	–	–	Remaining issues (tuning fleets, length composition). Absence of large size individuals. Improvement of standardized cpues. SS model update
Megrim in Subarea 7 and divisions 8abde	Bayesian catch-at-age	IBPMegrim (ICES, 2016)	Yes	–	Change to a4a due to the long computational time needed for the Bayesian model. Change of assessment model to a4a was initiated in early 2020 and continued in WKTaDSA (ICES, 2021d). Improvement of standardized cpues.
Megrim in divisions 8.c and 9.a	XSA	WKSOUTH (ICES, 2014)	Yes	–	XSA deterministic. Change of assessment model to a4a was initiated in WKTaDSA (ICES, 2021d). Improvement of standardized cpues.

Name	Assessment status	Latest Benchmark	Benchmark next year	Planning Year +2	Comments/Issues
Four-spot Megrim in divisions 8.c and 9.a	XSA	WKSOUTH (ICES, 2014)	Yes	.	XSA deterministic. Change of assessment model to a4a was initiated in WKTaDSA (ICES, 2021d). Improvement of standardized cpues.
Sea bass in divisions 8.a and 8.b	SS	WKBASS (ICES, 2018d), IBPBass (ICES, 2018e)	–	Yes	Stock identification; to be benchmarked in coordination with other Sea bass stocks in the Celtic Sea.
Nephrops in FU 25		WKMSYSPiCT (ICES, 2021c)	–	–	Improve the SPiCT model. MSE exploration.
Nephrops in FU 31		WKMSYSPiCT (ICES, 2021c)	–	–	Improve the SPiCT model. MSE exploration.
Sole in divisions 8.c and 9.a		WKWEST (ICES, 2021b)	–	–	Assessment using trends from combined biomass index between commercial Portuguese LPUE and Spanish bottom trawl survey index and LBI. 2021 Advice is only for *S. solea*. Evaluate the relevance of the recent 2-over-3 advice rule for category 3-4 stocks

1.8 Mohn's rho

As standard practice, for each of the stocks assessed using a full analytical assessment within a category 1 of stock assessment, the Mohn's rho (Mohn, 1999) was calculated (Figure 1.3) using a 5–year peel. WGBIE assesses eight stocks that fall into this category of assessment using a combination of age and/or length structured models and four stocks are assessed with surplus production models (SPiCT) (Pedersen and Berg, 2017). As can be observed in Figure 1.3, not all the stocks have Mohn's rho values within the 20% threshold for SSB and F. Recruitment shows much more retrospective bias suggesting that recruitment is not easily estimated by the models. In 2020, the assessment of Hake in divisions 8.c and 9.a with GADGET was rejected due to a marked and strong retrospective pattern for all stock characteristics and the stock was downgraded to category 3 as an interim solution until a new assessment model is developed and accepted in a benchmark. This year, the SPiCT model (Pedersen and Berg, 2017) was explored to estimate proxy reference points. Although Mohn's rho values were within acceptable limits, the models present wide confidence limits.

1.9 Evaluation of *Nephrops* Functional Units 29 and 30

Some stations in FU 29, near the border with FU30, were covered by the Spanish ISUNEPCA survey (U9111), with some stations with UWTV and some hauls carried out with beam trawl. The purpose was to investigate the continuity of *Nephrops* distribution in these two contiguous functional units. The WG 2020 (ICES, 2020b) reviewed the recent findings and available data which were standardized across the two units for comparison purposes. No further developments were presented this year.

1.10 Fisheries overviews

Some progress on the development of a mixed-fishery analysis has been made in WGMIXFISH-METHODS (ICES, 2021e) and WGMIXFISH-ADVICE (ICES, 2021f) using some Iberian stocks and some Bay of Biscay stocks in a separate analysis. The group has contributed to the review of the fisheries description and providing the inputs from the stocks assessment for the analyses carried out in these two groups.

1.11 Ecosystem overviews

No progress has been made on this term of reference.

1.12 TAF-based stock assessments

In 2020, two WGBIE stock assessments were implemented to a Transparent Assessment Framework (TAF): the northern Hake and the Bay of Biscay Sole, where the two stock coordinators and/or assessors were nominated as TAF ambassadors for WGBIE.

The facility of the implementation seems to be linked with the assessment model used for each stock. The Bay of Biscay Sole assessed using an age-structured XSA model demanded less time and effort for coding and integration into TAF while the northern Hake SS assessment model required some more work (i.e. coding and data tables reformatting) for its implementation.

The two SCs presented their specific experience, challenges encountered and overall evaluation on the implementation of a TAF-based assessment to the WG. The WG found these very informative considering the ICES and WG general objective of implementing the TAF-based assessment to most, if not all, of the WGBIE stocks.

1.13 Research needs of relevance for the expert group

Many of the stocks have recruitment indices available with limited indices for the adult population, therefore, it would be advantageous to develop and use adult biomass indices to help reduce the uncertainty in the spawning-stock biomass estimates. Further research and appropriate evaluation are recommended in the development of such indices for stocks where standard surveys are not appropriate due to catchability issues.

For the stocks of hake, megrim, four spot megrim, anglerfish, sea bass, and some of the *Nephrops* functional units, further studies are required to better understand the mixing between areas and the biology over time such as growth, maturity, length-weight, sex-ratio, and natural mortality. To fully make use of new research on these stocks it would be beneficial to focus on developing appropriate assessment methods and reviewing the performance of such models through comprehensive sensitivity analyses.

1.14 Recommendations

1. Benchmark for northern and southern hake

WGBIE, after reviewing the progress in the development of the Southern hake SS model, considers that this stock is in a position to succeed in an eventual 2022 benchmark. Furthermore, given the similarities between Northern and Southern hake stocks regarding productivity process (e.g. recruitment, growth, natural mortality) and the expectations of changes in the benchmark process, the WGBIE considers that a benchmark with both stocks would be more productive in improving the quality of both models. WGBIE recommends Northern hake and Southern hake to go to benchmark in 2022.

2. WKTaDSA follow-up meetings

WGBIE recommends that ICES coordinate follow-up meetings/workshops with relevant experts to continue the development of the integrated stock assessment of two hake stocks, four anglerfish stocks and one bass stock using Stock Synthesis in preparation for the benchmark process; this should also include working on and integrating the ICES criteria for the estimation of biological reference points; F_{MSY}, F_{PA}, F_{lim}, MSY $B_{trigger}$, B_{lim} and B_{pa}.

3. Improvement and validation of population structure identification

WGBIE recommends that SIMWG and WGAGFA review the recent studies on population structure and genetic identification of some stocks.

The progress on studies made regarding the northern and southern white anglerfish stocks population structure was presented to the group during the WG. The WG agrees that a request for review by SIMWG of these recent findings and observations on the white anglerfish population structure. The WG will prepare, collect and submit scientific materials (i.e. in prep or published articles to a peer-review journal, data and supporting literature) to SIMWG for review this year.

The recent genetic findings on white anglerfish show that:

a) the species forms a panmictic population throughout the Northeast Atlantic indicating that the two white anglerfish stocks belong to the same population);
b) there is a hybridization between white anglerfish;
c) there is misidentification between the white and black anglerfish even if the colour of the peritoneum is used for taxonomic identification.

WGBIE recommends that WGAGFA reviews these findings this or next year.

WGBIE also requests a joint WGBIE-WGCSE for sea bass population structure identification workshop to analyse and discuss the most recent studies, data analyses and future research needs for validation and improvement of current ICES stock definitions for this stock. Procedures for the integration of newly derived information on stock ID into the assessment model and evaluate their pertinence on future assessment and advice will also be discussed. Results from this intersessional workshop will be included, evaluated and used to propose revisions, if necessary, based on new findings, for a future benchmark.

4. Application of the advice rule on the stocks in divisions 8.c and 9.a

WGBIE recommends that WKLIFE in October 2021 further exploration and analyses of the impact of the application in the assessments of the updated 2-over-3 rules for category 3–4 stocks to understand and resolve contradictory responses observed that will ultimately affect the advice. ICES recommends that reference points for category 3–4 stocks should be estimated using the SPiCT model and apply length-based methods (i.e. LBI, MLZ or LBSPR) to define stock and exploitation status when the former is not applicable. However, an updated 2-over-3 rule (see Method 2.1 in ICES, 2020a) for category 3 and 4 stocks now includes new parameters (m, f, and b) in the equation compared to the previous one. This new rule, along with the other recommended methods, was implemented this year for the sole in divisions 8.c and 9.a stock and southern hake in WGBIE, and are expected to be implemented on the other category 3–4 stocks next year. The sole in divisions 8.c and 9.a was upgraded from category 5 to 3 stock after the recent benchmark (ICES, 2021b). Contradicting responses were observed in the assessment when these additional parameters ($m = 0.80$, $f = 1.03$, and $b = 0.91$) were included in the calculations. LBI, the selected indicator for this stock, showed relatively healthy levels of exploitation and stock status (LBI; ICES, 2018a; b), with the optimal yield attained. However, a strong reduction (32.3%) was observed, with respect to the average catch of the last three years, which is due to the inclusion of these parameters.

5. Development and improvement of standardized cpue series

WGBIE recommends the development and/or improvement of standardized cpue series for the following stocks:

- **Category 1 stocks**: white anglerfish (mon27.8c9a), megrim (meg.27.8c9a), and four-spot megrim (ldb.27.8c9a) in divisions 8.c and 9.a, megrim in divisions 7.b–k, 8.a–b, and 8.d (meg.27.7b-k8abd);
- **Category 2 stocks**: black anglerfish in divisions 8.c and 9.a (ank.27.8c9a);
- **Category 3 stock:** *Nephrops* in FUs 2829 (nep.fu.2829);
- **Category 5 and 6 stocks**: sea bass in divisions 8.c and 9.a (bss.27.8c9a), Pollack in Subarea 8 and Division 9.a, (pol.27.89a), whiting in Subarea 8 and Division 9.a (whg.27.89a).

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1.16 Tables and figures

Table 1.1. Biological sampling levels by stock and country. Number of individuals measured and aged from landings in 2020 (Part 1).

		Angler (*L.pisc.*)		**Angler (*L.bude.*)**		**Megrim (*L.whiff.*)**		**Megrim (*L. boscii*)**		**Sole (S. *solea*)**	
		7.b–7.k and 8.a,8.b,8.d	**8.c and 9.a**	**7.b–7.k and 8.a,8.b,8.d**	**8.c and 9.a**	**7.b–7.k and 8.a,8.b,8.d**	**8.c and 9.a**	**7.b–7.k and 8.a,8.b,8.d**	**8.c and 9.a**	**8.a and 8.b**	**8.c and 9.a**
Belgium	No. lengths	3954		2522		11121		39		13196	
	No. ages			0		969		36		404	
	No. samples**	21		17		21		21			
England & Wales (UK)	No. lengths	5135		24226		4568		0			
	No. ages			0		308		0			
	No. samples*	13		237		154		0			
France	No. lengths	1265		7713		5754		0		17051	
	No. ages			0		-				1713	
	No. samples*	165		597		102		0			
Portugal	No. lengths		26	0	538		77		2449		2716
	No. ages***			0							
	No. samples*		41	0	34		4		44		203
Ireland (Rep)	No. lengths	4064		1014		8692		1025			
	No. ages			0		-					

		Angler (*L.pisc.*)		**Angler (*L.bude.*)**		**Megrim (*L.whiff.*)**		**Megrim (*L. boscii*)**		**Sole (S. *solea*)**	
		7.b–7.k and 8.a,8.b,8.d	**8.c and 9.a**	**7.b–7.k and 8.a,8.b,8.d**	**8.c and 9.a**	**7.b–7.k and 8.a,8.b,8.d**	**8.c and 9.a**	**7.b–7.k and 8.a,8.b,8.d**	**8.c and 9.a**	**8.a and 8.b**	**8.c and 9.a**
	No. samples**	168		75		85		12			
Spain	No. lengths	2275	1125	4197	733	7244	1648	2023	3286	2	769
	No. ages			0		0	628	0	511		
	No. samples	25	95	414	99	28	40	116	22		68
Denmark	No. lengths			0							
	No. ages			0							
	No. samples			0							
Total	**No. lengths**	**16693**	**1125**	**39672**	**733**	**37379**	**1648**	**3087**	**3286**	**30249**	**769**
	No. ages					**1277**	**628**	**36**	**511**	**2117**	
Total nb. in international landings ('000)		**9533.622**		**5452069**		**43457**					
Nb. measured as % of annual nb. caught		**0.17 %**		**0.24%**	**0.3%**	**0.08%**					

*** Vessels**

**** Categories**

***** Ages, surveys**

****** Boxes/hauls (for sampling on board)**

******* Otoliths collected and prepared but not read**

Table 1.2. Biological sampling levels by stock and country. Number of individuals measured and aged from landings in 2020 (Part 2).

		Hake		*Nephrops*			Sea bass		Pollack	Whiting	Plaice
		3.a, 4, 6, 7 and 8.a, 8.b	8.c and 9.a	8.a, 8.b and FUs 23– 24	8.c and FUs 25– 31	9.a and FUs 26– 30	8.a and 8.b	8.c and 9.a	8 and 9.a	8 and 9.a	8 and 9.a
Scotland (UK)	No. lengths	1236									
	No. ages										
	No. samples*	39									
England & Wales (UK)	No. lengths	8800									
	No. ages										
	No. samples*	243									
France	No. lengths	15706		8987			10646		2584	2727	154
	No. Ages*****						895				
	No. samples****	474		230			595		222	155	
Portugal	No. lengths		9114			2343		2105	249		1326
	No. ages***										
	No. samples*		197			16		142	41		
Ireland (Rep)	No. lengths	7222									
	No. ages*****										
	No. samples*	241									
Spain	No. lengths	9584	16591		12227	724	192	454	228	395	

		Hake		*Nephrops*			Sea bass		Pollack	Whiting	Plaice
		3.a, 4, 6, 7 and 8.a, 8.b	8.c and 9.a	8.a, 8.b and FUs 23– 24	8.c and FUs 25– 31	9.a and FUs 26– 30	8.a and 8.b	8.c and 9.a	8 and 9.a	8 and 9.a	8 and 9.a
	No. ages				n/a						
	No. samples*	68	211		17 (a)	3	14	30	15	7	
Denmark	No. lengths	12005									
	No. ages										
	No. samples*	266									
Total	**No. lengths**	**54553**	**25705**	**8987**	**12227**	**3067**	**10838**	**2559**	**3061**	**3122**	**1480**
	No. ages						**895**				
Total No. in international landings ('000)		**55812**	**31437**	**100704**	**44**				**1020**	**4658**	
Nb. meas. as % of annual nb. caught		**0.24%**	**0.05%**	**0.01%**	**28%**				**0.3%**	**0.07%**	

* Vessels

** Categories

*** Ages, surveys

**** Boxes/hauls (for sampling on board), (a) hauls

***** Otoliths collected and prepared but not read

(a) Trips

Table 1.3. Biological sampling levels by stock and country. Number of individuals measured and aged from discards in 2020 (Part 1).

		Angler (*L.pisc.*)		Angler (*L.bude.*)		Megrim (*L.whiff.*)		Megrim (*L. boscii*)		Sole (*S. solea*)	
		7.b–7.k and 8.a,8.b,8.d	8.c and 9.a	7.b–7.k and 8.a,8.b,8.d	8.c and 9.a	7.b–7.k and 8.a,8.b,8.d	8.c and 9.a	7.b–7.k and 8.a,8.b,8.d	8.c and 9.a	8.a and 8.b	8.c and 9.a
Belgium	No. lengths	3707				4992					
	No. ages					773					
	No. samples	21				21					
England & Wales (UK)	No. lengths	4069				6933					
	No. ages					38					
	No. samples	119				16					
France	No. lengths	163									
	No. ages										
	No. samples	26									
Portugal	No. lengths		0		0		0		0		
	No. ages										
	No. samples (a)		4		4		4		4		
Ireland (Rep)	No. lengths	1288				1365					
	No. ages										
	No. samples	184				46					
Spain	No. lengths	0	6		6	1167	35		478		

		Angler (*L.pisc.)*		Angler (*L.bude.)*		Megrim (*L.whiff.)*		Megrim (*L. boscii*)		Sole (*S. solea*)	
		7.b–7.k and 8.a,8.b,8.d	**8.c and 9.a**	**7.b–7.k and 8.a,8.b,8.d**	**8.c and 9.a**	**7.b–7.k and 8.a,8.b,8.d**	**8.c and 9.a**	**7.b–7.k and 8.a,8.b,8.d**	**8.c and 9.a**	**8.a and 8.b**	**8.c and 9.a**
	No. ages					-					
	No. samples	46	26		27	195	44		70		
Denmark	No. lengths										
	No. ages										
	No. samples										
Total	**No. lengths**	**9227**	**6**		**6**	**14457**	**35**		**478**		
	No. ages										
Total no. in international discards ('000)		**6997**				**11854**					
Nb. meas. as % of annual nb. Discarded		**0.13 %**				**0.12%**					

Table 1.4. Biological sampling levels by stock and country. Number of individuals measured and aged from discards in 2020 (Part 2).

		Hake		*Nephrops*			Sea bass		Pollack	Whiting	Plaice
		3.a, 4, 6, 7 and 8.a, 8.b	8.c and 9.a	8.a, 8.b and FUs 23– 24	8.c and FUs 25– 31	9.a and FUs 26– 30	8.a and 8.b	8.c and 9.a	8 and 9.a	8 and 9.a	8 and 9.a
Scotland (UK)	No. lengths	1573									
	No. ages										
	No. samples	60									
E & W (UK)	No. lengths	379									
	No. ages										
	No. samples	27									
France	No. lengths	3845		2037			191		0	460	
	No. Ages										
	No. samples	147		58					0	50	
Portugal	No. lengths		497			0			0	0	0
	No. ages										
	No. samples (a)		31			8			31	32	32
Ireland (Rep)	No. lengths	7600									
	No. ages										
	No. samples	204									
Spain	No. lengths	3013	3034		558				0	7	

		Hake		*Nephrops*			Sea bass		Pollack	Whiting	Plaice
		3.a, 4, 6, 7 and 8.a, 8.b	8.c and 9.a	8.a, 8.b and FUs 23– 24	8.c and FUs 25– 31	9.a and FUs 26– 30	8.a and 8.b	8.c and 9.a	8 and 9.a	8 and 9.a	8 and 9.a
	No. ages				n/a						
	No. samples	278	388		20(a)				0	3	
Denmark	No. lengths	1747									
	No. ages										
	No. samples	102									
Total	**No. lengths**	**23137**	**3531**	**2037**	**558**		**191**			**467**	
	No. ages										
Total no. in international discards ('000)		**32936**	**17374**	**59102**	**8**	**0**			**n/a**		
Nb. meas. as % of annual nb. Discarded		**0.07%**	**0.2%**	**0.003%**	**7%**	**n/a**			**n/a**		

(a) Trips

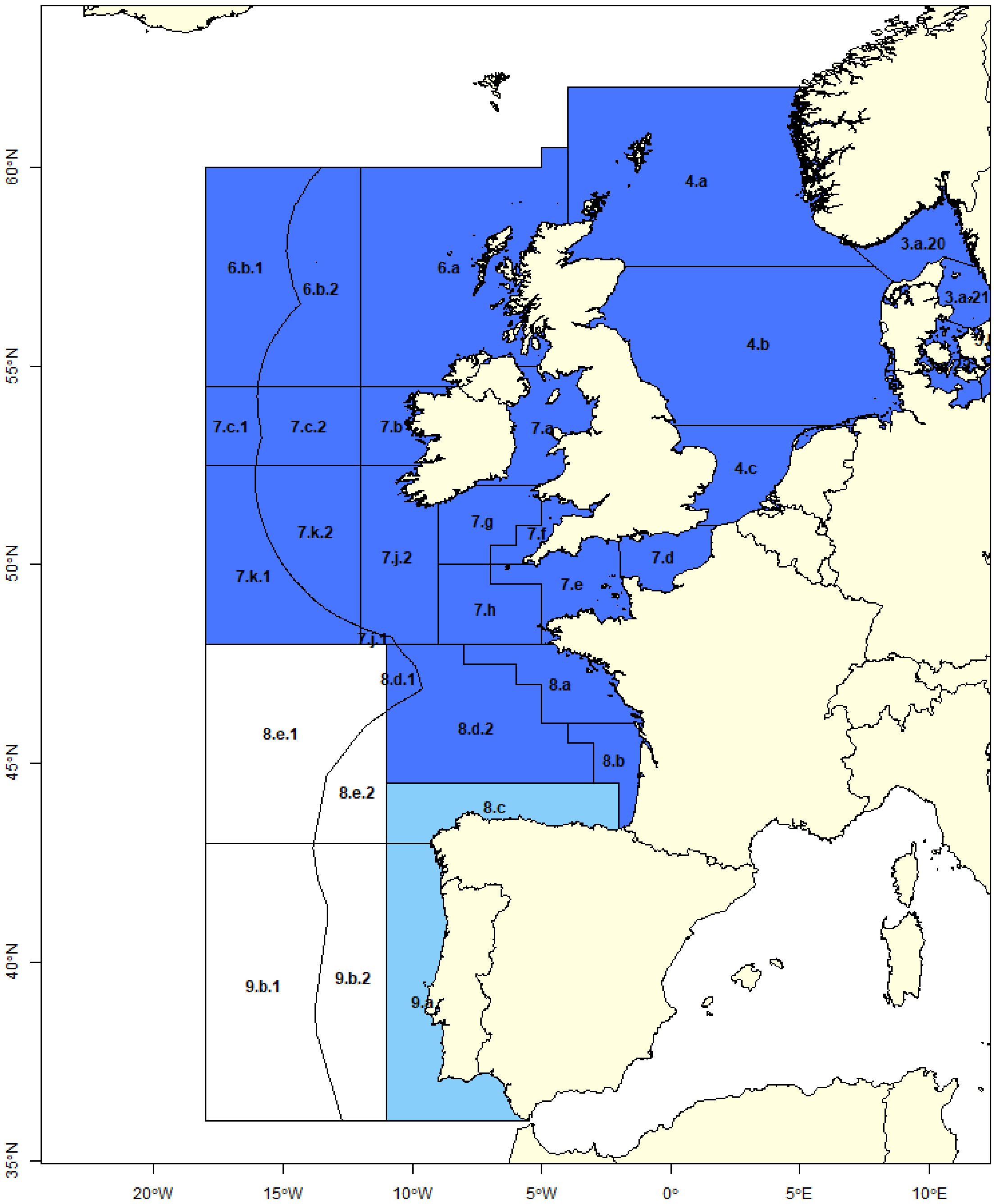

Figure 1.1. Map of ICES divisions. Northern (3.a, 4, 6, 7. and 8.a, 8.b, 8.d) and southern (8.c and 9.a) divisions are shown with different blue shading.

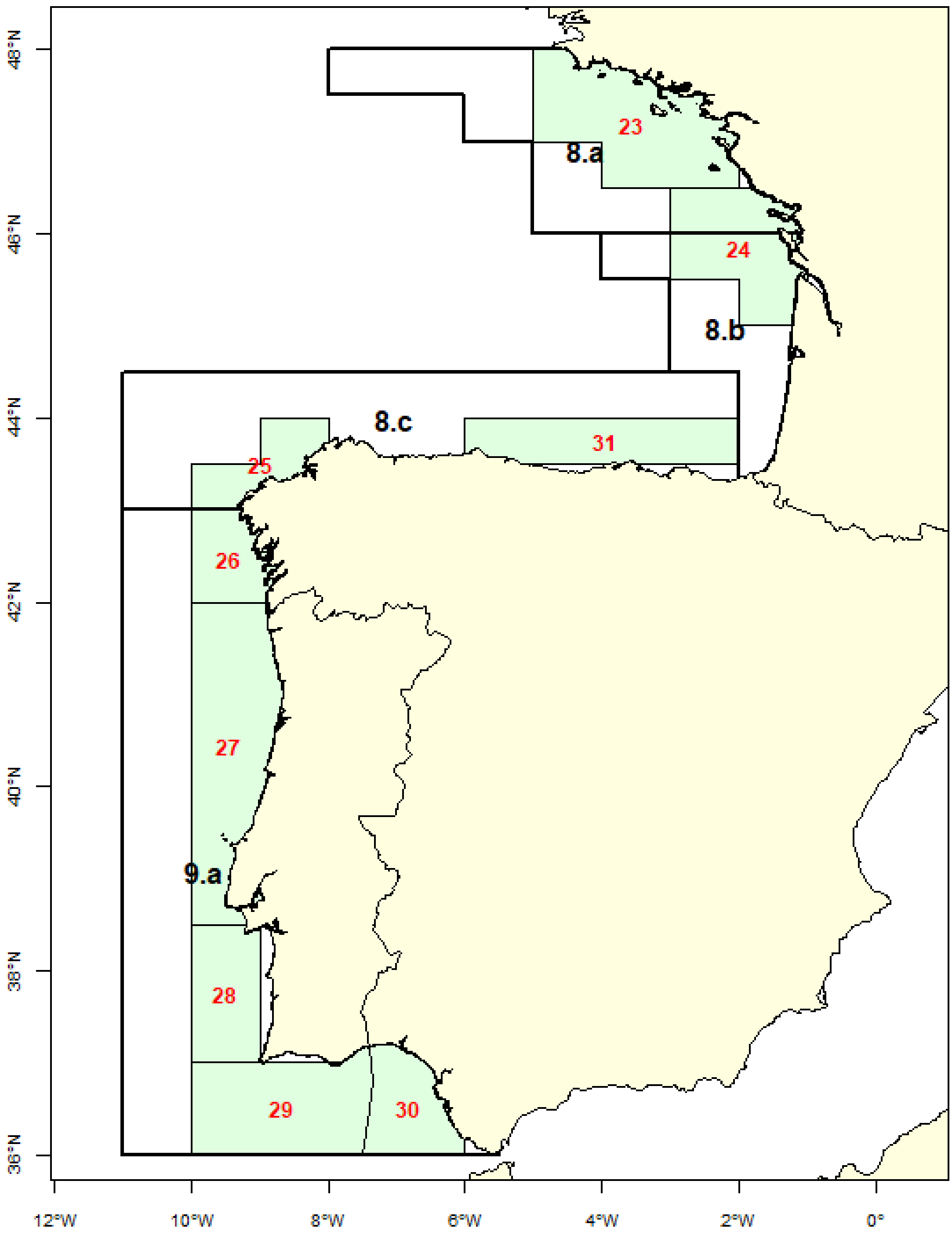

Figure 1.2. ICES divisions 8 and 9.a with *Nephrops* functional units (FUs). Divisions 8.a and 8.b: FUs 23–24. Division 8.c: FUs 25 and 31. Division 9.a: FUs 26–30.

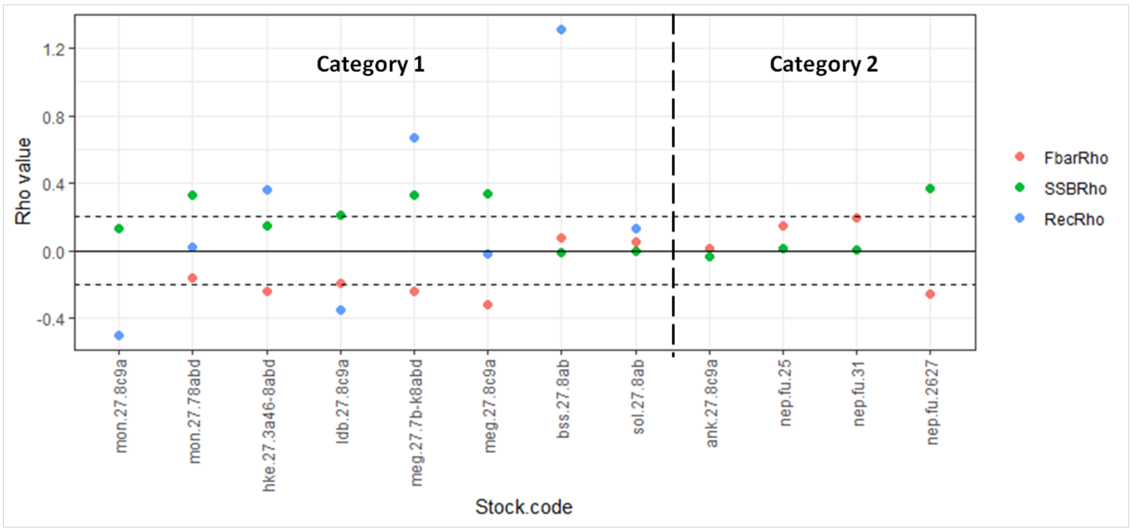

Figure 1.3. Mohn's rho for category 1 stocks with full analytical assessment and for category 2 stocks with SPiCT assessment (black anglerfish in 8.c and 9.a and Norway lobster in FUs 25, 31, and 26–27).

2 Description of commercial fisheries and research surveys

2.1 Fisheries description

This section describes the fishery units relevant to the stocks assessed in this working group (WG). Additionally, to facilitate the use of InterCatch, it presents the "fleets" that the WG proposes to use for data submission in InterCatch.

2.1.1 Celtic–Biscay Shelf (Subarea 7 and divisions 8.a, 8.b, and 8.d)

The fleets operating in the ICES Subarea 7 and divisions 8.a, 8.b, and 8.d are used in this WG following the Fishery Units (FUs) defined by the "ICES Working Group on Fisheries Units in subareas 7 and 8" (Table 2.1; ICES, 1991).

Table 2.1. ICES Fishery Units definition in Subarea 7 and Division 8.

Fishery Unit	Description	Sub-area
FU1	Longline in medium to deep water	7
FU2	Longline in shallow water	7
FU3	Gillnets	7
FU4	Non-*Nephrops* trawling in medium to deep water	7
FU5	Non-*Nephrops* trawling in shallow water	7
FU6	Beam trawling in shallow water	7
FU8	*Nephrops* trawling in medium to deep water	7
FU9	*Nephrops* trawling in shallow to medium water	8
FU10	Trawling in shallow to medium water	8
FU12	Longline in medium to deep water	8
FU13	Gillnets in shallow to medium water	8
FU14	Trawling in medium to deep water	8
FU15	Miscellaneous	7 and 8
FU16	Outsiders	3.a, 4, 5 and 6
FU00	French unknown	

Under the implementation of the mixed-fisheries approach in the ICES WG's new information, updating some of the national fleet segmentations was presented in WGHMM reports from general overviews (ICES, 2004; ICES, 2005) to detailed national descriptions: French fleets (ICES, 2006), Irish fleets (ICES, 2007), and Spanish fleets (ICES, 2008). This information in relation to the métiers definition did not change the FUs used in the single-stock assessments. However, the hierarchical disaggregation of FUs into métiers is essential not only for carrying out mixed-fisheries assessments but also for a deeper understanding of fisheries behaviour.

The EU Data Collection Framework (DCF; Council Regulation (EC) 199/2008; EC Regulation 665/2008; Decision 2008/949/EC) establishes a framework for the collection of economic, biological and transversal data by the Member States. One of the most relevant changes of this more recent period with respect to the previous Data Collection Regulation (DCR; Reg. (EC) No 1639/2001) has been the inclusion of the ecosystem approach by means of moving from stock-based to métier-based sampling. The DCF defines the métier as “a group of fishing operations targeting the same species or a similar assemblage of species, using similar gear, during the same period of the year and/or within the same area, and which are characterized by a similar exploitation pattern”. Due to the sampling design, established in 2009, which can affect the fishery data supplied to this WG, it has been agreed to detail the métiers related to the stocks assessed by this WG, trying to find the correspondence with the FUs.

Data for stock assessment are provided to InterCatch according to the DCF métiers. In the case of discards and/or biological data, although sampling may be done at the DCF métier Level 6, estimates are often re-aggregated to Level 5 due to low sampling levels reached by countries. Thus, this WG agreed to use DCF Level 5 (without mesh size) as the “fleet” level to introduce data in InterCatch. Table 2.2 shows the “fleets” to be used for InterCatch and their correspondence with the old FUs and the DCF métiers at Level 6.

Table 2.2. InterCatch fleets’ correspondence with the old Fishery Units and DCF métiers (Level 6).

FU	Fleet for InterCatch	DCF MÉTIER (Level 6)	DESCRIPTION	FR	IR	SP	UK
FU1	LLS_DEF	LLS_DEF_0_0_0	Set longline directed to demersal fish			X	X
FU2							
FU3	GNS_DEF	GNS_DEF_100-219_0_0	Set gillnet directed to demersal fish (100–219 mm)	X	X	X	
FU4	OTB_DEF	OTB_DEF_70-99_0_0	Bottom otter trawl directed to demersal fish (70–99 mm)		X	X	X
		OTB_DEF_100-119_0_0	Bottom otter trawl directed to demersal fish (100–119 mm)		X	X	X
FU5	OTB_DEF		Otter trawl directed to demersal Fish shallow water				X
FU6	TBB_DEF		Beam trawl		X		X
FU8	OTB_CRU						
FU9	OTB_CRU	OTB_CRU_70-99_0_0	Bottom otter trawl directed to crustaceans (70–99 mm)	X	X		X
FU10	OTB_DEF						
FU12	LLS_DEF	LLS_DEF_0_0_0	Set longline directed to demersal fish	X		X	

FU	Fleet for InterCatch	DCF MÉTIER (Level 6)	DESCRIPTION	FR	IR	SP	UK
FU13	GNS_DEF	GNS_DEF_45-59_0_0	Set gillnet directed to demersal fish (45–59 mm)	X			
		GNS_DEF_>=100_0_0	Set gillnet directed to demersal fish (at least 100 mm)	X	X	X	
FU14	OTB_DEF	OTB_DEF_>=70_0_0	Bottom otter trawl directed to demersal fish (at least 70 mm)	X	X	X	
	OTB_MCF	OTB_MCF _>=70_0_0	Bottom otter trawl directed to mixed cephalopods and demersal fish (at least 70 mm)			X	
	OTT_DEF	OTT_DEF _>=70_0_0	Multi-rig otter trawl directed to demersal fish (at least 70 mm)	X	X		
	OTB_CRU	OTB_CRU _>=70_0_0	Bottom otter trawl directed to crustaceans (at least 70 mm)	X	X		
	OTT_CRU	OTT_CRU _>=70_0_0	Multi-rig otter trawl directed to crustaceans (at least 70 mm)	X	X		
	OTB_MPD	OTB_MPD _>=70_0_0	Bottom otter trawl directed to mixed pelagic and demersal fish (at least 70 mm)			X	
	PTB_DEF	PTB_DEF _>=70_0_0	Bottom pair trawl directed to demersal fish (at least 70 mm)			X	
FU15	SSC_DEF		Fly shooting seine directed to demersal fish		X		
FU16	OTB_DEF	OTB_DEF _100-119_0_0	Bottom otter trawl directed to demersal fish (100–119 mm)	X	X	X	X
	LLS_DEF	LLS_DEF _0_0_0	Set longline directed to demersal fish			X	
	SSC_DEF		Fly shooting seine directed to demersal fish		X		
FU00	PTM_DEF		Midwater pair trawl directed to demersal fish				

For the Bay of Biscay sole stock, the correspondence with the DCF métiers is somewhat complicated because the fleets used are:

- Inshore-gillnets (French gillnetters with length < 12 m) (GNx or GTx)
- Offshore-gillnets (French gillnetters with length > 12 m) (GNx or GTx)
- Inshore-trawlers (French trawlers with length < 12 m) (OTx, TBx, PTx)
- Offshore-trawlers (French trawlers with length > 12 m)

In other words, the fleets used correspond to netters and trawlers fishing for sole in the Bay of Biscay, grouped according to vessel length.

2.1.2 Atlantic Iberian Peninsula Shelf (divisions 8.c and 9.a)

The FUs operating in the Atlantic Iberian Peninsula waters were described originally in the report of the "southern hake task force" meeting (STECF, 1994), and have been used in this WG as follows:

Country	Fishery Unit	Description
Spain	Small gillnet	Gillnet fleet using "beta" gear (60 mm mesh size) for targeting hake in divisions 8.c and 9.a North
	Gillnet	Gillnet fleet using "volanta" gear (90 mm mesh size) for targeting hake in Division 8.c
		Gillnet fleet using "rasco" gear (280 mm mesh size) for targeting anglerfish in Division 8.c
	Longline	Longline fleet targeting a variety of species (hake, great fork beard, conger) in Division 8.c
	Northern artisanal	Miscellaneous fleet exploiting a variety of species in divisions 8.c and 9.a North
	Southern artisanal	Miscellaneous fleet exploiting a variety of species in Division 9.a South (Gulf of Cádiz)
	Northern Trawl	Miscellaneous fleet operating in Divisions 8.c and 9.a North composed of bottom pairtrawlers targeting blue whiting and hake (55 mm mesh size, and 25 m of vertical opening); and two types of bottom otter trawlers (70 mm mesh size): trawlers using the "baca" gear (1.5 of vertical opening) targeting hake, anglerfish, megrim and *Nephrops*, and trawlers using "jurelera" (often referred to as "HVO", high vertical opening, in the present report) gear (> 5 m of vertical opening) targeting mackerel and horse mackerel.
	Southern Trawl	Bottom otter trawlers operating in Division 9.a South (Gulf of Cádiz) exploiting a variety of species (sparids, cephalopods, sole, hake, horse mackerel, blue whiting, shrimp, Norway lobster).
Portugal	Artisanal	Miscellaneous fleet with two components (inshore and offshore) operating in Portuguese waters of Division 9.a involving gillnet (80 mm mesh size), trammel (> 100 mm mesh size), longline and other gears. Species caught: hake, octopus, pout, horse mackerel and others
	Trawl	Trawl fleet operating in Portuguese waters of Division 9.a compounded by bottom otter trawlers targeting crustaceans (55 mesh size), and bottom otter trawlers targeting different species of fish (65 mm mesh size).

The Spanish and Portuguese fleets operating in the Atlantic Iberian Peninsula shelf were segmented into métiers under the EU project IBERMIX (DG FISH/2004/03-33), and the results were described in Section 2 of the 2007 WGHMM report (ICES, 2007). The correspondence between FUs and DCF métiers has also been compiled for the southern stock fleets and is presented in the following table.

COUNTRY	FU (STECF, 1994)	Métiers (Level 5)	MÉTIERS (Level 6)	DESCRIPTION (mesh size in brackets)	SP	PT
Spain	Gillnet	GNS_DEF	GNS_DEF_80-99_0_0	Set gillnet directed to demersal species (80–99 mm)	X	
			GNS_DEF_280_0_0	Set gillnet directed to demersal species (at least 280 mm)	X	
	Small gillnet		GNS_DEF_60-79_0_0	Set gillnet directed to demersal fish (60–79 mm)	X	
	Longline	LLS_DEF	LLS_DEF_0_0_0	Set longline directed to demersal fish	X	
	Southern artisanal	LLS_DWS	LLS_DWS_0_0_0	Set longline directed to deep-water species	X	
	Northern Trawl	PTB_MPD	PTB_MPD _> = 55_0_0	Pair bottom-trawl directed to mixed pelagic and demersal fish (at least 55 mm)	X	
		OTB_DEF	OTB_DEF_>=55_0_0	Otter bottom-trawl directed to demersal fish (at least 55 mm)	X	
		OTB_MPD	OTB_MPD_>=55_0_0	Otter bottom-trawl directed to mixed pelagic and demersal fish (at least 55 mm)	X	
	Southern trawl	OTB_MCD	OTB_MCD_>=55_0_0	Otter bottom-trawl directed to mixed crustacean and demersal fish (at least 55 mm)	X	
Portugal	Artisanal	GTR_DEF	GTR_DEF_>=100_0_0	Trammelnet directed to demersal fish (at least 100 mm)		X
		GNS_DEF	GNS_DEF_80-99_0_0	Set gillnet directed to demersal fish (80–99 mm)		X
		LLS_DEF	LLS_DEF_0_0_0	Set longline directed to demersal fish		X
		LLS_DWS	LLS_DWS_0_0_0	Set longline directed to deep-water species		X
	Trawl	OTB_CRU	OTB_CRU_>=55_0_0	Otter bottom-trawl directed to crustaceans (at least 55 mm)		X
		OTB_DEF	OTB_DEF_60-69_0_0	Otter bottom-trawl directed to demersal fish (60–69 mm)		X

2.2 Description of surveys

This section gives a brief description of the surveys referred to in this WG report. The surveys are listed in the following table, including the acronym used by WGBIE and previous to that by the WGHMM in 2010 (ICES, 2010). The DCF acronym and the new ICES survey acronym which will be used throughout this WG report and in the stock annexes are presented below. The new survey acronyms used this year were provided by ICES, aiming for consistency across all ICES Expert Groups. When an ICES survey is not included in the list for which acronyms has been provided, the WGHMM (ICES, 2010) acronym will remain in use.

Survey	WGHMM 2010 acronym	DCF acronym	ICES survey acronym as of 2011
Spanish groundfish survey – quarter 4	G2784 = SP-NSGFS	IBTS-EA-4Q	SpGFS-WIBTS-Q4
Spanish Porcupine groundfish survey	SP-PGFS	IBTS-EA	SpPGFS-WIBTS-Q4
Spanish Cádiz groundfish survey – Autumn	SP-GFS-caut		SPGFS-caut-WIBTS-Q4
Spanish Cádiz groundfish survey – Spring	SP-GFS-cspr		SPGFS-cspr-WIBTS-Q1
Spanish Cádiz ISUNEPCA *Nephrops* UWTV survey		UWTV/FU30	
Portuguese groundfish survey – October	P-GFS-oct	IBTS-EA-4Q	PtGFS-WIBTS-Q4
Portuguese groundfish survey – July (ended in 2001)	P-GFS-jul		----
Portuguese crustacean trawl survey / *Nephrops* Survey Offshore Portugal NepS	P-CTS	NepS (FU 28–29)	PT-CTS (UWTV (FU 28–29))
Portuguese winter groundfish survey/Western IBTS 1st quarter (2005 – 2008)	PESCADA-BD		PtGFS-WIBTS-Q1
French EVHOE groundfish survey	EVHOE	IBTS-EA-4Q	EVHOE-WIBTS-Q4
French RESSGASC groundfish survey (ended in 2002)	RESSGASC		----
French Bay of Biscay sole beam trawl survey	ORHAGO		ORHAGO
French *Nephrops* survey in Bay of Biscay	LANGOLF		LANGOLF
French *Nephrops* UWTV survey in Bay of Biscay		UWTV23-24	
UK west coast groundfish survey (ended in 2004)	UK-WCGFS		-----
UK Western English Channel Beam Trawl Survey			UK-WECBTS
UK Bottom-trawl Survey			EN-Cefas-A, B
English fisheries science partnership survey	EW-FSP		FSP-Eng-Monk
Irish groundfish survey	IGFS	IBTS-EA-4Q	IGFS-WIBTS-Q4
Combined IGFS/EVHOE WIBTS survey	-	-	FR_IE_IBTS
Irish Monkfish survey		SIAMISS/IAMS	IE_Monksurvey; IE_IAMS

A brief description of each survey follows. General maps identifying survey areas can be found in the ICES IBTS WG report (ICES, 2018a) and WGNEPS report (ICES, 2019).

2.2.1 Spanish groundfish survey (SpGFS-WIBTS-Q4, G2784)

The SpGFS-WIBTS-Q4 covers the northern Spanish shelf comprised in ICES Division 8.c and the northern part of 9.a, including the Cantabrian Sea and off Galicia waters. It is a bottom-trawl survey that aims to collect data on the distribution, relative abundance and biology of commercial fish species such as hake, monkfish and white anglerfish, megrim, four-spot megrim, blue whiting and horse mackerel. Abundance indices are estimated by length and in some cases by age, with indices also estimated for *Nephrops*, and data collected for other demersal fish and invertebrates. The survey is ca. 120 hauls and is from 30–800 m depths, usually starts at the end of the 3rd quarter (September) and finishes in the 4th quarter.

2.2.2 Spanish Porcupine groundfish survey (SpPGFS-WIBTS-Q4, G5768)

The SpPGFS-WIBTS-Q4 occurs at the end of the 3rd quarter (September) and the start of the 4th quarter (October). It is a bottom-trawl survey that aims to collect data on the distribution, relative abundance and biology of commercial fish in ICES Division 7.b-k, which corresponds to the Porcupine Bank and the adjacent area in western Irish waters between 180–800 m. The survey area covers 45 880 km^2 and approximately 80 hauls per year are carried out.

2.2.3 Cádiz groundfish surveys-Spring (SPGFS-cspr-WIBTS-Q1, G7511) and autumn (SPGFS-caut-WIBTS-Q4, G4309)

The bottom-trawl surveys SPGFS-cspr-WIBTS-Q1 and SPGFS-caut-WIBTS-Q4 occur in the southern part of ICES Division 9.a, the Gulf of Cádiz. It collects data on the distribution, relative abundance, and biology of commercial fish species. The area covered is 7224 km^2 and extends from 15–800 m. The primary species of interest are hake, horse mackerel, wedge sole, sea breams, mackerel and Spanish mackerel. Data and abundance indices are also collected and estimated for other demersal fish species and invertebrates such as rose and red shrimps, *Nephrops* and cephalopod molluscs.

2.2.4 Spanish FU30 UWTV surveys in the Gulf of Cádiz (ISUNEPCA, U9111)

The ISUNEPCA UnderWater TeleVision (UWTV) survey was launched in 2015 although an exploratory UWTV survey was conducted previously in 2014. ISUNEPCA is a multidisciplinary survey in nature but the main objective is to estimate the *Nephrops* burrows density using underwater videos and to confirm the boundaries of the *Nephrops* area distribution in FU 30. As result, geostatistical *Nephrops* abundance is estimated. Other ecosystem data are also collected (temperature, salinity, sediment samples, trawl marks and seabed morphological and backscatter data). The survey design follows a randomly isometric grid with stations at 4 nm spacing. The survey area covers 3000 km^2 between 100 and 700 m of depth and about 65–70 stations are planned every year.

2.2.5 Portuguese groundfish survey October (PtGFS-WIBTS-Q4, G8899)

PtGFS-WIBTS-Q4 extends from latitude 41°20' N to 36°30' N (ICES Division 9.a) and from 20–500 m depth. The survey takes place in autumn. The main objective of the survey is to estimate the abundance and study the distribution of the most important commercial species in the Portuguese trawl fishery (hake, horse mackerel, blue whiting, sea bream and *Nephrops*), and most importantly to monitor the abundance and distribution of hake and horse mackerel recruitment. The surveys aim to carry out ca. 90 stations per year.

2.2.6 Portuguese crustacean trawl survey/*Nephrops* survey offshore Portugal NepS (PT-CTS (UWTV (FU 28–29, G2913)))

The *Nephrops* Survey Offshore Portugal, NepS (FU 28–29), is carried out in May-July and covers the southwest coast (Alentejo or FU 28) and the south coast (Algarve or FU 29). The main objectives are to estimate the abundance, to study the distribution and the biological characteristics of the main crustacean species, namely *Nephrops norvegicus* (Norway lobster), *Parapenaeus longirostris* (rose shrimp) and *Aristeus antennatus* (red shrimp). The average number of trawl stations in the period 1997–2004 was 60. Sediment samples have been collected since 2005 with the aim to study the characteristics of the *Nephrops* fishing grounds. In 2008 and 2009, the crustacean trawl survey conducted in FUs 28 and 29 were combined with an experimental video sampling.

2.2.7 Portuguese winter groundfish survey/Western IBTS 1st quarter (PTGFS-WIBTS-Q1)

The PtGFS-WIBTS-Q1 survey has been carried out along the Portuguese continental waters from latitude 41°20' N to 36°30' N (ICES Div. 9.a) and from 20–500 m depth. Winter groundfish survey plan comprised 75 fishing stations, 66 at fixed positions and 9 at random. The main aim of the survey was to estimate the spawning biomass of hake. This survey ended in 2008.

2.2.8 French EVHOE groundfish survey (EVHOE-WIBTS-Q4, G9527)

The EVHOE-WIBTS-Q4 survey covers the Celtic Sea with ICES Divisions 7.f,g,h,j, and the French part of the Bay of Biscay in divisions 8.a and 8.b. This annual survey is conducted from 15 to 600 m depths, usually in the fourth quarter, starting at the end of October. The primary species of interest are hake, monkfish, anglerfish, megrim, cod, haddock and whiting, with data also collected for all other demersal and pelagic fish. The sampling strategy is stratified random allocation, the number of sets per stratum based on the 4 most important commercial species (hake, monkfish and megrim) leaving at least two stations per stratum and 140 valid tows are planned every year although this number depends on available sea time.

2.2.9 French RESSGASC groundfish survey (FR-RESSGASC, G2537)

The RESSGASC survey was conducted in the Bay of Biscay from 1978–2002. Over the years 1978–1997, the survey was conducted with quarterly periodicity. It was conducted twice a year, in spring and autumn, after that. Survey data prior to 1987 are normally excluded from the time-series since there was a change of vessel at that time.

2.2.10 French Bay of Biscay sole beam trawl survey (ORHAGO, B1706)

The ORHAGO survey was launched in 2007, with the aim of producing an abundance index and biological parameters such as length distribution for the Bay of Biscay sole. It is usually carried out in November, with approximately 23 days of duration and sampling 70–80 stations. It uses beam trawl gear and is coordinated by the ICES WGBEAM (ICES, 2018b).

2.2.11 French *Nephrops* survey in the Bay of Biscay (LANGOLF)

This survey commenced in 2006 specifically for providing abundance indices of *Nephrops* in the Bay of Biscay. It is carried out on the area of the Central Mud Bank of the Bay of Biscay (ca.11 680 km^2), in the second quarter (May apart from the 1st year when the survey occurred in April), using twin trawl, with hours of trawling around dawn and dusk. The whole mud bank is divided into five sedimentary strata and the sampling allocation combines the surface by stratum and the fishing effort concentration. 70–80 experimental hauls are carried out annually. Since the IBP *Nephrops* 2012 (ICES, 2012), this survey is included as tuning series in the stock assessment.

2.2.12 French *Nephrops* UWTV survey in Bay of Biscay

A new experimental UWTV survey for burrow counting has been undertaken since 2014 covering the five sedimentary muddy strata of the former trawl survey on the FU23–24 *Nephrops* stock. The survey is carried out by the Irish scientific vessel “Celtic Voyager” with a French scientific team on the basis of a systematic onboard sampling plan. A longer survey in the period 2016–2019 allowed covering the area contained in the outline of the Central Mud Bank not belonging to any sedimentary stratum. This area, known as not trawled due to rough seabed, is crossed by muddy channels and concentrates a moderate fishing effort targeting *Nephrops*. Investigations on the basis of stratified statistical estimators as well as on geostatistics were carried out and examined by WKNEP 2016 (ICES, 2017), which validated the UWTV approach.

2.2.13 UK west coast groundfish survey (UK-WCGFS)

This survey, which ended in 2004, was conducted every March in the Celtic sea with ca. 62 hauls. It does not include the 0-age-group, therefore, primarily aims at the investigation of age-groups 1 and 2. Numbers-at-age for this abundance index are estimated from length compositions using a mixed distribution by statistical method.

2.2.14 English fisheries science partnership survey (FSP-Eng-Monk)

The FSP-Eng-Monk survey, part of the English fisheries science partnership programme, has been carried out on an annual basis since 2003, reaching a total of 208 valid hauls in 2010, but was discontinued in 2012. The aims of the survey were to investigate abundance and size composition of anglerfish on the main UK anglerfish fishing grounds off the southwest coast of England within ICES subdivisions 7.e–h.

2.2.15 English Western English Channel beam trawl survey

Since 1989, the survey has remained relatively unchanged, apart from small adjustments to the position of individual hauls to provide an improved spacing. In 1995, two inshore tows in shallow water (8–15 m) were introduced. The survey now consists of 58 tows of 30 minutes duration, with a towing speed of 4 knots in an area within 35 miles radius of Start Point. The objective is to provide indices of abundance, which are independent of commercial fisheries, of all age-groups of sole and plaice on the western Channel grounds, and an index of recruitment of juvenile (1–3-year-old) soles before full recruitment to the fishery.

2.2.16 English bottom-trawl survey

This bottom-trawl survey covered the Irish, Celtic Sea and Western English Channel but was discontinued in 2004.

2.2.17 Irish groundfish survey (IGFS-WIBTS-Q4, G7212)

The IGFS-WIBTS-Q4 is carried out during the 4th quarter in Divisions 6.a, 7.b,c,g,j although only a part of 6.a and the border of Division 7.c, in depths of 30–600 m, are sampled. The annual target is 170 valid tows of 30-minute duration which are carried out in daylight hours at a fishing speed of 4 knots. Data are collected on the distribution, relative abundance and biological parameters of a large range of commercial fish such as haddock, whiting, plaice and sole with survey data provided also for cod, white and black anglerfish, megrim, lemon sole, hake, saithe, ling, blue whiting and a number of elasmobranchs as well as several pelagics (herring, horse mackerel and mackerel).

2.2.18 Combined EVHOE IGFS survey (FR_IE_IBTS)

The Irish IBTS Q4 groundfish survey (IGFS-WIBTS-Q4, G7212) covers areas 27.7bgjk. The French EVHOE-WIBTS-Q4 (G9527) survey covers areas 27.7j8ab. Both surveys are coordinated and largely standardized under WGIBTS and both use a GOV trawl. Together the two surveys cover the majority of the ank.27.78abd and mon.27.78abd stock areas up to depths of 200–300 m. This is where most of the young fish occur. Older fish migrate to deeper waters and are not fully available to these surveys.

Data for Irish and French IBTS Q4 groundfish surveys (IGFS and EVHOE) were obtained from DATRAS, quality checked and cleaned. The two surveys were combined into a single index (with the survey code FR_IE_IBTS) by weighting their average catches by the area covered by each survey series (IGFS gets a weight of approximately 45% and EVHOE 55%). Because the main recruitment area appears to change over time and sometimes occurs in the Irish or sometimes in the French survey area or sometimes in both, the combined survey gives a more coherent recruitment signal than the two separate surveys.

An index of catch numbers-at-length per hour fished was calculated for the years 2003 onwards.

2.2.19 Irish monkfish survey (IE_Monksurvey; IE-IAMS, G3098)

Irish anglerfish survey data in area 27.7 are available for the years 2007, 2008 under the acronym SIAMISS then IAMS from 2016 onwards. These surveys were designed to estimate the biomass of anglerfish and they cover a significant part of the stock in all depths up to 1000 m.

The survey index consists of catch numbers-at-length per swept-area.

The midpoint of the survey period is in January or February. However, because the survey data are available for the current year at the time of the WG assessment, it is beneficial to include the current year's survey in the assessment. The only way to do that in the current assessment framework is to offset the survey by a small amount so the survey is nominally taking place on the 31st of December of the previous year.

2.3 References

2008/949/EC: Commission Decision of 6 November 2008 adopting a multiannual Community programme pursuant to Council Regulation (EC) No 199/2008 establishing a Community framework for the collection, management and use of data in the fisheries sector and support for scientific advice regarding the common fisheries policy.

Council Regulation (EC) No.199/2008 concerning the establishment of a Community framework for the collection, management and use of data in the fisheries sector and support for scientific advice regarding the Common Fisheries Policy.

Commission *Regulation* (*EC*) No. *665/2008* laying down detailed rules for the application of Council *Regulation* (*EC*) No.199/*2008* concerning the establishment of a Community framework for the collection, management and use of data in the fisheries sector and support for scientific advice regarding the Common Fisheries Policy.

Commission Regulation (EC) No. 1639/2001 establishing the minimum and extended Community programmes for the collection of data in the fisheries sector and laying down detailed rules for the application of Council Regulation (EC) No. 1543/2000.

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3 White anglerfish and black-bellied anglerfish in Subarea 7 and divisions 8.a–b and 8.d

Lophius piscatorius – mon.27.78abd
(Celtic Seas, Bay of Biscay)

Lophius budegassa – ank.27.78abd
(Celtic Seas, Bay of Biscay)

3.1 General

3.1.1 Stock description and management units

The stock assessment area (27.78.abd) is the same for both species of anglerfish (*Lophius piscatorius* and *L. budegassa*). The two stocks are managed through TACs for the two species combined. There is a separate TAC for Subarea 27.7 and divisions 27.8.abde. Catches in 27.8.e are negligible.

3.1.2 ICES advice applicable to 2021

For *L. budegassa*, ICES advises that when the precautionary approach is applied, catches in 2021 should be no more than 15 551 t.

For *L. piscatorius*, ICES advises that when the EU multiannual plan (MAP; EU, 2019) for Western waters and adjacent waters is applied, catches in 2021 that correspond to the F ranges in the MAP are between 23 320 t and 45 996 t. According to the MAP, catches higher than those corresponding to F_{MSY} (34 579 t) can only be taken under conditions specified in the MAP, while the entire range is considered precautionary when applying the ICES advice rule.

3.1.3 Management applicable to 2021

Because the TAC for anglerfish in Subarea 7 is shared with the UK and because the UK can catch 10% of this TAC in area 8abde, there were considerable delays in setting the TAC for 2021. Initially, a roll-over TAC for Q1 2021 was agreed at 25% of the 2020 TAC; this was later replaced by a TAC of 50% of the 2021 advice for the first half of 2021 but at the time of writing this report, there was no agreed TAC for 2021.

3.1.4 The fishery

Both species of anglerfish (*L. piscatorius* and *L. budegassa*) are taken in a mixed fishery mainly with hake, megrim and *Nephrops*.

The fishery for anglerfish developed in the late 1960s and landings quickly reached around 25 000 tonnes (for both *Lophius* species combined). Since then, landings have fluctuated between 20 and 40 thousand tonnes per year (Figure 3.1.1).

France takes the vast majority of the landings; followed by Spain, the UK and Ireland. Minor landings have been recorded for Belgium, Germany, and Portugal (Figure 3.1.1. and Table 3.1.1).

Around 2/3 of the catches are taken by otter trawlers targeting demersal fish; gillnets take 10–20% and the remainder is taken by beam trawlers and otter trawlers targeting *Nephrops.*

Around 80% of the catch is taken in Subarea 27.7.

3.1.5 Information from stakeholders

WGBIE did not receive information from stakeholders regarding these stocks.

3.1.6 Data

3.1.6.1 Data revisions

No revised catch data prior to 2020 were submitted.

3.1.6.2 Landings and discards

Figure 3.1.1 shows the time-series of the official landings of the combined species. Table 3.1.1 gives the ICES estimates of landings and discards by species as well as the official landings.

The combined-species landings are split into species-specific landings at the national level, using the species composition in the sampling data from the onshore and offshore sampling programmes. Figure 3.1.2 shows the proportions of the two species over time by country. The proportions vary by country but the trends are similar between countries. The overall proportion of *L piscatorius* in the combined *Lophius* landings varied between 62% and 83% with a mean of 74%. The FR_IE_IBTS survey shows very similar trends in species proportion to the overall international landings proportion and the species proportion from the IE-IAMS (G3098) survey is very similar to the overall proportion.

3.1.6.3 Effort and LPUE

Figure 3.1.3 shows that the fishing effort of the main fleets catching anglerfish has declined substantially since the early 1990s. Figure 3.1.4 shows that the LPUE of *L. piscatorius* has increased considerably in many fleets since the 1990s. The LPUE of *L. budegassa*, however, (Figure 3.1.5) does not show a clear trend for most fleets except the IRE-OTB, which shows a strong increasing trend.

3.1.7 References

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3.1.8 Figures and tables

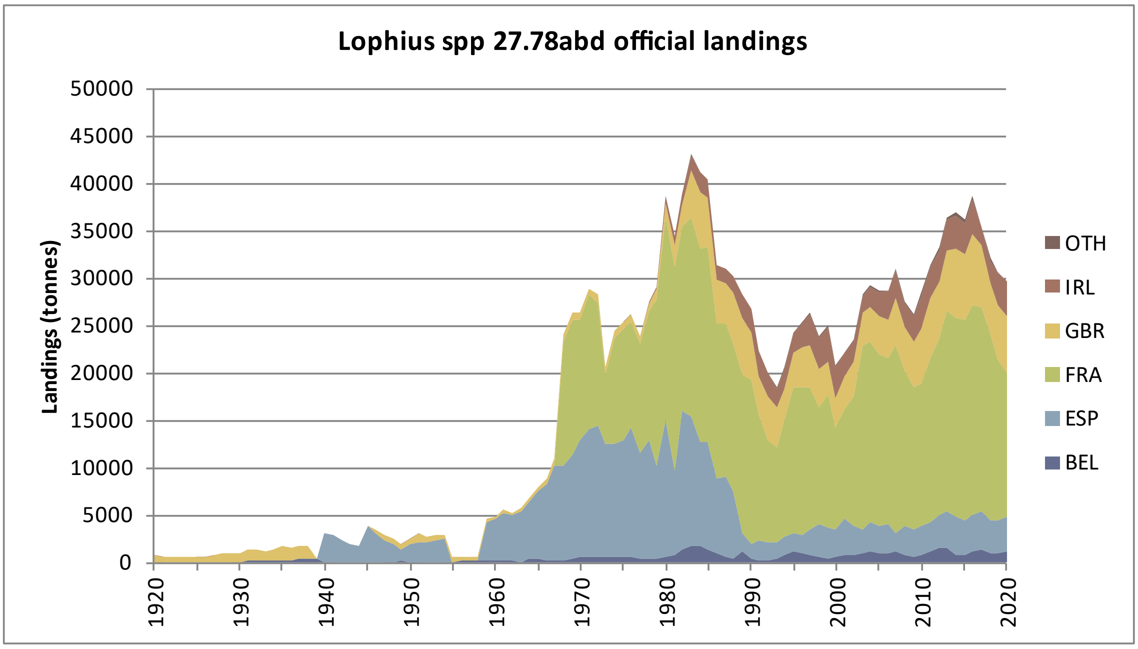

Figure 3.1.1. ***Lophius*** **spp in 27.78abd. Time-series of the official landings.**

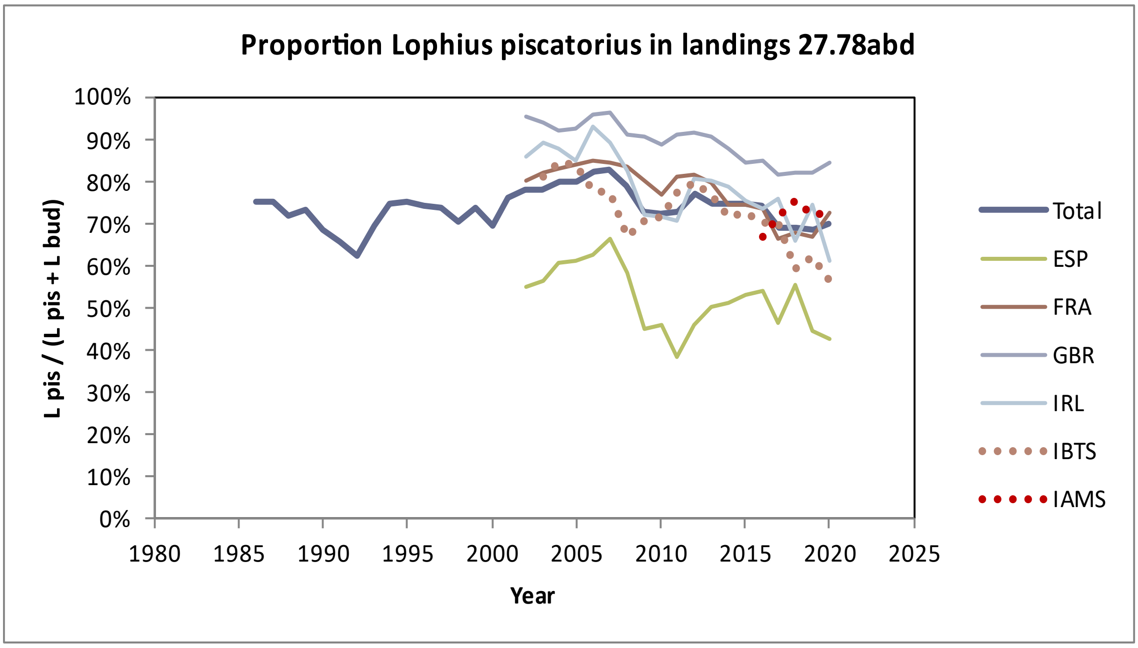

Figure 3.1.2. ***Lophius*** **spp in 27.78abd. Species composition by country. The species proportion in the combined FR_IE_IBTS survey is also shown but is not used to split the catches.**

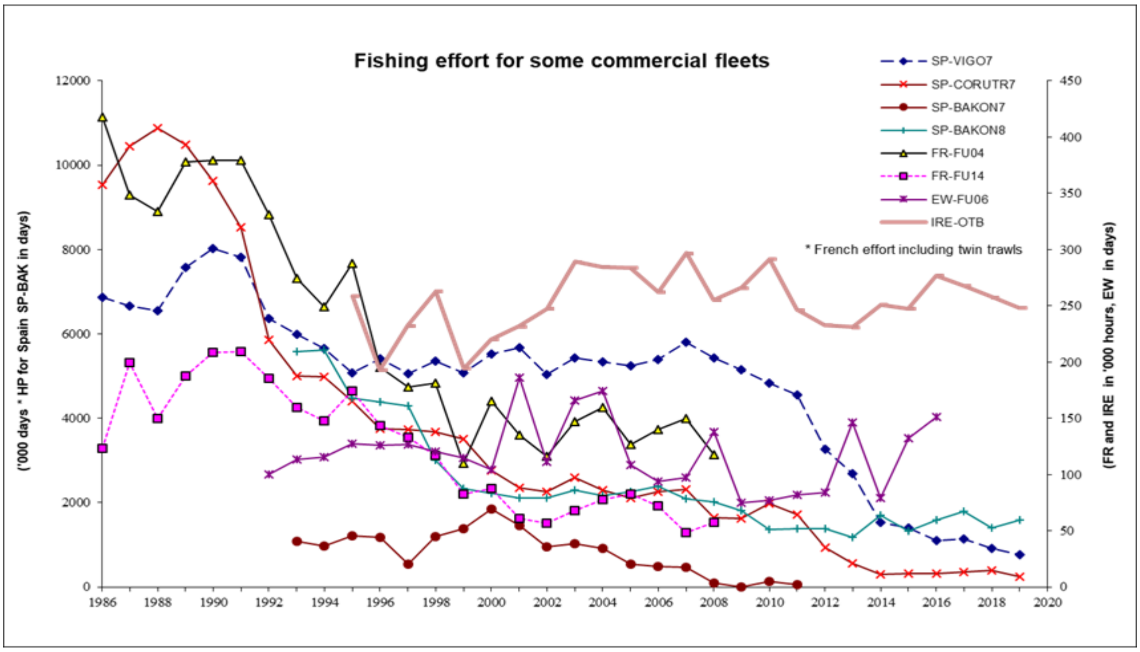

Figure 3.1.3. ***Lophius*** **spp in 27.78abd. Effort by main fleets.**

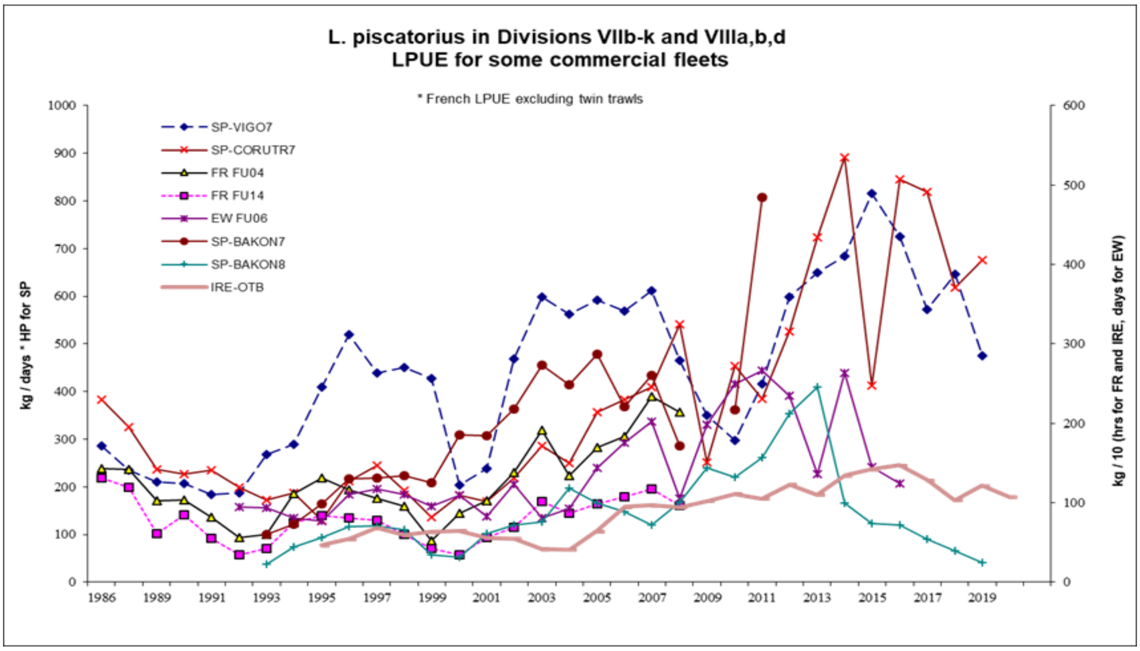

Figure 3.1.4. ***Lophius piscatorius*** **in 27.78abd. LPUE by the main fleets.**

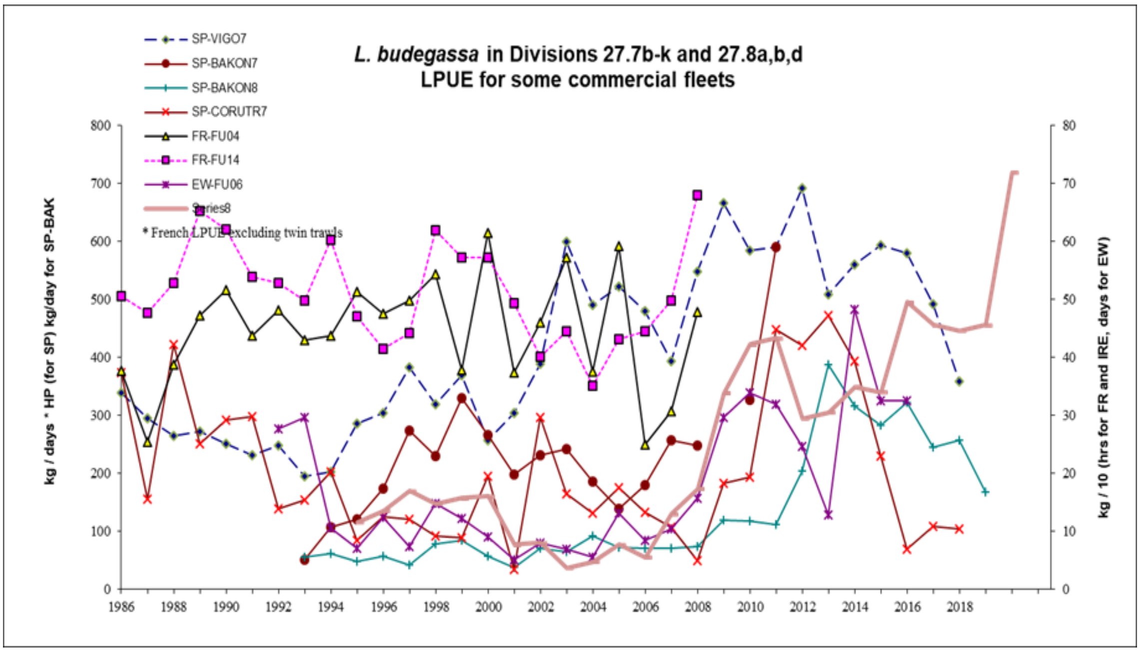

Figure 3.1.5. *Lophius budegassa* in 27.78abd. LPUE by the main fleets.

Table 3.1.1. *Lophius* spp in 27.78abd. Time-series of the ICES estimates of the landings, discards and official landings (in tonnes).

Year	*Lophius piscatorius*					*Lophius budegassa*				*L. piscatorius + L. budegassa*	
	Landings				Disc	Landings			Disc	ICES Land	Disc
	7a	7bk*	8abd	total	78abd	7bk	8abd	total	78abd	78abd	78abd
1986	1315	19545	4123	24983		6443	1774	8217		33200	
1987	1182	17181	4729	23092		5115	2503	7618		30710	
1988	1219	16148	3948	21315		6346	2035	8381		29696	
1989	2885	18240	2889	24014		6434	2387	8821		32835	
1990	1229	16374	3379	20982		7060	2571	9631		30613	
1991	603	14002	2159	16764		6254	2525	8779		25543	
1992	851	11404	1362	13617		6008	2168	8176		21793	
1993	1437	11870	1588	14895		4648	1919	6567		21462	
1994	1081	14075	2045	17201		3949	1796	5745		22946	
1995	1303	16618	3112	21033		5204	1750	6954		27987	
1996	1171	18174	3987	23332		5979	2114	8093		31425	
1997	1323	17742	3918	22983		6187	1929	8116		31099	
1998	902	16787	2787	20476		6509	2089	8598		29074	

Year	*Lophius piscatorius*					*Lophius budegassa*				*L. piscatorius + L. budegassa*	
	Landings				Disc	Landings			Disc	ICES Land	Disc
	7a	7bk*	8abd	total	78abd	7bk	8abd	total	78abd	78abd	78abd
1999	542	16776	1473	18791		5068	1670	6738		25529	
2000	505	12909	1031	14445		5219	1425	6644		21089	
2001	611	15056	1624	17291		4478	1250	5728		23019	
2002	672	17874	3537	22083		4734	1771	6505		28588	
2003	639	21980	5315	27933	2511	6256	1916	8171	179	36105	2690
2004	604	22479	5945	29028	2411	5358	2178	7537	676	36565	3087
2005	489	21882	5498	27869	2110	5214	1974	7187	727	35056	2837
2006	418	21947	5287	27652	892	4675	1456	6131	704	33783	1596
2007	428	25424	5361	31213	816	4857	1751	6608	413	37821	1229
2008	290	21097	5666	27053	993	6039	1360	7399	1585	34452	2579
2009	218	17145	4472	21835	2078	6478	1809	8287	2113	30122	4191
2010	177	17555	4483	22215	2672	6812	1815	8626	1436	30841	4107
2011	235	19309	5114	24657	1832	7416	1933	9348	971	34006	2802
2012	295	23007	4887	28188	2330	5959	2471	8429	1459	36618	3789
2013	269	25782	4560	30611	1684	7274	3200	10475	2285	41086	3970
2014	253	23276	4945	28474	1859	6114	3718	9832	2570	38306	4428
2015	234	23103	4521	27859	2324	6284	3365	9649	1460	37508	3784
2016	656	24836	3919	29411	3585	6127	4093	10220	2441	39630	6026
2017	312	22169	3154	25635	2175	7518	4172	11690	1770	37325	3945
2018	313	18865	3506	22685	1396	6341	3734	10076	1727	32420	3123
2019	110	18976	2181	21266	1444	6800	2880	9680	1084	30946	2528
2020	78	18226	1852	20156	1335	6502	2174	8676	855	28832	2190

3.2 White anglerfish (*L. piscatorius*) in Subarea 7 and divisions 8.a–b and 8.d

Type of assessment

Update category 1 assessment. Age-based analytical assessment with a4a (Millar and Jardim, 2019).

Feedback from ADG

No issues identified.

Feedback from EG audit 2020

No issues identified.

3.2.1 Data

In 2018, WGBIE was made aware of an issue with the sampling level of Q1 and Q2 in 2017 from France (ICES, 2018b). Because of the lack of market sampling for length (biological and onboard sampling was unaffected), efforts were made to try to fill the deficiency in the sample number by using simulation techniques. However, both simulated data and actual data were uploaded to InterCatch combined making it impossible to distinguish true samples from simulated ones (Quemar *et al.*, 2018 in ICES, 2018b). Therefore, it is not possible to assess the impact of such simulated data on the assessment and the group recommended that sensitivities with and without the simulated data are carried out.

The Stock Annex describes the methods for filling in unsampled landings and discards. Figure 3.2.1 shows that less than half of the landings had length data associated with them. More than half of the discards were unsampled and had to be estimated from the discard rate of the sampled catches. However, as discard rates are relatively low, this affects only a small proportion of the total catch weight.

In 2020, due to COVID-19, the numbers of landings and discards samples decreased compared with the previous year. There were no discard data from Spain during the first semester in Subarea 7. In the case of the French data, the discards of OTB_DEF and GNS_DEF were very high while the value for Ireland was too small. For the Spanish data, OTB_DEF discards are very similar to Subarea 8 and, therefore, Subarea 7 discards were filled with those data. For the French and Irish data, considering that discard values were similar for the last 3 years, the proportion of discards of this *métier* was assumed using the average of the last three years.

Figure 3.2.2 shows the quarterly length–frequency distribution (LFD) of the catch data.

The length data are converted to pseudo-ages by first estimating the mean lengths-at-age in each quarter from a von Bertalanffy growth function (VBGF) with the parameters $L_{inf} = 171$ cm, $K = 0.1075$ and $t_0 = 0$. Then, for each quarter and year, a mixed distribution is estimated for the length distribution of the catches with the mean values predicted by the VBGF and standard deviations that increase linearly from 3 cm at age-0 to 10 cm at age-9. This mixed distribution is then used as an age–length key (ALK) which is then applied to the catch, landings and discard numbers-at-length. Until now, when the total discards volume and the product of numbers-at-length discarded by the weight are different, the total discards are modified to fit the sum of products. However, in 2020 the code was modified in order to keep total discards as estimated and instead modify the number of individuals. In this way, the total discards in the assessment match the estimated total discards volume when the discards per country or area are summed. This affects the historical time-series of discards, with a difference of −1 to 3% when comparing with the last year's assessment values. The resulting numbers and weights-at-age are used as inputs for the assessment model.

Table 3.2.1 gives an overview of the model inputs.

Figures 3.2.3a and 3.2.3b show the age distribution of the catches in terms of abundance and biomass. Catch numbers are generally higher at ages 1 or 2. The highest biomass in the catches is at ages 3–5. Note that this stock is assumed to mature at age 5.

Figure 3.2.4 shows the cohort tracking of the catch numbers-at-age. Cohort tracking is reasonably consistent up to age 7.

Figure 3.2.5 shows the proportion of discards-at-age. Nearly all 0-group anglerfish are discarded; around 80% of 1-year-olds are discarded and in recent years an increasing proportion of 2-year-olds have been discarded.

3.2.1.1 Surveys

The surveys are described in detail in the Stock Annex and section 2 of the report.

The survey data are converted to pseudo-ages in the same way as the catch data (see above and Stock Annex for more details).

The combined IGFS-WIBTS-Q4 (G7212) and EVHOE-WIBTS-Q4 (G9527) survey (FR_IE_IBTS combined survey) are very consistent in cohort tracking for the younger ages (Figure 3.2.6a). Note that no index was available in 2017 because the French survey did not take place due to mechanical issues.

The IE_Monksurvey (G3098) survey only consists of five recent years of data but appears to track the 2014 and 2010 cohorts (Figure 3.2.6b).

The SpGFS-WIBTS-Q4 (G5768, the previous acronym was SP-PGFS) survey tracks cohorts very consistently up to at least age 6 (Figure 3.2.6c).

Figures 3.2.7a and b show the internal and external consistency of the surveys. The FR_IE_IBTS is very consistent for young ages while the IE_Monksurvey (G3098) survey is too short to clearly show any internal consistency. The SpPGFS-WIBTS-Q4 (G5768) survey is somewhat noisy at ages 1 and 6 but otherwise quite consistent (Figure 3.2.7a). The FR_IE_IBTS and SpPGFS-WIBTS-Q4 (G5768) have very similar signals for the 1-year olds but contradicting for the 2 and 3-year-olds. Figure 3.2.7c shows the overall abundance indices of the surveys.

3.2.1.2 Biological

The Stock Annex describes the background of the biological parameter estimates.

- Maturity is assumed to be 0% for ages 0–4 and 100% for ages 5–7+
- Natural mortality (M) is assumed to be 0.25 for all ages and years

3.2.2 Historical stock development

Model used: a4a (+length-split based on VBGF to estimate age comp; Millar and Jardim, 2019)

Software used*:* Fla4a package version 1.6.4 (Millar and Jardim, 2019) in R version 3.5.2 (R Core Team, 2020)

An overview of the available input data by year and age is shown in Figure 3.2.8.

Model specification (see Stock Annex for details):

fmodel: ~factor(replace(age, age > 6, 6)) + factor(year)
srmodel: ~factor(year)

```
n1model: ~factor(age)
qmodel:
  FR_IE_IBTS:    ~1
  IE_MONKSURVEY: ~I(1/(1 + exp(-age)))
  SP-PGFS :      ~factor(replace(age, age > 5, 5))
vmodel:
  catch:         ~s(age, k = 3)
  FR_IE_IBTS:    ~1
  IE_MONKSURVEY: ~1
  SP-PGFS :      ~1
```

The F_{bar} range was set to ages 3–6.

3.2.2.1 Data screening and exploratory model runs

The data were thoroughly explored using the functionality of FLR and other packages. The sensitivity of the model to the inclusion of the tuning fleets was explored and the final WKANGLER assessment outputs (ICES, 2018a) were compared to the first retrospective run of the current model. The details of the data exploration can be found in the 2021 presentations folder on the WGBIE SharePoint.

3.2.2.2 Final update assessment

Figure 3.2.9 shows the patterns in F-at-age and catchability estimated by the model. F is estimated to be quite low for age 0, then gradually increases over ages 1 to 5 and decreases again for ages 6 and 7+ (F is forced to be the same for ages 6 and 7+). This may indicate reduced availability of older fish to the fishery as they move to deeper waters probably to feed (Stagioni *et al.*, 2013) or a response due to a transfer of fishing effort (Abad *et al.*, 2010). Alternatively, it could indicate higher natural mortality. The catchability (Q) of the FR_IE_IBTS combined survey is set to be the same for all ages. For the IE_Monksurvey (G3098), Q increases along a logistic function. This survey uses commercial fishing gear and the catchability follows a similar pattern to the estimated F-at-age. For the SpPGFS-WIBTS-Q4 (G5768, the previous acronym was SP-PGFS) survey, Q is freely estimated for ages 2, 3, and 4 while ages 5 and 6 are bound with reduced availability of older fish.

Figure 3.2.10 shows the residuals. These do not show any pattern except for the 2-year-olds from the FR_IE_IBTS combined survey for which most of the residuals are positive.

Figure 3.2.11 shows the summary plot as well as the retrospective analysis. The recruits are estimated with quite high precision. However, the retrospective estimates in some years are outside the confidence interval indicating a lower precision of the recruitment estimates. The 2017 recruitment estimate is highly uncertain because there was no recruitment index available for 2017.

Fishing mortality (F) shows a decreasing trend since 2004 (Figure 3.2.11) and is now below F_{MSY}.

SSB shows a steady increasing trend in SSB since 2005 and continues to rise. There is a retrospective adjustment of both SSB and F at the start of the time-series (in the period where no survey data are available). This is because in a separable assessment the F-pattern of the entire time-series is adjusted with each new year of data. Mohn's rho (Mohn, 1999) was calculated using the default 5 peels of the mohn() function in the R package 'icesAdvice 2.0.0'. The Mohn's rho values for SSB (0.33) and F (−0.16) are outside the accepted range for long-lived species (−0.15, 0.2) but not for recruitment (0.023). However, in all cases, the retrospective pattern is inside of the confidence interval. Nevertheless, a sensitivity analysis was done during the benchmark (WKANGLER; ICES, 2018a), introducing different Q-pattern to the IE_Monksurvey (G3098) due to the residual patterns observed at age 4 and 5. Assuming a Q-pattern with flexibility between ages, the model estimates a dome-shaped curve and the retrospective pattern of F and SSB are improved, with Mohn's rho values of −0.115 and 0.188, respectively, but not for the recruitment (0.259). The results suggest that this could improve the retrospective pattern, but further analysis is required. However, according to the decision tree from the Workshop on Catch Forecast from Biased Assessments (WKFORBIAS; ICES,2020b), if the retrospective pattern is found to be inside of the confidence interval, which is the case, advice shall be given.

Parameter	Mohn's Rho
Recruitment	0.023
F_{bar}	−0.160
SSB	0.330

3.2.2.3 Comparison with previous assessments

The code was modified in 2018 for filling the landings and discards but the historical data until 2017 were not modified (ICES, 2018b). In WGBIE 2021, these values were reviewed but did not have an impact on the catch-at-age numbers neither on the final results (Figure 3.2.13) compared with last year's assessment (ICES, 2020a).

3.2.2.4 State of the stock

Fishing mortality is now below F_{MSY} and has been below for the last 6 years. SSB has been above MSY $B_{trigger}$ and is now at the highest value in the time-series.

3.2.3 Biological reference points

Biological reference points were established by WKANGLER (ICES, 2018a).

	Type	Value	Technical basis
MSY	MSY $B_{trigger}$	22 278 t	B_{pa}
Approach	F_{MSY}	0.28	Median Eqsim estimate for landings (F_{MSY} catch = 0.30)
	F_{MSY} range	0.181–0.39	
	B_{lim}	16 032 t	B_{loss}
Precautionary	B_{pa}	22 278 t	B_{lim} + assessment error
Approach	F_{lim}	0.53	F with 5% probability of SSB <B_{lim}
	F_{pa}	0.39	$F_{p0.5}$ with AR; the F that leads to SSB ≥ B_{lim} with 95% probability

The definition of F_{pa} was modified to $F_{p0.5}$ in 2021 (ICES, 2021a) and the process of how $Fp_{0.5}$ was estimated can be found in the Stock Annex. The assessment presents some retrospective bias in 2019 and also in 2020 in the start as well as the end of the time-series. In 2019, WGBIE investigated if the biological reference points were still appropriate and the analysis showed that the F_{MSY} estimate was still sensitive to the addition of an extra year of data (ICES, 2019). It was estimated to be 0.23 in the 2019 assessment (ICES, 2019) and 0.36 in 2018 (ICES, 2018b). WGBIE in 2019 (ICES, 2019) considered that F_{MSY} = 0.28 (similar in WKANGLER; ICES, 2018a) is a conservative and pragmatic reference point as F has always been above F_{MSY} and yet the stock shows a sharp increase in SSB. Therefore, WGBIE did not propose to update the reference points in 2019 (ICES, 2019).

3.2.4 Short-term projections

Short-term projections were carried out as described in the Stock Annex:

- Although F shows a downward trend, F_{2021} was assumed as the average of the last 3 years (F_{2018}, F_{2019}, F_{2020}) due to the uncertainty observed in the retrospective pattern.
- No catch constraint was applied in the intermediate year as the TAC does not appear to be restrictive.

Table 3.2.3 gives the catch options. Figure 3.2.14 shows the contributions of the cohorts to the 2022 forecasted landings and 2023 SSB. The 2021 assumed geometric mean (GM) recruitment contributes about 9% to the forecasted landings.

3.2.5 Uncertainties in the assessment and forecast

In 2018 was the first time since 2006 that ICES has provided advice based on an analytical assessment for this stock. Previously, the advice was based on a category 3 assessment until 2018 and was raised to a category 1 stock after the WKANGLER (ICES, 2018a) meeting.

WKANGLER (ICES, 2018a) has shown that the estimated stock trends are robust to various assumptions on growth, natural mortality, the selection of tuning fleets and model specifications.

The estimate of the F_{MSY} reference point appears to be sensitive to the exact shape of the stock-recruit curve. The current F_{MSY} of 0.28 is considered to be conservative because the stock has increased considerably during the last 15 years although the fishing effort was well above 0.28 during that period.

3.2.6 Management considerations

Management of the two anglerfish species under a combined TAC prevents effective control of the single-species exploitation rates and could lead to overexploitation of either species.

3.2.7 Recommendations for the next benchmark

WKANGLER (ICES, 2018a) accepted the current assessment model as an interim solution until a more appropriate model could be developed. One of the main concerns was that the allocation of length data into pseudo-ages was done outside the model. WKANGLER tested a number of growth parameters for use in the length-age conversion and the assessment was not overly sensitive to the growth parameters used. The conversion from length to age outside the model also has some advantages: although cohort strength is not explicitly taken into account in the length split, it is clear that cohorts can be tracked but until age 4 or 5 after which the tracking cohort is lost. However, the effect of this could be analysed in an integrated assessment model such as the Stock Synthesis (Methot and Wetzel, 2013) in the next benchmark. Other concerns include the retrospective pattern which is increasing for the last two years.

Roadmap of work in preparation for the next benchmark in 2021–2022

- During the WKTaDSA (ICES, 2021b), a preliminary base case in Stock Synthesis v3.30 was developed.
- The next steps include:
    1. Update of the 2020 data;
    2. Decide on an initial catch assumption;
    3. Analyse different spatial structures;

4. Analyse assumptions about growth and M and the option of implementing a sex-separated model;
5. Analyse the recruitment deviates;
6. Analyse the possibility of a spatially structured model;
7. Modify the se and cv of the surveys and number of samples of LFD data;
8. Try different options of weighting length–frequency data;
9. Compare SS (Merthot and Wetzel, 2013) assessment results with a4a (Millar and Jardim, 2019) results.

3.2.8 References

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3.2.9 Figures and tables

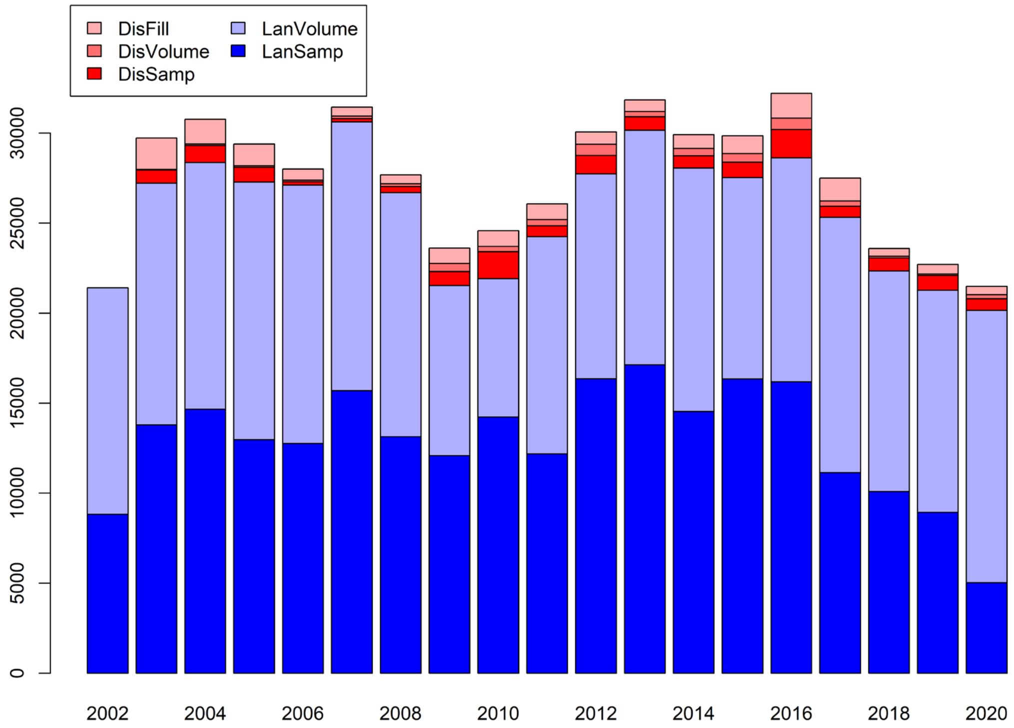

Figure 3.2.1. *Lophius piscatorius* in 27.78abd. Allocations of unsampled landings and discards by year. Dark blue represents the sampled landings while light blue represents landings for which only the total weight (in tonnes) was available but no length data and red represents the fully sampled discards (tonnage and length data). Medium pink represents discards for which an estimate of the tonnage was available but no length data (length data 'borrowed' from other strata) while the light pink represents the strata for which no discard tonnage or length data were available (discard rate and length data 'borrowed' from other strata).

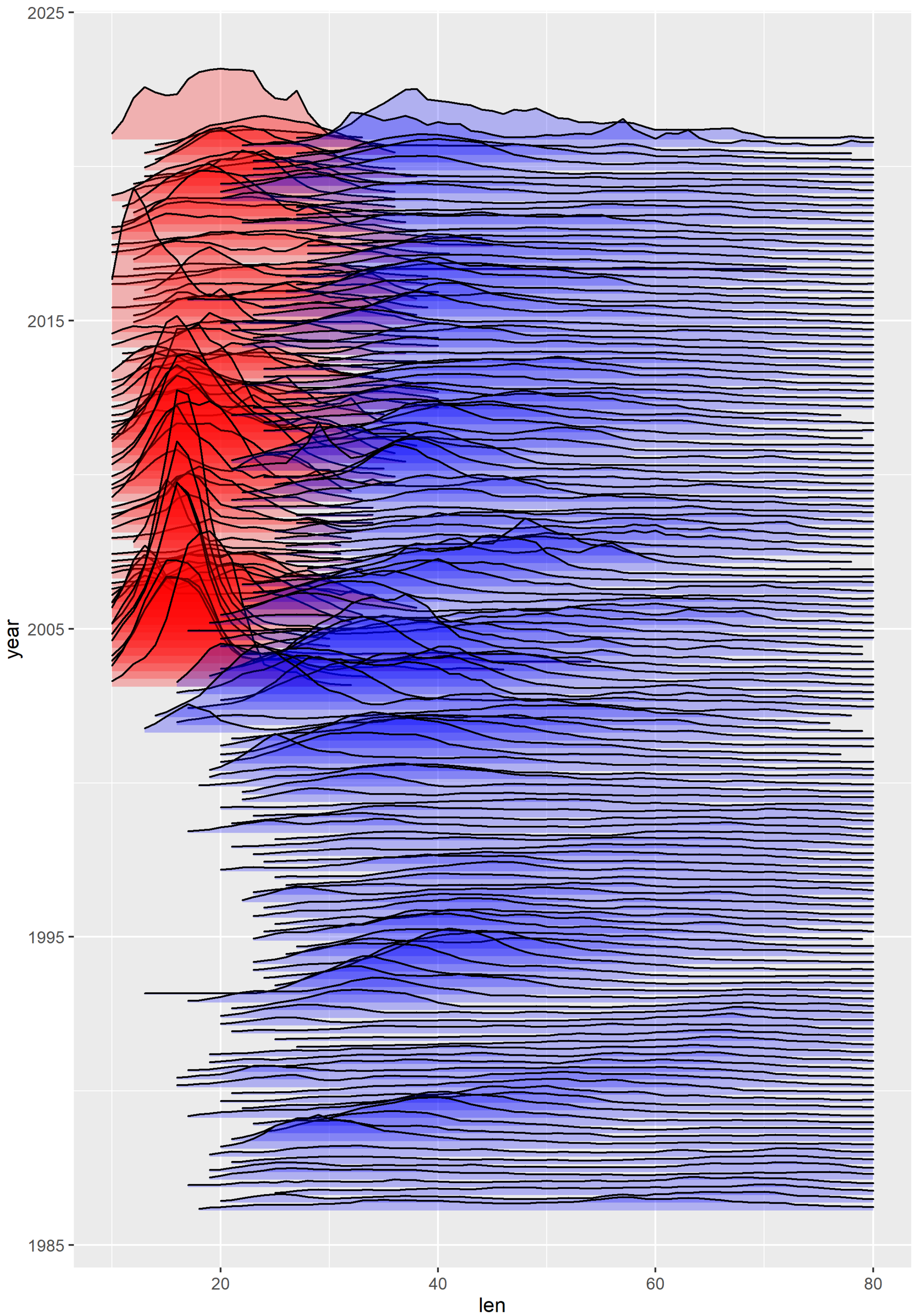

Figure 3.2.2. ***Lophius piscatorius*** **in 27.78abd. Quarterly length frequency distributions of the landings (blue) and discards (red). No discard data were available prior to 2003.**

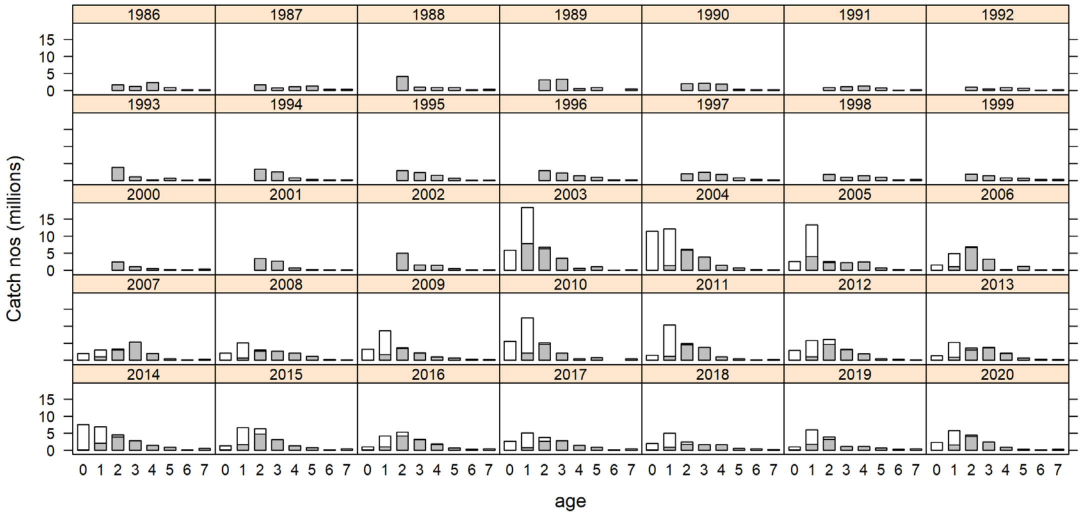

Figure 3.2.3a. ***Lophius piscatorius*** **in 27.78abd. Age distributions of the catches by year in terms of abundance**

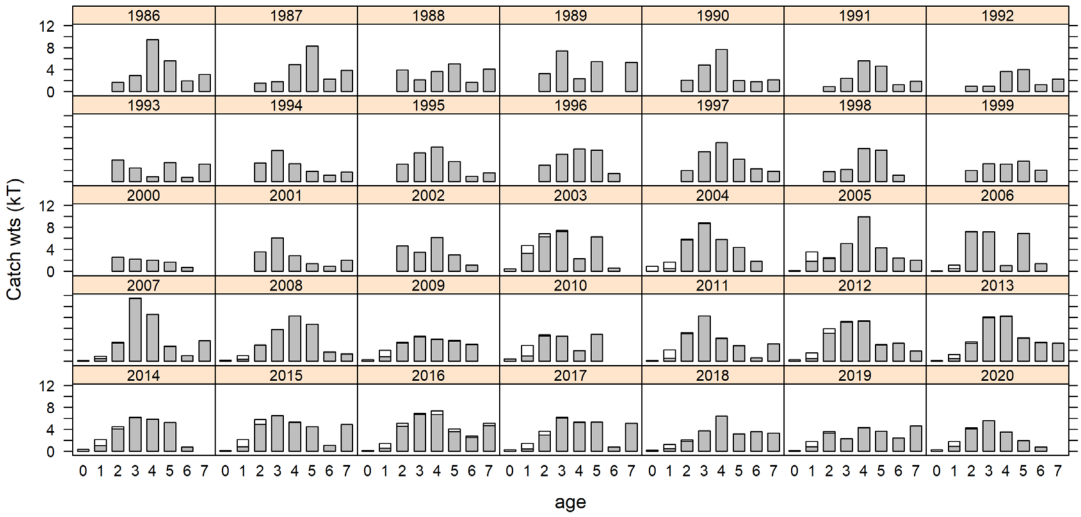

Figure 3.2.3b. ***Lophius piscatorius*** **in 27.78abd. Age distribution of the catches by year in terms of biomass.**

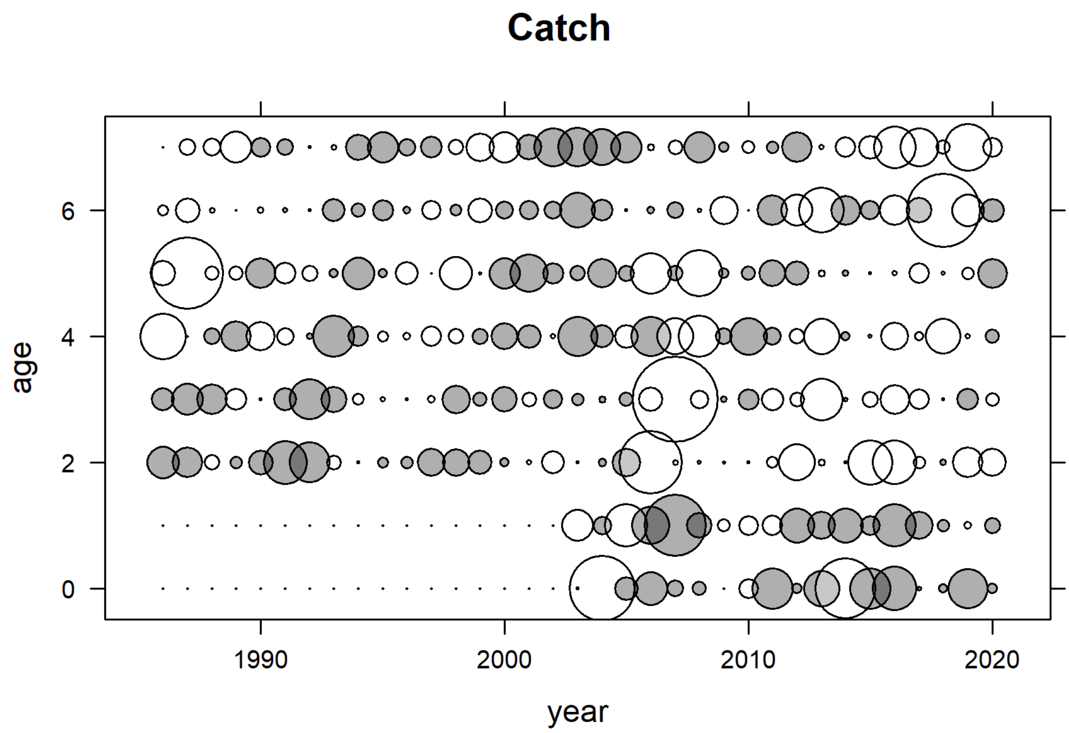

Figure 3.2.4 ***Lophius piscatorius*** **in 27.78abd. Standardized proportion at age-per-year of the catch numbers. Cohorts can be tracked consistently up to age 7.**

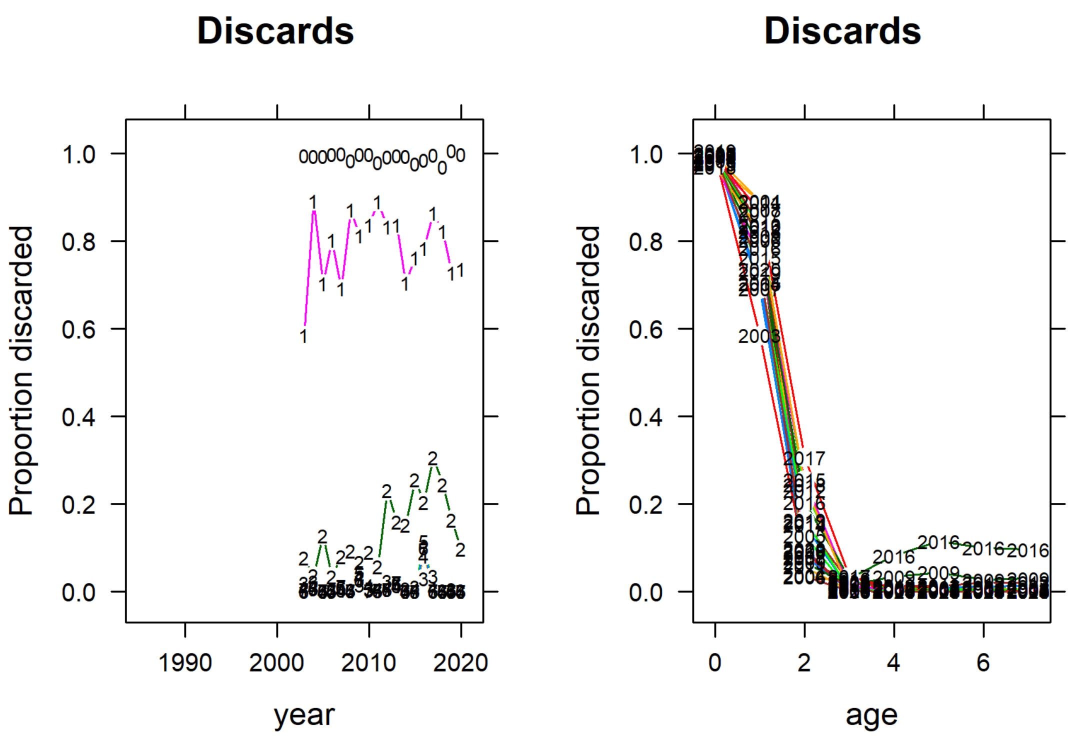

Figure 3.2.5. ***Lophius piscatorius*** **in 27.78abd. Proportions of discards-at-age over time (left) and by age (right).**

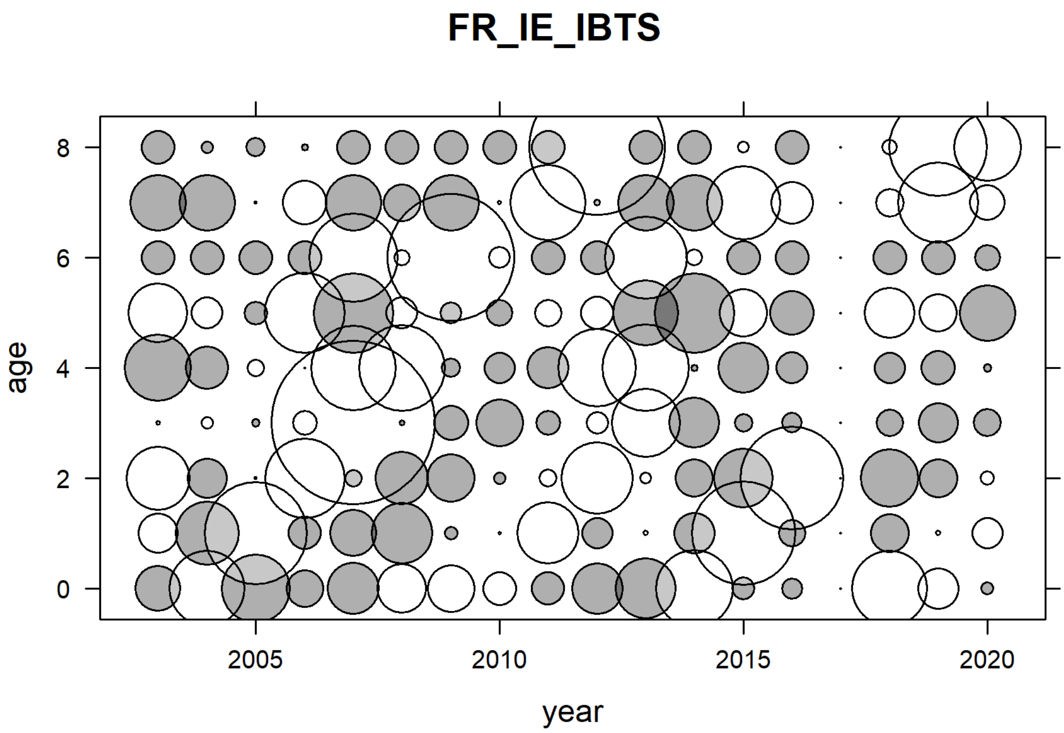

Figure 3.2.6a. ***Lophius piscatorius*** **in 27.78abd. Standardized proportion-at-age per year of the FR_IE_IBTS (combined IGFS-WIBTS-Q4 (G7212) and EVHOE-WIBTS-Q4 (G9527) survey) index.**

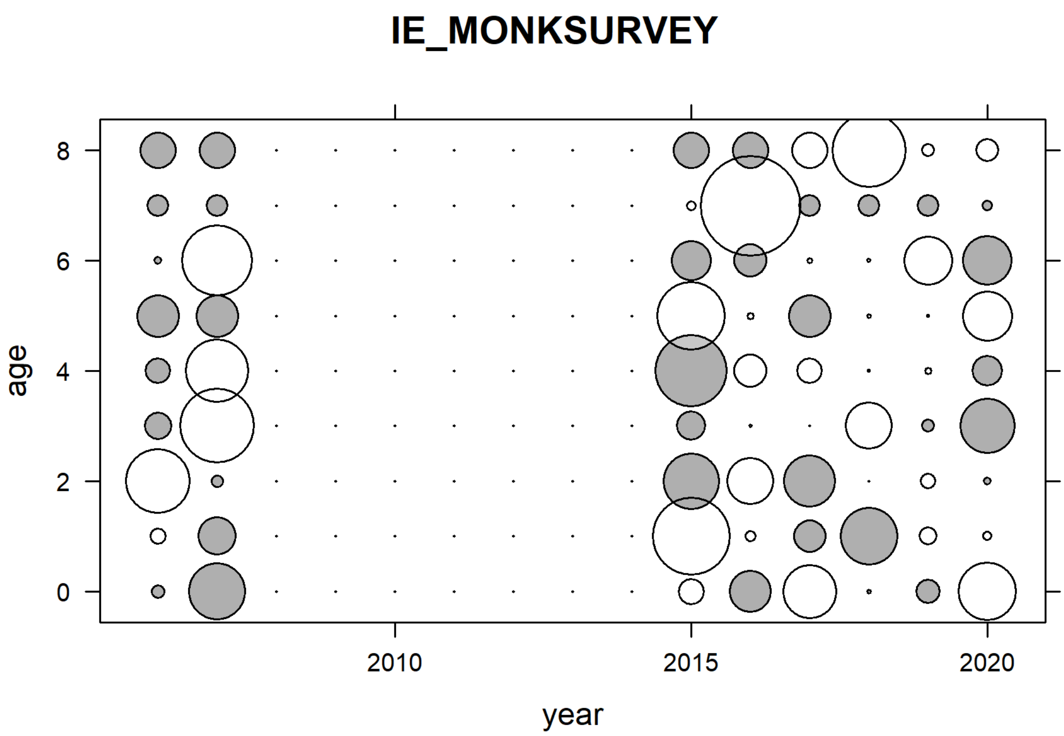

Figure 3.2.6b. ***Lophius piscatorius*** **in 27.78abd. Standardized proportion-at-age per year of the IE_Monksurvey (G3098) index.**

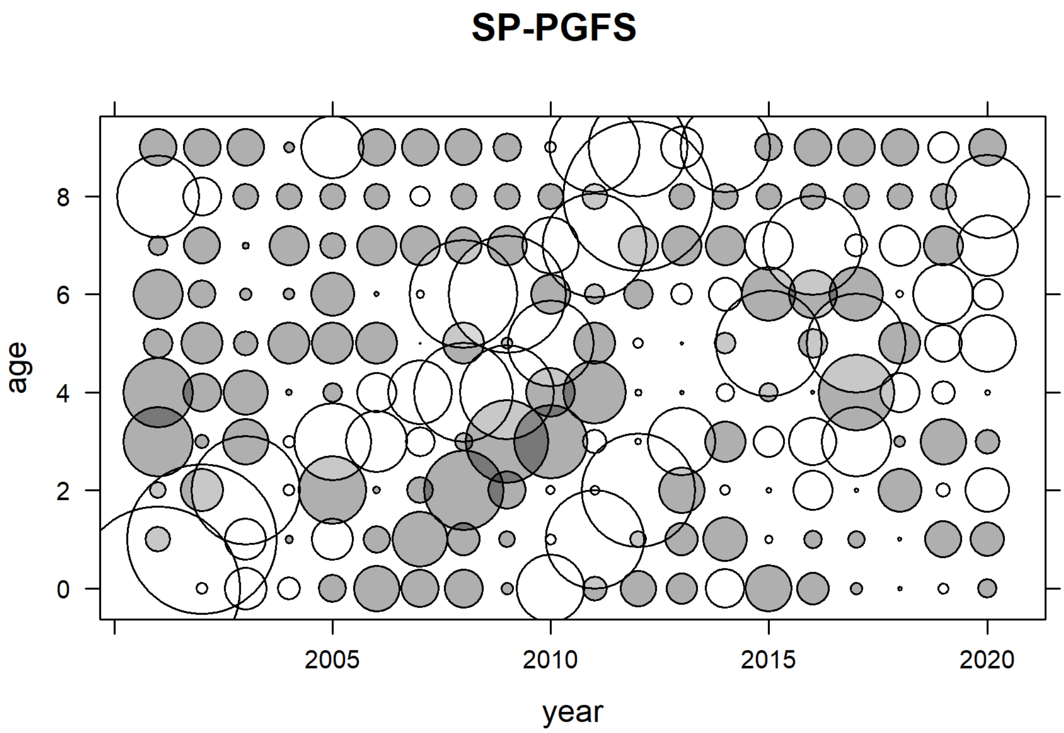

Figure 3.2.6c. ***Lophius piscatorius*** **in 27.78abd. Standardized proportion at age per year of the SpPGFS-WIBTS-Q4 (G5768, previous acronym SP-PGFS) survey index. Cohorts can be tracked consistently up to age 6.**

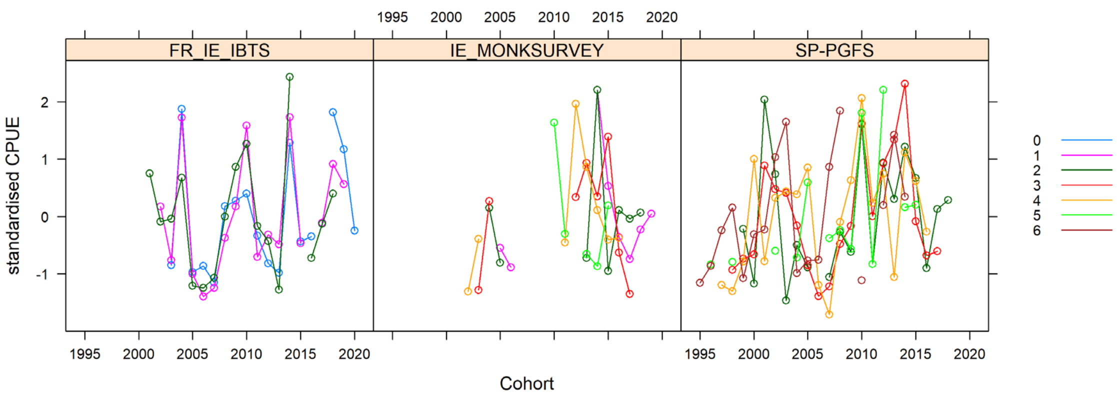

Figure 3.2.7a. ***Lophius piscatorius*** **in 27.78abd. Internal consistency of the standardized cpue indices from the FR_IE_IBTS (combined IGFS-WIBTS-Q4 (G7212) and EVHOE-WIBTS-Q4 (G9527) survey), IE_Monksurvey (G3098) and SpPGFS-WIBTS-Q4 (G5768, previous acronym SP-PGFS) surveys.**

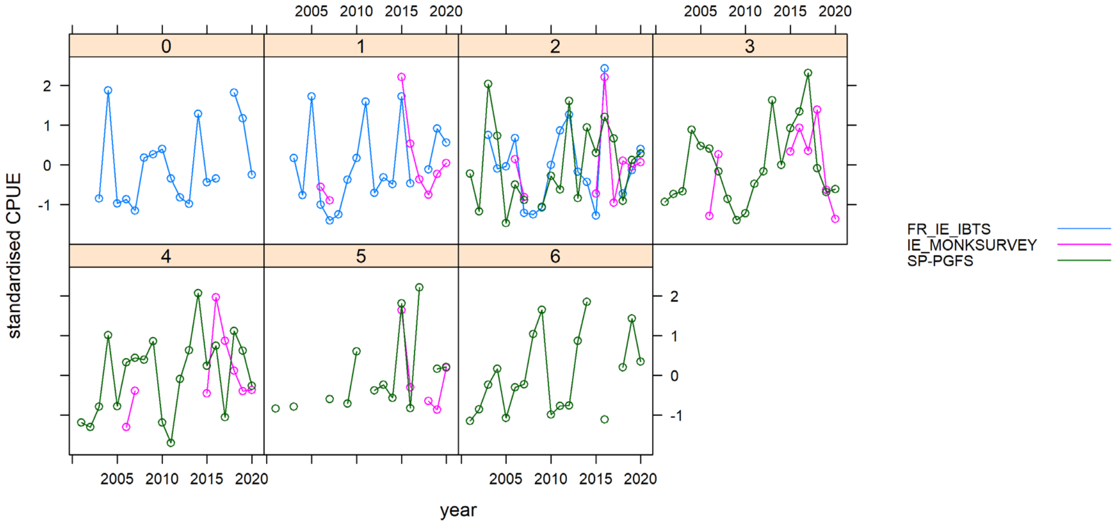

Figure 3.2.7b. ***Lophius piscatorius*** **in 27.78abd. External consistency of the standardized cpue indices from the FR_IE_IBTS (combined IGFS-WIBTS-Q4 (G7212) and EVHOE-WIBTS-Q4 (G9527) survey), IE_Monksurvey (G3098) and SpPGFS-WIBTS-Q4 (G5768, previous acronym SP-PGFS) surveys.**

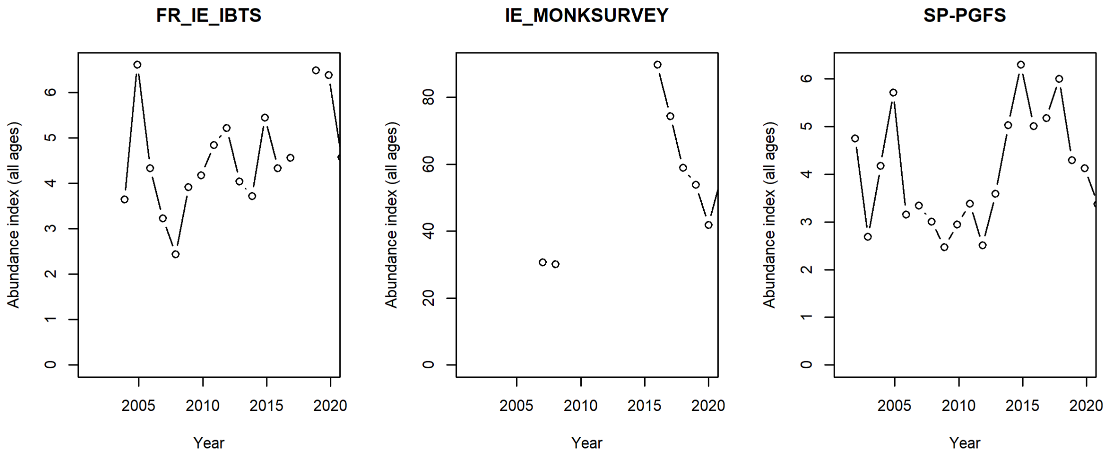

Figure 3.2.7c. ***Lophius piscatorius*** **in 27.78abd. Overall abundance trends (all ages combined) from the FR_IE_IBTS (combined IGFS-WIBTS-Q4 (G7212) and EVHOE-WIBTS-Q4 (G9527) survey), IE_Monksurvey (G3098) and SpPGFS-WIBTS-Q4 (G5768, previous acronym SP-PGFS) surveys.**

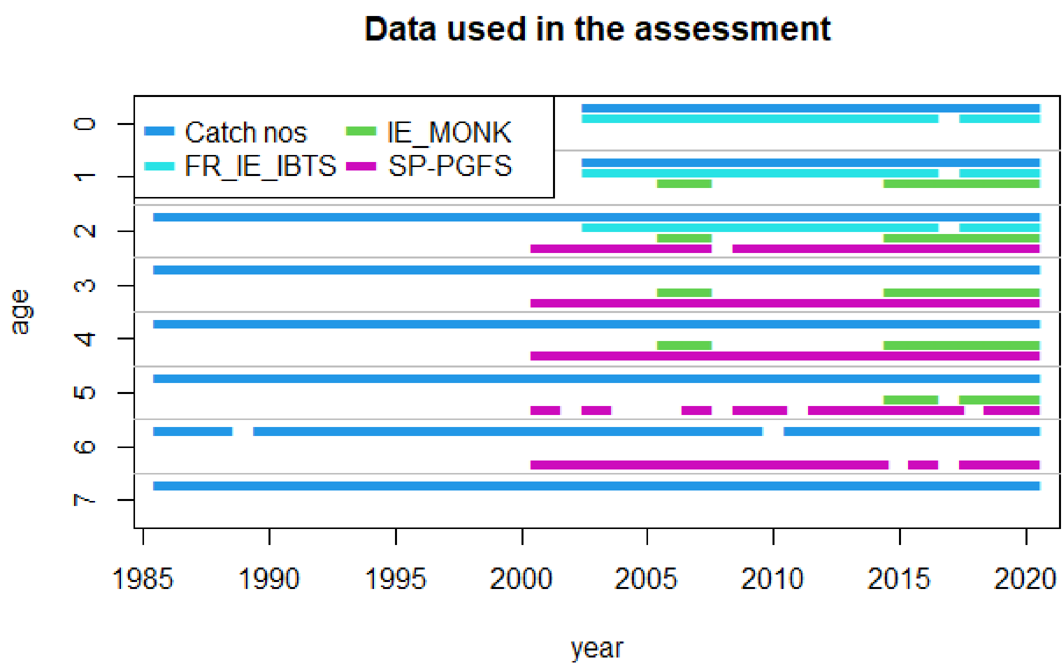

Figure 3.2.8. *Lophius piscatorius* in 27.78abd. Overview of the available catch and survey data. Age 7 is a plus group. FR_IE_IBTS (combined IGFS-WIBTS-Q4 (G7212) and EVHOE-WIBTS-Q4 (G9527) survey), IE_Monksurvey (G3098) and SpPGFS-WIBTS-Q4 (G5768, previous acronym SP-PGFS) surveys.

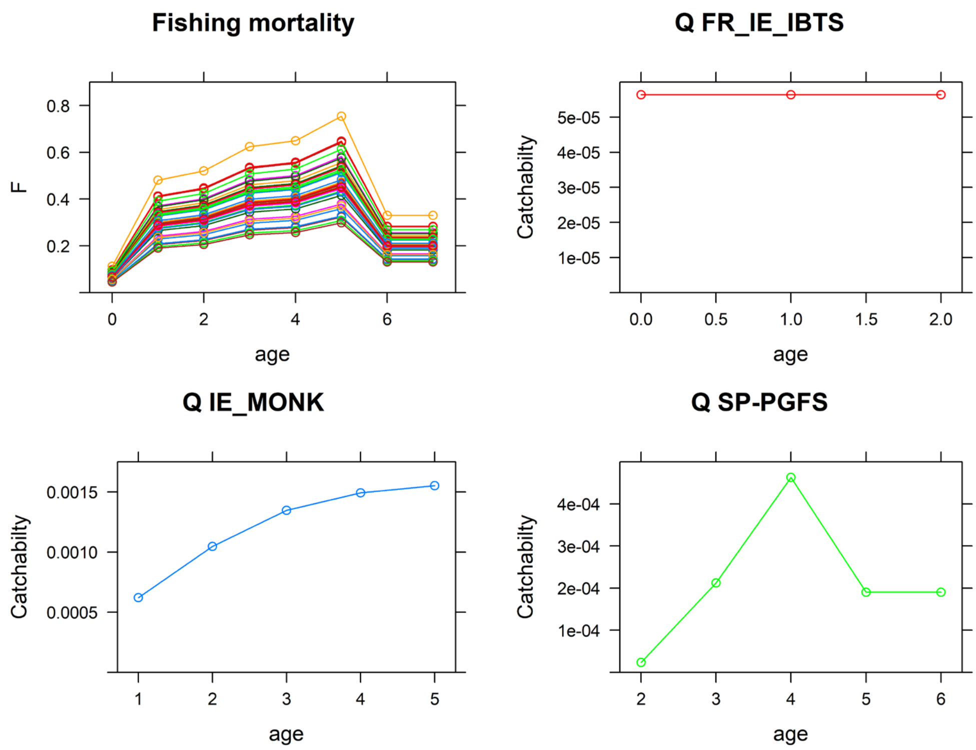

Figure 3.2.9. *Lophius piscatorius* in 27.78abd. F-at-age (colours indicate years) and catchability-at-age patterns of the FR_IE_IBTS (combined IGFS-WIBTS-Q4 (G7212) and EVHOE-WIBTS-Q4 (G9527) survey), IE_Monksurvey (G3098) and SpPGFS-WIBTS-Q4(G5768, previous acronym SP-PGFS) surveys.

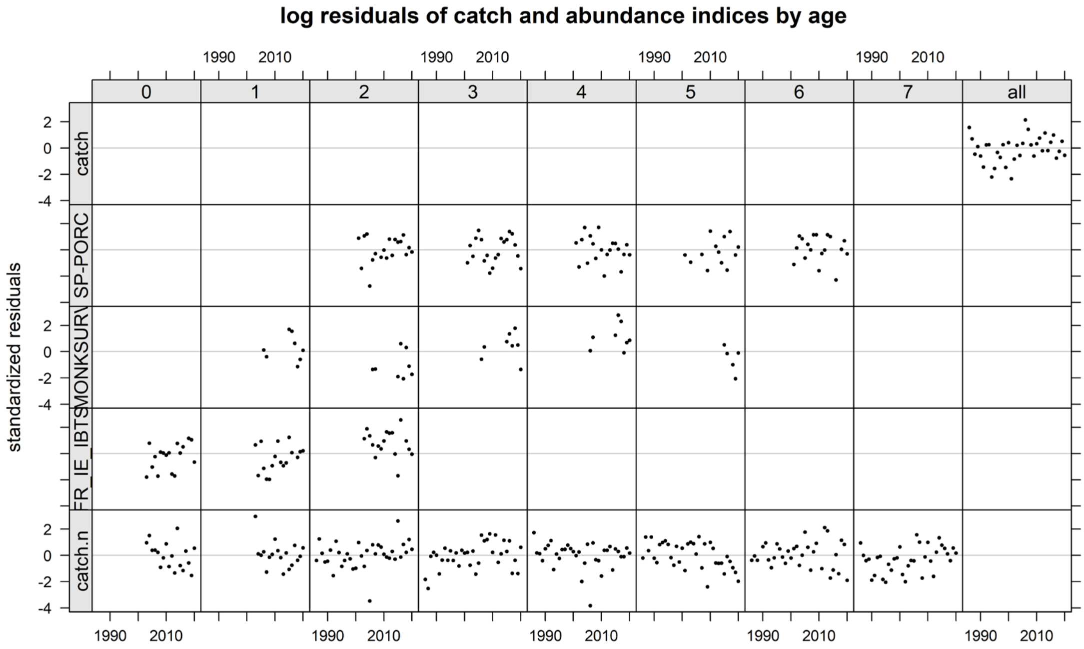

Figure 3.2.10. *Lophius piscatorius* in 27.78abd. Standardized residuals of the catch and the FR_IE_IBTS (combined IGFS-WIBTS-Q4 (G7212) and EVHOE-WIBTS-Q4 (G9527) survey), IE_Monksurvey (G3098) and SpPGFS-WIBTS-Q4(G5768, previous acronym SP-PGFS) surveys.

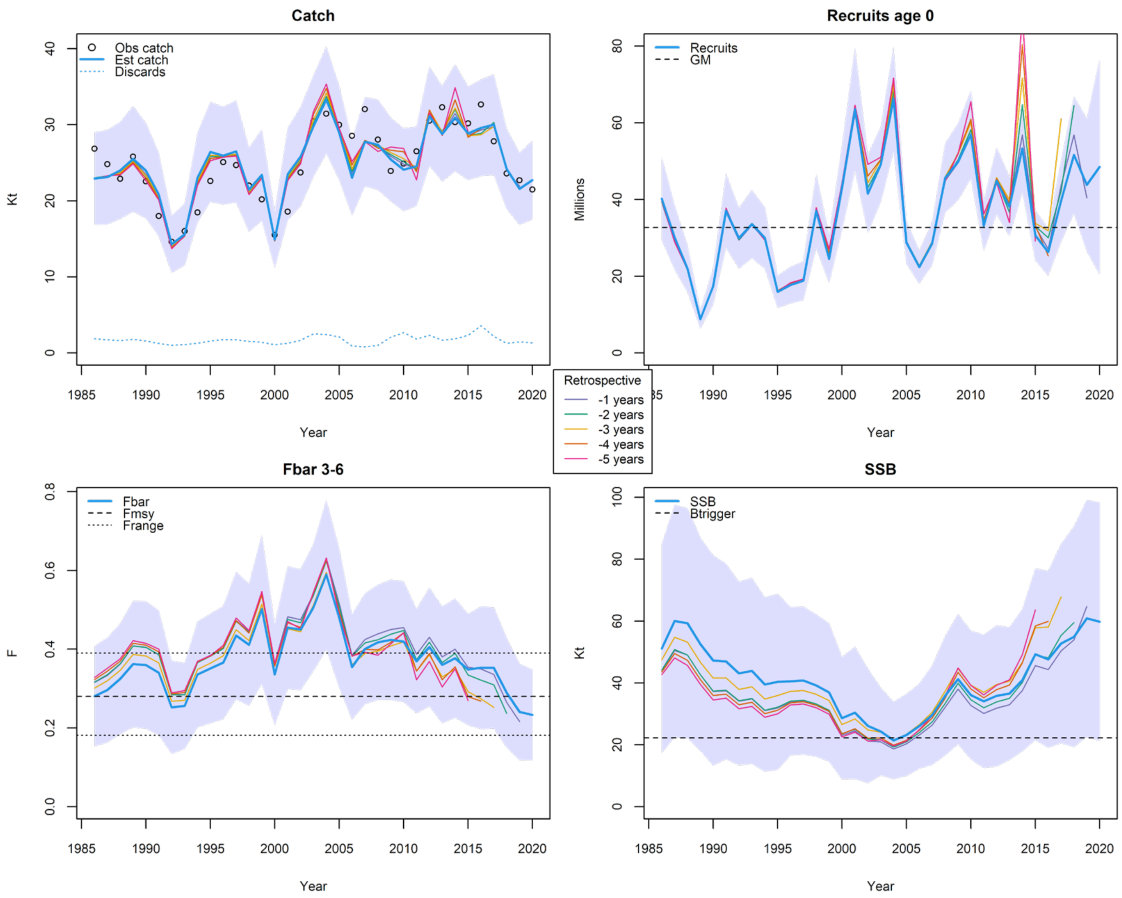

Figure 3.2.11. *Lophius piscatorius* in 27.78abd. Summary plot of the assessment outputs. Light blue areas are the 95% confidence intervals. The coloured lines are the retrospective runs.

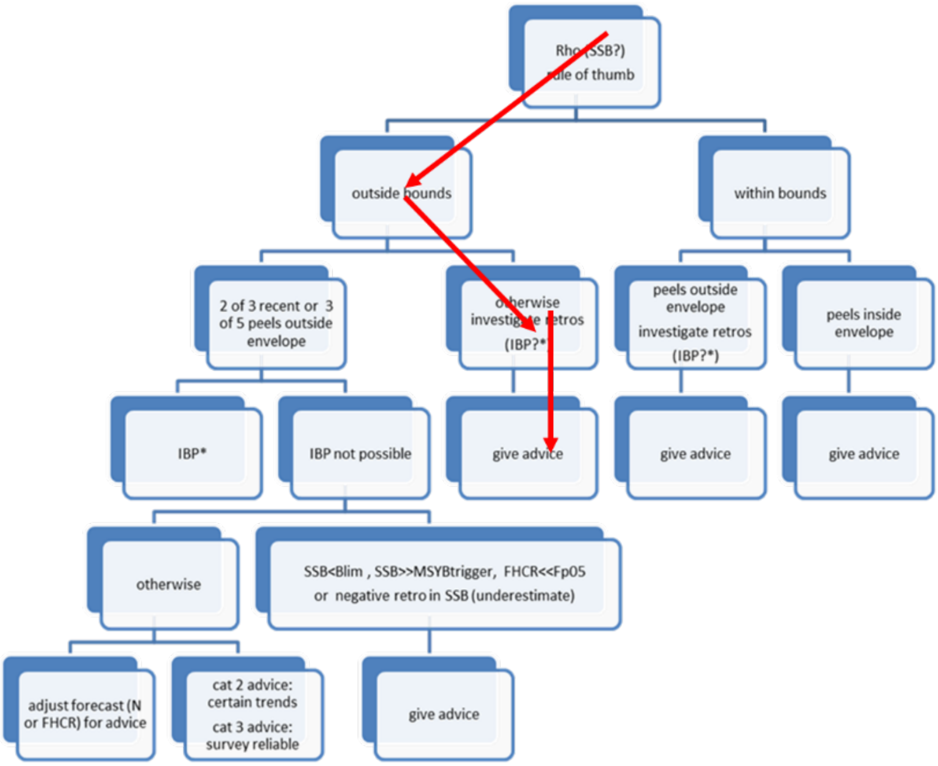

Figure 3.2.12. Decision tree from WKFORBIAS (ICES, 2020b) for handling assessments with retrospective patterns. The arrows show the path followed for the *Lophius piscatorius* in area 27.78abd 2021 assessment.

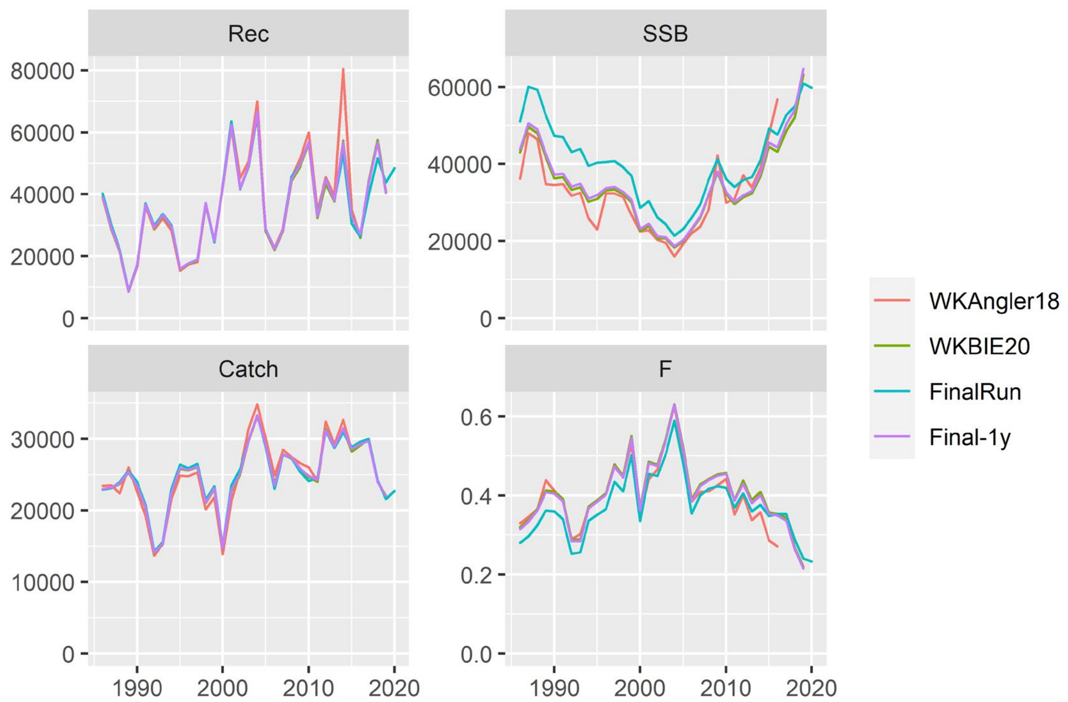

Figure 3.2.13. Comparison of the outputs from the previous assessment in WGBIE 2020 (ICES, 2020a) and this year assessment excluding the last year data (2020) Final-1y. FinalRun is the result of this year assessment and WKAngler18 is the result from the 2018 WKANGLER benchmark (ICES, 2018a).

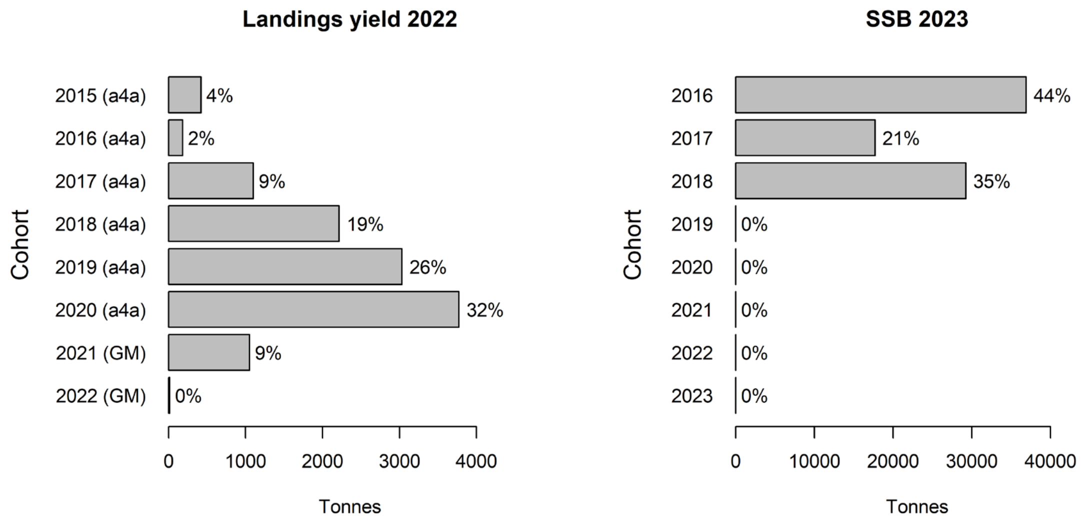

Figure 3.2.14. *Lophius piscatorius* in 27.78abd. Cohort contributions to the forecast landings in 2022 and SSB in 2023.

Table 3.2.1. *Lophius piscatorius* in 27.78abd. Stock assessment model input data. catch.n is the catch numbers-at-age (thousands), p.dis is the proportion of the catch numbers that are discarded, catch.wt and stock wt are the catch and stock weights-at-age (kg), respectively. FR_IE_IBTS (n/hr), IE_Monksurvey (G3098, n/km2) and SpPGFS-WIBTS-Q4 (G5768, previous acronym was SP-PGFS, n/30mis) are the tuning indices used.

catch.n	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1986			1649	1239	2365	935	219	244
1987			1661	828	1168	1386	266	295
1988			4159	971	883	840	205	331
1989			2920	3152	539	862		410
1990			2069	2120	1941	338	203	161
1991			927	1094	1423	789	146	154
1992			976	417	897	669	141	192
1993			3827	1089	196	564	82	253
1994			3350	2649	788	325	130	135
1995			2966	2401	1546	617	101	114
1996			2915	2243	1492	978	163	183
1997			1954	2460	1762	694	266	157
1998			1812	965	1489	965	129	290
1999			1957	1508	808	642	263	346
2000			2594	1034	527	295	97	344
2001			3676	2844	720	262	111	140
2002			4882	1574	1460	492	121	80
2003	5936	18336	6683	3488	516	1054	59	137
2004	11484	12171	5975	3886	1423	719	188	164
2005	2625	13344	2583	2255	2465	693	254	146
2006	1528	4887	6812	3172	273	1166	159	281
2007	2046	2986	3247	5246	1984	472	106	282
2008	2156	5111	2940	2616	2081	1100	178	97
2009	3196	8690	3602	2168	952	637	337	231
2010	5543	12473	5084	2045	483	798		452
2011	1429	10329	4787	3759	1035	475	66	245
2012	2922	5806	6058	3137	1869	482	369	127
2013	1313	5202	3475	3706	2049	704	363	254
2014	7516	6835	4480	2783	1441	846	76	460
2015	1280	6595	6302	3052	1327	740	116	389
2016	958	4143	5265	3111	1792	670	290	413
2017	2617	5115	3661	2777	1355	843	73	400
2018	1960	4938	2353	1629	1629	537	389	234
2019	950	5924	3850	1041	1060	631	253	367
2020	2333	5761	4411	2448	867	324	79	307
prop.dis	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1986								
1987								
1988								
1989								
1990								
1991								
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1999								
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2001								
2002								
2003	0.996	0.585	0.077	0.019	0.007	0.001	0	0.005
2004	0.994	0.892	0.036	0.021	0.009	0.006	0.007	0.006
2005	0.994	0.703	0.128	0.001	0.001	0.002	0	0.002
2006	0.998	0.802	0.033	0	0.002	0.002	0.004	0
2007	1	0.691	0.08	0.004	0.003	0.008	0.011	0.012
2008	0.984	0.872	0.092	0.001	0.001	0.001	0.004	0.001
2009	0.998	0.812	0.066	0.014	0.033	0.043	0.026	0.029
2010	0.999	0.837	0.09	0.003	0.013	0.006		0.001
2011	0.979	0.89	0.056	0.002	0.005	0.002	0.002	0.003
2012	0.992	0.832	0.23	0.024	0.007	0.005	0.004	0.004
2013	0.995	0.838	0.159	0.019	0.013	0.013	0.02	0.02
2014	0.995	0.704	0.151	0.006	0	0	0	0
2015	0.977	0.763	0.255	0.011	0.003	0.001	0	0
2016	0.985	0.783	0.204	0.029	0.082	0.114	0.099	0.095
2017	0.996	0.865	0.306	0.034	0.007	0.001	0	0.001
2018	0.97	0.823	0.244	0.002	0	0	0	0
2019	1.007	0.728	0.164	0.004	0.002	0.001	0	0
2020	0.998	0.736	0.096	0.002	0	0	0	0
catch.wt	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1986	0.124	0.385	1.015	2.367	4.114	6.131	9.078	13.062
1987	0.141	0.385	0.941	2.226	4.263	6.115	8.63	13.242
1988	0.125	0.466	0.964	2.276	4.225	6.175	8.395	12.717
1989	0.12	0.384	1.067	2.239	4.196	6.069	9.085	12.415
1990	0.118	0.352	1.027	2.331	4.077	6.109	8.907	13.784
1991	0.134	0.39	1.016	2.302	4.092	6.11	8.895	12.663
1992	0.12	0.451	1.003	2.252	4.133	6.016	9.008	11.944
1993	0.08	0.5	1.017	2.217	4.375	6.006	9.138	12.345
1994	0.097	0.549	1.027	2.208	4.202	5.802	9.366	12.772
1995	0.097	0.496	1.093	2.231	4.173	6.039	9.379	14.085
1996	0.097	0.414	1.04	2.278	4.12	6.073	9.125	12.455
1997	0.126	0.455	1.034	2.266	4.144	5.968	9.009	11.903
1998	0.127	0.412	1.019	2.371	4.138	6.117	9.071	11.617
1999	0.123	0.462	1.071	2.26	4.094	6.038	8.272	12.158
2000	0.11	0.452	1.034	2.298	4.077	5.979	7.907	12.623
2001	0.098	0.363	1.021	2.293	4.207	5.763	9.044	15.462
2002	0.117	0.362	0.921	2.132	4.094	5.832	8.957	18.11
2003	0.071	0.252	0.999	2.088	4.389	5.812	9.719	13.378
2004	0.077	0.135	0.965	2.23	4.016	5.977	9.604	12.586
2005	0.062	0.265	0.953	2.206	3.96	6.053	9.38	13.831
2006	0.07	0.231	1.053	2.243	3.706	5.872	8.693	11.945
2007	0.071	0.295	1.046	2.161	4.251	5.73	9.502	13.116
2008	0.087	0.195	1.002	2.194	3.951	6.063	9.374	13.683
2009	0.085	0.231	0.943	2.064	4.202	5.92	9.134	11.685
2010	0.078	0.233	0.942	2.201	3.973	6.101	9.085	11.715
2011	0.086	0.201	1.079	2.179	3.999	5.966	8.702	12.862
2012	0.084	0.259	0.972	2.289	3.914	6.187	8.813	14.625
2013	0.091	0.243	1.007	2.164	3.993	6.013	9.41	12.981
2014	0.04	0.31	0.983	2.193	4.015	6.095	9.58	11.917
2015	0.096	0.319	0.906	2.109	3.936	6.006	9.257	12.422

2016	0.083	0.337	0.962	2.189	4.06	5.945	9.281	12.218
2017	0.086	0.278	0.981	2.201	3.838	6.199	9.555	12.573
2018	0.091	0.247	0.879	2.287	3.945	5.822	9.159	14.035
2019	0.1	0.3	0.928	2.194	4.052	5.802	9.476	12.538
2020	0.095	0.309	0.964	2.278	4.043	5.795	8.975	11.623
stock.wt	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1986	0.012	0.197	0.702	1.784	3.394	5.45	7.845	12.463
1987	0.012	0.222	0.643	1.788	3.397	5.459	7.78	12.249
1988	0.012	0.248	0.589	1.789	3.412	5.452	7.853	11.642
1989	0.012	0.186	0.748	1.719	3.436	5.36	7.877	11.417
1990	0.012	0.203	0.661	1.801	3.4	5.452	7.836	13.013
1991	0.012	0.189	0.701	1.736	3.428	5.447	7.845	11.922
1992	0.012	0.227	0.647	1.751	3.444	5.441	7.845	11.092
1993	0.012	0.122	0.679	1.736	3.448	5.385	7.862	11.437
1994	0.012	0.253	0.711	1.736	3.424	5.385	7.877	12.131
1995	0.012	0.221	0.769	1.725	3.455	5.362	7.877	13.992
1996	0.012	0.26	0.618	1.777	3.43	5.449	7.813	11.35
1997	0.012	0.199	0.752	1.732	3.424	5.443	7.852	11.288
1998	0.012	0.187	0.73	1.739	3.433	5.449	7.849	10.743
1999	0.012	0.199	0.694	1.8	3.364	5.48	7.848	11.181
2000	0.012	0.217	0.691	1.736	3.423	5.455	7.831	11.564
2001	0.012	0.219	0.708	1.733	3.438	5.366	7.877	14.726
2002	0.012	0.2	0.609	1.718	3.438	5.264	7.877	15.446
2003	0.012	0.132	0.738	1.648	3.497	5.181	7.877	12.225
2004	0.012	0.094	0.721	1.727	3.411	5.411	7.877	11.618
2005	0.014	0.129	0.608	1.769	3.41	5.441	7.877	12.648
2006	0.007	0.135	0.712	1.646	3.494	5.289	7.877	10.757
2007	0.013	0.145	0.689	1.745	3.442	5.337	7.877	11.986
2008	0.012	0.128	0.676	1.692	3.387	5.405	7.877	13.212
2009	0.012	0.117	0.695	1.668	3.444	5.378	7.997	10.993
2010	0.01	0.134	0.699	1.65	3.476	5.288	7.877	10.657
2011	0.012	0.114	0.786	1.694	3.431	5.338	7.877	11.844
2012	0.012	0.137	0.662	1.797	3.37	5.504	7.96	13.785
2013	0.015	0.136	0.649	1.731	3.392	5.456	7.877	12.278
2014	0.012	0.134	0.716	1.695	3.404	5.483	7.877	11.094
2015	0.012	0.162	0.654	1.68	3.418	5.447	7.877	11.61
2016	0.012	0.159	0.683	1.713	3.416	5.459	7.993	11.286
2017	0.012	0.149	0.69	1.708	3.419	5.494	7.877	11.88
2018	0.012	0.148	0.605	1.733	3.389	5.461	8.032	13.278
2019	0.012	0.182	0.563	1.74	3.424	5.416	7.877	11.841
2020	0.012	0.161	0.68	1.712	3.412	5.402	7.877	10.946
FR_IE_IBTS	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
2003	0.871	1.126	1.03	0.507		0.1		
2004	3.944	0.647	0.745	0.981	0.129	0.145		
2005	0.739	1.922	0.762	0.554	0.284	0.05		0.023
2006	0.853	0.526	1.005	0.532	0.171	0.103		0.031
2007	0.533	0.322	0.365	0.818	0.291		0.073	
2008	2.035	0.402	0.353	0.514	0.478	0.086	0.046	0.007
2009	2.136	0.849	0.412	0.393	0.163	0.05	0.168	
2010	2.279	1.129	0.775	0.38	0.142	0.052	0.064	0.027
2011	1.45	1.853	1.069	0.559	0.107	0.11		0.066
2012	0.903	0.678	1.204	0.655	0.466	0.09		0.02
2013	0.724	0.877	0.719	0.817	0.454	0.011	0.107	

2014	3.281	0.788	0.629	0.402	0.265		0.065	
2015	1.335	1.925	0.342	0.496	0.059	0.11		0.054
2016	1.44	0.801	1.601	0.513	0.132	0.033		0.043
2017								
2018	3.883	0.983	0.53	0.674	0.192	0.168		0.052
2019	3.15	1.508	0.732	0.559	0.17	0.149		0.084
2020	1.55	1.329	0.91	0.472	0.219	0.022	0.009	0.04
IE_MONKSURVEY	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
2006	6.63	7.951	8.249	4.318	2.669		0.811	
2007	2.714	4.614	3.948	11.913	4.631		2.252	
2008								
2009								
2010								
2011								
2012								
2013								
2014								
2015	28.72	34.967	4.313	12.264	4.496	4.072	0.525	0.367
2016	9.883	18.559	17.502	15.179	9.693	1.464	0.783	1.306
2017	23.624	9.784	3.306	12.334	7.334		1.957	
2018	12.965	6.036	8.065	17.438	5.717	0.996	1.724	
2019	7.772	11.085	7.385	7.53	4.614	0.707	2.538	
2020	23.322	13.801	7.876	3.967	4.675	2.128		0.094
SP-PGFS	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
2001	2.933	0.228	0.254	0.567	0.608	0.064	0.016	0.049
2002	0.45	0.82	0.085	0.705	0.557		0.058	0.004
2003	1.077	0.597	0.655	0.754	0.8	0.077	0.145	0.069
2004	1.153	0.42	0.424	1.831	1.648		0.201	
2005	0.198	0.452	0.032	1.543	0.803		0.028	0.022
2006	0.027	0.15	0.205	1.5	1.326		0.136	
2007	0.099	0.008	0.135	1.104	1.38	0.13	0.147	
2008	0.076	0.09		0.624	1.355		0.324	0.004
2009	0.323	0.181	0.105	0.251	1.578	0.098	0.411	
2010	1.135	0.329	0.244	0.369	0.607	0.462	0.04	0.16
2011	0.179	0.576	0.183	0.883	0.365		0.071	0.18
2012	0.14	0.221	0.578	1.101	1.128	0.19	0.072	
2013	0.266	0.183	0.145	2.34	1.471	0.229	0.301	
2014	1.57	0.124	0.46	1.219	2.151	0.138	0.439	
2015	0.036	0.466	0.347	1.855	1.286	0.798		0.217
2016	0.254	0.303	0.509	2.144	1.525	0.067	0.023	0.358
2017	0.655	0.361	0.412	2.816	0.671	0.909		0.182
2018	0.559	0.371	0.132	1.158	1.701		0.207	0.169
2019	0.686	0.13	0.316	0.743	1.465	0.34	0.38	
2020	0.299	0.116	0.344	0.794	1.047	0.353	0.227	0.167

Table 3.2.2. *Lophius piscatorius* in 27.78abd. Summary of the assessment. Landings, discards, catch and estimated catch in tonnes. Total-stock biomass in kilotonnes, recruitment in millions. CV is the relative standard error.

Year	Lan	Dis	Cat	CatEst	Tsb	Ssb	SsbCv	Recr	RecrCv	Fbar	FbarCv
1986	24981	1861.375598	26842.3756	22932.38269	92.91198067	51.09325925	0.331933905	40.23587264	0.138344877	0.2804485	0.228060785
1987	23091	1720.548574	24811.54857	23115.87421	96.02187846	60.05490221	0.317287294	30.12545047	0.141697266	0.2962845	0.227370571
1988	21314	1588.141367	22902.14137	23988.64415	93.30874108	59.307149	0.321735473	22.00484233	0.141859465	0.3248335	0.215636925
1989	24015	1789.397341	25804.39734	25510.95794	91.04427828	52.59364089	0.338586955	8.786219187	0.141474902	0.36209225	0.228687509
1990	20982	1563.403498	22545.4035	23973.82732	87.59528043	47.28489551	0.371226027	17.40164989	0.139579577	0.35970225	0.225044962
1991	16763	1249.038835	18012.03884	20811.24896	75.21446905	46.95026213	0.34699849	37.08659584	0.133878778	0.33990575	0.23677936
1992	13617	1014.625176	14631.62518	14276.68492	68.0699918	43.09650577	0.353655541	29.91536277	0.13476185	0.25213675	0.234206922
1993	14895	1109.851068	16004.85107	15596.25553	71.13028345	43.91816829	0.352618012	33.59791672	0.134128846	0.25609625	0.212967142
1994	17201	1281.674939	18482.67494	23055.90512	84.08553902	39.50772728	0.366612731	29.95972972	0.134789971	0.33593125	0.203463956
1995	21033	1567.203592	22600.20359	26434.24302	90.82805543	40.37015246	0.362972255	15.95210298	0.137126654	0.3509665	0.200040961
1996	23333	1738.580394	25071.58039	25920.24041	81.62413032	40.55905104	0.303383074	17.69493776	0.137647712	0.3661135	0.197823322
1997	22983	1712.501315	24695.50132	26512.01895	76.35063532	40.79035896	0.300400894	18.837411	0.13598092	0.43484825	0.189164466
1998	20474	1525.551579	21999.55158	21453.63698	65.60415825	39.17338841	0.30170461	37.00892941	0.135978588	0.41126375	0.189979984
1999	18792	1400.222979	20192.22298	23388.2119	60.61528229	36.94482562	0.311586416	24.49618736	0.131141802	0.5016745	0.192764612
2000	14451	1076.767894	15527.76789	14901.23573	54.90597205	28.63853883	0.355628862	42.95332407	0.131405575	0.33562325	0.196414361
2001	17294	1288.604523	18582.60452	23501.67898	66.11857556	30.37137934	0.361849256	63.54657897	0.129670382	0.45464575	0.175363585
2002	22083.00977	1645.441556	23728.45133	25807.26501	68.32231723	26.12283756	0.364152408	41.51241756	0.128120331	0.44947625	0.172605226
2003	27933.46309	2510.817171	30444.28026	29817.63698	70.49641709	24.33665269	0.299681324	49.09411774	0.101206766	0.506068	0.16274016
2004	29028.00126	2410.556223	31438.55748	33276.28362	71.24656482	21.42969914	0.297572016	66.1884998	0.106851385	0.58944025	0.16148755
2005	27869.35939	2110.338056	29979.69745	28939.09192	69.51687347	23.1827284	0.294498088	28.80987817	0.098117944	0.4796245	0.186368856
2006	27652.49326	892.2528058	28544.74607	23033.3898	71.85244824	26.04280759	0.269842612	22.37880621	0.098502532	0.35449125	0.191778272
2007	31213.04686	816.3189681	32029.36583	27767.92387	80.29959928	29.58225919	0.277874494	28.53882231	0.099546813	0.400837	0.1786927
2008	27052.92671	993.0674397	28045.99415	27373.53472	80.109602	35.90409659	0.275546586	45.646796	0.101023505	0.41759	0.180077999
2009	21835.08873	2077.856726	23912.94546	25431.54875	73.02813856	41.24468048	0.260583509	49.7944748	0.10301779	0.423781	0.183409132
2010	22214.8459	2671.610317	24886.45622	24085.11104	72.6900707	36.11241472	0.294393845	56.94415544	0.103441335	0.41952125	0.187320091
2011	24657.2995	1831.627297	26488.9268	24536.95375	81.57656452	34.05049014	0.323667132	33.19657542	0.101081376	0.36936375	0.182382271
2012	28188.30083	2330.437647	30518.73848	31131.27928	92.51961589	35.83898336	0.324335034	44.8887716	0.099608765	0.40564225	0.189669966

Year	Lan	Dis	Cat	CatEst	Tsb	Ssb	SsbCv	Recr	RecrCv	Fbar	FbarCv
2013	30610.84745	1684.481731	32295.32918	28785.46007	91.61443067	36.5688335	0.299277014	38.1315977	0.102562815	0.36019425	0.211867005
2014	28474.47624	1858.624016	30333.10026	30929.33242	94.87847133	40.92842415	0.285977224	53.35373329	0.109293835	0.377076	0.201153086
2015	27858.77952	2324.197026	30182.97655	28853.43887	97.52928101	49.27661751	0.286483468	30.61038027	0.108640917	0.34837175	0.205932017
2016	29082.58175	3585.107215	32667.68897	29591.44361	101.7897246	47.62363197	0.305905434	26.30610651	0.118878912	0.3529085	0.225129975
2017	25633.57728	2174.834674	27808.41195	30014.90288	103.8070334	52.78169262	0.311511736	39.68414971	0.135705569	0.352439	0.224286241
2018	22344.81308	1249.805086	23594.61817	24171.97922	102.9236713	54.93541689	0.331511732	51.60750062	0.151217913	0.28936325	0.24364582
2019	21266.21357	1443.739683	22709.95325	21574.07403	104.639306	60.87096918	0.322087703	43.83299352	0.198421074	0.24074825	0.258813556
2020	20155.77051	1334.996028	21490.76654	22722.87941	115.2108823	59.80658679	0.330450181	48.51938613	0.294110797	0.23311875	0.256224286

*** Discards before 2003 were estimated from the proportion of the catch that was discarded over the period 2003–2020.**

Table 3.2.3. ***Lophius piscatorius*** **in 27.78abd. Catch options: Catch, landings and discards in 2021 (tonnes). F of the catch, landings and discards (tonnes) in 2021, SSB in 2023 (kilotonnes). dSSB, dLand and dCatch are the change in SSB, landings and catch with the previous year (%).**

Basis21	Catch21	Land21	Dis	FCatch21	FLand21	FDis21	SSB22	dSSB	dLand	dCatch	dadv21
FMSY	34275	32953	1322	0.28000	0.27972	0.00028	82203	15.82	52.79	50.40	-0.88
FMSYlower	23162	22277	885	0.18100	0.18082	0.00018	89903	26.67	3.29	1.64	-33.02
FMSYupper	45491	43720	1771	0.39000	0.38961	0.00039	74500	4.97	102.72	99.62	31.56
F = Fsq	31499	30287	1212	0.25441	0.25416	0.00026	84120	18.53	40.43	38.23	-8.91
F = 0	0	0	0	0.00000	NaN	NaN	106148	49.56	-100.00	-100.00	-100.00
F = 0.181	23162	22277	885	0.18100	0.18082	0.00018	89903	26.67	3.29	1.64	-33.02
F = 0.18	23045	22164	881	0.18000	0.17982	0.00018	89985	26.79	2.77	1.13	-33.36
F = 0.19	24215	23289	926	0.19000	0.18981	0.00019	89171	25.64	7.98	6.26	-29.97
F = 0.2	25375	24403	971	0.20000	0.19980	0.00020	88365	24.51	13.15	11.35	-26.62
F = 0.21	26524	25507	1016	0.21000	0.20979	0.00021	87567	23.38	18.27	16.39	-23.29
F = 0.22	27662	26601	1061	0.22000	0.21978	0.00022	86778	22.27	23.34	21.39	-20.00
F = 0.23	28790	27684	1105	0.23000	0.22977	0.00023	85996	21.17	28.36	26.33	-16.74
F = 0.24	29907	28758	1149	0.24000	0.23976	0.00024	85222	20.08	33.34	31.24	-13.51
F = 0.25	31014	29821	1193	0.25000	0.24975	0.00025	84456	19.00	38.27	36.10	-10.31
F = 0.26	32111	30875	1236	0.26000	0.25974	0.00026	83697	17.93	43.16	40.91	-7.14
F = 0.27	33198	31919	1279	0.27000	0.26973	0.00027	82947	16.87	48.00	45.68	-3.99
F = 0.28	34275	32953	1322	0.28000	0.27972	0.00028	82203	15.82	52.79	50.40	-0.88
F = 0.29	35342	33978	1364	0.29000	0.28971	0.00029	81467	14.79	57.55	55.09	2.21
F = 0.3	36399	34993	1406	0.30000	0.29970	0.00030	80739	13.76	62.25	59.72	5.26
F = 0.31	37447	35999	1448	0.31000	0.30969	0.00031	80018	12.75	66.92	64.32	8.29
F = 0.32	38485	36996	1489	0.32000	0.31968	0.00032	79304	11.74	71.54	68.88	11.30
F = 0.33	39513	37983	1530	0.33000	0.32967	0.00033	78597	10.74	76.12	73.39	14.27
F = 0.34	40532	38961	1571	0.34000	0.33966	0.00034	77897	9.76	80.65	77.86	17.22
F = 0.35	41542	39931	1611	0.35000	0.34965	0.00035	77204	8.78	85.15	82.29	20.14
F = 0.36	42543	40891	1652	0.36000	0.35964	0.00036	76518	7.81	89.60	86.68	23.03
F = 0.37	43535	41843	1692	0.37000	0.36963	0.00037	75839	6.86	94.01	91.03	25.90
F = 0.38	44517	42786	1731	0.38000	0.37962	0.00038	75166	5.91	98.39	95.34	28.74
F = 0.39	45491	43720	1771	0.39000	0.38961	0.00039	74500	4.97	102.72	99.62	31.56

3.3 Black-bellied anglerfish (*L. budegassa*) in Subarea 7 and divisions 8.a–b and 8.d

Type of assessment

Category 3 assessment using survey trends (ICES, 2012; ICES, 2021a).

Feedback from ADG, WC and audit

ADG: No specific issues raised that require further response.
WC: For mixed-species TAC the proportion of each species in the catches should be indicated in Table 3. Response WGBIE21: This proportion can be calculated from Table 3 but a sentence has been added to the "Issues relevant to the advice" section specifying the proportion of *L. budegassa* in the landings. No other issues were raised that require a further response.
EG Audit 2020: No specific issues raised.

3.3.1 Data

3.3.1.1 Catch numbers at length

No updated catch data were submitted for 2019.

The number of samples taken in 2020 was reduced for a number of strata due to the effects of COVID-19. WGBIE decided to retain data resulting from low sample numbers as none of the poorly sampled strata contributed more than 3% of the catch. The Stock Annex describes the methods for filling in unsampled landings and discards. Figure 3.3.1 shows that about 1/2 of the landings had length data associated with them while in most other years this figure is closer to 2/3. About half of the discards were unsampled and had to be estimated from the discard rate of the sampled catches. The discard rates of some of the fleets were very different from recently observed values (Figure 3.3.1a). WGBIE concluded that this was due to reduced sampling levels under COVID-19 conditions. Normally discard rates (proportion of the catchweight that was discarded) are used to fill in strata with missing discard data. This year, the discard rates of the French OTB_DEF fleet, the Irish OTB_DEF and OTB_CRU fleets and the UK TBB_DEF fleet were replaced with the average discard rates of those fleets from 2015–2019 (for the purpose of filling in unsampled discards only). Overall, discard rates are relatively low so this affects only a small proportion of the total catch weight.

Figures 3.3.2a shows the annual length–frequency distribution of the catch data both before and after allocating length data to unsampled catches. Figure 3.3.2b shows the quarterly length–frequency distributions and shows that there is limited cohort tracking in the length data.

Figure 3.3.3 shows the length distribution of the catches in terms of abundance and biomass. Catch numbers are generally highest at size classes 10–20 cm. The highest biomass in the catches is around 50–60 cm. Note that the females mature around 65 cm.

3.3.1.2 Discards

Discarding occurs nearly exclusively in the smaller length classes (Figure 3.3.2a). In the last three years, the average discard rate was 9% (in weight).

3.3.1.3 Surveys

The surveys are described in detail in the Stock Annex and section 2 of the report.

The combined IE-IGFS (IGFS-WIBTS-Q4, G7212) and FR-EVHOE (EVHOE-WIBTS-Q4, G9527) survey biomass index is used as the basis of the advice.

Figure 3.3.4a shows the spatial distribution of the catches of recruits on the FR_IE_IBTS surveys, combined Irish IBTS Q4 groundfish survey (IGFS-WIBTS-Q4, G7212) and French EVHOE-WIBTS-Q4 (G9527) survey. Recruitment generally occurs in the western Celtic Sea and in some years in Biscay. In 2020 there were widespread large numbers of recruits in the Biscay area. Figure 3.3.4b shows the spatial distribution of the catch weights on the two IBTS surveys. During some years, the catches are highest in the area covered by the IGFS-WIBTS-Q4 (G7212) survey, in other years the EVHOE-WIBTS-Q4 (G9527) survey has higher catches. It is unclear whether this is due to the movement of the stock or whether it is due to factors affecting the catchability on the surveys (e.g. weather, gear performance).

Figure 3.3.5a shows the biomass and recruitment indices of the two surveys as well as the combined index. The combined survey biomass index is more stable than the single survey indices but the uncertainty around the index is still considerable. Both surveys recorded high biomass in the last 3 years. Both surveys agree on a very strong 2013 recruitment. However, this cohort was not obvious in the length distributions of the following years in the surveys or catches. In 2020, recruitment in the EVHOE-WIBTS-Q4 (G9527) survey area was the highest on record; the IGFS-WIBTS-Q4 (G7212) survey also saw reasonably high recruitment but on a much smaller scale than the EVHOE-WIBTS-Q4 (G9527) survey.

In 2017, the French survey vessel Thalassa suffered major mechanical issues and the majority of the EVHOE bottom trawl survey could not be completed. The VAST (Vector Autoregressive Spatio-Temporal; Thorson 2019) model (www.github.com/james-thorson/VAST) was used to estimate the missing 2017 data. VAST is a spatially explicit model that predicts population density for all locations within a spatial domain, and then predicts derived quantities (e.g. biomass, abundance) by aggregating population density across the spatial domain while weighting density estimates by the area associated with each estimate. VAST imputes biomass or abundance in unsampled areas using spatially correlated random effects. Details are provided in Working Document (WD) 01 (Gerritsen and Minto, 2019) to WGBIE 2019 (ICES, 2019).

3.3.1.4 Advice rule

Table 3.3.1 provides the index values. The 3-over-2 ratio (mean biomass index in the most recent 2 years and the preceding 3 years) is 1.36. This will result in a 20% increase in advice after applying the uncertainty cap. The precautionary buffer was applied in 2018 and therefore does not have to be considered again this year.

3.3.2 Deviations from the Stock Annex

There were two deviations from the Stock Annex:

- The 2017 survey SSB index value was modelled using a spatio-temporal model to account for a large gap in survey coverage. This approach was accepted by WGBIE (ICES, 2019) and ACOM in 2019.
- The discard rates of some of the fleets were very different from recently observed values and these were replaced with the average values from 2015–2019.

3.3.3 Biological reference points

3.3.3.1 Length-based indicators

Length-based indicators were explored for this stock. Most of the indicators were well below the reference level set out by WKLIFE V (ICES, 2015). However, recent work Kell *et al.* (in prep) testing these indicators using Management Strategy Evaluations, has indicated that the reference levels need to be tuned to the life-history characteristics of the stock in order to be robust.

However, Kell *et al*. (in prep) found that trends in many length-based indicators can accurately describe trends in exploitation and stock development. Therefore, the length-based indicators are presented as trends in Figure 3.3.6. Most of the indicators show increasing trends in recent years. The exceptions are the indicators relating to immature fish; it is likely that these are driven by variation in recruitment, rather than describing actual changes in the stock structure. The overall conclusion is that there are relatively more large fish in the recent catches, which suggest that fishing mortality is decreasing.

3.3.3.2 F/F_{MSY} proxy

The mean-length Z method was applied to the catch data for the period 2003–2020 with the following life-history parameters:

Parameter	Value
L_{inf}	175
K	0.078
T_0	0
M	0.3
a	0.0195
b	2.93
maxage	10
L_c	36

F_{01} = 0.23 was estimated in an equilibrium yield-per-recruit analysis, using the parameters listed above (Figure 3.3.7).

The Mean Length Z analysis was then performed using the mlen_effort() function in the code from https://github.com/ices-tools-dev/ICES_MSY. A proxy of fishing effort was obtained by dividing the commercial catches of *L. budegassa* by the biomass index of the survey. WGBIE considered this to be an appropriate proxy for fishing effort. Figure 3.3.8 shows the outputs of the mean-length Z analysis. The trend in F is declining and F < F_{MSY} proxy in recent years. A number of sensitivity runs were performed with high and slow growth, estimated (rather than fixed) M and L_c = 16 and L_c = 25. Each of these runs resulted in $F<F_{0.1}$ in the last few years.

3.3.4 Quality of the assessment

Due to reductions in sampling levels, the precision of the catch length data are assumed to be reduced somewhat. Catch data are not used directly in providing the catch advice (this is based on survey data). However, the catch length data are used in the Mean Length Z method to estimate the stock status relative to the F_{MSY} proxy reference point. The 2020 estimate of F/F_{MSY} proxy is very close to the estimates of the previous two years so there is no particular concern regarding the quality of the 2020 catch length data.
The combined IE-IGFS (IGFS-WIBTS-Q4, G7212) and FR-EVHOE (EVHOE-WIBTS-Q4, G9527) surveys cover a large part of the stock distribution and most of the depth range of the stock (< 500 m). However, the catch rates are low, leading to some uncertainty around the index. These two surveys sometimes display conflicting signals and the combined index is expected to provide a more robust basis for the advice than the individual indices.

3.3.4.1 Other indicators

There are a number of other indicators of stock size:

- The Irish Anglerfish and Megrim Survey (IE-IAMS, G3098) covers the majority of the stock area in Subarea 27.7. Figure 3.3.9 indicates a large increase in biomass between 2006–2007 and 2016 but since then the biomass in the survey area appears to have decreased somewhat or possibly stabilized but there does not appear to be an increase in recent years. It should be noted that the IE-IGFS (IGFS-WIBTS-Q4, G7212) survey (which has similar spatial coverage) shows a similar pattern, so this may indicate that the biomass of the stock in the Biscay area is increasing while the biomass in the Celtic Sea is stagnating or decreasing.
- The two species of anglerfish largely overlap in distribution and are often caught together. The assessment for white anglerfish in 27.78abd indicates a reduction in effort and increase in SSB in the last 15 years. The proportion of the two species in the catches has remained relatively constant (Figure 3.1.2) this suggests that the black anglerfish stock in 27.78abd has followed a similar development over time.

Overall, nearly all indicators suggest that the stock size is at a high level. However, there are some indications that the stock size is no longer increasing in Subarea 27.7.

3.3.5 Management considerations

Management of the two anglerfish species under a combined TAC prevents effective control of the single-species exploitation rates and could lead to overexploitation of either species. However, currently, the stock size of both species is increasing and neither species appears to be at risk of overexploitation.

3.3.6 Recommendations for the next benchmark

The last benchmark, WKANGLER (ICES, 2018) could not agree on an analytical assessment for this stock. The stock was included in the Workshop on Tools and Development of Stock Assessment Models using a4a and Stock Synthesis (WKTaDSA; ICES, 2021b) with the purpose of developing a base case Stock Synthesis (SS; Methot and Wetzel, 2013) model to bring to the next benchmark which is planned for 2021–2022. The progress that was made during and after WKTaDSA (ICES, 2021b) was presented to WGBIE. The working group agreed that the current SS model has been developed to a stage where it is close to a base case to present to the benchmark workshop.

Roadmap of work in preparation for the next benchmark

- April 2021: ACOM agreed to include this stock in the benchmark process for 2021–2022.
- 2021: Further model development: Further model settings will be explored over the coming months (e.g. split the model into two areas (27.7 and 27.8abd); try to apply sex-specific growth (based on survey data).
- Late 2021: Data compilation: WKANGLER (2018a) compiled and formatted available data; it is unlikely that any new catch data will be available. Some progress may be made in developing improved estimation methods for the survey data (e.g. applying spatial-temporal models; sex separated indices)
- Early 2022: Benchmark workshop

Benchmark scoring

1. The assessment is judged to have high potential to be upgraded to cat1 (SS model in development; see roadmap below) (score: 4)

2. New methods will be available: SS model developed at WKTaDSA (score: 4)
3. Catch advice is requested by EC
   a) The stock managed under the multi-annual plan for Western Waters (WWMAP; EU, 2019)
   b) Most catches of anglerfish originate in directed fisheries
   c) The stock is not included in the mixed fisheries analysis for the Celtic Sea (score: 5)
4. The biomass is perceived to be near the highest on record (score: 1)
5. The stock was last benchmarked in 2018 in WKANGLER (ICES, 2018) (score: 2)

3.3.7 References

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Methot Jr., R.D., Wetzel, C. 2013. Stock synthesis: A biological and statistical framework for fish stock assessment and fishery management. Fisheries Research, 142: 86–99.

Thorson, J.T. 2019. Guidance for decisions using the Vector Autoregressive Spatio-Temporal (VAST) package in stock, ecosystem, habitat and climate assessments. Fisheries Research, 210, 143–161. doi:10.1016/j.fishres.2018.10.013.

3.3.8 Figures and tables

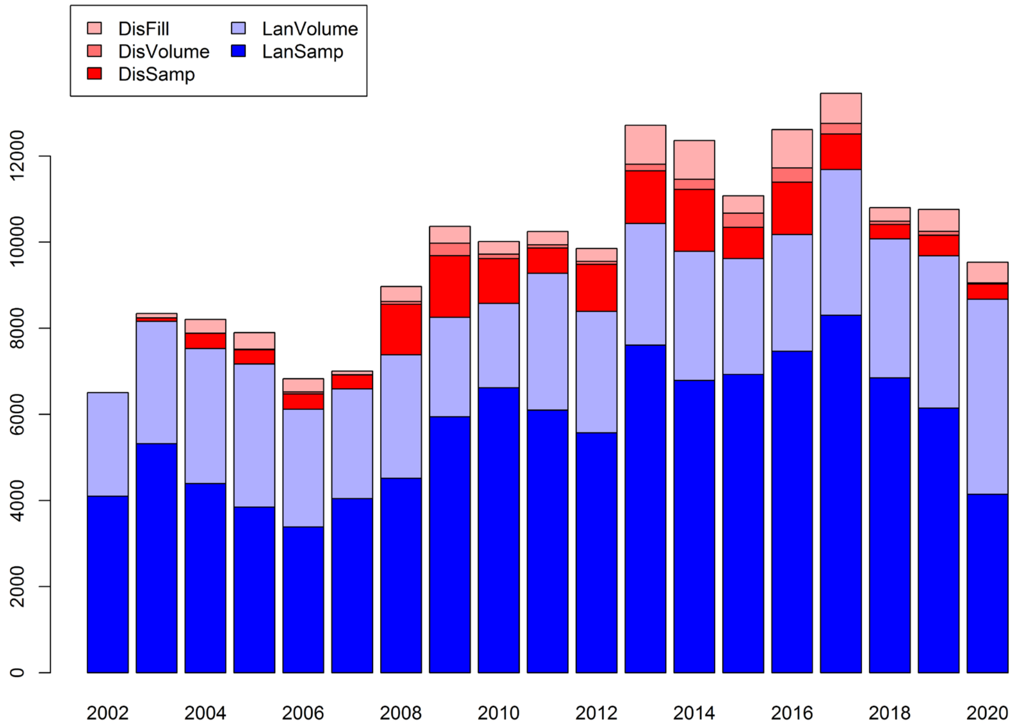

Figure 3.3.1. *Lophius budegassa* in 27.78abd. Allocations of unsampled landings and discards by year. Dark blue represents the sampled landings; light blue represents landings for which only the tonnage was available but no length data; Red represents the fully sampled discards (tonnage and length data); medium pink represents discards for which an estimate of the tonnage was available but no length data (length data 'borrowed' from other strata) and light pink represents strata for which no discard tonnage or length data were available (discard rate and length data 'borrowed' from other strata.

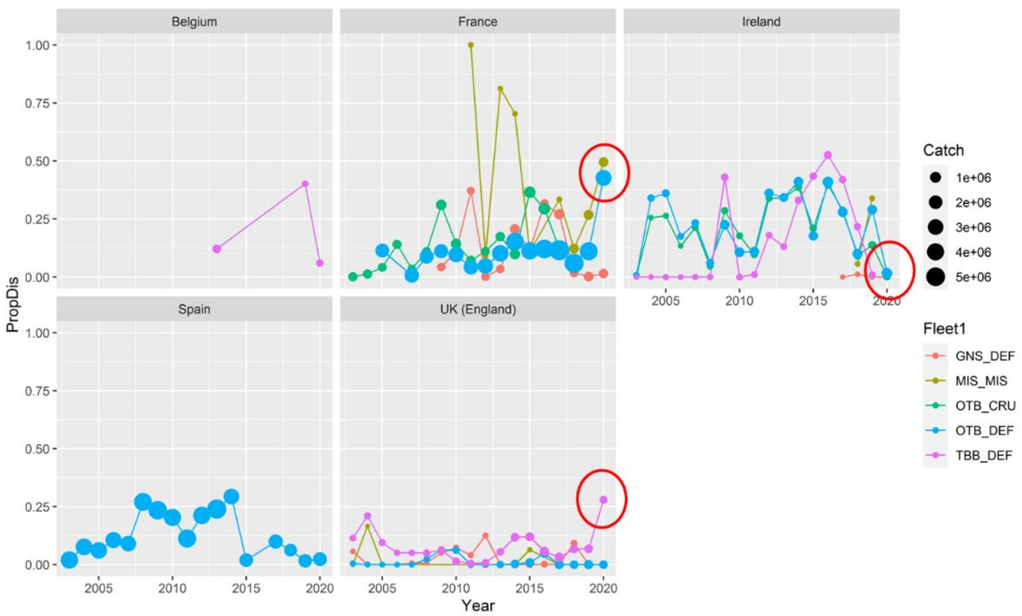

Figure 3.3.1a. *Lophius budegassa* in 27.78abd. Unsampled discards (i.e. métiers with landings without discard data) were filled in using available discard rates following the procedure described in the Stock Annex. However, the French OTB_DEF, UK TBB_DEF and Irish OTB_DEF and OTB_CRU proportions were very different from recently observed values and were replaced with the average values from 2015–2019.

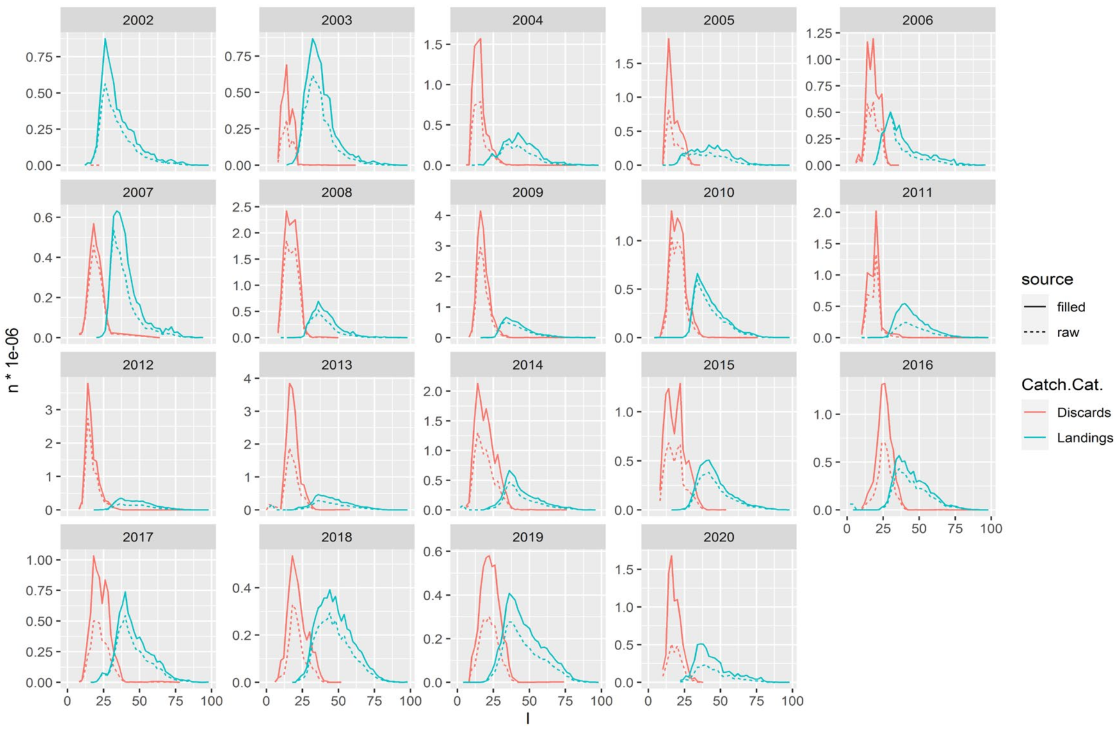

Figure 3.3.2a. ***Lophius budegassa*** **in 27.78abd. Annual length–frequency distributions of the landings (blue) and discards (red). The dotted lines show the sampled strata submitted to InterCatch; the solid lines are the estimates after allocations of unsampled catches. No discard data were available prior to 2003.**

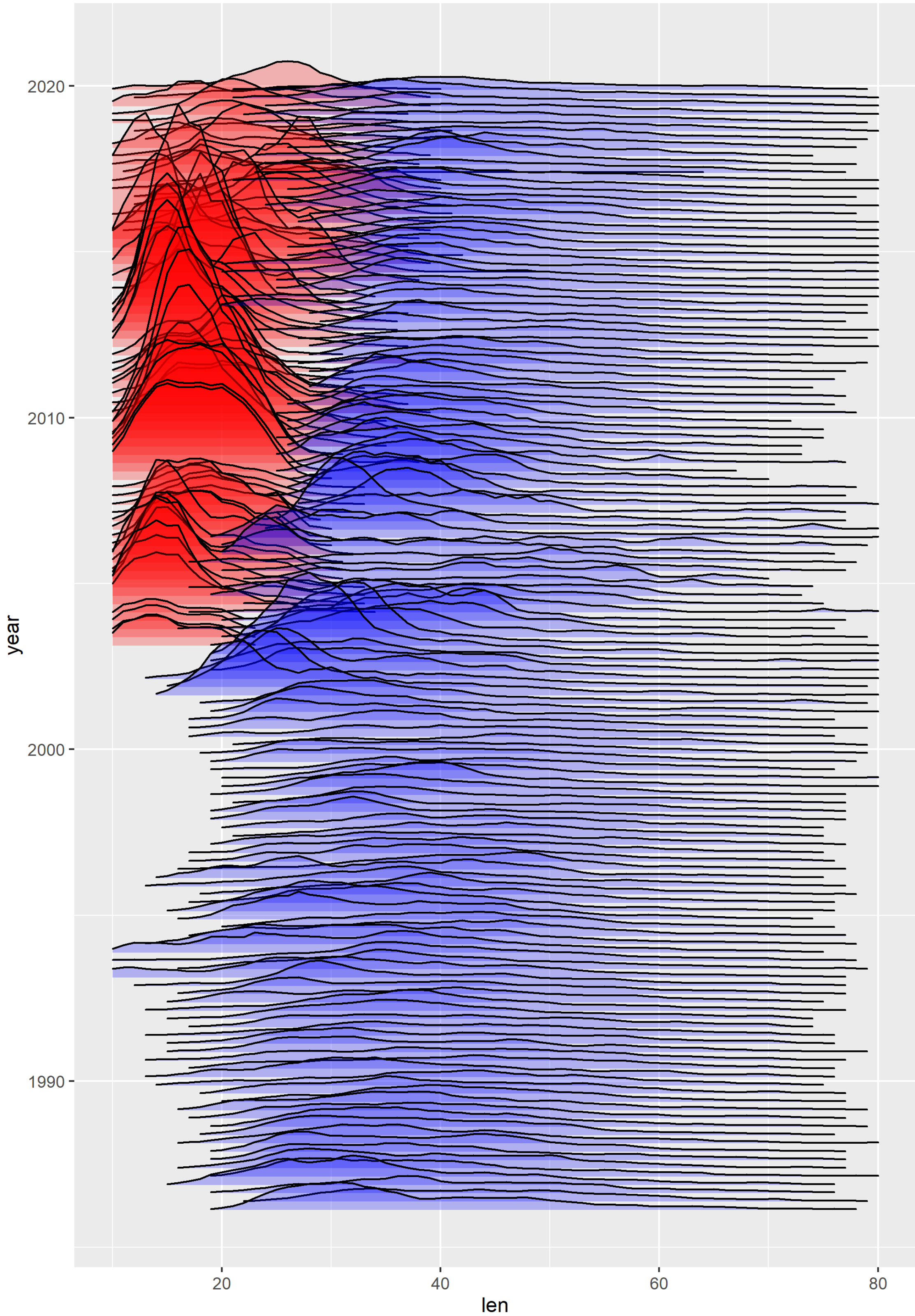

Figure 3.3.2b. ***Lophius budegassa*** **in 27.78abd. Quarterly raised length–frequency distributions of the landings (blue) and discards (red). No discard data were available prior to 2003.**

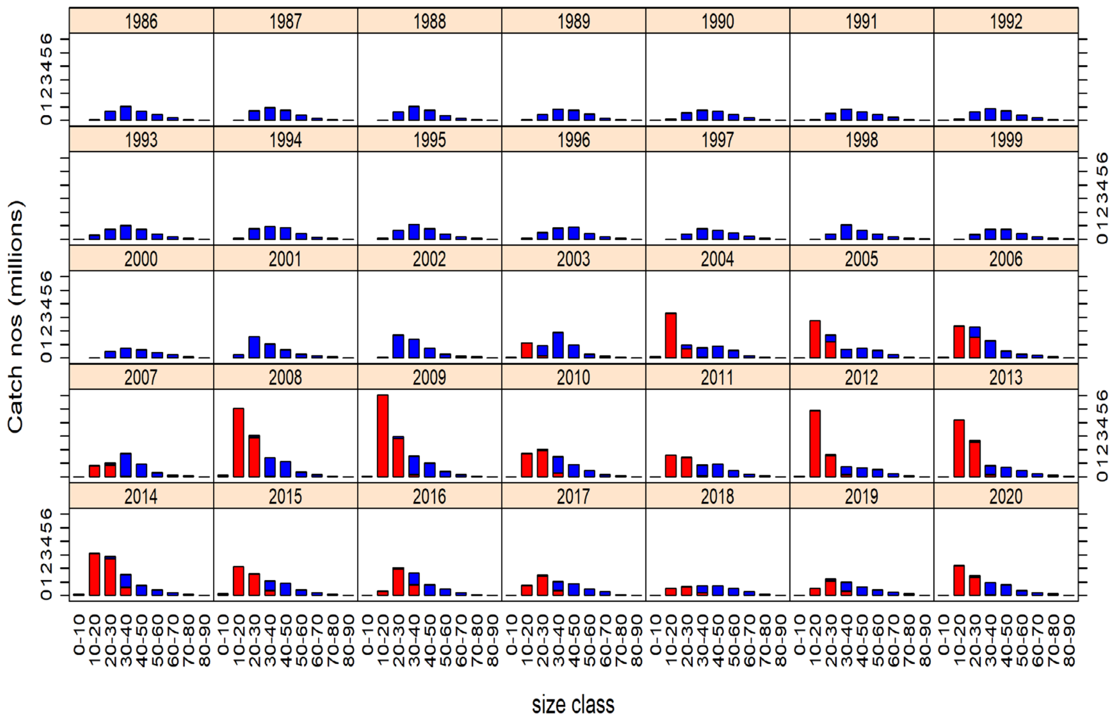

Figure 3.3.3a. ***Lophius budegassa*** **in 27.78abd. Length distributions of the catches (landings – blue, discards – red) by year in terms of abundance.**

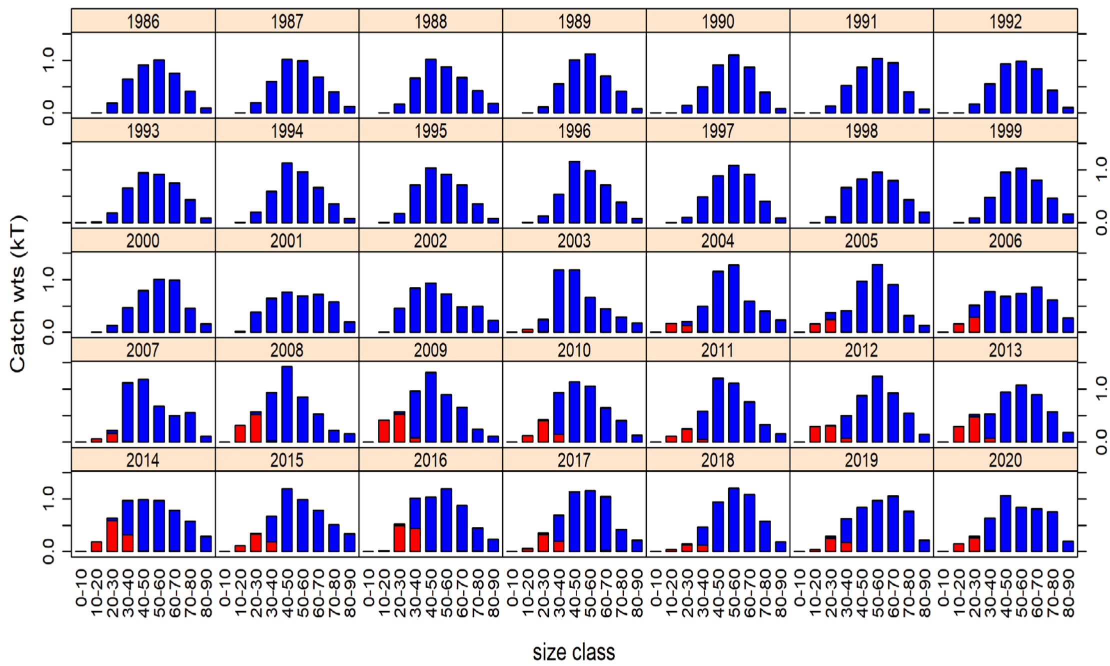

Figure 3.3.3b. ***Lophius budegassa*** **in 27.78abd. Length distributions of the catches (landings – blue, discards – red) by year in terms of biomass.**

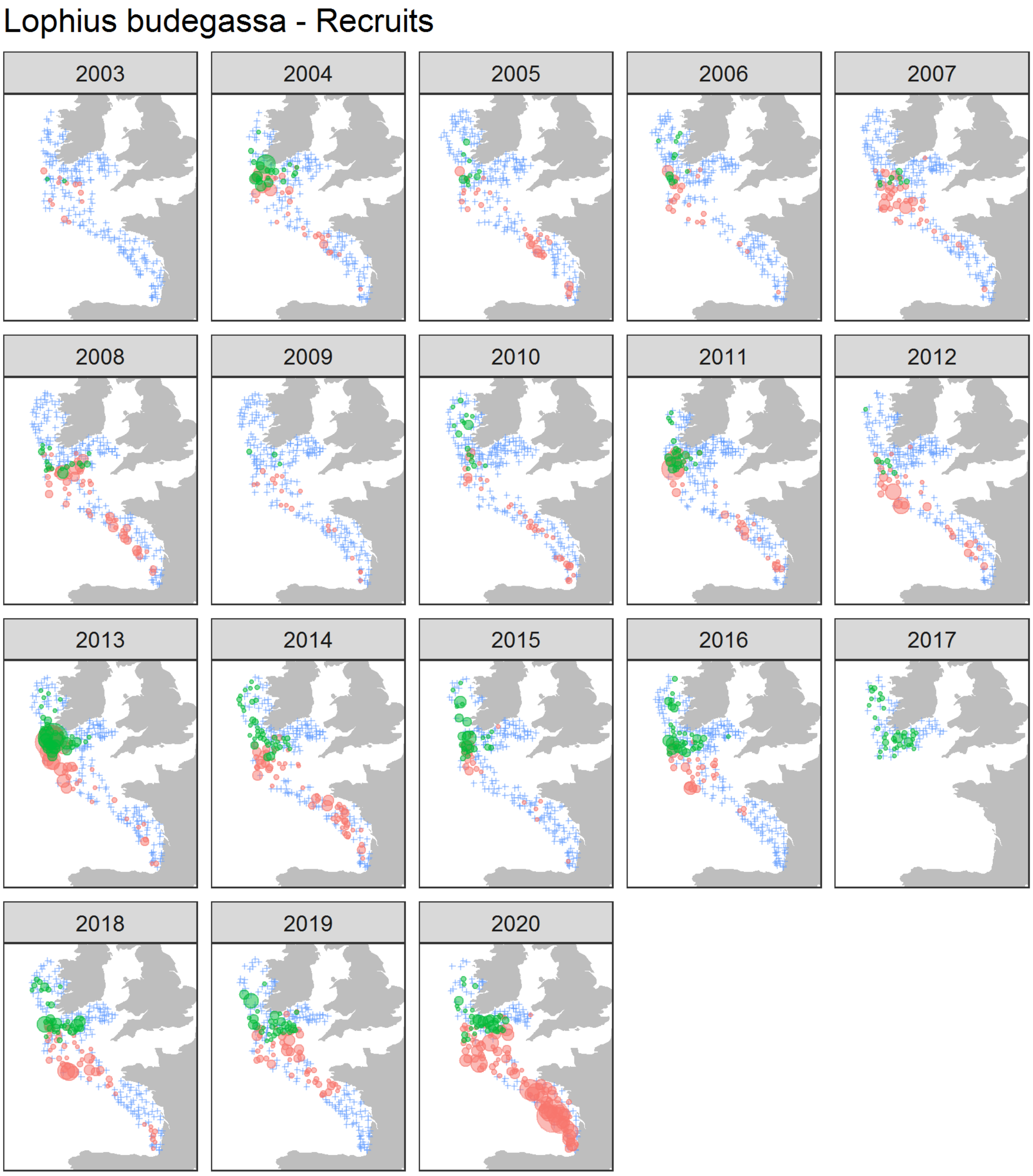

Figure 3.3.4a. *Lophius budegassa* in 27.78abd. Abundance of recruits on the IGFS-WIBTS-Q4 (G7212 in green) and EVHOE-WIBTS-Q4 (G9527 in red) surveys.

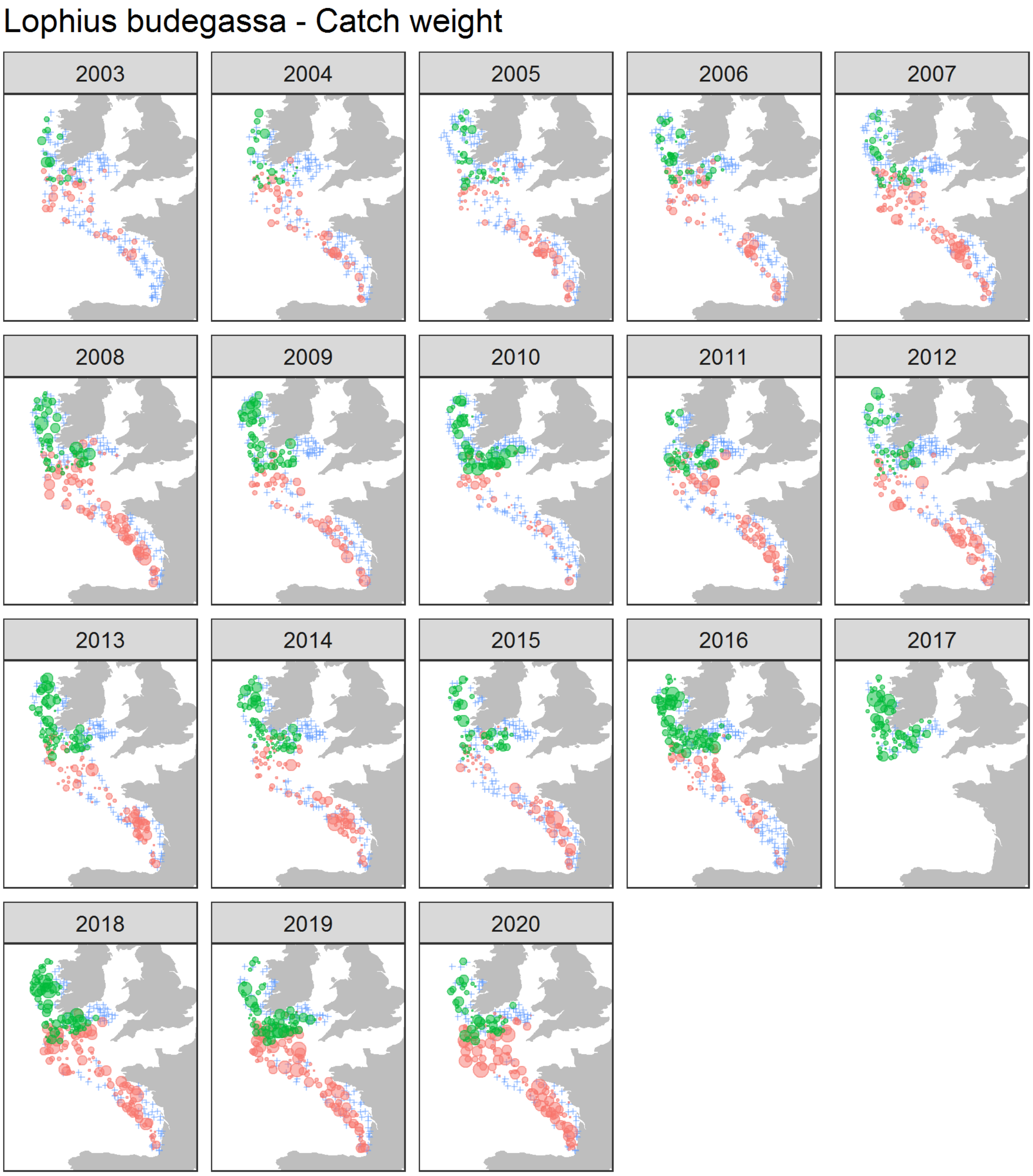

Figure 3.3.4b. ***Lophius budegassa*** **in 27.78abd. Catch weights on the IGFS-WIBTS-Q4 (G7212 in green) and EVHOE-WIBTS-Q4 (G9527 in red) surveys.**

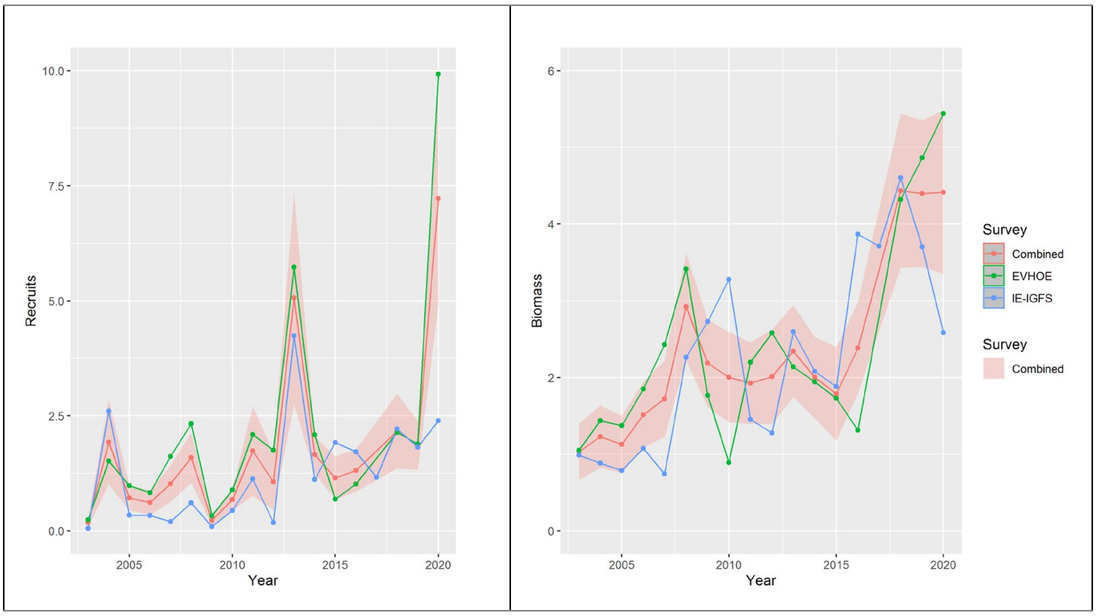

Figure 3.3.5a. ***Lophius budegassa*** **in 27.78abd. Survey trends in terms of biomass (left) and recruits (< 16 cm; right). The EVHOE-WIBTS-Q4 (G9527) index is shown in green, IGFS-WIBTS-Q4 (G7212) in blue and the combined FR_IE_IBTS survey index in red, all with 95% confidence intervals.**

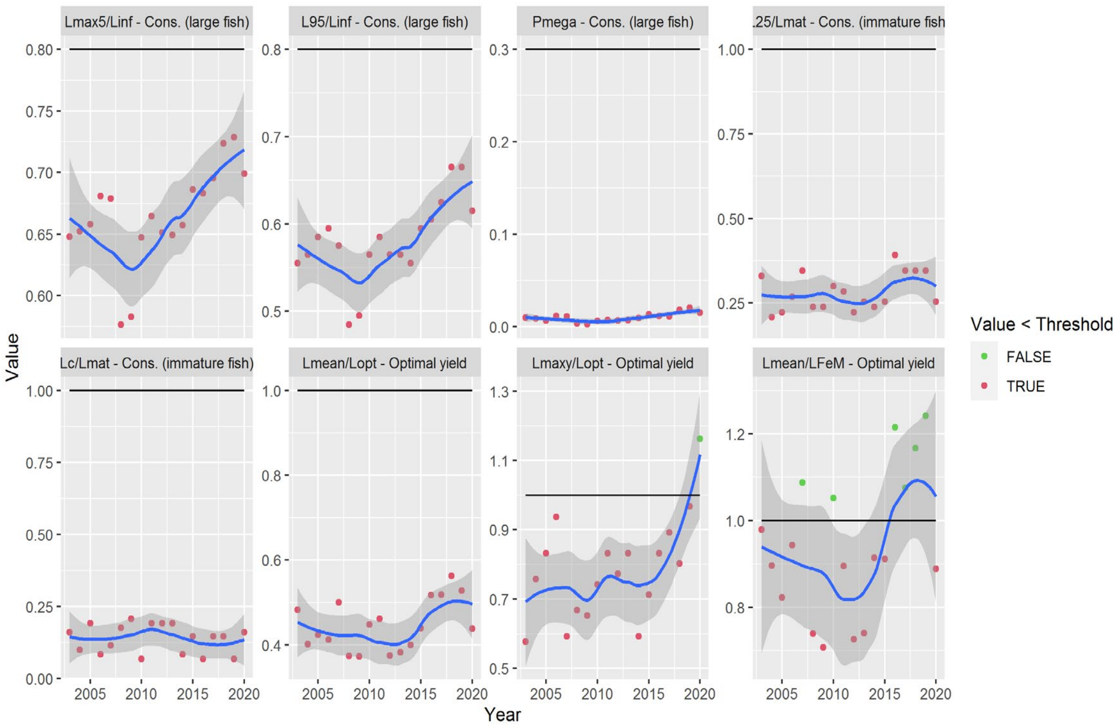

Figure 3.3.6. ***Lophius budegassa*** **in 27.78abd. Length-based indicators. Length-based indicators are presented for information only as WGBIE does not consider them appropriate to determining reference points. The horizontal black line indicates the reference value or threshold. Although most indicators are below the threshold, they are all showing positive trends.**

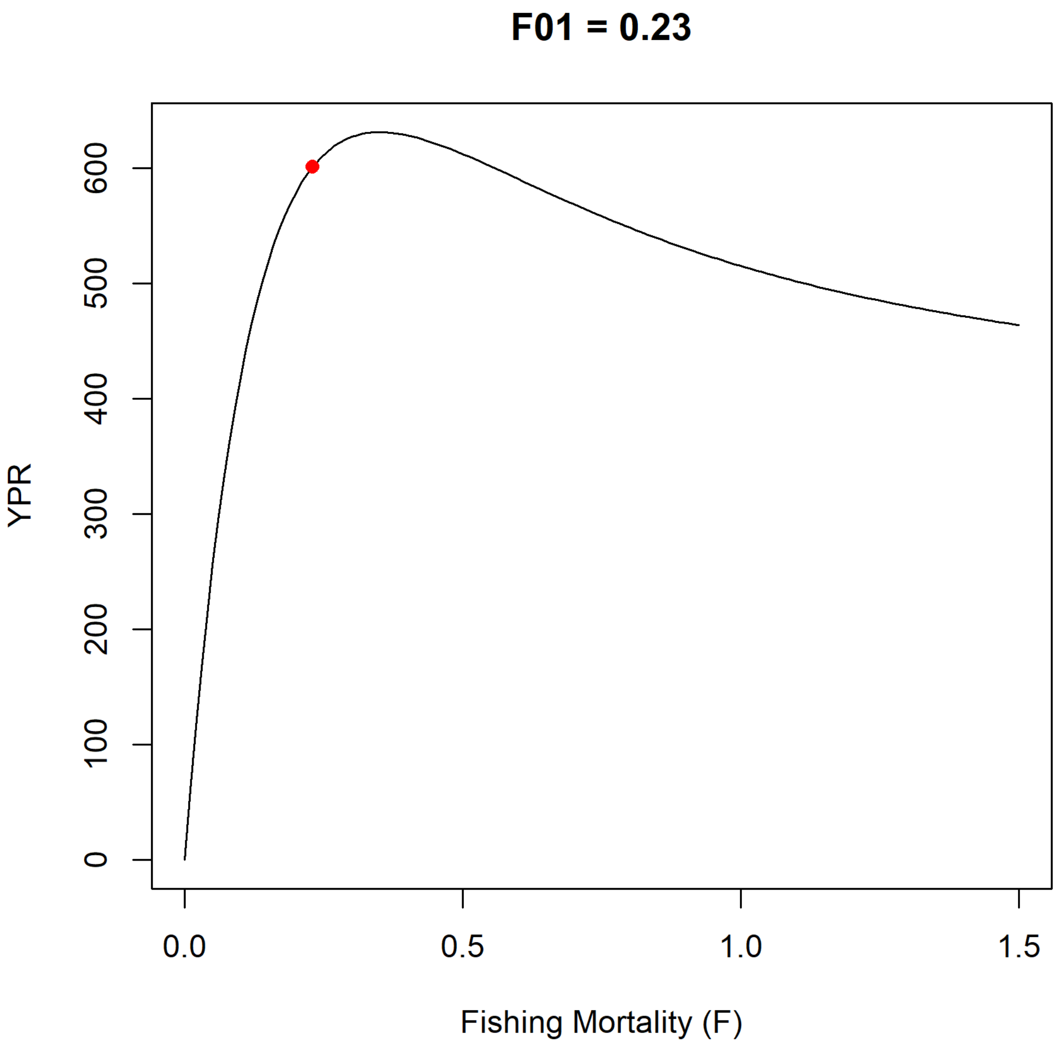

Figure 3.3.7. ***Lophius budegassa*** **in 27.78abd. YPR curve. F_{01}.**

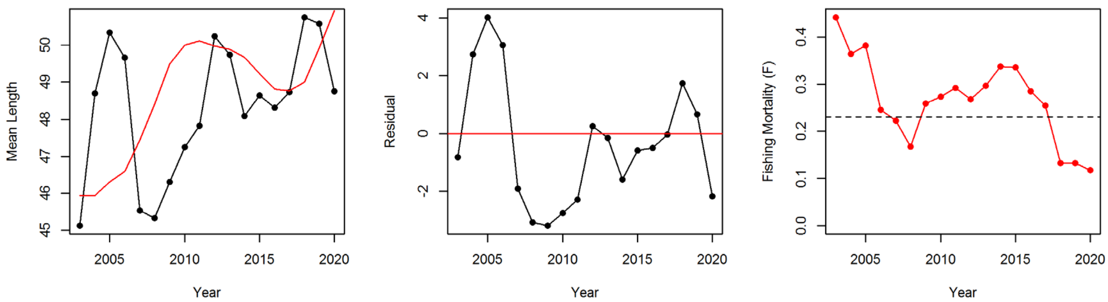

Figure 3.3.8. ***Lophius budegassa*** **in 27.78abd. Length-based Z (with effort) estimate of F (right), the dashed line is F_{01}. The trend in fishing effort is based on the commercial catch of** ***L. budegassa*****, divided by the survey index of biomass.**

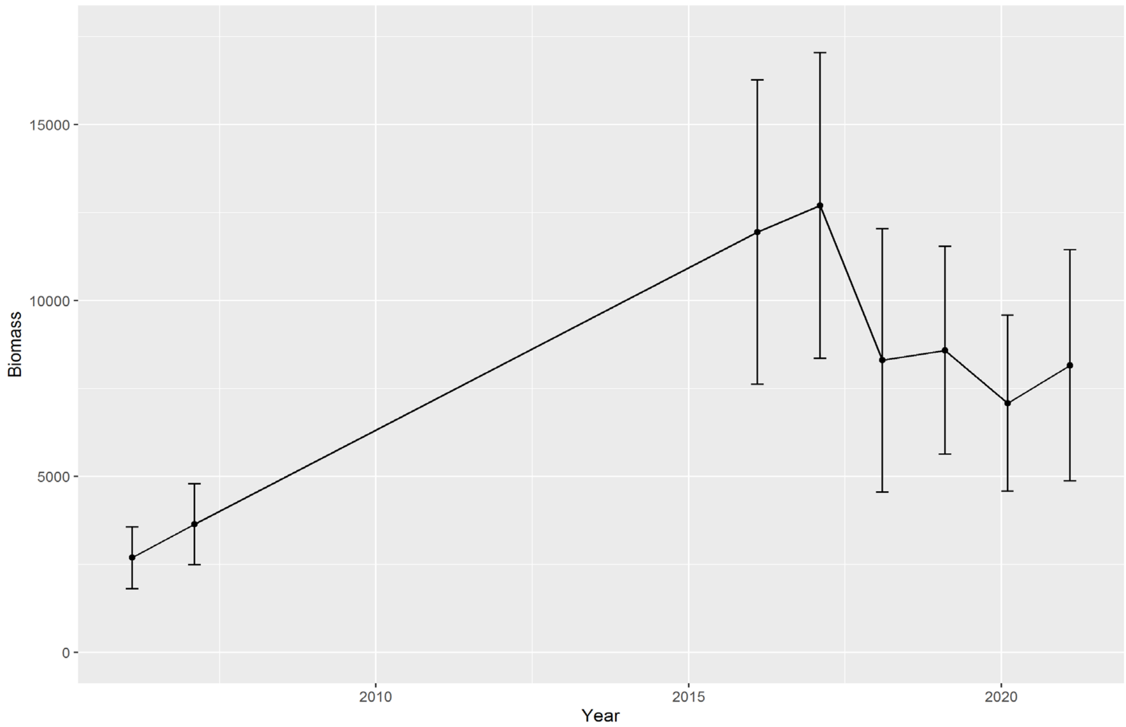

Figure 3.3.9. ***Lophius budegassa*** **in 27.78abd. IE-IAMS (G3098) survey biomass index (not used for the advice).**

Table 3.3.1. ***Lophius budegassa*** **in 27.78abd. Biomass and recruitment index for the individual surveys (EVHOE-WIBTS-Q4, G9527 and IGFS-WIBTS-Q4, G7212) and combined FR_IE_IBTS survey. Estimated values (Est) and 95% confidence limits (CiLo and CiHi). The average of the last 2 years and the preceding 3 years and its ratio are given at the bottom of the table. This is the basis for the catch advice.**

Year	Recruitment (nos < 16 cm / hr)			Biomass (kg / hr)			F/F_{MSY}
	Est	CiLo	CiHi	Est	CiLo	CiHi	
2003	0.18	0.07	0.29	1.03	0.66	1.40	1.92
2004	1.93	1.01	2.85	1.23	0.82	1.63	1.58
2005	0.72	0.44	0.99	1.13	0.76	1.50	1.66
2006	0.62	0.35	0.89	1.51	1.09	1.94	1.07
2007	1.02	0.63	1.42	1.72	1.22	2.22	0.97
2008	1.59	1.04	2.13	2.92	2.22	3.62	0.73
2009	0.22	0.13	0.32	2.19	1.62	2.76	1.13
2010	0.68	0.45	0.92	2.00	1.42	2.59	1.19
2011	1.74	0.76	2.72	1.93	1.39	2.46	1.27
2012	1.07	0.45	1.68	2.01	1.39	2.63	1.17
2013	5.06	2.75	7.37	2.34	1.75	2.94	1.29
2014	1.66	1.25	2.07	2.00	1.47	2.53	1.47
2015	1.16	0.69	1.64	1.80	1.19	2.42	1.46
2016	1.33	0.86	1.80	2.42	1.82	3.02	1.24
2017	0.84	0.60	1.17	2.88	2.19	3.78	1.11
2018	2.17	1.36	2.98	4.44	3.43	5.44	0.58
2019	1.87	1.33	2.41	4.43	3.47	5.40	0.57
2020	7.22	4.91	9.53	4.42	3.35	5.49	0.51
2019–2020			**Average A**	4.43			
2016–2018			**Average B**	3.24			
			Ratio A/B	1.36			

4 White anglerfish and black-bellied anglerfish in divisions 8.c and 9.a

Lophius piscatorius – mon.27.8c9a (Cantabrian Sea, Atlantic Iberian waters)

Lophius budegassa – ank.27.8c9a (Cantabrian Sea, Atlantic Iberian waters)

Type of assessment in 2021

Update assessment for L. piscatorius and benchmark assessment for *L. budegassa*.

Software used

Stock Synthesis (SS) for L. piscatorius and SPiCT for *L. budegassa*.

Data revisions this year

No data revisions.

4.1 General

Two species of anglerfish, *Lophius piscatorius* and *L. budegassa*, are found in ICES divisions 8.c and 9.a. Both species are caught in mixed bottom-trawl fisheries and in artisanal fisheries using mainly fixed nets.

The two species are not usually landed separately for the majority of the commercial categories and they are recorded together in the ports' statistics. Therefore, estimates of each species in Spanish landings from divisions 8.c and 9.a and Portuguese landings of Division 9.a are derived from their relative proportions in market samples.

The total anglerfish landings are given in Table 4.1.1 by ICES division, country and fishing gear. Landings increased in the early eighties reaching a maximum level in 1986 (9433 t) and 1988 (10 021 t), and decreased after that to a minimum of 1801 t in 2001. In 2002–2005 period landings increased reaching 4757 t. This period was followed by another one where landings gradually declined and in 2011 landings were less than half of the 2005 amount (2179 t). From 2011 to 2014, landings slightly increased to 3030 t. Annual values then progressively decreased again in the next 6 years to 1515 t in 2020, the lowest value recorded of the stocks' historical time-series.

The species proportion in the landings has changed since 1986. At the beginning of the time-series (1980–1986), *L. piscatorius* represented more than 70% of the total anglerfish landings. After 1986, the proportion of *L. piscatorius* decreased in the annual landings but in 1999–2002 both species showed approximately the same weight. In 2003, the proportion of *L. piscatorius* started to increase again, with a mean proportion of 60% in total landings from 2010 to 2020.

ICES performs assessments for each species separately. The latest benchmark assessment for *L. piscatorius* in Division 8.c and 9.a was carried out in 2018 (ICES, 2018) when new settings and data were incorporated to the existing Stock Synthesis (SS) model (Methot Jr. and Wetzel, 2013). A benchmark assessment using SPiCT (Pedersen and Berg, 2017) for *L. budegassa* was conducted during WKMSYSPiCT (ICES, 2021). The time-series of available cpue data were revised and several tests were conducted.

The ageing estimation problems detected during the previous benchmark (see WKFLAT report; ICES, 2012) continued unsolved for *L. piscatorius* (ICES, 2018) and no new studies were carried out for *L. budegassa*. The growth pattern inferred from mark-recapture and length composition data analyses (Landa *et al*., 2008) was used in the assessment of *L. piscatorius*.

4.1.1 References

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Methot Jr., R.D and Wetzel, C.C. 2013. Stock synthesis: A biological and statistical framework for fish stock assessment and fishery management. Fisheries Research, 142: 86–99.

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4.2 Summary of ICES advice for 2021 and management for 2020 and 2021

4.2.1 ICES advice for 2021

ICES gave a separate advice for each of these species in 2020 for 2021. For *L. piscatorius* ICES advises that when the EU multiannual plan (MAP) for Western waters and adjacent waters (EU, 2019) is applied, catches in 2021 that correspond to the F ranges are between 1295 t and 2472 t. Catches higher than those corresponding to F_{MSY} (1872 t) can only be taken under conditions specified in the MAP. For *L. budegassa,* ICES advises that when the precautionary approach is applied, catches in 2021 should be no more than 1800 t.

4.2.2 Management applicable for 2020 and 2021

The two species are managed under a common TAC that was set at 4023 t for 2020 and 3672 t for 2021. The reported landings in 2020 were 38% of the established TAC.

There is no minimum landing size for anglerfish. However, the Council Regulation laying down common marketing standards for certain fishery products (EU, 1996), fixes a minimum weight of 500 g for anglerfish. In Spain, this minimum weight was implemented in the year 2000.

4.2.3 Management considerations

Lophius piscatorius and *L. budegassa* are subject to a common TAC. Both species of anglerfish are reported together because of their similarity but they are assessed and their advice is provided separately.

It should be noted that both anglerfish are essentially caught in mixed fisheries. Hence, management measures applied to these species may have implications for other stocks and vice versa. Although these stocks are assessed separately, they are managed together. Due to the differences in the current status of the individual stocks the advice is given separately.

Table 4.1.1 ANGLERFISH (*L. piscatorius and L. budegassa*) - Divisions 8c and 9a.
Tonnes landed by the main fishing fleets for 1978-2020 as determined by the Working Group.

	Div. 8c						Div. 9a						Div. 8c+9a		Div. 8c+9a
	SPAIN			FRANCE			SPAIN			PORTUGAL					
Year	Trawl	Gillnet	Others	Trawl	Gillnet	TOTAL	Trawl	Gillnet	Others	Trawl	Artisanal	TOTAL	SUBTOTA	Unallocated/ Non-reported	TOTAL
1978	n/a	n/a				n/a	506			n/a	222	728	728		
1979	n/a	n/a				n/a	625			n/a	435	1 060	1 060		
1980	4 008	1 477				5 485	786			n/a	654	1 440	6 926		6926
1981	3 909	2 240				6 149	1 040			n/a	679	1 719	7 867		7867
1982	2 742	3 095				5 837	1 716			n/a	598	2 314	8 151		8151
1983	4 269	1 911				6 180	1 426			n/a	888	2 314	8 494		8494
1984	3 600	1 866				5 466	1 136			409	950	2 495	7 961		7961
1985	2 679	2 495				5 174	977			466	1 355	2 798	7 972		7972
1986	3 052	3 209				6 261	1 049			367	1 757	3 172	9 433		9433
1987	3 174	2 571				5 745	1 133			426	1 668	3 227	8 973		8973
1988	3 583	3 263				6 846	1 254			344	1 577	3 175	10 021		10021
1989	2 291	2 498				4 789	1 111			531	1 142	2 785	7 574		7574
1990	1 930	1 127				3 057	1 124			713	1 231	3 068	6 124		6124
1991	1 993	854				2 847	878			533	1 545	2 956	5 802		5802
1992	1 668	1 068				2 736	786			363	1 610	2 758	5 493		5493
1993	1 360	959				2 319	699			306	1 231	2 237	4 556		4556
1994	1 232	1 028				2 260	629			149	549	1 327	3 587		3587
1995	1 755	677				2 432	814			134	297	1 245	3 677		3677
1996	2 146	850				2 995	749			265	574	1 589	4 584		4584
1997	2 249	1 389				3 638	838			191	860	1 889	5 527		5527
1998	1 660	1 507				3 167	865			209	829	1 903	5 070		5070
1999	1 110	1 140				2 250	750			119	692	1 561	3 811		3811
2000	710	612				1 322	485			146	675	1 306	2 628		2628
2001	614	364				978	247			117	459	823	1 801		1801
2002	587	415		61	8	1 072	344			104	380	828	1 901		1901
2003	1 190	771		55	0	2 016	617			96	529	1 242	3 258		3258
2004	1 513	1 389		87	32	3 021	549			77	602	1 229	4 250		4250
2005	1 651	1 719		160	55	3 586	653			60	458	1 171	4 757		4757
2006	1 490	1 371		72	6	2 938	801			68	351	1 220	4 158		4158
2007	1 327	1 076		26	7	2 437	866			78	303	1 247	3 683		3683
2008	1 280	1 238		31	9	2 558	473			50	246	770	3 328		3328
2009	1 151	1 207		20	10	2 389	386			43	262	691	3 080		3080
2010	689	1 036		14	3	1 742	355			72	203	630	2 372		2372
2011	458	598	105	18	2	1 180	216	88	146	122	199	770	1 951	154	2105
2012	432	610	89	14	2	1 148	163	60	132	161	533	1 049	2 197	339	2536
2013	495	853	52	23	7	1 430	142	85	140	114	412	893	2 323	288	2612
2014	545	1 073	35	30	11	1 694	211	93	8	143	408	863	2 557	474	3030
2015	557	943	5	13	14	1 532	190	114	3	161	422	890	2 422	395	2818
2016	579	964	9	12	10	1 573	179	146	3	127	377	832	2 405	419	2824
2017	410	879	1	4	11	1 305	215	128	2	98	440	883	2 188	119	2307
2018	414	770	34	12	15	1 245	244	72	2	58	280	656	1 901	16	1916
2019	299	553	0	2	2	856	183	81	1	65	239	570	1 426	152	1577
2020	302	320	2	12	5	641	222	45	5	157	445	874	1 515	0	1515

n/a: not available

4.3 White anglerfish (*Lophius piscatorius*) in divisions 8.c and 9.a

4.3.1 General

4.3.1.1 Ecosystem aspects

The ecosystem aspects of the stock are common with *L. budegassa,* and are described in the Stock Annex.

4.3.1.2 Fishery description

L. piscatorius is mainly caught by Spanish and Portuguese bottom-trawlers and gillnet fisheries. For gillnet fishery, it is an important target species, while it is also a bycatch of the trawl fishery targeting hake or crustaceans (see Stock Annex). Since 2010, Spanish landings were on average 83% of total landings of the stock.

The length distribution of the landings is considerably different between both fisheries, with the gillnet landings showing higher mean lengths compared to those landed by trawls. From 2005 to 2020, the Spanish landings were on average 40% from the trawl fleet (in 2019, mean lengths of 63 cm and 73 cm in divisions 8.c and 9.a, respectively were observed) and 60% from the gillnet fishery (mean length of 85 cm in Division 8.c was observed in 2019). For the same period, Portuguese landings were on average 11% from bottom-trawlers (mean length of 54 cm in 2019) and 89% from the artisanal fleet (mean length of 70 cm in 2019).

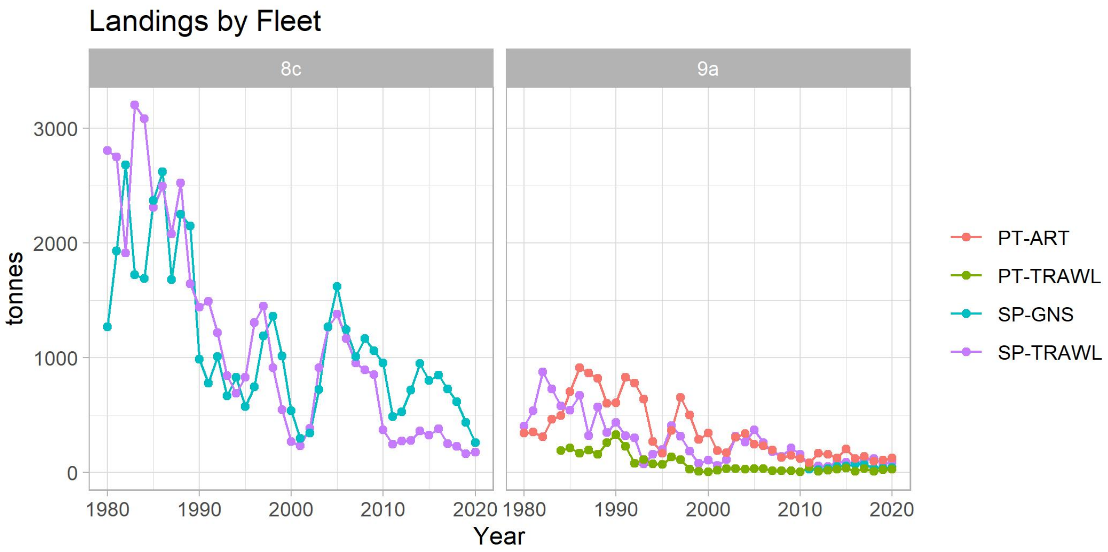
4.3.2 Feedback from Advice Drafting Group Bay of Biscay and Iberian Waters (ADGBBI) 2020

The ADG stock minutes for mon.27.8c9a raises some comments and questions about the assessment of the stock. The main issues are discussed below:

ADG: "Concern that the selectivity used is dome-shaped leaving out the large individuals, and the abundance index used comes largely from the survey that does not track the large individuals, so there's a need of information to support the increasing trend of the biomass index".

This concern is shared by the stock coordinator and the WGBIE. Unfortunately, there are no scientific surveys designed for this species, and the only information would come from commercial fishery. The need for a standardized abundance index from a commercial fleet for mon.27.8c9a was discussed many times. In February 2021, the IEO sent to the stock coordinator the logbooks records for a gillnet fleet targeting larger anglerfish (métier: GNS_DEF_>=100_0_0). There are still doubts about the possibility of using this information to build a standardized abundance index, as they do not include an appropriate unit of effort, the hauls are not identified, and the fishing operations are not geo-referenced. However, the objective is to standardize the index and use it as input data for the model in the next benchmark.

ADG: "Still important to have evidences or data that supports this increase in the abundance". The only information available is the time-series of landings from commercial fleets. No appropriate information from stakeholders neither scientific survey is available for the WGBIE. Since 2005, there is an overall decreasing trend in landings for the main fleets (SP-GNS, Spanish gillnets, and SP-TRAWL, Spanish trawlers) in Division 8.c (see figure below). Besides, the last 4 years, a sharp decline was observed on landings from fleet SP-GNS, which catches larger individuals (> 50 cm). In Division 9.a, landings have remained stable at low levels in recent years. No appropriate time-series of effort is available. Thus, there is no evidence of the increase in abundance, at least, in the areas/depths where fleets operate.



ADG: "The benchmark in 2018 recommended to use a dome-shaped curve for the artisanal fleet. If that was done to set the Reference points, was this settings used in the model this year?"

The Benchmark in 2018 (ICES, 2018) recommended modelling the selectivity of the four fleets included in the model as a double-normal function and to force at least one fleet to be asymptotic. The Portuguese artisanal fleet (PTART9a) was forced to be asymptotic, and it was accepted by the experts. The biological reference points were calculated as part of this Benchmark and using the settings described above (ICES, 2018). The settings used in the model for the assessments performed in WGBIE2020 were exactly the same: the selectivity of the 4 fleets is modelled as a double-normal function and the fleet PTART9A is forced to be asymptotic.

ADG: "These discussions make it clear that there is a need for the WG to look at these questions and the assumptions on large fish abundances and forecasts. The report for next year has to be clearer about the assumptions used in the model and forecasts"

All settings and assumptions used in the model and the forecast are included in the report this year.

ADG: "Look for a source of information on large specimens mainly driven by the decrease in catches and F."

With the information provided by IEO for gillnet fleet targeting anglerfish ("rasco"), attempts to build a standardized abundance index for the stock will be carried out in the next months.

4.3.2.1 ADG recommendations

ADG: "To look for information to confirm or review the increase on the abundance index for the stock despite the decrease of effort and the catches".

The information had been requested to the corresponding scientific laboratory many times in the last 3 years. Eventually, this information has been provided two months ago. It is still necessary a process of cleaning, analysis, and standardization of the data before reaching any conclusion about effort or abundance,

ADG: "Explore abundance indices for large specimens: data from gillnets?".

Work in progress. The abundance index from gillnet fleet ("rasco") will be used as input data of the model in a future benchmark.

4.3.3 Data

4.3.3.1 Commercial catches and discards

Total landings by country and gear for the period 1978–2020, as estimated by the WG, are given in Table 4.3.1. Unallocated and non-reported landings for this stock are available from 2011 to 2019. The unallocated and non-reported values are considered realistic and are taken into account for the assessment. Estimates of unallocated or non-reported landings were estimated based on the sampled vessels (Spanish concurrent sampling) and raised to the total effort of each métier and quarter.

Spanish discards estimates and landings below the minimum size of *L. piscatorius* in weight are shown in Table 4.3.2. No discards were reported in logbooks by any country. For the available time-series, anglerfish discards represent less than 16% of trawl catches. The maximum value observed from the time-series occurred in 2006 (99 t). Discards from the Spanish gillnet fleet are only available from 2013 to 2020 with quantities between 0 t and 144 t. The occasional high and zero values of discards reported for the gillnet fleet could be related to a very low sampling level. *L. piscatorius* discards in the Portuguese trawl fisheries are considered negligible (Fernandes and Prista, 2012; Prista *et al*., 2014). Based on the Spanish and Portuguese discards information, the WG concluded that discards could be considered negligible.

4.3.3.2 Biological sampling

The procedure for sampling this species is the same as for *L. budegassa* (see Stock Annex).

The sampling levels for Portugal in 2020 are shown in Table 1.4. Following the requirement of the EU Data Collection Framework, the métier sampling adopted in Spain and Portugal in 2009 can have an effect on the provided data. Spanish sampling levels are similar to previous years but a significant reduction of Portuguese samplings was observed in 2009–2011. Since 2012, Portugal has increased their sampling effort.

Length composition

The COVID-19 situation and Spanish administrative issues had a negative effect on the biological sampling. The sampling was reduced to minimum levels and for many Spanish métiers, there was no sampling in quarters 2 and 3.

Due to the low level of sampling and the gaps of information in many strata (métiers and quarters), it was not possible to estimate a length composition for total stock landings in 2020. Only for the Spanish gillnet fleet, a raised length composition of landings was available for quarters 1 and 4.

The annual length compositions for all combined fleets for the period 1986–2019 are presented in Figure 4.3.1.

Landings in number, the mean length and mean weight in the landings between 1986 and 2019 are shown in Table 4.3.3. The lowest total number in landings (year 2001) is 4% of the maximum value (year 1988). After 2001, increases were observed up to 2006, with decreases every year since then to year 2012. In the last 3 years, there is a strong downward trend in total landings number reaching 139 thousand in 2019 (value almost similar to the smallest number, 127 thousand in 2001, observed for the whole time-series). This decrease coincides with an increase in the mean length.

Mean lengths and mean weights in the landings increased sharply between 1995 and 2000. In 2002, low values of mean lengths and mean weights were observed, around the minimum of the time-series, due to the increase in smaller individuals. After that, increases in mean length were observed reaching 71 cm in 2010. In 2018, mean length and mean weight in landings increased with respect to the previous year and that year values, 77 cm and 7163 g respectively, were the highest of the time-series.

Biological information

The growth pattern used in the assessment follows a von Bertalanffy model with fixed K = 0.11 and L_{inf} estimated by the model. Length-weight relationship, updated during the benchmark (ICES, 2018), maturity ogive and natural mortality used in the assessment are described in the Stock Annex.

4.3.3.3 Abundance indices from surveys

Spanish and Portuguese survey results for the period 1983–2020 are summarized in Table 4.3.4.

The abundance index from Spanish survey SP-NSGFS-Q4 (G2784) is shown in Figure 4.3.2. Since 2000, the highest abundance values were detected in 2001 and 2006, following this year a downward trend was observed. In 2015, 2016, 2017 and 2018, the abundance indices were the lowest of the series (Figure 4.3.2) and almost no individuals < 20 cm were recorded (Figure 4.3.3). In 2019 and 2020 slight increases in the abundance were observed.

Since 2013, the SP-NSGFS-Q4 (G2784) is conducted using a different vessel. The results of two inter-calibration experiments carried out between the two oceanographic vessels in 2012 and 2014 indicated that catches of white anglerfish have not been affected by the change of the vessel.

4.3.3.4 Commercial catch-effort data

Landings, effort and LPUE data are given in Table 4.3.5 and Figure 4.3.4. Values for Spanish trawlers (Division 8.c) from the ports of Santander and Avilés were collected since 1986, for A Coruña since 1982 and the Portuguese trawlers (Division 9.a) since 1989. A Coruña fleet series (landings, effort and LPUE) were updated to incorporate years at the beginning of the series (1982–1985). Three series are presented for A Coruña fleet: (1) A Coruña port for trips that are exclusively landed in the port, (2) A Coruña trucks for trips that are landed in other ports and (3) A Coruña fleet that takes into account all the trips of the fleet. For 2020, no information for A Coruña port was provided. Although abundance series from A Coruña port can be potentially used in the assessment, a previous analysis of the whole time-series must be done before taking it into account. The A Coruña fleet index, used in the assessment as abundance index from 1982–2012, is not available since 2013.

Until 2011, most logbooks of Portuguese fleets were filled out on paper but have been progressively replaced thereafter by electronic logbooks. In 2013, more than 90% of the logbooks were completed in the electronic version. The LPUEs series were revised from 2012 onwards. To revise the series backwards, further refinement of the algorithm is required.

For each fleet, the proportion of the landings in the stock is also given in Table 4.3.5. In 2007, a dataseries from the artisanal fleet from the port of Cedeira in Division 8.c was provided. This LPUE series is annually standardized to incorporate a new year of data and the latest available standardized series, from 1999–2011, is presented. Due to the reduction in the number of vessels of Cedeira fleet, this tuning series could not be considered as a representative abundance index of the stock and it is no longer recorded. A series of standardized effort for Portuguese trawl fleets (1989–2008) and their corresponding LPUEs are also given in Table 4.3.5, but not represented in Figure 4.3.4.

All fleets show a general decrease in landings during the eighties and early nineties. Slight increases in 1996 and 1997 landings can be observed in all fleets. From 2000 to 2005, Spanish fleets of A Coruña, Avilés and Cedeira showed an increase in landings while those landed by the Portuguese fleets remained at low levels. Since 2005–2009, landings from A Coruña and Cedeira fleets showed an overall decreasing trend. Proportion in total landings per fleet is higher for the

Cedeira and A Coruña. Landings for both Portuguese fleets increased in 2014 and 2015 then decreased in 2016 and 2018.

Effort trends show a general decline since the mid-nineties in all trawl fleets. In the last five years, low effort values were observed despite some slight fluctuations. Despite these variations along the time-series, the artisanal fleet of Cedeira shows an overall increasing trend until 2008. After this year the effort sharply declined to the minimum value of the series in 2011. From 2007–2011 the effort from A Coruña fleet was reduced by 47%, showing the lowest values of the series in 2011. The Portuguese Crustacean fleet shows high effort values in 2001 and 2002 that might be related to a change in the target species due to the very high abundance of rose shrimp during that period.

LPUEs from all available fleets show a general decline during the eighties and early nineties followed by some increase (Table 4.3.5). From 2002 to 2005, LPUEs increased for all fleets. This general LPUE trend is consistent between fleets including the artisanal fleet. In 2010 and 2011, an important increase of Cedeira LPUE was observed. Portuguese fleets showed a one-off increase in 2011 and, in 2017 Portuguese trawl fleet target crustaceans showed the highest LPUE of the time-series with 2 kg/hour.

4.3.4 Assessment

This is an update assessment using the model adopted in 2018 benchmark (ICES, 2018). Last year assessment (ICES, 2020a) was updated with 2020 data.

4.3.4.1 Input data

Input data used in the assessment are presented in the Stock Annex.

Due to the problems described in the previous section (see Commercial catch-effort data), the A Coruña-fleet and Cedeira-fleet abundance indices from 2013 to 2019 were not included in the assessment. Length composition of landings for the Spanish artisanal fleet in ICES Division 8.c (SPART8C) in 1^{st} and 4^{th} quarter are the only length compositions used as input data for the year 2020.

4.3.4.2 Model

The Stock Synthesis (SS) software was selected to be used in the assessment. The description of the model including the structure, settings, and parameters assumptions are presented below:

Model used: Stock Synthesis (SS) (Methot, 2000).
Software used: Stock Synthesis v3.30.10 (Methot *et al.*, 2018).

Stock Synthesis is an integrated assessment model. SS has been used for stock assessment all around the world. The area of highest use is the US Pacific Coast. SS is coded in C++ using Auto-Differentiation Model Builder (http://www.admb-project.org) and available at the NOAA Virtual Laboratory (https://vlab.ncep.noaa.gov/). SS has three main characteristics that differentiate it from classical assessment models:

- SS model structure allows for building of simple to complex models depending upon the data available. It is capable to build models with age and/or length structure and spatial structure.
- It is capable to use different sources of information.
- All parameters have a set of controls to allow prior constraints, time-varying flexibility, and linkages to environmental data.

The overall SS model is subdivided into 3 submodels. The first submodel simulates the population dynamics, where the basic abundance, mortality and growth functions create a synthetic representation of the true population. The second is the observation submodel. It contains the processes and filters designed to derive expected values for the various types of data. The last one is the statistical submodel, which quantifies the magnitude of the difference between observed and expected data and employs an algorithm to find the set of parameters that maximizes the goodness-of-fit.

The SS model developed for white anglerfish during the WKANGLER 2018 has been designed for a particular set of data and specifications. White anglerfish is harvested by four fleets, and two commercial LPUE series and one fishery-independent survey provide information about relative abundance. No discard information is considered. Length composition data are available from both the fisheries and surveys. No age information is available for this stock.

Input data

- Years: 1980–2020.

Model structure:

- Temporal unit: quarterly based data (landings, LPUE and length–frequency) were used in SS calculations.
- Spatial structure: One area.
- Sex: Both sexes combined.

Fleet definition:

Four *fleets* were defined considering the gear type and country:

- Spanish trawlers in ICES divisions8.c–9.a (SPTR8C9A)
- Spanish artisanal in ICES Division 8.c (SPART8C)
- Portuguese trawlers in ICES Division 9.a (PTTR9A)
- Portuguese artisanal in ICES Division 9.a (PTART9A)

Landed catches:

Quarterly landings entered the model as biomass (in weight) for the four fleets. Landings data for January 1980 to December 2020 were used to conduct the stock assessment of white anglerfish.

From 1980 to 1988 quarterly landings were estimated using the average proportion for the following five years (1989–1993) by fleet. In the case of SPART8C quarterly landings were estimated from 1980 to 1993 using the average proportion for the next five years (1994–1998).

Abundance indices:

- A Coruña trawlers (SPCORTR8C): Quarterly LPUE in weight from 1982 to 2012, as four separate indices, i.e. one index per quarter.
- Cedeira gillnetters (SPCEDGN8C): Quarterly LPUE in weight from 1999 to 2011, as four separate indices, i.e. one index per quarter.
- Spanish Groundfish Survey (SPGFS): Abundance index in numbers from 1983 to 2020, except for 1987.

Length composition of data:

The length bin was set by 2 cm, from 4 to 100 cm, by 10 cm from 100 to 160 cm and by 40 cm from 160 to 200 cm. Length composition for the four fishing fleets and the three abundance indices were used. The available length data and their disaggregated level differ among fleets:

Length composition of Fleets:

- SPTR8C9A: 1986–2019, quarterly basis. From 1986 to 1988 quarterly length proportions were estimated from an annual proportion using the Data Super-Period approach available in SS.
- SPART8C: 1986–2020, quarterly basis. From 1986 to 1994 quarterly length proportions were estimated from an annual proportion using the Data Super-Period approach available in SS. For year 2020 only length proportions for 1st and 4th quarters were included.
- PTTR9A: 1986–2009, quarterly basis. From 1986 to 1988 quarterly length proportions were estimated from an annual proportion using the Data Super-Period approach presented in SS.
- PTART9A: 1986–2009, quarterly basis. From 1986 to 1988 quarterly length proportions were estimated from an annual proportion using the Data Super-Period approach present in SS.

Length composition of Abundance Indices:

- SPCORTR8C: 1982–2012, quarterly basis, with gaps in years 1982, 1984, 1985 and 1986.
- SPCEDGN8C: 1999–2011, quarterly basis.
- SPGFS: length composition for fourth quarter, from 1983–2020. 1987 length composition is missing.

Model assumptions and parameters

- Natural mortality: M = 0.2 for all ages and years.
- Growth: von Bertalanffy function: K = 0.11 fixed, L_{max} and mean length-at-age 0.75 are estimated.
- Maturity ogive: length-based logistic, L_{50} = 61.84 and slope = –0.1001, constant over time.
- Weight-at-length: a = 2.5×10^{-5}, b = 2.853, not estimated.
- Recruitment allocation in Quarter 3.
- Stock–recruitment relationship: Beverton–Holt model: steepness h = 0.999, sigmaR = 0.4, R0 estimated.
- Selectivity: For all fleets selectivity was only length-based and was modelled as a double normal function. Selectivity for fishery PTART9A was set to be flat-top (asymptotic). Selectivity varies among fleets, but is assumed to be time-invariant.

4.3.4.3 Assessment results

The model diagnosis is carried out by means of the analysis of residuals of abundance indices. Residual plots of the fits to the abundance indices are shown in Figure 4.3.5. Although some minor trends have been detected, as it happened for A Coruña indices from 1995 to 2000, it can be considered that the model follows trends of the abundance indices used in the model (A Coruña, Cedeira and the Spanish survey). For the Spanish survey (G2784), in the last 7 years, the model overestimates the index. It seems that the model does not follow the very low values of the index in the years 2014–2020. Pearson residual plots are presented for the model fits to the length-composition data of the abundance indices (Figure 4.3.6). No specific pattern was detected in any of the abundance indices. However, some high positive residuals are evident for G2784 index. Nevertheless, the model fits reasonably well.

The model estimates size-based selectivity functions for commercial fleets (Figure 4.3.7) and for abundance indices (Figure 4.3.8). All the selection patterns were assumed constant over the time. The selection pattern for the Spanish trawl fleet is efficient for a wide range of lengths, from smaller to very large individuals. The Spanish artisanal fleet is most efficient at a narrow length range of large-sized fish, mainly from 75 to 90 cm. The Portuguese trawl fleet selection pattern indicates that this fishery is most efficient for individuals ranging between 30 and 60 cm. This selection pattern shows strange selection over larger fish, possibly the effect of an insufficient length sampling. The Portuguese artisanal fleet selection pattern was modelled to be asymptotic, retaining all fish above 60 cm.

The selection patterns are equal for all quarters in A Coruña and Cedeira indices. For A Coruña index, the selection pattern has a wide length range while Cedeira index shows selectivity directed to larger individuals. The Spanish survey (G2784) index shows a well-defined selectivity to smaller individuals.

The variance-covariance matrix (Hessian calculation) was calculated to represent uncertainty in the spawning biomass and recruitment. The annual F summary reported in the standard SS output files (with both point estimate and standard deviation) do not correspond to the F summary used here (the average of over lengths 30 to 130 cm). The uncertainty of F could not be calculated from the variance-covariance matrix.

4.3.4.4 Historic trends in biomass, fishing mortality and recruitment

Table 4.3.6 and Figure 4.3.9 provide the summary of results from the assessment model and observed landings. Maximum values of recruitment are recorded at the beginning of the time-series (1982, 1986, 1987 and 1989) with values over 3 million. Along the time-series, other high recruitment values were detected in 1994 and 2001. Since 2006, the recruitment has been below 1 million except in 2010, 2011 and 2014. The abundance of age-0 in years 2015, 2016 and 2017 was very low, being at the minimum values throughout the time-series. A recruitment value above 1 million was estimated in 2019. Landings steadily decreased from 3.8 kt in 2005 to 1.1 kt in 2011, coinciding with the decrease in F, from 0.385 in 2005 to 0.133 in 2011. Compared to 2019, landings and F decreased in 2020 by 21% and 10%, respectively. Since 2005, SSB was above 6 kt and it steadily increased to the highest value of the times-series (11.9 kt) estimated at the beginning of 2019.

The very low recruitment values estimated by the model for years 2015 to 2018 have not been reflected in the SSB. In fact, the SSB has increased from 2015 to 2019 between 1% and 4% per year. Taking into account that white anglerfish reaches its maturity at 62 cm which corresponds approximately to 4 years, the potential impact of low recruitments on SSB will only be detected after 4 or 5 years. In 2020 and 2021, the SSB values decreased slightly related to the previous year estimates. However, the progressive decline in landings detected from 2017 to 2020, may reflect the low abundance of ages 2, 3 and 4 exploited by the fishery.

4.3.4.5 Retrospective pattern for SSB, fishing mortality, yield and recruitment

In order to assess the consistency of the assessment from year-to-year, a retrospective analysis was carried out. It was conducted by removing one year (2020), two years (2020 and 2019), three years (2020–2018), four years (2020–2017) and five years (2020–2016) of data while using the same model configuration (Figure 4.3.10). All the retrospective analysis runs were similar in the recruitment estimates. Although there are some uncertainties in recent recruitment estimates, no consistent bias was observed. Retrospective analysis showed an underestimation of the SSB in the final years and an overestimation of F. Nevertheless, there was no strong retrospective pattern and the assessment was accepted for projections. Mohn's Rho index (Mohn, 1999) for the last 5 years were estimated for recruitment (−0.50), F (0.13) and SSB (0.13).

4.3.5 Catch options and prognosis

4.3.5.1 Short-term projections

This year projections were performed on the basis of the present assessment.

For fishing mortality, the F *status quo* (F_{sq}) equals to 0.093, estimated as the average of $F_{2018\text{-}2020}$ over lengths 30–130 cm, was used for the intermediate year (2021). Although there is a decreasing trend in F, it was decided not to scale F_{sq} to the final year because of the uncertainty on SSB estimates. Unscaled F_{sq} was considered more precautionary as a higher value of F is closer to F_{MSY}.

The recruitment used for projections in this WG is the geometric mean calculated from 2003 to the final assessment year (2020), following the option indicated in the Stock Annex when a trend in the time-series was detected. Recruitment short-term projection assumption value is given in Table 4.3.7. Projected landings in 2022 and SSB at the beginning of 2023 for different management options in 2022 are presented in Table 4.3.7. Under F *status quo* scenario in 2022, a small increase in the 2022 landings, as well as an increase in the 2023 SSB, are expected with respect to 2021 landings and 2022 SSB, respectively.

4.3.5.2 Yield and biomass per recruit analysis

The summary table of Yield and SSB per recruit analysis is given in the table below:

	SPR level	Fmult	F(30-130cm)	YPR(land)	SSB/R
Fmax	0.14	3.18	0.263	1.99	6.51
F0.1	0.26	2.03	0.168	1.88	12.09
F40%	0.40	1.31	0.108	1.61	18.85
F35%	0.35	1.52	0.126	1.72	16.49
F30%	0.30	1.77	0.146	1.81	14.13

The F that maximizes the yield-per-recruit, F_{max}, is estimated at 0.263 which is well above F_{sq} (0.093) and which corresponds to a SPR level of 14%. The $F_{0.1}$, rate of fishing mortality at which the slope of the YPR curve falls to 10% of its value at the origin, is equal to 0.168 and it is corresponding to a SPR level of 26%. Fishing mortality of $F_{30\%,\ 35\%}$ and $_{40\%}$ were estimated at 0.146, 0.126 and 0.108, respectively. The *status quo* F is below F_{max}, $F_{0.1}$, and $F_{30\%}$, $F_{35\%}$ and $F_{40\%}$.

4.3.6 Biological reference points of stock biomass and yield

Biological reference points for southern white anglerfish stock were calculated in the Benchmark WKANGLER (ICES, 2018). In this year Working Group, and following the ACOM guidelines (ICES, 2020b), the value of F_{pa} was revised according to the new definition "$F_{p0.5}$: the F that leads to SSB ≥ B_{lim} with 95% probability" (calculated with $B_{trigger}$). Besides, as the new F_{pa} value was higher than the F_{lim}, previous F_{lim} value was discarded and has not been defined yet. The reference points in use for the stock are presented in the following table:

Framework	Reference points	Value	Rational
Precautionary approach	B_{lim}	1993 t	B_{loss}
	B_{pa}	2769 t	B_{lim}*exp (1.645*0.2)
	F_{lim}	not defined	
	F_{pa}	0.87	$F_{p0.5}$; the F that leads to SSB ≥ Blim with 95% probability, calculated using Btrigger.

MSY Approach	F_{MSY}	0.24	Stochastic simulation, F maximizes median equilibrium yield
	$F_{MSY\text{-}lower}$	0.164	Stochastic simulations, 5% reduction in long-term yield compared with MSY.
	$F_{MSY\text{-}upper}$	0.33	
	MSY $B_{trigger}$	6283 t	5th percentile of SSB when fishing at F_{MSY}

4.3.7 Comments on the assessment

The spawning-stock biomass has increased from 2007 to 2019. SSB in 2021 is estimated at 11.6 kt which is well above of B_{pa} (2769 t) and MSY $B_{trigger}$ (6283 t). Fishing mortality in 2020 has decreased by 10% relative to 2019. F in 2020 is estimated to be at a value of 0.083, below F_{pa} (0.87) and F_{MSY} (0.24). An increase in landings occurred from 1.1 kt in 2011 to 2.0 kt in 2014 but declined to 0.7 kt in 2020. For the period 2015–2018, recruitments were extremely low, being the main concern about the status of the stock. In 2019, the recruitment estimated indicates a moderate increase in the abundance of age-0, decreasing again in 2020.

4.3.8 Quality considerations

The available unallocated and non-reported landings for the years 2011–2019 are included in the stock assessment since the estimates were considered realistic. However, the importance of the unallocated/non-reported landings is difficult to assess and the results of the assessment might have been affected by the inclusion of these data.

Uncertainty of the assessment model may have increased due to the missing data for commercial abundance indices since 2012. For the last 10 years, the model lacks an abundance indicator for larger individuals which might impact the calculation of F for larger individuals and on the SSB estimates.

4.3.9 Management considerations

Management considerations are describing for both anglerfish stocks in section 4.2.

4.3.10 Recommendations for next benchmark

During the WKTaDSa (ICES, 2021), a number of issues to improve the current assessment model of mon.27.8c9a were identified. The following tasks are proposed for the next benchmark:

- Simplify the current model by changing the structure from quarter time-step to an annual time-step.
- Reduce the number of fishing fleets included in the model. The four fleets defined in the current model could be reduced to 2 fleets: Gillnet Fleet and Trawler Fleet.
- Explore the selectivity pattern of the fleets. The Stock Synthesis experts expressed that there are reasons against and for selecting a specific selectivity pattern, but they don't agree with general rules (like "at least one fleet-selectivity must be asymptotic"). A specific residual analysis should be carried out to identify the potential impact of different selectivity patterns on F and SSB estimates.
- Use an age-variant natural mortality. Also, it must be explored if the differential sex growth (females reach larger sizes than males) should be taken into account to define natural mortality for older ages.
- Inclusion of a standardized abundance index for larger individuals. It is proposed to use the commercial abundance index from Spanish gillnet fleet targeting anglerfish.

- The model-based estimates of effective sample size should be updated every year using the Dirichlet-Multinomial method (Mosimann, 1962).
- Create a protocol of modern model diagnostics for model development and selection using the functions included in the R library *ss3diags*.

4.3.11 References

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4.3.12 Tables and figures

Table 4.3.1 ANGLERFISH (*L. piscatorius*) - Divisions 8c and 9a.
Tonnes landed by the main fishing fleets for 1978-2020 as determined by the Working Group.

	Div. 8c						Div. 9a						Div. 8c+9a		Div. 8c+9a
	SPAIN			FRANCE			SPAIN			PORTUGAL					
Year	Trawl	Gillnet	Others	Trawl	Gillnet	TOTAL	Trawl	Gillnet	Others	Trawl	Artisanal	TOTAL	SUBTOTAL	Unallocated / Non-reported	TOTAL
1978	n/a	n/a				n/a	258				115	373			
1979	n/a	n/a				n/a	319				225	544			
1980	2 806	1 270				4 076	401				339	740	4 816	0	4 816
1981	2 750	1 931				4 681	535				352	887	5 568	0	5 568
1982	1 915	2 682				4 597	875				310	1 185	5 782	0	5 782
1983	3 205	1 723				4 928	726				460	1 186	6 114	0	6 114
1984	3 086	1 690				4 776	578			186	492	1 256	6 032	0	6 032
1985	2 313	2 372				4 685	540			212	702	1 454	6 139	0	6 139
1986	2 499	2 624				5 123	670			167	910	1 747	6 870	0	6 870
1987	2 080	1 683				3 763	320			194	864	1 378	5 141	0	5 141
1988	2 525	2 253				4 778	570			157	817	1 543	6 321	0	6 321
1989	1 643	2 147				3 790	347			259	600	1 206	4 996	0	4 996
1990	1 439	985				2 424	435			326	606	1 366	3 790	0	3 790
1991	1 490	778				2 268	319			224	829	1 372	3 640	0	3 640
1992	1 217	1 011				2 228	301			76	778	1 154	3 382	0	3 382
1993	844	666				1 510	72			111	636	819	2 329	0	2 329
1994	690	827				1 517	154			70	266	490	2 007	0	2 007
1995	830	572				1 403	199			66	166	431	1 834	0	1 834
1996	1 306	745				2 050	407			133	365	905	2 955	0	2 955
1997	1 449	1 191				2 640	315			110	650	1 075	3 714	0	3 714
1998	912	1 359				2 271	184			28	497	710	2 981	0	2 981
1999	545	1 013				1 558	79			9	285	374	1 932	0	1 932
2000	269	538				808	107			4	340	451	1 259	0	1 259
2001	231	294				525	57			16	190	263	788	0	788
2002	385	341		51	7	784	110			29	168	307	1 090	0	1 090
2003	911	722		46	0	1 679	312			29	305	645	2 324	0	2 324
2004	1 262	1 269		73	27	2 631	264			27	335	626	3 257	0	3 257
2005	1 378	1 622		134	46	3 180	371			29	244	643	3 824	0	3 824
2006	1 166	1 247		60	5	2 478	260			29	230	519	2 997	0	2 997
2007	955	1 009		22	6	1 992	181			13	192	386	2 378	0	2 378
2008	894	1 168		26	8	2 096	138			11	127	275	2 371	0	2 371
2009	850	1 058		17	9	1 935	213			10	148	371	2 306	0	2 306
2010	370	955		12	2	1 339	158			2	119	279	1 618	0	1 618
2011	243	483	73	15	2	816	59	28	48	46	80	260	1 077	80	1 157
2012	271	527	67	12	2	880	54	20	42	6	163	285	1 165	230	1 395
2013	274	718	38	19	6	1 054	47	30	50	15	154	296	1 350	190	1 541
2014	358	947	28	25	9	1 368	91	47	4	27	122	291	1 659	374	2 032
2015	324	802	4	11	12	1 152	86	53	2	34	200	375	1 527	244	1 771
2016	376	846	3	10	8	1 243	76	67	1	8	120	273	1 516	294	1 809
2017	248	726	1	3	8	986	106	66	1	30	138	341	1 327	119	1 446
2018	227	614	34	5	6	886	117	35	1	6	94	253	1 139	4	1 144
2019	161	435	0	0	0	597	74	33	1	22	104	233	830	78	909
2020	175	256	1	8	3	443	84	40	2	28	125	279	722	0	722

n/a: not available

Table 4.3.2 ANGLERFISH (*L. piscatorius*) - Divisions 8c and 9a.
Weight and percentage of unwanted catches for Spanish fleets.

Discards Recorded in Logbooks		Gillnet
Year	Weight (t)	Weight (t)
2019	0	0
2020	0	0

Landings BelowMinimumSize		Gillnet
Year	Weight (t)	Weight (t)
2018	0.027	0.111
2019	0	0
2020*	0.001	0

Discards Estimates: Trawl

Year	Weight (t)	CV	% Trawl Catches	% Total Catches
1994	20.9	34.05	2.2	1.0
1995	n/a	n/a	n/a	n/a
1996	n/a	"	n/a	n/a
1997	5.4	68.13	0.3	0.1
1998	n/a	n/a	n/a	n/a
1999	0.7	"	0.1	0.0
2000	6.2	"	1.6	0.5
2001	n/a	"	n/a	n/a
2002	n/a	"	n/a	n/a
2003	26.2	"	2.0	1.1
2004	64.9	"	3.8	2.0
2005	56.2	"	2.9	1.4
2006	99.3	"	6.2	3.2
2007	17.2	"	1.4	0.7
2008	5.1	"	0.5	0.2
2009	24.5	"	2.2	1.1
2010	12.5	"	2.3	0.8
2011	30.1	"	7.7	2.5
2012	66.7	"	16.3	4.6
2013	65.8	"	15.7	3.8
2014	24.4	"	4.6	1.2
2015	20.8	"	4.4	1.2
2016	0.03	"	0.0	0.0
2017	13.3	"	3.3	0.9
2018	4.1	"	1.2	0.4
2019	1.9	"	0.7	0.2
2020*	2.2	"	0.7	0.3

Discards Estimates: Gillnet

Year	Weight (t)	% Gillnet Catches	% Total Catches
2013	143.8	13.7	8.2
2014	0.0	0.0	0.0
2015	7.6	0.7	0.4
2016	24.2	2.3	1.3
2017	17.0	1.8	1.2
2018	1.8	0.2	0.2
2019	16.7	2.8	1.8
2020*	3.8	0.9	0.5

n/a: not available
CV: coefficient of variation
* only for 3rd and 4th quarter

Table 4.3.3 ANGLERFISH (*L. piscatorius*). Divisions 8c and 9a.
Numbers, mean weight and mean length of landings between 1986 and 2019.

Year	Total (thousands)	Mean Weight (g)	Mean Length (cm)
1986	1 872	3 670	61
1987	2 806	1 832	44
1988	2 853	2 216	50
1989	1 821	2 744	54
1990	1 677	2 261	49
1991	1 657	2 197	50
1992	1 256	2 692	54
1993	857	2 719	54
1994	704	2 850	54
1995	876	2 093	48
1996	1 153	2 564	52
1997	1 043	3 560	60
1998	583	5 113	68
1999	290	6 674	71
2000	190	6 885	72
2001	127	6 189	64
2002	381	2 766	50
2003	784	2 907	54
2004	809	3 456	61
2005	856	4 259	63
2006	923	3 211	58
2007	553	4 251	62
2008	540	4 327	63
2009	492	4 630	64
2010	288	5 569	71
2011	249	4 252	62
2012	244	4 711	65
2013	269	4 929	66
2014	289	5 630	70
2015	307	4 902	66
2016	327	5 485	69
2017	233	6 205	73
2018	161	7 163	77
2019	139	6 519	73

na: not available

Table 4.3.4 ANGLERFISH (*L. piscatorius*). Divisions 8c and 9a.
Abundance indices from Spanish and Portuguese surveys.

	SP-NSGFS-Q4 (G2784)					PtGFS-WIBTS-Q4 (G8899)		
	September-October (total area Miño-Bidasoa)					October		
Year	Hauls	kg/30 min		nº/30 min		Hauls	kg/60 min	nº/60 min
		Yst	se	Yst	se			
1983	145	2.03	0.29	3.50	0.46	117	n/a	n/a
1984	111	2.60	0.47	2.90	0.55	na	n/a	n/a
1985	97	1.33	0.36	1.90	0.26	150	n/a	n/a
1986	92	4.28	0.80	10.70	1.40	117	n/a	n/a
1987	ns	ns	ns	ns	ns	81	n/a	n/a
1988	101	3.33	0.70	1.50	0.25	98	n/a	n/a
1989	91	0.44	0.08	2.40	0.30	138	0.09	0.07
1990	120	1.19	0.22	1.20	0.22	123	0.46	0.05
1991	107	0.71	0.22	0.50	0.09	99	+	+
1992	116	0.76	0.15	1.18	0.16	59	0.09	0.01
1993	109	0.88	0.16	1.20	0.14	65	0.08	0.01
1994	118	1.66	0.62	3.70	0.49	94	+	0.02
1995	116	2.19	0.32	5.70	0.69	88	0.05	0.03
1996*	114	1.54	0.26	1.40	0.16	71	0.27	0.18
1997	116	1.69	0.39	0.67	0.11	58	0.49	0.03
1998	114	1.40	0.37	0.39	0.08	96	+	+
1999*	116	0.75	0.23	0.36	0.06	79	+	+
2000	113	0.57	0.19	0.88	0.18	78	+	+
2001	113	1.09	0.24	2.88	0.28	58	+	+
2002	110	1.34	0.21	2.76	0.29	67	0.06	0.04
2003*	112	1.67	0.40	1.41	0.16	80	0.29	0.15
2004*	114	2.09	0.32	2.71	0.32	79	0.16	0.12
2005	116	3.05	0.54	2.04	0.19	87	0.12	0.04
2006	115	1.88	0.40	2.86	0.30	88	+	+
2007	117	1.65	0.25	2.56	0.25	96	+	+
2008	115	1.85	0.37	1.96	0.35	87	+	+
2009	117	1.07	0.17	1.91	0.17	93	+	+
2010	114	1.29	0.25	1.95	0.28	87	+	+
2011	114	0.77	0.16	1.09	0.18	86	+	+
2012	115	1.11	0.27	1.06	0.14	ns	ns	ns
2013**	114	2.09	0.64	2.30	0.30	93	0.34	0.02
2014**	116	1.56	0.36	1.24	0.17	81	0.00	0.00
2015**	114	1.14	0.25	0.58	0.10	90	0.00	0.00
2016**	114	0.76	0.28	0.30	0.06	85	0.00	0.00
2017**	112	0.53	0.30	0.18	0.07	89	0.00	0.00
2018**	113	0.64	0.25	0.13	0.03	53	0.00	0.00
2019**	113	0.53	0.21	0.31	0.07	n/a	n/a	n/a
2020**	109	0.73	0.22	0.37	0.07	n/a	n/a	n/a

Yst = stratified mean
se = standard error
ns = no survey
n/a = not available
+ = less than 0.01
* For Portuguese Surveys - R/V Capricornio, other years R/V Noruega
** For Spanish Surveys - R/V Miguel Oliver, other years R/V Coornide de Saavedra

Table 4.3.5 ANGLERFISH (*L. piscatorius*) - Divisions 8c and 9a.
Landings, fishing effort and landings per unit effort for trawl and gillnet fleets.
For landings the percentage relative to total annual stock landings is given.

	SP-AVITR8C				SP-SANTR8C				STAND-SP-CEDGNS8C			
Year	LANDINGS	%	EFFORT (days*100hp)	LPUE (kg/day*100hp)	LANDINGS	%	EFFORT (days*100hp)	LPUE (kg/day*100hp)	LANDINGS	%	EFFORT (soaking days)	LPUE (kg/soaking day)
1986	500	7	10 845	46.1	516	8	18 153	28.4				
1987	500	10	8 309	60.2	529	10	14 995	35.3				
1988	401	6	9 047	44.3	387	6	16 660	23.3				
1989	214	4	8 063	26.5	305	6	17 607	17.3				
1990	260	7	8 497	30.6	278	7	20 469	13.6				
1991	245	7	7 681	31.9	281	8	22 391	12.6				
1992	198	6	--	--	222	7	22 833	9.7				
1993	76	3	7 635	9.9	186	8	21 370	8.7				
1994	116	6	9 620	12.0	188	9	22 772	8.2				
1995	192	10	6 146	31.2	186	10	14 046	13.2				
1996	322	11	4 525	71.1	270	9	12 071	22.4				
1997	345	9	5 061	68.1	381	10	11 776	32.3				
1998	286	10	5 929	48.3	316	11	10 646	29.7				
1999	108	6	6 829	15.8	182	9	10 349	17.6	342	18	4 582	74.5
2000	28	2	4 453	6.3	75	6	8 779	8.6	140	11	2 981	46.8
2001	23	3	1 838	12.5	54	7	3 053	17.6	87	11	1 932	44.8
2002	75	7	2 748	27.5	57	6	3 975	14.3	130	13	2 398	54.3
2003	111	5	2 526	44.0	85	4	3 837	22.1	159	7	2 703	59.0
2004	216	7	--	--	106	3	3 776	28.1	382	12	4 677	81.6
2005	278	8	--	--	59	2	1 404	41.9	434	12	3 325	130.4
2006	148	5	--	--	89	3	2 718	32.7	415	14	3 911	106.2
2007	101	4	--	--	103	4	4 334	23.8	233	10	3 976	58.6
2008	99	4	--	--	--	--	--	--	228	10	5 133	44.3
2009	69	3	--	--	35	2	1 125	31.3	183	8	2 300	79.5
2010	--	--	--	--	44	3	1 628	27.1	231	15	1 880	122.7
2011	--	--	--	--	44	4	--	--	60	6	522	115.9
2012	--	--	--	--	22	2	--	--	63	5	--	--

	SP-CORTR8C-PORT				SP-CORTR8C-TRUCKS				SP-CORTR8C-FLEET			
Year	LANDINGS	%	EFFORT (days*100hp)	LPUE (kg/day*100hp)	LANDINGS	%	EFFORT (days*100hp)	LPUE (kg/day*100hp)	LANDINGS	%	EFFORT (days*100hp)	LPUE (kg/day*100hp)
1982	1618	28	63 313	26					1618	28	63 313	25.6
1983	1490	24	51 008	29					1490	24	51 008	29.2
1984	1560	26	48 665	32					1560	26	48 665	32.1
1985	1134	18	45 157	25					1134	18	45 157	25.1
1986	825	12	40 420	20					825	12	40 420	20.4
1987	618	12	34 651	18					618	12	34 651	17.8
1988	656	10	41 481	16					656	10	41 481	15.8
1989	508	10	44 410	11					508	10	44 410	11.4
1990	550	15	44 403	12					550	15	44 403	12.4
1991	491	13	40 429	12					491	13	40 429	12.1
1992	432	13	38 899	11					432	13	38 899	11.1
1993	385	17	44 478	9					385	17	44 478	8.7
1994	245	12	39 602	6	63	3	12 795	5	309	15	52 397	5.9
1995	260	14	41 476	6	57	3	10 232	6	316	17	51 708	6.1
1996	413	14	35 709	12	83	3	8 791	9	496	17	44 501	11.2
1997	411	11	35 494	12	59	2	9 108	6	470	13	44 602	10.5
1998	138	5	29 508	5	30	1	--	--	168	6	--	--
1999	168	9	30 131	6	--	--	--	--	--	--	--	--
2000	85	7	30 079	3	2	0	--	--	88	7	--	--
2001	84	11	29 935	3	--	--	--	--	--	--	--	--
2002	130	12	21 948	6	61	6	6 747	9	191	18	28 695	6.7
2003	228	10	18 519	12	115	5	7 608	15	342	15	26 127	13.1
2004	277	9	19 198	14	162	5	10 342	16	439	13	29 540	14.9
2005	391	10	20 663	19	248	6	10 302	24	639	17	30 965	20.6
2006	242	8	19 264	13	273	9	12 866	21	515	17	32 130	16.0
2007	222	9	21 651	10	233	10	13 187	18	455	19	34 838	13.1
2008	274	12	20 212	14	153	6	9 812	16	428	18	30 024	14.2
2009	165	7	16 152	10	152	7	12 930	12	317	14	29 092	10.9
2010	129	8	16 680	8	70	4	9 003	8	165	10	22 746	7.3
2011	92	8	12 835	7	--	--	--	--	146	13	18 617	7.9
2012	132	9	14 446	9	--	--	--	--	142	10	21 110	6.7
2013	122	8	14 736	8	--	--	--	--	--	--	--	--
2014	114	6	18 060	6	--	--	--	--	--	--	--	--
2015	88	5	13 309	7	--	--	--	--	--	--	--	--
2016	138	8	13 718	10	--	--	--	--	--	--	--	--
2017	76	5	12 449	6	--	--	--	--	--	--	--	--
2018	95	8	13 247	7	--	--	--	--	--	--	--	--
2019	42	5	12 824	3	--	--	--	--	--	--	--	--
2020	--	--	--	--	--	--	--	--	--	--	--	--

	PT-CRUST						PT-FISH					
Year	LANDINGS	%	EFFORT (1000 hours)	EFFORT (1000 hauls)	LPUE (kg/hour)	LPUE (kg/haul)	LANDINGS	%	EFFORT (1000 hours)	EFFORT (1000 hauls)	LPUE (kg/hour)	LPUE (kg/haul)
1989	85	2	76	23	1.1	3.7	175	3	52	18	3.3	9.9
1990	106	3	90	20	1.2	5.2	219	6	61	17	3.6	12.8
1991	73	2	83	17	0.9	4.4	151	4	57	15	2.6	9.8
1992	25	1	71	15	0.3	1.6	51	2	49	14	1.0	3.7
1993	36	2	75	13	0.5	2.7	75	3	56	13	1.3	5.7
1994	23	1	41	8	0.6	3.0	47	2	36	10	1.3	4.9
1995	22	1	38	8	0.6	2.8	45	2	41	9	1.1	4.9
1996	45	2	64	14	0.7	3.1	88	3	54	12	1.6	7.1
1997	51	1	43	11	1.2	4.5	59	2	27	9	2.2	6.7
1998	11	<1	48	11	0.2	1.0	17	1	35	10	0.5	1.8
1999	3	<1	24	8	0.1	0.4	6	<1	18	6	0.3	1.0
2000	2	<1	42	10	0.0	0.2	2	<1	19	6	0.1	0.4
2001	9	1	85	18	0.1	0.5	7	1	19	5	0.4	1.4
2002	18	2	62	10	0.3	1.9	11	1	14	4	0.8	2.4
2003	13	1	42	10	0.3	1.3	16	1	17	6	0.9	2.8
2004	12	<1	21	7	0.6	1.9	14	<1	14	4	1.0	3.3
2005	12	<1	20	5	0.6	2.2	17	<1	13	4	1.3	4.7
2006	13	<1	22	5	0.6	2.4	16	1	12	4	1.3	4.2
2007	7	<1	22	6	0.3	1.1	6	<1	8	3	0.8	2.1
2008	6	<1	14	4	0.4	1.5	5	<1	5	2	1.0	2.9
2009	5	<1	15	--	0.3	--	5	<1	6	--	0.8	--
2010	1	<1	21	--	0.0	--	1	<1	14	--	0.1	--
2011	24	2	18	--	1.3	--	22	2	9	--	2.4	--
2012	3	<1	36	--	0.1	--	3	<1	16	--	0.2	--
2013	8	<1	27	--	0.3	--	7	<1	12	--	0.6	--
2014	16	1	32	--	0.5	--	13	1	16	--	0.8	--
2015	18	1	17	--	1.1	--	16	1	14	--	1.2	--
2016	4	<1	12	--	0.3	--	4	<1	11	--	0.3	--
2017	16	1	8	--	2.0	--	15	1	11	--	1.3	--
2018	3	<1	5	--	0.6	--	3	<1	6	--	0.4	--
2019	12	1	6	--	1.9	--	11	1	5	--	2.0	--
2020	15	2	13	--	0.6	--	14	2	7	--	0.9	--

Table 4.3.6 ANGLERFISH (*L. piscatorius*) - Division 8c and 9a.
Summary of the assessment results.

	Recruit Age0 (thousands)	Total Biomass (t)	Total SSB (t)	Landings (t)	Yield/SSB	F (30-130 cm)
1980	678	15 512	9 817	4 817	0.49	0.30
1981	1 933	16 536	11 387	5 566	0.49	0.33
1982	7 350	15 585	11 913	5 782	0.49	0.38
1983	1 946	14 368	10 647	6 113	0.57	0.49
1984	774	14 051	8 821	6 031	0.68	0.51
1985	1 829	13 024	8 418	6 139	0.73	0.53
1986	6 525	10 773	7 766	6 870	0.89	0.80
1987	3 708	7 407	4 799	5 139	1.07	0.92
1988	1 078	7 306	3 146	6 321	2.01	1.39
1989	3 332	5 959	2 483	4 995	2.01	1.09
1990	2 233	4 939	2 411	3 790	1.57	0.81
1991	1 064	4 806	2 213	3 640	1.65	0.83
1992	1 321	4 510	2 114	3 382	1.60	0.87
1993	1 699	3 788	1 973	2 329	1.18	0.63
1994	3 127	3 830	2 065	2 007	0.97	0.50
1995	1 821	4 638	2 333	1 835	0.79	0.33
1996	335	6 588	3 295	2 956	0.90	0.39
1997	282	7 540	4 362	3 715	0.85	0.45
1998	224	6 819	4 749	2 981	0.63	0.38
1999	742	5 789	4 588	1 933	0.42	0.30
2000	646	5 096	4 248	1 256	0.30	0.24
2001	3 714	4 938	3 988	788	0.198	0.16
2002	1 619	5 817	4 187	1 093	0.26	0.189
2003	348	7 959	4 808	2 326	0.48	0.29
2004	2 167	9 366	5 878	3 258	0.55	0.33
2005	1 370	9 577	6 813	3 827	0.56	0.39
2006	1 284	9 010	6 525	2 998	0.46	0.34
2007	713	8 806	6 304	2 377	0.38	0.28
2008	777	9 081	6 657	2 372	0.36	0.26
2009	879	9 130	7 028	2 307	0.33	0.25
2010	1 513	8 922	7 122	1 620	0.23	0.183
2011	1 177	9 334	7 442	1 156	0.155	0.133
2012	530	10 526	8 204	1 396	0.170	0.139
2013	818	11 676	9 142	1 540	0.168	0.136
2014	1 559	12 550	10 217	2 033	0.199	0.169
2015	247	12 814	10 679	1 771	0.166	0.148
2016	214	13 327	11 051	1 809	0.164	0.156
2017	202	13 336	11 351	1 447	0.127	0.125
2018	403	13 254	11 784	1 144	0.097	0.104
2019	1 053	13 032	11 958	908	0.076	0.092
2020	539	12 842	11 802	720	0.061	0.083
2021	706	12 983	11 625			

*geometric.mean(2003-2020)

Table 4.3.7 ANGLERFISH (*L. piscatorius*) - Divisions 8c and 9a.
Catch option table.

SSB(2021)	Rec proj	F(30-130cm)	Land(2021)	SSB(2022)
11 625	706	0.093	760	11 557

Fmult	Fland (30-130cm)	Landings (2022)	SSB (2023)
0	0	0	12 608
0.1	0.0093	82	12 518
0.2	0.0186	163	12 428
0.3	0.028	244	12 340
0.4	0.037	324	12 252
0.5	0.047	403	12 165
0.6	0.056	481	12 078
0.7	0.065	559	11 992
0.8	0.074	636	11 907
0.9	0.084	713	11 823
1	0.093	788	11 739
1.1	0.102	863	11 656
1.2	0.112	938	11 574
1.3	0.121	1011	11 493
1.4	0.130	1084	11 412
1.5	0.140	1157	11 332
1.6	0.149	1228	11 252
1.7	0.158	1300	11 173
1.8	0.167	1370	11 095
1.9	0.177	1440	11 018
2	0.186	1509	10 941
2.1	0.195	1578	10 864
2.2	0.20	1646	10 789
2.3	0.21	1713	10 714
2.4	0.22	1780	10 639
2.5	0.23	1846	10 566
2.6	0.24	1912	10 492
2.7	0.25	1977	10 420
2.8	0.26	2041	10 348
2.9	0.27	2105	10 276
3	0.28	2169	10206

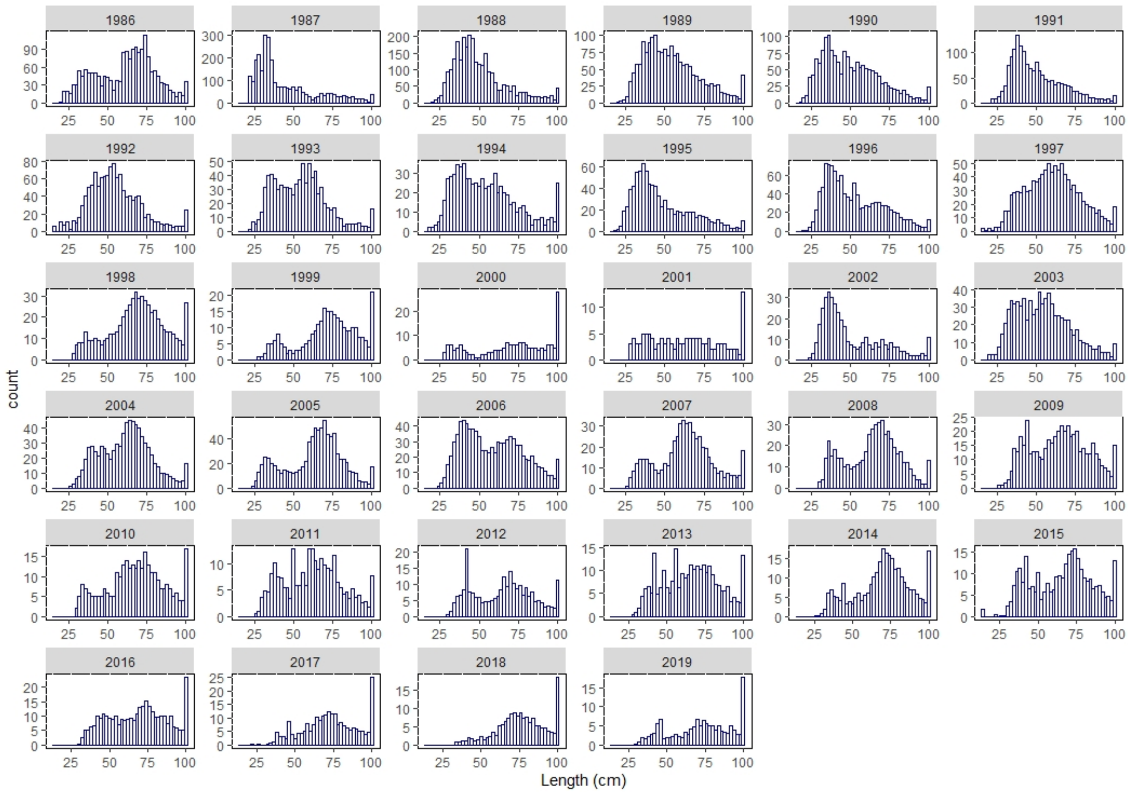

Figure 4.3.1. ANGLERFISH (*L. piscatorius*) - divisions 8.c and 9.a. Length distributions of landings (thousands, from 1986 to 2019).

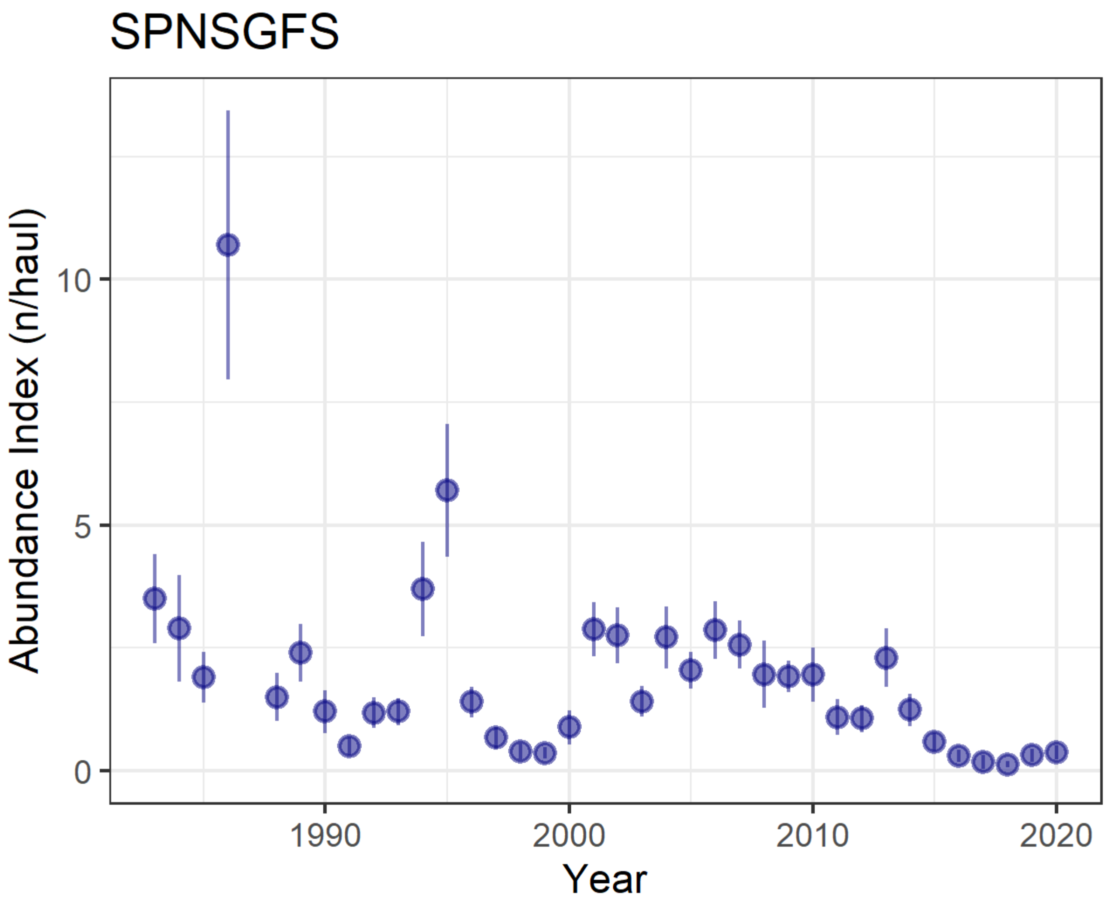

Figure 4.3.2. ANGLERFISH (*L. piscatorius*) - divisions 8.c and 9.a. Abundance index (in numbers/haul) from survey SP-NSGFS-Q4 (G2784). Bars represent 95% confidence intervals.

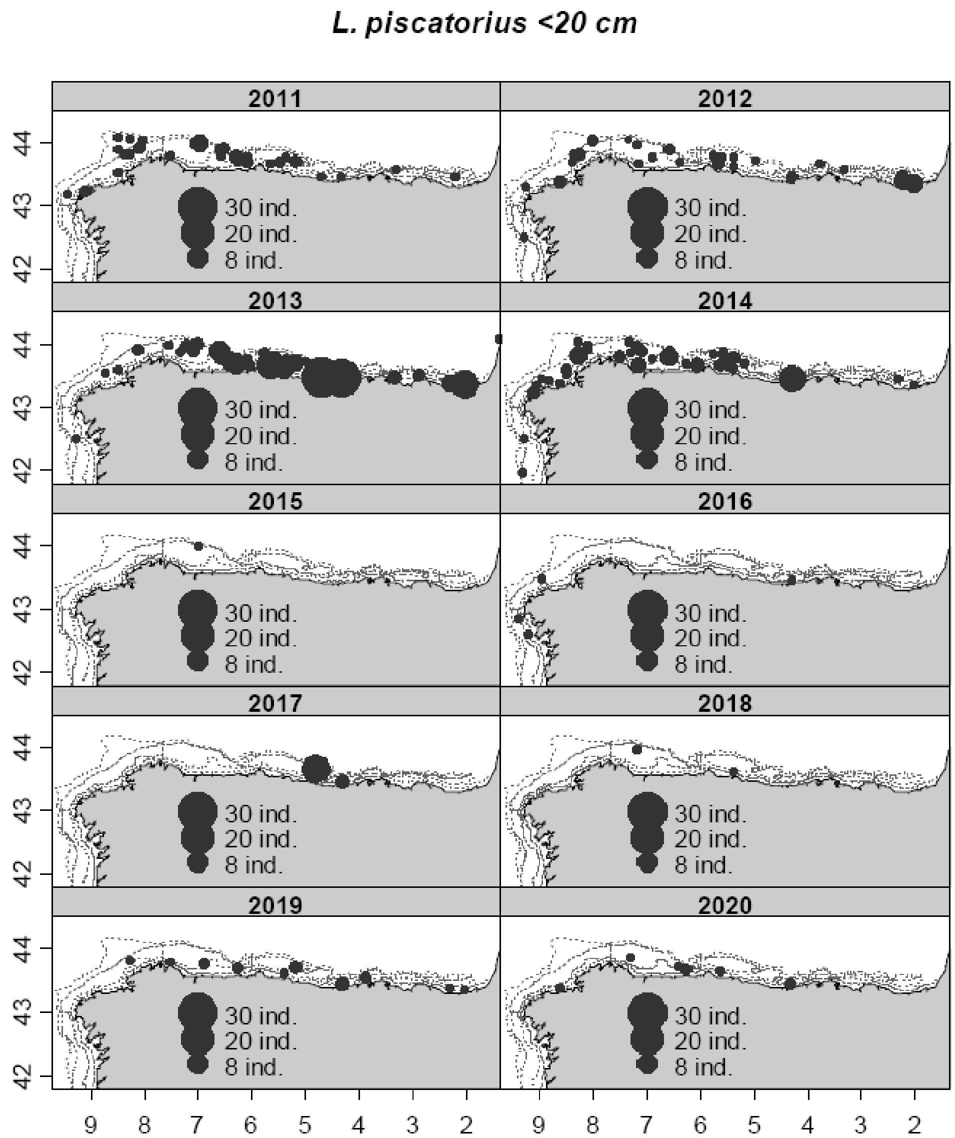

Figure 4.3.3. ANGLERFISH (*L. piscatorius*) - divisions 8.c and 9.a. Spatial distribution of juveniles (length 0–20 cm) in North Spanish Coast demersal survey (SP-NSGFS-Q4 (G2784)) between 2011 and 2020.

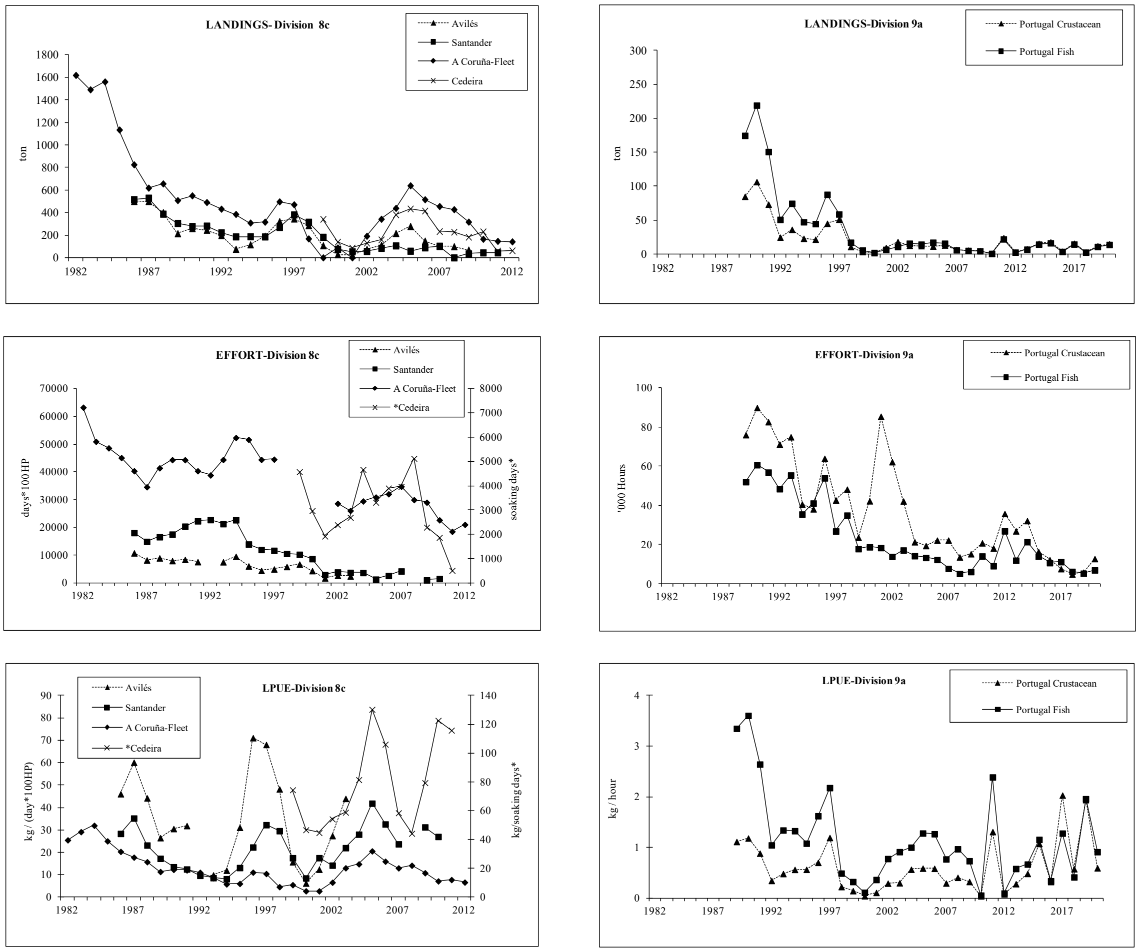

Figure 4.3.4. ANGLERFISH (*L. piscatorius*) - divisions 8.c and 9.a. Trawl and gillnet landings, effort and LPUE data between 1982–2020.

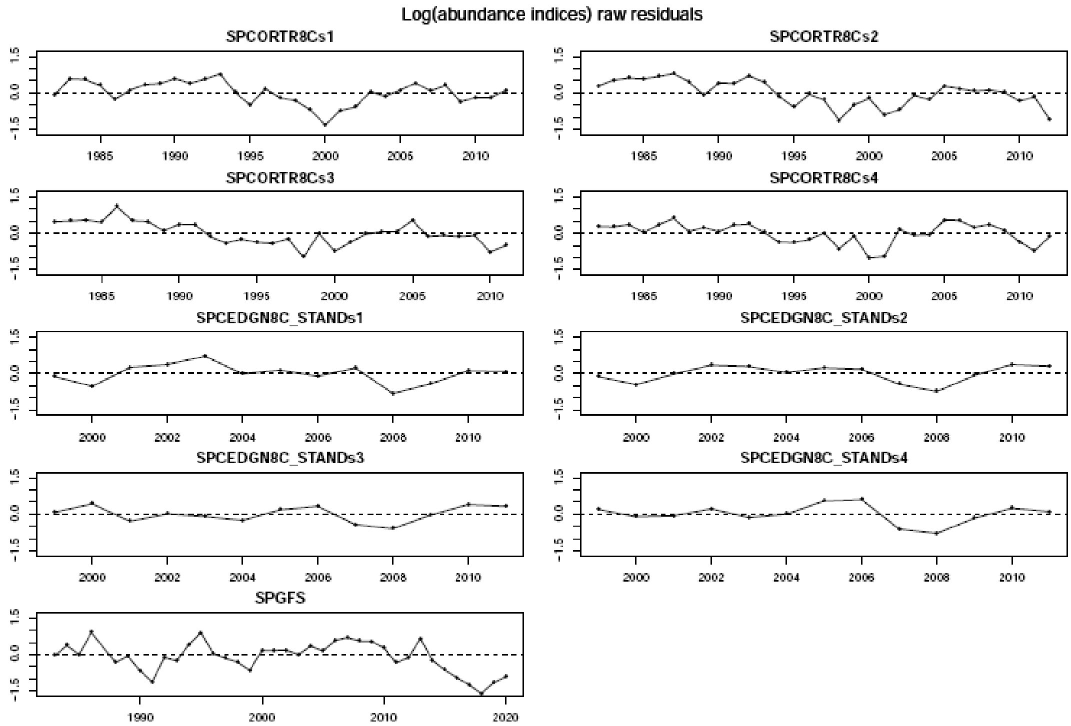

Figure 4.3.5 ANGLERFISH (*L. piscatorius*) - divisions 8.c and 9.a. Residuals of the fits to the surveys in log(abundance indices). A Coruña and Cedeira are by quarters.

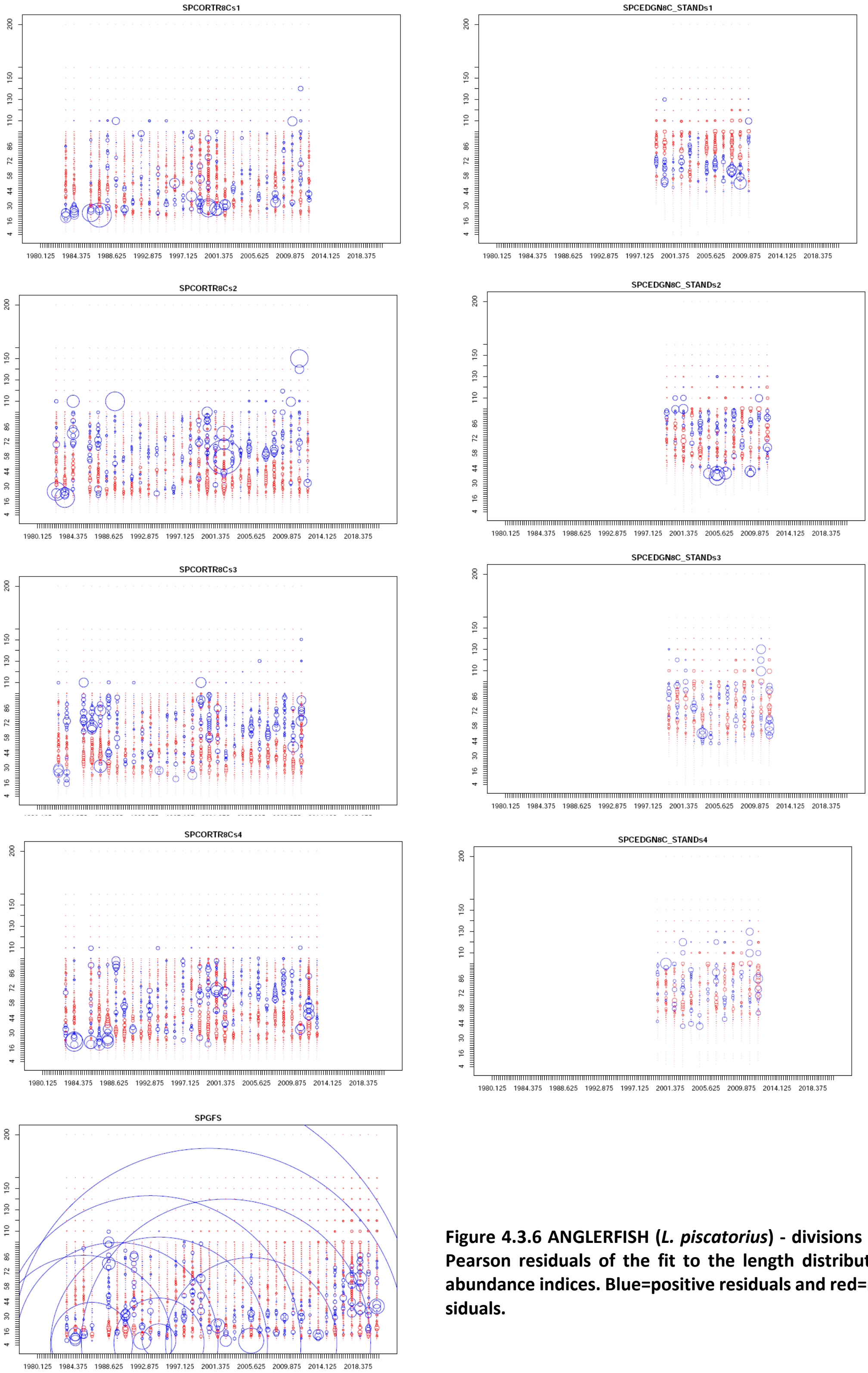

Figure 4.3.6 ANGLERFISH (*L. piscatorius*) - divisions 8.c and 9.a. Pearson residuals of the fit to the length distributions of the abundance indices. Blue=positive residuals and red=negative residuals.

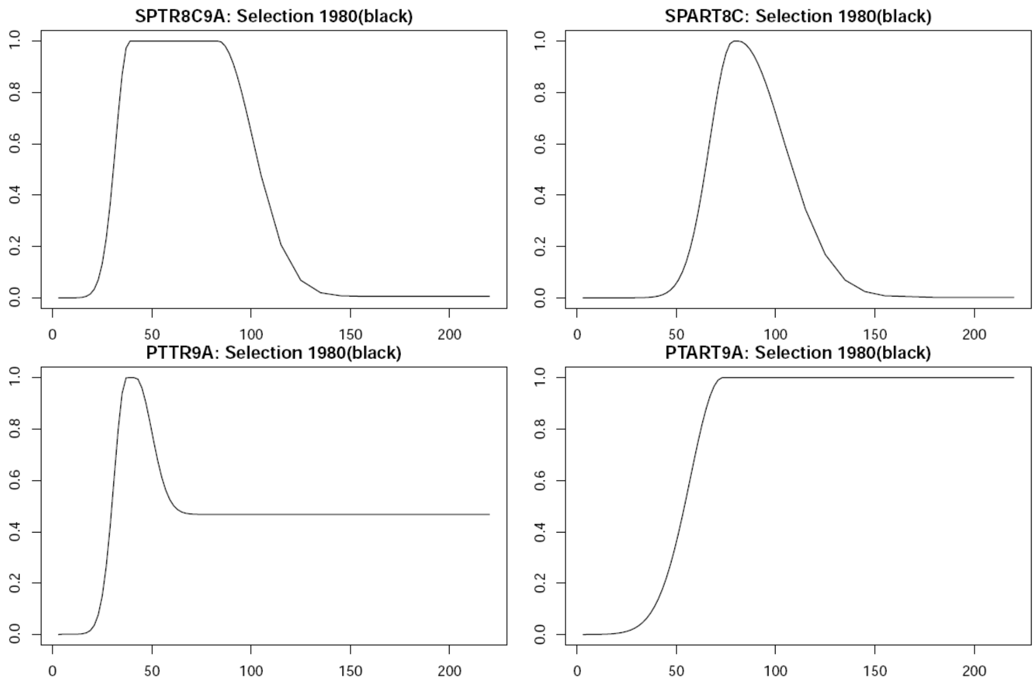

Figure 4.3.7 ANGLERFISH (*L. piscatorius*) - divisions 8.c and 9.a. Relative selection patterns at length by fishery estimated by Stock Synthesis.

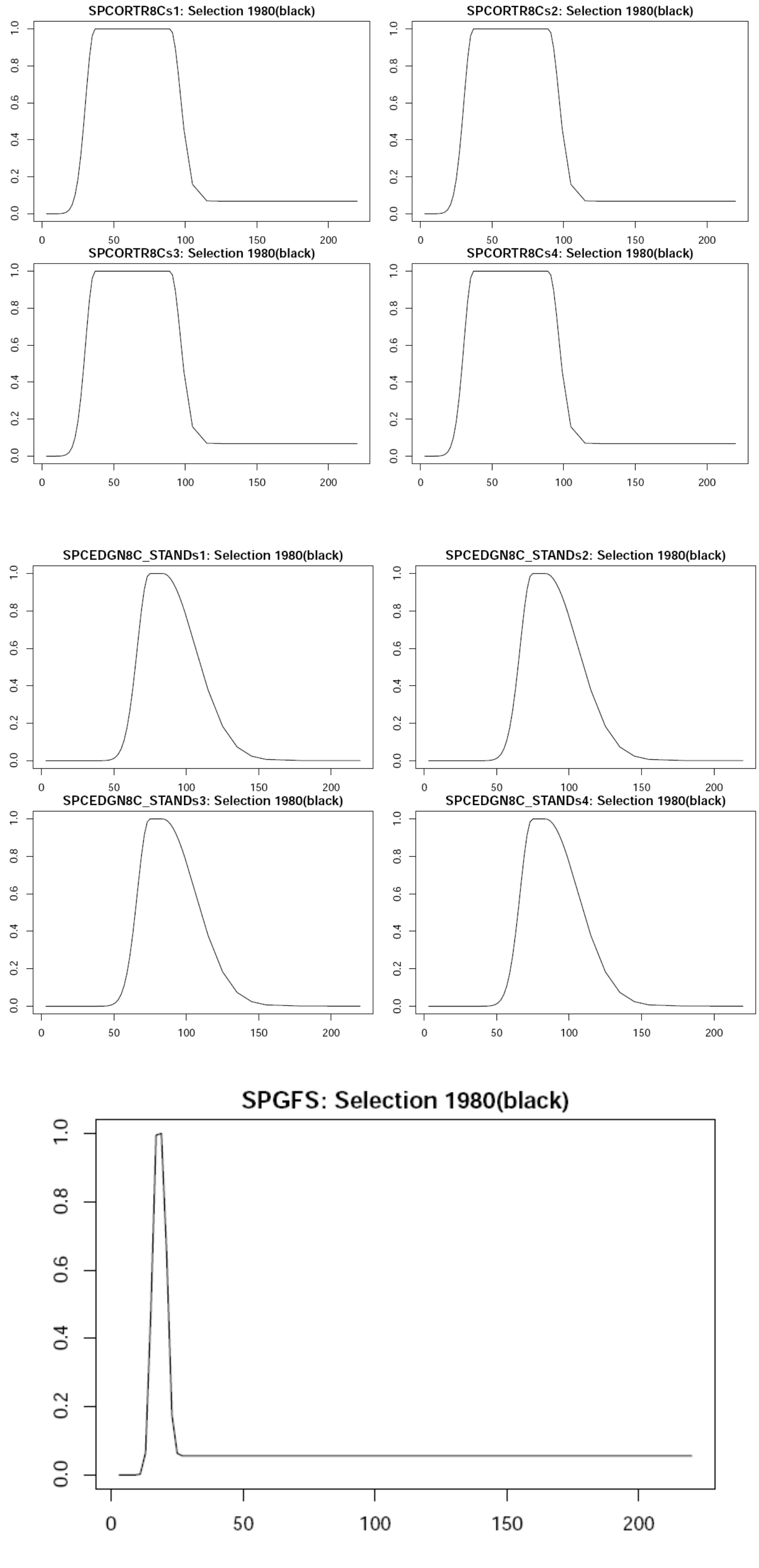

Figure 4.3.8 ANGLERFISH (*L. piscatorius*) - divisions 8.c and 9.a. Relative selection patterns at length by abundance index estimated by Stock Synthesis. A Coruña and Cedeira indices are by quarter.

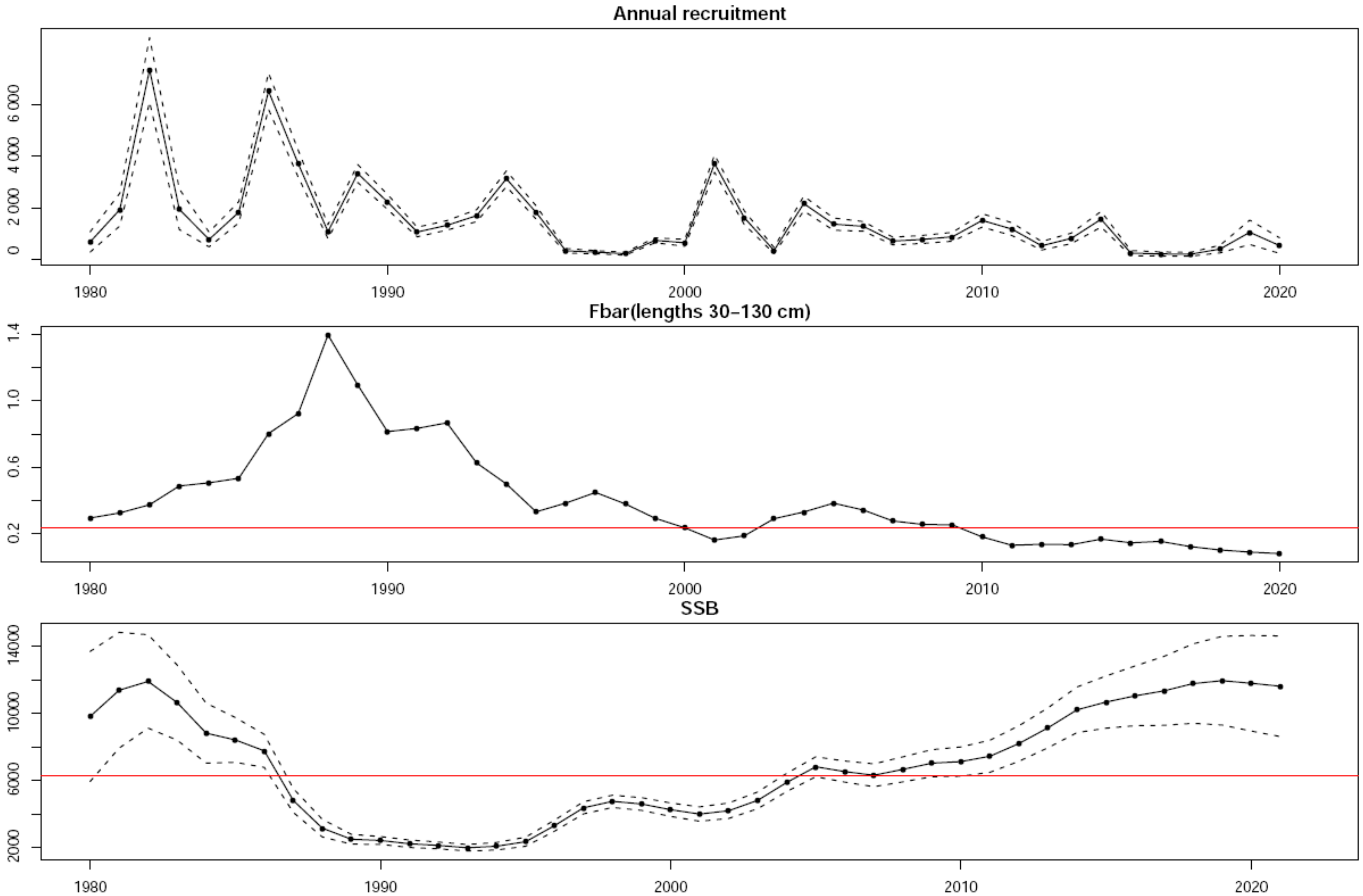

Figure 4.3.9 ANGLERFISH (*L. piscatorius*) - divisions 8.c and 9.a. Summary plots of stock trends (with 95% intervals for recruitment and SSB).

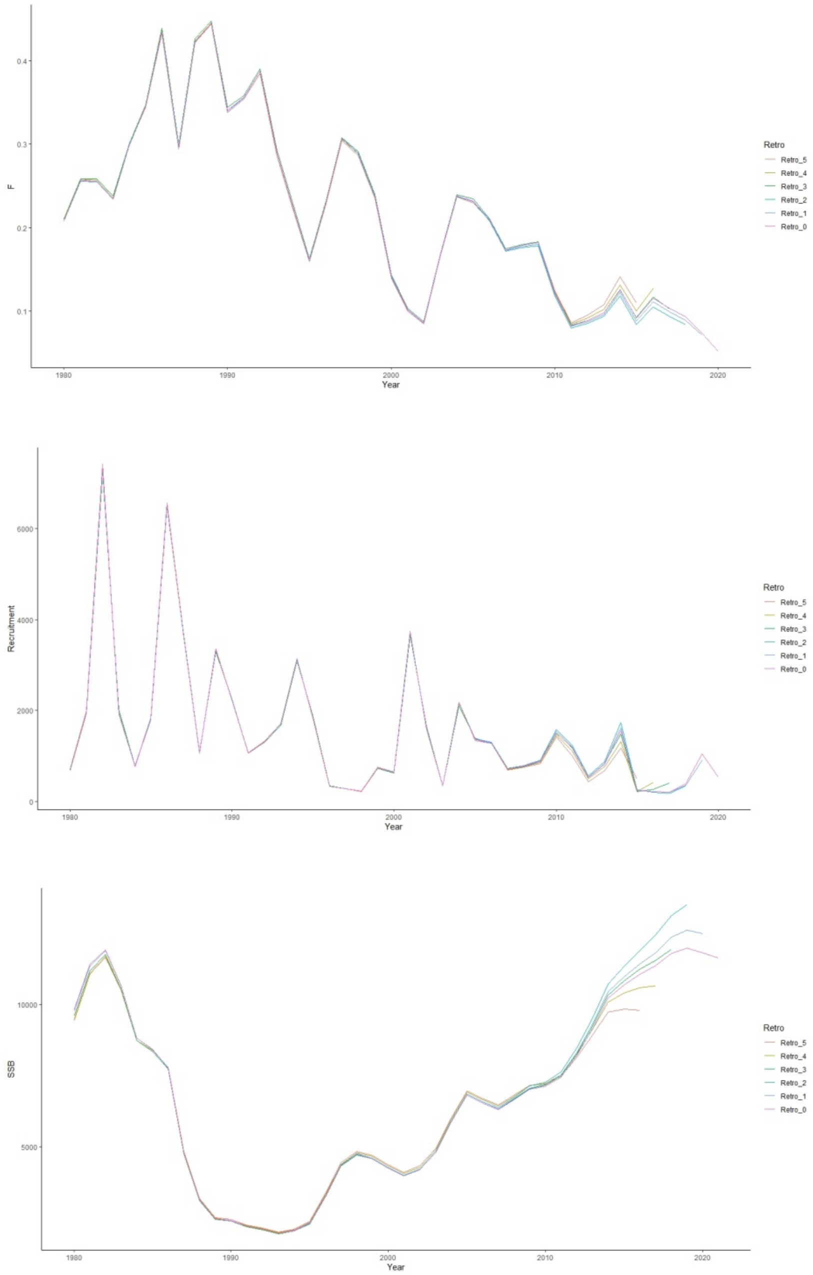

Figure 4.3.10 ANGLERFISH (*L. piscatorius*) - divisions 8.c and 9.a. Retrospective plots from SS model.

4.4 Black-bellied anglerfish (*Lophius budegassa*) in divisions 8.c and 9.a

4.4.1 General

4.4.1.1 Ecosystem aspects

Biological/ecosystem aspects are common with *L. piscatorius* and are described in the Stock Annex.

4.4.1.2 Fishery description

L. budegassa is mainly caught by Spanish and Portuguese bottom-trawlers and net fisheries (gillnet and trammelnets). As with *L. piscatorius*, *L. budegassa* is an important target species for the artisanal fleets and a bycatch for the trawl fleets targeting fish or crustaceans (see Stock Annex). French trawl, gillnet and trammelnet fisheries also catch *L. budegassa*, but reported values represent < 1% (on average) of the total landings of the stock.

The length distribution of the landings varies among fisheries, with gillnet and artisanal landings showing higher mean lengths compared to the trawl landings, except in 2017, when the mean lengths of the trawl and artisanal fisheries were similar. Since 2008, the Spanish landings were mostly allocated to the trawl fleet (66% in 2020; mean lengths in 2019 of 45.7 cm in divisions 8.c and 9.a), followed by the gillnet fishery (29% in 2020; mean length in 2019 of 59.7 cm in Division 8.c) and other fleets (5%). Portuguese landings, for the same period were mainly from the artisanal fleet (71%; mean length of 56.9 cm in 2020), followed by the trawl fleet (29%; mean length of 49.4 cm in 2020). French landings since 2008 correspond, on average, to 64% from the trawl fleet, 35% from the gillnet fleet and < 1% from others fleets.

4.4.2 Data

4.4.2.1 Commercial catches and discards

Total landings of *L. budegassa* by country and gear for the period 1978–2020, as estimated by the Working Group, are given in Table 4.4.1. Portuguese and Spanish landing data and discards were revised for WKANGLER 2018 benchmark (ICES, 2018a). French landings data were available to WGBIE since 2002. Historical landings analysis is presented in the Stock Annex. Unallocated/non reported landings for this stock were available from 2011 to 2016 and again in 2018–2019. Estimates of unallocated or non-reported landings were based on the sampled vessels (Spanish concurrent sampling) and raised to the total effort for each métier and quarter. The unallocated/non reported values were considered realistic and are included in the assessment.

From 2002 to 2007, landings increased to 1306 t, decreasing afterwards to levels between 754-774 t in 2009–2010. From 2011 to 2016, catches fluctuated between 948 and 1141 t but decreased since then, reaching 669 t in 2019. In 2020 landings increased to 793 t.

Spanish trawl and gillnet discard estimates of *L. budegassa* in weight and associated coefficient of variation (CV) are shown in Table 4.4.2. The estimated Spanish trawl discards observed from 1994–2019, show two peaks, in 2006 (114 t) and in 2010 (64 t), being relatively low since then. The estimated Spanish gillnet discards are available since 2011 and varied between 0 and 14.3 t.

Sampling effort and frequency of occurrence of *L. budegassa* discards in the trawl Portuguese fisheries were presented for the 2004–2013 period (Prista *et al*. 2014, WD03 in ICES, 2014). The maximum frequency of occurrence in discards in the trawl fleet targeting fish was 2% (sampling effort varies between 50 and 194 hauls per year). The maximum occurrence of discards in the trawl fleet targeting crustaceans was 8% (sampling effort varies between 28 and 111 hauls per year). Due to the low frequency of occurrence of anglerfish in the discards, it is not possible to apply the algorithm used for hake (presented in Prista *et al*. 2014 – WD3 in ICES, 2014). For this reason, discard estimates were not calculated since 2014.

Partial information on the Spanish and Portuguese discards was available and the WG concluded that discards could be considered negligible.

4.4.2.2 Biological sampling

The procedure for sampling this species is the same as for *L. piscatorius* (see both *L. piscatorius* and *L. budegassa* Stock Annexes).

The sampling levels for 2020 are shown in Table 1.4. The number of samples decreased due to the COVID-19 pandemic both in Portugal and Spain and also due to administrative issues in Spain.

The métier sampling adopted in Spain and Portugal in 2009, following the requirement of EU Data Collection Framework, can have an effect on the data provided. Excluding 2020, Spanish sampling levels are similar to previous years but a notable reduction of Portuguese sampling levels was observed in 2009–2011. Since 2012, Portugal increased the sampling effort.

Length composition

Table 4.4.3 gives the annual length compositions by ICES division, country and gear and the adjusted length composition for total stock landings for 2020). The new data should be interpreted with caution given the low levels of sampling for some fleets. Length composition is not used in the assessment of *L. budegassa* but provides ancillary information.

The annual length compositions for the years between 2002 and 2020 are presented in Figure 4.4.1. The total annual landings in numbers, the annual mean length and the mean weight are presented in Table 4.4.4. In 2020, individuals < 25 cm were frequent in catches, in values close to those observed in 2013 and 2014. This is the first peak in those classes since 2015, when a small number of individuals was also recorded. The estimated mean length (42 cm) is the lowest since 2007. The decrease in the number of samples can lead to some bias in these estimates.

The estimated total number of landed individuals shows a remarkable decrease in the year 2000, when compared to previous years. In 2005, the value was 9% of the maximum value (observed in 1987). In 2006 and 2007, the number of landed fish more than doubled the 2005 number. The estimated number of landed fish decreased to a minimum in 2009 and varied between 230 and 531 thousand since then, showing the lowest values in the time-series. The estimated mean weight is relatively high since 2012 (> 2 kg).

4.4.2.3 Abundance indices from surveys

Spanish and Portuguese survey results for the period 1983–2020 are summarized in Table 4.4.5. The Portuguese survey was not performed in 2012, 2019 and 2020. Considering the very small number of anglerfish caught in the SpGFS-WIBTS-Q4 (code: G2784) and PtGFS-WIBTS-Q4 (code: G8899) surveys, these indices were considered unsuitable to evaluate the change in abundance of this species. However, they can provide some information about recruitment. On the contrary, data from SPGFS-caut-WIBTS-Q4 (Gulf of Cádiz, code: G4309) are regular and its usefulness has been considered promising (ICES, 2018a, 2021a) but more studies on species distribution are needed to better interpret results from this survey. The biomass index from this survey increased since the beginning of the time-series, reaching a maximum value in 2015. The biomass values in 2019 and 2020 are lower than the value estimated for 2018 but are still among the highest values of the time-series.

The small number of specimens < 20 cm in the Spanish bottom-trawl surveys on the Northern Spanish Shelf suggest a lack of recruitment in the surveyed area during the period 2017–2019 (Figure 4.4.2). The peak of individuals < 20 cm observed in 2020 is the first signal of recruitment since 2016. A similar distribution is observable in the length distribution from the SPGFS-caut-WIBTS-Q4 (Gulf of Cádiz; code: G4309) in 2020 (Figure 4.4.3).

4.4.2.4 Commercial catch-effort data

Landings, effort and LPUE data are given in Table 4.4.6 and Figure 4.4.4 for Spanish trawlers from ports of Santander, Avilés and A Coruña (all in Division 8.c) since 1986, and for Portuguese trawlers (Division 9.a) since 1989. Data are also available for the standardized Cedeira gillnet fleet from 1999 to 2012. For each fleet, the proportion in relation to the total landings is given. Landed values for each of the Portuguese trawl fleets were updated from 2012 onwards.

Since 2013, Spain only provides information for A Coruña port series. Effort data for this tuning fleet in 2013 were calculated using the information from electronic logbooks and following different criteria than those established for previous years. In order to check the consistency of the Spanish time-series, a backward revision of the time-series is needed to compare the different estimation methods and sources of information used. The standardization of the series should be also conducted. This series was not updated with information for the year 2020.

Three LPUE series were presented in the past for the A Coruña trawler fleet: (a) "A Coruña port" for trips that are exclusively landed in the port; (b) "A Coruña trucks" for trips that are landed in other ports; (c) and "A Coruña fleet" that takes into account all the trips of the A Coruña trawler fleet. The LPUE series previously used in the assessment (A Coruña fleet) was not updated since 2012.

Until 2011, for the Portuguese fleets, most logbooks were filled in paper but have thereafter been progressively replaced by electronic logbooks. Since 2013, > 90% of the logbooks were reported in the electronic version. Generalized linear mixed models (GLMMs) were used to standardize both LPUE data, considering as independent variables Year, Quarter, Area and as the random variable Vessel. Details can be found in the Benchmark Workshop on the development of MSY advice for category 3 stocks using Surplus Production Model in Continuous Time report (WKMSYSPiCT – ICES, 2021a).

Logbook data from the Portuguese artisanal fleet, particularly from vessels targeting *Lophius* spp. are also available since 2008 (electronic and paper). A LPUE series for the fleet targeting anglerfish with trammelnets was presented to WKMSYSPiCT (ICES, 2021a). However, more work is needed particularly to accommodate targeting effects using more adequate methodologies (e.g. clustering methods) as well as higher spatial resolution (ICES, 2021a).

Excluding the Avilés and Santander fleets, the overall trend in landings for all fleets was decreasing from the late eighties to mid-nineties (Figure 4.4.4). A slight increase was observed from 1995 to 1998. The A Coruña fleet showed the most important drop in landings and in relative proportion of total landings in 2002. LPUEs of Spanish Avilés and Santander fleets show high values during the second half of the 90s. Despite the variability observed, a decreasing trend was observed for all fleets from 2000 to 2005 which was then followed by a slightly increasing trend. The LPUE time-series from the Portuguese trawl fleet targeting crustaceans shows an increasing trend reaching a maximum value in 2018. The value in 2020 is among the highest of the time-series. The LPUE time-series from the Portuguese trawl fleet targeting fish is variable but also shows an increasing trend from 2001 to 2012. Similarly to the crustacean fleet, the value in 2020 is among the highest of the time-series.

Effort trend analysis was presented in section 4.3.4.4.

4.4.3 Assessment

4.4.3.1 History of the assessment

In WKANGLER 2018 (ICES, 2018a), a new model, SPiCT (Pedersen and Berg, 2017), was proposed for the assessment of *L. budegassa*, a stochastic production model in continuous time. This model was considered more reliable than the previous model used, ASPIC (Prager, 1992, 1994).The benchmarked approach gave comparable trends, but the estimates of stock biomass were notably higher, and fishing mortality lower compared with the previous assessment method. A stepwise approach was proposed by WGBIE 2018 but was rejected by ACOM. Given the uncertainties regarding the absolute levels of biomass and fishing pressure, the assessment was considered as indicative of trends only and it was decided to present the advice as a category 3.2 stock with proxy reference points, based on SPiCT results (ICES, 2018b).

A new benchmark was proposed for this stock in 2021 using SPiCT. cpue data available for the stock were revised and several tests were conducted. Results and discussion of the results are available at WKMSYSPiCT report (ICES, 2021a).

4.4.3.2 Exploratory assessment with Stock Synthesis

Tests with stock synthesis model (SS3; Methot and Wetzel, 2013) were conducted during the Workshop on Tools and Development of Stock Assessment Models Using a4a and Stock Synthesis (WKTaDSA). A length-based model was developed assuming one area, one season, catch data from nets fleets (gillnets and trammelnets) and from trawl fleets (data from Portugal and Spain combined), two commercial LPUE indices and one biomass series from SpGFS-WIBTS-Q4 (code: G2784) to inform about recruitment. Several model configurations were tested but more work is required to reach a base model. The workshop was conducted prior to WKMSYPiCT and conclusions from this benchmark should be considered in future. However, results from SS model were promising and are available at WKTaDSA report (ICES, 2021b). Some comments are also available at WKMSYSPiCT report (see reviewers' comments).

4.4.3.3 SPiCT Model

The SPiCT model was revised at WKMSYSPiCT (ICES, 2021a). The new model assumes the Schaefer population growth model (fixed parameter) and the default biomass and catches observed/process error ratios (alpha and beta, respectively).

The SPiCT input data:

- Total landings from 1980–2020 (discards are considered negligible).
- Portuguese trawl fleet targeting fish (1989–2020) (Index 1)

The input data are presented in Tables 4.4.1 (Landings) and 4.4.6. (cpue index for the Portuguese trawl fleet targeting fish) and Figure 4.4.5.

SPiCT settings:

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

From the LPUE tuning indices previously used, only the PT-TRF9a, now standardized, was maintained. The other two indices were not considered due to uncertainty around the trends in the last years of the series in the case of PT-TRC9 and autocorrelation issues with the SP-CORTR8c (fleet series; not updated since 2012). PT-TRC9 was driving the stock to a very optimistic status which is not in agreement with the historical landings trajectory and with the low landings obtained in 2019. In this model, a prior for B/K of 0.5 was assumed, as exploitation was likely to occur before the beginning of the available time-series. Despite target fisheries development in the late 1970s, previously, the species was likely to be caught and discarded in other fisheries.

4.4.3.4 Assessment diagnostics

No significant bias or autocorrelation were found and both QQ-plot and the Shapiro test shows normality in the residuals (Figure 4.4.6.). Confidence intervals for F/F_{MSY} and B/B_{MSY} do not extend more than 1 order of magnitude, as proposed by Mildenberger *et al*. (2021).

Some retrospective pattern is observed, suggesting some past overestimation of fishing mortality and underestimation of biomass. However, each peel of the retro is within the 95% confidence intervals of the assessment (Figure 4.4.7.). The Mohn's rho statistics (Mohn, 1999) were estimated as - 0.033 and 0.01 for B/B_{MSY} and F/F_{MSY}, respectively, indicating no strong retrospective pattern.

4.4.3.5 Assessment results

SPiCT results are presented in Tables 4.4.7. and 4.4.8 and in Figure 4.4.8. The stock biomass (B) increased from 2002 to 2013 and was then stable until 2018. An increase was registered in the last two years of the series. B/B_{MSY} is estimated to be above MSY $B_{trigger}$ proxy over the whole time-series. Fishing mortality (F) has decreased since 1998 and is estimated to have been below F_{MSY} proxy since 2004 (with exception of 2007).

The perception of the status of stock did not change with the new model. Trends in F/F_{MSY} are similar to those obtained in the 2020 assessment, but less optimistic. Regarding B/B_{MSY}, trends are also similar to those previously presented but no increase in biomass is visible around the 2000s.

4.4.4 Short-term projections

Short-term projections consider the fishing mortality in the intermediate year as the estimated F at the time-step of the last observation and the estimated seasonal F process. Results for each scenario discussed in WKMSYPiCT are presented in Table 4.4.9. All the scenarios considered for fishing mortality are expected to keep the stock above B_{MSY} in 2022. Although the stock is included in the multiannual plan for stocks fished in the Western Waters and adjacent waters (EU, 2019), F_{MSY} ranges were not yet defined.

4.4.5 Biological reference points

WKANGLER (ICES, 2018a) reiterated the basis for MSY reference points previously assumed by ICES. Those reference points were later considered as proxies (ICES, 2018b). See section 4.4.4. for further details.

Framework	Reference point	Relative value	Technical basis	Source
MSY approach	MSY $B_{trigger}$	0.5*	Relative value (B/BMSY) from the SPiCT assessment model. BMSY is estimated directly from the SPiCT model and changes when the assessment is updated.	ICES (2021a)
	F_{MSY}	1*	Relative value (F/FMSY) from the SPiCT assessment model. FMSY is estimated directly from the SPiCT model and changes when the assessment is updated.	ICES (2021a)
Precautionary approach	$B_{lim\ proxy}$	0.3 × B_{MSY} *	Relative value (equilibrium yield at this biomass is 50% of the MSY proxy).	ICES (2021a)

	B_{pa}	Not defined		
	$F_{lim\ proxy}$	1.7 × F_{MSY} *	Relative value (the F that drives the stock to the proxy of B_{lim}).	ICES (2021a)
	F_{pa}	Not defined		
Management plan	SSB_{mgt}	Not applicable		
	F_{mgt}	Not applicable		

***No reference points are defined for this stock in terms of absolute values. The SPiCT-estimated values of the ratios F/FMSY and B/BMSY are used to estimate stock status relative to the MSY reference points.**

4.4.6 Comments on the assessment

This stock was benchmarked in 2021 and advice is now given under MSY approach (WKMSYSPiCT, 2021a). Therefore, the present assessment is not fully comparable with previous years assessment (see section 4.4.4. Assessment).

The stock is included in the multiannual plan for stocks fished in the Western Waters and adjacent waters (EU, 2019) but reference points for F_{MSY} ranges are still not defined for this stock under the new assessment model.

The collection of data from the commercial fishery and research surveys during 2020 has been impacted by COVID-19 restrictions to a varying degree across member states. For this stock, the diagnostics for the assessment were deemed acceptable and the impact on the perception of the stock status and advice is considered minimal.

4.4.7 Quality considerations

Until 2011, for the Portuguese fleets, most logbooks were filled in paper but have thereafter been progressively replaced by e-logbooks. Since 2013 more than 90% of the logbooks are being completed in the electronic version. The LPUE series were standardized using the data previously used in the assessment. Revision of the data and improvement in the standardization methods should also be considered to accommodate targeting effects using more adequate methodologies (e.g. clustering methods) as well as higher spatial resolution. Standardized LPUEs are also required from fleets operating in other areas where the stock distributes. In addition, more accurate information on stock biology, ecology and distribution as well as on the behaviour of the fisheries is desirable to understand and validate some biomass indicators available for the stock (ICES, 2021a).

4.4.8 Management considerations

Management considerations are in section 4.2.

4.4.9 References

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4.4.10 Tables and figures

Table 4.4.1. Black-bellied anglerfish (*L. budegassa*) - divisions 8.c and 9.a. Tonnes landed by the main fishing fleets for 1978–2020 as determined by the Working Group. n/a: not available

	Div. 8c							Div. 9a							Div. 8c+9a	
	SPAIN			FRANCE				SPAIN			PORTUGAL				Unallocated/	
Year	Trawl	Gillnet	Others	Trawl	Gillnet	Others	TOTAL	Trawl	Gillnet	Others	Trawl	Artisanal	TOTAL	SUBTOTAL	Non reported	TOTAL
1978	n/a	n/a					n/a	248			n/a	107	355	355		355
1979	n/a	n/a					n/a	306			n/a	210	516	516		516
1980	1203	207					1409	385			n/a	315	700	2110		2110
1981	1159	309					1468	505			n/a	327	832	2300		2300
1982	827	413					1240	841			n/a	288	1129	2369		2369
1983	1064	188					1252	699			n/a	428	1127	2379		2379
1984	514	176					690	558			223	458	1239	1929		1929
1985	366	123					489	437			254	653	1344	1833		1833
1986	553	585					1138	379			200	847	1425	2563		2563
1987	1094	888					1982	813			232	804	1849	3832		3832
1988	1058	1010					2068	684			188	760	1632	3700		3700
1989	648	351					999	764			272	542	1579	2578		2578
1990	491	142					633	689			387	625	1701	2334		2334
1991	503	76					579	559			309	716	1584	2162		2162
1992	451	57					508	485			287	832	1603	2111		2111
1993	516	292					809	627			196	596	1418	2227		2227
1994	542	201					743	475			79	283	837	1580		1580
1995	924	104					1029	615			68	131	814	1843		1843
1996	840	105					945	342			133	210	684	1629		1629
1997	800	198					998	524			81	210	815	1813		1813
1998	748	148					896	681			181	332	1194	2089		2089
1999	565	127					692	671			110	406	1187	1879		1879
2000	441	73					514	377			142	336	855	1369		1369
2001	383	69					452	190			101	269	560	1013		1013
2002	202	74		10	1	0	288	234	0	0	75	213	522	810		810
2003	279	49		9	0	0	338	305	0	0	68	224	597	934		934
2004	251	120		14	5	0	391	285	0	0	50	267	603	993		993
2005	273	97		26	9	0	405	283	0	0	31	214	527	933		933
2006	323	124		12	1	0	460	541	0	0	39	121	701	1161		1161
2007	372	68		4	1	0	444	684	0	0	66	111	861	1306		1306
2008	386	70		5	1	0	462	336	0	0	40	119	495	957		957
2009	301	148		3	1	0	454	172	0	0	34	114	320	774		774
2010	319	81		2	1	0	403	197	0	0	70	84	351	754		754
2011	214	115	32	3	0	0	364	157	60	98	75	119	510	874	74	948
2012	161	83	22	2	0	0	268	109	40	90	156	370	765	1033	109	1141
2013	221	135	14	4	1	0	375	95	55	90	100	258	598	973	98	1071
2014	187	126	7	5	2	0	326	120	47	4	116	286	572	898	100	998
2015	233	141	1	2	2	0	380	103	62	2	126	222	515	895	152	1047
2016	203	118	5	2	2	0	330	103	79	2	120	257	560	889	125	1014
2017	163	153	0	1	3	0	319	109	62	1	68	302	542	861		861
2018	186	156	1	7	9	0	359	126	37	1	52	185	402	761	11	773
2019	137	117	0	1	2	0	259	109	49	1	43	135	337	595	73	669
2020	126	65	0	4	2	0	198	138	5	3	128	321	596	793		793

Table 4.4.2. Black-bellied anglerfish (*L. budegassa*) - divisions 8.c and 9.a. Weight and percentage of discards for Spanish trawl and gillnet fleets.

TRAWL				
Year	**Weight (t)**	**CV**	**% Trawl Catches**	**% Total Catches**
1994	6.1	24.4	0.6	0.4
1995	n/a	n/a	n/a	n/a
1996	n/a	n/a	n/a	n/a
1997	21.3	35.2	1.6	1.2
1998	n/a	n/a	n/a	n/a
1999	19.7	43.7	1.6	1.0
2000	8.7	35.1	1.1	0.6
2001	n/a	n/a	n/a	n/a
2002	n/a	n/a	n/a	n/a
2003	1.4	n/a	0.2	0.1
2004	10.9	n/a	2.0	1.1
2005	9.3	n/a	1.7	1.0
2006	114.0	n/a	11.7	9.8
2007	4.2	n/a	0.4	0.3
2008	4.9	n/a	0.7	0.5
2009	23.3	n/a	4.7	3.0
2010	63.5	n/a	11.0	8.4
2011	19.7	n/a	5.0	2.1
2012	5.9	n/a	2.1	0.5
2013	22.3	n/a	6.6	2.1
2014	27.8	n/a	8.3	2.8
2015	0.5	n/a	0.2	0.0
2016	0.4	n/a	0.1	0.0
2017	3.7	n/a	1.3	0.4
2018	1.1	n/a	0.3	0.1
2019	2.2	n/a	0.9	0.3
2020	2.2	n/a	0.8	0.3

TRAWL				
Year	**Weight (t)**	**CV**	**% Trawl Catches**	**% Total Catches**
GILLNETS				
2011	10.6	n/a		
2012	14.3	n/a		
2013	0	n/a		
2014	0.1	n/a	0.03	0.01
2015	0.4	n/a	0.18	0.04
2016	5.0	n/a	2.47	0.49
2017	10.9	n/a	4.82	1.26
2018	2.6	n/a	1.33	0.34
2019	13.3	n/a	7.40	1.98
2020	0.9	n/a	1.33	0.12

n/a: not available

CV: coefficient of variation

Table 4.4.3. ANGLERFISH (*L. budegassa*) - divisions 8.c and 9.a. Length composition by fleet for landings (thousands) in 2020. Unreported catches excluded. Adjusted Total: adjusted to landings from fleets without length composition. n/a: not available.

	Div.8c			Div.9a				Div. 8c+9a	
	SPAIN			SPAIN	PORTUGAL				Adjusted
Length (cm)	Trawl	Gillnet	TOTAL	Trawl	Trawl	Artisanal	TOTAL	TOTAL	TOTAL
14				3,617			3,617	3,617	3,711
15									
16				7,233			7,233	7,233	7,421
17				7,233			7,233	7,233	7,421
18				7,233			7,233	7,233	7,421
19				10,850			10,850	10,850	11,133
20				18,083			18,083	18,083	18,554
21				3,617			3,617	3,617	3,711
22				21,700			21,700	21,700	22,265
23				18,083			18,083	18,083	18,554
24				7,233			7,233	7,233	7,421
25				18,083			18,083	18,083	18,554
26									
27									
28									
29									
30				3,617			3,617	3,617	3,711
31	0,125		0,125					0,125	0,133
32	0,008		0,008		0,232		0,232	0,240	0,240
33	0,006		0,006		0,465		0,465	0,470	0,471
34	0,137		0,137		0,465		0,465	0,601	0,609
35	0,006		0,006		0,529		0,529	0,535	0,535
36	0,039	0,006	0,045		1,142		1,142	1,187	1,190
37	0,110		0,110	0,781	2,235		3,016	3,126	3,152
38	0,064		0,064	0,523	1,953		2,476	2,540	2,557
39	0,106	0,021	0,128	0,781	1,107		1,888	2,016	2,044
40	0,060	0,011	0,072		1,177	1,448	2,626	2,698	2,702
41	0,309	0,039	0,347	1,078	3,307	2,686	7,071	7,419	7,467
42	0,743	0,025	0,769	0,607	2,951	2,868	6,426	7,195	7,255
43	2,498	0,006	2,503	0,229	1,915	2,330	4,473	6,977	7,127
44	0,359	0,011	0,371		1,090	4,505	5,595	5,965	5,987
45	0,752	0,065	0,817		1,756	0,895	2,652	3,469	3,516
46	0,367	0,074	0,441	0,378	3,479	4,491	8,348	8,789	8,825
47	0,439	0,011	0,450		2,993	2,330	5,323	5,773	5,799
48	0,261	0,046	0,307	1,256	1,372	0,895	3,524	3,830	3,881
49	0,364	0,000	0,364		1,438	4,085	5,522	5,886	5,907
50	0,075	0,044	0,119		2,869	1,819	4,688	4,806	4,813
51	0,490	0,116	0,606		3,429	10,471	13,900	14,506	14,541
52	0,973	0,248	1,221	0,634	2,399	20,951	23,985	25,206	25,293
53	0,266	0,206	0,472		2,051	0,895	2,946	3,418	3,446
54	0,925	0,260	1,185	0,781	4,366	5,890	11,037	12,222	12,311
55	0,231	0,278	0,508		2,972	0,895	3,867	4,375	4,405
56	0,202	0,125	0,328		1,811		1,811	2,138	2,157
57	0,031	0,239	0,270		2,473		2,473	2,744	2,759
58	0,781	0,513	1,294		1,555		1,555	2,850	2,925
59	0,960	0,209	1,169	0,781	1,346	0,895	3,022	4,192	4,280
60	0,006	0,246	0,252		0,762		0,762	1,014	1,029
61	0,294	0,392	0,686	0,634	0,046		0,680	1,366	1,423
62	0,631	0,529	1,160		0,207	0,895	1,102	2,262	2,330
63	0,659	0,198	0,858	0,781	0,999	1,434	3,215	4,072	4,143
64	1,515	0,335	1,851	0,987	0,478		1,465	3,316	3,449
65	0,478	0,337	0,815	0,674	0,212		0,886	1,700	1,765
66	0,184	0,244	0,429	1,046	0,074		1,120	1,549	1,601
67	1,079	0,391	1,470		0,161		0,161	1,631	1,717
68	1,040	0,496	1,536	0,523	0,028	8,616	9,167	10,703	10,806
69	0,847	0,481	1,327	0,210	0,125		0,335	1,663	1,745
70	0,035	0,287	0,321	0,443	0,207		0,650	0,971	1,002
71	0,284	0,123	0,406	0,515	0,107		0,622	1,029	1,066
72	0,461	0,657	1,118	0,903			0,903	2,021	2,110
73	0,020	0,316	0,337		0,046		0,046	0,383	0,403
74	0,894	0,189	1,083	0,210	0,093	1,791	2,094	3,177	3,245
75	0,085	0,265	0,350		0,065		0,065	0,415	0,435
76	0,009	0,253	0,262	1,568	0,079		1,647	1,909	1,965
77	0,099	0,091	0,190	0,523	0,152	0,909	1,584	1,774	1,799
78				0,519			0,519	0,519	0,533
79		0,028	0,028			1,434	1,434	1,463	1,464
80	0,006	0,066	0,072			0,909	0,909	0,982	0,986
81	0,015	0,035	0,050		0,087	0,895	0,982	1,032	1,035
82	0,044	0,149	0,193		0,087		0,087	0,280	0,291
83	0,000	0,083	0,083		0,087	0,539	0,626	0,709	0,714
84	0,177		0,177					0,177	0,187
85	0,432		0,432					0,432	0,457
86					0,357		0,357	0,357	0,357
87									
88		0,028	0,028		0,174	0,895	1,069	1,098	1,100
89		0,028	0,028		0,299		0,299	0,326	0,328
90						1,448	1,448	1,448	1,448
91						0,895	0,895	0,895	0,895
92				0,210		1,434	1,644	1,644	1,650
93		0,081	0,081			1,791	1,791	1,871	1,876
94						1,434	1,434	1,434	1,434
95									
96									
97		0,141	0,141					0,141	0,150
98									
99		0,088	0,088					0,088	0,093
100+		0,344	0,344		0,087		0,087	0,431	0,451
TOTAL	21	9	30	144	60	94	298	328	334
Landings (t)	126	65	191	138	128	321	587	778	793
Mean Weight (g)	6029	6822	6275	959	2144	3424	1973	2372	2377
Mean Length (cm)	57,2	63,3	59,0	25,9	49,4	56,9	40,4	42,1	42,0
Measured weight (t)	n/a	n/a	n/a	n/a	1171,3	738,8	1910,1	n/a	n/a

Table 4.4.4. Black-bellied anglerfish (*L. budegassa*) - divisions 8.c and 9.a. Number, mean weight and mean length of landings between 1986 and 2020.

Year	Total (thousands)	Mean Weight (g)	Mean Length (cm)
1986	1704	1504	43
1987	4673	820	34
1988	2653	1395	43
1989	1815	1420	44
1990	1590	1468	44
1991	1672	1294	42
1992	1497	1410	45
1993	1238	1799	48
1994	1063	1486	44
1995	1583	1157	40
1996	1146	1422	44
1997	1452	1248	41
1998	1554	1380	42
1999	1268	1487	42
2000	680	2010	47
2001	435	2329	49
2002	514	1497	41
2003	507	1826	46
2004	468	1974	47
2005	408	2198	49
2006	1030	1115	37
2007	1036	1255	39
2008	503	1889	48
2009	298	2585	51
2010	387	1940	45
2011	531	1641	43
2012	435	2366	49
2013	361	2678	50

Year	Total (thousands)	Mean Weight (g)	Mean Length (cm)
2014	442	2011	43
2015	406	2195	49
2016	340	2602	52
2017	324	2662	50
2018	295	2015	51
2019	230	2591	50
2020	334	2377	42

Table 4.4.5. Black-bellied anglerfish (*L. budegassa*) - divisions 8.c and 9.a. Abundance indices from Spanish (SpGFS-WIBTS-Q4, G2784: stratified mean; SPGFS-caut-WIBTS-Q4, G4309: stratified mean) and Portuguese research surveys (PtGFS-WIBTS-Q4, G8899; simple mean).

	SpGFS-WIBTS-Q4					PtGFS-WIBTS-Q4			SPGFS-caut-WIBTS-Q4				
	September-October (total area Miño-Bidasoa)					October			Gulf of Cádiz				
Year	Hauls	kg/30 min		n/30 min		Hauls	n/h	kg/h	Hauls	g/h	se (biom.)	n/h	se (abund.)
		Yst	Sst	Yst	Sst								
1983	145	0,68	0,17	0,50	0,09	117	n/a	n/a					
1984	111	0,60	0,17	0,60	0,11	na	n/a	n/a					
1985	97	0,46	0,11	0,50	0,07	150	n/a	n/a					
1986	92	1,42	0,32	2,50	0,33	117	n/a	n/a					
1987	ns	ns	ns	ns	ns	81	n/a	n/a					
1988	101	2,27	0,38	1,50	0,21	98	n/a	n/a					
1989	91	0,45	0,10	0,90	0,21	138	0,23	0,19					
1990	120	1,52	0,47	1,50	0,22	123	0,11	0,17					
1991	107	0,83	0,14	0,60	0,10	99	+	0,02					
1992	116	1,16	0,19	0,80	0,11	59	+	+					
1993	109	0,90	0,20	0,90	0,13	65	0,02	0,04	29	215	20.95	0.22	0.02
1994	118	0,75	0,17	1,00	0,12	94	0,06	0,09	ns	ns	ns	ns	ns
1995	116	0,72	0,12	1,00	0,11	88	0,02	0,08	ns	ns	ns	ns	ns
1996*	114	0,95	0,17	1,30	0,18	71	0,27	0,50	ns	ns	ns	ns	ns
1997	116	1,16	0,20	0,97	0,11	58	0,03	0,01	27	267	28.94	0.24	0.02
1998	114	0,88	0,18	0,57	0,09	96	0,02	0,12	34	139	10.18	0.17	0.01
1999*	116	0,43	0,12	0,26	0,06	79	0,08	0,07	38	89	8.21	0.27	0.02
2000	113	0,66	0,18	0,40	0,08	78	0,13	0,13	30	514	29.84	0.92	0.04
2001	113	0,19	0,06	0,52	0,10	58	+	+	39	298	24.36	0.41	0.04
2002	110	0,26	0,09	0,33	0,07	67	0	0	39	224	22.58	0.33	0.02
2003*	112	0,36	0,11	0,35	0,10	80	0,22	0,21	41	370	30.2	0.3	0.02
2004*	114	0,76	0,23	0,44	0,12	79	0,14	0,21	40	509	37.94	0.26	0.02
2005	116	0,64	0,20	1,62	0,30	87	0,01	+	42	990	43.43	2.6	0.08
2006	115	1,08	0,22	1,16	0,19	88	0,02	0,46	41	465	37.91	0.22	0.01
2007	117	0,59	0,12	0,48	0,08	96	0,02	0,03	37	703	54.25	0.4	0.03
2008	115	0,35	0,09	0,29	0,05	87	0,07	0,36	41	449	25.49	0.24	0.01
2009	117	0,30	0,08	0,35	0,08	93	0,02	+	43	561	35.11	0.43	0.02
2010	127	0,35	0,09	0,53	0,09	87	0,09	0,18	44	726	60.01	0.73	0.04
2011	111	0,63	0,15	0,52	0,08	86	0,02	0,06	40	806	43.58	0.57	0.03
2012	115	0,61	0,10	0,74	0,11	ns	ns	ns	37	723	53.73	0.77	0.03
2013**	114	1,27	0,36	1,40	0,35	93	0,02	0,03	43	1572	69.91	1.29	0.07
2014**	116	1,11	0,27	0,87	0,15	81	0,00	0,00	45	531	28.31	0.38	0.02
2015**	114	0,55	0,13	0,36	0,08	90	0,00	0,00	43	2058	96.93	1.45	0.05
2016**	114	0,51	0,10	0,40	0,06	85	0,02	0,30	45	1196	51.7	1.16	0.05
2017**	112	0,55	0,15	0,35	0,08	89	0,09	0,05	44	1085	49.24	0.76	0.03
2018**	113	0,76	0,23	0,29	0,07	53	0,08	0,10	45	1645	82.01	1.85	0.05
2019**	113	0,41	0,15	0,17	0,04	ns	ns	ns	43	1252	50.62	0.68	0.02
2020**	109	0,29	0,12	0,27	0,07	ns	ns	ns	44,00	1296	65.29	1.23	0.03

Yst = stratified mean
Sst = Standard error of the mean
ns = no survey
n/a = not available
+ = less than 0.01
*** For Portuguese Surveys - R/V Capricornio, other years R/V Noruega**
**** For both Spanish Surveys - R/V Miguel Oliver, other years R/V Cornide Saavedra**

Table 4.4.6. Black-bellied anglerfish (*L. budegassa*) - divisions 8.c and 9.a. Landings, fishing effort, standardized fishing effort, landings per unit effort and standardized landings per unit effort for trawl (all but STAND-SP-CEDGNS8C) and gill-net fleets (STAND-SP-CEDGNS8C). For landings, the percentage relative to the total annual stock landings is given.

	Avilés, SP-AVITR8C				Santander, SP-SANTR8C				Standardized Cedeira, STAND-SP-CEDGNS8C			
Year	LANDINGS	%	EFFORT (days*100hp)	LPUE (kg/day*100hp)	LANDINGS	%	EFFORT (days*100hp)	LPUE (kg/day*100hp)	LANDINGS	%	EFFORT (soaking days)	LPUE (kg/soaking day)
1986	64	3	10845	5,9	21	1	18153	1,1	--	--	--	--
1987	85	2	8309	10,3	16	0	14995	1,1	--	--	--	--
1988	125	3	9047	13,9	30	1	16660	1,8	--	--	--	--
1989	119	5	8063	14,7	32	1	17607	1,8	--	--	--	--
1990	58	2	8497	6,8	40	2	20469	1,9	--	--	--	--
1991	52	2	7681	6,7	62	3	22391	2,8	--	--	--	--
1992	33	2	--	--	107	5	22833,0	4,7	--	--	--	--
1993	53	2	7635	7,0	143	6	21370	6,7	--	--	--	--
1994	65	4	9620	6,7	196	12	22772	8,6	--	--	--	--
1995	141	8	6146	23,0	126	7	14046	9,0	--	--	--	--
1996	162	10	4525	35,8	89	5	12071	7,4	--	--	--	--
1997	143	8	5061	28,3	122	7	11776	10,4	--	--	--	--
1998	91	4	5929	15,3	114	5	10646	10,7	--	--	--	--
1999	41	2	6829	5,9	67	4	10349	6,5	14	1	4 582	3,0
2000	23	2	4453	5,1	44	3	8779	5,0	4	<1	2 981	1,3
2001	12	1	1838	6,7	28	3	3053	9,3	6	1	1 932	3,0
2002	11	1	2748	4,1	16	2	3975	4,1	7	1	2 398	3,0
2003	9	1	2526	3,6	15	2	3837	4,0	3	<1	2 703	0,9
2004	32	3	--	--	23	2	3776,0	6,0	5	1	4 677	1,1
2005	54	6	--	--	7	1	1404,0	4,9	2	<1	3 325	0,7
2006	16	1	--	--	18	2	2717,5	6,8	4	<1	3 911	1,0
2007	11	1	--	--	19	1	4333,7	4,5	2	<1	3 976	0,6
2008	10	1	--	--	--	--	--	--	0	<1	5 133	0,1
2009	5	1	--	--	8	1	1124,8	6,8	4	1	2 300	1,7
2010	--	--	--	--	19,4	3	1627,8	11,9	4	1	1 880	2,1
2011	--	--	--	--	36,4	4	--	--	1	<1	522	1,3
2012	--	--	--	--	21,8	2	--	--	4	<1	--	--

	A Coruña-Port, SP-CORTR8C-PORT				A Coruña-Trucks, SP-CORTR8C-TRUCKS				A Coruña-Fleet, SP-CORTR8C-FLEET			
Year	LANDINGS	%	EFFORT (days*100hp)	LPUE (kg/day*100hp)	LANDINGS	%	EFFORT (days*100hp)	LPUE (kg/day*100hp)	LANDINGS	%	EFFORT (days*100hp)	LPUE (kg/day*100hp)
1982	655	28	63 313	10,3	--	--	--	--	655	28	63 313	10,3
1983	765	32	51 008	15,0	--	--	--	--	765	32	51 008	15,0
1984	574	30	48 665	11,8	--	--	--	--	574	30	48 665	11,8
1985	253	14	45 157	5,6	--	--	--	--	253	14	45 157	5,6
1986	352	14	40 420	8,7	--	--	--	--	352	14	40 420	8,7
1987	673	18	34 651	19,4	--	--	--	--	673	18	34 651	19,4
1988	570	15	41 481	13,7	--	--	--	--	570	15	41 481	13,7
1989	344	13	44 410	7,7	--	--	--	--	344	13	44 410	7,7
1990	288	12	44 403	6,5	--	--	--	--	288	12	44 403	6,5
1991	225	10	40 429	5,6	--	--	--	--	225	10	40 429	5,6
1992	211	10	38 899	5,4	--	--	--	--	211	10	38 899	5,4
1993	199	9	44 478	4,5	--	--	--	--	199	9	44 478	4,5
1994	166	11	39 602	4,2	37	2	12 795	2,9	204	13	52 397	3,9
1995	353	19	41 476	8,5	75	4	10 232	7,3	428	23	51 708	8,3
1996	334	21	35 709	9,4	68	4	8 791	7,8	403	25	44 501	9,0
1997	298	16	35 494	8,4	43	2	9 108	4,8	341	19	44 602	7,7
1998	323	15	29 508	10,9	72	3	--	--	394	19	--	--
1999	374	20	30 131	12,4	--	--	--	--	--	--	--	--
2000	287	21	30 079	9,6	6	0	--	--	293	21	--	--
2001	281	28	29 935	9,4	--	--	--	--	--	--	--	--
2002	76	9	21 948	3,5	31	4	6 747	4,6	107	13	28 695	3,7
2003	85	9	18 519	4,6	43	5	7 608	5,6	128	14	26 127	4,9
2004	68	7	19 198	3,5	40	4	10 342	3,8	107	11	29 540	3,6
2005	54	6	20 663	2,6	32	3	10 302	3,1	86	9	30 965	2,8
2006	70	6	19 264	3,6	81	7	12 866	6,3	151	13	32 130	4,7
2007	109	8	21 651	5,1	113	9	13 187	8,6	223	17	34 838	6,4
2008	163	17	20 212	8,1	98	10	9 812	10,0	261	27	30 024	8,7
2009	80	10	16 152	5,0	67	9	12 930	5,2	147	19	29 092	5,1
2010	74	10	16 680	4,4	87	12	9 003	9,7	199	26	22 746	8,7
2011	64	7	12 835	5,0	--	--	--	--	144	15	18 617	7,7
2012	102	9	14 446	7,0	--	--	--	--	172	15	21 110	8,2
2013	88	8	14 736	6,0	--	--	--	--	--	--	--	--
2014	79	8	18 060	4,4	--	--	--	--	--	--	--	--
2015	67	6	13 309	5,0	--	--	--	--	--	--	--	--
2016	89	9	13 718	6,5	--	--	--	--	--	--	--	--
2017	64	7	12 449	5,2	--	--	--	--	--	--	--	--
2018	79	10	13 247	6,0	--	--	--	--	--	--	--	--
2019	75	11	12 824	5,9	--	--	--	--	--	--	--	--
2020	--	--	--	--	--	--	--	--	--	--	--	--

	Portugal Crustacean, PT-TRC9A						Portugal Fish, PT-TRF9A					
Year	LANDINGS	%	EFFORT (1000 hours)	EFFORT (1000 hauls)	LPUE (kg/hour)	LPUE (kg/haul)	LANDINGS	%	EFFORT (1000 hours)	EFFORT (1000 hauls)	LPUE (kg/hour)	LPUE (kg/haul)
1989	89	3	76	23	--	3,92	183	7	52	18	3	10,4
1990	127	5	90	20	0,8	6,2	261	11	61	17	5	15,2
1991	101	5	83	17	--	6,1	208	10	57	15	3,6	13,5
1992	94	4	71	15	1,0	6,2	193	9	49	14	2,4	14,1
1993	64	3	75	13	0,9	4,8	132	6	56	13	2,3	10,1
1994	26	2	41	8	0,6	3,4	53	3	36	10	1,2	5,5
1995	22	1	38	8	0,7	2,8	46	2	41	9	1,5	5,0
1996	45	3	64	14	0,7	3,1	88	5	54	12	2,2	7,1
1997	38	2	43	11	0,9	3,3	43	2	27	9	1,3	4,9
1998	70	3	48	11	1,3	6,3	111	5	35	10	1,2	11,5
1999	41	2	24	8	0,9	5,0	69	4	18	6	1,6	12,2
2000	66	5	42	10	2,6	6,5	76	6	19	6	2,0	12,6
2001	59	6	85	18	0,8	3,2	42	4	19	5	1,0	8,5
2002	47	6	62	10	--	4,8	28	3	14	4	2,9	6,2
2003	30	3	42	10	0,7	3,1	38	4	17	6	2,4	6,7
2004	23	2	21	7	0,9	3,5	27	3	14	4	1,9	6,2
2005	12	1	20	5	0,6	2,4	19	2	13	4	1,2	5,0
2006	18	2	22	5	0,9	3,3	22	2	12	4	1,4	5,6
2007	34	3	22	6	1,3	5,6	31	2	8	3	2,7	10,5
2008	21	2	14	4	1,2	5,4	19	2	5	2	2,1	10,6
2009	18	2	15	--	1,0	--	16	2	6	--	1,8	--
2010	37	5	21	--	1,6	--	34	4	14	--	2,8	--
2011	39	4	18	--	2,3	--	36	4	9	--	2,7	--
2012	66	6	36	--	2,7	--	90	8	16	--	5,0	--
2013	37	3	27	--	2,5	--	62	6	12	--	3,8	--
2014	50	5	17	--	2,8	--	66	7	16	--	3,1	--
2015	48	5	17	--	3,3	--	78	7	14	--	2,7	--
2016	52	5	12	--	4,4	--	67	7	11	--	3,8	--
2017	42	5	9	--	3,8	--	26	3	11	--	2,5	--
2018	36	5	5	--	4,8	--	16	2	6	--	2,9	--
2019	27	4	6	--	3,5		16	2	5	--	2,7	--
2020	52	7	--	--	4,2		76	10	--	--	4,2	--

Table 4.4.7. Black-bellied anglerfish (*L. budegassa*) - divisions 8.c and 9.a. SPiCT summary results.

Model parameter estimates w 95% CI					
	estimate	**cilow**	**ciupp**	**log.est**	
alpha	2.715	0.656	11.247	0.999	
beta	0.138	0.024	0.804	-1.983	
r	0.247	0.104	0.590	-1.397	
rc	0.247	0.104	0.590	-1.397	
rold	0.247	0.104	0.590	-1.397	
m	1767	1262	2474	7.477	
K	28584	12495	65387	10.261	
q	0.000	0.000	0.000	-8.486	
sdb	0.108	0.031	0.379	-2.225	
sdf	0.193	0.129	0.290	-1.643	
sdi	0.293	0.213	0.403	-1.226	
sdc	0.027	0.005	0.146	-3.626	
Deterministic reference points (Drp)					
	estimate	**cilow**	**ciupp**	**log.est**	
B_{MSYD}	14292	6248	32694	9.567	
F_{MSYD}	0.124	0.052	0.295	-2.090	
MSYd	1767	1262	2474	7.477	
Stochastic reference points (Srp)					
	estimate	**cilow**	**ciupp**	**log.est**	**rel.diff.Drp**
B_{MSYS}	13909	6054	31955	9.540	-0.028
F_{MSYS}	0.121	0.051	0.286	-2.114	-0.024
MSYs	1678	1241	2269	7.425	-0.053
States w 95% CI (inp$msytype: s)					
	estimate	**cilow**	**ciupp**	**log.est**	
B_2020.94	17620	8098	38338	9.777	

Model parameter estimates w 95% CI				
	estimate	**cilow**	**ciupp**	**log.est**
F_2020.94	0.048	0.021	0.107	-3.044
B_2020.94/B_{MSY}	1.267	0.683	2.349	0.237
F_2020.94/F_{MSY}	0.394	0.195	0.798	-0.930

Predictions w 95% CI (inp$msytype: s)				
	prediction	**cilow**	**ciupp**	**log.est**
B_2022.00	18352	8539	39445	9.818
F_2022.00	0.048	0.019	0.117	-3.044
B_2022.00/B_{MSY}	1.320	0.723	2.408	0.277
F_2022.00/F_{MSY}	0.394	0.176	0.883	-0.930
Catch_2021.00	857	610	1204	6.753
E(B_inf)	21564	NA	NA	9.979

Table 4.4.8. Black-bellied anglerfish (*L. budegassa*) - divisions 8.c and 9.a. SPiCT estimates for B/B_{MSY} and F/F_{MSY}. CI, 95% confidence intervals.

Year	B/B_{MSY}			F/F_{MSY}		
	Estimate	CI high	CI Low	Estimate	CI high	CI Low
1980	1.36	2.81	0.66	0.96	1.78	0.52
1981	1.36	2.65	0.7	1.03	1.86	0.57
1982	1.35	2.54	0.72	1.08	1.93	0.61
1983	1.34	2.45	0.73	1.02	1.79	0.58
1984	1.27	2.28	0.71	0.88	1.52	0.51
1985	1.21	2.14	0.69	0.97	1.65	0.57
1986	1.26	2.17	0.73	1.39	2.6	0.73
1987	1.36	2.55	0.73	1.82	4.0	0.82
1988	1.33	2.85	0.62	1.60	3.5	0.74
1989	1.14	2.37	0.55	1.35	2.8	0.64
1990	1.05	2.12	0.52	1.36	2.9	0.64
1991	0.98	2.01	0.48	1.39	2.8	0.69
1992	0.89	1.73	0.45	1.63	3.3	0.81
1993	0.82	1.6	0.42	1.58	3.0	0.84
1994	0.69	1.28	0.38	1.51	2.8	0.83
1995	0.65	1.18	0.36	1.66	3.1	0.89
1996	0.63	1.16	0.35	1.60	2.9	0.87
1997	0.61	1.11	0.34	1.91	3.6	1.01
1998	0.62	1.15	0.33	2.1	4.2	1.01
1999	0.6	1.19	0.3	1.73	3.6	0.82
2000	0.56	1.15	0.27	1.31	2.7	0.63
2001	0.54	1.08	0.26	0.97	1.98	0.48
2002	0.54	1.07	0.27	0.86	1.77	0.42
2003	0.59	1.18	0.29	0.94	1.99	0.44
2004	0.63	1.29	0.31	0.90	1.84	0.44
2005	0.63	1.25	0.32	0.90	1.84	0.44
2006	0.66	1.32	0.33	1.04	2.3	0.48

Year	B/B_{MSY}			F/F_{MSY}		
	Estimate	CI high	CI Low	Estimate	CI high	CI Low
2007	0.75	1.59	0.35	0.91	2.0	0.41
2008	0.76	1.62	0.36	0.66	1.39	0.32
2009	0.76	1.54	0.37	0.55	1.13	0.26
2010	0.81	1.62	0.4	0.54	1.14	0.25
2011	0.91	1.87	0.45	0.61	1.40	0.26
2012	1.05	2.32	0.48	0.61	1.45	0.26
2013	1.11	2.49	0.49	0.55	1.24	0.25
2014	1.1	2.33	0.52	0.55	1.19	0.25
2015	1.11	2.29	0.53	0.56	1.21	0.26
2016	1.13	2.33	0.55	0.50	1.06	0.24
2017	1.11	2.2	0.56	0.44	0.90	0.22
2018	1.1	2.11	0.57	0.38	0.75	0.195
2019	1.1	2.06	0.59	0.36	0.70	0.186
2020	1.17	2.16	0.63	0.39	0.80	0.195
2021	1.27	2.35	0.69			
Average	**0.95**	**1.87**	**0.48**	**1.05**	**2.1**	**0.53**

Table 4.4.9. Black-bellied anglerfish (*L. budegassa*) - divisions 8.c and 9.a. Estimates of catch, B/B_{msy} and F/F_{msy} for the scenarios proposed.

Scenario	Catch (t)	B/BMSY	F/FMSY
F = 0	0	1.42	0.00
F = Fsq	888	1.36	0.39
F = Fmsy	2179	1.27	1.00
F = Fmsy_c_fractile	1969	1.29	0.90

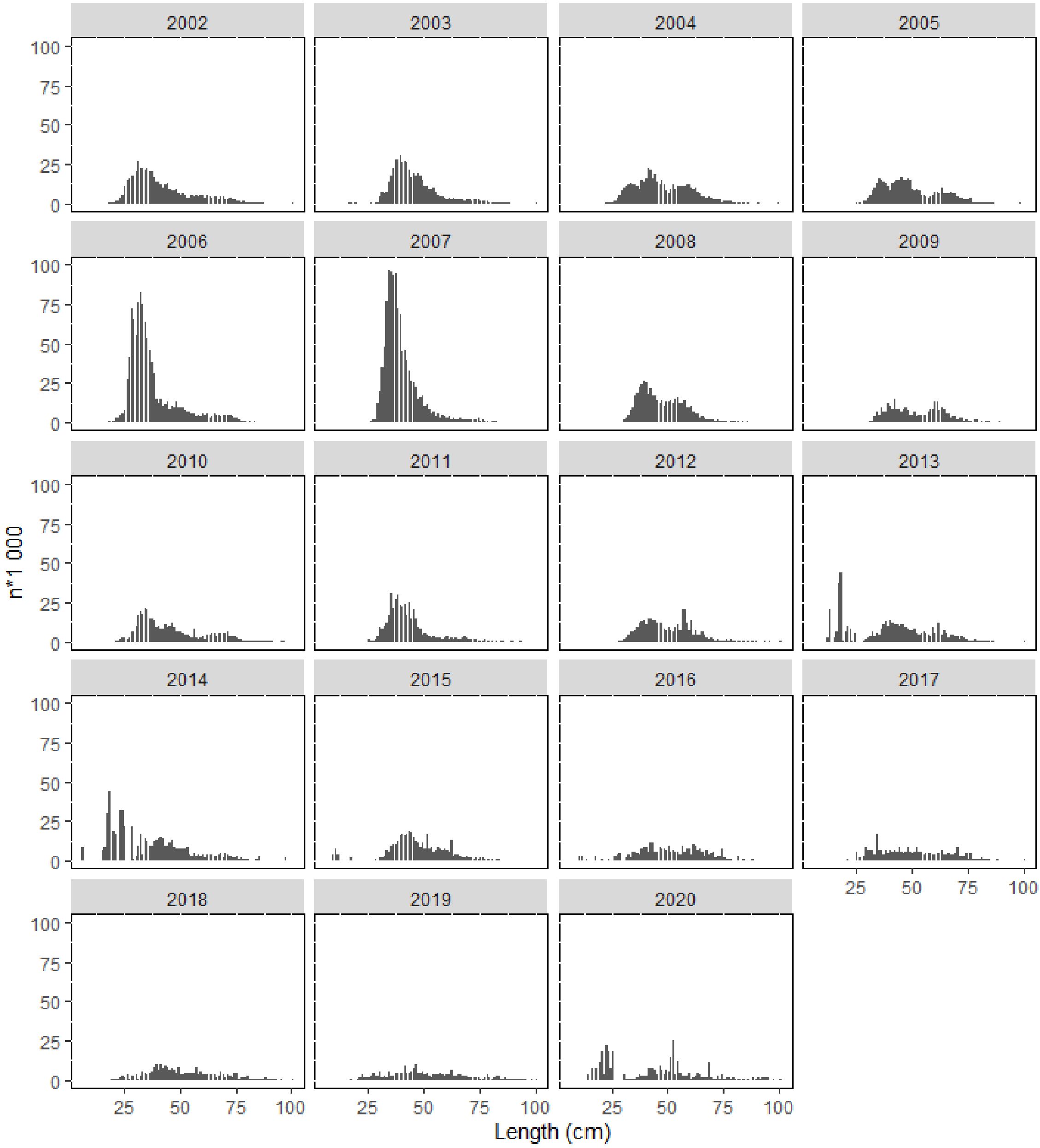

Figure 4.4.1. Black-bellied anglerfish (*L. budegassa*) - divisions 8.c and 9.a. Length distributions of landings (thousands for 2002–2020).

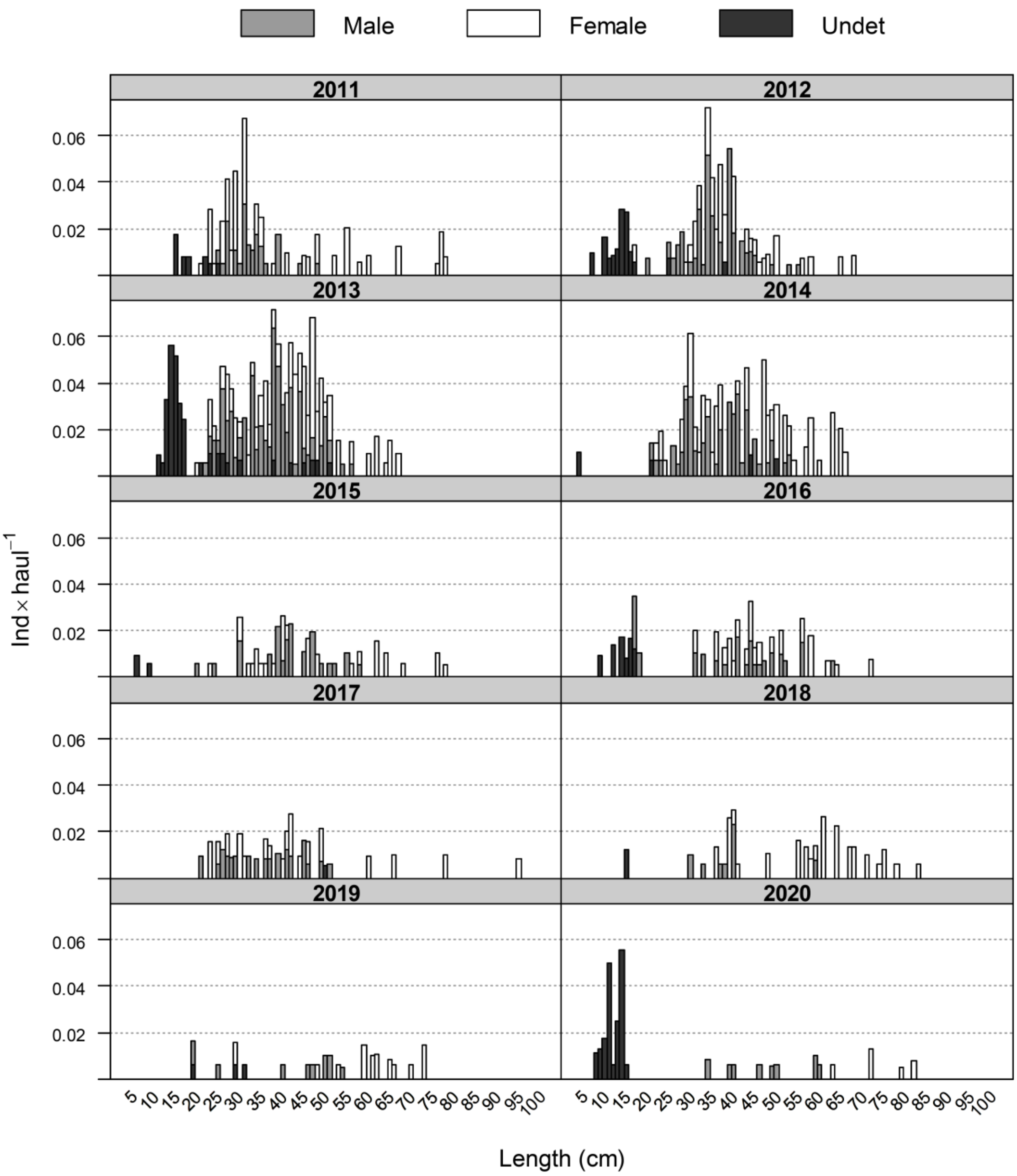

Figure 4.4.2. Black-bellied anglerfish (*L. budegassa*) - divisions 8.c and 9.a. Mean stratified length distributions of *Lophius budegassa* in the Northern Spanish Shelf Groundfish Survey (SpGFS-WIBTS-Q4; code: G2784) in the period 2011–2020 (from Ruiz-Pico *et al*., 2021).

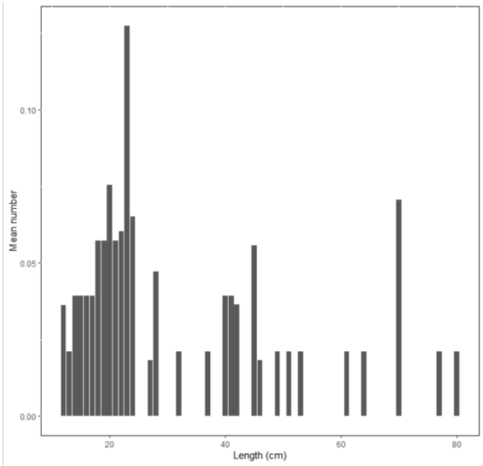

Figure 4.4.3. Black-bellied anglerfish (*L. budegassa*) - divisions 8.c and 9.a. Mean stratified length distributions of *Lophius budegassa* in the SPGFS-caut-WIBTS-Q4 (Gulf of Cádiz; code: G4309) in 2020.

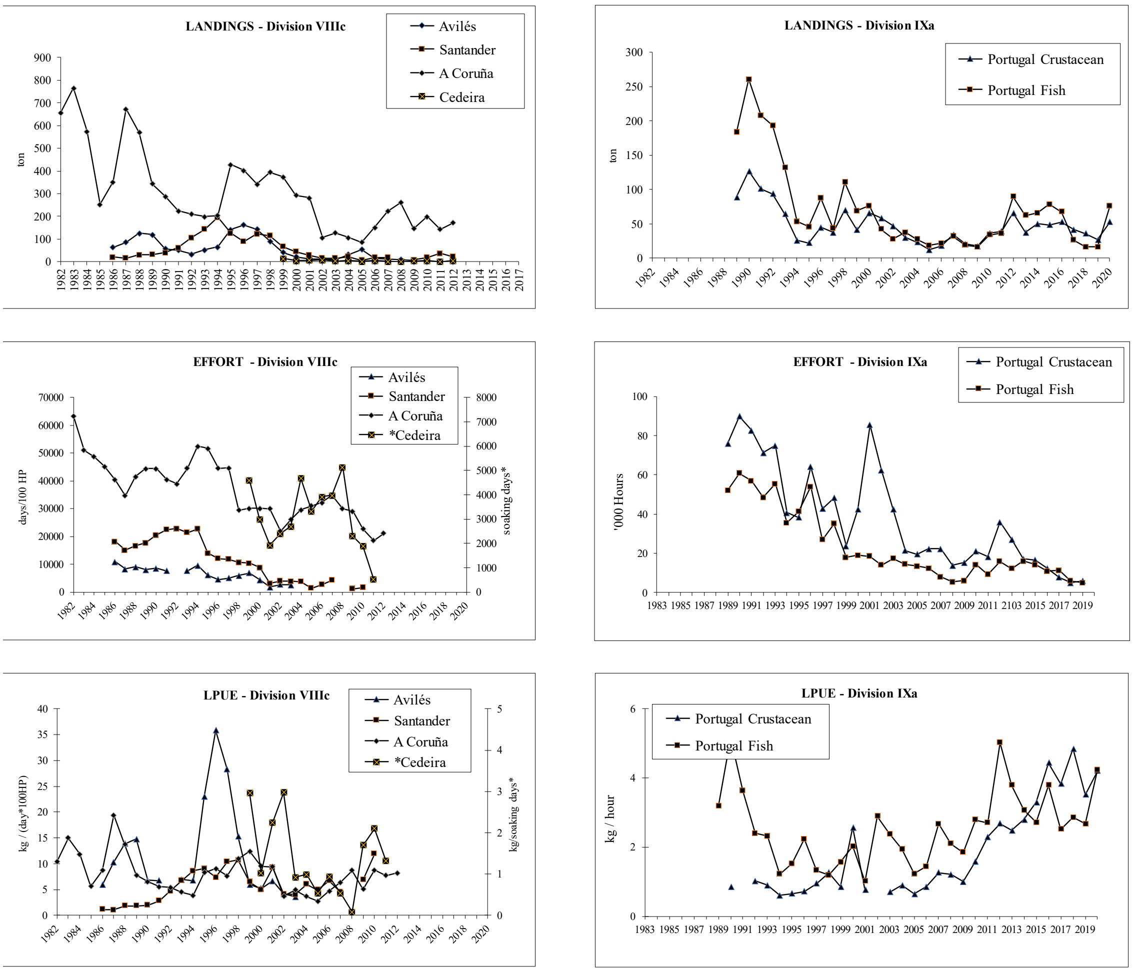

Figure 4.4.4. Black-bellied anglerfish (*L. budegassa*) - divisions 8.c and 9.a. Trawl and gillnet landings, effort and LPUE data between 1986 and 2020.

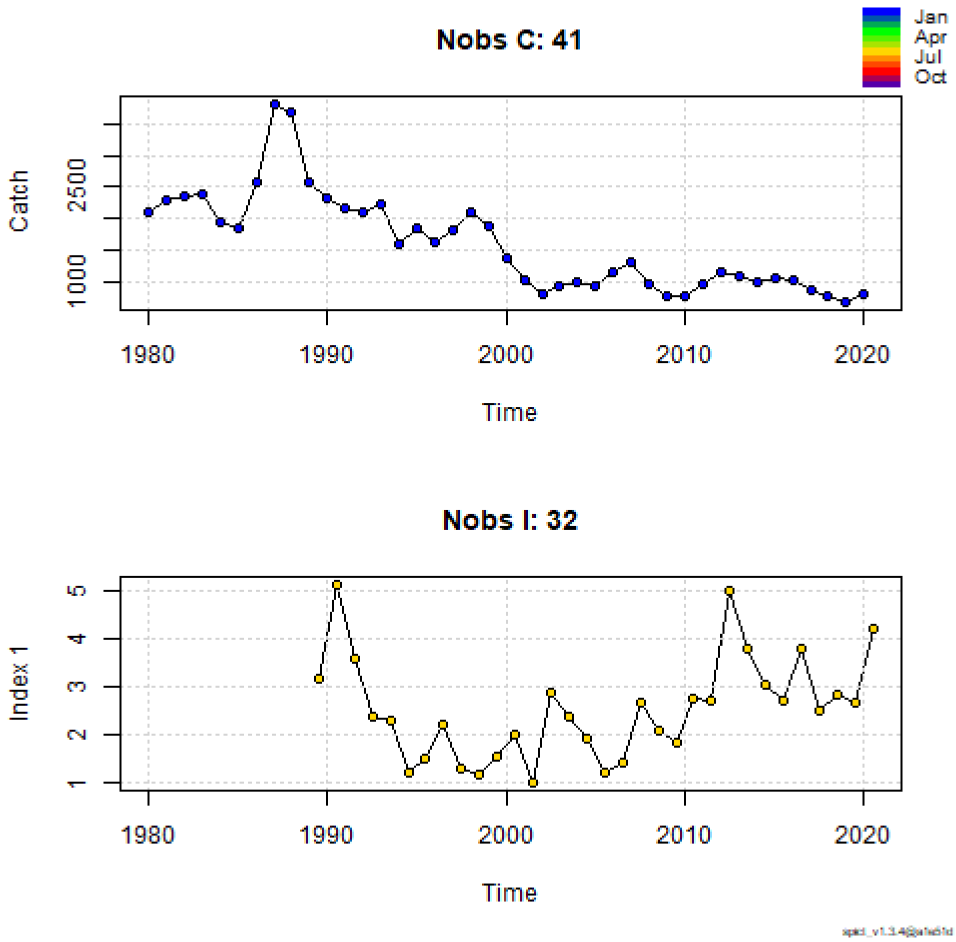

Figure 4.4.5. Black-bellied anglerfish (*L. budegassa*) - divisions 8.c and 9.a. SPiCT input data. Upper panel, Catch data. Lower panel, PT-TRF9a LPUE index (Portuguese trawl fleet targeting fish, 1989 - 2020).

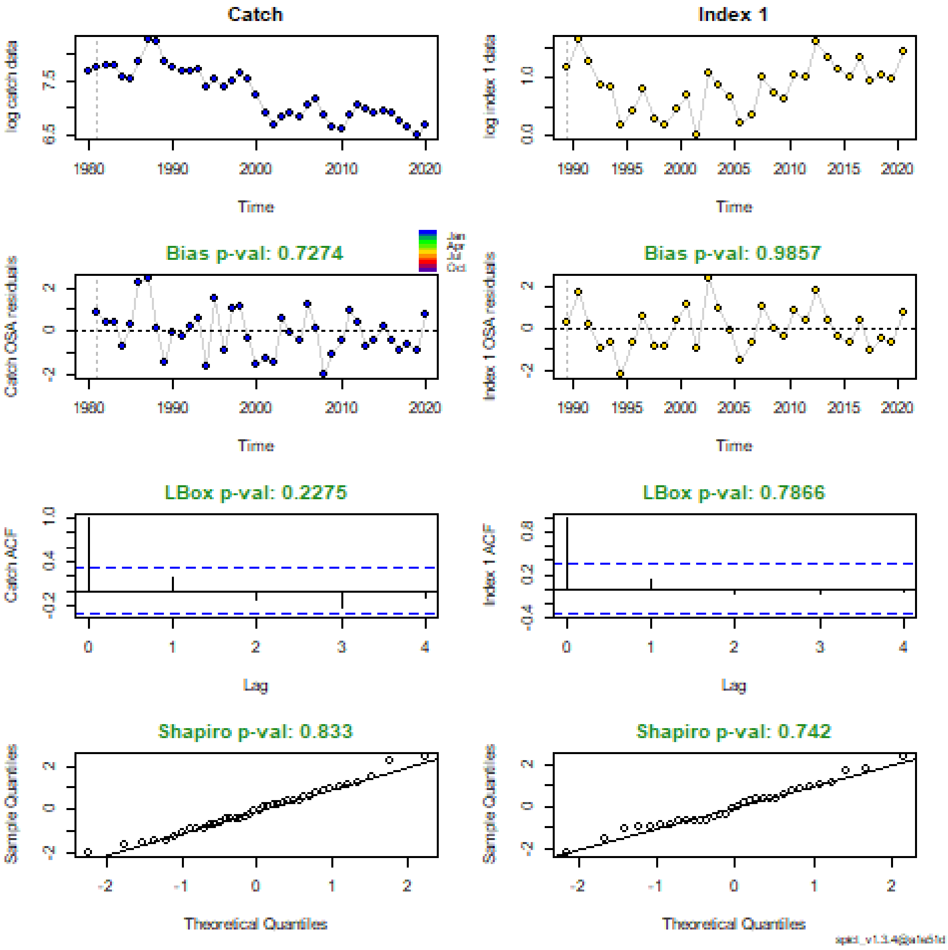

Figure 4.4.6. Black-bellied anglerfish (*L. budegassa*) - divisions 8.c and 9.a. SPiCT diagnostics. Row1, Log of the input dataseries. Row 2, OSA residuals with the p-value of a test for bias. Row 3, Empirical autocorrelation of the residuals with tests for significant autocorrelation. Row 4, Tests for normality of the residuals, QQ-plot and Shapiro test.

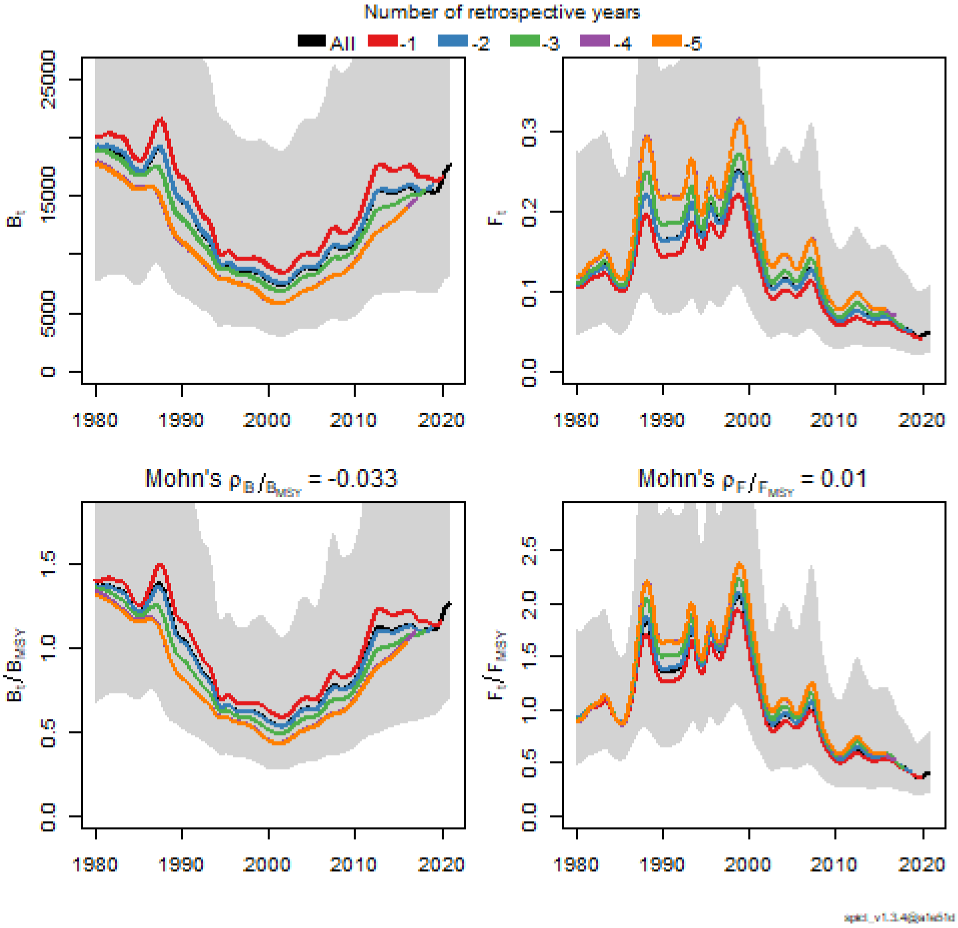

Figure 4.4.7. Anglerfish (*L. budegassa*) - divisions 8.c and 9.a. 5 years retrospective analysis. Upper panel, absolute biomass and fishing mortality. Lower panel, relative biomass and fishing mortality. Grey regions represent 95% CIs.

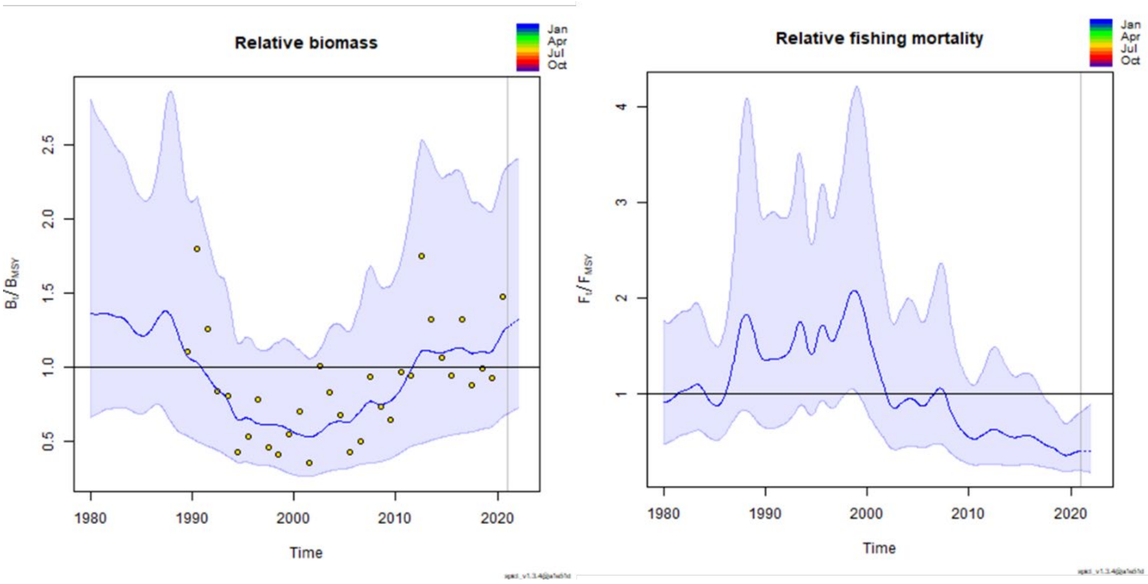

Figure 4.4.8. Black-bellied anglerfish (*L. budegassa*) - divisions 8.c and 9.a. SPiCT results: Left panel, relative biomass; right panel, relative fishing mortality. Solid blue lines are estimated values; vertical grey lines indicate the time of the last observation beyond which dotted lines indicate forecasts; shaded blue regions are 95% CIs for relative estimates; solid circles correspond to the index PT-TRF9a (Portuguese fish fleet).

5 Megrim and four-spot megrim in divisions 7.b–k, 8.a, 8.b, and 8.d

Lepidorhombus whiffiagonis – meg.27.7b-k8abd (west and southwest of Ireland, Bay of Biscay)

Assessment type

An updated assessment has been carried out as this stock was benchmarked in 2016 (ICES, 2016a)—executing a full assessment for this stock—and is now considered a category 1 stock.

Data revisions

This was done through an Inter Benchmark Process (IBPMegrim; ICES, 2016a); no additional revisions have been done during this Working Group (WG).

Lepidorhombus boscii – ldb.27.7b-k8abd (west and southwest of Ireland, Bay of Biscay)

Assessment type

First assessment.

Data revisions

First assessment (survey indices included).

5.1 General

See Stock Annex for more details on the general aspects related to megrim assessment.

5.1.1 Ecosystem aspects

See Stock Annex for more details on the ecosystem aspects related to megrim assessment.

5.1.2 Fishery description

Megrim in the Celtic Sea, west of Ireland, and in the Bay of Biscay are caught in a mixed fishery predominantly by French followed by Spanish, UK and Irish demersal vessels. In 2020, the four countries together have reported around 94% of the total landings (Table 5.1). Estimates of total landings (including unreported or misreported landings) and catches (landings and discards) as used by the WG up to 2020 are shown in Table 5.2.

5.1.3 Summary of ICES advice for 2020 and management for 2019 and 2020

5.1.3.1 ICES advice for 2021 (as extracted from ICES Advice 2020):

ICES advises that when the EU multiannual plan (EU MAP; EU, 2019) for Western Waters and adjacent waters is applied, catches in 2021 that correspond to the F ranges in the MAP are between 12 706 t and 27 748 t. According to the MAP, catches higher than those corresponding to F_{MSY} (19 184 t) can only be taken under conditions specified in the MAP, whereas the entire range is considered precautionary when applying the ICES advice rule.

Management of catches of the two megrim species, *L. whiffiagonis* and *L. boscii*, under a combined species TAC prevents effective control of the single-species exploitation rates and could lead to overexploitation of either species.

5.1.3.2 Management applicable for 2020 and 2021:

The agreed TAC for the combined species was set at 20 526 t for 2020. Due to Brexit, fishing quotas are partially published with a provisional value of 4460 t for the first quarter of 2021.

The minimum landing size for megrim was reduced from 25 to 20 cm in 2000.

5.2 Megrim (*L. whiffiagonis*) in divisions 7.b–k, 8.a, 8.b, and 8.d

5.2.1 General

See general section for both species.

5.2.2 Data

5.2.2.1 Commercial catches and discards

Stock catches for the period 1984–2020, as estimated by the WG, are given in Table 5.1. This is the fourth year where all landings and discards data that have been uploaded to InterCatch were used to make data allocations.

Landings in 2020 (11 141 t) are slightly lower than in 2019 (12 164 t) (< 9%).

Since 2011, estimates of unallocated or non-reported landings have been included in the assessment. These were estimated based on the sampled vessels (Spanish concurrent sampling) raised to the total effort for each *métier*.

Spanish data showed a decreasing trend from 2009 onwards. During the IBPMegrim held in 2016 (ICES, 2016a), France landing dataseries were updated from 2003–2014. Landings data from France showed initially an increasing trend from 2015 onwards then decreased in the last two years. In 2020, landings from Ireland and UK decreased while Belgium increased.

French discard data from 2004–2014 were provided for the IBPMegrim in 2016 (ICES, 2016a), and have been updated in 2017. An increase in discards was only observed in Belgium while significant decreases were declared by France, Spain, Ireland and UK.

Discard data available by country and the procedure to derive them are summarized in Table 5.3. The discards decrease in year 2000 can be partly explained by the reduction in the minimum landing size from 25 cm to 20 cm. Since 2000, fluctuating trends are observed with a peak in 2004 and the minimum observed level in year 2020.

Table 5.4 presents the discard ratio in percentage (%) from catches in weight of the most recent years.

5.2.2.2 Biological sampling

Age and length distribution data provided by countries are explained in Stock Annex-Meg78 (Annex E).

Age

France, Ireland, UK and Belgium provided numbers-at-age to InterCatch and eventually completed numbers- and weights-at-age up to 2020. Age distribution for landings and discards from 2011–2020 are presented in Figure 5.1.

Lengths

Table 5.5 shows the available original length composition of landings by Fishing Unit in 2020. Data for the OTB DEF 70-99 Spanish fleet was not provided in 2020.

Natural Mortality

A value of 0.2 for the natural mortality (M) has been used as input data for all ages and years in the final model.

5.2.2.3 Survey data

UK survey Deep Waters (UK-WCGFS-D, Depth > 180 m) and UK Survey Shallow Waters (UK-WCGFS-S, Depth < 180 m) indices for the period 1987–2004 and French EVHOE survey (EVHOE-WIBTS-Q4, G9527) indices for the period 1997–2020 are summarized in Table 5.6. Due to vessel technical problems, no French EVHOE survey was carried out in 2017 but recommenced in 2018.

The UK-WCGFS-D and UK-WCGFS-S show the same pattern of indices for ages 2 and 3 since 1997; in agreement with the high values of EVHOE-WIBTS-Q4 (G9527) age 1 index for the years 1998 and 2000. These high indices in the deep component of the UK Surveys are even more remarkable in 2003 for all age-groups and in 2004 for the younger ages (1–2).

When comparing Spanish (SpPGFS-WIBTS-Q3, G5768), French (EVHOE-WIBTS-Q4, G9527) and Irish (IGFS-WIBTS-Q4, G7212) survey biomass indices some contradictory signals are detected (Figure 5.2). The EVHOE-WIBTS-Q4 (G9527) survey index decreased from 2001 until 2005 and since then has sharply increased until 2011. The SpPGFS-WIBTS-Q4 (G5768) survey shows an increasing but fluctuating trend until 2014 and then started declining with a fluctuating trend until 2020. In the case of the IGFS-WIBTS-Q4 (G7212) survey, the highest biomass index was estimated in 2005. In 2011, a slight increase of the index occurred following a sharp decline in 2010 compared to 2009, a trend similarly observed in the Spanish survey during the same year.

Figure 5.3 shows the abundance indices by age-group for the three surveys. The abundance index by age-group for the IGFS-WIBTS-Q4 (G7212) survey from 2003–2020 shows an increasing trend during the last 4 years for younger ages (1–2), in line with middle ages (3–5), while declining for older (6–9) ages during the last five years in the dataseries. The abundance index per age-group for the EVHOE-WIBTS-Q4 (G9527) survey from 1997–2020, with the absence of 2017 value, shows increasing trends for all age-groups despite a decline for ages 3–5 in the last year.

In Figure 5.4, the time-series of *L. whiffiagonis* abundance by age composition of the SpPGFS-WIBTS-Q4 (G5768) survey from 2001 to 2020 is presented.

In Figure 5.5, the time-series of *L. whiffiagonis* abundance by age composition of the EVHOE-WIBTS-Q4 (G9527) survey from 2011 to 2020 is presented. In most years, middle ages (3–5) show the highest abundance except in 2012 where the abundance of *L. whiffiagonis* was low.

It must be noted that the areas covered by the three surveys almost do not overlap (Figure 5.6). There are some overlaps between the northern component of the EVHOE-WIBTS-Q4 (G9527) and the southern coverage of the IGFS-WIBTS-Q4 (G7212) surveys, whereas the eastern boundary of the SpPGFS-WIBTS-Q4 (G5768) survey essentially coincides with the western one of the IGFS-WIBTS-Q4 (G7212).

5.2.2.4 Commercial catch and effort data

During the WKFLAT Benchmark (ICES, 2012), a new Irish trawler index was provided as the result of the revision carried out for the Irish otter trawl fleet. Irish beam trawl (TBB) data are limited to mesh sizes of 80–89 mm as larger mesh sizes are no longer used since 2006.

The evolution of the different bottom-trawl fleets effort is described in Figure 5.7. Efforts of SP-CORUTR7 and SP-VIGOTR7 fleets have decreased sharply until 1993 and continues to progressively decline until 2020. SP-VIGOTR7 showed a very slight increase in 2007 then gradually declined again until 2014. SP-CANTAB7 remains quite stable since 1991 and has decreased slightly since 2000, for the last six years no effort was deployed. The effort of the French benthic trawlers in the Celtic Sea decreased until 2008 after which no more information was provided to the WG.

Commercial series of the catch-at-age and effort data were available for the three Spanish fleets in Subarea 7 (Figure 5.8): A Coruña (SP-CORUTR7) for the period 1984–2019, Cantábrico (SP-CANTAB7) from 1984 to 2011 as no effort has been deployed onwards by this fleet in subarea 7, and Vigo (SP-VIGOTR7) for the period 1984–2019. No updated data were provided for year 2020 for these fleets due to the COVID-19 disruption. Cpues of SP-CORUTR7 have fluctuated until 1990 when it started to decrease followed with a slight increase in 2003 with a peak in 2011 then decreased afterwards. Over the same period, SP-VIGOTR7 has remained relatively stable until 1999, reaching in 2004 and 2014, the highest cpue values of the time-series. In recent years, the cpues have fluctuated but with a decreasing trend.

From 1985 to 2008, LPUEs from four French trawling fleets: FR-FU04, Benthic Bay of Biscay, Gadoids Western Approaches and *Nephrops* Western Approaches were available. (Table 5.7 and Figure 5.9). No data from 2009 onwards was received for these fleets.

The LPUE of all Irish beam trawlers fleets shows oscillating trends. From 2007, an increase in the LPUE was observed with a peak in 2013 (Figure 5.10) followed by a slightly decreasing trend afterwards.

An analysis of the abundance indices of the different age-groups in the dataseries for commercial fleets was carried out (Figure 5.11). Age-groups were categorized as: i) ages 1–2; ii) age 3–5 and iii) age 6–10. For Spanish and Irish commercial fleets, the most abundant age-group was ii) at the beginning of the dataseries. Age-group i) appears more abundant than group iii) from 2003 onwards in the Spanish fleets. French fleets appear to land mostly old individuals (group iii) at the beginning of the dataseries but a marked decrease in abundance index for this age-group was observed afterwards.

5.2.3 Assessment

An analytical assessment was conducted using the updated landings and discards data for 2020. With the inclusion of French discard data in 2016, some changes to the model were executed in relation to the discard estimation coefficient and the data input for the Bayesian model (ICES. 2016a).

5.2.3.1 Data exploratory analysis

In summary, the stock's catch-at-age matrix shows three periods: 1984–1989; 1990–1998 and 1999–2020.

The data analysed consist of landed, discarded and catch numbers-at-age and abundance indices-at-age. Five of the available fleets were considered appropriate to include in the assessment model as tuning fleets: SpPGFS_WIBTS-Q4 (G5768), EVHOE-WIBTSQ4 (G9527), Vigo commercial trawl cpue series separated in two periods: 1984–1998 (VIGO84) and 1999–2019 (VIGO99), and Irish Otter trawlers LPUE (IRTBB), based on their representativeness of the megrim stock abundance. Several exploratory data analyses were performed to examine their ability to track cohorts through time.

These analyses were carried out with the R software (R Core Team, 2020). The analysis of the standardized log abundance indices for the updated data revealed an increase in ages 1–5 in the EVHOE-WIBTSQ4 (G9527) survey (Figure 5.12). Otherwise, a slight increase in ages 4–8 was observed in the SpPGFS-WIBTS-Q4 (G5768) survey. Figure 5.12 shows little or no cohort tracking in the surveys. Presumably as a consequence of the lack of variability of recruitment, leading to an absence of contrast between cohorts.

The analysis of the standardized log abundance indices revealed yearly trends for VIGO99 with an increase in the index of group iii) individuals detected in 2019. IRTBB shows a slight increase of ages 1–2 (group i).

The time-series of catch-at-age (Figure 5.13) showed very low catches of ages 1–5 from 1984 to 1989. From 2004 to 2010, the catch of older ages (> 6) was remarkably low, whereas catches of ages 1 and 2 increased markedly from 2003. This could be a result of an underestimation of catches of these younger ages (especially age 1) during the previous years and probably due to the sparseness of discard data during the same period. For ages 6 and older, large discrepancies in the number of individuals caught before and after 1990 are apparent, with large catches of these ages before 1990 and a decrease of all ages at the end of the dataseries.

The analysis of landings since 1990 is presented in Figure 5.14. Landings of ages 1 and 2 have increased from the beginning of the time-series. In fact, the proportion of older ages in the landings decreased significantly from 2004 to 2009, as already discussed in relation to the catch. From year 2017, ages 1 increased significantly mainly due to the French landings.

The signal coming from the discard data showed that, at the beginning of the dataseries, discards of age 1 were low (Figure 5.15 and 5.16). Discards of this age increased along the dataseries, particularly from 2003 onwards. From 2010 to 2013, ages 1 to 3 appear to be highly discarded and in the last six years (2015–2020) overall discards decrease.

5.2.3.2 Model

The model explored during the WKFLAT benchmark (ICES, 2012) is an adaptation of the one originally developed for the southern hake stock published in Fernández *et al*. (2010). It is a statistical catch-at-age model that allows incorporating data at different levels of aggregation in different years, and also works with missing discards data in certain fleets and/or in some years. These are all relevant features for the megrim stock.

The model is described in the Stock Annex.

5.2.3.3 Results

The model results were analysed by looking at three different kinds of plots: convergence plots to analyse the convergence behaviour of the MCMC chains, diagnostic plots to analyse the goodness of the fit and, finally, model estimates plots which display the estimated stock status over time.

Regarding the settings of the prior for the final run, some changes were done in relation to the inclusion of the French discards during the IBPMegrim in 2016 (ICES, 2016a), which became input data instead of being estimated by the model. Settings used in WGBIE 2021 are listed in Table 5.8.

In order to ensure that the model has produced a representative sample of the posterior distribution, the MCMC chain was examined for behaviour ("convergence" properties). This was done by examining trace and autocorrelation plots for most parameters in the model (Figure 5.17 to Figure 5.19) showing good behaviour.

Model diagnostic plots examined were: prior-posterior plots and time-series and bubble plots of the residuals. Prior-posterior distributions are shown in Figure 5.20. Posterior distributions for log-population abundance in the first assessment year (1984), log-f(y) and log-catchabilities of abundance indices were much more concentrated than the priors and were often centred at different places. This indicates that the model was able to extract information from the data in order to substantially revise the prior distribution. In these cases, the model fits are mostly driven by the data, with the prior having only a small influence. The posterior distributions for log-rSPD, log-rFR or log-rOTD in the first assessment year (1984) were similar to the prior distributions in most cases. This was especially true for log-rOTD, where data directly associated with it was not available to the model. This indicates that the available data does not contain sufficient information concerning these parameters and that the priors have to be chosen carefully to be realistic.

Results of the estimated spawning-stock biomass (SSB), reference fishing mortality (F_{bar}), recruits and catch, landings and discards time-series are shown in Figure 5.21. The SSB shows an overall decreasing trend from the start of the series in 1984–2005 followed by a marked increasing trend until 2020. The uncertainty in the SSB was low for the whole time-series. The median recruitment fluctuated between 200 000 and 300 000 thousand in the whole series, with a decreasing trend in the last years. The F showed three marked periods which coincide with the data periods, 1984–1989, 1990–1998 and 1999–2020 with a decreasing trend and reaching its lowest value in 2020 with small uncertainty. This decreasing F trend in recent years explains the increase of SSB since catches and recruitment remain relatively constant. Overall, the catches showed a slightly decreasing trend reaching their minimum value in 2020 with the landings showing a similar trend. In the last year, a decreasing trend in landings and discards can be observed.

5.2.3.4 Retrospective pattern

Retrospective analysis was conducted for 5 years, the retrospective time-series of the most relevant indicators are shown in Figure 5.22. In terms of SSB, estimates were very similar throughout the entire time-series and there was a downward revision of the SSB with a Mohn's rho (Mohn, 1999) value of 0.329. F was revised upwards year after year with a Mohn's rho value of −0.24. Recruitment estimates towards the end of the time-series showed significant revisions in the retrospective analysis with a Mohn's rho value of 0.670, but this is something common, as recruitment in the most recent year(s) is usually not correctly estimated by assessment models.

5.2.3.5 Short-term forecasts

Short-term projections have been made using the R script developed by Fernández *et al*. (2010). Some modifications have been done to the script during the IBPMegrim in 2016 (ICES, 2016a) as the previous results of the projection were inconsistent with the stock dynamics estimated by the assessment model. During WGBIE 2017, a short R script was added to the short-term projection script to allow the change of last year recruitment data, if it is not considered credible (ICES, 2017a). As the recruitment-at-age 1 estimated by the model for the year 2020 was not considered credible, it was replaced by the geometric mean of all the recruitments since 1984 except for the last two years (1984–2018). The Baranov catch equation (Baranov, 1918) was used to project the recruitment one year forward.

For the current projection, the following short-term forecast settings were used: the average of the last three years is used for F-at-age pattern, the proportion landed-at-age, and the vectors of weight-at-age and maturity-at-age.

Although there is a clear decreasing trend in the F estimates due to a significant retrospective pattern that revises the F upwards year after year, F *status quo* was not scaled to the last year and the mean of the last three years was used for the projections. For the 2021 recruitment, the geometric mean of the recruitment posteriors during all the assessment years except for the final 2 years was used.

Landings in 2022 and SSB in 2023 predicted for various levels of F in 2022 are given in Table 5.9. Maintaining F status quo in 2022 is expected to result in an increase in landings and an increase in SSB in 2022 with respect to 2021.

5.2.4 Biological reference points

Biological reference points were calculated during the IBPMegrim in 2016 (ICES, 2016a) and reviewed by the WGBIE (ICES, 2016b). The reference points for this stock were estimated using methods based on the recommendations from the WKMSYREF4 (ICES, 2017b). They are listed in Table 5.10 and the Stock Annex, and where F_{MSY} ranges have also been included. A new definition for F_{pa} has been also included in WGBIE 2021 based on the ACOM recommendation.

5.2.5 Conclusions

The incorporation of the requested data, mainly French discards and also the reviewed French landings data, was completed and the script to deal with these new data were updated. The model results show that the new data does not alter substantially the perception of the stock status and F compared with the preliminary models performed by WGBIE in 2015 (ICES, 2015).

The group considers that the model diagnosis is adequate to evaluate the quality of the fit. The use of the Bayesian statistical catch-at-age model, the methodology for deriving biological reference points, the methodology for short-term forecast and the estimation of discards are statistically sound and adequate to the stock.

Nevertheless, as in most stock assessments, the stock–recruitment relationship and M remain uncertain, which have an impact on the assessment and the reference points that should be investigated in future.

However, the increase of assessment years makes the JAGS software (Plummer, 2003) less efficient as each model run takes 10 hours to complete.

In addition, in the issue list identified in WGBIE 2019 (ICES, 2019) it was stated: *"The Bayesian SCA model was ad-hoc implemented to solve the lack of discard data from France. After IBP, Megrim 2016 discard from France were provided, so the problem disappeared. Therefore, a change to a more standardized model is proposed to ease the implementation and shorten the iteration times."*

To provide an answer to this issue, intersessional work was done to implement the a4a (Millar and Jardim, 2019) model which was presented in WD06 in WGBIE 2020 (Iriondo *et al*., in ICES, 2020). It shows promising results and a proposal to change this model will be analysed. In addition, during the WKTADSA early this year (ICES, 2021), some progress was made in relation to the different assessment trials which is why this stock was finally proposed to go to a benchmark in 2022–2023.

5.2.6 References

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5.2.7 Tables and figures

Table 5.1. .Megrim (*L. whiffiagonis*) in divisions 7.b–k and 8.a, 8.b, and 8.d. Nominal landings and catches (t) by country provided by the Working Group.

	Landings									Discards									
	France	Spain	U.K. (England & Wales)	U.K. (Scotland)	Ireland	Northern Ireland	Belgium	Unallocated	Total landings	France	Spain	U.K.	Ireland	Northern Ireland	Belgium	Others	Total discards	Total catches	TAC
1984									**16659**							2169	**2169**	**18828**	
1985									**17865**							1732	**1732**	**19597**	
1986	4896	10242	2048		1563		178		**18927**							2321	**2321**	**21248**	
1987	5056	8772	1600		1561		125		**17114**							1705	**1705**	**18819**	16460
1988	5206	9247	1956		995		173		**17577**							1725	**1725**	**19302**	18100
1989	5452	9482	1451		2548		300		**19233**							2582	**2582**	**21815**	18100
1990	4336	7127	1380		1381		147		**14370**							3284	**3284**	**17654**	18100
1991	3709	7780	1617		1956		32		**15094**							3282	**3282**	**18376**	18100
1992	4104	7349	1982		2113		52		**15600**							2988	**2988**	**18588**	18100
1993	3640	6526	2131		2592		40		**14929**							3108	**3108**	**18037**	21460
1994	3214	5624	2309		2420		117		**13684**							2700	**3284**	**16968**	20330
1995	3945	6129	2658		2927		203		**15862**				422			2230	**2652**	**18514**	22590
1996	4146	5572	2493		2699		199		**15109**				410			2616	**3026**	**18135**	21200
1997	4333	5472	2875		1420		130		**14230**		414		568			2083	**3066**	**17296**	25000
1998	4232	4870	2492		2621		129		**14345**		381		681			4309	**5371**	**19716**	25000
1999	3751	4615	2193		2597		149		**13305**		3135		162				**3297**	**16601**	20000
2000	4173	6047	2185		2512		115		**15031**		1033	208	630				**1870**	**16901**	20000
2001	3645	7575	1710		2767		80		**15778**		1275	250	736				**2262**	**18040**	16800
2002	2929	8797	1787		2413		62		**15987**		1466	435	912				**2813**	**18800**	14900
2003	3227	8340	1732		2249		163		**15711**		3147	279	582				**4008**	**19719**	16000
2004	2817	7526	1622		2288		106		**14358**	1003	4511	257	472				**6243**	**20602**	20200
2005	2972	5841	1764		2155		156		**12888**	697	1831	289	458				**3275**	**16163**	21500
2006	2763	5916	1509		1751		99		**12037**	382	2568	271	529				**3751**	**15788**	20400
2007	2745	6895	1462		1763		195		**13060**	330	2114	272	317				**3033**	**16092**	20400
2008	2578	5402	1387		1514		167		**11048**	329	1479	289	764				**2860**	**13908**	20400
2009	3032	8062	1840		1918	2	209		**15064**	674	1761	389	454				**3278**	**18342**	20400
2010	3651	7095	1805		2283	5	261		**15101**	937	3489	463	453				**5343**	**20444**	20106
2011	3235	3500	1845		2227		330	2089	**13226**	847	2097	898	344				**4187**	**17413**	20106
2012	4012	4055	1744		3047		609	966	**14433**	796	2668	88	152				**3704**	**18137**	19101
2013	4549	4982	2918		3038		538		**16025**	748	3792	53	286		5		**4885**	**20910**	19101
2014	4311	3318	2753	176	2391		179	150	**13277**	795	1337	72	360		5		**2569**	**15846**	19101
2015	3073	2863	2804	147	2436		246	1	**11569**	634	513	47	308		4		**1507**	**13076**	19101
2016	3141	2672	2694	145	2593		302	1	**11548**	1276	649	74	404		42		**2445**	**13992**	20056
2017	5101	3178	2512	176	2458		360		**13784**	783	706	265	378		40		**2173**	**15957**	15043
2018	4680	2276	2337	112	2128	6	347	261	**12147**	610	483	85	495		66		**1738**	**13885**	13528
2019	4332	2617	2150	129	2454	1	481		**12164**	424	130	63	252		120		**989**	**13153**	19836
2020	4387	2420	1883	5	1797	1	649		**11141**	398	253	53	64		117		**885**	**12026**	20526

Table 5.2. Megrim (*L. whiffiagonis*) in divisions 7.b–k and 8.a, 8.b, and 8.d. Nominal landings and catches (t) provided by the Working Group.

	Total landings	Total discards	Total catches	Agreed TAC (1)
1984	16659	2169	18828	
1985	17865	1732	19597	
1986	18927	2321	21248	
1987	17114	1705	18819	16460
1988	17577	1725	19302	18100
1989	19233	2582	21815	18100
1990	14370	3284	17654	18100
1991	15094	3282	18376	18100
1992	15600	2988	18588	18100
1993	14929	3108	18037	21460
1994	13684	2700	16384	20330
1995	15862	3206	19068	22590
1996	15109	3026	18135	21200
1997	14230	3066	17296	25000
1998	14345	5371	19716	25000
1999	13305	3297	16601	20000
2000	15031	1870	16750	20000
2001	15778	2262	18040	16800
2002	15987	2813	18800	14900
2003	15711	4008	19719	16000
2004	14358	6243	20602	20200
2005	12888	3275	16163	21500
2006	12037	3751	15788	20425
2007	13060	3033	16092	20425
2008	11048	2860	13908	20425
2009	15064	3278	18342	20425
2010	15101	5343	20444	20106
2011	13226	4187	17413	20106
2012	14433	3704	18137	19101
2013	16025	4885	20910	19101
2014	13277	2569	15846	19101
2015	11569	1507	13076	19101
2016	11548	2445	13992	20056
2017	13784	2173	15957	15043
2018	12147	1738	13528	13528
2019	12164	989	13153	19836
2020	11141	885	12026	20526

(1) for both megrim species and VIIa included.

Table 5.3. Megrim (*L. whiffiagonis*) in divisions 7.b–k and 8.a, 8.b, and 8.d. Discards information and derivation.

	FR	SP	IR	UK
1984	**FR84-85**	-	-	-
1985	**FR84-85**	-	-	-
1986	(FR84-85)	(SP87)	-	-
1987	(FR84-85)	**SP87**	-	-
1988	(FR84-85)	**SP88**	-	-
1989	(FR84-85)	(SP88)	-	-
1990	(FR84-85)	(SP88)	-	-
1991	**FR91**	(SP94)	-	-
1992	(FR91)	(SP94)	-	-
1993	(FR91)	(SP94)	-	-
1994	(FR91)	**SP94**	-	-
1995	(FR91)	(SP94)	**IR**	-
1996	(FR91)	(SP94)	**IR**	-
1997	(FR91)	(SP94)	**IR**	-
1998	(FR91)	(SP94)	**IR**	-
1999	-	**SP99**	**IR**	-
2000	-	**SP00**	**IR**	**UK**
2001	-	**SP01**	**IR**	**UK**
2002	-	(SP01)	**IR**	**UK**
2003	-	**SP03**	**IR**	**UK**
2004	**FR04**	**SP04**	**IR**	**UK**
2005	**FR05**	**SP05**	**IR**	**UK**
2006	**FR06**	**SP06**	**IR**	**UK**
2007	**FR07**	**SP07**	**IR**	**UK**
2008	**FR08**	**SP08**	**IR**	**UK**
2009	**FR09**	**SP09**	**IR**	**UK**
2010	**FR10**	**SP10**	**IR**	**UK**
2011	**FR11**	**SP11 (*)**	**IR**	**UK**
2012	**FR12**	**SP12 (*)**	**IR**	**UK**
2013	**FR13**	**SP13 (*)**	**IR**	**UK**
2014	**FR14**	**SP14 (*)**	**IR**	**UK**
2015	**FR15**	**SP15 (*)**	**IR**	**UK**
2016	**FR16**	**SP16 (*)**	**IR**	**UK**
2017	**FR17**	**SP17 (*)**	**IR**	**UK**
2018	**FR18**	**SP18 (*)**	**IR**	**UK**
2019	**FR19**	**SP19 (*)**	**IR**	**UK**
2020	**FR20**	**SP20 (*)**	**IR**	**UK**

- In bold: years where discards sampling programs provided information

- In (): years for which the length distribution of discards has been derived

(*) Scientific estimates were provided

Table 5.4. Discard ratio in percentage (%) from catches in weight for the years 2008–2020.

Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
% Discard	21%	18%	26%	24%	20%	24%	16%	12%	17%	14%	13%	8%	7%

Table 5.5. Megrim (*L. whiffiagonis*) in divisions 7.b–k and 8.a, 8.b, and 8.d. Length composition by fleet (thousands) in 2020.

		NOT UPDATED
Length	FRANCE	SPAIN
class (cm)	OTT_DEF_>=70_0_0 (ICES 8a)	OTB_DEF_70-99_0_0 (ICES 7b-k)
10	0	
11	0	
12	0	
13	0	
14	0	
15	0	
16	0	
17	0	
18	0	
19	0	
20	0	385
21	678	7486
22	0	26959
23	4344	80878
24	4044	179766
25	23964	414540
26	33004	485666
27	73252	436620
28	61274	374552
29	98820	275765
30	84940	248516
31	99424	153617
32	89542	128715
33	92867	92220
34	69387	72630
35	72153	57275
36	82423	49390
37	67838	37645
38	85301	31484
39	64327	21646
40	42177	22128
41	39542	14778
42	29775	13998
43	17480	9454
44	10093	8907
45	12392	13533
46	13000	8516
47	6509	5988
48	7462	5022
49	3850	5204
50	2009	4200
51	742	1583
52	650	1446
53	288	1307
54	144	75
55	0.00	0
56	0.00	173
57	0	
58	0	
59		
60		
61		
62		
TOTAL	1293693	3292067

Table 5.6. Megrim (*L. whiffiagonis*) in divisions 7.b–k and 8.a, 8.b, and 8.d. Abundance Indices for UK-WCGFS-D, UK-WCGFS-S, IGFS-WIBTS-Q4 (G7212) , SpPGFS-WIBTS-Q4 (G5768) and EVHOE-WIBTS-Q4 (G9527).

		UK-WCGFS-D							Effort in hours	
		Age								
	Effort	1	2	3	4	5	6	7	8	9
1987	100		863	5758	0	0	0	95	1753	151
1988	100	8	256	59	49	0	228	1008	1262	632
1989	100		70	188	471	2540	788	3067	680	1060
1990	100	8	526	1745	553	2584	1985	974	1154	974
1991	100		415	1375	1250	989	912	1677	593	731
1992	100	7	28	425	414	349	189	206	132	121
1993	100		122	382	1758	1505	728	739	666	718
1994	100		69	1593	1542	2663	1325	1278	825	595
1995	100	47	582	747	1755	1686	1303	548	281	421
1996	100	15	69	475	549	1580	1231	870	327	117
1997	100		329	751	1702	1518	541	149	47	17
1998	100		120	797	1432	1134	866	242	246	13
1999	100		237	270	734	760	302	94	33	17
2000	100		143	1004	619	681	395	67	35	13
2001	100	20	384	690	1426	581	460	376	226	45
2002	100		162	2680	1915	1349	761	690	315	104
2003	100		330	1705	3149	2662	1451	676	417	179
2004	100	168	1001	1382	1069	897	628	208	47	
		UK-WCGFS-S							Effort in hours	
		Age								
	Effort	1	2	3	4	5	6	7	8	9
1987	100		499	3082	641	891	180	794	264	587
1988	100		47	55	585	95	367	0	50	93
1989	100		616	574	547	1540	576	361	297	198
1990	100		375	1057	816	661	1220	195	454	176
1991	100	2	373	829	822	394	460	550	178	293
1992	100		149	278	323	193	109	164	93	36
1993	100		470	877	1140	601	327	321	143	233
1994	100		74	1000	1301	998	521	374	185	153
1995	100	28	435	878	1167	1054	805	488	359	130
1996	100	2	64	401	389	823	592	372	152	43
1997	100	3	284	1028	550	540	289	202	75	29
1998	100	4	30	438	665	381	209	97	48	21
1999	100		69	82	222	214	103	53	41	20
2000	100		72	377	249	313	169	81	52	20
2001	100	2	131	297	594	104	145	122	80	37
2002	100		134	808	506	757	339	326	181	82
2003	100	5	184	289	639	416	328	113	102	36
2004	100	50	343	467	270	394	303	124	49	21

		FR-EVHOE (NEW TIME SERIES PROVIDED IN WGBIE 2018)								
		Age								
	Effort	1	2	3	4	5	6	7	8	9
1997	100	0.64	1.37	0.96	1.16	1.70	1.57	1.32	0.79	0.56
1998	100	0.64	0.58	0.58	0.64	0.38	1.02	1.02	0.45	0.19
1999	100	1.18	3.04	0.79	2.20	4.02	2.92	1.46	1.20	1.52
2000	100	0.96	1.31	2.26	1.06	1.09	1.12	0.99	1.14	0.71
2001	100	1.03	1.68	0.76	0.67	0.97	1.57	2.58	1.36	1.12
2002	100	1.42	0.58	1.35	1.10	2.01	0.95	1.94	1.07	0.55
2003	100	1.26	1.15	0.82	1.37	0.96	1.94	0.88	0.80	0.71
2004	100	0.40	1.73	1.02	0.88	1.47	1.13	1.05	1.39	0.99
2005	100	0.62	0.91	2.41	0.83	0.76	1.11	1.16	0.56	0.87
2006	100	0.83	0.62	0.95	1.86	0.82	1.10	1.69	0.75	0.84
2007	100	1.91	1.71	1.12	0.64	1.26	1.42	1.75	1.23	1.15
2008	100	0.53	3.18	4.01	2.13	1.49	1.92	1.73	0.57	0.26
2009	100	2.04	2.12	5.41	1.67	1.16	1.17	0.49	0.20	
2010	100	2.01	1.68	1.74	4.08	1.92	1.16	1.11	1.38	2.15
2011	100		2.73	2.81	3.11	2.37	2.70	1.07	0.45	1.01
2012	100	0.78	0.72	1.36	0.72	0.96	0.80	1.25	1.14	0.70
2013	100	1.72	1.91	2.82	3.89	0.96	2.15	2.60	0.35	0.90
2014	100	0.45	3.31	2.16	4.05	2.54	2.46	0.93	0.38	
2015	100	1.57	1.77	4.41	3.06	2.76	1.93	0.72	0.26	0.26
2016	100	0.80	2.26	1.90	2.31	1.84	3.09	1.13	2.72	0.74
2017	No updated data									
2018		1.68	1.60	1.84	3.48	2.96	2.31	0.98	0.73	0.32
2019		1.69	3.30	6.97	5.22	3.86	2.41	1.97	0.63	0.32
2020		0.97	2.59	3.18	2.95	2.76	2.41	2.20	1.48	0.75

		IGFS									
		Age									
	Effort	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
2003	100	0	152	316	368	238	96	36	14	5	2
2004	100	0	153	461	595	454	162	57	30	12	3
2005	100	29	414	643	431	370	215	68	44	18	17
2006	100	44	505	548	481	215	154	68	10	7	5
2007	100	1	100	293	125	91	70	25	7	7	3
2008	100	5	140	481	349	101	66	60	17	12	5
2009	100	3	1	234	371	455	346	159	53	44	23
2010	100	6	1	128	377	259	173	90	38	13	10
2011	100	5	2	121	333	331	144	69	40	25	30
2012	100	4	24	141	140	108	52	36	16	9	33
2013	100	9	31	132	93	83	58	30	10	8	22
2014	100	40	62	143	106	56	57	52	22	23	17
2015	100	26	127	149	154	57	44	30	16	10	7
2016	100	28	211	370	207	108	83	75	37	27	39
2017	100	13	201	310	142	61	36	23	12	18	27
2018	100	19	251	559	266	77	32	20	22	17	29
2019	100	25	317	486	349	96	46	17	16	10	34
2020	100	1	278	463	334	68	29	9	6	4	22

	NEW	**SP-PGFS**									
		Age									
	Effort	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7+**		
2001	100	43	1770	2208	2842	3434	1941	1357	740		
2002	100	6	1069	2502	3168	3997	2237	1107	515		
2003	100	11	1081	2913	4105	5262	2789	1284	636		
2004	100	7	719	3457	5498	5569	3071	1125	828		
2005	100	77	633	626	2279	8249	4959	2605	688		
2006	100	5	1776	1443	3275	4719	3312	901	383		
2007	100	30	4856	6990	3556	3622	1814	852	399		
2008	100	14	260	2219	5406	4010	1807	1219	428		
2009	100	6	534	661	5320	7097	1635	877	606		
2010	100	39	318	2158	2557	6723	2313	494	476		
2011	100	37	393	1174	2510	3940	5141	1452	626		
2012	100	5	157	692	3759	2862	3207	2926	1902		
2013	100	6	1473	1184	1174	1619	3703	2657	2579		
2014	100	39	243	3174	1001	2286	4400	3409	2198		
2015	100	23	2220	2188	4056	2078	1847	2099	1830		
2016	100	15	1104	6137	3263	4137	2248	2176	1712		
2017	100	10	1869	5166	3608	2563	3122	1650	1079		
2018	100	5	826	5347	7702	2762	1766	869	988		
2019	100	12	939	4392	5543	3262	3292	1880	565		
2020	100	6	224	2957	5074	4227	2783	2068	444		

Table 5.6. (cont). Megrim (*L. whiffiagonis*) in divisions 7.b–k and 8.a, 8.b, 8.d. Abundance Indices by kilograms and numbers per 30 minutes haul duration IGFS-WIBTS-Q4 (G7212) , SpPGFS-WIBTS-Q4 (G5768) and EVHOE-WIBTS-Q4 (G9527).

FR-EVHOEFS Abundance Indices by kilograms and numbers by 30 minutes haul duration

	kg/30'	Nb/30'	
1997	1.93	12.03	
1998	2.12	13.52	
1999	1.82	13.41	
2000	1.45	11.69	
2001	2.19	17.03	
2002	2.04	16.95	
2003	1.79	12.81	
2004	1.50	10.67	
2005	1.45	9.94	
2006	1.69	15.59	
2007	1.97	14.68	
2008	2.05	13.66	
2009	2.49	14.68	
2010	2.57	15.53	
2011	3.22	17.13	
2012	2.93	17.71	
2013	2.89	14.69	
2014	2.07	13.16	
2015	2.51	13.82	
2016	2.63	14.91	
2017			NO updated information
2018	2.67	17.00	
2019	3.62	23.67	
2020	3.18	26.20	

SP-PGFS Abundance Indices by kilograms and numbers by 30 minutes haul duration

	OLD	SP-PGFS	NEW	SP-PGFS	
	kg/30'	Nb/30'	AÑO	kg/30'	Nb/30'
2001	6.80	143.34	2001	6.80	143.34
2002	6.66	147.00	2002	6.66	146.00
2003	8.15	180.79	2003	8.16	180.81
2004	7.45	167.47	2004	9.01	202.72
2005	8.28	170.17	2005	9.81	201.19
2006	6.03	125.37	2006	7.64	158.14
2007	7.31	177.38	2007	9.15	221.18
2008	5.99	109.70	2008	8.46	153.61
2009	8.11	113.68	2009	11.79	165.49
2010	8.52	112.56	2010	11.47	150.76
2011	9.82	126.60	2011	11.89	152.72
2012	10.82	130.21	2012	13.03	155.08
2013	12.82	124.92	2013	12.82	143.96
			2014	15.78	166.68
			2015	13.07	163.42
			2016	14.77	207.93
			2017	14.11	190.65
			2018	11.15	202.65
			2019	13.64	205.12
			2020	12.63	181.00

IGFS Abundance Indices by numbers by 10 square kilometers

2003	1227
2004	1926
2005	2254
2006	2039
2007	725
2008	1238
2009	1724
2010	1103
2011	1116
2012	583
2013	497
2014	593
2015	629
2016	1224
2017	864
2018	1311
2019	1406
2020	1225

Table 5.7. Megrim (*L. whiffiagonis*) in divisions 7.b–k and 8.a, 8.b, and 8.d. French and Spanish cpues for the different bottom-trawl fleets.

	French (single and twin bottom trawls combined) CPUE (kg/h)				Spanish CPUE (kg/(100day*100 hp))			Irish LPUE ('000 h)
	Benthic Bay of Biscay	Benthic Western Approaches	Gadoids Western Approaches	Nephrops Western Approaches	A Coruña -VII	Cantábrico- VII	Vigo-VII	Otter trawlers
1984					16.3	130.1	99.1	-
1985	3.0	5.3	4.7	4.7	9.8	39.5	108.9	-
1986	3.2	4.8	2.8	4.4	21.1	52.8	105.1	-
1987	3.3	5.1	2.7	4.5	8.3	80.7	96.2	-
1988	3.8	5.8	3.0	4.1	9.8	78.3	106.1	-
1989	3.6	5.5	2.6	4.2	14.6	48.1	92.1	-
1990	3.1	4.2	1.8	3.4	15.1	18.4	73.8	-
1991	2.6	4.0	1.3	2.8	12.9	25.9	85.4	-
1992	2.5	4.5	1.5	3.4	6.9	32.8	105.6	-
1993	1.9	4.6	1.2	3.5	5.1	33.5	92.3	-
1994	1.9	4.2	1.2	3.4	7.4	52.7	78.7	-
1995	2.3	4.9	1.4	3.4	7.8	61.3	94.3	13.7
1996	2.6	5.0	1.4	3.5	3.9	58.4	79.3	13.6
1997	3.3	5.6	1.2	3.0	3.0	46.9	96.0	12.1
1998	2.9	6.5	1.5	3.6	2.4	35.7	82.4	10.0
1999	3.0	6.3	0.9	3.4	1.1	32.5	137.0	11.3
2000	2.9	6.8	0.6	4.0	5.5	45.0	128.9	13.4
2001	2.2	6.8	0.7	4.1	1.3	75.6	131.2	13.1
2002	2.1	6.8	0.5	3.2	1.3	76.4	185.3	12.2
2003	1.8	5.8	0.6	3.2	11.2	54.0	192.1	8.2
2004	1.8	4.6	0.5	3.4	3.3	60.0	211.0	9.3
2005	1.9	5.1	0.4	4.2	1.7	58.46	135.3	10.0
2006	2.5	4.8	0.3	3.6	1.4	76.42	146.1	7.5
2007	2.4	5.1	0.4	2.9	2.4	87.86	144.3	8.5
2008	2.2	4.6	0.5	3.1	3.0	37.58	114.0	8.4
2009	NA	NA	NA	NA	8.3	0.00	173.2	10.3
2010	NA	NA	NA	NA	7.9	38.78	198.3	11.8
2011	NA	NA	NA	NA	19.7	0.0	151.2	13.5
2012	NA	NA	NA	NA	6.4	0.0	135.3	19.3
2013	NA	NA	NA	NA	10.0	0.0	210.2	19.4
2014	NA	NA	NA	NA	3.4	0.0	116.7	15.3
2015	NA	NA	NA	NA	4.5	0.0	89.7	17.9
2016	NA	NA	NA	NA	3.3	0.0	96.6	17.8
2017	NA	NA	NA	NA	2.6	0.0	85.5	16.1
2018	NA	NA	NA	NA	1.7	0.0	65.5	13.7
2019	NA	NA	NA	NA	2.4	0.0	78.2	15.9
2020	NA	NA	NA	NA	NA	0.0	NA	16.0

(*) LPUEs, no discards available

Table 5.8. Megrim (*L. whiffiagonis*) in divisions 7.b–k and 8.a, 8.b, and 8.d. IBP 2016 Prior distributions of the final run.

$LN(\mu,\psi)$ **denotes the lognormal distribution with median** μ **and coefficient of variation** ψ **, and** $\Gamma(u,v)$ **denotes the Gamma distribution with mean** u/v **and variance** u/v^2 **.**

Parameter and prior distribution	Values used in prior settings
$N(y,1) \sim LN(medrec,2)$	$medrec = 250000$
$N(1984,a) \sim LN(medrec$ $\exp[-(a-1)M - \sum_{j=1}^{a-1} medF(j)],2), a = 2,...,9$	$medrec$ as above, $M = 0.2$, $medF = (0.05,0.1,0.3,0.3,0.3,0.3,0.3,0.3,($
$N(1984,10+) \sim LN(medrec \exp[-9M - \sum_{j=1}^{9} medF(j)]/\{1-\exp[-M - medF(9)]\}, 2)$	$medrec, M, medrecF$ as above
$f(y) \sim LN(med_f, CV_f)$	$med_f = 0.3, CV_f = 1$
$\rho \sim Uniform\ (0,1)$	
$r_L(1984,a) \sim LN(medr_L(a),1), a = 1,...,8$	$medr_L = (0.0005,0.05,1,1,1,1,1,1)$
$r_L(y,9) = r_L(y,10+) = 1$	
$r_{SPD}(1984,a) \sim LN(medr_{SPD}(a),1), a = 1,..$	$medr_{SPD} = (0.002,0.02,0.02,0.02,$ $0.01,0.01,0.01)$
$r_{IRD}(1984,a) \sim LN(medr_{IRD}(a),1), a = 1,..$	$medr_{IRD} = (0.001,0.01,0.01,0.01,$ $0.005,0.005,0.005,0.001)$
$r_{UKD}(1984,a) \sim LN(medr_{UKD}(a),1), a = 1,$	$medr_{UKD} = (0.00001,0.001,0.001,0.001,$ $0.001,0.001,0.001,0.001)$
$r_{FRD}(1984,a) \sim LN(medr_{FRD}(a),1), a = 1,$	$medr_{FRD} = (0.002,0.02,0.02,0.02,$ $0.01,0.01,0.01,0.01)$
$r_{OTD}(1984,a) \sim LN(medr_{OTD}(a),1), a = 1,..$	$medr_{OTD} = (0.002,0.02,0.02,0.02,$ $0.01,0.01,0.01,0.002)$
$r_{SPD}(y,7) = r_{SPD}(y,a) = r_{IRD}(y,a)$ $= r_{UKD}(y,a) = r_{FRD}(y,a) = r_{OTD}(y,a) = 0,\ a = 8,9,10+$	
$\tau_C(a), \tau_L(a), a = 1,2,3; \tau_D(a), a = 1,...,8$	$\Gamma(4,0.345)$
$\tau_C(a), \tau_L(a), a = 4,...,10+$	$\Gamma(10,0.1)$
$\tau_{SPD}(a), a = 1,...,7; \tau_{IRD}(a), \tau_{UKD}(a), \tau_{FRD}(a) a = 1,...,8$	$\Gamma(4,0.345)$
$\log[q_k(a)] \sim N(\mu_{Ik}, \tau_{Ik}), a \le 8,$ index $k = 1,...,5$	$\mu_{Ik} = -7,\ \tau_{Ik} = 0.2$
$q_k(a) = q_k(8), a > 8,$ indices k with ages >	
$\tau_k(a),$ index $k = 1,...,5$	$\Gamma(4,0.345)$

Table 5.9. Megrim (*L. whiffiagonis*) in divisions 7.b–k and 8.a, 8.b, and 8.d. Catch forecast: management option table.

Short term forecast table		F UNSCALED								
Model: NMEG0-R1		R 2021-2022 REPLACED								
Projection: 3										
Quantile	Rec_2021	SSB_2021	TSB_2021	Fbar_2021	Catch_2021	Land_2021	Disc_2021	Rec_2022	SSB_2022	TSB_2022
5%	216068	108523	154524	0.17	18672	16063	2374	216068	115984	159410
50%	221690	126311	177349	0.19	20682	17806	2860	221690	136377	181799
95%	227698	145747	202755	0.21	23128	19874	3560	227698	159408	206530
Table for quantile: 0.5										
Fmult	F_2022	Catch_2022	Land_2022	Disc_2022	Rec_2023	SSB_2023	TSB_2023			
0	0	0	0	0	221690	162887	207283			
0.1	0.019	2461	2162	296	221690	160273	204534			
0.2	0.038	4878	4284	587	221690	157758	201928			
0.3	0.056	7249	6364	875	221690	155252	199338			
0.4	0.075	9576	8404	1158	221690	152819	196782			
0.5	0.094	11860	10408	1437	221690	150422	194250			
0.6	0.113	14100	12380	1712	221690	147963	191775			
0.7	0.131	16299	14306	1983	221690	145660	189357			
0.8	0.15	18456	16197	2251	221690	143360	187003			
0.9	0.169	20570	18047	2515	221690	141092	184663			
1	0.188	22656	19871	2774	221690	138843	182356			
1.1	0.207	24692	21659	3030	221690	136674	180051			
1.2	0.225	26702	23416	3282	221690	134511	177863			
1.3	0.244	28677	25138	3530	221690	132386	175683			
1.4	0.263	30620	26826	3774	221690	130361	173559			
1.5	0.282	32516	28487	4017	221690	128408	171536			
1.6	0.3	34383	30115	4256	221690	126443	169544			
1.7	0.319	36217	31709	4491	221690	124529	167545			
1.8	0.338	38025	33288	4723	221690	122648	165571			
1.9	0.357	39792	34829	4951	221690	120805	163680			
2	0.376	41527	36352	5175	221690	118989	161803			

Table 5.10. Megrim (*L. whiffiagonis*) in divisions 7.b–k and 8.a, 8.b, and 8.d. Reference points table updated in WGBIE 2021.

From the IBP megrim (ICES, 2016):	Type	Value	Technical Basis
MSY approach	MSY $B_{trigger}$	41 800	B_{pa}, because the fishery has not been at F_{MSY} in the last 10 years
	F_{MSY}	0.191	F giving maximum yield at equilibrium Computed using Eqsim.
	F_{MSY} ranges	0.122–0.289	Stochastic simulations, 5% reduction in long-term yield compared with MSY.
Precautionary approach	B_{lim}	37 100	$B_{loss,}$ which is the lowest biomass observed corresponding to year 2006
	B_{pa}	41 800	$\mathbf{B_{lim}} e^{1.645\,\sigma}$ where $\boldsymbol{\sigma = 0.07}$isthe standard deviation of the logarithm of SSB in 2014
	F_{lim}	0.533	It is the F that gives 50% probability of SSB being above B_{lim} in the long-term. It is computed using Eqsim based on segmented regression with the breakpoint fixed at B_{lim}, without advice/assessment error and without $B_{trigger}$
	F_{pa}	0.417	$F_{p0.5}$: The F that provides a 95% probability for SSB to be above B_{lim} $F_{p0.5}$ (5% risk to B_{lim} with $B_{trigger}$=B_{pa}).

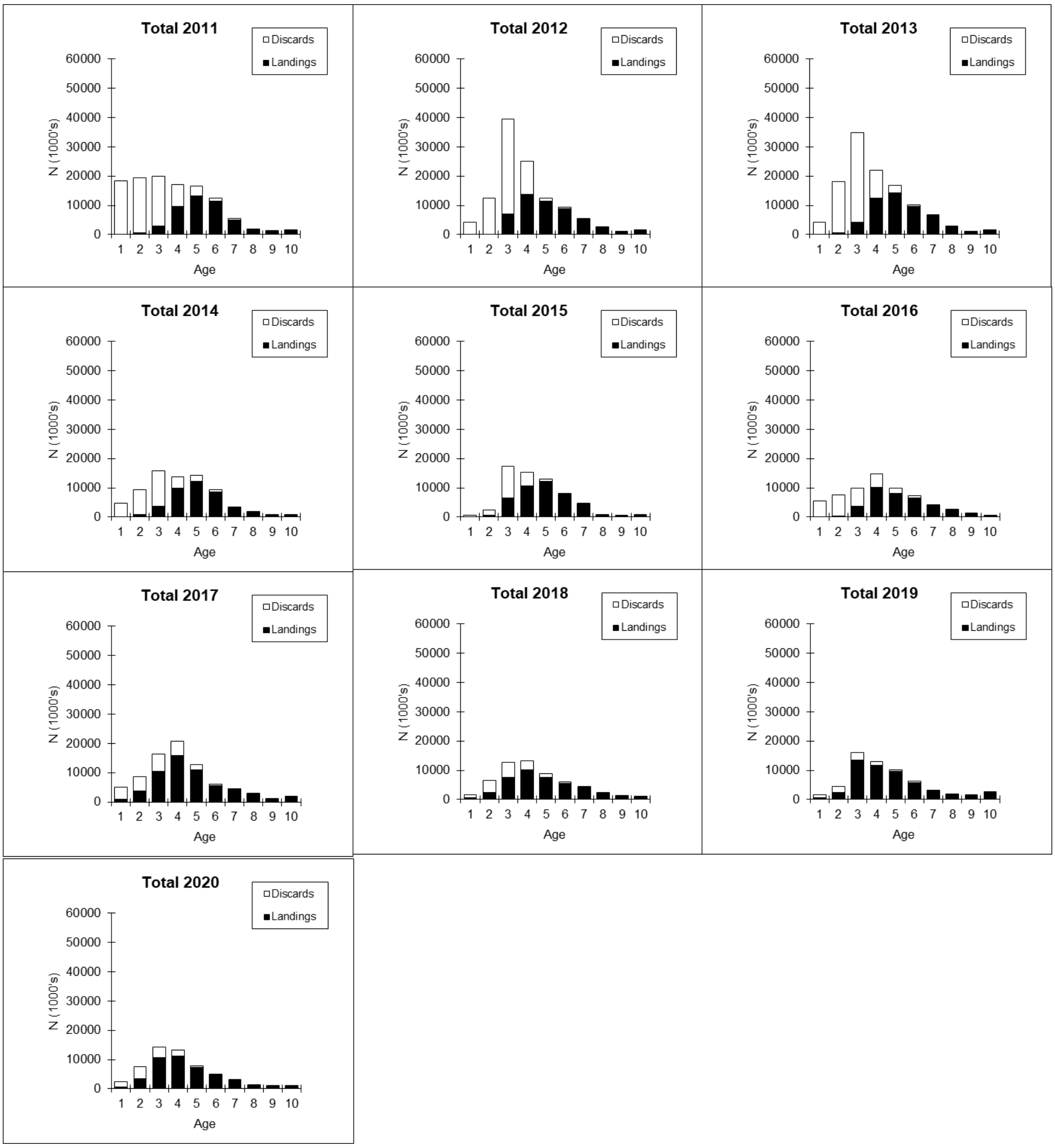


Figure 5.1. Megrim (*L. whiffiagonis*) in divisions 7.b–k and 8.a, 8.b, and 8.d. Age composition of catches for the years 2011–2020.

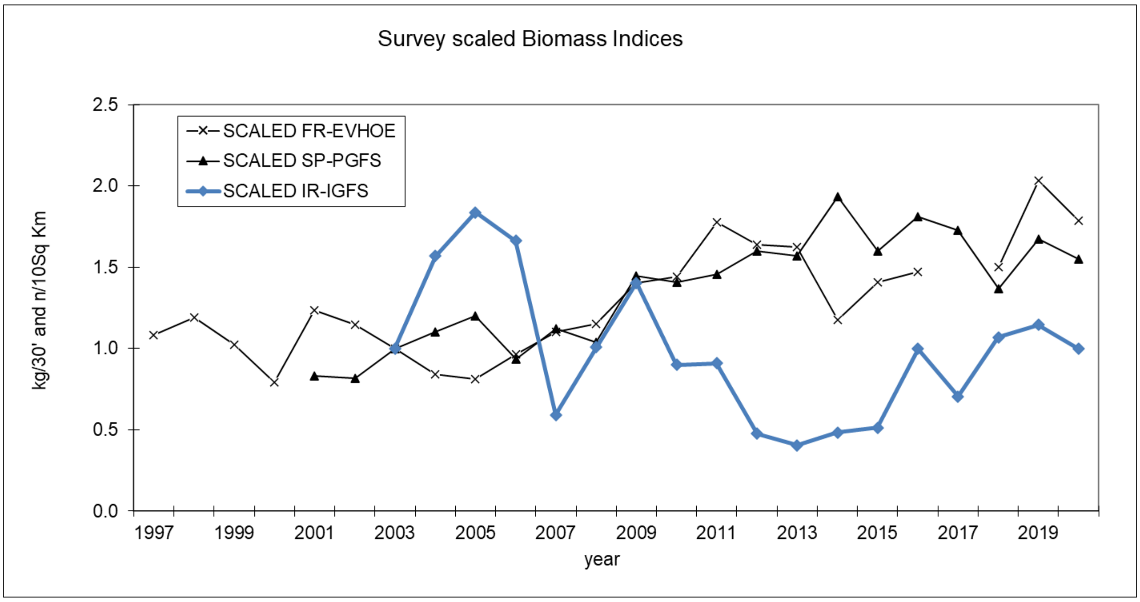


Figure 5.2. Megrim (*L. whiffiagonis*) in divisions 7.b–k and 8.a, 8.b, and 8.d. Scaled Biomass Indices for IGFS-WIBTS-Q4 (G7212), SpPGFS-WIBTS-Q4 (G5768) and EVHOE-WIBTS-Q4 (G9527).

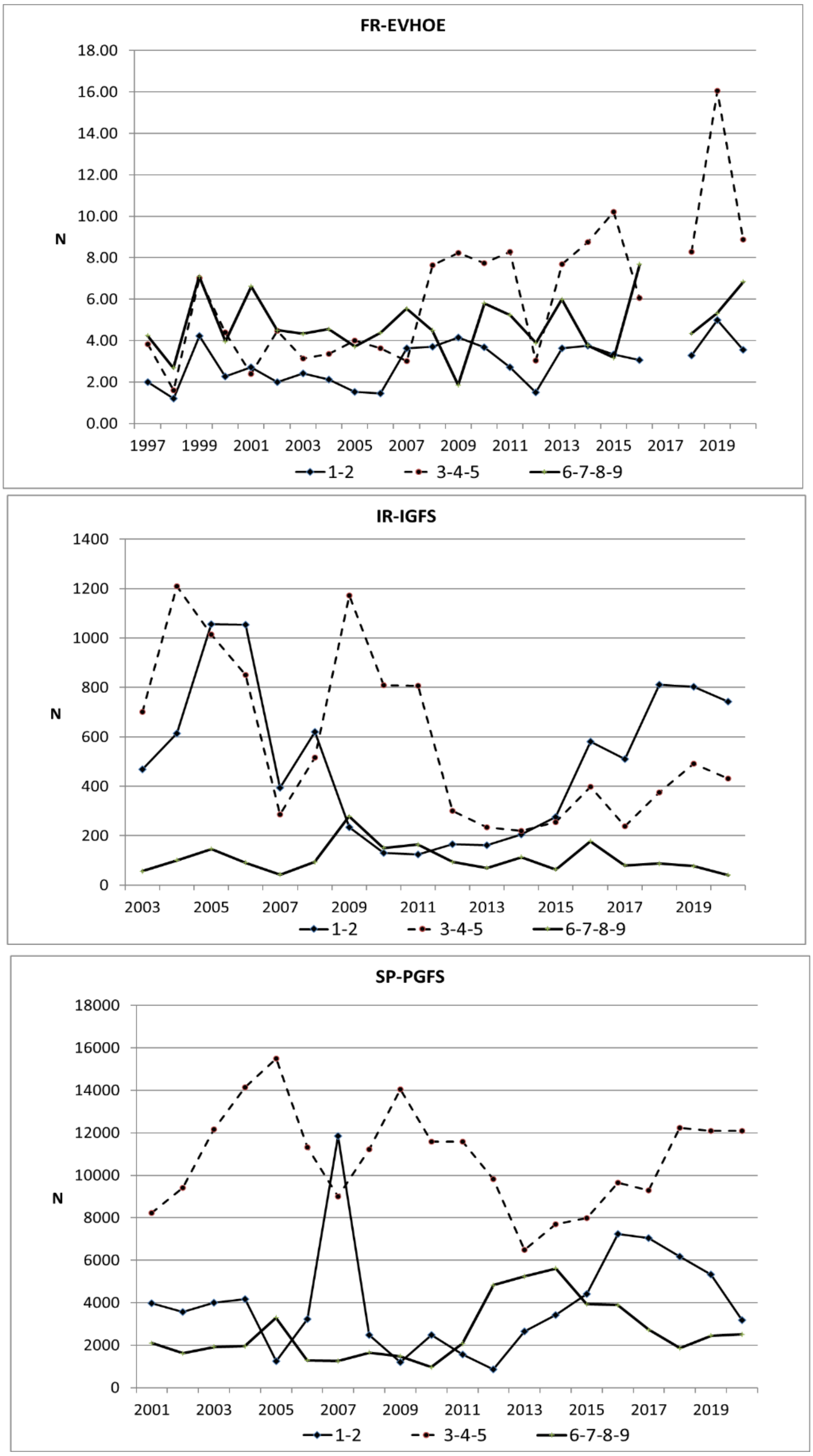


Figure 5.3. Megrim (*L. whiffiagonis*) in divisions 7.b–k and 8.a, 8.b, and 8.d. Abundance Indices for IGFS-WIBTS-Q4 (G7212), SpPGFS-WIBTS-Q4 (G5768) and EVHOE-WIBTS-Q4 (G9527) by ages grouped: i) 1+2; ii) 3+4+5 and iii) 6+7+8+9+10+.

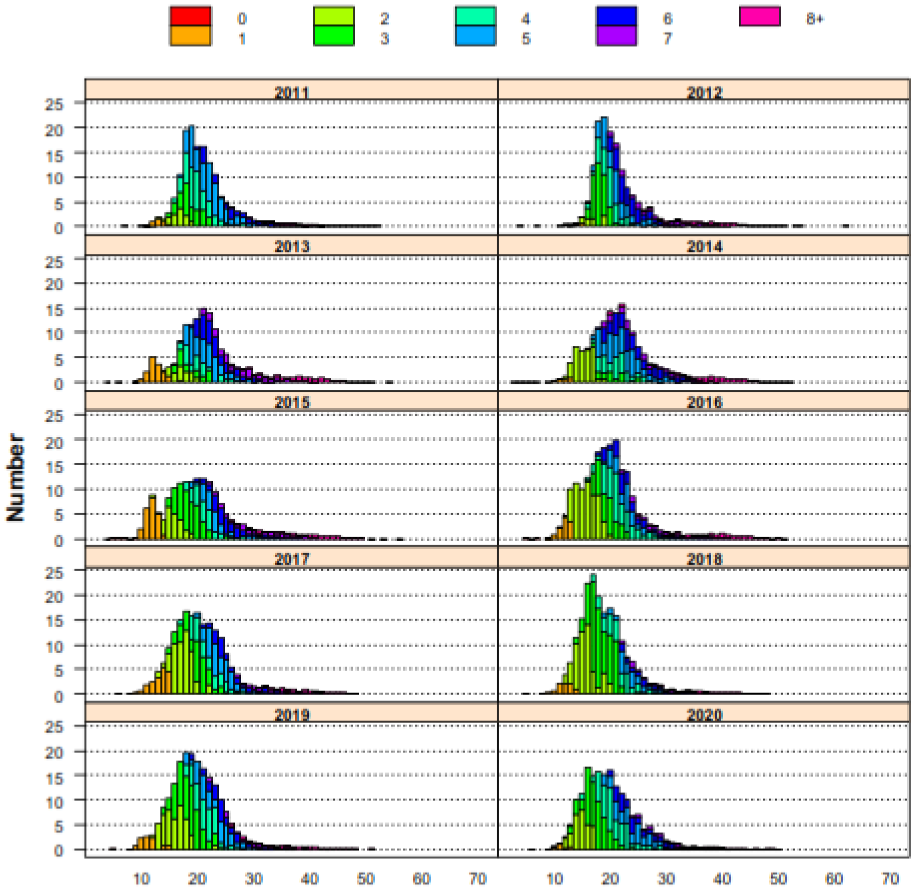


Figure 5.4. Megrim (*L. whiffiagonis*) in divisions 7.b–k and 8.a, 8.b, and 8.d. Age composition of SpPGFS-WIBTS-Q4 (G5768) survey in abundance (numbers).

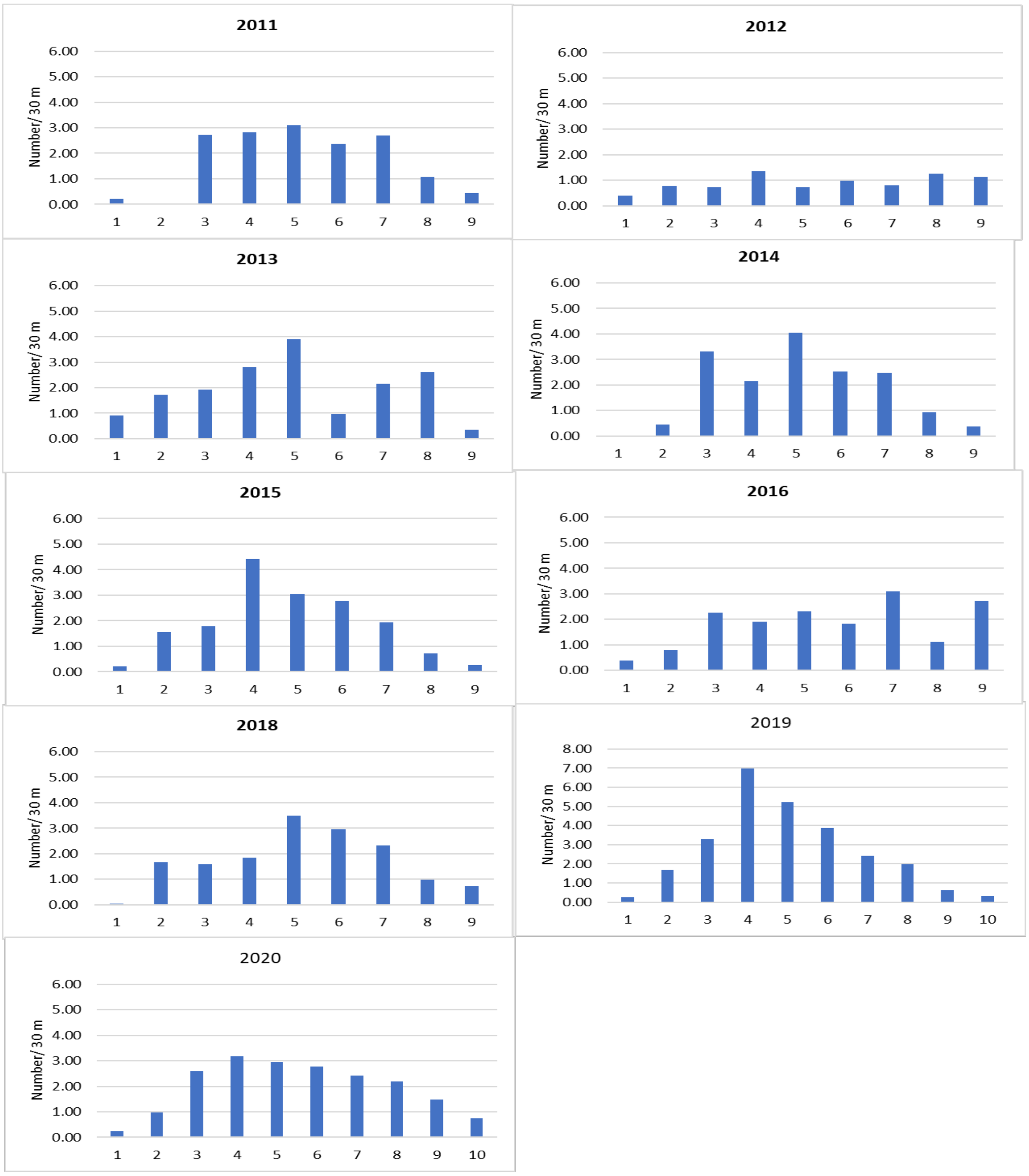


Figure 5.5. Megrim (*L. whiffiagonis*) in divisions 7.b–k and 8.a, 8.b, and 8.d. Age composition of EVHOE-WIBTS-Q4 (G9527) survey in abundance (numbers/30min haul).

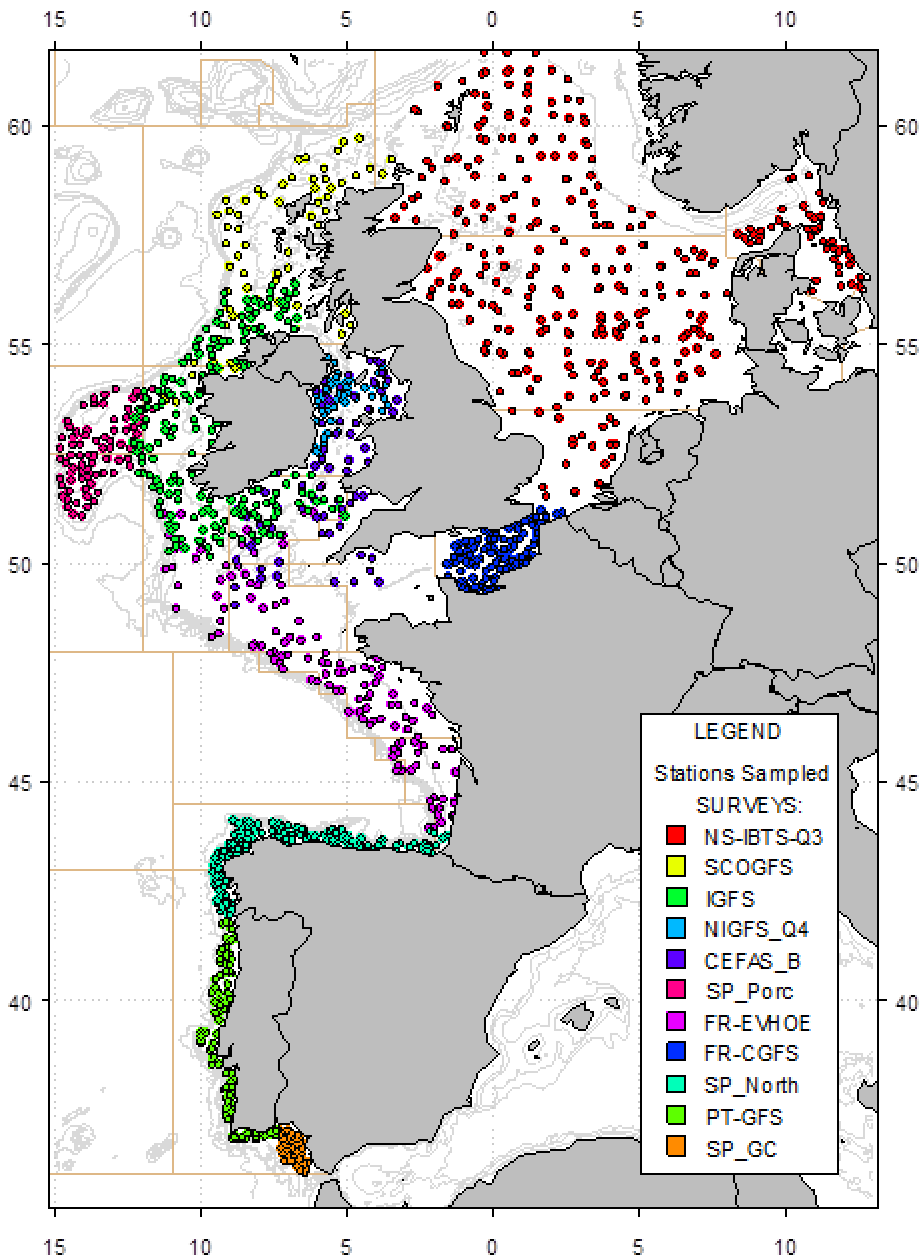


Figure 5.6. Station positions for the IBTS Surveys carried out in the Western Atlantic and North Sea area in autumn/winter of 2008. (From IBTSWG Report, ICES 2009). Just to be used as general location of the surveys.

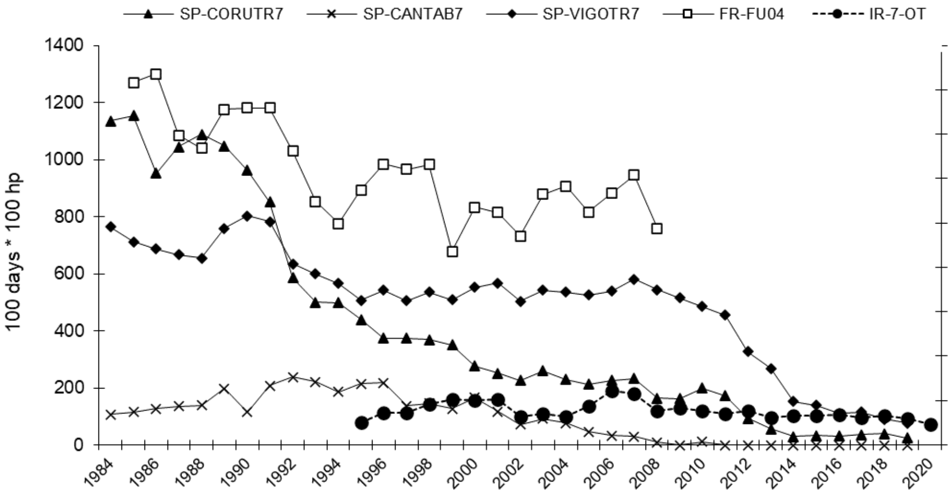


Figure 5.7. Megrim (*L. whiffiagonis*) in divisions 7.b–k and 8.a, 8.b, and 8.d. Evolution of effort for different bottom-trawler fleets.

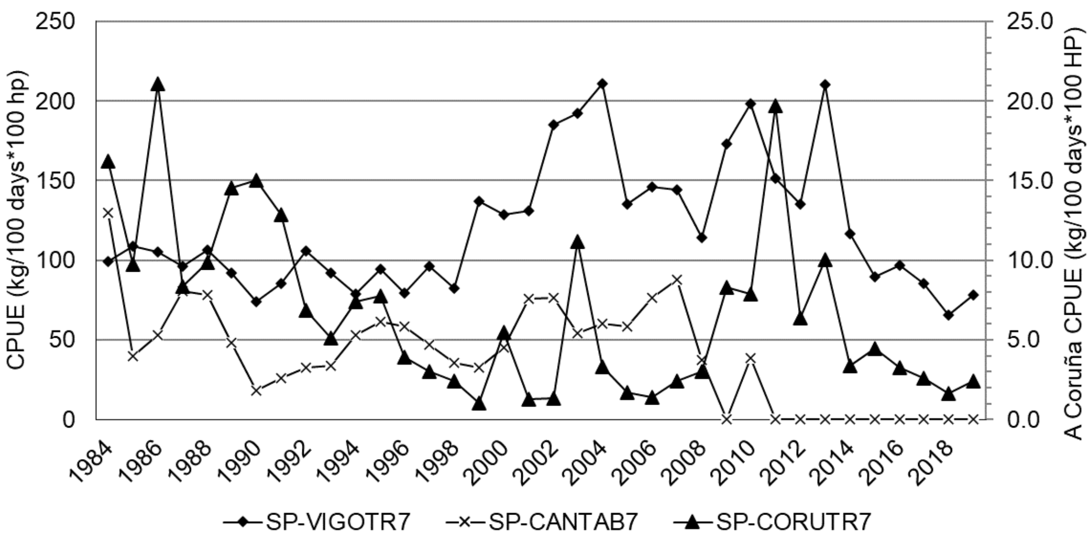


Figure 5.8. Megrim *(L. whiffiagonis*) in divisions 7.b, 7.c, 7.e–k and 8.a, 8.b, and 8.d. Spanish cpue for different bottom-trawler fleets.

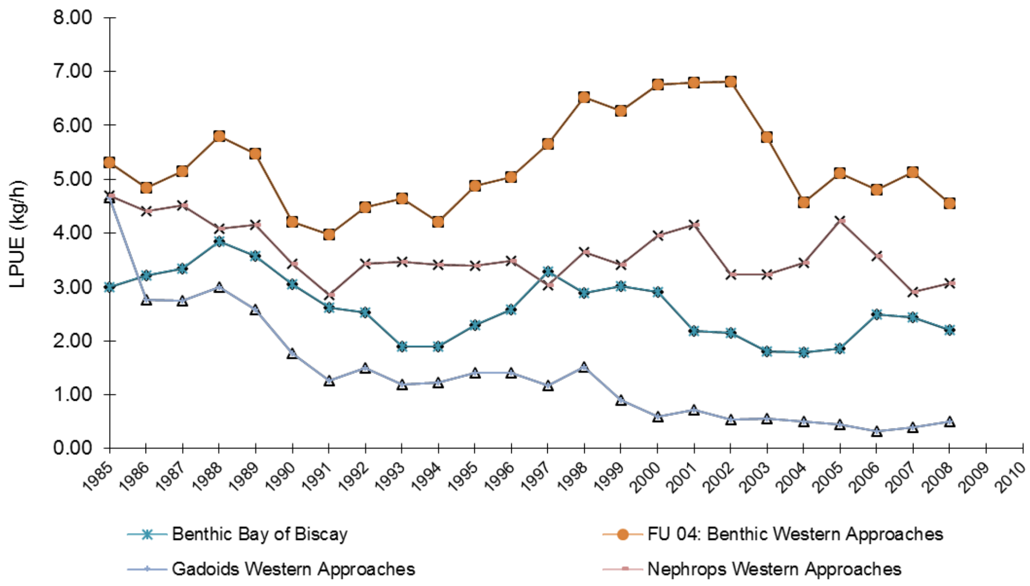


Figure 5.9. Megrim *(L. whiffiagonis*) in divisions 7.b, 7.c, 7.e–k and 8.a, 8.b, and 8.d. French LPUE for different bottom-trawler fleets.

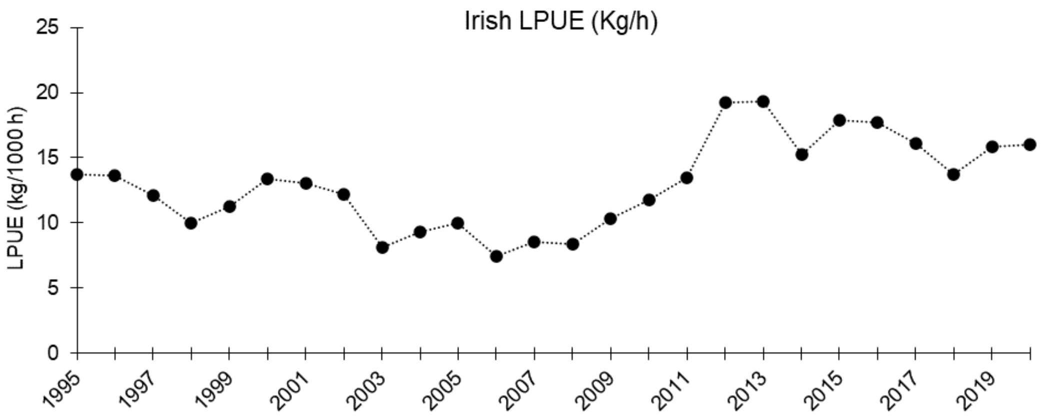


Figure 5.10. Megrim (*L. whiffiagonis*) in divisions 7.b, 7.c, 7.e–k and 8.a, 8.b, and 8.d. Irish LPUE for beam trawl fleet.

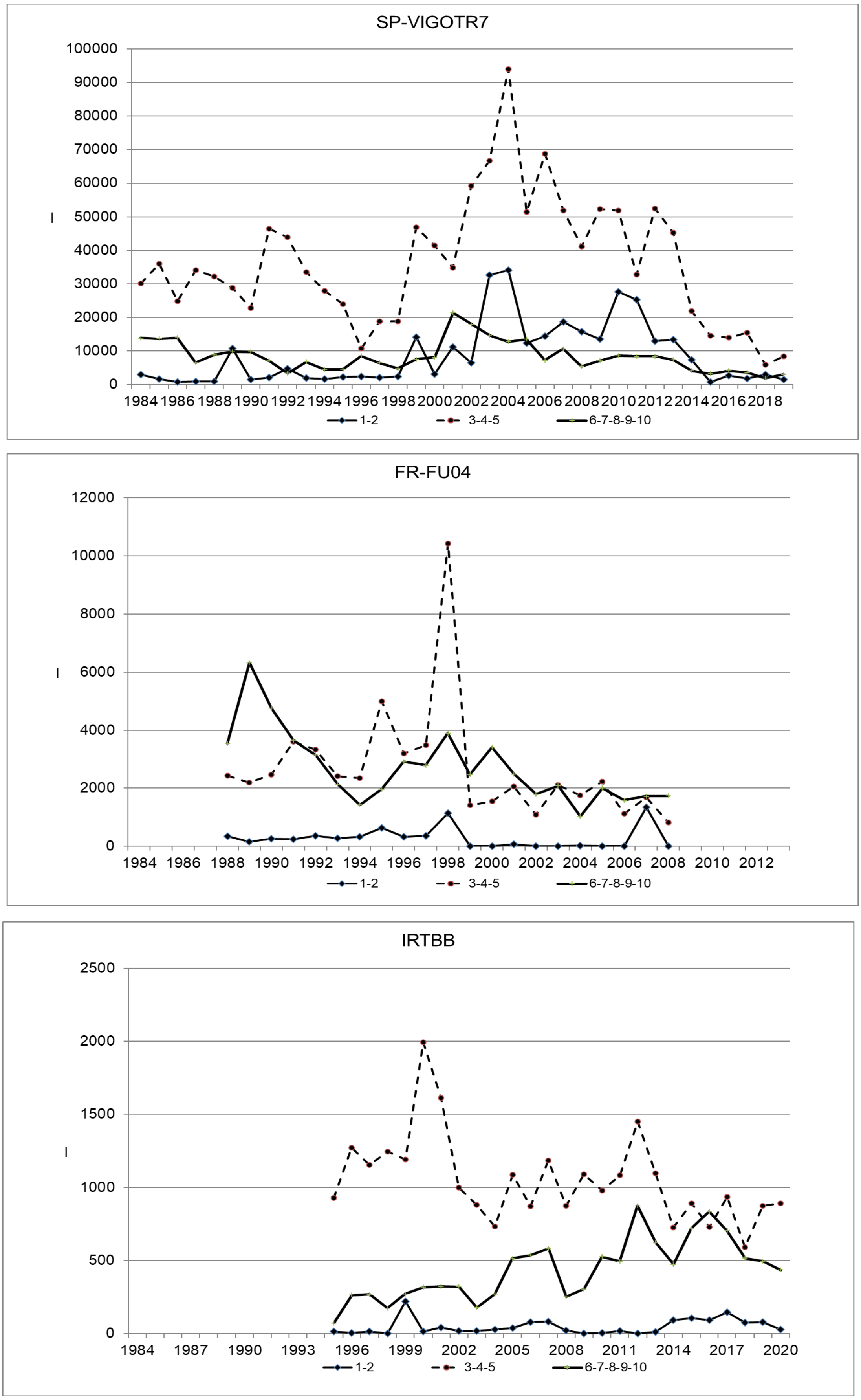


Figure 5.11. Megrim (*L. whiffiagonis*) in divisions 7.b–k and 8.a, 8.b, and 8.d. Abundance Indices for SP-VIGOTR7, FR-FU04 and IRTBB by ages grouped: i) 1+2; ii) 3+4+5 and iii) 6+7+8+9+10⁺.

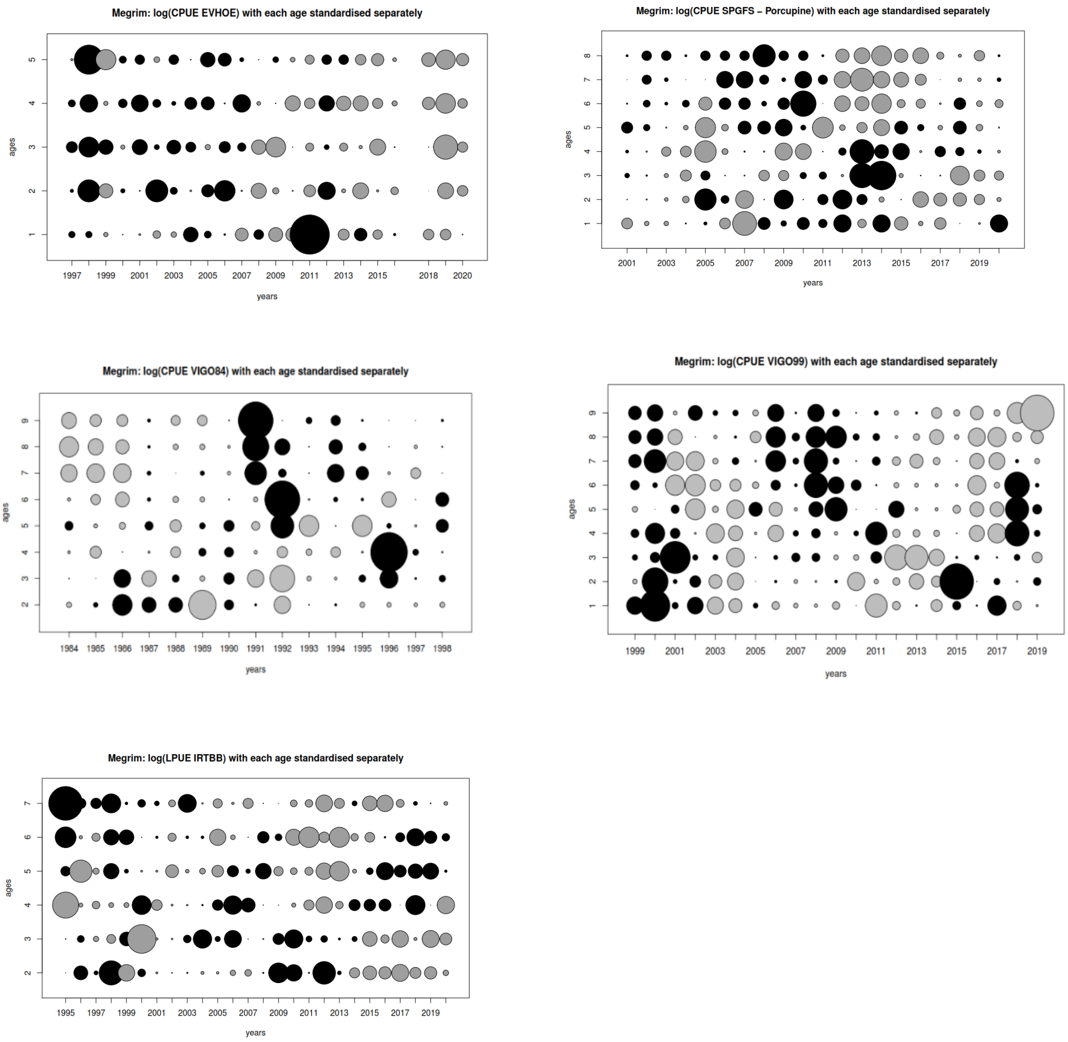


Figure 5.12. Megrim (*L. whiffiagonis*) in divisions 7.b–k and 8.a, 8.b, and 8.d. Bubble plots of the standardized log abundance indices of the surveys and commercial fleets used as tuning fleets (grey – positive values, black – negative values).

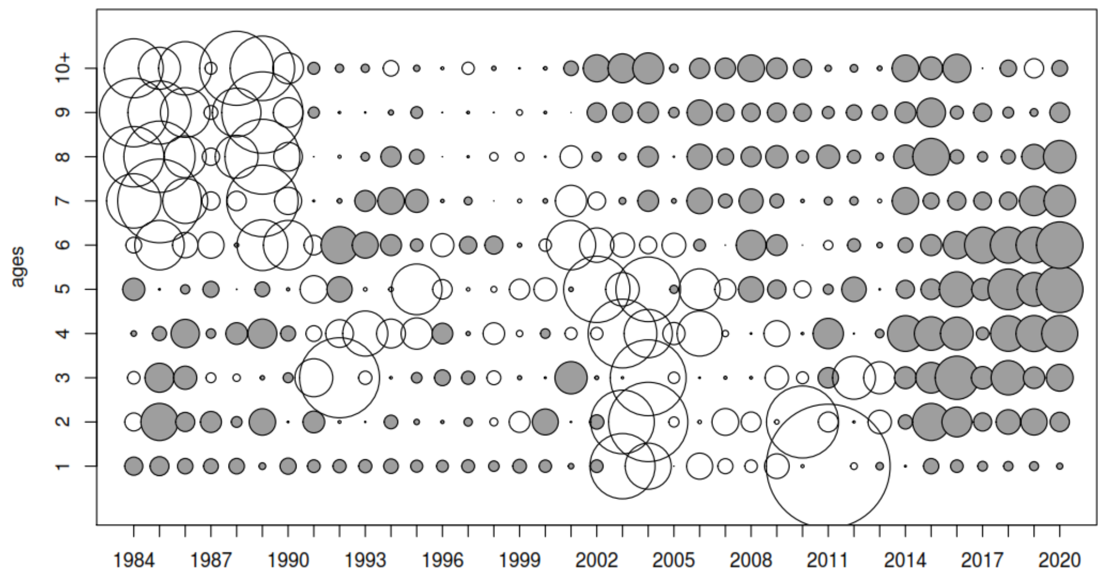


Figure 5.13. Megrim (*L. whiffiagonis*) in divisions 7.b–k and 8.a, 8.b, and 8.d. Bubble plots for catch numbers-at-age (grey – positive values, black – negative values).

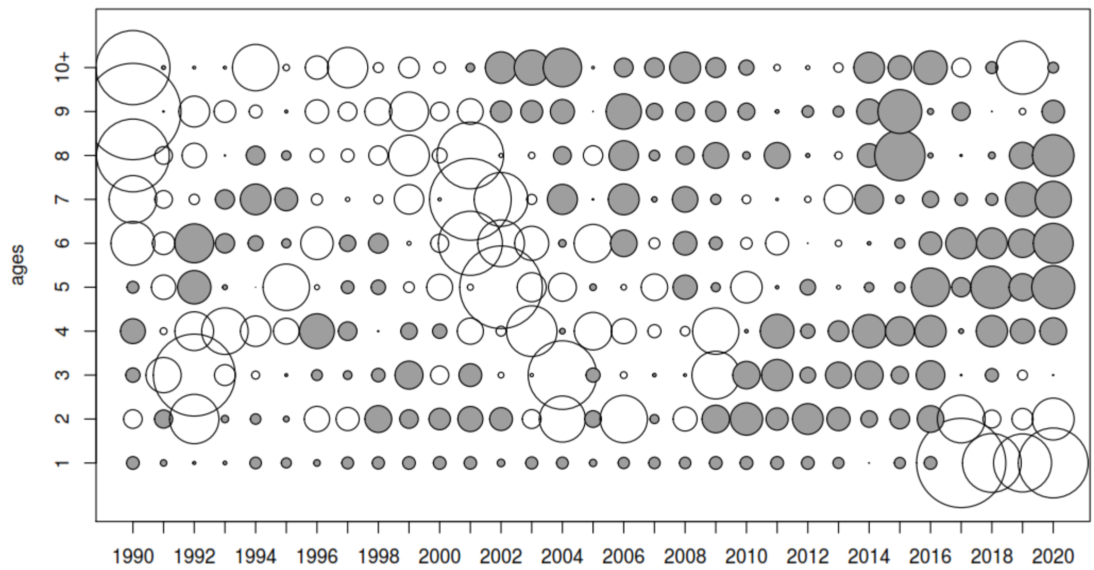


Figure 5.14. Megrim (*L. whiffiagonis*) in divisions 7.b–k and 8.a, 8.b, and 8.d. Bubble plots for landing numbers-at-age (grey – positive values, black – negative values).

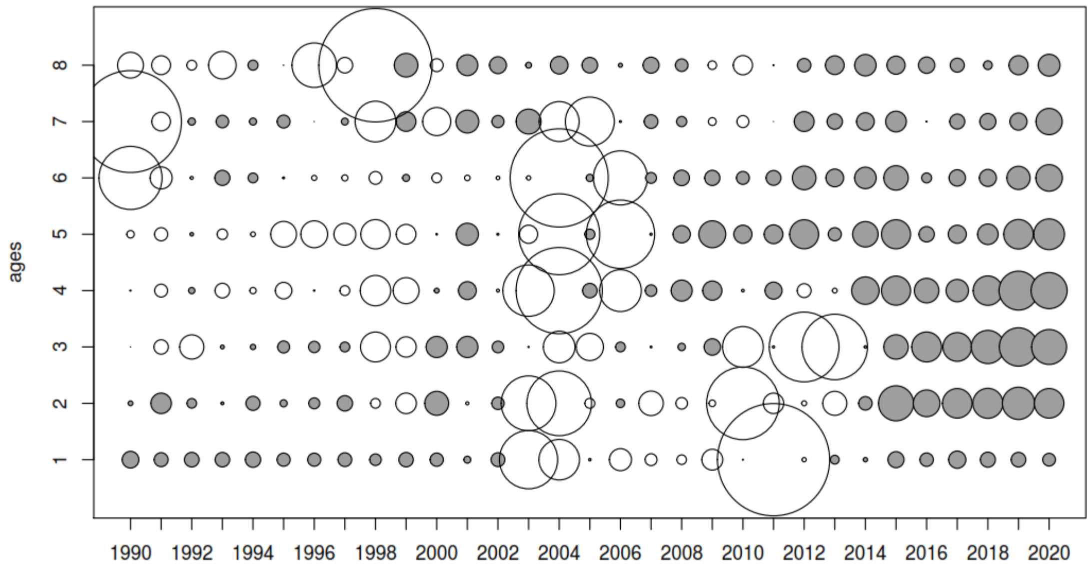


Figure 5.15. Megrim (*L. whiffiagonis*) in divisions 7.b–k and 8.a, 8.b, and 8.d. Bubble plots for discarded numbers-at-age (grey – positive values, black – negative values).

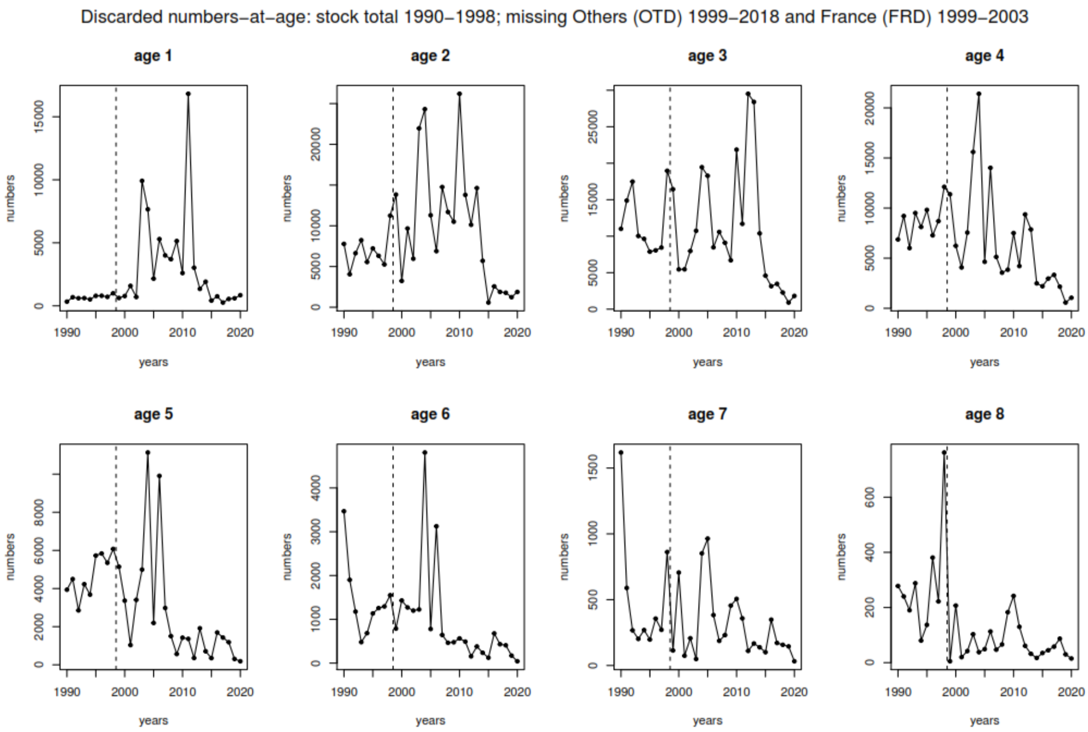


Figure 5.16. Megrim (*L. whiffiagonis*) in divisions 7.b–k and 8.a, 8.b, and 8.d. Discarded numbers-at-age separated by age from 1990 to 2019.

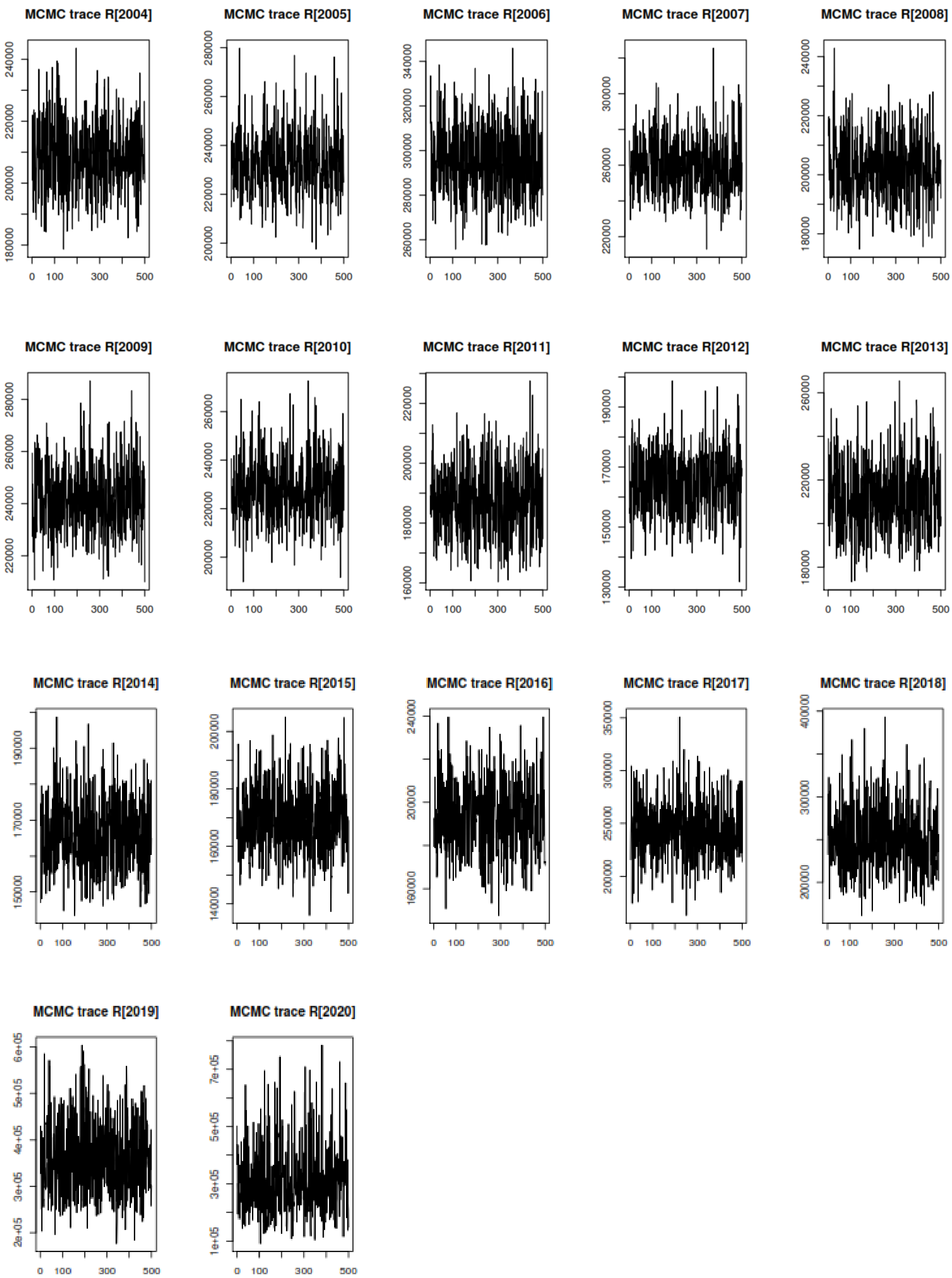


Figure 5.17. Trace plots of recruitment draws from 2004 to 2020.

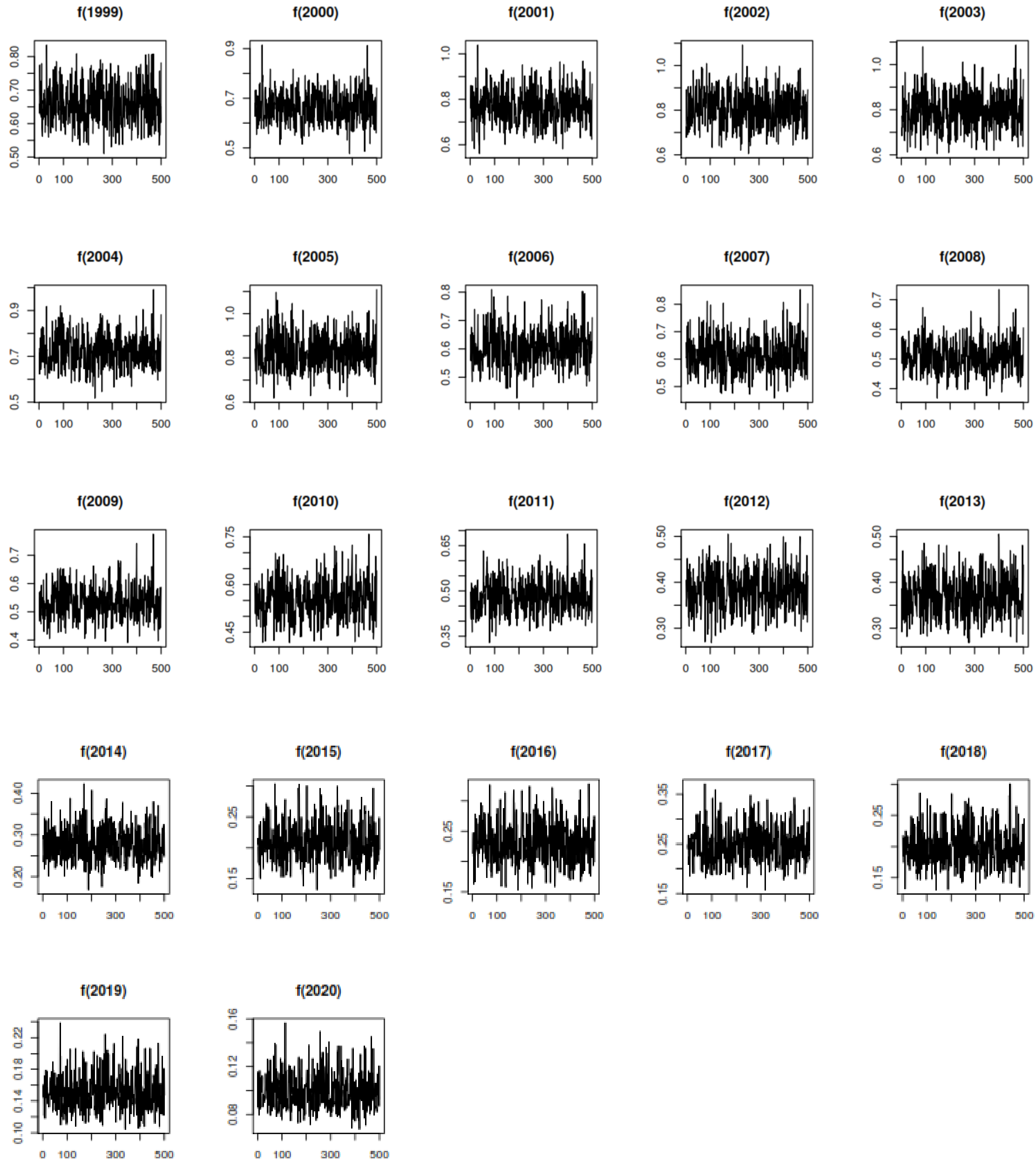


Figure 5.18. Trace plots of f(y) fishing mortality in ages 9 and 10 from 1999 to 2020.

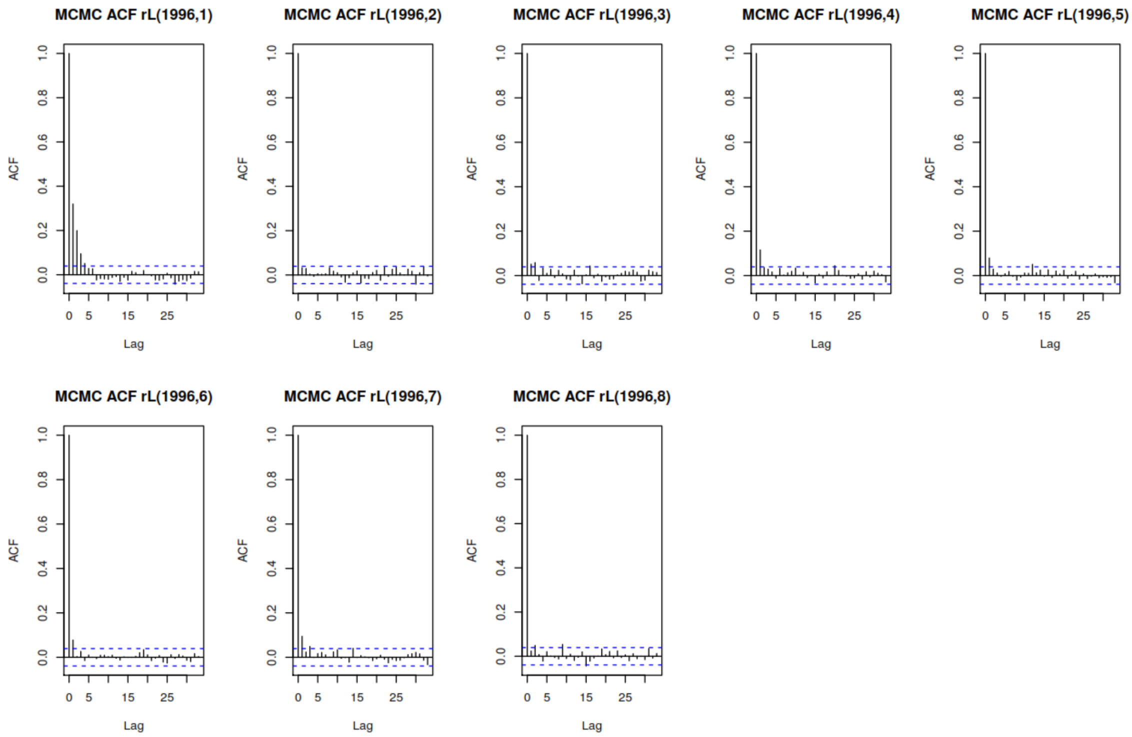


Figure 5.19. Autocorrelation plots of rL for years 1996 and 2020.

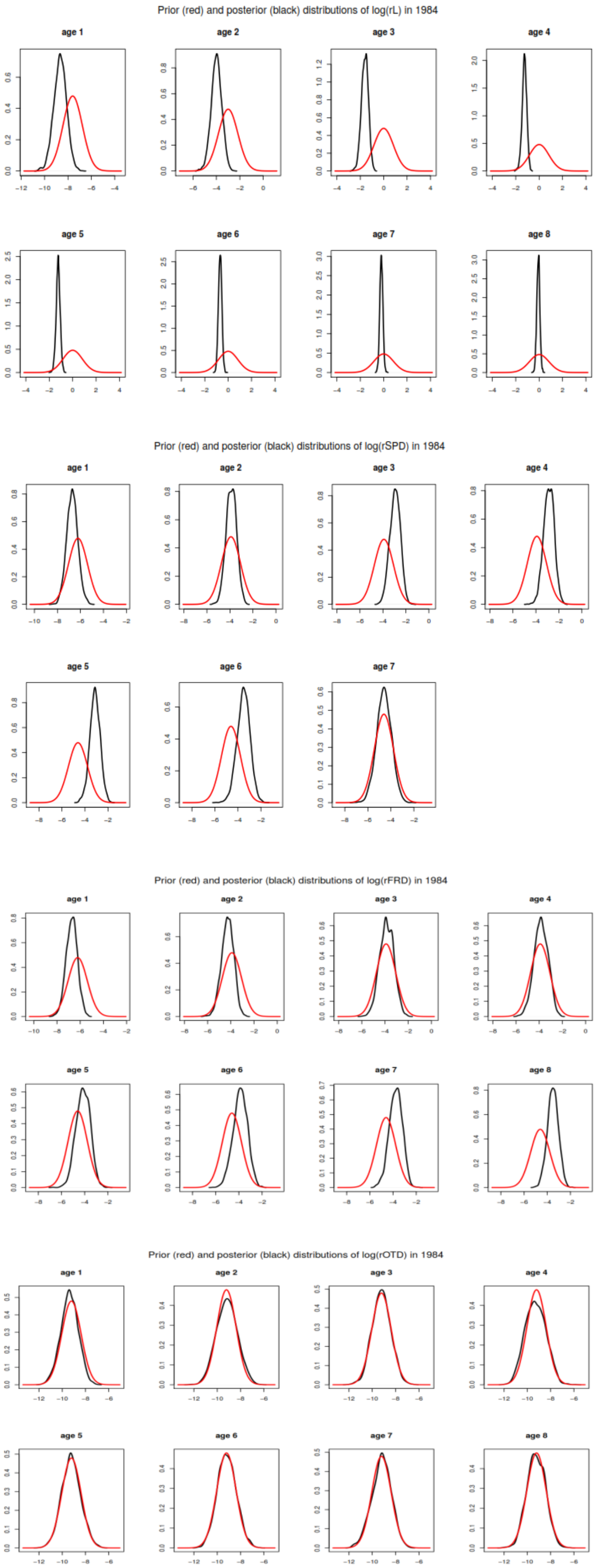


Figure 5.20. Prior (red) and posterior distribution of log (L) in 1984, log (rSPD) at age in 1984, log (rFRD) at age in 1984 and log (rOTD) at age in 1984.

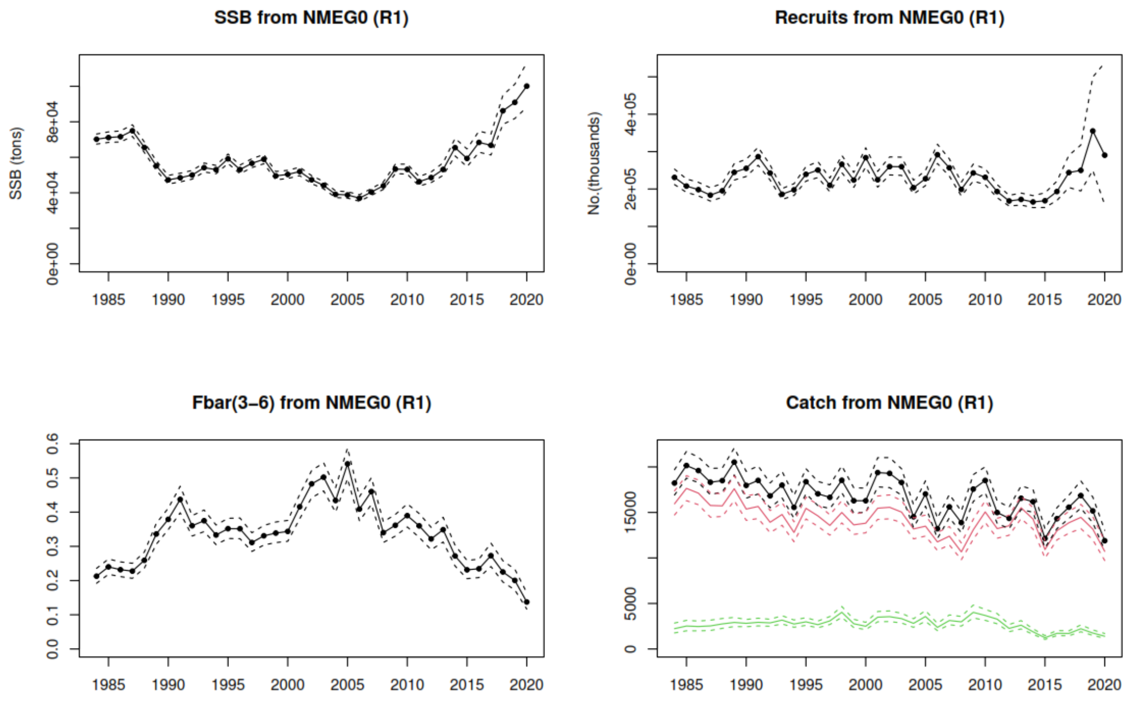


Figure 5.21. WGBIE 2021 results of time-series of spawning-stock biomass (SSB), recruits, F_{bar}, catch (black), landings (red) and discards (green) from 1984 to 2020. The solid dotted lines correspond to the median of the distribution and the dashed lines to the 5% and 95% quantiles.

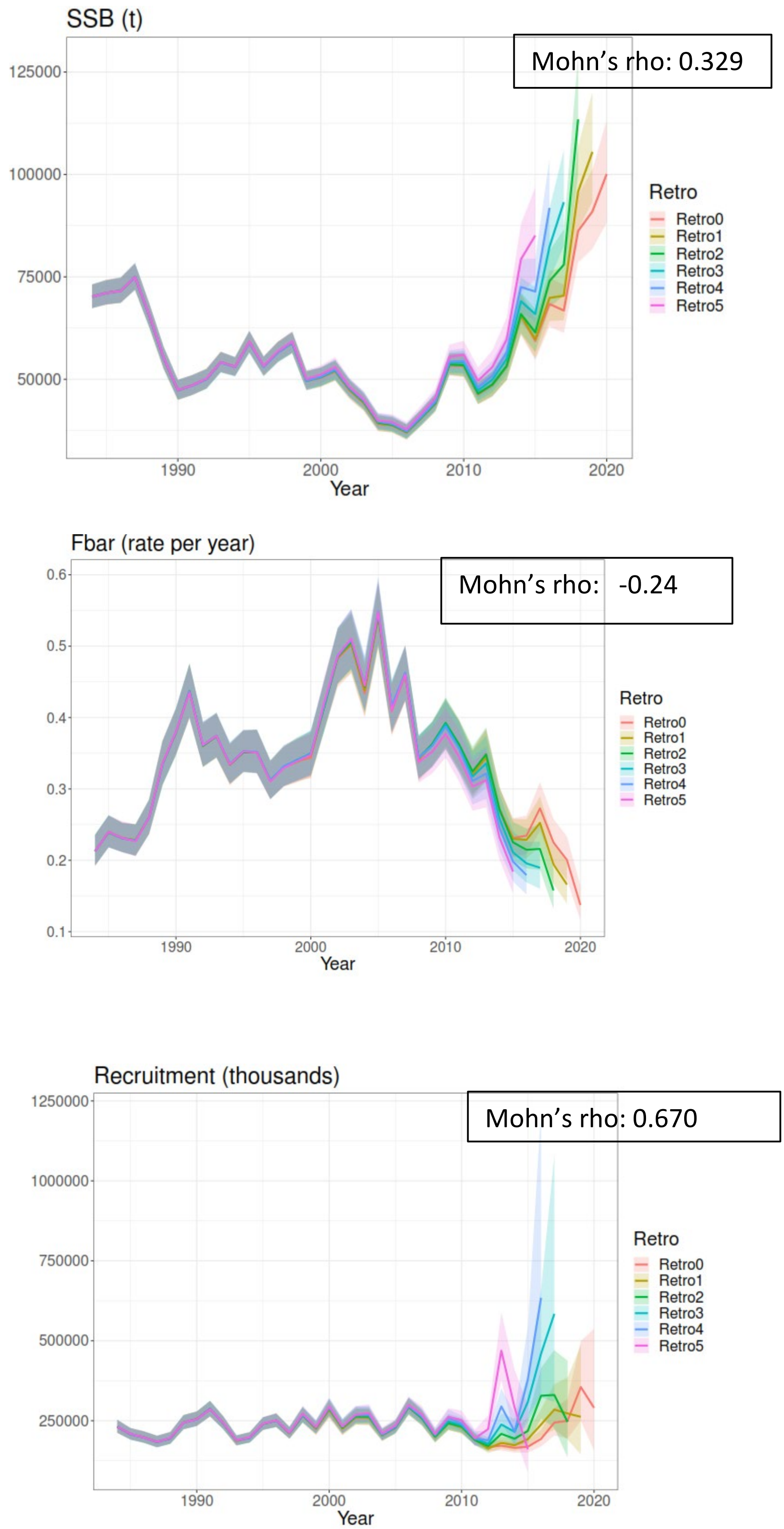


Figure 5.22. Time-series of median SSB, recruitment and F_{bar} in retrospective analysis.

5.3 Four-spot megrim (*L. boscii*) in divisions 7.b–k, 8.a, 8.b, and 8.d

5.3.1 Fishery description

Four-spot megrim (*Lepidorhombus boscii*) in the Celtic Sea, west of Ireland, and in the Bay of Biscay are caught in a mixed fishery predominantly by French followed by Spanish, UK and Irish demersal vessels (see Stock Annex for details).

5.3.2 Summary of ICES Advice for 2022 and Management applicable for 2021 and 2022

5.3.2.1 ICES advice for 2022

ICES has been requested to provide advice on fishing opportunities for four-spot megrim in divisions 7.b–k, 8.a–b, and 8.d. ICES advises that when the precautionary approach is applied, catches in 2022 should be reduced by at least 20% relative to the average catches of 2017–2019 resulting in catch advice of 867 t.

5.3.2.2 Management applicable for 2021 and 2022

Management of four-spot megrim and megrim under a combined species TAC prevents effective control of the single-species exploitation rates and could lead to overexploitation of either species.

5.3.3 Data

5.3.3.1 Commercial catches and discards

Four-spot megrim was included in the ICES catch and discard data call for the first time in 2018 and data on commercial catch and discard information were made available to the working group (WG) from France, Ireland, Spain and UK. Historical data on commercial catch and discards, going back to 2003, were requested in the 2020 ICES data call and France, Ireland, Spain and UK responded to this request. Historical Spanish catches were requested again in the 2021 ICES data call but are still unavailable prior to 2017. Belgium provided catch and biological information to WGBIE for the first time this year.

Sampling of commercial catches in 2020 was negatively impacted by COVID-19 and France could not estimate four-spot megrim catches for this year as the proportion of this species in the mixed landings could not be determined.

Table 5.1. Commercial catches (in tonnes) of four-spot megrim in 2020 by country and gear type.

	BMS landing	Discards	Landings	Logbook Registered Discard	Total
Belgium					
TBB_DEF	-	0	0	-	0
France					
MIS_MIS	-	-	0	-	0
OTB_CRU	-	-	0	-	0
OTB_DEF	-	0	0	-	0
OTT_CRU	-	0	0	-	0
OTT_DEF	-	-	0	-	0
Ireland					
GNS_DEF	-	-	1	-	1
MIS_MIS	-	-	0	-	0
OTB_CRU	-	2	2	-	4
OTB_DEF	-	4	32	-	36
SSC_DEF	-	0	3	-	3
TBB_DEF	-	0	12	-	12
Spain					
GNS_DEF	-	-	1	-	1
LLS_DEF	-	-	0	-	0
OTB_DEF	0	117	436	0	553
OTB_MPD	-	-	0	-	0
PTB_DEF	-	-	0	-	0
UK (England)					
GNS_DEF	-	-	0	-	0
UK(Scotland)					
MIS_MIS	-	-	0	-	0
Total	0	122	488	0	611

Table 5.2. Commercial catches (in tonnes) of four-spot megrim 2003–2020 by year and country.

	France		Ireland		Spain				UK (England)	UK(Scotland)	Belgium		Total
	Discards	Landings	Discards	Landings	BMS Landings	Discards	Landings	Logbook Discards	Landings	Landings	Discards	Landings	
2003	-	0.0	-	-	-	-	-	-	-	-	-	-	**0**
2004	-	0.0	-	-	-	-	-	-	-	-	-	-	**0**
2005	0	62	-	-	-	-	-	-	-	-	-	-	**62**
2006	4	1	-	-	-	-	-	-	-	-	-	-	**5**
2007	3	123	-	-	-	-	-	-	-	-	-	-	**126**
2008	-	0.0	-	-	-	-	-	-	-	-	-	-	**0**
2009	1	2	-	-	-	-	-	-	-	-	-	-	**2**
2010	8	65	-	-	-	-	-	-	-	-	-	-	**73**
2011	2	39	31	-	-	-	-	-	-	-	-	-	**71**
2012	1	2	73	-	-	-	-	-	-	-	-	-	**75**
2013	3	33	-	-	-	-	-	-	-	-	-	-	**36**
2014	2	31	-	-	-	-	-	-	-	-	-	-	**33**
2015	2	131	-	-	-	-	-	-	-	-	-	-	**133**
2016	8	268	-	-	-	-	-	-	-	-	-	-	**275**
2017	5	25	288	130	-	273	439	-	-	-	-	-	**1160**
2018	4	16	35	64	-	214	833	0.0	0.0	-	-	-	**1166**
2019	24	380	41	62	0.4	41	378	0.0	0.2	0.0	-	-	**926**
2020	0	0.0	6	51	0.1	117	437	0.0	0.0	0.0	0.1	0.2	**611**

5.3.3.2 Biological sampling

Biological sampling data for four-spot megrim were included in the ICES data call for the first time in 2018. Data on length were made available to the 2019 WG from Ireland and Spain. Historical data on length, going back to 2003, were requested in the 2019 and 2020 data calls and Ireland, France, Spain and UK responded to this request (UK has not sampled this species).

Length frequency distributions for landings and discards were not available from all countries due to COVID-19 pandemic. Spain provided length distributions for landings and discards, whereas Ireland could only provide information on discard length distribution. Belgium also provided landings length distributions and information on age at length.

Age

Age data were made available for the first time to the 2021 WG from Belgium only. Fish from age 4 to age 11 were identified in landings with a modal age of 7 years.

Lengths

Table 5.3. Number of length samples and measurements of four-spot megrim by year and country.

	Number of Length Samples	Number of Length Measurements
France		
2007	140	202
2014	8	124
2015	9	32
2016	14	103
2017	23	39
2019	45	393
2020	0	0
Ireland		
2011	168	2120
2012	184	8352
2017	402	34 736
2018	171	1198
2019	100	11 475
2020	12	1025
Spain		
2017	424	13 396
2018	427	15 502

	Number of Length Samples	Number of Length Measurements
2019	323	7410
2020	116	2023
Belgium		
2020	21	39

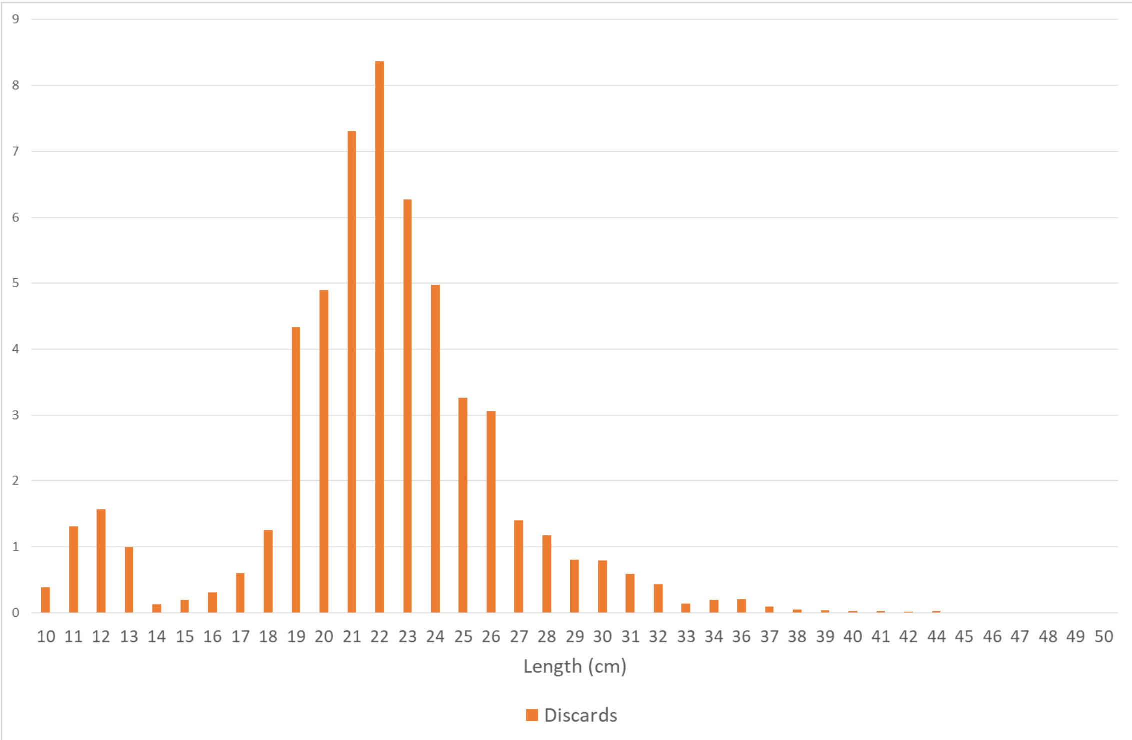


Figure 5.1.Length–frequency distribution of discards from Irish fleets.

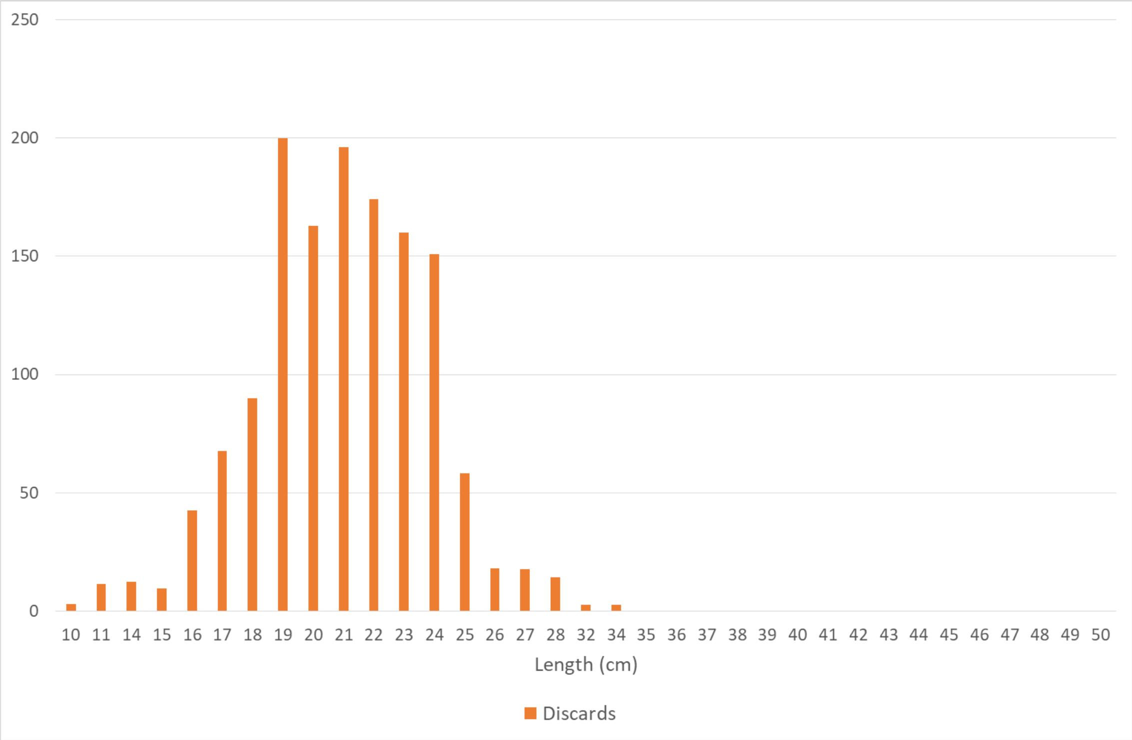


Figure 5.2. Length–frequency distribution of discards from Spanish fleets (source: IEO).

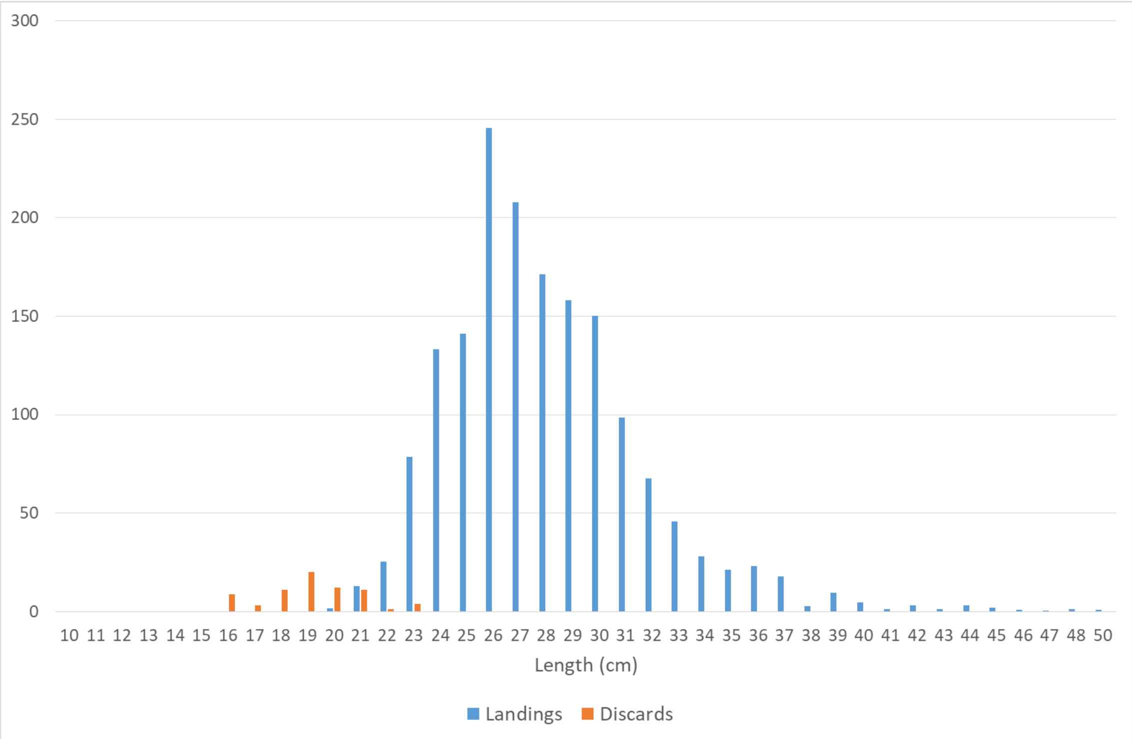


Figure 5.3. Length–frequency distribution of landings and discards from Spanish fleets (source: AZTI).

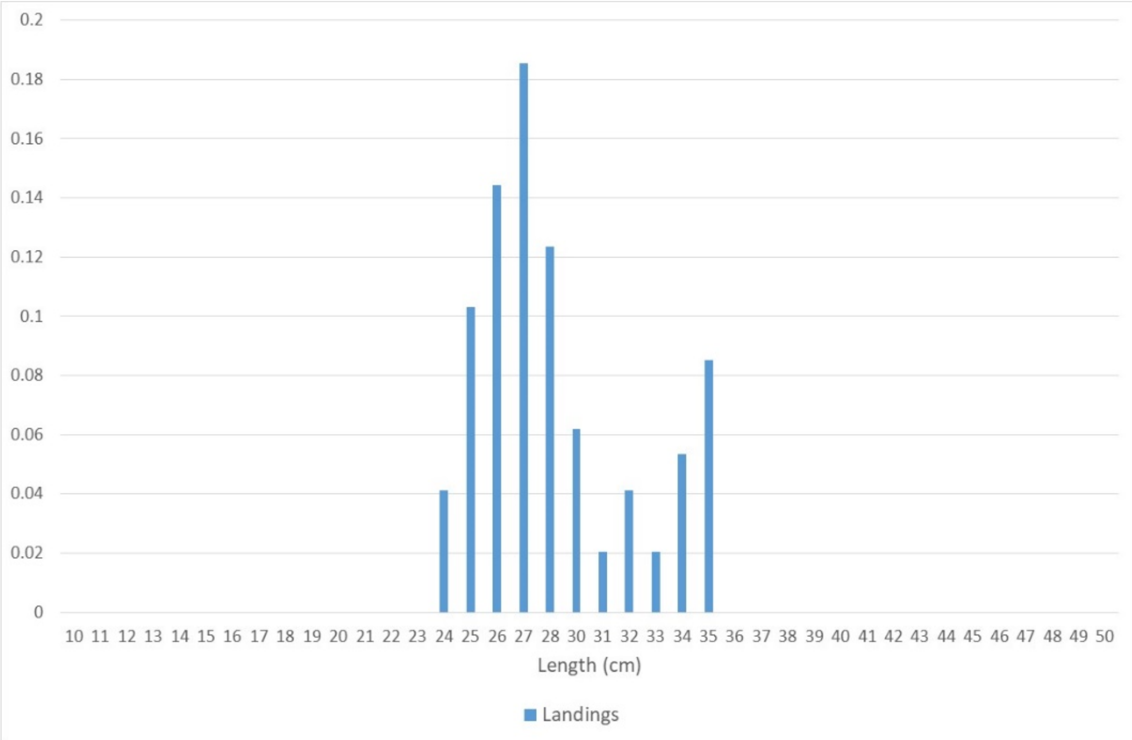


Figure 5.4. Length–frequency distribution of landings from Belgian fleets.

Natural Mortality

Not included in the assessment.

5.3.3.3 Survey data

Survey data were extracted from DATRAS for Spanish Porcupine Bottom Trawl Survey (SpPGFS-WIBTS-Q3, G5768), Irish Ground Fish Survey (IGFS-WIBTS-Q4, G7212) and French EVHOE Survey (EVHOE-WIBTS-Q4, G9527). French survey data were not available for 2017 but recommenced in 2018. The Spanish Porcupine index was initially down weighted by an arbitrary factor of ten because the Baka trawl used was highly more efficient at catching megrim than the GOV (Grande Ouverture Verticale) trawl used in the Irish and French surveys. Due to the large differences in catchability between Baka and GOV gears, it was decided to remove the SpPGFS-WIBTS-Q3 (G5768) data from the final index which are based on data from IGFS-WIBTS-Q4 (G7212) and EVHOE-WIBTS-Q4 (G9527) surveys. This combined French and Irish survey index is referred to by the ICES acronym 'FR_IE_IBTS'. To include Spanish Porcupine Bottom Trawl Survey (G5768) data in the final index will require inter-calibration correction based on comparison of four-spot megrim catches in the area where the Spanish and Irish surveys overlap. No difference in catchability was found between the Irish and the French surveys in the area where they overlap.

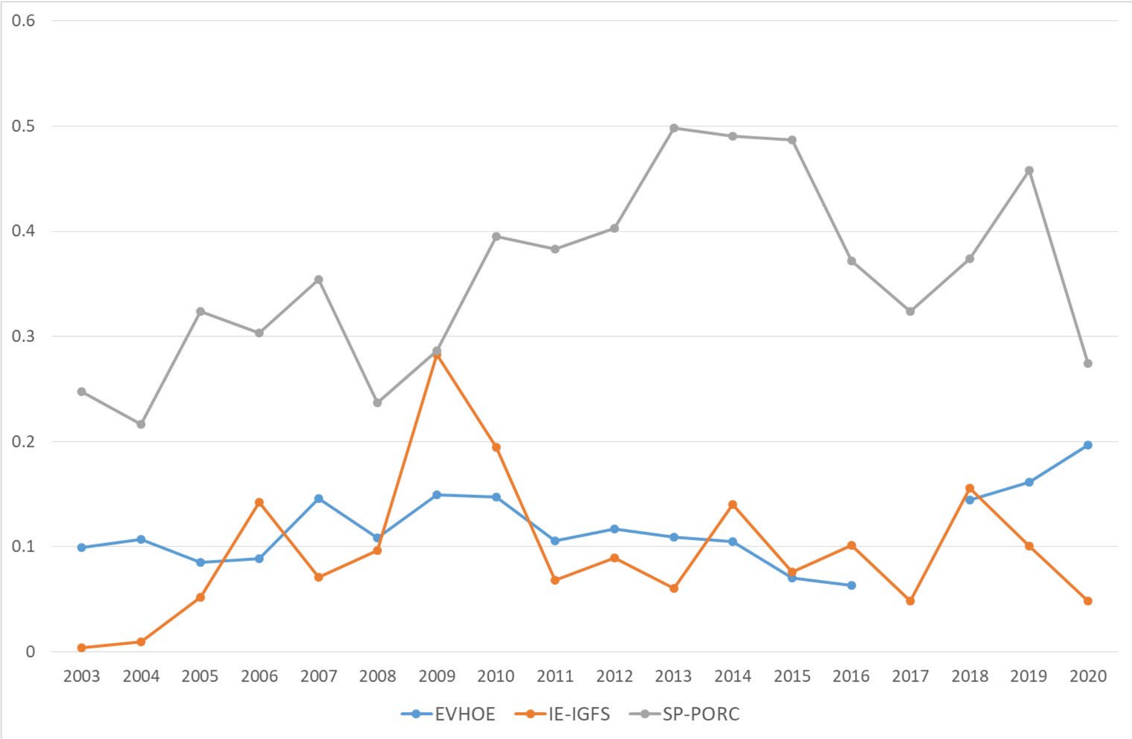


Figure 5.5. Abundance indices of four-spot megrim from French EVHOE (EVHOE-WIBTS-Q4, G9527), Irish Ground Fish Survey (IGFS-WIBTS-Q4, G7212) and Spanish Porcupine Bottom Trawl Survey (SpPGFS-WIBTS-Q3, G5768).

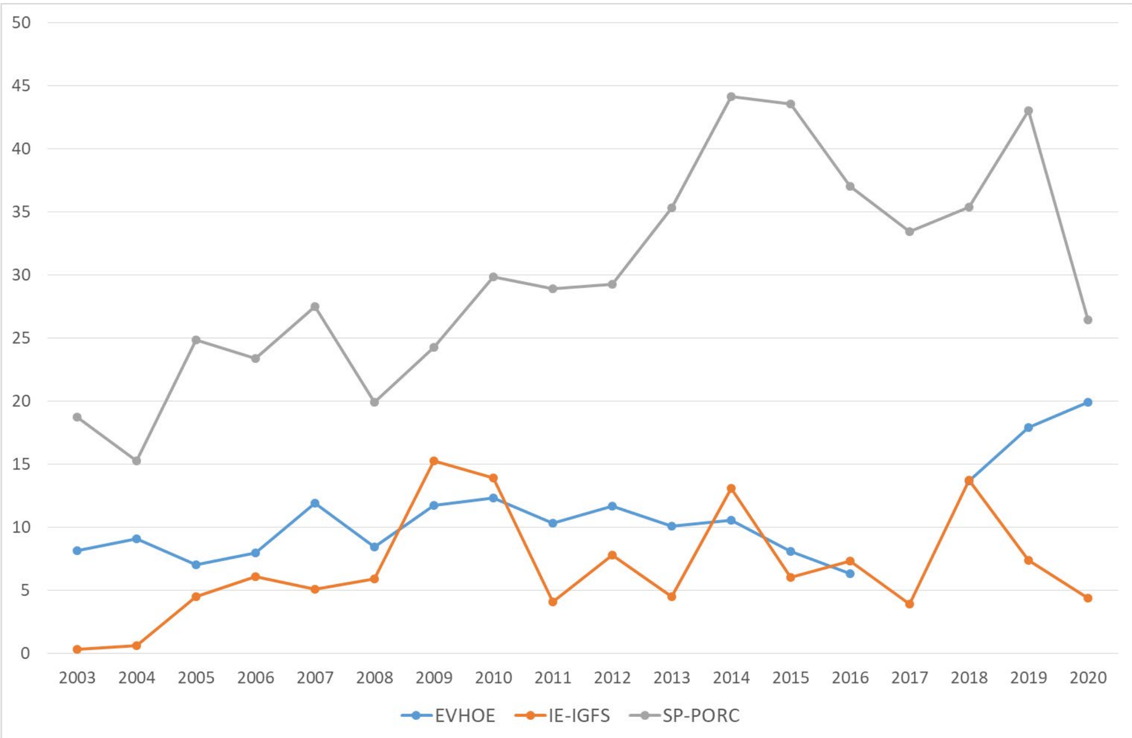


Figure 5.6. Biomass indices of four-spot megrim from French EVHOE (EVHOE-WIBTS-Q4, G9527), Irish Ground Fish Survey (IGFS-WIBTS-Q4, G7212) and Spanish Porcupine Bottom Trawl Survey (SpPGFS-WIBTS-Q3, G5768).

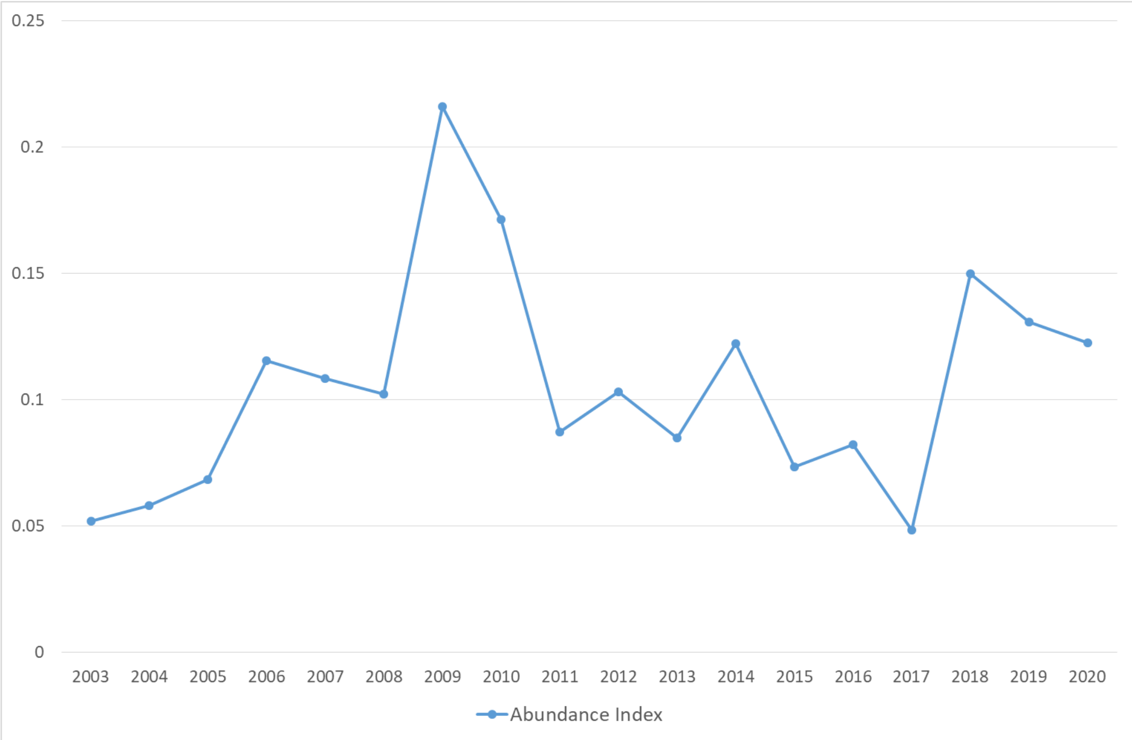


Figure 5.7. Abundance index of four-spot megrim from combined French EVHOE (EVHOE-WIBTS-Q4, G9527) and Irish Ground Fish Survey (IGFS-WIBTS-Q4, G7212).

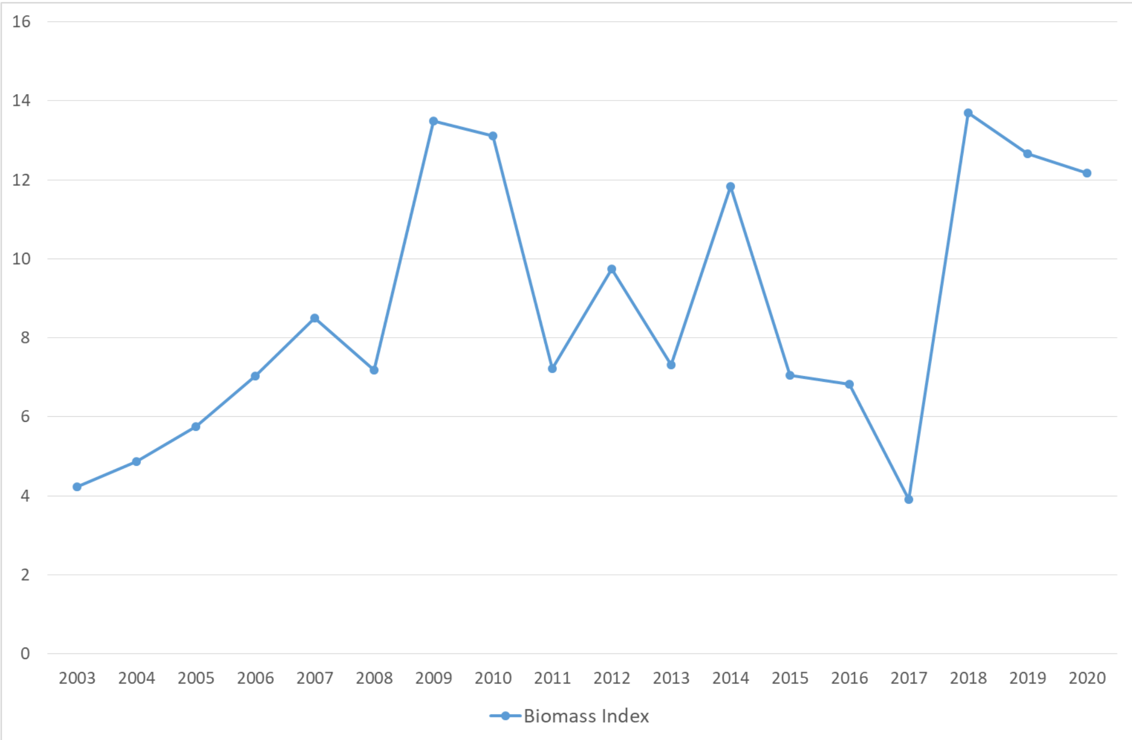


Figure 5.8. Biomass index of four-spot megrim from combined French EVHOE (EVHOE-WIBTS-Q4, G9527) and Irish Ground Fish Survey (IGFS-WIBTS-Q4, G7212).

Figure 5.9. Biomass densities distribution of four-spot megrim from French EVHOE (EVHOE-WIBTS-Q4, G9527), Irish Ground Fish Surveys (IGFS-WIBTS-Q4, G7212) and Spanish Porcupine Bottom Trawl Survey (SpPGFS-WIBTS-Q3, G5768).

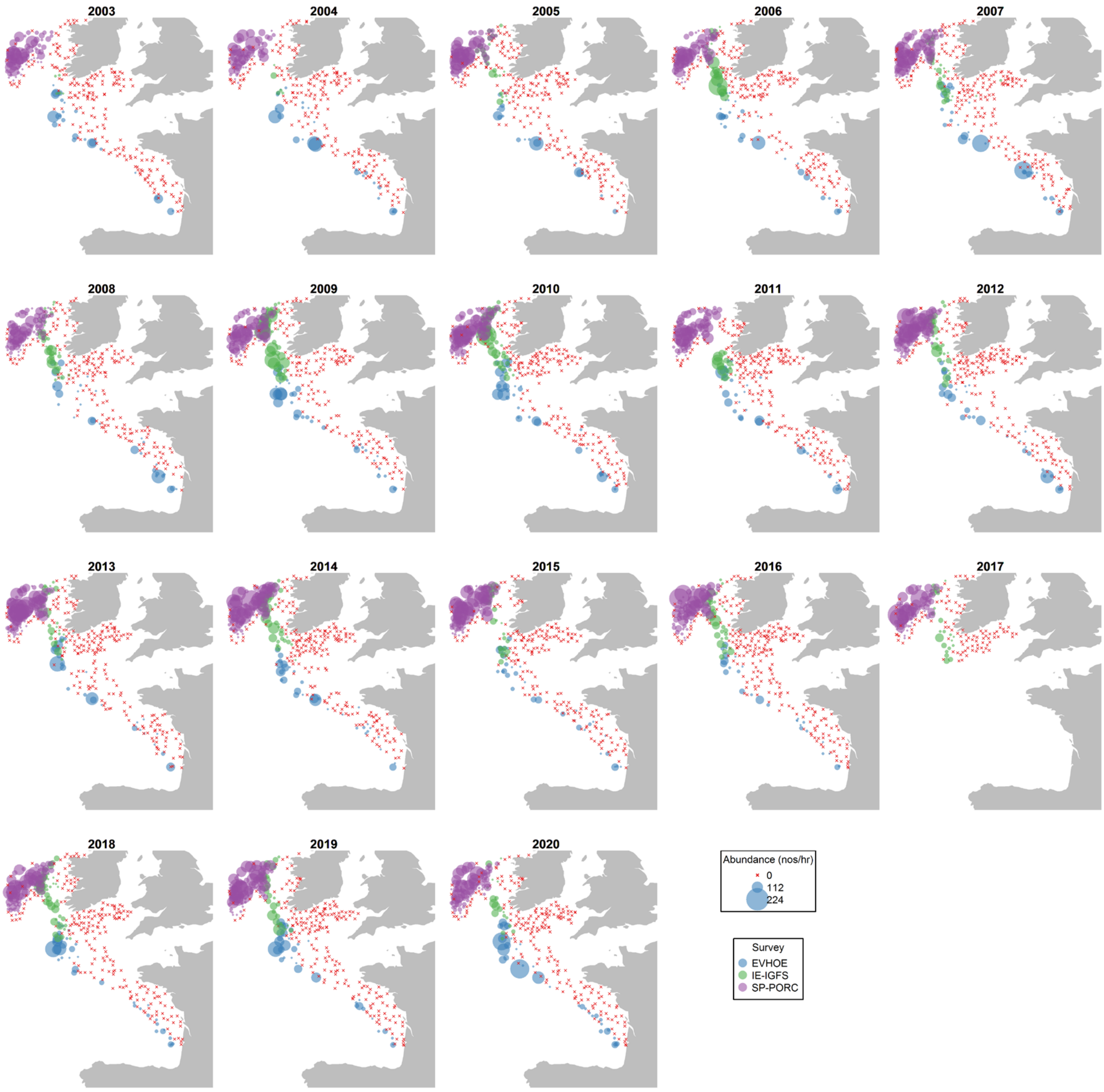


Figure 5.10. Abundance densities distribution of four-spot megrim from French EVHOE (EVHOE-WIBTS-Q4, G9527), Irish Ground Fish Survey (IGFS-WIBTS-Q4, G7212) and Spanish Porcupine Bottom Trawl Survey (SpPGFS-WIBTS-Q3, G5768).

5.3.4 Assessment

No quantitative stock assessment was carried out at WGBIE 2021 although the analysis was updated with available catch data and biological information from 2020.

5.3.4.1 Data exploratory Analysis

The following exploratory analyses were carried out for quality control reasons: sample weights were checked against expected weights (as estimated from length-weight parameters), excessive raising factors (from sample to catch weight) were checked and abundance indices (numbers per hour) were calculated for each survey series using all valid hauls and ignoring the spatial stratification.

5.3.4.2 Model

No model was used in the assessment.

5.3.4.3 Results

The stock status relative to candidate reference points is unknown. The precautionary buffer was last applied in 2017. Therefore, the precautionary buffer was applied again this year. Discards were not estimated in 2020 due to insufficient sampling, but average discards from 2017 to 2019 were estimated to be 27% of the total catch.

5.3.4.4 Retrospective pattern

No retrospective analysis was performed.

5.3.4.5 Short-term forecasts

No short-term forecast was produced.

5.3.5 Biological reference points

No biological reference points were produced at WGBIE 2021.

5.3.6 Conclusions

This was the fifth year that an assessment was carried out for this stock and the fourth year that the stock was included in the ICES data call. This year, catch advice was requested and it was decided to apply the precautionary buffer to recent average catches from 2017, 2018 and 2019. Catch data from 2020 were deemed to be incomplete due to unavailability of data from France.

The quality of this assessment was improved on the previous year by the addition of commercial landings, discards and length data. However, the incomplete historical (2003–2016) catch data from Spain means that the time-series of commercial catch is not sufficiently long to support the assessment.

There is still a requirement for substantial port samplings to provide an accurate species split for the landings as it is unsure how the survey catches relate to the commercial catches. The COVID-19 pandemic reduced the availability of samples of landings and discards and meant that catches of four-spot megrim from France could not be estimated. In 2019, France contributed 44% of total landings (403 t) and the absence of these data undermined confidence in 2020 catch data.

Last year investigations into Length-Based indicators (LBI; ICES, 2017) and Mean Length-Z (MLZ) as defined in WKLIFE V (ICES, 2015) was carried out using data from SpPGFS-WIBTS-Q3 (G5768). However, it was decided that this survey did not sufficiently cover the stock area to provide catch advice (ICES, 2020). Future work on combining survey indices and using spatial models such as the Vector Autoregressive Spatio-Temporal (VAST; Thorson, 2019) package (www.github.com/james-thorson/VAST) in R (R Core Team, 2020) will be advanced before next year's WG.

5.3.7 References

ICES, 2015. Report of the Fifth Workshop on the Development of Quantitative Assessment Methodologies based on Life-history Traits, Exploitation Characteristics and other Relevant Parameters for Data-limited Stocks (WKLIFE V), 5–9 October 2015, Lisbon, Portugal. ICES CM 2015/ACOM: 56, 157 pp.

ICES. 2020. Working Group for the Bay of Biscay and the Iberian Waters Ecoregion (WGBIE). ICES Scientific Reports. 2:49. 845 pp. http://doi.org/10.17895/ices.pub.6033.

ICES. 2021. Advice on fishing opportunities. *In* Report of the ICES Advisory Committee, 2021. ICES Advice 2021, Section 1.1.1. https://doi.org/10.17895/ices.advice.7720.

R Core Team. 2020. A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.

Thorson, J.T. 2019. Guidance for decisions using the Vector Autoregressive Spatio-Temporal (VAST) package in stock, ecosystem, habitat and climate assessments. Fisheries Research 210: 143–161.

6 Megrim and four-spot megrim in divisions 8.c and 9.a

Lepidorhombus whiffiagonis – meg.27.8c9a (Cantabrian Sea and Atlantic Iberian waters)

Type of assessment in 2021

Update.

Data revisions this year

No revisions this year.

Lepidorhombus boscii – ldb.27.8c9a (southern Bay of Biscay and Atlantic Iberian waters East)

Type of assessment in 2021

Update.

Data revisions this year

No revisions this year.

ADG issues for *L. boscii*

'Maybe the F-age ranges need to be revised'. This recommendation will be explored in the next benchmark in 2022.

6.1 General

See Stock Annex for general aspects related to megrim assessment.

6.1.1 Ecosystem aspects

See Stock Annex for ecosystem aspects related to megrim assessment.

6.1.2 Fishery description

See Stock Annex for fishery description.

6.2 Summary of ICES advice for 2021 and management for 2020 and 2021

6.2.1.1 ICES advice for 2021 (as extracted from ICES advice on fishing opportunities, catch and effort 2020):

The two megrim species (*L. whiffiagonis* and *L. boscii*) are not completely separated in the landings. A single TAC covers both species and species-specific landings are estimated by ICES (ICES, 2020). ICES considers that management of the two megrim species under a combined TAC prevents effective control of the single-species exploitation rates and could lead to overexploitation of either species. Therefore, the advice since 2016 is based on the single-species F_{MSY}.

A mixed-fisheries analysis covering the stocks in Iberian waters of hake, megrim, four-spot megrim, and white anglerfish is provided in ICES (ICES, 2020; ICES, 2021).

ICES advises that when the EU multiannual plan (MAP; European Parliament and Council Regulation (EU) No. 2019/472) for Western waters and adjacent waters is applied, catches in 2021 that correspond to the F ranges in the MAP are between 312 and 571 t for *L. whiffiagonis* and between 1148 and 2375 t for *L. boscii*. According to the MAP, catches higher than those corresponding to F_{MSY} /468 t for *L. whiffiagonis* and 1690 t for *L. boscii*) can only be taken under conditions specified in the MAP, while the entire range is considered precautionary when applying the ICES advice rule.

6.2.1.2 Management applicable for 2020 and 2021:

The agreed combined TAC for megrim and four-spot megrim in ICES divisions 8.c and 9.a was 2322 t in 2020 and 2158 t in 2021.

6.2.2 References

ICES. 2020. ICES Fisheries Overviews. Bay of Biscay and Iberian Coast ecoregion. ICES Advice 2020. https://doi.org/10.17895/ices.advice.7604.

ICES. 2021. Working Group on Mixed Fisheries Advice (WGMIXFISH-ADVICE; outputs from 2020 meeting). ICES Scientific Reports. 3:28. 204 pp. https://doi.org/10.17895/ices.pub.7975.

6.3 Megrim (*L. whiffiagonis*) in divisions 8.c and 9.a

6.3.1 General

See general section for both species.

6.3.2 Data

6.3.2.1 Commercial catches and discards

The Working Group estimates of landings, discards, and catches for the period 1986 to 2020 are given in Table 6.3.1. The sampling programs coordinated by the Spanish Institute of Oceanography-IEO (onshore, observers at-sea and biological sampling) were partially suspended in 2020 due to administrative problems and to the COVID-19 disruption. This affected all stocks. From 2011 to 2018, estimates of unallocated or non-reported landings were included in the assessment. These were estimated based on the sampled vessels (Spanish concurrent sampling) raised to the total effort for each métier. These estimates are considered the best information available at this time. In 2015, data revised for the period 2011–2013 were provided. This revision produced an improvement in the allocation of sampling trips and the revised data are used in the assessment. The total estimated international landings in divisions 8.c and 9.a for 2020 were 315 t. Landings reached a peak of 977 t in 1990, followed by a steady decline until 2002. Some increase in landings has been observed since then, but landings have again decreased annually from 2007 until 2010 to 83 t, the lowest value of the entire time-series. Since 2011, the stock increased again and has then remained stable. Historical landings for both species combined are shown in Figure 6.1.1. The last period shows a decreasing trend since 2014 and in 2020, the international landings were 1026 t.

Discards estimates were available from the Spanish "observers' onboard sampling programme" for the years displayed in Table 6.3.2(a). In 2020, discards data of the first semester were missing for the reasons previously mentioned and were estimated based on the discard per unit of effort of the second semester applied to the exerted effort in the first semester. Discards in number represent between 10–47% of the total catch, with the exception of the years 2007 and 2020 when discards were very low and in 2011 when the value observed was extremely high. Following the recommendations, during the WKSOUTH benchmark in 2014 (ICES, 2014), an effort was made to complete the time-series back until 1986 in years without samplings. Total discards, given in tonnes (Table 6.3.1) and numbers-at-age (Table 6.3.2b), were included in the assessment model.

6.3.2.2 Biological sampling

Annual length compositions of total stock landings are provided in Figure 6.3.2 for the whole period and in Table 6.3.3a for 2020. Due to the lack of samplings in 2020, some length distributions in some quarters were missing. The existing ones were raised to the total catch of the métier. Unallocated/non-reported value was included in the raising of total length distribution in previous years. The bulk of sampled specimens corresponds to individuals of 20–35 cm.

Sampling levels for both species are given in Table 1.4.

Mean lengths and mean weights in landings since 1990 are shown in Table 6.3.3b. The mean length and mean weight values observed in 2013 were the highest in the historic series.

Age compositions of catches are presented in Table 6.3.4 and weights-at-age of catches in Table 6.3.5, from 1986 to 2020. These values were also used as the weights-at-age in the stock.

More biological information, the parameters used in the length-weight relationship, natural mortality and maturity ogive are provided in the Stock Annex.

6.3.2.3 Abundance indices from surveys

Two Portuguese (PtGFS-WIBTS-Q4 (G8899), also called "October" survey, and PT-CTS (UWTV (FU 28–29)), also called "Crustacean" survey) and one Spanish (SP-NSGFS-Q4 (G2784)) survey indices are summarized in Table 6.3.6. In 2012, 2019 and 2020, Portuguese surveys were not conducted.

As noted in the Stock Annex, indices from these Portuguese surveys are not considered representative of the megrim abundance due to the very low catch rates.

The Spanish survey (SP-NSGFS-Q4, G2784) covers the distribution area and depth strata of this species in Spanish waters 8c and 9a. Total biomass and abundance indices from this survey were higher during the period 1988 to 1990, subsequently declining to lower mean levels, which were common throughout the rest of the time-series. There has been an overall declining trend in the abundance index after year 2000, with the values for 2008 and 2009 being the two lowest in the entire series. Since then, there is a general increasing trend with the highest value in 2019 (Figure 6.3.3a, bottom right panel). In 2013, the survey was carried out in a new vessel. This year the abundance indices were high for flatfish and benthic species. Although there was an inter-calibration exercise performed between both vessels, the results were not consistent with the results of the inter-calibration. Therefore, the WG decided not to include the abundance index value for that year in the assessment model. Since 2014, the gear used was similar to the gear used in the survey before 2013. A new inter-calibration exercise was conducted in 2014 and the index was considered suitable for inclusion in the assessment.

The Spanish survey recruitment index for age 1 (Recruitment age) indicates an extremely weak year-class in 1994, which improved in the following years. From 2000 to 2014, low values of year-classes were observed except in 2010. However, since 2015, there was a considerable increase in age 1 with the highest value of the time-series in 2016. In 2020, the value was within this last period trend (Figure 6.3.3b and Table 6.3.7).

Catch numbers-at-age per unit effort and effort values for the Spanish survey are given in Table 6.3.7. In addition, Figure 6.3.3b displays a bubble plot of log (survey abundance-at-age), with the values for each age standardized by subtracting the mean and dividing by the standard deviation over the years. The size of the bubbles is related to the magnitude of the standardized value, with grey and black bubbles corresponding to positive and negative values, respectively. The figure indicates that the survey is quite good at tracking cohorts through time and highlights the weakness of the last few cohorts.

6.3.2.4 Commercial catch-effort data

The commercial LPUE and effort data of the Portuguese trawlers fishing in Division 9a covers the period 1988–2020 (Table 6.3.8 and Figure 6.3.3a).

It is known that the Northern Spanish coastal bottom otter trawl fleet is a fleet deploying a variety of fishing strategies with different target species. In fact, these fishing strategies are identified under the current Data Collection Framework (DCF; Commission Regulation (EC) No 1639/2001, Council Regulation (EC) No 199/2008) sampling programme, such that they can be then re-aggregated under two DCF métiers: bottom otter trawl targeting demersal species (OTB_DEF_>=55_0_0) and bottom otter trawl targeting pelagic stocks accompanied by some demersal species (OTB_MPD_>55_0_0). Therefore, the LPUE of these métiers was estimated backwards until 1986 and two new time-series of bottom otter trawl targeting demersal species, one per port (A Coruña and Avilés), were provided to the WKSOUTH benchmark in 2014 (ICES, 2014). These tuning fleets (SP-LCGOTBDEF and SP-AVSOTBDEF) were accepted to tune the assessment model instead of the old ones based on A Coruña (SP-CORUTR8c) and Avilés (SP-AVILESTR) trawls. The LPUEs and effort values are given in Table 6.3.8 and Figure 6.3.3a.

Commercial fleets used in the assessment to tune the model

Both Spanish commercial fleets could not be updated because of the problems in samplings that were mentioned in section 6.3.2.1. Before 2003, A Coruña (SP-LCGOTBDEF) effort was generally stable. After that year, the trend was similar but in lower values. The 2011 effort value is the lowest in the series. In 2014, effort reached its highest value and in 2019 decreased again. The LPUE shows a general faintly increasing trend. The 2019 value represented an increase, being the highest value of the time-series.

Avilés (SP-AVSOTBDEF) effort presents a slightly decreasing trend throughout the whole period. The highest value occurred in 1998 and the lowest in 2001. LPUE shows a decreasing trend from 1986 to 2003. Since then, up and down fluctuations were observed, with a peak in 2011.

Landed numbers-at-age per unit effort and effort data for these fleets are given in Table 6.3.7.

Figure 6.3.3c displays bubble plots of standardized log (landed numbers-at-age per unit effort) values for these commercial fleets, with the standardization performed by subtracting the mean and dividing by the standard deviation over the years. The panel corresponding to A Coruña trawl fleet clearly indicates below-average values from year 2003 to 2010, but since then values above average are frequent. Avilés fleet shows a decreasing trend.

Commercial fleets not used in the assessment to tune the model

Portuguese effort values are quite variable, with a slightly decreasing trend, being the last years the lowest ones in the time-series (Table 6.3.8 and Figure 6.3.3a). The Portuguese LPUE series was revised from 2012 onwards. Further refinement of the algorithms is required to revise the series backwards. The LPUE shows a steep decrease between 1990 and 1992 and has since then remained at low levels, except for a peak in 1997–1998. LPUE for recent years shows an increasing trend.

6.3.3 Assessment

An update assessment was conducted, according to the Stock Annex specifications. Assessment years are 1986–2020 and ages 1–7+.

6.3.3.1 Input data

Following the Stock Annex, discards and landed numbers-at-age were incorporated resulting in catch numbers-at-age as input data from 1986 to 2020 and the year 2020 was added to the index of Spanish survey (G2784). A Coruña (SP-LCGOTBDEF) and Avilés (SP-AVSOTBDEF) tuning fleets were used without the 2020 data..

6.3.3.2 Model

Data screening

Figure 6.3.4a shows catch proportions-at-age where larger proportions can be observed for ages 1 to 3. The top panel of Figure 6.3.4b shows landings proportions at age, indicating that the bulk of the landings consisted of ages 1 and 2 before 1994 then shifted mostly to ages 2 to 4 since the mid-1990s. The bottom panel of the same figure displays standardized (subtracting the mean and dividing by the standard deviation over the years) proportions at age, indicating the same change around the mid 1990's, with proportions-at-age decreasing for ages 1 and 2 and increasing for the older ages. Some weak and strong cohorts can be observed in this figure, particularly around the mid 1990s. In 2010, an increase in landings of older ages, especially ages 5 to 7+ was observed. In the last period, the high abundance of age 1 in the Spanish survey in 2010 can be tracked in the following years. Figure 6.3.4c shows discards proportions-at-age, being more abundant for age 1 from 2000 onwards. Before this year, discarding was higher in age 2. Visual inspection of Figures 6.3.3b and 6.3.3c indicates that all tuning series are good up to age 5 in relation to their internal consistency. Age 6 is harder to track along cohorts, particularly for the Spanish survey and the A Coruña tuning fleet.

Final run

XSA model (Extended Survivor Analysis; Shepherd, 1999) was selected for use in this assessment. Model description and settings are detailed in the Stock Annex.

The retrospective analysis shows a small but consistent pattern of overestimation of SSB and underestimation of F in recent years (Figure 6.3.5).

6.3.3.3 Assessment results

Diagnostics from the XSA run are presented in Table 6.3.9 and log-catchability residuals plotted in Figure 6.3.6. Residuals in A Coruña tuning fleet in the last years present mainly positive values. No pattern was found in the survey residuals. Several year effects are apparent in all tuning series.

Fishing mortality and population numbers-at-age from the final XSA run are given in Tables 6.3.10 and 6.3.11, respectively. The summary results are presented in Table 6.3.12 and Figure 6.3.7a.

Fishing mortality decreases in the last year. Catches show a small increase and the value is around the last 10 years average. The SSB values in 2007–2010 were the lowest in the series. Since 2011, values were significantly higher and there is an increasing trend especially in the most recent years. Since the high recruitment value (at age 1) in 2015, similar values were observed.

Bubble plots of standardized estimated F-at-age (by subtracting the mean and dividing by the standard deviation over the years) and relative F-at-age (F-at-age divided by F_{bar}) are presented in Figure 6.3.7b. The top panel of the figure indicates that fishing mortality has been lower for all ages in 2000 until 2011, afterwards slightly increasing again. However, since 2017, a decrease in F in all ages was observed. In terms of the relative exploitation pattern-at-age (bottom panel of the figure), the most obvious changes are the reduction of ages 1 and 2 around 1994 and the increase of age 3 soon after that. This might be related to the discarding practices. There is no clear pattern over time in the age 4 selection, whereas for ages 5 and older, there seems to be an increase during the mid to late 1990s, which dropped down to lower values afterwards. Since 2010, there appears to have been an increase of the relative exploitation towards older ages, with high values above the average for ages 5 to 7+ for some years.

6.3.3.4 Year-class strength and recruitment estimations

The 2017 year-class is estimated to have 8.5 million fish at 1 year of age, based on the Spanish survey (SP-NSGFS- Q4, G2784) (96% of the weight and F shrinkage (4%).

The 2018 year-class is estimated to have 8.1 million individuals at 1 year of age based on the information from the Spanish survey (G2784) (72% of weight), P-shrinkage (25% of the weight) and F-shrinkage (4%).

The 2019 year-class is estimated to have 7.4 million fish at 1 year of age, based on the information from the Spanish survey (G2784) (65% of weight), P-shrinkage (29% of the weight) and F-shrinkage (6%).

The working group considered that the XSA last year recruitment value was well estimated. The signal from the survey index is in accordance with the estimated value and age 1 is well represented in the catch data. Working Group estimates of year-class strength used for prediction can be summarized as follows:

Recruitment-at-age 1:

Year-class	Thousands	Basis	Surveys	Commercial	Shrinkage
2017	8530	XSA	96%	0%	4%
2018	8120	XSA	72%	25%	4%
2019	7390	XSA$_{)}$	65%	29%	6%
2020	3633	GM $_{(98-18)}$			

6.3.3.5 Historic trends in biomass, fishing mortality, and recruitment

From Table 6.3.12 and Figure 6.3.7a, we see that SSB decreased from 2449 t in 1990 to 950 t in 1995. From 1996 to 2000, it remained relatively stable at low levels with an average value close to 1200 t. Starting from 2001, SSB is estimated to have decreased further. The values for 2001–2010 are the lowest in the series, with SSB in 2008 (616 t) corresponding to the lowest value. Since 2011, SSB values are significantly increasing, being the 2020 value (2498 t), the highest of the recent years.

After a decline from 2006 (0.43) to 2010 (0.08), F showed an increasing trend reaching 0.49 in 2015. In the most recent years, F presents lower values, with 0.12 in 2020.

Recruitment (at age 1) varies substantially throughout the time-series, but shows a general decline from the high levels seen until the 1992 year-class. Since 1998, recruitment has been continuously at low levels (recruitment in 2009 was estimated as the lowest value of the series). In 2010, good recruitment occurred, with a value more similar to those estimated for the previous decade. However, from 2011 to 2014, the values of recruitments decreased again. In the last years, recruitment seems to be very high, with values similar to those of the mid-1990s.

6.3.3.6 Catch options and prognosis

Stock projections were calculated with the settings specified in the Stock Annex.

6.3.3.7 Short-term projections

Short-term projections have been made using MFDP (Multi Fleet Deterministic Projection; Smith, 2000).

The input data for deterministic short-term predictions are shown in Table 6.3.13. Average F_{bar} for the last three years is assumed for the interim year. The exploitation pattern is the scaled F-at-age computed for each of the last five years and then the average of these scaled five years was weighted to the final year. This selection pattern was split into selection-at-age of landings and discards (corresponding to $F_{bar} = 0.175$ for landings and $F_{bar} = 0.024$ for discards, being 0.20 for catches).

According to the Stock Annex, geometric mean (GM) recruitment is computed over years 1998-final assessment year minus 2.

Management options for catch prediction are in Table 6.3.14. Figure 6.3.8 shows the short-term forecast summary. The detailed output by age-group is given in Table 6.3.15 for landings and discards.

Under *status quo* F, landings in 2021 and 2022 are predicted to be 542 and 554 t respectively, and discards 27 and 19 t, respectively. SSB would decrease from the 2782 t estimated for 2021 to 2661 t in 2022 and 2425 t in 2023.

The contributions of recent year-classes to the predicted landings in 2021 and SSB in 2022, assuming $GM_{98\text{-}18}$ recruitment, are presented in Table 6.3.16. The assumed $GM_{98\text{-}18}$ age 1 recruitment for the 2020 and 2021 year-classes contributes with 6% to landings in 2022 and 19% to the predicted SSB at the beginning of 2023. Megrim starts to contribute strongly to SSB at 2 years of age (see maturity ogive in Table 6.3.13).

6.3.3.8 Yield and biomass per recruit analysis

The results of the yield- and SSB-per-recruit analyses are in Table 6.3.17 (see also left panel of Figure 6.3.8, which plots yield-per-recruit and SSB-per-recruit vs. F_{bar}). Assuming s*tatus quo* exploitation $F_{bar} = 0.175$ for landings and $F_{bar} = 0.024$ for discards and $GM_{98\text{-}19}$ for recruitment, the equilibrium yield would be 272 t of landings and 15 t of discards with an SSB of 1383 t.

6.3.4 Biological reference points

The stock-recruitment time-series is plotted in Figure 6.3.9. See Stock Annex for information about biological reference points. The BRP are:

	Type	Value	Technical basis
MSY Approach	MSY $B_{trigger}$	980 t	B_{pa}
	F_{MSY}	0.191	
	F_{MSY} lower	0.122	based on 5% reduction in yield
	F_{MSY} upper (with advice rule)	0.29	based on 5% reduction in yield
	F_{MSY} upper (without advice rule)	0.24	based on 5% reduction in yield
	$F_{P.05}$	0.40	5% risk to B_{lim} with $B_{trigger}$.
Precautionary Approach	B_{lim}	700 t	B_{loss} estimated in 2015
	B_{pa}	980 t	1.4 B_{lim}
	F_{lim}	0.45	Based on segmented regression simulation of recruitment with B_{lim} as the breakpoint and no error
	F_{pa}	0.40	F_{pa} = $F_{P0.5}$

6.3.5 Comments on the assessment

The behaviour of commercial fleets with regards to landings of age 1 individuals appears to have changed in time. Hence, data from commercial fleets used for tuning are only taken for ages 3 and older, as set in the Stock Annex. However, the Spanish survey (SP-NSGFS-Q4 (G2784)) provides good information on age 1 abundance.

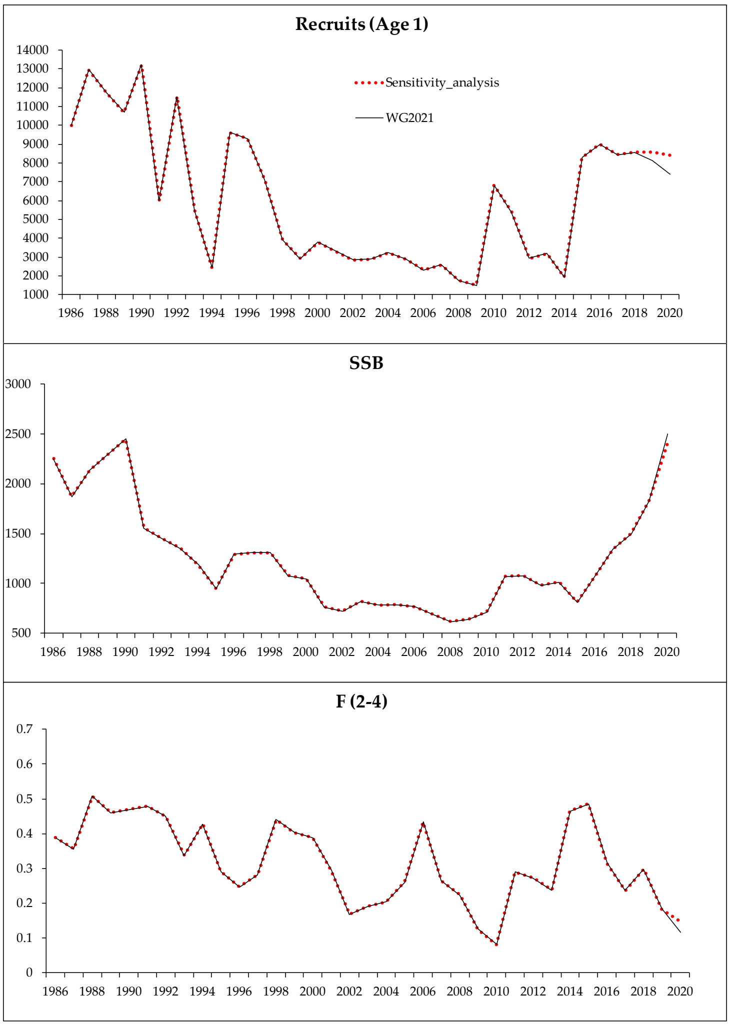
Megrim starts to contribute strongly to SSB at 2 years of age. Around 20% of the predicted SSB in 2023 relies on year-classes for which recruitment has been assumed to be GM_{98-18}.

6.3.5.1 Sensitivity analysis

Some missing data in 2020 had to be estimated due to the data issues in 2020 resulting from the impact of COVID-19 in the data collection from the commercial fishery and research surveys. In the case of discards, the first semester data are missing and were estimated based on the discard per unit of effort of the second semester applied to the exerted effort in the first semester. This estimation showed values that appear to be low. In order to check the impact of a possible underestimation of discards in the assessment and advice, a sensitivity analysis has been carried out. For that, a re-estimation of discards using the average of the last three years proportions of discards at age was done and the estimated values are shown in the next table:

	Landings (tonnes)	Discards (tonnes)	Catch (tonnes)
Duplicate	315	5	320
Average	315	52	366

The assessment and forecast were carried out again with the new discards by age and the impact on the results was negligible. A comparison between both assessments and forecasts are shown in the figure and table below, respectively.



WGBIE

2021 Biomass	SSB	Catch FMult	Landings FBar	Yield	Discards FBar	Yield
2927	2782	1	0.1747	542	0.0243	27

Sensitivity_analysis

2021 Biomass	SSB	Catch FMult	Landings FBar	Yield	Discards FBar	Yield
2921	2775	1	0.1777	545	0.0315	35

WGBIE

2022 Biomass	SSB	Catch FMult	Landings FBar	Yield	Discards FBar	Yield	2023 Biomass	SSB
2780	2661	0	0.0000	0	0.0000	0	3218	3099
.	2661	0.1	0.0175	63	0.0024	2	3142	3022
.	2661	0.2	0.0349	123	0.0049	4	3068	2948
.	2661	0.3	0.0524	183	0.0073	6	2996	2876
.	2661	0.4	0.0699	240	0.0097	8	2926	2806
.	2661	0.5	0.0874	296	0.0122	10	2857	2738
.	2661	0.6	0.1048	351	0.0146	12	2791	2672
.	2661	0.7	0.1223	404	0.0170	13	2726	2607
.	2661	0.8	0.1398	455	0.0195	15	2664	2545
.	2661	0.9	0.1573	506	0.0219	17	2603	2484
.	2661	1	0.1747	554	0.0243	19	2543	2425
.	2661	1.1	0.1922	602	0.0268	21	2485	2367
.	2661	1.2	0.2097	648	0.0292	22	2429	2311
.	2661	1.3	0.2272	693	0.0316	24	2375	2256
.	2661	1.4	0.2446	737	0.0341	26	2321	2203
.	2661	1.5	0.2621	779	0.0365	27	2270	2152
.	2661	1.6	0.2796	821	0.0389	29	2219	2101
.	2661	1.7	0.2970	861	0.0414	31	2170	2053
.	2661	1.8	0.3145	900	0.0438	32	2123	2005
.	2661	1.9	0.3320	939	0.0462	34	2076	1959
.	2661	2	0.3495	976	0.0487	35	2031	1914

Input units are thousands and kg - output in tonnes

Sensitivity_analysis

2022 Biomass	SSB	Catch FMult	Landings FBar	Yield	Discards FBar	Yield	2023 Biomass	SSB
2777	2660	0	0.0000	0	0.0000	0	3216	3097
.	2660	0.1	0.0178	63	0.0032	3	3138	3020
.	2660	0.2	0.0355	124	0.0063	5	3063	2945
.	2660	0.3	0.0533	183	0.0095	7	2990	2872
.	2660	0.4	0.0711	241	0.0126	10	2919	2801
.	2660	0.5	0.0889	297	0.0158	12	2850	2732
.	2660	0.6	0.1066	351	0.0189	14	2783	2665
.	2660	0.7	0.1244	405	0.0221	17	2717	2600
.	2660	0.8	0.1422	456	0.0252	19	2653	2536
.	2660	0.9	0.1599	507	0.0284	21	2592	2474
.	2660	1	0.1777	555	0.0315	23	2531	2414
.	2660	1.1	0.1955	603	0.0347	26	2473	2356
.	2660	1.2	0.2132	649	0.0378	28	2416	2299
.	2660	1.3	0.2310	695	0.0410	30	2360	2243
.	2660	1.4	0.2488	738	0.0441	32	2306	2190
.	2660	1.5	0.2666	781	0.0473	34	2254	2137
.	2660	1.6	0.2843	823	0.0505	36	2202	2086
.	2660	1.7	0.3021	863	0.0536	38	2153	2037
.	2660	1.8	0.3199	903	0.0568	40	2104	1988
.	2660	1.9	0.3376	941	0.0599	42	2057	1941
.	2660	2	0.3554	978	0.0631	44	2011	1896

Input units are thousands and kg - output in tonnes

6.3.6 Management considerations

It should be taken into account that megrim, *L. whiffiagonis,* is caught in mixed fisheries. There is a common TAC for both megrim species (*L. whiffiagonis* and *L. boscii*), so the status of both stocks should be taken into consideration when formulating management advice. Megrims are bycatch in mixed fisheries generally directed to white fish. Therefore, fishing mortality of megrims could be influenced by restrictions imposed on demersal mixed fisheries, aimed at preserving and rebuilding the overexploited stocks of southern hake and *Nephrops*.

This is a small stock (average stock SSB since 1986 is 1258 t). Managing according to a very low F for megrim could cause serious difficulties for the exploitation of other stocks in the mixed fishery (choke species effect). Both Iberian megrim stocks are assessed separately but managed together, a situation that may produce inconsistencies when these stocks are considered in a mixed fisheries approach. This effect was observed in the results of the mixed fisheries analysis developed for Iberian stocks by the WGMIXFISH-ADVICE (ICES, 2021). Of course, any F to be applied for the management of megrim must conform with the precautionary approach.

The WG considered that this stock could be just “the tail” of the much larger stock of megrim in ICES Subarea 7 and divisions 8.a, 8.b, and 8.d and suggested reconsidering the stock limits and the inclusion in the Northern megrim stock. This option was studied during the Stock Identification Methods Working Group (SIMWG) in 2015 and the conclusion was that SIMWG did not find strong evidence to support combining the northern and southern stock areas and recommends that the current stock definition stands until more studies are developed (ICES, 2015).

6.3.7 References

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6.3.8 Tables and Figures

Table. 6.3.1. Megrim (*L. whiffiagonis*) in divisions 8.c and 9.a. Landings, discards and catch in tonnes.

	Spain landings			Portugal landings	Unallocated	Total landings	Discards	Total catch
Year	8c	9a*	Total	9a				
1986	508	98	606	53		659	46	705
1987	404	46	450	47		497	40	537
1988	657	59	716	101		817	42	859
1989	533	45	578	136		714	47	761
1990	841	25	866	111		977	45	1022
1991	494	16	510	104		614	41	655
1992	474	5	479	37		516	42	558
1993	338	7	345	38		383	38	421
1994	440	8	448	31		479	13	492
1995	173	20	193	25		218	40	258
1996	283	21	305	24		329	44	373
1997	298	12	310	46		356	52	408
1998	372	8	380	66		446	36	482
1999	332	4	336	7		343	43	386
2000	238	5	243	10		253	35	288
2001	167	2	169	5		175	19	193
2002	112	3	115	3		117	19	137
2003	113	3	116	17		134	15	148
2004	142	1	144	5		149	11	159
2005	120	1	121	26		147	19	166
2006	173	2	175	35		210	16	226
2007	139	2	141	14		155	0.4	155
**2008	114	2	116	17		133	11	144
2009	74	2	77	7		84	11	94
2010	66	8	74	10		83	5	88
^2011	242	0	242	34	26	302	69	371
^2012	151	11	161	18	83	262	31	293
^2013	128	3	131	11	90	231	18	250
2014	225	5	231	30	116	377	23	399
2015	188	2	190	23	63	276	21	297
2016	171	1	172	15	48	235	63	298
2017	189	4	193	16	39	247	41	288
2018	227	8	234	7	74	315	37	352
2019	226	7	233	6		239	51	289
2020	278	26	305	10		315	5	320

^Data revised in WG2015

*9a is without Gulf of Cádiz till 2016

** Data revised in WG2010

*** Official data by country and unallocated landings

Table. 6.3.2a. Megrim (*L. whiffiagonis*) in divisions 8.c and 9.a. Discard/Total Catch ratio and estimated CV for Spain from on-board sampling.

Year	1994	1997	1999	2000	2003	2004	2005	2006	2007
Weight Ratio	0.03	0.14	0.12	0.13	0.11	0.07	0.14	0.08	0.00
CV	50.83	32.23	33.4	48.41	19.93	29.24	43.17	31.62	55.01
Number Ratio	0.10	0.38	0.34	0.45	0.26	0.16	0.28	0.21	0.01

Year	2008	2009	2010	2011*	2012	2013	2014	2015	2016
Weight Ratio	0.08	0.13	0.06	0.23	0.12	0.07	0.06	0.07	0.21
CV	58.8	52.9	61.6	23.7	28.8	30.3	44.7	49.8	57.1
Number Ratio	0.20	0.36	0.27	0.57	0.37	0.24	0.20	0.29	0.47

Year	2017	2018	2019	2020
Weight Ratio	0.14	0.10	0.17	0.02
CV	28.9			
Number Ratio	0.34	0.26	0.37	0.05

All discard data revised in WG2011

*Data revised in WG2013

Table. 6.3.2b. Megrim (*L. whiffiagonis*) in divisions 8.c and 9.a. Discards in numbers-at-age (thousands) for Spanish trawlers.

	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	138	138	138	138	138	138	138	138	104
2	339	339	339	339	339	339	339	339	93
3	425	425	425	425	425	425	425	425	136
4	130	130	130	130	130	130	130	130	51
5	10	10	10	10	10	10	10	10	3
6	4	4	4	4	4	4	4	4	1
7	1	1	1	1	1	1	1	1	0

	1995	1996	1997	1998	1999	2000	2001	2002	2003
1	138	138	41	138	270	27	10	10	0
2	339	339	453	339	471	611	338	338	239
3	425	425	857	425	284	160	82	82	57
4	130	130	142	130	197	73	31	31	12
5	10	10	1	10	26	19	9	9	4
6	4	4	5	4	6	0	1	1	0
7	1	1	3	1	0	0	1	1	0

	2004	2005	2006	2007	2008	2009	2010	2011*	2012
1	4	20	0	0	0	96	16	12	8
2	164	223	19	11	126	142	119	2044	808
3	28	61	108	0	86	21	6	346	85
4	6	38	115	0	8	15	1	1	41
5	5	11	28	0	5	7	2	2	2
6	3	4	13	0	2	7	0	0	1
7	2	1	4	0	0	3	1	0	1

	2013	2014	2015	2016	2017	2018	2019	2020
1	330	442	624	1074	492	203	487	42
2	53	94	10	373	410	387	337	54
3	13	16	4	3	43	110	135	3
4	5	2	1	1	0	28	40	0
5	0	0	0	0	0	1	6	0
6	0	0	0	0	0	1	0	0
7	0	0	0	0	0	0	0	0

Table 6.3.3a. Megrim (*L. whiffiagonis*) in divisions 8.c and 9.a. Annual length distribution of landings in 2020.

Length (cm)	Total
10	
11	
12	
13	
14	
15	
16	12954
17	0
18	12954
19	12954
20	28130
21	15485
22	36510
23	83932
24	98918
25	158785
26	286746
27	238866
28	197180
29	133145
30	96688
31	103651
32	89401
33	60162
34	53024
35	31098
36	25190
37	16762
38	8311
39	7696
40	17389
41	4751
42	9560
43	4524
44	4860
45	2587
46	3816
47	3652
48	0
49	0
50+	1067
Total	1860750

Table 6.3.3b. Mean lengths and mean weights in landings since 1990.

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Mean length (cm)	22.3	23.5	24.6	23.4	25.1	24.7	24.6	24.6	24.7	25.3	25.8	25.1
Mean weight (g)	105	108	129	108	124	121	120	118	119	127	134	124

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Mean length (cm)	26.15	26.68	26.64	27.58	29.4	27.63	28.2	29.39	28.6	28.72	26.81	26.41
Mean weight (g)	137	148	146.8	163.2	187.4	159.5	163.2	187.5	170.7	172.3	145.7	134.1

Table 6.3.4. Megrim (*L. whiffiagonis*) in divisions 8.c and 9.a. Catch numbers-at-age.

Catch numbers at age Numbers*10**-3

YEAR	1986	1987	1988	1989	1990
AGE					
1	1352	2359	3316	1099	4569
2	2377	2728	3769	2328	2560
3	798	882	1168	808	905
4	649	404	748	641	878
5	505	293	534	505	333
6	202	81	182	191	377
+gp	194	71	130	253	558
TOTALNUM	6077	6818	9847	5825	10180
TONSLAND	705	537	858	761	1022
SOPCOF %	95	95	95	99	99

YEAR	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
AGE										
1	1357	1401	858	133	848	537	535	416	491	620
2	2777	817	2128	568	461	1911	1919	1307	524	282
3	931	807	442	1835	384	167	1153	1335	1157	671
4	700	1130	536	552	630	289	77	891	719	526
5	647	595	361	625	245	506	367	218	448	361
6	142	78	103	330	70	148	308	329	105	83
+gp	59	68	36	119	72	81	116	149	207	161
TOTALNUM	6613	4896	4464	4162	2710	3639	4475	4645	3651	2704
TONSLAND	655	558	421	492	258	373	408	482	386	288
SOPCOF %	100	100	101	100	101	101	100	100	101	101

YEAR	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
AGE										
1	378	369	368	210	346	110	90	133	170	149
2	387	233	299	264	276	526	161	370	111	39
3	331	341	277	211	438	582	232	215	159	53
4	253	95	179	247	171	276	297	153	102	112
5	221	165	80	187	156	183	142	168	80	97
6	161	81	54	102	87	110	81	60	60	81
+gp	118	37	48	72	41	36	56	35	29	43
TOTALNUM	1849	1321	1305	1293	1515	1823	1059	1134	711	574
TONSLAND	194	136	149	160	166	226	155	144	95	88
SOPCOF %	100	99	101	100	98	100	100	100	101	100

YEAR	2011**	2012**	2013**	2014	2015	2016	2017	2018	2019	2020
AGE										
1	2054	812	359	469	712	1187	530	206	554	77
2	1087	275	152	705	224	1275	1160	782	716	396
3	156	834	320	420	536	218	877	668	658	540
4	220	157	612	432	239	116	64	912	553	384
5	266	192	81	518	257	87	81	141	197	338
6	209	106	61	74	191	85	35	74	14	165
+gp	184	139	89	144	82	96	41	78	20	62
TOTALNUM	4176	2515	1674	2762	2241	3064	2788	2861	2712	1962
TONSLAND	371	293	250	399	297	298	288	352	289	320

Table 6.3.5. Megrim (*L. whiffiagonis*) in divisions 8.c and 9.a. Catch weights-at-age (kg).

Mean weight at age

YEAR	1986	1987	1988	1989	1990
AGE					
1	0.041	0.046	0.043	0.045	0.04
2	0.095	0.079	0.086	0.094	0.091
3	0.113	0.086	0.098	0.114	0.121
4	0.163	0.142	0.149	0.163	0.165
5	0.215	0.175	0.191	0.223	0.206
6	0.315	0.311	0.289	0.292	0.24
+gp	0.477	0.415	0.424	0.52	0.369
SOPCOFAC	0.9502	0.9535	0.9509	0.995	0.9874

YEAR	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
AGE										
1	0.035	0.031	0.031	0.039	0.051	0.041	0.033	0.032	0.033	0.037
2	0.085	0.075	0.073	0.063	0.044	0.08	0.062	0.061	0.058	0.057
3	0.102	0.116	0.102	0.099	0.087	0.081	0.095	0.095	0.084	0.089
4	0.145	0.155	0.146	0.13	0.126	0.127	0.126	0.13	0.118	0.119
5	0.173	0.209	0.194	0.15	0.164	0.164	0.14	0.154	0.159	0.161
6	0.251	0.318	0.235	0.19	0.21	0.21	0.198	0.189	0.216	0.215
+gp	0.42	0.534	0.538	0.344	0.34	0.354	0.341	0.324	0.296	0.296
SOPCOFAC	1.0041	0.9983	1.005	1.0004	1.0091	1.014	1.0005	1.0047	1.0057	1.0107

YEAR	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
AGE										
1	0.039	0.038	0.047	0.048	0.0510	0.0570	0.061	0.033	0.031	0.037
2	0.078	0.07	0.083	0.082	0.0770	0.0820	0.088	0.084	0.088	0.091
3	0.085	0.111	0.115	0.109	0.1080	0.1100	0.11	0.118	0.135	0.116
4	0.117	0.115	0.149	0.13	0.1400	0.1500	0.144	0.145	0.16	0.168
5	0.148	0.162	0.194	0.157	0.1640	0.1740	0.197	0.187	0.189	0.203
6	0.171	0.205	0.252	0.203	0.1990	0.2230	0.236	0.246	0.246	0.228
+gp	0.256	0.387	0.382	0.319	0.3790	0.3900	0.366	0.409	0.404	0.37
SOPCOFAC	1.0046	0.9944	1.0061	1.0008	0.9847	1.0034	0.9966	1.0034	1.0062	0.9989

YEAR	2011**	2012**	2013**	2014	2015	2016	2017	2018	2019	2020
AGE										
1	0.026	0.027	0.039	0.035	0.037	0.041	0.038	0.035	0.041	0.044
2	0.088	0.089	0.079	0.097	0.102	0.086	0.081	0.073	0.076	0.096
3	0.135	0.138	0.127	0.13	0.133	0.147	0.131	0.107	0.112	0.134
4	0.134	0.164	0.179	0.166	0.174	0.198	0.184	0.144	0.146	0.155
5	0.201	0.172	0.232	0.22	0.197	0.244	0.217	0.224	0.209	0.219
6	0.242	0.228	0.281	0.264	0.277	0.304	0.295	0.243	0.414	0.29
+gp	0.371	0.343	0.391	0.381	0.388	0.388	0.43	0.438	0.496	0.405
SOPCOFAC	0.9976	1.0031	1.0124	0.9988	0.9986	1.0012	1.006	1.0033	1.0019	0.9992

* Data revised in WG2010 from original value presented

** Data revised in WG2014 from original value presented

Table 6.3.6. Megrim (*L. whiffiagonis*) divisions 8.c and 9.a. Biomass, Abundance and Recruitment indices from Portuguese and Spanish surveys.

	Biomass Index						Abundance index					Recruitment index		
	Portugal (k/h)			Spain (k/30 min)			Portugal (n/h)		Spain (n/30 min)			At age 1	At age 0	At age 1
												Portugal (n)	Spain (n/30 min)	
	October	Crustaceans	s.e	Mean	s.e.		Crustaceans	s.e.	Mean	s.e.		October		
1983				0.96	0.14	1983			14.0	2.45	1983		1.88	7.72
1984				1.92	0.34	1984			28.0	4.57	1984		0.32	16.08
1985				0.89	0.15	1985			9.0	1.34	1985		0.10	2.74
1986				1.65	0.2	1986			33.0	6.22	1986		13.78	11.19
1987				ns		1987			ns		1987		ns	ns
1988				3.52	0.64	1988			43.0	8.82	1988		0.65	16.60
1989				3.13	0.5332	1989			42.0	7.04	1989		2.90	13.96
1990	0.08			3.08	0.86	1990			28.0	5.5	1990	5	0.11	9.13
1991	0.11			1.22	0.17	1991			10.0	1.67	1991	5	1.26	1.38
1992	0.11			1.39	0.2	1992			18.0	3.35	1992	8	0.01	12.03
1993	0.04			1.46	0.24	1993			15.0	3.23	1993	1	0.00	2.76
1994	0.05			1.02	0.2	1994			8.0	1.87	1994 +		0.60	0.05
1995	0.01			1.03	0.16	1995			11.0	1.86	1995 +		0.41	7.38
A,1996 +				1.64	0.22	A,1996			21.0	3.6	A,1996 +		0.45	11.26
1997 +		1.41	1.04	1.79	0.25	1997	7.22	4.82	20.0	3.26	1997 +		0.15	5.91
1998	0.01	0.20	0.09	1.47	0.23	1998	1.09	0.51	14.8	2.64	1998 +		0.02	2.56
,B,1999 +		0.11	0.11	1.59	0.29	A,B,1999	0.57	0.53	15.5	3.05	A,B,1999 +		0.56	1.26
2000 +		0.06	0.05	1.8	0.35	2000	0.27	0.17	19.4	4.46	2000 +		0.05	6.92
2001	0	0.04	0.03	1.45	0.28	2001	0.07	0.04	12.8	2.77	2001 +		0.19	1.97
2002	0.04	0.07	0.04	1.26	0.24	2002	0.21	0.10	12.1	2.65	2002 +		0.08	2.53
A,2003	0.01	0.07	0.05	0.82	0.16	A,2003	0.16	0.08	7.2	1.26	A,2003	0.05	0.05	1.91
A,2004	0.01	ns		1.08	0.2	A,2004	ns		8.44	1.39	A,2004 +		0.14	1.83
2005	0.01	0.37	0.20	1.29	0.21	2005	0.71	0.35	9.76	1.73	2005 +		0.08	2.21
2006	0.02	0.29	0.18	1.03	0.18	2006	0.43	0.24	6.38	1.16	2006		0.00	0.89
2007	0	0.15	0.09	1.13	0.24	2007	0.49	0.37	6.87	1.52	2007		0.01	1.87
2008	0	0.25	0.11	0.68	0.15	2008	1.49	0.71	4.33	1.07	2008		0.00	0.23
2009	0.00	*0.05	0.03	0.80	0.12	2009	*0.19	0.10	4.17	0.59	2009		0.19	0.20
2010	0.01	0.20	0.10	0.89	0.16	2010	0.56	0.23	10.15	1.97	2010		0.01	7.63
2011	0.00	0.84	0.67	1.83	0.35	2011	1.75	1.30	17.45	3.86	2011		0.00	1.94
2012	ns	ns	ns	1.38	0.19	2012	ns	ns	9.07	1.29	2012		0.03	0.58
**2013	0	0.20	0.13	2.44	0.39	2013	0.43	0.22	15.89	2.58	2013		0.02	3.24
2014	0.02	0.30	0.18	1.34	0.21	2014	0.81	0.41	9.04	1.26	2014		0.40	1.32
2015	0.06	0.27	0.14	1.86	0.26	2015	0.89	0.39	30.75	5.64	2015		0.28	25.46
2016	0.06	0.26	0.13	2.71	0.28	2016	0.90	0.35	43.10	5.35	2016		0.02	26.31
2017	0.06	0.21	0.09	3.75	0.39	2017	2.04	1.37	50.23	6.04	2017		0.00	15.42
2018	0.04	0.18	0.11	3.42	0.30	2018	1.49	1.01	41.45	4.37	2018		0.05	7.62
2019	ns	ns	ns	3.93	0.43	2019	ns	ns	46.19	5.86	2019		0.09	14.58
2020	ns	ns	ns	3.79	0.49	2020	ns	ns	51.00	6.34	2020		0.04	19.20

\+ less than 0.04

ns no survey

A Portuguese October Survey with different vessel and gear (Capricórnio and CAR net)

B Portuguese Crustacean Survey covers partial area only with a different Vessel (Mestre Costeiro)

* Revised in WG2011

** Since 2013 new vessel for Spanish survey (Miguel Oliver)

Table 6.3.7. Megrim (*L. whiffiagonis*) in divisions 8.c and 9.a. Tuning data.

FLT01: SP-LCGOTBDEF 1000 Days by 100 HP (thousand)

1986	2019								
1	1	0	1						
1	7							Eff.	
10	13.0	32.1	24.9	24.3	21.5	11.1	6.7	7.1	1986
10	105.5	114.2	46.8	22.4	15.1	7.5	5.8	12.7	1987
10	18.5	55.0	41.2	32.3	22.9	10.2	5.5	11.3	1988
10	4.6	24.4	23.6	25.7	20.8	9.8	5.7	11.9	1989
10	6.1	23.7	25.3	34.1	32.9	17.6	10.5	8.8	1990
10	6.8	31.1	30.5	36.8	32.3	16.0	9.0	9.6	1991
10	1.2	16.6	21.3	31.1	31.1	16.9	13.5	10.2	1992
10	0.2	12.0	15.1	20.7	17.8	8.2	3.9	7.1	1993
10	0.0	4.9	72.9	40.0	58.6	41.7	8.8	8.5	1994
10	65.1	4.1	19.6	42.9	15.4	4.2	2.9	13.4	1995
10	1.4	64.0	3.2	20.6	54.7	17.2	10.1	11.0	1996
10	1.1	37.2	56.8	5.7	29.0	27.0	9.3	12.5	1997
10	0.7	20.1	56.1	69.8	19.8	40.8	18.4	8.2	1998
10	0.8	8.6	44.3	46.5	38.3	10.7	21.4	8.8	1999
10	1.5	7.0	46.7	64.3	61.6	15.6	18.2	10.5	2000
10	2.6	25.7	25.8	31.0	33.4	27.1	19.0	12.1	2001
10	2.0	12.8	43.6	12.1	32.9	17.3	6.9	11.0	2002
10	25.9	19.2	20.0	20.1	12.2	10.0	8.5	10.2	2003
10	2.2	12.0	13.5	20.4	19.2	14.3	13.5	7.0	2004
10	5.7	12.4	27.6	12.6	13.5	8.3	5.6	7.1	2005
10	3.4	17.9	24.8	17.5	13.3	9.5	3.8	7.8	2006
10	12.9	19.2	21.7	27.7	16.7	10.0	8.0	7.3	2007
10	0.2	21.9	20.2	14.9	16.3	5.5	3.8	9.0	2008
10	6.0	17.2	22.6	12.7	8.8	5.9	2.8	8.0	2009
10	1.6	7.0	12.1	25.4	24.5	18.1	10.3	5.8	2010
10	2.3	134.6	27.5	38.0	31.8	15.8	9.3	5.1	2011
10	2.3	108.1	392.9	68.3	76.2	27.9	18.2	7.6	2012
10	1.6	19.9	54.6	89.3	9.8	7.2	6.8	10.8	2013
10	2.8	33.7	17.9	16.2	17.0	2.6	5.3	13.4	2014
10	16.4	32.2	64.7	25.3	26.3	19.8	7.1	9.8	2015
10	69.4	254.4	24.7	11.1	8.2	7.1	7.3	10.6	2016
10	10.0	178.8	193.9	15.9	19.0	7.0	4.7	8.7	2017
10	1.6	66.4	74.9	108.4	14.5	7.6	4.3	8.1	2018
10	28.7	120.0	153.1	137.0	48.2	1.8	2.8	7.8	2019

FLT02: SP-AVSOTBDEF 1000 Days by 100 HP (thousand) (*)

1986	2019								
1	1	0	1						
1	7							Eff.	
10	408.3	516.4	427.9	208.7	181.7	153.1	91.6	3.9	1986
10	589.9	470.6	510.4	242.2	145.3	167.8	55.4	3.0	1987
10	1458.2	905.1	749.0	357.4	154.7	193.1	84.9	3.4	1988
10	835.9	513.9	538.8	252.8	145.1	174.1	67.7	3.3	1989
10	4366.2	949.0	224.8	173.4	45.8	49.9	70.8	3.2	1990
10	980.1	855.3	228.9	99.8	83.6	14.7	7.3	3.5	1991
10								10.2	1992
10	1149.0	1489.5	91.4	99.7	52.6	24.9	19.4	2.4	1993
10	19.0	175.6	547.0	135.3	132.9	51.0	23.7	4.5	1994
10	40.5	2.4	43.0	139.5	69.5	25.9	14.3	3.5	1995
10	135.0	796.8	14.0	116.8	258.6	74.2	62.5	2.3	1996
10	96.0	880.4	621.3	34.1	153.4	127.8	46.3	2.6	1997
10	16.0	308.5	374.9	233.1	51.9	69.5	38.1	5.1	1998
10	10.3	109.8	397.8	262.9	162.2	38.0	69.7	4.9	1999
10	28.7	54.3	238.7	229.5	146.0	35.7	52.8	2.5	2000
10	36.6	199.6	192.6	121.6	115.1	83.5	85.2	1.3	2001
10	54.5	157.6	238.5	64.6	92.9	53.5	46.8	2.0	2002
10	26.1	84.5	105.0	70.5	31.4	24.1	28.1	2.2	2003
10	52.5	231.5	208.5	248.0	193.4	102.9	59.9	1.6	2004
10	118.2	181.5	309.0	117.1	106.9	58.6	26.1	3.0	2005
10	42.8	181.8	235.7	120.5	83.2	45.5	12.4	2.8	2006
10	24.6	48.0	72.4	93.0	40.7	24.5	19.9	2.2	2007
10	5.0	153.3	85.0	50.6	48.7	18.1	15.7	2.0	2008
10	12.4	41.2	66.8	49.6	39.1	38.7	21.2	2.3	2009
10	49.8	45.0	66.0	160.3	135.6	120.9	61.5	2.0	2010
10	6.4	483.1	95.2	133.1	167.6	133.8	109.7	2.2	2011
10	0.4	27.8	117.6	22.7	29.1	17.7	27.9	2.6	2012
10	10.6	35.1	128.7	279.4	38.4	31.1	62.1	1.5	2013
10	7.2	116.4	64.5	72.8	116.6	21.5	53.2	3.0	2014
10	32.8	42.3	100.0	52.4	62.9	62.9	33.0	1.8	2015
10	37.6	261.5	65.3	47.3	43.4	48.0	55.6	1.6	2016
10	40.1	416.5	352.2	21.5	33.9	22.4	45.0	2.0	2017
10	2.0	113.8	149.9	245.6	53.6	29.5	58.2	1.5	2018
10	8.2	86.7	161.8	197.3	104.0	17.5	25.6	2.0	2019

FLTO3: SPGFS-WIBTS-Q4 (n/30 min)

1988	2020								
1	1	0.75	0.83						
1	7								
1	16.60	12.48	5.18	4.54	2.66	0.74	0.53	101	1988
1	13.96	11.20	5.38	5.64	1.47	0.48	0.43	91	1989
1	9.13	7.69	3.04	3.61	1.26	1.36	1.57	120	1990
1	1.38	3.23	1.45	1.84	0.87	0.23	0.03	107	1991
1	12.03	1.07	1.57	2.24	1.14	0.21	0.15	116	1992
1	2.76	8.79	0.66	1.69	0.85	0.17	0.01	109	1993
1	0.05	0.65	4.24	1.30	0.71	0.27	0.04	118	1994
1	7.38	0.20	0.55	1.65	0.70	0.17	0.10	116	1995
1	11.26	6.45	0.25	1.03	1.00	0.35	0.27	114	1996
1	5.91	7.54	3.44	0.46	0.99	0.39	0.06	116	1997
1	2.56	4.30	4.33	2.08	0.41	0.60	0.15	114	1998
1	1.26	4.47	4.36	2.50	1.46	0.46	0.77	116	1999
1	6.92	2.46	2.84	3.42	2.14	0.70	0.39	113	2000
1	1.97	4.60	1.14	2.31	1.58	0.61	0.40	113	2001
1	2.53	3.15	3.74	0.44	1.38	0.51	0.29	110	2002
1	1.91	1.44	1.66	1.14	0.52	0.26	0.16	112	2003
1	1.83	1.94	1.31	1.30	0.80	0.66	0.47	114	2004
1	2.21	1.58	2.04	1.43	1.57	0.60	0.25	116	2005
1	0.89	1.40	1.57	0.82	0.88	0.61	0.22	115	2006
1	1.87	0.94	1.27	1.24	0.68	0.44	0.42	117	2007
1	0.23	1.54	1.23	0.56	0.52	0.18	0.08	115	2008
1	0.20	0.44	1.52	0.91	0.40	0.30	0.22	117	2009
1	7.63	0.26	0.28	0.75	0.52	0.50	0.21	114	2010
1	1.94	12.47	1.32	0.30	0.63	0.40	0.39	111	2011
1	0.58	2.22	4.81	0.41	0.16	0.30	0.56	115	2012
0	3.24	1.63	3.29	5.63	0.67	0.35	0.87	114	2013
1	1.32	2.80	1.30	1.38	1.21	0.20	0.42	116	2014
1	25.46	1.24	1.45	0.75	0.73	0.46	0.38	114	2015
1	26.31	14.54	0.88	0.57	0.30	0.30	0.18	114	2016
1	15.42	25.02	8.71	0.33	0.35	0.21	0.15	112	2017
1	7.62	19.01	9.75	4.10	0.33	0.18	0.40	113	2018
1	14.58	18.46	9.50	2.40	0.68	0.13	0.35	113	2019
1	19.20	20.53	6.12	2.16	1.65	0.96	0.34	109	2020

Table 6.3.8. Megrim (*L. whiffiagonis*). LPUE data by fleet in divisions 8.c and 9.a.

	SP-LCGOTBDEF			SP-AVSOTBDEF			Portugal trawl in 9a		
Year	Landings (t)	Effort	LPUE[1]	Landings (t)	Effort	LPUE[1]	Landings (t)	Effort	LPUE[2]
1986	16	7.1	2.24	83	3.9	21.17			
1987	36	12.7	2.85	52	3.0	17.65			
1988	29	11.3	2.59	83	3.4	24.65	74.9	38.5	1.95
1989	24	11.9	2.03	65	3.3	19.76	92.2	44.7	2.06
1990	27	8.8	3.05	120	3.2	36.91	86.0	39.0	2.20
1991	29	9.6	3.05	52	3.5	14.96	85.5	45.0	1.90
1992	32	10.2	3.10	35	2.3	15.46	32.6	50.9	0.64
1993	11	7.1	1.53	45	2.4	18.55	31.7	44.2	0.72
1994	32	8.5	3.79	52	4.5	11.39	25.8	45.8	0.56
1995	12	13.4	0.86	34	3.5	9.72	21.4	37.0	0.58
1996	26	11.0	2.36	39	2.3	17.13	22.2	46.5	0.48
1997	30	12.5	2.43	51	2.6	19.16	41.5	33.4	1.24
1998	30	8.2	3.65	62	5.1	12.19	60.1	43.1	1.39
1999	23	8.8	2.65	63	4.9	12.67	4.3	25.3	0.17
2000	35	10.5	3.33	26	2.5	10.49	6.9	27.0	0.25
2001	28	12.1	2.30	15	1.3	11.15	1.3	43.1	0.03
2002*	22	11.0	2.01	18	2.0	9.14	1.0	31.2	0.03
2003*	18	10.2	1.73	12	2.2	5.72	15.3	40.5	0.38
2004	12	7.0	1.66	23	1.6	14.77	3.4	35.4	0.10
2005	9	7.1	1.29	33	3.0	11.10	19.0	42.6	0.45
2006	11	7.8	1.44	27	2.8	9.62	26.3	40.3	0.65
2007**	13	7.3	1.78	11	2.2	4.85	10.5	43.8	0.24
2008**	12	9.0	1.30	11	2.0	5.27	14.4	38.4	0.37
2009	9	8.0	1.06	11	2.3	5.05	6.0	49.3	0.12
2010	12	5.8	2.02	24	2.0	11.74	7.3	48.0	0.15
2011	17	5.1	3.43	41	2.2	18.67	24.8	49.4	0.50
2012	43	7.6	5.58	11	2.6	4.40	14.5	30.9	0.47
2013***	33	10.8	3.02	16	1.5	11.07	8.1	28.0	0.29
2014	20	13.4	1.47	26	3.0	8.80	25.7	49.2	0.52
2015	29	9.8	3.00	14	1.8	7.54	18.0	17.7	1.02
2016	40	10.6	3.77	15	1.6	9.55	12.3	16.4	0.75
2017	47	8.7	5.43	25	2.0	12.52	12.7	15.4	0.83
2018	29	8.1	3.53	18	1.5	11.51	5.5	7.9	0.70
2019	48	7.8	6.19	23	2.0	11.39	5.2	7.1	0.73
2020	ns	ns	ns	ns	ns	ns	8.7	7.9	1.10

[1] LPUE as catch (kg) per fishing day per 100 HP.

[2] LPUE as catch (kg) per hour.

* Effort from Portuguese trawl revised from original value presented

** Effort from Portuguese trawl revised in WG2010 from original value presented

*** Effort from SP-LCGOTBDEF and SP-AVSOTBDEF revised in WG2015 from original value presented

Table 6.3.9. Megrim (*L. whiffiagonis*) in divisions 8.c and 9.a. Tuning diagnostics.

Lowestoft VPA Version 3.1

29/04/2021 12:05

Extended Survivors Analysis

Megrim (L. whiffiagonis.) in Divisions 27.7.8c and 27.7.9a

CPUE data from file fleetw.txt

Catch data for 35 years. 1986 to 2020. Ages 1 to 7.

Fleet	First year	Last year	First age	Last age	Alpha	Beta
SP-LCGOTBDEF	1986	2020	3	6	0	1
SP-AVSOTBDEF	1986	2020	3	6	0	1
SP-GFS	1990	2020	1	6	0.75	0.83

Time series weights :

Tapered time weighting not applied

Catchability analysis :

Catchability dependent on stock size for ages < 3

Regression type = C
Minimum of 5 points used for regression
Survivor estimates shrunk to the population mean for ages < 3

Catchability independent of age for ages >= 5

Terminal population estimation :

Survivor estimates shrunk towards the mean F
of the final 5 years or the 3 oldest ages.

S.E. of the mean to which the estimates are shrunk = 1.500

Minimum standard error for population
estimates derived from each fleet = .200

Prior weighting not applied

Tuning had not converged after 90 iterations

Total absolute residual between iterations
89 and 90 = .00017

Final year F values

Age	1	2	3	4	5	6
Iteration 89	0.0116	0.0739	0.1293	0.1456	0.2391	0.2832
Iteration 90	0.0116	0.0739	0.1293	0.1456	0.239	0.2831

1

Regression weights

	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1	1	1	1

Fishing mortalities

Age	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	1	0	0	0	0	0	0.072	0.027	0.078	0.012
2	0	0	0	0	0	0	0.228	0.144	0.124	0.074
3	0	0	0	0	1	0	0.288	0.198	0.174	0.129
4	0	0	0	0	1	0	0.194	0.552	0.251	0.146
5	1	1	0	1	1	0	0.329	0.862	0.216	0.239
6	1	0	1	1	1	0	0.275	0.569	0.181	0.283

XSA population numbers (Thousands)

YEAR	AGE 1	2	3	4	5	6
2011	5390	5440	840	752	671	431
2012	2930	2550	3470	547	416	308
2013	3180	1660	1840	2080	305	167
2014	1910	2280	1220	1220	1150	177
2015	8290	1140	1230	622	605	475
2016	9000	6140	730	519	293	263
2017	8430	6300	3870	400	320	161
2018	8530	6430	4110	2380	270	188
2019	8120	6800	4550	2760	1120	93.3
2020	7390	6150	4920	3130	1760	740

Estimated population abundance at 1st Jan 2021

0	5980	4680	3540	2220	1130

Taper weighted geometric mean of the VPA populations:

5060	3560	2210	1300	721	338

Standard error of the weighted Log(VPA populations) :

0.6464	0.6552	0.5697	0.5533	0.4949	0.5241

1

Log catchability residuals.

Fleet : SP-LCGOTBDEF

Age	1986	1987	1988	1989	1990
1	No data for this fleet at this age				
2	No data for this fleet at this age				
3	-0.71	-0.44	-0.1	-0.86	-0.71
4	-0.54	-0.74	-0.72	-0.22	-0.24
5	-0.53	-0.84	-0.54	-1.04	0.44
6	-0.63	-0.86	-0.56	-0.6	-0.57

Age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1	No data for this fleet at this age									
2	No data for this fleet at this age									
3	-0.75	-0.74	-0.86	0.09	-0.76	-1.64	-0.09	-0.07	-0.02	0.58
4	-0.07	-0.4	-0.55	0.29	-0.15	-0.67	-1.23	0.4	0.02	0.68
5	0.33	0.35	-0.59	1.06	-0.39	0.3	-0.3	0.08	0.13	0.49
6	0.66	0.86	0.32	1.32	-0.2	0.47	0.51	0.89	0.21	-0.17

Age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	No data for this fleet at this age									
2	No data for this fleet at this age									
3	0.22	0.45	-0.37	-0.56	0.29	-0.06	0.13	-0.09	0	-0.35
4	0.46	-0.49	-0.3	-0.3	-0.53	0.12	0.34	-0.22	-0.56	0.11
5	0.17	0.65	-0.6	-0.37	-0.65	-0.47	0.29	0.04	-0.76	-0.01
6	0.28	0.02	0	0.04	-0.67	-0.61	-0.19	-0.09	-0.32	0.46

Age	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	No data for this fleet at this age									
2	No data for this fleet at this age									
3	0.7	1.98	0.6	0.01	1.36	0.8	1.16	0.11	0.71	99.99
4	0.82	1.74	0.67	-0.44	0.7	-0.05	0.52	0.81	0.75	99.99
5	0.37	1.8	-0.16	-0.72	0.33	-0.18	0.53	0.66	0.14	99.99
6	0.2	0.98	0.29	-0.63	0.24	-0.17	0.15	0.2	-1.03	99.99

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

Age	3	4	5	6
Mean Log q	-6.215	-5.8414	-5.3753	-5.3753
S.E(Log q)	0.7278	0.6112	0.6002	0.5639

Regression statistics :

Ages with q independent of year class strength and constant w.r.t. time.

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
3	1.13	-0.519	6.02	0.32	34	0.84	-6.21
4	1.28	-1.113	5.48	0.33	34	0.78	-5.84
5	1.75	-2.05	4.49	0.19	34	1	-5.38
6	0.98	0.096	5.36	0.46	34	0.56	-5.35

Fleet : SP-AVSOTBDEF

Age	1986	1987	1988	1989	1990
1	No data for this fleet at this age				
2	No data for this fleet at this age				
3	0.51	0.32	1.17	0.66	-0.11
4	0.21	0.22	0.26	0.66	-0.03
5	0.33	0.12	0.05	-0.41	-0.52
6	0.68	0.89	1.03	0.96	-0.79

Age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1	No data for this fleet at this age									
2	No data for this fleet at this age									
3	-0.35	99.99	-0.7	0.5	-1.58	-1.97	0.71	0.21	0.57	0.59
4	-0.49	99.99	-0.42	0.1	-0.39	-0.37	-0.84	0.18	0.33	0.51
5	-0.03	99.99	-0.8	0.58	-0.21	0.54	0.1	-0.27	0.26	0.04
6	-0.73	99.99	0.1	0.21	0.24	0.62	0.78	0.12	0.24	-0.61

Age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	No data for this fleet at this age									
2	No data for this fleet at this age									
3	0.62	0.52	-0.31	0.61	1.05	0.6	-0.29	-0.25	-0.55	-0.28
4	0.4	-0.22	-0.49	0.77	0.26	0.6	0.16	-0.41	-0.65	0.5
5	0.12	0.36	-0.91	0.67	0.08	0.08	-0.1	-0.16	-0.57	0.41
6	0.11	-0.12	-0.46	0.69	-0.07	-0.27	-0.63	-0.11	0.21	1.01

Age	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	No data for this fleet at this age									
2	No data for this fleet at this age									
3	0.33	-0.86	-0.18	-0.34	0.19	0.13	0.12	-0.8	-0.84	99.99
4	0.65	-0.78	0.36	-0.37	0.05	0	-0.7	0.22	-0.3	99.99
5	0.75	-0.55	0	-0.11	-0.05	0.15	-0.19	0.63	-0.4	99.99
6	1.03	-0.68	0.49	-0.03	0.18	0.41	-0.09	0.4	0.41	99.99

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

Age	3	4	5	6
Mean Log q	-4.602	-4.4118	-4.0727	-4.0727
S.E(Log q)	0.7103	0.4563	0.4138	0.5733

Regression statistics :

Ages with q independent of year class strength and constant w.r.t. time.

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
3	0.92	0.38	4.84	0.43	33	0.66	-4.6
4	0.84	1.232	4.83	0.67	33	0.38	-4.41
5	0.98	0.114	4.12	0.58	33	0.41	-4.07
6	0.94	0.349	4	0.51	33	0.51	-3.88
1							

Fleet : SP-GFS

Age	1986	1987	1988	1989	1990
1	99.99	99.99	99.99	99.99	-0.36
2	99.99	99.99	99.99	99.99	-0.21
3	99.99	99.99	99.99	99.99	0.02
4	99.99	99.99	99.99	99.99	0.71
5	99.99	99.99	99.99	99.99	0.63
6	99.99	99.99	99.99	99.99	0.31

Age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1	-0.59	-0.22	-0.19	-1.45	-0.3	-0.07	-0.11	0.08	0.05	0.64
2	-0.49	-0.69	-0.23	-1.03	-0.99	-0.27	-0.18	-0.23	0.38	0.39
3	-0.97	-0.53	-1.22	0.14	-1.55	-1.54	-0.06	0.23	0.55	0.67
4	0.11	0.19	0.06	0.04	-0.29	-0.62	-0.7	0.06	0.24	0.89
5	0.41	0.7	-0.27	0.39	-0.12	-0.3	-0.31	-0.39	0.27	0.49
6	-0.06	-0.13	-0.11	-0.02	-0.06	0	-0.21	0.22	0.51	0.03

Age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	0.12	0.41	0.25	0.08	0.32	0.05	0.3	-0.34	-0.23	0.03
2	0.48	0.3	0.05	0.19	-0.13	0.08	-0.13	0.09	-0.27	-0.4
3	-0.08	0.78	-0.07	-0.06	0.51	0.07	0.07	-0.1	0.07	-1.38
4	0.97	-0.74	-0.09	0.05	0.35	0.2	0.38	-0.4	-0.14	-0.39
5	0.46	0.84	-0.46	-0.2	0.46	0.19	0.5	-0.07	-0.57	-0.58
6	-0.19	-0.22	-0.33	0.29	-0.02	0.02	0.04	-0.15	-0.04	0.14

Age	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	-0.21	-0.28	99.99	0.54	0.47	0.42	0.19	-0.19	0.2	0.41
2	0.34	0.03	99.99	0.41	0.55	0.31	0.59	0.37	0.28	0.42
3	0.45	0.39	99.99	0.26	0.51	0.32	0.86	0.84	0.69	0.14
4	-0.89	-0.26	99.99	0.24	0.35	0.04	-0.32	0.7	-0.22	-0.53
5	-0.13	-0.92	99.99	0.07	0.16	-0.18	-0.17	0.36	-0.85	-0.4
6	0.01	-0.17	99.99	0.09	-0.09	-0.04	-0.04	-0.12	-0.05	-0.04

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

Age	3	4	5	6
Mean Log q	-6.5688	-6.4732	-6.2258	-6.2258
S.E(Log q)	0.6915	0.472	0.4637	0.175

Regression statistics :

Ages with q dependent on year class strength

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Log q
1	0.5	3.986	7.75	0.69	30	0.42	-7.07
2	0.58	3.226	7.25	0.68	30	0.44	-6.65

Ages with q independent of year class strength and constant w.r.t. time.

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
3	0.86	0.761	6.72	0.5	30	0.6	-6.57
4	0.86	1.07	6.56	0.66	30	0.4	-6.47
5	1.01	-0.046	6.22	0.49	30	0.48	-6.23
6 0.94		0.991	6.21	0.91	30	0.16	-6.24
1							

Terminal year survivor and F summaries :

Age 1 Catchability dependent on age and year class strength

Year class = 2019

Fleet	ES	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
SP-LCGOTBDEF	1	0	0	0	0	0	0
SP-AVSOTBDEF	1	0	0	0	0	0	0
SP-GFS	8971	0.434	0	0	1	0.654	0.008
P shrinkage mea	3556	0.66				0.291	0.019
F shrinkage mea	765	1.5				0.055	0.087

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
5979	0.35	0.54	3	1.537	0.012

1

Age 2 Catchability dependent on age and year class strength

Year class = 2018

Fleet	ES	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
SP-LCGOTBDEF	1	0	0	0	0	0	0
SP-AVSOTBDEF	1	0	0	0	0	0	0
SP-GFS	6368	0.315	0.112	0.35	2	0.719	0.055
P shrinkage mea 2210		0.57				0.246	0.15
F shrinkage mea	1607	1.5				0.035	0.201

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
4675	0.27	0.34	4	1.261	0.074

Age 3 Catchability constant w.r.t. time and dependent on age

Year class = 2017

Fleet	E S	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
SP-LCGOTBDEF	1	0	0	0	0	0	0
SP-AVSOTBDEF	1	0	0	0	0	0	0
SP-GFS	3723	0.286	0.155	0.54	3	0.956	0.123
F shrinkage mea	1180	1.5				0.044	0.346

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
3539	0.28	0.19	4	0.663	0.129

Age 4 Catchability constant w.r.t. time and dependent on age

Year class = 2016

Fleet	E S	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
SP-LCGOTBDEF	4492	0.738	0	0	1	0.092	0.075
SP-AVSOTBDEF	960	0.721	0	0	1	0.096	0.309
SP-GFS	2358	0.25	0.257	1.03	4	0.781	0.137
F shrinkage mea	778	1.5				0.031	0.369

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
2218	0.22	0.23	7	1.013	0.146

Age 5 Catchability constant w.r.t. time and dependent on age

Year class = 2015

Fleet	E S	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
SP-LCGOTBDEF	1900	0.477	0.313	0.66	2	0.143	0.149
SP-AVSOTBDEF	742	0.391	0.216	0.55	2	0.217	0.345
SP-GFS	1209	0.231	0.231	1	5	0.615	0.226
F shrinkage mea	482	1.5				0.025	0.491

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
1133	0.18	0.17	10	0.918	0.239

Age 6 Catchability constant w.r.t. time and age (fixed at the value for age) 5

Year class = 2014

Fleet	E S	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
SP-LCGOTBDEF	753	0.396	0.29	0.73	3	0.088	0.181
SP-AVSOTBDEF	385	0.3	0.205	0.69	3	0.161	0.328
SP-GFS	442	0.161	0.164	1.02	6	0.738	0.291
F shrinkage mea	795	1.5				0.013	0.172

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
456	0.13	0.12	13	0.857	0.283

Table 6.3.10. Megrim (*L. whiffiagonis*) divisions 8.c and 9.a. Estimates of fishing mortality-at-age.

Run title : Megrim (L. whiffiagonis.) in Divisions 27.7.8c and 27.7.9a

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Terminal Fs derived using XSA (With F shrinkage)

Table 8 Fishing mortality (F) at age

YEAR		1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
AGE													
	1	0.1624	0.2245	0.3742	0.1206	0.4816	0.2886	0.1442	0.191	0.062	0.1026	0.066	0.0872
	2	0.389	0.57	0.6757	0.4928	0.4535	0.6148	0.2823	0.3394	0.1865	0.3161	0.3531	0.3532
	3	0.3104	0.2427	0.5137	0.2914	0.3601	0.2943	0.3587	0.2428	0.5544	0.1855	0.1797	0.374
	4	0.4649	0.255	0.3348	0.5981	0.596	0.5269	0.7076	0.4309	0.5433	0.372	0.2075	0.1175
	5	0.6621	0.395	0.6327	0.3973	0.7328	1.3218	1.2736	0.5135	1.457	0.4963	0.5836	0.4426
	6	0.4449	0.2033	0.4581	0.4871	0.5884	0.8277	0.5191	0.7856	1.3836	0.5988	0.6426	0.8895
+gp		0.4449	0.2033	0.4581	0.4871	0.5884	0.8277	0.5191	0.7856	1.3836	0.5988	0.6426	0.8895
FBAR 2- 4		0.3881	0.3559	0.5081	0.4608	0.4699	0.4786	0.4496	0.3377	0.4281	0.2912	0.2468	0.2816

Table 8 Fishing mortality (F) at age

YEAR		1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
AGE													
	1	0.1253	0.2072	0.1994	0.1351	0.1556	0.1524	0.0747	0.1426	0.0541	0.0393	0.0875	0.1344
	2	0.3171	0.23	0.1762	0.1843	0.1153	0.1823	0.1558	0.1329	0.335	0.1046	0.2249	0.0979
	3	0.4462	0.5167	0.5182	0.3232	0.2456	0.1953	0.1892	0.418	0.456	0.2413	0.1983	0.142
	4	0.5589	0.462	0.471	0.375	0.1436	0.1966	0.2678	0.2308	0.5099	0.4465	0.2483	0.136
	5	0.5642	0.6158	0.4465	0.3692	0.4501	0.1729	0.3246	0.2704	0.4146	0.5411	0.4924	0.1984
	6	0.9407	0.5905	0.2139	0.3661	0.2231	0.2578	0.3481	0.2458	0.3111	0.3254	0.4629	0.3251
+gp		0.9407	0.5905	0.2139	0.3661	0.2231	0.2578	0.3481	0.2458	0.3111	0.3254	0.4629	0.3251
FBAR 2- 4		0.4407	0.4029	0.3885	0.2941	0.1681	0.1914	0.2043	0.2606	0.4336	0.2641	0.2238	0.1253

Table 8 Fishing mortality (F) at age

YEAR		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	FBAR 18-20
AGE													
	1	0.0245	0.5473	0.366	0.1334	0.3167	0.0998	0.1575	0.072	0.027	0.0784	0.0116	0.0390
	2	0.0412	0.2498	0.1269	0.1065	0.4189	0.2451	0.2607	0.2276	0.1444	0.1237	0.0739	0.1140
	3	0.0618	0.2297	0.3091	0.2135	0.4771	0.6601	0.4007	0.288	0.1982	0.174	0.1293	0.1672
	4	0.1407	0.3907	0.382	0.3925	0.4984	0.5532	0.2839	0.1945	0.5516	0.2506	0.1456	0.3159
	5	0.1853	0.577	0.7125	0.3469	0.687	0.6338	0.3982	0.3285	0.8619	0.2159	0.239	0.4390
	6	0.3166	0.7675	0.478	0.5161	0.6212	0.5885	0.4422	0.2749	0.5691	0.1814	0.2831	0.3445
+gp		0.3166	0.7675	0.478	0.5161	0.6212	0.5885	0.4422	0.2749	0.5691	0.1814	0.2831	
FBAR 2- 4		0.0812	0.2901	0.2726	0.2375	0.4648	0.4861	0.3151	0.2367	0.2981	0.1828	0.1162	

Table 6.3.11. Megrim (*L. whiffiagonis*) divisions 8.c and 9.a. Estimates of stocks numbers-at-age.

Run title : Megrim (L. whiffiagonis.) in Divisions 27.7.8c and 27.7.9a

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Terminal Fs derived using XSA (With F shrinkage)

Table 10 Stock number at age (start of year) Numbers*10**-3

YEAI	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
AGE												
1	9970	12965	11741	10692	13212	5983	11530	5454	2443	9609	9298	7083
2	8152	6939	8480	6612	7759	6683	3671	8172	3689	1880	7100	7127
3	3305	4524	3213	3533	3307	4036	2959	2266	4765	2506	1122	4083
4	1929	1984	2906	1574	2161	1889	2462	1692	1455	2241	1705	768
5	1153	992	1259	1702	709	975	913	993	900	692	1265	1134
6	622	487	547	547	937	279	213	209	487	172	345	578
+gp	592	424	387	718	1371	114	184	72	171	175	187	214
TOTAL	25723	28316	28534	25378	29456	19959	21932	18859	13912	17275	21021	20987

Table 10 Stock number at age (start of year) Numbers*10**-3

YEAI	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
AGE												
1	3903	2899	3790	3306	2830	2877	3225	2876	2309	2579	1754	1494
2	5315	2819	1930	2542	2365	1983	2022	2450	2042	1791	2030	1316
3	4099	3169	1834	1325	1731	1725	1353	1417	1756	1196	1321	1327
4	2300	2148	1548	894	785	1108	1162	917	764	911	769	887
5	559	1077	1108	791	503	557	746	728	596	376	478	491
6	596	260	476	580	448	263	383	441	455	322	179	239
+gp	266	507	919	422	203	232	269	207	148	221	103	115
TOTAL	17037	12879	11604	9860	8865	8745	9160	9036	8070	7396	6634	5868

Table 10 Stock number at age (start of year) Numbers*10**-3

YEAI	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	GM 98-18
AGE													
1	6803	5385	2928	3177	1909	8285	9003	8435	8533	8121	7387	0	3633
2	1069	5435	2551	1662	2276	1139	6139	6297	6426	6800	6148	5979	
3	977	840	3467	1839	1223	1226	730	3873	4106	4554	4919	4675	
4	943	752	547	2084	1216	622	519	400	2377	2757	3133	3539	
5	634	671	416	305	1152	605	293	320	270	1121	1757	2218	
6	330	431	308	167	177	475	263	161	188	93	740	1133	
+gp	174	374	400	241	340	201	294	187	196	133	276	627	
TOTAL	10929	13888	10617	9477	8294	12553	17241	19673	22097	23579	24360	18171	

Table 6.3.12. Megrim (*L. whiffiagonis*) in divisions 8.c and 9.a. Summary of landings and XSA results.

Run title : Megrim (L. whiffiagonis.) in Divisions 27.7.8c and 27.7.9a

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Table 16 Summary (without SOP correction)

Terminal Fs derived using XSA (With F shrinkage)

	RECRUITS Age 1	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 2- 4
1986	9970	2597	2250	705	0.3134	0.3881
1987	12965	2317	1868	537	0.2875	0.3559
1988	11741	2545	2139	858	0.4012	0.5081
1989	10692	2675	2295	761	0.3316	0.4608
1990	13212	2868	2449	1022	0.4174	0.4699
1991	5983	1750	1555	655	0.4213	0.4786
1992	11530	1714	1451	558	0.3846	0.4496
1993	5454	1525	1353	421	0.3111	0.3377
1994	2443	1275	1189	492	0.4138	0.4281
1995	9609	1282	950	258	0.2715	0.2912
1996	9298	1602	1294	373	0.2882	0.2468
1997	7083	1506	1308	408	0.3119	0.2816
1998	3903	1422	1307	482	0.3687	0.4407
1999	2899	1156	1077	386	0.3585	0.4029
2000	3790	1150	1047	288	0.2751	0.3885
2001	3306	869	764	194	0.254	0.2941
2002	2830	807	720	136	0.1889	0.1681
2003	2877	926	821	149	0.1816	0.1914
2004	3225	900	781	160	0.2049	0.2043
2005	2876	902	787	166	0.211	0.2606
2006	2309	870	766	226	0.2951	0.4336
2007	2579	809	689	155	0.2249	0.2641
2008	1754	671	616	144	0.2337	0.2238
2009	1494	681	639	95	0.1487	0.1253
2010	6803	889	713	88	0.1234	0.0812
2011	5385	1210	1070	371	0.3467	0.2901
2012	2928	1153	1078	293	0.2717	0.2726
2013	3177	1074	979	250	0.2553	0.2375
2014	1909	1078	1012	399	0.3942	0.4648
2015	8285	1023	809	297	0.3672	0.4861
2016	9003	1373	1076	298	0.2769	0.3151
2017	8435	1609	1346	288	0.2139	0.2367
2018	8533	1742	1498	352	0.235	0.2981
2019	8121	2101	1830	289	0.158	0.1828
2020	7387	2771	2498	320	0.1281	0.1162
Arith. Mean	6108	1453	1258	368	0.282	0.3164
Units	(Thousands)	(Tonnes)	(Tonnes)	(Tonnes)		

Table 6.3.13. Megrim (*L. whiffiagonis*) in divisions 8.c and 9.a. Prediction with management option table: Input data.

MFDP version 1a
Run: meg
Time and date: 13:19 29/04/2021
Fbar age range (Total) : 2-4
Fbar age range Fleet 1 : 2-4

2021 Age	Stock size	Natural mortality	Maturity ogive	Prop. of F bef. Spaw.	Prop. of M bef. Spaw.	Weight in Stock	Exploit pattern	Weight CWt	Exploit pattern	Weight DWt
1	3633	0.2	0.34	0	0	0.040	0.0058	0.055	0.0508	0.039
2	5979	0.2	0.9	0	0	0.082	0.0918	0.098	0.0510	0.053
3	4675	0.2	1	0	0	0.126	0.1922	0.131	0.0155	0.079
4	3539	0.2	1	0	0	0.165	0.2402	0.167	0.0065	0.102
5	2218	0.2	1	0	0	0.223	0.3473	0.223	0.0022	0.041
6	1133	0.2	1	0	0	0.309	0.3132	0.310	0.0014	0.017
7	627	0.2	1	0	0	0.431	0.3146	0.432	0.0000	0.038

2022 Age	Stock size	Natural mortality	Maturity ogive	Prop. of F bef. Spaw.	Prop. of M bef. Spaw.	Weight in Stock	Exploit pattern	Weight CWt	Exploit pattern	Weight DWt
1	3633	0.2	0.34	0	0	0.040	0.0058	0.055	0.0508	0.039
2	.	0.2	0.9	0	0	0.082	0.0918	0.098	0.0510	0.053
3	.	0.2	1	0	0	0.126	0.1922	0.131	0.0155	0.079
4	.	0.2	1	0	0	0.165	0.2402	0.167	0.0065	0.102
5	.	0.2	1	0	0	0.223	0.3473	0.223	0.0022	0.041
6	.	0.2	1	0	0	0.309	0.3132	0.310	0.0014	0.017
7	.	0.2	1	0	0	0.431	0.3146	0.432	0.0000	0.038

2023 Age	Stock size	Natural mortality	Maturity ogive	Prop. of F bef. Spaw.	Prop. of M bef. Spaw.	Weight in Stock	Exploit pattern	Weight CWt	Exploit pattern	Weight DWt
1	3633	0.2	0.34	0	0	0.040	0.006	0.055	0.051	0.039
2	.	0.2	0.9	0	0	0.082	0.092	0.098	0.051	0.053
3	.	0.2	1	0	0	0.126	0.192	0.131	0.016	0.079
4	.	0.2	1	0	0	0.165	0.240	0.167	0.007	0.102
5	.	0.2	1	0	0	0.223	0.347	0.223	0.002	0.041
6	.	0.2	1	0	0	0.309	0.313	0.310	0.001	0.017
7	.	0.2	1	0	0	0.431	0.315	0.432	0.000	0.038

Input units are thousands and kg - output in tonnes

Table 6.3.14. Megrim (*L. whiffiagonis*) in divisions 8.c and 9.a catch forecast: management options table.

MFDP version 1a
Run: meg
Time and date: 13:19 29/04/2021
Fbar age range (Total) : 2-4
Fbar age range Fleet 1 : 2-4

2021		Catch	Landings		Discards	
Biomass	SSB	FMult	FBar	Yield	FBar	Yield
2927	2782	1	0.1747	542	0.0243	27

2022		Catch	Landings		Discards		2023	
Biomass	SSB	FMult	FBar	Yield	FBar	Yield	Biomass	SSB
2780	2661	0	0.0000	0	0.0000	0	3218	3099
.	2661	0.1	0.0175	63	0.0024	2	3142	3022
.	2661	0.2	0.0349	123	0.0049	4	3068	2948
.	2661	0.3	0.0524	183	0.0073	6	2996	2876
.	2661	0.4	0.0699	240	0.0097	8	2926	2806
.	2661	0.5	0.0874	296	0.0122	10	2857	2738
.	2661	0.6	0.1048	351	0.0146	12	2791	2672
.	2661	0.7	0.1223	404	0.0170	13	2726	2607
.	2661	0.8	0.1398	455	0.0195	15	2664	2545
.	2661	0.9	0.1573	506	0.0219	17	2603	2484
.	2661	1	0.1747	554	0.0243	19	2543	2425
.	2661	1.1	0.1922	602	0.0268	21	2485	2367
.	2661	1.2	0.2097	648	0.0292	22	2429	2311
.	2661	1.3	0.2272	693	0.0316	24	2375	2256
.	2661	1.4	0.2446	737	0.0341	26	2321	2203
.	2661	1.5	0.2621	779	0.0365	27	2270	2152
.	2661	1.6	0.2796	821	0.0389	29	2219	2101
.	2661	1.7	0.2970	861	0.0414	31	2170	2053
.	2661	1.8	0.3145	900	0.0438	32	2123	2005
.	2661	1.9	0.3320	939	0.0462	34	2076	1959
.	2661	2	0.3495	976	0.0487	35	2031	1914

Input units are thousands and kg - output in tonnes

Table 6.3.15. Megrim (*L. whiffiagonis*) in divisions 8.c and 9.a. Single option prediction. Detailed tables.

MFDP version 1a
Run: meg
Time and date: 13:19 29/04/2021
Fbar age range (Total) : 2-4
Fbar age range Fleet 1 : 2-4

Year: 2021 F multiplier: 1 Fleet1 HCFbar: 0.1747 Fleet1 DFbar: 0.0243

Age	Catch F	CatchNos	Yield	DF	DCatchNos	DYield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
1	0.0058	19	1	0.0508	163	6	3633	145	1235	49	1235	49
2	0.0918	465	45	0.051	258	14	5979	493	5381	443	5381	443
3	0.1922	738	97	0.0155	60	5	4675	590	4675	590	4675	590
4	0.2402	686	114	0.0065	19	2	3539	585	3539	585	3539	585
5	0.3473	593	132	0.0022	4	0	2218	494	2218	494	2218	494
6	0.3132	277	86	0.0014	1	0	1133	350	1133	350	1133	350
7	0.3146	154	67	0	0	0	627	270	627	270	627	270
Total		2931	542		504	27	21804	2927	18808	2782	18808	2782

Year: 2022 F multiplier: 1 Fleet1 HCFbar: 0.1747 Fleet1 DFbar: 0.0243

Age	Catch F	CatchNos	Yield	DF	DCatchNos	DYield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
1	0.0058	19	1	0.0508	163	6	3633	145	1235	49	1235	49
2	0.0918	218	21	0.051	121	6	2811	232	2530	208	2530	208
3	0.1922	670	88	0.0155	54	4	4244	536	4244	536	4244	536
4	0.2402	602	100	0.0065	16	2	3110	514	3110	514	3110	514
5	0.3473	605	135	0.0022	4	0	2264	504	2264	504	2264	504
6	0.3132	313	97	0.0014	1	0	1280	396	1280	396	1280	396
7	0.3146	259	112	0	0	0	1052	454	1052	454	1052	454
Total		2686	554		360	19	18394	2780	15715	2661	15715	2661

Year: 2023 F multiplier: 1 Fleet1 HCFbar: 0.1747 Fleet1 DFbar: 0.0243

Age	Catch F	CatchNos	Yield	DF	DCatchNos	DYield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
1	0.0058	19	1	0.0508	163	6	3633	145	1235	49	1235	49
2	0.0918	218	21	0.051	121	6	2811	232	2530	208	2530	208
3	0.1922	315	41	0.0155	25	2	1995	252	1995	252	1995	252
4	0.2402	547	91	0.0065	15	2	2823	467	2823	467	2823	467
5	0.3473	532	119	0.0022	3	0	1989	443	1989	443	1989	443
6	0.3132	320	99	0.0014	1	0	1307	404	1307	404	1307	404
7	0.3146	343	148	0	0	0	1394	601	1394	601	1394	601
Total		2293	521		329	16	15952	2543	13273	2425	13273	2425

Input units are thousands and kg - output in tonnes

Table.6.3.16. Megrim (*L. whiffiagonis*) in divisions 8.c and 9.a. Stock numbers of recruits and their source for recent year-classes used in predictions, and the relative (%) contributions to catches and SSB (by weight) of these year-classes.

Year-class	2017	2018	2019	2020	2021
Stock No. (thousands) of 1 year-olds	8533	8121	7387	3633	3633
Source	XSA	XSA	XSA	GM98-18	GM98-18
Status Quo F:					
% in 2021 catch	20.4	17.9	10.4	1.2	-
% in 2022	23.6	17.8	16.1	4.7	1.2
% in 2021 SSB	21.0	21.2	15.9	1.8	-
% in 2022 SSB	18.9	19.3	20.1	7.8	1.8
% in 2023 SSB	16.7	18.3	19.3	10.4	8.6

GM : geometric mean recruitment

Megrim (L. whiffiagonis) in Divisions 8c and 9a : Year-class % contribution to

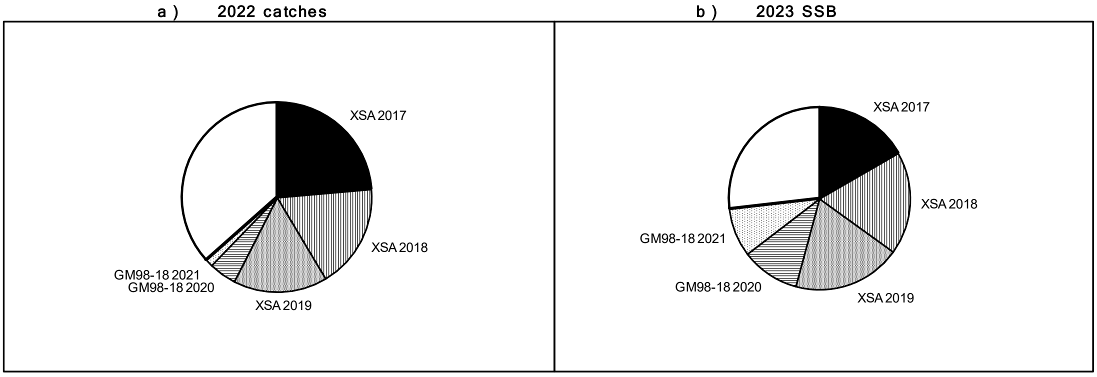


Table 6.3.17. Megrim (*L. whiffiagonis*) in divisions 8.c and 9.a, yield-per-recruit results.

MFYPR version 2a
Run: meg
Time and date: 13:27 29/04/2021
Yield per results

Catch	Landings			Discards								
FMult	Fbar	CatchNos	Yield	Fbar	CatchNos	Yield	StockNos	Biomass	SpwnNosJan	SSBJan	SpwnNosSpwn	SSBSpwn
0	0	0	0	0	0	0	5.5167	1.2132	4.7748	1.1802	4.7748	1.1802
0.1	0.0175	0.0881	0.0253	0.0024	0.0097	0.0005	5.0295	1.0247	4.2881	0.9918	4.2881	0.9918
0.2	0.0349	0.1538	0.0422	0.0049	0.0191	0.001	4.6557	0.8841	3.9147	0.8511	3.9147	0.8511
0.3	0.0524	0.2042	0.0536	0.0073	0.0284	0.0014	4.359	0.7757	3.6185	0.7428	3.6185	0.7428
0.4	0.0699	0.2439	0.0614	0.0097	0.0374	0.0018	4.1172	0.69	3.3772	0.6571	3.3772	0.6571
0.5	0.0874	0.2757	0.0667	0.0122	0.0462	0.0023	3.9158	0.6208	3.1762	0.588	3.1762	0.588
0.6	0.1048	0.3015	0.0702	0.0146	0.0548	0.0027	3.7451	0.564	3.006	0.5312	3.006	0.5312
0.7	0.1223	0.3227	0.0725	0.017	0.0633	0.0031	3.5982	0.5167	2.8595	0.4839	2.8595	0.4839
0.8	0.1398	0.3403	0.0738	0.0195	0.0716	0.0035	3.4702	0.4768	2.7319	0.4441	2.7319	0.4441
0.9	0.1573	0.3551	0.07	0.0219	0.0797	0.0039	3.36	0.4427	2.6196	0.4101	2.6196	0.4101
1	0.1747	0.3674	0.0748	0.0243	0.0877	0.0043	3.2571	0.4135	2.5197	0.3808	2.5197	0.3808
1.1	0.1922	0.3779	0.0746	0.0268	0.0955	0.0046	3.1672	0.388	2.4302	0.3554	2.4302	0.3554
1.2	0.2097	0.3868	0.0743	0.0292	0.1031	0.005	3.086	0.3658	2.3495	0.3332	2.3495	0.3332
1.3	0.2272	0.3943	0.0737	0.0316	0.1106	0.0053	3.0121	0.3462	2.2761	0.3137	2.2761	0.3137
1.4	0.2446	0.4007	0.0731	0.0341	0.118	0.0057	2.9446	0.3288	2.209	0.2963	2.209	0.2963
1.5	0.2621	0.4061	0.0723	0.0365	0.1252	0.006	2.8826	0.3133	2.1474	0.2809	2.1474	0.2809
1.6	0.2796	0.4107	0.0715	0.0389	0.1323	0.0063	2.8253	0.2994	2.0905	0.267	2.0905	0.267
1.7	0.297	0.4146	0.0706	0.0414	0.1393	0.0066	2.7722	0.2869	2.0378	0.2545	2.0378	0.2545
1.8	0.3145	0.4178	0.0697	0.0438	0.1461	0.007	2.7228	0.2756	1.9888	0.2432	1.9888	0.2432
1.9	0.332	0.4205	0.0688	0.0462	0.1528	0.0073	2.6766	0.2653	1.9431	0.233	1.9431	0.233
2.0	0.3495	0.4228	0.0679	0.0487	0.1594	0.0076	2.6334	0.2559	1.9003	0.2236	1.9003	0.2236

Reference point	F multiplier	Absolute F
Fleet1 Landings Fbar(2-4)	1	0.1747
FMax	1.0119	0.1768
F0.1	0.5775	0.1009
F35%SPR	0.8905	0.1556

Weights in kilograms

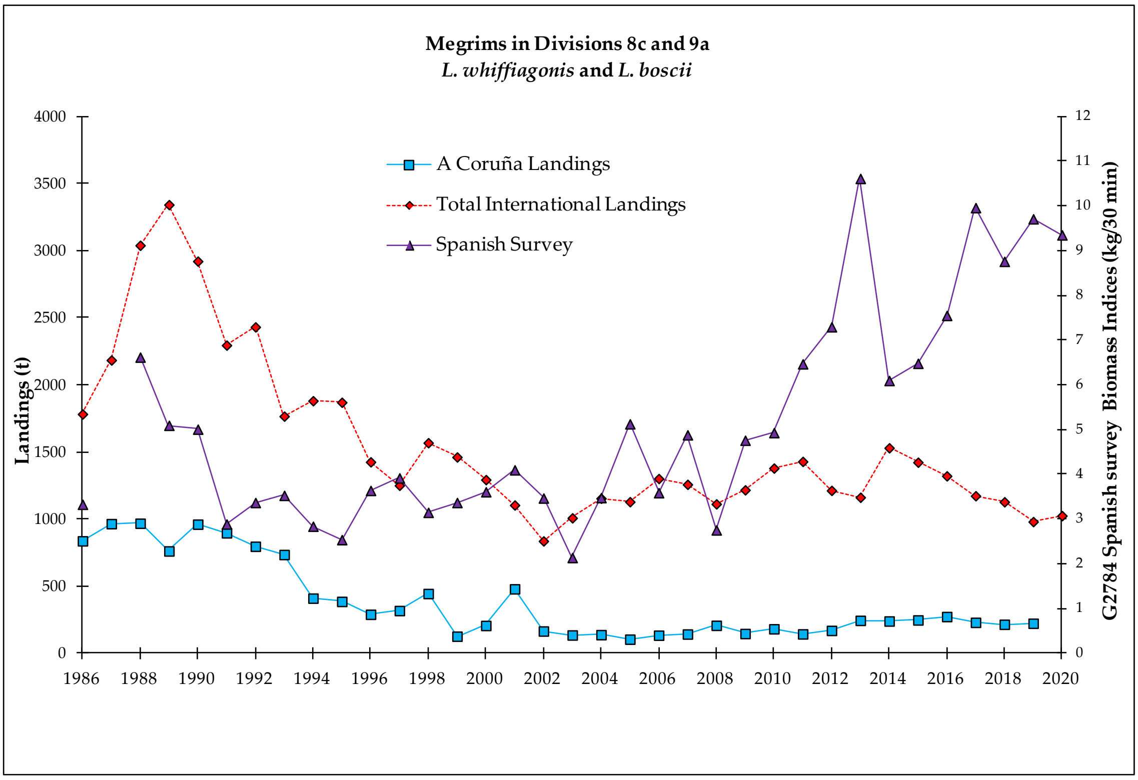


Figure 6.3.1. Historical landings and biomass indices of Spanish survey of megrims (both species combined).

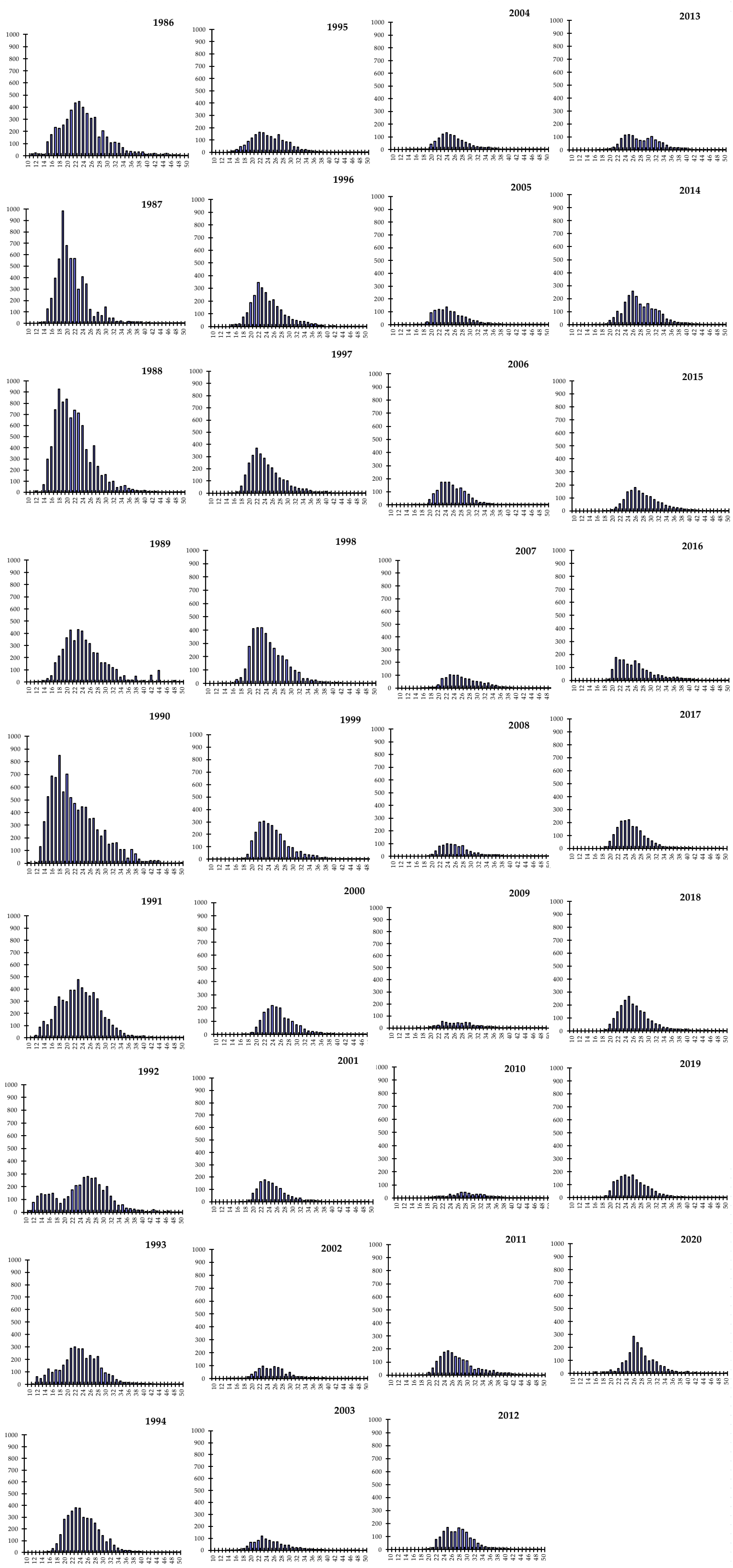


Figure 6.3.2. Megrim (*L. whiffiagonis*) in divisions 8.c and 9.a. Annual length compositions of landings ('000).

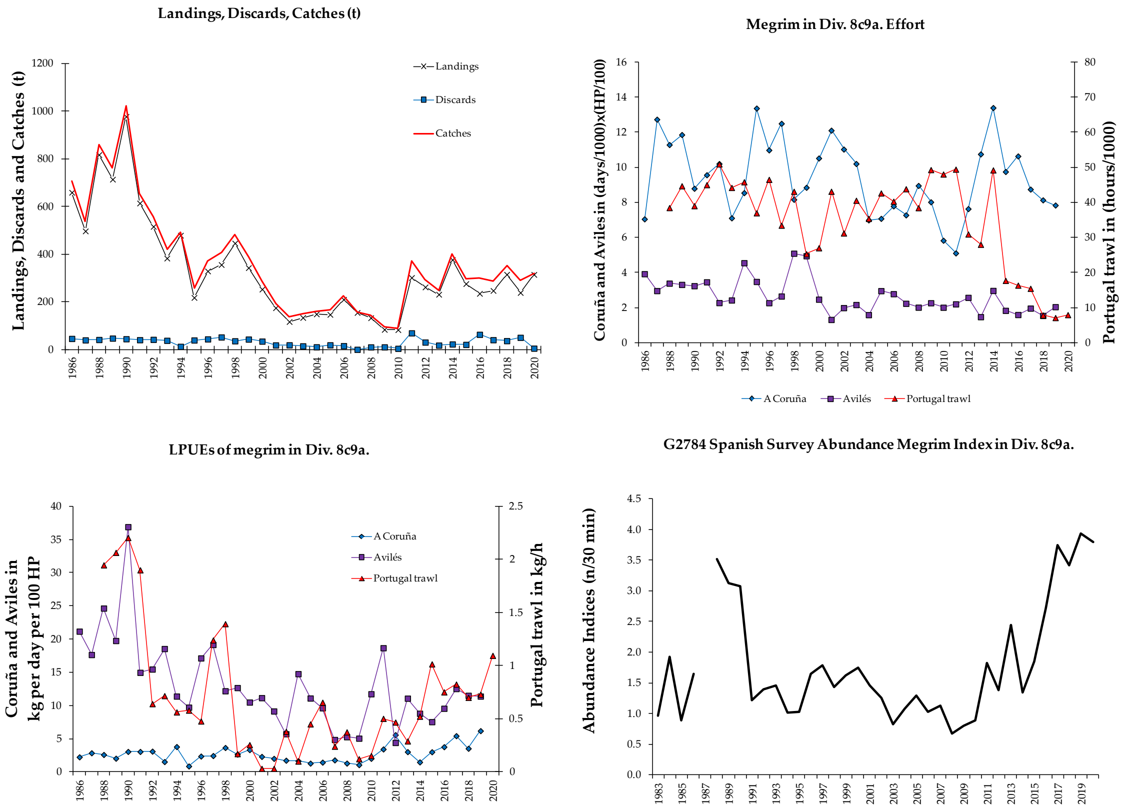


Figure 6.3.3a. Megrim (*L.whiffiagonis*) in divisions 8.c and 9.a. Catches (t), Efforts, LPUEs and Abundance Indices.

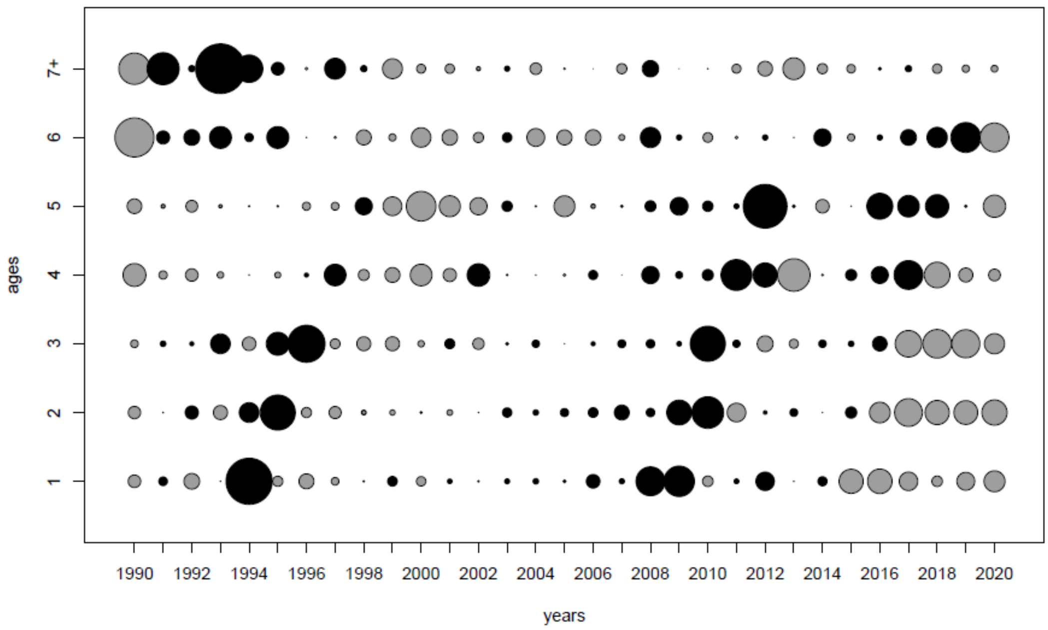
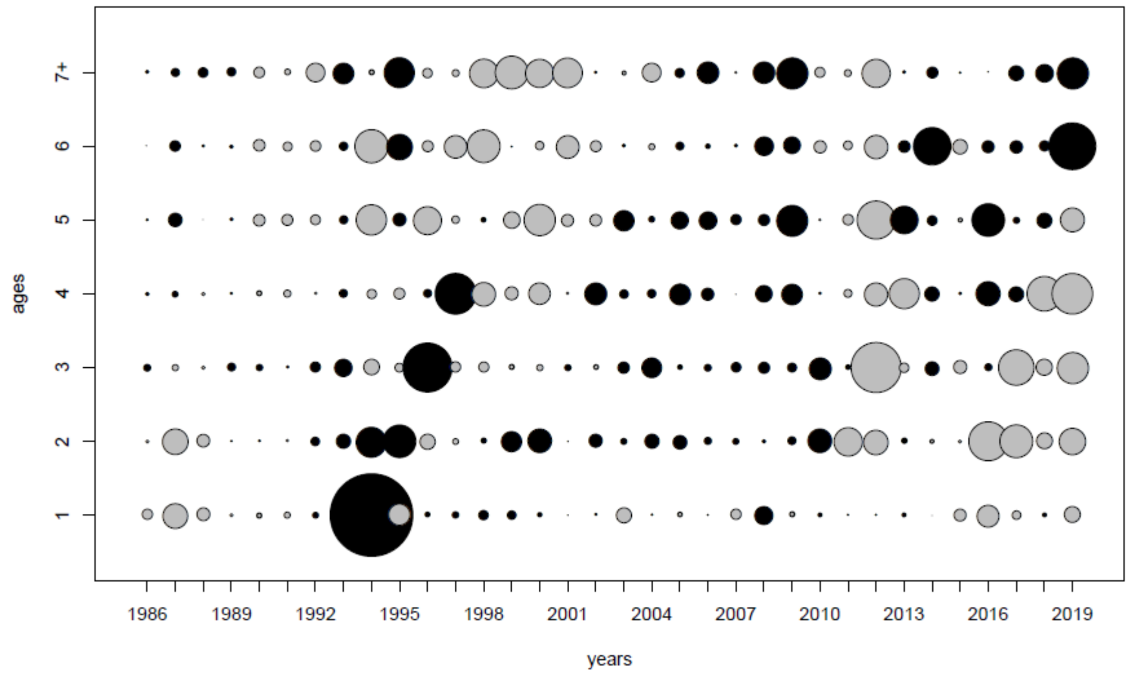


Figure 6.3.3b. Megrim (*L. whiffiagonis*) in divisions 8.c and 9.a. Standardized log (abundance index at age) from survey SP-NSGFS-Q4 (G2784) (Bubbles colour scale: black – negative, grey – positive).

Standardized log (abundance index at age) from A Coruña fleet (SP-LCGOTBDEF).



Standardized log (abundance index at age) from Avilés fleet (SP-AVSOTBDEF).

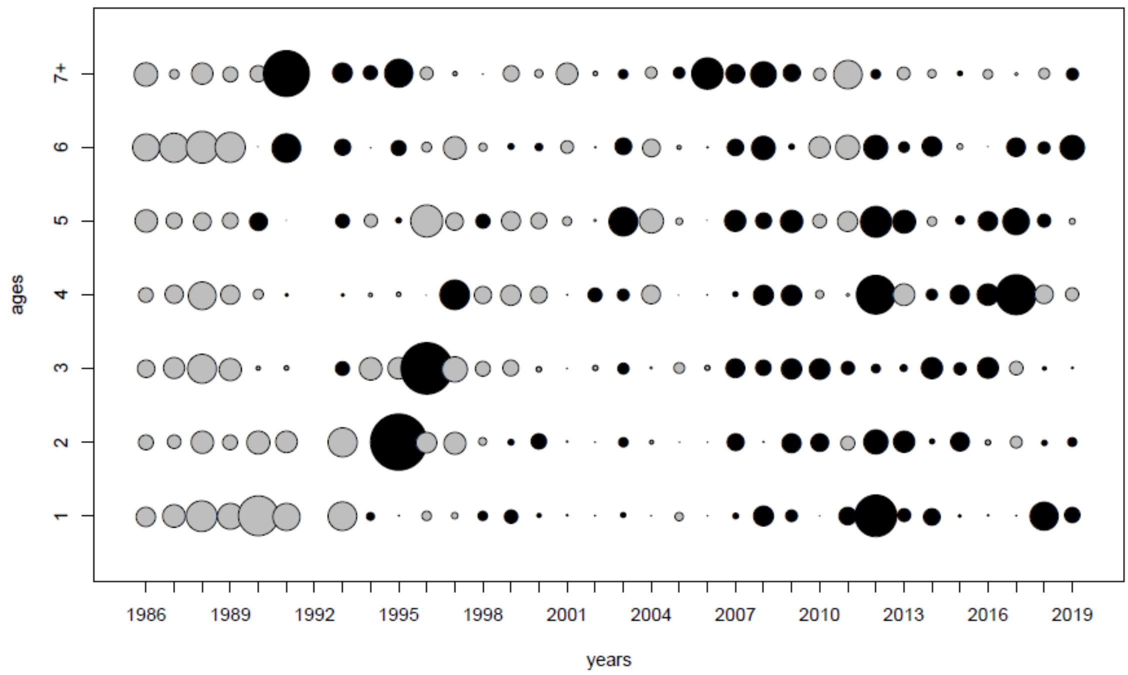
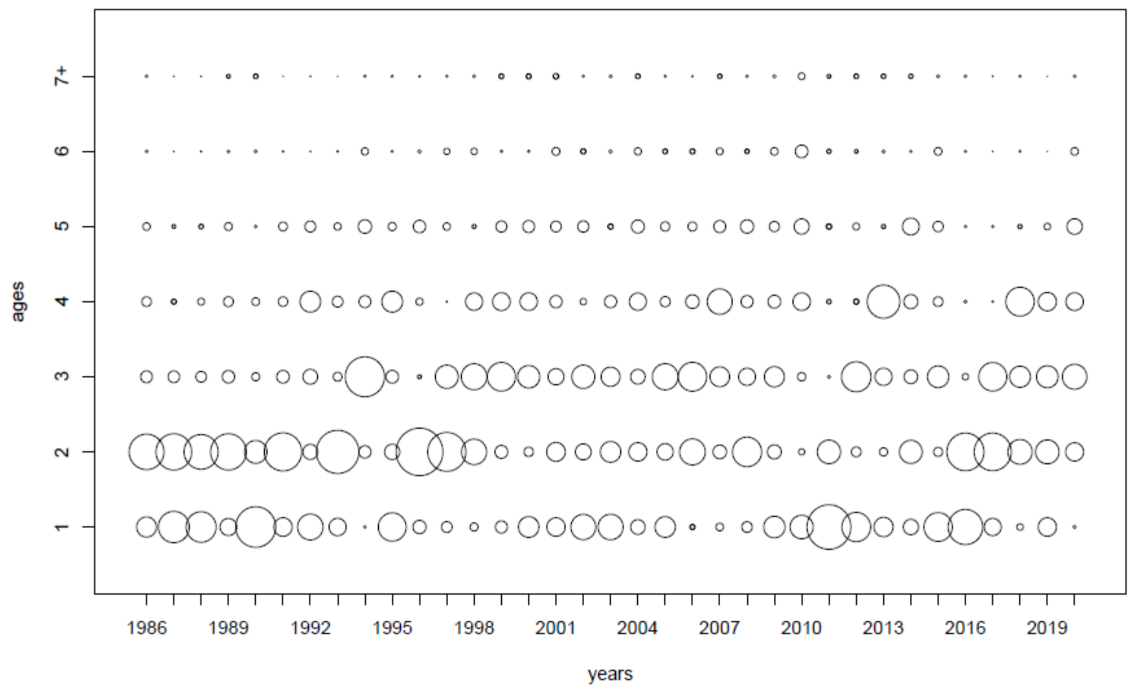


Figure 6.3.3c. Megrim (*L. whiffiagonis*) in divisions 8.c and 9.a. Standardized log (abundance index at age) from A Coruña SP-LCGOTBDEF) and Avilés (SP-AVSOTBDEF) fleets. Bubbles colour scale: black – negative, grey – positive.

Catches proportions at age



Standardized catches proportions-at-age (Bubbles colour scale: black – negative, grey – positive)

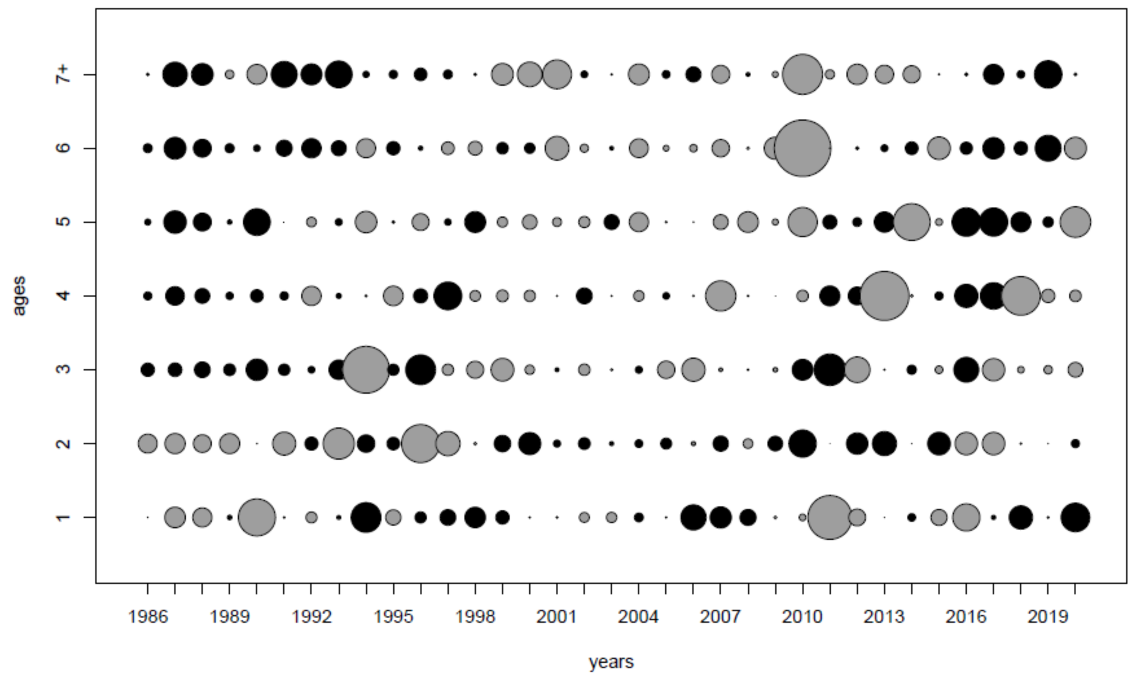
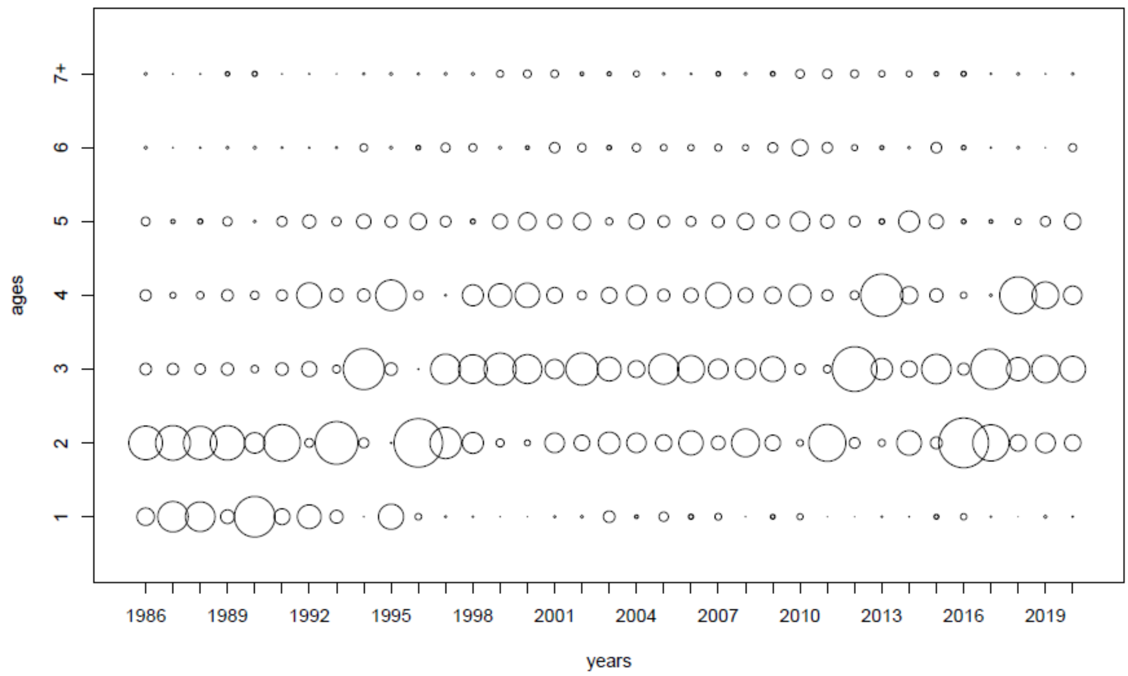


Figure 6.3.4a. Megrim (*L. whiffiagonis*) in divisions 8.c and 9.a. Catch proportions-at-age.

Landings proportions-at-age



Standardized landings proportions-at-age (Bubbles colour scale: black – negative, grey – positive)

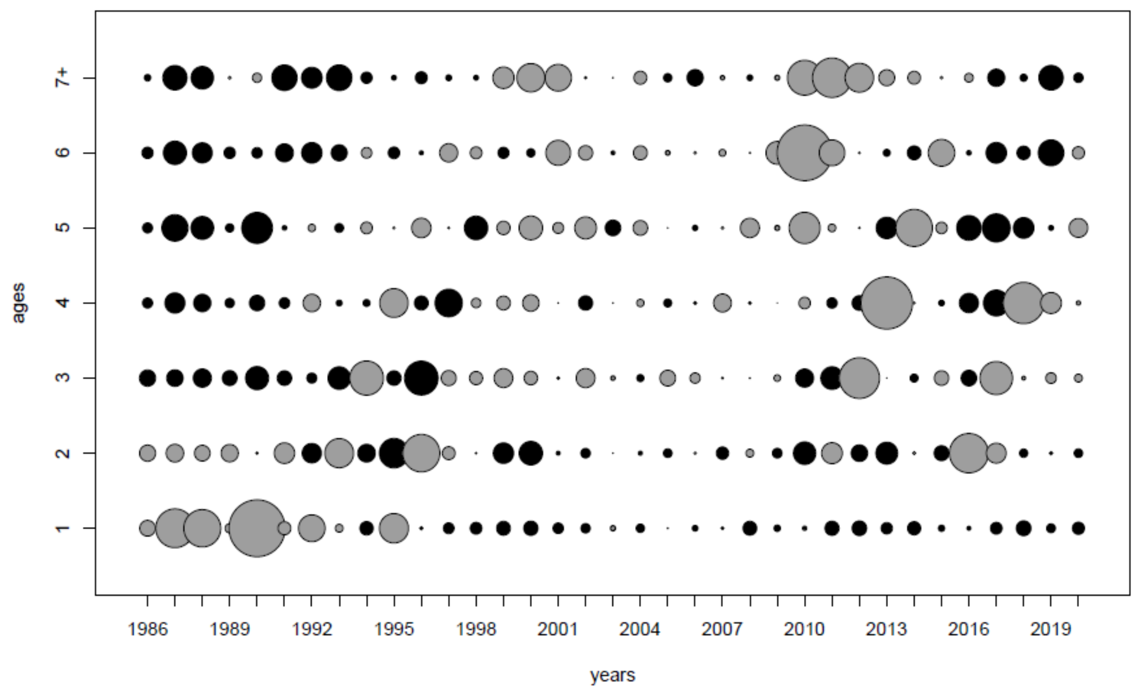
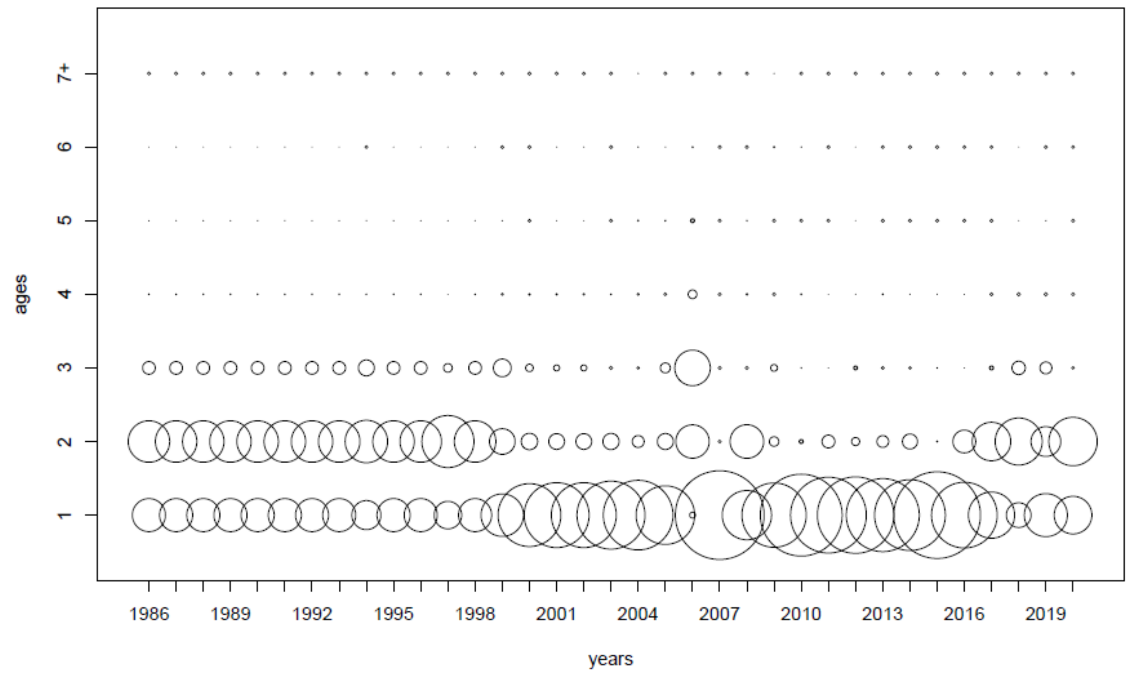


Figure 6.3.4b. Megrim (*L. whiffiagonis*) in divisions 8.c and 9.a. Landings proportions-at-age.

Discards proportions-at-age



Standardized discards proportions-at-age (Bubbles colour scale: black – negative, grey – positive)

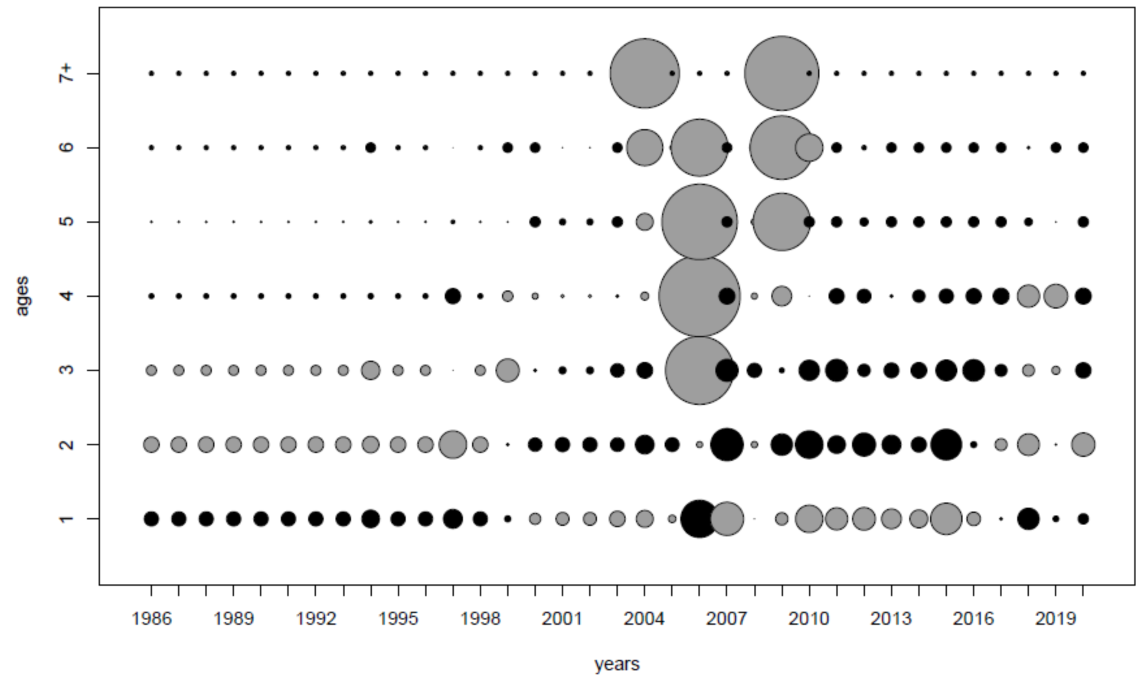


Figure 6.3.4c. Megrim (*L. whiffiagonis*) in divisions 8.c and 9.a. Discards proportions-at-age.

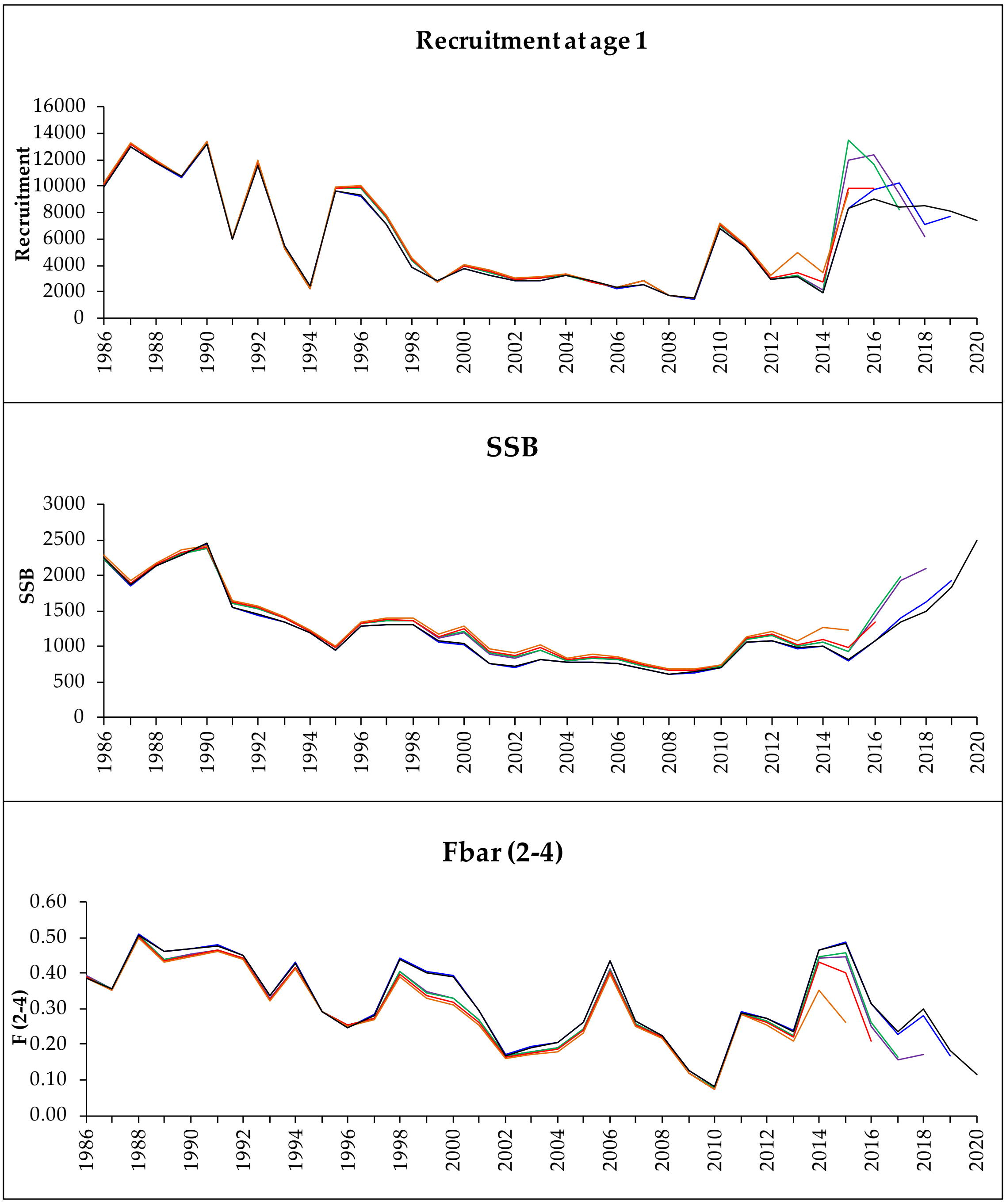


Figure 6.3.5. Megrim (*L. whiffiagonis*) in divisions 8.c and 9.a. Retrospective XSA.

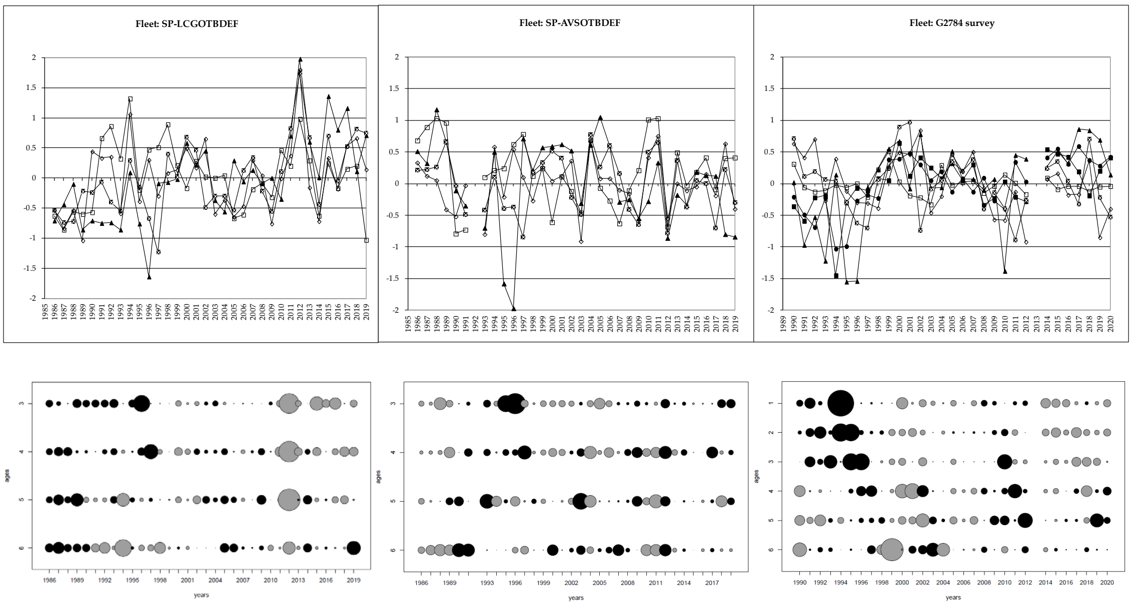


Figure 6.3.6. Megrim in divisions 8.c and 9.a. Log-catchability residual plots (XSA).

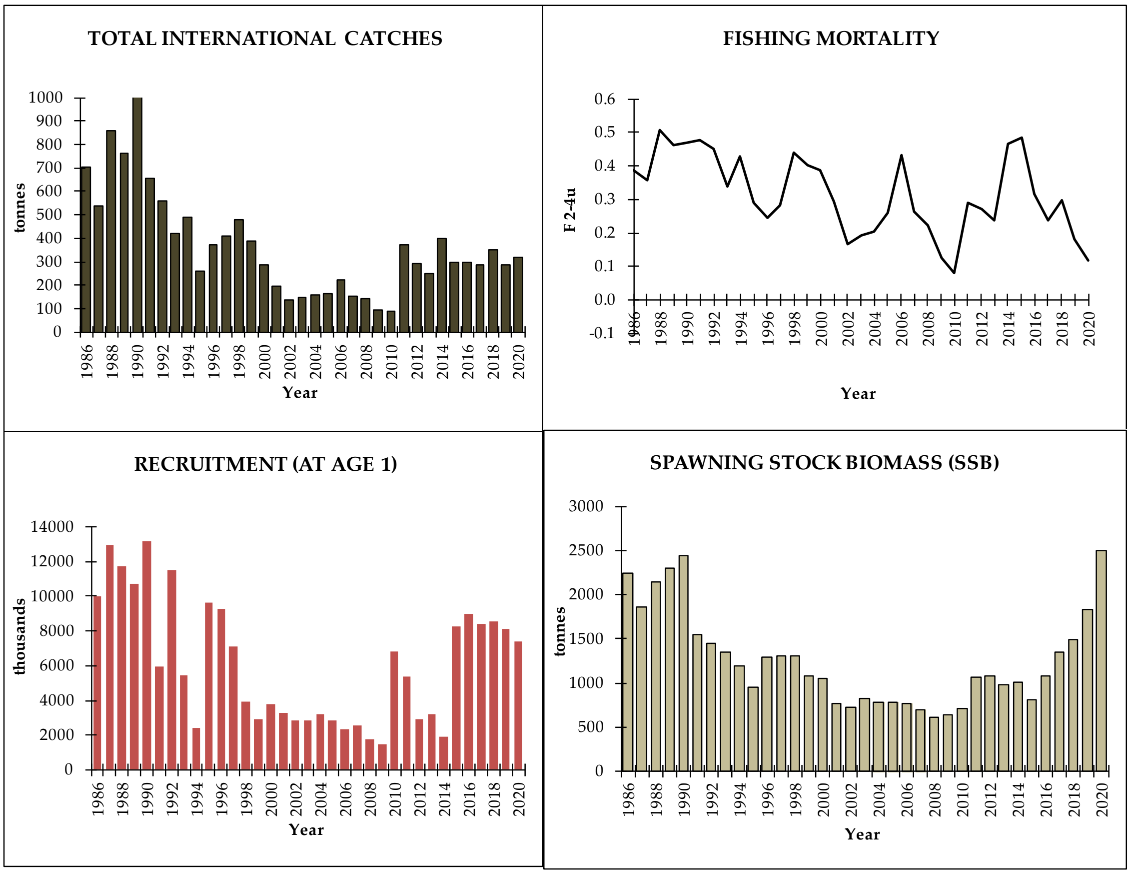
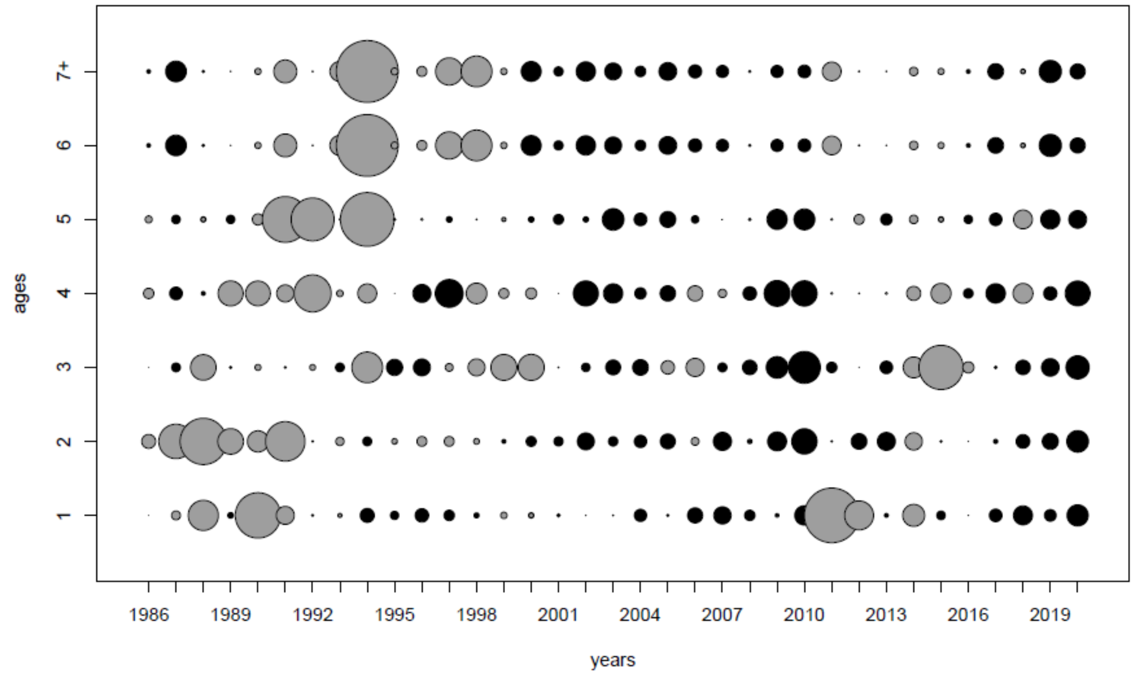


Figure 6.3.7a. Megrim (*L. whiffiagonis*) in divisions 8.c and 9.a. Stock Summary.

Standardized F-at-age (Bubbles colour scale: black – negative, grey – positive)



Standardized relative F-at-age (Bubbles colour scale: black – negative, grey – positive)

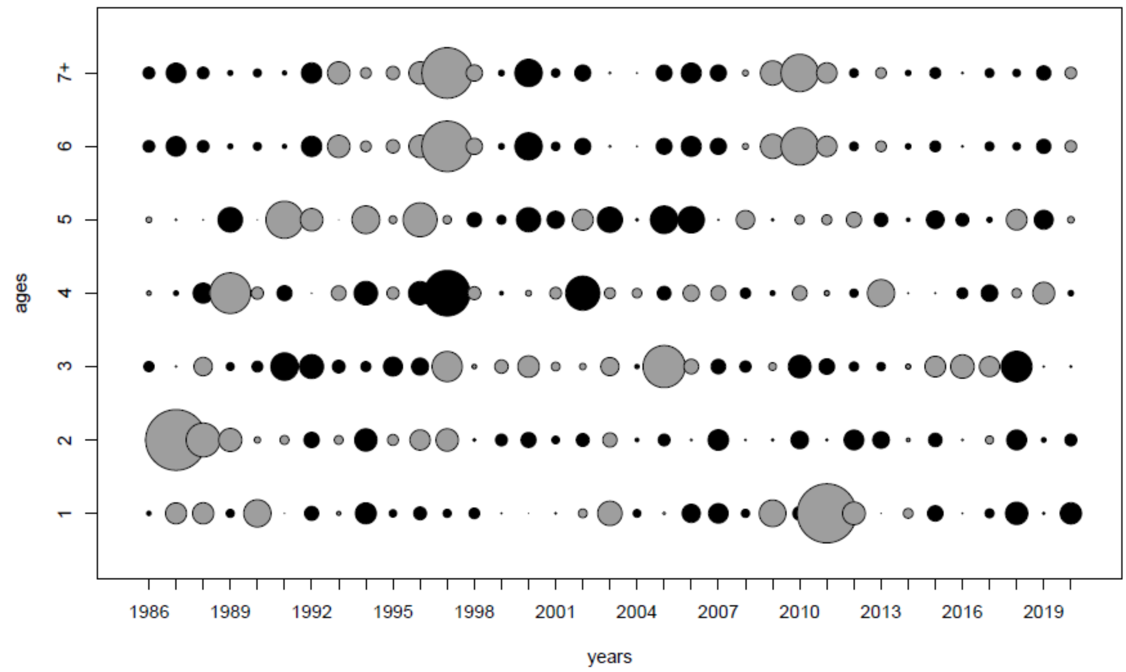
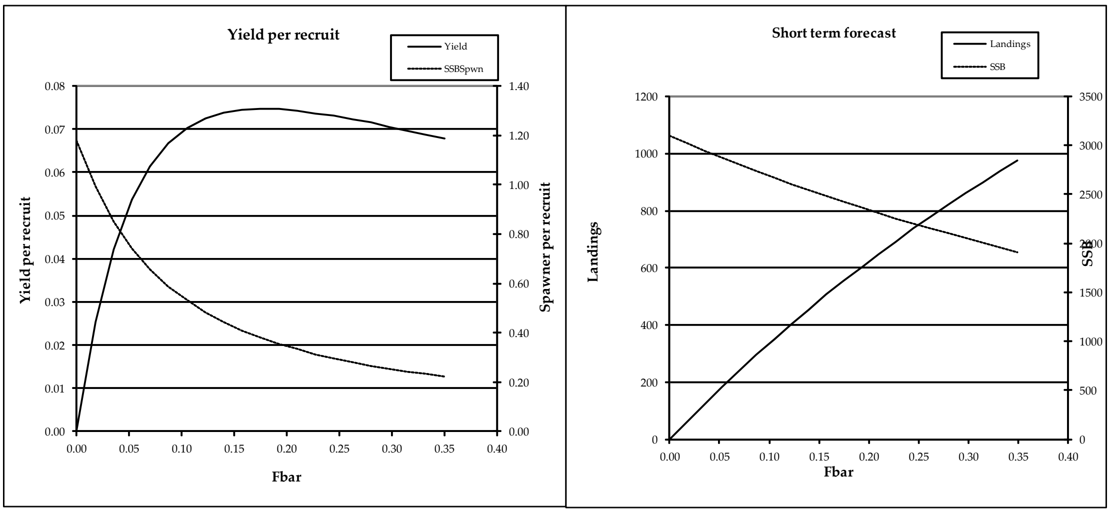


Figure 6.3.7b. Megrim (*L. whiffiagonis*) in divisions 8.c and 9.a. F-at-age.



MFYPR version 2a
Run: meg
Time and date: 13:27 29/04/2021

Reference point	F multiplier	Absolute F
Fleet1 Landings Fbar	1.0000	0.1747
FMax	1.0119	0.1768
F0.1	0.5775	0.1009
F35%SPR	0.8905	0.1556

MFDP version 1a
Run: meg
Time and date: 13:19 29/04/2021
Fbar age range (Total) : 2-4
Fbar age range Fleet 1 : 2-4

Input units are thousands and kg - output in tonnes

Figure 6.3.8. Megrim (*L. whiffiagonis*) in divisions 8.c and 9.a, forecast summary.

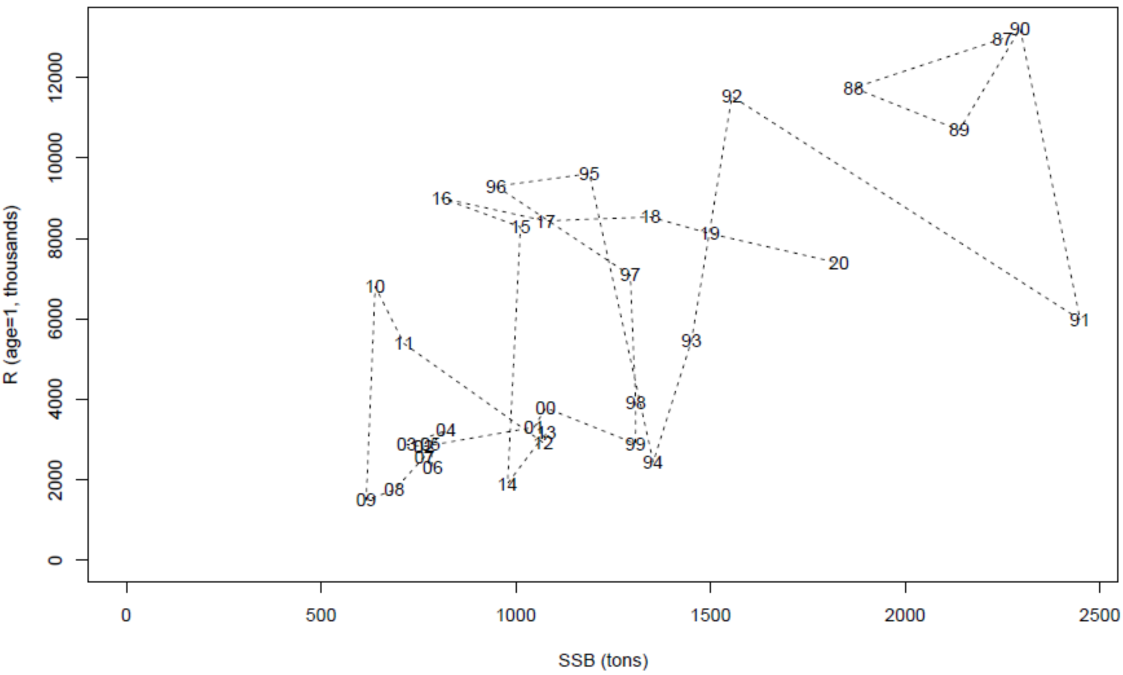


Figure 6.3.9. Megrim (*L.whiffiagonis*) in divisions 8.c and 9.a. SSB-Recruitment plot (numbers in graph, 1987–2020, are recruitment years).

6.4 Four-spot megrim (*Lepidorhombus boscii*) in divisions 8.c and 9.a

6.4.1 General

See general section for both species.

6.4.2 Data

6.4.2.1 Commercial catches and discards

The WG estimates of four-spot megrim international landings, discards, and catches for the period 1986 to 2020 are given in Table 6.4.1. The sampling programs coordinated by the Spanish Institute of Oceanography-IEO (onshore, observers at-sea and biological sampling) were suspended partially of 2020 due to administrative problems and to the COVID-19 disruption. This affected all stocks. From 2011 to 2018, estimates of unallocated or non-reported landings were included in the assessment. These were estimated based on the sampled vessels (Spanish concurrent sampling) raised to the total effort for each métier. These estimates are considered the best information available at this time. In 2015, data revised for the period 2011–2013 were provided. This revision produced an improvement in the allocation of sampling trips and the data revised are used in the assessment. Landings reached a peak of 2629 t in 1989 and have generally declined since then to their lowest value of 720 t in 2002. There has been some increase again in the last few years. Landings in 2010 are 1297 t, the highest value after 1995. In 2020, the landings value of 711 t is one of the lowest of the time-series.

Discards estimates were available from the "observers' onboard sampling programme" for Spain in the years displayed in Table 6.4.2a. In 2020, discards data of the first semester were missing for the reasons previously mentioned and were estimated based on the discard per unit of effort of the second semester applied to the exerted effort in the first semester. Discard / Total Catch ratio and CV are also presented, where discards in number represent between 21–67% of the total catch. Following the ICES recommendations in the advice sheet and using the same methodology described for *L. whiffiagonis* in section 6.1.2.1, discards missing data were also estimated for *L. boscii* in the WKSOUTH benchmark in 2014 (ICES, 2014). Spanish discards in numbers-at-age are shown in Table 6.4.2b, indicating that the bulk of discards (in numbers) is for ages 1 to 3. Total discards are given in tons in Table 6.4.1

6.4.2.2 Biological sampling

Annual length compositions of total stock landings are provided in Figure 6.4.1 for the period 1986–2020 and in Table 6.4.3a for the year 2020. Due to the lack of samplings in 2020, some length distributions in some quarters were missing. The existing ones were raised to the total catch of the métier.

Mean length and mean weight in landings since 1990 are shown in Table 6.4.3b.

Age compositions of catches are presented in Table 6.4.4. Weights-at-age of catches (given in Table 6.4.5) were also used as weights-at-age in the stock. There is some variability of the weights-at-age through the historical time-series.

For more information about biological data see Stock Annex.

6.4.2.3 Abundance indices from surveys

Portuguese and Spanish survey indices are summarized in Table 6.4.6.

Two Portuguese surveys, named "Crustacean“ (PT-CTS (UWTV(FU28–29))) and ”October“ (PtGFS-WIBTS-Q4 (G8899)), provide biomass and abundance indices. The October survey was conducted with a different vessel and gear in 2003 and 2004. Excluding these two years, the biomass index from this survey in 2017 was the highest observed since 1994, whereas the value in 2010 is the second-lowest in the series. In 2011, both the biomass and abundance indices from the Crustacean survey are the highest in the time-series. In 2012 and the last two years, 2019 and 2020, the Portuguese Surveys were not carried out. Total biomass, abundance and recruitment indices from the Spanish Groundfish Survey (SP-NSGFS-Q4 (G2784)) are also presented in Table 6.4.6. Total biomass indices from this survey generally remained stable after a maximum level in 1988 until 2003, when a very low value was obtained (as done in previous years, the 2003 index has been excluded from the assessment, as it was felt to be too much in contradiction with the rest of the time-series). Since then, this was followed by a period of higher values until the present days, with the only exception of 2008. In 2013, the biomass and the abundance indices were the highest of the series. For the same reason that for *L. whiffiagonis*, i.e. the survey carried out in a new vessel, the abundance value of 2013 was not included in the assessment model. In 2017, the survey presented the second-highest value in both biomass and abundance indices, remaining high in 2019 and 2020.

The recruitment index for age 0 in 2005 was very high and also in 2009 and 2014. A medium value was estimated for the year 2020. The high index in 2009 applies to all ages and not just the recruitment (see Table 6.4.7, which gives abundance indices by age, and Figure 6.4.2, which is a bubble plot of log(abundance index at age) standardized by subtracting the mean and dividing by the standard deviation over the years). Since 2009, almost all ages appear to be above average. From Figure 6.4.2, the survey appears to have been quite good in tracking cohorts in the last ten years, the stronger cohorts of 2005, 2009 and 2014 can be followed, especially the last two.

6.4.2.4 Commercial catch-effort data

Two new commercial tuning indices were also provided for this stock as in the case of *L. whiffiagonis*. The LPUEs of the métiers of bottom otter trawl targeting demersal species, previously described in section 6.1.2.4, one per port (A Coruña and Avilés), was made available for the WKSOUTH benchmark in 2014 (ICES, 2014). From these new tuning fleets, SP-LCGOTBDEF and SP-AVSOTBDEF, only the first one was accepted to tune the assessment model. The LPUE and effort values and landed numbers-at-age are given in Table 6.4.7 and Figure 6.4.3a.

These fleets operate in different areas, each covering only a small part of the distribution of the stock, which may partly explain differences between patterns from these fleets and those from the Spanish survey in some years. Furthermore, commercial catches are mostly composed of ages 3 and 4, while the Spanish survey catches mostly fish of ages 1 and 2.

Table 6.4.8 displays landings (in tonnes), fishing effort and LPUE for the Spanish trawl fleet SP-LCGOTBDEF for the period 1986–2019, SP-AVSOTBDEF for the period 1986–2015 and for the Portuguese trawl fleet fishing in Division 9a for the period 1988–2020 (see also Figure 6.4.3). As SP-AVSOTBDEF is not used in the assessment, the sampling for this species in this port has been suspended since 2015. After a very high value in 2010 and a drop in the two following years, the LPUE of Coruña (SP-LCGOTBDEF) shows in 2019 a small decrease relative to the previous year. The Portuguese LPUE series was revised from 2012 onwards. To revise the series backwards, further refinement of the algorithms is required.

6.4.2.4.1.1 Commercial fleets used in the assessment to tune the model

Both Spanish commercial fleets could not be updated because of the problems in samplings that were mentioned in section 6.4.2.1. Because of the trend in the residuals, A Coruña fleet (SP-LCGOTBDEF) was split in two (SP-LCGOTBDEF-1 and SP-LCGOTBDEF-2) for tuning, considering values until 1999 and from 2000 onwards, as indicated in the Stock Annex. In Figure 6.4.3b, the bubble plots of log (abundance index at age) standardized by subtracting the mean and dividing by the standard deviation over the years) of these two fleets are presented. Some cohorts can be followed in the time-series. The effort of the SP-LCGOTBDEF fleet had been generally stable until year 2009, when effort is declining to its lowest value in the series, reached in 2011. After this year, the effort began to increase until 2014 when the highest value of the time-series was observed.

6.4.2.4.1.2 Commercial fleets not used in the assessment to tune the model

The effort of the Avilés fleet (SP-AVSOTBDEF) presents two periods, the first one with a mean value of 3.2 and the second with 2.2 (days/1000) x (HP/100). The value in 2013 is one of the lowest of the series and was similar in 2015. The effort of the Portuguese trawl fleet shows a slightly declining trend until last year, one of the lowest of the time-series.

The LPUE series from the Avilés trawl fleet (SP-AVSOTBDEF) shows a generally upwards trend during all the series. The LPUE of the Portuguese trawl fleet has generally declined from 1992 to 2001, followed by an increase until 2010, when the values started a decreasing trend. Since 2014, there is an increasing trend and the 2020 value is the highest observed over the years.

6.4.3 Assessment

An update assessment was conducted, according to the Stock Annex specifications. Assessment years are 1986–2020 and ages 0–7+.

6.4.4 Model

Data screening

Figures 6.4.4a, b and c are bubble plots representing catch, landings and discards proportions-at-age, respectively. These plots clearly indicate that the bulk of the landings generally corresponds to ages 2 to 4 and the discards to ages 1–2, although in the last years, it seems to be an increase in age 5 and a decrease in age 2. The bottom panel of Figures 6.4.4a, b and c also present bubble plots corresponding to standardized catch, landings and discards proportions-at-age, respectively, showing that the one corresponding to landings is the best to follow cohorts.

Very weak cohorts corresponding to year-classes of 1993 and 1998 can be clearly identified from the standardized landing proportions-at-age matrix and stronger cohorts corresponding to year-classes of 1991, 1992, 1995, 2005 and 2009 can also be tracked.

Final XSA run

Settings for the assessment are those detailed in the Stock Annex.

The retrospective analysis shows no particular worrying features (Figure 6.4.5). The model tends to underestimate F and overestimate SSB in the last years.

6.4.4.1 Assessment results

Diagnostics from the XSA final run are presented in Table 6.4.9 and log-catchability residuals plotted in Figure 6.4.6. Diagnostics and residuals are similar to those found in the previous assessment. Many of the survey residuals are negative until the 2000s. After that, positive survey residuals are more abundant in this period.

Table 6.4.10 presents the fishing mortality-at-age estimates. F_{bar} (= $F_{2\text{-}4}$) is estimated to be 0.108 in 2020.

Population numbers-at-age estimates are presented in Table 6.4.11.

6.4.4.2 Year-class strength and recruitment estimations

The 2018 year-class estimate is 47 million individuals, obtained by averaging estimates coming from the Spanish survey tuning data (97% of weight) and F-shrinkage (3% weight).

The 2019 year-class estimate is 37 million individuals, estimated from the Spanish survey (95% of weight) and F-shrinkage (5% weight).

The 2020 year-class estimate is 46 million individuals, obtained a value from the Spanish survey (100% weight).

The working group considered that the XSA last year recruitment is poorly estimated. Following the procedure stated in the Stock Annex, the geometric mean of estimated recruitment over the years 1990–2018 has been used for the computation of 2020 and subsequent year-classes, for prediction purposes. Working Group estimates of year-class strength used for prediction are:

Recruitment-at-age 0:

Year-class	Thousand	Basis	Survey	Commercial	Shrinkage
2018	46800	XSA	97%	-	3%
2019	36800	XSA	95%	-	5%
2020	43194	GM_{90-18}		-	
2021	43194	GM_{90-18}			

6.4.4.3 Historic trends in biomass, fishing mortality, and recruitment

Estimated fishing mortality and population numbers-at-age from the XSA run are given in Tables 6.4.10 and 6.4.11. Further results, including SSB estimates, are summarized in Table 6.4.12 and Figure 6.4.7a.

SSB decreased gradually from 6698 t in 1988 to 3133 t in 2001, the lowest value in the series, and has since increased. In 2020, the SSB was estimated at 7353 t, the highest of the time-series.

Recruitment has fluctuated around 47 million fish during all the series. Very weak year-classes are found in 1993 and 1998. The second highest value occurred in 2012, while the 2014 value is the third one in the series. Last year value is considered in the average.

Estimates of fishing mortality values show two different periods: an initial one with higher values from 1986 to 1996 and, following a decrease in 1997, a second period at a lower level, with small ups and downs. From 2007, the F has been decreasing until 2013. After two years of increasing values, the last five years show a decline in F, with the lowest values of the time-series observed in 2020.

There seems to be interannual variability of the relative fishing exploitation pattern at age (F over F_{bar} (Figure 6.4.7b), bottom panel), with alternating periods of time with higher and lower relative exploitation patterns on older ages.

6.4.5 Catch options and prognosis

Stock projections were calculated according to the settings specified in the Stock Annex.

6.4.5.1 Short-term projections

Short-term projections have been made using MFDP software (Multi Fleet Deterministic Projection; Smith, 2000). The input data for deterministic short-term projections are given in Table

6.4.13. Average F_{bar} for the last three years is assumed for the interim year. The exploitation pattern was the scaled F-at-age computed for each of the last five years and then the average of these scaled five years was weighted to the final year. This selection pattern was split into selection-at-age of landings and discards (corresponding to F_{bar} = 0.09 for landings and F_{bar} = 0.04 for discards, being 0.13 for catches). The recruitment in 2020 (age 0) has been replaced by the geometric mean (in accordance with the Stock Annex, GM is computed over years 1990-final assessment year minus 2), age 1 in 2021 has been recalculated from GM reduced by total estimated mortality obtained from the fishing mortality of age 0 of the last year and the natural mortality.

Table 6.4.14 gives the management options for 2022, and their consequences in terms of projected landings and stock biomass. Figure 6.4.8 (right panel) plots short-term yield and SSB vs. F_{bar}. The detailed output by age-group, assuming F *status quo*, is given in Table 6.4.15 for landings and discards. Under this scenario, projected landings for 2021 and 2022 are 1145 and 1185 t, respectively. Projected discards for the same years are 129 and 128 t.

Under F *status quo*, projected SSB values for 2022 and 2023 are about 8954 t and 9337 t, respectively.

The contributions of recent year-classes to the projected landings and SSB are presented in Table 6.4.16. GM_{90-18} recruitment is assumed to contribute with 6% to catches in 2022 and with 27% to SSB in 2023.

6.4.5.2 Yield and biomass per recruit analysis

The analysis is conducted following the Stock Annex specifications and results presented in Table 6.4.17. The left panel of Figure 6.4.8 plots yield-per-recruit and SSB-per-recruit vs. F_{bar}.

Under F s*tatus quo* (F_{bar} = 0.09 for landings and F_{bar} = 0.04 for discards and assuming GM_{90-18} recruitment of 43 million, the equilibrium yield would be around 1369 t of landings and 134 t of discards, with an SSB value of 10 025 t.

6.4.5.3 Biological reference points

The stock-recruitment time-series is plotted in Figure 6.4.9. See Stock Annex for more information about the biological reference points. The BRPs are:

	Type	Value	Technical basis
MSY Approach	MSY $B_{trigger}$	4600 t	B_{pa}
	F_{MSY}	0.193	
	F_{MSY} lower	0.125	based on 5% reduction in yield
	F_{MSY} upper (with advice rule)	0.29	based on 5% reduction in yield
	F_{MSY} upper (without advice rule)	0.29	based on 5% reduction in yield
	$F_{P.05}$	0.58	5% risk to B_{lim} with $B_{trigger}$.
Precautionary Approach	B_{lim}	3300 t	B_{loss} estimated in 2015
	B_{pa}	4600 t	1.4 B_{lim}
	F_{lim}	Undefined	
	F_{pa}	0.58	$F_{pa} = F_{P0.5}$

6.4.6 Comments on the assessment

Two commercial fleets (SP-LCGOTBDEF-1 and SP-LCGOTBDEF-2) and the Spanish survey (SP-NSGFS-Q4 (G2784)) were used for tuning. The commercial fleet data used for tuning corresponds to ages 3 and older, which are not well represented in the survey. The Spanish survey covers a large part of the distribution area of the stock. The survey appears to have been quite good at tracking cohorts.

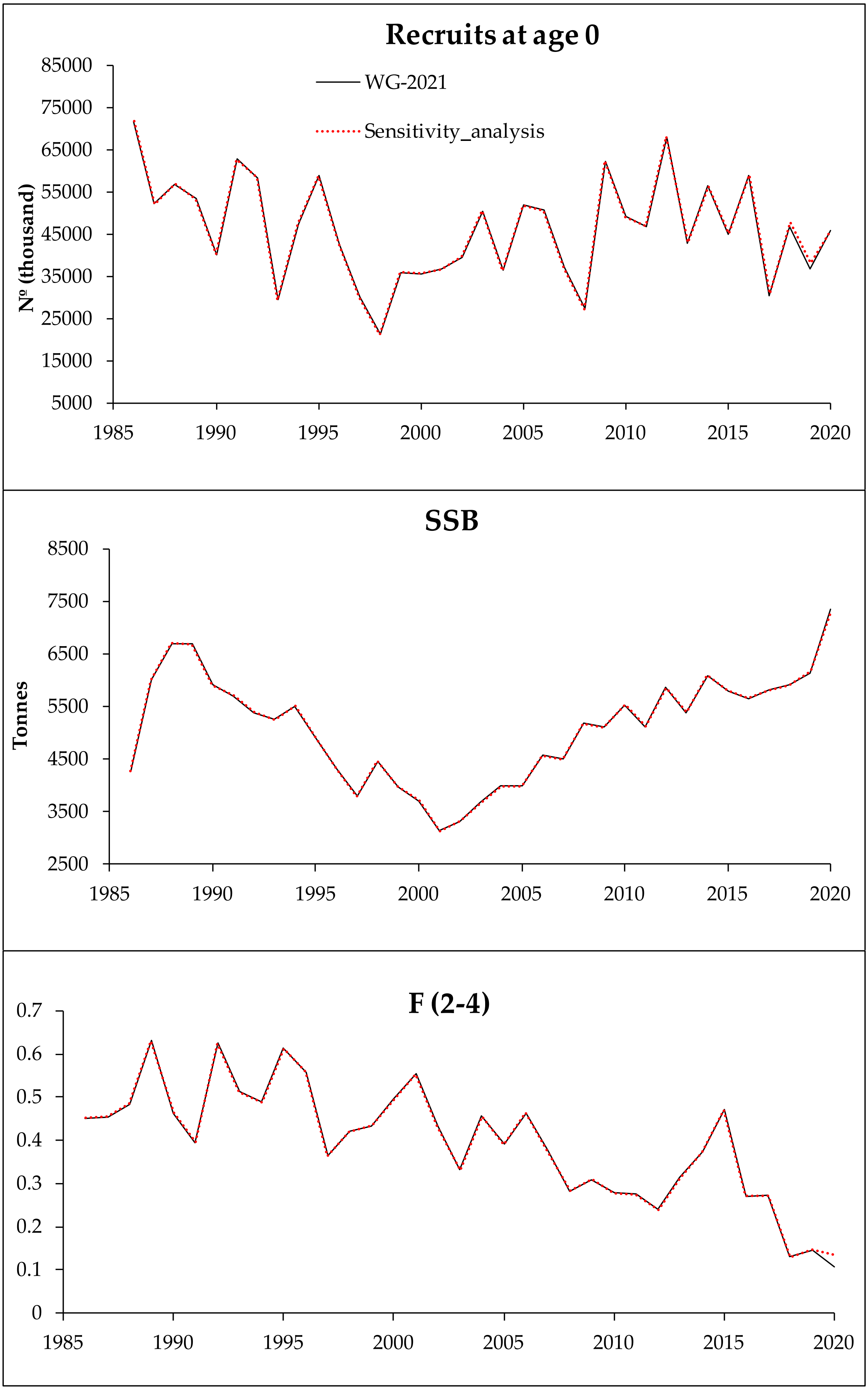
Since the benchmark in 2014, the model converges. It seems that the convergence issue was solved for this stock.

6.4.6.1 Sensitivity analysis

Some missing data in 2020 had to be estimated due to the data issues in 2020 resulting from the impact of COVID-19 in the data collection from the commercial fishery and research surveys. In the case of discards, the first semester data are missing and were estimated based on the discard per unit of effort of the second semester applied to the exerted effort in the first semester. This estimation showed values that appear to be low. In order to check the impact of a possible underestimation of discards in the assessment and advice, a sensitivity analysis has been carried out. For that, a re-estimation of discards using the average of the last three years proportions of discards at age had done and the estimated values are shown in the next table:

	Landings (tonnes)	Discards (tonnes)	Catch (tonnes)
Duplicate	711	81	792
Average	711	154	865

The assessment and forecast were carried out again with the new discards by age and the impact on the results was negligible. A comparison between both assessments and forecasts are shown in the figure and table below, respectively.


Recruits at age 0
WG-2021
Sensitivity_analysis
Nº (thousand)
85000
75000
65000
55000
45000
35000
25000
15000
5000
1985
1990
1995
2000
2005
2010
2015
2020
SSB
Tonnes
8500
7500
6500
5500
4500
3500
2500
1985
1990
1995
2000
2005
2010
2015
2020
F (2-4)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1985
1990
1995
2000
2005
2010
2015
2020

WGBIE2021

2021

		Catch	Landings		Discards	
Biomass	**SSB**	**FMult**	**FBar**	**Yield**	**FBar**	**Yield**
9105	8490	1	0.0862	1145	0.0416	129

2022							2023	
		Catch	**Landings**		**Discards**			
Biomass	**SSB**	**FMult**	**FBar**	**Yield**	**FBar**	**Yield**	**Biomass**	**SSB**
9587	8954	0	0.0000	0	0.0000	0	11485	10842
.	8954	0.1	0.0086	129	0.0042	13	11320	10678
.	8954	0.2	0.0172	256	0.0083	27	11159	10517
.	8954	0.3	0.0259	381	0.0125	40	11000	10359
.	8954	0.4	0.0345	503	0.0167	53	10845	10205
.	8954	0.5	0.0431	622	0.0208	66	10693	10053
.	8954	0.6	0.0517	739	0.0250	78	10543	9904
.	8954	0.7	0.0603	854	0.0291	91	10397	9758
.	8954	0.8	0.0689	967	0.0333	104	10253	9615
.	8954	0.9	0.0776	1077	0.0375	116	10112	9475
.	8954	1	0.0862	1185	0.0416	128	9974	9337
.	8954	1.1	0.0948	1291	0.0458	140	9838	9202
.	8954	1.2	0.1034	1395	0.0500	152	9705	9070
.	8954	1.3	0.1120	1497	0.0541	164	9574	8940
.	8954	1.4	0.1206	1597	0.0583	176	9446	8813
.	8954	1.5	0.1293	1695	0.0625	187	9321	8688
.	8954	1.6	0.1379	1791	0.0666	199	9197	8565
.	8954	1.7	0.1465	1885	0.0708	210	9076	8445
.	8954	1.8	0.1551	1978	0.0749	221	8958	8327
.	8954	1.9	0.1637	2068	0.0791	232	8841	8211
.	8954	2	0.1723	2157	0.0833	243	8727	8097

Input units are thousands and kg - output in tonnes

Sensitivity_analysis

2021

		Catch	Landings		Discards	
Biomass	**SSB**	**FMult**	**FBar**	**Yield**	**FBar**	**Yield**
9068	8453	1	0.089	1174	0.0471	147

2022							2023	
		Catch	**Landings**		**Discards**			
Biomass	**SSB**	**FMult**	**FBar**	**Yield**	**FBar**	**Yield**	**Biomass**	**SSB**
9501	8870	0	0.0000	0	0.0000	0	11399	10758
.	8870	0.1	0.0089	132	0.0047	15	11228	10588
.	8870	0.2	0.0178	262	0.0094	30	11061	10422
.	8870	0.3	0.0267	389	0.0141	45	10897	10259
.	8870	0.4	0.0356	513	0.0188	60	10737	10099
.	8870	0.5	0.0445	635	0.0236	74	10579	9942
.	8870	0.6	0.0534	754	0.0283	89	10425	9789
.	8870	0.7	0.0623	871	0.0330	103	10274	9638
.	8870	0.8	0.0712	986	0.0377	117	10126	9491
.	8870	0.9	0.0801	1098	0.0424	131	9980	9346
.	8870	1	0.0890	1208	0.0471	145	9838	9204
.	8870	1.1	0.0979	1315	0.0518	158	9698	9066
.	8870	1.2	0.1068	1421	0.0565	172	9561	8929
.	8870	1.3	0.1157	1524	0.0612	185	9427	8796
.	8870	1.4	0.1246	1625	0.0659	198	9296	8665
.	8870	1.5	0.1336	1724	0.0707	211	9167	8537
.	8870	1.6	0.1425	1821	0.0754	224	9040	8411
.	8870	1.7	0.1514	1917	0.0801	237	8916	8288
.	8870	1.8	0.1603	2010	0.0848	249	8795	8167
.	8870	1.9	0.1692	2101	0.0895	262	8676	8049
.	8870	2	0.1781	2191	0.0942	274	8559	7933

Input units are thousands and kg - output in tonnes

6.4.7 Management considerations

This assessment indicates that SSB decreased substantially between 1988 and 2001, the year with the lowest SSB, followed by a smooth increasing trend from 2001 to the present. Fishing at *status quo* F during 2021 would result in some biomass increase for 2021 and 2022.

There is no evidence of reduced recruitment at low stock levels.

As with *L. whiffiagonis*, it should be noted that four-spot megrim (*L. boscii*) is caught in mixed fisheries, and management measures applied to this species may have implications for other stocks. Both species of megrim are subject to a common TAC, so the joint status of these species should be taken into account when formulating management advice.

6.4.8 References

ICES. 2014. Report of the Benchmark Workshop on Southern megrim and hake (WKSOUTH), 3–7 February 2014, ICES HQ, Copenhagen, Denmark. ICES CM 2014/ACOM:40. 236 pp.

Smith, M.T. 2000. Multi Fleet Deterministic Projection (MFDP): a user guide. NAFO Scientific Council Studies, 36: 115–134.

6.4.9 Tables and figures

Table 6.4.1. Four-spot megrim (*L. boscii*) in divisions 8.c and 9.a. Total landings (t).

	Spain landings			Portugal landings	Unallocated/ Non reported	Total landings	Discards	Total catch
Year	8c	9a*	Total	9a				
1986	799	197	996	128		1124	284	1408
1987	995	586	1581	107		1688	333	2021
1988	917	1099	2016	207		2223	363	2586
1989	805	1548	2353	276		2629	408	3037
1990	927	798	1725	220		1945	409	2354
1991	841	634	1475	207		1682	447	2129
1992	654	938	1592	324		1916	437	2353
1993	744	419	1163	221		1384	438	1822
1994	665	561	1227	176		1403	517	1920
1995	685	826	1512	141		1652	406	2058
1996	480	448	928	170		1098	368	1466
1997	505	289	794	101		896	308	1204
1998	725	284	1010	113		1123	378	1501
1999	713	298	1011	114		1125	317	1442
2000	674	225	899	142		1041	373	1414
2001	629	177	807	124		931	290	1221
2002	343	247	590	130		720	308	1028
2003	393	314	707	169		876	191	1067
2004	534	295	829	177		1006	348	1354
2005	473	321	794	189		983	375	1358
2006	542	348	891	201		1092	335	1427
2007	591	295	886	218		1104	292	1396
**2008	546	262	808	172		980	202	1182
2009	577	342	919	215		1134	279	1413
2010	616	484	1100	197		1297	265	1562
^2011	390	384	774	181	172	1128	269	1397
^2012	240	239	479	98	374	952	369	1321
^2013	338	283	621	80	230	931	496	1427
2014	427	313	739	142	273	1154	788	1942
2015	460	255	715	137	296	1148	597	1745
2016	403	276	679	105	303	1087	332	1419
2017	346	265	611	144	172	926	246	1173
2018	381	231	612	130	72	814	92	906
2019	385	240	625	118		742	201	943
2020	346	224	569	141		711	81	792

^Data revised in WG2015

*9a is without Gulf of Cádiz till 2016

** Data revised in WG2010

* Official data by country and unallocated landings

Table. 6.4.2a. Four-spot megrim (*L. boscii*) in divisions 8.c and 9.a. Discard/Total Catch ratio and estimated CV for Spain from onboard sampling.

Year	1994	1997	1999	2000	2003	2004	2005	2006	2007
Weight Ratio	0.30	0.28	0.24	0.29	0.21	0.30	0.32	0.27	0.25
CV	23.2	11.2	14.4	16.5	10.2	23.1	24.0	48.4	18.3
Number Ratio	0.50	0.63	0.59	0.61	0.47	0.55	0.55	0.42	0.47

Year	2008	2009	2010	2011*	2012	2013	2014	2015	2016
Weight Ratio	0.20	0.23	0.19	0.24	0.39	0.35	0.41	0.34	0.23
CV	22.6	21.1	18.8	16.0	15.5	23.2	17.8	20.1	16.4
Number Ratio	0.42	0.39	0.62	0.50	0.52	0.63	0.67	0.60	0.47

Year	2017	2018	2019	2020
Weight Ratio	0.21	0.10	0.21	0.10
CV	15.2			
Number Ratio	0.39	0.24	0.41	0.21

**All discard data revised in WG2011

*Data revised in WG2013

Table. 6.4.2b. Four-spot megrim (*L. boscii*) in divisions 8.c and 9.a. Discards in numbers-at-age (thousands) for Spanish trawlers.

	1986	1987	1988	1989	1990	1991	1992	1993	1994
0	1289	1289	1289	1289	1289	1289	1289	1289	678
1	3322	3322	3322	3322	3322	3322	3322	3322	2741
2	4322	4322	4322	4322	4322	4322	4322	4322	4134
3	2211	2211	2211	2211	2211	2211	2211	2211	2710
4	605	605	605	605	605	605	605	605	581
5	94	94	94	94	94	94	94	94	189
6	20	20	20	20	20	20	20	20	55
7	4	4	4	4	4	4	4	4	11

	1995	1996	1997	1998	1999	2000	2001	2002	2003
0	1289	1289	256	1289	2933	354	208	208	238
1	3322	3322	3273	3322	3954	6148	5673	5673	4479
2	4322	4322	6099	4322	2734	1207	1750	1750	989
3	2211	2211	2108	2211	1815	1888	1025	1025	495
4	605	605	146	605	1088	1218	477	477	50
5	94	94	90	94	3	171	67	67	2
6	20	20	3	20	0	12	4	4	0
7	4	4	0	4	1	2	1	1	

	2004	2005	2006	2007	2008	2009	2010	2011*	2012
0	33	10	1	100	202	2	2879	30	682
1	6393	3515	1233	3248	2342	1525	10362	5132	5313
2	3053	5482	2497	4541	2374	2490	1301	3595	2480
3	693	609	1445	757	1384	1970	696	544	1057
4	163	183	486	105	52	480	283	174	15
5	27	56	168	44	10	51	83	37	5
6		23	22	7	3	7	11	1	2
7		6	9	1	3		1		0

	2013	2014	2015	2016	2017	2018	2019	2020
0	275	0	157	2	0	0	0	0
1	5499	5645	2437	1606	526	209	717	180
2	4379	11089	7061	5506	2116	1066	1183	628
3	3030	2139	4588	785	2305	638	2192	622
4	707	582	532	232	363	297	446	252
5	39	161	26	70	29	16	86	34
6	12	11	4	30	1	3	1	2
7	2	0	0	1	0	0	0	0

Table 6.4.3a. Four-spot megrim (*L. boscii*) divisions 8.c and 9.a. Annual length distributions in landings in 2019.

Length (cm)	Total
10	
11	
12	
13	
14	44638
15	15016
16	124760
17	71456
18	154860
19	285391
20	521371
21	749969
22	1046682
23	857567
24	751900
25	499105
26	398317
27	276268
28	166745
29	121349
30	80140
31	49234
32	20051
33	28070
34	29649
35	22710
36	28474
37	3457
38	5827
39	251
40	
41	
42	
43	
44	
45	
46	
47	
48	
49	
50+	
Total	6353259

Table 6.4.3b. Four-spot megrim (*L. boscii*) divisions 8.c and 9.a. Mean lengths and mean weights in landings since 1990.

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Mean length (cm)	23.1	23.5	23.8	24.2	23.3	22.3	23	23.3	23.3	23.5	24.2	23.8	23.1	22.9	22.7	22.7
Mean weight (g)	116	118	122	128	111	96	107	112	109	113	121	114	105	101	98	97.0

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Mean length (cm)	22.9	23.5	23.6	23.6	24.1	23.7	23.7	23.9	24.2	24.1	24.2	23.7	24.0	23.8	23.5
Mean weight (g)	99.4	109.1	109.7	110.7	118.4	112.2	112.0	114.0	117.8	117.4	118.6	111.8	115.6	112.5	110.6

Table 6.4.4. Four-spot megrim (*L. boscii*) in divisions 8.c and 9.a. Catch numbers-at-age.

YEAR	1986	1987	1988	1989	1990
AGE					
0	1289	1289	1289	1289	1289
1	3432	5605	4847	4055	4766
2	7797	15902	14414	11462	9506
3	5901	7284	7666	7603	4096
4	4545	4198	5384	6514	4434
5	1226	1438	2460	3573	2405
6	869	589	1181	1798	1403
+gp	233	145	467	634	807
TOTALNUM	25292	36450	37708	36928	28706
TONSLAND	1408	2021	2586	3037	2354
SOPCOF %	100	100	100	100	100

YEAR	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
AGE										
0	1289	1289	1289	678	1289	1289	256	1289	2933	354
1	4482	4168	3868	2824	4743	3719	3308	3367	3992	6193
2	8001	6989	6656	7049	6527	6458	7343	5526	3895	1862
3	5539	6211	4307	7225	8349	3478	4978	6447	4596	3533
4	2516	5784	4404	2849	6201	4419	890	3545	4996	4000
5	2744	2294	1245	1801	1150	1990	1714	792	1405	2020
6	1048	758	655	894	602	224	1069	849	235	797
+gp	483	71	282	457	284	555	443	353	489	840
TOTALNUM	26102	27564	22706	23777	29145	22132	20001	22168	22541	19599
TONSLAND	2129	2353	1822	1920	2058	1466	1204	1501	1442	1414
SOPCOF %	99	103	99	100	100	100	102	100	101	100

YEAR	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
AGE										
0	208	208	238	33	10	1	100	202	2	2879
1	5840	5863	4846	6785	3638	1267	3257	2357	1546	10377
2	2888	4139	3791	5568	8004	5232	6147	3935	3136	2364
3	2276	3386	3368	3777	3604	5951	3390	4879	4887	3568
4	2870	1220	1526	2602	2024	2639	2705	2204	4640	3817
5	1937	454	501	1155	1426	1156	1909	1003	1662	2529
6	941	240	447	279	802	274	855	354	640	496
+gp	358	360	142	337	399	228	461	298	222	438
TOTALNUM	17318	15870	14859	20536	19907	16748	18824	15232	16735	26468
TONSLAND	1221	1028	1067	1354	1358	1427	1396	1182	1413	1562
SOPCOF %	100	100	101	101	100	101	101	101	100	101

YEAR	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
AGE										
0	30	682	275	0	157	2	0	0	0	0
1	5139	5342	5499	5646	2438	1610	527	209	720	235
2	4397	3260	4919	11954	7412	6739	2458	1296	1251	937
3	2454	4101	4820	4249	7742	2844	4986	2050	3783	1598
4	2833	1926	4113	3214	3622	2495	2469	2754	2783	3040
5	2711	1620	1363	2983	1580	1936	1817	1388	2072	1359
6	1164	991	846	751	1105	1153	684	954	365	618
+gp	399	422	371	562	462	559	618	555	188	285
TOTALNUM	19127	18344	22206	29359	24518	17338	13559	9206	11162	8072
TONSLAND	1397	1321	1427	1942	1745	1419	1173	906	943	792
SOPCOF %	101	101	101	100	100	100	101	101	101	101

* Data revised in WG2010 from original value presented

** Data revised in WG2014 from original value presented

Table 6.4.5. Four-spot megrim (*L. boscii*) in divisions 8.c and 9.a. Mean weights-at-age in catches (kg).

YEAR	1986	1987	1988	1989	1990
AGE					
0	0.004	0.004	0.004	0.004	0.003
1	0.013	0.027	0.027	0.027	0.019
2	0.034	0.046	0.049	0.055	0.051
3	0.055	0.062	0.069	0.079	0.081
4	0.090	0.089	0.100	0.108	0.134
5	0.129	0.125	0.138	0.144	0.154
6	0.159	0.151	0.167	0.167	0.183
+gp	0.263	0.239	0.280	0.275	0.272
SOPCOFAC	1.0014	1.0022	1.0034	0.9996	1.0009

YEAR	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
AGE										
0	0.004	0.004	0.003	0.005	0.004	0.003	0.004	0.004	0.0060	0.006
1	0.022	0.021	0.014	0.023	0.030	0.023	0.016	0.019	0.018	0.023
2	0.055	0.052	0.052	0.056	0.046	0.043	0.030	0.040	0.045	0.057
3	0.097	0.093	0.092	0.082	0.082	0.054	0.063	0.073	0.072	0.066
4	0.114	0.120	0.136	0.114	0.096	0.106	0.091	0.105	0.090	0.087
5	0.164	0.159	0.174	0.148	0.143	0.135	0.123	0.137	0.147	0.126
6	0.19	0.225	0.218	0.178	0.168	0.209	0.180	0.179	0.197	0.169
+gp	0.263	0.351	0.295	0.243	0.255	0.231	0.252	0.293	0.268	0.228
SOPCOFAC	0.993	1.0284	0.9892	1.0015	0.9963	0.9993	1.0171	1.0027	1.0090	1.001

YEAR	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
AGE										
0	0.004	0.006	0.008	0.006	0.006	0.006	0.005	0.005	0.004	0.004
1	0.024	0.024	0.025	0.027	0.021	0.023	0.022	0.017	0.025	0.012
2	0.05	0.057	0.066	0.053	0.05	0.06	0.045	0.053	0.045	0.056
3	0.073	0.09	0.088	0.081	0.083	0.091	0.079	0.079	0.069	0.084
4	0.099	0.109	0.123	0.108	0.108	0.104	0.114	0.112	0.104	0.108
5	0.122	0.163	0.142	0.131	0.122	0.136	0.123	0.151	0.142	0.141
6	0.166	0.209	0.201	0.175	0.132	0.176	0.152	0.201	0.175	0.182
+gp	0.255	0.247	0.247	0.235	0.197	0.233	0.198	0.235	0.288	0.271
SOPCOFAC	1.0012	0.9993	1.0129	1.0069	1.0038	1.0066	1.0109	1.0063	1.0011	1.0104

YEAR	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
AGE										
0	0.003	0.009	0.004	0.002	0.008	0.004	0.001	0.001	0.002	0.001
1	0.02	0.033	0.017	0.024	0.026	0.022	0.029	0.013	0.018	0.022
2	0.039	0.052	0.045	0.044	0.04	0.048	0.044	0.041	0.037	0.041
3	0.078	0.076	0.063	0.071	0.066	0.086	0.067	0.068	0.061	0.063
4	0.099	0.105	0.099	0.101	0.099	0.107	0.096	0.093	0.095	0.096
5	0.128	0.127	0.131	0.133	0.136	0.13	0.126	0.126	0.126	0.125
6	0.168	0.159	0.159	0.165	0.172	0.149	0.164	0.156	0.186	0.169
+gp	0.24	0.199	0.21	0.222	0.23	0.217	0.212	0.224	0.274	0.251
SOPCOFAC	1.009	1.006	1.0065	1.0046	1.0018	1.0027	1.0054	1.0073	1.0087	1.0128

* Data revised in WG2010 from original value presented

** Data revised in WG2014 from original value presented

Table 6.4.6. Four-spot megrim (*L. boscii*) divisions 8.c and 9.a. Abundance and Recruitment indices of Portuguese and Spanish surveys.

	Biomass Index						Abundance index					Recruitment index		
	Portugal (k/h)			Spain (k/30 min)			Portugal (n/h)		Spain (n/30 min)			At age 1	At age 0	At age 1
												Portugal (n)	Spain (n/30 min)	
	October	Crustacean	SE	Mean	SE		Crustacean	SE	Mean	SE		October		
1983				0.67	0.13	1983			11.80	1.80	1983		0.98	5.74
1984				0.76	0.08	1984			15.80	2.00	1984		1.80	7.83
1985				0.71	0.11	1985			14.00	1.74	1985		0.15	7.45
1986				1.68	0.28	1986			32.60	3.82	1986		2.99	16.36
1987				ns	-	1987			ns	-	1987		ns	ns
1988				3.10	0.33	1988			59.20	6.49	1988		2.90	24.64
1989				1.97	0.28	1989			40.75	6.24	1989		8.49	16.68
1990	0.26			1.93	0.14	1990			40.30	3.00	1990	153	0.44	19.06
1991	0.18			1.67	0.17	1991			27.70	2.62	1991	26	2.53	9.25
1992	0.14			1.98	0.20	1992			49.10	5.20	1992	42	2.37	35.00
1993	0.11			2.07	0.25	1993			43.30	5.39	1993	8	0.30	21.38
1994	0.16			1.82	0.23	1994			26.90	3.63	1994	2	3.48	2.94
1995	0.08			1.51	0.12	1995			32.30	2.78	1995	4	1.92	19.58
A,1996	0.10			2.00	0.19	A,1996			44.80	4.05	A,1996	16	3.57	20.56
1997	0.06	2.97	1.31	2.17	0.22	1997	31.57	15.52	43.50	3.84	1997	1	3.54	13.34
1998	0.04	2.66	0.87	1.80	0.20	1998	26.46	10.68	34.30	4.45	1998	+	0.27	9.57
A,B,1999	+	0.04	0.02	1.93	0.24	A,B,1999	1.23	1.07	29.30	3.22	A,B,1999	+	0.94	7.46
2000	0.08	2.18	0.84	1.89	0.28	2000	20.61	8.47	33.00	4.56	2000	16	1.07	13.96
2001	0.09	1.72	0.75	2.65	0.25	2001	17.17	7.08	42.70	3.35	2001	25	0.59	16.95
2002	0.02	2.78	1.02	2.21	0.22	2002	40.61	13.69	34.60	3.33	2002	1	1.04	9.95
A,2003	1.36	3.65	1.20	1.32	0.16	A,2003	60.80	20.97	16.90	1.54	A,2003	8	0.65	4.95
A,2004	1.27	ns		2.40	0.24	A,2004	ns		43.94	3.71	A,2004	5	1.19	21.10
2005	0.05	2.62	0.85	3.84	0.41	2005	34.51	12.03	62.89	6.16	2005	+	4.71	17.70
2006	0.10	1.63	0.56	2.56	0.24	2006	19.89	6.49	41.47	3.02	2006		0.59	14.70
2007	0.14	2.20	0.70	3.75	0.35	2007	32.30	11.30	51.10	4.30	2007		0.88	11.30
2008	0.07	2.50	0.87	2.08	0.22	2008	26.27	9.60	32.20	3.00	2008		0.37	8.13
2009	0.06	*1.50	0.65	3.96	0.32	2009	*12.22	5.88	52.83	3.97	2009		3.37	7.42
2010	0.03	4.03	1.44	4.04	0.38	2010	63.78	22.64	72.75	6.82	2010		0.65	34.22
2011	0.14	4.55	1.78	4.64	0.39	2011	68.56	26.34	69.26	5.72	2011		0.91	8.90
2012	ns	ns	ns	5.92	0.47	2012	ns	ns	82.14	5.98	2012		1.71	11.58
**2013	0.10	1.45	0.51	8.17	1.13	2013	23.81	8.02	119.99	17.48	2013		1.32	25.86
2014	0.12	1.40	0.56	4.75	0.28	2014	20.31	8.18	67.42	3.72	2014		3.72	12.32
2015	0.13	1.66	0.52	4.62	0.48	2015	27.29	8.25	78.00	7.47	2015		1.12	33.18
2016	0.12	1.80	0.65	4.84	0.32	2016	35.62	12.16	86.70	5.19	2016		2.43	18.06
2017	0.22	1.91	0.74	6.21	0.96	2017	37.79	14.77	111.24	13.61	2017		1.03	23.69
2018	0.11	3.59	1.70	5.35	0.45	2018	57.65	27.61	88.04	7.05	2018		0.46	6.36
2019	ns	ns	ns	5.77	0.48	2019	ns	ns	102.03	8.21	2019		0.94	20.46
2020	ns	ns	ns	5.56	0.49	2020	ns	ns	97.85	7.88	2020		1.42	15.66

+ less than 0.04
ns no survey
A Portuguese October Survey with different vessel and gear (Capricórnio and CAR net)
B Portuguese Crustacean Survey covers partial area only with a different Vessel (Mestre Costeiro)
* Revised in WGHMM2011
** From 2013 new vessel for Spanish survey (Miguel Oliver)

Table 6.4.7. Four-spot megrim (*L. boscii*) in divisions 8.c and 9.a. Tuning data.

FLT01: SP-LCGOTBDEF1. 1000 Days by 100 HP (thousand)

1986	1999									
1	1	0	1							
1	7								Eff.	
10		98	376	337	251	95	30	13	7.1	1986
10		473	963	565	318	97	31	16	12.7	1987
10		35	202	200	163	76	30	19	11.3	1988
10		11	86	126	136	83	39	22	11.9	1989
10		5	104	60	174	105	73	38	8.8	1990
10		10	89	145	93	189	80	41	9.6	1991
10		0.4	20	100	168	105	39	2	10.2	1992
10		0.1	37	98	227	85	46	17	7.1	1993
10		0	62	208	169	156	87	46	8.5	1994
10		1	33	278	301	124	83	24	13.4	1995
10		1	33	34	222	133	20	51	11.0	1996
10		0.4	23	111	40	143	125	59	12.5	1997
10		0.3	82	420	350	98	127	62	8.2	1998
10		0.3	62	210	331	165	33	45	8.8	1999

FLT02: SP-LCGOTBDEF2. 1000 Days by 100 HP (thousand)

2000	2020									
1	1	0	1							
1	7								Eff.	
10		0.4	70	144	349	303	164	153	10.5	2000
10		14	148	219	475	436	242	83	12.1	2001
10		7	126	214	91	66	45	70	11.0	2002
10		19	287	363	214	75	67	22	10.2	2003
10		29	341	496	440	219	60	81	7.0	2004
10		10	248	383	253	196	114	68	7.1	2005
10		7	364	625	305	151	41	40	7.8	2006
10		2	261	403	415	298	143	82	7.3	2007
10		3	313	727	481	227	88	81	9.0	2008
10		8	145	524	640	226	87	34	8.0	2009
10		0.1	146	520	743	616	132	105	5.8	2010
10		0	48	224	424	594	323	133	5.1	2011
10		1	107	719	562	505	302	123	7.6	2012
10		0	87	336	806	313	170	65	10.8	2013
10		0.1	119	332	427	431	99	55	13.4	2014
10		0.1	67	619	625	322	218	80	9.8	2015
10		0.1	244	402	449	383	230	117	10.6	2016
10		0.1	77	641	494	417	154	132	8.7	2017
10		0.2	87	530	821	392	238	118	8.1	2018
10		0.3	21	514	725	613	104	51	7.8	2019

FLT03: SP-NSGFS-Q4 (n/30 min)

1988	2019									
1	1	0.75	0.83							
0	7								Eff.	
1	2.9	24.6	20.6	7.3	1.9	1.1	0.4	0.3	101	1988
1	8.5	16.7	8.4	3.6	2.1	1.1	0.3	0.1	91	1989
1	0.4	19.1	13.0	2.2	2.8	1.6	0.7	0.4	120	1990
1	2.5	9.3	9.3	3.7	1.6	1.0	0.2	0.1	107	1991
1	2.4	35.0	4.1	4.1	2.1	1.0	0.4	0.0	116	1992
1	0.3	21.4	16.7	2.3	1.5	0.5	0.4	0.2	109	1993
1	3.5	2.9	11.2	6.3	1.5	0.7	0.4	0.4	118	1994
1	1.9	19.6	2.4	4.4	3.2	0.3	0.2	0.2	116	1995
1	3.6	20.6	14.4	1.4	1.9	2.4	0.3	0.3	114	1996
1	3.5	13.3	14.0	8.7	1.1	1.5	1.0	0.3	116	1997
1	0.3	9.6	10.0	9.2	3.6	0.7	0.8	0.3	114	1998
1	0.9	7.5	10.9	6.0	2.9	1.0	0.2	0.3	116	1999
1	1.1	14.0	5.4	5.2	4.1	1.7	0.6	0.9	113	2000
1	0.6	17.0	12.7	4.7	3.8	2.2	1.0	0.7	113	2001
1	1.0	10.0	12.7	7.4	1.8	0.7	0.3	0.6	110	2002
0	0.7	5.0	4.1	4.1	1.7	0.6	0.5	0.3	112	2003
1	1.2	21.1	11.3	6.1	2.7	0.8	0.2	0.5	114	2004
1	4.7	17.7	22.4	11.2	4.0	1.6	0.6	0.7	116	2005
1	0.6	14.7	13.3	8.2	2.5	1.0	0.5	0.6	115	2006
1	0.9	11.3	21.3	10.2	4.9	1.4	0.7	0.3	117	2007
1	0.4	8.1	11.7	7.9	2.6	0.8	0.5	0.3	115	2008
1	3.4	7.4	13.6	14.1	9.6	3.1	1.1	0.5	117	2009
1	0.6	34.2	16.6	10.8	7.2	2.2	0.5	0.6	114	2010
1	0.9	8.9	33.8	13.8	7.7	2.8	0.9	0.5	111	2011
1	1.7	11.6	22.1	31.1	9.6	3.4	1.7	1.0	115	2012
0	1.3	25.9	29.6	35.7	21.1	3.9	1.5	1.0	114	2013
1	3.7	12.3	21.8	12.1	7.6	8.0	1.1	0.7	116	2014
1	1.1	33.2	14.3	15.9	7.6	3.3	1.9	0.7	114	2015
1	2.4	18.1	45.4	10.6	4.3	2.8	2.0	1.1	114	2016
1	1.0	23.7	31.2	40.1	8.38	4.31	1.17	1.29	112	2017
1	0.5	6.4	32.1	22.4	19.3	3.7	2.6	1.0	113	2018
1	0.9	20.5	18.5	41.5	12.8	6.33	0.9	0.62	113	2019
1	1.4	15.7	28.8	24.6	20.3	4.7	1.8	0.6	109	2020

Table 6.4.8. Four-spot megrim (*L. boscii*). LPUE data by fleet in divisions 8.c and 9.a.

	SP-LCGOTBDEF			SP-AVSOTBDEF***			Portugal trawl in 9a		
Year	Landings (t)	Effort	LPUE [1]	Landings (t)	Effort	LPUE [1]	Landings (t)	Effort	LPUE [2]
1986	69.0	7.1	9.8	26.5	3.9	6.8			
1987	189.8	12.7	14.9	30.7	3.0	10.4			
1988	78.6	11.3	7.0	47.3	3.4	14.0	146	38.5	3.8
1989	72.9	11.9	6.2	36.1	3.3	10.9	183	44.7	4.1
1990	68.8	8.8	7.8	63.8	3.2	19.7	164	39.0	4.2
1991	94.0	9.6	9.8	42.1	3.5	12.2	166	45.0	3.7
1992	67.2	10.2	6.6	35.2	2.3	15.5	280	50.9	5.5
1993	55.2	7.1	7.8	38.9	2.4	16.1	180	44.2	4.1
1994	90.8	8.5	10.6	63.7	4.5	14.0	146	45.8	3.2
1995	147.6	13.4	11.0	85.9	3.5	24.7	121	37.0	3.3
1996	78.7	11.0	7.2	37.1	2.3	16.4	155	46.5	3.3
1997	99.0	12.5	7.9	49.5	2.6	18.7	76	33.4	2.3
1998	117.4	8.2	14.4	56.2	5.1	11.0	83	43.1	1.9
1999	103.9	8.8	11.7	55.9	4.9	11.3	73	25.3	2.9
2000	172.3	10.5	16.4	34.1	2.5	13.8	93	27.0	3.4
2001	245.0	12.1	20.2	16.5	1.3	12.5	89	43.1	2.1
2002	143.8	11.0	13.0	22.5	2.0	11.3	97	31.2	3.1
2003	118.7	10.2	11.6	12.4	2.2	5.7	117	40.5	2.9
2004	127.3	7.0	18.2	23.5	1.6	14.8	111	35.4	3.1
2005	96.0	7.1	13.6	45.0	3.0	15.2	140	42.6	3.3
2006	123.5	7.8	15.9	32.3	2.8	11.6	149	40.3	3.7
2007*	130.5	7.3	17.9	19.9	2.2	8.9	165	43.8	3.8
2008*	196.8	9.0	22.0	14.5	2.0	7.2	146	38.4	3.8
2009	138.8	8.0	17.3	42.0	2.3	18.5	183	49.3	3.7
2010	170.7	5.8	29.3	51.1	2.0	25.4	150	48.0	3.1
2011	126.9	5.1	24.8	43.1	2.2	19.6	134	49.4	2.7
2012	127.8	7.6	16.7	11.1	2.6	4.3	78	30.9	2.5
2013**	212.8	10.8	19.8	19.5	1.5	13.2	59	28.0	2.1
2014	220.8	13.4	16.5	31.9	3.0	10.7	120	49.2	2.4
2015	219.1	9.8	22.5	13.8	1.8	7.5	109	17.7	6.1
2016	233.8	10.6	22.0				84.9	16.4	5.2
2017	183.0	8.7	20.9				117.6	15.4	7.6
2018	187.5	8.1	23.0				108.5	7.9	13.8
2019	175.3	7.8	22.4				102.3	7.1	14.4
2020							125.8	7.9	15.8

[1] LPUE as catch (kg) per fishing day per 100 HP
[2] LPUE as catch (kg) per hour
* Effort from Portuguese trawl revised in WG2010 from original value presented
** Effort from SP-LCGOTBDEF and SP-AVSOTBDEF revised in WG2015 from original value presented
*** Sampling suspended in 2015

Table 6.4.9. Four-spot megrim (*L.boscii*) in divisions 8.c and 9.a. Tuning diagnostics.

Lowestoft VPA Version 3.1

3/05/2021 12:37

Extended Survivors Analysis

Four spot megrim (L. boscii) Divisions 27.7.8c and 27.7.9a

CPUE data from file fleetb.txt

Catch data for 35 years. 1986 to 2020. Ages 0 to 7.

Fleet	First year	Last year	First age	Last age	Alpha	Beta
SP-LCGOTBDEF1	1986	2020	3	6	0	1
SP-LCGOTBDEF2	2000	2020	3	6	0	1
SP-GFS	1988	2020	0	6	0.75	0.83

Time series weights :

Tapered time weighting not applied

Catchability analysis :

Catchability independent of stock size for all ages

Catchability independent of age for ages >= 5

Terminal population estimation :

Survivor estimates shrunk towards the mean F
of the final 5 years or the 3 oldest ages.

S.E. of the mean to which the estimates are shrunk = 1.500

Minimum standard error for population
estimates derived from each fleet = .300

Prior weighting not applied

Tuning converged after 29 iterations

1

Regression weights

1	1	1	1	1	1	1	1	1	1

Fishing mortalities

Age	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
0	0.001	0.011	0.007	0	0.004	0	0	0	0	0
1	0.164	0.167	0.117	0.197	0.06	0.05	0.012	0.009	0.021	0.009
2	0.163	0.148	0.229	0.399	0.43	0.235	0.1	0.037	0.071	0.034
3	0.266	0.225	0.341	0.317	0.49	0.29	0.273	0.113	0.146	0.122
4	0.395	0.346	0.369	0.402	0.492	0.287	0.442	0.238	0.221	0.168
5	0.505	0.413	0.442	0.503	0.352	0.536	0.35	0.48	0.284	0.159
6	0.484	0.347	0.395	0.469	0.35	0.472	0.365	0.313	0.221	0.127

XSA population numbers (Thousands)

YEAR	AGE 0	1	2	3	4	5	6
2011	4.68E+04	3.76E+04	3.24E+04	1.16E+04	9.59E+03	7.56E+03	3.35E+03
2012	6.81E+04	3.83E+04	2.61E+04	2.25E+04	7.28E+03	5.29E+03	3.74E+03
2013	4.29E+04	5.51E+04	2.65E+04	1.84E+04	1.47E+04	4.21E+03	2.86E+03
2014	5.64E+04	3.49E+04	4.02E+04	1.73E+04	1.07E+04	8.34E+03	2.22E+03
2015	4.51E+04	4.62E+04	2.34E+04	2.21E+04	1.03E+04	5.88E+03	4.13E+03
2016	5.88E+04	3.68E+04	3.56E+04	1.25E+04	1.11E+04	5.16E+03	3.39E+03
2017	3.05E+04	4.81E+04	2.86E+04	2.31E+04	7.64E+03	6.80E+03	2.47E+03
2018	4.68E+04	2.49E+04	3.89E+04	2.12E+04	1.44E+04	4.02E+03	3.93E+03
2019	3.68E+04	3.84E+04	2.02E+04	3.07E+04	1.55E+04	9.27E+03	2.04E+03
2020	4.59E+04	3.01E+04	3.08E+04	1.54E+04	2.17E+04	1.02E+04	5.71E+03

Estimated population abundance at 1st Jan 2021

0.00E+00	3.76E+04	2.45E+04	2.43E+04	1.12E+04	1.50E+04	7.11E+03

Taper weighted geometric mean of the VPA populations:

4.46E+04	3.63E+04	2.65E+04	1.64E+04	9.11E+03	4.19E+03	1.79E+03

Standard error of the weighted Log(VPA populations) :

0.2788	0.2989	0.3432	0.362	0.4327	0.4748	0.5578

1

Log catchability residuals.

Fleet : SP-LCGOTBDEF1

Age	1986	1987	1988	1989	1990
0	No data for this fleet at this age				
1	No data for this fleet at this age				
2	No data for this fleet at this age				
3	0.55	0.86	-0.1	-0.41	-0.76
4	0.29	0.27	-0.61	-0.55	-0.21
5	0.04	-0.26	-0.85	-0.86	-0.2
6	-0.3	-0.18	-0.4	-0.24	0.16

Age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
0	No data for this fleet at this age									
1	No data for this fleet at this age									
2	No data for this fleet at this age									
3	-0.19	-0.46	-0.04	-0.09	0.37	-0.56	-0.3	0.71	0.41	99.99
4	-0.58	-0.08	0.31	0.48	0.13	0.05	-0.46	0.65	0.29	99.99
5	0.42	-0.02	-0.24	0.53	0.8	-0.31	-0.04	0.78	0.21	99.99
6	0.82	0.06	0.35	0.72	1.03	-0.05	0.37	0.58	0.65	99.99

Age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
0	No data for this fleet at this age									
1	No data for this fleet at this age									
2	No data for this fleet at this age									
3	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
4	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
5	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
6	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99

Age		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
	0	No data for this fleet at this age									
	1	No data for this fleet at this age									
	2	No data for this fleet at this age									
	3	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
	4	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
	5	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
	6	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99

Mean log catchability and standard error of ages with catchability
independent of year class strength and constant w.r.t. time

Age	3	4	5	6
Mean Log q	-6.6988	-5.8259	-5.3772	-5.3772
S.E(Log q)	0.5018	0.4191	0.5171	0.5297

Regression statistics :

Ages with q independent of year class strength and constant w.r.t. time.

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
3	0.57	2.049	8.02	0.66	14	0.26	-6.7
4	0.96	0.153	5.97	0.52	14	0.42	-5.83
5	-22.54	-4.696	72.76	0	14	7.2	-5.38
6	1.21	-0.626	4.67	0.43	14	0.57	-5.12
1							

Fleet : SP-LCGOTBDEF2

Age		1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
	0	No data for this fleet at this age									
	1	No data for this fleet at this age									
	2	No data for this fleet at this age									
	3	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	-0.58
	4	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	-0.06
	5	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	-0.22
	6	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	0.2

Age		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
	0	No data for this fleet at this age									
	1	No data for this fleet at this age									
	2	No data for this fleet at this age									
	3	0.36	-0.25	0.22	0.46	0.12	0.53	0.2	0.19	-0.12	0.21
	4	0.77	-0.48	-0.37	0.4	-0.31	-0.19	0.16	0.24	-0.07	0.04
	5	0.97	-0.63	-0.23	-0.05	0.2	-0.52	0.34	-0.07	-0.1	0.28
	6	0.26	-0.28	0.08	0.28	0.1	-0.51	0.19	-0.03	-0.39	0.1

Age		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
	0	No data for this fleet at this age									
	1	No data for this fleet at this age									
	2	No data for this fleet at this age									
	3	-0.35	0.14	-0.38	-0.33	0.12	0.18	0.02	-0.16	-0.54	99.99
	4	-0.18	0.37	0.02	-0.28	0.18	-0.31	0.23	0.01	-0.2	99.99
	5	0.14	0.29	0.05	-0.28	-0.3	0.1	-0.18	0.35	-0.13	99.99
	6	0.33	0.1	-0.2	-0.45	-0.34	-0.02	-0.15	-0.21	-0.42	99.99

Mean log catchability and standard error of ages with catchability
independent of year class strength and constant w.r.t. time

Age	3	4	5	6
Mean Log q	-5.6739	-4.9636	-4.6518	-4.6518
S.E(Log q)	0.3226	0.3079	0.3569	0.2775

Regression statistics :

Ages with q independent of year class strength and constant w.r.t. time.

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
3	1.27	-1.085	4.62	0.48	20	0.41	-5.67
4	1.05	-0.259	4.77	0.62	20	0.33	-4.96
5	0.94	0.353	4.86	0.69	20	0.34	-4.65
6	1	0.032	4.73	0.8	20	0.27	-4.72
1							

Fleet : SP-GFS

Age	1986	1987	1988	1989	1990
0	99.99	99.99	0.52	1.66	-1.01
1	99.99	99.99	0.37	-0.13	0.09
2	99.99	99.99	0.04	-0.45	-0.28
3	99.99	99.99	-0.49	-1.02	-1.16
4	99.99	99.99	-1.19	-0.74	-0.43
5	99.99	99.99	-0.57	-0.68	0.15
6	99.99	99.99	-0.04	-0.11	0.18

Age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
0	0.28	0.29	-1.07	0.88	0.07	1.02	1.35	-0.83	-0.09	-0.02
1	-0.31	0.5	0.08	-1.15	0.23	0.03	-0.05	-0.02	0.26	0.37
2	-0.54	-0.97	-0.26	-0.56	-1.06	-0.02	-0.34	-0.31	0.16	-0.02
3	-0.97	-0.71	-0.87	-0.69	-0.83	-0.7	0.06	-0.22	-0.26	0.04
4	-0.79	-0.45	-0.72	-0.31	-0.49	-0.81	-0.2	-0.04	-0.56	0.32
5	-0.18	-0.1	-0.9	-0.3	-0.52	0.07	-0.19	0.36	-0.56	-0.27
6	-0.35	0.02	0.05	0.04	-0.33	0.05	-0.06	-0.03	-0.16	-0.24

Age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
0	-0.65	-0.16	99.99	0.06	1.08	-0.98	-0.26	-0.82	0.56	-0.8
1	0.45	-0.12	99.99	0.28	0.38	-0.25	-0.44	-0.45	-0.25	0.59
2	0.29	0.23	99.99	-0.03	0.47	0.16	0.1	-0.48	0	0.5
3	0.47	0.32	99.99	0	0.5	0.18	0.44	-0.44	0.14	0.21
4	0.81	0.35	99.99	0.05	0.23	-0.27	0.46	-0.3	0.43	0.07
5	1.07	-0.14	99.99	-0.51	0.63	-0.44	0.26	-0.69	0.78	-0.24
6	-0.08	-0.04	99.99	-0.17	0.11	0.24	0.14	-0.08	0.31	-0.36

Age	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
0	-0.46	-0.2	99.99	0.76	-0.22	0.29	0.09	-1.15	-0.19	0
1	-0.53	-0.28	99.99	-0.1	0.5	0.11	0.09	-0.57	0.17	0.14
2	0.54	0.32	99.99	0.08	0.22	0.8	0.54	0.21	0.34	0.33
3	0.74	0.85	99.99	0.25	0.41	0.42	1.13	0.5	0.77	0.92
4	0.49	0.95	99.99	0.38	0.49	-0.31	0.84	0.89	0.39	0.47
5	-0.1	0.38	99.99	0.86	0.19	0.32	0.32	0.81	0.35	-0.15
6	-0.46	0.02	99.99	0.21	0.02	0.33	0.04	0.34	-0.14	-0.55

Mean log catchability and standard error of ages with catchability
independent of year class strength and constant w.r.t. time

Age	0	1	2	3	4	5	6
Mean Log q	-10.2262	-7.536	-7.1218	-7.1055	-7.152	-7.2523	-7.2523
S.E(Log q)	0.7361	0.3844	0.4397	0.6401	0.5726	0.5076	0.2264

Regression statistics :

Ages with q independent of year class strength and constant w.r.t. time.

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
0	0.53	1.962	10.44	0.37	31	0.37	-10.23
1	0.7	1.777	8.42	0.54	31	0.26	-7.54
2	0.98	0.092	7.19	0.38	31	0.44	-7.12
3	1.04	-0.107	7.01	0.23	31	0.67	-7.11
4	1.17	-0.609	6.82	0.31	31	0.68	-7.15
5	0.93	0.337	7.33	0.48	31	0.48	-7.25
6	1	0.023	7.29	0.87	31	0.23	-7.29
1							

Terminal year survivor and F summaries :

Age 0 Catchability constant w.r.t. time and dependent on age

Year class = 2020

Fleet	ES	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
SP-LCGOTBDEF1	1	0	0	0	0	0	0
SP-LCGOTBDEF2	1	0	0	0	0	0	0
SP-GFS	37604	0.748	0	0	1	1	0
F shrinkage mean	0	1.5				0	0

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
37604	0.75	0	1	0	0

Age 1 Catchability constant w.r.t. time and dependent on age

Year class = 2019

Fleet	ES	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
SP-LCGOTBDEF1	1	0	0	0	0	0	0
SP-LCGOTBDEF2	1	0	0	0	0	0	0
SP-GFS	26178	0.346	0.135	0.39	2	0.949	0.008
F shrinkage mean	6866	1.5				0.051	0.03

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
24451	0.34	0.23	3	0.691	0.009

Age 2 Catchability constant w.r.t. time and dependent on age
Year class = 2018

Fleet	E S	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
SP-LCGOTBDEF1	1	0	0	0	0	0	0
SP-LCGOTBDEF2	1	0	0	0	0	0	0
SP-GFS	25822	0.274	0.338	1.23	3	0.966	0.032
F shrinkage mean	4425	1.5				0.034	0.175

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
24331	0.27	0.33	4	1.224	0.034

Age 3 Catchability constant w.r.t. time and dependent on age
Year class = 2017

Fleet	E S	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
SP-LCGOTBDEF1	1	0	0	0	0	0	0
SP-LCGOTBDEF2	1	0	0	0	0	0	0
SP-GFS	11519	0.252	0.32	1.27	4	0.967	0.118
F shrinkage mean	4786	1.5				0.033	0.264

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
11191	0.25	0.28	5	1.139	0.122

Age 4 Catchability constant w.r.t. time and dependent on age
Year class = 2016

Fleet	E S	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
SP-LCGOTBDEF1	1	0	0	0	0	0	0
SP-LCGOTBDEF2	8712	0.331	0	0	1	0.323	0.274
SP-GFS	20173	0.232	0.113	0.49	5	0.655	0.128
F shrinkage mean	6844	1.5				0.021	0.338

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
15024	0.19	0.18	7	0.968	0.168

Age 5 Catchability constant w.r.t. time and dependent on age
Year class = 2015

Fleet	E S	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
SP-LCGOTBDEF1	1	0	0	0	0	0	0
SP-LCGOTBDEF2	5938	0.229	0.016	0.07	2	0.466	0.188
SP-GFS	8660	0.215	0.125	0.58	6	0.517	0.133
F shrinkage mean	2477	1.5				0.017	0.403

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
7114	0.16	0.11	9	0.698	0.159

Age 6 Catchability constant w.r.t. time and age (fixed at the value for age) 5
Year class = 2014

Fleet	E S	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
SP-LCGOTBDEF1	1	0	0	0	0	0	0
SP-LCGOTBDEF2	3975	0.197	0.05	0.25	3	0.418	0.132
SP-GFS	4247	0.189	0.256	1.35	7	0.568	0.124
F shrinkage mean	3448	1.5				0.013	0.15

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
4120	0.14	0.15	11	1.1	0.127

Table 6.4.10. Four-spot megrim (*L. boscii*) in divisions 8.c and 9.a. Estimates of fishing mortality-at-age.

Run title : Four spot megrim (L. boscii) Divisions 27.7.8c and 27.7.9a

At 3/05/2021 12:38

Terminal Fs derived using XSA (With F shrinkage)

Table 8 Fishing mortality (F) at age

YEAR	1986	1987	1988	1989	1990
AGE					
0	0.0201	0.0277	0.0254	0.027	0.0361
1	0.0641	0.1139	0.1381	0.1039	0.1322
2	0.2441	0.4696	0.4762	0.5582	0.3761
3	0.38	0.3789	0.4352	0.4991	0.3949
4	0.7292	0.5136	0.5377	0.8346	0.6182
5	0.6338	0.5359	0.6549	0.8609	0.8867
6	1.0242	0.7321	1.2418	1.7469	1.0636
+gp	1.0242	0.7321	1.2418	1.7469	1.0636
FBAR 2- 4	0.4511	0.454	0.483	0.6306	0.4631

Table 8 Fishing mortality (F) at age

YEAR	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
AGE										
0	0.023	0.0247	0.0497	0.0159	0.0245	0.034	0.0095	0.0694	0.0945	0.011
1	0.1695	0.0962	0.0962	0.1465	0.1472	0.0914	0.1147	0.1657	0.3171	0.2951
2	0.3421	0.4336	0.2194	0.2544	0.5896	0.3063	0.2625	0.2849	0.2939	0.239
3	0.393	0.4891	0.5252	0.3935	0.5433	0.7399	0.4115	0.3885	0.4078	0.4756
4	0.4515	0.9519	0.7903	0.8167	0.7042	0.6283	0.4193	0.5849	0.5968	0.7663
5	1.0405	1.0091	0.5416	0.9197	0.9746	0.5119	0.5349	0.8351	0.4858	0.516
6	1.4251	0.9614	0.9363	0.9955	0.9569	0.4985	0.5774	0.5585	0.6404	0.568
+gp	1.4251	0.9614	0.9363	0.9955	0.9569	0.4985	0.5774	0.5585	0.6404	0.568
FBAR 2- 4	0.3955	0.6249	0.5116	0.4882	0.6124	0.5582	0.3645	0.4195	0.4328	0.4936

Table 8 Fishing mortality (F) at age

YEAR	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
AGE										
0	0.0063	0.0058	0.0052	0.001	0.0002	0	0.003	0.0082	0	0.067
1	0.2525	0.2447	0.1821	0.2015	0.1451	0.0336	0.0908	0.0902	0.0801	0.2546
2	0.2175	0.2859	0.2471	0.3289	0.388	0.3207	0.226	0.1511	0.1666	0.1693
3	0.5159	0.4277	0.3989	0.4173	0.368	0.563	0.3556	0.2821	0.2842	0.2902
4	0.927	0.5834	0.3478	0.621	0.4139	0.5073	0.5441	0.4142	0.4758	0.3763
5	1.1434	0.3496	0.5063	0.4854	0.8584	0.4426	0.8766	0.3967	0.6398	0.5202
6	0.4849	0.3908	0.6996	0.5949	0.7548	0.3842	0.699	0.3823	0.4772	0.3955
+gp	0.4849	0.3908	0.6996	0.5949	0.7548	0.3842	0.699	0.3823	0.4772	0.3955
FBAR 2- 4	0.5535	0.4323	0.3313	0.4557	0.39	0.4637	0.3752	0.2825	0.3089	0.2786

Table 8 Fishing mortality (F) at age

YEAR	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	FBAR 18-20
AGE											
0	0.0007	0.0111	0.0071	0	0.0039	0	0	0	0	0	0
1	0.1638	0.1673	0.1168	0.1972	0.0601	0.0496	0.0122	0.0093	0.021	0.0087	0.013
2	0.1626	0.1484	0.2292	0.3988	0.4302	0.2347	0.0997	0.0375	0.0708	0.0343	0.0475
3	0.2664	0.2246	0.3409	0.3171	0.4904	0.2902	0.2731	0.1129	0.1464	0.1215	0.1269
4	0.3952	0.3461	0.3689	0.4018	0.4918	0.2865	0.4417	0.2381	0.2208	0.1681	0.209
5	0.5048	0.4133	0.4423	0.5028	0.3523	0.5356	0.3497	0.4802	0.2838	0.1595	0.3078
6	0.4838	0.347	0.3952	0.4691	0.3504	0.4722	0.3649	0.3126	0.2206	0.1273	0.2202
+gp	0.4838	0.347	0.3952	0.4691	0.3504	0.4722	0.3649	0.3126	0.2206	0.1273	
FBAR 2- 4	0.2747	0.2397	0.313	0.3725	0.4708	0.2705	0.2715	0.1295	0.146	0.108	

Table 6.4.11. Four-spot megrim (*L. boscii*) in divisions 8.c and 9.a. Estimates of stock numbers-at-age.

Run title : Four spot megrim (L. boscii) Divisions 27.7.8c and 27.7.9a

At 3/05/2021 12:38

Terminal Fs derived using XSA (With F shrinkage)

Table 10 Stock number at age (start of year) Numbers*10**-3

YEAR	1986	1987	1988	1989	1990
AGE					
0	71718	52147	56895	53386	40227
1	61076	57552	41528	45415	42542
2	39791	46899	42048	29614	33514
3	20629	25523	24009	21383	13875
4	9702	11550	14306	12720	10628
5	2886	3831	5658	6841	4521
6	1498	1254	1835	2407	2368
+gp	394	304	710	824	1337
TOTAL	207696	199061	186989	172591	149010

Table 10 Stock number at age (start of year) Numbers*10**-3

YEAR	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
AGE										
0	62747	58378	29393	47513	58876	42636	30047	21255	35958	35716
1	31769	50206	46630	22899	38287	47038	33741	24368	16236	26786
2	30518	21954	37334	34677	16193	27055	35146	24632	16905	9681
3	18837	17747	11651	24544	22013	7352	16307	22131	15167	10316
4	7654	10411	8910	5642	13557	10468	2872	8847	12286	8259
5	4689	3990	3290	3310	2041	5489	4572	1546	4036	5538
6	1525	1356	1191	1567	1080	631	2693	2193	549	2033
+gp	686	125	504	787	501	1547	1104	902	1129	2119
TOTAL	158424	164167	138902	140938	152548	142215	126482	105874	102264	100447

Table 10 Stock number at age (start of year) Numbers*10**-3

YEAR	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
AGE										
0	36690	39523	50457	36385	51826	50661	36991	27341	62312	49092
1	28921	29851	32171	41095	29760	42423	41477	30195	22202	51015
2	16327	18395	19135	21954	27507	21074	33586	31011	22589	16779
3	6241	10754	11315	12236	12937	15278	12519	21936	21829	15657
4	5249	3051	5741	6217	6600	7331	7124	7183	13545	13450
5	3142	1701	1394	3319	2735	3572	3614	3385	3886	6891
6	2706	820	982	688	1673	949	1879	1231	1864	1678
+gp	1020	1220	308	821	821	783	1000	1028	640	1470
TOTAL	100297	105314	121501	122716	133858	142071	138190	123311	148868	156031

Table 10 Stock number at age (start of year) Numbers*10**-3

YEAR	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	GMST 90-18
AGE												
0	46845	68109	42880	56411	45070	58781	30467	46848	36792	45928	0	44225
1	37588	38326	55146	34859	46185	36758	48124	24944	38356	30123	37604	
2	32378	26124	26545	40174	23431	35607	28638	38924	20233	30752	24451	
3	11598	22530	18439	17282	22075	12477	23055	21223	30695	15434	24331	
4	9590	7275	14735	10735	10305	11069	7642	14364	15521	21708	11191	
5	7558	5288	4214	8343	5881	5160	6805	4023	9269	10189	15024	
6	3354	3735	2864	2217	4131	3385	2473	3927	2038	5714	7114	
+gp	1139	1579	1246	1643	1714	1626	2217	2269	1044	2625	6012	
TOTAL	150050	172968	166070	171664	158794	164863	149420	156522	153948	162472	125726	

Table 6.4.12. Four-spot megrim (*L. boscii*) in divisions 8.c and 9.a. Summary of landings and XSA results.

Run title : Four spot megrim (L. boscii) Divisions 27.7.8c and 27.7.9a

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Table 16 Summary (without SOP correction)

Terminal Fs derived using XSA (With F shrinkage)

	RECRUITS Age 0	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 2- 4
1986	71718	5156	4280	1408	0.329	0.4511
1987	52147	7271	6004	2021	0.3366	0.454
1988	56895	7783	6698	2586	0.3861	0.483
1989	53386	7745	6688	3037	0.4541	0.6306
1990	40227	6679	5908	2354	0.3985	0.4631
1991	62747	6567	5703	2129	0.3733	0.3955
1992	58378	6313	5383	2353	0.4371	0.6249
1993	29393	5947	5249	1822	0.3471	0.5116
1994	47513	6322	5509	1920	0.3485	0.4882
1995	58876	5837	4913	2058	0.4189	0.6124
1996	42636	5110	4309	1466	0.3402	0.5582
1997	30047	4328	3784	1204	0.3182	0.3645
1998	21255	4946	4457	1501	0.3368	0.4195
1999	35958	4470	3973	1442	0.363	0.4328
2000	35716	4306	3710	1414	0.3812	0.4936
2001	36690	3725	3133	1221	0.3897	0.5535
2002	39523	4052	3314	1028	0.3102	0.4323
2003	50457	4644	3665	1067	0.2912	0.3313
2004	36385	4902	3985	1354	0.3398	0.4557
2005	51826	4814	3990	1358	0.3404	0.39
2006	50661	5532	4563	1427	0.3127	0.4637
2007	36991	5338	4493	1396	0.3107	0.3752
2008	27341	5831	5174	1182	0.2285	0.2825
2009	62312	5798	5098	1413	0.2772	0.3089
2010	49092	6191	5534	1562	0.2823	0.2786
2011	46845	5813	5121	1397	0.2728	0.2747
2012	68109	7292	5861	1321	0.2254	0.2397
2013	42880	6193	5383	1427	0.2651	0.313
2014	56411	6869	6084	1942	0.3192	0.3725
2015	45070	6881	5794	1745	0.3011	0.4708
2016	58781	6538	5656	1419	0.2509	0.2705
2017	30467	6697	5809	1173	0.2019	0.2715
2018	46848	6374	5901	906	0.1535	0.1295
2019	36792	6692	6132	943	0.1538	0.146
2020	45928	7924	7353	792	0.1077	0.108
Arith. Mean	46180	5911	5103	1565	0.3115	0.3957
Units	(Thousands)	(Tonnes)	(Tonnes)	(Tonnes)		

Table 6.4.13. Four-spot megrim (*L. boscii*) in divisions 8.c and 9.a.

Prediction with management option table: Input data

MFDP version 1a
Run: ldb
Time and date: 13:34 03/05/2021
Fbar age range (Total) : 2-4
Fbar age range Fleet 1 : 2-4

2021 Age	Stock size	Natural mortality	Maturity ogive	Prop. of F bef. Spaw.	Prop. of M bef. Spaw.	Weight in Stock	Exploit pattern	Weight LWt	Exploit pattern	Weight DWt
0	43194	0.2	0	0	0	0.002	0.0000	0.001	0.0000	0.002
1	35364	0.2	0.55	0	0	0.021	0.0003	0.030	0.0131	0.020
2	24451	0.2	0.86	0	0	0.042	0.0098	0.066	0.0497	0.038
3	24331	0.2	0.97	0	0	0.069	0.0784	0.079	0.0514	0.053
4	11191	0.2	0.99	0	0	0.097	0.1703	0.102	0.0238	0.065
5	15024	0.2	1	0	0	0.127	0.2590	0.128	0.0068	0.083
6	7114	0.2	1	0	0	0.165	0.2074	0.165	0.0020	0.110
7	6012	0.2	1	0	0	0.236	0.2093	0.236	0.0001	0.031

2022 Age	Stock size	Natural mortality	Maturity ogive	Prop. of F bef. Spaw.	Prop. of M bef. Spaw.	Weight in Stock	Exploit pattern	Weight LWt	Exploit pattern	Weight DWt
0	43194	0.2	0	0	0	0.002	0.0000	0.001	0.0000	0.002
1	.	0.2	0.55	0	0	0.021	0.0003	0.030	0.0131	0.020
2	.	0.2	0.86	0	0	0.042	0.0098	0.066	0.0497	0.038
3	.	0.2	0.97	0	0	0.069	0.0784	0.079	0.0514	0.053
4	.	0.2	0.99	0	0	0.097	0.1703	0.102	0.0238	0.065
5	.	0.2	1	0	0	0.127	0.2590	0.128	0.0068	0.083
6	.	0.2	1	0	0	0.165	0.2074	0.165	0.0020	0.110
7	.	0.2	1	0	0	0.236	0.2093	0.236	0.0001	0.031

2023 Age	Stock size	Natural mortality	Maturity ogive	Prop. of F bef. Spaw.	Prop. of M bef. Spaw.	Weight in Stock	Exploit pattern	Weight LWt	Exploit pattern	Weight DWt
0	43194	0.2	0	0	0	0.002	0.0000	0.001	0.0000	0.002
1	.	0.2	0.55	0	0	0.021	0.0003	0.030	0.0131	0.020
2	.	0.2	0.86	0	0	0.042	0.0098	0.066	0.0497	0.038
3	.	0.2	0.97	0	0	0.069	0.0784	0.079	0.0514	0.053
4	.	0.2	0.99	0	0	0.097	0.1703	0.102	0.0238	0.065
5	.	0.2	1	0	0	0.127	0.2590	0.128	0.0068	0.083
6	.	0.2	1	0	0	0.165	0.2074	0.165	0.0020	0.110
7	.	0.2	1	0	0	0.236	0.2093	0.236	0.0001	0.031

Input units are thousands and kg - output in tonnes

Table 6.4.14. Four-sport megrim (*L. boscii*) in divisions 8.c and 9.a catch forecast: management option table.

MFDP version 1a
Run: ldb
Time and date: 13:34 03/05/2021
Fbar age range (Total) : 2-4
Fbar age range Fleet 1 : 2-4

2021

		Catch	Landings		Discards	
Biomass	**SSB**	**FMult**	**FBar**	**Yield**	**FBar**	**Yield**
9105	8490	1	0.0862	1145	0.0416	129

2022							2023	
		Catch	Landings		Discards			
Biomass	**SSB**	**FMult**	**FBar**	**Yield**	**FBar**	**Yield**	**Biomass**	**SSB**
9587	8954	0	0.0000	0	0.0000	0	11485	10842
.	8954	0.1	0.0086	129	0.0042	13	11320	10678
.	8954	0.2	0.0172	256	0.0083	27	11159	10517
.	8954	0.3	0.0259	381	0.0125	40	11000	10359
.	8954	0.4	0.0345	503	0.0167	53	10845	10205
.	8954	0.5	0.0431	622	0.0208	66	10693	10053
.	8954	0.6	0.0517	739	0.0250	78	10543	9904
.	8954	0.7	0.0603	854	0.0291	91	10397	9758
.	8954	0.8	0.0689	967	0.0333	104	10253	9615
.	8954	0.9	0.0776	1077	0.0375	116	10112	9475
.	8954	1	0.0862	1185	0.0416	128	9974	9337
.	8954	1.1	0.0948	1291	0.0458	140	9838	9202
.	8954	1.2	0.1034	1395	0.0500	152	9705	9070
.	8954	1.3	0.1120	1497	0.0541	164	9574	8940
.	8954	1.4	0.1206	1597	0.0583	176	9446	8813
.	8954	1.5	0.1293	1695	0.0625	187	9321	8688
.	8954	1.6	0.1379	1791	0.0666	199	9197	8565
.	8954	1.7	0.1465	1885	0.0708	210	9076	8445
.	8954	1.8	0.1551	1978	0.0749	221	8958	8327
.	8954	1.9	0.1637	2068	0.0791	232	8841	8211
.	8954	2	0.1723	2157	0.0833	243	8727	8097

Input units are thousands and kg - output in tonnes

Table 6.4.15. Four-spot megrim (*L. boscii*) in divisions 8.c and 9.a. Single option prediction. Detail Tables.

MFDP version 1a
Run: ldb
Time and date: 13:34 03/05/2021
Fbar age range (Total) : 2-4
Fbar age range Fleet 1 : 2-4

Year: 2021 F multiplier: 1 Fleet1 HCFbar: 0.0862 Fleet1 DFbar: 0.0416

Age	Catch F	CatchNos	Yield	DF	DCatchNos	DYield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
0	0	0	0	0	0	0	43194	78	0	0	0	0
1	0.0003	8	0	0.0131	417	9	35364	736	19450	405	19450	405
2	0.0098	211	14	0.0497	1070	41	24451	1032	21028	887	21028	887
3	0.0784	1625	129	0.0514	1065	57	24331	1679	23601	1628	23601	1628
4	0.1703	1575	161	0.0238	220	14	11191	1090	11079	1079	11079	1079
5	0.259	3111	398	0.0068	82	7	15024	1902	15024	1902	15024	1902
6	0.2074	1211	200	0.002	12	1	7114	1172	7114	1172	7114	1172
7	0.2093	1033	243	0.0001	0	0	6012	1416	6012	1416	6012	1416
Total		8773	1145		2867	129	166681	9105	103308	8490	103308	8490

Year: 2022 F multiplier: 1 Fleet1 HCFbar: 0.0762 Fleet1 DFbar: 0.0359

Age	Catch F	CatchNos	Yield	DF	DCatchNos	DYield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
0	0	0	0	0	0	0	43194	78	0	0	0	0
1	0.0003	8	0	0.0131	417	9	35364	736	19450	405	19450	405
2	0.0098	247	16	0.0497	1251	48	28569	1206	24570	1037	24570	1037
3	0.0784	1260	100	0.0514	826	44	18862	1302	18297	1262	18297	1262
4	0.1703	2462	251	0.0238	344	22	17496	1704	17321	1687	17321	1687
5	0.259	1562	200	0.0068	41	3	7546	955	7546	955	7546	955
6	0.2074	1605	265	0.002	15	2	9430	1554	9430	1554	9430	1554
7	0.2093	1497	353	0.0001	1	0	8716	2054	8716	2054	8716	2054
Total		8641	1185		2895	128	169177	9587	105329	8954	105329	8954

Year: 2023 F multiplier: 1 Fleet1 HCFbar: 0.0762 Fleet1 DFbar: 0.0359

Age	Catch F	CatchNos	Yield	DF	DCatchNos	DYield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
0	0	0	0	0	0	0	43194	78	0	0	0	0
1	0.0003	8	0	0.0131	417	9	35364	736	19450	405	19450	405
2	0.0098	247	16	0.0497	1251	48	28570	1206	24570	1037	24570	1037
3	0.0784	1472	117	0.0514	965	52	22039	1521	21378	1475	21378	1475
4	0.1703	1909	195	0.0238	267	17	13563	1321	13428	1308	13428	1308
5	0.259	2443	313	0.0068	64	5	11797	1494	11797	1494	11797	1494
6	0.2074	806	133	0.002	8	1	4736	781	4736	781	4736	781
7	0.2093	2070	488	0.0001	1	0	12050	2839	12050	2839	12050	2839
Total		8954	1261		2972	132	171313	9974	107409	9337	107409	9337

Input units are thousands and kg - output in tonnes

Table 6.4.16. Four-spot megrim (*L. boscii*) in divisions 8.c and 9.a. Stock numbers of recruits and their source of recent year-classes used in predictions and the relative (%) contributions to catches and SSB (by weight) of these year-classes.

Year-class	2018	2019	2020	2021	2022
Stock No. (thousands) of 0 year-olds	46848	36792	43194	43194	43194
Source	XSA	XSA	GM90-18	GM90-18	GM90-18
Status Quo F:					
% in 2021 catch	14.6	4.3	0.7	0.0	-
% in 2022	20.8	11.0	4.9	0.7	0.0
% in 2021 SSB	19.2	10.4	4.8	0.0	-
% in 2022 SSB	18.8	14.1	11.6	4.5	0.0
% in 2023 SSB	16.0	14.0	15.8	11.1	4.3

GM : geometric mean recruitment

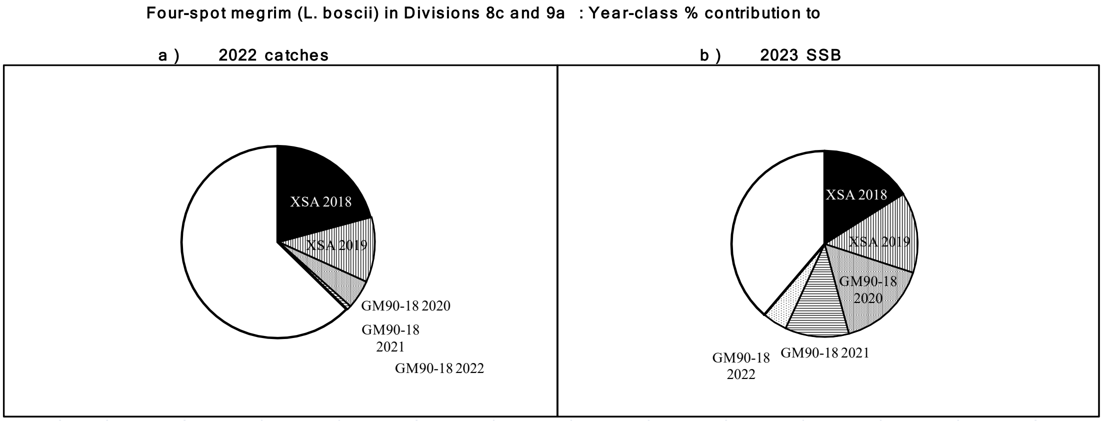


Table 6.4.17. Four-spot megrim (*L. boscii*) in divisions 8.c and 9.a. Yield-per-recruit results.

MFYPR version 2a
Run: ldb
Time and date: 13:40 03/05/2021
Yield per results

Catch FMult	Landings Fbar	CatchNos	Yield	Discards Fbar	CatchNos	Yield	StockNos	Biomass	SpwnNosJan	SSBJan	SpwnNosSpwn	SSBSpwn
0	0	0	0	0	0	0	5.5167	0.5455	4.0334	0.5305	4.0334	0.5305
0.1	0.0086	0.046	0.008	0.0042	0.0077	0.0004	5.2488	0.4874	3.7659	0.4724	3.7659	0.4724
0.2	0.0172	0.083	0.0141	0.0083	0.0152	0.0007	5.0273	0.44	3.5448	0.4251	3.5448	0.4251
0.3	0.0259	0.1131	0.0187	0.0125	0.0226	0.001	4.841	0.4008	3.3588	0.3859	3.3588	0.3859
0.4	0.0345	0.1379	0.0223	0.0167	0.0298	0.0014	4.6821	0.3678	3.2002	0.3529	3.2002	0.3529
0.5	0.0431	0.1585	0.025	0.0208	0.0368	0.0017	4.5448	0.3399	3.0632	0.325	3.0632	0.325
0.6	0.0517	0.1757	0.0272	0.025	0.0437	0.002	4.4251	0.3158	2.9438	0.301	2.9438	0.301
0.7	0.0603	0.1903	0.0288	0.0291	0.0504	0.0023	4.3196	0.295	2.8387	0.2802	2.8387	0.2802
0.8	0.0689	0.2026	0.0301	0.0333	0.057	0.0026	4.226	0.2769	2.7454	0.2621	2.7454	0.2621
0.9	0.0776	0.2131	0.03	0.0375	0.0635	0.0028	4.14	0.261	2.6619	0.2462	2.6619	0.2462
1	0.0862	0.222	0.0317	0.0416	0.0698	0.0031	4.0669	0.2469	2.5869	0.2321	2.5869	0.2321
1.1	0.0948	0.2296	0.0322	0.0458	0.076	0.0034	3.9987	0.2344	2.519	0.2196	2.519	0.2196
1.2	0.1034	0.2361	0.0325	0.05	0.082	0.0036	3.9366	0.2232	2.4572	0.2085	2.4572	0.2085
1.3	0.112	0.2417	0.0327	0.0541	0.088	0.0039	3.8798	0.2132	2.4007	0.1984	2.4007	0.1984
1.4	0.1206	0.2465	0.0328	0.0583	0.0938	0.0041	3.8276	0.2041	2.3488	0.1894	2.3488	0.1894
1.5	0.1293	0.2505	0.0328	0.0625	0.0995	0.0044	3.7795	0.1959	2.301	0.1812	2.301	0.1812
1.6	0.1379	0.254	0.0328	0.0666	0.1051	0.0046	3.735	0.1885	2.2568	0.1738	2.2568	0.1738
1.7	0.1465	0.2569	0.0327	0.0708	0.1106	0.0048	3.6936	0.1817	2.2157	0.1671	2.2157	0.1671
1.8	0.1551	0.2594	0.0325	0.0749	0.116	0.005	3.6551	0.1755	2.1775	0.1609	2.1775	0.1609
1.9	0.1637	0.2615	0.0323	0.0791	0.1213	0.0053	3.619	0.1698	2.1417	0.1552	2.1417	0.1552
2.0	0.1723	0.2632	0.0321	0.0833	0.1265	0.0055	3.5852	0.1646	2.1082	0.15	2.1082	0.15

Reference point	F multiplier	Absolute F
Fleet1 Landings Fbar(2-4)	1	0.0862
FMax	1.4689	0.1266
F0.1	0.8571	0.0739
F35%SPR	1.4447	0.1245

Weights in kilograms

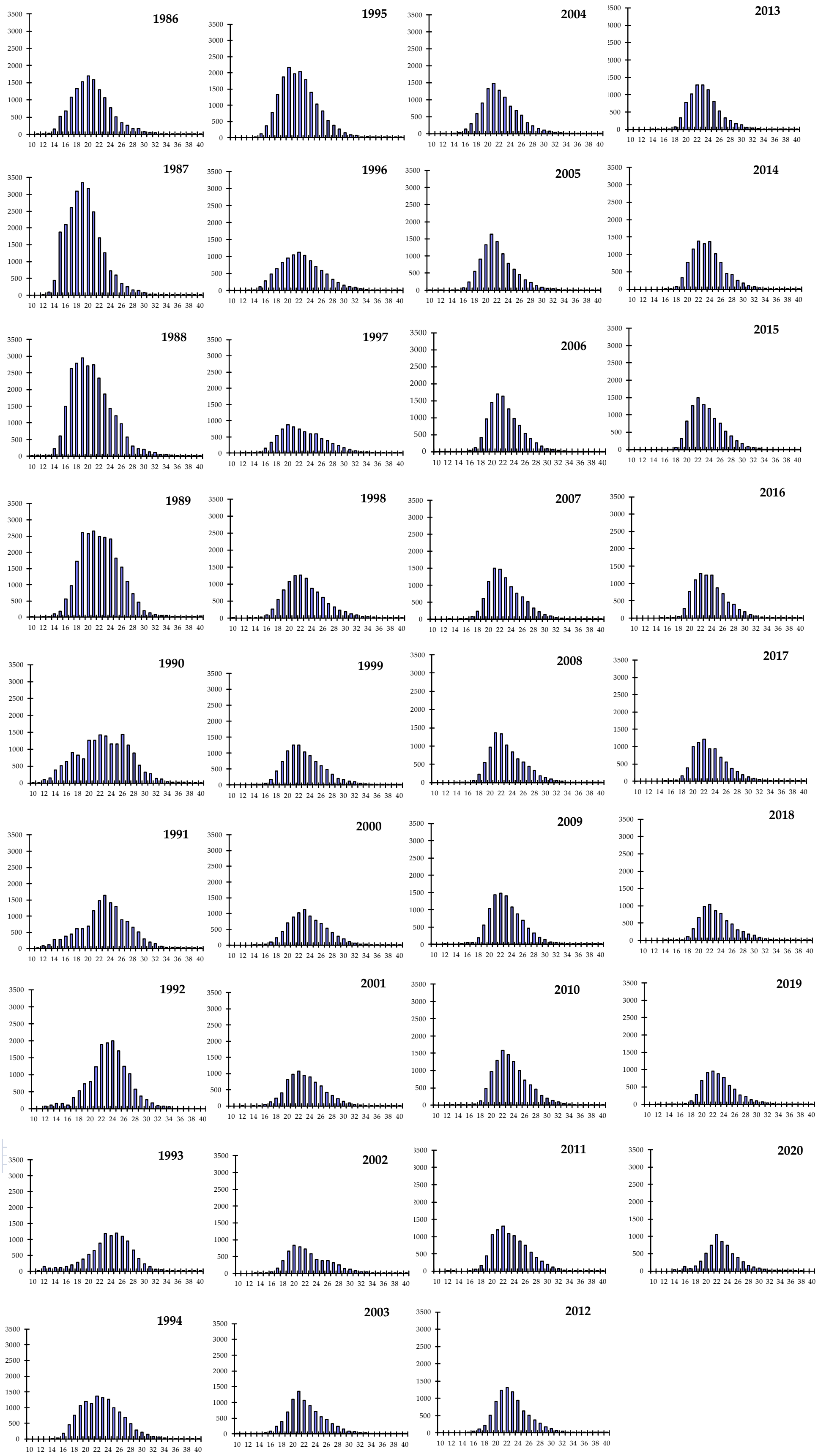


Figure 6.4.1. Four-spot megrim (*L. boscii*) in divisions 8.c and 9.a. Annual length compositions of landings ('000).

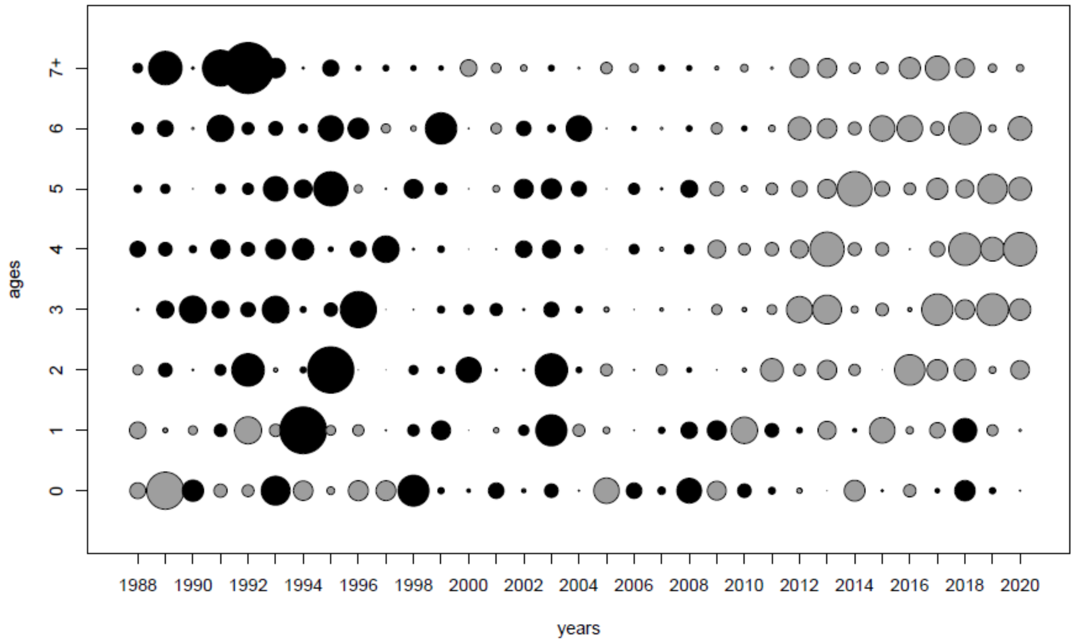
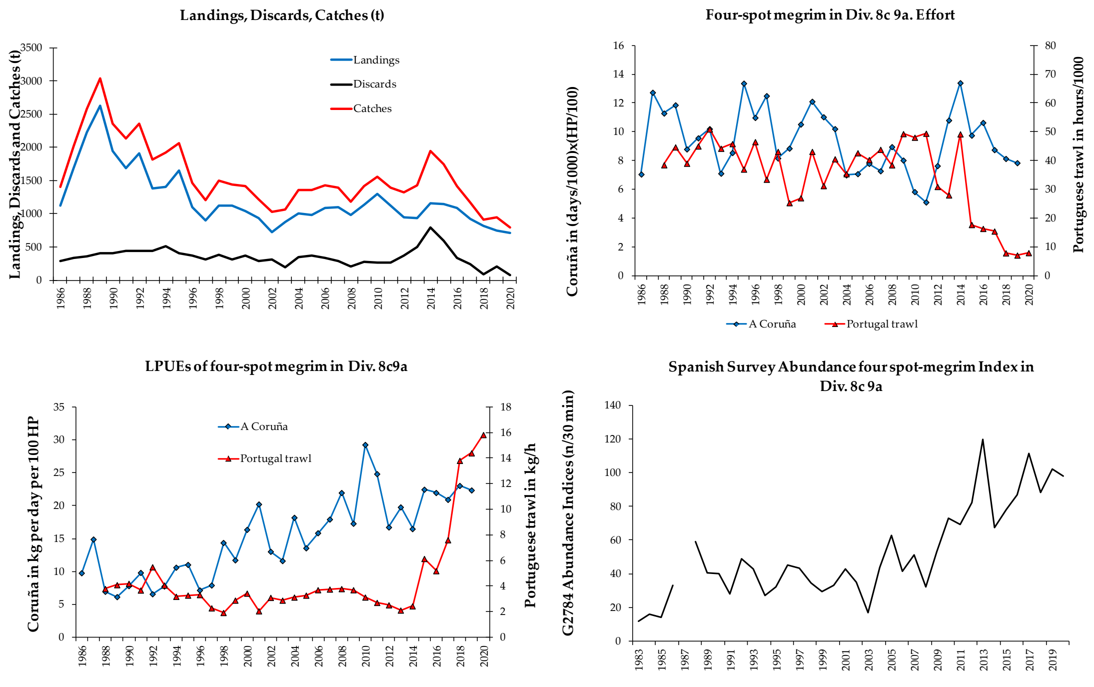


Figure 6.4.2. Four-spot megrim (*L. boscii*) in Divisions 8c&9a. Standardized log (abundance index at age) from survey SP-NSGFS-Q4 (G2784) (Bubbles colour scale: black – negative, grey – positive).

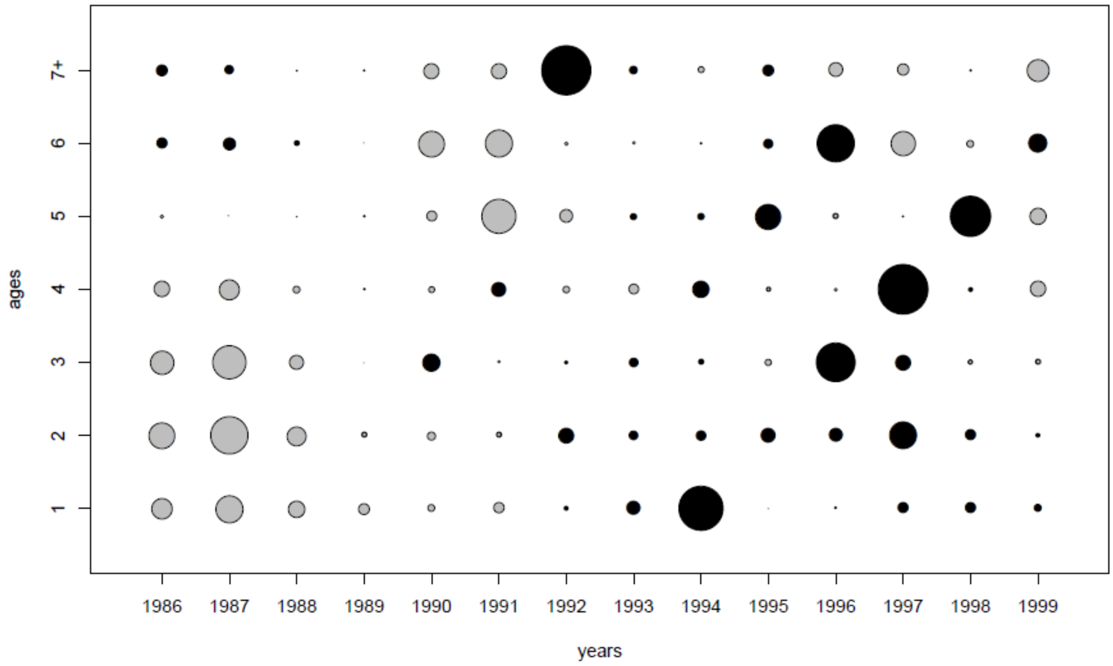


* Spanish Landings of 2008 revised in WG2010 from original value presented

* Portuguese Trawl Effort of 2007 and 2008 revised in WG2010 from original value presented

Figure 6.4.3a. Four-spot megrim (*L.boscii*) in divisions 8.c and 9.a. Landings (t), Efforts, LPUEs and Abundance Indices.

Standardized log(abundance index at age) from SP-LCGOTBDEF-1



Standardized log(abundance index at age) from SP-LCGOTBDEF-2

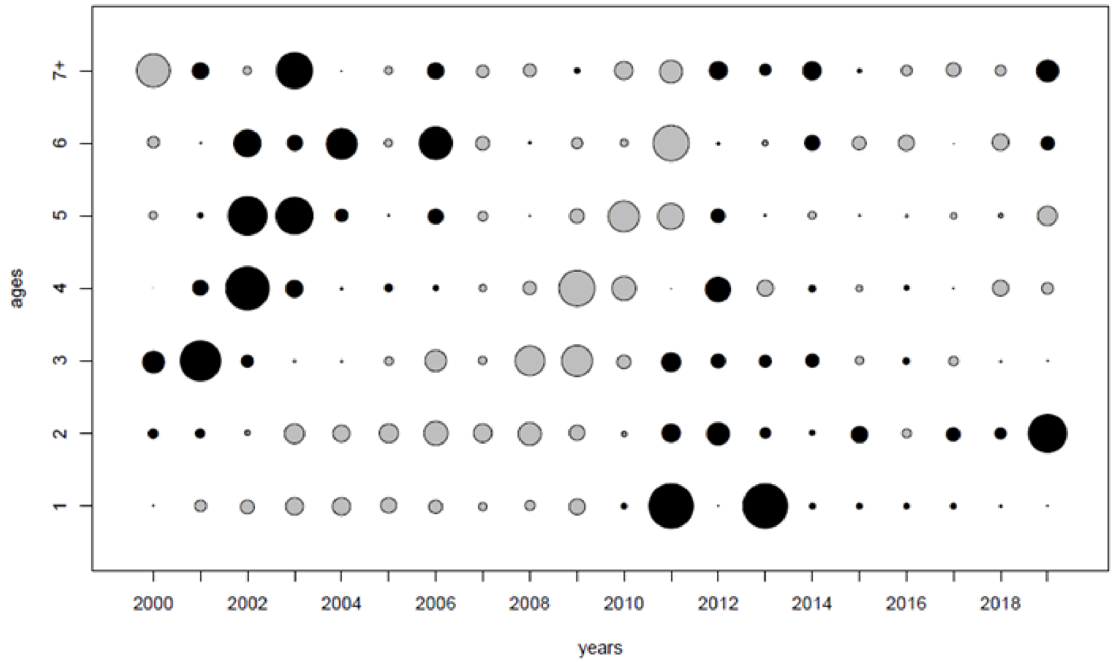
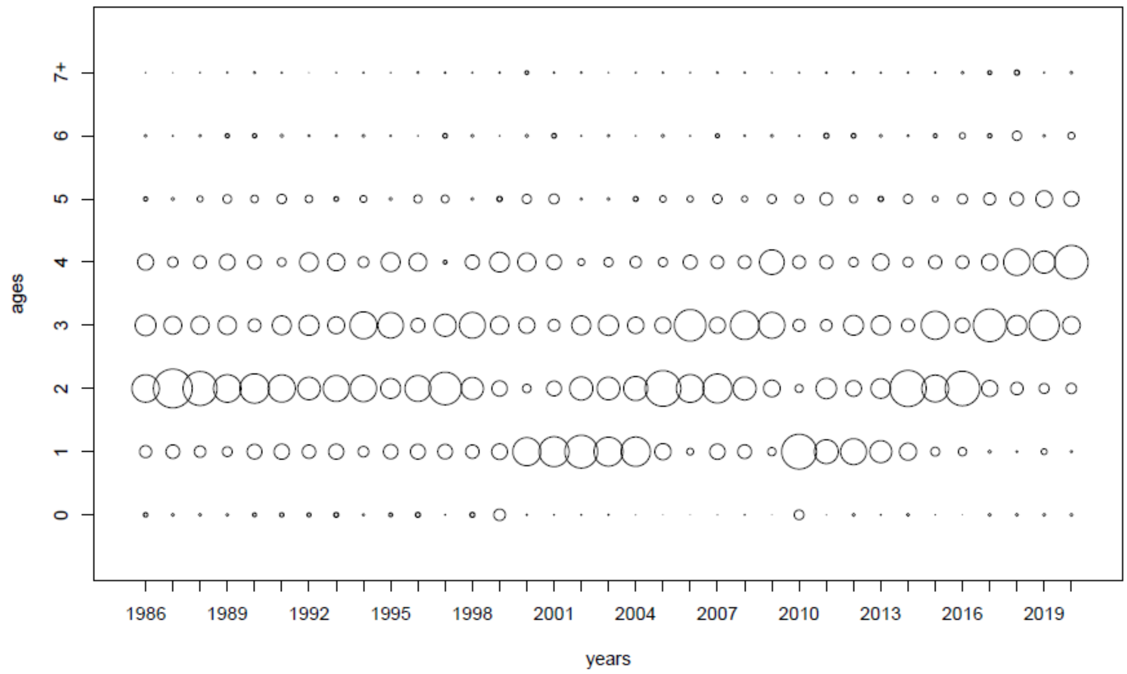


Figure 6.4.3b. Four-spot megrim (*L. boscii*) in Divisions 8c&9a. Standardized log(abundance index at age) of SP-LCGOT-BDEF-1 and SP-LCGOTBDEF-2 (Bubbles colour scale: black – negative, grey – positive).

Catches proportions-at-age



Standardized catches proportions-at-age (Bubbles colour scale: black – negative, grey – positive)

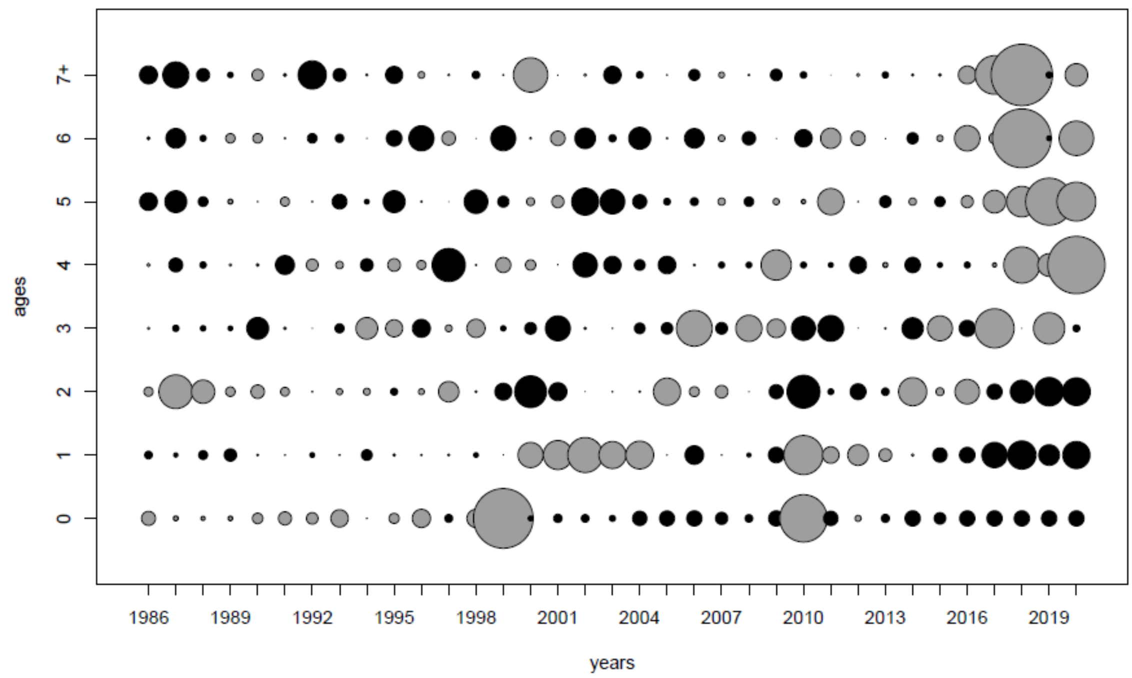
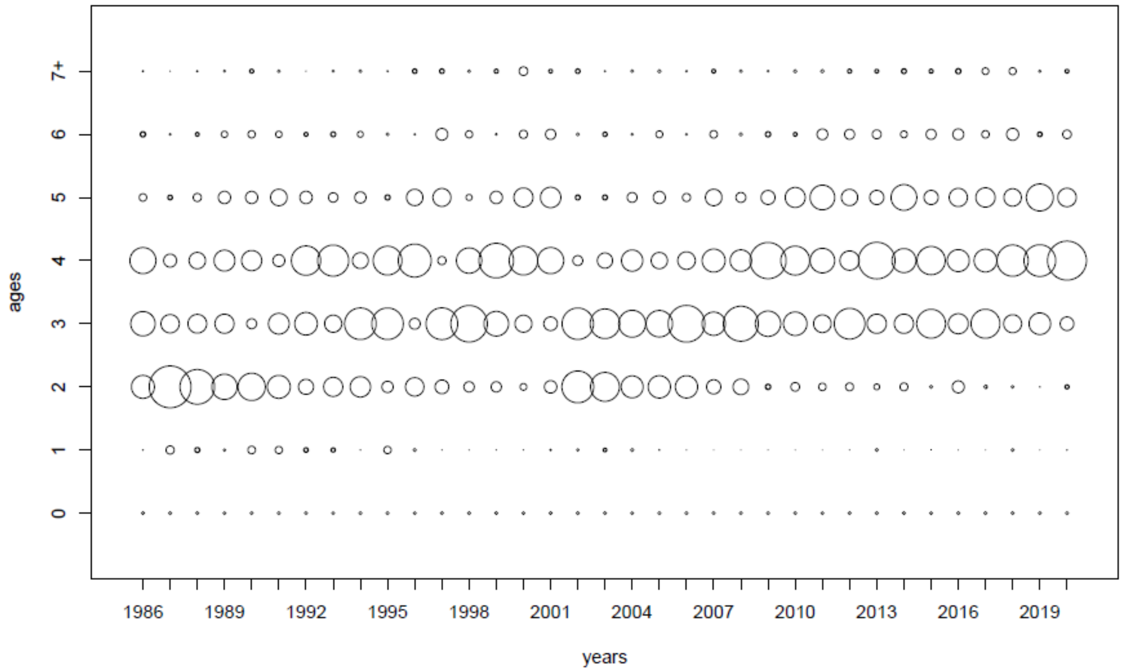


Figure 6.4.4a. Four-spot megrim (*L. boscii*) in divisions 8.c and 9.a. Catches proportions-at-age.

Landings proportions-at-age



Standardized landings proportions-at-age (Bubbles colour scale: black – negative, grey – positive)

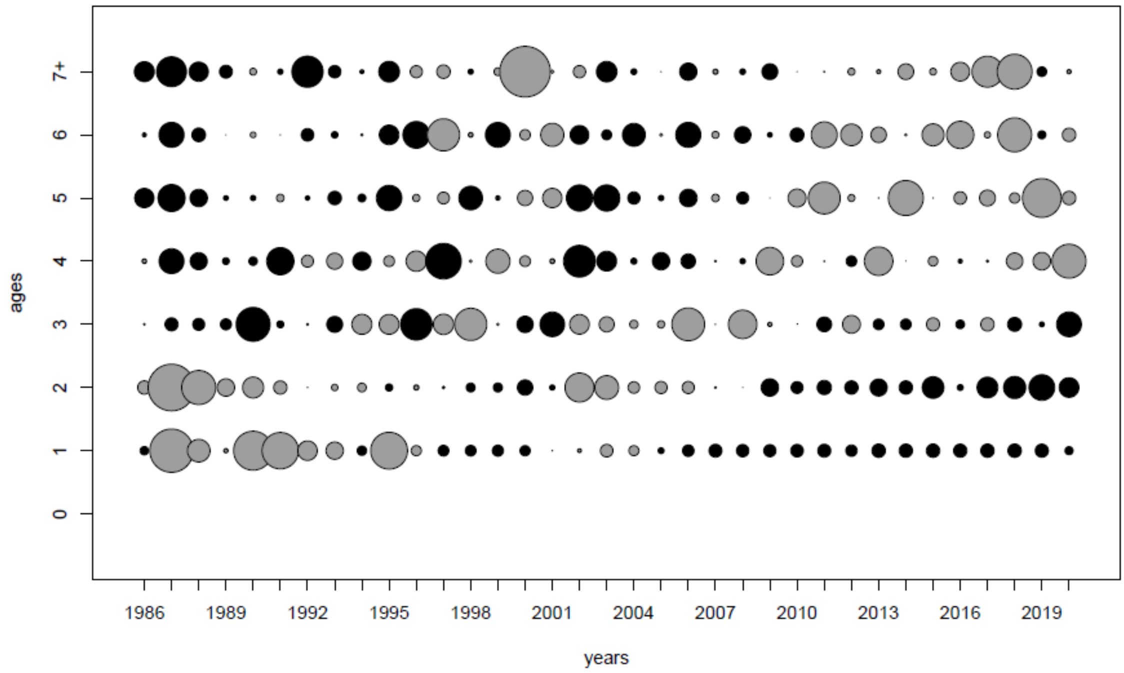
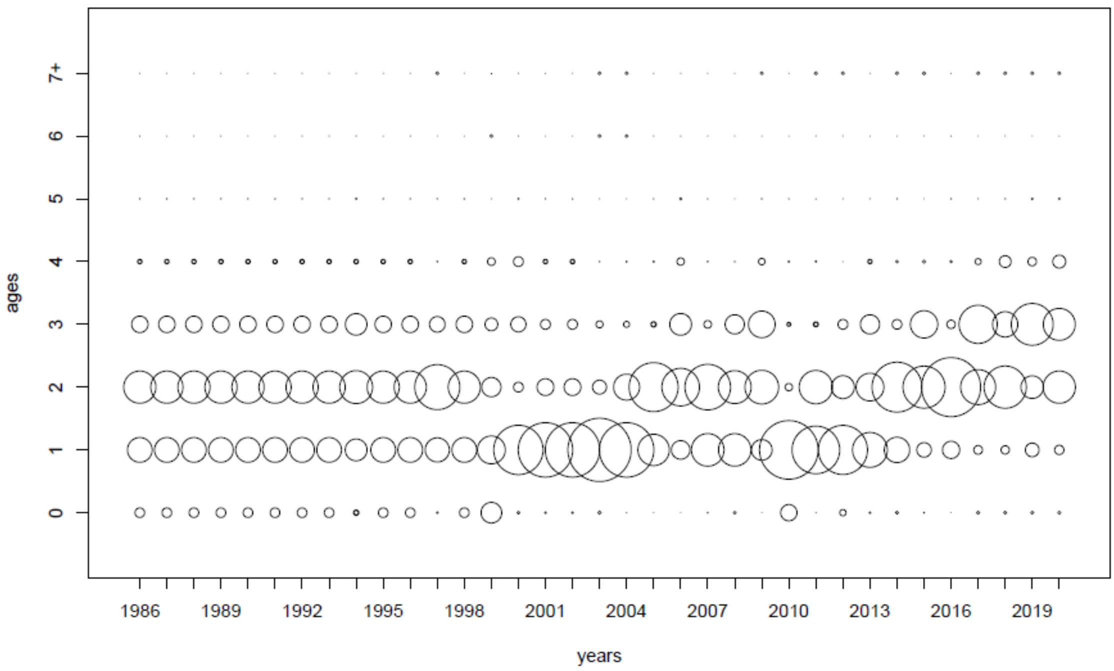


Figure 6.4.4b. Four-spot megrim (*L. boscii*) in divisions 8.c and 9.a. Landings proportions-at-age.

Discards proportions-at-age



Standardized discards proportions-at-age (Bubbles colour scale: black – negative, grey – positive)

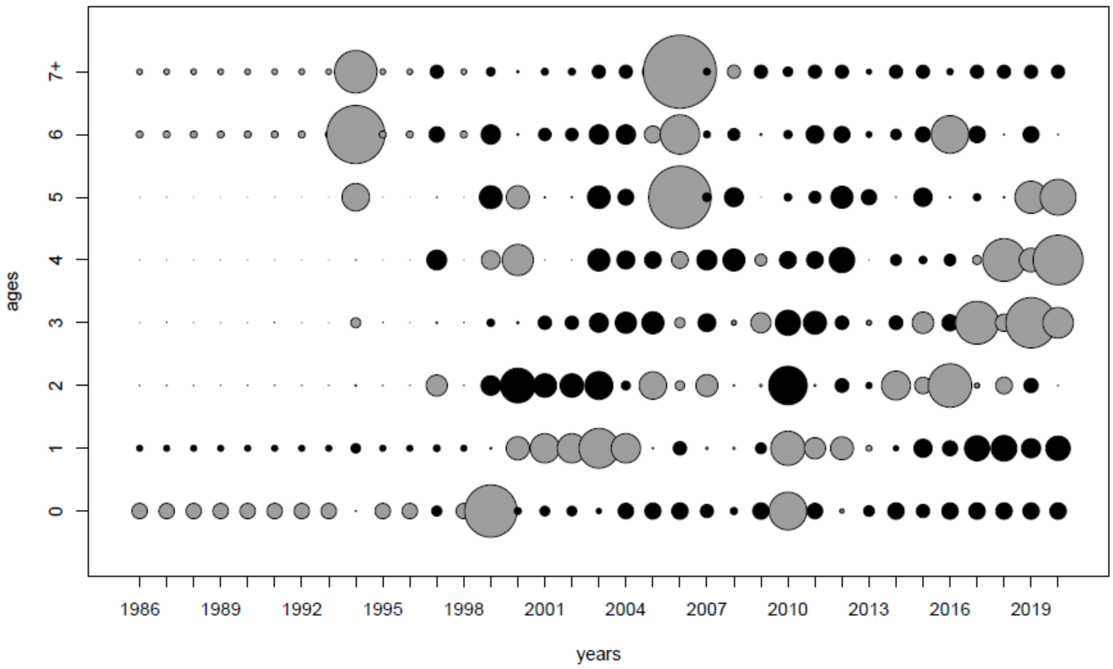


Figure 6.4.4c. Four-spot megrim (*L. boscii*) in divisions 8.c and 9.a. Discards proportions-at-age.

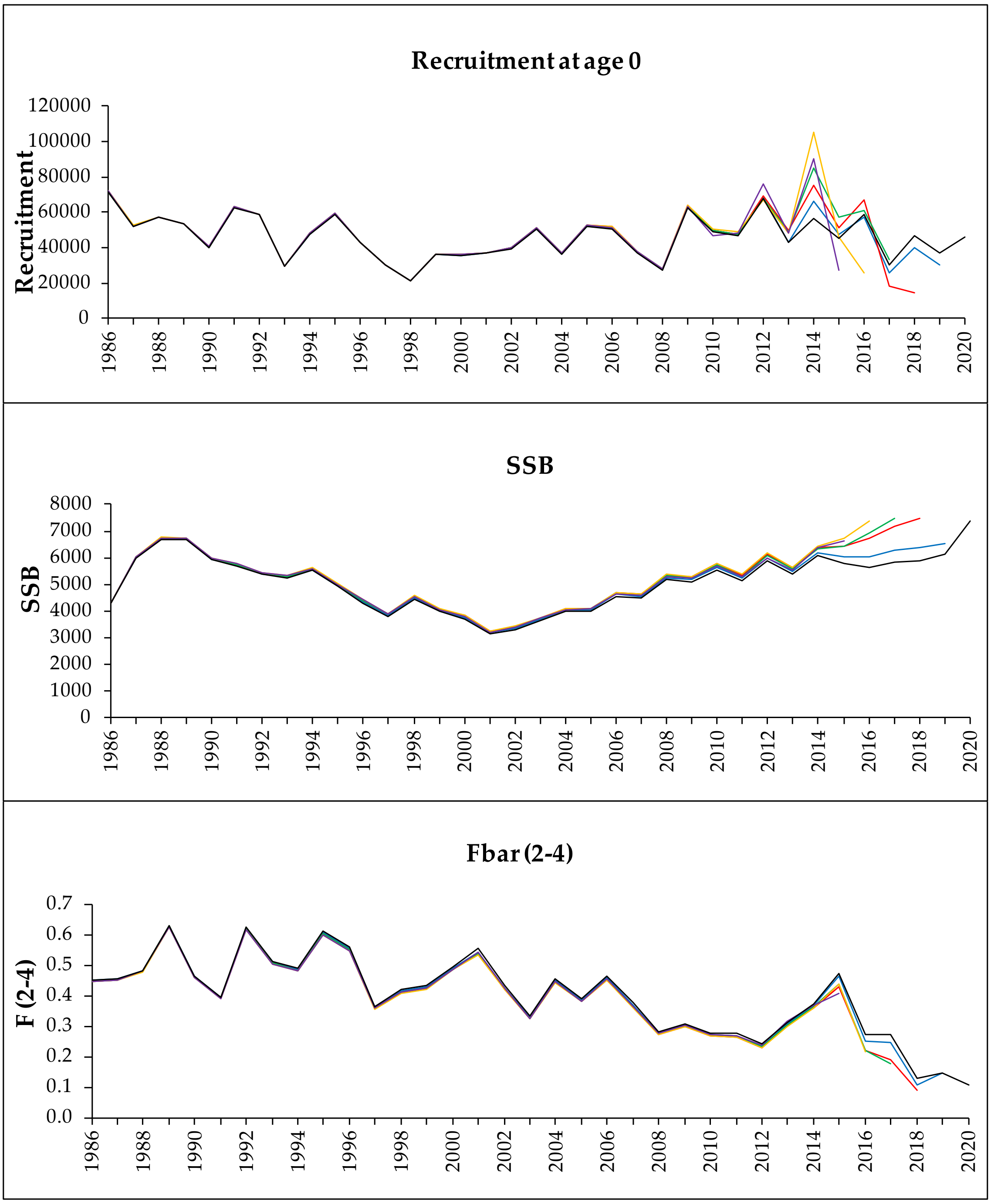


Figure 6.4.5. Four-spot megrim (*L. boscii*) in divisions 8.c and 9.a. Retrospective XSA.

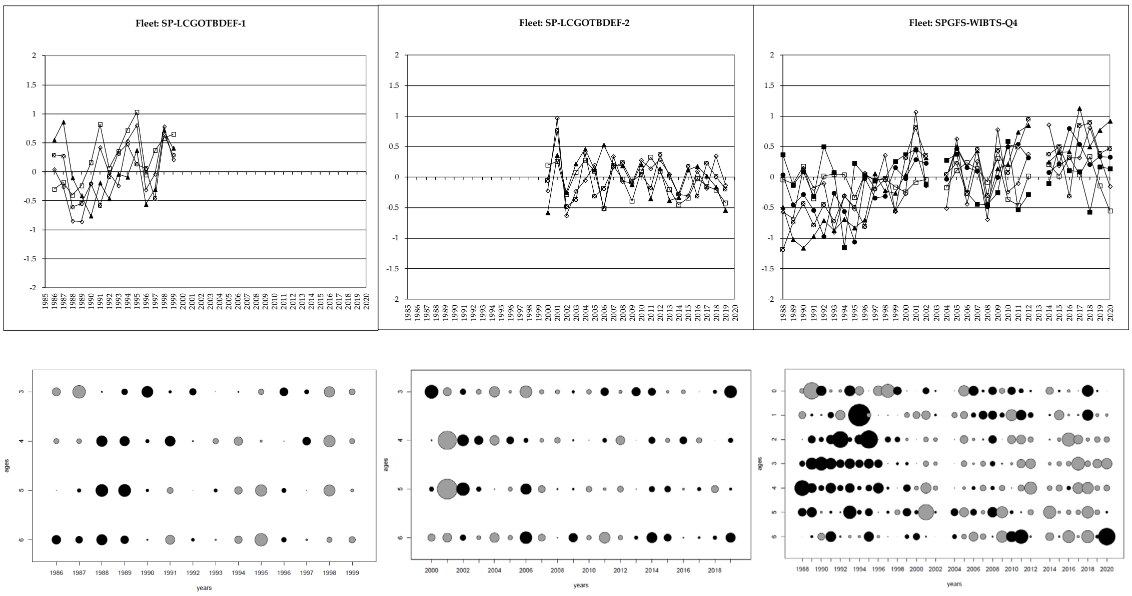


Figure 6.4.6. Four spot megrim (*L. boscii*) in divisions 8.c and 9.a. LOG-CATCHABILITY RESIDUAL PLOTS (XSA)

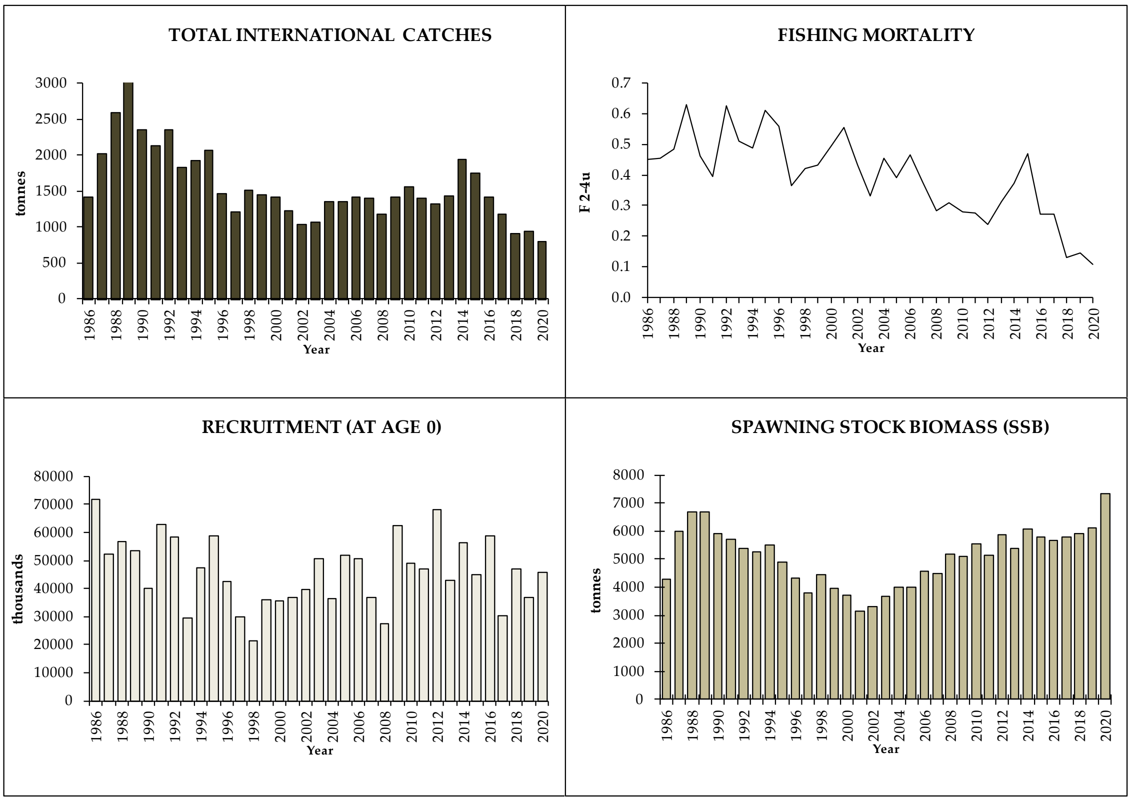


Figure 6.4.7a. Four-spot megrim (*L. boscii*) in divisions 8.c and 9.a. Stock Summary.

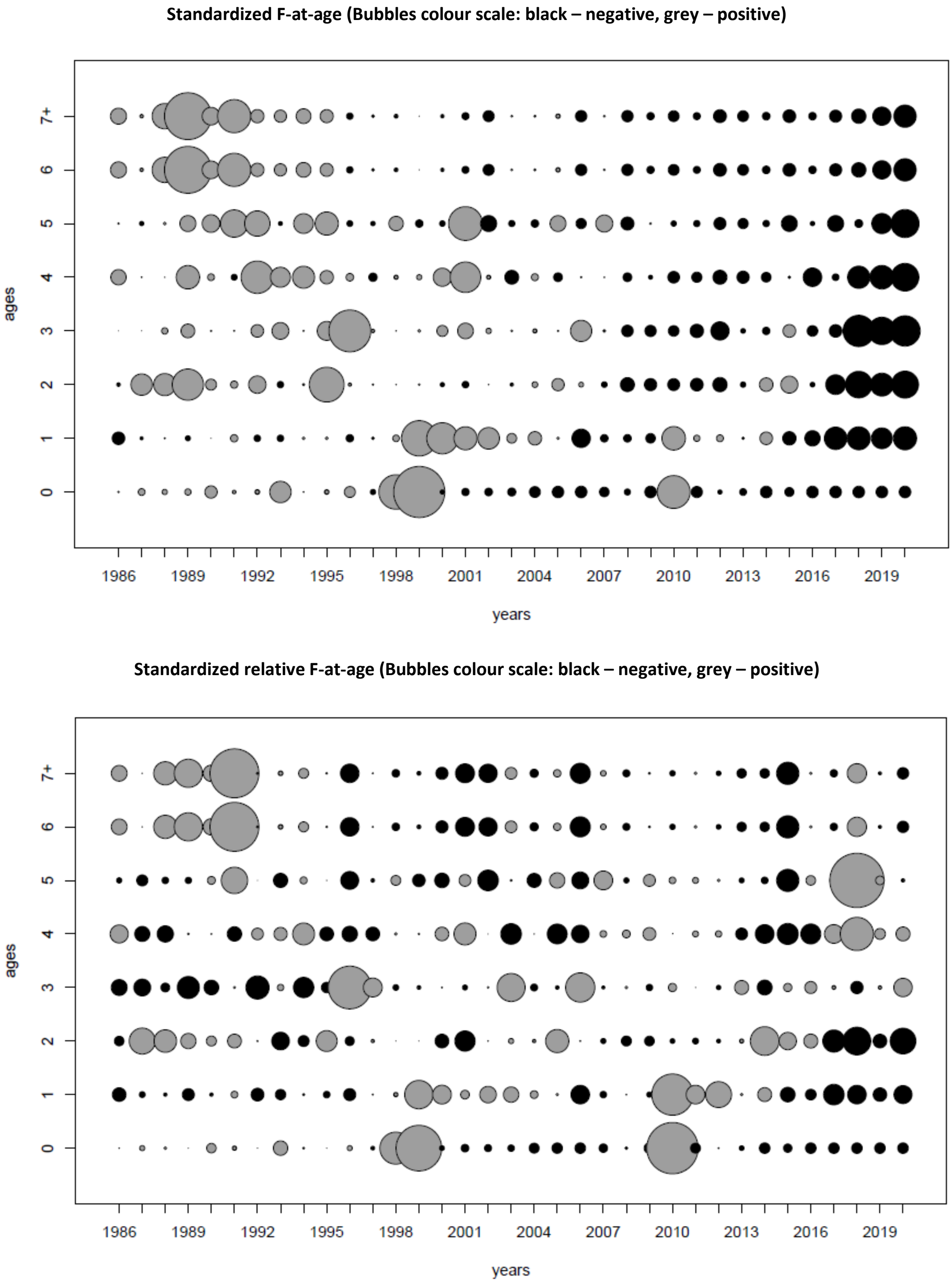
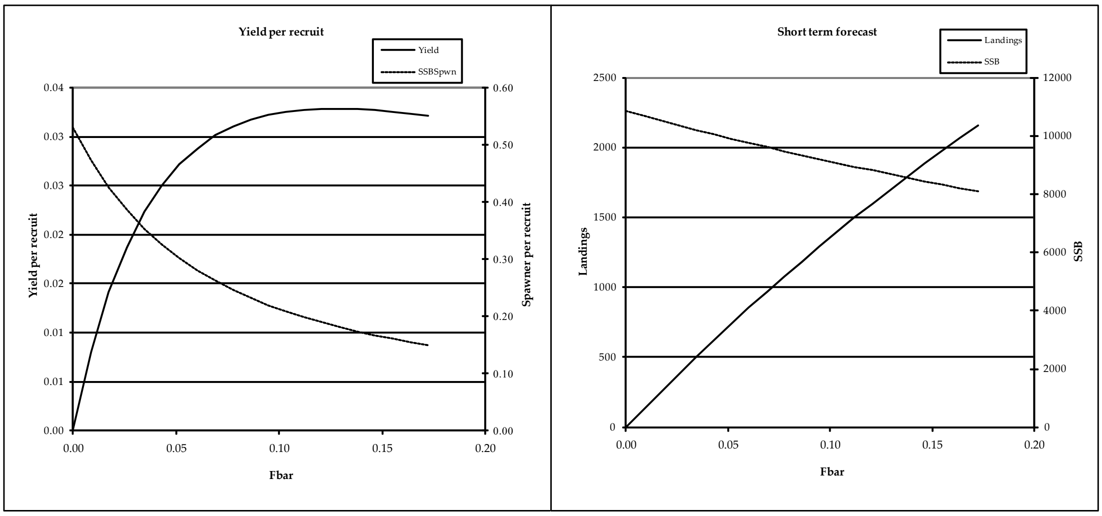


Figure 6.4.7b. Four-spot megrim (*L. boscii*) in Divisions 8cand9a. F-at-age.



MFYPR version 2a
Run: ldb
Time and date: 13:40 03/05/2021

Reference point	F multiplier	Absolute F
Fleet1 Landings Fbar(2-4)	1.0000	0.0862
FMax	1.4689	0.1266
F0.1	0.8571	0.0739
F35%SPR	1.4447	0.1245

MFDP version 1a
Run: ldb
Time and date: 13:34 03/05/2021
Fbar age range (Total) : 2-4
Fbar age range Fleet 1 : 2-4

Input units are thousands and kg - output in tonnes

Figure 6.4.8. Four-spot megrim (*L. boscii*) in divisions 8.c and 9.a. Forecast summary.

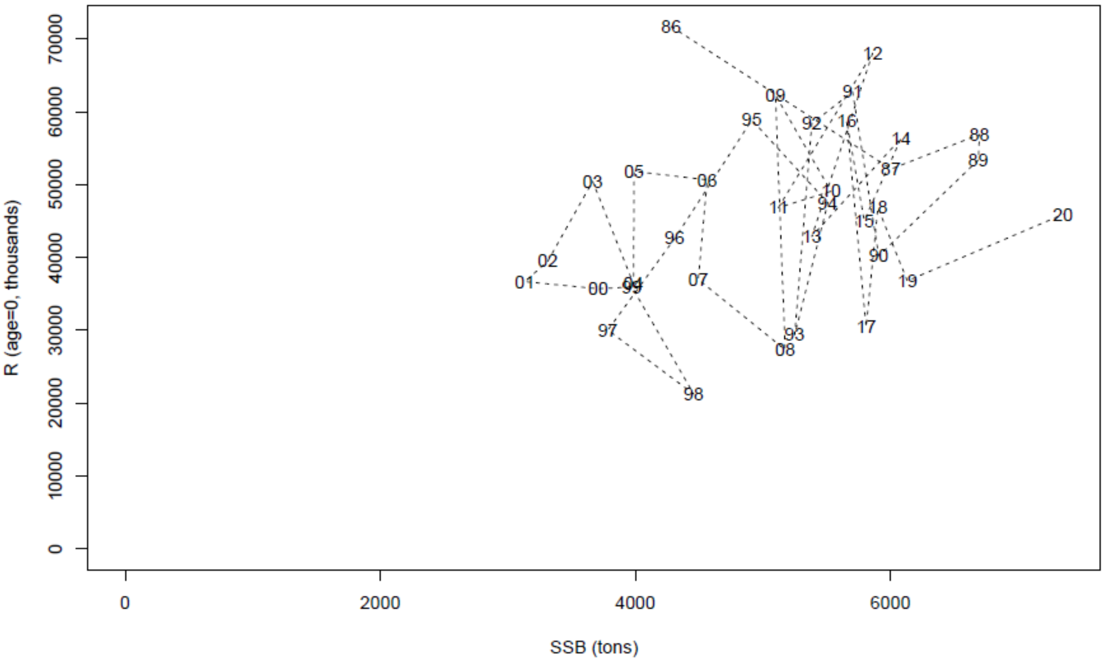


Figure 6.4.9. Four spot megrim (*L. boscii*) in divisions 8.c and 9.a. SSB-Recruitment plot.

6.5 Combined forecast for megrims (*L. whiffiagonis and L. boscii*)

Figure 6.5.1 plots total international landings and estimated stock trends for both species of megrim in the same graph, in order to facilitate comparisons. The two species of megrims are included in the landings from ICES divisions 8.c and 9.a. Both are taken as bycatch in mixed bottom-trawl fisheries.

Assuming status quo F for both species in 2020 (average of estimated F over 2018–2020, corresponding to $F_{bar} = 0.175$ for landings and $F_{bar} = 0.024$ for discards for *L. whiffiagonis* and $F_{bar} = 0.09$ for landings and $F_{bar} = 0.04$ for discards for *L. boscii*), Figure 6.5.2 gives the combined predicted landings for 2022 and individual SSB for 2023, under different multiplying factors of their respective status quo F values. The combined projected values for the two species have been computed as the sum of the individual projected values obtained for each species separately under its assumed exploitation pattern. As usual, the exploitation pattern for each species has been assumed to remain constant during the forecast period.

At F *status quo* (average F over 2018–2020) for both species, predicted combined landings in 2022 are 1739 t and individual SSBs in 2023 are 2425 t for *L. whiffiagonis* and 9337 t for *L. boscii*.

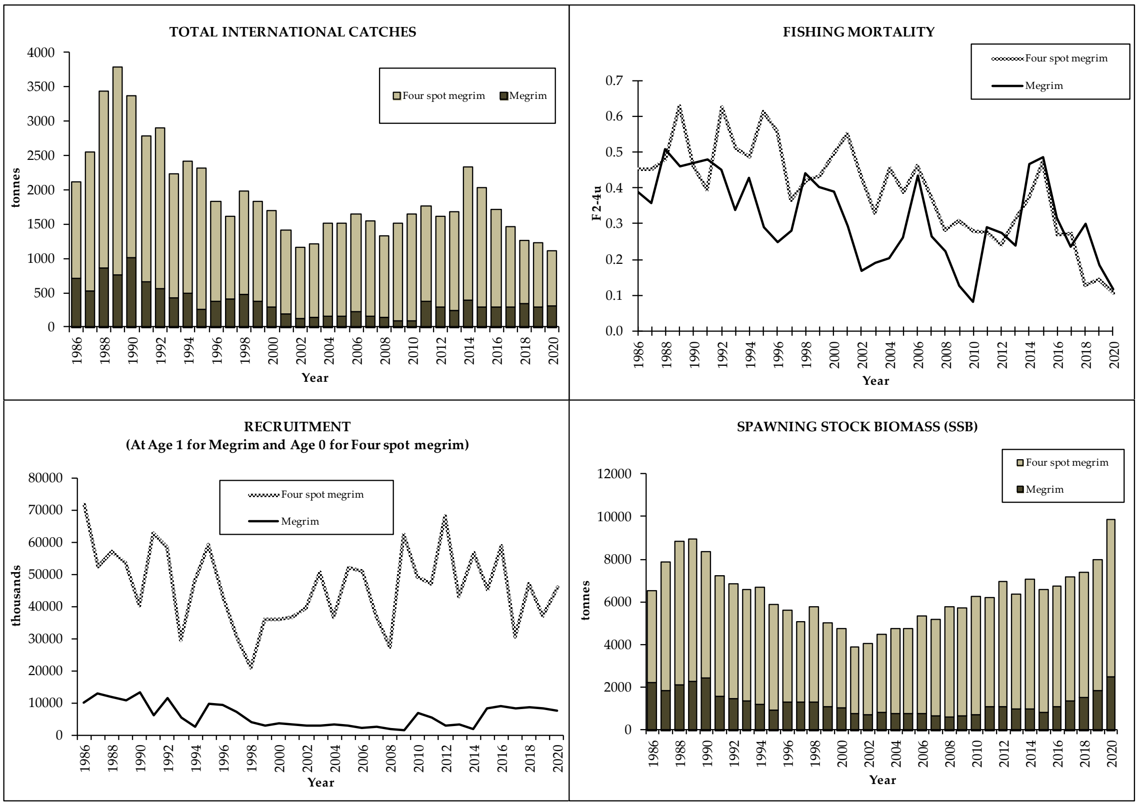


Figure 6.5.1. Stock trends for both stocks. Megrim and four-spot megrim in divisions 8.c and 9.a.

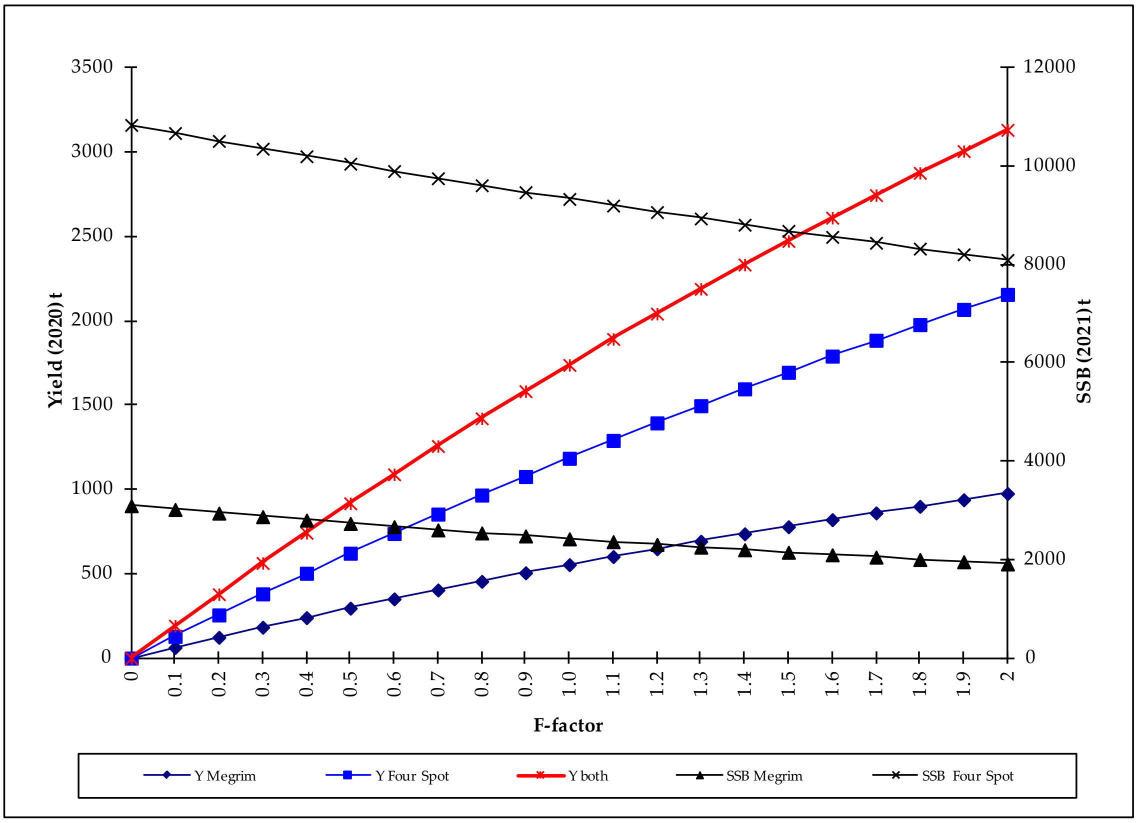


Figure 6.5.2. Megrims (*L. whiffiagonis* and *L. boscii*) in divisions 8.c and 9.a. Combined Short-term Forecasts assuming status quo in 2020 and 2021.

7 Sole in divisions 8.a–b (northern and central Bay of Biscay)

Solea solea – sol.27.8ab

Type of assessment in 2021

Update. Age-structured XSA model. Category 1 stock (ICES, 2021).

Data revisions in 2021

Compared to last year's assessment, there is only very limited change in the ORAGHO (B1706) survey cpue.

7.1 General

7.1.1 Ecosystem aspects

See Stock Annex.

7.1.2 Fishery description

See Stock Annex.

7.1.3 Summary of ICES advice for 2021 and management applicable to 2020

ICES advice for 2021

ICES advises that when the EU multiannual plan (MAP; European Parliament and Council Regulation; EU, 2019) for Western waters and adjacent waters is applied, catches in 2021 that correspond to the F ranges in the MAP are between 2036 t and 4814 t. According to the MAP, catches higher than those corresponding to F_{MSY} (3483 t) can only be taken under the conditions specified in the MAP, whereas the entire range is considered precautionary when applying the ICES advice rule.

Management applicable to 2020 and 2021

The sole landings in the Bay of Biscay are subject to a TAC regulation. The TAC was set at 3666 t and 3483 t for 2020 and 2021, respectively.

The minimum landing size is 24 cm and the minimum mesh size is 70 mm for trawls and 100 mm for fixed nets when directed at sole. Since 2002, the hake recovery plan has increased the minimum mesh size for trawls to 100 mm in a large part of the Bay of Biscay (EU, 2002). However, since 2006, trawlers using a square mesh panel were allowed to use 70 mm mesh size in this area.

Since the end of 2006, the French vessels must have a European Fishing Authorization when their sole annual landing is above 2 t or be allowed to have more than 100 kg onboard. The Belgian vessel owners get a monthly non-transferable individual quota for sole and the amount is related to the capacity of the vessel.

A regulation establishing a multiannual plan (MAP) for Western waters and adjacent waters was adopted in March 2019 (EU, 2019). One of the objectives is to maintain or restore populations of harvested species at levels that can produce the maximum sustainable yield (MSY) in the context of mixed fisheries. The target fishing mortality (F) corresponds to the objective of reaching and maintaining MSY as ranges of values that are consistent with achieving MSY (F_{MSY}). The F_{MSY} upper limit is set that the probability of the stock falling below B_{lim} is no more than 5%. ICES considers that the F_{MSY} range for this stock used in the MAP is precautionary.

In addition to this MAP, the industry implemented a mesh size restriction of > = 80 mm for the bottom-trawls for the periods from 1 January to 31 May and from 1 October to 31 December. A seasonal closure was also applied during the spawning period, 1 January to 31 March, for the directed fishery for common sole. This closure consists of three periods of seven consecutive days for a total of 21 days of closure.

Since 2015, the French sole fishery in the Bay of Biscay (ICES divisions 8.a and 8.b) has been subjected to additional management measures aimed at reducing F and improving the recruitment level of the stock. Since 2016, these measures have concerned at least a 15-day fishing activity suspension during the first quarter for netters and a reinforcement of the trawl selectivity for at least 8 months of the year (including the first quarter).

7.1.4 Data

7.1.4.1 Commercial catches and discards

The working group (WG) estimates of landings and catches are shown in Table 7.1. Over 90% of the total landings are caught by France while Belgium catches amount to less than 10%. There are some incidental landings by other countries such as Spain (less than 1% of the total landings).

The official landings are lower than the WG landings estimates before 2008 but became higher from 2009. This discrepancy in estimates before 2009 and 2009–2010 was due to a new method that has been implemented to calculate the French official landings. This important discrepancy in 2009–2010 values was likely caused by some assumptions in the algorithm implemented to calculate French official landings for these 2 years, which was again modified in 2011. Consequently, the official and the WG landing estimates are closely similar since 2011. This latest WG method for evaluating landings is considered appropriate in providing the best available estimates of the landing series.

In 2002, landings increased to 5486 t due to very favourable weather conditions for the fixed nets fishery (frequent strong swell periods in the first quarter).

The 2020 landings (3221 t) is 12% below the landings constraint set at 3666 t for 2020.

Discards estimates were provided for the French offshore trawler fleet from 1984 to 2003 using the RESSGASC programme. The monitoring halted in 2004 and the discards are no longer used in the assessment. However, these surveys showed that discards from offshore trawlers are low at age 2 and above.

These low discard rates were confirmed by observations at sea in recent years. These observations have also shown that discards of beam trawlers and gillnetters are generally low but that the inshore trawler fleets may have occasionally high discards of sole. Unfortunately, these are difficult to estimate because the effort data of inshore trawlers are not precise enough to allow estimation by relevant areas.

The analysis of discards with data from OBSMER (SIH Harmonie, 2003) shows that the overall discard rate for sole in the Bay of Biscay is less than 5% (2.4% average discard ratio over 2015–2020).

7.1.4.2 Biological sampling

The quarterly French samplings for length composition are by gear (trawl or fixed net) and by boat length (below or over 12 m long). The split of the French landings by *métier* and length class is described in the Stock Annex. The observed split between fleets is presented in Table 7.2.

French and Belgian data were extracted from InterCatch for 2020.

Although age reading from otoliths now uses the same method in France and Belgium (see Stock Annex), the discrepancy between French and Belgian mean weight-at-age observed during the preceding WGs are still present. Work was carried out at the beginning of 2012 by the ICES Planning Group on Commercial Catches, Discards and Biological Sampling (PGCCDBS) to compare the age reading methods (ICES, 2012). The conclusion was the absence of bias between readers from the two countries using otoliths prepared with the same staining technique. All readers produced the same age estimates (i.e. no bias) of otoliths with or without staining. However, a likely effect of the weight-at-age determination process may also be presumed (weight-length relationship used in France and direct estimates in Belgium) and should be investigated. International age compositions are estimated using the same procedure as in previous years, as described in the Stock Annex. International mean weights-at-age of the catch are French-Belgian quarterly weighted mean weights. The catch and landings numbers-at-age are shown in Table 7.3 and Figure 7.1, respectively, and the mean catch weight-at-age in Table 7.4. The COVID-19 restrictions had a negligible impact on the biological sampling because most of the French catches occurred outside the period of the 2020 French spring lockdown.

7.1.5 Abundance indices from surveys

Since 2007, a beam trawl survey (ORHAGO, B1706) is carried out by Ifremer (France) to provide a sole abundance index in the Bay of Biscay. This survey is coordinated by the ICES WGBEAM. During the 2013 WGBEAM meeting, several cpue series were compared (ICES, 2013a). The index found to be the most appropriate was the one based on all the reference stations and carried out during the daytime. This was used to provide the abundance index for sole in divisions 8.a and 8.b. The 2013 WGHMM assessment was carried out according to the 2013 revised Stock Annex, which adds the ORHAGO (B1706) survey to the tuning files. This was a consequence of the IBP during the WGHMM 2013 which considered that the addition of the survey tuning fleet appears to be useful to the assessment (ICES, 2013b). In 2015, the survey vessel was changed. However, the gear configuration and method remained the same as in the previous years and the conclusion of the WGBEAM 2016 was: "*This change has had no consequence on the gear configuration*" (ICES, 2016c). On this basis, the WG agreed to retain the ORHAGO (B1706) abundance index for the assessment. Figure 7.2 shows the tuning fleets' time-series and their internal consistency. The ORHAGO survey (B1706) was not affected by the COVID-19 restrictions.

7.1.6 Commercial catch-effort data

The French La Rochelle and Les Sables trawler series of commercial fishing effort data and LPUE indices were completely revised in 2005. A selection of fishing days (or trips before 1999) was implemented with a double threshold (sole landings > 10% and *Nephrops* landings < = 10%) for a group of vessels. The process is described in the Stock Annex.

The risk that the sole 10% threshold may lead to an underestimation of the decrease in stock abundance was pointed out by RG in 2010 (M. Lissardy, Ifremer, pers. comm.). This general point is acknowledged by this WG. However, in this particular case and by using the knowledge of the fishery, this threshold was set to avoid the effect of changing target species which may also affect the LPUE trend. Indeed, the choice of target species may affect effort repartition between the stock's major habitats and peripheral areas where sole abundance is lower. According to fishers, a minimum of 10% in catch for sole was implemented when carrying out mixed-species trawling on sole grounds in order to ensure that sole LPUEs are not driven by a fishing strategy evolution (i.e. the targeting of cephalopods more particularly).

The La Rochelle LPUE series (FR-ROCHELLE) shows a decreasing trend from 1990 to 2001 followed by the absence of any clear trend, only some up and down variations (Figure 7.2). The Les Sables d'Olonne LPUE series (FR-SABLES) also shows a declining trend up to 2003. Thereafter, a short increase in 2004–2005 was observed followed by a flat trend from 2005 onwards.

Two new tuning series were added to the assessment according to the WKFLAT 2011 (ICES, 2011): the Bay of Biscay offshore trawler fleet (14–18 m) in the second quarter (FR-BB-OFF-Q2) and the Bay of Biscay inshore trawler fleet (10–12 m) in the fourth quarter (FR-BB-IN-Q4) for 2000 to the last year. A selection of fishing days was made by a double threshold (sole landings > 6% and *Nephrops* landings <= 10%). The process is described in the Stock Annex.

Unfortunately, the fishing effort for the FR-BB-OFF-Q2 is no longer available since 2013. This is due to the use of electronic logbooks, for which the fishing effort is not a required value. Since 2013, these data are not well exported in the official database, and the majority of the fishing effort value is equal to 1. Therefore, the commercial LPUE could not be calculated for this fleet.

However, LPUE for the FR-BB-IN-Q4 fleet is still available from paper logbooks which are still used by this fleet. The computation of the FR-BB-IN-Q4 was not affected by the COVID-19 restrictions, because in the fourth quarter of 2020, the inshore trawler was not affected by COVID-19 restrictions.

For the ORHAGO (B1706) survey, the trend of the cpue shows an increase since 2008 despite some annual fluctuations which stabilized from 2013 onwards.

ORHAGO (B1706) shows a slight decrease in numbers-at-age 2 (Figure 7.2) in the last 5 years but the index is about the average of the whole time-series. It is worth noting that an important decrease of the ORHAGO (B1706) and FR-BB-IN-Q4 tuning fleet indices were observed in 2019 for age 2. Both also showed a decrease of the age 3 indices for the same year and in 2020, with a slight decrease for the FR-BB-IN-Q4 and a significant decrease for the ORHAGO (B1706) survey. A subsequent decrease in ages 2 and 3 indices was observed in 2020 where indices for both ages are lower than the 2019 values for the ORHAGO (B1706) survey and the FR-BB-IN-Q4 fleet. In general, these two fleets ORHAGO (B1706) and FR-BB-IN-Q4, are consistent among ages and allow for cohorts tracking.

7.2 Assessment

7.2.1 Input data

See Stock Annex.

7.2.2 Model

The model used in 2021 to assess the sole in the Bay of Biscay is the R FLXSA package (Kell, 2020) in R (R Core Team, 2020). The age range in the assessment is 2–8+, similar to last year's assessment. The year range used is 1984–2020.

Result of XSA runs

The final XSA model used the same settings as in last year's assessment run. Figure 7.1 shows the landings-at-age distribution and, similar to last year's landings which consist mainly of ages 3 and 4-year-old individuals.

			2020 XSA		2021 XSA
Catch data range			84–19		84–20
Catch age range			2–8+		2–8+
Fleets	FR – SABLES	91–09	2–7	91–09	2–7
	FR – ROCHELLE	91–09	2–7	91–09	2–7
	FR-BB-IN-Q4	00–19	3–7	00–20	3–7
	FR-BB-OFF-Q2	00–12	2–6	00–12	2–6
	FR-ORHAGO	07–19	2–8	07–20	2–8
Taper			No		No
Ages catch dep. stock size			No		No
Q plateau			6		6
F shrinkage se			1.5		1.5
Year range			5		5
Age range			3		3
Fleet se threshold			0.2		0.2
F bar range			3–6		3–6

The log-catchability residuals are shown in Figure 7.3 and retrospective results in Figure 7.4. The retrospective pattern shows a good estimation of F, SSB for 2018 data. Table 7.5 gives the results of Mohn's rho calculation from the most recent assessments and five retrospective assessments with terminal years (2016–2020). Mohn's rho value is −0.00042 for recruitment, 0.13000 for SSB and 0.04900 for F.

Because of the lack of FR-BB-OFF-Q2 abundance indices in the tuning data, the estimated survivors at age 2 are only based on the ORHAGO (B1706) survey. Recruits at age 2 were not well estimated for 2019.

Fs and stock numbers-at-age are given in Table 7.6 and Table 7.7, respectively. The results are summarized in Table 7.8. Trends in yield, F, SSB and recruitment are plotted in Figure 7.5. F in 2020 is estimated by XSA (Shepherd, 1999) at 0.38. F was 0.36 in 2019 and 0.34 in 2018.

7.2.2.1 Estimating year-class abundance

In this year's assessment, the retrospective analyses show that the recruitment was well estimated by the XSA model. The recruitment assumed for projections is computed as the geometric mean of the estimated recruitment over the period 2016–2020, which is equal to 12 688 thousand recruits.

7.2.2.2 Historic trends in biomass, fishing mortality, and recruitment

A full summary of the XSA time-series results are given in Table 7.8 and illustrated in Figure 7.6. Since 1984, F gradually increased, peaked in 2002 and decreased substantially in the following two years. It increased since 2005 then was stable at around F = 0.4. In 2017, the value was below F_{MSY} but increased since 2018 to be above F_{MSY}. The SSB trend in earlier years increased from 12 300 t in 1984 to 16 300 t in 1993. Afterwards, it showed a continuous decline to 9600 t in 2003. After an increase in SSB was observed between 2004 and 2006, then the values remained close to 11 000 t from 2007 to 2009. Although above the MSY $B_{brigger}$ (10 600 t) from 2004, SSB has been decreasing since 2012. SSB values for 2014 and 2015 were below the $B_{pa,}$ then was above since 2016 and for the last year (2020) estimated SSB is below MSY $B_{trigger}$ and B_{pa} (both equal to 10 600 t). The recruitment values were decreasing since 1993. Between 2004 and 2008, the series was stable at around 17 or 18 million then increased in 2009 to the highest value since 1992. After a short increase, the recruitment declined again since 2015, with the lowest values of 9101 and7986 observed in 2019 and 2020, respectively.

7.2.3 Catch options and prognosis

The exploitation pattern is the mean throughout 2018–2020 scaled at the last year. As the take up of TAC is less than 80%, a F-*status quo* for the intermediate year is used and set at 0.38. The recruits at age 2 from 2020 to 2021 are assumed equal to the geometric mean of 2016–2020 (GM_{16-20}). Stock numbers-at-age 3 and above are the XSA survivor estimates. Weights-at-age in the landings are the 2018–2020 means using the old fresh/gutted transformation coefficient of French landings (1.11). The fresh/gutted transformation coefficient of French landings was not computed in 2021. The predicted spawning biomass is consequently still comparable to the biomass reference point.

7.2.3.1 Short-term predictions

Input values for the catch forecast are given in Table 7.10. For the intermediate year (2021), the F-*status quo* was used to perform the short-term predictions (F_{2021} = 0.38).

In 2020, the WGBIE was concerned by the decrease in recruitment over the past two decades. The time-series used to compute the recruitment as a geometric mean was shortened to account for the low recruitment observed in the past 10 years using the mean of 2004 to 2017. In 2021, the retrospective analysis indicates that recruitment is well estimated in recent years, but still decreasing. In order to account for the lower recruitment in recent years, the geometric mean of the recruitment was again shortened and computed over the period 2016–2020, giving the value of 12 688 thousand recruits. The shorter period to compute the GM of the recruitment is more precautionary than the longer period used in previous stock assessments.

Assuming recruitment at GM_{16-20}, the SSB is predicted to decrease to 8934 t in 2022, and will decrease compared with 2021 at $F = F_{MSY} \times SSB_{2022}/MSYB_{trigger}$, to reach 9372 t in 2023 and will remain under B_{pa} and $MSYB_{trigger}$ (Table 7.10 and Table 7.11).

7.2.4 Biological reference points

ICES (2016a) and WKMSYRef4 for MSY approach reference points (ICES, 2016b) are given below as a technical basis with the values adopted for the precautionary approach reference points:

The F pattern is known, with low uncertainty, because of the limited discards and the satisfactory sampling level of the catches.

	Type	Value	Technical basis
MSY Approach	MSY $B_{trigger}$	10 600 t	B_{pa}
	FMSY	0.33	F_{MSY} without $B_{trigger}$
	B_{lim}	7600 t	$B_{lim} = B_{pa} / \exp(\sigma \times 1.645)$
Precautionary Approach	B_{pa}	10 600 t	The third lowest value
	F_{lim}	Undefined	
	F_{pa}	0.88	F_{pa} = FP.05 (5% risk to B_{lim} with $B_{trigger}$)

7.2.5 Comments on the assessment

Sampling

The sampling level for this stock is considered to be satisfactory. The ORHAGO (B1706) survey provides information on several year-classes from age 2. At other ages, it is particularly useful to have a tuning fleet in the tuning file because the recent use of electronic logbooks has caused some obvious misreporting of effort which limits the available commercial tuning data in 2012 and 2013 coupled with the lack of FR-BB-OFF-Q2 abundance indices since 2013. Stopping the use of fleets of La Rochelle and Les Sables tuning series led to a paucity of information at age 2 in 2013, which were only provided by the Offshore Q2 tuning fleet (when data were available). That is no longer the case with the incorporation of the ORHAGO (B1706) survey in the assessment. The same age reading method is now adopted by France and Belgium. However, a discrepancy still exists between French and Belgian weights-at-age which requires further investigation.

Discarding

Available data on discards have shown that discards may be important at age 1 for some trawlers. Discards at age 2 were assumed to be low in the past due to the high commercial value of the sole catches. Recently, there are some reports of highgrading practices due to the landing limits adopted by some producers' organizations. Overall, discards remain low in recent years and are used to produce catch advice. Discards could be included in the assessment during the next benchmark.

Consistency

Since the 2013 assessment, the ORHAGO (B1706) survey has been included in the tuning fleets. This survey is the only tuning fleet that provides a recruitment index series for the more recent period. A GM is only used for recruitment predictions (2020–2023). It is worth noting that the variability of the recruitment series has increased in the period 2001 to 2019. The retrospective pattern in F shows that F_{2016} is well estimated (Figure 7.5). The definition of reference groups of vessels and the use of thresholds on species percentage to build the French series of commercial fishing effort data and LPUE indices are considered to provide LPUE representative of changes in stock abundance by limiting the effect of long-term change in fishing power (technological creep) and change in fishing practices in the sole fishery.

Misreporting

Misreporting is likely to be limited for this stock but it may have occurred for fish of the smallest market size category for some years. There are some reports of highgrading practices due to the landing limits adopted by some producers' organizations.

Industry input

The traditional meeting with representatives of the fishing industry was organized in France prior to the WG to present the data used during the WGBIE 2021 to assess the state of stock in the Bay of Biscay (ICES, 2021).

Since 2015, the French sole fishery in the Bay of Biscay (ICES divisions 8.a and 8.b) has been subjected to additional management measures aimed at reducing F and improving the stock's recruitment level. Since 2016, these measures include a fishing closure of at least 15 days during the first quarter for netters and a reinforcement of the selectivity for at least 8 months of the year (including the first quarter) for trawlers.

In addition to the European measures of the management plan of the Bay of Biscay sole stock (EU, 2006) and the harvest control rules defined in the framework of the South West Waters Advisory Council, France has set up from 2015 a national management regime towards the French sole fishery in the Bay of Biscay. In 2019, this management regime provides for:

- A 15-day fishing activity suspension per period of 5 consecutive days during the first quarter of the year, for netters holding a European fishing authorization for sole in the Bay of Biscay. From 2016 to 2018, these vessels were subjected to a 21-day fishing activity suspension per period of 7 consecutive days during the first quarter;
- The obligation to use a mesh size greater than or equal to 80 mm (the regulatory mesh size being 70 mm) from 1 January to 31 May and for at least 3 consecutive months from 1 June to 31 December, for bottom-trawlers holding a European fishing authorization for sole in the Bay of Biscay. The actual effectiveness of these management measures is not fully assessed;
- Suspension of netters from fishing during the months with the highest yields should significantly reduce landings. A study made by Ifremer (Ifremer, 2015) quantified that closing the fishery 5 days per month during the first quarter corresponds to a reduction of 16% of the annual landings of the netters compared to identical conditions of activity elsewhere;
- The increase in the mesh size of the bottom-trawls should also limit catches of sole that have not reached maturity (26 cm). A study made by AGLIA (AGLIA 2009) showed that size compositions of trawl catches differed between 70 and 80 mm mesh sizes and catches of sole less than 28 cm are considerably reduced.

Management considerations

The assessment indicates that SSB has decreased continuously to 9600 t in 2003, reached a peak in 1993 (16 308 t), then decreased to 14 446 t in 2011. After another decrease from 2012 to 2015, SSB increased from 2016 to 2017 followed by a decreasing trend since 2018 to 10 355 t in 2020. The SSB in 2019 was above B_{pa} and $MSYB_{trigger}$ (10 600 t), but is now under B_{pa} and $MSYB_{trigger}$, assuming a 12 688 recruitment value for 2021. A slight decrease of SBB is predicted by the short-term forecast in 2023 (9372 t), a value still under B_{pa} and $MSYB_{trigger}$ (Table 7.11). In 2006, a management plan (EU, 2006) was agreed for the Bay of Biscay sole but a long-term target for F was not set. This plan was not evaluated by ICES.

7.2.6 References

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7.2.7 Tables and figures

Table 7.1. Bay of Biscay sole in divisions 8.a and 8.b. International landings and catches used by WGBIE (in tonnes).

Year	Belgium	France	Spain	Total	ICES landings	discards	ICES catches
1979	0	2376	62	2443	2619	-	-
1980	33	2549	107	2689	2986	-	-
1981	4	2581	96	2694	2936	-	-
1982	19	1618	57	1746	3813	-	-
1983	9	2590	38	2669	3628	-	-
1984	0	2968	40	3183	4038	99	4137
1985	25	3424	308	3925	4251	64	4315
1986	52	4228	75	4567	4805	27	4832
1987	124	4009	101	4379	5086	198	5284
1988	135	4308	0	4443	5382	254	5636
1989	311	5471	0	5782	5845	356	6201
1990	301	5231	0	5532	5916	303	6219
1991	389	4315	3	4707	5569	198	5767
1992	440	5928	0	6359	6550	123	6673
1993	400	6096	13	6496	6420	104	6524
1994	466	6627	2	7095	7229	184	7413
1995	546	5326	0	5872	6205	130	6335
1996	460	3842	0	4302	5854	142	5996
1997	435	4526	0	4961	6259	118	6377
1998	469	3821	0	4334	6027	127	6154
1999	504	3280	0	3784	5249	110	5359
2000	451	5293	5	5749	5760	51	5811
2001	361	4350	0	4912	4836	39	4875
2002	303	3680	2	3985	5486	22	5508
2003	296	3805	4	4105	4108	21	4129
2004	324	3739	9	4072	4002	-	-
2005	358	4003	10	4371	4539	-	-

Year	Belgium	France	Spain	Total	ICES landings	discards	ICES catches
2006	393	4030	9	4432	4793	-	-
2007	401	3707	9	4117	4363	-	-
2008	305	3018	11	3336	4299	-	-
2009	364	4391	0	4755	3650	-	-
2010	451	4248	0	4699	3966	-	-
2011	386	4259	0	4645	4632	-	-
2012	385	3819	0	4204	4321	-	-
2013	312	4181	0	4492	4235	-	-
2014	307	3793	10	4110	3928	-	-
2015	302	3465	8	3775	3644	62	3706
2016	288	3054	4	3346	3232	134	3366
2017	274	2953	8	3236	3249	55	3304
2018	295	3165	8	3468	3308	79	3332
2019	322	3032	24	3351	3376	88	3464
2020	299	2091	21	3221	3219	74	3293

Table 7.2. Bay of Biscay sole in divisions 8.a and 8.b. Total landings by different fleets (in tonnes).

Year	Offshore trawlers	Inshore trawlers	Offshore gillnetters	Inshore gillnetters	Belgian Beam trawlers
1997	1874	667	1927	1356	435
1998	1826	605	1674	1414	463
1999	1261	289	2094	1105	499
2000	1197	474	2510	1114	459
2001	994	411	1947	913	368
2002	968	373	2760	1054	311
2003	992	329	1736	749	296
2004	898	369	1710	686	319
2005	923	326	2053	788	365
2006	923	373	2117	896	393
2007	920	392	1768	870	401
2008	813	238	2085	856	305
2009	745	235	1615	692	363
2010	792	323	1733	667	451
2011	807	327	2197	915	386
2012	744	365	1938	889	385
2013	744	313	2052	814	312
2014	716	345	1811	748	307
2015	537	263	1786	748	302
2016	471	259	1522	687	288
2017	514	245	1545	663	274
2018	470	230	1667	725	295
2019	457	227	1589	759	322
2020	437	226	1520	723	299

Table 7.3. Bay of Biscay sole in divisions 8.a and 8.b, catch number-at-age.

Year	2	3	4	5	6	7	8
1984	5901	3164	2786	2034	1164	880	1181
1985	8493	4606	2479	1962	906	708	729
1986	5901	3164	2786	2034	1164	880	1181
1987	8493	4606	2479	1962	906	708	729
1988	6126	4208	2673	2301	1512	1044	1235
1989	3794	5634	3578	2005	1482	690	714
1990	4962	5928	4191	2293	1388	874	766
1991	4918	6551	3802	3147	2046	967	499
1992	7122	6312	4423	2833	972	1018	870
1993	4562	6302	4512	2083	1113	1063	981
1994	4640	7279	4920	2991	2236	1124	951
1995	1897	7816	6879	3661	1625	566	708
1996	2603	5502	8803	5040	1968	970	696
1997	3249	5663	6356	3644	1795	843	986
1998	3027	5180	5409	2343	1697	1366	1319
1999	3801	9079	5380	3063	1578	692	877
2000	4096	5550	6351	2306	1237	785	1188
2001	2851	5113	4870	2764	1314	902	977
2002	5677	7015	5143	2542	955	421	444
2003	3180	6528	4948	1776	899	513	486
2004	5198	4777	4932	3095	1269	615	432
2005	4274	6309	2236	1220	729	377	250
2006	3411	5415	3291	917	661	272	333
2007	3976	3464	3738	2309	991	461	508
2008	3535	4436	2747	2012	1030	530	1537
2009	3885	5181	2615	1419	1262	686	946
2010	3173	4794	2886	1353	938	892	1193
2011	2860	3986	2233	1501	946	541	960
2012	2084	7707	3758	1272	484	269	284

Year	2	3	4	5	6	7	8
2013	1516	5222	8347	1019	570	275	516
2014	1302	4680	4264	3787	1008	225	517
2015	2312	2939	3777	3205	1450	286	635
2016	3767	3198	1769	2426	1810	791	522
2017	2531	3365	1742	2057	1305	939	636
2018	1144	3368	2682	1193	762	759	867
2019	1492	3608	2199	1023	606	587	949
2020	1736	3497	2448	1823	885	484	933

Table 7.4. Bay of Biscay sole in divisions 8.a and 8.b, catch weight-at-age (in kg).

Year	2	3	4	5	6	7	8
1984	0.13	0.18	0.228	0.288	0.352	0.394	0.614
1985	0.109	0.179	0.26	0.322	0.402	0.471	0.719
1986	0.104	0.176	0.25	0.334	0.417	0.508	0.67
1987	0.144	0.206	0.292	0.385	0.479	0.509	0.699
1988	0.135	0.192	0.274	0.36	0.499	0.507	0.609
1989	0.137	0.189	0.259	0.356	0.439	0.546	0.803
1990	0.132	0.18	0.242	0.349	0.438	0.603	0.857
1991	0.146	0.196	0.265	0.331	0.445	0.545	0.728
1992	0.146	0.196	0.262	0.341	0.404	0.49	0.715
1993	0.145	0.197	0.267	0.341	0.439	0.569	0.678
1994	0.147	0.195	0.251	0.325	0.422	0.57	0.775
1995	0.16	0.206	0.253	0.309	0.404	0.485	0.66
1996	0.159	0.204	0.268	0.319	0.399	0.453	0.625
1997	0.143	0.194	0.257	0.321	0.408	0.504	0.681
1998	0.162	0.214	0.259	0.338	0.414	0.506	0.706
1999	0.177	0.219	0.246	0.305	0.404	0.533	0.582
2000	0.172	0.208	0.278	0.345	0.455	0.577	0.76
2001	0.154	0.222	0.268	0.344	0.432	0.524	0.625
2002	0.173	0.211	0.266	0.324	0.472	0.599	0.689
2003	0.181	0.227	0.309	0.363	0.49	0.661	0.646
2004	0.192	0.229	0.293	0.395	0.498	0.65	0.818
2005	0.192	0.229	0.303	0.373	0.437	0.475	0.666
2006	0.198	0.245	0.286	0.352	0.426	0.461	0.54
2007	0.176	0.226	0.299	0.327	0.389	0.42	0.512
2008	0.174	0.229	0.287	0.352	0.392	0.401	0.519
2009	0.173	0.218	0.279	0.322	0.367	0.454	0.61
2010	0.179	0.206	0.273	0.338	0.415	0.478	0.769
2011	0.194	0.224	0.254	0.344	0.434	0.491	0.609
2012	0.182	0.225	0.258	0.308	0.37	0.415	0.586

Year	2	3	4	5	6	7	8
2013	0.21	0.242	0.274	0.306	0.371	0.522	0.525
2014	0.179	0.243	0.283	0.299	0.351	0.397	0.581
2015	0.198	0.226	0.318	0.314	0.389	0.367	0.52
2016	0.188	0.238	0.286	0.352	0.372	0.382	0.526
2017	0.219	0.239	0.301	0.376	0.434	0.427	0.523
2018	0.191	0.251	0.285	0.357	0.407	0.382	0.444
2019	0.2	0.248	0.288	0.334	0.332	0.372	0.424
2020	0.205	0.245	0.296	0.314	0.353	0.376	0.456

Table 7.5. Mohn’s rho for R, SSB and R.

Variable	Mohn’s rho
SSB	−0.00042
Mean F	0.04900
Recruits	0.13000

Table 7.6. Fishing mortality-at-age.

	2	3	4	5	6	7	8
1984	0.297	0.243	0.336	0.348	0.320	0.336	0.336
1985	0.360	0.354	0.272	0.372	0.229	0.292	0.292
1986	0.258	0.271	0.318	0.388	0.485	0.398	0.398
1987	0.175	0.356	0.347	0.372	0.411	0.378	0.378
1988	0.217	0.400	0.433	0.347	0.423	0.402	0.402
1989	0.203	0.437	0.429	0.598	0.526	0.519	0.519
1990	0.266	0.385	0.526	0.581	0.327	0.480	0.480
1991	0.144	0.354	0.464	0.446	0.419	0.631	0.631
1992	0.149	0.320	0.456	0.566	1.101	0.868	0.868
1993	0.0804	0.354	0.501	0.644	0.611	0.824	0.824
1994	0.110	0.328	0.754	0.747	0.771	0.812	0.812
1995	0.157	0.330	0.684	0.723	0.575	0.800	0.800
1996	0.115	0.355	0.531	0.510	0.790	1.059	1.059
1997	0.185	0.516	0.673	0.577	0.685	0.782	0.782
1998	0.212	0.396	0.738	0.606	0.429	0.778	0.778
1999	0.131	0.393	0.638	0.746	0.744	0.565	0.565
2000	0.273	0.480	0.767	0.723	0.550	0.496	0.496
2001	0.220	0.509	0.654	0.579	0.535	0.571	0.571
2002	0.249	0.526	0.809	1.018	0.968	0.765	0.765
2003	0.204	0.478	0.443	0.416	0.616	0.767	0.767
2004	0.237	0.381	0.436	0.292	0.370	0.433	0.433
2005	0.263	0.356	0.438	0.551	0.518	0.423	0.423
2006	0.228	0.464	0.471	0.395	0.450	0.513	0.513
2007	0.265	0.535	0.485	0.420	0.410	0.542	0.542
2008	0.201	0.535	0.572	0.442	0.480	0.503	0.503
2009	0.093	0.369	0.452	0.586	0.562	0.500	0.500
2010	0.094	0.344	0.625	0.447	0.334	0.270	0.270
2011	0.081	0.317	0.677	0.302	0.327	0.286	0.286
2012	0.104	0.338	0.411	0.664	0.486	0.185	0.185

	2	3	4	5	6	7	8
2013	0.193	0.32	0.444	0.548	0.509	0.218	0.218
2014	0.260	0.394	0.289	0.506	0.607	0.511	0.511
2015	0.161	0.347	0.344	0.562	0.496	0.652	0.652
2016	0.074	0.297	0.454	0.372	0.370	0.533	0.533
2017	0.098	0.309	0.287	0.278	0.292	0.479	0.479
2018	0.122	0.311	0.317	0.364	0.365	0.355	0.355
2019	0.135	0.347	0.391	0.326	0.362	0.381	0.381
2020	0.22	0.38	0.51	0.35	0.28	0.24	0.24

Table 7.7. Bay of Biscay sole in divisions 8.a and 8.b, stock number-at-age (start of year). Numbers*10 −3.**

	2	3	4	5	6	7	8
1984	24146	15402	10263	7273	4471	3246	4342
1985	29505	16235	10927	6636	4646	2939	3017
1986	28293	18619	10309	7529	4139	3342	3939
1987	24882	19774	12844	6785	4624	2307	2378
1988	26717	18905	12533	8218	4232	2774	2422
1989	28114	19455	11467	7353	5255	2509	1289
1990	32062	20761	11372	6759	3660	2809	2390
1991	35677	22236	12781	6083	3421	2387	2191
1992	35306	27942	14126	7273	3522	2037	1710
1993	24865	27532	18359	8101	3736	1060	1317
1994	26171	20694	17477	10069	3848	1834	1307
1995	23542	21204	13491	7441	4316	1610	1870
1996	29349	18211	13800	6161	3266	2198	2103
1997	23707	23676	11551	7341	3346	1341	1688
1998	22581	17836	12787	5334	3729	1527	2295
1999	24379	16536	10859	5529	2633	2197	2368
2000	24968	19347	10098	5193	2374	1132	1189
2001	16909	17192	10833	4245	2281	1239	1168
2002	24755	12275	9346	5095	2152	1209	843

	2	3	4	5	6	7	8
2003	24329	17455	6563	3765	1666	740	487
2004	17007	17949	9792	3812	2246	814	993
2005	18064	12144	11090	5730	2577	1404	1541
2006	18247	12563	7693	6479	2988	1389	4009
2007	17533	13148	7148	4348	3948	1724	2366
2008	18346	12169	6969	3980	2585	2372	3158
2009	33751	13582	6451	3560	2314	1446	2555
2010	24517	27818	8498	3713	1794	1194	1258
2011	20557	20202	17840	4114	2149	1162	2175
2012	13840	17158	13312	8202	2753	1403	3217
2013	13833	11285	11074	7989	3820	1533	3395
2014	17300	10317	7415	6427	4180	2077	1364
2015	17880	12070	6293	5027	3508	2061	1388
2016	16967	13771	7721	4038	2592	1933	2197
2017	16758	14264	9256	4435	2518	1620	2608
2018	15900	13744	9474	6284	3039	1702	3270
2019	9109	12735	9110	6245	3952	1908	2714
2020	7986	7204	8143	5577	4077	2489	4789

Table 7.8. Summary of sole in the Bay of Biscay.

Year	Recruits (in thousands)	SSB (in t)	Landings (in t)	Mean F (age 3–6)
1984	24146	12313	4038	0.31
1985	29505	13355	4251	0.31
1986	28293	14462	4805	0.37
1987	24882	15451	5086	0.37
1988	26717	15321	5382	0.4
1989	28114	14421	5845	0.5
1990	32062	14764	5916	0.45
1991	35677	14715	5569	0.42
1992	35306	15909	6550	0.61

Year	Recruits (in thousands)	SSB (in t)	Landings (in t)	Mean F (age 3–6)
1993	24865	16308	6420	0.53
1994	26171	15773	7229	0.65
1995	23542	14169	6205	0.58
1996	29349	13743	5854	0.55
1997	23707	13256	6259	0.61
1998	22581	13176	6027	0.54
1999	24379	12277	5249	0.63
2000	24968	11794	5760	0.63
2001	16909	10536	4836	0.57
2002	24755	9781	5486	0.83
2003	24329	9600	4108	0.49
2004	17007	11096	4002	0.37
2005	18064	11455	4539	0.47
2006	18247	12038	4793	0.44
2007	17533	11031	4363	0.46
2008	18346	10922	4299	0.51
2009	33751	10734	3650	0.49
2010	24517	12633	3966	0.44
2011	20557	14446	4632	0.41
2012	13840	14107	4321	0.47
2013	13833	13245	4235	0.46
2014	17300	10645	3928	0.45
2015	17880	10308	3644	0.44
2016	16967	10757	3232	0.37
2017	16758	13034	3244	0.29
2018	15900	12360	3517	0.34
2019	9109	11564	3400	0.36
2020	7986	10355	3219	0.38

Table 7.9: XSA tuning diagnostics

Fleet = FR-SABLES

Catchability residuals:

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
2	-0.23	-0.14	-0.38	-0.41	-0.09	-0.21	-0.13	-0.04	-0.18	0.19	-0.17	0.22	-0.13
3	0.10	-0.19	0.15	-0.11	-0.18	-0.03	0.20	-0.02	-0.43	0.39	0.06	0.25	0.01
4	0.12	-0.28	-0.10	0.36	0.13	0.01	0.01	0.44	-0.24	0.12	-0.06	0.12	-0.31
5	0.07	-0.17	-0.12	0.22	-0.02	-0.13	-0.25	0.15	0.27	-0.10	-0.29	0.33	-0.19
6	-0.20	0.16	-0.40	0.02	-0.25	0.23	-0.03	-0.40	0.43	-0.03	-0.24	0.34	0.04
7	-0.06	-0.15	-0.26	0.19	0.07	0.49	0.00	0.11	0.54	0.11	-0.19	0.06	0.07

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
2	0.30	0.49	0.82	0.26	0.15	-0.31	NA	NA	NA	NA	NA	NA	NA	NA
3	-0.30	-0.18	0.00	-0.02	0.16	0.14	NA	NA	NA	NA	NA	NA	NA	NA
4	-0.19	-0.16	-0.47	0.07	0.36	0.06	NA	NA	NA	NA	NA	NA	NA	NA
5	-0.51	0.24	-0.74	0.34	0.34	0.57	NA	NA	NA	NA	NA	NA	NA	NA
6	-0.36	0.14	-0.53	0.27	0.34	0.46	NA	NA	NA	NA	NA	NA	NA	NA
7	-0.12	0.05	-0.17	0.69	0.37	0.34	NA	NA	NA	NA	NA	NA	NA	NA

Mean log catchability and standard error of ages with
independant of year class strength and constant w.r.t time:

	2	3	4	5	6	7
Mean log q	-15.0660	-14.5115	-14.4653	-14.6451	-14.6388	-14.6388
S.E. log q	0.3169	0.2008	0.2415	0.3276	0.3067	0.2896

Regression Statistics:

	Model used?	slope	Intercept	RSquare	Num Pts	Reg s.e	Mean Q
2	"No"	"5.74"	"38.76"	"0.03"	"19"	"1.46"	"-15.07"
3	"No"	"1.04"	"14.68"	"0.63"	"19"	"0.21"	"-14.51"
4	"No"	"0.87"	"13.81"	"0.7"	"19"	"0.21"	"-14.47"
5	"No"	"1.23"	"16.03"	"0.35"	"19"	"0.41"	"-14.65"
6	"No"	"1.45"	"17.64"	"0.27"	"19"	"0.44"	"-14.64"
7	"No"	"0.73"	"12.57"	"0.8"	"19"	"0.18"	"-14.53"

Fleet = FR-ROCHELLE

Catchability residuals:

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
2	-0.09	-0.18	-0.46	-0.40	-0.04	0.32	-0.06	0.19	-0.03	0.19	-0.24	0.70	0.16
3	0.19	-0.05	-0.02	-0.22	-0.12	0.05	0.11	-0.11	-0.50	-0.28	-0.09	0.18	0.23
4	0.44	0.12	-0.22	0.29	0.30	-0.15	-0.08	0.47	-0.26	-0.12	0.13	-0.33	-0.08
5	0.45	0.16	-0.09	0.18	0.21	-0.36	-0.36	0.00	0.18	-0.18	-0.07	-0.07	-0.08
6	0.11	0.33	-0.26	0.11	-0.36	-0.12	-0.02	-0.54	0.52	-0.29	0.08	-0.02	0.10
7	0.01	0.07	-0.02	0.00	-0.05	-0.08	-0.09	0.03	0.23	-0.19	0.15	-0.10	-0.24

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
2	0.37	0.13	0.00	0.07	0.21	-0.83	NA	NA	NA	NA	NA	NA	NA	NA
3	-0.09	-0.38	-0.24	0.59	0.59	0.15	NA	NA	NA	NA	NA	NA	NA	NA
4	-0.23	-0.21	-0.29	-0.17	0.38	0.02	NA	NA	NA	NA	NA	NA	NA	NA
5	-0.49	0.32	-0.29	-0.27	0.29	0.46	NA	NA	NA	NA	NA	NA	NA	NA
6	-0.22	0.39	-0.04	-0.24	0.15	0.32	NA	NA	NA	NA	NA	NA	NA	NA
7	-0.02	0.18	-0.02	-0.17	0.24	0.20	NA	NA	NA	NA	NA	NA	NA	NA

Mean log catchability and standard error of ages with
independant of year class strength and constant w.r.t time:

	2	3	4	5	6	7
Mean log q	-15.0003	-14.5528	-14.7682	-15.1189	-15.1756	-15.1756
S.E. log q	0.3381	0.2867	0.2634	0.2836	0.2781	0.1418

Regression Statistics:

	Model used?	slope	Intercept	RSquare	Num Pts	Reg s.e	Mean Q
2	"No"	"1.98"	"19.84"	"0.13"	"19"	"0.64"	"-15"
3	"No"	"1.27"	"15.84"	"0.36"	"19"	"0.37"	"-14.55"
4	"No"	"0.84"	"13.91"	"0.68"	"19"	"0.22"	"-14.77"

```
5 "No"        "0.96" "14.86"   "0.53"  "19"    "0.28"  "-15.12"
6 "No"        "1.62" "19.65"   "0.28"  "19"    "0.43"  "-15.18"
7 "No"        "0.84" "13.89"   "0.91"  "19"    "0.11"  "-15.17"


Fleet =  FR-BB-IN-Q4

 Catchability residuals:

   2000  2001  2002  2003 2004  2005  2006  2007  2008  2009  2010  2011 2012
3  0.40 -0.25  0.40  0.82 0.38 -0.14  0.08  0.12  0.27 -0.02 -0.11 -0.37 0.26
4  0.46 -0.45 -0.63  0.19 0.40  0.17 -0.44  0.27  0.62 -0.30  0.44 -0.06 0.55
5  0.08 -0.35 -0.13 -0.73 0.50  0.23 -0.51  0.24  0.21 -0.01  0.16 -0.06 0.81
6 -0.46 -0.02  0.58 -0.34 0.83 -0.02  0.04  0.04 -0.01  0.13 -0.47 -0.18 0.03
7 -0.19 -0.10  0.55  0.28 0.23 -0.14  0.46 -0.52 -0.20 -0.32 -0.86 -0.42 0.02
   2013  2014  2015  2016  2017  2018  2019  2020
3 -0.33  0.09 -0.20 -0.10  0.09 -0.85 -0.55  0.00
4  0.13 -0.48 -0.27 -0.32 -0.21 -0.40  0.03  0.31
5 -0.15 -0.24  0.15  0.10 -0.55 -0.02  0.05  0.22
6  0.33 -0.12 -0.12  0.00 -0.03  0.02 -0.13 -0.13
7 -0.01 -0.66  0.16 -0.38  0.15 -0.05  0.27 -0.12


 Mean log catchability and standard error of ages with
 independant of year class strength and constant w.r.t time:

                  3        4        5        6        7
Mean log q -14.5909 -14.9661 -15.1649 -15.0662 -15.0662
S.E. log q   0.3694   0.3873   0.3532   0.3000   0.3714


 Regression Statistics:

  Model used? slope  Intercept RSquare Num Pts Reg s.e Mean Q
3 "No"        "0.86" "13.89"   "0.44"  "21"    "0.32"  "-14.59"
4 "No"        "0.84" "14.01"   "0.39"  "21"    "0.33"  "-14.97"
5 "No"        "0.83" "14.04"   "0.43"  "21"    "0.3"   "-15.16"
6 "No"        "0.93" "14.58"   "0.48"  "21"    "0.29"  "-15.07"
7 "No"        "1.36" "18.01"   "0.3"   "21"    "0.49"  "-15.15"



Fleet =  FR-BB-OFF-Q2

 Catchability residuals:

   2000  2001 2002  2003  2004  2005  2006  2007  2008  2009  2010  2011  2012
2  0.42  0.46 0.89  0.94  0.44  0.39 -0.25  0.56  0.93 -1.68 -1.43 -1.96  0.28
3 -0.44 -0.14 0.21  0.16  0.19 -0.18 -0.18  0.79  0.41 -0.10  0.00 -0.71 -0.01
4  0.35  0.23 0.13 -0.02 -0.07 -0.02 -0.65 -0.37  0.05 -0.19  0.29  0.44 -0.18
5  0.72  0.45 0.79 -0.20 -0.93  0.26 -0.56 -0.98  0.02 -0.10  0.36 -0.33  0.52
6  0.70  1.13 1.35  0.39 -0.52 -0.76  0.32 -0.01 -0.77 -0.35 -1.31  0.18 -0.34
  2013 2014 2015 2016 2017
2   NA   NA   NA   NA   NA
3   NA   NA   NA   NA   NA
4   NA   NA   NA   NA   NA
5   NA   NA   NA   NA   NA
6   NA   NA   NA   NA   NA


 Mean log catchability and standard error of ages with
 independant of year class strength and constant w.r.t time:

                  2        3        4        5        6
Mean log q -15.9002 -14.4985 -14.7267 -15.3321 -15.8530
S.E. log q   1.0181   0.3753   0.3036   0.5853   0.7784


 Regression Statistics:

  Model used? slope   Intercept RSquare Num Pts Reg s.e Mean Q
2 "No"        "-1.33" "1.95"    "0.04"  "13"    "1.3"   "-15.9"
3 "No"        "2.29"  "20.7"    "0.09"  "13"    "0.82"  "-14.5"
4 "No"        "0.67"  "12.86"   "0.74"  "13"    "0.18"  "-14.73"
```

```
5 "No"        "0.58"  "12.43"   "0.38"  "13"    "0.34"  "-15.33"
6 "No"        "1.07"  "16.4"    "0.06"  "13"    "0.87"  "-15.85"


Fleet =  FR-ORHAGO

 Catchability residuals:

   2007  2008  2009  2010  2011  2012  2013  2014  2015  2016  2017  2018  2019
2  0.06 -0.29  0.34 -0.24 -0.01 -0.43 -0.41  0.42  0.13  0.08 -0.01  0.15  0.24
3  0.11  0.20  0.27  0.04 -0.40  0.08 -0.22 -0.06 -0.17  0.36  0.19 -0.15 -0.10
4  0.13  0.01 -0.18 -0.23 -0.52  0.15  0.48 -0.06 -0.04 -0.01  0.00  0.02  0.23
5  0.40 -0.80 -0.46 -1.26 -1.30  0.38  0.38  0.51  0.53  0.64  0.18  0.51  0.24
6  0.29 -0.61 -0.67 -3.51 -0.92  0.19  0.96  1.12  0.96  0.59  0.97  0.54  0.22
7 -1.20 -0.34 -2.04 -0.96 -0.12  0.10  0.40  0.82  0.90  0.47  0.99  1.02  0.48
   2020
2 -0.03
3 -0.14
4  0.04
5  0.04
6 -0.14
7 -0.14


 Mean log catchability and standard error of ages with
 independant of year class strength and constant w.r.t time:

                2       3       4        5        6        7
Mean log q -9.0337 -9.4154 -9.7797 -10.1951 -10.4993 -10.4993
S.E. log q  0.2624  0.2133  0.2297   0.6726   1.2043   0.9113


 Regression Statistics:

  Model used? slope  Intercept RSquare Num Pts Reg s.e Mean Q
2 "No"        "0.91" "9.1"     "0.7"   "14"    "0.25"  "-9.03"
3 "No"        "0.97" "9.42"    "0.7"   "14"    "0.21"  "-9.42"
4 "No"        "1.14" "9.88"    "0.56"  "14"    "0.27"  "-9.78"
5 "No"        "0.41" "9.22"    "0.6"   "14"    "0.24"  "-10.2"
6 "No"        "0.25" "8.61"    "0.62"  "14"    "0.22"  "-10.5"
      7 "No"        "0.45" "8.8"     "0.27"  "14"    "0.4"   "-10.47"
```

Table 7.10. Short-term forecasts input parameters.

Variable	Value	Notes
$F_{age\ 3–6}$ (2021)	0.38	Average selection pattern from 2018 to 2020, scaled to the F of 2020.
SSB (2022)	8 934	Assessment forecast; in tonnes.
$R_{age\ 2}$ (2021–2022)	12 688	Geometric mean (2016–2020); in thousands.
Landings (2021)	3 219	Total catch in 2020 without discards; in tonnes.
Discards (2021)	77	Computed using the average discard ratio (2.4%) over 2015–2020 but not used in the assessment; in tonnes.

Table 7.11. Management options table. Annual catch scenarios (all weights are in tonnes).

Basis	Total catch* (2022)	Wanted catch** (2022)	Unwanted catch** (2022)	F_{wanted} (2022)	SSB (2023)	% SSB change ^	% TAC change ^^	% Advice change^ ^^
ICES advice basis								
EU MAP # : F = F_{MSY} × SSB_{2022}/MSY $B_{trigger}$	2233	2180	53	0.28	9372	+5%	−36%	−36%
F = MAP F = F_{MSY} lower × SSB_{2022}/MSY $B_{trigger}$	1265	1235	30	0.15	10359	+16%	−38%	−38%
F = MAP F = F_{MSY} upper × SSB_{2022}/MSY $B_{trigger}$	3097	3023	74	0.41	8493	−5%	−36%	−36%
Other scenarios								
MSY approach = F_{MSY}	2578	2516	62	0.33	9022	+1%	−26%	−26%
F = 0	0	0	0	0	11647	+30%	−100%	−100%
F_{pa}	5522	5390	132	0.88	6046	−32%	+59%	+59%
F_{lim} (not applicable)								
SSB_{2023} = B_{lim}	3979	3884	95	0.56	7600	−15%	+14%	+14%
SSB_{2023} = B_{pa} = MSY $B_{trigger}$	1028	1004	24	0.12	10600	+18%	−70%	−70%
SSB_{2023} = SSB_{2022}	2663	2600	63	0.34	8934	0%	−24%	−24%
F = F_{2021}	2907	2837	70	0.38	8687	−3%	−17%	−17%
Projected landings ** = TAC_{2021}	3569	3483	86	0.49	8016	−10%	+2%	+2%
Total catch equal to TAC_{2021}	3483	3399	84	0.47	8098	−9%	0%	0%

*** Total catch is calculated based on projected landings and the assumed projected discard ratio (2.4%).**

**** "Projected landings" and "projected discards" are used to describe fish that would be landed and discarded based on the average discard rate estimate of 2015–2019 (2.4%).**

 # The EU multiannual plan (MAP; EU, 2019).

^ SSB_{2023} relative to SSB_{2022}.

^^ Total catch in 2022 relative to TAC in 2021 (3483 t).

^^^ Advice values for 2022 relative to the corresponding 2021 values (MAP advice of 3483, 2036, and 4814 t, respectively; other values are relative to F_{MSY}).

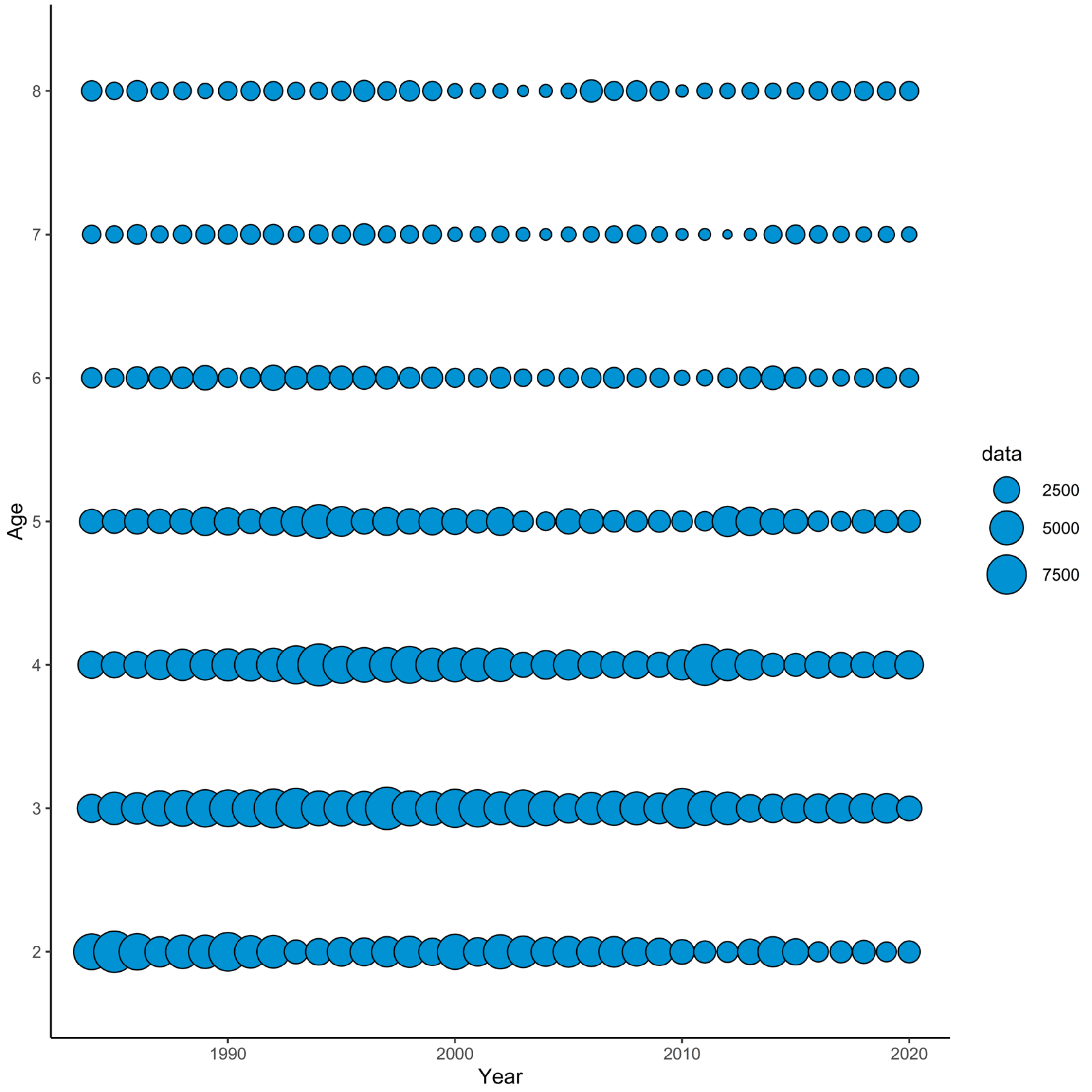

Figure 7.1.Bay of Biscay sole in divisions 8.a and 8.b, landings-at-age distributions.

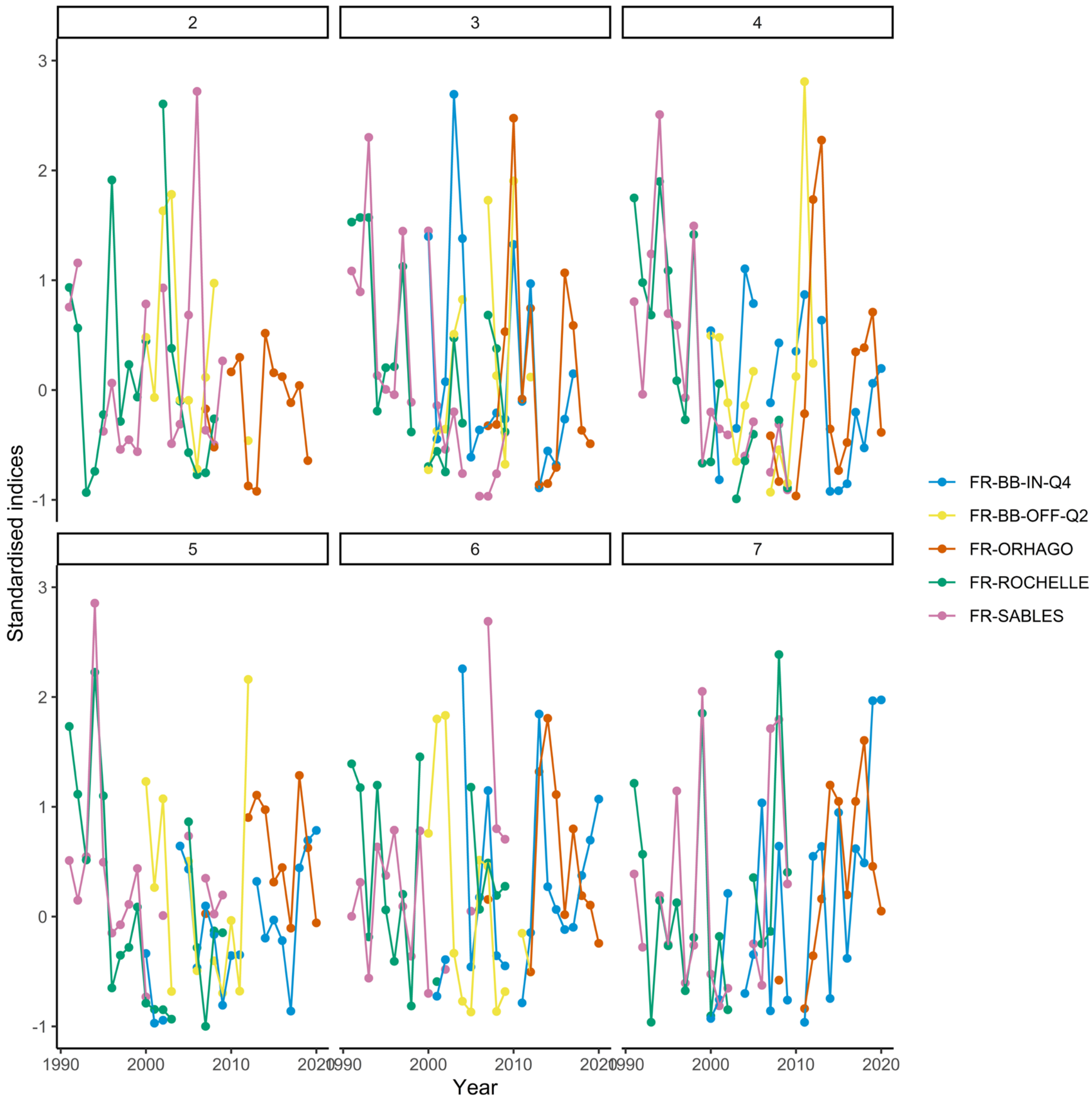

Figure 7.2.Time-series of standardized indices per age-classes. Colours represent tuning fleets.

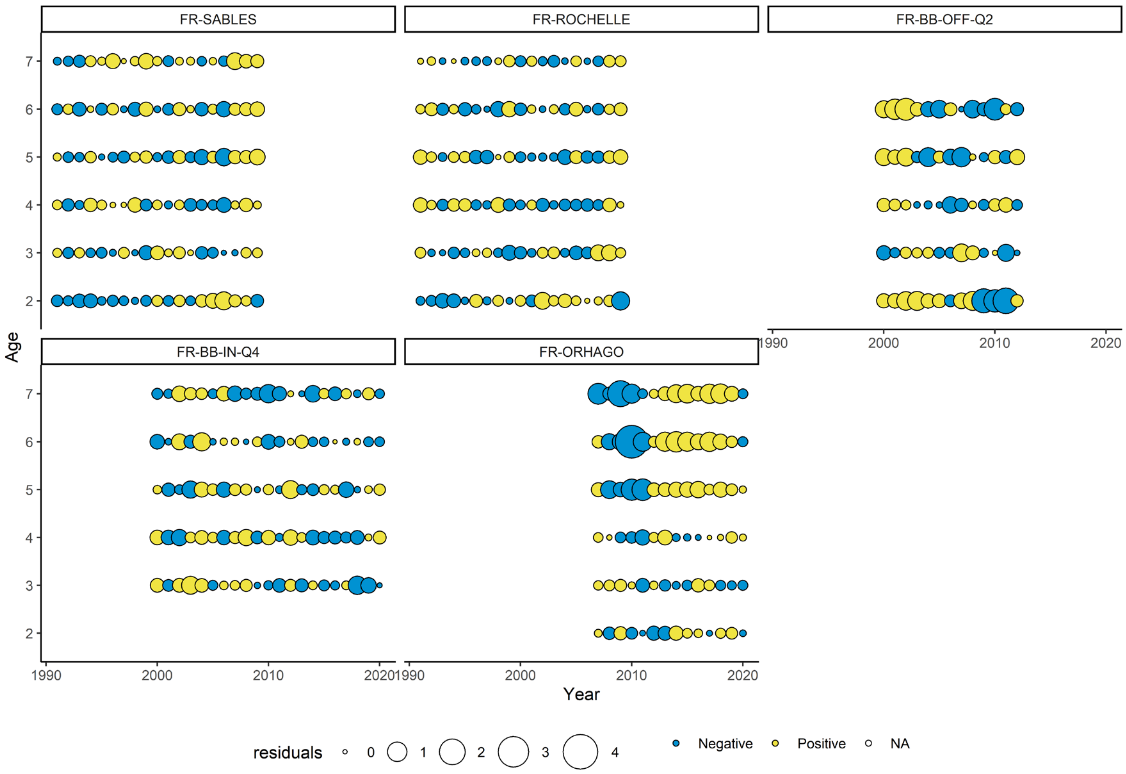

Figure 7.3.Bay of Biscay sole in divisions 8.a and 8.b, XSA assessment residuals (No Taper, mean q, s.e. shrink = 2.5, s.e. min = 2).

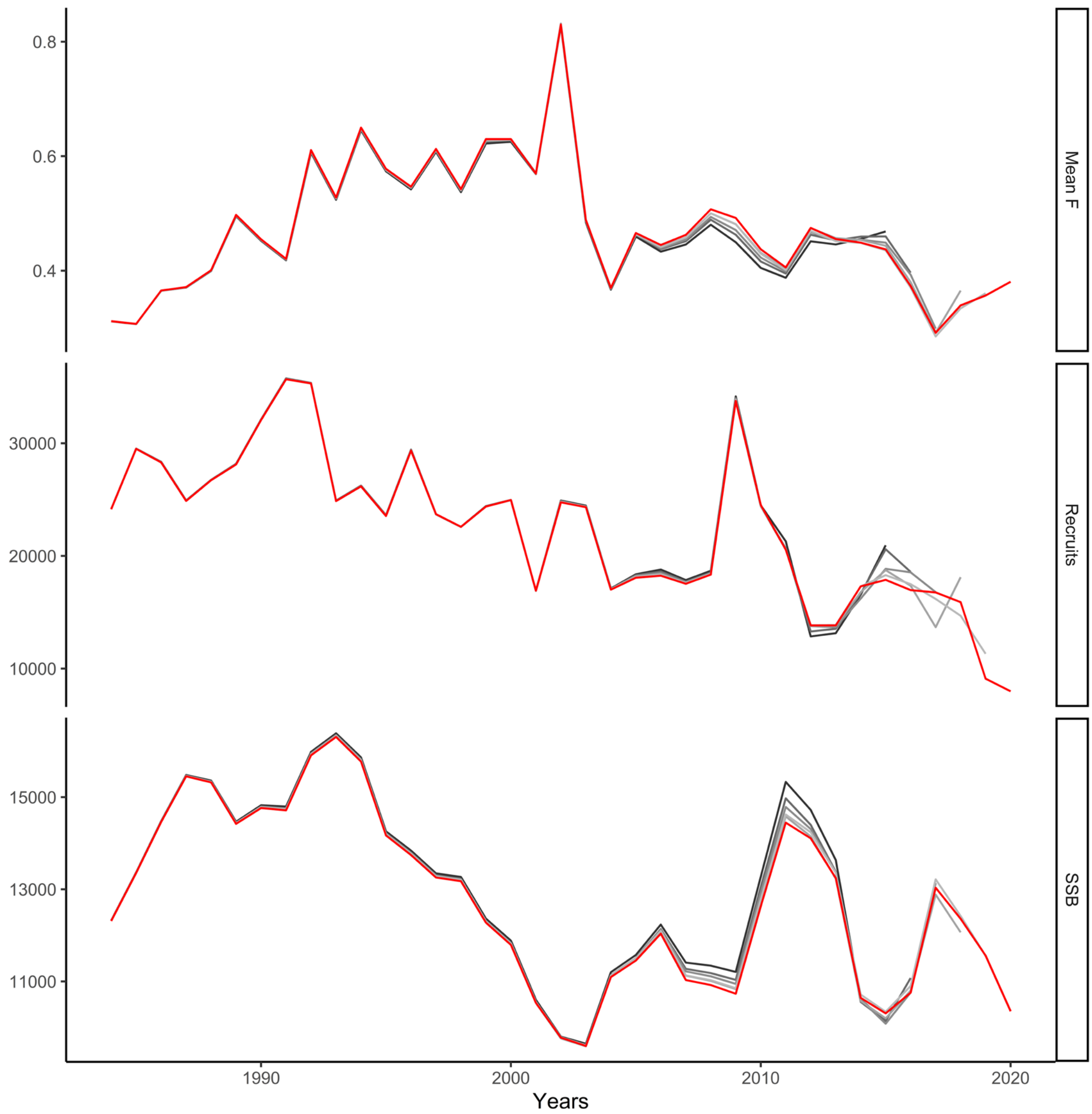

Figure 7.4. Bay of Biscay sole in divisions 8.a and 8.b. Retrospective patterns (No taper, q indep. stock size all ages, q indep. of age > = 6, shr. = 1.5).

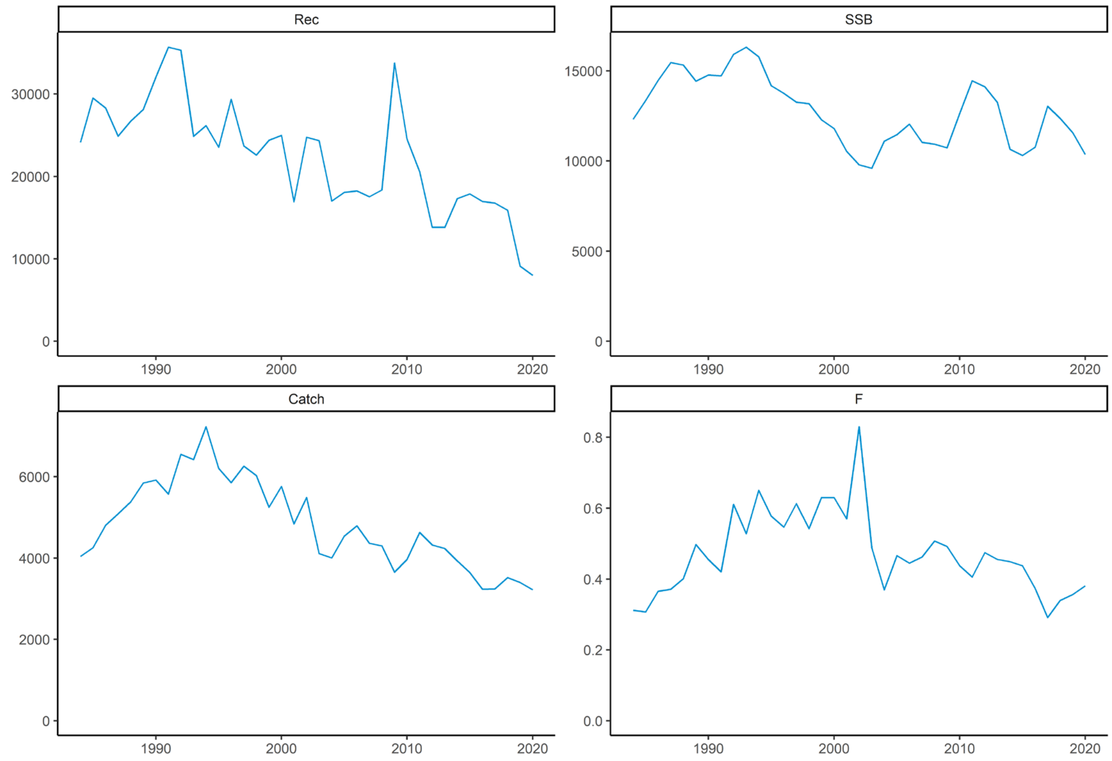

Figure 7.5. Bay of Biscay sole in divisions 8.a and 8.b. Trends for landings, F, recruitment, SSB and total catch data.

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

Solea solea – sol.27.8c9a

8.1 General biology

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

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

8.2 Stock identity and possible assessment areas

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

8.3 Management regulations (TACs, minimum landing size)

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

Management of all sole species is made under a combined species TAC which prevents effective control of the single-species exploitation rates and could lead to the overexploitation of either species. For the period 2011–2020, *Solea solea* represented on average 56% of the total catches of sole species, while *Solea senegalensis* represented on average 24%, *Pegusa lascaris* 19%, and *Solea spp.* only 1% (Table 8.3.1).

8.4 Fisheries data

Table 8.4.1 presents common sole catches for divisions 8.c and 9.a., as well as landings for the other sole species (*S. senegalensis, Pegusa lascaris,* and *Solea spp.*). Discards are considered negligible (< 1%) and therefore, from there on, the words catch or landings can be used indistinctly.

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

Reviewed catches reported in InterCatch are now available from 2009 to 2020 by Spain and France and from 2011 to 2020 by Portugal (Figure 8.4.1). Information on discards indicates that discarding can be considered negligible (< 1%) (Figure 8.4.2). Presently, only damaged specimens are discarded, while specimens under the minimum conservation reference size are landed under the landing obligation (in negligible numbers).

The majority of catches are from ICES Division 9.a (Figure 8.4.3). The two main fleets that fish this stock are the polyvalent fleet from Portugal (i.e. "MIS_MIS_0_0_0") and the trammelnet fleet from Spain (i.e. "GRT_DEF_60-79_0_0") (Figure 8.4.4). The distribution of the catches is almost homogenous along the year for the two main countries (i.e. Portugal and Spain), as well as for the main fleets.

In InterCatch, data on length-frequency distribution are available for the years 2011–2020 (Figure 8.4.5). The majority of the data are from the polyvalent fleet (i.e. métier "MIS_MIS_0_0_0") from Portugal and the distribution seems to be homogeneous in the last years. Market sampling in Portuguese ports during 2020 was affected by the COVID-19 pandemic, resulting in the sampling suspension during the period March-June and resumption after that. In order to overcome the decrease in the amount of data collected by the National sampling program PNAB/DCF, samples were collected under the Project "Pequena Pesca na Costa Ocidental Portuguesa - PPCENTRO" (ref: MAR-01.03.02-FEAMP-0007) were also used to estimate landings by species and length frequency distribution.

For the WKWEST benchmark an official data call was issued for this stock to get all the possible data, not only for the common sole (*S. solea*) but also for the other sole species, i.e. *Solea senegalensis, Pegusa lascaris,* and *Solea spp.* (Figure 8.4.6) due to misassignment problems identified in official statistics.

During the benchmark, Spanish landings of *S. senegalensis, P. lascaris* and *Solea spp*. were available for the period 2009–2019, while from Portugal for 2011 to 2019. No French data on these species were available.

For Portugal, as for the catches of *S.solea*, also the catches of *S. senegalensis, P. lascaris* and *Solea spp.* were proportionally split by sole species applying the species weight proportion to the total weight of *Soleidae* in each year, landing port, and semester and using a simple random sampling estimator, following Figueiredo *et al*. (2020) (ICES, 2021).

8.4.1 Survey data, recruit series

Two biomass indices are available for this stock, a standardized commercial Landing Per Unit Effort (LPUE) from Portugal and a standardized biomass index from the Spanish IBTS-Q4 bottom-trawl survey (G2784).

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

Common sole data were collected during the Spanish IBTS-Q4 bottom trawl survey (G2784) performed by the Instituto Español de Oceanografía (IEO) in autumn (September and October) between 2000 and 2020. Surveys were conducted on the northern continental shelf of the Iberian Peninsula (ICES divisions 8.c and the northern part of 9.a) which has a total surface area of almost 18 000 km^2. Surveys were performed using a stratified sampling design based on depth with three depth strata: 70–120 m, 121–200 m, and 201–500 m. Sampling stations consisted of 30 min trawling hauls located within each stratum at the beginning of the design. The gear used is the baka 44/60 and the survey follows the protocol of the International Bottom Trawl Survey Working Group (IBTSWG) of ICES (ICES, 2017).

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

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

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

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

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

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

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

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

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

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

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

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

From this analysis, we obtained a new spatio-temporal abundance index (Figure 8.5.1).

8.4.1.2 Landings Per Unit Effort (LPUE) from Portugal

Portuguese LPUE estimates rely on fishery-dependent data derived from the polyvalent fleet and are based on the estimated *S. solea* landed weight by fishing trip. The analysis was restricted to the most important landing ports in terms of *S. solea* landed weight: Viana do Castelo, Matosinhos, Aveiro, Peniche and Setúbal. The Portuguese polyvalent fleet segment comprises multi-gear/multispecies fisheries, usually licensed to operate with more than one fishing gear (most commonly gill and trammelnets, longlines and traps), that can be deployed in the same trip, targeting different species. The period considered in the present study extends from 2011 to 2020.

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

All the explanatory variables were considered categorical variables. The function "*bestglm*" implemented in R software, used to select the best subset of explanatory variables (McLeod and Xu, 2010), is based on a variety of information criteria and their comparison following a simple exhaustive search algorithm (Morgan and Tatar, 1972). The diagnostic plots, distribution of residuals and the quantile-quantile (Q-Q) plots, were used to assess model fitting. Changes in deviance explained by the selected model and the proportions of deviance explained to the total explained deviance were determined and used as indicative of r2. Finally, annual estimates of LPUE and the corresponding standard error were determined using estimated marginal means with the R package "*emmeans*" (Lenth, 2016, 2020).

The final model explained 86% of the variability and included as explanatory variables the year, the month, the landing port and the vessel size. The final LPUE index is presented in Figure 8.5.2. Finally, it is worth mentioning that sensitivity tests were carried out on this dataset to assess the sensibility of the model to a possible increase or reduction of the weight per trip by 25% for data from 2020. Results highlighted that the model performed well and consequently consistent outputs were obtained with the original dataset.

8.5 Biological sampling

Existing biological sampling is based on fishery data from commercial vessel landings.

8.5.1 Population biology parameters and a summary of other research

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

8.6 Assessment

8.6.1 Length based indicators (LBI) method

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

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

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

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

From the reference model, we can conclude that the stock is exploited at the MSY level and the optimal yield is attained (Table 8.8.1 and Figure 8.8.1). Immature individuals are well preserved whereas the proportion of mega-spawners is low, although it has been increased in the last years.

Finally, the sensitivity analysis shows that (Figure 8.8.2):

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

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

8.6.2 Length-based spawning potential ratio (LBSPR)

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

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

The LFDs are the same used for the LBI method.

The SPR values for this stock vary from a minimum of 0.28 in 2015 to a maximum of 0.41 in 2019 (Figure 8.8.3). The SPR value for 2020 is 0.34. Overall the trend of the SPR is increasing and within the recommended range of 0.30–0.40.

8.6.3 Mean length-based mortality estimators (MLZ)

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

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

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

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

The output from the model indicates that the fishing mortality estimates range from a maximum of 0.38 at the beginning of the time-series (2012) to a minimum of 0.24 in 2013 (Figure 8.8.4). The value of F for 2020 is 0.27. Overall, the F time-series shows a decreasing pattern.

In addition, the Yield-Per-Recruit (YPR) estimations produce a F_{max} of 1.04 and $F_{0.1}$ of 0.32 (Figure 8.8.5).

8.7 General problems

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

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8.9 Tables and figures

Table 8.3.1. Percentage of *S. Solea*, *S. senegalensis*, *Pegusa lascaris* and *Solea spp.* in the total landed weight of sole species from 2009–2020.

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

Table 8.4.1. Catches (in tonnes) of *S. Solea, S. senegalensis, Pegusa lascaris* and Solea spp. from 2009–2020.

Year	*S. solea*	*S. senegalensis*	*P. lascaris*	*Solea spp.*	Total catch
2009*	190				190
2010*	247				247
2011	447	261	206	14	928
2012	354	191	200	14	759
2013	448	171	219	17	855
2014	458	243	156	10	867
2015	521	161	101	5	787
2016	485	126	94	2	707
2017	491	147	107	5	751
2018	431	171	92	5	698
2019	399	186	159	1	745
2020	431	248	183	1	864

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

Table 8.8.1. Traffic light indicator table for the LBI analysis.

	Conservation				Optimizing Yield	MSY
Year	Lc/Lmat	L25%/Lmat	Lmax5%/L∞	Pmega	Lmean/Lopt	Lmean/LF = M
2011	1.10	1.10	0.94	0.13	1.00	0.99
2012	0.83	1.02	0.90	0.17	0.96	1.12
2013	1.02	1.10	0.89	0.14	0.99	1.01
2014	1.02	1.10	0.91	0.15	0.99	1.02
2015	1.06	1.10	0.88	0.12	0.98	0.98
2016	0.87	0.98	0.93	0.17	0.95	1.08
2017	1.10	1.13	0.91	0.15	1.02	1.00
2018	1.02	1.10	0.93	0.18	1.00	1.03
2019	1.13	1.17	0.94	0.23	1.05	1.01
2020	1.06	1.10	0.89	0.20	1.03	1.03

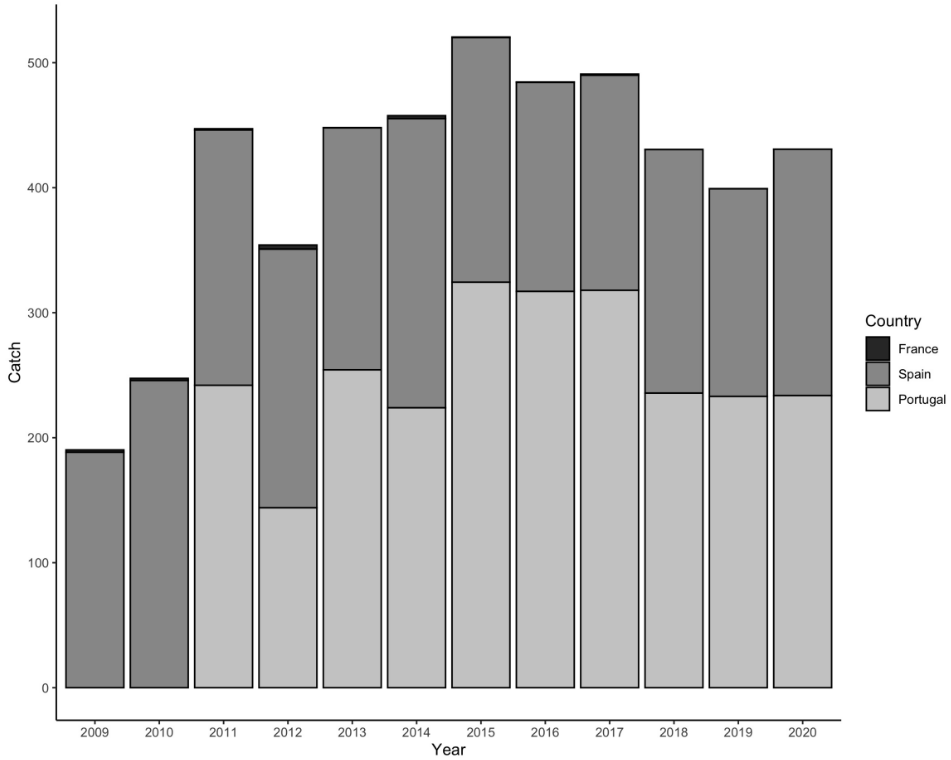

Figure 8.4.1. Catches for *Solea solea* in the ICES divisions 8.c and 9.a by country from 2009 to 2020. Source: InterCatch. Note that in 2009–2010 no Portuguese data were available.

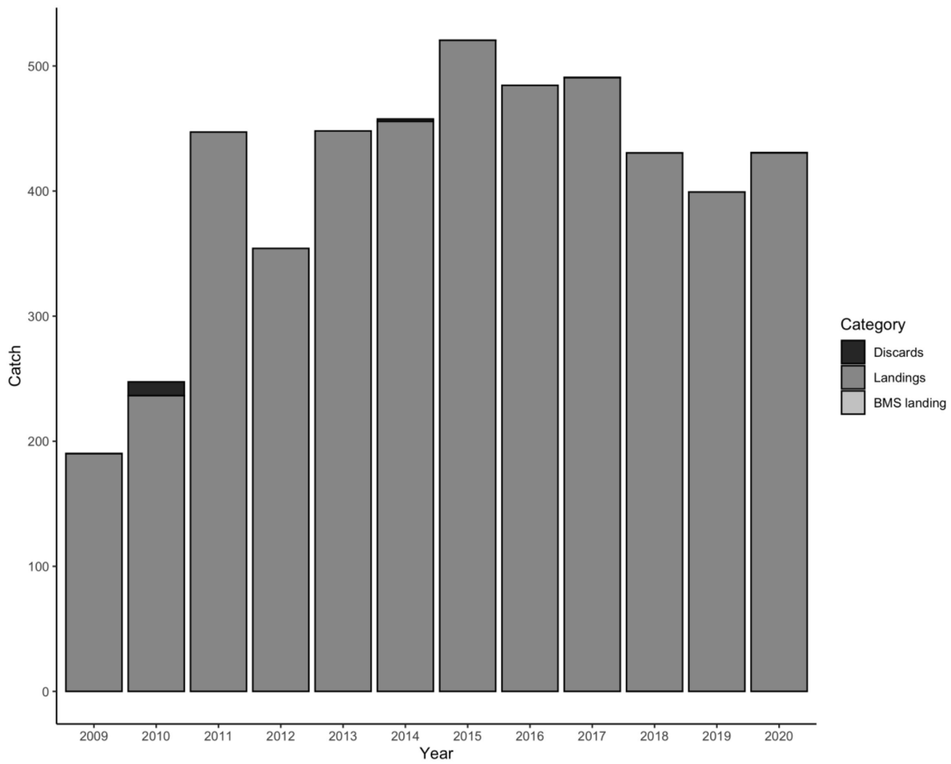

Figure 8.4.2. Catches for *Solea solea* by category (landings, discards, and BMS landing) in the ICES divisions 8.c and 9.a for Spain and France (2009–2020) and Portugal (2011–2020). Source data: InterCatch.

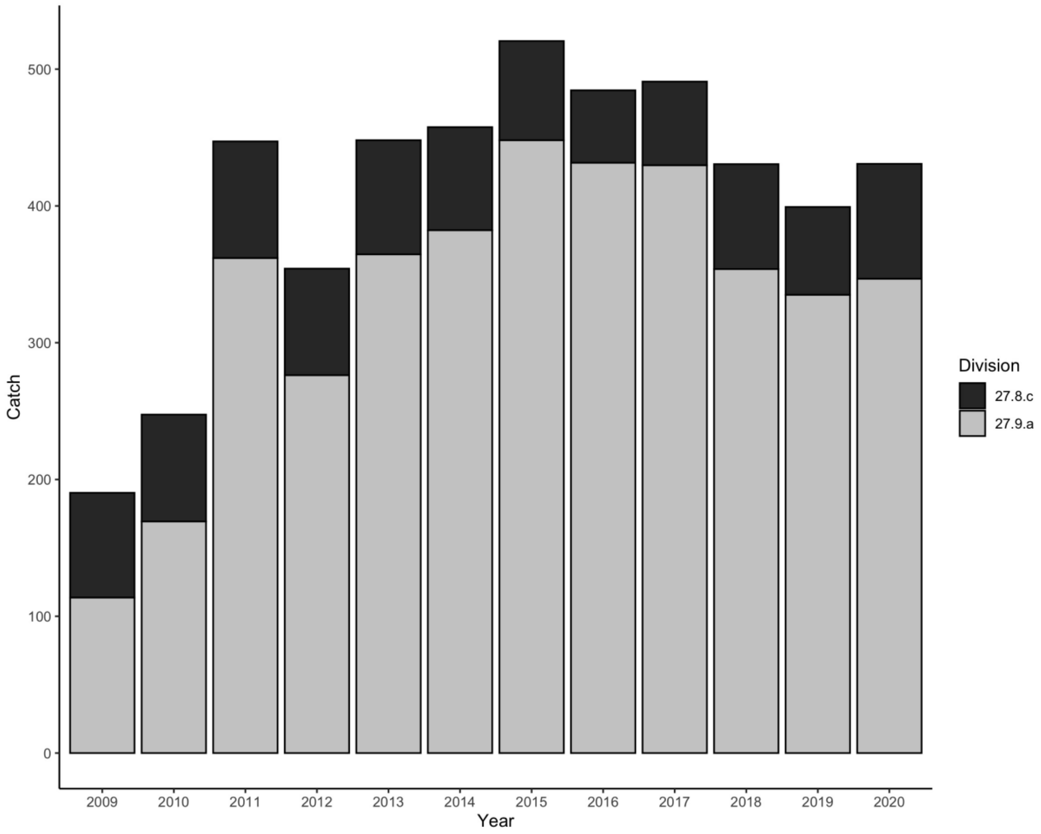

Figure 8.4.3. Catches for *Solea solea* by ICES divisions 8.c and 9.a for Spain and France (2009–2020) and Portugal (2011–2020). Source data: InterCatch.

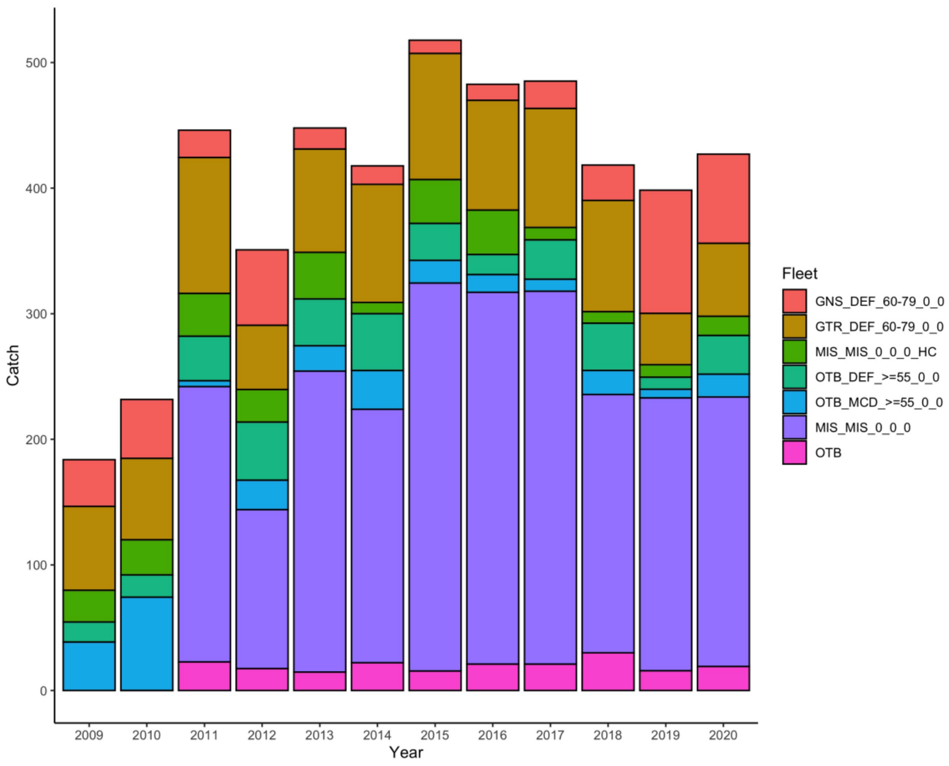

Figure 8.4.4. Catches for *Solea solea* by the main fleet in the ICES divisions 8.c and 9.a for Spain and France (2009–2020) and Portugal (2011–2020). Source data: InterCatch.

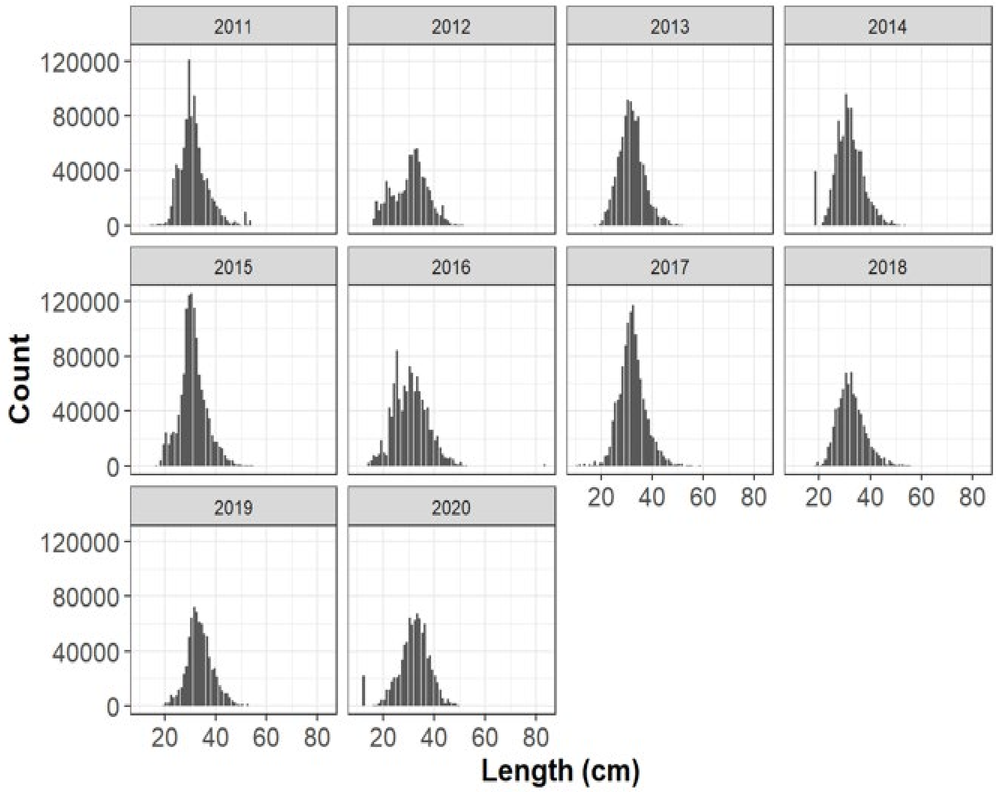

Figure 8.4.5. Annual length frequency distribution of catches for *Solea solea* in the ICES divisions 8.c and 9.a for the period 2011–2020, for Portugal and Spain. Source data: InterCatch.

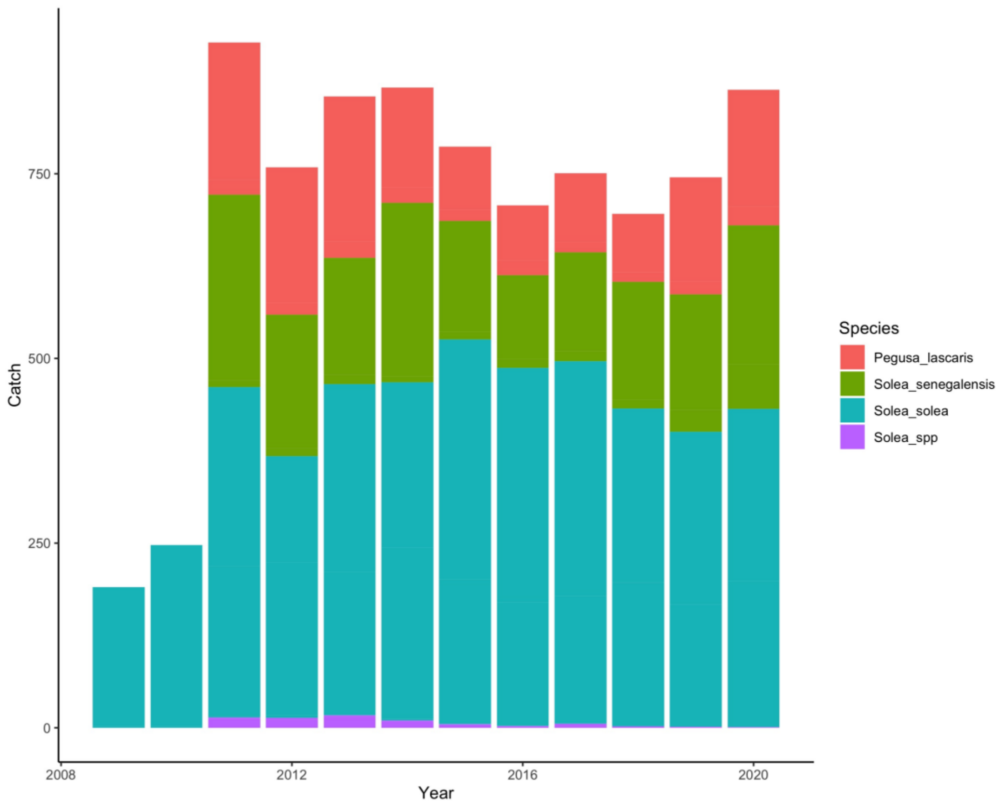

Figure 8.4.6. Sole species landings for divisions 8.c and 9.a. Data are from Spain and Portugal together. Please note that in 2009–2010 no Portuguese data were available.

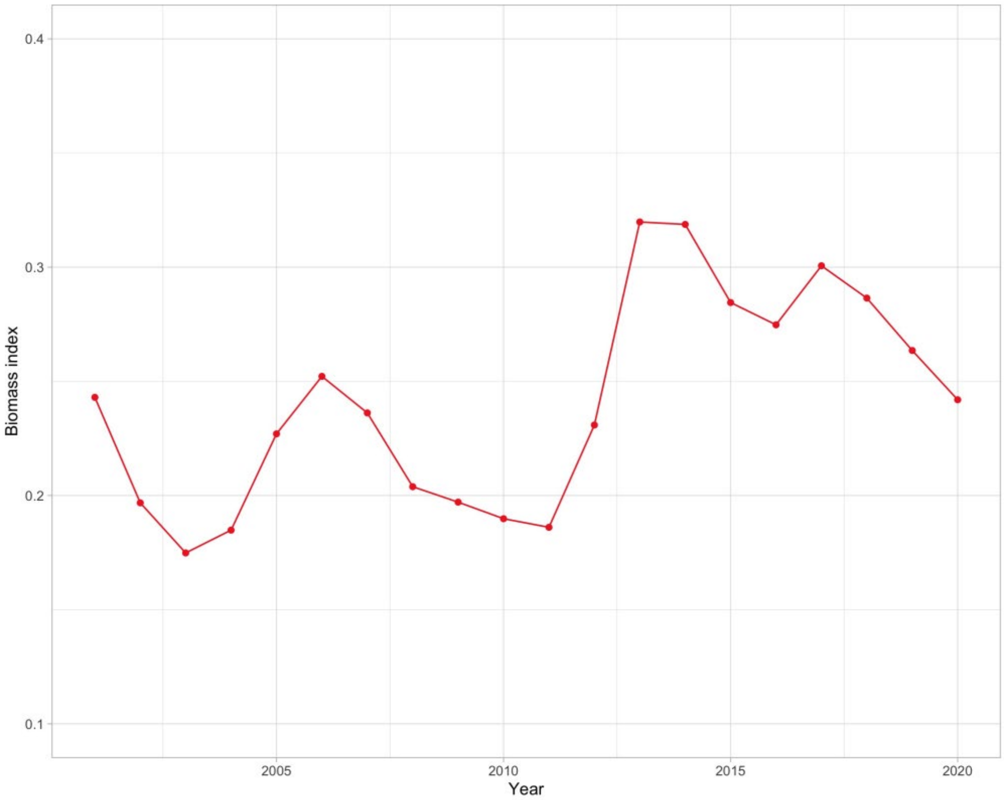

Figure 8.5.1. Temporal trend of the spatio-temporal biomass index for the G2784 for *Solea solea*.

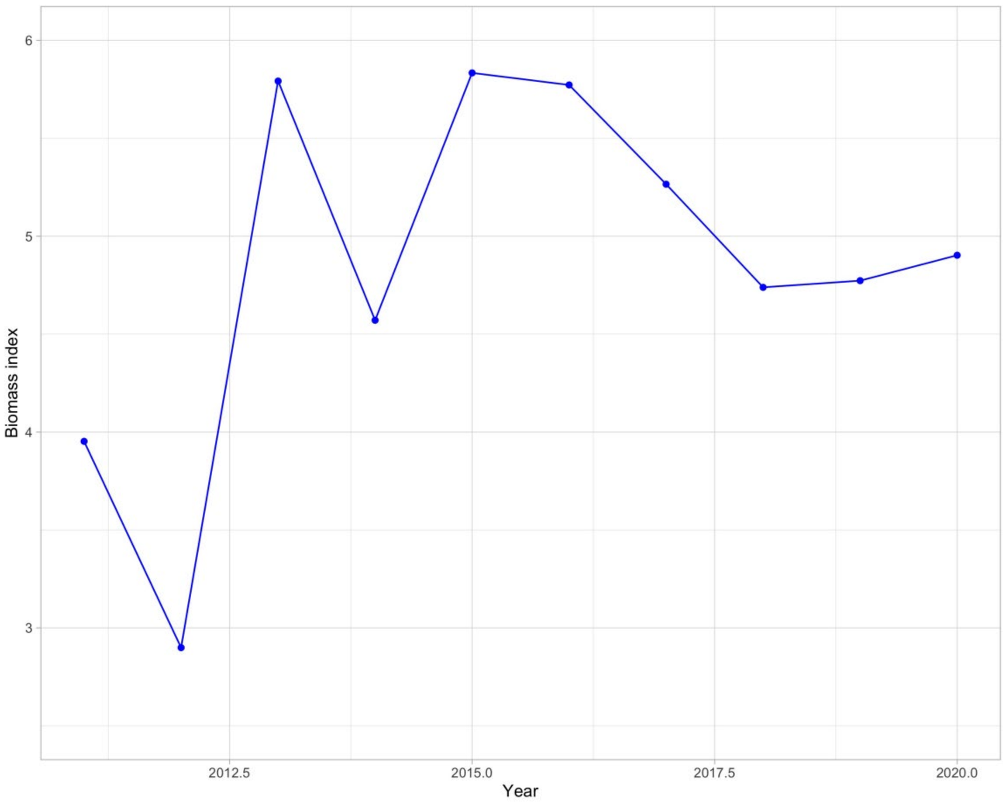

Figure 8.5.2. Standardized commercial LPUE of the Portuguese polyvalent fleet in ICES Subdivision 9.a for *Solea solea* (2011–2020).

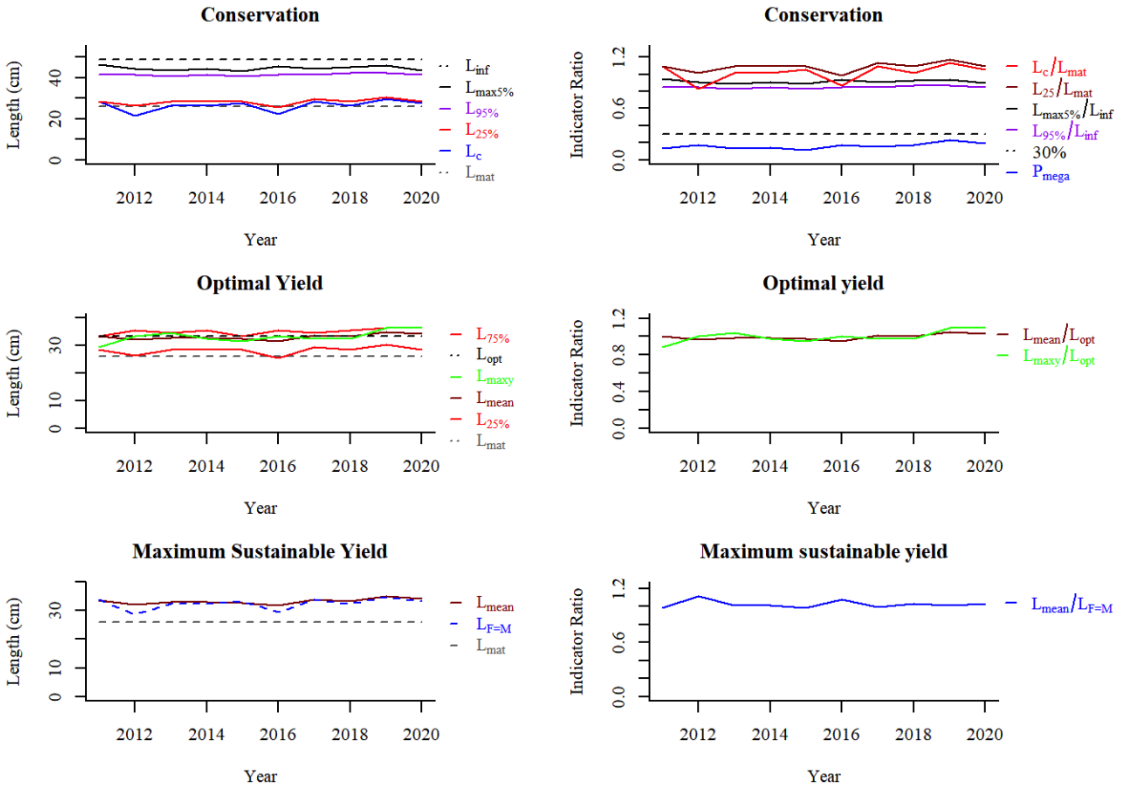

Figure 8.8.1. LBI indicators for *Solea solea* (2011–2020).

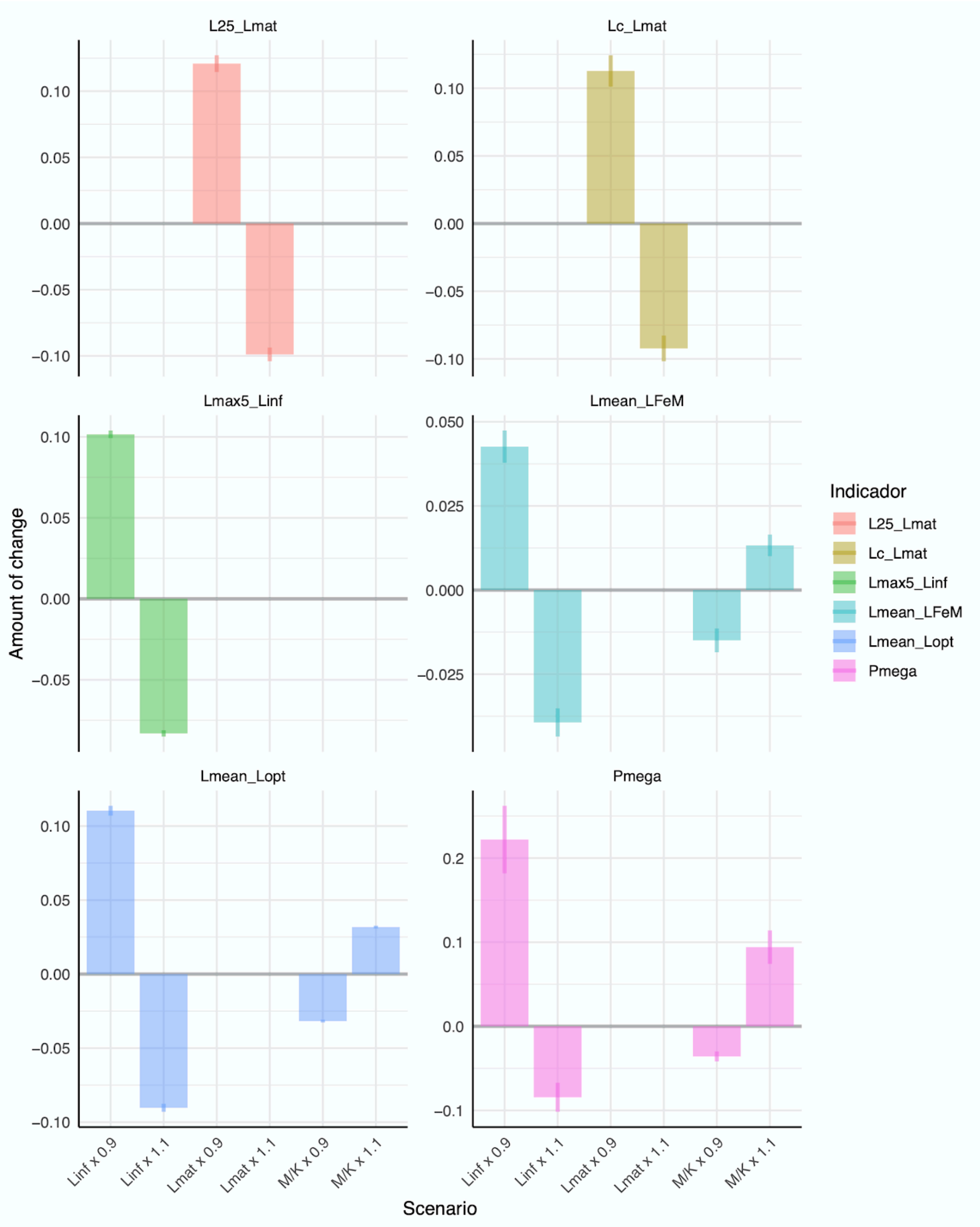

Figure 8.8.2. LBI sensitive analysis using underestimation and overestimation of L_{inf}, M/K and L_{50} parameters with respect the selected model values. The 95% confidence limits are represented through a vertical line.

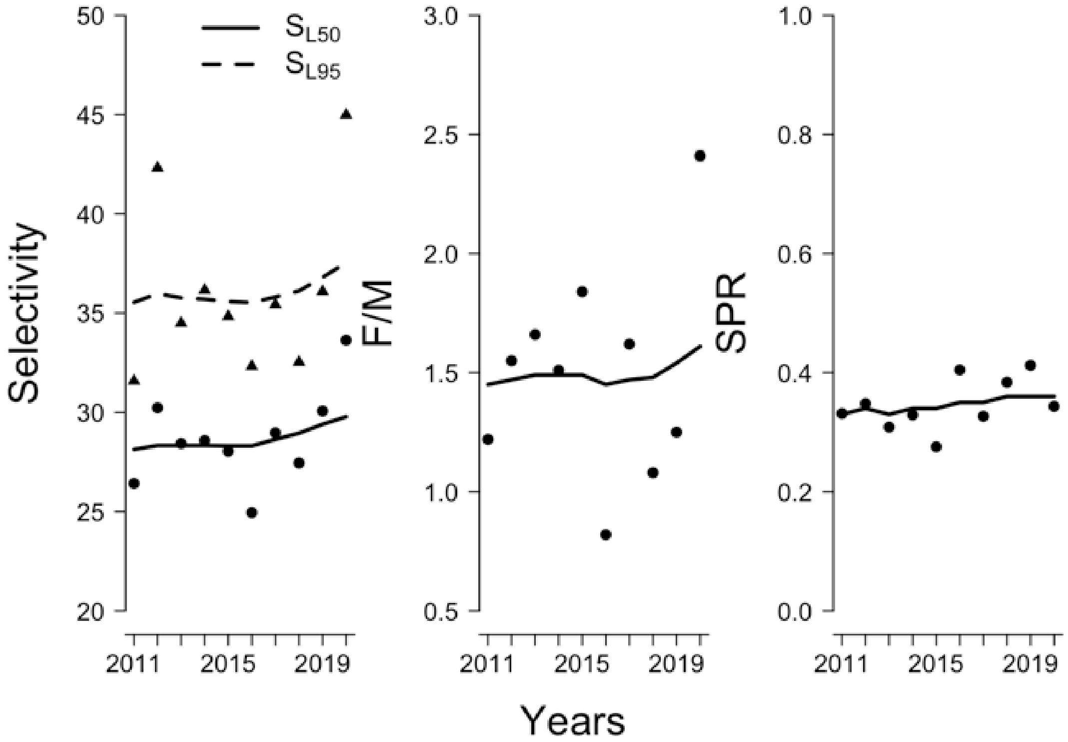

Figure 8.8.3. Results of the LBSPR method applied to *S. solea* in 2011–2020.

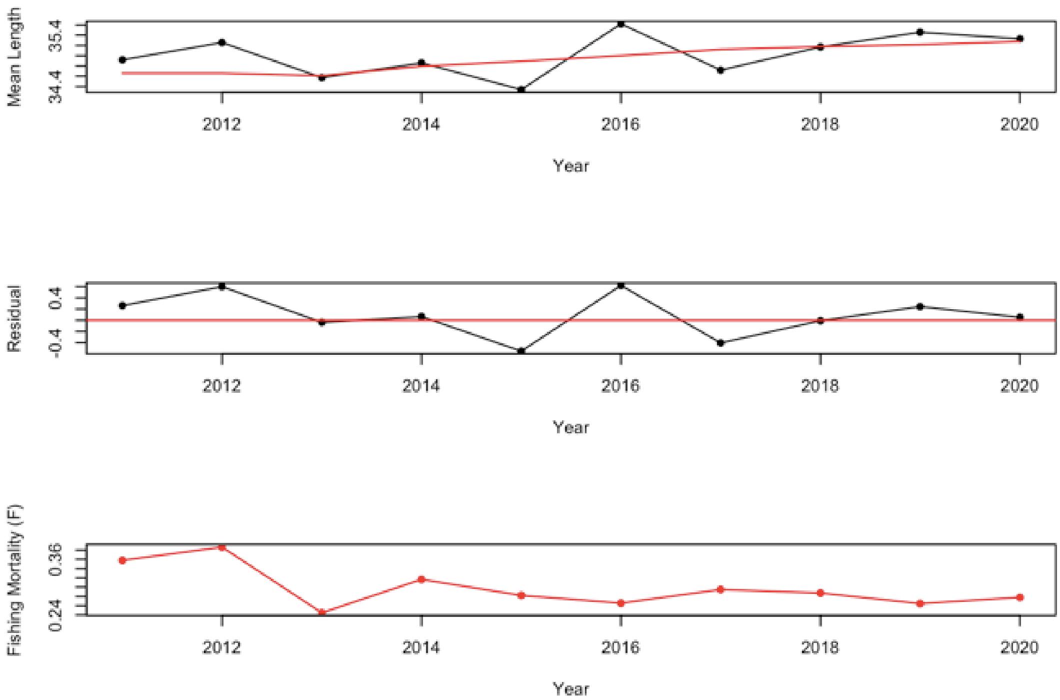

Figure 8.8.4. Fishing mortality trend computed using the MLZ model for *S. solea* in 2011–2020.

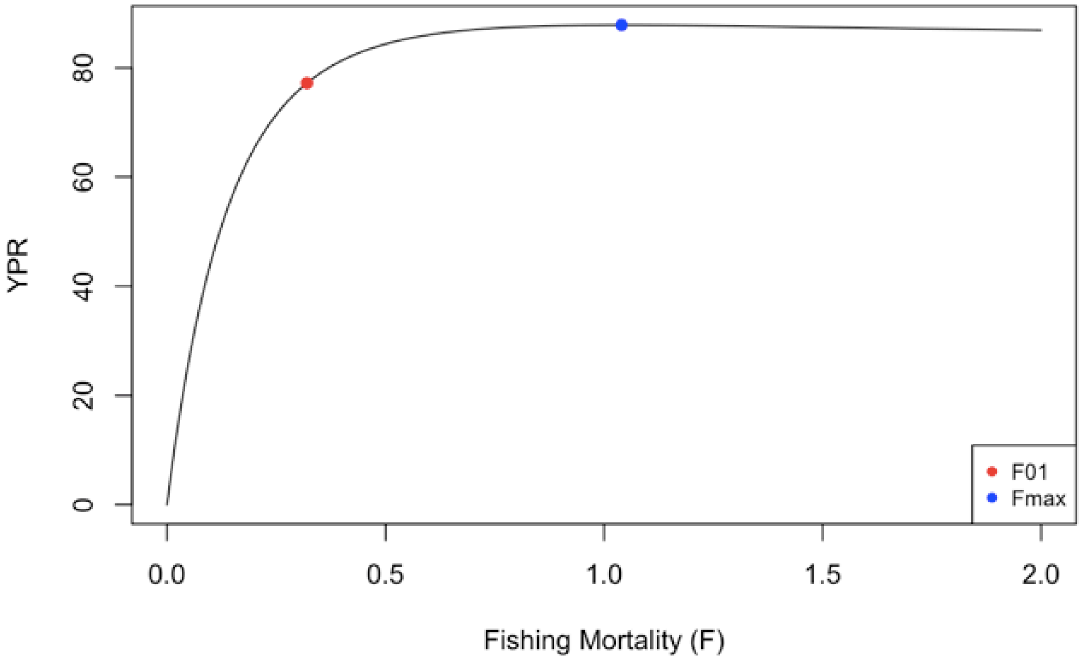

Figure 8.8.5. Yield-per-recruits approximation obtained with the MLZ methods for *S.solea* 2011–2020.

9 Hake in subareas 4, 6, and 7; divisions 3.a, 8.a–b, and 8.d (Greater North Sea, Celtic Seas, northern Bay of Biscay)

Merluccius merluccius – hke.27.3a46-8abd

9.1 General

9.1.1 Stock definition and ecosystem aspects

This section is described in the Stock Annex.

9.1.2 Fishery description

The general description of the fishery is now presented in the Stock Annex.

9.1.3 Summary of ICES advice for 2021 and historical management

9.1.3.1 ICES advice for 2021

The stock was considered to be above any potential MSY $B_{trigger}$. Following the ICES MSY framework implied fishing mortality to be maintained at 0.26, resulting in landings of 88 545 t and total catches of 100 278 in 2021.

Like the main stocks of the EU, Northern hake is managed by a TAC and quotas. The TACs for recent years are presented in the table below. In 2021, there has not been an agreement to set an annual TAC.

TAC (t)	2014	2015	2016	2017	2018	2019	2020	2021
3a, 3b,c,d (EC Zone)	2466	2738	2997	3371	3136	4286	3403	
2a (EC Zone), 4	2874	3190	3492	3928	3653	4994	3940	
Vb (EC Zone), 6, 7	45896	50944	61902	67658	62536	79762	63325	
8a,b,d,e	30610	33977	40393	44808	42460	52118	42235	
Total northern Stock	81846	90849	108784	119765	111785	141160	112903	

9.1.3.2 Historical management

The minimum legal sizes for fish caught in subareas 4-6-7 and 8 is set at 27 cm total length (30 cm in Division 3.a) since 1998 (Council Reg. no 850/98).

On 14 June 2001, an Emergency Plan was implemented by the Commission for the recovery of the Northern hake stock (Council Regulations N°1162/2001, 2602/2001 and 494/2002). In addition to a TAC reduction, two technical measures were implemented. First, a 100 mm minimum mesh size was implemented for otter trawlers when hake comprises more than 20% of the total amount of marine organisms retained onboard. This measure did not apply to vessels less than 12 m in length and which return to port within 24 hours of their most recent departure. Furthermore, two areas were defined, one in Subarea 7 and the other in Subarea 8, where a 100 mm minimum mesh size is required for all otter trawlers, whatever the amount of hake caught.

In 2004, explicit management objectives for the recovery of this stock were implemented under the EC Reg. No 811/2004. It was aiming at increasing the quantities of mature fish to values equal to or greater than 140 000 t (the B_{PA} value at that time). This could be achieved by limiting fishing mortality to 0.25 and by allowing a maximum change of 15% in TAC between years. According to ICES advice for 2012, due to the new perspective of historical stock trends resulting from the new assessment, the previously defined precautionary reference points are no longer appropriate. In particular, the absolute levels of spawning biomass, fishing mortality, and recruitment have shifted to different scales. As a consequence, the TAC corresponding to the recovery plan (EC Reg. No. 811/2004) should no longer be considered because the plan uses target values based on precautionary reference points that are no longer appropriate.

The TACs from 2016 to 2019 were slightly below the ICES advised TAC. The difference was due to the way the STECF calculated the TAC adjustments for stocks subject to the landing obligation. In 2019, according to the MSY framework, ICES proposed a decrease in the 2020 TAC advice of 26% from 142 240 t to 104 763 t. The agreed TAC limited the interannual variability to 20% (TAC = 112 903 t). For 2021 there is no TAC for the whole year, only extensions of the previous TAC for several months was agreed.

9.2 Data

9.2.1 Commercial catches and discards

Total landings from the northern stock of hake by area for the period 1961–2020 as used by the WG are given in Table 9.1. They include landings from Division 3.a, subareas 4, 6 and 7, and divisions 8.a, 8.b, and 8.d, as reported to ICES. Unallocated landings are also included in the table; they are high over the first decade (1961–1970) when the uncertainties in the fisheries statistics were high. In the years 2011, 2012 and 2013, they have increased again due to differences between official statistics and scientific estimations. In 2014 and 2015, the differences between scientific and official landings decreased greatly which produced a big decrease in unallocated landings. The 2016 unallocated landings were reported by area and in 2017 there were no unallocated landings, so they disappeared from Table 9.2. Table 9.1 of the Stock Annex provides a historical perspective of the level of aggregation at which landings have been available.

Except for 1995, landings decreased steadily from 66 500 t in 1989 to 35 000 t in 1998. Up to 2003, landings fluctuated around 40 000 t. Since then, except for 2006, landings have been increasing up to 107 500 t in 2016, the highest in the whole time-series. From 2009 to 2015 the landings and in 2016 the catches were above the TAC advice. Since 2016 the catches have decreased every year and they have been below both, the TAC and the catch advice.

The discard data sampling and data availability are presented in the Stock Annex. Table 9.2 presents discard, landings and the number of samples collected for each of the fleets considered in the assessment model since 2013. The discards had an increasing trend until 2011 and decreased steadily afterwards. The increase was general to all the fleets. It is remarkable the case of gillnetters which did not discard before 2012 and since that year they have had a high level of discards. In 2016, the discards increased for all the fleets except for Spanish trawlers in Area 7. In 2017, the total discards decreased for all the fleets, except for the Spanish trawlers, with an overall decrease of 36%. The increase in the Spanish trawlers in divisions 8.a, 8.b, and 8.d was equal to 38%. In 2018, the discards increased in Spanish trawlers in Area 7 and the trawl others fleet but decreased in all the rest of the fleets. The number of samples and number of measured fish is relatively stable every year, except in TRAWLOTH fleet that has high variability. In 2020 a decrease in both, number of samples and the number of measured fish is observed. The decrease is specially marked in LONGLINE fleet and the discards sampling in SPTRAWL7 fleet. Spain contributes the most to the LONGLINE sampling. In 2020, Spain apart from the COVID disruption it has other administrative problems that caused problems in the sampling.

9.2.2 Biological sampling

Which countries contribute to the total catch of each FU and which contribute with length-frequency distribution is given in Table 9.3.

Length compositions of the 2020 landings by Fishery Unit and quarter were provided mainly by Ireland, France, Scotland, Spain, UK(E&W), Denmark. However, some other countries also provide some data.

Length compositions samples are not available for all FUs of each country in which landings are observed (see Stock Annex). Only the main FUs are sampled (Table 9.3).

9.2.3 Abundance indices from surveys

Four surveys provide relative indices of hake abundance over time: (1) the French RESSGASC survey conducted in the Bay of Biscay from 1978 to 2002, (2) the EVHOE-WIBTS-Q4 (G9527) survey covering the Bay of Biscay and the Celtic Sea with a new design since 1997, (3) the SpPGFS-WIBTS-Q3 (G5768) survey conducted in the Porcupine Bank since 2001 and (4) the Irish Groundfish Survey (IGFS-WIBTS-Q4, G7212) carried out in the west of Ireland and the Celtic Sea since 2003. A brief description of each survey is given in the Stock Annex and section 2 of this report. Figure 9.1 presents the abundances indices obtained from these surveys.

From 1985 until the end of the survey in 2002, the index from RESSGASC showed a slightly decreasing trend. The 2002 index is considered not reliable and is not presented in the figure.

Throughout the available time-series, the abundance index provided by EVHOE-WIBTS-Q4 (G9527) showed five peaks in 2002, 2004, 2008, 2012, and 2016. The index obtained in 2012 was the highest value of the series, 193% higher than the previous year. In 2013 and 2014, the index accumulated a decrease of 78%. In 2015 and 2016, it increased and the 2016 index value was three times higher than the 2015 value. In 2017, the index was not available since the survey was not conducted. In 2018, the index value decreased relative to the 2016 value and was around the value in 2015. It increased again in 2019 but in 2020 the value decreased to the historical minimum level.

The abundance index provided by the IGFS-WIBTS-Q4 (G7212) is consistent with EVHOE WIBTS-Q4 (G9527) survey over recent years. The index showed four peaks coincident with those observed in the EVHOE-WIBTS-Q4 (G9527) index but to a lesser extent. In 2012, the index achieved the highest value of the series, 268% higher than the previous year index. The accumulated decrease in 2013 and 2014 was equal to 86%. The index increased moderately from 2015 to 2017. However, the increase in 2016 was not as sharp as that observed with the EVHOE-WIBTS-Q4 (G9527) index. The index decreased in 2018 and in the last two years, the variation has been low. The index is around its historical minimum level.

The abundance index from SpPGFS-WIBTS-Q4 (G5768) survey follows an increasing trend since 2003, reaching its highest value in 2009 and slightly decreasing in 2010 and 2011. After two years of an increasing trend, with an accumulated increase of 218%, the index decreased sharply in 2015 and again but moderately in 2016. The peaks detected by EVHOE-WIBTS-Q4 (G9527) and IGFS-WIBTS-Q4 (G7212) were also detected in this survey but occurring a year later, confirming the sharp increase observed in 2017. This is consistent with the fact that this survey catches bigger individuals. In the last three years, the index has decreased to a value comparable to that observed in 2007.

The spatial distribution of the EVHOE-WIBTS-Q4 (G9527), IGFS-WIBTS-Q4 (G7212) and SpPGFS-WIBTS-Q4 (G5768) biomass indices (kg/hr) is provided in Figure 9.2 since 2005. The SpPGFS-WIBTS-Q4 (G5768) biomass index shows a homogenous spatial distribution in the sampled area throughout the time-series. Among the three surveys, the SpPGFS-WIBTS-Q4 (G5768) shows the higher biomasses values in the maps, confirming that this survey catches bigger individuals. A contraction of the spatial distribution is visible in some years, with the year 2018 showing the greatest contraction (Figure 9.2). In 2017 EVHOE-WIBTS-Q4 (G9527) was only carried out partially). For the IGFS-WIBTS-Q4 (G7212) the spatial distribution of the biomass index was stable throughout the time-series, with a slight decrease in 2018. The southern region of the sampled area showed a higher biomass index in recent years. For the IGFS-WIBTS-Q4 (G7212), high biomass concentration seems to occur in areas closer to the continental French shelf. Overall for all surveys, a contraction of the spatial distribution is visible since 2015.

EVHOE-WIBTS-Q4 (G9527) and IGFS-WIBTS-Q4 (G7212) surveys catch mainly young individuals below 25 cm while SpPGFS-WIBTS-Q4 (G5768) captures larger size individuals (35–75 cm) (Figure 9.3). In the case of EVHOE-WIBTS-Q4 (G9527), the distribution is quite homogeneous year after year, with the mode around 12 cm. In the case of the Irish survey, in 2018 and 2020, most of the individuals were around 25 cm, and there were almost no individuals around 12 cm, which is the mode of the distribution in most of the years. The length distribution from SpPGFS-WIBTS-Q4 (G5768) is quite flat between 40 and 65 cm, with a peak around 20 cm which is associated with previous year recruitment in the previous year. This peak was very high in 2017. The variability of the shape of length-frequency distributions of these two indices could be motivated by the limited area covered compared with the EVHOE-WIBTS-Q4 (G9527) index that covers a bigger area.

9.3 Assessment

This is an update assessment in relation to the assessment carried out during the inter-benchmark working group at the beginning of 2019 (ICES, 2019a). This year in the WKTaDSa (ICES, 2021) the model was updated to the last version of the Stock Synthesis model (3.30) (Methot Jr. and Wetzel, 2013). There were small differences between the estimates of the old and new versions of the software that were considered acceptable by the group.

9.3.1 Input data

See Stock Annex (under "Input data for SS3"). The catch contribution of the fleets used in the configuration of the model has changed over time (Figure 9.4). At the beginning of the time-series more than 75% of the catch was caught by trawlers fleets. However, in the last years, their contribution is around 25% to the total catch. On the contrary, the catch of longliners and gillnetters was residual in the past but currently, the contribution of each of these fleets is similar to the contribution of trawlers. The increase in the biomass of the stock in the last decade has motivated a high increase in the catch of the OTHER fleet. Nowadays the catch outside the Bay of Biscay and Celtic Sea (that covered by the OTHER fleet) is similar to the catch in the Bay of Biscay.

The quarterly length frequency distributions for landings and discards are given in Figure 9.5. For most of the fleets, the length–frequency distribution of landings is quite stable over time. The fleets in Area 8 catch smaller individuals. For trawlers, discards occur in the lower part of the distribution and for gillnetters and OTHER fleet in the whole range indiscriminately. The collection of data from the commercial fishery and research surveys during 2020 were impacted by

COVID-19 restrictions to a varying degree across member states. Spanish discard data and length frequency distributions in SPTRAWL7 fleet were missing in some quarters. The sampling in LONGLINE fleet was lower than in previous years and the corresponding length frequency distributions, which are usually smooth and well defined, had an odd shape.

9.3.1.1 Data Revisions

No data revisions have been provided in 2021.

9.3.2 Model

The Stock Synthesis (SS) assessment model (Methot Jr. and Wetzel, 2013) was selected for use in this assessment. Model description and settings are presented in the Stock Annex (under "Current assessment" for model description and "SS3 settings (input data and control files)" for model settings).

9.3.2.1 Model results

Residuals of the fit to the surveys log(abundance indices) are presented in Figure 9.6. The upward trend, in relative abundance, was observed until 2017 in all three contemporary trawl surveys (EVHOE-WIBTS-Q4 (G9527), SpPGFS-WIBTS-Q4 (G5768) and IGFS-WIBTS-Q4 (G7212), has been captured by the model. In the last three years, the model estimates are higher than the observed values in the IGFS-WIBTS-Q4 (G7212) survey, and SpPGFS-WIBTS-Q4 (G5768) and EVHOE-WIBTS-Q4 (G7212) surveys in the last two years and last year respectively.

The Pearson residuals of the length-frequency distributions of the EVHOE-WIBTS-Q4 (G7212) survey have a "fairly random" pattern with no general trend or lack of fit (Figure 9.7, where blue and red circles denote positive and negative residuals, respectively). However, in the other two surveys, the model has problems explaining the peak in small individuals observed in SpPGFS-WIBTS-Q4 (G5768) index, and the lack of small individuals in IGFS-WIBTS-Q4 (G7212) index for some years (i.e. 2018 and 2020).

Residuals of the length frequency distributions of the commercial fleets landings and discards (not presented in this report but available on the GitHub repository[1] show some patterns, as mentioned in the benchmark report (ICES, 2014a).

The assessment model includes estimation of size-based selectivity functions (selection pattern at length) for commercial fleets and population abundance indices (surveys). For commercial fleets, total catch is subsequently partitioned into discarded and retained portions. Figure 9.8 presents the selectivity for the total catch and Figure 9.9 the retention functions by fleet estimated by the model. The selection curve is assumed constant over the whole period for all the fleets except for those operating outside areas 7 and 8 (the OTHERS fleet). For the Spanish trawl fleet in Area 7, three retention functions are estimated, one for the period 1978–1997, a second one for the period 1998–2009 and a third one for the period 2010-present. For the Spanish trawl fleet in Area 8, two retention functions are estimated: one for the period 1978–1997 and a second one for 1998-present. The change in retention in 1998 for both trawl fleets was clearly observed when examining the length frequency distributions of the landings and might be due to more rigorous enforcement of the minimum landing size. The most recent change in the retention of the Spanish trawl fleet in Area 7 was motivated by the observed change in the mean size of discards from 23.6 cm before 2010 to 28.8 cm after that year. For the French trawlers targeting *Nephrops* in Area 8, the same retention function is assumed throughout the entire assessment period (1978-present). For the other fleets, both selection and retention curves are considered constant until 2002

[1] https://github.com/ices-taf/2021_hke.27.3a46-8abd_assessment

varying from year-to-year since then. The variation is modelled using a random walk as described in the Stock Annex. The selection pattern has changed significantly over the years. Furthermore, there was a big change in the selection pattern from 2019 to 2020. While in 2019 the retention was similar to those is most recent years (dashed black line), in 2020 the retention curve (solid black line) was the one with the sharper increase near the origin of the whole time-series. However, the retention ogives in 2019 and 2020 were almost identical (Figure 9.9). Residuals of the length frequency distributions of the commercial fleets landings and discards (not presented in this report but available on the GitHub repository[2] show some patterns, as mentioned in the benchmark report (ICES, 2014a).

The retrospective analysis (Figure 9.10) shows that for the three summary indicators (F, SSB and Recruitment) the model results are sensitive to the exclusion of recent data, especially recruitment. The inclusion of new data impacted the recruitment estimates especially in the most recent years, in general, they were revised downwards. The change in the recruitment estimates motivated, in turn, a retrospective pattern in the SSB and fishing mortality. Although the update to 3.30 version had a negligible impact on the stock status estimates for the last year, the retrospective pattern was worst overall. Before, the pattern did not show a clear trend so the cancellation effects reduced the value of Mohn's rho. However, the systematic overestimation of recruitment removed the cancellation effects and the obtained Mohn's rhos were higher (Figure 9.11). Although only some of time-series were within the confidence intervals estimated by the model (Figure 9.10), according to the guidelines of WKFORBIAS (ICES, 2020), the observed retrospective pattern is acceptable to provide advice (see Figure 9.12). The Mohn's rho value for SSB is inside the bounds (< 0.2). For fishing mortality, Mohn's rho is outside the bounds (> 0.2) and 2 recent peels are outside the envelope. However, although an interbenchmark to investigate the pattern is not possible, due to the short time available, as the pattern is close to the limit and the SSB is well below the reference points, it is possible to give advice with the assessment model presented in this report.

Summary results from SS are given in Table 9.4 and Figure 9.13.

Recruitment values (age 0) estimated by the model are provided in Table 9.4. For the recruitment, fluctuations appear to be without substantial trend over the whole series. The recruitment in 2008 was the highest in the whole series with 753 million individuals and the one in 2020 was below the geometric mean (252 million). From high levels at the start of the series (100 000 t in 1980), the SSB decreased steadily to a low level at the end of the 1990s (23 000 t in 1998). Since then, SSB has increased to the highest value of the series in 2016 (291 000 t) and decreased until 2019. In 2020 a slight increase has been predicted by the model.

The fishing mortality is calculated as the average annual F for sizes 15–80 cm. This measure of F is nearly identical with the average F for ages 1–5. Values of F increased from values around 0.5–0.6 in the late 1970s and early 1980s to values around 1.0 during the 1990s. Between 2006 and 2011, F declined sharply. Since 2012, F fluctuates around FMSY (f fmsy). The F estimate for 2020 (0.259) is slightly above F_{msy}.

The 90% confidence intervals are quite narrow (Table 9.4). These intervals correspond to the uncertainty estimated by the SS model and do not include all the existing uncertainty. For example, it does not include uncertainty in the input data. In the next benchmark, the data weighting in SS should be revisited in order to get more realistic confidence intervals.

[2] https://github.com/ices-taf/2021_hke.27.3a46-8abd_assessment

9.4 Catch options and prognosis

9.4.1 Replacement of recruitment in 2019 and 2020 by geometric mean recruitment

In 2019 and 2020 assessments, recruitment estimates for the last two data years (2016–2017 and 2017–2018 respectively), were replaced by the geometric mean (GM). The recruitment in 2017 was the second-highest value in the time-series but this high estimate was not supported by the available data at that time, length frequency distributions and abundance indices (ICES, 2019b). The 2017 year-class had a large contribution to the TAC advice, thus, reliable and precautionary recruitment was required for the short-term projections. With the inclusion of 2020 data, the assessment model has revised the 2017 recruitment downwards and the estimate is closer to the geometric mean (Figure 9.13).

This year, the recruitment estimates for the last two years, (2020 and 2019), were also replaced by the GM. The 2020 recruitment was close to the geometric mean. However, the 2019 estimate was well above that level. The assessment model overestimated the three abundance indices available in the last two years. Furthermore, the model has revised the most recent recruitments downwards. Hence, replacing the recruitment estimates for the last two years was considered more reliable and precautionary for projections.

Figure 9.14 shows the contribution of each age-class to the catch advice in 2020, when $F_{advice} = F_{msy}$ was used, replacing the recruitment in the last two years by the geometric mean and without replacing it. When the recruitment was not replaced, the contribution of 2019 year-class (age 3) to the advice was around 35%. However, when the recruitments were replaced the contribution reduced to half. Thus, the catch advice strongly depends on this year-class and replacing it with the geometric mean is considered more precautionary.

9.4.2 Short-term projections

SS has a forecast module that provides the capability to do a projection for a user-specified number of years that is directly linked to the model ending conditions and associated uncertainty, and a specified level of fishing intensity. The forecast requires information on life history, fishery selectivity, relative harvest rate between fleets, overall fishing intensity, and recruitment. However, due to some inconsistencies with the ICES short-term forecast observed in 2010 on SS short-term projection, the forecast has never been done internally in the model but transferred to and estimated by another module, a specific R script written for this specific task.

For the current projection, unscaled F is used, corresponding to F(15–80 cm) = 0.259. The recruitment used for projections in this WG is the GM calculated from 1990 to the final assessment year minus 2 (2018). Recruitment short-term projection assumption values are given in Table 9.5. Landings in 2022 and SSB in 2023 predicted for various levels of fishing mortality in 2022 are given in Table 9.5 and Figure 9.15.

Maintaining status quo F in 2022 is expected to result in a decrease in the catch and the SSB with respect to 2021, around −24% and −6% respectively.

9.4.3 Yield and biomass per recruit analysis

Options for long-term projection are indicated in the Stock Annex. Results of equilibrium yield and SSB per recruit are presented in Table 9.6 and Figure 9.16. The F-multiplier in Table 9.6 is with respect to *status quo* F (average F in the final 3 assessment years, 2018–2020). Considering the yield and SSB per recruit curves, F_{max}, F0.1, F35% and F30% are respectively estimated to be 99%, 66%, 72%, and 84 of *status quo* F. The maximum equilibrium yield-per-recruit is similar to the equilibrium yield at F_{sq}.

9.5 Biological reference points

Biological reference points for the stock of Northern Hake were calculated in 2019 after the inter-benchmark was carried out in February (Garcia, 2019, WD 06 in ICES, 2019b). This year the value of F_{PA} has been revised according to general ICES guidelines, now it is defined as $F_{P0.5}$ (with $B_{trigger}$). The value was already calculated in 2019. As the new F_{PA} is higher than the F_{LIM} we had before, it has been discarded and new F_{LIM} value has not been defined. The reference points in use for the stock are as follows:

	Type	Value	Technical basis
MSY Approach	MSY $B_{trigger}$	56 000	B_{pa} (WD 06, ICES, 2019b)
	F_{MSY}	0.26	F_{MSY} in the segmented regression stock recruitment relationship (WD 06, ICES, 2019b)
Precautionary Approach	B_{lim}	40 000	The median of the breakpoints in the segmented stock recruitment relationship estimated with a Bayesian Model.
	B_{pa}	56 000	1.4Blim (WD 06, ICES, 2019b)
	F_{lim}	Not defined	
	F_{pa}	1.02	$F_{p0.5}$ (WD 06, ICES, 2019b)
MAP	F_{low}	0.18	The lowest F that produces catch in the long term 5% below of the catch at F_{MSY}. (WD 06, ICES, 2019b)
	F_{upp}	0.4	The lowest F that produces catch in the long term 5% below of the catch at F_{MSY}. (WD 06, ICES, 2019b)

9.6 Comments on the assessment

The retrospective pattern in 2008 recruitment was partially corrected during the last benchmark (ICES, 2014a). However, the retrospective pattern is still significant. It could be related to the changes in the estimates of the selection patterns for some fleets and surveys. As they are considered constant by the model and new data on length–frequency distributions is introduced every year in the model, if the selection pattern is not really constant, it could result in significant changes in selection curve estimates, which in turn could result in a retrospective pattern in recruitment, F, and SSB. Moreover, the recruitment in the most recent years is difficult to estimate, because there is little information in the data on it. Thus, the uncertainty in the recent estimates of recruitment is high and the estimated value needs several years to stabilize.

In this year assessment, the effective sample size used for 2020 samples has been the default used for all the fleets, as stated in the Stock Annex. However, the number of samples and sampled individuals has been lower than in other years, especially for some countries and fleets. The model results are sensitive to the effective sample size and it should be related to the samples available yearly.

During the working group, it was detected a mistake in the control file of the assessment model, the 'year from which deviations from recruitment are no longer considered parameters, was equal to 2019 instead of 2020. The same mistake was done last year. The results obtained, in trends, were very similar, but the biomass was slightly lower and the fishing mortality higher, which produced significantly lower catch advice.

9.7 Future benchmark

In WKTaDSa (ICES, 2021) a working plan was defined to advance in the improvement of the quality of the stock assessment model configuration for this stock.

- Incorporate the advanced options to model recruitment proposed by Rick Method in WKTaDSA. This has been already included and their impact analysed. The impact is low but significant.
- Biological parameters: Update the biological parameters using the work done in Southern hake. A sensitivity analysis was done changing growth parameters and natural mortality. The obtained indicators had the same trend as the current assessment but the productivity of the stock changed. The differences in the likelihood were not big. The signal in the length frequency distribution and natural mortality was opposite.
- Variability of selection pattern. The fleets more impacted by a retrospective pattern in selection curves have been detected, Gillnetters and Spanish trawlers in areas 7 and 8. There is also a big retrospective pattern in the selectivity of IGFS-WIBTS-Q4 (G7212) and SpPGFS-WIBTS-Q4 (G5768) surveys. The introduction of a random walk in the selection pattern of the fleets is straightforward. The problem is in the selectivity of the surveys. The selectivity is constant in the surveys, but changes in the availability of the resources could have the same effect as the model assumes the distribution of fish is homogeneous in the whole area.
- Weighting options. The likelihood of the model is driven by the likelihood in length frequency data. The sensitivity of the estimates to the weighting of likelihood components should be investigated and adequate weights defined. Furthermore, a protocol to update the effective sample size needs to be defined to deal with big changes in sampling.
- Split of OTHER fleet in trawlers and non-trawlers. This could only be done for the years with data in InterCatch. The catch in this fleet started increasing in 2008, with the increase in biomass. Thus, splitting of the fleet since that year could be advisable.

9.8 Management considerations

The significant increase in SSB and the decrease in fishing mortality are the consequences of the strong recruitment in 2008 and 2012. However, the increase rate should be taken with caution as limited information is currently available to explain the variation in abundance of large fish and the model is very sensitive to the data and settings used. It must be noted that the high growth rate combined with the assumed high natural mortality rate ($M = 0.4$ since the 2010 benchmark, ICES, 2010) generates a rapid turnover of the hake stock dynamic. This means that short-term predictions in SSB and landings are strongly related to variations in recruitment. Now, that the SSB has decreased, caution is needed to avoid a rapid decrease in biomass. Since 2017, the observed catches have been significantly below the TAC and the catch advice, which would be a signal of an overestimation of stock productivity.

The ICES catch advice is for the whole stock but the sum of the TACs for 2019 and 2020 in this report is only for the EU member states.

9.9 References

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9.10 Tables and figures

Table 9.1. Hake in Division 3.a, subareas 4, 6, and 7 and divisions 8.a, 8.b, and 8.d (northern stock). Estimates of landings ('000 t) by area for 1961–2019.

	Landings (t)[1]										Discards (t)[2]							Catches(t)[3]
Year	1	2	3	4	5	6	7	8	Unn.	Tot.	3	4	5	6	7	8	Tot.	Total
1961									95.6	95.6								95.6
1962									86.3	86.3								86.3
1963									86.2	86.2								86.2
1964									76.8	76.8								76.8
1965									64.7	64.7								64.7
1966									60.9	60.9								60.9
1967									62.1	62.1								62.1
1968									62.0	62.0								62.0
1969									54.9	54.9								54.9
1970									64.9	64.9								64.9
1971			8.5				19.4	23.4	0.0	42.8								42.8
1972			9.4				14.9	41.2	0.0	56.1								56.1
1973			9.5				31.2	37.6	0.0	68.8								68.8
1974			9.7				28.9	34.5	0.0	63.4								63.4
1975			11.0				29.2	32.5	0.0	61.7								61.7
1976			12.9				26.7	28.5	0.0	55.2								55.2
1977			8.5				21.0	24.7	0.0	45.7								45.7
1978			8.0				20.3	24.5	-2.2	42.6								42.6
1979			8.7				17.6	27.2	-2.4	42.4								42.4
1980			9.7				22.0	28.4	-2.8	47.6								47.6
1981			8.8				25.6	22.3	-2.8	45.1								45.1
1982			5.9				25.2	26.2	-2.3	49.1								49.1
1983			6.2				26.3	27.1	-2.1	51.3								51.3
1984			9.5				33.0	22.9	-2.1	53.8								53.8
1985			9.2				27.5	21.0	-1.6	46.9								46.9
1986			7.3				27.4	23.9	-1.5	49.8								49.8

	Landings (t)[1]										Discards (t)[2]							Catches(t)[3]
Year	1	2	3	4	5	6	7	8	Unn.	Tot.	3	4	5	6	7	8	Tot.	Total
1987			7.8				32.9	24.7	-2.0	55.6								55.6
1988			8.8				30.9	26.6	-1.5	56.0								56.0
1989			7.4				26.9	32.0	0.2	59.1								59.1
1990			6.7				23.0	34.4	-4.2	53.3								53.3
1991			8.3				21.5	31.6	-3.4	49.8								49.8
1992			8.6				22.5	23.5	2.1	48.1								48.1
1993			8.5				20.5	19.8	3.3	43.7								43.7
1994			5.4				21.1	24.7	0.0	45.8								45.8
1995			5.3				24.1	28.1	0.1	52.3								52.3
1996			4.4				24.7	18.0	0.0	42.8								42.8
1997			3.3				18.9	20.3	-0.1	39.2								39.2
1998			3.2				18.7	13.1	0.0	31.9								31.9
1999			4.3				24.0	11.6	0.0	35.6								35.6
2000			4.0				26.0	12.0	0.0	38.0								38.0
2001			4.4				23.1	9.2	0.0	32.3								32.3
2002			2.9				21.2	15.9	0.0	37.2								37.2
2003			3.3				25.4	14.4	0.0	39.9							1.4	41.3
2004			4.4				27.5	14.5	0.0	42.0							2.6	44.6
2005			5.5				26.6	14.5	0.0	41.1							4.6	45.7
2006			6.1				24.7	10.6	0.0	35.3							1.2	36.6
2007			7.0				27.5	10.6	0.0	38.1							2.2	40.2
2008			10.7				22.8	14.3	0.0	37.2							3.4	40.5
2009			13.1				25.3	20.4	0.0	45.7							11.0	56.8
2010			14.2				33.5	25.1	0.0	58.6							12.1	70.7
2011			18.8				18.6	16.6	32.0	87.5							13.9	101.4
2012			22.4				22.2	16.7	19.3	85.6							14.9	100.5
2013			0.3	10.7		5.2	50.1	19.9	0.0	86.1	0.3	2.9		1.5	6.6	4.1	15.4	101.6
2014			0.4	12.1		11.4	40.5	25.6	0.0	89.9	0.3	3.1		1.0	4.0	1.5	9.8	99.8

	Landings (t)[1]										Discards (t)[2]							Catches(t)[3]
Year	1	2	3	4	5	6	7	8	Unn.	Tot.	3	4	5	6	7	8	Tot.	Total
2015			0.4	14.6	0	7.1	44.4	28.5	0.0	95.0	0.1	3.4		0.1	4.2	3.1	10.9	106.0
2016			0.7	19.6	0	11.4	49.4	26.5	0.0	107.5	0.1	4.2	0	0.3	2.3	4.2	11.1	118.7
2017			0.8	19.7	0	9.6	45.7	28.9	0.0	104.7	0.1	1.8	0	0.3	1.2	3.7	7.1	111.8
2018			0.7	18.9	0	7.3	36.9	25.9	0.0	89.7	0.3	1.3		0.3	2.1	3.1	7.0	96.7
2019	0	0.8	0.7	15.6	0	6.8	36.9	21.5	0.0	82.3	0.2	0.9		0.3	1.4	2.1	4.9	87.2
2020			0.6	13.1	0	4.1	35.1	19.7	0.0	72.6	0.3	0.3		0.3	0.4	2.0	3.3	75.8

[1] **Divisions 3a and 4b,c are included in column '3a, 4 and 6' only after 1976. There are some unallocated landings (moreover for the period 1961–1970).**

[2]**Discard estimates from observer programmes. In 2003–2020, partial discard estimates are available and used in the assessment. For remaining years for which no values are presented, some estimates are available but not considered valid and thus not used in the assessment.**

[3]**From 1978 total catches used for the Working Group.**

Table 9.2. Hake in Division 3.a, subareas 4, 6, and 7 and divisions 8.a, 8.b, and 8.d (northern stock). Discards and landings (in tonnes), number of length samples per catch category (NLgSp_D and NLgSp_L) and number of fish measured per catch category (NLgMs_D and NLgMs_L) since 2013 for the fleets used in the assessment model.

Year	ss3_fleet	Discards	Landings	NLgSp_D	NLgSp_L	NLgMs_D	NLgMs_L
2013	FRNEP8	1475	1219	0	0	0	0
2014	FRNEP8	391	1566	0	0	0	0
2015	FRNEP8	1134	1197	0	0	0	0
2016	FRNEP8	2310	973	39	51	1414	1627
2017	FRNEP8	1819	1124	31	53	1073	1360
2018	FRNEP8	889	1029	26	92	832	3495
2019	FRNEP8	816	1131	26	75	811	2365
2020	FRNEP8	1193	1076	20	42	551	1031
2013	GILLNET	1257	15671	0	31	0	12133
2014	GILLNET	65	22549	27	412	164	27691
2015	GILLNET	857	16876	29	501	218	28777
2016	GILLNET	1175	25017	475	855	4964	49702
2017	GILLNET	653	25299	228	574	2406	32823
2018	GILLNET	1014	25848	459	526	3339	38290
2019	GILLNET	333	24800	219	536	1803	34874

Year	ss3_fleet	Discards	Landings	NLgSp_D	NLgSp_L	NLgMs_D	NLgMs_L
2020	GILLNET	444	23003	139	516	3364	20521
2014	LONGLINE	1	26289	0	77	0	37386
2015	LONGLINE	559	36881	0	59	0	26655
2016	LONGLINE	2	31390	0	126	0	42003
2017	LONGLINE	1	29728	0	113	0	28754
2018	LONGLINE	4	20710	0	101	0	33141
2019	LONGLINE	0	19112	0	99	0	30853
2020	LONGLINE	0	18869	0	17	0	1693
2013	LONGLINE		14516		51		24319
2013	OTHER	6287	45004	145	328	7282	20454
2014	OTHER	5007	26165	288	863	9944	20898
2015	OTHER	4154	23515	257	895	11164	13048
2016	OTHER	4687	33099	530	834	11138	34417
2017	OTHER	2326	31371	413	577	9338	17731
2018	OTHER	1943	28396	521	802	17024	27263
2019	OTHER	1817	26437	426	596	16457	22876
2020	OTHER	948	19695	237	516	8860	18712
2013	SPTRAWL7	3495	1948	300	61	2518	13864
2014	SPTRAWL7	1467	1991	310	77	1433	17568
2015	SPTRAWL7	2064	1975	268	52	2125	13773
2016	SPTRAWL7	616	2099	357	48	1208	10898
2017	SPTRAWL7	651	1711	340	56	3014	18703
2018	SPTRAWL7	903	1850	324	57	3063	19211
2019	SPTRAWL7	318	1891	193	51	1340	14001
2020	SPTRAWL7	157	2351	48	5	113	1243
2014	SPTRAWL8	183	2720	287	44	1610	7360
2015	SPTRAWL8	589	4405	0	43	0	9181
2016	SPTRAWL8	656	3647	95	43	3008	9482
2017	SPTRAWL8	906	4622	296	45	9240	9859

Year	ss3_fleet	Discards	Landings	NLgSp_D	NLgSp_L	NLgMs_D	NLgMs_L
2018	SPTRAWL8	347	3467	280	53	3748	10526
2019	SPTRAWL8	586	2956	299	58	5390	5829
2020	SPTRAWL8	310	2768	213	47	2825	5652
2013	SPTRAWL8		1988		38		5138
2013	TRAWLOTH	2936	5801	0	0	0	0
2014	TRAWLOTH	2718	8659	478	817	24072	7841
2015	TRAWLOTH	1564	10192	381	404	11649	6766
2016	TRAWLOTH	1669	11321	1367	1423	37190	36008
2017	TRAWLOTH	744	10815	169	595	13117	11732
2018	TRAWLOTH	1937	8394	1536	832	71517	21048
2019	TRAWLOTH	1070	5970	408	526	13734	11199
2020	TRAWLOTH	205	4816	204	270	7683	6960

Table 9.3. Hake in Division 3.a, subareas 4, 6, and 7 and divisions 8.a, 8.b, and 8.d (northern stock). Catches (C) and Length Frequency Distribution (LFD) provided in 2020.

FU	Quarter	Denmark	France	Ireland	Others	Spain	UK (England)	UK (Scotland)
FU1 & FU2	1	0	C	0	0	C+LFD	C	0
FU1 & FU2	2	0	C	0	0	C	0	0
FU1 & FU2	3	0	C	0	0	C	C	0
FU1 & FU2	4	0	C	0	0	C	C	0
FU03	1	0	C	C+LFD	0	C+LFD	C+LFD	0
FU03	2	0	C	C+LFD	0	C	C+LFD	0
FU03	3	0	C	C+LFD	0	C	C+LFD	0
FU03	4	0	C	C+LFD	0	C	C+LFD	0
FU4 + FU5 + FU6	1	0	C+LFD	C+LFD	C	C+LFD	C	0
FU4 + FU5 + FU6	2	0	C	C+LFD	C	C	C	0
FU4 + FU5 + FU6	3	0	C	C+LFD	C	C+LFD	C	0
FU4 + FU5 + FU6	4	0	C+LFD	C+LFD	C	C+LFD	C+LFD	0

FU	Quarter	Denmark	France	Ireland	Others	Spain	UK (England)	UK (Scotland)
FU8	1	0	C+LFD	C+LFD	C	0	0	0
FU8	2	0	C	C+LFD	C	0	0	0
FU8	3	0	C	C+LFD	C	0	C	0
FU8	4	0	C	C+LFD	C	0	0	0
FU9	1	0	C	0	0	0	0	0
FU9	2	0	C	0	0	0	0	0
FU9	3	0	C	0	0	0	0	0
FU9	4	0	C	0	0	0	0	0
FU10&FU14	1	0	C+LFD	0	0	C+LFD	0	0
FU10&FU14	2	0	C+LFD	0	0	C+LFD	0	0
FU10&FU14	3	0	C+LFD	0	0	C+LFD	0	0
FU10&FU14	4	0	C+LFD	0	0	C+LFD	C	0
FU12	1	0	C+LFD	0	0	C+LFD	0	0
FU12	2	0	C+LFD	0	0	C+LFD	0	0
FU12	3	0	C+LFD	0	0	C	0	0
FU12	4	0	C	0	0	C	0	0
FU13	1	0	C+LFD	0	0	C+LFD	0	0
FU13	2	0	C+LFD	0	0	C	0	0
FU13	3	0	C+LFD	0	0	C	C	0
FU13	4	0	C+LFD	0	0	C	0	0
FU15	1	0	C	C+LFD	C	0	C	0
FU15	2	0	C	C+LFD	C	0	0	0
FU15	3	0	C	C+LFD	0	0	C+LFD	0
FU15	4	0	C	C+LFD	C	0	C+LFD	0
FU16	1	C+LFD	C+LFD	C+LFD	C+LFD	C+LFD	C	C+LFD
FU16	2	C+LFD	C	C+LFD	C+LFD	C+LFD	C	C
FU16	3	C+LFD	C+LFD	C+LFD	C+LFD	C+LFD	C	C+LFD
FU16	4	C+LFD	C+LFD	C+LFD	C+LFD	C+LFD	C	C+LFD

Table 9.4. Hake in Division 3.a, subareas 4, 6, and 7 and divisions 8.a, 8.b,and 8.d (northern stock). Summary of landings and assessment results.

Year	Recruit Age 0	Total Bio-mass	Total SSB	Landings	Discards	Catch	Yield/SSB	F (15–80 cm)
1978	319509	457282	72229	50551		50551	0.70	0.54
1979	313044	477163	92987	51096		51096	0.55	0.58
1980	307338	448802	95511	57265		57265	0.60	0.68
1981	616913	388237	81942	53918		53918	0.66	0.69
1982	428809	381218	66018	54994		54994	0.83	0.72
1983	140607	415488	64190	57507		57507	0.90	0.66
1984	303080	409535	77358	63286		63286	0.82	0.70
1985	650417	342515	74253	56099		56099	0.76	0.85
1986	383785	295648	55102	57092		57092	1.04	0.95
1987	448690	289942	40364	63369		63369	1.57	1.04
1988	518914	295834	43908	64823	2	64825	1.48	1.05
1989	500919	290262	43036	66473	73	66546	1.55	1.13
1990	500015	279283	40361	59954		59954	1.49	1.07
1991	283680	262868	39644	58129		58129	1.47	1.02
1992	302910	245421	38176	56617		56617	1.48	1.05
1993	541960	213685	37391	52144		52144	1.39	1.10
1994	300812	214402	29333	51259	356	51615	1.76	1.11
1995	156159	239418	28653	57621		57621	2.0	1.17
1996	377299	197402	33659	47210		47210	1.40	1.03
1997	261533	178714	28846	42465		42465	1.47	1.11
1998	434771	176929	23231	35060		35060	1.51	1.03
1999	222697	201770	26594	39814	349	40163	1.51	1.01
2000	193857	208622	29381	42026	83	42109	1.43	0.95
2001	354055	209681	34905	36675		36675	1.05	0.79
2002	283150	231638	35956	40107		40107	1.12	0.84
2003	165395	245150	36566	43162	2110	45272	1.24	0.84
2004	354020	242701	41638	46417	2552	48969	1.18	0.85

Year	Recruit Age 0	Total Biomass	Total SSB	Landings	Discards	Catch	Yield/SSB	F (15–80 cm)
2005	228685	221092	39729	46550	4676	51226	1.29	0.99
2006	306454	227227	32217	41467	1816	43283	1.34	0.88
2007	470423	270604	39067	45028	2191	47219	1.21	0.75
2008	772351	375344	46620	47739	3248	50987	1.09	0.60
2009	249675	618723	70773	58818	10590	69408	0.98	0.49
2010	270027	913343	129738	72799	9978	82777	0.64	0.37
2011	276796	1078613	211698	87540	14156	101696	0.48	0.31
2012	519015	1116520	238004	85677	12680	98357	0.41	0.27
2013	376267	1176338	238566	77753	15886	93639	0.39	0.27
2014	208076	1295903	248043	89940	9913	99853	0.40	0.25
2015	215682	1380741	283027	93670	9820	103490	0.37	0.24
2016	313605	1355913	307092	109106	12741	121847	0.40	0.27
2017	340551	1203555	280165	104671	7386	112057	0.40	0.37
2018	317969	1073415	235279	89671	7034	96705	0.41	0.29
2019	422146	1064739	217121	82298	4940	87238	0.40	0.28
2020	227146	1143594	224675	72579	3257	75836	0.34	0.26
Arithmetic mean	353005	519890	96582	60708	5906	63867	1.01	0.73
Units	Thousands of individuals	Thousands	Tonnes	Tonnes	Tonnes	Tonnes	Percentage	

Table 9.5. Hake in Division 3.a, subareas 4, 6, and 7 and divisions 8.a, 8.b, and 8.d (northern stock). Catch option table.

SSB(2021)	Rec proj	F(15–80 cm)	Catch(2021)	Land(2021)	SSB(2022)		
239 091	309 417	0.28	87 708	82 428	218 924		
Fmult	**Fcatch(15–80 cm)**	**Fland(15–80 cm)**	**Fdisc (15–80 cm)**	**Catch(2022)**	**Land(2022)**	**Disc(2022)**	**SSB(2023)**
0.0	0.0000	0.0000	0.0000	0	0	0	280183
0.1	0.0279	0.0221	0.0059	9255	8617	638	271192
0.2	0.0559	0.0441	0.0117	18199	16937	1262	262508
0.4	0.1117	0.0883	0.0235	35194	32722	2472	246017
0.5	0.1397	0.1104	0.0293	43267	40209	3058	238189
0.7	0.1956	0.1545	0.0411	58609	54416	4193	223320
0.8	0.2235	0.1766	0.0469	65898	61155	4743	216261
0.9	0.2514	0.1986	0.0528	72943	67662	5281	209439
1.0	0.2794	0.2207	0.0587	79754	73945	5808	202847
1.1	0.3073	0.2428	0.0645	86338	80013	6325	196477
1.3	0.3632	0.2869	0.0763	98857	91531	7326	184371
1.4	0.3911	0.3090	0.0821	104806	96995	7811	178621
1.5	0.4190	0.3311	0.0880	110559	102273	8286	173062
1.6	0.4470	0.3531	0.0938	116122	107370	8752	167689
1.7	0.4749	0.3752	0.0997	121501	112293	9208	162495
1.8	0.5029	0.3973	0.1056	126703	117048	9654	157473
1.9	0.5308	0.4193	0.1114	131733	121641	10092	152618
2.0	0.5587	0.4414	0.1173	136598	126077	10521	147924

Table 9.6. Hake in Division 3.a, subareas 4, 6, and 7 and divisions 8.a, 8.b, and 8.d (northern stock). Yield-per-recruit table.

SPR-level	F-mult	F(15–80cm)	YPR-catch	YPR-landings	SSB-PR
1.00	0.00	0.00	0.00	0.00	3.2
0.84	0.100	0.030	0.088	0.085	2.7
0.72	0.20	0.060	0.153	0.146	2.3
0.62	0.30	0.080	0.20	0.191	1.97
0.53	0.40	0.110	0.23	0.22	1.70
0.46	0.50	0.140	0.26	0.24	1.48
0.41	0.60	0.170	0.28	0.26	1.30
0.36	0.70	0.190	0.29	0.27	1.14
0.32	0.80	0.22	0.30	0.28	1.02
0.28	0.90	0.25	0.30	0.28	0.91
0.25	1.00	0.28	0.30	0.28	0.81
0.23	1.10	0.30	0.30	0.28	0.73
0.21	1.20	0.33	0.30	0.28	0.66
0.189	1.30	0.36	0.30	0.27	0.60
0.172	1.40	0.39	0.30	0.27	0.55
0.158	1.50	0.41	0.29	0.26	0.50
0.145	1.60	0.44	0.29	0.26	0.46
0.134	1.70	0.47	0.29	0.26	0.43
0.124	1.80	0.50	0.28	0.25	0.40
0.115	1.90	0.52	0.28	0.24	0.37
0.107	2.0	0.55	0.27	0.24	0.34
SPR.level	F-mult	F(15–80cm)	YPR-catch.	YPR-landings	SSB-PR
0.26	0.99	0.27	0.30	0.28	0.82
0.38	0.66	0.18	0.28	0.27	1.21
0.35	0.72	0.20	0.29	0.27	1.12
0.30	0.84	0.23	0.30	0.28	0.97

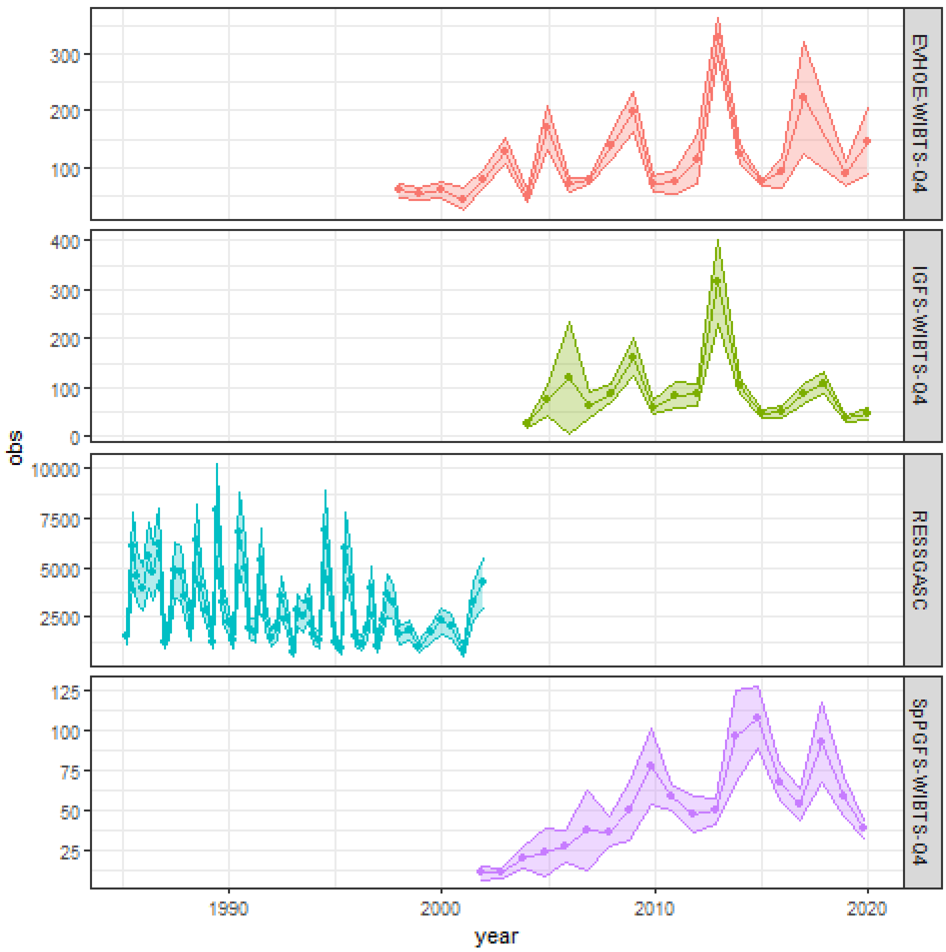

Figure 9.1. Hake in Division 3.a, subareas 4, 6, and 7 and divisions 8.a, 8.b, and 8.d (northern stock). Abundance indices from surveys.

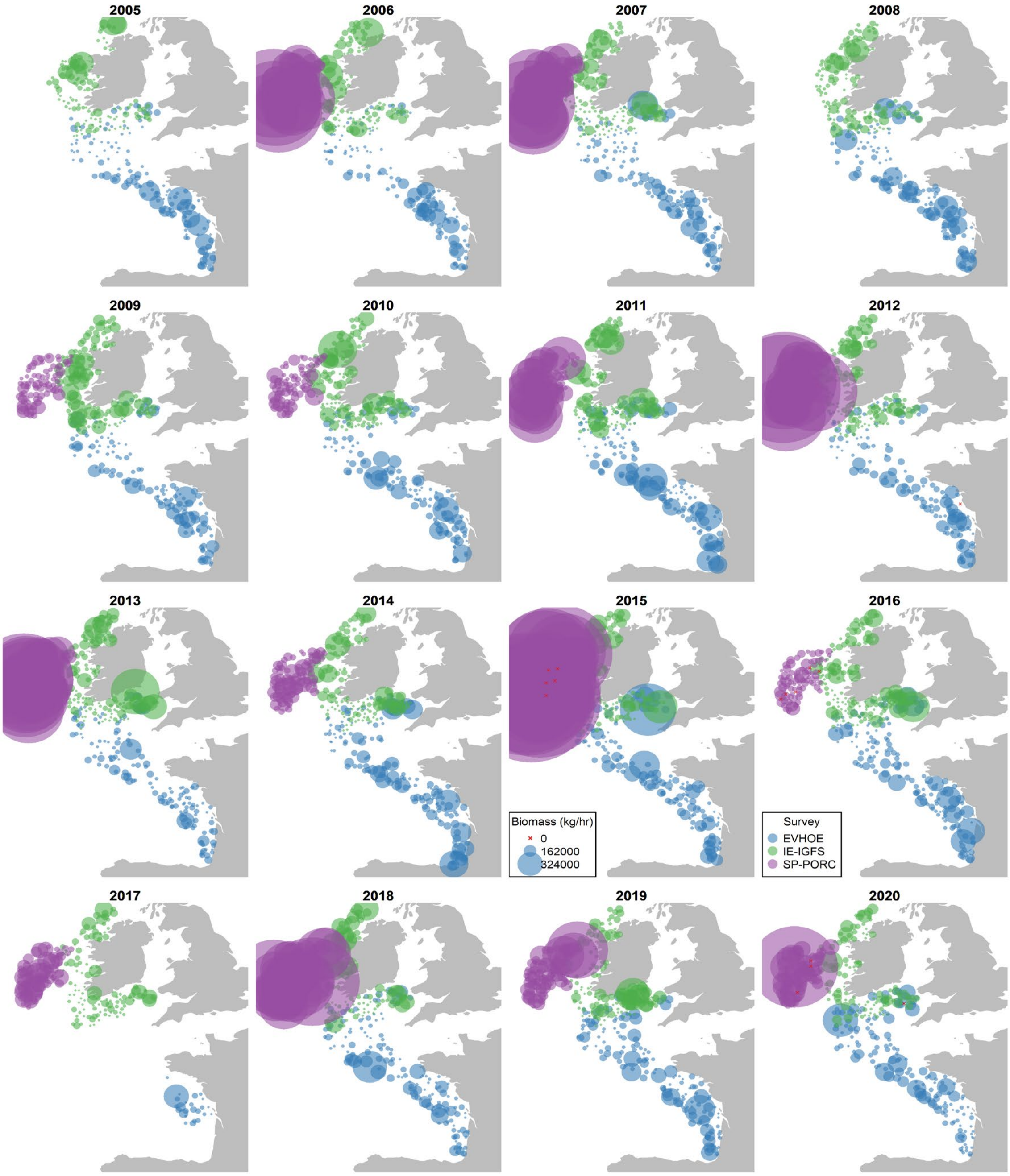

Figure 9.2. Hake in Division 3.a, subareas 4, 6, and 7 and divisions 8.a, 8.b, and 8.d (northern stock). Spatial distribution of the EVHOE-WIBTS-Q4 (G9527), IGFS-WIBTS-Q4 (G7212) and SpPGFS-WIBTS-Q4 (G5768) index of biomass (Kg/hr) from 2003 to 2018.

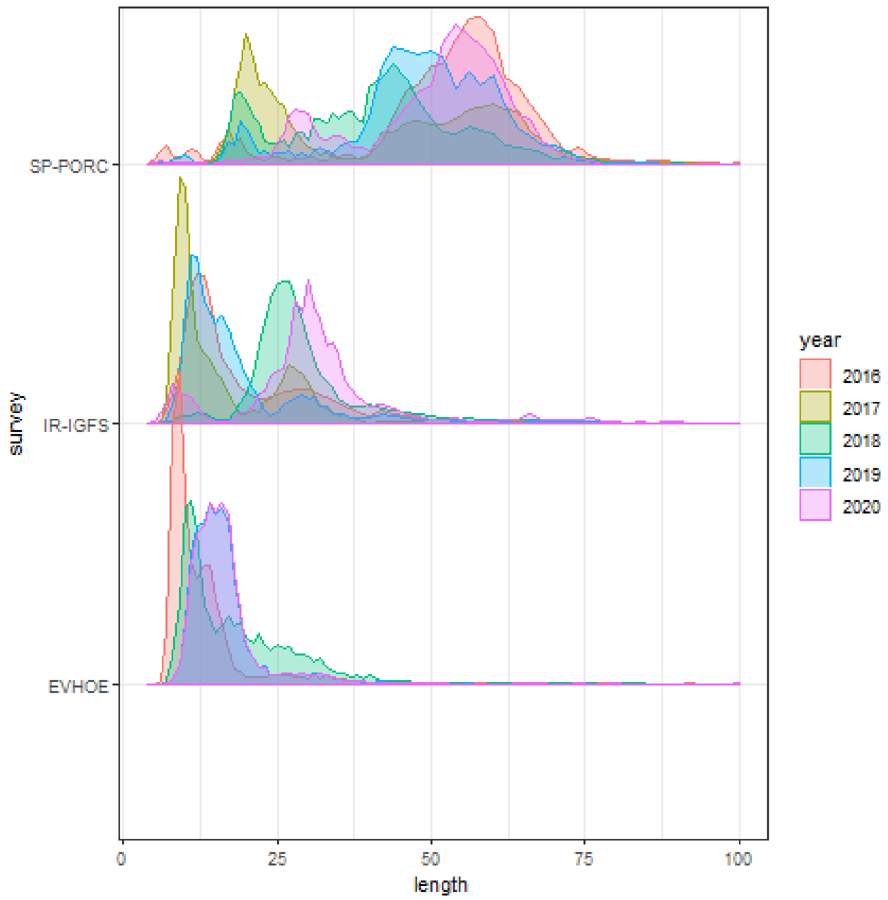

Figure 9.3. Hake in Division 3.a, subareas 4, 6, and 7 and divisions 8.a, 8.b, and 8.d (northern stock). Length frequency distribution of surveys in the most recent years, from 2018 to 2020.

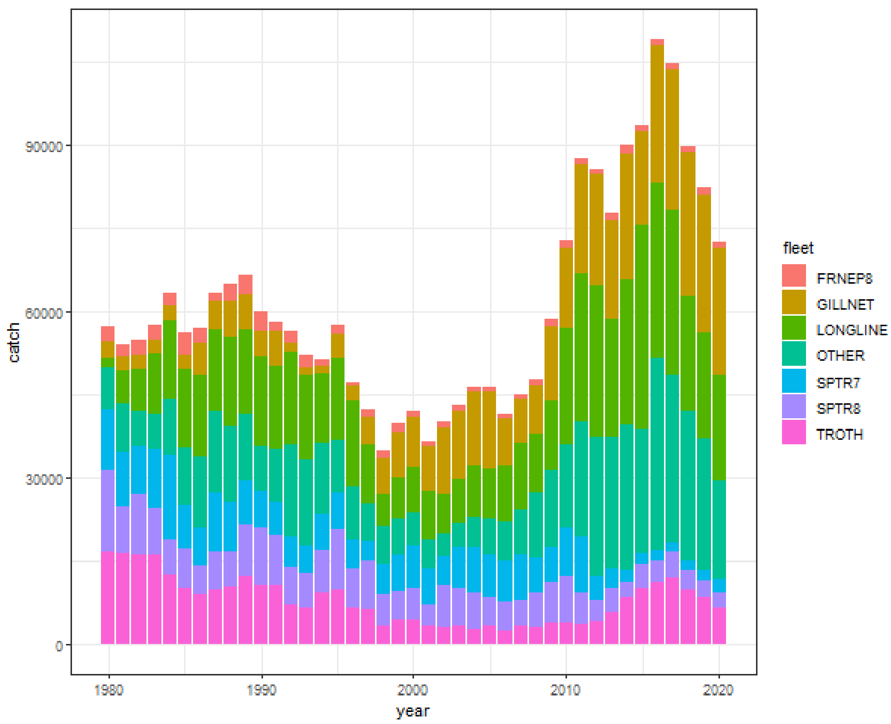

Figure 9.4. Hake in Division 3.a, subareas 4, 6, and 7 and divisions 8.a, 8.b, and 8.d (northern stock). Total catch over time, the colours correspond to the fleets used in the assessment model configuration.

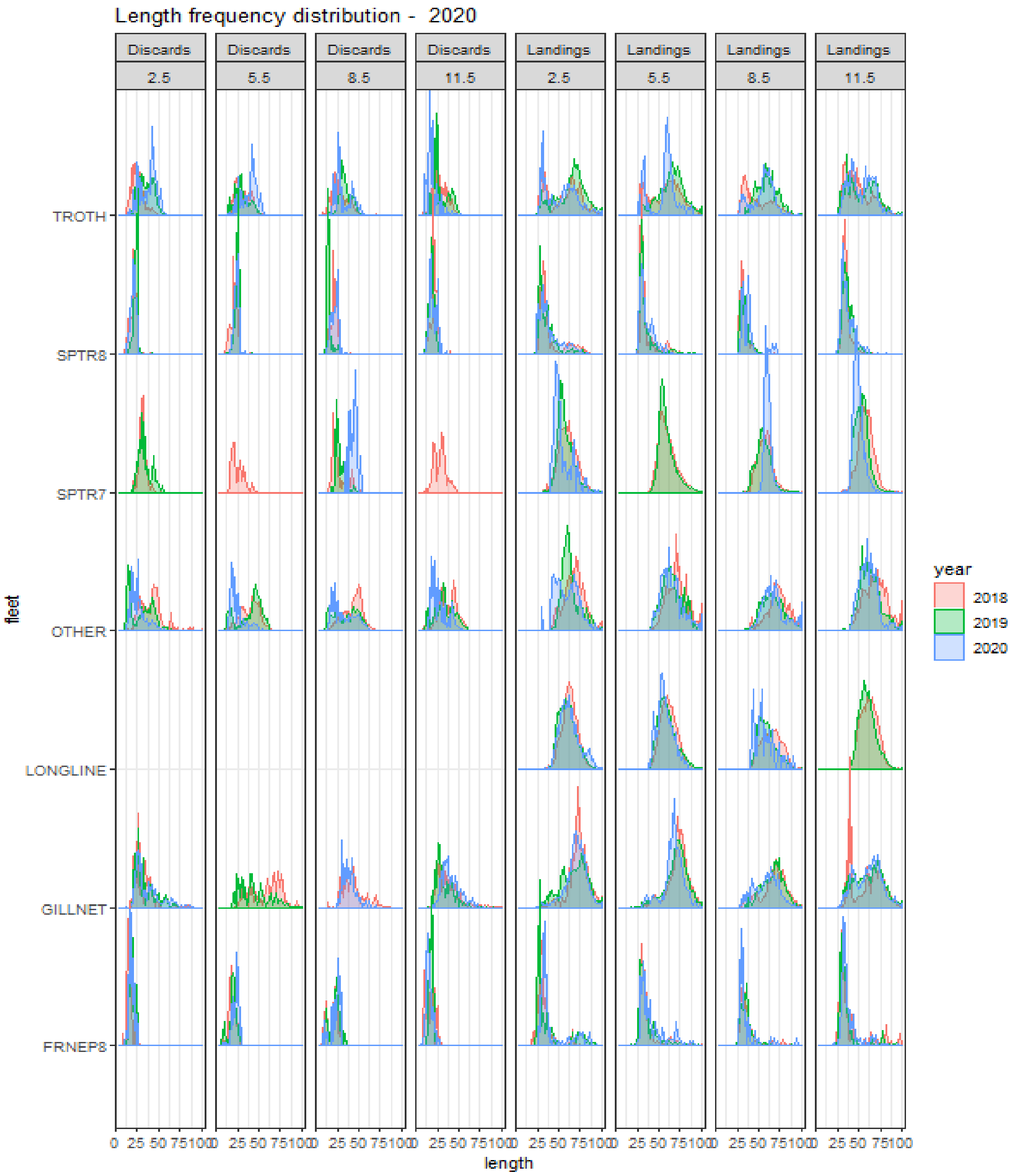

Figure 9.5. Hake in Division 3.a, subareas 4, 6, and 7 and divisions 8.a, 8.b, and 8.d (northern stock). Length frequency distribution for landings and discards by fleet in the most recent years, from 2018 to 2020, by season and the fleet as used in the assessment model configuration.

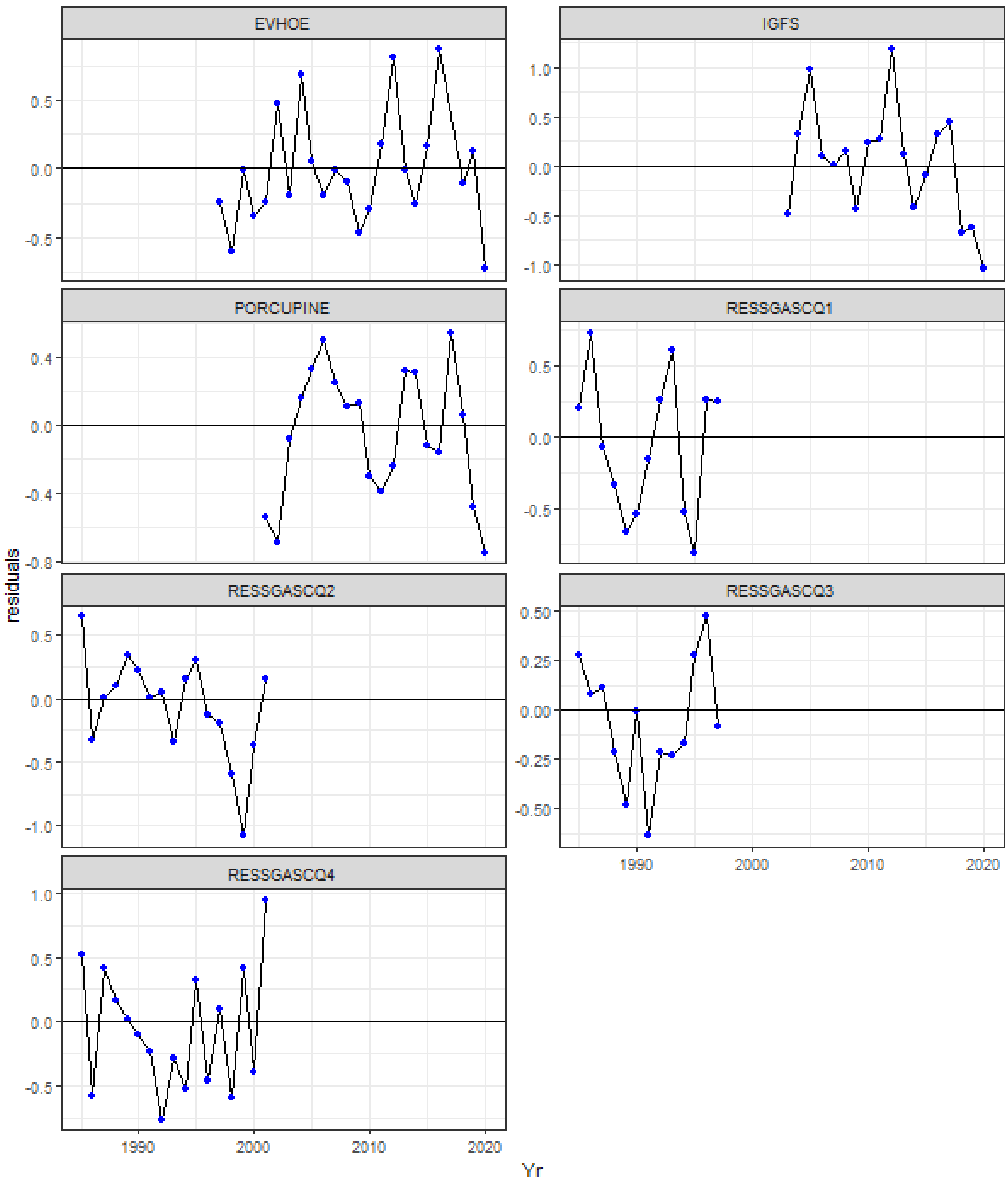

Figure 9.6. Hake in Division 3.a, subareas 4, 6, and 7 and divisions 8.a, 8.b, and 8.d (northern stock). Residuals of the fits to the surveys log(abundance indices). For RESSGASC, EVHOE (EVHOE-WIBTS-Q4), PORCUPINE (SpPGFS-WIBTS-Q3, G5768) and IGFS (IGFS-WIBTS-Q4, G7212), fits are by quarter.

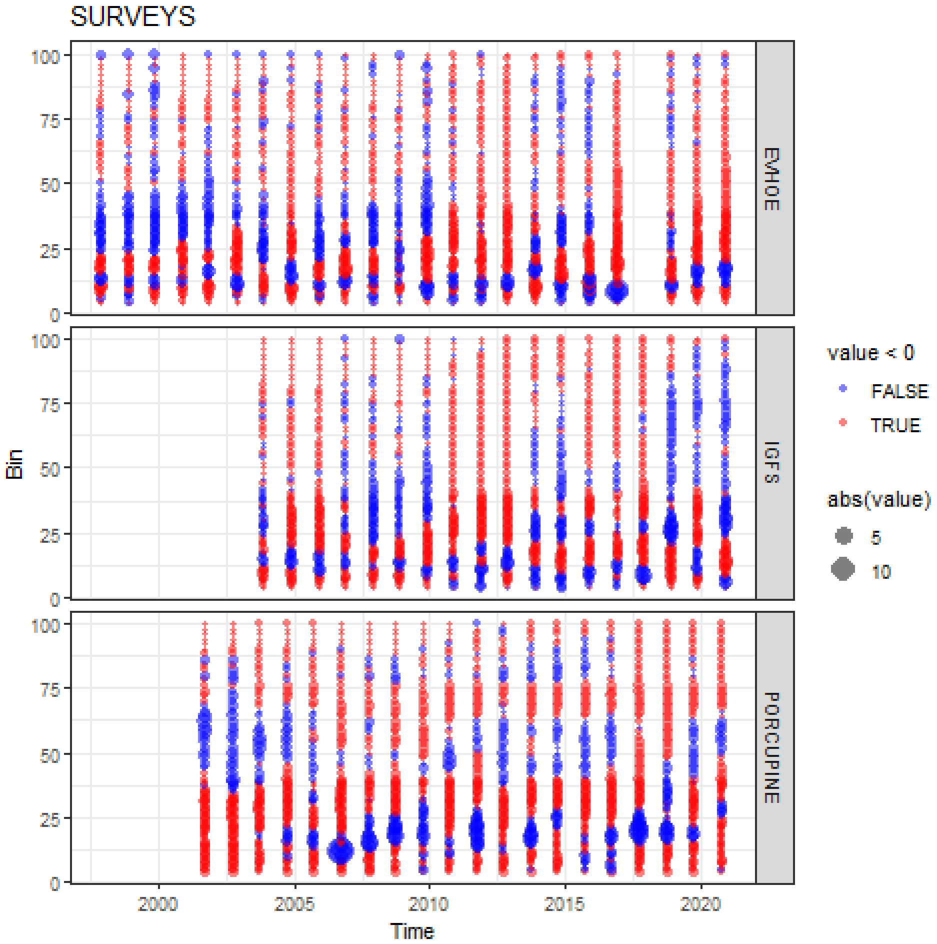

Figure 9.7. Hake in Division 3.a, subareas 4, 6, and 7 and divisions 8.a, 8.b, and 8.d (northern stock). Pearson residuals of the fit to the length distributions of the surveys abundance indices. For EVHOE (EVHOE-WIBTS-Q4), PORCUPINE (SPGFS-WIBTS-Q3) and IGFS (IGFS-WIBTS-Q4, G5768), fits are by quarter.

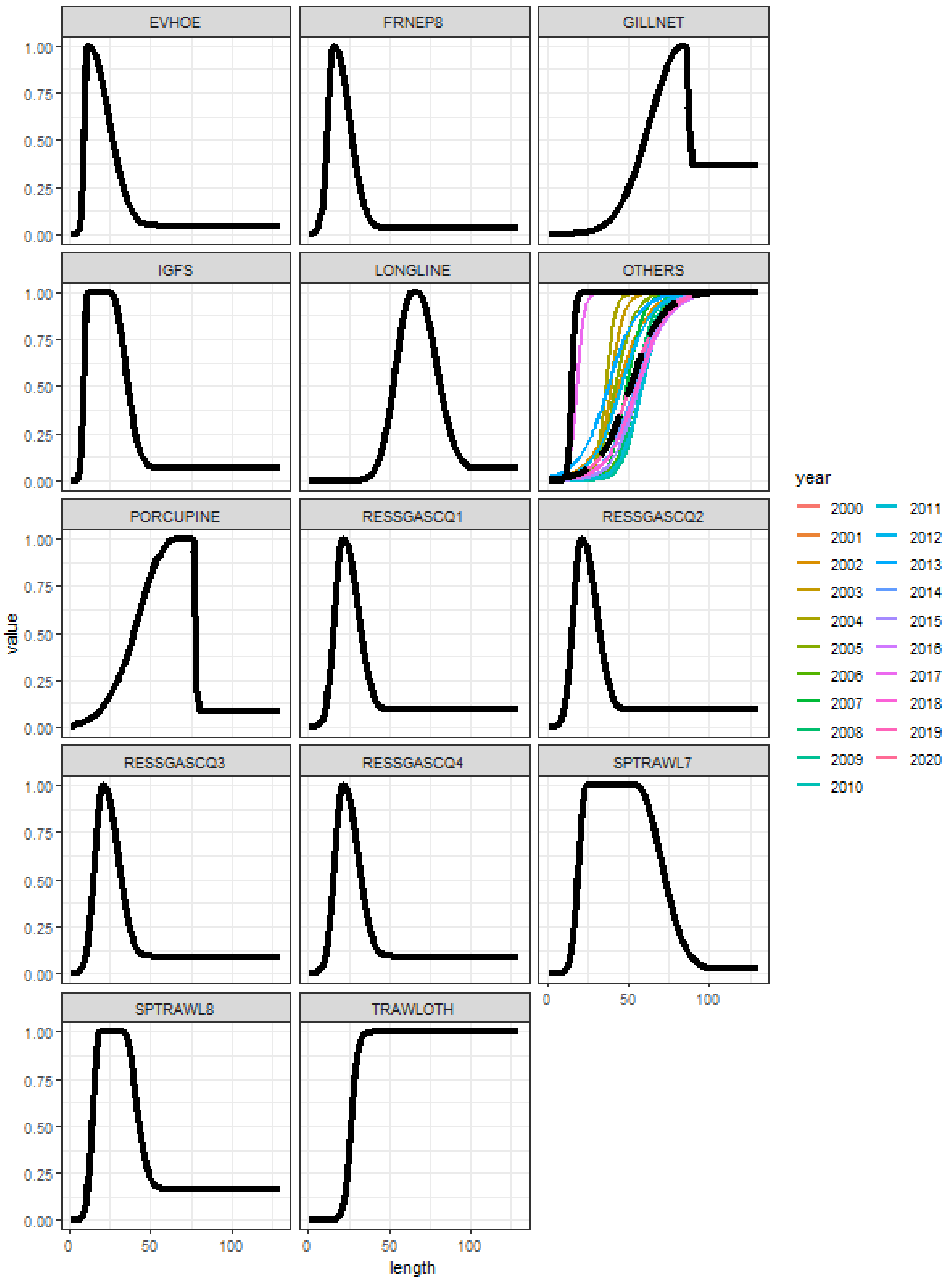

Figure 9.8. Hake in Division 3.a, subareas 4, 6, and 7 and divisions 8.a, 8.b, and 8.d (northern stock). Selection curves by commercial fleet estimated by SS. The solid black line corresponds to the selectivity in 2020 and the black dashed line with the selection in 2019.

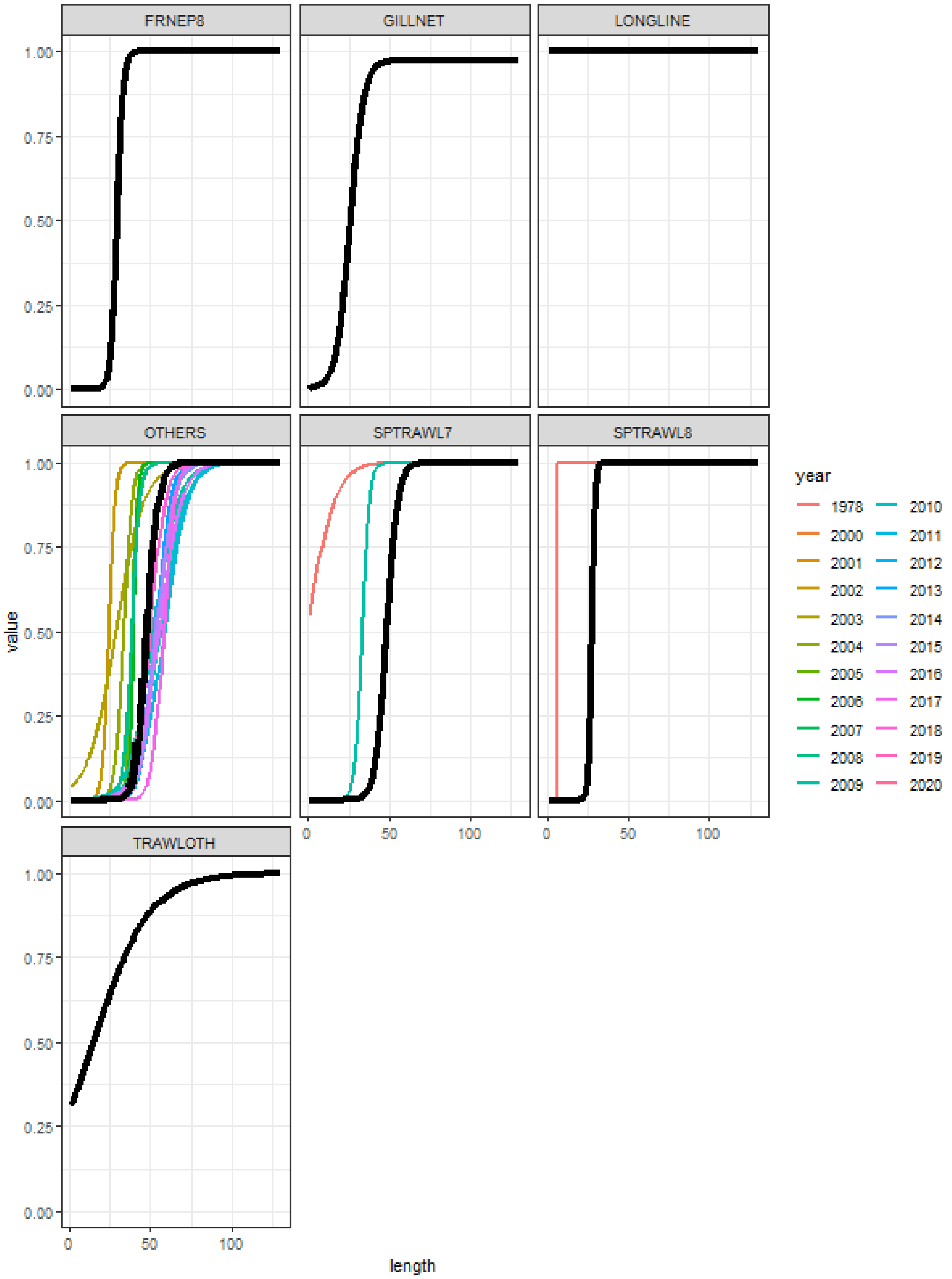

Figure 9.9. Hake in Division 3.a, subareas 4, 6, and 7 and divisions 8.a, 8.b, and 8.d (northern stock). Retention curves by commercial fleet estimated by SS. The solid black line corresponds to the selectivity in 2020 and the black dashed line with the selection in 2019.

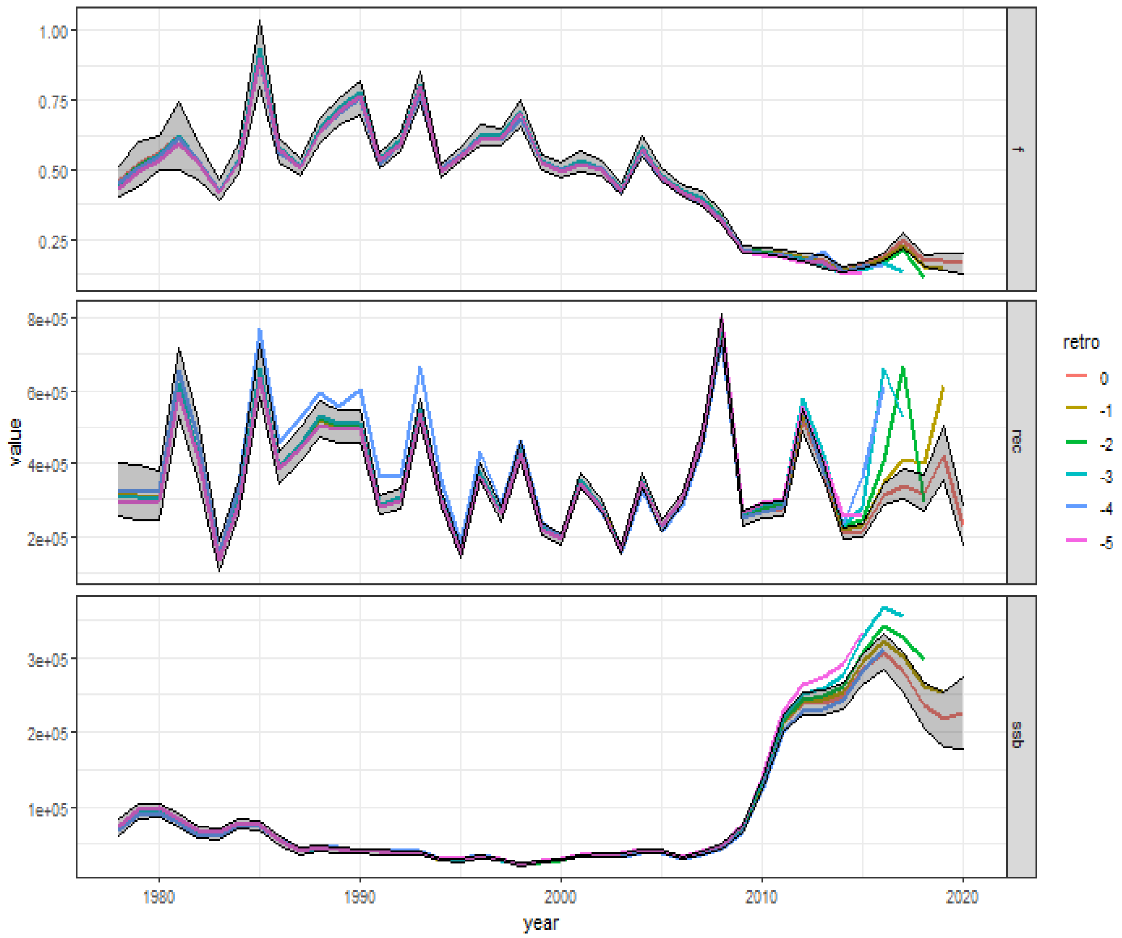

Figure 9.10. Hake in Division 3.a, subareas 4, 6, and 7 and divisions 8.a, 8.b, and 8.d (northern stock). Retrospective plot from SS3 including confidence intervals.

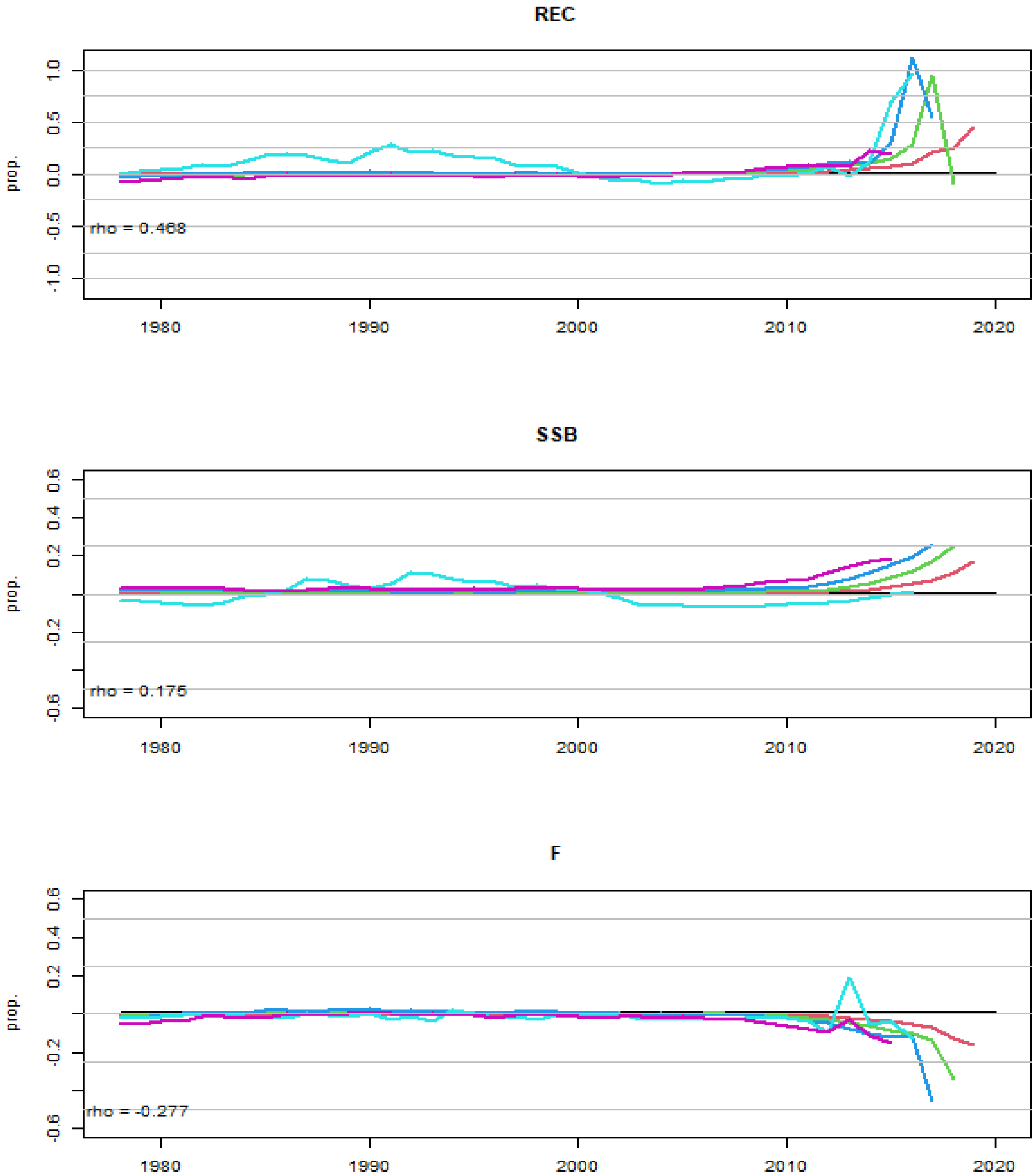

Figure 9.11. Hake in Division 3.a, subareas 4, 6, and 7 and divisions 8.a, 8.b, and 8.d (northern stock). Differences between time-series in the retrospective analysis plot from SS3 for 2015–2020. The number in the bottom-left of the plot corresponds to the Mohn's rho.

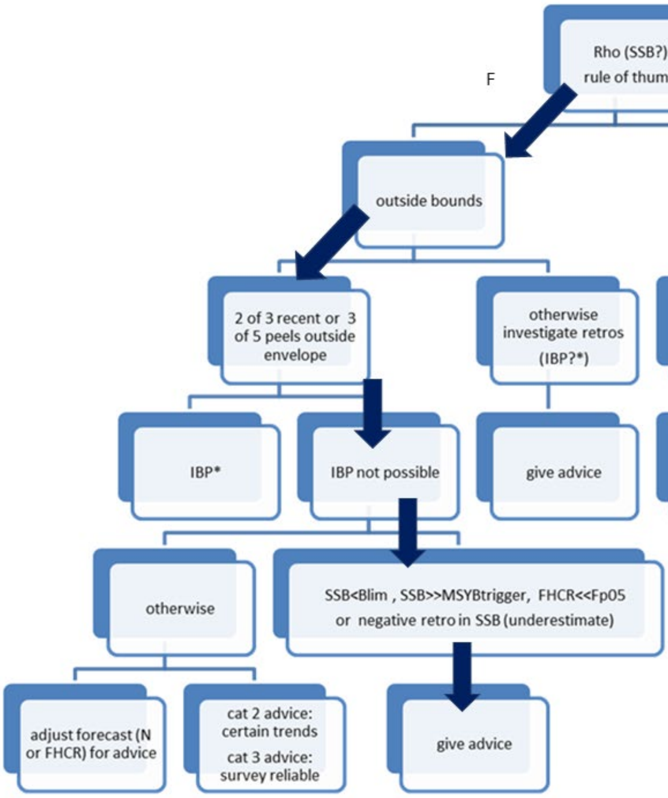

Figure 9.12. Hake in Division 3.a, subareas 4, 6, and 7 and divisions 8.a, 8.b, and 8.d (northern stock). Scheme from WKFORBIAS (ICES, 2020) to assess determine if it is possible to produce advice based on an assessment model with a given retrospective pattern

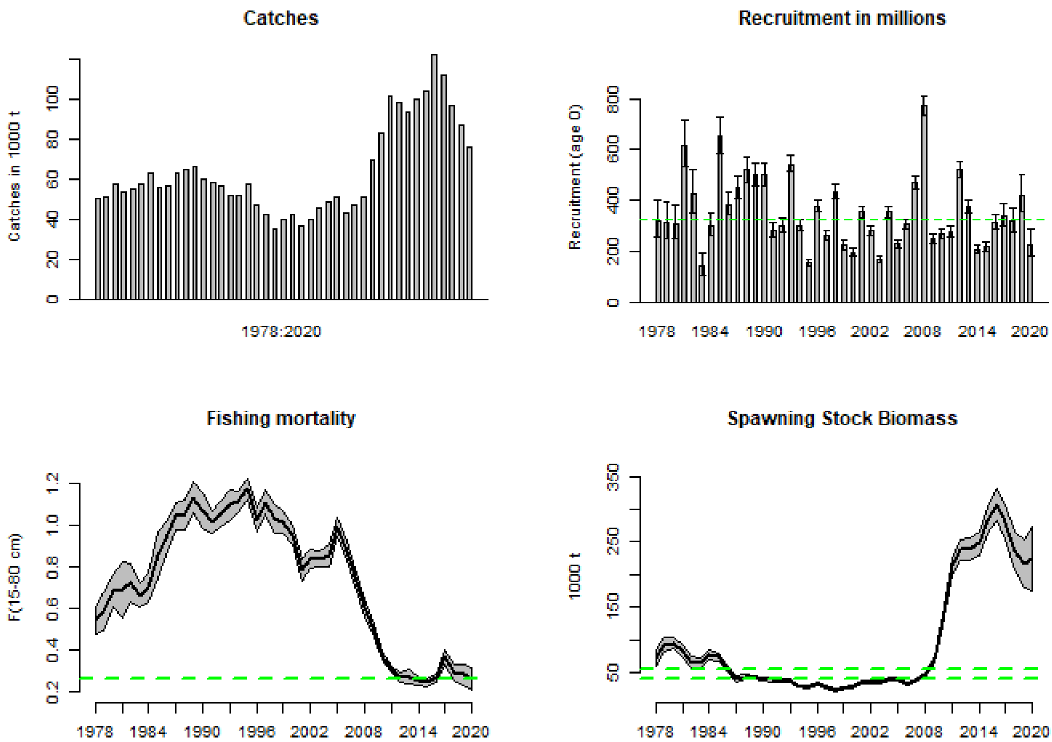

Figure 9.13. Hake in Division 3.a, subareas 4, 6, and 7 and divisions 8.a, 8.b, and 8.d (northern stock). Summary plot of stock trends. Green dashed lines correspond to geometric mean recruitment, F_{MSY} and, B_{lim} and B_{pa}.

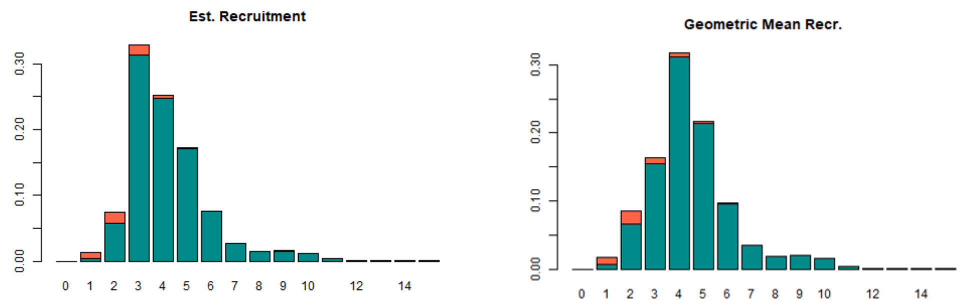

Figure 9.14. Hake in Division 3.a, subareas 4, 6, and 7 and divisions 8.a, 8.b, and 8.d (northern stock). Contribution of age-classes to catch advice in r fy using $F_{advice} = F_{msy}$ in the scenario where the estimated recruitment is used in the whole time-series (top) and in the scenario where the recruitment is replaced by the geometric mean in the last two years (bottom). The blue part of the bar corresponds to landings and red one with discards.

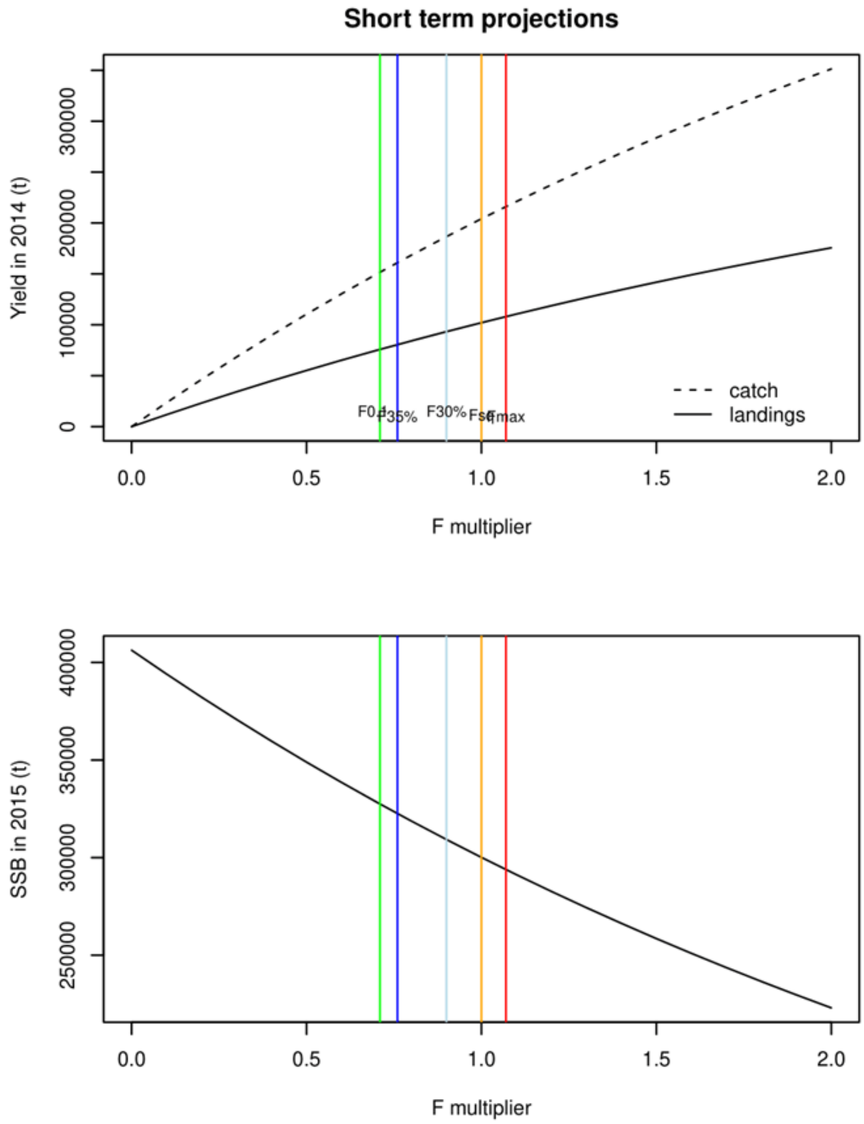

Figure 9.15. Hake in Division 3.a, subareas 4, 6, and 7 and divisions 8.a, 8.b, and 8.d (northern stock). Summary plot of stock trends. Green dashed lines correspond to geometric mean recruitment, F_{MSY} and, B_{lim} and B_{pa}.

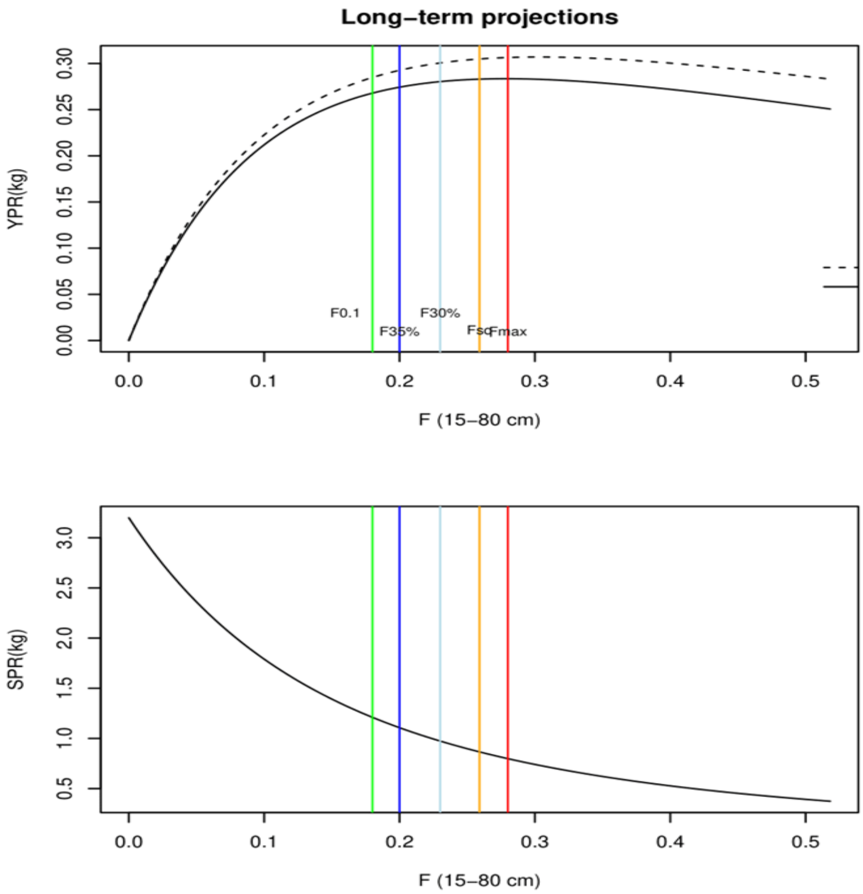

Figure 9.16. Hake in Division 3.a, subareas 4, 6, and 7 and divisions 8.a, 8.b, and 8.d (northern stock). Summary plot of stock trends. Green dashed lines correspond to geometric mean recruitment, F_{MSY} and, B_{lim} and B_{pa}.

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

Merluccius merluccius – hke.27.8c9a

10.1 General

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

10.1.1 Fishery description

Fishery description is available in the Stock Annex.

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

10.1.2.1 ICES advice for 2021

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

10.1.2.2 Management applicable for 2020 and 2021

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

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

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

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

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

10.2 Data

10.2.1 Commercial catch: landings and discards

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

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

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

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

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

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

10.2.2 Growth, length-weight relationship and M

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

10.2.3 Maturity ogive

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

10.2.4 Abundance indices from surveys

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

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

10.2.5 Commercial catch-effort data

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

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

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

10.3 Catch options with category 3

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

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

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

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

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

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

10.4 Biological reference points

10.4.1 Reference points

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

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

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

10.4.2 Data

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

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

10.4.3 Length based indicators (LBI)

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

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

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

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

10.4.4 Mean length total mortality (MLZ)

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

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

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

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

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

10.4.5 Length based Spawning Potential Ratio (LB-SPR)

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

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

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

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

10.4.6 SPiCT (Surplus Production model in continuous time)

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

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

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

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

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

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

10.4.7 Conclusions

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

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

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

10.4.8 Proposed Reference points

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

10.5 Comments on the assessment

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

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

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

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

10.6 Management considerations

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

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

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10.8 Tables and figures

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

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

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

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

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

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

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

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

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

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

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

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

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

Since 2002 tow duration is 30 min for autumn survey

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

Data in 2014–2016 reviewed in 2018

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

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

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

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

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

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

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

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

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

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

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

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

Table 10.7 Traffic light indicator table for the LBI analysis.

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

Table 10.8 SPiCT runs summary

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

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

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

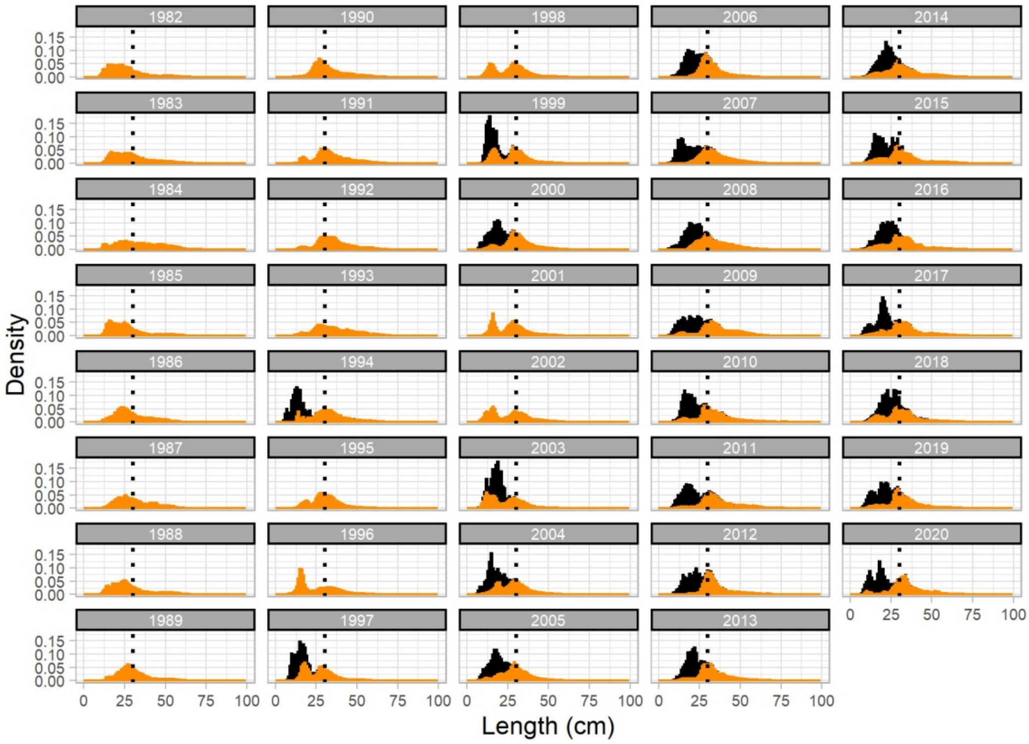

Figure 10.1. Length distribution of catches. Landings 1982–2020 (orange), discards from 1992–2020 (black), minimum landing size (MLS, dashed line) since 1992 at 27 cm.

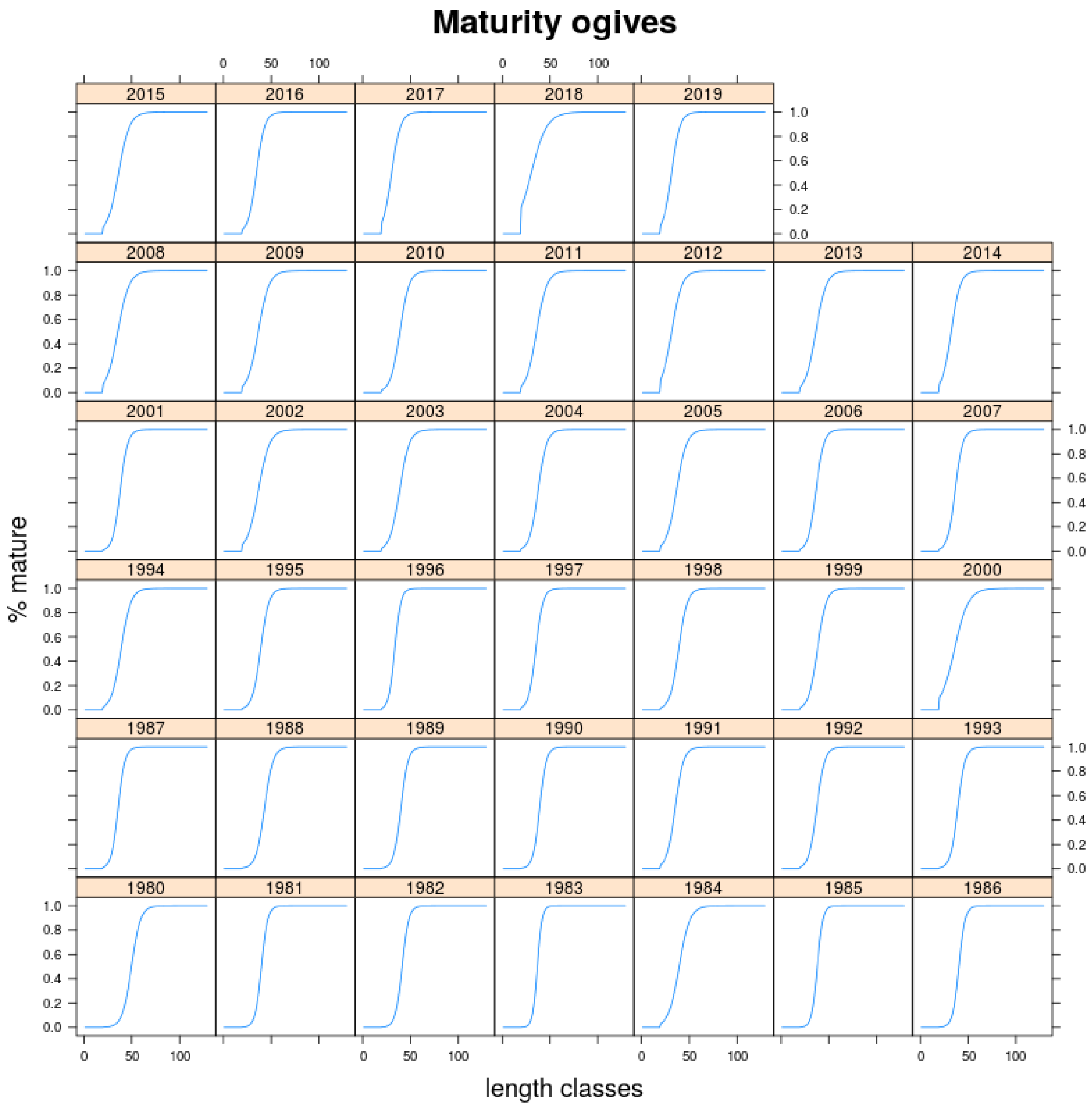

Figure 10.2. Maturity ogives from 1982 (upper plot) and L_{50} trend (lower plot).

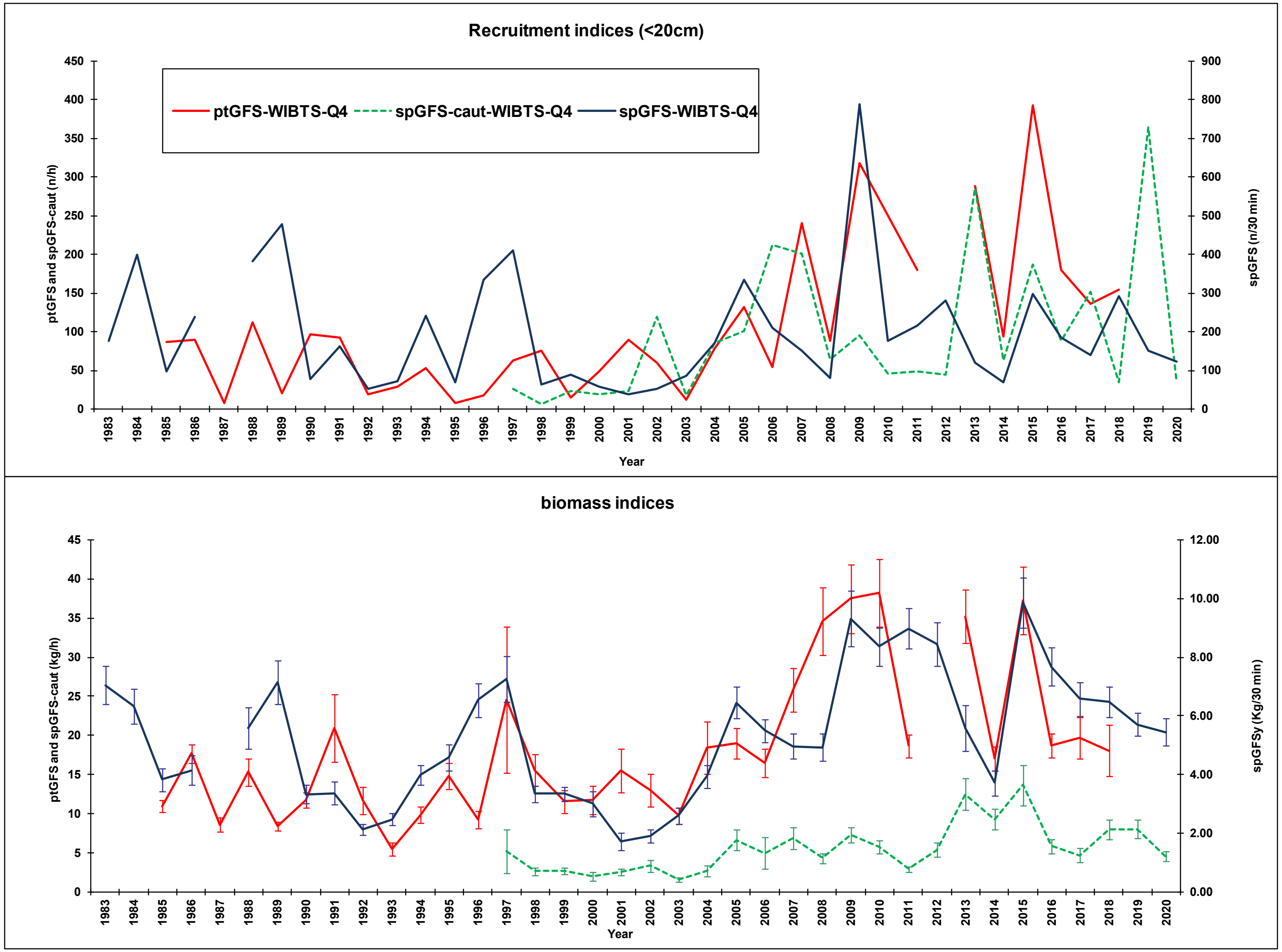

Figure 10.3. Southern hake stock. Recruitment and biomass Indices from groundfish surveys. Vertical bars = 90% CI.

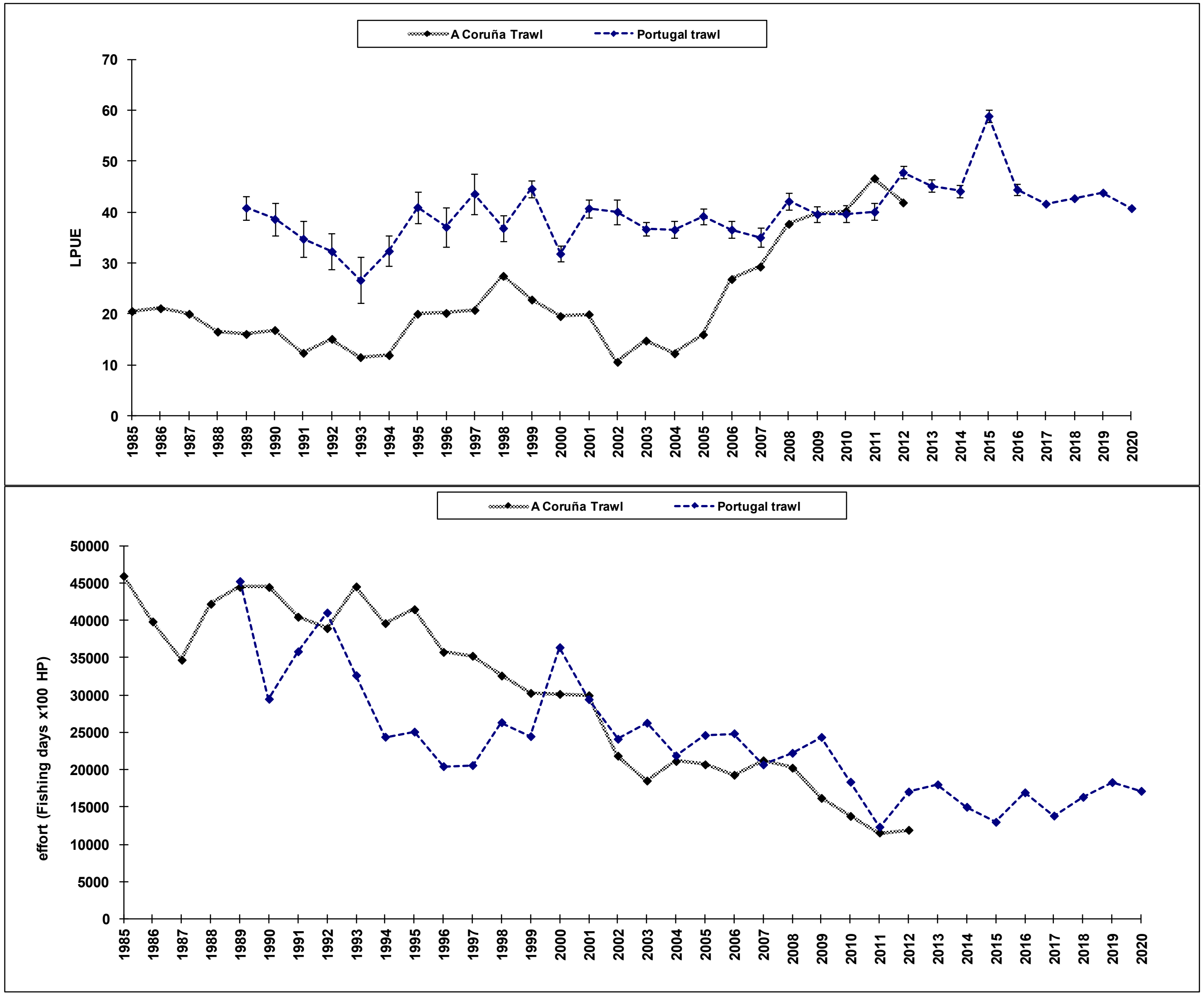

Figure 10.4. Hake southern stock, LPUE and fishing effort trends for trawl fleets. Vertical bars = 90%

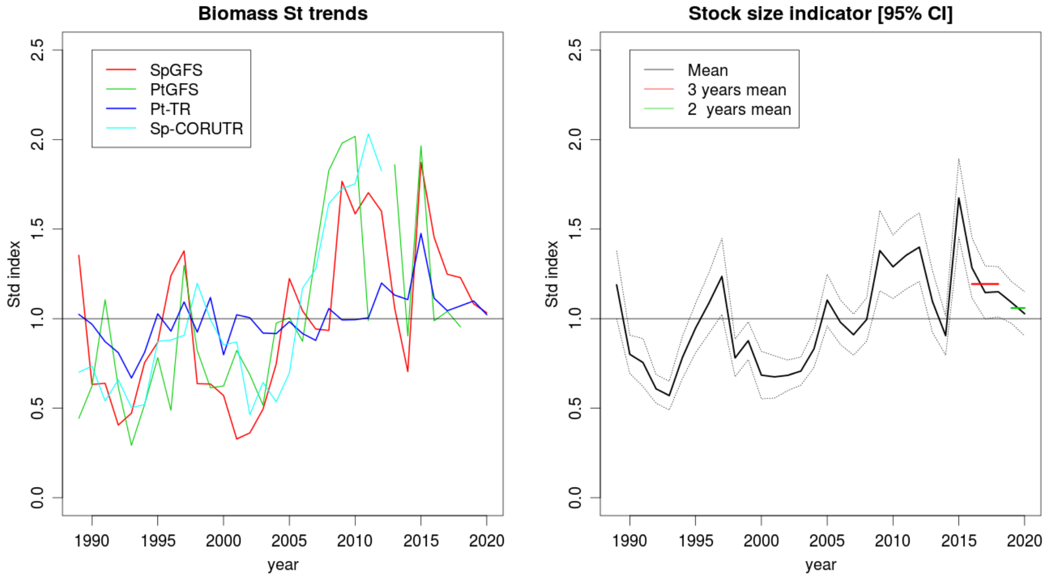

Figure 10.5. Biomass indices standardized (left) and the combined index for SpGFS and P-TR (right) showing the difference between last two years (green) and previous three (red). Names of the indices are SpGFS-WIBTS-Q4-G2784 (red), PtGFS-WIBTS-Q4-G8899 (green), Pt-TR (dark blue) and Sp-CORUTR (light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

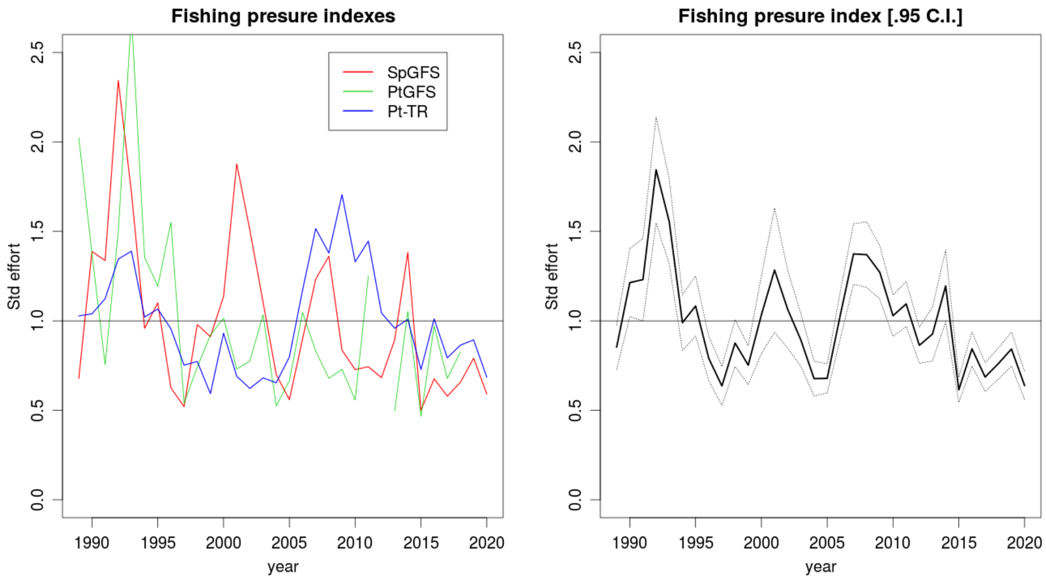

Figure 10.6. Fishing pressure index standardized (left) and the combined index for SpGFS and P-TR (right. Names of the indices are SpGFS-WIBTS-Q4-G2784 (red), PtGFS-WIBTS-Q4-G8899 (green), Pt-TR (dark blue) and Sp-CORUTR (light blue).

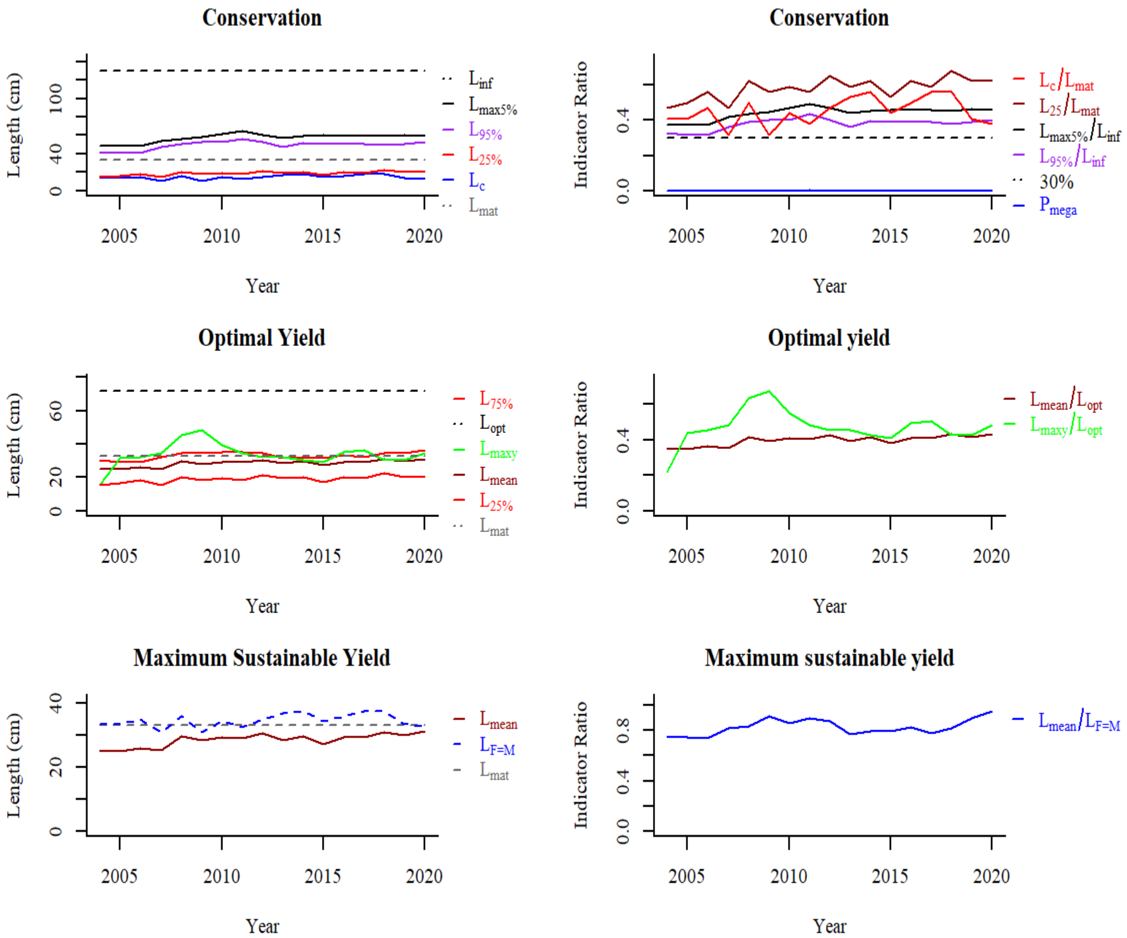

Figure 10.7. Length based indicators.

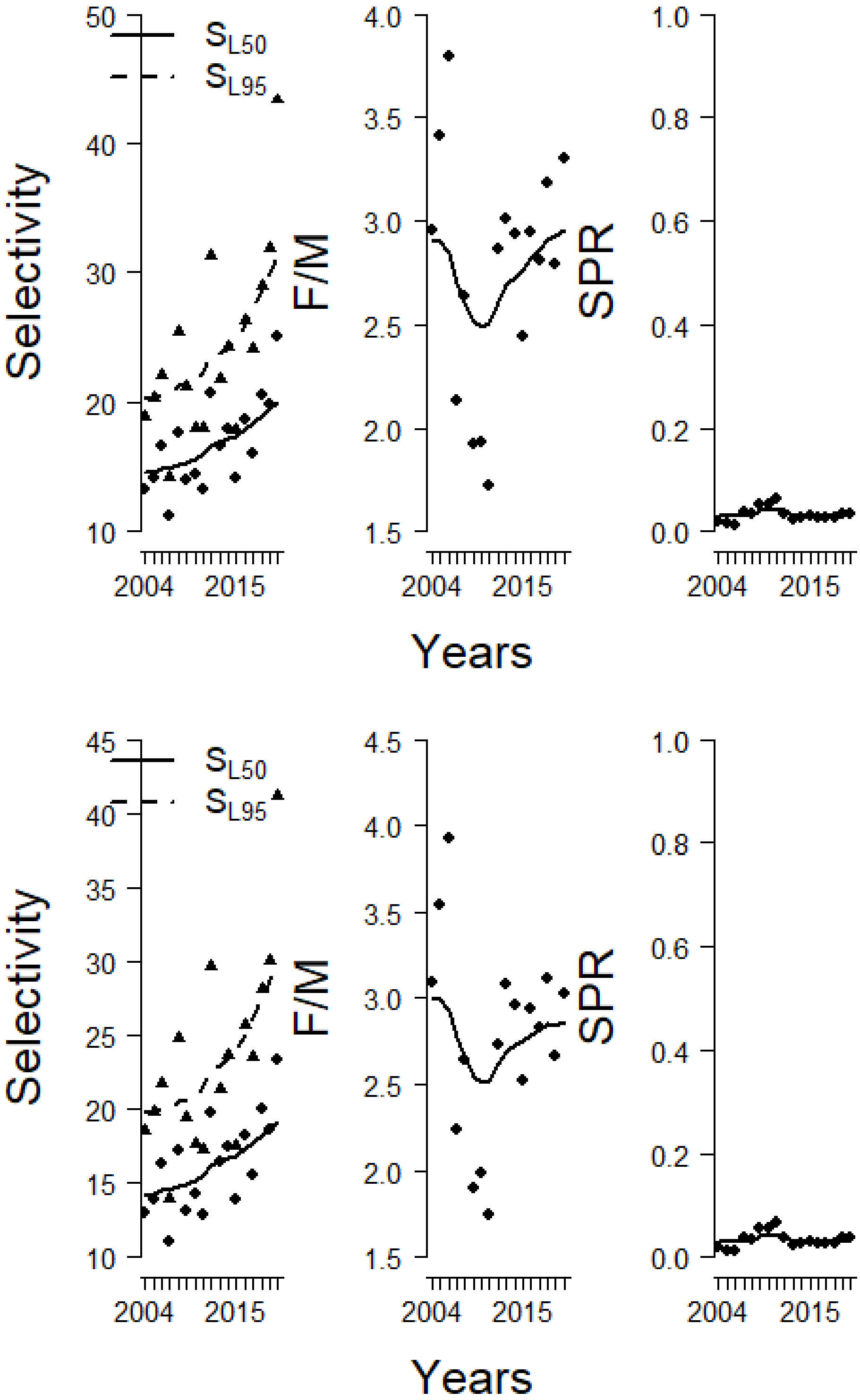

Figure 10.8. Estimated values for selectivity, F/M and SPR using GADGET biological parameter (upper plots) and LHI parameters (lower plots) values. Selectivity (left), F/M (centre) and SPR (right).

11 Norway lobster in divisions 8.a and 8.b

Nephrops norvegicus – nep.fu.2324

Functional Units 23–24 (northern and central Bay of Biscay)

11.1 General

11.1.1 ICES Advice for 2021

Previously, advice for this stock was provided biennially under category 3, with only trends of the annual assessment taken into account for the advice. The UWTV survey, routinely carried out since 2014, was validated as the standard assessment method for this stock during the 2016 benchmark workshop WKNEP (ICES, 2017a). The stock was upgraded to category 1 and the advice is provided annually. The latest ICES advice provided in 2020 recommended that when the MSY approach is applied, catches in 2021 should be no more than 6105 t, corresponding to 3984 t of landings considering the revised survival rate for discards to 50% instead of 30% adopted during the WK*Nephrops* (ICES, 2020b).

11.1.2 Management applicable for 2020 and 2021

The *Nephrops* fishery is managed by a TAC [articles 3, 4, 5(2) of Regulation (EC) No 847/96] along with technical measures. The agreed TAC for 2020 was 3886 t and for 2021, the TAC was fixed at 3984 t.

For a long-time, a minimum landing size (MLS) of 26 mm CL (8.5 cm total length) was adopted by the French producers' organization, which is larger than the EU MLS set at 20 mm CL i.e. 7 cm total length. Since December 2005, a new French MLS regulation (9 cm total length) was established. This change had significantly affected the data used by the WG (see report WGHMM in 2007; ICES, 2007).

A mesh size change was implemented in 2000 and the minimum codend mesh size (MMS) in the Bay of Biscay was 70 mm which replaced the 50 mm mesh size implemented in 1990–1991. Technical regulations have also been introduced to reduce *Nephrops* bycatch in the Bay of Biscay fishery. In 2002, the European Commission (EC) established some technical measures for the recovery of the northern stock of European hake, under which the minimum codend mesh size (MMS) was increased from 70 to 100 mm in the hake box to reduce the high level of hake discarding by *Nephrops* trawlers in the Bay of Biscay (EU Reg. 2341/2002). In 2006 and 2007, *Nephrops* trawlers were allowed to fish in the hake box with a mesh size smaller than 100 mm once they have adopted a square mesh panel of 100 mm. This derogation was maintained onwards.

As cited in paragraph 24 of the preamble of the European Regulation (EC) No. 41/2007, fixing the fishing opportunities for 2007: *"In order to ensure sustainable exploitation of the hake stocks and to reduce discards, the latest developments on selective gears should be maintained as transitional measures in ICES zones VIIIa, VIIIb and VIIId"*. In agreement with this, the National French Committee of Fisheries (deliberations 39/2007, 1/2008) fixed the rules for trawling activities targeting *Nephrops* in the areas 8.a and 8.b applicable from 1 April 2008. All vessels catching more than 50 kg of *Nephrops* per day must use a selective device from at least one of the following: (1) a ventral panel of 60 mm square mesh; (2) a flexible grid or (3) an 80 mm codend mesh size. The majority of *Nephrops* directed vessels (districts of South Brittany) chose the increase of the MMS whereas the ventral squared panel was adopted by multi-purpose trawlers mainly in harbours outside Brittany.

A licence system was adopted in 2004 and, since then, there has been a cap of 250 *Nephrops* trawlers operating in the Bay of Biscay. This limit of *Nephrops* trawlers decreased to 180 in 2018–2020. At the beginning of 2006, the French producers' organizations adopted regulations (e.g. monthly quotas) which had some effects on fishing effort limitation. From 2017 onwards, some additional decisions were implemented by the producers' organizations, such as spreading landings sales over several days, in order to prevent any excess in productivity and/or quota overshot.

Since 1 January 2017, the use of a discarding quick-chute system on-board has become compulsory. There has been an impact on the survival rate of discards which is currently considered higher (50%; Mérillet *et al.*, 2018) than the historical value of 30% (Charuau *et al.*, 1982). This new rate was taken into account during the WK*Nephrops* in 2019 (ICES, 2020b) for future assessment and advice of the stock.

11.2 Data

11.2.1 Commercial catches and discards

Total catches, landings and discards, of *Nephrops* in divisions 8.a, b for the period 1960–2020 are provided in Table 11.1.

During the mid-1960s, the French landings gradually increased to a peak value of 7000 t in 1973–1974, then decreased with values fluctuating between 4500 and 6000 t during the 1980s and the mid-1990s. An increase has been noticeable during the early 2000s. Landings showed a decreasing trend from 3991 t in 2005 to 2987 t in 2019. In 2010 and 2011, total landings increased (3398 and 3559 t, respectively), followed by a strong reduction of landings in 2012 and 2013 (2520 and 2380 t, respectively). During the period 2014–2016, landings increased continuously (2807 t in 2014; 3569 t in 2015; 4091 t in 2016). In 2017, landings decreased again by 17% (3412 t) due to the implementation of more constraining regulations cited above. The lowest levels of landings in the stock time-series were observed in 2018 (2125 t) and 2019 (2154 t), with a slight increase in 2020 (2273 t).

In 2005, when the northern hake stock was under a recovery plan, the use of dorsal mesh square panels became mandatory for the trawlers targeting *Nephrops* in the Bay of Biscay, as this area is is an important nursery area for the hake stock. The implementation of the selective devices previously referred (a ventral panel of 60 mm square mesh or an 80 mm codend mesh size) coincided with a peak of discarded hake in weight and proportion following a slightly smaller proportion of discarded hake in 2006–2007. Similarly, in 2008, *Nephrops* length distribution in discards remained unchanged despite the mandatory use of the above mentioned selective modifications (Nikolic *et al.*, 2015). The decrease in discarded *Nephrops* weight in recent years may be due to the decreasing fishing mortality imposed on the stock since 2006 which consequently resulted in lower catches (ICES, 2012b), rather than due to a change in selectivity.

Males usually predominate in the landings with the sex ratio (defined as number of females divided by the total number of both sexes) fluctuating between 0.28 and 0.46 for the overall period (1987–2020) with the historically lowest value in 2017. In 2020, the sex ratio of landings was 0.33. The same predominance, although to a lesser degree, was observed for the removals (sex ratio in the range 0.35–0.49) which shows a sex ratio of 0.39 in 2020. Females are less accessible in winter because of their burrowing behaviour during the egg-bearing period.

Discards represent most of the catches of the smallest individuals as indicated by the available data (Figure 11.1). The average weight of discards per year in the period up to the early 2000s (not routinely sampled) is about 1543 t whereas discards estimate for the most recent sampled years (2003–2020) reached a higher level (1932 t). This change in the number of discards could be due to 1) the restriction of individual quotas, 2) the strength of some recruitments in the mid-2000s and 3) the change in the MLS (which tends to increase the discards), although improvements in selectivity may contribute to reducing the discards. The relative contribution of each of these three factors remains unknown. In 2019, the minimum level of discards had been observed (59 million individuals, 634 t) since the start of the European Union Data Collection Framework (DCF; Commission Regulations (EC) Nos. 1639/2001 and 199/2008) and the discard rate had decreased (38% against 58% in 2017 and 65% in 2018). In 2020, discards considerably increased up to 154 million individuals (1908 t).

11.2.2 Biological sampling

Landings

French sampling plan at auction started in 1984, but only from 1987 onwards, the data can be used on a quarterly basis. Since 2003, additional landings database was also provided from on-board routine sampling for estimating discards under the European DCF. As the landed fraction of *Nephrops* is usually size graded, the sampling plan is stratified by time and commercial category vs.. size. The numbers of sampling units by quarter and year as well as the numbers of sampled landed individuals of *Nephrops* are presented in Tables 11.2 and 11.3, respectively.

During the first two quarters of 2017, the French onshore sampling program at auctions was discontinued due to a planned shift towards a subcontracted program as already performed for the French on-board sampling. The delay in the call for tenders disrupted the onshore sampling collection for six months. Compared to other onshore species, the Bay of Biscay *Nephrops* was less affected as complementary biological parameters (such as maturity) complementary samples were collected by other ongoing European projects during the first half of the year. In order to compensate for the lack of Q1 and Q2 landings data in 2017, a simulation was performed using the method proposed by Quemar *et al.* (2018) to generate missing auction sampling units from onboard samples using stratified estimators (quarter/harbour/commercial category vs. size). This method was not specifically developed for the FU23–24 *Nephrops* and only actually sampled units were retained for quarterly and global estimates.

The particular problem of lower sampling rate for landings during the first and second quarters of 2017 due to the delay in the sampling shift between operators, as explained above, affected the precision of estimates (decrease of the sampling units and measured *Nephrops* at auction) although it did not change the overall perception for the stock status (LFDs and mean weight for landings). As shown by unpublished studies on recent DCF sampled years (2014–2017), the LFDs for landings by sex did not significantly change their overall shape when the raising is undertaken on the exclusive database from the sampling onboard despite the higher CVs obtained. This problem was resolved in 2018 and 2019 and the global sampling levels were more satisfactory than previously.

In 2020, the auction and onboard samplings were affected by the COVID-19 pandemic restrictions especially during the first severe lockdown (mid-March/mid-May) enforced in France. The coverage of the most substantial quarter for this fishery (2nd quarter) was consequently reduced to only one month of sampling (June) although sensitivity a first analysis demonstrated that these dataset gaps did not strongly modify the LFDs shape when compared with completely sampled data in previous years. Moreover, this procedure did not increase the uncertainties.

Discards

Discards data from onboard sampling are available for the years 1987, 1991, and 1998 and then from 2003 onwards. Since the former WGNEPH, for the intermediate years up to 2002, discarded numbers-at-length were derived using the "proportional method" where discards by sex for years with no onboard sampling were estimated by applying identical quarterly LFDs of the preceding sampled year raised to the quarterly landings i.e. for years 1992–1997 derivation used quarterly LFDs from 1991. This method was suspected to induce inter-dependence throughout the time-series, therefore, lack of contrast for annual recruitment. IBP*Nephrops* 2012 (ICES, 2012a) investigated the probabilistic (logistic) approach developed for the WGHMM since 2007, although it was not conclusive (Table 11.4; see Stock Annex).

Since 2003, discards have been estimated from catch sampling programmes onboard the *Nephrops* trawlers (706 trips and 1867 hauls have been sampled over 18 years). Despite improvements in the agreement between logbook declarations and auction hall sales since the mid-2000s, the quality of crossed information fluctuates between years. For instance, for years 2007–2020, the percentage of cross-validation item by item between logbooks and sales ranged from 69 to 90% with an improvement in the last period (85% for 2016, 88% in 2017, 90% in 2018 and 88% in 2019 and 2020). Therefore, the total number of trips, not well known in the past, is more accurately provided for the recent years and can be reliably used as raising factor for discards. Nevertheless, the number of trips mostly represented by the number of sales at auction is heterogeneous as the boats in the northern part of the Bay of Biscay conduct daily trips whereas in the southern part, trips last 2 to 3 days with a more diverse profile of catches. Discards sampling from the southern part of the Bay of Biscay fishery was carried out only once in the past (2005), but the sampling plan has been routinely applied since 2010. The numbers of sampled units by quarter and for the whole year and those of discarded sampled *Nephrops* are summarized in Table 11.5. As for the landings, COVID-19 restrictions disrupted the routinely conducted onboard sampling for the major part of the second quarter of 2020. Moreover, the sampling rate onboard during the 1st quarter was also reduced due to meteorological conditions.

The length distribution of landings, discards, and catches from the DCF sampling since 2003 are presented in Table 11.6.a through Table 11.6.c and in Figure 11.1 (for LFDs from years 1987–2002: see Stock Annex). Combined sex mean lengths are presented for catches, landings and discards in Figure 11.2. Figure 11.3 provides the annual LFDs by sex and their CVs for landings and discards in 2020. Similar information for years 2014–2019 is available in the Stock Annex.

11.2.3 Abundance indices from surveys

Trawl survey (LANGOLF)

For many years, abundance indices were not available for this stock. LANGOLF series (see Section 2 of this report and Stock Annex), a specially designed survey to evaluate abundance indices of *Nephrops*, started in 2006 being conducted during the most appropriate season (2nd quarter), hours (around dawn and dusk) and fishing gear (twin trawl). This survey occurred once a year in May and its sampling design was stratified based on the sedimentary structure. Therefore, based on the investigations carried out during the IBP*Nephrops* in 2012 (ICES, 2012a), the abundance indices were included in the assessments of WGHMM 2012 and 2013 (ICES, 2012c; ICES, 2013) and WGBIE 2014 (ICES, 2014). Nevertheless, the relative improvement in retrospective analysis did not substantially modify the quality of the stock assessment performed by the XSA model. The time-series provided by this survey ended in 2013.

UWTV survey (LANGOLF-TV)

A new experimental survey for counting UWTV burrows, as routinely operated for many *Nephrops* stocks in areas 6 and 7, has been conducted since 2014 on a yearly basis. In the first two years, this UWTV survey, named "LANGOLF-TV", aimed to demonstrate the technical feasibility of such a survey in the local context and to identify the necessary competencies and equipment for its sustainable use. Burrow counting was carried out by the Irish research vessel "Celtic

Voyager" on the basis of a systematic sampling plan. In this period, UWTV experiments were combined with trawling operations by two commercial vessels applying the same sampling plan (stratified random) and using the same twin trawls (20 mm codend mesh size) as those of the former LANGOLF trawl survey with the purpose of providing *Nephrops* LFDs by sex and estimating the proportion of other burrowing crustaceans (mainly *Munida sp.*) which can induce bias in the burrows counting.

From 2016 onwards, the trawling operations were cancelled as these were considered no longer necessary for further analytical investigations on the stock exclusively based on the UWTV tools. A longer survey duration in the period 2016–2020 allowed to cover the area within the outline of the central mud bank not belonging to any sedimentary stratum (Figure 11.4). This area is not trawled due to the rough seabed crossed by muddy channels and concentrates a moderate fishing effort targeting *Nephrops*. Investigations based on stratified statistical estimators (Table 11.7) as well as on geostatistics (Table 11.8; Figure 11.5 and 11.6) were carried out and then examined during the WKNEP (ICES, 2017a) which validated the UWTV approach. The number of sampled stations decreased between 2016 and 2017 (from 196 validated ones to 124) although a larger area than the Central Mud Bank was covered in 2017 in order to accurately delimit the actual outline of the stock following the recommendations of the WGNEPS in 2016 (ICES, 2017b). In 2018 and 2019, 184 and 145 valid stations were respectively sampled in the area. Between 2016 and 2017, the total number of burrows decreased by −19% (3373 billion in 2017 against 4168 in 2016) whereas an increase (+12%) was observed in 2018 (3788 billion) and (+9%) in 2019 (4113 billion).

The annual survey occurred in different seasons for the years 2014–2019 (September 2014, July 2015, May 2016, 2017 and 2019, end April 2018) as sampling period was constrained and determined by the availability of the UWTV equipment and staff from the Marine Institute of Ireland.

In 2020, due to the COVID-19 pandemic, the survey initially scheduled in late April to early May was strongly compromised, before being rescheduled to the end of July. During the 2020 UWTV survey, only two Irish experienced scientists were able to participate in order to respect the social distancing obligation on board (31 m vessel: "Celtic Voyager"; Irish company P&O). This also led to the reduction of the sampling plan to around 130 stations (134 finally validated) but still with an acceptable statistical precision level of estimates and all the video interpretations by Ifremer agents were carried out in the laboratory after the end of the survey. As the survey occurred later in the season and exploration of the footage could not be completed before late summer, schedule constraints linked to the stock assessment and advice in late September/early October implied a first investigation of samples by only one reader. The number of burrows was estimated at 3425 billion (−17% against 2019's survey) and the stock was advised on this basis. According to WGNEPS 2020 recommendations (ICES, 2021b), a second reader per sample is needed, and in several cases a third one will be necessary, in case of divergence between experts vs. the statistical Lin's concordance correlation coefficient (CCC; Lin, 1989; Lin, 2000) test value occurs. The revised estimate recently provided gave the current number of burrows as equal to 3602 billion which is –12% compared to the 2019 estimate.

11.2.4 Commercial catch-effort data

Up to 1998, the majority of the vessels were not obliged to keep logbooks because their size and fishing forms were established by inquiries. Since 1999, logbooks became compulsory for all vessels longer than 10 m. The available logbook data cannot be currently considered as representative of the fishing effort of the whole fishery during the overall time-series. Hence, since 2004, attempts to define a better effort index were done.

Effort data indices, landings and LPUE for the "Le Guilvinec District" *Nephrops* trawlers in the second quarter (noted GV-Q2) are available for the overall time-series (Table 11.9; Figure 11.7).

Effort increased from 1987 to 1992, but there has been a decreasing trend since then. In recent years, the lowest fishing effort value for the whole period was observed.

In 2019, the fishing effort slightly decreased compared to 2018 (−2%) which further decreased in 2020 (−12%) mainly because of the COVID-19 disruptions. The overall downward trend in effort can be explained by the reduction in the number of fishing vessels following the decommissioning schemes implemented by the EU. The LPUEs of the GV-Q2 fleet were reasonably stable for a long period, fluctuating around a long-term average of 14.0 kg/h (Figure 11.7), with four peaks (1988, 2001, 2010 and 2017). LPUE reached the historically highest level in the middle of the last decade (2015: 19.5 kg/h; 2016: 19.7 kg/h; 2017: 21.9 kg/h), but declined in 2018 (−22%; 17.0 kg/h) then was reduced again in 2019 (−7%, 15.7 kg/h) and remained at the same level in 2020 (15.6 kg/h).

Changes in fishing gear efficiency and individual catch capacities of vessels imply that the time spent at sea may not be a good indicator of effective effort and, hence, the LPUE trends are possibly biased. Since the early '90s, the number of boats using twin-trawls increased (10% in 1991, more than 90% in recent years, almost 100% in the northern part of the fishery) and also the number of vessels using rock-hopper gear on the rough seabed of the extreme NW part of the central mud bank of the Bay of Biscay. Moreover, an increase in onboard computer technology has occurred. The effects of these changes are difficult to quantify as twin-trawling is not always recorded explicitly in the fisheries statistics and improvement due to computing technology is not continuous for the overall time-series.

11.3 Assessment

An analytical assessment based on the adopted UWTV survey was carried out for the first time in November 2016 after the WKNEP benchmark (ICES, 2017a) in order to propose advice for 2017 for the stock. An update of the stock data is performed in spring each year covering the LFDs and mean weights for landings and discards of the three preceding years but the results from the UWTV survey of the same year are not yet available. The estimated *status quo* harvest rates for 2016, calculated as the removals divided by the UWTV abundance, was equal to 7.3% under the historical value of 30% for the survival rate of discards. After the adoption of the survival rate of 50% as a consequence of the compulsory quick chute system for discards since January 2017, the harvest rates for years 2017–2020 were 7.2%, 4.2%, 3.1% and 4.9%, respectively which are much below the MSY target (7.7%), with the exception of the year 2017.

The summary from the assessment 2020 is provided in the table below (ICES, 2020a).

Variable	Value	Source	Notes
Abundance in TV assessment	3425.061 3601.500	ICES (2020a)	UWTV 2020 (end of July) 1st value: one reader per sample (used for assessment and advice for 2021) 2nd value: two readers per sample (revised estimate)
Mean weight in landings	23.820	ICES (2020a)	Average 2017–2019
Mean weight in discards	10.990	ICES (2020a)	Average 2017–2019
Discard rate (total)	53.57%	ICES (2020a)	Average 2017–2019 (proportion by number)
Discard survival rate	50%	ICES (2020a)	Only applies in scenarios where discarding is allowed.
Dead discard rate (total)	37.38%	ICES (2020a)	Average 2017–2019 (proportion by number), only applies in scenarios where discarding is allowed.

11.4 Catch options and prognosis

For 2021, the catch options containing updated information on the fishery (mean weight for landings and discards, discard rate, the survival rate for discards) is given below and will be updated in autumn with the results from the UWTV survey.

Variable	Value	Source	Notes
Abundance in TV assessment	available in summer 2021	ICES (2021b)*	UWTV 2021 (undertaken in late April/early May 2021; exploration of footage should be carried out in lab)
Mean weight in landings	23.417	ICES (2021b)	Average 2018–2020
Mean weight in discards	11.144	ICES (2021b)	Average 2018–2020
Discard rate (total)	54.32%	ICES (2021b)	Average 2018–2020 (proportion by number)
Discard survival rate	50.00%	ICES (2021b)	Only applies in scenarios where discarding is allowed.
Dead discard rate (total)	38.14%	ICES (2021b)	Average 2018–2020 (proportion by number), only applies in scenarios where discarding is allowed.

*** This Working Group report, to be updated in October 2021**

11.5 Biological reference points

The F_{MSY} reference point (harvest rate of 7.7%; ICES, 2017a) is based on the average realized harvest rates (HR) of *Nephrops* functional units with an observed history of sustainable exploitation, while also taking into account the low harvest rates applied to the FUs 23–24 stock in the recent past. As the WK*Nephrops* 2019 (ICES, 2020b) was not conclusive at the aim of defining new reference points for this stock exclusively based on the SCA outputs and the scenarios under $F_{0.1}$ provided irrelevant results, the current reference value of HR = 7.7% was kept.

11.6 Comments on the assessment

The French *Nephrops* trawlers onboard sampling programme avoids the use of “derived” data for missing years (14 over 34 years). Since 2009, there has been a relevant improvement of the sampling design as many trips were sampled in the Southern part of the fishery. Derivations based on the probabilistic approach should improve knowledge of further analytical retrospective investigations on this stock.

The upgrade to category 1 stock is the consequence of a representative sampling survey on the whole Central Mud Bank of the Bay of Biscay as performed in 2016–2020. In addition to the unbiased spatial fishery information, such as the VMS data, these results demonstrate the accurate knowledge of the stock area and its sedimentary heterogeneous structure.

11.7 Information from the fishing industry

Several meetings were held between scientists and the fishing industry prior to the WG in order to discuss the partnership for the UWTV survey conducted on years 2017–2019 and the possibility of extending this for the period 2020–2022 (scientific methodological and financial supporting project). Many discussions prior to the WG underlined the steep decrease of landings in the period 2016–2020 which was considered by the industry as a temporary status and not as a signal of a declining trend. As prior to the WG of the two last years, they devalued such a decrease and pointed out many additional regulations aiming to control the productivity of *Nephrops* trawlers and to avoid quotas overshot. They argued that this situation had already been observed in the recent past: the positive dynamics in 2014–2016 occurred after the downwards moving in 2011–2013. The impact of the COVID-19 pandemic and the first lockdown in France in spring 2020 were emphasized during the more crucial period of the year for targeting *Nephrops*. The industry underlined the heterogeneous feature of the whole area of the stock and debated about the overall declining trend for the southern part of the Bay of Biscay which is considered problematic. Divergent interpretations were advanced for this decline although all of them converge that it might be the consequence of a gradual modification of the sedimented nature of this area from a typically muddy to a more mixed one.

The industry was satisfied by the realization of the UWTV survey in 2020 allowing an actual update on the stock status. The survey was maintained after modification from the initial scheduled plan and the industry praised the efficient and flexible partnership between the French and Irish scientists who participated in the survey. Currently and under a similar context to last year's, it was also possible to carry out the survey in 2021 which will provide results for the stock assessment and advice in autumn.

11.8 Management considerations

Some positive signals in the mid-2010s (increase of LPUEs, landings, removals) and relative stability of burrow indices from the 2014–2016 UWTV surveys suggested a stock status within safe limits. However, the oscillating trends of UTWV indices since 2017, i.e. the steep decrease in 2017 followed by an increase in 2018–2019 and a slight decline in 2020, combined with the historically lowest landings level in 2018–2020 suggest considering cautiously the current situation which will be examined after including the 2021 UWTV survey results.

11.9 References

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11.10 Tables and figures

Table 11.1. *Nephrops* in FUs 23–24 Bay of Biscay (8.a, 8.b). Estimates of catches (t) by FU for 1960–2020.

	Landings (1)					Total Discards		Catches
Year	FU 23-24 (2)	FU 23	FU 24	Unallocated (MA N)(3)	Total VIIIa,b	FU 23-24		Total
	VIIIa,b	VIIIa	VIIIb		used by WG	VIIIa,b		VIIIa,b
1960	3524	-	-	-	3524	-		3524
1961	3607	-	-	-	3607	-		3607
1962	3042	-	-	-	3042	-		3042
1963	4040	-	-	-	4040	-		4040
1964	4596	-	-	-	4596	-		4596
1965	3441	-	-	-	3441	-		3441
1966	3857	-	-	-	3857	-		3857
1967	3245	-	-	-	3245	-		3245
1968	3859	-	-	-	3859	-		3859
1969	4810	-	-	-	4810	-		4810
1970	5454	-	-	-	5454	-		5454
1971	3990	-	-	-	3990	-		3990
1972	5525	-	-	-	5525	-		5525
1973	7040	-	-	-	7040	-		7040
1974	7100	-	-	-	7100	-		7100
1975	-	6460	322	-	6782	-		6782
1976	-	6012	300	-	6312	-		6312
1977	-	5069	222	-	5291	-		5291
1978	-	4554	162	-	4716	-		4716
1979	-	4758	36	-	4794	-		4794
1980	-	6036	71	-	6107	-		6107
1981	-	5908	182	-	6090	-		6090
1982	-	4392	298	-	4690	-		4690
1983	-	5566	342	-	5908	-		5908
1984	-	4485	198	-	4683	-		4683
1985	-	4281	312	-	4593	-		4593
1986	-	3968	367	99	4335	-		4335
1987	-	4937	460	64	5397	1767	*	7164
1988	-	5281	594	69	5875	4123		9997
1989	-	4253	582	77	4835	2634		7470
1990	1	4613	359	87	4972	627		5599
1991	1	4353	401	55	4754	1213	*	5967
1992	0	5123	558	47	5681	1354		7034
1993	0	4577	532	49	5109	1007		6116
1994	0	3721	371	27	4092	741		4833
1995	0	4073	380	14	4452	706		5159
1996	0	4034	84	15	4118	495		4614
1997	2	3450	147	41	3610	805		4415
1998	2	3565	300	40	3865	1453	*	5318
1999	2	2873	337	26	3209	1148		4357
2000	0	2848	221	36	3069	1455		4523
2001	1	3421	309	22	3730	2537		6267
2002	2	3323	356	36	3679	2620		6299
2003	1	3564	322	49	3886	1977	*	5863
2004	na	3223	348	5	3571	1932	*	5503
2005	na	3619	372	na	3991	2698	*	6689
2006	na	3026	420	na	3447	4544	*	7990
2007	na	2881	292	na	3176	2411	*	5587
2008	na	2774	256	na	3030	2123	*	5154
2009	na	2816	212	na	2987	1833	*	4820
2010	na	3153	245	na	3398	1275	*	4673
2011	na	3240	319	na	3559	1263	*	4822
2012	na	2290	230	na	2520	1012	*	3532
2013	na	2195	185	na	2380	1521	*	3900
2014	na	2699	108	na	2807	1326	*	4133
2015	na	3425	144	na	3569	1822	*	5391
2016	na	3873	217	na	4091	2531	*	6622
2017	na	3283	129	na	3412	2387	*	5799
2018	na	2038	86	na	2125	1571	*	3696
2019	na	2065	89	na	2154	634	*	2789
2020	na	2200	73	na	2273	1908	*	4181

(1) WG estimates (2) landings from VIIIa and VIIIb aggregated until 1974 (3) outside FU 23-24

Table 11.2. ***Nephrops*** **in FUs 23–24 Bay of Biscay (8.a, 8.b). Quarterly and yearly number of sampled units in the landings sampling program.**

Year	Q1			Q2			Q3			Q4		
	auction	sea	Σ	auction	sea	Σ	auction	sea	Σ	auction	sea	Σ
2014	96	23	119	122	82	204	107	64	171	106	30	136
2015	119	37	156	119	71	190	123	70	193	114	12	126
2016	108	30	138	139	93	232	112	109	221	142	23	165
2017	26	30	56	27	36	63	63	47	110	92	19	111
2018	70	14	84	90	45	135	86	43	129	70	16	86
2019	86	18	104	92	46	138	64	29	93	80	17	97
2020	68	6	74	30	24	54	31	12	43	28	31	59
Total	**573**	**158**	**731**	**619**	**397**	**1016**	**586**	**374**	**960**	**632**	**148**	**780**

Table 11.3. ***Nephrops*** **in FUs 23–24 Bay of Biscay (8.a, 8.b). Quarterly and yearly number of sampled landed individuals.**

year	Q1			Q2			Q3			Q4		
	auc-tion	sea	Σ	auction	sea	Σ	auction	sea	Σ	auction	sea	Σ
2014	3774	855	4629	5400	3662	9062	4957	2321	7278	4642	1115	5757
2015	5347	1488	6835	5520	2760	8280	5695	2835	8530	4905	345	5251
2016	4562	1130	5692	6367	3340	9707	4801	3751	8552	6150	765	6915
2017	951	949	1900	1191	1606	2797	2863	1259	4122	4080	670	4750
2018	3528	554	4082	4285	1911	6196	3630	1661	5291	2991	470	3461
2019	3669	635	4304	3770	1554	5324	2632	819	3451	3257	566	3823
2020	2669	228	2897	1222	970	2192	1217	435	1652	1185	1061	2246
Total	**24500**	**5839**	**30339**	**27755**	**15803**	**43558**	**25795**	**13081**	**38876**	**27210**	**4992**	**32203**

Table 11.4. ***Nephrops*** **in FUs 23–24 Bay of Biscay (8.a, 8.b). Derivation and estimation of discards.**

1987	sampled
1988-1990	from 1987's logistic function of sorting by quarter+density of probability
1991	sampled
1992-1997	from 1991's logistic function of sorting by quarter+density of probability
1998	sampled
1999-2002	from 1998's logistic function of sorting by quarter+density of probability
since 2003	sampled

Table 11.5. ***Nephrops*** **in FUs 23–24 Bay of Biscay (8.a, 8.b). Quarterly and yearly discards from onboard sampling program.**

year	quarter	sampled FO	total FO	nb_trips	total trips	Nb *Nephrops*
2014	1	7	13	4	2689	377
	2	25	91	13	5615	1146
	3	21	99	12	5274	712
	4	10	27	8	3973	436
	total	**63**	**230**	**37**	**17551**	**2671**
2015	1	16	28	7	2785	655
	2	36	124	14	5598	1334
	3	28	131	13	4999	747
	4	7	31	3	3480	194
	total	**87**	**314**	**37**	**16862**	**2930**
2016	1	16	39	7	3441	549
	2	40	119	15	6207	1168
	3	46	153	17	5443	1135
	4	15	85	8	3906	256
	total	**117**	**396**	**47**	**18997**	**3108**
2017	1	20	97	9	3719	516
	2	29	138	12	6139	932
	3	23	55	9	4850	793
	4	10	26	17	3498	332
	total	**82**	**316**	**37**	**18206**	**2573**
2018	1	8	25	6	3015	237
	2	28	65	11	5784	1222
	3	25	67	14	4895	898
	4	9	29	8	3058	215
	total	**70**	**186**	**39**	**16752**	**2572**
2019	1	10	24	8	3366	367
	2	24	58	14	5610	1076
	3	16	42	9	4381	360
	4	8	20	5	2791	234
	total	**58**	**144**	**36**	**16148**	**2037**
2020	1	3	6	3	2622	118
	2	12	27	8	5178	527
	3	6	14	5	4660	280
	4	16	50	9	2768	476
	total	**37**	**97**	**25**	**15228**	**1401**

Table 11.6.a. *Nephrops* in FUs 23–24 Bay of Biscay (8.a, 8.b) landings length distributions in 2003–2020.

Landings CL mm/	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
10																		
11																		
12																		
13																		
14																		
15																		
16																		
17	20	7																
18	14		25	5	4	12									6			
19		14	27						1		5				18			
20	87	47	82	5	4	77	37	14	22	35	31	1	16	21	24	18		81
21	280	249	270	70	14	191	73	75	6	25	151	74	130	138	320	106	15	232
22	661	899	771	131	18	208	288	252	11	235	682	180	575	532	368	90	153	230
23	1614	2194	2588	227	48	322	473	386	111	334	1002	764	1121	772	1155	185	331	480
24	3966	5664	6511	822	188	721	1929	1238	515	1399	3162	1836	2523	1341	1787	410	1166	1479
25	8164	10930	13678	2844	1201	2742	3670	3940	1803	3843	7873	4419	3478	3842	3845	1823	4325	3502
26	13297	13998	17811	6376	5684	6319	8258	8499	4773	7875	13242	7910	6651	7285	9264	4362	8273	7187
27	17614	16094	22006	12010	9439	10891	12759	14173	7520	11079	14926	12869	9702	12566	14413	6905	11811	11125
28	18572	15350	21879	14647	13248	12640	15732	15390	8991	11920	13260	13788	14431	16617	14546	7753	12245	12670
29	16843	14808	18027	14591	12516	12890	13524	15340	9602	11120	13397	14560	13726	18269	17209	9186	11409	10421
30	17264	14143	15570	13690	12219	10726	13271	15736	8821	9636	10296	12662	13690	16596	16695	8812	10076	11320
31	13345	12353	12634	11814	10698	9772	10859	12749	8253	8393	9137	11051	12456	16820	12979	8307	7377	10397
32	11276	10322	9907	9694	9274	8845	9310	11366	6954	7414	7116	10354	12021	13096	12950	6417	6352	7660
33	8253	8020	7800	8421	7859	7436	7086	8851	6175	6069	5558	6509	9882	12519	7752	7079	5178	6198
34	6195	6298	6537	7112	6539	6425	5985	7140	5467	4505	4123	6657	7881	8416	7638	4991	4882	3911
35	4653	4673	5100	5135	6529	5366	4568	5852	4541	3507	2783	4961	6122	6809	5052	3676	4423	3802
36	3818	3308	3369	4104	4735	3867	3697	3626	4260	2649	1978	3264	5219	6474	4829	3537	2292	3126
37	3075	2875	2597	3196	3839	3121	2565	3024	3648	1976	1472	2682	4511	4785	2620	2263	1749	1718
38	2660	2098	2380	2662	2639	2398	1871	2247	3911	1563	998	1783	3311	3342	2005	1890	1189	1684
39	2174	1683	1650	1956	2245	2043	1491	1630	3472	1314	936	1844	2726	2850	2176	1775	946	696
40	1936	1555	1628	1599	1711	1633	1190	1280	3296	1103	518	843	2676	1976	1294	1232	942	788
41	1423	1188	1154	1171	1227	1190	878	966	2740	878	438	669	1635	1394	1020	652	530	441
42	1403	889	953	990	1111	1015	742	742	2497	635	351	412	1284	1185	779	329	329	374
43	1054	774	842	741	710	805	540	560	2157	558	320	343	883	749	585	388	330	317
44	810	707	640	633	746	706	473	509	1762	536	249	234	637	658	471	319	129	192
45	808	613	605	595	518	536	396	442	1177	478	177	206	467	708	442	296	107	151
46	535	485	415	479	373	405	307	305	1024	441	181	159	236	368	271	153	79	118
47	456	388	353	440	311	361	262	290	858	378	88	151	216	332	261	86	80	113
48	339	313	339	382	257	294	245	237	656	381	98	87	149	230	143	80	46	77
49	206	318	288	319	237	262	196	204	557	212	74	72	200	195	100	51	30	66
50	253	306	276	287	190	228	156	160	501	160	46	63	108	123	126	68	36	53
51	170	214	176	246	163	201	115	135	383	132	37	58	68	83	53	32	27	26
52	150	152	184	201	138	116	110	120	296	128	32	24	46	88	96	36	24	26
53	120	111	142	137	140	121	98	97	198	96	24	42	33	56	37	21	13	12
54	80	90	104	156	115	95	63	95	271	93	17	18	29	59	49	18	11	6
55	57	47	109	137	79	73	75	79	152	58	15	11	26	23	38	10	5	8
56	23	86	69	117	60	67	54	75	132	46	8	5	15	21	24	8	2	2
57	47	49	58	134	70	41	31	67	98	48	22	10	18	7	12	6	1	3
58	22	27	43	134	45	40	48	47	105	52	3	8	5	7	12	11	3	3
59	10	32	41	85	33	19	23	48	79	33	12	3	3	8	6	1	2	1
60	8	10	19	115	33	23	14	42	48	22	3	2	3	5	7	3		3
61	5	5	28	40	23	7	8	30	39	15	8	1		3	2	1	1	
62	4	3	16	21	9	9	9	16	55	18	1	1	7	3	6	3		2
63	1	5	9	19	9	7	10	7	23	11	2	1			1	1		
64		8	8	18	10	6	3	16	12	8			1	1	2	72		
65		1	14	11	9	1	3	9	11	7			1	1	3			1
66	1	1	6	10	1		2	3	11	3				1	1			
67		1	5	8	1		2	3	6	1								
68		2	4	7	3			4	7									
69	1		1	6	2		1	1	2	2								
70			2	4				1	2					1	1			
71	1		1	5				1	1									
72			1	5											1			
73				2	1										1			
74				4					1			1			1			
75			1	4						1				2	5			
Total	**163771**	**154405**	**179758**	**128777**	**117273**	**115274**	**123504**	**138120**	**108011**	**101424**	**114853**	**121594**	**138920**	**161371**	**143502**	**83463**	**96919**	**100704**
Weights	**3886**	**3571**	**3991**	**3447**	**3176**	**3030**	**2987**	**3398**	**3559**	**2520**	**2380**	**2807**	**3569**	**4091**	**3412**	**2125**	**2154**	**2273**

Table 11.6.b. *Nephrops* in FUs 23–24 Bay of Biscay (8.a, 8.b) discards length distributions in 2003–2020.

Total Discards

CL mm/	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
10	28				22		82								26			55
11			94		171	38	135	2								23	8	
12	70	363	413	70	202	98	79		237				75	76	54		8	
13	294	1722	1085	234	122	235	177	97	596	532		28	184	76	111	47	110	83
14	636	3152	3190	1138	900	389	291	83	834	665	229	101	606	327	384	31	428	249
15	1198	5548	7287	3102	1288	189	1157	155	941	1425	870	281	1476	578	1228	533	583	457
16	3386	6784	13528	7810	2959	1027	2315	822	1230	4544	1313	1300	2354	569	1668	1029	606	75
17	5927	8836	15094	11655	3636	1832	3059	1333	2430	4737	4179	1647	3242	2717	3697	3499	741	506
18	8078	10161	19795	16139	4590	2626	4843	2309	3630	8066	3372	2808	5073	5207	4175	6531	1456	1598
19	11506	17361	19522	25891	5244	6473	6485	3532	4546	8024	8730	3822	8084	9685	8517	7534	1951	3456
20	12142	19250	22265	39742	8735	11444	12766	5692	7227	10125	9682	6457	9246	9420	13805	9555	3042	5479
21	18597	25898	32409	54220	11585	15630	16772	7699	10393	12145	15281	9195	10952	12022	16601	13562	4330	8770
22	21416	25210	35523	69870	17930	24730	18701	11689	15161	14034	20618	11284	11324	15704	16245	17648	6379	11969
23	28429	26756	40041	70094	24086	27560	21693	13672	13837	12904	26287	15130	14109	18312	20400	20617	6817	17291
24	26501	21343	36279	55408	30615	29638	24105	16963	15551	14889	21750	14000	16820	19435	21961	16825	8875	20577
25	23211	20085	30222	52660	32917	28007	20736	14670	16545	10873	17823	18051	18746	22159	21886	18966	8383	22133
26	17357	12006	19003	38812	27376	23127	14205	11852	10047	7747	10188	11947	15874	24994	21474	12621	6065	21676
27	9680	6436	8498	20124	20567	10129	9188	8558	8127	4304	5439	8155	11931	17139	13660	8548	3506	14931
28	6187	3487	4603	10263	10365	5893	5927	5986	3201	919	2824	5026	8056	11441	11298	5719	2625	8239
29	2537	2115	1201	4188	4464	3225	3163	3360	2086	588	2146	2316	5771	10887	5361	3151	913	5056
30	1605	1901	1600	2578	2868	1923	3261	1876	2011	680	945	1672	4714	5283	5464	1457	885	3741
31	1326	1115	1417	1109	1316	925	1824	1274	1246	125	922	1263	2033	4343	3766	1135	517	2567
32	574	735	526	592	737	454	839	716	492	200	684	1482	1745	2458	2470	513	181	1657
33	313	503	296	544	484	421	671	350	265	13	365	384	812	3193	814	1014	183	2332
34	261	385	553	411	537	1025	830	274	272	145	494	433	1108	1071	1132	744	146	439
35	176	424	260	230	265	206	332	242	174	24	233	125	147	874	1540	296	163	186
36	113	108	46	73	336	78	197	55	59	3	260	391	243	774	503	140	74	10
37	83	74	246	25	299	153	188	162	149	146	130	45	298	573	681	11	8	333
38	93	31	116	99	40	93	269	16	97	68	81	71	246	576	320	18	8	115
39	15	139	147		3	369	55	33	24		33	230	65	598	409	60	35	
40	37	73	37	169	47		66	38	25	3		122	175	72	235	39	64	261
41	34	60	20		40		8	4				7	46	148	126	40		
42	4	12	31		20	53		4	157				508	186	139		8	161
43	14	13			11		38		4	4		152	199		202	20		
44		13					14	6					12		164			
45	13			36					5				56		38			
46								6					44	77				
47									6			7			23			
48							8				36							
49													23					
50					11													
51																		
52																		
53																		
54																		
55															23			
56																		
57																		
58						39												
59																		
60																		
61																		
62																		
63																		
64																		
65																		
66																		
67																		
68																		
69																		
70																		
71																	3	
72																		
73																		
74																		
75																		
Total	**201841**	**222102**	**315346**	**487288**	**214788**	**198031**	**174480**	**113530**	**121603**	**117935**	**154914**	**117930**	**156400**	**200973**	**200600**	**151926**	**59102**	**154401**
Weights	**1977**	**1932**	**2698**	**4544**	**2411**	**2123**	**1833**	**1275**	**1263**	**1012**	**1521**	**1326**	**1822**	**2531**	**2387**	**1571**	**634**	**1908**

Table 11.6.c. *Nephrops* in FUs 23–24 Bay of Biscay (8.a, 8.b) catches length distributions in 2003–2020.

Total catches																		
CL mm/	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
10	28				22		82								26			55
11			94		171	38	135	2								23	8	
12	70	363	413	70	202	98	79		237				75	76	54		8	
13	294	1722	1085	234	122	235	177	97	596	532		28	184	76	111	47	110	83
14	636	3152	3190	1138	900	389	291	83	834	665	229	101	606	327	384	31	428	249
15	1198	5548	7287	3102	1288	189	1157	155	941	1425	870	281	1476	578	1228	533	583	457
16	3386	6784	13528	7810	2959	1027	2315	822	1230	4544	1313	1300	2354	569	1668	1029	606	75
17	5947	8843	15094	11655	3636	1832	3059	1333	2430	4737	4179	1647	3242	2717	3697	3499	741	506
18	8092	10161	19820	16144	4593	2638	4843	2309	3630	8066	3372	2808	5073	5207	4181	6531	1456	1598
19	11506	17376	19549	25891	5244	6473	6485	3532	4546	8024	8735	3822	8084	9685	8535	7534	1951	3456
20	12229	19297	22348	39747	8738	11521	12803	5706	7249	10160	9713	6458	9262	9441	13829	9573	3042	5560
21	18877	26146	32679	54289	11598	15820	16845	7775	10398	12170	15433	9269	11082	12160	16921	13668	4346	9001
22	22077	26109	36293	70001	17948	24938	18989	11941	15171	14269	21300	11464	11899	16237	16613	17738	6531	12199
23	30042	28950	42629	70322	24134	27882	22167	14058	13948	13238	27289	15894	15231	19084	21554	20802	7148	17771
24	30467	27006	42790	56230	30803	30359	26034	18202	16065	16288	24913	15836	19343	20775	23747	17236	10041	22055
25	31376	31015	43900	55504	34119	30750	24406	18610	18348	14716	25696	22470	22223	26001	25731	20789	12708	25635
26	30654	26004	36814	45189	33060	29446	22463	20352	14820	15622	23430	19857	22526	32279	30738	16983	14338	28863
27	27294	22530	30504	32134	30006	21020	21948	22730	15647	15383	20365	21024	21633	29705	28073	15453	15317	26056
28	24759	18837	26482	24909	23613	18533	21659	21375	12191	12838	16084	18814	22487	28058	25844	13471	14869	20909
29	19381	16923	19228	18779	16980	16115	16687	18700	11687	11708	15543	16876	19498	29156	22570	12337	12322	15476
30	18868	16044	17170	16268	15087	12649	16531	17612	10832	10315	11241	14334	18403	21879	22159	10269	10961	15061
31	14672	13469	14051	12923	12014	10697	12682	14024	9500	8518	10059	12314	14489	21163	16745	9442	7893	12964
32	11849	11057	10433	10286	10011	9299	10150	12082	7447	7614	7801	11836	13766	15554	15419	6930	6533	9317
33	8566	8523	8095	8965	8343	7857	7757	9201	6440	6082	5923	6892	10695	15712	8566	8093	5362	8530
34	6456	6684	7090	7524	7076	7449	6815	7414	5739	4649	4617	7091	8990	9487	8770	5735	5028	4350
35	4829	5097	5361	5366	6793	5573	4900	6094	4715	3531	3016	5087	6270	7683	6592	3972	4586	3989
36	3931	3416	3415	4177	5071	3945	3894	3681	4319	2652	2237	3654	5462	7247	5332	3677	2366	3136
37	3158	2949	2844	3221	4138	3273	2753	3186	3797	2122	1602	2727	4809	5358	3302	2274	1758	2052
38	2752	2129	2496	2760	2679	2491	2139	2263	4007	1632	1079	1854	3556	3918	2325	1908	1197	1799
39	2189	1822	1797	1956	2247	2412	1546	1662	3496	1314	968	2075	2791	3448	2585	1835	981	696
40	1973	1628	1665	1768	1758	1633	1257	1318	3321	1107	518	965	2851	2048	1529	1271	1006	1049
41	1457	1248	1174	1171	1267	1190	886	971	2740	878	438	676	1681	1542	1146	691	530	441
42	1407	901	984	990	1130	1069	742	746	2654	635	351	412	1792	1370	918	329	337	535
43	1068	787	842	741	722	805	578	560	2161	563	320	495	1082	749	787	407	330	317
44	810	719	640	633	746	706	487	515	1762	536	249	234	649	658	636	319	129	192
45	821	613	605	631	518	536	396	442	1182	478	177	206	523	708	480	296	107	151
46	535	485	415	479	373	405	307	312	1024	441	181	159	280	445	271	153	79	118
47	456	388	353	440	311	361	262	290	865	378	88	158	216	332	284	86	80	113
48	339	313	339	382	257	294	254	237	656	381	134	87	149	230	143	80	46	77
49	206	318	288	319	237	262	196	204	557	212	74	72	223	195	100	51	30	66
50	253	306	276	287	201	228	156	160	501	160	46	63	108	123	126	68	36	53
51	170	214	176	246	163	201	115	135	383	132	37	58	68	83	53	32	27	26
52	150	152	184	201	138	116	110	120	296	128	32	24	46	88	96	36	24	26
53	120	111	142	137	140	121	98	97	198	96	24	42	33	56	37	21	13	12
54	80	90	104	156	115	95	63	95	271	93	17	18	29	59	49	18	11	6
55	57	47	109	137	79	73	75	79	152	58	15	11	26	23	61	10	5	8
56	23	86	69	117	60	67	54	75	132	46	8	5	15	21	24	8	2	2
57	47	49	58	134	70	41	31	67	98	48	22	10	18	7	12	6	1	3
58	22	27	43	134	45	80	48	47	105	52	3	8	5	7	12	11	3	3
59	10	32	41	85	33	19	23	48	79	33	12	3	3	8	6	1	2	1
60	8	10	19	115	33	23	14	42	48	22	3	2	3	5	7	3		3
61	5	5	28	40	23	7	8	30	39	15	8	1		3	2	1	1	
62	4	3	16	21	9	9	9	16	55	18	1	1	7	3	6	3		2
63	1	5	9	19	9	7	10	7	23	11	2	1			1	1		
64		8	8	18	10	6	3	16	12	8			1	1	2	72		
65		1	14	11	9	1	3	9	11	7			1	1	3			1
66	1	1	6	10	1		2	3	11	3				1	1			
67		1	5	8	1		2	3	6	1								
68		2	4	7	3			4	7									
69	1		1	6	2		1	1	2	2								
70			2	4				1	2					1	1			
71	1		1	5				1	1								3	
72			1	5											1			
73				2	1										1			
74				4					1			1			1			
75			1	4						1				2	5			
Total	**365612**	**376507**	**495103**	**616065**	**332060**	**313304**	**297984**	**251649**	**229614**	**219358**	**269766**	**239522**	**295318**	**362344**	**344101**	**235388**	**156020**	**255104**
Weights	**5863**	**5503**	**6689**	**7990**	**5587**	**5154**	**4820**	**4673**	**4822**	**3532**	**3900**	**4133**	**5391**	**6622**	**5799**	**3696**	**2789**	**4181**

Table 11.7. Total number of burrows (10^6), densities (nb/m²) and CVs (%) by spatial stratum for the whole Bay of Biscay. In years 2016–2020, the rough seabed (noted RO) within the outline of the central mud bank (16 164 km² instead of 11 67 km² for the five sedimentary strata *sensu stricto*) was included. For the year 2020, estimates are provided for two datasets: (1) upper: initial estimates after the first exploration of the footage by only one reader per sample (time constraint due to the delay of the UWTV survey caused by the COVID-19 pandemic up to late summer with assessment and advice expected in early autumn) and (2) lower: final estimates after the addition of a second reader per sample in accordance with the standard procedure (WGNEPS, ICES, 2020).

	2016 (196 stations)				*2017 (124 stations)*			
	nb/m²	total burrows	CV (%)	%burrows	nb/m²	total burrow	CV (%)	%burrows
	0.258	**4167.48**	**7.84**		**0.209**	**3372.54**	**9.87**	
CB	0.208	527.75	19.84	12.66%	0.122	310.07	20.10	9.19%
CL	0.191	219.94	20.87	5.28%	0.211	243.57	14.76	7.22%
LI	0.228	1063.80	13.86	25.53%	0.169	789.10	14.75	23.40%
VS	0.677	428.37	17.92	10.28%	0.925	585.84	27.94	17.37%
VV	0.518	1393.62	14.52	33.44%	0.342	921.58	19.82	27.33%
RO	0.119	533.99	29.61	12.81%	0.116	522.38	34.23	15.49%

	2018 (184 stations)				*2019 (145 stations)*			
	nb/m²	total burrows	CV (%)	%burrows	nb/m²	total burrow	CV (%)	%burrows
	0.234	**3787.77**	**8.30**		**0.254**	**4113.42**	**8.34**	
CB	0.209	529.78	19.56	13.99%	0.139	351.89	25.39	8.55%
CL	0.417	480.33	23.64	12.68%	0.325	374.86	43.28	9.11%
LI	0.184	858.15	13.27	22.66%	0.236	1099.78	14.34	26.74%
VS	0.678	429.38	23.30	11.34%	0.473	299.14	21.46	7.27%
VV	0.397	1067.54	17.30	28.18%	0.533	1433.90	12.12	34.86%
RO	0.094	422.59	31.79	11.16%	0.123	553.85	28.17	13.46%

			2020 (134 stations)			
	nb/m²	total burrows	CV (%)	%burrows	Δ(2019-2020)	% surf
	0.212	**3425.06**	**12.74**		-16.73%	
CB	0.058	147.05	24.46	4.29%	-58.21%	15.69%
CL	0.184	212.69	44.46	6.21%	-43.26%	7.13%
LI	0.158	735.12	18.76	21.46%	-33.16%	28.85%
VS	0.728	461.04	20.14	13.46%	54.12%	3.92%
VV	0.424	1140.33	16.96	33.29%	-20.47%	16.65%
RO	0.162	728.84	46.57	21.28%	31.60%	27.76%

			2020 (134 stations)			
	nb/m²	total burrows	CV (%)	%burrows	Δ(2019-2020)	% surf
	0.223	**3601.50**	**12.04**		-12.45%	
CB	0.070	177.93	19.18	4.94%	-49.44%	15.69%
CL	0.191	219.71	43.03	6.10%	-41.39%	7.13%
LI	0.164	765.40	17.91	21.25%	-30.40%	28.85%
VS	0.748	473.70	18.91	13.15%	58.35%	3.92%
VV	0.431	1161.13	16.51	32.24%	-19.02%	16.65%
RO	0.179	803.63	42.10	22.31%	45.10%	27.76%

Table 11.8. Estimation of the abundance of *Nephrops* burrows (10^6) by UWTV. Example of years 2014 and 2015 (rough numbers of burrows with no correction by cumulative bias factor equal to 1.24; WKNEP (ICES, 2017a)).

Year	2014		2015	
Number of data	204	204	114	114
Method of estimate for average (A = arithmetic; KO = ordinary kriging)	A	KO	A	KO
Estimation	0.415930	0.425463	0.410321	0.414796
CV geo	0.052829	0.046598	0.180002	0.183475
CV iid	0.072647	-	0.082643	-
Surface (km²)	11 676	11 676	11 676	11 676
Abundance (Estimation * Surface)	4856	4968	4791	4843

Table 11.9. *Nephrops* in FUs 23–24 Bay of Biscay (8.a, 8.b). Effort and LPUE values of commercial fleets.

	Le Guilvinec District Quarter 2		
Year	Landings(t)	Effort(100h)	LPUE(Kg/h)
1987	603	437	13.81
1988	777	471	16.52
1989	862	664	12.99
1990	801	708	11.31
1991	717	728	9.84
1992	841	757	11.12
1993	805	735	10.96
1994	690	671	10.30
1995	609	627	9.72
1996	715	598	11.97
1997	638	539	11.83
1998	622	489	12.72
1999	505	423	11.93
2000	438	405	10.82
2001	697	417	16.71
2002	527	371	14.20
2003	487	356	13.68
2004	410	321	12.74
2005	455	336	13.57
2006	414	306	13.50
2007	401	291	13.76
2008	410	271	15.15
2009	384	279	13.78
2010	471	253	18.61
2011	422	279	15.13
2012	348	229	15.17
2013	288	224	12.83
2014	252	198	12.73
2015	451	231	19.52
2016	475	241	19.74
2017	520	238	21.88
2018	374	220	16.98
2019	338	216	15.66
2020	296	190	15.61

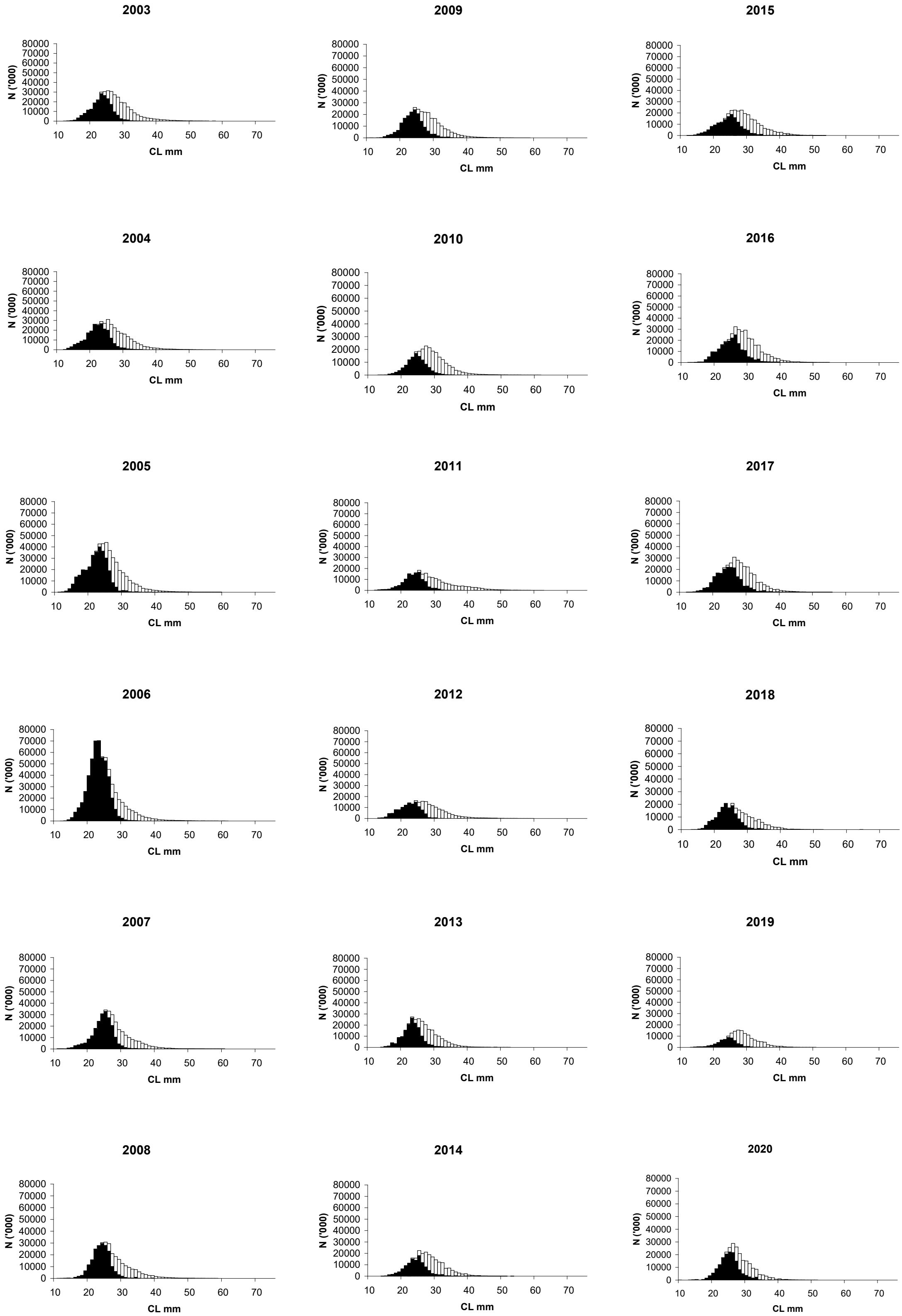


Figure 11.1. ***Nephrops*** **in FU23–24 Bay of Biscay (8.a, 8.b). Catches (landings in white, discards in black) in 2003–2020.**

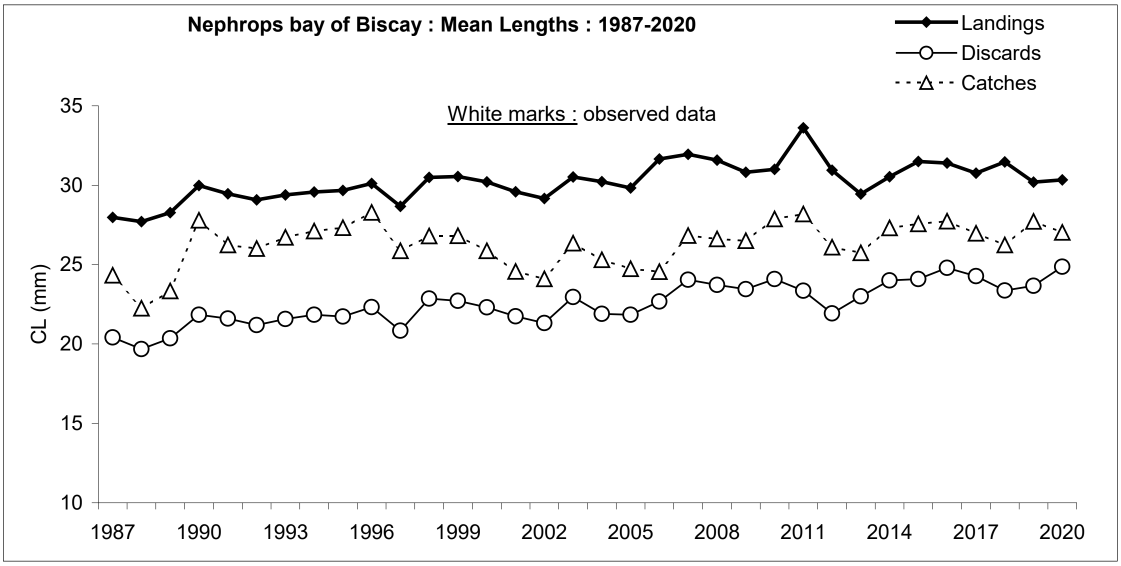
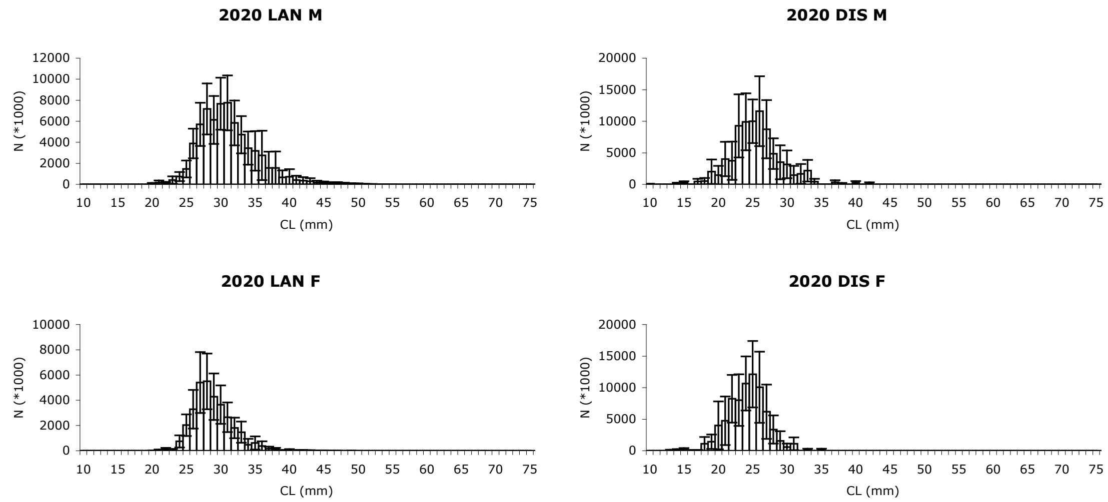


Figure 11.2. ***Nephrops*** **in FUs 23–24 Bay of Biscay (8.a, 8.b). Mean length of landings, discards and catches (in mm).**



		males		females				males		females	
2014	LAN	21.5	13.4	22.7	19.0	2018	LAN	24.3	12.9	20.5	15.0
	DIS	29.9	28.4	35.6	35.0		DIS	20.7	19.8	21.0	20.4
2015	LAN	13.5	10.8	14.4	14.3	2019	LAN	11.2	11.3	13.2	14.1
	DIS	16.9	15.9	15.9	15.9		DIS	20.1	18.2	22.4	19.5
2016	LAN	15.0	13.5	13.7	13.9	2020	LAN	13.6	14.4	16.7	16.0
	DIS	24.9	25.2	22.6	25.0		DIS	16.5	14.3	17.6	16.3
2017	LAN	17.3	18.8	19.5	24.2						
	DIS	25.2	25.5	20.5	19.4						

Figure 11.3. ***Nephrops*** **in FU23–24 Bay of Biscay (8.a, 8.b). LFDs and confidence intervals for landings and discards by sex in 2020.**

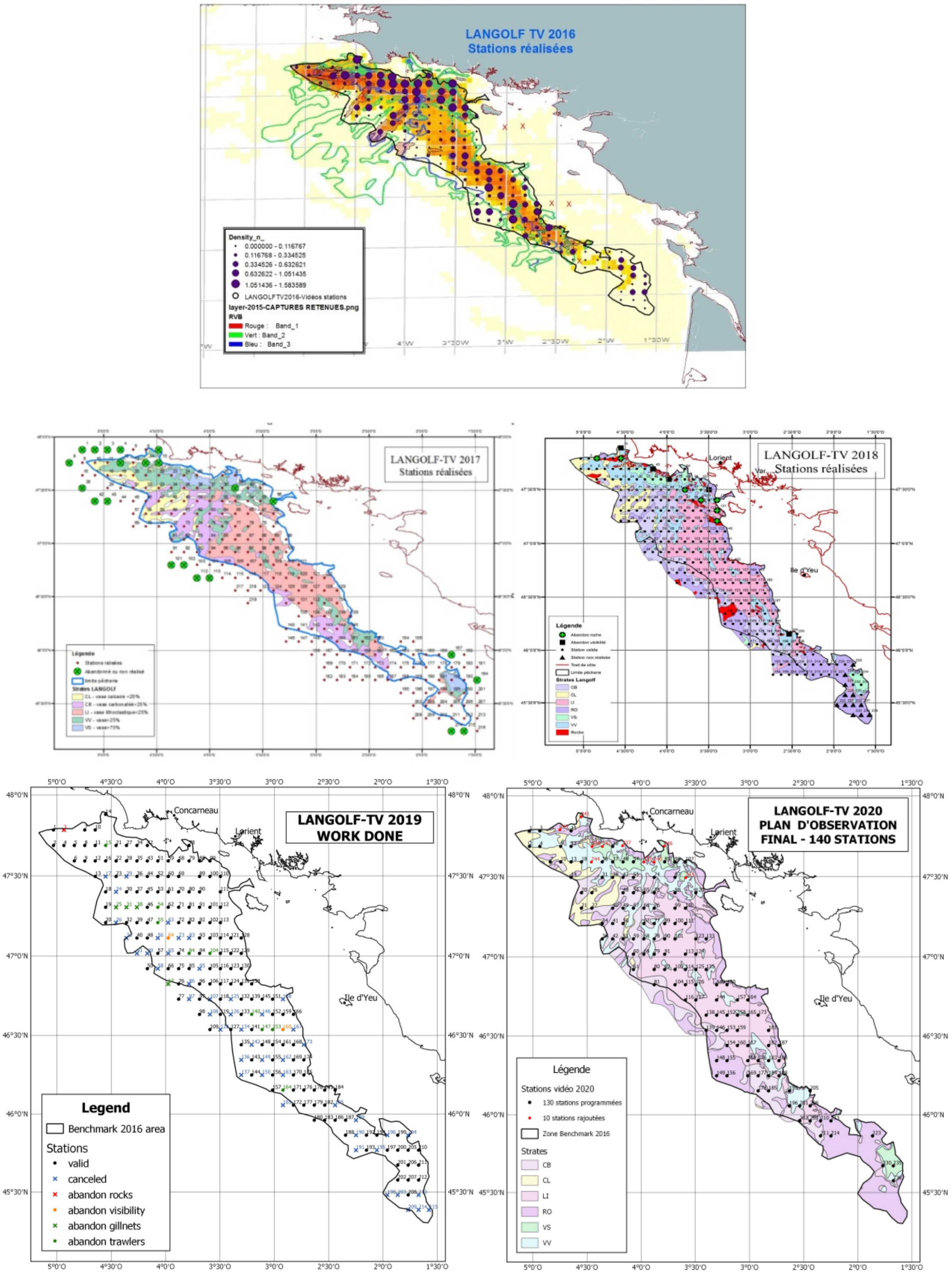


Figure 11.4. ***Nephrops*** **in FU23–24 Bay of Biscay (8.a, 8.b). Systematic grids for the UWTV surveys from 2016–2020. For 2016 the grid was combined with VMS data on 3 min*3 min rectangles. (Source: National Fisheries Direction; compilation: SIH Ifremer).**

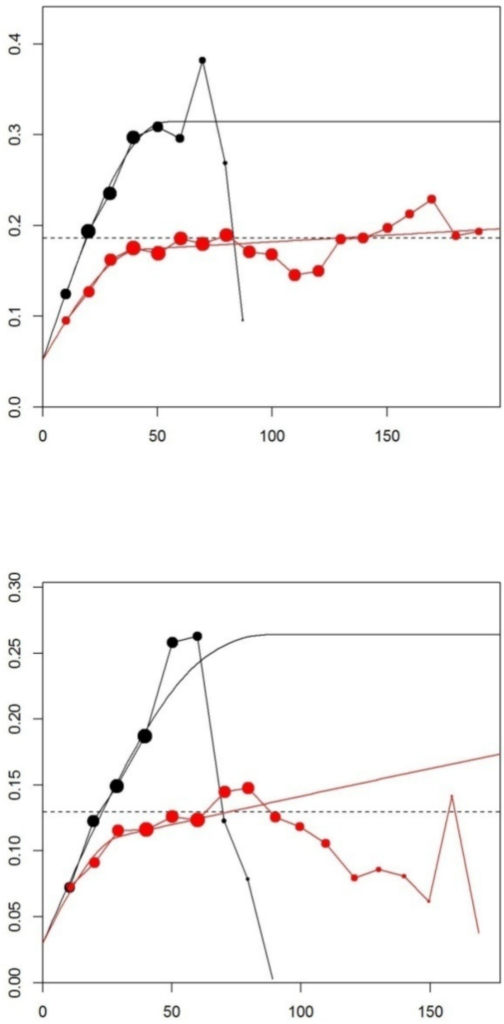


Figure 11.5. *Nephrops* in FU23–24 Bay of Biscay (8.a, 8.b). Experimental variograms (circles proportional to the number of pairs) and models (continuous curves) for the main anisotropic directions (red: NW->SE, black: SW->NE).

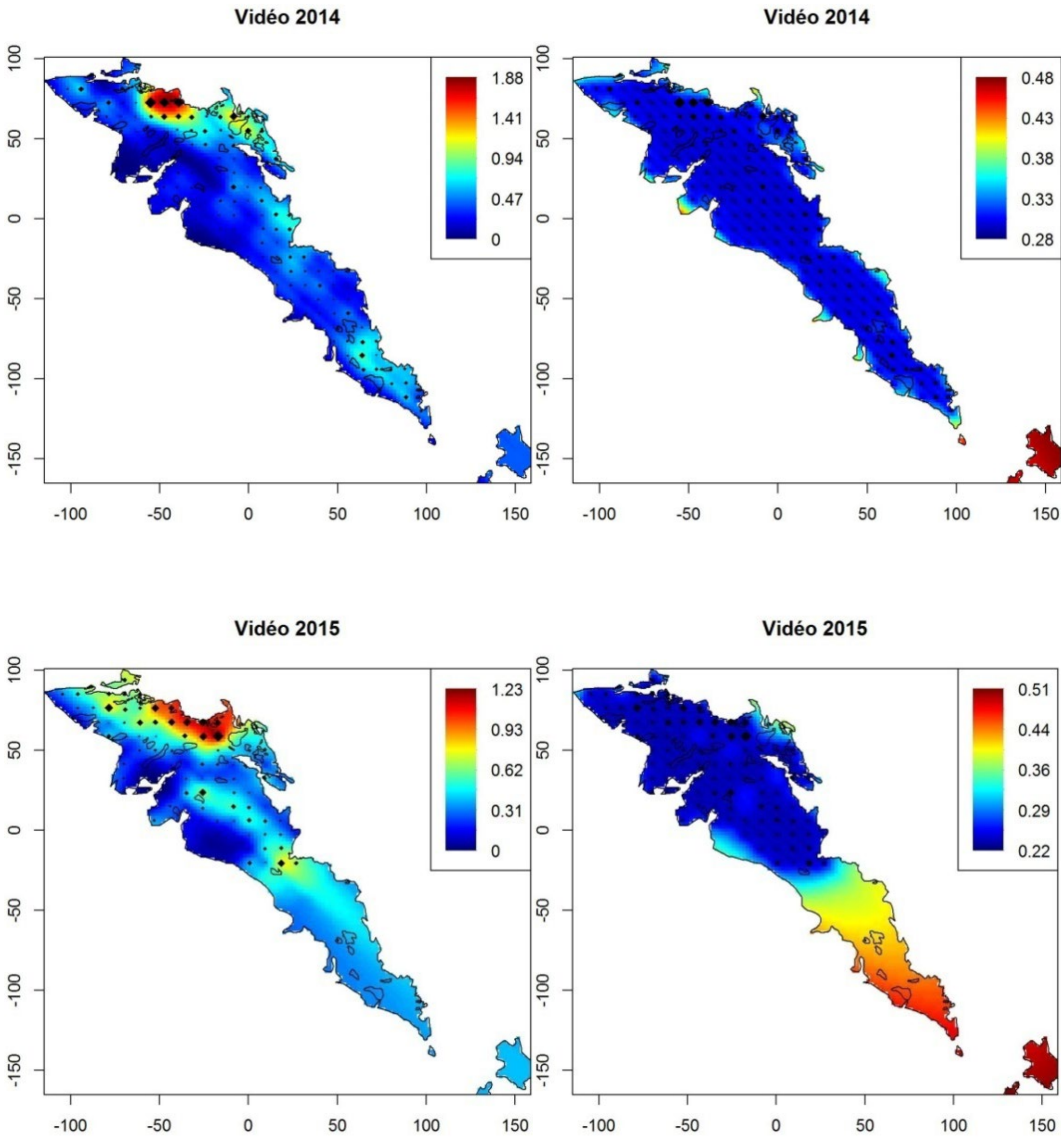


Figure 11.6. ***Nephrops*** **in FU23–24 Bay of Biscay (8.a, 8.b). Estimation of the burrows densities (nb/m²) using ordinary kriging (left column) and error of kriging (right column) in 2014 and 2015.**

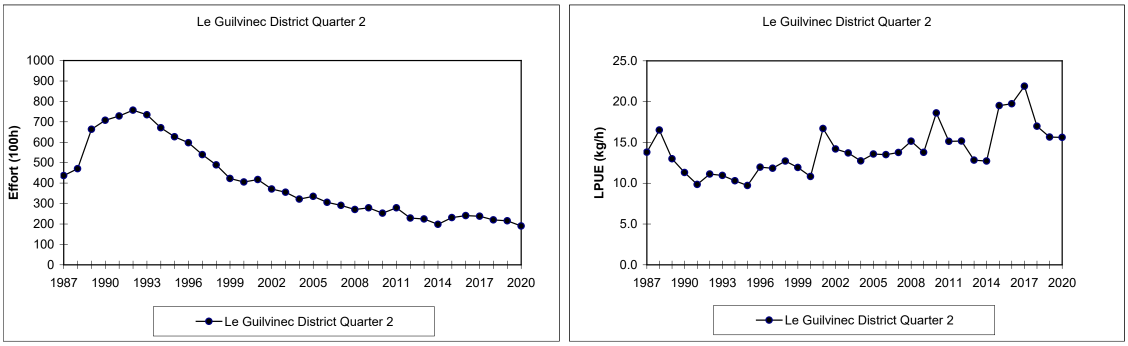


Figure 11.7. *Nephrops* in FUs 23–24 Bay of Biscay (8.a, 8.b). Effort and LPUE values for standardized commercial fleets.

12 Norway lobster in Division 8.c

Nephrops norvegicus – nep.fu.25, nep.fu.31

Functional Unit 25 (southern Bay of Biscay and northern Galicia)
Functional Unit 31 (southern Bay of Biscay and Cantabrian Sea)

The ICES Division 8.c includes two Nephrops Functional Units (FUs): FU 25, North Galicia and FU 31, Cantabrian Sea (Figure 1.2). FU 25 contributes with 63% to the Spanish Nephrops landings from 8.c, FU 31 with 25% and the other rectangles of 8.c with the remaining 12% of landings (logbooks 2003–2016) (Figure 12.1).

12.1 FU 25 (North Galicia) *Nephrops*

12.1.1 General

Up to this date, the status of the FU 25 *Nephrops* stock is considered undesirable (ICES, 2016) with extremely low biomass and zero catch advice was issued (ICES, 2017) in recent years.

After the identification of the FU 25 *Nephrops* area using hauling data from the SPGFS-WIBTS-Q4 (G2784) survey (1983–2020), discards from the onboard sampling programme (1994–2020) and the Sentinel fishery onboard sampling programme (2017–2020), it was proposed to include the statistical rectangles 16E0 and 17E1 in FU 25. *Nephrops* from those rectangles belongs to the same system as that of FU 25 and their catches are higher than in rectangle 15E1 which is part of FU 25.

After the WKMSYSPiCT benchmark (ICES, 2021b), FU 25 *Nephrops* stock was upgraded from category 3 (assessment based on trends) to 2 (production model) assessment (ICES, 2021a).

12.1.1.1 Ecosystem aspects

See Stock Annex.

12.1.1.2 Fishery description

Nephrops is caught by the Spanish OTB_DEF_≥55, which is described as the “Northern trawl” fleet in section 2.1.2 of this report. See Stock Annex for more information.

12.1.1.3 Summary of ICES Advice for 2021 and management applicable to 2020 and 2021

ICES advice for 2021

The advice for this *Nephrops* stock is triennial and valid for 2020, 2021, and 2022.

ICES advises that when the precautionary approach is applied, there should be zero catch in each of the years 2020, 2021 and 2022.

To protect the stock in this FU, ICES advises that the management area should be consistent with the assessment area. Therefore, management should be implemented at the Functional Unit level.

Management applicable to 2020 and 2021

Since 2011 there is a Spanish regulation that establishes an Individual Transferable Quota system (ITQs) which includes *Nephrops* (ARM/3158/2011, BOE, 2011).

In 2016, a zero TAC was set for *Nephrops* in ICES Division 8.c for 2017, 2018 and 2019. In 2019, this measure was advised again for the years 2020, 2021 and 2022.

Special quotas of 4.3 t in 2017, 2.0 t in 2018, 2019, and 2020 were set for *Nephrops* in FU 25 in order to conduct an observers on-board programme (*Nephrops* Sentinel fishery), supervised by the Spanish Oceanographic Institute (IEO) for obtaining a *Nephrops* abundance index and complementary data.

12.1.2 Data

12.1.2.1 Commercial catches and discards

Spanish landings are based on sales notes which are compiled and standardized by IEO. Since 2003, trips data from sales notes are also combined with their respective logbooks. Data are available by statistical rectangle since 2003 and by métier since 2008 (EC, 2008).

Nephrops landings were reported by Spain. The time-series of the commercial landings (Table 12.1.1 and Figure 12.1.1) shows a clear declining trend. From 1975 to 1978, landings were around 600 t. In the period 1979–1993, landings values fluctuated around 400 t. In the period 1993 to 1998, landings decreased by 62%. From 1998 to 2016 (the last year with non-zero *Nephrops* TAC), landings decreased from 103 to 13 t. It should be noted that 88% of *Nephrops* landings are from the statistical rectangle 16E1, 10% from 15E0 and 2% from 15E1 (source: logbooks 2003–2016).

From 2017 to 2020, although the annual *Nephrops* TAC was zero, a special quota of 2 t each year was allowed for the FU 25 *Nephrops* Sentinel fishery (special onboard observers' programme in commercial fishing vessels to monitor the status of the stock in this FU). Details on the Sentinel fisheries were presented in working documents (WDs) to WGBIE (Vila *et al*., 2018; González Herraiz *et al*., 2019; González Herraiz *et al.,* 2020). In 2020, the Sentinel fishery was extended to all *Nephrops* areas of the FU in order to provide information representative of the whole FU and to collect spatial data to detect a possible stock area contraction (Figures 12.1.2c-d, 12.1.7, 12.1.8).

Information on landings, discards and length distributions was uploaded to InterCatch. *Nephrops* discards are negligible in FU 25. Estimates for 1994, 1997 and 1999 ranged from 0.4 to 2.4% of the catches by weight. However, as the *Nephrops* TAC is zero in this FU, discards were observed in 2018 (179 kg), 2019 (769 kg), and 2020 (921 kg).

VMS information

VMS data since 2009 for the trawl fleet operating in FU 25 in 2009–2018 provided some information about the spatial distribution of *Nephrops* catches in this FU before the zero-TAC was implemented (2009–2016) and during the years when the zero-TAC was implemented (2017–2020). These data were collected from a trawl fleet and for two vessels engaged in the Sentinel fishery (Figures 12.1.2a through 12.12c, and Figure 12.1.7). Logbook data were assigned to VMS pings by vessel, fishing day and statistical rectangle. About 22% of the VMS pings could not be identified in logbooks. Only 27% of the 2009–2016 VMS pings revealed the presence of *Nephrops*.

Sentinel cpue maps are represented in Figure 12.1.2.b (2017 and 2018) and Figure 12.1.2.c (2019 and 2020), in kg/fishing day, considering all sentinel surveys hauls (directed and not directed to *Nephrops*). These maps are used and compared with the maps showing the distribution of the rest of the commercial fishing fleet activity. Regular commercial fleet catch data are based on fishing days from logbooks since data by haul are only available for trips with observers on board.

Sentinel maps in Figure 12.1.2.d (2017–2020) are represented in kg/haul only for the hauls directed to *Nephrops*, which were used for the Sentinel *Nephrops* cpue estimates. Some of the red points of the 2019 Sentinel map in Figure 12.1.2.c are not represented in Figure 12.1.2.d because they correspond to non-directed hauls.

The maps for the years 2017, 2018, 2019 and 2020 show that the area covered by FU 25 *Nephrops* Sentinel fishery in the first three years was very small, compared with the area of *Nephrops* fishery in the past. It should be noted that this small area has a high occurrence of *Nephrops* (Figure 12.1.2a and Figure 12.1.2b, 2009–2016). Therefore, FU areas with low or no occurrence of *Nephrops* before the zero TAC implementation (Figure 12.1.2a and Figure 12.1.2b, 2009–2016) were not explored by the Sentinel fishery during the first three years (Figure 12.1.2b through Figure 12.1.2d, 2017–2019).

The comparison of the *Nephrops* area estimated with the position of the hauls with *Nephrops* catches from the whole time-series (1983–2020) of SPGFS-WIBTS-Q4 (G2784) survey plus discard programme and Sentinel fisheries with the area estimated only with 2017-2020 data suggests a contraction of the stock area since 1983 to 2020 by around 63% (Figure 12.1.8).

12.1.2.2 Biological sampling

The biological sampling programme and the Sentinel fishery provided since 1982 length–frequency distributions (LFDs) by sex of *Nephrops* landings and discards, sex ratio, recruitment proxies and mean sizes. The sampling levels in Division 8.c are shown in Table 1.4. SPGFS-WIBTS-Q4 (G2784) survey also provides LFDs by sex and, therefore, mean sizes and sex ratios since 1983.

Annual length compositions for males and females combined, mean size and mean weight in the landings time-series are presented in Table 12.1.2a and Table 12.1.2b for the period 1982–2020. LFDs for 1982–2019 is presented in Figure 12.1.3a, Figure 12.1.3b and Figure 12.1.3c.

Mean sizes in landings (Figure 12.1.1) show an increasing trend in the time-series for both sexes. The maximum value was recorded in 2009. Low mean sizes observed in the years 1983–1986, 1991 and 2013 may suggest recruitment failure. Mean carapace length in males was 41.4 and 39.5 mm CL for females from the 2020 FU 25 *Nephrops* Sentinel survey catch (landings and discards).

Low quantities of males in a *Nephrops* stock could be related to a high fishing pressure since ovigerous females are protected in burrows during most of the year (Fariña Pérez, 1996). In the worst cases, low quantities of males could affect mating (ICES, 2013), and consequently, recruitment in subsequent years. The percentage of males in landings in FU 25 from the commercial fleet from 1982 to 2016 has its minimum in 1990 and 2013 (red line in Figure 12.1.4a).

Recruitment proxies estimated from the SPGFS-WIBTS-Q4 (G2784) survey and the fishery show a decreasing trend up to 2008 in the survey and up to 2011 in the fishery (Figure 12.1.4b).

12.1.2.3 Abundance index from survey

Figures 12.1.5 and 12.1.6a-d show two periods in FU 25 *Nephrops* cpue (kg/haul) time-series and spatial distribution from SPGFS-WIBTS-Q4 (G2784) survey (1983–2020): the first period with high abundances before 1997 and the other with low abundance since then. Moreover, Figures 12.1.6c-d could indicate a very small increase in cpue in the statistical rectangles 16E1 (inside FU 25) and 17E1 (outside FU 25) since 2008. This is a bottom-trawl survey carried out every year in October to estimate hake recruitment and to collect information on the relative abundance of demersal species (see survey description in section 2.2.1 of this report as the Spanish IBTS survey in 3rd quarter). The survey haul positions are the same every year.

12.1.2.4 Commercial catch-effort data

Fishing effort and LPUE data are available for the bottom-trawl fleet selling in the port of A Coruña from 1975 to 2020 (Table 12.1.4 and Figure 12.1.1).

Until 2008, the effort series was from the Northwestern Spanish OTB fleet (see "Northern trawl" in section 2.1.1) selling in A Coruña (SP-CORUTR8c). Since the implementation of the current Data Collection Framework (DCF) sampling program (EC, 2008) in 2009, the Northern trawl was categorized into two different *métiers*: OTB_DEF_>55_0_0 ("baca", trips targeting demersal fish including *Nephrops*) and OTB_MPD_>55_0_0 ("jurelera", trips targeting pelagic and demersal fish). Since then, only OTB_DEF_>55_0_0 (SP-LCGOTBDEF) data were used for 8.c *Nephrops* (Castro and Morlán, 2015).

The effort and LPUE time-series (Figure 12.1.1) show general decreasing trends.

In trips catching *Nephrops*, the cpue (in kg/haul and kg/hour) in rectangle 15E0 used to be half of the cpue in rectangles 15E1 and 16E1 (source: logbooks 2006–2016).

In Portugal, cpue of species with an affinity for temperate waters (in opposition to tropical waters) decreased from 1992 to 2009, especially in the case of long-living species such as *Nephrops* (Teixeira *et al*., 2014). Cpue time-series of "temperate" species are directly correlated with rain and inversely with temperature (Teixeira *et al*., 2014). This phenomenon may have occurred and could have affected FU 25 *Nephrops* from 1992 to 2009.

In 2017, the fishing industry with cpue indices estimated from catches and effort data of two trawl vessels based in the A Coruña port for the years 2015 and 2016 in FU 25 (Table 12.1.5) was presented to WGBIE in 2017 as a WD (Fernández *et al*., 2017).

An observers' program (FU 25 Sentinel survey) was authorized during August and September for the years of 2017, 2018, 2019 and 2020 in order to obtain a *Nephrops* abundance index (Vila *et al*., 2018; González Herraiz *et al*., 2019; González Herraiz, 2020).

In 2020, the Sentinel fishery was extended to all *Nephrops* areas of the FU in order to provide information that will be representative of the whole FU and collect spatial data relative to a possible stock area contraction (Figures 12.1.2c-e and Figure 12.1.7). Sentinel fishery *Nephrops* catch in 2020 was composed of 2122 kg of retained catch and 12 kg of discards. Data of Sentinel fishery were included in the Spanish data uploaded to InterCatch. 2020 Sentinel fishery showed that *Nephrops* no longer occur in a large part of the area where these were previously available (Figure 12.1.7 and Figure 12.1.8).

Table 12.1.6 shows the *Nephrops* abundance indices (cpue) estimated for the years of 2017, 2018, 2019, and 2020 from the original area of the Sentinel fishery. However, this information is not representative of the whole FU 25 (Figure 12.1.2e).

12.1.3 Assessment

According to the ICES data-limited approach (ICES, 2015), this stock was considered as category 3.1.4—a stock with extremely low biomass and zero catch advice (ICES, 2019). The assessment of FU 25 is triennial. After the WKMSYSPiCT benchmark (ICES, 2021c), FU 25 was upgraded to category 2 (ICES, 2021a).

The SPiCT model (Pedersen and Berg, 2017) was considered suitable for the assessment of the FU 25 *Nephrops* stocks since, unlike other data-limited stocks (DLSs) methods, this model takes into account the history of the fishery and does not use a long list of life-history parameters that usually come with high uncertainty.

12.1.3.1 SPiCT model

The SPiCT model (Pedersen and Berg, 2017) was implemented for assessment and accepted in the WKMSYSPiCT benchmark (ICES, 2021b) with data until 2019. The same model revised with the 2020 data were used in this WG (ICES, 2021c).

Input data:

- Catches (1975–2020) (Table 12.1.1)
- SPGFS-WIBTS-Q4 (G2784) survey index (1983–2020) (Table 12.1.3, Figure 12.1.5)

SPiCT settings:

- Euler time-step (years): 1/12
- Medium level of exploitation before the beginning of the time-series
- Fixed shape parameter *n* to 2
- Intrinsic growth parameter *r* mean 0.2 and coefficient of variation 0.2
- Priors on the CV of the catches and the F process noise
- High uncertainty for the 2017–2020 catches (period with TAC zero)

12.1.3.2 Assessment diagnostics

The SPiCT diagnostics and retrospective plots did not show major problems in this year's assessment (Figures 12.1.9 and 12.1.10).

12.1.3.3 Assessment results

SPiCT results are presented in Table 12.1.7, Table 12.1.8, and Figure 12.1.11. The stock biomass (B) decreases from 1975 to 2007 and has had a very slight increase since then. Except in 1975 and 1976, biomass has been below the B_{MSY}. Fishing mortality (F) has been above F_{MSY} until 2012.

The biomass at the end of 2020 was 10% of the B_{MSY} and the fishing mortality was 17% of the F_{MSY} (Table 12.1.7).

12.1.3.4 Short-term projections

SPiCT predicted catch and stock status for 2022 specific scenarios are shown in Table 12.1.9.

12.1.3.5 Biological reference points

No reference points are defined for this stock in terms of absolute values. The SPiCT-estimated values of the ratios F/F_{MSY} and B/B_{MSY} are used to estimate stock status relative to the MSY reference points. The table below presents these relative reference points accepted by WKMSYSPiCT and used in the assessment to provide advice.

Framework	Reference point	Relative value *	Technical basis	Source
MSY approach	MSY $B_{trigger}$	0.5	Relative value. B_{MSY} proxy is estimated directly from the assessment model and changes when the assessment is updated.	ICES (2021b)
	F_{MSY}	1	Relative value. The F_{MSY} proxy is estimated directly from the assessment model and changes when the assessment is updated.	ICES (2021b)
Precautionary approach	$B_{lim\ proxy}$	$0.3 \times B_{MSY}$	Relative value (equilibrium yield at this biomass is 50% of the MSY proxy).	ICES (2021b)
	B_{pa}	Not defined		

Framework	Reference point	Relative value *	Technical basis	Source
	F_{lim}	1.7 × F_{MSY}	Relative value (the F that drives the stock to the proxy of B_{lim}).	ICES (2021b)
	F_{pa}	Not defined		

12.1.4 Stakeholder information

The fishing industry presented a WD to WGBIE in 2017 with qualitative and quantitative information about *Nephrops* fishery in FU25 (Fernández *et al.*, 2017). The WG considered that the LPUE data provided could be examined as an abundance index of *Nephrops* in a future benchmark as long as the data collection is continued and the time-series is extended to provide longer historical information. Details on how these data were collected (e.g. area, season) was not provided to the WG.

In April 2020, WGBIE received a letter from stakeholders (two Spanish fishing producers' organizations, OPP no. 31 and 07) regarding *Nephrops* in ICES Division 8.c. The document analysed market and sales notes data and the fisheries management measures of the recent years in relation with 8.c *Nephrops*. This document was discussed in a subgroup meeting during the WG in 2020. The sources of data and the issues mentioned in the document, together with additional sources of data and any other relevant information relative to the 8.c *Nephrops* stocks, are taken into account each year to make an integral analysis of the stock status and to elaborate a scientifically sound assessment.

No further information was presented to WGBIE in 2021.

12.1.5 Management considerations

Nephrops is taken mainly as a bycatch in the mixed bottom-trawl fishery (*métier* OTB_DEF≥55).

The overall trend in *Nephrops* landings from the North Galicia (FU 25) is strongly declining. Landings have dramatically decreased since the beginning of the series (1975–2016) representing, in 2016, 11% of the 1975 landings. During the years 2017, 2018, 2019, and 2020, the *Nephrops* TAC was zero.

A Fishing Plan for the Northwest Cantabrian ground was established in 2011 (ARM/3158/2011, BOE, 2011). This new regulation established an Individual Transferable Quota system (ITQs) where *Nephrops* was included.

An observer's programme in FU 25 supervised by the Spanish Oceanographic Institute (IEO) to obtain a *Nephrops* abundance index (Sentinel) was carried out from 2017 to 2020 (Vila *et al.*, 2018; González Herraiz *et al.*, 2019; González Herraiz *et al.*, 2020). A special quota allowance for *Nephrops* in FU 25 was authorized by the EU for the Sentinel fishery.

12.1.6 References

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12.1.7 Tables and figures

Table 12.1.1. *Nephrops* in FU 25, North Galicia. Catch, landings and discards in tonnes.

Year	Landings	Discards	Catch
1975	743		743
1976	578		578
1977	828		828
1978	706		706
1979	475		475
1980	532		532
1981	318		318
1982	431		431
1983	433		433
1984	515		515
1985	477		477
1986	364		364
1987	412		412
1988	445		445
1989	405		405
1990	335		335
1991	453		453
1992	428		428
1993	274		274
1994	246		246
1995	275		275
1996	209		209
1997	219		219
1998	103		103
1999	124		124
2000	81		81
2001	147		147
2002	143		143
2003	89		89
2004	75		75
2005	63		63
2006	62		62
2007	67		67
2008	39		39
2009	23		23
2010	32		32
2011	46		46
2012	9		9
2013	11		11
2014	10		10
2015	14		14
2016	13		13
2017	2*		2
2018	2*	0	2
2019	2*	1	3
2020	2*	1	3

(*) *Nephrops* TAC was zero in 8c (FU 25 & FU 31) in 2017, 2018, 2019 and 2020, but there was *Nephrops* Sentinel Fishery in FU 25.

Table 12.1.2a.*Nephrops* in FU 25, North Galicia. Length compositions of landings, mean weight (kg) and mean length (CL, mm) for the period of 1982–2001.

Carapace length (mm)	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
15																				
16																				
17																				
18																				
19	1	8			6							5								
20	1	17		16	1				3			34			1			0		
21	7	31	10							1		49	1	0	2				0	
22	10	99	22	8	50	0						32	1	7	5	5		0		
23	41	144	20	68	68	6	4		6	15		15	10	6	6	7	1	1	0	10
24	53	351	150	198	136	38	1		10	20	13	80	10	19	29	16	2	5	2	
25	105	497	163	300	192	191	16		35	71	19	57	60	64	38	18	6	15	7	10
26	142	511	372	326	279	185	42	1	36	204	26	70	118	78	56	53	12	26	9	19
27	275	749	564	575	299	467	17	3	70	360	102	71	179	109	91	49	16	21	5	20
28	303	733	746	799	495	302	208	25	223	1039	332	105	281	214	179	186	47	67	32	79
29	382	762	1092	943	500	366	175	22	208	851	280	134	262	190	225	178	38	91	24	125
30	648	1070	1422	1253	471	506	537	91	332	1428	565	176	335	427	266	441	92	194	85	112
31	611	1006	1205	1215	603	447	505	103	394	1048	586	152	330	373	342	303	65	136	60	129
32	782	1011	1720	1045	780	619	614	267	640	1321	885	308	410	448	404	492	99	197	127	288
33	874	957	1439	817	812	527	908	397	654	947	833	472	471	436	454	387	69	100	95	319
34	906	783	1298	975	886	742	720	437	536	982	1117	533	507	483	520	695	152	300	219	302
35	927	778	1122	797	764	821	746	673	664	884	979	670	564	712	396	543	193	258	218	265
36	991	758	1057	823	682	946	821	446	673	710	811	549	547	483	360	500	139	241	158	243
37	728	611	700	637	695	846	991	665	534	739	925	563	462	465	341	323	192	208	144	285
38	582	668	496	484	601	453	800	816	513	642	658	546	454	462	329	407	178	211	113	238
39	553	514	392	593	341	491	439	467	377	405	529	362	330	317	257	299	123	138	82	192
40	480	439	481	494	416	478	583	513	416	450	518	336	301	511	233	326	203	202	134	212
41	368	349	351	307	329	284	462	547	364	280	366	230	178	240	166	141	101	110	64	115
42	347	286	448	230	251	226	674	404	281	296	387	243	222	302	145	166	106	106	73	150
43	250	194	203	301	283	312	314	449	292	231	297	175	113	220	122	98	81	58	30	103
44	193	124	220	239	108	286	236	301	216	146	215	173	99	117	82	57	65	61	48	98
45	238	126	223	104	102	125	220	255	188	170	138	158	99	143	74	84	82	72	40	68
46	111	87	105	223	64	302	123	225	111	109	138	124	52	74	55	31	35	42	20	35
47	100	56	86	65	80	137	104	168	93	97	104	43	38	56	55	37	41	23	10	22
48	81	44	197	85	31	108	107	175	84	79	35	69	25	30	37	26	31	26	17	24
49	48	23	97	52	42	93	44	97	43	32	45	23	29	12	21	16	16	16	11	18
50	48	17	61	48	25	41	30	77	31	34	31	25	18	16	21	28	28	41	13	18
51	32	16	70	41	17	9	23	53	26	10	16	17	8	8	12	3	5	6	8	16
52	16	6	4	4	20	19	20	44	28	9	33	26	11	6	6	5	9	9	8	10
53	12	9	7	34	8	21	5	44	21	13	14	20	10	6	11	4	4	4	2	15
54	9	6	27	33	8	1	7	28	10	4	5	2	7	4	7	3	3	5	5	4
55	8	6	27	7	4	3	5	14	11	1	12	10	7	3	5	5	3	7	7	7
56	3	3	27	5	0	10	3	10	3	3	2	2	4	2	3	0	2	4	2	5
57	4	1		6	0	7	4	9	6	3	0		5	1	2	1	0	2	3	0
58	1	3	1	0	11	8		5	1	3	0	0	2	1	5	0	1	2	4	1
59	3	2		2	1		10	2	2	1	0	0	1	1	5	0	1	0	0	1
60	2	2	1	1	0	3	2	9	1	0	1		0	1	3	1	1	0	2	1
61	0	2		1	0			4	2				1	1	2	0	0		2	
62	3	2		1	0			2		1	1		0	1	3	0	0	0	0	0
63	1	1		1		1		1	0	0	0		1	1	1	2	0		0	0
64	2	0		3	0	1	2	3	1				0	1	1	0	0		0	0
65	1	0		0	0	1	12	1	0	2	1		0	0	4				0	0
66	0	1		1	0			1	1					0	1	1	0		0	0
67	1	2		0					1	1			0	0	0	1	0		0	
68	0	1		1			2	0	1				0	0	1	0	0		0	
69	1	0		1			2	1	1				0		1		0		0	
70	0	1		1				0	0	0					1	0	1		1	
71	1	1		0			2		1	0						0	0		0	
72	1	0				1		0				0			0	0	0		0	0
73	0	1		1					1				0		0					
74	0	1		0	0			1		0			0	0	1	1	0		0	0
75	0	1		1					0	0			1		1		0		0	0
76	1	1		0									0		1	0	0			
77	0	0		0		1			0				1	0	0		0			0
78	0	2		1				1		0			0	0	0		0			0
79	0	0		0									0		0					
80	1	0		0				0								0	0		0	
81																				
82																				
83																				
84																				
Total number (thousand)	11289	13872	16626	14167	10463	10431	10542	7858	8147	13641	11017	6661	6567	7054	5388	5939	2243	3004	1888	3562
Total weight (tonnes)	431	433	515	477	364	412	445	405	335	453	428	274	246	275	209	219	103	124	81	147
Mean weight (kg)	0.038	0.031	0.031	0.034	0.035	0.039	0.042	0.052	0.041	0.033	0.039	0.041	0.037	0.039	0.039	0.037	0.046	0.041	0.043	0.041
Mean length (CL, mm)	35.5	33.0	34.0	33.9	34.4	35.8	36.8	39.4	36.6	33.9	35.9	36.4	35.3	35.8	35.5	35.3	37.8	36.5	36.9	36.5

Table 12.1.2b. *Nephrops* in FU 25, North Galicia. Length compositions of landings, mean weight (kg) and mean length (CL, mm) for the period 2002–2020. * *Nephrops* TAC in 8.c (FUs 25 and 31) was zero in the years 2017, 2018, 2019 and 2020. Length distributions from FU 25 *Nephrops* Sentinel fishery used for those years.

Carapace length (mm)	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017*	2018*	2019*	2020*
15												7							
16																			
17																			
18																			
19								0	0										
20						0		0	0			0							
21	1	0		0		0		0	0			0	0						
22			1	1	0	1		0	0			9	0			0			
23	2	0	1	1	1	1		0	0								0		
24	2	1	2	2	1	1	0	0	0					1		0	0		
25	2	0	7	5	2	1	1	0	0			9	1	2		0	0	0	
26	5	2	7	8	3	5	1		0			9	0	1		0	0	0	0
27	14	3	12	13	9	4	3	0	2	0		0	1	1	0	0	0	0	0
28	30	2	26	25	15	8	4		2	1	5	10	1	3	0	0	0	0	0
29	43	5	28	25	18	11	6	0	2	2	3	2	1	2	2	0	0	0	0
30	105	14	46	43	25	19	10	1	9	2	5	13	3	18	6	0	0	0	0
31	102	26	45	56	39	36	10	1	9	3	7	2	2	11	5	0	0	0	0
32	198	36	60	66	55	44	15	1	18	4	8	3	2	14	8	1	0	1	1
33	181	51	71	87	69	69	13	3	20	5	8	5	5	25	12	1	0	2	1
34	272	66	70	83	62	75	16	4	27	14	5	6	8	26	16	2	1	2	1
35	308	85	91	98	85	90	25	6	34	26	11	20	13	47	31	2	1	3	2
36	259	110	98	102	88	101	31	7	30	22	9	9	17	26	26	3	2	4	2
37	236	123	101	88	87	105	37	10	34	24	13	10	13	22	23	3	3	5	3
38	185	147	98	92	80	101	35	11	26	67	9	7	14	22	33	3	3	5	3
39	129	130	81	69	67	86	37	11	23	48	3	16	12	12	20	3	2	4	3
40	186	129	96	81	64	90	47	13	20	82	20	12	14	16	30	3	2	4	3
41	99	81	78	61	59	73	44	13	23	65	9	8	10	11	16	3	2	3	3
42	117	79	63	52	49	63	38	12	23	53	9	6	9	12	10	3	3	3	3
43	67	65	57	47	44	59	35	13	24	55	3	16	9	10	10	2	2	2	2
44	109	52	39	36	32	46	29	16	22	36	8	7	8	10	6	2	2	2	2
45	78	46	44	34	30	42	23	15	21	25	7	8	5	6	6	1	1	1	2
46	65	57	35	26	26	37	22	12	22	18	3	8	6	5	3	1	1	1	1
47	34	42	26	20	18	30	20	15	22	14	2	2	4	5	3	1	1	1	1
48	35	37	23	14	17	22	16	10	17	16	1	5	2	3	2	1	1	1	1
49	23	27	16	13	11	16	14	9	14	18	4	3	2	3	2	1	1	0	1
50	24	27	19	11	14	18	10	8	13	13	1	2	2	2	2	0	0	0	1
51	34	20	13	7	9	11	11	7	11	7	3	2	2	2	1	0	0	0	0
52	18	16	12	8	8	8	9	7	8	8	1	2	1	2	1	0	1	0	0
53	13	11	9	6	7	7	8	8	9	5	3	2	2	2	1	0	0	0	0
54	4	9	7	5	4	4	6	6	7	7	1	2	1	1	1	0	0	0	0
55	9	6	6	5	4	3	6	6	7	6	3	1	1	1	1	0	0	0	0
56	6	5	5	3	9	3	4	4	4	5	1	1	1	1	0	0	0	0	0
57	5	7	4	3	4	2	5	4	5	4	1	1	0	0	0	0	0	0	0
58	9	4	4	3	2	2	4	4	3	5	1	1	1	0	0	0	0	0	0
59	4	5	3	2	1	1	3	3	2	1	0	1	0	0	0	0	0	0	0
60	2	2	2	2	1	1	2	3	3	4	0	0	0	0	0	0	0	0	0
61	1	1	3	1	1	1	2	2	1	3	3		0		0	0	0		0
62	3	3	2	1	7	1	1	2	1	6	1	1	0	0	0	0	0	0	0
63	10	0	2	1	1	1	1	2	1	2	1		0	0	0	0	0		0
64	0	1	2	1	6	0	1	1	0	2	0	0	0	0	0	0	0		
65	4	1	2	1	1	0	1	1	1	1	1		0		0	0	0	0	
66	1	2	1	1	0	0	1	1	1	1	0	0	0	0	0		0		
67	2	1	1	1	1	0	1	1	0	2	0		0			0	0	0	0
68	0	1	1	1	0	0	1	1	1	2	0		0	0	0	0	0	0	
69	0	2	1	1	0	0	1	1	0	0	0	0	0		0	0	0		
70	2	1	1	1	0	0	0	1	0	1	0		0		0	0	0	0	
71	0	1	2	0	6	0	0	1	0		0		0		0		0	0	
72	0	1	1	0	6	0	0	1	0	1	0		0				0		
73	0	1	1	1	0	0	0	1	0	1	0		0				0		
74	1	0	1	0	0	0		0	0	1	0						0		
75	0	1	0	0	0	0		0			0		0		0	0	0		
76	0	0	0	0	0	0	0	0			0				0				
77		0	0	0	0			0			0						0		
78	0	0	0		0	0		0	0		0		0				0		
79			0	0				0	0		0								
80	0		0	0	0		0	0			0								
81								0	0										
82								0											
83																			
84								0											
Total number (thousand)	3043	1543	1425	1314	1147	1298	612	258	528	686	175	229	175	327	280	38	32	47	37
Total weight (tonnes)	143	89	75	63	62	67	39	23	34	46	10	11	10	14	13	2	2	2	2
Mean weight (kg)	0.047	0.058	0.052	0.048	0.054	0.051	0.064	0.089	0.065	0.067	0.057	0.048	0.057	0.043	0.046	0.054	0.063	0.041	0.055
Mean length (CL, mm)	37.8	40.6	39.0	37.9	39.6	40	42.2	46.9	42.2	42.6	40.0	41.0	39.9	37.2	38.2	40.1	41.5	39.6	40.5

Table 12.1.3. *Nephrops* FU 25, North Galicia. SP-NSGFS Spanish IBTS 4Q trawl survey (G2784). *Nephrops* yield in gramme/haul (1983–2020).

Year	Nephrops yield
1983	127
1984	565
1985	281
1986	353
1987	
1988	453
1989	81
1990	249
1991	1267
1992	468
1993	256
1994	153
1995	494
1996	288
1997	59
1998	74
1999	87
2000	57
2001	90
2002	81
2003	29
2004	57
2005	48
2006	11
2007	10
2008	13
2009	28
2010	45
2011	59
2012	37
2013	96
2014	80
2015	36
2016	81
2017	47
2018	37
2019	49
2020	30

Table 12.1.4. *Nephrops* FU 25, North Galicia. Landings, fishing effort and LPUE from the fleet selling in A Coruña port (1986–2020).

Year	Landings (t)	Effort (trips)		LPUE (kg/trip)	
		SP-CORUTR8c	SP-LCOTBDEF	SP-CORUTR8c	SP-LCOTBDEF
1986	302	5017		60.1	
1987	356	4266		83.5	
1988	371	5246		70.7	
1989	297	5753		51.7	
1990	199	5710		34.9	
1991	334	5135		65.1	
1992	351	5127		68.5	
1993	229	5829		39.2	
1994	207	5216		39.6	
1995	233	5538		42.0	
1996	182	4911		37.0	
1997	187	4850		38.5	
1998	67	4560		14.7	
1999	121	4023		30.1	
2000	77	3547		21.7	
2001	145	3239		44.8	
2002	115	2333		49.5	
2003	65	1804		35.9	
2004	40	2091		18.9	
2005	32	2063		15.5	
2006	33	1699		19.4	
2007	37	2075		17.8	
2008	21	2128		9.9	
2009	11		1355		8.3
2010	22		1164		18.6
2011	35		906		38.4
2012	10		1460		6.8
2013	8		1582		5.3
2014	8		1869		4.5
2015	13		1358		9.3
2016	11		1589		6.6
2017	2*		1152		0.0
2018	2*		883		0.0
2019	2*		824		0.0
2020	2*		844		0.0

* *Nephrops* TAC in 8c (FU 25 and FU 31) was zero in 2017, 2018, 2019 and 2020, but there was Nephrops Sentir fishery in FU 25.

Table 12.1.5. *Nephrops* FU 25, North Galicia. Cpue (kg/hour) estimated by the fishing industry with data of two fishing vessels (2015 and 2016).

Source	Year	Period	Directed cpue (kg/hour)	Non-directed cpue (kg/hour)
Fishing Industry (Fernández *et al.*, 2017)	2015	Year	6.46	0.18
	2016	Year	10.81	0.27

Table 12.1.6. *Nephrops* FU 25, North Galicia. Cpue (kg/hour) from Sentinel Fisheries for the years of 2017, 2018, 2019 and 2020 in the original area of the Sentinel fishery.

Source	Year	Period	*Nephrops* directed hauls			
			cpue (kg/hour)	s.d.	CV	n
Observers on board Sentinel survey	2017	Aug-Sep	7.2	3.1	43%	54
	2018	Aug-Sep	5.1	3.0	59%	66
	2019	Aug-Sep	16.2	11.1	69%	22
	2020	Aug-Sep	16.6	11.7	70%	24

***To avoid the effect of daily variations in the catchability of *Nephrops*, which is a consequence of the changes in their behaviour, the hauls that were carried out in more than 50% of the time between dusk and dawn were considered non-directed to *Nephrops*.**

Table 12.1.7. ***Nephrops*** **FU 25, North Galicia. SPiCT summary results.**

Parameter estimates

Parameter	estimate	cilow	ciupp	log.est
alpha	2.8277	0.8191	9.7616	1.0395
beta	0.4439	0.2510	0.7850	-0.8122
r	0.1795	0.1243	0.2594	-1.7174
rc	0.1795	0.1243	0.2594	-1.7174
rold	0.1795	0.1243	0.2594	-1.7174
m	405.5033	209.9941	783.0360	6.0051
K	9034.2754	4567.2685	17870.2287	9.1088
q	0.0010	0.0005	0.0019	-6.9312
sdb	0.2037	0.0746	0.5563	-1.5913
sdf	0.3982	0.2695	0.5882	-0.9209
sdi	0.5759	0.4082	0.8125	-0.5518
sdc	0.1767	0.1278	0.2445	-1.7330

Stochastic reference points

Reference points	estimate	cilow	ciupp	log.est	rel.diff.Drp
Bmsys	3945.1177	1930.3088	8062.9346	8.2802	-0.1450
Fmsys	0.0794	0.0524	0.1204	-2.5330	-0.1303
MSYs	307.4125	135.5493	697.1816	5.7282	-0.3191

$B_{trigger}$ 1973 t B_{lim} 1184 t

Estimated states

	estimate	cilow	ciupp	log.est
B_2020.92	379.2235	165.3588	869.6875	5.9381
F_2020.92	0.0136	0.0028	0.0649	-4.3006
B_2020.92/Bmsy	0.0961	0.0341	0.2706	-2.3421
F_2020.92/Fmsy	0.1707	0.0370	0.7879	-1.7676

Table 12.1.8. *Nephrops* FU 25, North Galicia. SPiCT estimates for B/B$_{MSY}$ and F/F$_{MSY}$.

B/Bmsy	ll	est	ul	F/Fmsy ll	est	ul
1975	0.70	1.15	1.87	0.96	2.16	4.87
1976	0.57	1.03	1.85	0.98	2.00	4.09
1977	0.50	0.99	1.95	1.11	2.26	4.62
1978	0.42	0.91	1.97	1.29	2.66	5.51
1979	0.36	0.79	1.73	1.09	2.29	4.81
1980	0.32	0.73	1.64	1.05	2.22	4.68
1981	0.29	0.66	1.49	0.91	1.93	4.09
1982	0.28	0.64	1.44	0.90	1.87	3.89
1983	0.27	0.63	1.45	1.09	2.19	4.39
1984	0.26	0.61	1.44	1.24	2.40	4.64
1985	0.24	0.63	1.60	1.32	2.54	4.87
1986	0.23	0.58	1.50	1.21	2.35	4.55
1987	0.21	0.56	1.49	1.17	2.29	4.48
1988	0.20	0.55	1.49	1.28	2.50	4.90
1989	0.19	0.51	1.41	1.37	2.68	5.24
1990	0.17	0.45	1.18	1.28	2.50	4.89
1991	0.16	0.46	1.34	1.33	2.68	5.37
1992	0.14	0.46	1.55	1.39	3.03	6.65
1993	0.11	0.41	1.50	1.10	2.61	6.18
1994	0.10	0.37	1.29	0.94	2.27	5.48
1995	0.09	0.34	1.25	1.00	2.47	6.11
1996	0.08	0.30	1.21	0.99	2.58	6.69
1997	0.07	0.25	0.94	1.17	2.88	7.10
1998	0.06	0.18	0.58	1.11	2.49	5.61
1999	0.05	0.16	0.47	1.11	2.31	4.81
2000	0.05	0.14	0.40	1.11	2.23	4.50
2001	0.05	0.14	0.37	1.33	2.62	5.15
2002	0.04	0.13	0.38	1.87	3.74	7.45
2003	0.03	0.10	0.29	1.79	3.57	7.15
2004	0.03	0.08	0.22	1.63	3.19	6.22
2005	0.03	0.07	0.19	1.61	3.10	5.98
2006	0.02	0.06	0.16	1.71	3.28	6.29
2007	0.02	0.05	0.13	1.96	3.82	7.43
2008	0.02	0.05	0.12	1.62	3.27	6.58
2009	0.02	0.05	0.12	0.96	1.97	4.01
2010	0.02	0.05	0.16	0.78	1.63	3.41
2011	0.02	0.07	0.25	0.80	1.88	4.43
2012	0.02	0.07	0.26	0.40	1.03	2.63
2013	0.02	0.07	0.25	0.21	0.54	1.40
2014	0.02	0.08	0.30	0.16	0.43	1.12
2015	0.02	0.09	0.34	0.17	0.44	1.14
2016	0.02	0.09	0.35	0.18	0.46	1.17
2017	0.03	0.09	0.32	0.12	0.34	0.94
2018	0.03	0.09	0.26	0.07	0.24	0.78
2019	0.03	0.09	0.24	0.05	0.20	0.71
2020	0.03	0.09	0.25	0.04	0.18	0.71
2021	0.03	0.10	0.28	0.04	0.17	0.80
2022	0.04	0.11	0.34	0.03	0.17	0.96
2023	0.04	0.13	0.42	0.03	0.17	1.14

Table 12.1.9. *Nephrops* FU 25, North Galicia. SPiCT predicted catch and stock status for 2022.

	C	B/Bmsy	F/Fmsy	B/Bmsy.lo	B/Bmsy.hi	F/Fmsy.lo	F/Fmsy.hi
1. F=0	0.0	0.13	0.00	0.04	0.42	0.00	0.00
2. F=Fsq	6.4	0.13	0.17	0.04	0.42	0.03	1.14
3. F=Fmsy	0.0	0.13	0.00	0.04	0.42	0.00	0.00
4. F=Fmsy_C_fractile	0.0	0.13	0.00	0.04	0.42	0.00	0.00

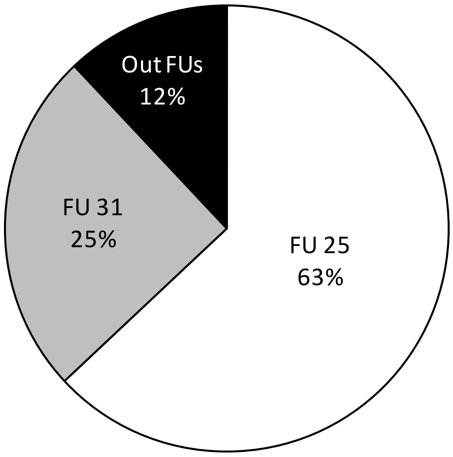

Figure 12.1. ICES Division 8.c *Nephrops* landings (in tonnes) by FU (2003–2016). *Nephrops* TAC in 8.c was zero for the years 2017, 2018, 2019 and 2020.

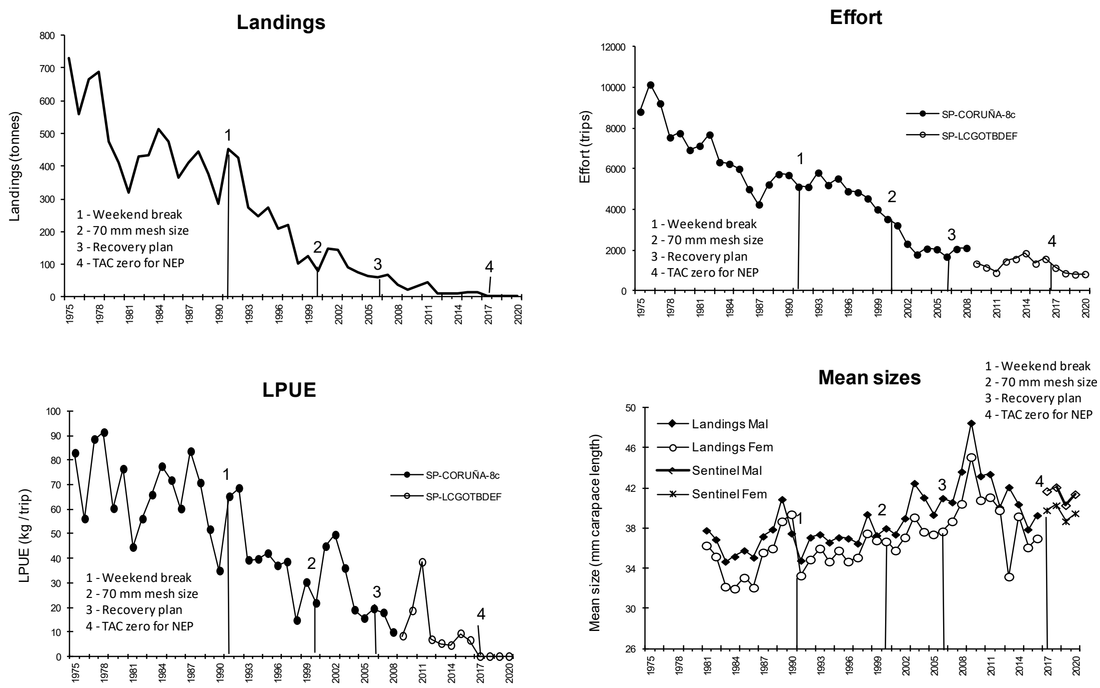

Figure 12.1.1. *Nephrops* FU 25, North Galicia. Long-term trends in landings, effort, LPUE and mean sizes. Landings (in tonnes) and mean sizes from the FU. Effort and LPUE from the fleet selling in the A Coruña port. *Nephrops* TAC in 8.c (FUs 25 and 31) was zero for the years 2017, 2018, 2019 and 2020. Mean sizes information during these years were from the FU 25 *Nephrops* Sentinel fisheries.

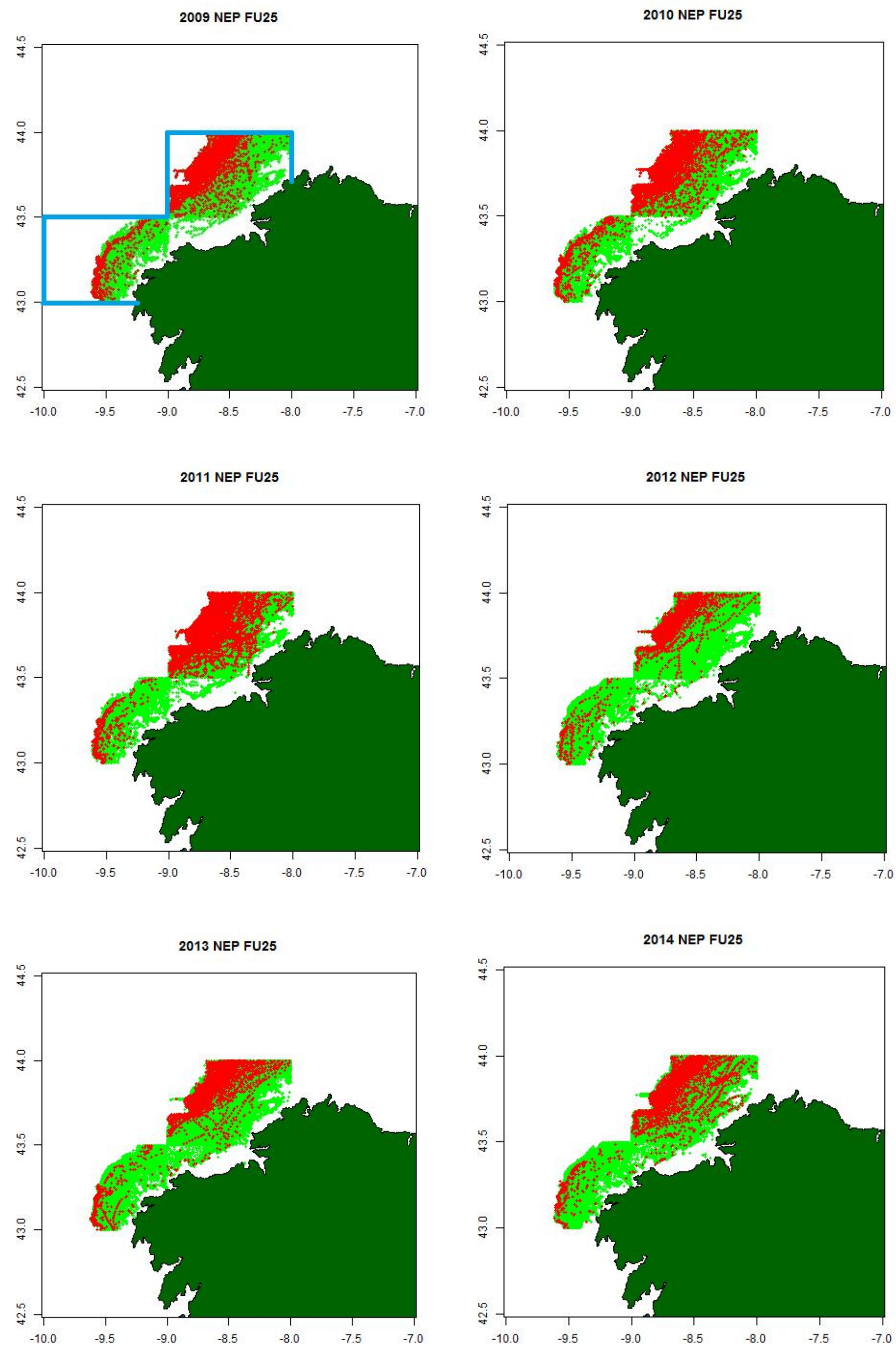

Figure 12.1.2a. ***Nephrops*** **FU 25, North Galicia. LPUE (kg/fishing day) distribution from commercial fleet activity. Red points:** ***Nephrops*** **LPUE > 0 kg/fd, green points:** ***Nephrops*** **LPUE = 0 kg/fd. Limits of the FU in blue in the 2009 map.**

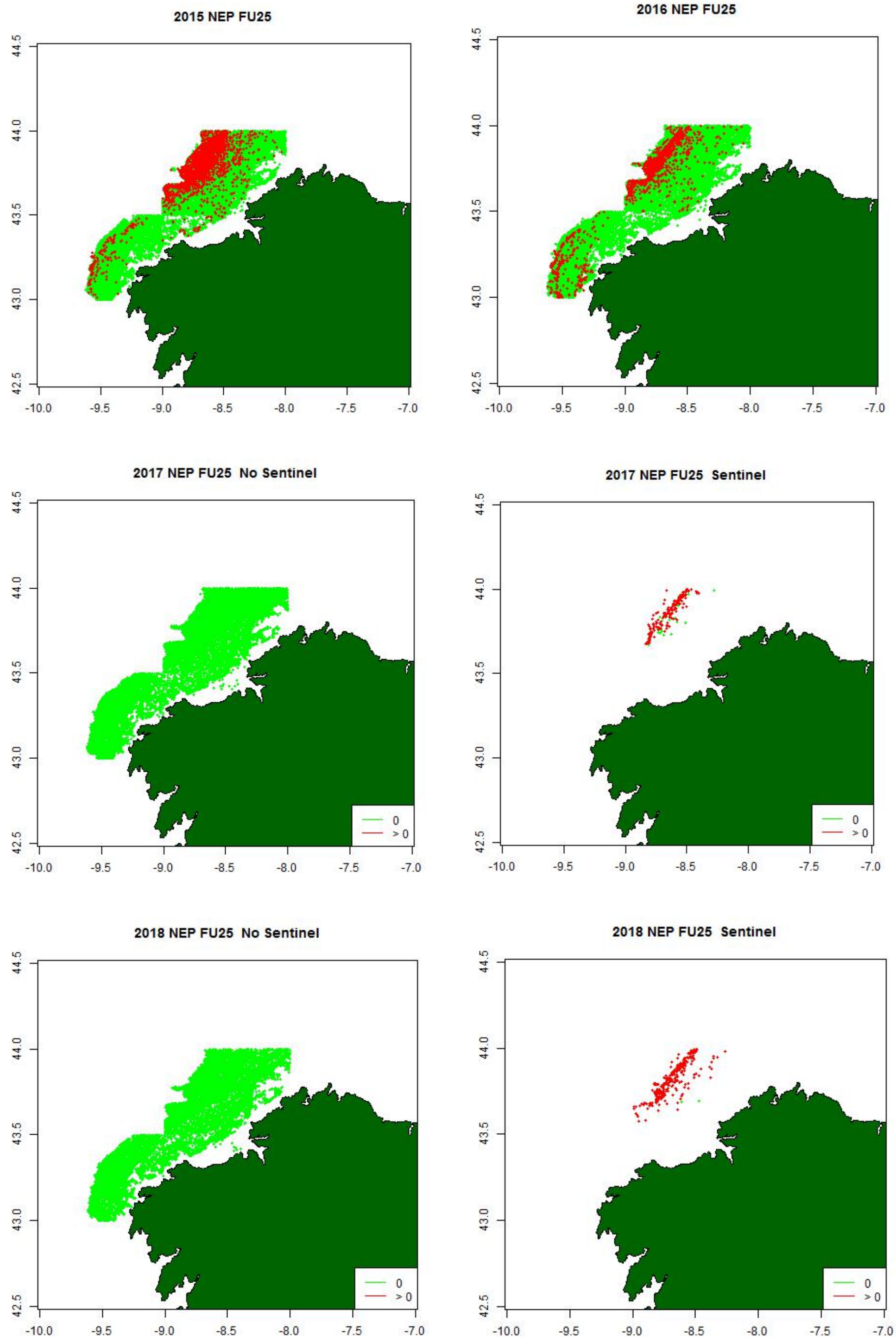

Figure 12.1.2b. ***Nephrops*** **FU 25, North Galicia. LPUE (kg/fishing day) distribution from commercial fleet activity (2015, 2016, 2017 and 2018 "no sentinel" maps) and from Sentinel fishery (2017 and 2018 "sentinel"). Red points: Nephrops LPUE > 0 kg/fd, green points: Nephrops LPUE = 0 kg/fd. Limits of the FU in blue in the 2009 map in Figure 12.1.2a.**

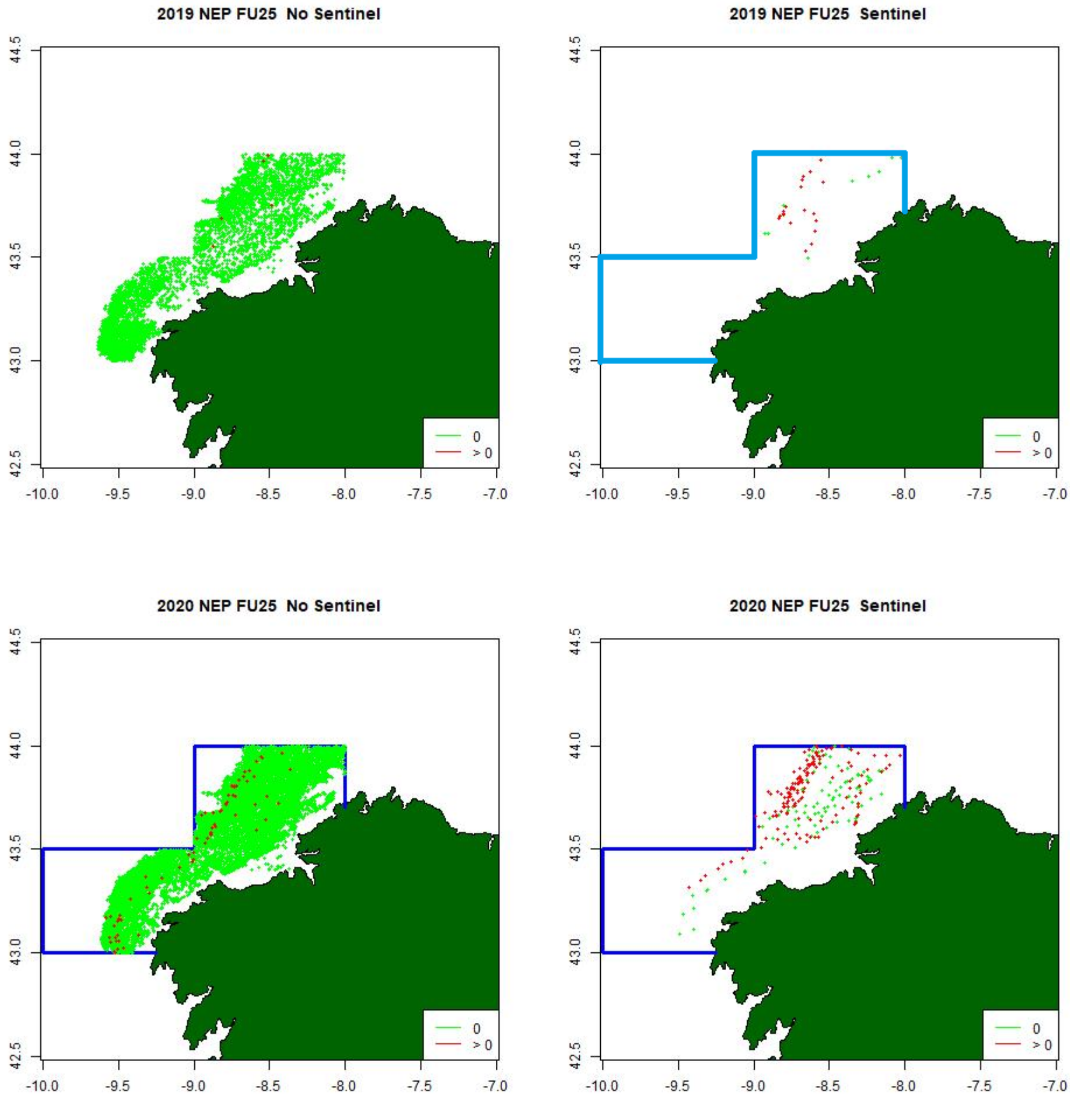

Figure 12.1.2c. *Nephrops* FU 25, North Galicia. LPUE (kg/fishing day) distribution from commercial fleet activity ("no sentinel") and from Sentinel fishery ("sentinel"). Red points: *Nephrops* LPUE > 0 kg/fd, green points: *Nephrops* LPUE = 0 kg/fd. Limits of the FU in blue. In 2020, the sentinel was extended to the whole previous FU 25 *Nephrops* area.

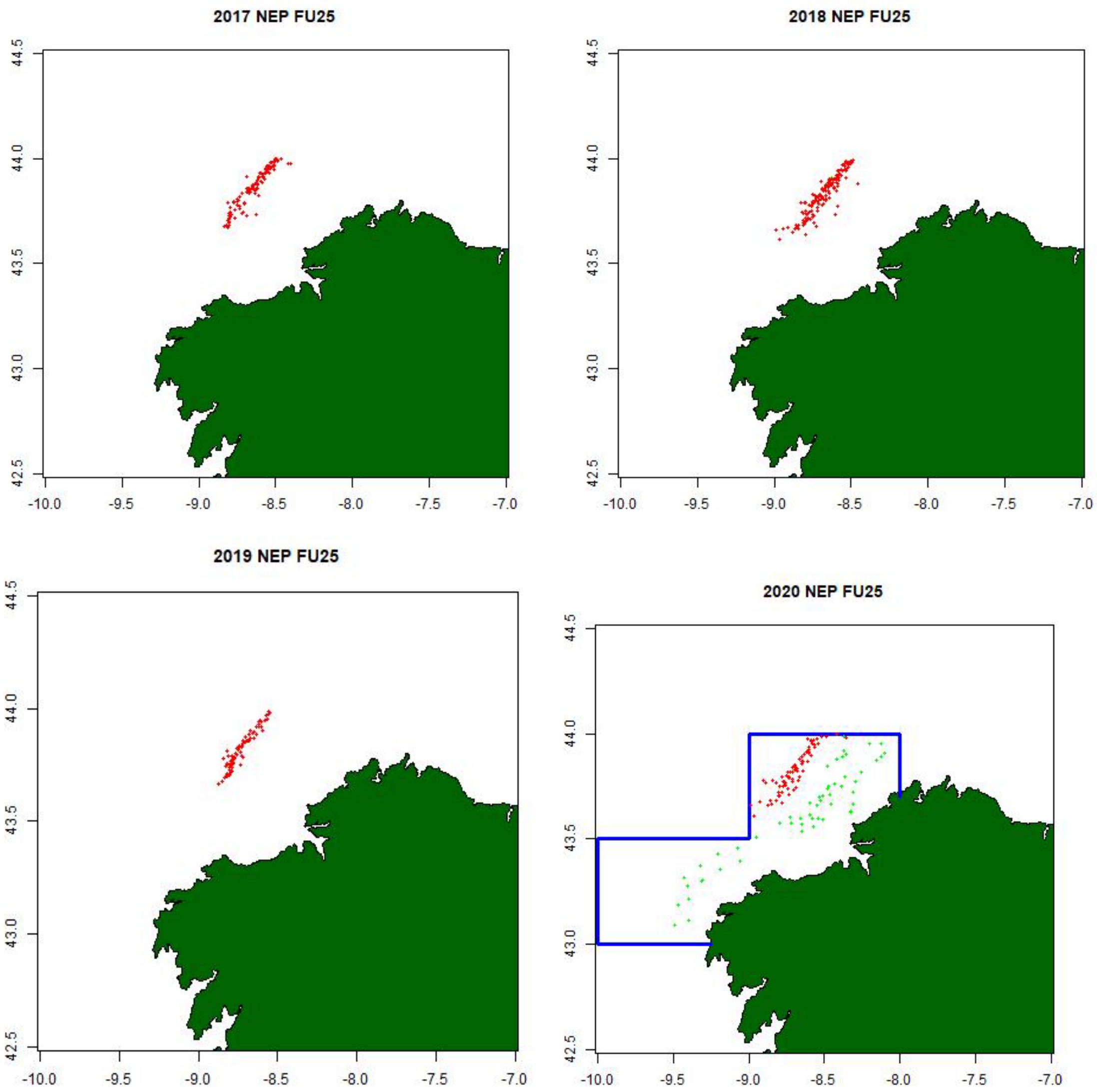

Figure 12.1.2d *Nephrops* FU 25, North Galicia. LPUE (kg/haul) distribution from Sentinel fishery (“sentinel”). Only *Nephrops* directed hauls. Red points: *Nephrops* LPUE > 0 kg/haul, green points: *Nephrops* LPUE = 0 kg/haul. Limits of the FU are in blue. In 2020, the sentinel was extended to the whole previous FU 25 *Nephrops* area.

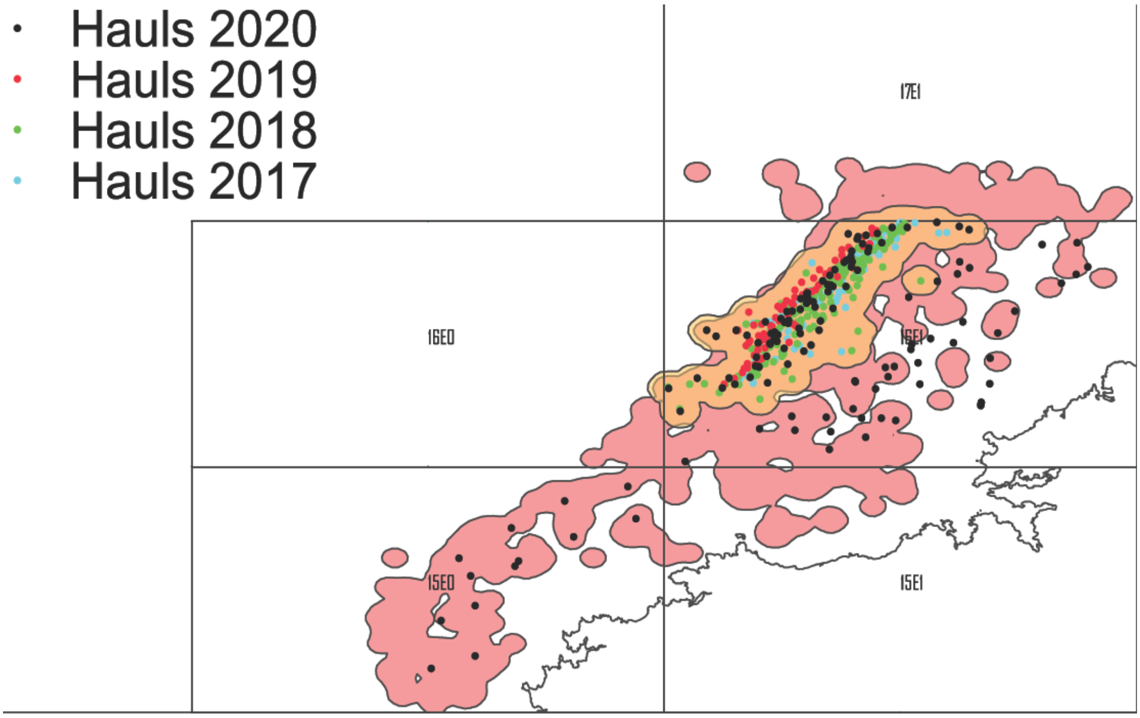

Figure 12.1.2e. *Nephrops* FU 25, North Galicia. Sentinel effort (hauls) distribution in 2017–2020. In pink FU 25 *Nephrops* assessment area, in yellow 2017–2019 Sentinel area. Only hauls directed to *Nephrops*.

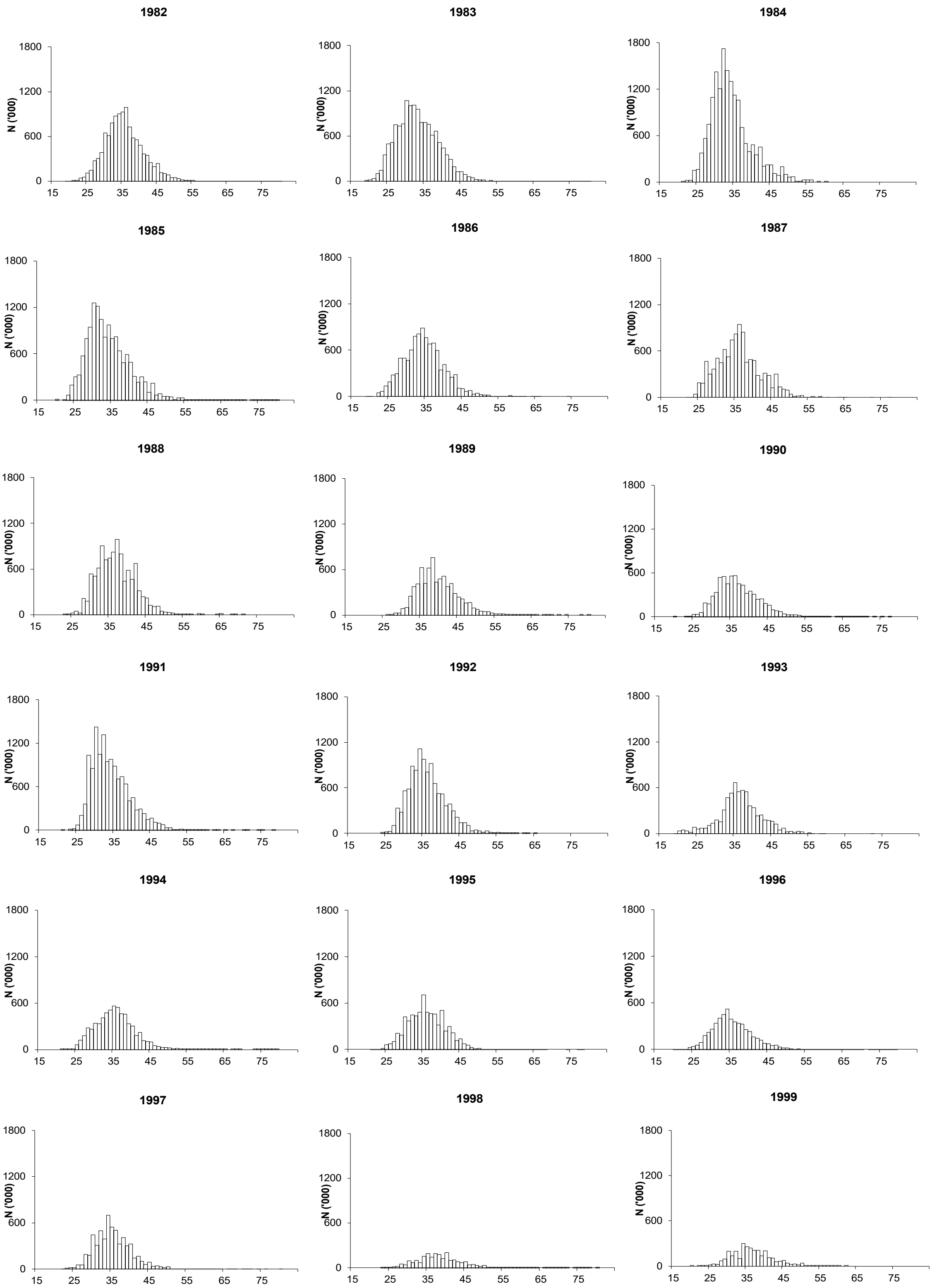

Figure 12.1.3a. *Nephrops* FU 25, North Galicia. Length distributions of landings, 1982–1999. Maximum of y-axis 1800 thousand. Carapace length in mm in the x-axis.

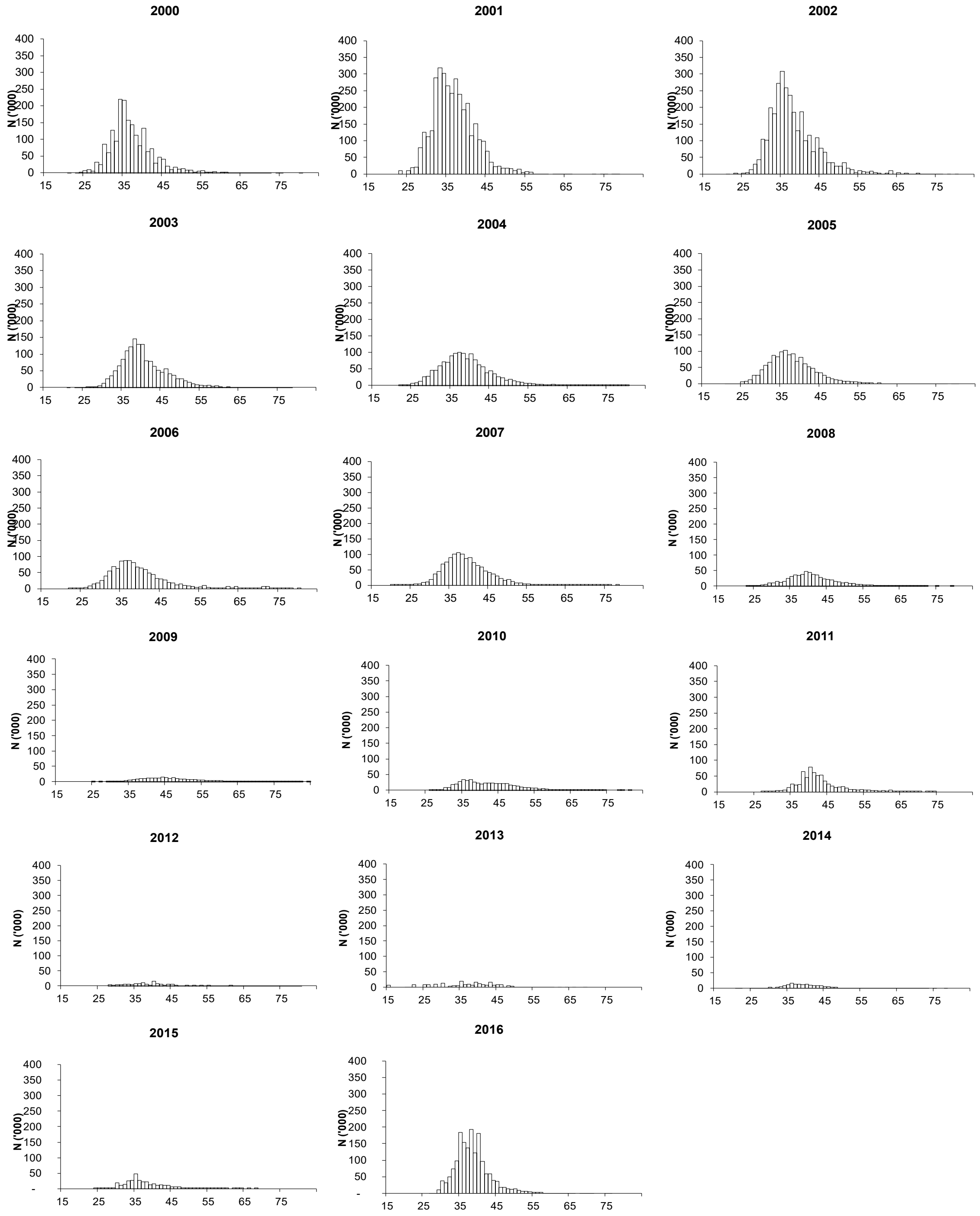

Figure 12.1.3b. ***Nephrops*** **FU 25, North Galicia. Length distributions of landings, 2000–2016. Maximum of y-axis 400 thousand (2001–2016). Carapace length in mm in the x-axis.**

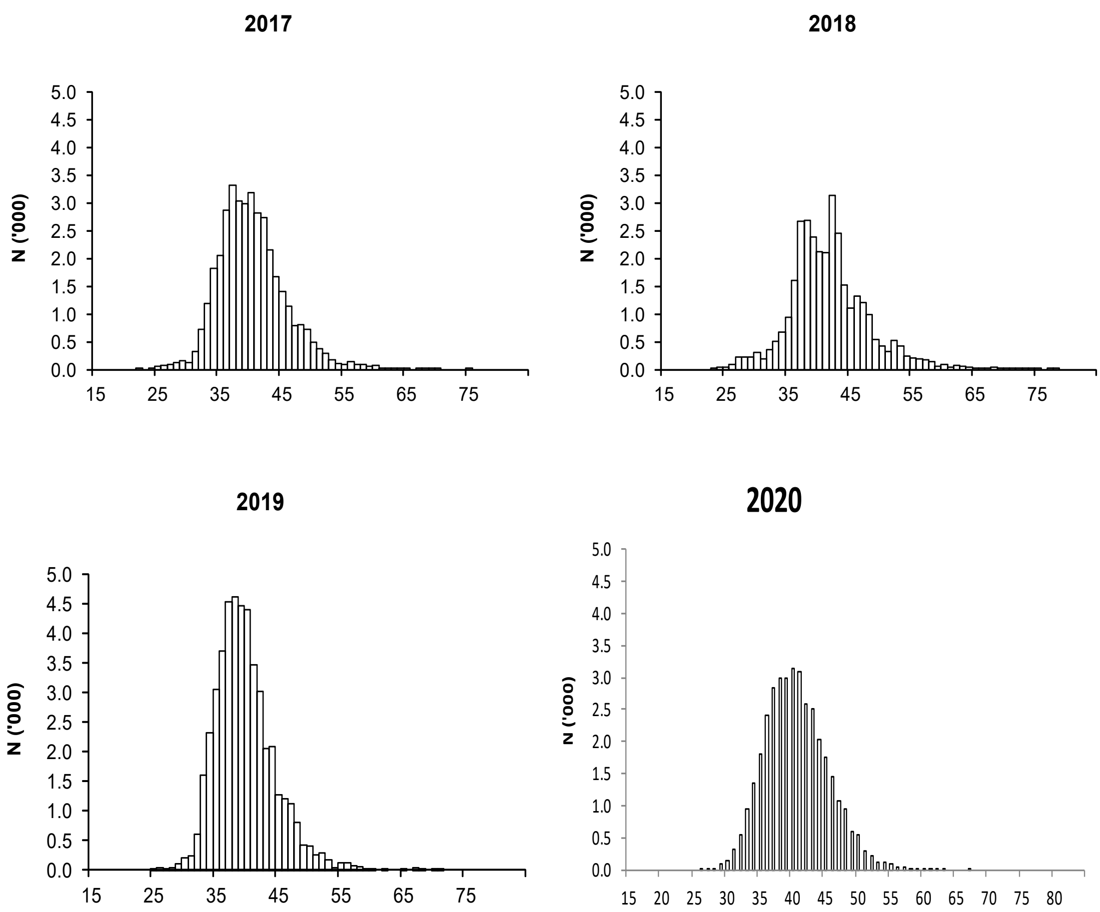

Figure 12.1.3c. ***Nephrops*** **FU 25, North Galicia. TAC in 8.c (FU 25 and FU 31) was zero for the years 2017, 2018. 2019 and 2020. Length distributions of landings for these years were from the** ***Nephrops*** **Sentinel fishery. Maximum of y-axis 5 thousand. Carapace length in mm in the x-axis. The number of measured individuals: 7266 (2017), 8524 (2018), 4633 (2019), and 6316 (2020).**

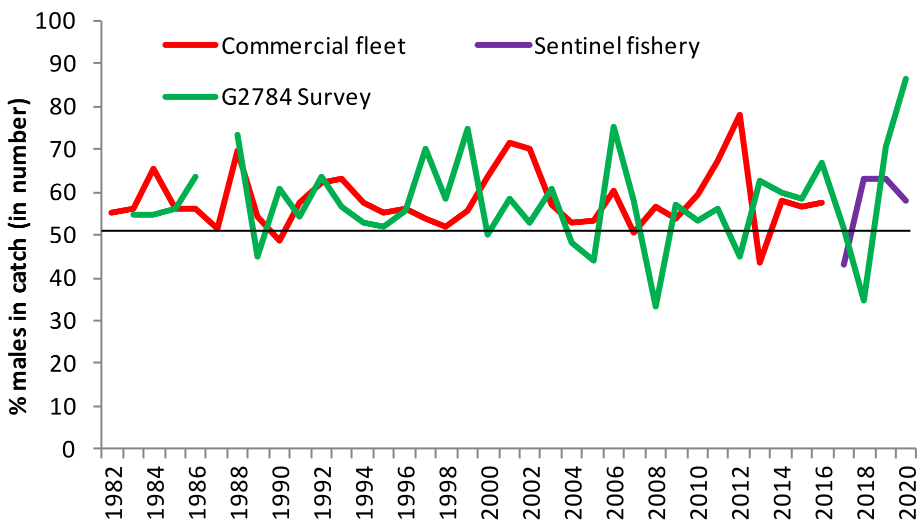

Figure 12.1.4a. ***Nephrops*** **FU 25, North Galicia. Proportion of males in catches for the period 1982–2020. Commercial fleet (1982–2016), Sentinel fishery (2017–2020) and SPGFS-WIBTS-Q4 (G2784) survey (1983–2020).**

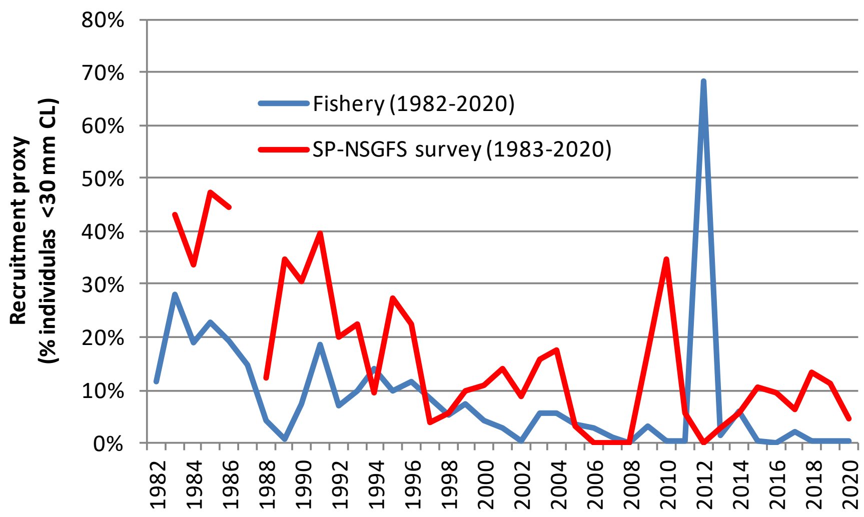

Figure 12.1.4b. *Nephrops* FU 25, North Galicia. Recruitment proxy. Blue line = Commercial fleet (1982–2016) and Sentinel fleet (2017–2020). Red line = SPGFS-WIBTS-Q4 (G2784) survey (1983–2020)

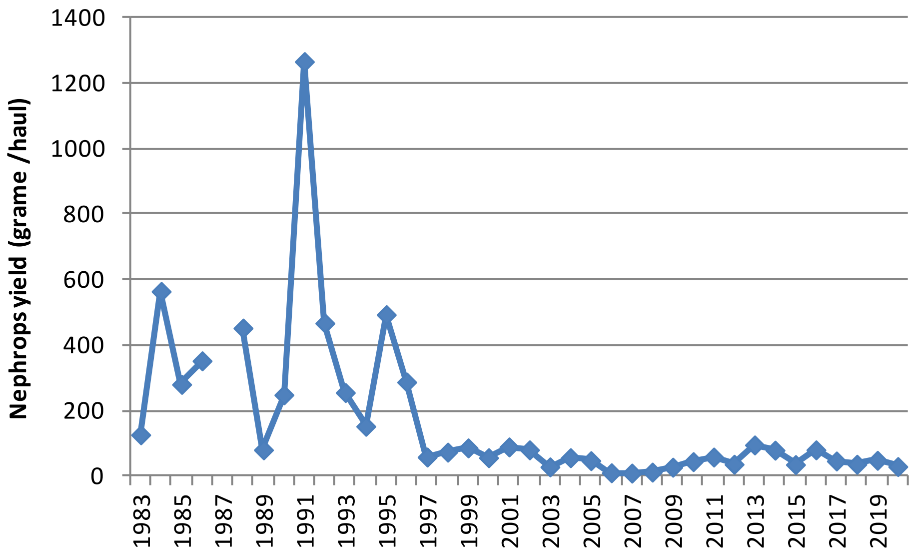

Figure 12.1.5. *Nephrops* FU 25, North Galicia. Cpue (gramme/hour) from SPGFS-WIBTS-Q4 (G2784) survey (1983–2020). No survey was carried out in 1987. Only hauls in the *Nephrops* area have been used.

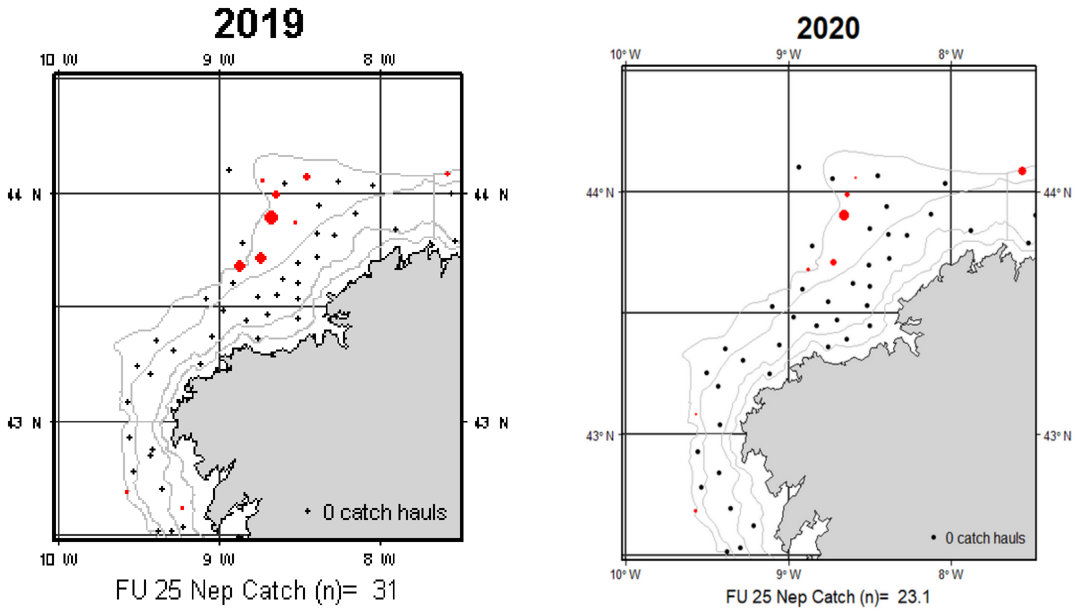

Figure 12.1.6d. ***Nephrops*** **FU 25, North Galicia. Cpue (kg/haul) from SPGFS-WIBTS-Q4 (G2784) survey. Black points: zero kg of *Nephrops*/haul. Limits of FU 25 in blue in the 2009 map in Figure 12.1.6c.**

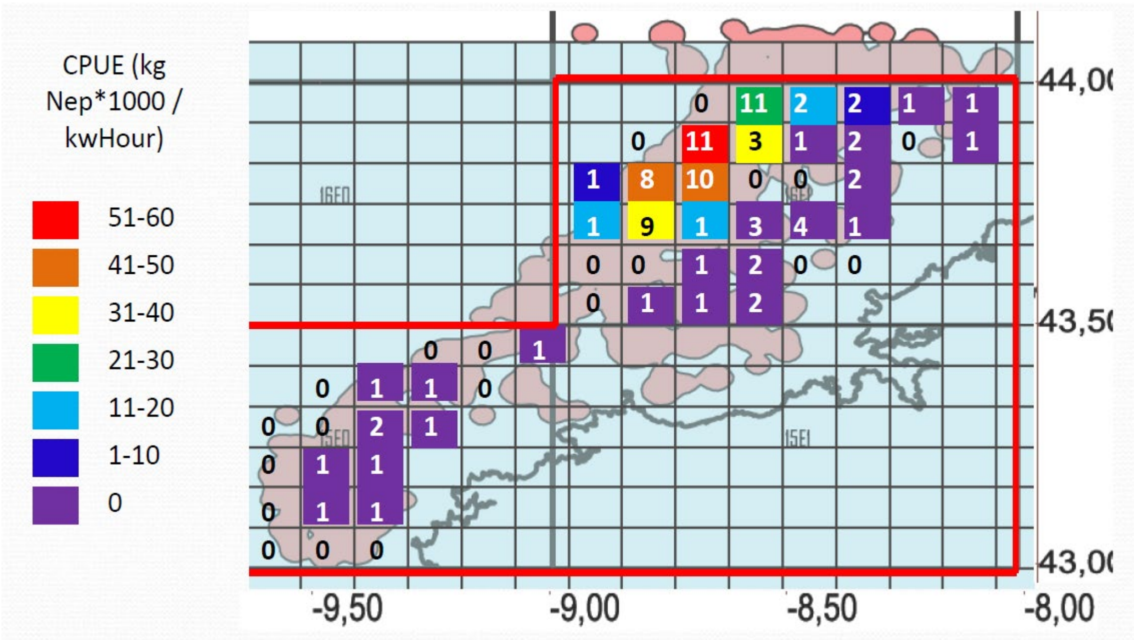

Figure 12.1.7. ***Nephrops*** **FU 25, North Galicia. Cpue (kg*1000/kwHour) from the 2020 Sentinel fishery. Numbers in the map correspond to the number of hauls that were fished in each sampling cell. FU 25 limits in red.**

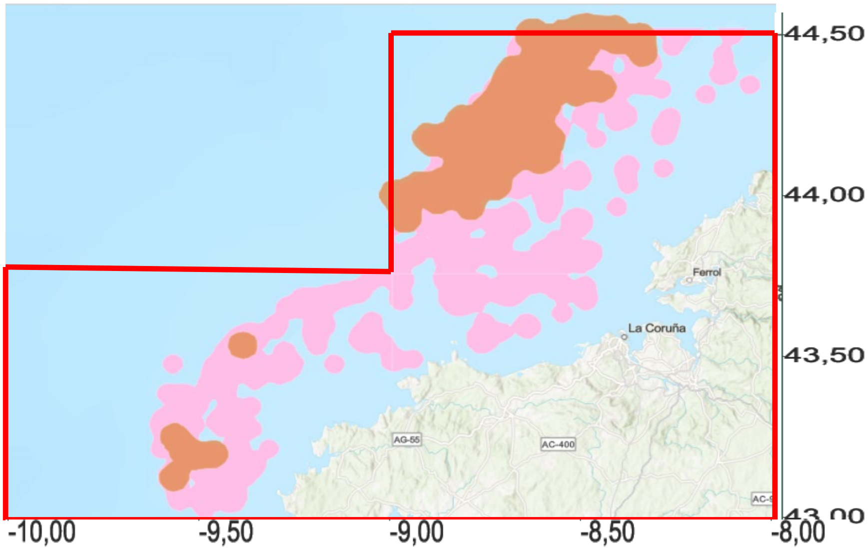

Figure 12.1.8. ***Nephrops*** **FU 25, North Galicia. Limits of FU 25 in red. Pink area (3710 km²) calculated with the positions of the hauls with *Nephrops* catches from SPGFS-WIBTS-Q4 (G2784) survey (1983–2020), Discarding programme (1994–2020) and Sentinel fishery (2017–2020). Brown area (1354 km2) was calculated from the same data sources but only with 2017–2020 data incorporated.**

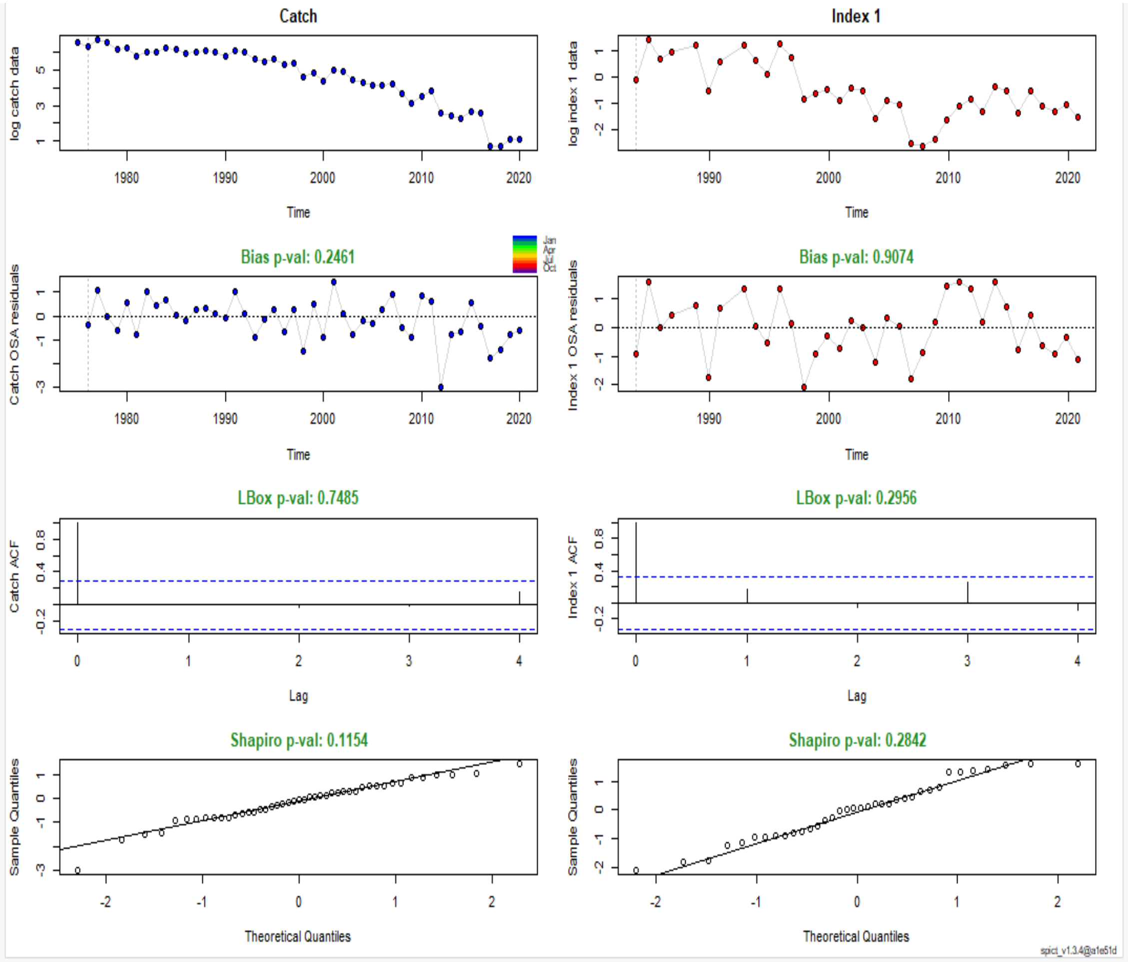

Figure 12.1.9. ***Nephrops*** **FU 25, North Galicia. SPiCT diagnostics.**

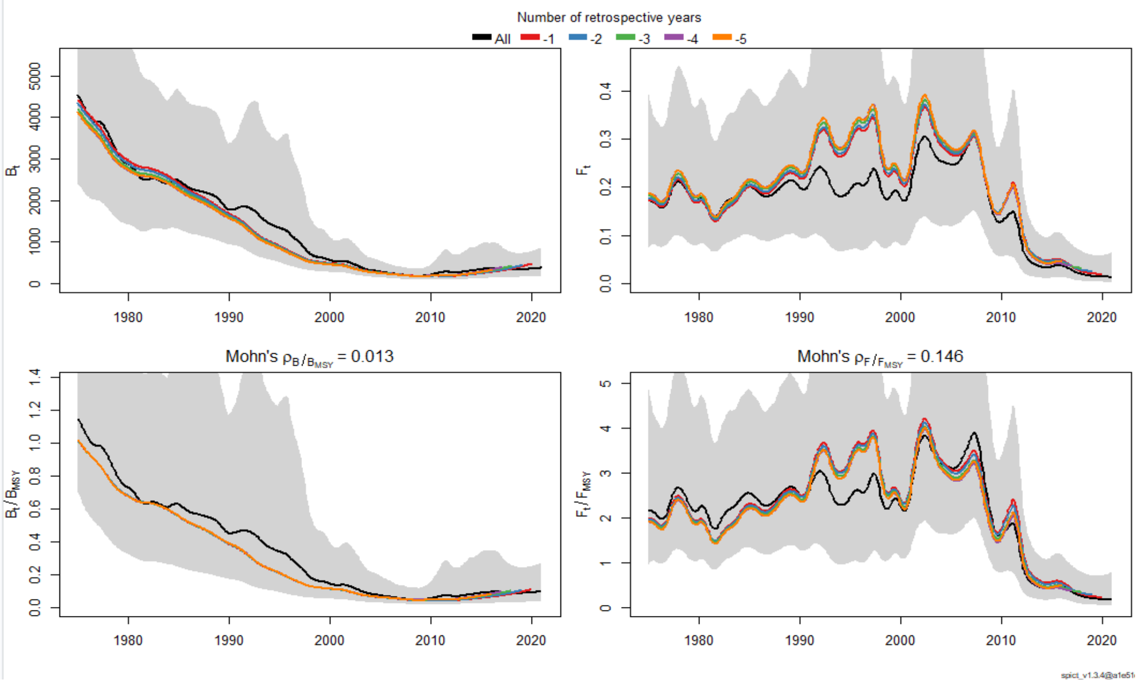

Figure 12.1.10. ***Nephrops*** **FU 25, North Galicia. Retrospective patterns.**

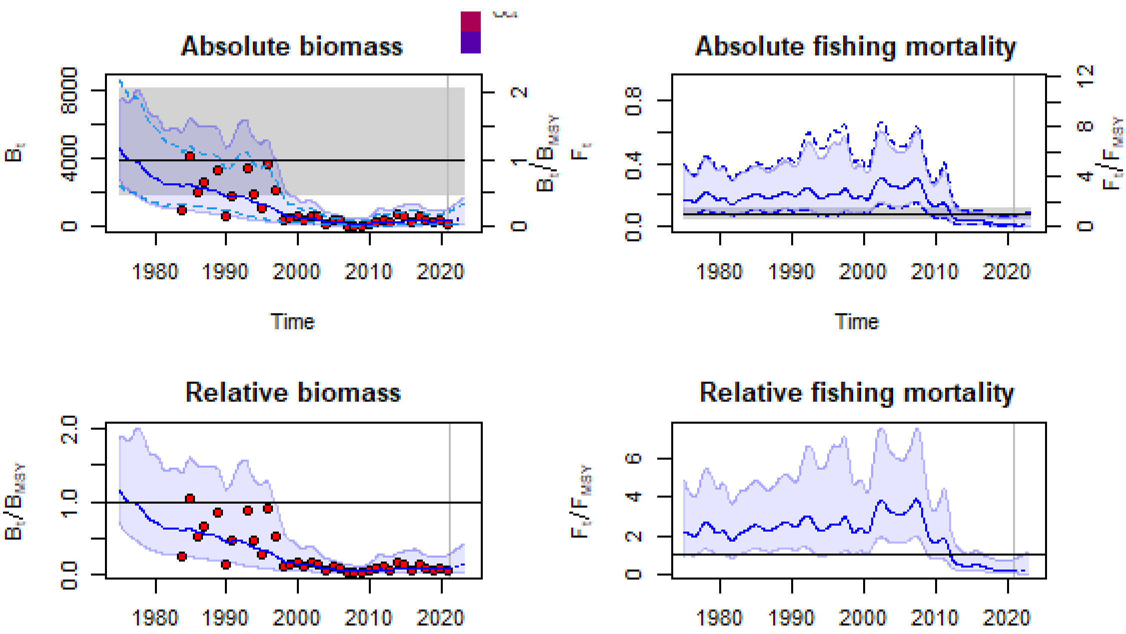

Figure 12.1.11. ***Nephrops*** **FU 25, North Galicia. Absolute and relative biomass and fishing mortality.**

12.2 FU 31 (southern Bay of Biscay and Cantabrian Sea) Nephrops

12.2.1 General

Up to this date, the status of the FU 31 *Nephrops* stock was considered undesirable (ICES, 2016) with extremely low biomass and zero-catch advice (ICES, 2017).

After the WKMSYSPiCT benchmark (ICES, 2021), FU 31 *Nephrops* stock was upgraded from a category 3 (based on trends) to a category 2 (production model) assessment.

12.2.1.1 Ecosystem aspects

See Stock Annex.

12.2.1.2 Fishery description

FU 31 *Nephrops* is caught by the Spanish OTB_DEF_≥55, which is described as the "Northern trawl" fleet in section 2.1.2 of this report. See also Stock Annex for more information.

12.2.1.3 Summary of ICES advice for 2021 and management applicable to 2020 and 2021

ICES advice for 2021

The advice for this *Nephrops* stock is triennial and valid for 2020, 2021 and 2022.

ICES advises that when the precautionary approach is applied, there should be zero catch in each of the years 2020, 2021, and 2022.

To protect the stock in this FU, ICES advises that the management area should be consistent with the assessment area. Therefore, management should be implemented at the FU level.

Management applicable to 2020 and 2021

Since 2011, there is a Spanish regulation that established an Individual Transferable Quota system (ITQs) which includes *Nephrops* (ARM/3158/2011, BOE, 2011).

In 2016, a zero TAC was set for *Nephrops* in ICES Division 8.c for the years 2017, 2018 and 2019. In 2019, this measure was advised again for the years 2020, 2021 and 2022.

A special quota of 0.7 t for 2019 and 2020 was set for *Nephrops* in FU 31 in order to conduct an observer's onboard programme (*Nephrops* Sentinel Fishery) supervised by the Spanish Oceanographic Institute (IEO) to obtain a *Nephrops* abundance index and complementary data.

12.2.2 Data

12.2.2.1 Commercial catches and discards

Spanish landings are based on sales notes which are compiled and standardized by IEO. Since 2003, trips sales notes are also combined with their respective logbooks. Data are available by statistical rectangle since 2003 and by *métier* since 2008 (EC, 2008). A revision of the 2003–2009 FU 31 *Nephrops* landings was made in 2019 based on logbooks data.

Nephrops landings from FU 31 were reported by Spain (Table 12.2.1 and Figure 12.2.1) and are available for the period 1983–2020. The highest landings were recorded in 1989 and 1990, 177 t and 174 t, respectively. Since 1996, landings have declined sharply to 3 t in 2016, the last year with non-zero *Nephrops* TAC. About 39% of *Nephrops* landings in FU 31 comes from the statistical rectangle 16E7 (Basque Country), 36% from 16E4 (Asturias region), 18% from 16E6 (Cantabrian region) and 8% from 16E5 (logbooks 2003–2016).

For the years 2017, 2018, 2019, and 2020, *Nephrops* TAC was set at zero, landings were zero, but 814 and 552 kg of landings were obtained in the 2019 and 2020 FU 31 Sentinel fishery, respectively (special on-board observers' programme in commercial vessels to monitor the FU stock status), which was granted a special quota. More details were provided to this WG in 2020 (González Herraiz *et al.*, 2020).

Information on landings, discards and length distributions was uploaded to InterCatch. *Nephrops* discards were negligible in FU 31, nevertheless, since the *Nephrops* TAC is zero, estimated discards amounted to 31.4 kg, 3.4 t, 5.7 t and 9.9 t for years 2017, 2018, 2019 and 2020, respectively.

VMS information

VMS data from 2009–2018 from FU 31 trawl fleet (Figure 12.2.2a) were used to provide some information about the spatial distribution of *Nephrops* catches in the FU when TAC was higher than zero (2009–2016). Figure 12.2.2a also shows the catch spatial distribution under zero TAC (2017–2018). Logbook data were assigned to VMS pings by vessel, fishing day and statistical rectangle. About 28% of the VMS pings could not be identified in logbooks while only 9% of the 2009–2016 VMS pings revealed the presence of *Nephrops*. The occurrence *of Nephrops* in the Sentinel fishery area in 2019 and 2020 are represented in Figure 12.2.2.b.

The comparison of the *Nephrops* area estimated with the position of the hauls with *Nephrops* catches from the whole time-series (1983–2020) of SPGFS-WIBTS-Q4 (G2784) survey, discarding programme and Sentinel fisheries with the area estimated only with 2017–2020 data could suggest a contraction of the stock area since 1983 to 2020 by around 19% (Figure 12.2.5).

12.2.2.2 Biological sampling

The biological sampling programme from 1988 to 2016 and the Sentinel fishery in 2019 and 2020 provided length–frequency distributions (LFDs) by sex of *Nephrops* landings and discards, sex ratio, recruitment proxies and mean sizes. No LFDs was available for FU 31 in 2017 and 2018 because the *Nephrops* TAC was zero. The sampling levels in Division 8.c are shown in Table 1.4. SPGFS-WIBTS-Q4 (G2784) survey also provides FLDs by sex and, therefore, mean sizes and sex ratio since 1983. The number of *Nephrops* individuals from the SPGFS-WIBTS-Q4 (G2784) survey was insufficient in 2017 and 2018 to provide a reliable estimate of mean length.

Mean sizes series show increasing trends until 2009 (Figure 12.2.1), the year where the mean size for males was observed at 55.8 mm CL and 45.9 mm CL for females. Mean sizes decreased in the years 1991, 2002, 2011, and 2015. The decline of mean sizes could be related to recruitment. Mean size in 2016 was 52.1 mm CL for males and 45.8 mm CL for females. Mean sizes from Sentinel fishery were 45.4 and 49.2 mm CL for males and 41.4 and 44.1 for females, for the years 2019 and 2020, respectively.

Low quantities of males in a *Nephrops* stock could be related to a high fishing pressure since ovigerous females are protected in burrows during most of the year (Fariña Pérez, 1996). In worst cases, low quantities of males could affect mating (ICES, 2013), and consequently, recruitment in subsequent years. The minimum percentages of males in FU 31 in the SPGFS-WIBTS-Q4 (G2784) survey time-series were recorded in 1996 and 2010 (blue line in Figure 12.2.2c).

Recruitment proxies from the SPGFS-WIBTS-Q4 (G2784) survey and the fishery show a decreasing trend up to 2009 in the survey and up to 2016 in the fishery (Figure 12.2.2d).

12.2.2.3 Abundance index from survey

Figure 12.2.3 and Figures 12.2.4a through 12.24c show two periods in FU 31 *Nephrops* cpue (kg/haul) time-series and spatial distribution from SPGFS-WIBTS-Q4 (G2784) survey (1983–2020): the first period with high abundance was observed until 1993 and another with low abundance since 1994. A bottom-trawl survey is carried out every year in October to estimate hake recruitment and to collect information on the relative abundance of demersal species (see survey description in section 2.2.1 of this report as Spanish IBTS survey in 3rd quarter). The survey hauls positions are the same each year.

12.2.2.4 Commercial catch-effort data

The fishing effort and cpue dataseries include bottom-trawl fleets operating in the Cantabrian Sea selling in the harbours of Santander, Gijón and Avilés. In recent years, the information from the different fleets is intermittent. A combined effort series that includes Santander, Avilés and Gijón from 2009 onwards are presented in Figure 12.2.1. In order to standardize the effort units, the unit considered for this series is the trip. All the available effort time-series show decreasing trends from 1983–2016 (Figure 12.2.1). The increase in the use of other gears (HVO and pair trawl) resulted in the reduction of the baca trawl fleet effort. The combined Santander-Gijón-Avilés effort values decreased since 2014 (Figure 12.2.1). The effort in 2020 was 659 trips.

The Santander LPUE series shows fluctuations and a general downward trend (Figure 12.2.1) until 2013 (2.3 kg/fishing days). The combined Santander-Gijón-Avilés LPUE series also shows a decreasing trend. The cpue in 2016 was 4.3 kg/trip. For the years 2017, 2018, 2019, and 2020 *Nephrops* TAC was zero in 8.c (FU 25 and FU 31).

In Portugal, cpue of species with an affinity for temperate waters (in opposition to tropical waters) decreased from 1992 to 2009, especially in long-lived species as *Nephrops* (Teixeira *et al.*, 2014). Cpue time-series of "temperate" species are directly correlated with rain and inversely with temperature (Teixeira *et al.*, 2014). Similar processes could have affected the FU 31 *Nephrops* from 1988 to 2010.

The FU 31 fishing sector requested a Sentinel fishery in that area in order to obtain a *Nephrops* abundance index. ICES delivered a Special Request Advice (ICES, 2019b) establishing the technical requirements and the Sentinel fishery was carried out in July 2019 (González Herraiz *et al.*, 2020). However, in 2020 the Sentinel fishery was delayed to August due to administrative reasons. The *Nephrops* cpue obtained in this fishery was 22.6 kg * 1000/kWhour in 2019 and 15.6 kg * 1000/kWhour in 2020 (the 2020 cpue was multiplied by a factor of 1.37 in order to compare with the value estimated for the July 2019 cpue). The *Nephrops* retained catch was 735 kg in 2019 and 552 kg in 2020. *Nephrops* discards were negligible (79 kg in 2019 and 11 kg in 2020). Sentinel fishery data were included in the Spanish data uploaded to InterCatch.

12.2.3 Assessment

According to the ICES data-limited approach (ICES, 2015), this stock was considered as category 3.1.4—a stock with extremely low biomass and zero catch advice (ICES, 2019a). The assessment of FU 31 is triennial After the WKMSYSPiCT benchmark (ICES, 2021b), FU 31 was upgraded from a category 3 to 2 stock (ICES, 2021a).

The SPiCT model (Pedersen and Berg, 2017) was considered suitable for the assessment of the FU 31 *Nephrops* stocks since, unlike other data-limited stocks (DLSs) methods, this method takes into account the history of the fishery and does not use a long list of life-history parameters that usually come with high uncertainty.

12.2.3.1 SPiCT model

The SPiCT model was accepted in the WKMSYSPiCT (ICES, 2021b) with data until 2019. The same model was updated by adding the 2020 data and was used in this WG (ICES, 2021c).

Input data:

- Catches (1983–2020) (Table 12.2.1)
- SPGFS-WIBTS-Q4 (G2784) survey index (1983–2020) (Table 12.2.2, Figure 12.2.3)

SPiCT settings:

- Euler time-step (years): 1/12
- Medium level of exploitation before the beginning of the time-series
- Fixed shape parameter *n* to 2
- Intrinsic growth parameter *r* mean 0.2 and coefficient of variation 0.2
- Priors on the CV of the catches and the F process noise
- High uncertainty for the 1983–1994 catches

12.2.3.2 Assessment diagnostics

The SPiCT diagnostics and retrospective plots did not show major problems during the assessment (Figures 12.2.6 and 12.2.7).

12.2.3.3 Assessment results

SPiCT results are presented in Tables 12.2.3 and 12.2.4 and Figure 12.2.8. The stock biomass (B) decreased from 1983 to 2000 and has been stable since then. Since 1990, biomass has been below the B_{MSY}. Fishing mortality (F) has been above F_{MSY} until 2008.

The biomass at the end of 2020 was 44% of the B_{MSY} and F was 44% of the F_{MSY} (Table 12.2.4).

12.2.3.4 Short-term projections

SPiCT-predicted catch and stock status for 2022 are shown in Table 12.2.5.

12.2.3.5 Biological reference points

No reference points are defined for this stock in terms of absolute values. The SPiCT-estimated values of the ratios F/F_{MSY} and B/B_{MSY} are used to estimate stock status relative to the MSY reference points. The table on the next page presents these relative reference points that were used in the assessment.

Framework	Reference point	Relative value *	Technical basis	Source
MSY approach	MSY $B_{trigger}$	0.5	Relative value. B_{MSY} proxy is estimated directly from the assessment model and changes when the assessment is updated.	ICES (2021b)
	F_{MSY}	1	Relative value. The F_{MSY} proxy is estimated directly from the assessment model and changes when the assessment is updated.	ICES (2021b)
Precautionary approach	$B_{lim\ proxy}$	0.3 × B_{MSY}	Relative value (equilibrium yield at this biomass is 50% of the MSY proxy).	ICES (2021b)
	B_{pa}	Not defined		
	F_{lim}	1.7 × F_{MSY}	Relative value (the F that drives the stock to the proxy of B_{lim}).	ICES (2021b)
	F_{pa}	Not defined		

12.2.4 Stakeholders information

In April 2020, WGBIE received a letter from stakeholders (two Spanish fishing producers' organizations, OPP no. 31 and 07) regarding *Nephrops* in ICES Division 8.c. The document analysed market and sales notes data and the fisheries management measures of the recent years in relation with Division 8.c *Nephrops*. This document was discussed in a subgroup meeting during the WGBIE in 2020. The data sources and the issues mentioned in the document, together with additional data and any other relevant information relative to the 8.c *Nephrops* stocks, are taken into account each year to make an integral analysis of the stock status and elaborate a scientifically sound assessment.

No further information was presented to WGBIE in 2021.

12.2.5 Management considerations

Nephrops is taken as bycatch in the mixed bottom-trawl fishery. In FU 31, the bulk of the Spanish *Nephrops* landings are from the bottom-trawlers, 7% from crustacean pots (FPO_CRU) and 1% from other pots or traps (FPO_FIF) (logbooks 2008–2016).

The overall trend in *Nephrops* landings from the Cantabrian Sea (FU 31) is strongly declining. Landings have dramatically decreased since the beginning of the series (1983–2016), representing in 2016 less than 2% of the 1989 maximum value observed. The TAC for *Nephrops* was zero for the years 2017, 2018, 2019 and 2020.

A Fishing Plan for the Northwest Cantabrian ground was established in 2011 (ARM/3158/2011, BOE, 2011). This new regulation established an Individual Transferable Quota system (ITQs) and includes the *Nephrops*.

A *Nephrops* Sentinel Fishery in FU 31 supervised by the IEO was carried out in 2019 and 2020 to obtain a *Nephrops* abundance index (González Herraiz *et al.*, 2020). This fishery followed the technical requirements established by a specific ICES Special Request Advice (ICES, 2019b).

Spain requested a Sentinel fishery for *Nephrops* in FU 31 for 2019, similar to those carried out in FU 25 in 2017 and 2018. An ICES Special Request Advice on a Sentinel fishery for *Nephrops* in FU 31 for 2019 was released in March 2019. ICES advised that, if a UWTV survey cannot be conducted, the collection of sentinel fishery cpue data would require no more than 0.7 t (ICES, 2019b). FU 31 Sentinel fishery had been conducted in 2019 and 2020.

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12.2.7 Tables and figures

Table 12.2.1. *Nephrops* in FU 31, southern Bay of Biscay and Cantabrian Sea. Landings and discards in tonnes.

Year	Landings		Discards	Catch
	Trawl	Other gears		
1983	63			63
1984	100			100
1985	128			128
1986	127			127
1987	118			118
1988	151			151
1989	177			177
1990	174			174
1991	105	4		109
1992	92	2		94
1993	95	6		101
1994	146	2		148
1995	90	4		94
1996	120	9		129
1997	97	1		98
1998	69	3		72
1999	46	2		48
2000	33	1		34
2001	26	1		27
2002	25	1		26
2003	34	1		35
2004	29	0		29
2005	48	0		48
2006	37	0		37
2007	32	0		32
2008	19	1		20
2009	9	1		10
2010	8	0		9
2011	7	0		7
2012	10	0		10
2013	10	0		10
2014	4	0		4
2015	3	0		3
2016	3	0		3
2017	0	0		0
2018	0	0	3	3
2019	1*	0	6	6
2020	1*	0	10	10

* Nephrops TAC was zero in 8c (FU 25 & FU 31) in 2017, 2018, 2019 and 2020, but in 2019 and 2020 there was *Nephrops* Sentinel fishery in FU 31.

Table 12.2.2. *Nephrops* in FU 31, southern Bay of Biscay and Cantabrian Sea. Yield from the SP-NSGFS Spanish IBTS 4Q trawl survey (G2784) for the period 1983–2020.

Year	Nephrops yield (gram/haul)
1983	97
1984	247
1985	319
1986	371
1987	No survey
1988	729
1989	105
1990	217
1991	178
1992	311
1993	245
1994	99
1995	124
1996	43
1997	104
1998	70
1999	82
2000	84
2001	107
2002	81
2003	108
2004	130
2005	86
2006	60
2007	79
2008	47
2009	39
2010	22
2011	65
2012	74
2013	103
2014	118
2015	176
2016	59
2017	50
2018	79
2019	55
2020	77

Table 12.2.3. ***Nephrops*** **in FU 31, southern Bay of Biscay and Cantabrian Sea. SPiCT summary results.**

Parameter estimates

Parameter	estimate	cilow	ciupp	log.est
alpha	1.4050	0.5651	3.4932	0.3400
beta	0.1861	0.1139	0.3041	-1.6813
r	0.1825	0.1250	0.2665	-1.7011
rc	0.1825	0.1250	0.2665	-1.7011
rold	0.1825	0.1250	0.2665	-1.7011
m	76.6562	38.3967	153.0382	4.3393
K	1680.2627	801.0101	3524.6528	7.4267
q	0.0018	0.0006	0.0050	-6.3301
sdb	0.2296	0.1218	0.4328	-1.4715
sdf	0.5113	0.3767	0.6941	-0.6707
sdi	0.3226	0.2181	0.4771	-1.1314
sdc	0.0952	0.0657	0.1379	-2.3521

Stochastic reference points

Reference points	estimate	cilow	ciupp	log.est	rel.diff.Drp
Bmsys	706.9167	329.8336	1515.1011	6.5609	-0.1884
Fmsys	0.0781	0.0520	0.1173	-2.5498	-0.1684
MSYs	53.4554	23.9666	119.2278	3.9788	-0.4340

$B_{trigger}$ 353 t B_{lim} 212 t

Estimated states

	estimate	cilow	ciupp	log.est
B_2020.92	311.2351	108.4439	893.2477	5.7405
F_2020.92	0.0345	0.0106	0.1120	-3.3672
B_2020.92/Bmsy	0.4403	0.1442	1.3444	-0.8204
F_2020.92/Fmsy	0.4416	0.1370	1.4237	-0.8174

Table 12.2.4. ***Nephrops*** **in FU 31, southern Bay of Biscay and Cantabrian Sea. SPiCT estimates for B/B_{MSY} and F/F_{MSY}.**

	B/Bmsy ll	est	ul	F/Fmsy ll	est	ul
1983	0.7705	1.2063	1.8887	0.3535	0.8711	2.1466
1984	0.6892	1.2822	2.3857	0.501	1.1237	2.5203
1985	0.64	1.3576	2.8796	0.6751	1.5668	3.6366
1986	0.5879	1.4428	3.5409	0.6686	1.6403	4.0241
1987	0.5444	1.4754	3.9982	0.5599	1.4533	3.7724
1988	0.5211	1.5328	4.5084	0.579	1.5684	4.2483
1989	0.4844	1.5369	4.8759	0.6818	1.9516	5.5863
1990	0.4253	1.4563	4.9871	0.7905	2.3601	7.0459
1991	0.3586	1.1739	3.8429	0.6816	2.0359	6.0815
1992	0.3277	1.0669	3.474	0.562	1.6499	4.8442
1993	0.3145	1.0136	3.2664	0.5664	1.6444	4.7737
1994	0.3018	1.0099	3.3798	0.822	2.3914	6.9573
1995	0.2518	0.8241	2.6969	0.8664	2.5029	7.2306
1996	0.2284	0.6922	2.0982	1.0396	2.8514	7.8208
1997	0.1847	0.5662	1.7357	1.3896	3.8466	10.648
1998	0.1493	0.4471	1.3385	1.129	3.1926	9.0283
1999	0.1351	0.4528	1.5177	0.7774	2.3543	7.1292
2000	0.1294	0.4331	1.4496	0.5201	1.6155	5.0178
2001	0.1324	0.4501	1.5301	0.3812	1.1895	3.7115
2002	0.1402	0.475	1.6095	0.3038	0.9512	2.9785
2003	0.1511	0.5278	1.8442	0.3494	1.096	3.4384
2004	0.1525	0.5217	1.7844	0.3327	1.0481	3.3018
2005	0.1563	0.565	2.0426	0.3786	1.2251	3.9646
2006	0.1438	0.5497	2.1017	0.4313	1.4585	4.9319
2007	0.1262	0.4631	1.6986	0.4073	1.3533	4.4968
2008	0.1091	0.3914	1.4037	0.3598	1.1912	3.9436
2009	0.0953	0.3323	1.1587	0.2206	0.7089	2.2785
2010	0.0884	0.2826	0.9035	0.1937	0.5938	1.8204
2011	0.0848	0.2554	0.7693	0.1827	0.5405	1.5987
2012	0.0905	0.2667	0.7859	0.1809	0.5331	1.571
2013	0.1089	0.3706	1.262	0.1826	0.566	1.7544
2014	0.1187	0.4204	1.4888	0.0762	0.2466	0.7982
2015	0.1293	0.4885	1.8455	0.0377	0.1269	0.4266
2016	0.1345	0.5175	1.9904	0.0208	0.0723	0.2514
2017	0.1331	0.4887	1.7942	0.0161	0.0531	0.175
2018	0.1314	0.4129	1.2979	0.0286	0.0882	0.2722
2019	0.1342	0.4083	1.2419	0.0644	0.1908	0.5647
2020	0.1415	0.4403	1.3702	0.1139	0.3411	1.0218
2021	0.1443	0.4435	1.3633	0.1322	0.4416	1.4747
2022	0.1461	0.4834	1.5995	0.0921	0.4416	2.1182
2023	0.149	0.5253	1.8521	0.0687	0.4416	2.8391

Table 12.2.5. *Nephrops* in FU 31, southern Bay of Biscay and Cantabrian Sea. *Nephrops* SPiCT predicted catch and states for 2022.

	C	B/Bmsy	F/Fmsy	B/Bmsy.lo	B/Bmsy.hi	F/Fmsy.lo	F/Fmsy.hi
1. F=0	0.0	0.54	0.00	0.16	1.87	0.00	0.00
2. F=Fsq	12.2	0.53	0.44	0.15	1.85	0.07	2.84
3. F=Fmsy	26.3	0.50	0.97	0.14	1.84	0.15	6.22
4. F=Fmsy_C_fractile	20.2	0.51	0.74	0.14	1.84	0.11	4.73

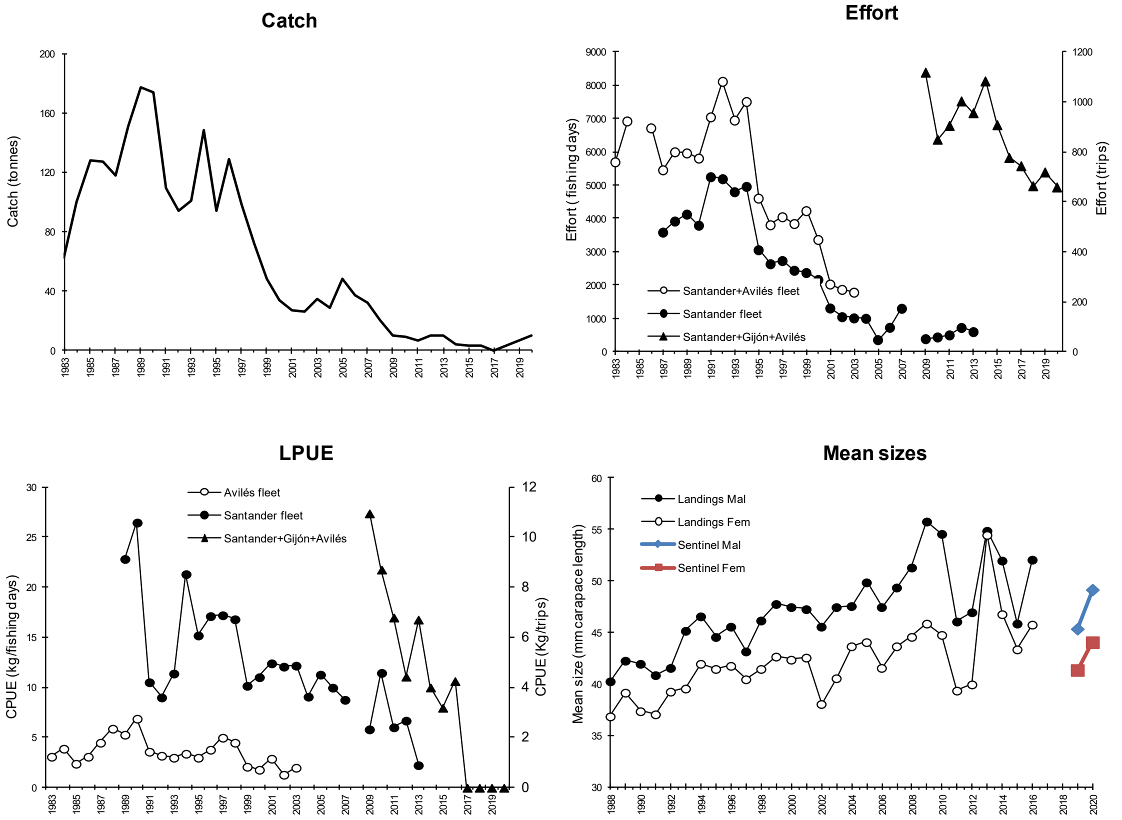

Figure 12.2.1. ***Nephrops*** **in FU 31, southern Bay of Biscay and Cantabrian Sea. Long-term trends in catch, effort, LPUE and mean sizes. Catch and mean sizes of** ***Nephrops*** **from the whole FU 31. Effort and LPUE for the "bacas" (métier OTB_DEF≥55) selling in the ports of Santander, Gijón and Avilés.** ***Nephrops*** **in 8.c (FUs 25 and 31) had TAC zero in 2017, 2018, 2019, and 2020.**

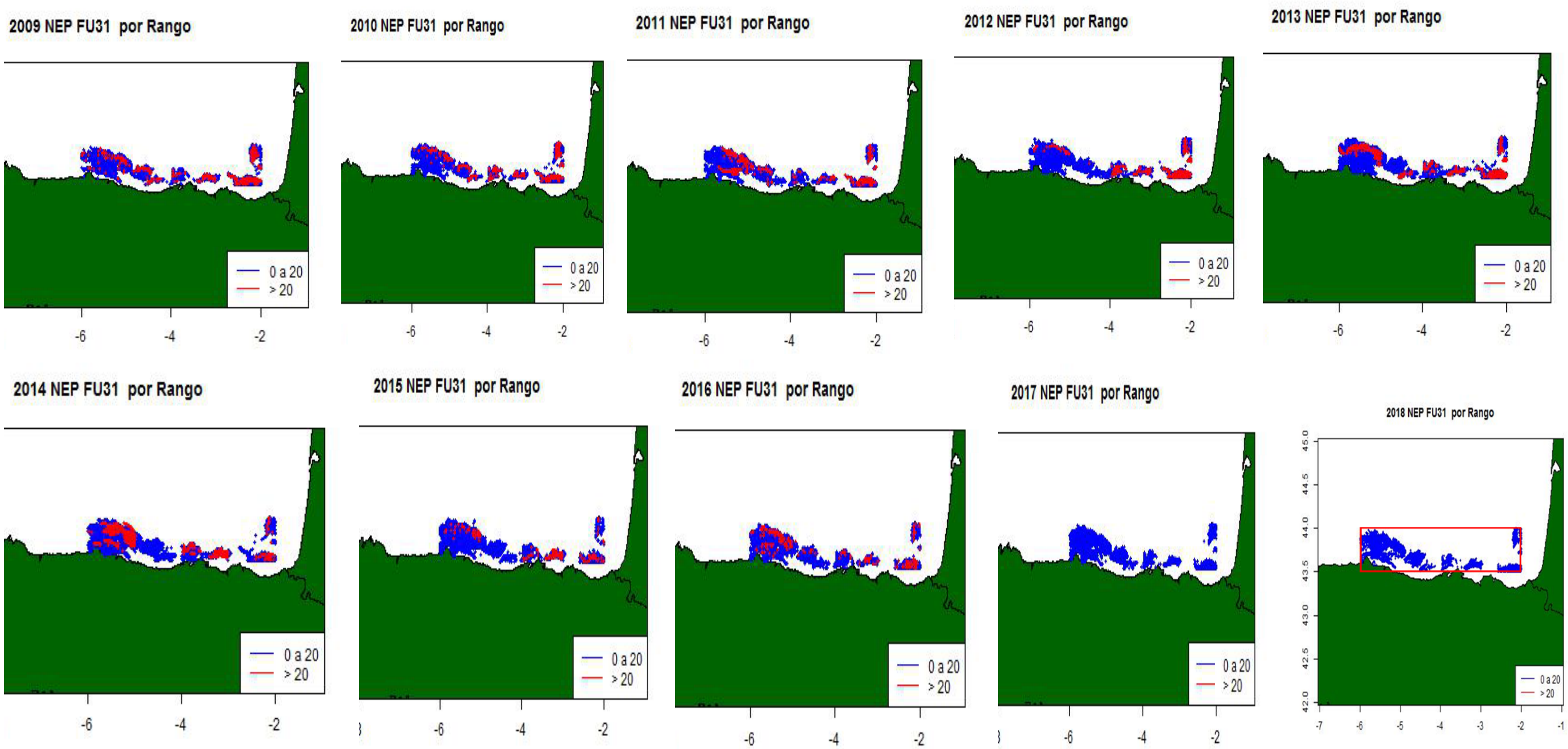

Figure 12.2.2a. *Nephrops* in FU 31, southern Bay of Biscay and Cantabrian Sea. Distribution of FU 31 *Nephrops* LPUE (kg/fishing day). FU 31 limits indicated in red in the 2018 map. Red points: *Nephrops* LPUE > 20 kg/fd, blue: *Nephrops* LPUE ≤20 kg/fd. *Nephrops* TAC in 8.c (FUs 25 and 31) was zero for the years 2017, 2018 and 2019.

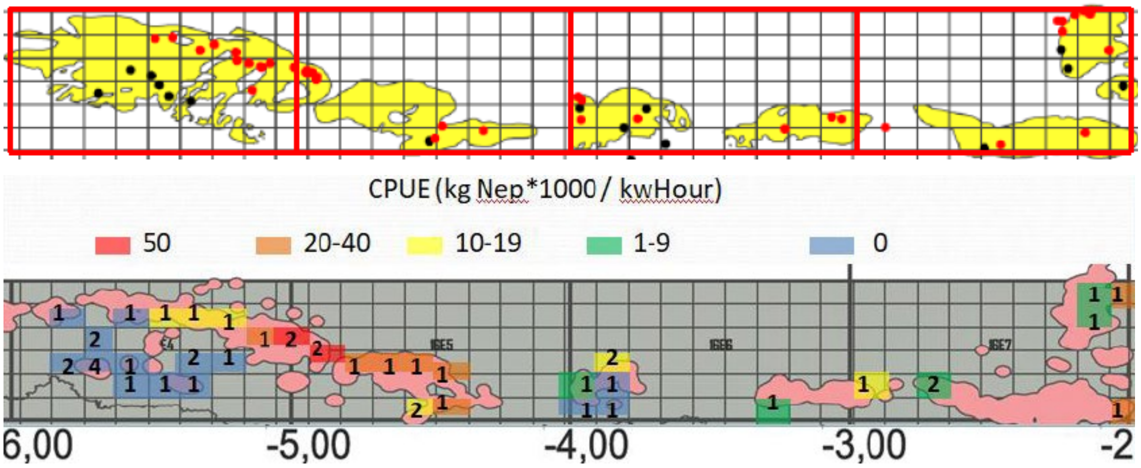

Figure 12.2.2b. *Nephrops* in FU 31, southern Bay of Biscay and Cantabrian Sea. Sentinel Fishery. Top: 2019 Sentinel effort distribution (hauls VMS points). Red points: hauls with *Nephrops* catch. Black points: hauls without *Nephrops* catch. Yellow patches estimated with daily data (logbooks). Bottom: 2020 Sentinel cpue (*Nephrops* kg*1000/kwHour) represented by colours and effort in number of hauls conducted in each sampling cell). Pink patches mapped with haul data (survey and observers on board).

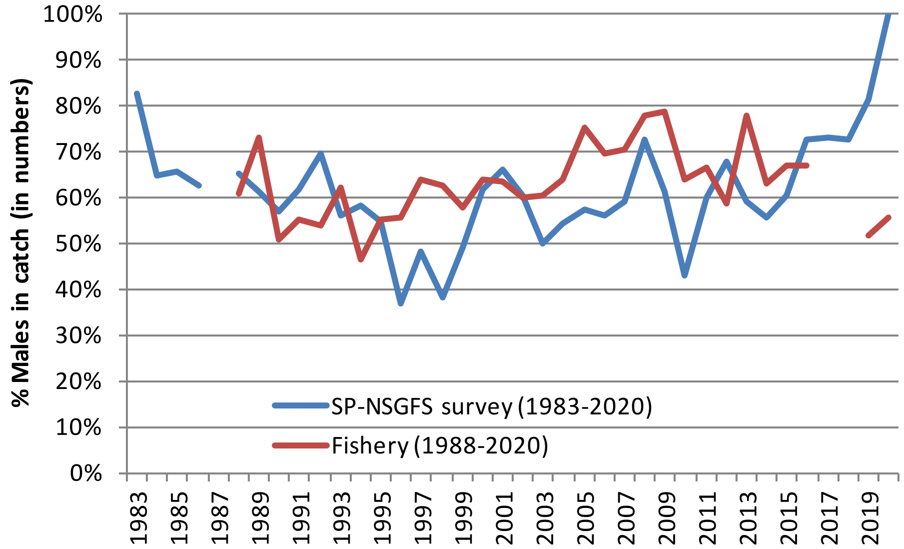

Figure 12.2.2c.*Nephrops* in FU 31, southern Bay of Biscay and Cantabrian Sea. Catches proportion of males (1983–2020) from the SPGFS-WIBTS-Q4 (G2784) survey.

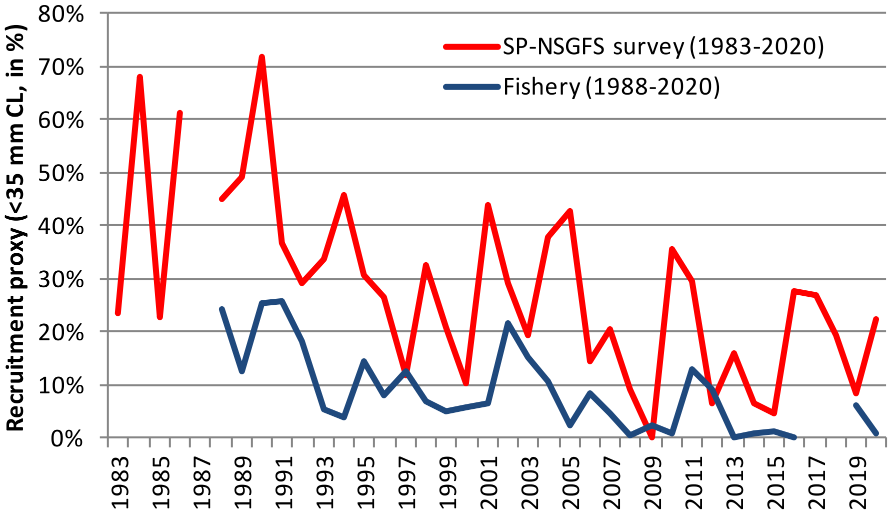

Figure 12.2.2d. *Nephrops* in FU 31, southern Bay of Biscay and Cantabrian Sea. Recruitment proxy. Blue line = Commercial fleet (1988–2016) and Sentinel fleet (2019–2020). Red line = SP-NSGFS or SPGFS-WIBTS-Q4 (G2784) survey (1983–2020).

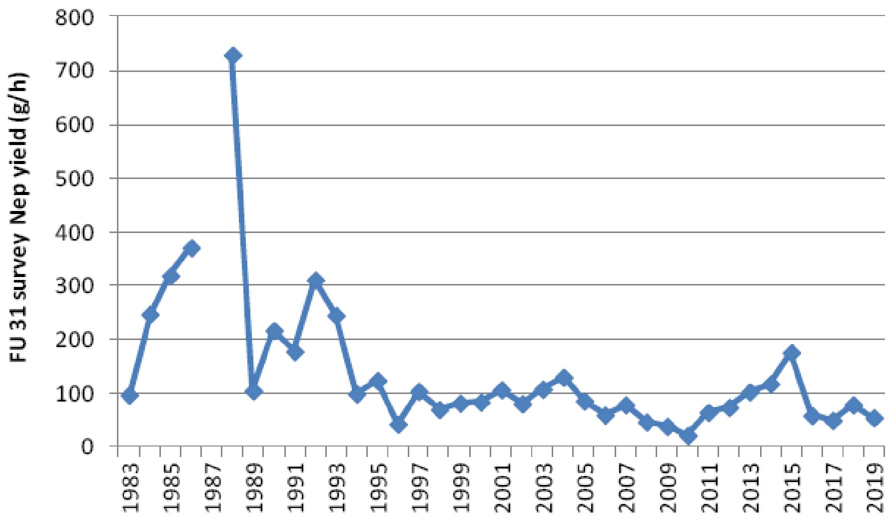

Figure 12.2.3. *Nephrops* in FU 31, southern Bay of Biscay and Cantabrian Sea. *Nephrops* cpue (gramme/haul) from SPGFS-WIBTS-Q4 (G2784) survey (1983–2020). No survey was carried out in 1987.

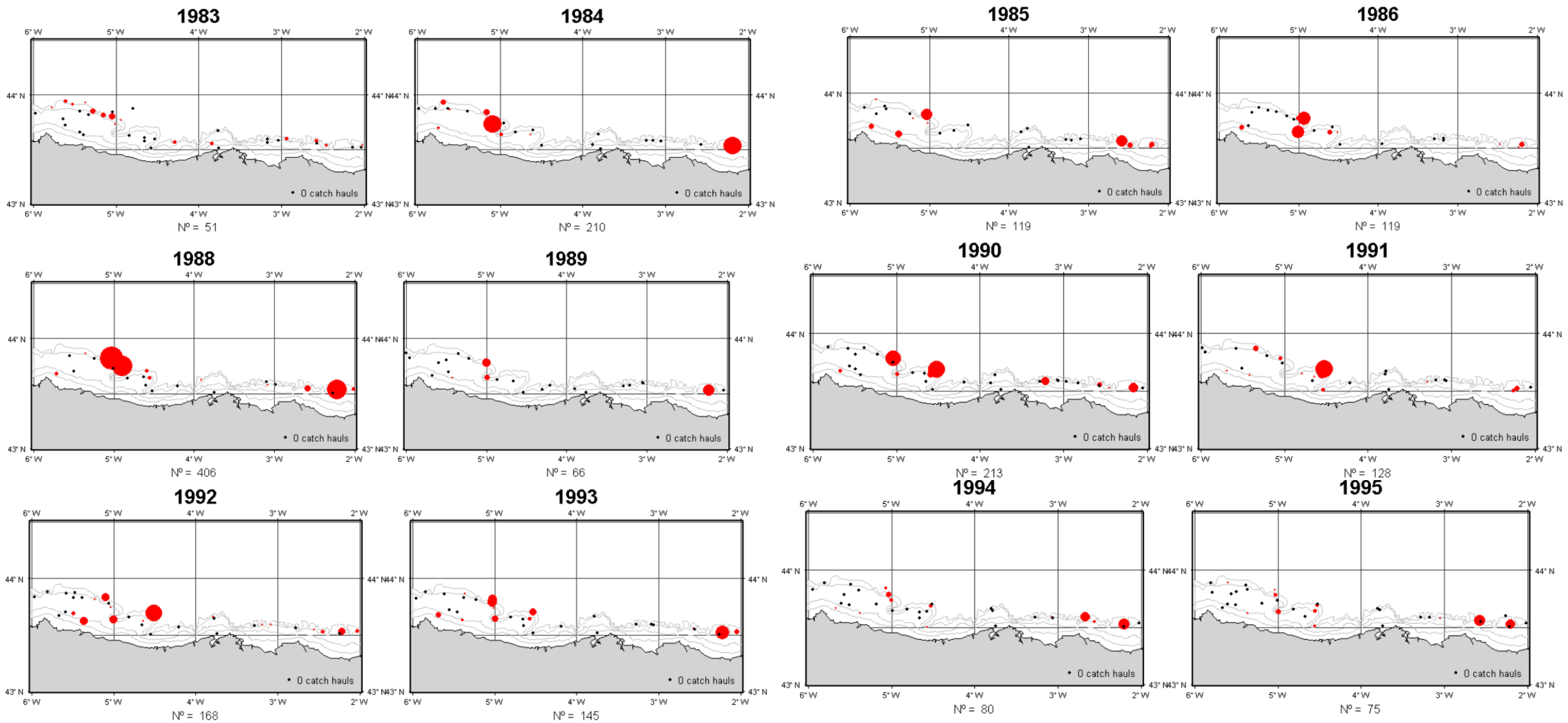

Figure 12.2.4a. *Nephrops* in FU 31, southern Bay of Biscay and Cantabrian Sea. Cpue (kg/haul) from SPGFS-WIBTS-Q4 (G2784) survey. Black points: zero kg of *Nephrops* by haul. No survey was carried out in 1987. Higher cpues period (1983–1995).

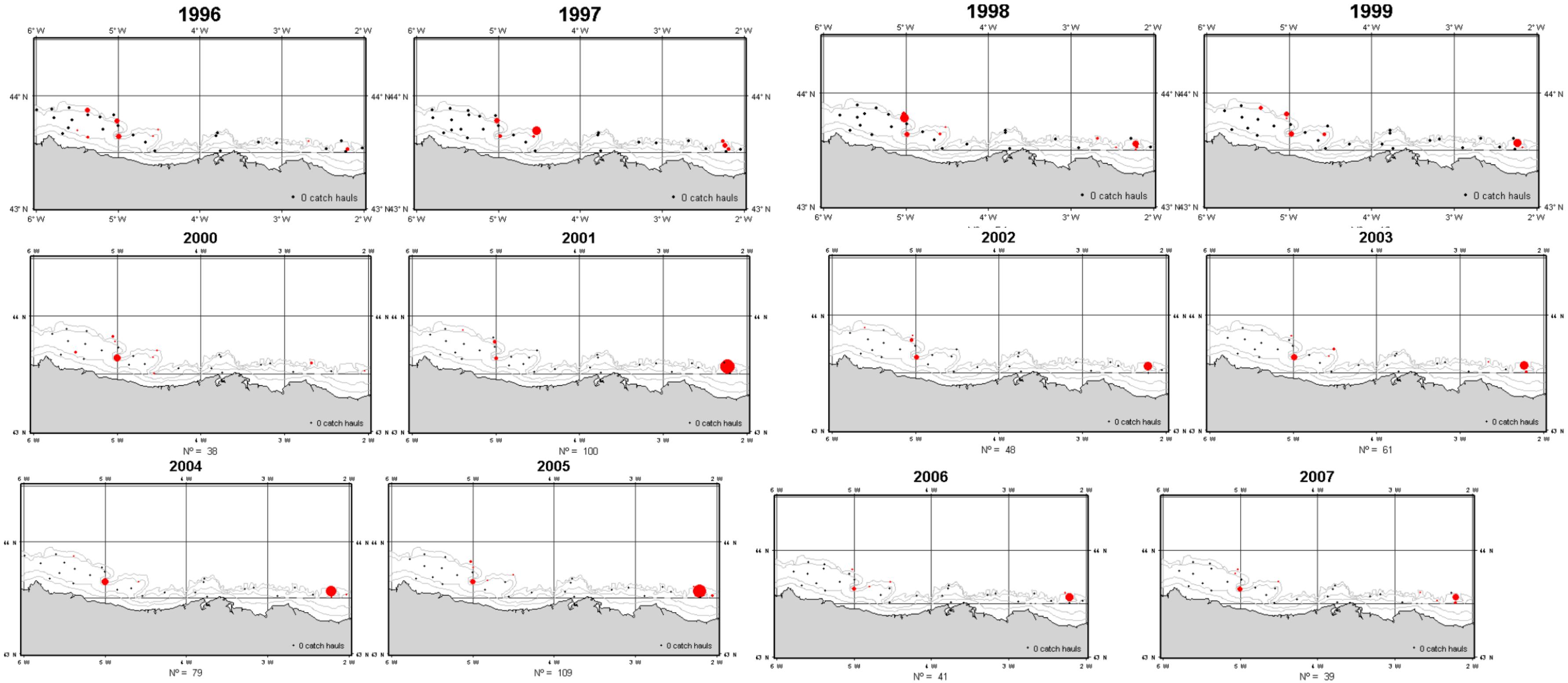

Figure 12.2.4b. *Nephrops* in FU 31, southern Bay of Biscay and Cantabrian Sea. Cpue (kg/haul) from SPGFS-WIBTS-Q4 (G2784) survey. Black points: zero kg of *Nephrops* by haul. Lower cpues, eastern patch prevalence.

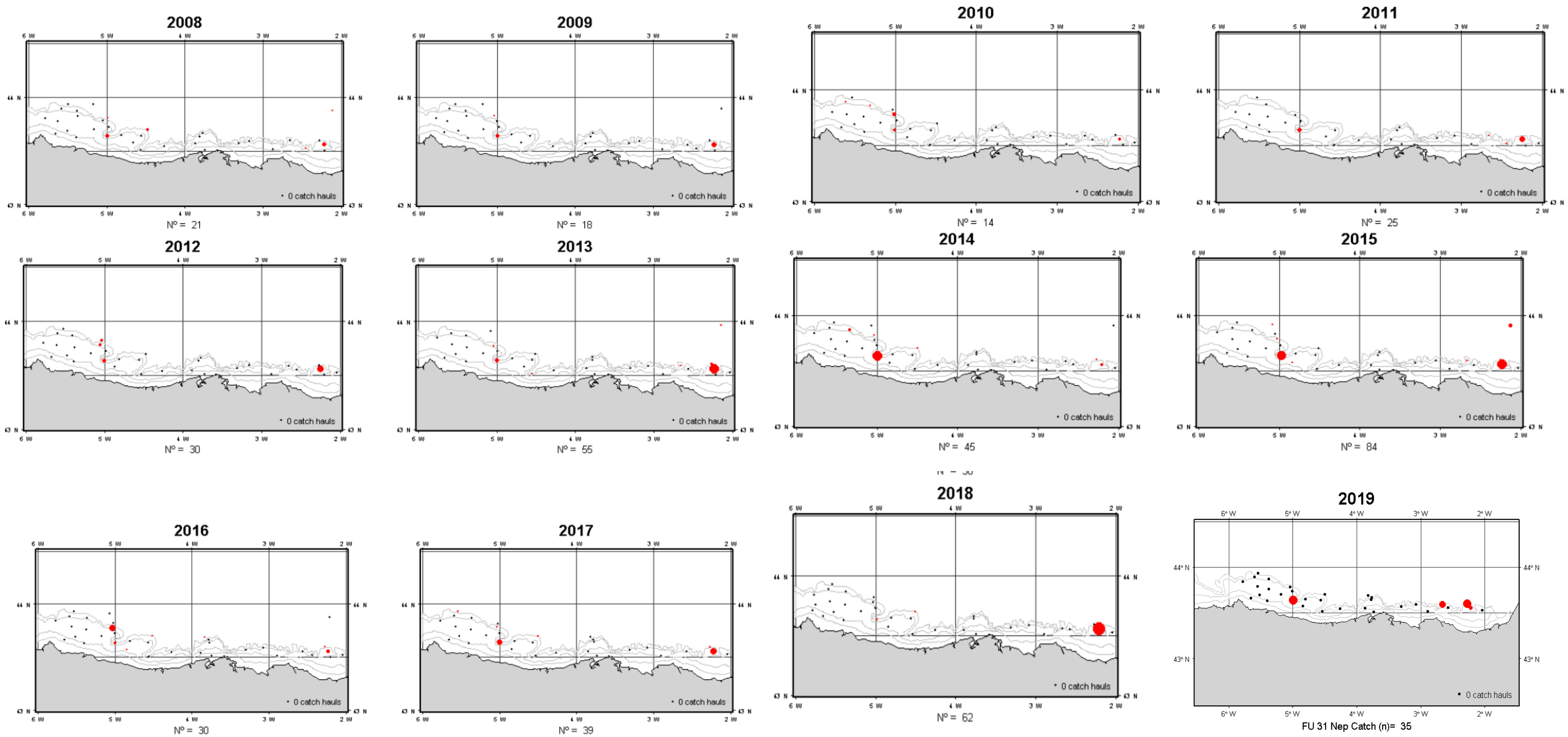

Figure 12.2.4c. ***Nephrops*** **in FU 31, southern Bay of Biscay and Cantabrian Sea. Cpue (kg/haul) from SPGFS-WIBTS-Q4 (G2784) survey. Black points: zero kg of** ***Nephrops*** **by haul. Lower cpues.**

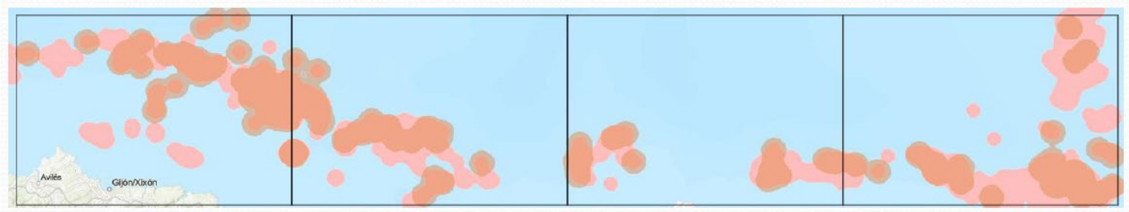

Figure 12.2.5. ***Nephrops*** **in FU 31, southern Bay of Biscay and Cantabrian Sea.** ***Nephrops*** **area. Pink area (3783 km2) calculated with the positions of the hauls with** ***Nephrops*** **catches from SPGFS-WIBTS-Q4 (G2784) survey (1983–2020), discarding programme (1994–2020) and Sentinel Fishery (2019–2020). Brown area (3077 km²) was calculated from the same data sources but only with 2017–2020 data.**

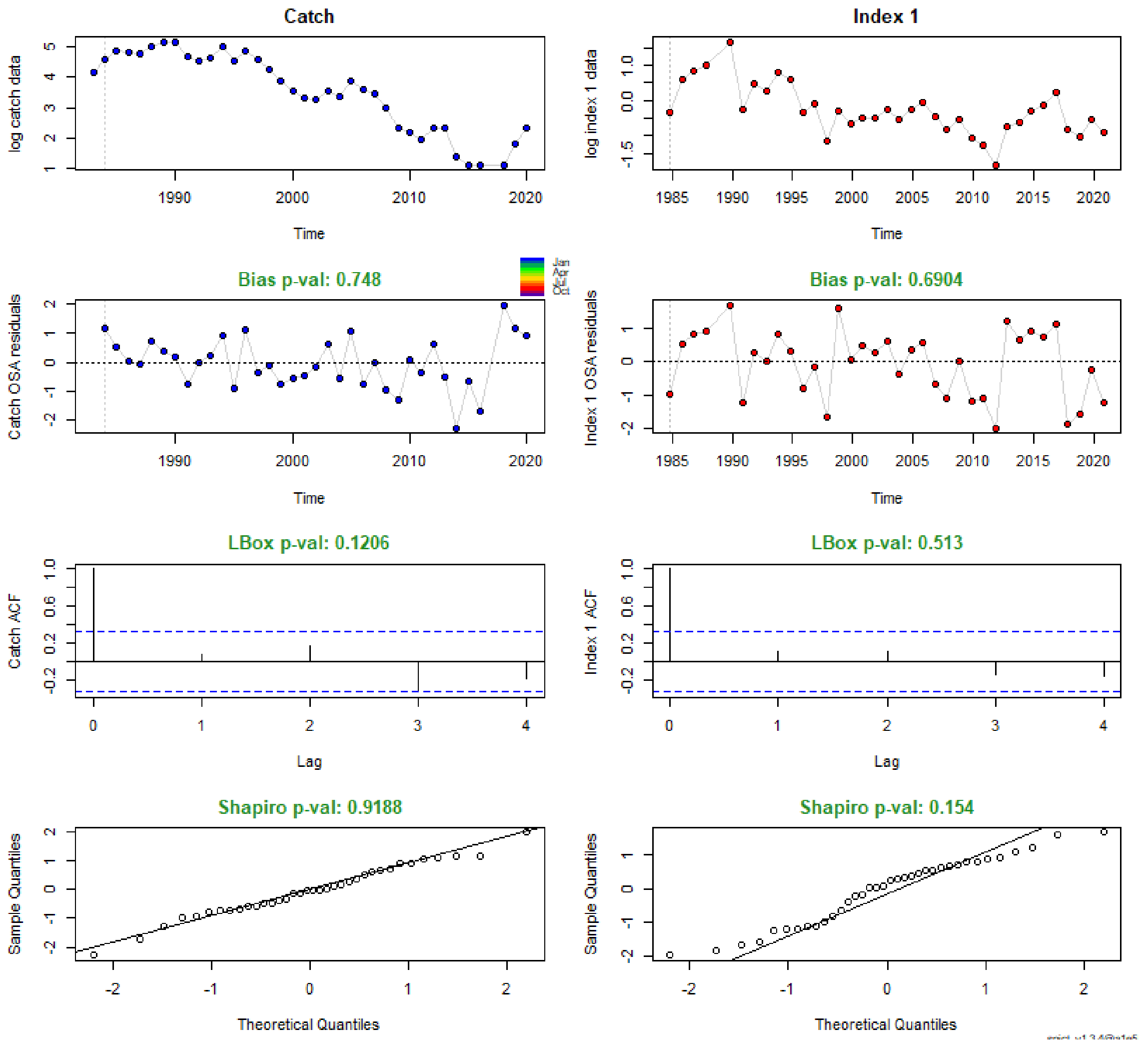

Figure 12.1.6. ***Nephrops*** **in FU 31, southern Bay of Biscay and Cantabrian Sea. SPiCT diagnostics.**

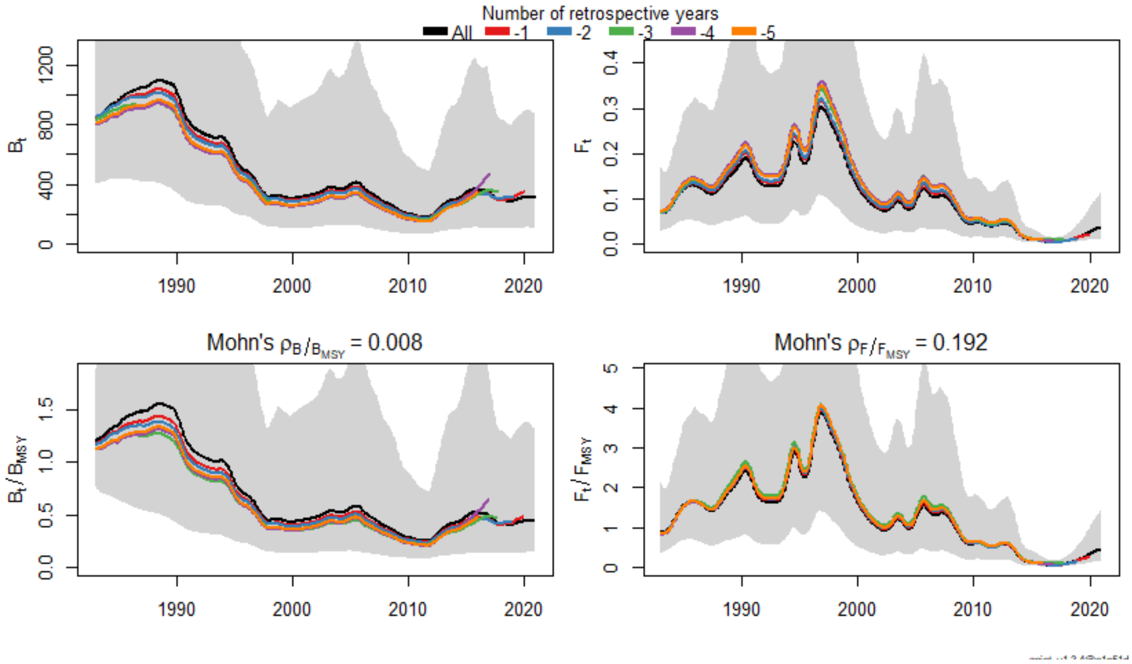

Figure 12.1.7. ***Nephrops*** **in FU 31, southern Bay of Biscay and Cantabrian Sea. Retrospective patterns.**

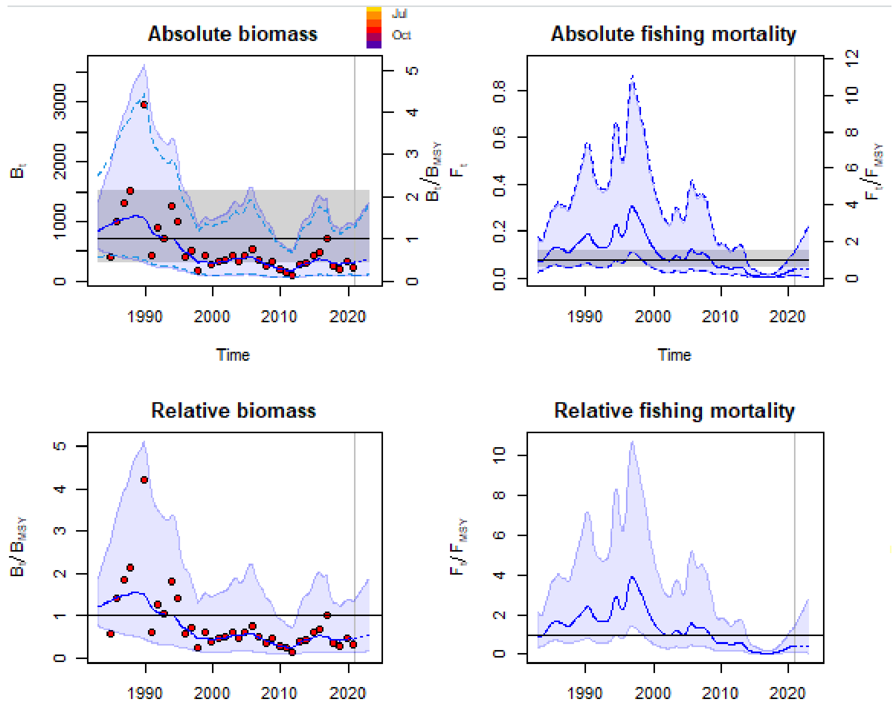

Figure 12.1.8.***Nephrops*** **in FU 31, southern Bay of Biscay and Cantabrian Sea. Absolute and relative biomass and fishing mortality.**

12.3 Summary for Division 8.c

Atlantic *Nephrops* landings from the Iberian Peninsula (ICES divisions 8.c and 9.a) have been decreasing at about 93% from 1978 to 2014 (Figure 12.3.1). Separate 8.c and 9.a landings have different magnitude but offer similar evolution information except for the period of 2002–2007, 2016, and 2017 (Figure 12.3.2).

Division 8.c includes FU 25 (North Galicia) and FU 31 (southern Bay of Biscay and Cantabrian Sea) and is shown in Figure 1.2. FU 25 provides about 63% of the Spanish *Nephrops* landings, FU 31 the 25% and 12% for the other rectangles in 8.c (logbooks 2003–2016) (Table 12.3.1 and Figure 12.1).

The significantly low levels of landings from FU 25, FU 31 and rectangles outside these FUs coupled with the decreasing LPUE trends indicate that both stocks are in very poor condition. TAC in Division 8.c was zero catch for the years of 2017, 2018, 2019 and 2020. However, special quotas were authorized for FU 25 since 2017 and FU 31 since 2019 in order for the Sentinel fishery to collect some data for the estimation of a commercial abundance index.

Low quantities of males in a *Nephrops* stock could be related to a high fishing pressure since ovigerous females are protected in burrows for most of the year (Fariña Pérez, 1996). In worst cases, low quantities of males could affect mating (ICES, 2013) and consequently recruitment in subsequent years. The percentage of males in the Spanish "Demersales" trawl survey (SPGFS-WIBTS-Q4 (G2784)) in Division 8.c from 1983 to 2018 fluctuates around 55%, with the lowest values observed in 1998 and 2004 (Figure 12.3.3).

Decreases in mean length could be related to recruitment. In Division 8.c, *Nephrops* mean length from SPGFS-WIBTS-Q4 (G2784) showed an increasing trend from 1983 to 2008 (Figure 12.3.4). Atlantic Iberian Northern *Nephrops* stocks mean length showed an increasing trend until 2009–2011 (Figures 12.1.1 and 12.2.1). Both the landings and cpue decreased in the fisheries. The decreasing F together with an increase in mean size could be related to global processes (e.g. Teixeira *et al*., 2014) occurring in this division. The resilience of the different stocks to these processes could be related to their different population and/or fishery characteristics (fishing pressure, stock density and size, etc.) and local/punctual events (*Nephrops* larvae mortality, etc.).

12.3.1 References

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12.3.2 Table and figures

Table 12.3.1. *Nephrops* in Division 8.c. Landings and discards (tonnes). *Nephrops* TAC in 8.c was zero for the years 2017, 2018, 2019, and 2020.

Year	FU25		FU 31		8c Outside FUs		Total 8c
	Landings	Discards	Landings	Discards	Landings	Discards	
1975	731						731
1976	559						559
1977	667						667
1978	690						690
1979	475						475
1980	412						412
1981	318						318
1982	431						431
1983	433		63				496
1984	515		100				615
1985	477		128				605
1986	364		127				491
1987	412		118				530
1988	445		151				596
1989	376		177				553
1990	285		174				459
1991	453		109				562
1992	428		94				522
1993	274		101				375
1994	245		148				393
1995	273		94				367
1996	209		129				338
1997	219		98				317
1998	103		72				175
1999	124		48				172
2000	81		34				115
2001	147		27				174
2002	143		26				169
2003	89		35		30		154
2004	75		29		10		114
2005	63		48		12		123
2006	62		37		11		110
2007	67		32		13		112
2008	39		20		10		69
2009	21		10		5		36
2010	34		9		5		47
2011	44		7		3		54
2012	10		10		5		25
2013	11		10		4		25
2014	9		4		2		15
2015	14		3		2		19
2016	13		3		4		20
2017*	2*		0		0		2
2018*	2*	0	0	3	0	4	10
2019*	2*	1	1*	6	0	3	12
2020*	2*	1	1*	10	0	0	13

* *Nephrops* TAC was zero in 8c (FU 25 & FU 31) in 2017, 2018, 2019 and 2020, but there *were Nephrops* Sentinel Fisheries in FU 25 and FU 31.

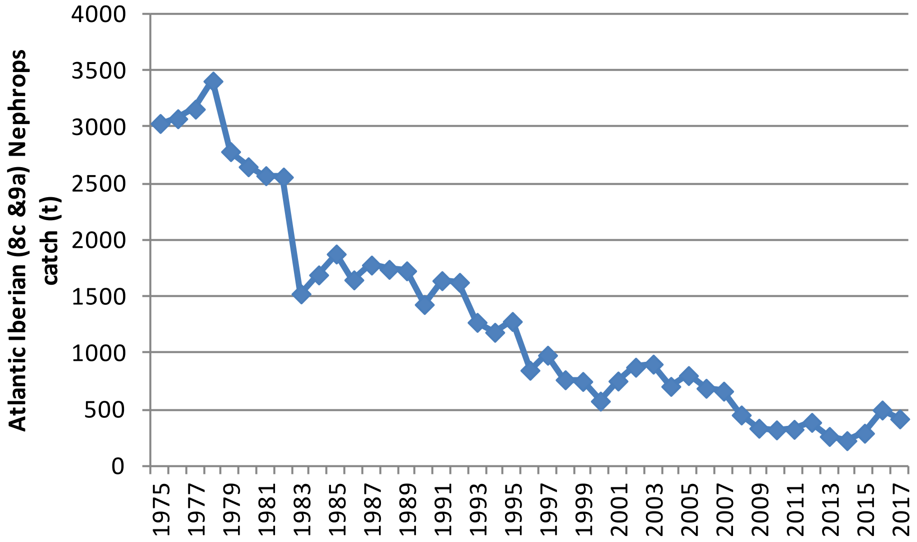

Figure 12.3.1. Atlantic Iberian (8.c+9.a) *Nephrops* landings (t) for the period 1975–2017.

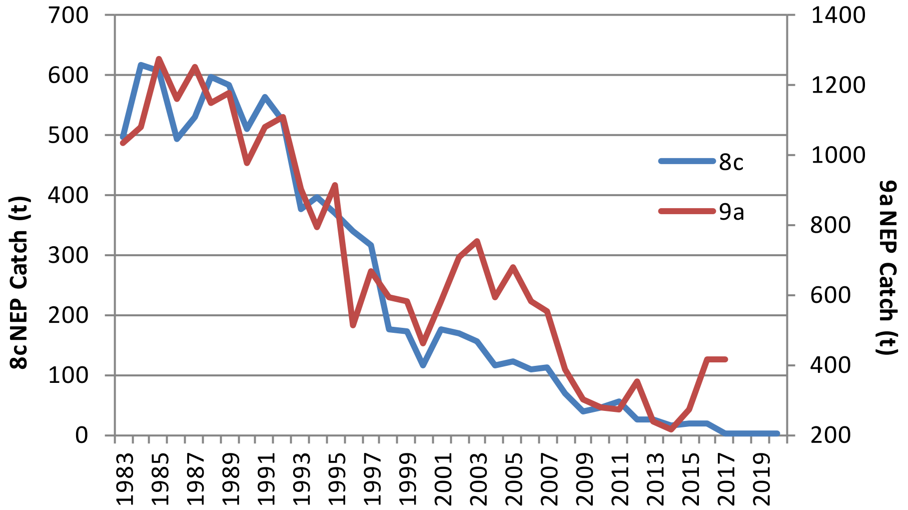

Figure 12.3.2. 8.c and 9.a *Nephrops* landings (t) for the period of 1983–2020.

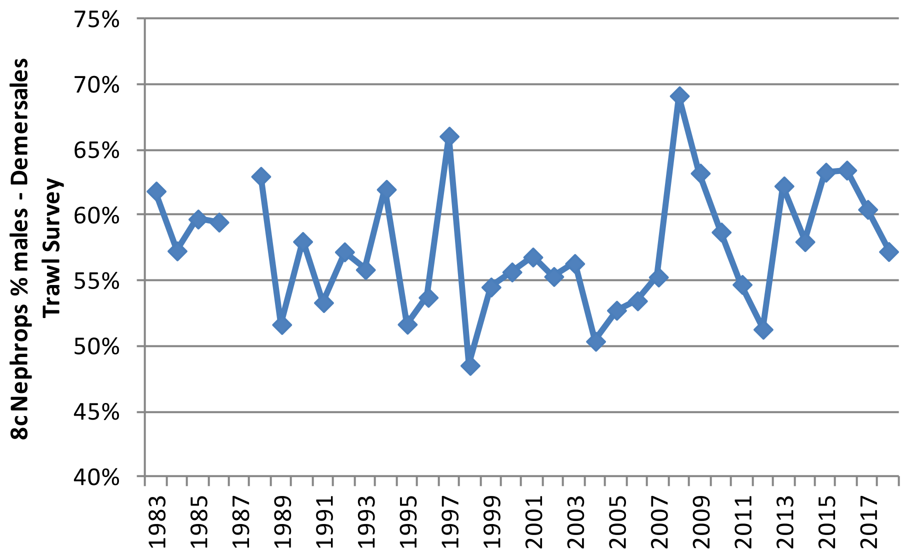

Figure 12.3.3. ***Nephrops*** **in Division 8.c. Percentage of males from the whole Spanish "Demersales" Trawl Survey, SPGFS-WIBTS-Q4 (G2784), for the period of 1983–2018.**

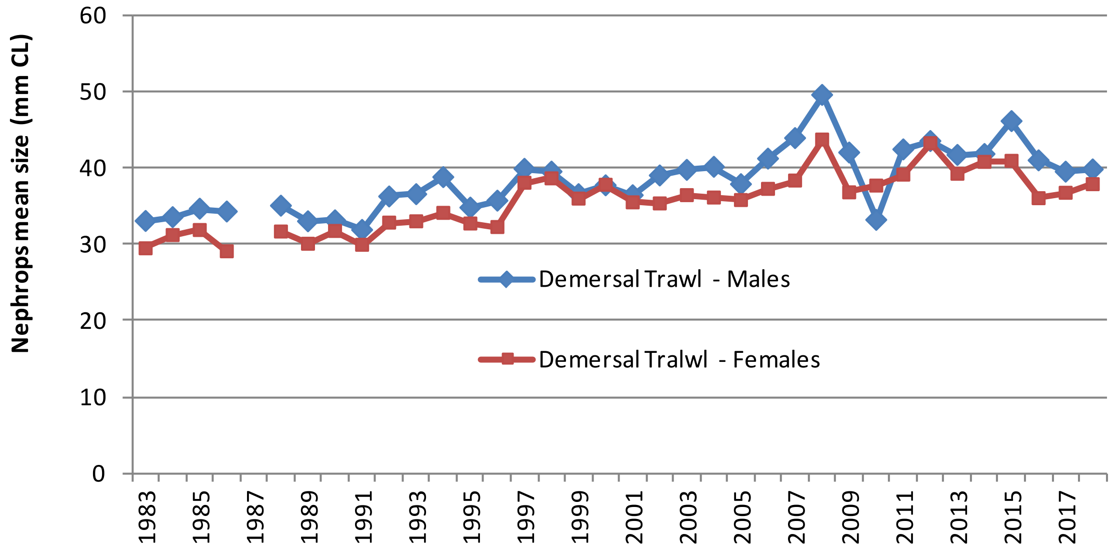

Figure 12.3.4. ***Nephrops*** **in Division 8.c. Mean sizes from the whole Spanish "Demersales" Trawl Survey (SP-NSGFS) from 1983 to 2018.**

13 Norway lobster in Division 9.a

Nephrops norvegicus – nep.fu.2627, nep.fu.2829, nep.fu.30

Functional Units 26–27 (Atlantic Iberian waters East, western Galicia, and northern Portugal)
Functional Units 28–29 (Atlantic Iberian waters East and southwestern and southern Portugal)
Functional Unit 30 (Atlantic Iberian waters East and Gulf of Cádiz)

The ICES Division 9.a has five *Nephrops* Functional Units (FUs): FU 26, West Galicia; FU 27 North Portugal; FU 28, Alentejo, Southwest Portugal; FU 29, Algarve, South Portugal and FU 30, Gulf of Cádiz.

13.1 *Nephrops* in FUs 26–27, West Galicia and North Portugal (Division 9.a)

Nephrops in FUs 26–27 was recently benchmarked by WKMSYSPiCT 2021 (ICES, 2021a). The Surplus Production in Continuous Time (SPiCT) model (Pedersen and Berg, 2017) was accepted to produce MSY advice and the stock was upgraded to category 2.

The last advice given in 2019 was valid for 2020, 2021, and 2022. However, as it is now considered a category 2 stock, new advice according to this category will be given in 2021 for 2022.

13.1.1 General

13.1.1.1 Ecosystem aspects

See Stock Annex.

13.1.1.2 Fishery description

See Stock Annex.

13.1.2 ICES advice for 2021 and management applicable to 2020 and 2021

13.1.2.1 ICES advice for 2021

The advice for these *Nephrops* stocks was triennial and valid for 2020, 2021 and 2022. However, new advice for 2022 according to category 2 stock will be given this year.

For *Nephrops* in FUs 26–27, ICES advises that when the precautionary approach is applied, there should be zero catch in each of the years 2020 and 2021.

To ensure that the stocks in FUs 26 and 27 are exploited sustainably, ICES advises that management should be implemented at the functional unit level.

13.1.2.2 Management applicable to 2020 and 2021

A recovery plan for southern hake and Iberian *Nephrops* stocks has been in force since the end of January 2006. The aim of the recovery plan was to rebuild the stocks within 10 years, with a reduction of 10% in F relative to the previous year and the TAC set accordingly (EU, 2005). This plan was based on the precautionary reference points for the southern hake stock. In March 2019, the European Parliament and the Council have published a multiannual management plan (MAP) for the Western Waters (EU, 2019a) and repealed the previous recovery plan. This plan applies to demersal stocks including *Nephrops* in FUs 26–27 in ICES Division 9.a.

In order to further reduce F on *Nephrops* stocks in this division, seasonal fishing restrictions were introduced in the trawl and creel fishery in two boxes, located in FU 26 and 28, in the peak of the *Nephrops* fishing season. These boxes are closed for *Nephrops* direct fishing in June–August and in May–August, respectively (EU, 1998 amended by EU, 2005). A new regulation on technical measures implemented in 2019 (EU, 2019b), repealed the CR(EC) No 850/98 but kept the two boxes allowing the fishing of *Nephrops* only as bycatch.

The TAC set for the whole Division 9.a was 386 t for 2020 and 374 t for 2021, respectively, of which no more than 6% may be taken in FUs 26 and 27 and no more than 77 t in 2020 and 62 t in 2021 may be taken in FU 30. In the current Management Plan for Western Waters, applied from 2020 onwards, no effort limitations were established.

A Fishing Plan for the Northwest Cantabrian ground was established in 2013 (BOE, 2013) and modified in 2014 (BOE, 2014). These regulations establish a quota assignment system for several stocks (including *Nephrops*) by vessel.

13.1.3 Data

The sampling programs coordinated by the IEO (onshore, onboard observers and biological sampling) were partially suspended in 2020 due to administrative problems and to the COVID-19 disruption, affecting the data collection for all stocks. Details of the impact on each individual stock are provided in the templates provided to ICES and in each stock-specific section.

13.1.3.1 Commercial catches and discards

Spanish landings are based on sales notes which are compiled and standardized by IEO. Since 2013, trips from sales notes are also combined with their respective logbooks which allowed the georeferencing of catches. During the same year, the Spanish concurrent sampling is used to raise the FUs 26–27 observed landings to total effort by *métier*. When the estimated landings exceed the official landings, the difference is provided to InterCatch as non-reported landings.

Landings in these FUs are reported by Spain and, in minor quantities, by Portugal. The catches are taken by the Spanish fleets fishing along the coast of western Galicia (FU 26) and northern Portugal (FU 27) fishing grounds, and by the artisanal Portuguese fleet fishing on FU 27. *Nephrops* represents a minor percentage in the composition of total trawl landings and can be considered as bycatch despite being considered a very valuable species.

Considering the whole 1975–2019 landings time-series for both FUs and countries combined, two periods can be distinguished (Figure 13.1.1). During 1975–1989, the mean landing was 680 t fluctuating between 575 and 800 t, approximately. From 1990 onwards, there has been a marked downward trend in landings, being below 50 t from 2005 to 2011 and below 10 t since 2012. Landings remained minimal and not even reaching 10 t since that year, with recently recorded landings of 2, 7, and 5 t in 2018, 2019, and 2020, respectively.

Table 13.1.1 shows the total landings in FUs 26–27 by FU and country for the time-series. Information on discards was sent to the WG through InterCatch although no discards are recorded in these FUs. Differences between landings in both FUs diminished with FU 27 recording higher landings despite remaining stable at low levels. Landings in FU 27 represent 64% of the total landings (5 t) in 2019 and 74% (4 t) in 2020.

Along the time-series, landings by the Spanish fleets are mostly from FU 26, together with smaller quantities taken from FU 27. Yet, before 1996, no distinction was made between these two FUs and therefore they were considered together. Overall, Spanish landings recorded in both FUs decreased in the time-series, from a maximum of 359 t in 1997 in FU 26 and 68 t in

FU 27 to a minimum of near 0 t in both FUs in recent years. From 2005 onwards, Spanish landings from both FUs were of the same order of magnitude.

Total Portuguese landings from FU 27 have decreased from almost 100 t in 1988 to 17 t in 1996. During the 1997–2004 period, landings decreased to a mean value of 7 t but a slight increase was observed from 2005 to 2009 (mean value of 11 t). From 2010 onwards, landings decreased to the lowest values in the time-series (ranging from 0 to 4 t). In 2019 and 2020, Portuguese landings were 4 t and 2 t, respectively.

13.1.3.2 Biological sampling

The sampling levels for 2020 are shown in section 1 of this report. The number of samples decreased due to some administrative problems coupled with the COVID-19 disruptions.

Mean size (carapace length, CL) for both sexes showed an increasing trend from 2001 to 2010 with the highest value recorded in 2010 for both males (52.0 mm CL) and females (43.7 mm CL) (Figure 13.1.1). In contrast, mean carapace length declined in both sexes in the period 2011–2013. The mean size trend increased for males from 2014 onwards but it declined for females in 2016. In 2016, males achieved a mean carapace length of 45.1 mm and females 37.5 mm. No length frequencies distributions for both sexes were available in 2017 and 2018. In 2019, the mean length in both sexes was higher than in the previous data available: 46.9 mm for males and 40.6 mm for females. Sampling was only partially conducted in 2020 because of the COVID-19 disruption and administrative issues. Only two samples of *Nephrops* were carried out in the third quarter of 2020. Information obtained from these samples were deemed not representative of the stock size composition and, therefore, not considered. Annual length compositions for males and females combined, mean size and mean weight in landings for the period 1988–2019 are given in Tables 13.1.2a and 13.1.2b and Figures 13.1.2a and 13.1.2b.

13.1.3.3 Commercial catch-effort data

Fishing effort and LPUE estimates are available for the Marin trawl fleet (SP-MATR) for the period 1990–2019 (Table 13.1.3; Figure 13.1.1). LPUE estimate is not available in 2020 because of the COVID-19 pandemic disruption and administrative problems which affected the sampling programs. However, it should be noted that the overall trends for the SP-MATR effort and LPUE time-series are decreasing. Fishing effort have remained at very low levels since 2010 (mean value of 447 trips). LPUE series shows are also very low since 2012, with values lower than 1 kg/trip since 2014, indicating that the abundance of the stock in these FUs is very poor. In 2019, the fishing effort was 383 trips and the LPUE 0.3 kg/trip.

Time-series of fishing effort and LPUE of the bottom-trawl fleets with the Spanish home ports of Muros (1984–2003), Riveira, (1984–2004) and Vigo (1995–2008 and 2010) are also available. These data are plotted in Figure 13.1.1 for complementary information.

13.1.4 Biomass index from surveys

13.1.4.1 International bottom-trawl surveys

The Spanish International Bottom Trawl Survey-Q4 (SPGFS-WIBTS-Q4, G2784) covers the northern Spanish shelf in ICES Division 8.c and the northern part of 9.a, including the Cantabrian Sea and off Galicia waters from 70 m to 500 m of depth (Figure 13.1.3). This survey usually starts at the end of the third quarter (September) and finishes in the 4th quarter. Time-series is available for the 1984–2020 period. No survey was carried out in 1987. This survey is designed to estimate demersal species abundance but it could be used for the analysis of the *Nephrops* abundance trends. In the past, the abundance index survey was estimated for the whole surveyed area and not by FU. Data from the G2784 survey was used to estimate a *Nephrops* index for all ICES statistical rectangles (14E0, 13E0, 13E1) in FU 26 (West Galicia). This survey index time-series was presented for the first time in WGBIE 2020 (ICES, 2020) and it was expressed as the mean biomass or abundance per haul (mean kg/haul and mean number of individuals per haul). WKMSYSPiCT 2021 did not consider appropriated this estimation because depth was not taken into account and the quality of the index was questioned. Based on the depth stratification and the total area in FU 26, a new G2784 survey index was estimated and standardized to one hour during WKMSYSPiCT 2021 (ICES, 2021a).

The survey index shows an increasing trend from 1985 to 1991 (Figure 13.1.4) when the highest value was recorded (3.5 kg/h). The *Nephrops* index decreased in 1994 (0.1 kg/h) and fluctuated up to 2001 (0.6 kg/h). In 2002, the biomass index decreased and remained at very low levels onwards. The mean value in the 2001–2020 period was 0.05 kg/haul (Table 13.1.4 and Figure 13.1.4).

The Portuguese International Bottom Trawl Survey Q4 (PTGFS-WIBTS-Q4, G8899) is carried out in Division 9.a covering the Portuguese continental waters from 20 to 500 m of depth (Figure 13.1.3). The abundance index is available from 1989 to 2018. The survey was not carried out in 2019 due to external administrative issues and then again in 2020 due to the COVID-19 disruption. The main objective of the survey is to estimate the abundance of the most important commercial fish species in the Portuguese trawl fishery and it is conducted in autumn (October). *Nephrops* biomass index in FU 27, from the depth, stratified G8899 survey, was estimated using hauls included in ICES statistical rectangles corresponding to FU 27 (6E0–12E0) during the WKMSYSPiCT benchmark (ICES, 2021a).

The biomass index was almost zero g/h at the beginning of the time-series (1985–1988 period). After that, the *Nephrops* biomass index increased but has greatly fluctuated up to 2000. In 2001, the G8899 survey index decreased and it has remained at about zero g/h since then, only a peak was observed in 2015 although not very high (Table 13.1.4 and Figure 13.1.4).

Figure 13.1.5 shows the sector areas from Spanish (G2784) and Portuguese (G8899) IBTS surveys-Q4 covering FUs 26 and 27, respectively. *Nephrops* is mainly distributed in the Miño-Fisnisterre sector (GAL) in FU 26 from about 100 to 700 m depth and the Caminha sector (CAM) in the northern part of FU 27 from 100 to 500 m depth (Table 13.1.4). In the rest of the FU 27, *Nephrops* patches occur particularly in the Figueira da Foz sector (FIG) in the deepest stratum and Berlengas sector (BER) in a higher bathymetric range. In the Lisbon sector (LIS), *Nephrops* is present in a small patch in front of Cascais about 350 m depth.

The annual spatial distribution of *Nephrops* biomass index in FUs 26–27 for the time-series is shown in Figure 13.1.6a and Figure 13.1.6b, indicating a declining trend of the biomass index since 1983 as well as of the *Nephrops* patches in FUs 26–27.

A new depth stratified biomass index (G2784_G8899) based on the area and depth strata for the total area covering FUs 26–27 was estimated during WKMSYSPiCT (ICES, 2021a) considering the following area/sectors: Miño-Finisterre (GAL), Caminha (CAM), Matosinhos (MAT), Aveiro (AVE), Figueira da Foz (FIG), Berlengas (BER) and Lisbon (LIS) from Spanish and Portuguese IBTS surveys (Figure 13.1.4; Table 13.1.4), as parts of a unique survey and taking into account the area corresponding to each stratum of depth. *Nephrops* weight by haul was standardized to one hour. Both surveys use different vessels and gears so catchability could be also different for some species. The Portuguese survey is not suitable for flatfish, anglerfish and probably *Nephrops*. However, no weight has been applied to these surveys in order to standardize the *Nephrops* biomass index. The knowledge of the fishery in FUs 26–27 suggests that the main *Nephrops* fishing ground is in FU 26 and a small part in the north of Portugal near the border with Spain which is exploited by the Spanish trawl fleet. Therefore, the combined biomass index trend should not be very different.

The new combined (G2784_G8899) index increased from 1983 to 1991, recording the highest value of the time-series (0.17 g/h) but it showed a decreasing trend from that year to 1994

(0.01 g/h). In 1995, *Nephrops* biomass index increased again and after that, it has fluctuated at low levels up to 2001 (0.03 g/h). The G2784_G8899 biomass index value has been minimal since 2002.

13.1.4.2 Trawl surveys with the fishing industry

Marine Fishing Industry (OPROMAR, Productores de Pesca Fresca del Puerto y la Ría de Marín) promoted a survey with a commercial vessel in order to estimate *Nephrops* abundance index in FU 26 with an observer onboard under the IEO supervision. The survey hereinafter referred to as GALNEP-26 started in 2019 and was also carried out in 2020. These surveys were conducted in summer (July–August) during the main *Nephrop*s fishing season when both males and females are accessible to the gear due to their reproductive behaviour. The survey design followed a systematic sampling over a 5 x 5 nm grid over the *Nephrops* distribution area estimated by VMS and sediment information (Vila *et al*., 2020). The survey index from GALNEP-26 with a 95% confidence interval was estimated at 0.74 ± 0.58 kg/h in 2019. The index increased in 2020 (1.82 ± 1.86 kg/h). Figure 13.1.7 shows the *Nephrops* biomass index distribution in FU 26. *Nephrops* represented about 1% of the total retained catch while the discard rate was zero in both years. The spatial analysis of the survey index indicates that *Nephrops* is concentrated in a small area on the Northwest half within the original distribution area of FU 26 (Figure 13.1.7). In 2019, the mean lengths were 39.9 mm CL for females and 43.9 mm CL for males. Similar mean length sizes were observed in 2020 (Table 12.1.5). Figure 13.1.8 shows the LFDs by sex in 2019 and 2020.

13.1.5 Assessment

This stock was considered as category 3.1.4 according to the ICES data-limited approach since 2012 (ICES, 2012) and it was assessed by analysing the LPUE series trend.

The Surplus Production in Continuous Time (SPiCT) model (Pedersen and Berg, 2017) was proposed during WKMSYSPiCT (ICES, 2021a) to produce MSY advice. Data available for the stock were reviewed and several tests were conducted. Results and discussions about the exploratory runs and the final accepted model are available in the WKMSYSPiCT report (ICES, 2021a). Assessment has been carried out this year according to category 2 using the SPiCT model and the Stock Annex was modified accordingly.

13.1.5.1 SPiCT model

Input data (Table 13.1.6 and Figure 13.1.9.)*:*

- Total landings from 1975–2020 (discards are considered negligible).
- Spanish and Portuguese International Bottom Trawl surveys-Q4 combined index (G2784+ G8899) from 1983–2020 (no data in 1987).

Settings:

- Euler time-step (years): 1/16 (default).
- The biomass index time-series was scaled to mean 1 in order to obtain better numerical stability.
- An extra uncertainty was applied to landings from 1975 to 1980 as during this period is possible that a wrong gear identification in some trips could have occurred and as consequence *Nephrops* landings were more uncertain.
- Moreover, the uncertainty of the survey index for the period 1983–1990 was also increased.

- The following priors were applied:
    i. Initial biomass depletion level, *B/K* prior: 0.5 with a low CV (medium level), i.e. inp$priors$logbkfrac <-c(log(0.5),0.2,1)
    ii. Intrinsic growth rate, *r* prior: 0.2 with a low CV in order to increase model stability, i.e inp$priors$logr <-c(log(0.2),0.2,1)
    iii. Schaefer production curve type using a tighter prior for *n*, i.e. inp$priors$logn <-c(log(2),0.5,1)
    iv. Default priors on alpha and beta are disabled: inp$priors$logalpha <- c(0,0,0); inp$priors$logbeta <- c(0,0,0)
    v. In order to decrease the confidence intervals of the results, priors for the F process noise and for catch observation noise are set as: inp$priors$logsdf <- c(log(3), 0.5, 1); inp$priors$logsdc <- c(log(0.1), 0.2, 1)

13.1.5.2 Assessment diagnostics

Diagnosis is conducted using the OSA (one step ahead) approach to assess the goodness-of-fit. The plots in Figure 13.1.10 confirm normality in the residuals, using the QQ-plot and Shapiro test. Confidence intervals for F/F_{MSY} and B/B_{MSY} do not span more than 1 order of magnitude, as proposed by Mildenberger *et al*. (2020).

The retrospective patterns for the relative biomass and relative fishing mortality, using the peels of the last five years assessments, are shown in Figure 13.1.11. The Mohn's rho values (Mohn, 1999) estimated for B/B_{MSY} and F/F_{MSY} were 0.365 and -0.259, respectively. However, all five peels are within the 95% confidence intervals of the assessment and the plots do not show a strong retrospective pattern.

13.1.5.3 Assessment results

SPiCT results are shown in Tables 13.1.7 and 13.1.8 and in Figure 13.1.12

Nephrops landings in FU26–27 decreased more than 95% along time-series and the biomass survey indices indicate extremely low biomass. Spatial analysis of the biomass surveys indices shows a reduction of the historical *Nephrops* distribution in these stocks.

The biomass decreased from the beginning of the time-series to the 2000s, remaining at a very low level since then. Biomass dropped below MSY $B_{trigger}$ since the end of the 1980s and the fishing mortality is below F_{MSY} since 2013. In the last year of the time-series, F was 43% below F_{MSY} with very low biomass. Results indicate a depleted stock.

13.1.6 Short-term projections

Short-term projections consider the fishing mortality in the intermediate year as the estimated F in 2020. Results for the scenarios discussed in WKMSYPiCT (ICES, 2021a) are presented in Table 13.1.9 and Figure 13.1.13. All scenarios recommend zero catch for 2022 except for F_{sq} with projected catches of 5.2 t.

13.1.7 Comment on the assessment

Portuguese IBTS survey-Q4 (G8899) was not carried out in 2019 due to external issues and again in 2020 due to the COVID-19 disruption. However, this survey has very little weight in the estimation of the new combined (G2784_G8899) survey index. Therefore, this survey had very little or no impact on the current assessment.

13.1.8 Quality considerations

A combined biomass index from Spanish and Portuguese IBTS surveys-Q4 taking into account the spatial-temporal analysis using a Bayesian hierarchical model was estimated. This work was presented in WKMSYSPiCT 2021 (ICES, 2021a). However, the model-based index used an auto-regressive process to estimate the time-trend. This implies that the resulting indices by year are not independent of each other, and the time-series will appear smoother as opposed to when year effects are treated independently. This is undesirable when the index is used as data in an assessment model that assumes that each data point is independent of the others. It was therefore recommended to use independent year effects in model-based approaches. A simpler approach to estimating a combined index survey based on area and depth was used in the assessment.

13.1.9 Biological reference points

In the SPiCT model, the stock status evaluation and stock catch forecast options are based on relative reference points. This is because the absolute reference points are re-estimated every time the model is applied as opposed to many other assessments where the reference points remain fixed until the next benchmark.

WKMSYSPiCT (ICES, 2021a) reiterated the use of MSY reference points as previously defined for biomass dynamics models (now updated in ICES, 2021b). Reference points are shown in the table below.

Framework	Reference point	Relative value	Technical basis	Source
MSY approach	MSY $B_{trigger}$	0.5	Relative value. B_{MSY} is estimated directly from the assessment model and changes when the assessment is updated.	ICES (2021a)
	F_{MSY}	1	Relative value. F_{MSY} is estimated directly from the assessment model and changes when the assessment is updated.	ICES (2021a)
Precautionary approach	B_{lim} proxy	0.3 × B_{MSY}	Relative value (equilibrium yield at this biomass is 50% of the MSY proxy).	ICES (2021a)
	B_{pa}	Not defined		
	F_{lim} proxy	1.7 × F_{MSY}	Relative value (the F that drives the stock to the proxy of B_{lim}).	ICES (2021a)
	F_{pa}	Not defined		
Management plan	SSB_{mgt}	Not defined		
	F_{mgt}	Not defined		

13.1.10 Management Considerations

Nephrops is taken as bycatch in a mixed bottom-trawl fishery. Landings of *Nephrops* have substantially declined since 1995. Recent landings represent less than 1% of the average landings in the early period of the time-series (1975–1992). Fishing effort in FUs 26–27 has decreased throughout the time-series.

There is a seasonal closure (June–August) for *Nephrops* in a *box* within West Galicia (FU 26) fishing grounds, which was amended in the Council Regulation (EC) No 850/98 (EU, 1998). A new regulation on technical measures, the Regulation (EU) No 2019/1241 (EU, 2019b) replaced and repealed the CR (EC) No 850/98 but kept the *box* previously defined, allowing fishing *Nephrops* only as bycatch.

A multiannual management plan (MAP) for the Western Waters has been published by the European Parliament and the Council (EU, 2019a). This plan applies to demersal stocks including *Nephrops* in FUs 26–27 in ICES Division 9.a.

A Fishing Plan for the Cantabrian and Northwest fishing grounds was established in 2013 (BOE, 2013) and modified in 2014 (BOE, 2014). These regulations establish a quota assignment system for several stocks (including *Nephrops*) by vessel.

Unwanted catches from *Nephrops* are regulated by the discard plan for demersal fisheries in Southwestern waters for the period 2019–2021 (EU, 2018 replaced by EU, 2019c), under which an exemption from the landing obligation is applied based on this species high survival rates. This exemption applies to all catches of Norway lobster from ICES subareas 8 and 9 with bottom-trawls, with the immediate release of all discards in the area where they were caught.

13.1.11 References

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13.1.12 Tables and Figures

Table 13.1.1. *Nephrops* in FUs 26–27, West Galicia and North Portugal. Landings in tonnes by FU and country.

	Spain		Portugal	Total
Year	FU 26*	FU 27	FU 27	FU 26–27
1975				622
1976				603
1977				620
1978				575
1979				580
1980				599
1981				823
1982				736
1983				786
1984	603		14	617
1985	731		15	746
1986	655		37	692
1987	670		71	741
1988	631		96	727
1989	577		88	665
1990	402		48	450
1991	515		54	569
1992	584		52	636
1993	472		50	522
1994	428		22	450
1995	501		10	511
1996	264	50	17	331
1997	359	68	6	433
1998	294	42	8	344
1999	192	48	6	246
2000	102	21	9	132

Year	FU 26*	Spain FU 27	Portugal FU 27	Total FU 26–27
2001	105	21	6	132
2002	59	24	4	87
2003	39	26	8	73
2004	38	24	9	71
2005	16	16	11	43
2006	15	17	12	44
2007	20	17	10	47
2008	17	12	13	42
2009	10	17	10	37
2010	9	13	4	26
2011	7	8	4	19
2012	2	4	1	7
2013	1	< 1	1	3
2014	1	1	1	3
2015	1	< 1	1	2
2016	1	< 1	3	5
2017	< 1	< 1	2	3
2018	1	1	0	2
2019	3	1	4	7
2020	1	2	2	5

*** Prior to 1996, landings of Spain recorded in FU 26 included catches in FU 27.**

Table 13.1.2a. ***Nephrops*** **in FUs 26–27, West Galicia and North Portugal. Length compositions, mean weight (kg) and mean size (CL, mm) in landings for the 1988–2019 period. Data were not available in 2017, 2018 and 2020.**

Lenght (mm)	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
12	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	71	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	69	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	451	110	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	191	289	13	0	0	0	0	0	0	0	0	3	17	0	0	0	0	0	0	0	0	0	0	0
17	0	128	518	17	0	0	7	0	0	0	0	0	3	11	0	0	0	0	0	0	0	0	0	0	0
18	0	683	898	25	0	0	2	1	0	0	0	0	16	19	0	4	0	0	0	0	0	0	0	0	0
19	0	679	1502	38	0	0	0	0	0	0	0	0	38	52	0	4	0	0	0	0	0	0	0	0	0
20	27	1057	2044	97	6	5	10	7	25	3	0	0	86	151	3	29	0	0	0	0	0	0	0	0	0
21	27	1260	2489	199	12	24	19	8	78	0	0	0	119	236	3	27	0	0	1	0	0	0	0	0	0
22	39	1657	2642	398	48	99	84	47	202	12	1	0	129	348	11	11	1	0	1	0	0	0	0	0	0
23	109	1901	3063	568	103	99	77	151	373	26	6	0	127	518	16	31	0	0	0	0	1	0	0	0	0
24	198	1626	2736	1216	284	222	169	338	550	46	7	3	93	466	22	17	1	2	1	0	2	0	0	0	0
25	290	2212	1802	1477	541	381	199	672	906	113	45	15	134	441	35	28	1	2	1	0	3	1	0	0	0
26	574	1675	1451	1516	829	542	289	709	960	184	40	43	145	365	56	22	7	2	2	1	2	1	0	0	0
27	854	1878	1333	1351	926	904	409	933	746	306	80	68	129	419	106	40	18	8	5	2	3	1	0	0	0
28	1272	1560	1319	1940	1079	1017	524	1298	842	402	138	109	123	274	74	46	23	12	8	6	9	4	0	0	0
29	1487	1716	913	1797	1023	987	613	1223	706	489	191	134	143	266	86	60	20	15	13	7	7	9	0	0	0
30	1615	1510	845	1501	1069	1140	767	1371	792	681	295	195	172	252	118	90	31	25	20	12	13	11	0	2	1
31	1960	1106	632	1450	1180	890	802	1378	609	719	359	239	182	209	105	102	27	21	21	13	16	9	1	2	0
32	1951	1472	772	1484	1197	912	847	1491	601	888	411	292	285	220	160	95	49	29	35	23	27	11	2	5	2
33	2288	1313	601	1126	1378	878	898	1444	517	780	525	377	176	201	167	84	56	26	40	47	23	11	2	3	2
34	1581	1299	572	1160	1001	849	853	1255	542	745	551	376	192	156	131	83	56	31	51	43	37	22	5	3	2
35	1487	952	518	1044	915	855	745	963	506	637	569	432	200	148	96	91	53	26	48	46	25	18	4	5	2
36	1161	634	407	879	776	901	611	744	433	527	484	360	176	120	110	85	56	21	42	36	22	15	4	4	1
37	838	545	284	651	627	736	546	580	348	484	417	321	175	143	106	111	70	31	51	49	31	17	7	2	2
38	1196	608	294	616	545	682	621	542	346	534	425	308	128	110	76	72	86	35	61	38	28	20	6	2	2
39	837	451	226	600	505	510	475	425	285	406	292	240	128	85	95	79	65	27	43	36	21	14	6	8	3
40	501	325	199	450	666	573	412	455	284	466	393	218	115	65	76	60	90	24	55	39	32	21	7	7	4
41	428	288	165	375	431	385	321	321	213	399	312	182	112	58	88	48	60	21	40	32	23	16	8	6	4
42	367	287	144	220	362	375	314	214	182	360	249	210	66	57	81	54	101	22	47	43	26	14	6	7	6
43	433	296	156	203	425	307	293	188	165	325	292	219	64	36	76	47	73	25	38	49	25	13	9	7	4
44	164	277	87	136	301	251	200	152	127	290	207	193	61	44	52	33	62	20	32	38	36	13	10	7	4
45	165	286	58	110	303	219	178	125	118	218	196	162	58	42	44	34	56	17	18	29	17	12	8	10	5
46	96	135	23	90	350	153	129	116	94	191	178	152	40	28	49	26	29	20	18	24	18	8	10	11	3
47	94	117	45	82	228	104	92	84	56	123	120	84	38	47	42	31	38	26	18	28	17	8	8	9	4
48	71	100	25	49	222	58	96	55	70	117	147	96	23	18	22	13	28	18	12	15	16	7	7	7	3
49	73	76	29	42	148	84	71	46	23	60	105	64	21	16	15	16	18	13	11	14	9	5	7	7	3
50	83	127	14	46	63	81	69	29	31	81	95	54	17	12	12	15	16	15	13	14	9	9	10	14	3
51	15	48	9	14	71	27	59	13	21	43	59	21	17	6	7	15	7	15	7	7	9	6	4	5	3
52	20	75	14	33	71	21	59	18	22	43	55	30	18	6	7	10	12	10	8	10	9	6	5	5	3
53	23	34	13	26	34	20	28	6	13	30	37	33	5	5	6	10	5	7	6	8	4	6	5	6	2
54	14	10	11	23	23	14	12	6	15	42	28	27	8	3	2	8	4	11	10	6	7	4	5	4	3
55	6	27	1	6	13	17	12	1	9	25	26	12	6	7	3	4	5	8	3	6	6	5	7	5	1
56	6	9	1	5	5	10	5	1	9	14	14	14	7	4	3	5	3	4	2	3	6	6	4	5	1
57	10	5	1	2	6	5	10	0	4	8	12	6	5	3	3	2	2	3	2	4	5	5	3	2	0
58	11	5	1	4	6	5	14	0	3	6	11	5	4	5	4	3	3	4	4	4	5	5	4	2	0
59	7	0	4	0	7	2	7	0	0	2	1	5	3	3	0	1	4	3	1	3	2	2	1	3	1
60	2	0	2	0	4	3	3	0	0	1	2	3	2	2	2	2	7	4	2	1	3	3	4	3	1
61	4	0	1	0	3	2	12	0	0	0	2	0	3	2	0	2	1	14	1	2	1	1	3	2	1
62	2	0	1	0	1	0	7	0	0	0	0	0	1	5	0	2	2	4	2	1	3	2	1	1	1
63	1	0	1	0	3	0	5	0	0	1	0	0	3	3	0	2	1	2	1	1	1	1	2	2	0
64	2	0	1	0	3	1	4	0	0	0	1	0	2	2	0	2	1	1	1	1	2	3	2	2	0
65	2	0	1	0	1	0	2	0	0	0	0	0	1	1	1	1	2	2	1	1	1	2	2	2	0
66	3	0	1	0	1	0	2	0	0	0	1	0	2	2	0	1	0	1	1	1	1	1	1	1	1
67	2	4	1	0	1	1	1	0	0	0	1	0	3	1	0	2	1	2	1	1	1	1	1	1	0
68	2	11	1	0	2	2	6	0	0	0	0	0	2	1	0	2	1	1	2	2	2	1	2	2	0
69	1	4	1	0	1	1	0	0	0	0	0	0	2	1	0	1	1	1	2	1	1	1	1	1	1
70	12	25	1	2	12	6	8	0	1	0	3	0	11	1	1	5	4	8	1	1	4	1	1	1	0
71	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	1	2	0
72	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
73	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
74	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
76	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
78	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
79	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
81	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
82	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
83	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
84	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total number (thousand)	22409	31275	29319	23087	17811	15360	12003	17411	11828	10827	7383	5302	3822	5712	2169	1666	1257	638	800	752	569	355	191	191	81
Total weight (t)	727	708	450	603	636	522	448	511	331	432	344	246	132	132	87	72	70	42	44	46	36	25	19	20	8
Mean weight (kg)	0.032	0.023	0.015	0.026	0.036	0.034	0.037	0.029	0.028	0.040	0.047	0.046	0.035	0.023	0.040	0.043	0.056	0.066	0.057	0.061	0.063	0.071	0.099	0.105	0.098
CL Mean length (mm)	34.0	29.1	25.9	31.4	34.5	34.3	35.2	32.9	31.9	36.2	38.1	38.1	33.5	29.5	36.0	36.2	40.2	42.0	40.0	41.3	41.5	42.6	48.4	46.5	46.1

(Continued in the next page)

Table 13.1.2b. *Nephrops* in FUs 26–27, West Galicia and North Portugal. Length compositions, mean weight (kg) and mean size (CL, mm) in landings for the 1988–2019 period. Data were not available in 2017, 2018 and 2020. (continued from the previous page).

Lenght (mm)	2013	2014	2015	2016	2017	2018	2019
12	0						
13	0						
14	0						
15	0						
16	0						
17	0						
18	0						
19	0						
20	0						
21	0						
22	1						
23	0						
24	0	1					
25	0	2	0	1			0
26	0	1	0	0			0
27	0	1	0	0			0
28	0	2	0	1			0
29	0	2	0	2			0
30	1	4	0	4			2
31	1	1	0	0			1
32	1	1	0	2			1
33	1	0	1	2			1
34	1	5	1	3			3
35	1	5	2	5			2
36	1	2	1	2			3
37	1	3	1	2			3
38	1	1	1	3			2
39	1	2	1	2			3
40	1	4	3	5			4
41	1	1	1	1			3
42	1	1	1	2			2
43	1	1	2	1			6
44	0	3	1	3			3
45	0	3	1	6			5
46	0	1	0	1			2
47	0	1	0	3			3
48	1	1	0	2			3
49	0	1	0	2			3
50	0	2	0	3			3
51	0	0	0	1			1
52	0	0	0	1			1
53	0	0	0	1			2
54	0	1	0	1			1
55	0	1	0	2			1
56	0	0	0	0			1
57	0	0	0	0			0
58	0	1	0	0			1
59	0	0	0	0			1
60	0	1	0	1			1
61	0	0	0	1			0
62	0	0	0	0			1
63	0	0	0	0			1
64	0	0	0	0			0
65	0	0	0	0			0
66	0	0	0	0			0
67	0	0	0	0			0
68	0	0	0	0			0
69	0	0	0	0			0
70	0	0	0	1			0
71	0	0	0	0			0
72	0	0	0	0			0
73	0	0	0	0			0
74	0	0	0	0			0
75	0	0	0	0			0
76	0	0	0				0
77	0	0	0				0
78	0	0	0				0
79	0	0					
80	0						
81	0						
82	0						
83	0						
84	0						
Total number (thousand)	20	60	23	69			72
Total weight (t)	3	4	2	5			5
Mean weight (kg)	0.081	0.059	0.087	0.077			0.065
CL Mean length (mm)	35.8	39.4	42.0	42.2			45.0

Table 13.1.3. *Nephrops* in FUs 26–27, West Galicia and North Portugal. Fishing effort and LPUE for the SP-MATR fleet.

Year	Landings (t)	trips	LPUE (kg/trip)
1994	234	2692	87.0
1995	267	2859	93.2
1996	158	3191	49.5
1997	246	3702	66.3
1998	189	2857	66.0
1999	134	2714	49.5
2000	72	2479	28.9
2001	80	2374	33.6
2002	52	1671	31.2
2003	38	1597	24.0
2004	38	1986	19.2
2005	17	1629	10.3
2006	18	1547	11.9
2007	22	1196	18.1
2008	17	980	17.2
2009	7	517	14.1
2010	5	676	7.7
2011	3	513	6.0
2012	1	483	2.1
2013	< 1	418	1.0
2014	< 1	491	0.8
2015	< 1	384	0.8
2016	< 1	396	0.8
2017	< 1	386	0.3
2018	< 1	369	1.1
2019	< 1	383	0.3
2020*	na	na	na

***No estimate can be made in 2020 as sampling was only partially conducted due to COVID-19 disruption and administrative issues.**

Table 13.1.4. *Nephrops* FU 26–27, West Galicia and North Portugal: Biomass index from Spanish International Bottom Trawl Survey in FU26 (SPGFS-WIBTS-Q4, code G2784), Portuguese International Bottom Trawl Survey in FU27 (PTGFS-WIBTS-Q4, code G8899) and combined index estimated from both surveys (G2784_ G8899) in g/h.

Years	Spanish International Bottom Trawl Survey (G2784)	Portuguese International Bottom Trawl Survey (G8999)							Combined index (G2784-G8999)
	FU26	FU27							FU26-27
	GAL	CAM	MAT	AVE	FIG	BER	LIS	All sectors	
1983	711.11								0.0304
1984	382.53								0.0164
1985	261.67	12.03	3.81	0.00	0.00	10.77	0.00	0.0014	0.0123
1986	866.49	0.00	0.00	0.00	0.00	0.00	0.00	0.0000	0.0371
1987	na	8.56	0.00	0.00	0.00	0.00	0.00	0.0004	na
1988	1488.09	0.00	0.00	0.00	0.00	0.00	0.00	0.0000	0.0636
1989	643.79	49.66	0.00	19.09	0.00	202.68	0.00	0.0142	0.0391
1990	1495.42	293.99	50.12	164.78	5.45	18.31	69.77	0.0316	0.0897
1991	3460.29	377.36	0.00	8.47	0.15	22.69	6.77	0.0218	0.1658
1992	971.21	300.42	0.00	58.89	2.92	23.15	0.00	0.0202	0.0580
1993	239.85	160.92	4.89	10.89	11.36	41.64	0.00	0.0121	0.0201
1994	146.91	4.77	0.00	0.00	0.00	77.87	0.00	0.0043	0.0098
1995	748.55	16.14	0.00	26.54	112.50	592.77	0.00	0.0393	0.0640
1996	117.28	87.55	0.00	0.00	0.00	59.63	0.00	0.0077	0.0113
1997	163.11	174.52	0.00	158.77	1.54	164.28	43.66	0.0285	0.0302
1998	315.49	0.00	0.00	138.11	0.00	56.96	0.00	0.0102	0.0218
1999	359.80	26.06	0.00	0.00	0.00	0.00	0.00	0.0014	0.0165
2000	188.58	33.16	0.00	105.84	2.34	115.32	0.00	0.0135	0.0190
2001	610.60	4.44	0.00	0.00	0.00	63.91	0.00	0.0036	0.0290
2002	59.95	18.62	0.00	0.00	0.00	0.00	0.00	0.0010	0.0034
2003	88.02	33.50	0.00	0.00	8.28	0.00	0.00	0.0022	0.0056
2004	44.56	0.00	0.00	0.00	0.00	0.00	0.00	0.0000	0.0019
2005	15.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0000	0.0007
2006	78.31	0.00	0.00	0.00	0.00	0.00	0.00	0.0000	0.0033
2007	28.34	0.00	0.00	0.00	4.36	0.00	0.00	0.0002	0.0014
2008	46.64	18.87	0.00	0.00	0.00	0.00	0.00	0.0010	0.0028
2009	30.41	0.00	0.00	0.00	0.00	0.00	0.00	0.0000	0.0013
2010	135.44	0.00	0.00	0.00	0.00	0.00	0.00	0.0000	0.0058
2011	20.04	0.00	0.00	0.00	0.00	0.00	0.00	0.0000	0.0009
2012	9.47	0.00	0.00	0.00	0.00	0.00	0.00	0.0000	0.0004
2013	81.30	0.00	0.00	0.00	0.00	0.00	0.00	0.0000	0.0035
2014	21.39	0.00	0.00	0.00	0.00	0.00	0.00	0.0000	0.0009
2015	28.70	0.00	0.00	0.00	0.00	24.40	315.14	0.0178	0.0157
2016	62.34	0.00	0.00	0.00	0.00	79.26	0.00	0.0042	0.0061
2017	61.16	0.00	0.00	0.00	0.00	0.00	0.00	0.0000	0.0026
2018	54.76	0.00	0.00	0.00	0.00	0.00	0.00	0.0000	0.0023
2019	56.06	na	na	na	na	na	na	na	0.0024
2020	19.89	na	na	na	na	na	na	na	0.0009

Table 13.1.5. *Nephrops* in FUs 26–27, West Galicia and North Portugal. Biomass index from the GALNEP-26 in FU 26 and mean sizes by sex.

	Biomass survey index		Mean size		
Year	K/h	nº indiv./h	Males	Females	Combined
2019	0.74	11.4	43.98	39.95	42
2020	1.82	30.18	43.4	39.31	41.51

Table 13.1.6. *Nephrops* in FUs 26–27, West Galicia and North Portugal. SPICT input data.

Year	Catch (t)	New combined survey index (G2784_G8899) (g/h)
1975	622	
1976	603	
1977	620	
1978	575	
1979	580	
1980	599	
1981	823	
1982	736	
1983	786	0.030
1984	618	0.016
1985	765	0.012
1986	694	0.037
1987	742	na
1988	727	0.064
1989	708	0.039
1990	449	0.090
1991	603	0.166
1992	636	0.058
1993	522	0.020
1994	448	0.010
1995	511	0.064
1996	331	0.011
1997	433	0.030
1998	345	0.022
1999	248	0.017
2000	132	0.019
2001	132	0.029
2002	87	0.003
2003	73	0.006
2004	71	0.002
2005	43	0.001
2006	44	0.003
2007	47	0.001
2008	42	0.003
2009	37	0.001
2010	26	0.006
2011	19	0.001
2012	7	0.000
2013	3	0.003
2014	3	0.001
2015	2	0.016
2016	5	0.006
2017	3	0.003
2018	2	0.002
2019	7	0.002
2020	5	0.001

Table 13.1.7. ***Nephrops*** **in FU 26–27, West Galicia and North Portugal. Summary SPiCT results.**

Parameter estimates W 95% CI

	estimate	cilow	ciupp	log.est
alpha	58.083	0.077	43604.620	4.062
beta	0.188	0.112	0.317	-1.671
r	0.191	0.131	0.280	-1.654
rc	0.139	0.073	0.265	-1.975
rold	0.109	0.042	0.281	-2.218
m	507.576	369.115	697.977	6.230
K	13029.563	7913.568	21452.965	9.475
q	0.001	0.001	0.002	-7.094
n	2.757	1.501	5.066	1.014
sdb	0.015	0.000	11.098	-4.209
sdf	0.509	0.388	0.668	-0.676
sdi	0.864	0.685	1.088	-0.147
sdc	0.096	0.065	0.141	-2.347

Stochastic Reference Points W 95% CI

	estimate	cilow	ciupp	log.est
B_{MSY}	7309	3822.415	13977.373	8.897
F_{MSY}	0.069	0.036	0.132	-2.670
MSYs	506	368.377	696.197	6.227
$B_{trigger}$ = 0.5*B_{MSY}	3655	1911	6989	
B_{lim} = 0.3*B_{MSY}	2193	1147	4193	
F_{lim} =1.7*F_{MSY}	0.12	0.06	0.23	

Estimated states W 95% CI

	estimate	cilow	ciupp	log.est
B_2020.94	156	70	348	5.049
F_2020.94	0.030	0.011	0.079	-3.523
B_2020.94/B_{MSY}	0.021	0.007	0.061	-3.848
F_2020.94/F_{MSY}	0.426	0.132	1.381	-0.853

Predictions W 95% CI

	prediction	cilow	ciupp	log.est
B_2023.00	183	75	446	5.212
F_2023.00	0.030	0.005	0.168	-3.523
B_2023.00/B_{MSY}	0.025	0.007	0.085	-3.685
F_2023.00/F_{MSY}	0.426	0.067	2.718	-0.853
Catch_2022.00	5.2	1.4	18.7	1.6
E(B_inf)	10856	NA	NA	9.293

Table 13.1.8. ***Nephrops*** **in FUs 26–27, West Galicia and North Portugal. SPiCT estimates for B/B_{MSY} and F/F_{MSY}. CI, 95% confidence intervals.**

Year	B/B$_{MSY}$			F/F$_{MSY}$		
	Estimate	CI low	CI high	Estimate	CI low	CI high
1975	0.909	0.581	1.424	1.351	0.719	2.538
1976	0.893	0.574	1.389	1.367	0.732	2.554
1977	0.878	0.568	1.357	1.358	0.728	2.533
1978	0.863	0.562	1.327	1.348	0.722	2.515
1979	0.851	0.556	1.302	1.425	0.762	2.663
1980	0.838	0.550	1.276	1.821	1.044	3.175
1981	0.815	0.538	1.235	1.997	1.204	3.313
1982	0.770	0.513	1.158	2.090	1.261	3.464
1983	0.732	0.490	1.093	1.939	1.171	3.211
1984	0.689	0.464	1.023	2.042	1.224	3.404
1985	0.662	0.447	0.982	2.343	1.412	3.889
1986	0.619	0.419	0.914	2.428	1.455	4.052
1987	0.579	0.393	0.853	2.724	1.636	4.537
1988	0.531	0.361	0.781	3.087	1.863	5.116
1989	0.481	0.328	0.704	2.420	1.453	4.029
1990	0.432	0.296	0.632	2.411	1.420	4.093
1991	0.410	0.278	0.607	3.496	2.073	5.898
1992	0.369	0.249	0.548	3.615	2.141	6.104
1993	0.318	0.215	0.472	3.288	1.926	5.614
1994	0.278	0.186	0.414	4.060	2.369	6.957
1995	0.243	0.162	0.365	3.895	2.275	6.670
1996	0.199	0.133	0.299	4.289	2.464	7.463
1997	0.172	0.113	0.261	6.035	3.543	10.279
1998	0.132	0.088	0.198	6.135	3.682	10.223
1999	0.097	0.066	0.142	4.540	2.768	7.446
2000	0.073	0.051	0.104	4.253	2.597	6.965
2001	0.061	0.043	0.087	4.291	2.672	6.892
2002	0.050	0.035	0.070	3.522	2.175	5.701
2003	0.043	0.030	0.060	4.058	2.533	6.499
2004	0.037	0.026	0.052	3.386	2.119	5.410
2005	0.031	0.022	0.043	2.891	1.778	4.702
2006	0.028	0.020	0.040	3.641	2.241	5.915
2007	0.025	0.018	0.036	4.099	2.507	6.703
2008	0.021	0.015	0.031	4.438	2.670	7.379
2009	0.018	0.012	0.027	4.100	2.354	7.141
2010	0.015	0.009	0.023	3.684	1.964	6.911
2011	0.013	0.007	0.022	1.950	0.955	3.979
2012	0.011	0.006	0.022	0.668	0.311	1.435
2013	0.012	0.006	0.023	0.481	0.221	1.047
2014	0.012	0.006	0.025	0.323	0.144	0.724
2015	0.013	0.007	0.028	0.427	0.186	0.983
2016	0.015	0.007	0.031	0.543	0.228	1.294
2017	0.016	0.007	0.035	0.233	0.091	0.596
2018	0.017	0.007	0.040	0.388	0.145	1.037
2019	0.019	0.008	0.046	0.650	0.226	1.872
2020	0.020	0.008	0.053	0.426	0.128	1.417
2021	0.021	0.007	0.062			
Average	**0.305**	**0.202**	**0.462**	**2.581**	**1.508**	**4.456**

Table 13.1.9. *Nephrops* in FUs 26–27, West Galicia and North Portugal. Estimates of catch, B/B_{MSY} and F/F_{MSY} for the scenarios proposed and CI 95%.

SPiCT timeline:

Observations	Intermediate	Management
1975.00 - 2021.00	2021.00 - 2022.0(	2022.00 - 2023.00

|----------------------| --------------------- ---------------------|

Management evaluation: 2023.00

Predicted catch for management period and states at management evaluation time:

	C	B/Bmsy	F/Fmsy	B	F	perc.dB	perc.dF
1 F=0	0	0.03	0	188.9	0	12	-100
2 F=Fsq	5.2	0.03	0.43	183.4	0.03	8.8	0
3 F=Fmsy	0	0.03	0	188.9	0	12	-100
4 F=Fmsy_C_fr	0	0.03	0	188.9	0	12	-100

95% confidence intervals for states:

	B/Bmsy.lo	B/Bmsy.hi	F/Fmsy.lo	F/Fmsy.hi	B.lo	B.hi	F.lo	F.hi
1 F=0	0.01	0.09	0	0	79.6	448.3	0	0
2 F=Fsq	0.01	0.09	0.07	2.72	75.5	445.9	0.01	0.17
3 F=Fmsy	0.01	0.09	0	0	79.6	448.3	0	0
4 F=Fmsy_C_fr	0.01	0.09	0	0	79.6	448.3	0	0

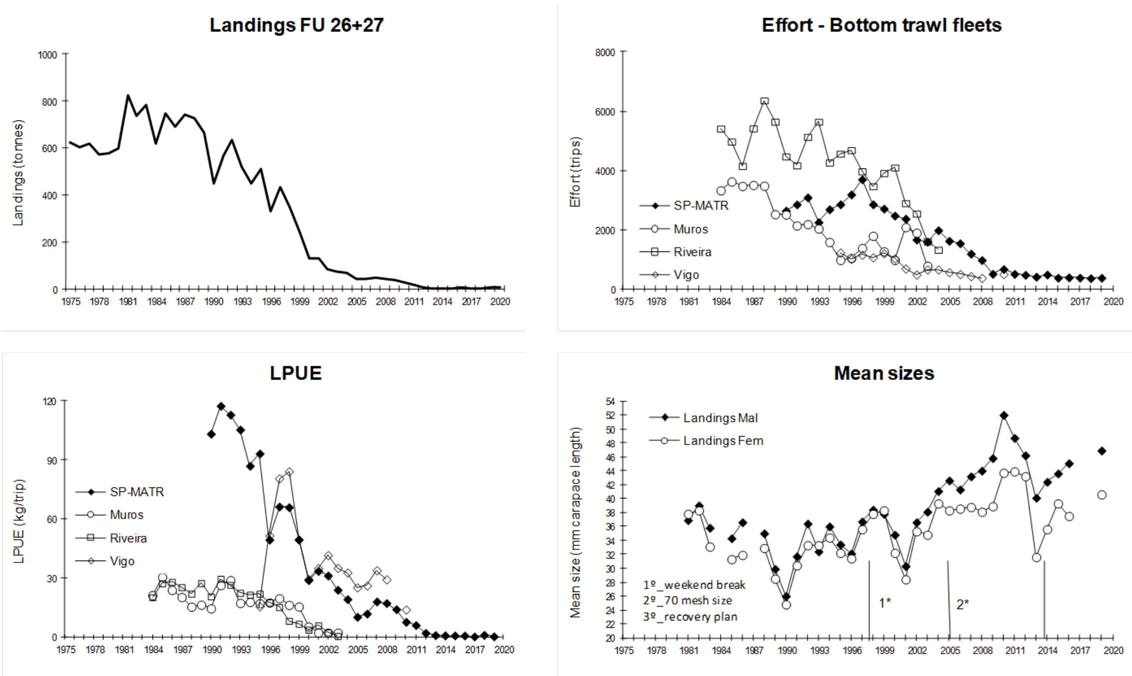

Figure 13.1.1. Figure 13.1.1. Nephrops in FUs 26–27. West Galicia and North Portugal. Long-term trends in landings, effort and mean sizes. Effort, LPUE and mean sizes for 2020 are not available.

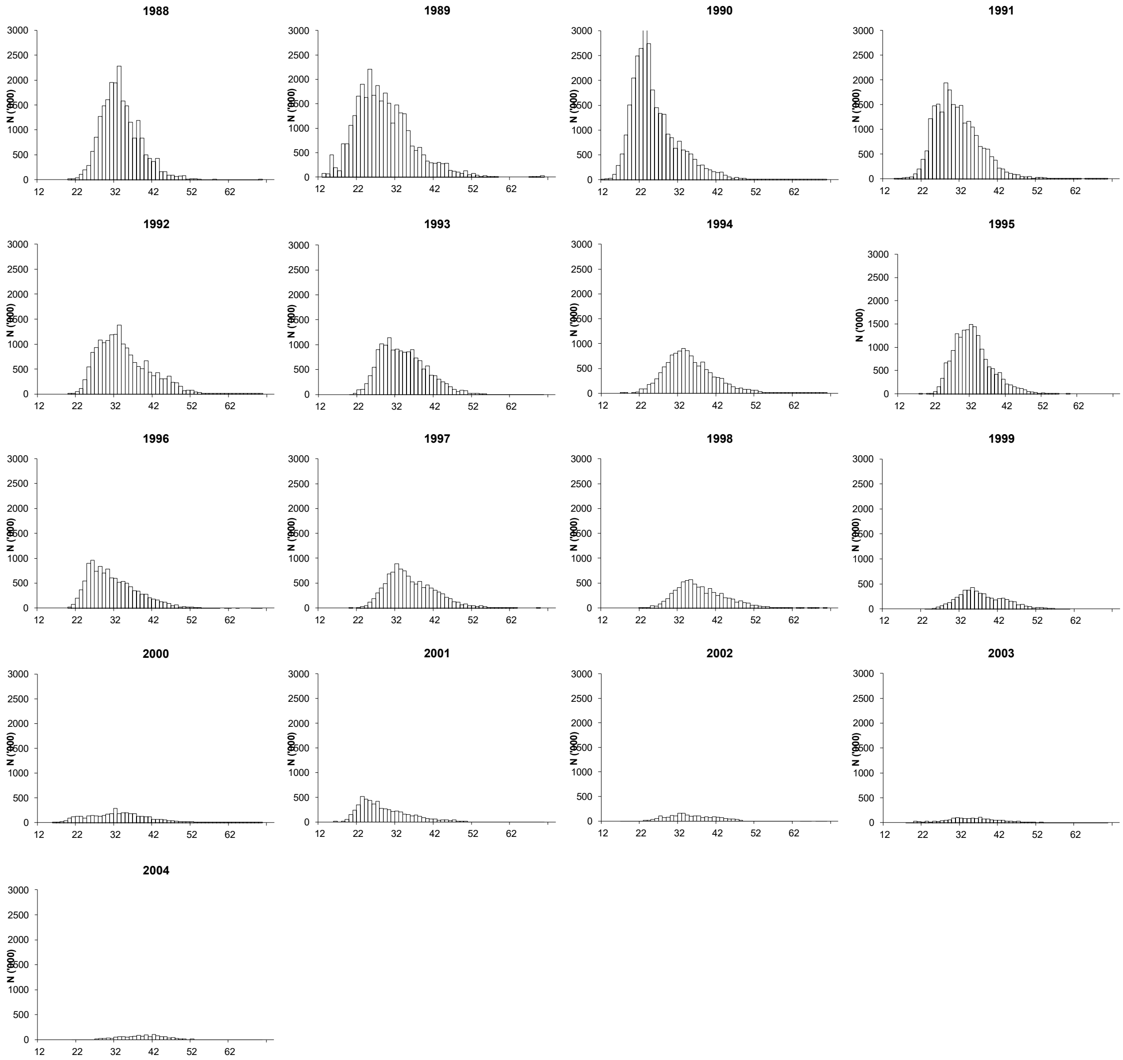

Figure 13.1.2a. *Nephrops* in FUs 26–27. West Galicia and North Portugal. Length–frequency distributions in landings for the 1988–2004 period.

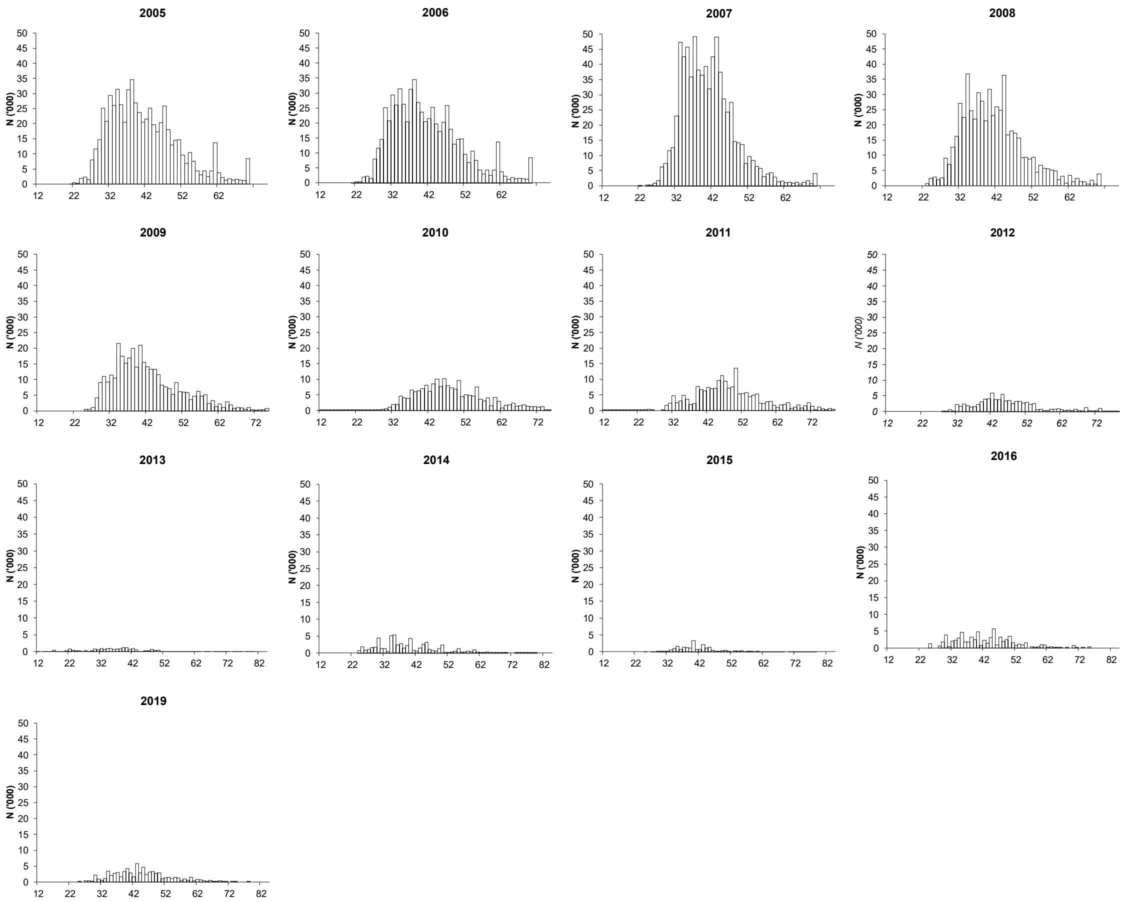

Figure 13.1.2b. *Nephrops* in FUs 26–27. West Galicia and North Portugal. Length–frequency distributions in landings for the 2005–2019 period. Data not available for 2017, 2018 and 2020.

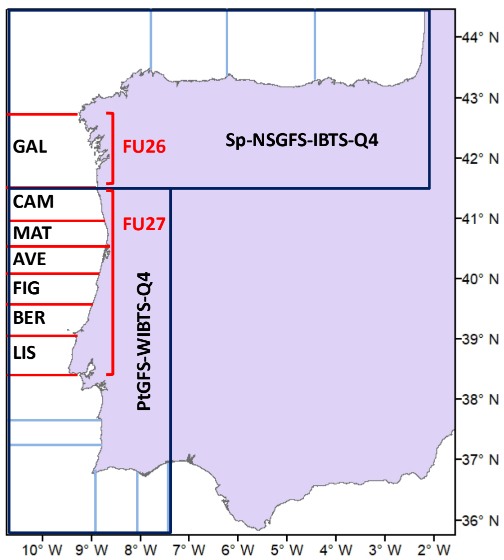

Figure 13.1.3. *Nephrops* in FUs 26–27. West Galicia and North Portugal. Area sectors covered by the Spanish International Bottom Trawl Survey-Q4 (G2784) in FU 26 and the Portuguese International Bottom Trawl Survey-Q4 (G8899) in FU 27. (GAL:Miño-Fisterra; CAM: Caminha; MAT: Matosinhos; AVE: Aveiro; FIG: Figueira da Foz; BER: Berlengas; LIS: Lisbon).

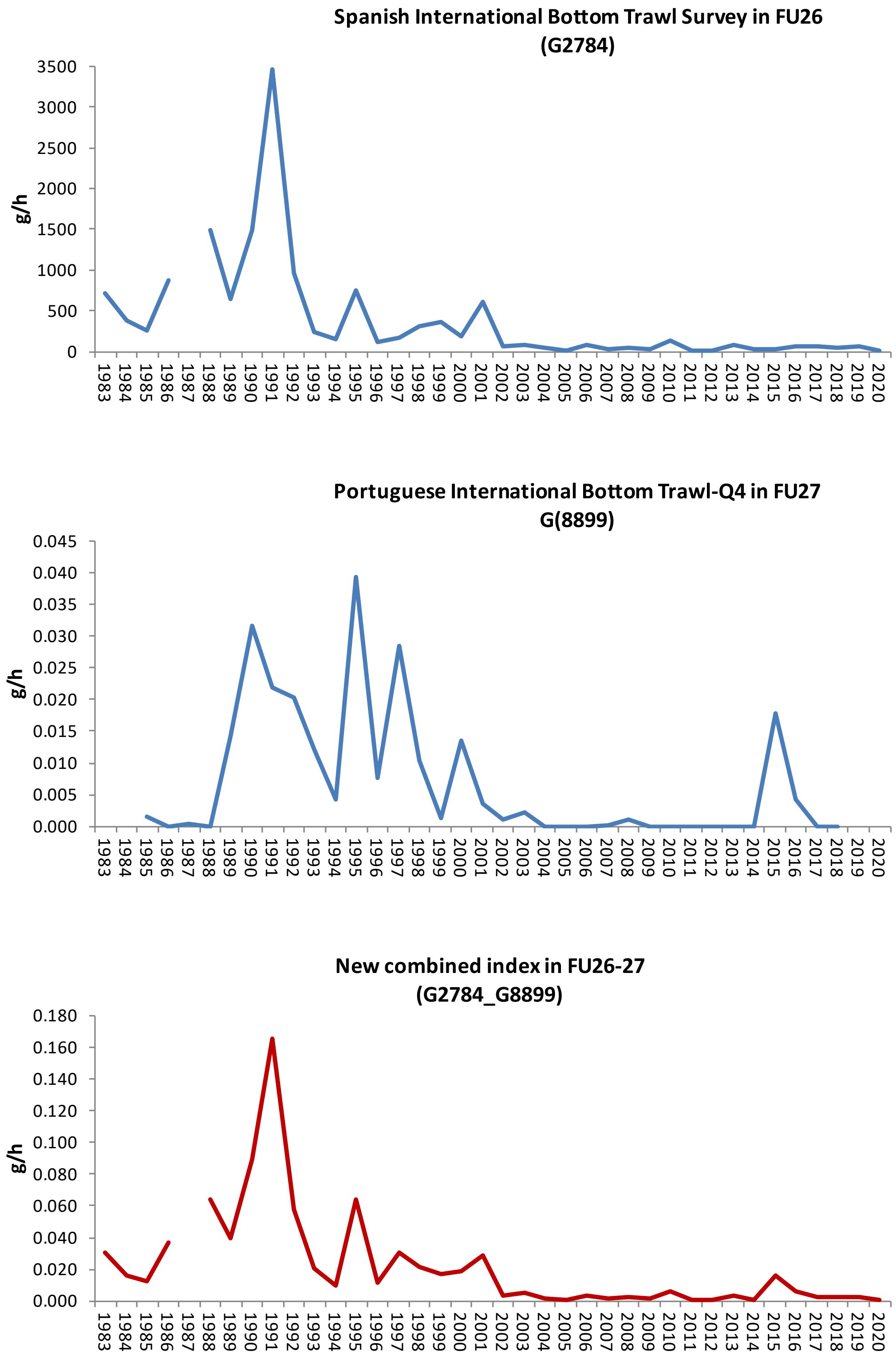

Figure 13.1.4. *Nephrops* in FUs 26–27. West Galicia and North Portugal. Biomass index (g/h) from Spanish International Bottom Trawl Survey-Q4 (G2784) in FU 26 (top panel), Portuguese International Bottom Trawl Survey-Q4 (G8899) in FU 27 (middle panel) and the new combined index from both surveys in FUs 26–27 (G2784_G8899) (bottom panel).

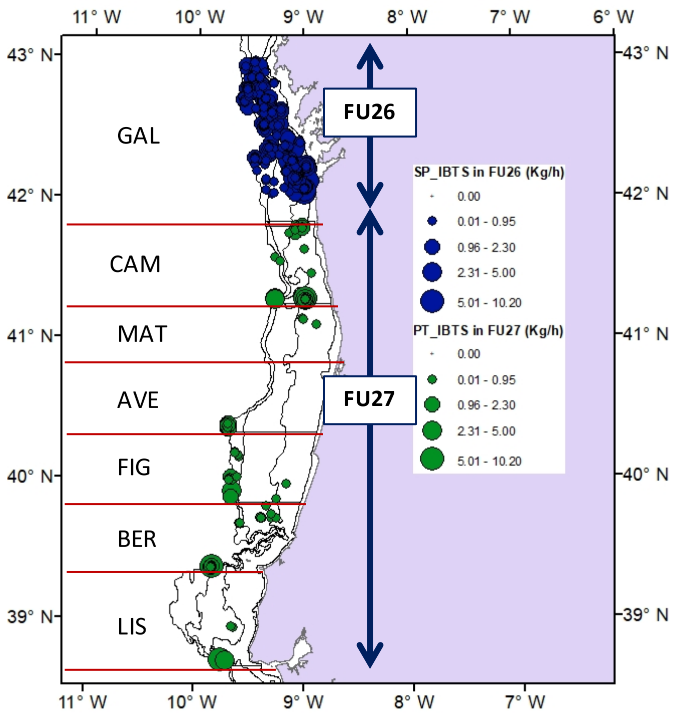

Figure 13.1.5. *Nephrops* in FU 26–27. West Galicia and North Portugal. *Nephrop*s spatial distribtion in FUs 26–27 from the Spanish (G2784) and Portuguese (G8899) International Bottom Trawl Surveys (blue and green, respectively) for the entire period (1983–2020). (GAL:Miño-Fisterra; CAM: Caminha; MAT: Matoshinhos; AVE: Aveiro; FIG: Figueira da Foz; BER: Berlengas; LIS: Lisbon).

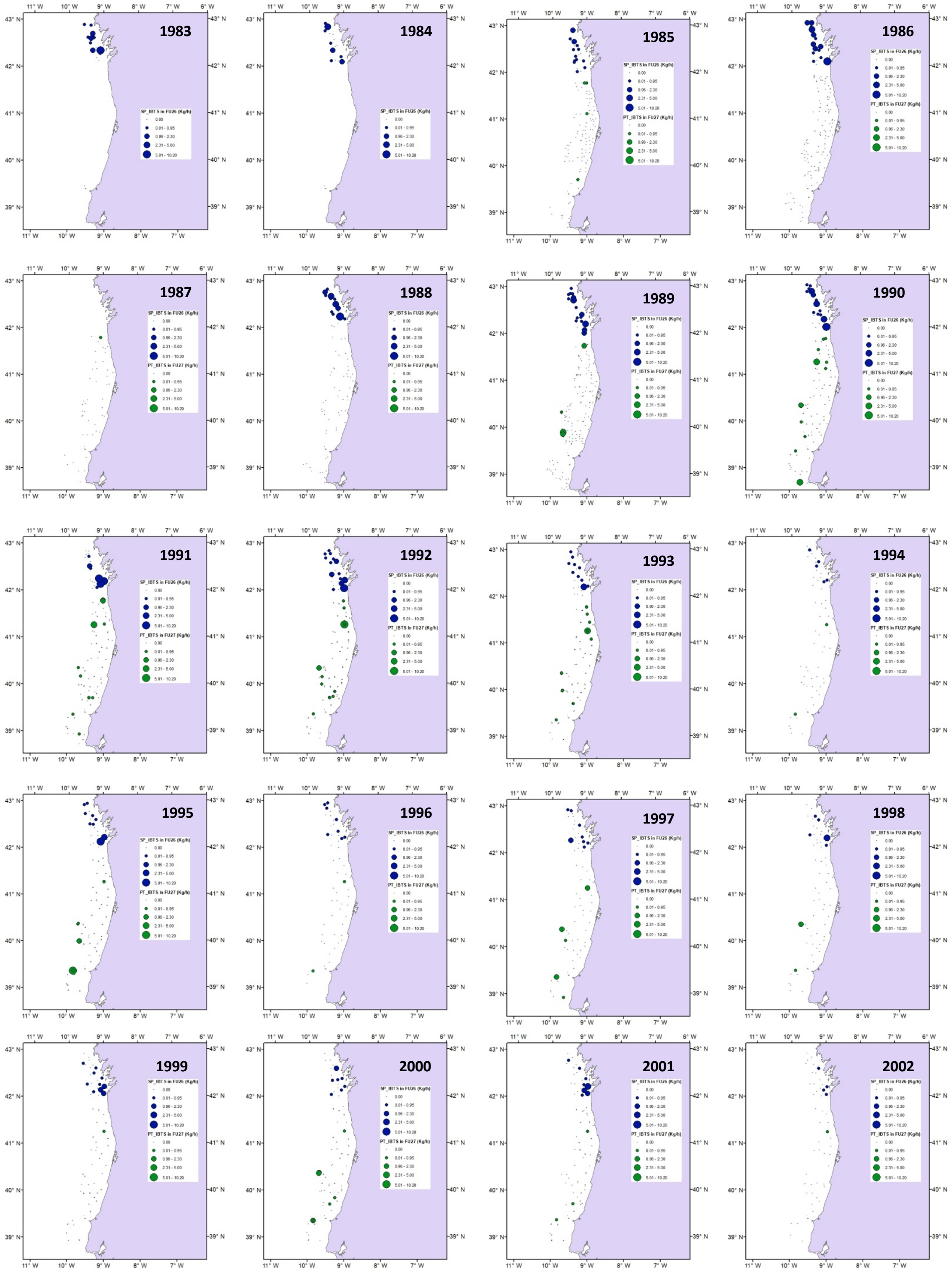

Figure 13.1.6a. *Nephrops* in FUs 26–27. West Galicia and North Portugal. Annual *Nephrops* spatial distribution from Spanish (G2784) and Portuguese (G8899) International Bottom Trawl Surveys (blue and green, respectively) for 1983–2002 period.

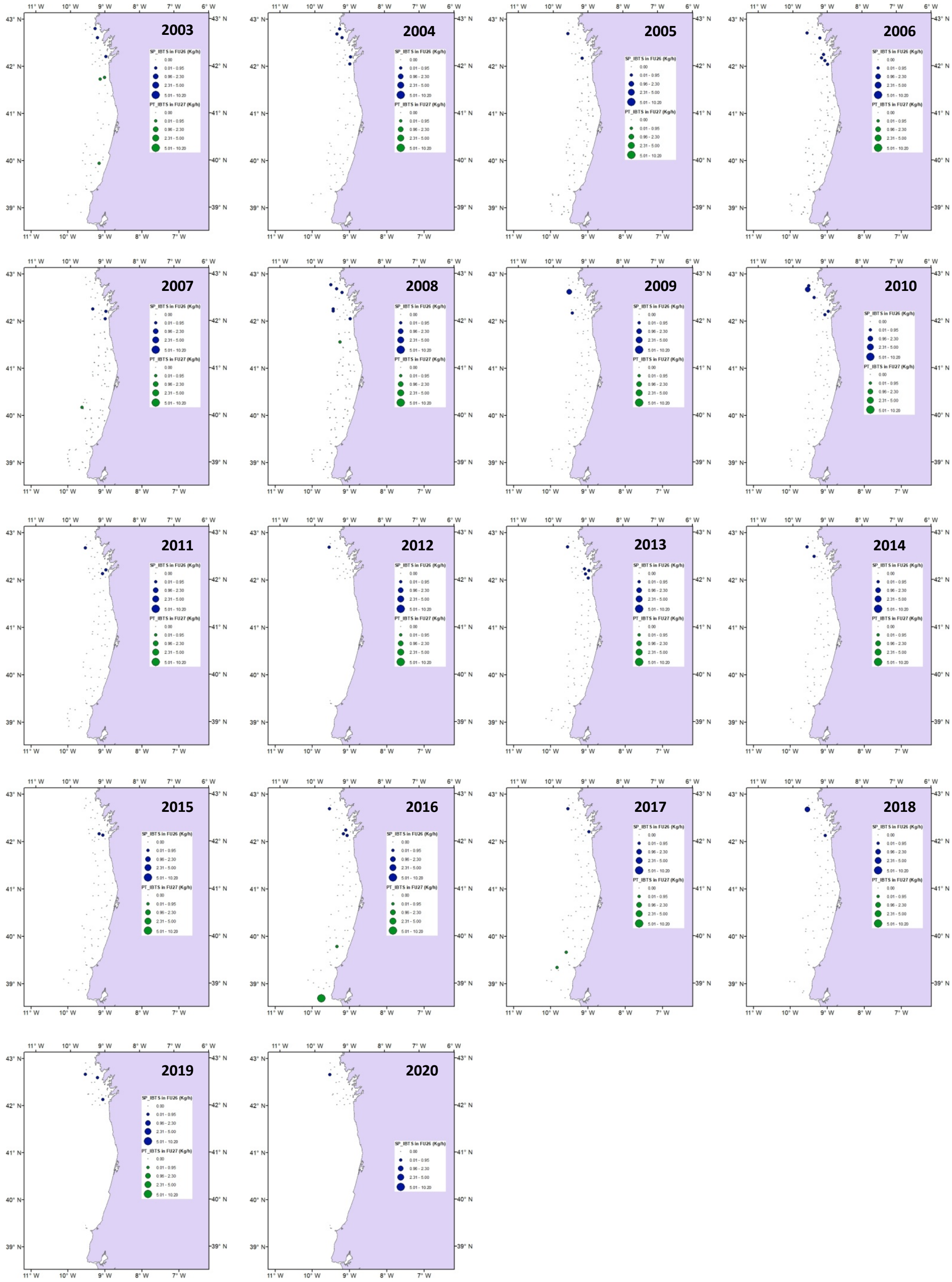

Figure 13.1.6b. *Nephrops* in FUs 26–27. West Galicia and North Portugal. Annual *Nephrops* spatial distribution from Spanish (G2784) and Portuguese (G8899) International Bottom Trawl Surveys (blue and green, respectively) for 2003–2020 period.

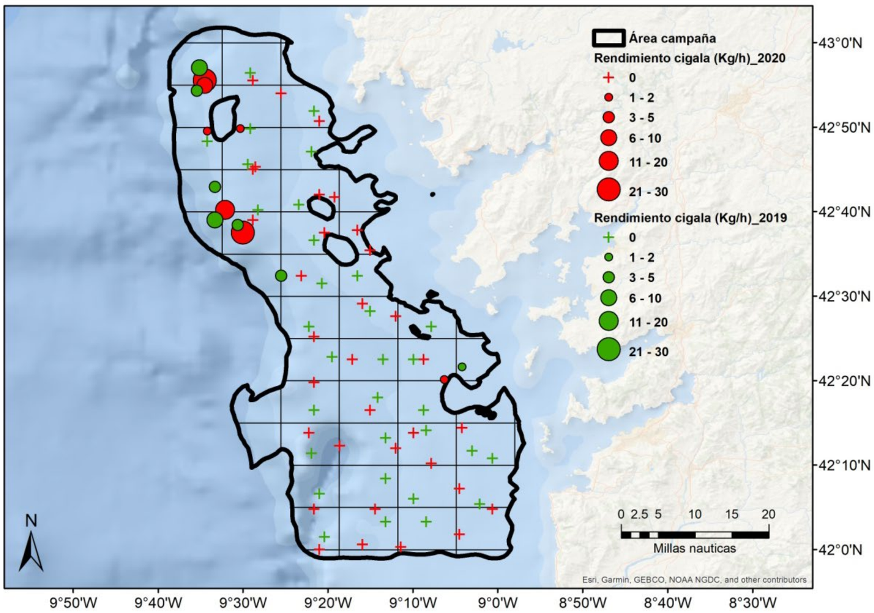

Figure 13.1.7. ***Nephrops*** **in FUs 26–27. West Galicia and North Portugal.** ***Nephrops*** **biomass spatial distribution from the 2019 (green bubble) and 2020 (red bubble) GALNEP_26 survey in FU 26.**

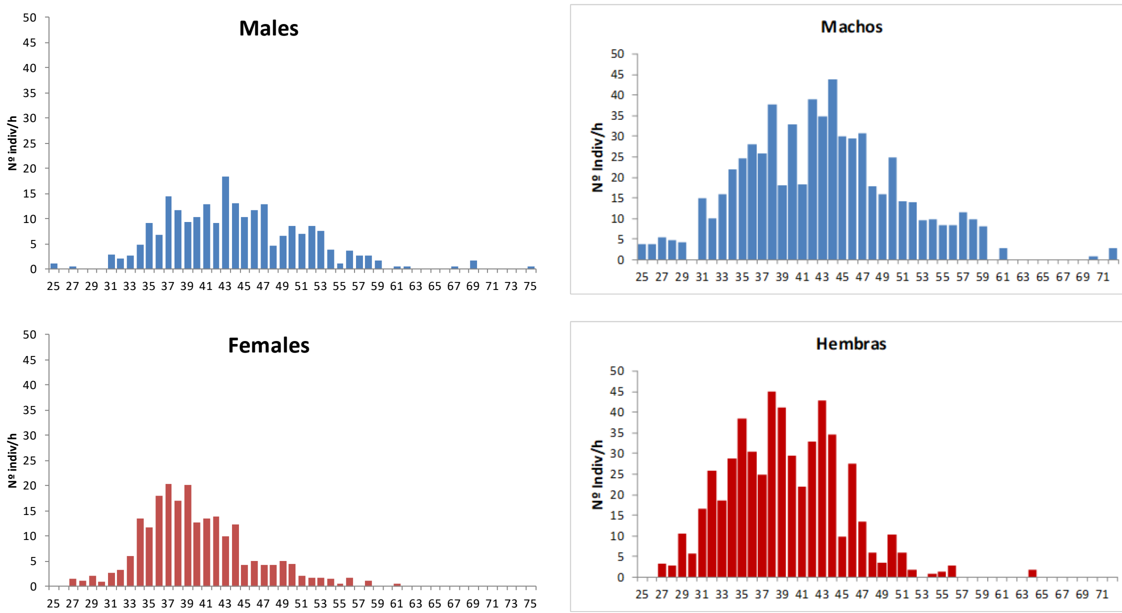

Figure 13.1.8.*Nephrops* **in FUs 26–27. West Galicia and North Portugal. Length–frequency distribution by sex from GAL-NEP-26 survey.**

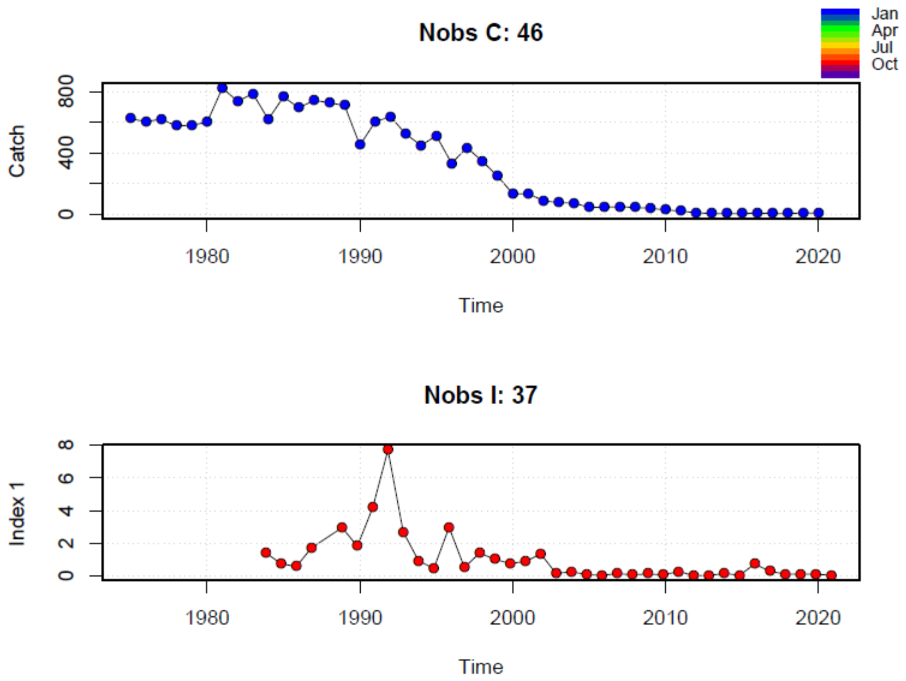

Figure 13.1.9. ***Nephrops*** **in FUs 26–27. West Galicia and North Portugal Input data in the SPiCT Model. Total landings (tonnes) in FUs 26–27 (1975–2020, top panel) and new combined index (G2784_G8899) in FUs 26–27 (1983 – 2020, lower panel).**

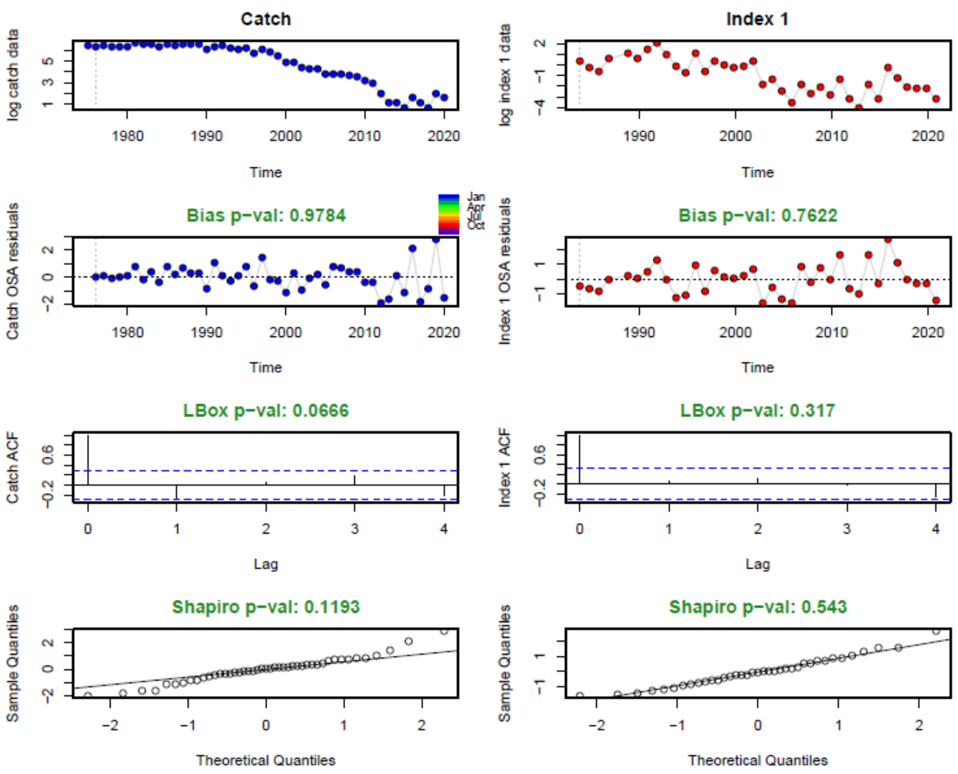

Figure 13.1.10. ***Nephrops*** **in FUs 26–27. West Galicia and North Portugal. SPiCT Model: Diagnostics. Row1, Log of the input dataseries. Row 2, OSA residuals with the p-value of a test for bias. Row 3, Empirical autocorrelation of the residuals with tests for significant autocorrelation. Row 4, Tests for normality of the residuals, QQ-plot and Shapiro test.**

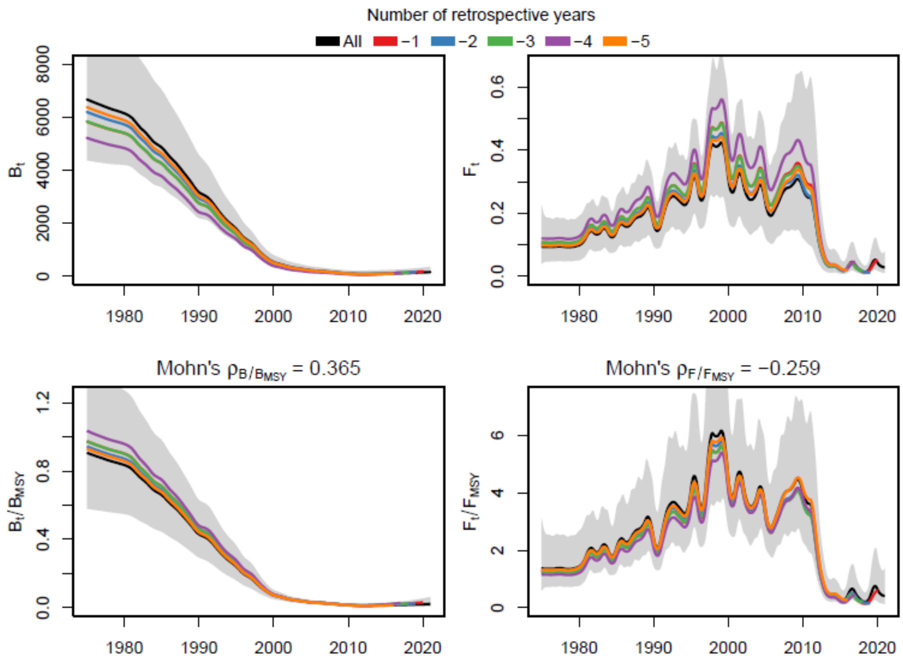

Figure 13.1.11. ***Nephrops*** **in FUs 26–27. West Galicia and North Portugal. SPiCT Model: 5 years' retrospective pattern. Absolute biomass and fishing mortality. (top panel); Relative biomass and fishing mortality (Bottom panel). Grey regions represent the 95% CIs.**

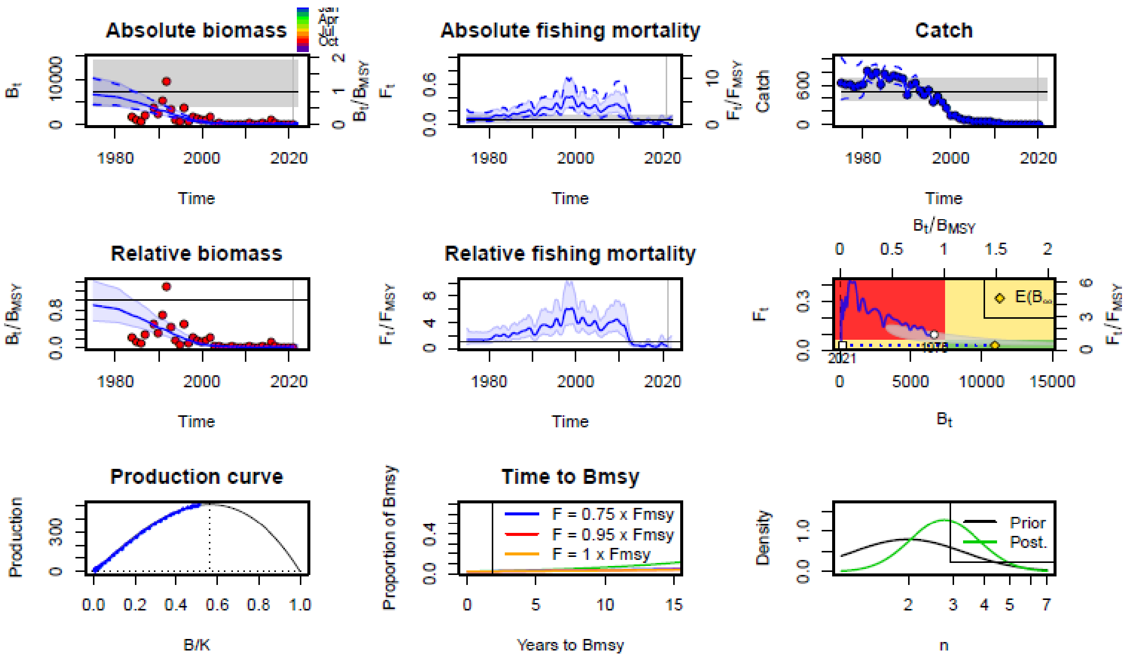

Figure 13.1.12. ***Nephrops*** **in FUs 26–27. West Galicia and North Portugal. SPiCT Model: Results. Absolute biomass, fishing mortality and catch (top panel); Relative biomass, fishing mortality and Kobe plot (middle panel), Production curve and n density plot (bottom panel). Solid blue lines are estimated values; vertical grey lines indicate the time of the last observation beyond which dotted lines indicate forecasts; dashed lines are 95% CIs for absolute estimated values; shaded blue regions are 95% CIs for relative estimates; grey regions represent 95% CIs for estimated absolute reference.**

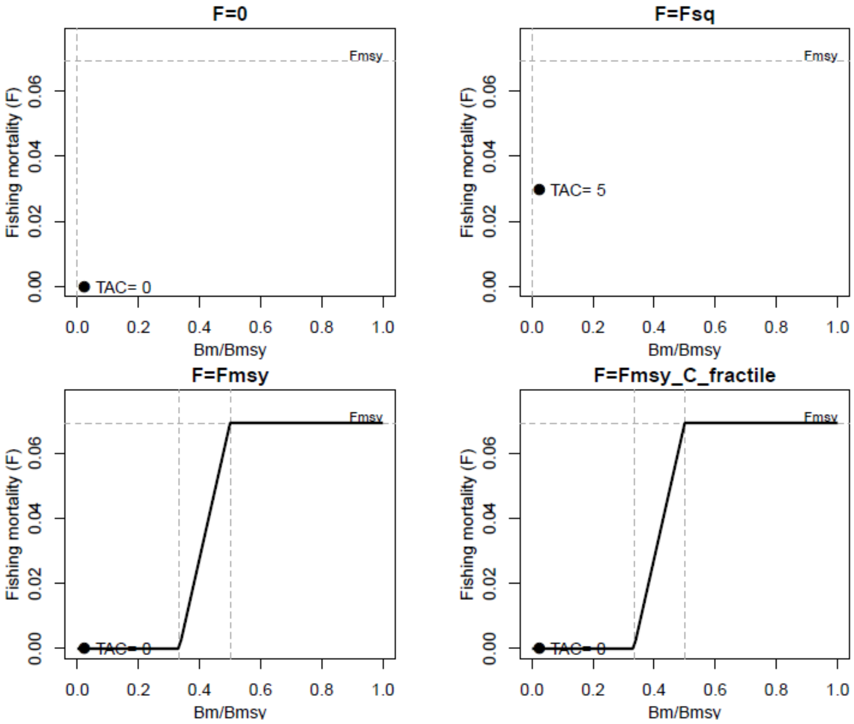

Figure 13.1.13. *Nephrops* in FUs 26–27. West Galicia and North Portugal. Harvest control rule for the four scenarios used in the forecast.

13.2 *Nephrops* in Functional Units (FUs) 28–29 (SW and S Portugal)

13.2.1 General

13.2.1.1 Ecosystem aspects

See Stock Annex.

13.2.1.2 Fishery description

See Stock Annex (in Annex L of this WG report)

13.2.1.3 ICES Advice for 2021 and management applicable for 2020 and 2021

ICES Advice for 2021

The advice for this stock is biennial and valid for 2020 and 2021. Based on the ICES approach for data-limited stocks (DLSs), ICES advises that catches in 2021 for FUs 28 and 29 should be no more than 309 t.

To ensure that the stock in FUs 28 and 29 are exploited sustainably, ICES advises that management should be implemented at the FU level.

Management applicable for 2020 and 2021

A recovery plan for southern hake and Iberian *Nephrops* stocks was enforced since the end of January 2006. The aim of the recovery plan was to rebuild the stocks within 10 years, with a reduction of 10% in F relative to the previous year and the TAC set accordingly (Council Regulation (EC) No 2166/2005, 2005). ICES did not evaluate the recovery plan for *Nephrops* in relation to the precautionary approach. This plan was based on precautionary reference points for southern hake that are no longer appropriate. A new Management Plan for Western Waters (Regulation (EU) 2019/472, 2019a) was established in 2019 for demersal species including *Nephrops* in these FUs and the former recovery plan was repealed. In the current Management Plan for Western Waters, applied to 2020 onwards, no effort limitations were established.

In order to further reduce the fishing pressure on *Nephrops* stocks in Division 9.a, seasonal restrictions were introduced in the trawl and creel fishery for two boxes (geographic areas) located in FUs 26 and 28, during the peak of the *Nephrops* fishing season. These restrictions are applied to *Nephrops* fishing in these boxes in June–August and May–August, respectively, which is an amendment by the Council Regulation (EC) No 2166/2005 (2005) of the previous one issued in 1998 (Council Regulation (EC) No 850/98, 1998). The latter was also repealed by a recent regulation (Regulation (EU) 2019/1241, 2019b) but kept the two boxes allowing fishing *Nephrops* only as bycatch.

The TAC set for the whole Division 9.a was 386 and 374 t for 2020 and 2021, respectively, of which no more than 6% may be taken in FUs 26 and 27, and no more than 77 t in 2020 and 65 t in 2021 may be taken in FU 30 (Council Regulation (EU) 2021/92, 2021).

13.2.2 Data

13.2.2.1 Commercial catches and discards

Table 13.2.1 and Figure 13.2.1 show the landings dataseries for these FUs. For the period 1984 to 1992, the recorded landings from FUs 28 and 29 have fluctuated between 420 and 530 t, with a long-term average of about 480 t, falling drastically down to 132 t in the period 1990–1996. From 1997 to 2005, landings increased to similar levels observed during the early 1990s then decreased until 2009. The landings values were approximately at the same level (≈ 150 t) for the years 2009–2011, presenting an increasing trend in the last period of the series. In recent years, the reduced TAC has limited the fishing activity, and the fishery has been closed for 1–2 months in the second semester from 2013 onwards.

Since 2011, landings include the Spanish official landings. Spanish vessels are licensed to fish for crustaceans in these FUs under a bilateral agreement since 2004. No data from these vessels' operations is available prior to 2011.

Spanish official landings are derived from logbooks. This source of information allows landings disaggregation by ICES statistical rectangles. In 2012 and 2013, *Nephrops* catches were recorded in statistical rectangles outside the FUs in Division 9.a were allocated to the closest rectangles in each FU. In 2014–2017, 100% of the caches were from FUs 28–29.

Males are the dominant component in most of the years in the time-series with an exception for 1995 and 1996 when total female landings exceeded male landings (ICES, 2006). The male:female ratio in 2019 and 2020 were 1.8:1.0 and 1.6:1.0, respectively.

Information on discards and on the sampling program was sent to the WG through the ICES Accessions. The frequency of *Nephrops* occurrence in discards samples is very low. Discards are negligible in this fishery and mostly due to quality and not related to the minimum landing size (MLS = 20 mm of carapace length). It was only in 2013 when the occurrence of *Nephrops* in discards samples was greater than 30% and a total amount of 3 t was estimated, with a high coefficient of variation (CV = 58%). In 2020, the Portuguese on-board sampling programme was compromised by the COVID-19 pandemic situation and the sampling only occurred during the first quarter of the year. Since discards were considered negligible for *Nephrops* during the whole sampling period 2004–2019, this was also assumed to be the case for the 2020 assessment.

13.2.2.2 Biological sampling

Length distributions for both males and females for the Portuguese trawl landings are obtained from samples taken weekly at the main auction port, Vila Real de Santo António. Sampling frequency in 2019 was at the same level as in previous years and occurred in months when the Norway lobster fishing was open. The sampling data were raised to the total landings by market size category, vessel, and month.

The length compositions by sex of the landings are presented in Tables 13.2.2a-b and Figures 13.2.2a-b. The number of samples and measured individuals are presented in Table 1.4a.

Length compositions for the period 2017–2019 were revised in 2020 due to a problem in the extraction process.

In 2020, *Nephrops* sampling in Portuguese markets was affected by the COVID-19 pandemic and no sampling was conducted during April, May, July, and August. Raising of the length compositions for the missing months was based on the mean length composition of the last three years (2017–2019) in each of those months.

13.2.2.3 Biomass indices from surveys

Trawl surveys

Since 1997, groundfish (PtGFS-WIBTS-Q4; G8899) and crustacean trawl surveys (NepS (FU 28–29)) were carried out every year, covering FUs 28 and 29. Table 13.2.3 and Figure 13.2.1 shows the average *Nephrops* cpues (kg/h trawling) from the crustacean trawl surveys, which can be used as an overall biomass index. As the surveys were performed with a smaller mesh size than the commercial fishery, this information provides a better estimation of the abundance for small-sized individuals. There was an increase in the overall biomass index in the period 2003–2005, and of small individuals in a particular juvenile concentration area in 2005, which could be an indication of higher recruitment.

The R/V "NORUEGA" had some technical problems in 2010 and could not trawl in areas deeper than 600 m. The survey plan had to be adapted accordingly. The cpue value estimated for 2010, the highest value for the whole series, was probably affected by this change. In 2011, due to an engine failure, the survey did not cover the whole area of *Nephrops* distribution. No cpue index was presented for this year. The following year, budgetary constraints of national scope led to the unfeasibility of the R/V NORUEGA to be repaired as well as the chartering of a replacement research vessel and, therefore, no survey was conducted in 2012.

The biomass index estimated from the 2013 survey is only comparable to the value of 2009, which covered the same area. Comparing the fraction of the area covered in 2011 and the same area in 2013, the biomass of *Nephrops* increased in the area of Alentejo (FU 28). The survey in 2011 did not cover the main area of concentration in Algarve (FU 29).

The survey area was adapted in 2014, taking into account the information from the fishing grounds obtained from the VMS data. Figure 13.2.3 shows the spatial distribution of the survey biomass index in the last 4 years.

In 2019, the survey was not conducted due to issues external to IPMA.

In 2020, the survey was also not conducted due to legal constraints at the national level that made it unfeasible for hiring fishing and vessel crews on time to undertake the survey. This was not due to the COVID-19 pandemic disruptions.

UWTV experiments

In 2005 and 2007, some experiments to collect UWTV images from the *Nephrops* fishing grounds were made with a camera hanging from the trawl headline. In 2008, the images collected from 9 stations in FU 28 with the same procedure showed very promising results. During the 2009 survey, a two-beam laser pointer was attached to the camera and UWTV images were recorded from 58 of the 65 sampled stations. The trawling speed and the water turbidity were the main problems affecting image clarity and the high variation of the camera height to the ground. Both factors contributed to significant variations in the field of view. It was not possible to guarantee that this method can be used for abundance estimation, mainly due to these uncertainties (information presented to SGNEPS 2012–Study Group of *Nephrops* Surveys (ICES, 2012b).

13.2.2.4 Mean sizes

Mean carapace length (CL) data for males and females in the landings and surveys are presented for the period 1994-2020 (Table 13.2.4). Figure 13.2.1 shows the mean CL trends since 1984. The mean sizes of males and females have fluctuated along the period with no apparent trend.

13.2.2.5 Commercial catch-effort data

The effort in 2003–2004 corresponds to only eleven months of fleet operations for each year as the crustacean fishery was experimentally closed in January 2003 and 30 days for *Nephrops* fishery in September–October 2004.

A Portuguese national regulation (Portaria no. 1142/2004, 2004) closed the crustacean fishery in January-February 2005 and enforced a ban in *Nephrops* fishing for 30 days in September – October 2005. As a result, the effort in 2005 corresponds only to nine months.

The recovery plan for southern hake and Iberian *Nephrops* stocks was approved in December 2005 and entered into force at the end of January 2006. This recovery plan includes a reduction of 10% in F relative to the previous year (Council Regulation (EC) No 2166/2005, 2005). As a result, the number of fishing days per vessel was progressively reduced. Additional days were allocated in 2010 to Spanish and Portuguese vessels within divisions 8.c and 9.a excluding the Gulf of Cádiz, on the basis of the permanent cessation of vessels from each country (Commission Decision No 2010/370/EU, 2010a; Commission Decision No 2010/415/EU, 2010 b).

Besides this effort reduction, the Council Regulation (EC) No 850/98 (1998) was amended by the Council Regulation (EC) No 2166/2005 (2005), with the introduction of two boxes in Division 9.a, with one of them located in FU 28. In the period of higher catches (May-August), this box is closed for *Nephrops* fishing. By way of derogation, fishing with bottom-trawls in these areas and periods is authorized provided that the bycatch of Norway lobster does not exceed 2% of the total weight of the catch. The same applies to creels that do not catch *Nephrops*.

The effort reduction measures were combined with a national regulation closing the crustacean fishery every year in January (Portaria no. 43/2006, 2006). In 2016, this period was extended until February. Besides the closed season in 2013–2016, the Portuguese vessels had to stop fishing for 1.5 to 2 months, in October-November, due to quota limitations. With regards to the Spanish fleet, the number of fishing days was reduced due to sanctions imposed by EC related to the catches exceeding the quota in 2012. The operation of this fleet was also affected in the Portuguese fishing grounds for the period 2013–2015.

Crustacean vessels target two main species, rose shrimp and Norway lobster, which have different market values. Depending on their abundance and availability, the effort is mostly directed at one species or the other (Figure 13.2.4). A standardized cpue series for *Nephrops* (Figure 13.2.5) based on Portuguese crustacean trawlers' logbooks and VMS records, is used to estimate the fishing effort in standard hours. The model used to standardize the cpue is described in the Stock Annex. In 2020, a new approach for the standardization of the cpue series to incorporate both positive and null catches of *Nephrops* was presented and accepted during the WKMSYSPiCT (ICES, 2021). Other improvements made to the model, include i) the incorporation of a variable to account for the spatial dimension of the *Nephrops* distribution (fishing ground), ii) the replacement of the variables used to mimic the target fishing in the previous model, that was not truly independent from the response variable, by a cluster-based variable estimated from the catch composition of the main crustacean species caught by the fishery; iii) the inclusion of the 'vessel' variable as a random effect, and iv) the estimation of the mean standardized annual cpue considering all the factor levels and not only for a reference set of levels like in the previous model. The variability explained by the model increased from 51% to 60%, although both the previous and the new model produced similar trends (Figure 13.2.5).

Standardized effort in trawling hours is estimated based on the latest modelled series, dividing the total catch by the standardized cpue. In the period 2008–2020, the standardized fishing effort has fluctuated around an average of approximately 199 thousand hours (Table 13.2.5).

13.2.3 Assessment

The advice for this stock is biennial. The stock data were updated with the new information for 2020.

The advice is based on the standardized commercial cpue trend and the relative F obtained from Mean Length-Z (MLZ) model. According to the ICES data-limited approach, this stock is classified as category 3.2.0 (ICES, 2012).

The standardized effort (Figure 13.2.1) shows a consistent declining trend since 2005 reaching a historic low in 2009–2010. Since then, the effort has fluctuated at a low level due to a quota reduction derived from the application of the former recovery plan rules.

The standardized commercial cpue (Figure 13.2.5), used as an index of biomass, shows an overall increasing trend since 2014. Despite the decreasing values in the last three years, this index is still above the levels from 2014–2017. The crustacean survey biomass index also showed an increasing trend in 2014–2018 (Figure 13.2.3).

Length-based indicators (LBIs), defined at WKLIFE V (ICES, 2015), were used to assess the status of the stock conservation. The ratios L_c/L_{mat} and $L_{25\%}/L_{mat}$ indicate that immature individuals are preserved. However, $P_{mega} < 30\%$ indicates a truncated length distribution of the female catch which may be explained by their reproductive behaviour of not leaving the burrows during the egg-bearing period (Table 13.2.6 and Figure 13.2.6).

Assuming a constant M of 0.3 for males and 0.2 for females, F was estimated using the MLZ method as defined in WKLIFE-V (ICES, 2015) and WKProxy (ICES, 2016). The input data and the output of Gedamke and Hoenig (G&H; Gedamke and Hoenig, 2006) and Then, Hoenig and Gedamke (THoG; Then, 2014) models are summarized in Table 13.2.7. Figures 13.2.7 and 13.2.8 show the model diagnostics for G&H model and the F series estimated by the THoG model.

G&H model with two periods gives a better fit and a lower AIC. For the last period, fishing mortality was estimated at 0.17 for males and 0.10 for females.

The results indicate that the stock is exploited at a level below the F_{MSY} proxy, either with the Gedamke & Hoenig or the THoG model, although the latter gives much lower F values. The M value estimated by the THoG model is also greater than the fixed M, historically assumed for *Nephrops* stocks. The results of the models were accepted using fixed values for M (0.3 for males and 0.2 for females) which give higher F values, although still below F_{MSY}.

Length-based Stock Potential Ratio (LBSPR), defined at WKLIFE V (ICES, 2015), was used to estimate the values of ratio F/M, selectivity-at-length, and the resulting SPR (Hordyk *et al.*, 2015) (Figure 13.2.9). As one of the assumptions of the model is parity of the sex ratio of the catch, and males are more abundant in catches than females, the recommendation is to only consider the model for females (Hordik *et al.*, 2015). The lowest F/M and highest SPR are observed since 2000.

The SPR estimates are above SPR target (30–40%) which indicate that the spawning-stock biomass (SSB) is maintained at a sustainable level (ICES, 2015).

In February 2021, a Benchmark workshop (WKMSYSPiCT) on the application of SPiCT to produce MSY advice for selected stocks including *Nephrops* in FUs 28–29 was conducted (ICES, 2021). Given the input data available for the stock, different model configurations produced contradictory results and it was not possible to distinguish between two alternative stock statuses. For this reason, the SPiCT model was not accepted to provide assessment and advice for this stock. Thus, the stock remains in category 3.

13.2.4 Biological reference points

Proxies of MSY reference points were reviewed in WGBIE 2017 (ICES, 2017) using the methods developed in WKLIFE V and WKProxy (ICES, 2015; 2016). From length-based analysis of the period 1984–2016, the values of $F_{0.1}$ were updated at 0.23 for males and 0.24 for females, as proxies of F_{MSY}. No proxy for B_{MSY} was identified (ICES, 2017).

In November 2019, a workshop on methodologies for *Nephrops* reference points was held in Lisbon to evaluate reference point estimation methods for stocks with UWTV surveys and to evaluate the utility of other modelling frameworks to assess and provide reference points for *Nephrops* stocks (ICES, 2020). Besides the LBIs and MLZ models (WKLIFE V, ICES, 2015) which are already used in the assessment of this stock, other approaches as Separable Cohort Analysis (*SCA* R package, version 1.2.0; Bell, 2019), Separable Length Cohort Analysis (SLCA – *nepref* R package, version 0.2.2; Dobby, 2019), Length-based Stock Potential Ratio (LBSPR, Hordyk *et al.*, 2015) and Surplus Production in Continuous Time (SPiCT, Pedersen and Berg, 2017) were tested.

13.2.5 Management considerations

Nephrops is caught by a multispecies and mixed bottom-trawl fishery.

A recovery plan for southern hake and Iberian *Nephrops* stocks was approved in December 2005 and in action since the end of January 2006 (Council Regulation (EC) No 2166/2005, 2005). This recovery plan includes a reduction of 10% in the hake F relative to the previous year and TAC set accordingly, within the limits of ± 15% of the previous year TAC. Although no clear targets were defined for Norway lobster stocks in the plan, the same 10% reduction has been applied to these stocks' TAC. The number of allowed fishing days is set in each year by EU regulation fixing the fishing opportunities for fish stocks, applicable in Union waters. The recovery plan target and rules have not been changed since it was implemented. In March 2019, a new multiannual plan (MAP) for stocks fished in the Western Waters (including the *Nephrops* stocks in these FUs) and adjacent waters was established, repealing the previous recovery plan (Regulation (EU) 2019/1241, 2019b).

Besides the recovery plan, the Council Regulation (EC) No 850/98 (1998) was amended with the introduction of two boxes in Division 9.a, one of them located in FU 28 (Council Regulation (EC) No 2166/2005, 2005). In the period of higher catches (May-August), this box is closed for *Nephrops* fishing. By derogation, fishing with bottom-trawls in these areas and periods are authorized provided that the bycatch of Norway lobster does not exceed 2% of the total weight of the catch. The same applies to creels that do not catch *Nephrops*. Recently, a new Regulation (Regulation (EU) 2019/1241, 2019b) repealed the one implemented in 1998 but kept the two boxes allowing fishing *Nephrops* only as bycatch.

With the aim of reducing effort on crustacean stocks, a Portuguese national regulation (Portaria no. 1142/2004, 2004) closed the crustacean fishery in January-February 2005 and enforced a ban in *Nephrops* fishing for 30 days in September–October 2005 in FUs 28–29. This regulation was revoked in January 2006, after the entry in force of the recovery plan and the amendment to the 1998’ management plan, keeping only one month of closure of the crustacean fishery in January (Portaria no. 43/2006, 2006). This one-month closure period was extended for another month, until 29 February in 2016 (Portaria no. 8-A/2016, 2016). The national regulations are only applicable to the Portuguese fleet.

Portugal and Spain have bilateral agreements for fishing in each other’s waters. The agreement for the period 2004–2013 was reviewed and extended for the period 2014–2016. Under this agreement, a number of Spanish trawlers are licensed to fish crustaceans in Portuguese waters. No information from landings of these vessels is available for the years prior to 2011.

Unwanted catches from *Nephrops* are regulated by the discard plan for demersal fisheries in South-Western waters for the period 2019–2021 (Commission Delegated Regulation (EU) 2018/2033, 2018 replaced by Commission Delegated Regulation (EU) 2019/2237, 2019), under which they are exempted from the landing obligation based on the species’ high survival rates as provided for in Article 5(4b) of Regulation (EU) No 1380/2013 (2013). This exemption applies to all catches of Norway lobster from ICES subareas 8 and 9 with bottom-trawls, and where all *Nephrops* discards shall be released immediately, and in the area where they were caught (Commission Delegated Regulation (EU) 2019/2237, 2019).

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13.2.7 Tables and figures

Table 13.2.1. *Nephrops* in South-West and South Portugal (FUs 28–29). Total landings (tonnes) per country.

Year	FU 28+29 SW+S Portugal					
	28*	29			28+29	Total
	Spain	Spain			Portugal	
	Trawl	Trawl	Artisanal	Trawl	Total	
1975	137	1510		34	34	1681
1976	132	1752		30	30	1914
1977	95	1764		15	15	1874
1978	120	1979		45	45	2144
1979	96	1532		102	102	1730
1980	193	1300		147	147	1640
1981	270	1033		128	128	1431
1982	130	1177		86	86	1393
1983				244	244	244
1984				461	461	461
1985				509	509	509
1986				465	465	465
1987			11	498	509	509
1988			15	405	420	420
1989			6	463	469	469
1990			4	520	524	524
1991			5	473	478	478
1992			1	469	470	470
1993			1	376	377	377
1994				237	237	237
1995			1	272	273	273
1996			4	128	132	132
1997			2	134	136	136
1998			2	159	161	161

Year	FU 28+29 SW+S Portugal					
	28*	29			28+29	Total
	Spain	Spain			Portugal	
	Trawl	Trawl	Artisanal	Trawl	Total	
1999			5	206	211	**211**
2000			4	197	201	**201**
2001			2	269	271	**271**
2002			1	358	359	**359**
2003			35	335	370	**370**
2004			31	345	375	**375**
2005			31	360	391	**391**
2006			17	274	291	**291**
2007			18	274	291	**291**
2008			35	188	223	**223**
2009			17	133	151	**151**
2010			16	131	147	**147**
2011		17	16	117	133	**150**
2012	0	14	3	211	214	**229**
2013		10	1	198	199	**209**
2014		8	3	183	186	**193**
2015		12	4	231	235	**247**
2016		21	8	254	262	**283**
2017		26	9	241	249	**275**
2018		25	10	263	273	**299**
2019		31	8	245	253	**284**
2020**		31	7	209	216	**247**

* **Spanish landings from FU 28 are included in FU 29.**

** **Preliminary values.**

Table 13.2.2.a. *Nephrops* in FUs 28–29. Length composition of males from 1984–2020.

Landings (thousands)														
Length/Year	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
17														
18														
19					4	21					0			
20			0	16	4			6	4					
21		17	9			84		16	37	9				
22	7	5	14	15		97	9	29	96	38	9			
23	24	7	7	8		143	5	19	55	34			8	4
24	14	40	121	209	51	272	27	53	202	42	18		17	9
25	109	83	115	81	97	229	116	69	181	149	34	3	23	6
26	250	170	137	446	128	205	182	111	263	72	68	0	36	43
27	282	326	170	718	208	269	149	94	185	95	77	0	54	95
28	374	500	289	871	399	280	337	139	506	272	157	0	56	78
29	439	559	341	727	456	283	415	159	462	382	95	28	38	88
30	412	742	328	584	442	317	695	239	725	548	187	11	68	104
31	277	670	389	742	457	230	813	325	755	548	231	24	92	172
32	373	784	680	806	446	367	866	260	670	674	383	108	151	283
33	339	531	213	236	428	265	702	133	345	365	149	83	70	90
34	389	635	609	721	656	328	785	239	451	655	270	215	159	251
35	478	525	590	245	664	291	755	171	296	475	224	169	147	169
36	378	463	519	342	572	295	449	138	399	639	221	147	78	154
37	528	346	322	406	424	356	465	77	351	391	107	262	172	149
38	496	383	606	355	571	302	479	120	378	344	179	134	113	58
39	353	309	361	240	326	332	611	126	348	306	95	151	62	46
40	447	337	323	156	366	316	829	200	248	174	144	232	83	82
41	247	230	316	335	164	314	797	141	243	158	93	247	78	37
42	371	246	507	264	215	360	628	174	246	170	168	293	85	33
43	199	156	198	62	102	364	335	121	242	107	127	65	31	21
44	194	233	422	215	128	481	553	125	371	179	150	88	42	28
45	165	144	233	206	93	339	324	90	220	150	87	27	22	21
46	148	178	189	170	72	231	228	128	167	55	79	58	21	33
47	129	161	140	74	76	191	202	122	191	96	68	31	38	20
48	176	212	149	79	85	193	121	62	178	102	78	25	15	9
49	89	138	104	58	43	73	92	78	111	47	47	16	20	4
50	91	142	50	34	53	94	58	67	69	30	50	12	9	3
51	66	120	63	27	34	114	59	44	50	38	29	4	6	7
52	64	135	66	44	38	77	33	40	35	15	46	11	16	7
53	45	99	32	37	23	40	19	16	29	18	22	5	6	6
54	73	101	35	45	22	35	27	29	50	23	18	5	8	16
55	20	67	25	31	22	37	30	26	29	19	9	3	4	10
56	20	35	14	20	16	20	30	19	5	5	11	2	4	3
57	10	33	5	15	12	22	7	10	6	5	11	3	7	16
58	13	14	8	14	11	17	14		11	4	6		5	3
59	7	10	3	9	4	16	5	2	9	3	10	0	5	2
60	3	6	3	4	3	13	2		10	8	1	1	1	4
61	3	1	4	4	1	5		1	3	2	1	0	1	9
62	3	1	2	1	2	3		1	7	5	1		2	7
63	1	1		1	1	4		5	0	1	0		2	3
64		2	0	2	1			1	3	1	2		0	4
65	0	0		2	2				3	1	1		0	4
66	0			0	1					1			0	4
67	0			0	0	0			6	5				6
68					0	2				0	1			0
69				0										0
70	0			1		0				2				0
71										0				
72				0		0				1				
73														0
74	0									1				
75														
76														
77														
78		0			0									
79														
80									0					
81														
82														
83														
Total	8106	9897	8709	9679	7925	8329	12255	4023	9249	7463	3766	2466	1854	2200
Landings (t)	292	353	315	277	249	318	351	345	304	232	139	98	65	74

Table 13.2.2.a. *Nephrops* in FUs 28–29. Length composition of males from 1984–2020 (continued).

Landings (thousands)

Length/Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
17														
18														
19						0				2	0			
20		4				0		4		3	1	0	0	
21		3	3	0	2	0	0	33		5	0	0	0	
22	2	0	16	1	2	13	4	51	10	20	8	2		0
23		5	8	3	1	3	15	32	22	31	10	4		1
24	8	9	20	5	2	11	20	107	53	53	26	29	8	0
25	16	39	13	6	3	40	45	120	46	65	28	30	10	1
26	32	33	58	8	11	56	126	153	75	121	32	38	8	3
27	81	49	85	24	24	87	187	206	94	111	52	63	22	6
28	65	68	44	24	48	62	205	286	144	141	60	89	14	4
29	65	109	148	53	60	147	246	330	220	189	62	83	33	5
30	160	133	87	74	139	248	300	533	290	297	60	129	44	5
31	129	272	111	92	123	188	277	573	270	256	93	116	75	22
32	289	88	161	274	233	325	475	757	378	295	129	135	116	32
33	95	182	92	139	281	248	352	437	247	246	108	80	78	21
34	269	152	160	224	257	264	352	574	311	327	150	94	104	52
35	118	175	100	173	274	275	347	333	194	252	121	76	83	31
36	166	143	158	163	265	195	224	263	168	256	83	59	77	34
37	167	128	162	167	247	234	167	293	172	224	109	57	78	64
38	85	75	106	99	254	197	147	226	164	265	73	58	125	69
39	47	180	81	109	229	174	93	175	100	173	75	61	71	39
40	83	83	96	159	254	215	165	152	100	188	77	63	84	44
41	53	184	102	130	163	163	108	129	125	163	102	53	55	49
42	167	58	91	195	163	168	177	152	190	198	128	105	75	68
43	43	102	47	181	167	172	113	118	95	82	76	38	51	45
44	69	63	86	173	122	121	122	176	144	90	61	51	65	43
45	34	111	61	140	113	103	131	140	96	83	60	25	39	19
46	38	67	85	144	106	76	103	117	118	71	38	25	26	15
47	34	59	88	120	111	75	97	113	61	60	48	25	43	18
48	24	40	55	80	104	83	90	66	54	65	48	23	35	12
49	13	50	37	79	86	59	58	52	41	38	34	24	23	12
50	33	32	65	93	103	94	82	69	28	42	36	20	25	11
51	14	32	34	71	72	65	41	40	30	37	27	17	20	15
52	31	8	53	88	94	73	65	45	37	48	29	32	30	24
53	11	13	18	41	69	58	31	22	22	21	24	13	16	9
54	19	15	31	54	53	57	50	24	33	27	23	19	21	24
55	8	9	19	34	28	46	26	12	15	10	20	12	14	15
56	6	13	19	29	43	29	57	14	11	8	15	13	8	25
57	8	8	19	37	37	25	16	9	6	6	17	11	9	25
58	5	4	13	23	26	21	12	9	7	7	20	7	11	45
59	3	4	10	15	16	13	15	8	9	5	11	4	6	19
60	1	1	8	15	25	16	24	12	6	3	9	7	5	13
61	1	2	14	9	11	8	11	8	8	4	8	4	5	7
62	1	3	6	10	11	15	16	8	8	3	15	8	6	22
63	0	2	1	4	11	11	7	7	7	1	8	4	6	7
64	0	1	1	9	11	8	10	10	7	1	10	6	5	17
65		0	4	6	5	4	3	10	7	1	9	2	3	9
66	0		1	5	8	3	7	3	4	2	11	1	3	5
67	0			4	3	5	2	2	6	1	6	1	3	3
68	0			1	6	6	2	3	4	0	8	0	4	3
69	0		0	3	3	2	2	2	4	1	4	1	0	2
70	0		0	6	2	4	3	4	5	0	4	1	0	1
71	0			2	2	4	1	1	3	1	2	0	0	0
72	0			2	2	4	1	3	4	0	3	1	0	1
73			0	0	1	1	1	2	2		1	0	0	1
74				0	1	1	1	3	1		1	1	0	1
75				0	1	0	0	1	1		1	1	2	0
76				0	0	0	0	0	1		1	0		0
77					0	0	0	0	1		1	0	0	0
78							0	1			0			0
79					0		0	1	0		0	0		
80								0			0			0
81									0		0	0		
82					0				0		0	0		
83											0			
Total	2491	2811	2680	3602	4486	4575	5233	7036	4259	4598	2280	1822	1649	1018
Landings (t)	88	116	117	190	222	205	205	231	162	159	114	73	79	72

Table 13.2.2.a. ***Nephrops*** **in FUs 28–29. Length composition of males from 1984–2020 (continued).**

Landings (thousands)									
Length/Year	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
17									
18									
19				1					
20									
21			0				1		
22	3		1				1		
23	0	3	1	0		8	20		0
24	8		1	1		4	28		11
25	27	8	6	5		8	180	22	16
26	37	6	7	3		23	89	19	10
27	47	27	15	8		68	162	70	30
28	37	25	12	10		109	201	34	30
29	143	55	35	27	10	149	241	86	80
30	158	84	36	71	27	324	321	163	149
31	248	82	49	112	51	293	382	188	131
32	573	217	120	138	36	345	433	189	169
33	329	109	47	96	75	207	281	124	163
34	436	276	119	162	166	277	334	222	195
35	356	155	144	263	128	295	387	325	290
36	248	191	119	202	173	138	146	115	101
37	211	145	108	191	155	145	191	158	112
38	206	216	144	179	240	82	89	136	82
39	126	95	129	125	300	71	116	106	59
40	112	162	160	139	247	114	128	174	88
41	114	113	90	117	179	86	69	119	66
42	140	171	129	142	185	101	112	138	76
43	79	64	58	85	182	64	45	89	43
44	87	89	104	127	222	94	82	105	70
45	52	42	59	92	187	108	64	111	57
46	46	81	59	62	211	75	23	59	64
47	47	89	83	61	129	53	42	49	66
48	30	67	26	28	157	18	26	26	21
49	32	53	36	48	92	32	33	25	30
50	19	59	25	58	69	41	53	48	43
51	17	37	32	56	58	27	47	28	34
52	33	47	64	70	26	46	57	33	37
53	22	18	25	45	34	38	34	26	29
54	32	36	44	48	52	46	54	37	46
55	15	16	24	60	41	38	45	36	47
56	24	20	20	43	51	30	30	29	38
57	20	15	20	27	36	22	33	32	34
58	7	12	10	14	45	5	19	12	10
59	7	8	9	16	38	12	18	15	19
60	4	10	7	10	30	10	15	9	11
61	9	7	4	4	21	4	10	5	5
62	3	1	12	4	10	5	8	2	2
63	2	4	3	3	14	2	3	1	1
64	2	3	8	3	10	2	4	4	1
65	1	1	2	1	9	2	9	5	4
66	3	2	3	2	6	3	5	5	2
67	3	1	2	1	4	2	5	4	3
68	3	1	1	0	4	1	2	3	11
69	1		1	0	8	1	3	4	9
70	3	1	1	0	3	1	4	3	8
71	1		1	0	3	1	0	1	3
72	3	0	1		2	0	2	1	0
73	1		1		0	0	0	2	3
74	1		1		0	0	0	2	0
75	1		0		0	0	3	2	0
76	0			0			0	0	2
77	0				0		0	0	0
78					0	0	0		1
79	0				0		0		1
80							0		0
81									
82									
83									
Total	**4170**	**2928**	**2217**	**2959**	**3725**	**3632**	**4693**	**3204**	**2615**
Landings (t)	**149**	**132**	**114**	**147**	**166**	**139**	**169**	**150**	**151**

Table 13.2.2.b. *Nephrops* in FUs 28–29. Length composition of females from 1984–2020.

Landings	(thousands)														
Length/Year	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
17															
18					4										
19		0				35					0				
20	3	1	7		8	21				18					
21	1	1	22	3	21	102		21	9	49					
22	8	21	30	78		88	19	11	102	63			0	13	2
23	66	21	7	31	28	135	15	69	38	21	2		0	0	4
24	79	102	118	270	153	258	38	173	164	41	22	2	11	20	15
25	228	205	104	357	163	197	138	198	203	191	73		13	20	25
26	272	284	186	684	220	282	140	436	361	111	92	1	35	102	74
27	345	491	359	902	429	326	247	418	448	235	134	0	37	77	91
28	431	523	322	1421	471	231	345	598	597	413	170	6	36	152	148
29	443	672	419	1253	516	285	491	590	514	523	269	31	45	178	114
30	422	588	381	928	499	317	575	771	599	775	326	104	50	199	199
31	487	593	418	948	482	501	639	414	736	752	427	182	95	394	168
32	485	653	700	946	766	306	859	807	617	824	558	322	198	502	376
33	613	415	406	227	527	314	596	375	430	449	283	251	53	163	116
34	618	467	654	774	813	511	734	310	369	359	353	641	209	278	298
35	562	563	447	447	460	435	519	284	287	194	246	674	184	150	112
36	469	329	316	386	489	274	243	130	267	203	237	811	142	135	166
37	505	353	400	223	206	318	189	108	333	154	147	692	267	129	171
38	383	284	330	269	265	285	207	135	251	100	128	348	151	39	48
39	274	142	211	146	288	148	216	74	176	150	66	194	67	35	59
40	171	119	80	119	132	131	230	131	147	110	114	344	120	21	89
41	58	106	55	65	128	149	73	39	68	108	77	361	63	31	64
42	50	36	133	54	43	127	210	62	69	95	73	165	111	18	84
43	30	27	21	40	28	109	58	82	26	43	23	64	29	2	34
44	17	13	47	147	27	91	77	6	46	42	43	88	90	18	71
45	14	11	27	84	19	27	41	21	40	34	13	54	36	8	22
46	7	6	5	40	14	38	31	45	25	37	11	13	15	4	28
47	5	3	3	26	9	24	16	7	12	29	7	18	23	3	23
48	4	1		71	11	29	7	15	18	15	4	15	8	2	6
49	1	0	3	17	4	9	1	17	17	23	4	1	6	7	6
50	1	0		2	6	3	1	2	32	8	17	1	2	1	6
51	0	0	3	4	3	7	2	4	4	5	0			1	2
52	1			5	5	8	1		5	6	1	1	0	1	1
53	2			2	3	1			9	6	0			0	0
54				4	1	1			1	1			1	0	1
55				0	1	1			6	2					
56				3	0	2		5	14	5					0
57				0	0	1			4	1			0		0
58				0		0			4	1					
59				1	0	0									
60					0				1	0					
61						1									
62															
63									4	1					
64															
65															
66															
67															
68									4	1					
69															
70															
71															
72															
73															
74															
75															
76															
77															
78															
79															
80															
81															
82															
83															
Total	7052	7032	6218	10978	7243	6126	6962	6358	7059	6198	3920	5385	2095	2702	2621
Landings (t)	169	156	150	232	171	151	174	134	165	145	97	174	67	62	72

Table 13.2.2.b. *Nephrops* in FUs 28–29. Length composition of females from 1984–2020 (continued).

Landings (thousands)														
Length/Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
17						0								
18							0				0			
19						1				2	0			
20				0		0	0	8		4	1			
21			3	1	0	3	12	48	3	15	2	1		
22	2	5	18	0		3	10	88	14	26	12	1	0	
23	4	4	6	7	0	9	43	54	37	34	11	4	1	1
24	15	25	49	7	10	19	62	135	44	53	25	22	10	1
25	25	27	24	15	11	36	101	129	55	130	23	23	11	1
26	74	94	81	24	15	67	211	272	113	227	38	80	12	3
27	91	76	139	34	34	67	266	294	152	298	73	138	20	7
28	148	100	64	44	107	98	336	242	179	355	81	170	26	7
29	114	121	171	90	127	173	395	420	392	458	123	149	51	4
30	199	236	152	131	237	241	406	654	321	365	145	205	67	7
31	168	263	131	167	195	152	334	565	305	317	129	132	99	26
32	376	485	283	316	296	360	530	857	510	409	252	209	145	45
33	116	187	153	184	467	270	433	448	272	253	182	110	91	51
34	298	346	235	252	429	314	400	462	341	386	177	122	140	96
35	112	287	193	158	470	255	324	254	249	351	187	103	120	56
36	166	317	225	174	351	194	222	203	162	213	103	83	144	60
37	171	201	213	144	302	203	178	182	142	240	121	90	119	73
38	48	184	85	108	300	206	151	178	152	247	134	83	106	151
39	59	151	92	112	213	160	113	89	173	138	123	86	95	113
40	89	111	79	133	186	284	136	84	114	109	125	62	80	68
41	64	81	66	79	110	170	82	73	129	73	95	83	65	65
42	84	73	67	91	80	192	122	116	112	56	75	94	52	80
43	34	38	41	55	87	132	70	70	44	16	30	25	28	80
44	71	34	49	56	57	75	66	61	46	21	24	43	40	41
45	22	18	23	29	51	68	66	50	35	18	28	17	25	21
46	28	18	38	33	40	37	51	39	54	19	14	22	19	11
47	23	7	52	26	25	25	44	35	23	9	26	16	18	15
48	6	9	25	12	24	28	37	18	11	8	20	7	12	9
49	6	4	21	15	19	18	24	24	7	7	13	6	7	7
50	6	5	10	15	26	24	20	23	7	3	13	8	7	2
51	2	2	10	9	22	14	13	17	11	5	11	3	6	5
52	1	3	16	6	19	21	13	17	7	3	7	3	4	4
53	0		6	6	10	13	8	10	2	1	8	3	2	3
54	1		5	2	2	14	7	6	9	1	8	1	2	5
55			1	2	3	10	4	5	1	1	3	4	0	5
56	0		3	1	3	7	6	2	1	0	3	0	0	2
57	0		1	0	2	4	2	3	1		1	0	0	1
58				1	1	1	2	0	1	0	1	1	0	4
59			0	1	0	0	1	1	1			0	0	2
60				0		0		2			1		0	2
61			3	1		0	1					0	0	1
62					0	0	0	1	0				0	0
63				0	0			0				0	0	2
64							1	0		0	0	0		
65							0	0						0
66			0	0				0						
67														0
68														
69														
70							0					0		
71														
72														
73														
74														
75														
76														
77														
78														
79														
80														
81														
82														
83														
Total	2621	3509	2829	2540	4332	3969	5304	6240	4229	4871	2449	2211	1628	1138
Landings (t)	72	95	84	79	135	130	140	151	112	114	74	60	52	45

Table 13.2.2.b. *Nephrops* in FUs 28–29. Length composition of females from 1984–2020 (continued).

Landings (thousands)									
Length/Year	2012	2013	2014	2015	2016	2017	2018	2019	2020
17									
18									
19				0					
20									
21	7				4				
22		3	1		4		19		0
23		7	1	0	1		4	10	1
24	5	7	3		2	13	66	14	5
25	8	18	10	5	19	91	150	32	25
26	17	7	10	7	19	23	87	47	13
27	40	36	17	13	46	100	110	145	55
28	51	33	23	23	44	134	125	76	49
29	130	59	60	39	57	169	203	86	124
30	164	119	80	85	219	464	351	336	246
31	330	129	99	143	149	290	260	310	146
32	397	290	203	208	307	462	327	560	306
33	195	194	105	146	214	290	247	251	167
34	297	278	202	167	325	353	235	435	215
35	165	232	188	303	362	365	381	316	430
36	138	166	153	203	193	196	138	199	172
37	98	199	151	162	203	142	149	202	127
38	76	206	148	171	125	81	78	140	110
39	46	61	121	136	112	105	75	146	79
40	46	67	145	134	130	108	89	131	89
41	37	41	66	104	82	56	51	70	34
42	35	65	90	87	112	72	94	75	48
43	33	9	27	54	59	55	33	55	49
44	27	13	40	58	48	53	35	50	52
45	10	9	17	56	25	45	38	34	42
46	10	11	17	36	28	36	15	24	30
47	11	13	18	16	14	21	22	15	67
48	5	7	5	8	3	14	9	4	8
49	6	5	7	8	5	7	14	3	23
50	6	5	4	8	14	7	16	6	6
51	6	1	3	7	4	7	12	3	10
52	9	5	4	9	8	6	13	2	8
53	5	1	3	6	0	5	7	1	4
54	5	3	8	12	2	4	6	3	5
55	2	1	3	12	2	3	4	1	3
56	1	1	6	10	1	1	6	2	2
57	3	2	2	4	0	1	5	0	1
58	2	0		1	0	0	5	0	1
59	0	1	1	3	0	0	2		0
60	0		2	3	1	1	3	0	1
61	0					0	1		0
62	0	0	0	0			0		0
63	0						0		0
64	0			0			2		0
65				0		0			0
66				0		0	0		0
67				0					
68							0		0
69				0					
70				0					
71									
72									
73									
74									
75									
76									
77									
78									
79									
80									
81									
82									
83									
Total	2424	2306	2044	2446	2946	3782	3487	3783	2755
Landings (t)	65	66	66	85	88	102	94	95	96

Table 13.2.3. *Nephrops* in SW and S Portugal (FUs 28–29). cpues (kg/h) estimated from research trawl surveys from 1994–2020.

Year	Demersal surveys			Crustacean surveys	
	CPUE (kg/hour)			Month and year of survey	CPUE (kg/hour)
	Summer	Autumn	Winter		
1994	ns	0.40	ns	May-94	2.3
1995	1.3	0.26	ns	ns	ns
1996	ns	0.03	ns	ns	ns
1997	0.7	0.06	ns	Jun-97	2.7
1998	0.7	0.02	ns	Jun-98	1.4
1999	0.3	0.02	ns	Jun-99	2.5
2000	1.0	0.92	ns	Jun-00	1.6
2001	0.6	0.35	ns	Jun-01	0.8
2002	ns	0.02	ns	Jun-02	2.8
2003	ns	0.19	ns	Jun-03	2.9
2004	ns	0.51	ns	Jun-04	nr
2005	ns	0.09	0.16	Jun-05	5.3
2006	ns	0.19	0.06	Jun-06	2.8
2007	ns	0.04	0.73	Jun-07	2.9
2008	ns	0.13	0.25	Jun-08	5.4
2009	ns	0.13	ns	Jun-09	2.8
2010	ns	0.34	ns	Jun-10	8.1
2011	ns	0.11	ns	Jun-11	nc
2012	ns	ns	ns	ns	ns
2013	ns	0.64	ns	Jun-13	2.5
2014	ns	0.06	ns	Jul-14	1.0
2015	ns	0.21	ns	Jul-15	3.2
2016	ns	0.69	ns	Jun-16	4.9
2017	ns	1.21	ns	Jul-17	5.0
2018	ns	0.46	ns	Aug-18	5.0
2019	ns	ns	ns	ns	ns
2020	ns	ns	ns	ns	ns
ns = no survey nr = not reliable nc = whole area not covered					

Table 13.2.4. *Nephrops* in SW and S Portugal (FUs 28–29): Mean sizes (mm CL) of male and females in Portuguese landings and surveys from 1994–2020.

Year	Landings		Demersal surveys						Crustacean surveys	
			Summer		Autumn		Winter			
	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females
1994	37.4	33.6	ns	ns	39.0	33.6	ns	ns	ns	ns
1995	39.3	37.0	42.1	35.6	42.0	34.9	ns	ns	ns	ns
1996	36.9	36.6	ns	ns	38.6	32.2	ns	ns	ns	ns
1997	35.9	32.8	40.4	36.9	39.1	31.7	ns	ns	43.7	41.9
1998	36.8	34.5	36.0	33.9	40.6	35.9	ns	ns	39.5	36.7
1999	38.7	34.6	45.1	40.4	43.8	32.8	ns	ns	39.7	37.5
2000	38.9	35.2	40.8	37.1	39.0	35.1	ns	ns	41.7	40.2
2001	41.6	36.1	40.5	34.5	47.2	41.6	ns	ns	44.5	39.9
2002	40.7	36.2	na	na	35.0	39.0	ns	ns	44.8	40.7
2003	39.1	36.4	ns	ns	37.5	32.3	ns	ns	39.7	36.7
2004	37.3	33.8	ns	ns	36.7	31.3	ns	ns	39.0	37.0
2005	35.6	33.0	ns	ns	40.6	39.1	40.6	40.9	37.3	35.7
2006	37.2	34.1	ns	ns	36.1	32.8	31.7	35.0	37.7	35.2
2007	36.5	32.8	ns	ns	42.0	38.5	39.0	36.2	38.3	35.0
2008	40.1	35.5	ns	ns	43.2	41.4	46.7	40.6	40.1	36.7
2009	37.4	34.2	ns	ns	45.3	39.8	ns	ns	41.4	36.6
2010	40.1	36.5	ns	ns	39.7	33.7	ns	ns	37.7	36.6
2011	45.0	39.2	ns	ns	43.1	40.0	ns	ns	nc	nc
2012	36.9	34.4	ns	ns	ns	ns	ns	ns	ns	ns
2013	39.7	35.3	ns	ns	42.6	37.3	ns	ns	39.1	39.5
2014	41.3	36.7	ns	ns	46.5	39.2	ns	ns	37.8	35.2
2015	40.9	37.4	ns	ns	42.4	35.2	ns	ns	39.2	37.3
2016	39.5	35.8	ns	ns	43.7	41.6	ns	ns	38.7	36.1
2017	37.7	34.6	ns	ns	45.2	45.3	ns	ns	40.6	34.5
2018	36.2	33.8	ns	ns	43.5	37.9	ns	ns	37.7	34.0
2019	39.1	34.6	ns	ns	ns	ns	ns	ns	ns	ns
2020	39.7	35.6	ns	ns	ns	ns	ns	ns	ns	ns

ns = no survey nr = not reliable nc = whole area not covered

Table 13.2.5. *Nephrops* in SW and S Portugal (FUs 28–29). Effort and cpues (kg/h) of Portuguese trawlers from 1994–2020.

Year	No. of trawlers	CPUE (t/vessel)	Estimated hours	CPUE** (kg/hour)
1994	31	7.6		
1995	30	9.1		
1996	25	5.3		
1997	25	5.5		
1998	25	6.4	676 134	0.2
1999	26	8.1	507 697	0.4
2000	27	7.4	707 654	0.3
2001	33	8.2	318 189	0.9
2002	31	11.5	176 609	2.0
2003	32	10.5	124 979	3.0
2004	23	15.0	261 393	1.4
2005	25	15.3	204 234	1.9
2006	25	11.0	140 731	2.1
2007	26	10.5	151 912	1.9
2008	27	7.0	95 974	2.3
2009	27	4.9	58 359	2.6
2010	25	5.2	72 243	2.0
2011	26	4.5	77 328	1.9
2012	21	10.2	90 508	2.5
2013	24	8.2	107 295	2.0
2014	24	7.5	112 153	1.7
2015	22	10.5	134 999	1.8
2016	22	11.5	117 035	2.4
2017	22	11.0	131 405	2.1
2018	24	11.0	104 406	2.9
2019	25	9.8	104 524	2.7
2020*	24	8.7	96 048	2.6
* provisional; ** standardized CPUE				

Table 13.2.6. Length-based indicators for Nephrops males and females in FUs 28–29.

Sex	Year	Conservation				Optimizing Yield	MSY
		L_c/L_{mat}	$L_{25\%}/L_{mat}$	$L_{max5\%}/L_{inf}$	P_{mega}	L_{mean}/L_{opt}	$L_{mean}/L_{F=M}$
		>1	>1	>0.8	>30%	~1 (>0.9)	≥1
Males	2018	0.95	1.11	0.84	0.07	0.79	0.98
	2019	1.02	1.18	0.86	0.09	0.85	1.01
	2020	1.02	1.11	0.90	0.14	0.86	1.02
Females	2018	0.90	1.02	0.74	0.02	0.80	0.94
	2019	0.97	1.05	0.71	0.01	0.81	0.93
	2020	0.97	1.08	0.76	0.03	0.83	0.95

Table 13.2.7. Results from the application of the Mean Length Z approach.

Method		Males	Females
Input:			
	LFD period	1984-2019	1984-2019
	Effort series	1998-2019	1998-2019
	Growth		
	Linf =	70	65
	K =	0.2	0.065
	t0 =	-0.15	-0.15
	W~L relationship		
	a =	0.00028	0.00056
	b =	3.2229	3.0288
	External M	0.3	0.2
Method	**Results**		
Gedamke & Hoenig	Z =	0.47	0.31
	F* =	0.17	0.11
THoG	q estimate =	0.0004	0.0002
	q estimate* =	0.005	0.002
	M estimate =	0.46	0.28
	F_{2020} estimate =	0.004	0.002
	F_{2020} estimate* =	0.05	0.02
Y/R	F_{MSY} proxy: $F_{0.1}$ =	0.23	0.24

* indicates estimates with external fixed M

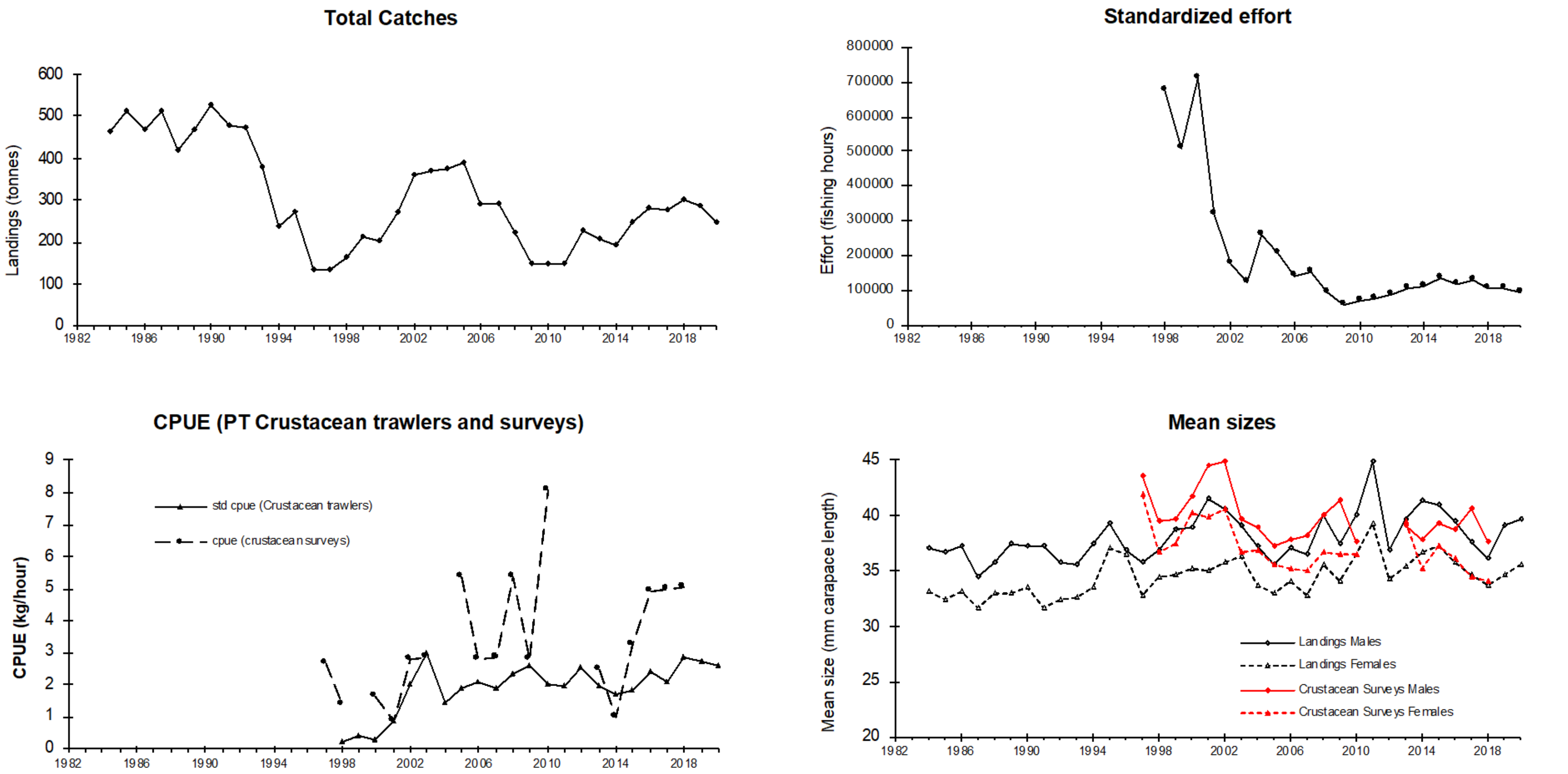


Figure 13.2.1. ***Nephrops*** **in SW and S Portugal (FU 28+29). Annual landings, effort, biomass indices and mean sizes in Portuguese landings and surveys. Note: Values of cpues and effort updated with the new cpue standardization.**

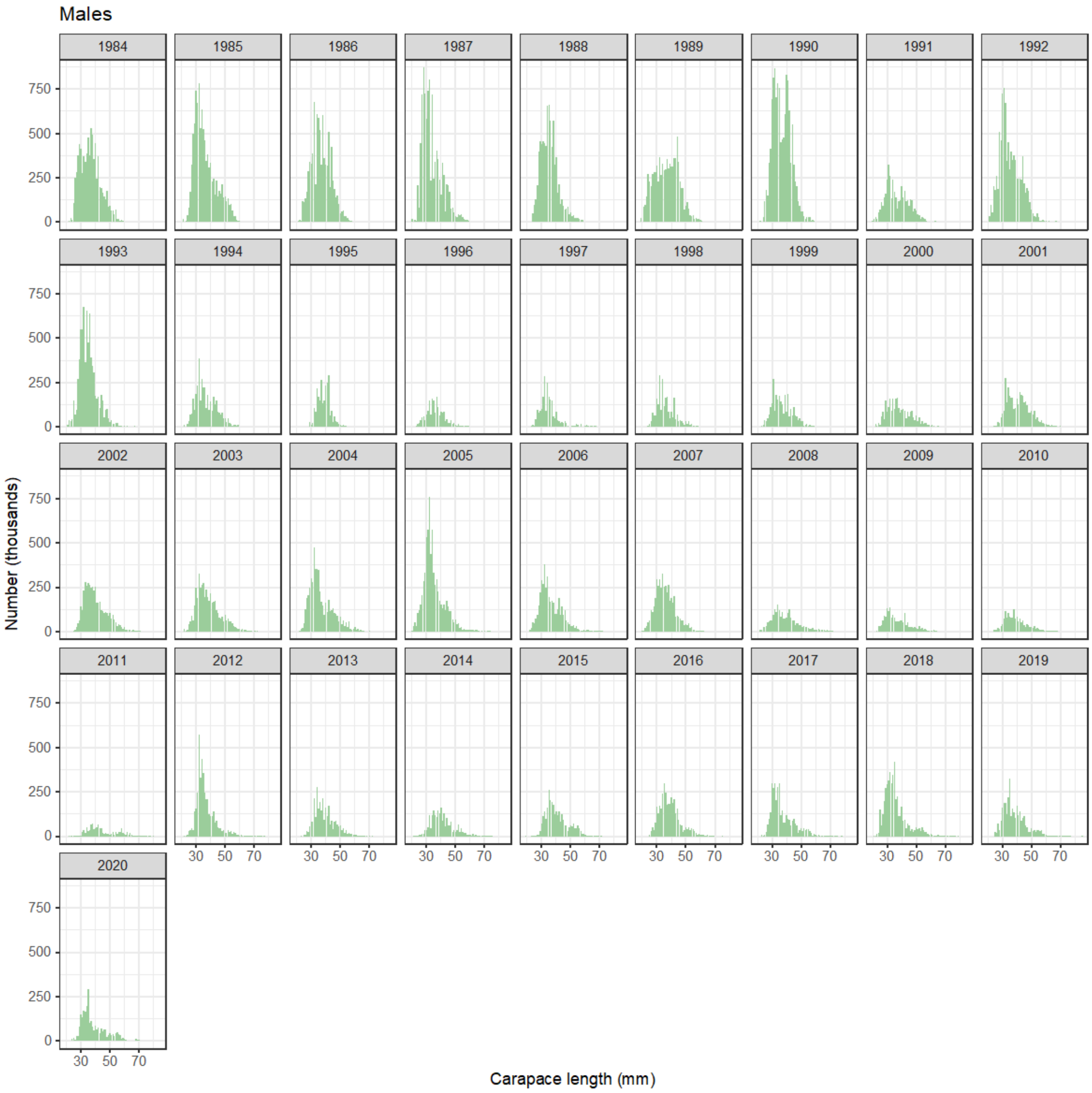


Figure 13.2.2.a. *Nephrops* in SW and S Portugal (FUs 28–29). Males length distributions for the period 1984–2020.

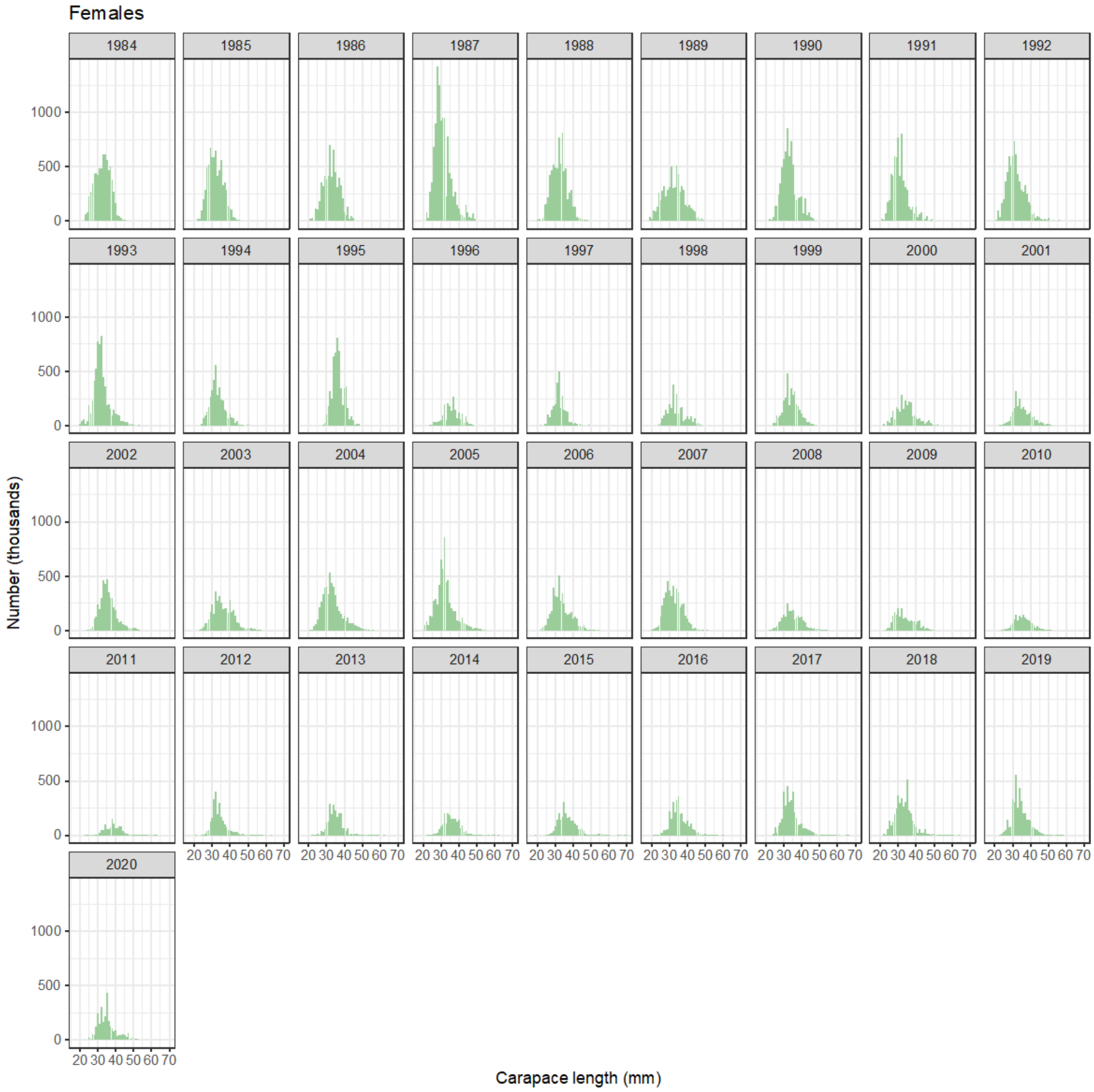
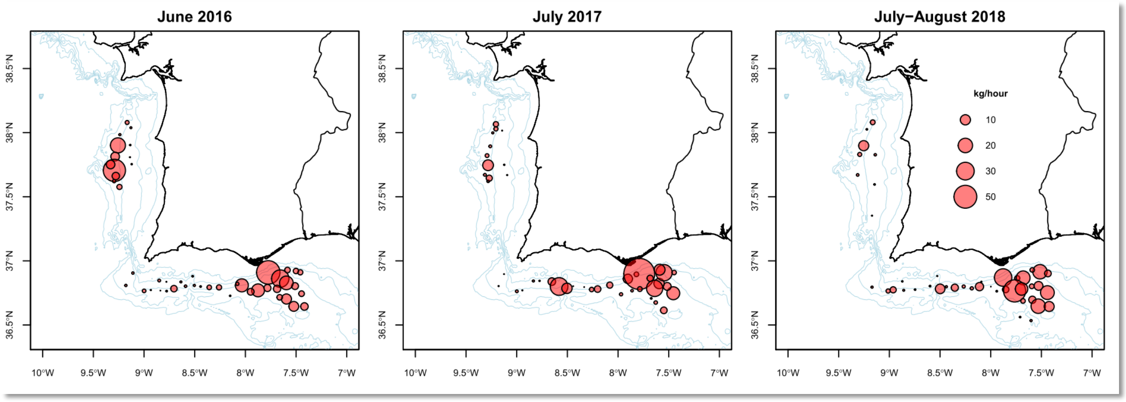


Figure 13.2.2.b. *Nephrops* in SW and S Portugal (FUs 28–29). Females length distributions for the period 1984–2020.



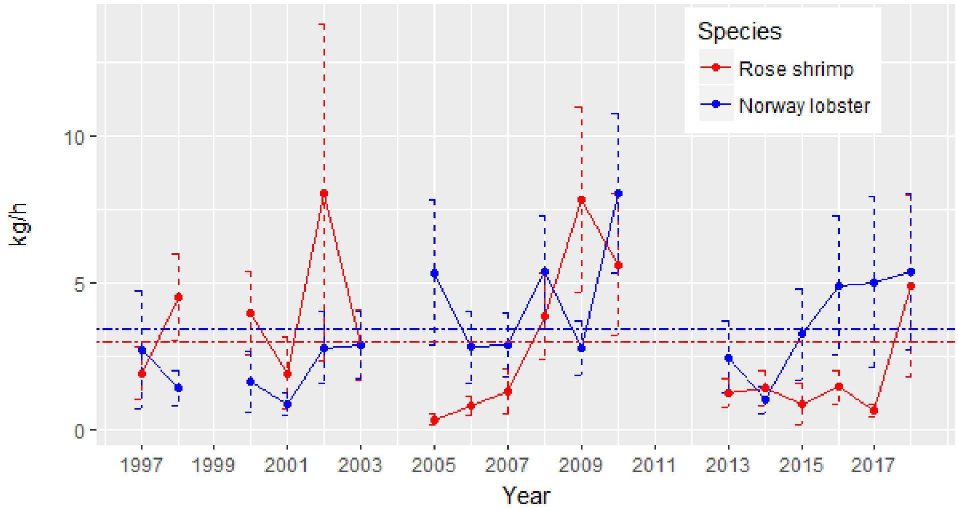


Figure 13.2.3. Spatial distribution of Norway lobster's biomass survey index in the period 2016–2018 (upper panel). Stratified mean biomass time-series (lower panel) with 95% confidence interval of Norway lobster (blue) and deep-water rose shrimp (red).

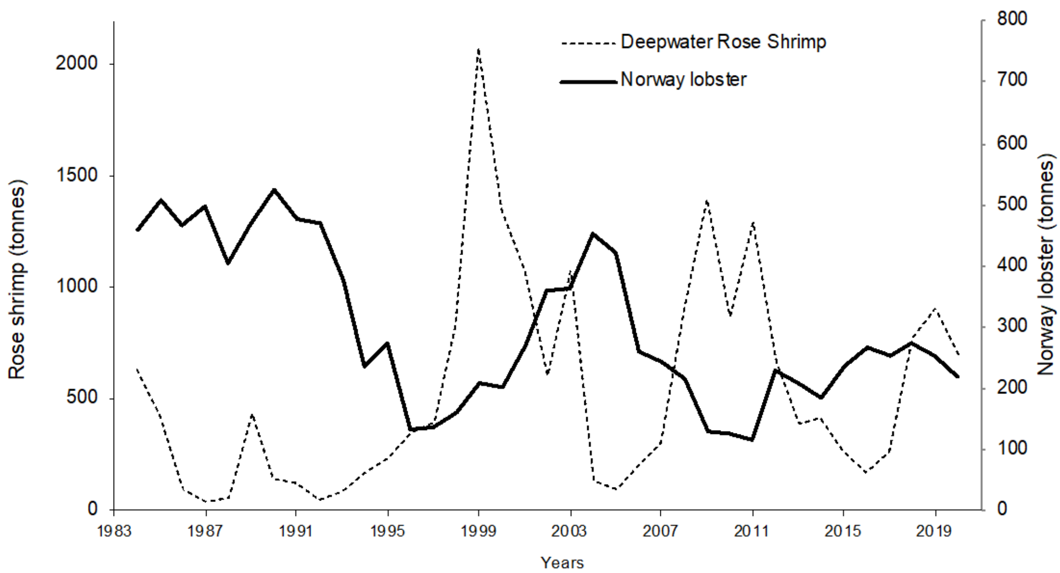


Figure 13.2.4 *Nephrops* in FUs 28–29. Landings (tonnes) of the two main target species of the crustacean fisheries in the period 1984–2020.

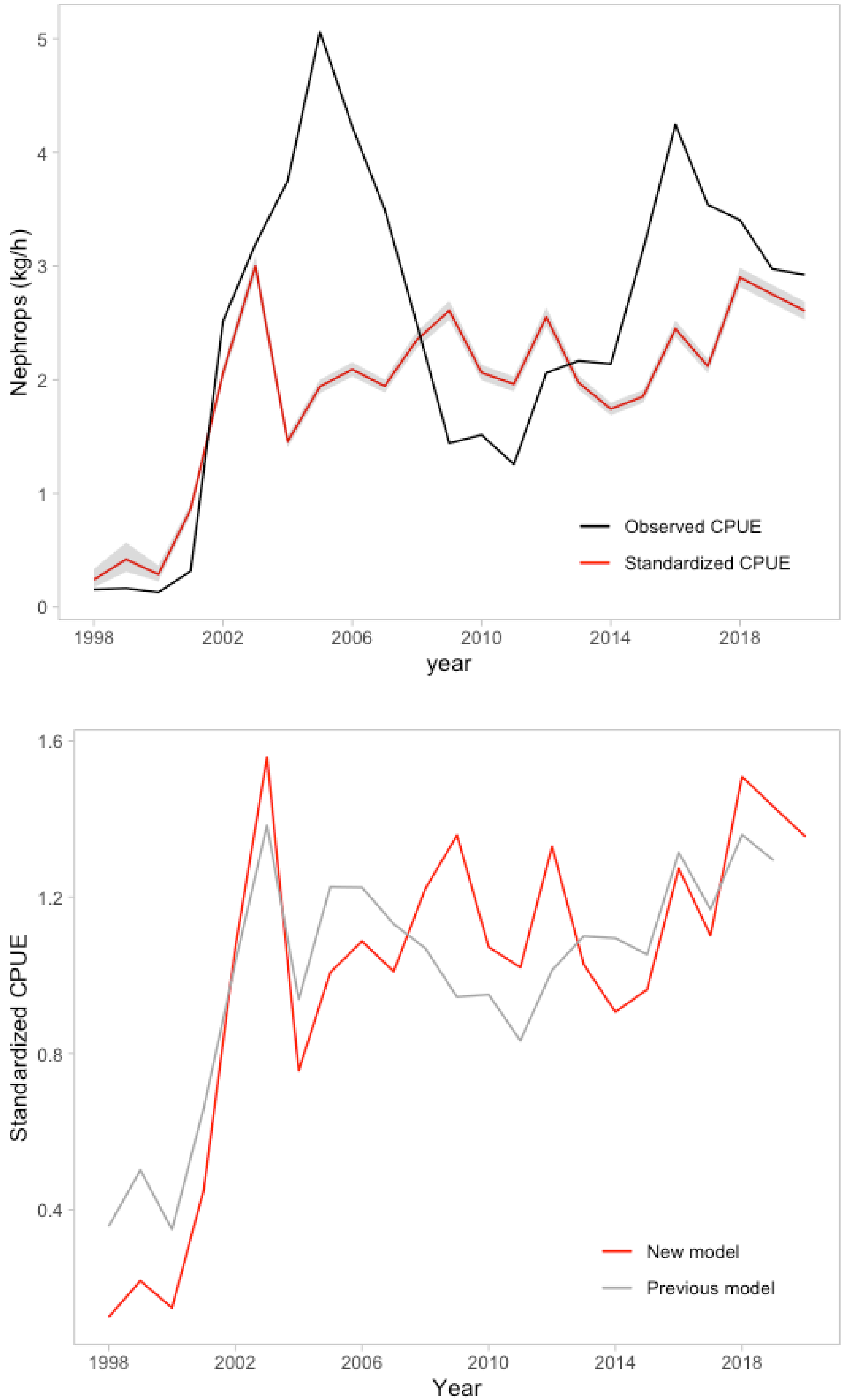


Figure 13.2.5. Comparison of the observed and standardized *Nephrops* cpue trends using the new model (above). Comparison between the output from the new and previous cpue standardization models, normalized to the overall mean (below). The shaded area represents the 95% confidence intervals.

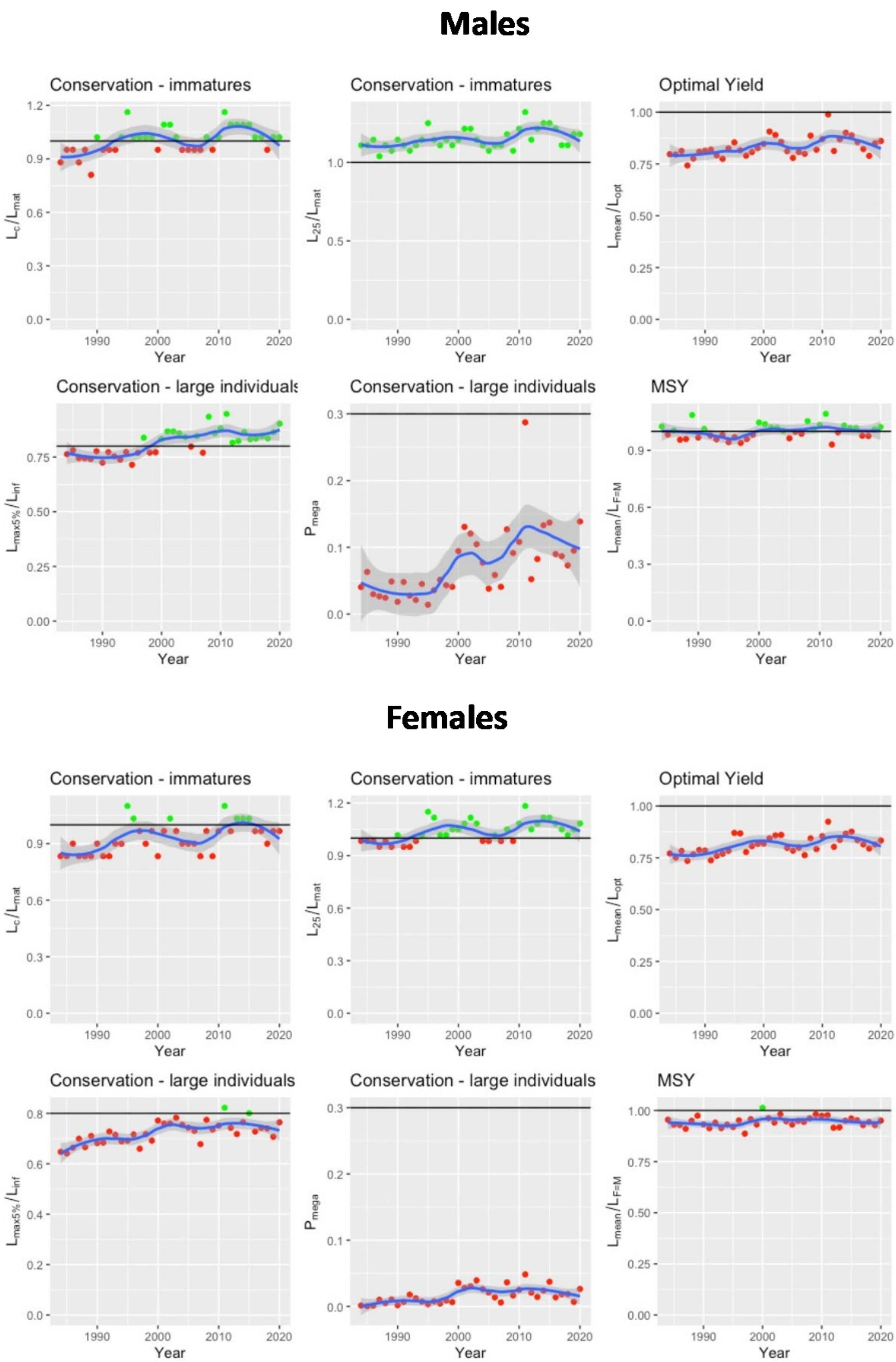


Figure 13.2.6. Length-based indicator ratios for *Nephrops* males (above) and females (below) in FUs 28–29.

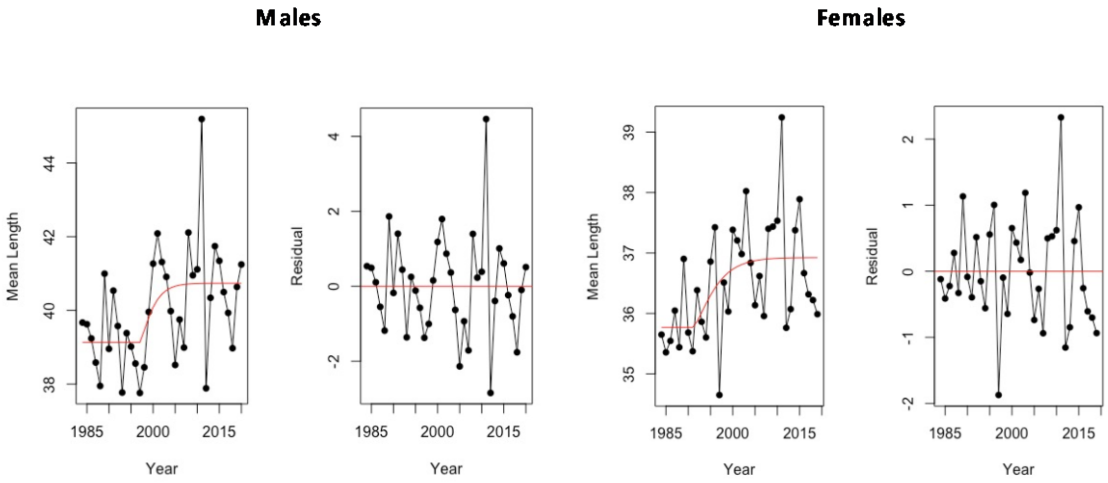


Figure 13.2.7. ***Nephrops*** **in FUs 28–29. Gedamke & Hoenig Mean Length-Z model diagnostics for males (2 graphs on the left side) and females (2 graphs on the right side).**

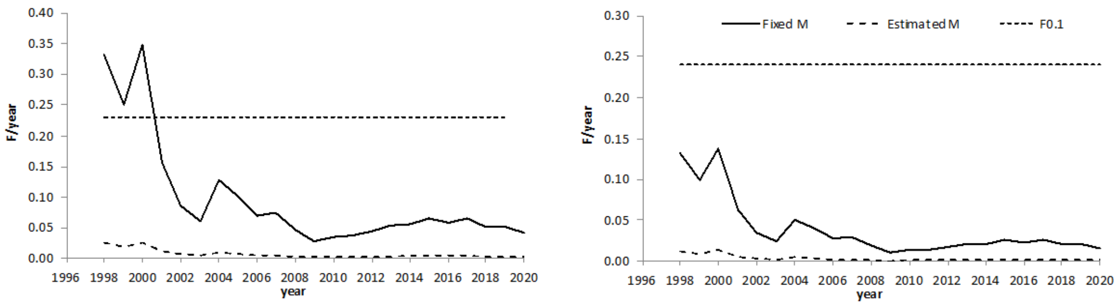


Figure 13.2.8. ***Nephrops*** **in FUs 28–29. Fishing mortality from the THoG model using an external fixed M or an M estimated by the model. Left panel: males, right panel: females.**

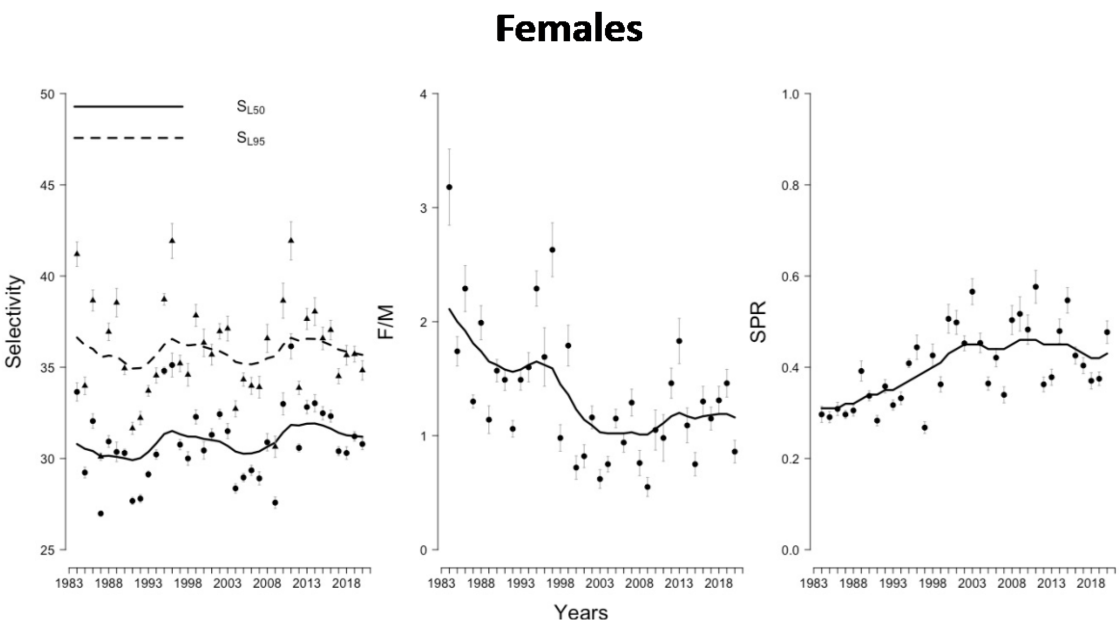


Figure 13.2.9. ***Nephrops*** **in FUs 28–29. LB-SPR outputs showing Selectivity (left), F/M (centre) and Spawning Potential Ratio (SPR, right) for females with 95% confidence intervals and a smoother.**

13.3 *Nephrops* in FU 30 (Gulf of Cádiz)

Nephrops FU 30 was benchmarked by WKNEP 2016 (ICES, 2017a). A UWTV survey-based approach was considered appropriate to provide scientific advice on the stock abundance in this FU. However, a stock-specific MSY harvest rate could not be derived. The basis of advice for this stock follows a category 3 using the 2-over-3 rule. When the stock-specific MSY reference points could be estimated, *Nephrops* FU 30 will meet the requirements for category 1 assessment.

13.3.1 General

13.3.1.1 Ecosystem aspects

See Stock Annex.

13.3.1.2 Fishery description

See Stock Annex.

13.3.1.3 ICES advice for 2020 and management applicable for 2020 and 2021

ICES Advice for 2021

ICES advises that when the precautionary approach is applied, catches in 2020 should be no more than 62 t.

To ensure that the stock in FU 30 is exploited sustainably, ICES advises that management should be implemented at the FU level.

Management applicable for 2020 and 2021

The European Parliament and the Council have published a multiannual management plan (MAP) for the Western Waters (EU, 2019a). This plan applies to demersal stocks including *Nephrops* in FU 30.

An increase of mesh size to 55 mm was established starting September 2009 (Orden ARM/2515/2009) for the bottom-trawl fleet.

The TAC set for the whole Division 9.a was 386 t for 2020 and 374 t for 2021, of which no more than 6% may be taken in FUs 26 and 27, and no more than 77 t in 2020 and 65 t in 2021 may be taken in FU 30.

A modification of the Fishing Plan for the Gulf of Cádiz was established in 2014 (AAA/1710/2014). This new regulation establishes an assignment of *Nephrops* quotas by vessel. A closed season in autumn for the bottom-trawl fleet of the Gulf of Cádiz is implemented since 2004. Since 2018, this closed season is from 16 September to 31 October (APM/453/2018).

13.3.2 Data

The sampling programs coordinated by the IEO (onshore, observers at sea and biological sampling) were partially suspended in 2020 due to administrative problems and to the COVID-19 disruption. This affected all stocks. Details of the impact on each individual stock are provided in the templates provided by ICES and in each stock-specific section.

13.3.2.1 Commercial catch and discard

Landings in this FU are reported by Spain, and in minor quantities, by Portugal. Spanish landings are based on sales notes which are compiled and standardized by IEO. Since 2013, trips from sales notes are also combined with their respective logbooks, which allow georeferencing the catches.

The total landings have been estimated by this WG since 2016 when the concurrent sampling was satisfactorily implemented. The Spanish concurrent sampling is used to raise the FU 30 observed landings to total effort by *métier*. When the estimated landings exceed the official landings, the difference is provided to InterCatch as non-reported landings.

Since the WGHMM meeting in 2010 (ICES, 2010), *Nephrops* landings in Ayamonte port were incorporated in the Gulf of Cádiz landings time-series, as well as, directed effort and LPUE from 2002 (Table 13.3.1 and Table 13.3.5). *Nephrops* total landings in FU 30 decreased from 108 t in 1994 to 49 t in 1996. After that, there has been an increasing trend, reaching 307 t in 2003 but sharply declined to 147 t in 2004, which is more than a 50% drop. After a new increase in 2005 (246 t), landings trend declined up to 120 t in 2008. In 2008–2012, landings remained relatively stable at around 100 t. Landings declined again in 2013–2015 up to a mean value of 22 t. Since the quota in 2012 was exceeded, the European Commission applied a sanction to be paid within 3 years, 2013–2015 (Figure 13.3.1). The TAC was limiting the fishery during this period. Moreover, the *Nephrops* fishery was closed in 2013 and vessels could only go *Nephrops* fishing for only a few days during summer and winter. Total estimated landings increased in 2016 and 2017 (124 t and 140 t, respectively), representing almost six times the landings observed in 2013–2015. Landings estimations were 75 t in 2018, representing 46% less than the previous year (Figure 13.3.1). In 2019, landings slightly decreased, recording a total of 65 t. Landings in 2020 were only 2 t lower than in 2019 (63 t). Estimates since 2016 are considered the best information available.

A modification of the regulation implemented for the Spanish Administration for the Gulf of Cádiz grounds in 2014 (Orden AAA/1710/2014) established the assignment of *Nephrops* quotas by vessel. This regulation may have caused unreported *Nephrops* landings in the period 2016–2018. The highest value of non-reported landings was recorded in 2017. In 2019, the non-reported landings were lower than 10% of the official landings and were considered zero. Non-reported landings were not recorded in 2020.

Information on discards is submitted to the WG through InterCatch. The discard rate of *Nephrops* in this fishery fluctuates annually but is always very low or zero and thus, discards are considered negligible (Table 13.3.2). In 2019, the percentage of discards was 1.6%, lower than in the last two years. The mean carapace length of the discarded fraction was also lower than that observed in previous years (21.4 mm). Figure 13.3.2 shows the estimated length–frequency distributions (LFDs) of the discarded and retained *Nephrops* by trip for the annual discarding program (2005–2019). The discard sampling program in 2020 was suspended partially due to pandemic and administrative issues and, therefore, no information on *Nephrops* discards was obtained. This has not affected the stock assessment this year because the discard rate in *Nephrops* FU 30 is considered negligible.

13.3.2.2 Biological sampling

The sampling level for the species is given in Table 1.4. The number of samples was much reduced due to the COVID-19 disruption.

Figure 13.3.3 shows the annual landings length distribution for males, females and both sexes combined during the period 2001–2020. The length composition of landings was considered biased from 2001 to 2005 since the sampling of landings was not stratified by commercial categories (Silva *et al*., 2006). A new sampling scheme was applied from 2006 to 2008, making information more reliable. The mean sizes for both sexes remained relatively stable after the sampling scheme was changed, around 29 mm CL for both sexes combined.

Since 2009, onboard concurrent sampling is carried out, as required by the Data Collection Framework (DCF; EU, 2007). Outside the *Nephrops* fishing season, a larger proportion of observer trips are likely not sufficient to cover *Nephrops* catches, whereas, when the directed *Nephrops* sampling was carried out in harbours during the past, the length distribution of landings were covered for all months. This fact could reduce the consistency of the catch-at-length distribution data. The number of samples between 2013 and 2015 was influenced by the EU sanction in this period coupled with the closure of *Nephrops* fishery in 2013. The sampling effort has been increasing since summer of 2016 due to the additional *Nephrops*-directed sampling to improve the quality of the commercial length distributions. In 2019, the sampling level decreased in the third quarter and was zero during the fourth quarter. This fact could have some impact on the annual estimation of the sex ratio, the mean length and the mean weight in landings. Summer is the main *Nephrops* fishing season, when females are out from their burrows for reproduction, making them more accessible to the fishery. So, sex ratio and mean weight might be affected by the sampling effort distribution along the year.

Onboard sampling was partially conducted in 2020 because of the COVID-19 disruption and administrative issues. Only one *Nephrops* sample was carried out in the third quarter of 2020, but it was not considered representative of the stock size composition. The total annual landings in number in 2020 were used to estimate the harvest rate (%) for that year, so it might have certain impacts on the stock assessment. As an approach, the landings size composition in 2020 has been estimated from the average length–frequency distribution of the last three years (2017–2019 period) and raised to the total landings in 2020.

Mean size of males and females in *Nephrops* landings in 2001–2020 are shown in Figure 13.3.1. The mean sizes show a slightly increasing trend from 2006 to 2013 (35.3 mm CL in males and 31.9 mm CL in females). In 2014 and 2015, the mean size in females was higher than for males, the opposite of what should be expected. It could be due to sampling problems. This fact was investigated in collaboration with the observers. The number of samples and the number of individuals sampled were low in both years which could distort the sex ratio and the mean size in both sexes. The length frequency distribution in both sexes improved since 2016 when additional directed *Nephrops* sampling was implemented. The mean sizes remained relatively stable in 2016–2018. Thus, the average for that period was 32 mm CL in males and 30 mm in females (31.1 mm for combined sexes). Length–frequency distribution shows an increase of small size individuals in 2017 and 2018 (see Figure 13.3.3). In 2019, mean sizes increased, mainly in males (36.9 mm CL in males, 31.9 mm CL in females and 35 mm CL for combined sexes). The male mean size was 32.6 mm CL while the female mean size was 29.5 mm CL, similar to the period 2016–2018.

The proportion of males in the sex ratio of the landings is shown in Figure 13.3.4. The proportion of males remained stable, around 50% since 2009, despite an increase of males observed in 2017 and 2019 (representing 60% and 65% of the landings, respectively). Nevertheless, the proportion of males in 2017 and 2019 might be influenced by the low sampling level during the third quarter. Females are more accessible to the fishing gear in summer (the main *Nephrops* fishing season) when they are out of their burrows for reproduction. In 2020, the sex ratio was estimated as the average from the last three years (2017–2019).

13.3.2.3 Mean weight in landings

The mean weights in landings are shown, for the whole time-series, in Figure 13.3.5. Since 2009, an increasing trend of the mean weight was observed. In 2013, it declined but remained stable to about 31 g until 2015 (period affected by the sanction and TAC limitation). In 2016, a decline in the mean weight in landings was observed again then remained stable in 2017 and 2018, reaching a mean value of 23.4 g during these last three years. The mean weight increased up to 32.4 g in 2019. The low level of sampling when females are more accessible to the *Nephrops* fishery could have caused an increment in the mean weight of the annual landings as males tend to be larger and heavier than females. Mean weight in 2020 has been estimated from the average length–

frequency distribution in the period 2017–2019 due to the pandemic and administrative problems explained before.

13.3.2.4 Abundance indices from surveys

Trawl surveys

The biomass and the abundance indices of *Nephrops* by depth strata, estimated from the Spanish Gulf of Cádiz International Bottom Trawl Surveys Q1 (G7511) (1993–2020 time-series) are shown in Table 13.3.3.

The overall abundance index trend decreased from 1993 to 1998 and remained stable from 1999 to 2009 despite the occurrence of strong fluctuations in some years. The lowest values in the time-series were recorded in 2004 and 2012. In 2010, the deeper strata (500–700 m) were not sampled due to a reduction in the number of fishing days, as a consequence of adverse weather conditions. Therefore, only the abundance index for the strata 200–500 m is available for 2010 (and its value is similar to the corresponding strata in previous years. The abundance index increased significantly in 2013 and 2014 (Table.13.3.3). The survey index has fluctuated since 2015 then declined in 2017 and 2018. Results in 2019 and 2020, show an increasing trend of the abundance survey index achieving the highest value recorded in 2020 (Figure 13.3.6). It should be noted that this survey is not specifically directed to *Nephrops* and is not carried out during the main *Nephrops* fishing season.

The length distributions of *Nephrops* obtained in the Spanish Gulf of Cádiz International Bottom Trawl Surveys Q1 (G7511) during the period 2001–2020 are presented in Figure 13.3.7 In 2015 and 2016, an increase of smaller individuals was observed. The mean size for both sexes increased in 2017 while remaining relatively stable in 2018 and 2019 (~ 36 mm CL in males and ~ 30 mm CL in females). In 2020, the mean size decreased to 33.9 mm CL in males while remained stable at around 30 mm CL in females. The *Nephrops* mean sizes time-series for males, females and combined sexes obtained in this survey are shown in Figure 13.3.8. No apparent trends are observed. The mean size ranged between 28.3 and 32.7 mm CL for females and 31.9 and 42.9 mm CL for males.

UWTV surveys

An exploratory *Nephrops* UWTV survey on the Gulf of Cádiz fishing grounds (U9111), named ISUNEPCA survey, was carried out within the framework of a project supported by Biodiversity Foundation (Spanish Ministry of Agriculture, Food and Environment) and European Fisheries Fund (EFF) in 2014 (Vila *et al*., 2014). This survey was considered exploratory in 2014 and, currently, five UWTV surveys are available (2015 to 2019). UWTV survey was not conducted in 2020 due to the COVID-19 disruption.

The ISUNEPCA UWTV surveys (U9111) surveys are based on a randomized isometric grid design with stations spaced by 4 nm. The methods used during the surveys are according to WKNEPHTV (ICES, 2007), WKNEPHBID (ICES, 2008), and SGNEPS (ICES, 2012) and WGNEPS (ICES, 2020b). A description of UWTV surveys carried out in FU 30 since 2014 is documented in the Stock Annex.

UWTV surveys results were evaluated in WKNEP, the Benchmark Workshop on *Nephrops* Stocks in 2016 (ICES, 2017a). WKNEP concluded that the UWTV survey in FU 30 is appropriate to providing scientific advice on stock abundance.

The highest mean burrow density (adjusted to the cumulative bias) was obtained in 2017 (0.13 burrows/m^2). This value slightly decreased in 2018 (0.12 burrows/m^2) and has declined considerably in 2019 (0.04 burrows/m^2) reaching the lowest value of the time-series (Table 13.3.4).

The final modelled density surfaces for the time-series (2015–2019) are shown as heat maps and bubble plots in Figure 13.3.9. The abundance estimate derived from the krigged burrow surface (and adjusted for the cumulative bias) increased from 298 in 2015 to 371 million burrows in 2017 with a lower value recorded in 2016 of 232 million burrows. The coefficient of variation was about 7% in 2015 and 2016 but this increased in 2017 (CV = 8.7%). In 2018, the geostatistic abundance estimate was slightly lower than the previous year (329 million burrows) with a CV of 6%. However, the heat map of the abundance estimates in the main patch within the *Nephrops* distribution area, where the commercial bottom-trawl operates, shows an increase compared to 2017. In 2019, the geostatistical abundance estimate was 113 million burrows, representing 65% less than the previous year (Table 13.3.4). The CV was 9.7%, higher than the previous year.

The total number of TV stations was increased up to 65 in 2017 and raised to 70 in 2018 and 2019. However, the stations used in the geostatistical abundance estimate were 62, 60, and 65, respectively. Deviation of the planned stations is usually due to the poor visibility related to recent fishing activity in some stations or due to the uncertainty generated by the presence of other crustaceans burrows.

In 2019, many technical problems occurred in the UWTV survey, which was related to the communication between the sledge and the desk unit by the vessel coaxial cable. This resulted in a reduction of the effective survey time. So, the planned stations had to be prioritized. In the shallowest edge, besides the very poor visibility, the available VMS data from the *Nephrops*-directed trips and the Spanish Gulf of Cádiz International Bottom Trawl Survey series (G7511 and G4309) indicate a very low density which generates a high uncertainty in the *Nephrops* burrows identification. Additional information obtained from the beam trawl hauls carried out in the 2017–2019 period indicated the absence of *Nephrops* in the hauls at depths lower than 200 m. Therefore, it was decided to sacrifice the 12 stations located at lower depths, which were considered *Nephrops* zero density stations although still included in the geostatistical analysis (Figure 13.3.9).

The final modelled density surfaces in the ISUNEPCA UWTV surveys (U9111) time-series (2015–2019) are shown as heat maps and bubble plots in Figure 13.3.9 UWTV survey in 2020 could not be conducted due to the COVID-19 disruption.

Data compiled during ISUNEPCA UWTV survey series (U9111) suggest that the survey area is probably smaller than the current area and, therefore, should be reviewed during the next benchmark. New and more accurate information is available for this issue. The Andalusia Regional Government has installed its own vessel monitoring system on vessels using GPRS/GSM, a cellular network technology that sends vessel positions and speed data every three minutes instead of two hours in the traditional VMS. Additionally, information obtained from beam trawl and sediment samples obtained in the ISUNEPCA UWTV survey (U9111) during 2017–2019, as well as, the more detailed seabed morphology information and new information about the relationship between sediments and habitats in the Gulf of Cádiz (Lozano *et al.*, 2019; Lozano *et al.*, 2020) could also be very useful to redefine the survey area in FU 30. A provisional new survey area was presented during the WGNEPS 2020 (ICES, 2021). The WGNEPS recommended finalizing this analysis and reviewing footage that are out of the new provisional survey area before the 2021 WGBIE. Unfortunately, this work has not been finished on time for this WG but it is planned to be presented in WGNEPS 2021 and WGBIE 2022.

13.3.2.5 Commercial catch and effort data

Figure 13.3.1 and Table 13.3.5 show directed *Nephrops* effort estimates and LPUE series modified after the incorporation of data from Ayamonte port since 2002. Directed effort is estimated from trips that land at least 10% *Nephrops*. The directed fishing effort trend is clearly increasing from 1994 to 2005, where the highest value of the time-series was recorded (4336 fishing days). After that, the effort declined up to 2008 (73%) remaining relatively stable during the 2009–2012 period.

As a consequence of the sanction in 2012, the effort dropped (mean value 283 fishing days) in 2013–2015. Fishing effort increased from 2016 (443 fishing days) to 2019 (675 fishing days). In 2020, a slight decrease was observed (625 fishing days) (Figure 13.3.1).

LPUE obtained from the directed effort shows a gradual decrease from 1994 to 1998. After 1998, the trend slightly increased until 2003. In 2004, the LPUE decreased to the lowest value recorded (44.3 kg/fishing day) in the time-series. LPUE then increased until 2008 to around 60% higher. In the following years, the LPUE declined to 50 kg/fishing day in 2009 (about 30% less with respect to 2008) and 45.5 kg/fishing day in 2010. The increased abundance of rose shrimp in 2008 is believed to have led to a change in the fishery objectives as rose shrimp achieves a higher market value and is caught in shallower fishing grounds (90–380 m) which are closer to the coast. Since 2010, LPUE shows an increasing trend with a high rise in 2013. After a drop in the LPUE in 2014, the commercial abundance index showed an increasing trend up to 2016. The commercial index declined in 2017 and remained relatively stable in 2018 compared to the previous year. In 2019, commercial LPUE increased by 57% in relation to the previous year but in 2020, this index reduced about 20% (Figure 13.3.1). LPUE in the period 2013–2015 must be taken with caution as during this period a penalty for exceeding the quota in 2012 was applied, which increases the uncertainty associated with the LPUE index. Moreover, the assignment of *Nephrops* quotas by vessel implemented in 2014 might have caused unreported landings and contributed to increasing the uncertainties around the commercial index estimate since this date. On the other hand, LPUE was estimated using the official landings (reported landings) and not the total landings estimated by the WG since 2016. This fact might contribute to increase the uncertainty of the commercial abundance index.

13.3.3 Assessment

This stock was benchmarked in October 2016 (ICES, 2017a). The assessment is based on UWTV survey trends according to category 3 for *Nephrops* stocks, following the 2-over-3 rule.

13.3.4 Catch options

Table 13.3.6 shows the UWTV (U9111) abundance, estimates of the mean weight and harvest rate (HR) for the period 2017–2020. A decreasing trend of the HR was observed from 2016 to 2018 but it increased in 2019. HR in 2020 is not available and abundance was not estimated as the UWTV survey was not carried out because of COVID-19 disruption.

The prediction of landings for the FU 30, using the procedure agreed upon at WKNEP 2016 (ICES, 2017a) and outlined in the Stock Annex, is usually made on the basis of the UWTV survey estimated abundance obtained in the advice year and is presented in October for the provision of advice. The 2021 UWTV survey is scheduled for the period June 2–14. Input table for the catch options in 2021 is given below:

Variable	Value	Source	Notes
Stock abundance	Available in October	ICES (2021)	UWTV survey 2021
Mean weight in landings	26.8	ICES (2021)	Average 2018-2020
Mean weight in discards	-	ICES (2021)	Not relevant
Discard proportion	0%	ICES (2021)	Negligible
Discard survival rate	-	ICES (2021)	Not relevant
Dead discard rate	0%	ICES (2021)	Negligible

13.3.5 Biological reference points

F_{MSY} proxy ($F_{0.1}$) derived from the SCA (Separable Cohort Analysis; Pope and Shepherd, 1982) model during WKNEP 2016 (ICES, 2017a), corresponds to a harvest rate of 9.5% but this resulted in much higher catch advice than the historically observed values. WKNEP 2016 decided to derive the HR from historical catches of this stock and the exploitation in similar stocks as an interim solution until a more consolidated basis for generating advice from UWTV survey abundance estimates can be developed (ICES, 2017a). Taking into account the history of the fishery in *Nephrops* FU 30, HR was estimated to range between 1.5% in 2010–2012 and 4% when landings achieved the highest value (2003). The 2013–2015 period was not considered because TAC was limiting the fishery as a consequence of the penalty applied for exceeding the TAC in 2012. So WKNEP 2016 recommended setting an initial F_{MSY} proxy to 4% and moving gradually towards this level despite the absence of a current transition scheme definition. As the UWTV survey approach was just recently initiated for the FU 30 during WKNEP 2016, caution was recommended in the definition of the transition scheme towards F_{MSY} proxy (ICES, 2017a).

WKNEP 2016 also recommended a new EG on reference points that will examine the methodology for all *Nephrops* reference points with focus on M and growth.

ADGNEP agreed in October 2017 that in the absence of stock-specific MSY harvest rate in *Nephrops* FU 30 (due to poor fits in length–frequency model analyses), normally used for calculating F_{MSY} for category 1 in *Nephrops* stocks, that the basis of advice for this stock should follow the category 4 approach for Norway lobster stocks and not category 1. ADGNEP recommended that when stock-specific MSY reference points can be estimated, *Nephrops* FU 30 will meet the requirements for category 1 assessment.

The WGBIE 2017 supported the proposal of a specific workshop before the 2018 WGs assessment (ICES, 2017b). The WK*Nephrops* was finally held in November 2019 (ICES, 2020c). Different models were applied to *Nephrops* in FU30 during WK*Nephrops*. Some of them are methods developed for data-limited stocks as Length-Based Indicators (LBI) or Mean Length-Z at WKLIFE V (ICES, 2015) while others are used for calculating MSY Reference Points for Category 1 *Nephrops* stocks, such Separable Cohort Analysis (*SCA* R package, version 1.2.0, Bell, 2019) and Separable Length Cohort Analysis (SLCA–*nepref* R package, version 0.2.2, Dobby, 2019) (Leocádio *et al.*, 2018). SCA model gave FU 30 stock estimates far below those estimated from the UWTV survey. Factors as the uncertainties around natural mortality and growth parameters can affect the shape of the catch-at-length distribution and can produce different magnitudes of stock abundance. On the other hand, the abundance from UWTV input value in the model for FU 30 seems to be very sensitive, where lower UWTV survey input resulted in a model with a better fit. Some exploratory runs were carried out using SLCA but the resulting HRs were also very high.

To conclude, the MSY reference point could not be properly derived for FU 30 during the WK*Nephrops* in 2019 (ICES, 2020c). Other methods need to be explored in order to obtain specific FU 30 MSY reference points and upgrade this *Nephrops* stock to category 1.

Estimates from Length-Based Indicators (LBIs) and Mean Length-Z method as defined in WKLIFE-V (ICES, 2015) and WKProxy (ICES, 2016) were updated during the WK*Nephrops* in 2019 (ICES, 2020c) and presented in WGBIE 2020 (ICES, 2020a). Results are included in the Stock Annex. However, reference points resulting from the application of these methods are not suitable to use for *Nephrops* Stocks assessed using UWTV surveys because they use a harvest rate, expressed as a percentage, and not a fishing mortality reference point.

13.3.6 Management considerations

Nephrops fishery is taken in mixed bottom-trawl fisheries; therefore the harvest control rules (HCRs) applied to other species will affect this stock.

In 2013 and 2014, the *Nephrops* fishery was closed for most of the year because the quota in 2012 was exceeded and the European Commission applied a sanction to be paid in 3 years.

A Recovery Plan for the Iberian stocks of hake and *Nephrops* was approved in December 2005 (EU, 2005). This recovery plan was based on a precautionary reference point for southern hake that is considered no longer appropriate. By derogation, a different method for effort management was applied to the Gulf of Cádiz. A multiannual management plan (MAP) for the Western Waters was published by the European Parliament and the Council (EU, 2019a). This plan applies to demersal stocks including *Nephrops* in FU 30 in ICES Division 9.a.

Different Fishing Plans for the Gulf of Cádiz have been established by the Spanish Administration since 2004 in order to reduce the fishing effort of the bottom-trawl fleet (ORDENES APA/3423/2004, APA/2858/2005, APA/2883/2006, APA/2801/2007, ARM/2515/2009, ARM/58/2010, ARM/2457/2010; AAA/627/2013). These plans established a closed fishing season of 45 days, between September and November, plus 5 additional days to be selected by the shipowner during the duration of this Plan. The potential effect of the closed seasons on the *Nephrops* population has not been evaluated. Additionally, an increase of the mesh size to 55 mm or more was implemented at the end of 2009 in order to reduce discards of individuals below the minimum landing size. In 2014, a modification of the last Fishing Plan for the Gulf of Cádiz was established (AAA/1710/2014, modified by AAA/1406/2016). This new regulation establishes the assignment of *Nephrops* quotas by fishing vessel. The Fishing Plan for the Gulf of Cádiz (APM/453/2018) changes the closed season for the bottom-trawl fleet to the period from 16 September to 31 October.

Several regulations were established by the Regional Administration with the aim of distributing the fishing effort throughout the year (Resolutions: 13 February 2008, BOJA nº 40; 16 February 2009, BOJA nº 36; 23 November 2009, BOJA nº 235; 15 October 2010, BOJA nº 209). These regional regulations control the days and time when the Gulf of Cádiz bottom-trawl fleet can enter or leave the fishing ports. Although the regulations varied among them, they generally allowed large flexibility during late spring and summer (e.g. the 2010 Regulation established a continuous period from Monday 3 am to Thursday 9 pm during May–August, that was implemented in 2011), which is the main *Nephrops* fishing season, and a more restricted period in other months. This fishing flexibility during summer might have induced fleets from the ports closer to *Nephrops* grounds, such as Ayamonte or Isla Cristina, to direct their fishing effort to this species between 2008 and 2011. Currently, this regulation is not implemented.

Unwanted catches from *Nephrops* are regulated by the discard plan for the demersal fisheries in South-Western waters for the period 2019–2021 (EU, 2018 replaced by EU, 2019b), under which they are exempted from the landing obligation based on the species' high survival rates. This exemption applies to all catches of Norway lobster from ICES subareas 8 and 9 with bottom-trawls, with the immediate release of all discards in the area where they were caught.

13.3.7 References

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13.3.8 Tables and figures

Table 13.3.1. *Nephrops* in FU 30. Gulf of Cádiz: Landings (in tonnes) by country.

Year	Spain**	Portugal	Non-reported	Total
1994	108			**108**
1995	131			**131**
1996	49			**49**
1997	97			**97**
1998	85			**85**
1999	120			**120**
2000	129			**129**
2001	178			**178**
2002	262			**262**
2003	303	4		**307**
2004	143	4		**147**
2005	243	3		**246**
2006	242	4		**246**
2007	211	4		**215**
2008	117	3		**120**
2009	117	2		**119**
2010	106	1		**107**
2011	93	3		**96**
2012	115	1		**116**
2013	26	< 1		**27**
2014	14	< 1		**15**
2015	25	< 1		**25**
2016	35	< 1	89	**124**
2017	38	< 1	101	**140**
2018	49	< 1	27	**75**
2019	65	0	0	**65**
2020	55	8	0	**63**

**** Ayamonte landings are included since 2002.**

Table 13.3.2. *Nephrops* in FU 30. Gulf of Cádiz. Mean carapace length (in mm) of the discarded and retained fraction and percentage of discard in weight and number (2005–2020) for the annual discarding program.

	MEAN CARAPACE LENGTH (mm)		% DISCARDED	
	Discarded fraction	Retained fraction	Weight	Number
2005	23.4	33.5	5.2	15.2
2006	20.5	29.4	4.6	11.8
2007	23.2	33.7	0.5	1.4
2008	20.8	35.2	2.5	7.7
2009	21.2	30.2	2.7	4.0
2010	21.9	31.7	1.3	4.5
2011	-	32.7	0.0	0.0
2012	-	32.6	0.0	0.0
2013	23.9	32.7	3.7	10.9
2014	-	34.5	0.0	0.0
2015	21.2	33.6	2.0	5.4
2016	20.5	31.0	0.0	0.1
2017	24.2	29.8	2.5	3.0
2018	23.5	32.0	2.9	7.6
2019	21.4	35.6	1.6	7.2
2020*	na	na	na	na

*** Discard sampling was only partially conducted due to the COVID-19 pandemic and administrative problems in IEO.**

Table 13.3.3. ***Nephrops*** in **FU 30**. **Gulf of Cádiz. Abundance index from Spanish Gulf of Cádiz Bottom Trawl Surveys Q1 (G7511).**

Spanish Gulf of Cádiz International bottom trawl surveys Q1 (G7511)						
Year	200–500 meters		500–700 meters		200–700 meters	
	kg/60'	Nb/60'	kg/60'	Nb/60'	kg/60'	Nb/60'
1993	0.77	19	1.16	34	0.95	26
1994	1.23	31	0.60	8	0.94	21
1995	0.55	8	**	**	na	na
1996	0.56	10	1.33	29	0.93	19
1997	0.08	2	0.70	23	0.38	12
1998	0.40	16	0.23	7	0.30	11
1999	0.50	15	0.28	7	0.41	12
2000	0.22	7	0.57	15	0.37	10
2001	0.32	8	0.61	14	0.44	11
2002	0.49	17	0.45	11	0.47	14
2003	ns	ns	ns	ns	ns	ns
2004	0.15	5	0.15	4	0.15	5
2005	0.54	18	0.76	25	0.64	21
2006	0.24	6	0.66	20	0.42	12
2007	0.44	16	0.23	9	0.35	13
2008	0.88	26	0.81	14	0.85	20
2009	0.64	18	0.30	4	0.37	9
2010	0.63	20	**	**	na	na
2011	0.35	11	0.08	2	0.23	7
2012	0.15	4	0.22	4	0.18	4
2013	0.36	13	1.39	51	0.79	29
2014	2.97	84	0.50	9	1.92	52
2015	1.04	45	1.58	52	1.27	48
2016	4.38	194	0.5	15	2.73	118
2017	2.27	79	0.86	20	1.67	54

Spanish Gulf of Cádiz International bottom trawl surveys Q1 (G7511)						
Year	200–500 meters		500–700 meters		200–700 meters	
	kg/60'	Nb/60'	kg/60'	Nb/60'	kg/60'	Nb/60'
2018	0.49	15	0.23	5	0.38	11
2019	1.49	46	1.14	27	1.34	38
2020	7.07	262	4.93	405	6.16	323

ns = no survey.

** = no simple.

Table 13.3.4. *Nephrops* in FU 30. Gulf of Cádiz. Summary table of results from the geostatistical analysis for ISUNEPCA UWTV survey (U9111).

Year	Nª stations	Mean density adjusted	Area Surveyed	Domine area	Geoestatistical Abundance estimate adjusted	CV on burrow estimate
		Burrow/m2	Km2	Km2	Millions burrows	
2015	58	0.0905	3000	3000	298	7.6
2016	58	0.0776	3000	3000	233	7.3
2017	62	0.1336	3000	3000	371	8.7
2018	60	0.1197	3000	3000	329	6.0
2019	65	0.0377	3000	3000	113	9.7
2020*	NA	NA	NA	NA	NA	NA

* UWTV Survey in 2020 was not carried out due the COVID-19 disruption.

Table 13.3.5. *Nephrops* in FU 30. Gulf of Cádiz. Total landings and landings, LPUE and effort of the bottom trawl fleet making fishing trips with at least 10% of *Nephrops* catches.

Year	*Total landings (t)	**Landings (t)	**LPUE (kg/day)	**Effort (Fishing days)
1994	108	90	98.6	915
1995	131	107	99.4	1079
1996	49	40	88.2	458
1997	97	75	79.2	943
1998	85	51	62.3	811
1999	120	83	66.2	1259
2000	129	90	60.6	1484
2001	178	130	67.7	1924

Year	*Total landings (t)	**Landings (t)	**LPUE (kg/day)	**Effort (Fishing days)
2002	262	196	69.4	2827
2003	307	214	75.4	2840
2004	147	98	44.3	2206
2005	246	228	52.7	4336
2006	246	227	64.0	3555
2007	215	198	63.7	3105
2008	120	84	72.9	1150
2009	119	83	50.0	1653
2010	107	73	45.5	1603
2011	97	62	54.6	1135
2012	116	80	58.0	1380
2013	27	24	92.1	262
2014	15	12	40.1	293
2015	25	17	58.8	294
2016***	124	29	64.6	443
2017	140	24	45.5	535
2018	76	31	47.1	658
2019	65	50	73.7	675
2020	63	37	59.0	625

***Ayamonte landings are included since 2002.**

****Landings, LPUE and fishing effort from fishing trips with at least 10% of *Nephrops* catches.**

***** Since 2016, total landings were estimated by WGBIE. Official landings are used for LPUE estimation.**

Table 13.3.6. *Nephrops* in FU 30. Gulf of Cádiz. Summary for the assessment which will be updated after the 2021 UWTV survey.

Year	Landing in number	Total discard in number*	Removals in number	UWTV Abundance estimates	95% conf. intervals	Harvest Rate	Mean weight in landings	Mean weight in discard	Discard rate	Dead discard rate
	millions	millions	millions	millions	millions	%	g	g	%	%
2014**	0.48	0	0.48	282		0.2	31.2	0	0	0
2015	0.80	0	0.80	298	45	0.3	30.8	0	0	0
2016	5.35	0	5.35	233	34	2.3	23.2	0	0	0
2017	5.95	0	5.95	370	63	1.6	23.3	0	0	0
2018	3.21	0	3.21	329	39	1.0	23.4	0	0	0
2019	1.99	0	1.99	113	21	1.8	32.5	0	0	0
2020***	2.55	0	2.55	NA	NA	-	24.6	0	0	0

*** Discards are considered negligible and are not included in the assessment.**

**** UWTV survey in 2014 is considered exploratory. UWTV abundance estimate is not adjusted by the cumulative bias.**

***** UWTV survey in 2020 was not carried out due to the COVID-19 disruption.**

***** Landings length distribution sampling in 2020 was not carried out because of the COVID-19 pandemic disruption and administrative issues.**

***** Landings in number in 2020 estimated as the average of the length distribution for 2017–2019 period raised to the total landings in 2020.**

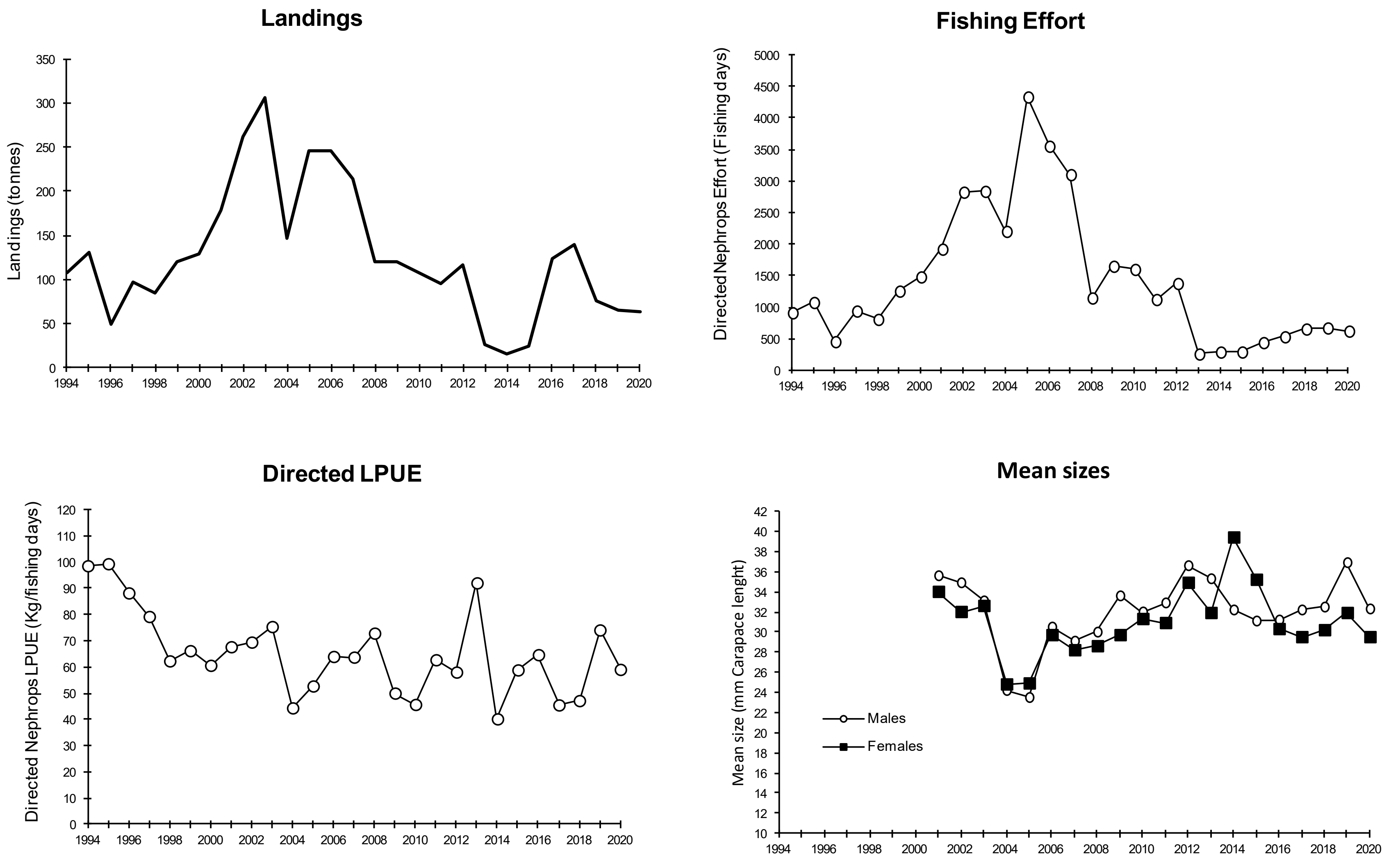


Figure 13.3.1. ***Nephrops*** **in FU 30. Gulf of Cádiz. Long-term trends in the landings,** ***Nephrops*****-directed effort and LPUE and mean sizes.**

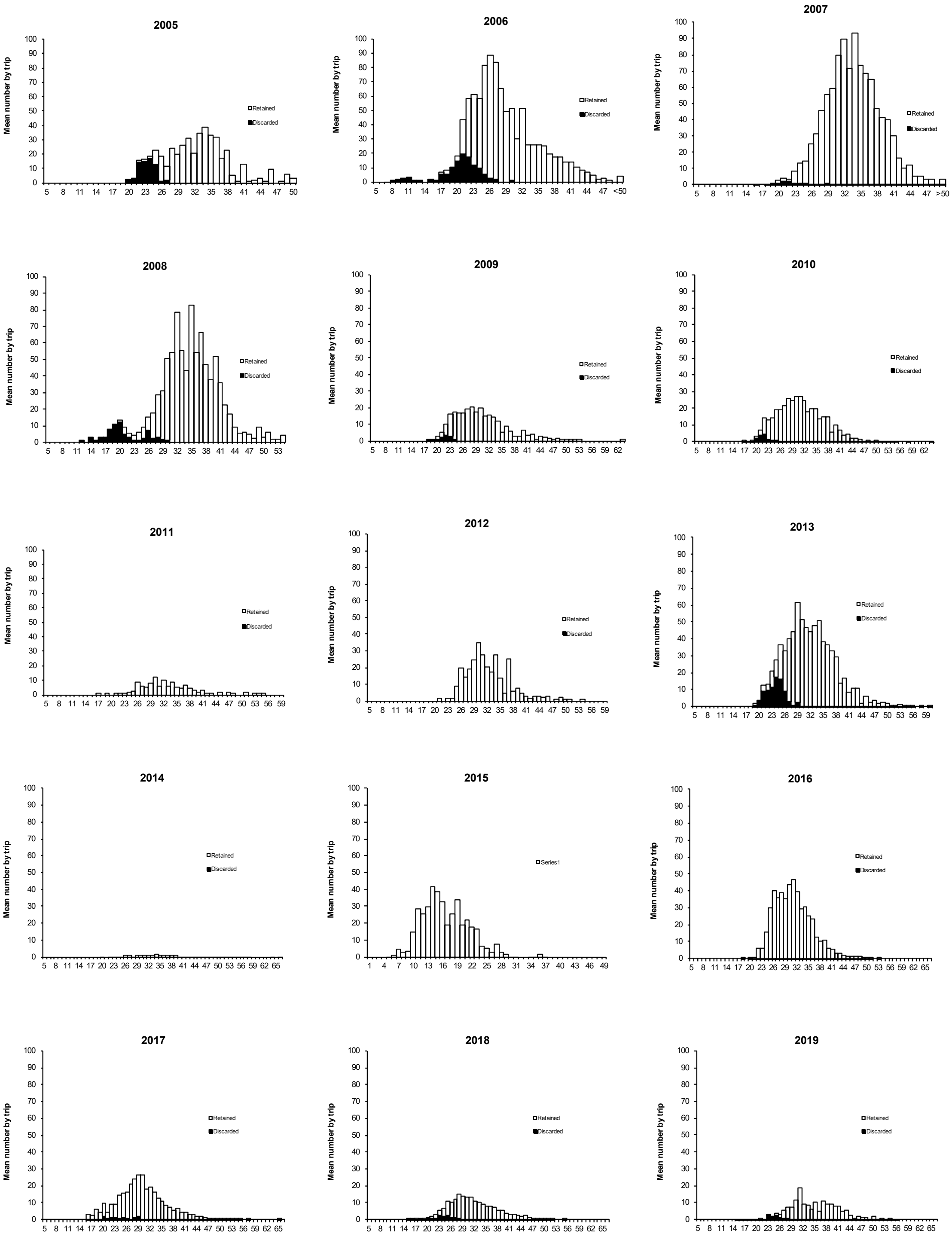


Figure 13.3.2. *Nephrops* in FU 30. Gulf of Cádiz. Length–frequency distribution of retained and discarded fractions *Nephrops* from discards program (2005–2019 period). Discard sampling was partially carried out due to pandemic and administrative problems in 2020. No data were available in 2020.

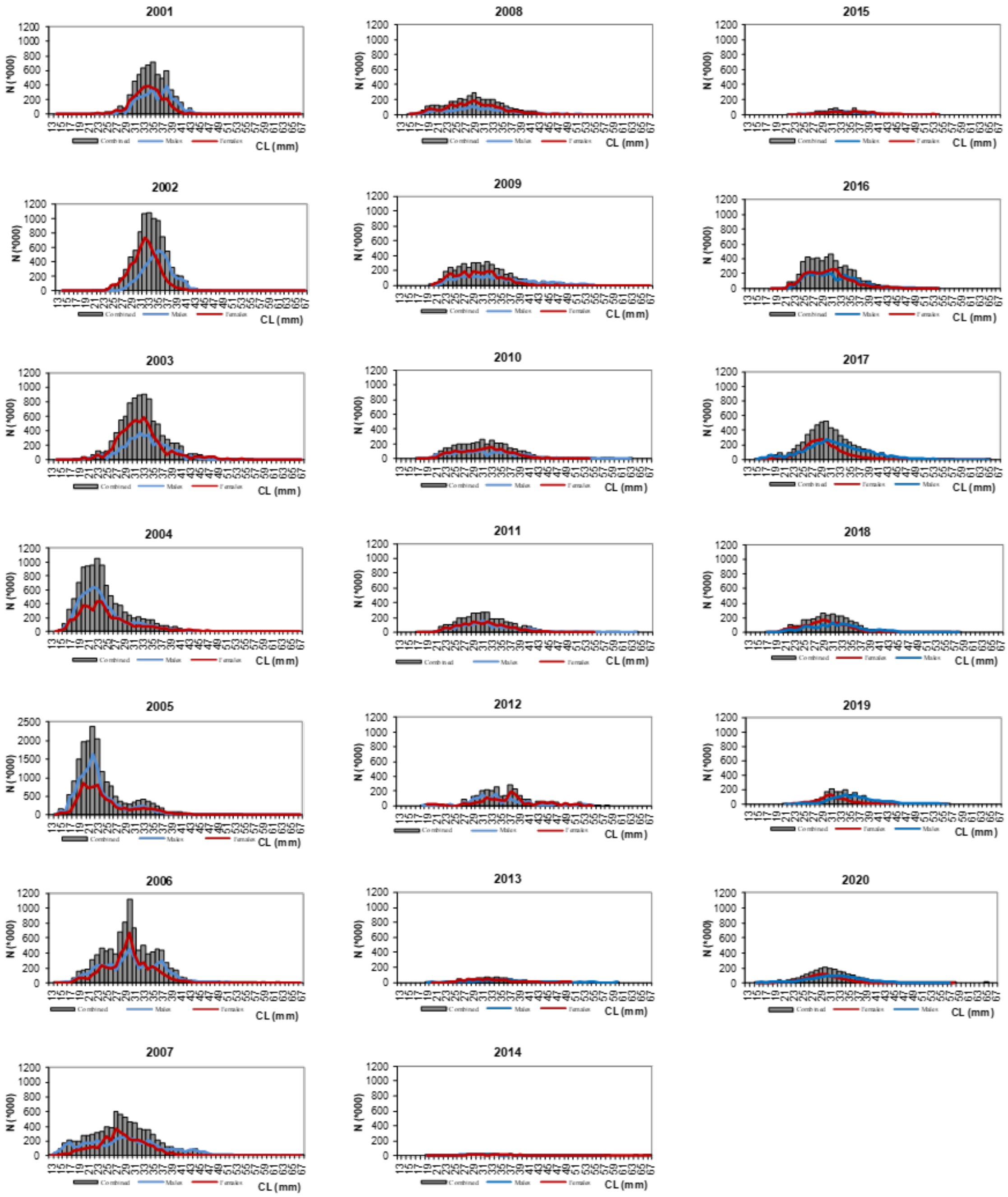


Figure 13.3.3. ***Nephrops* in FU 30. Gulf of Cádiz. Length distributions of landings for the period 2001–2020. Landings size composition in 2020 has been estimated from the average length frequency distribution of the last three years (2017–2019 period) and raised to the total landings in 2020.**

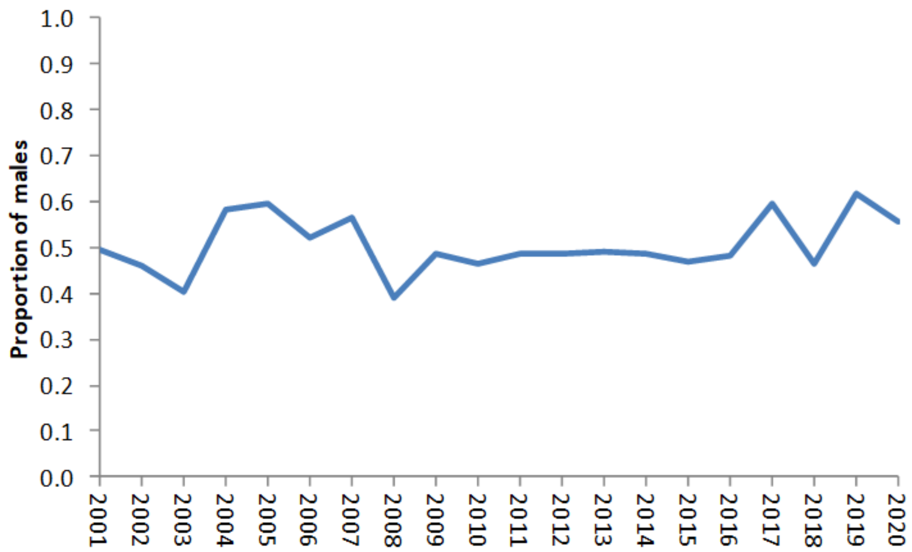


Figure 13.3.4. *Nephrops* in FU 30. Gulf of Cádiz. Proportion of males in landings for the time-series. Sex-ratio in 2020 has been estimated using the average length–frequency distribution of the last three years (2017–2019 period).

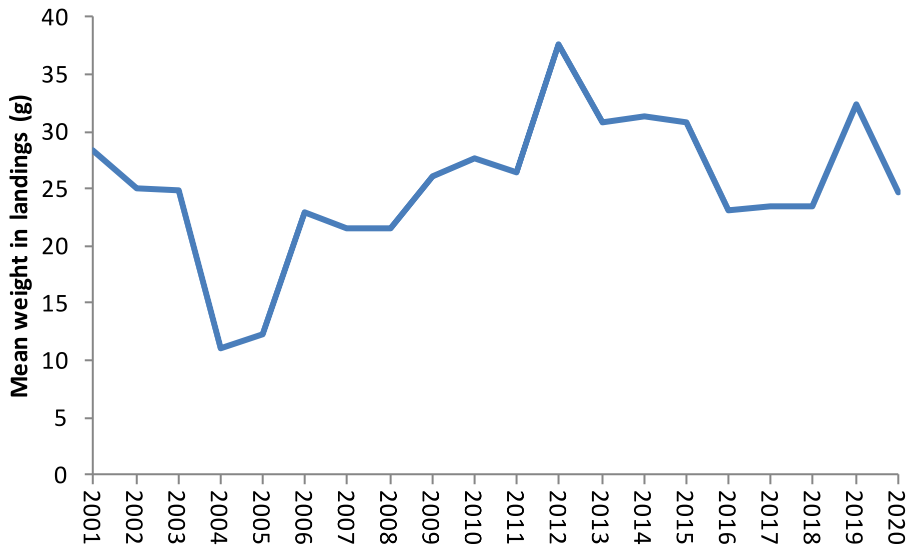
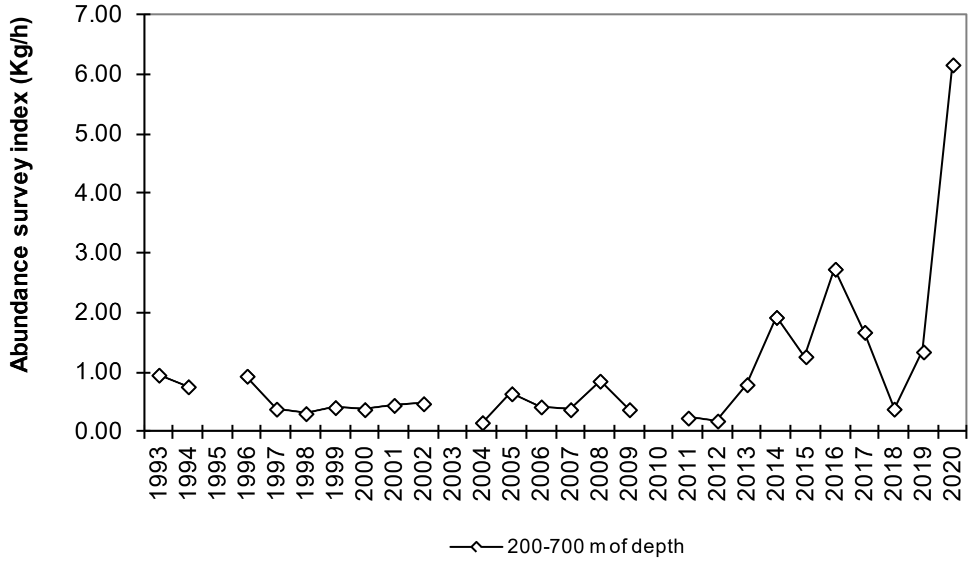


Figure 13.3.5. *Nephrops* in FU 30. Gulf of Cádiz. Time-series of the mean weight trend in commercial landings. Data in 2020 has been estimated using the average length–frequency distribution of the last three years (2017–2019 period).



* 1995 and 2010: strata 500-700 m no sampled

** 2003: no survey

Figure 13.3.6. *Nephrops* in FU 30. Gulf of Cádiz, Abundance index from Spanish International Gulf of Cádiz Bottom Trawl Surveys Q1 (G7511).

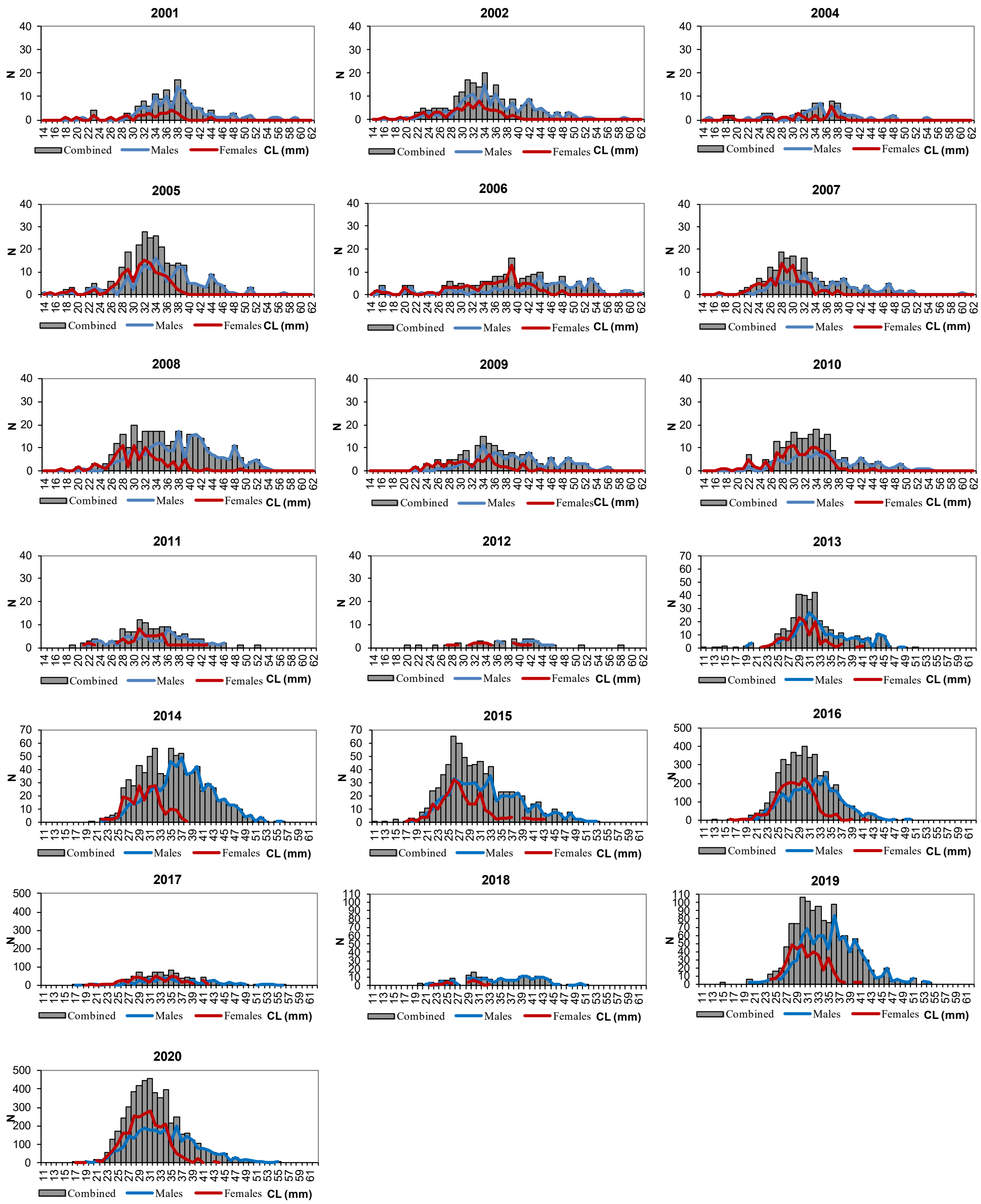


Figure 13.3.7. *Nephrops* in FU 30. Gulf of Cádiz. Length–frequency distributions from Spanish International Gulf of Cádiz Bottom Trawl Surveys Q1 (G7511) for the period 2001–2020.

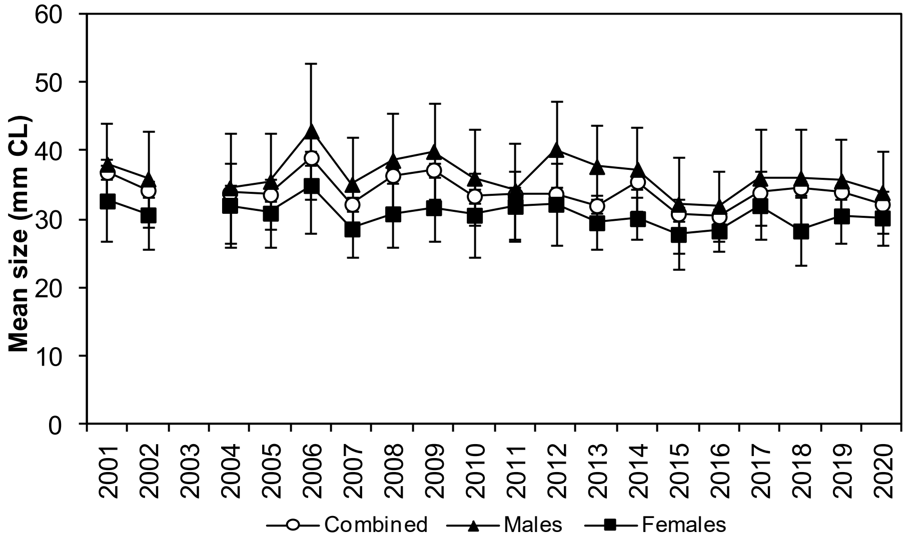


Figure 13.3.8. *Nephrops* in FU 30, Gulf of Cádiz. Mean size in Spanish International Gulf of Cádiz Bottom Trawl Surveys Q1 (G7511) for the period 2001–2020.

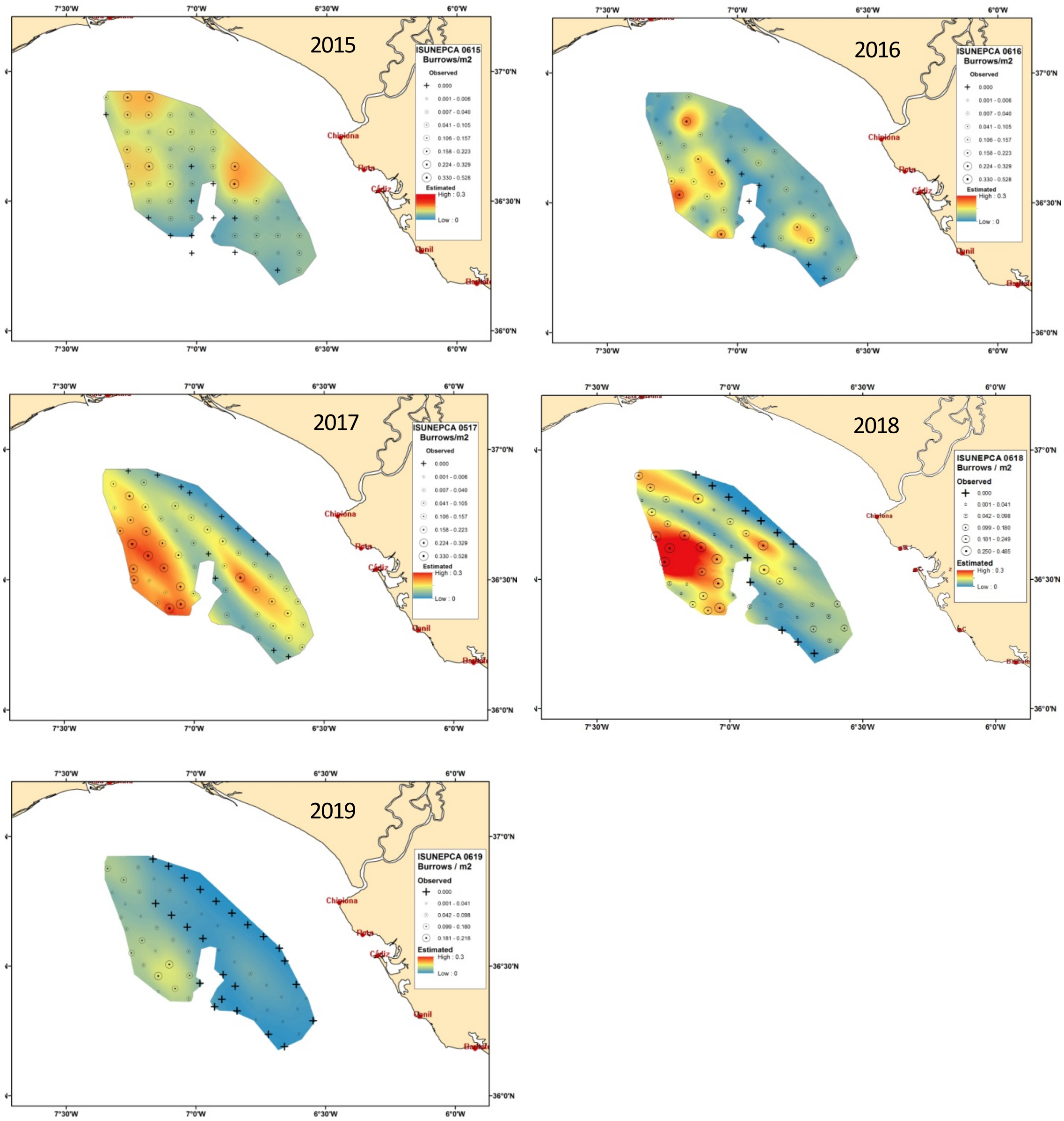


Figure 13.3.9. ***Nephrops*** **in FU 30. Gulf of Cádiz. Contour plots of the krigged density estimates for the ISUNEPCA UWTV surveys (U9111) time-series (2015–2019). No UWTV survey was conducted in 2020 due to the COVID-19 disruption. This figure will be updated after the UWTV survey in 2021.**

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

Dicentrarchus labrax – bss.27.8ab

Type of assessment

Age-at-length stock synthesis (SS) runs/update for a category 1 stock. Stock benchmarked in WKBASS 2017/2018 (ICES, 2018a) and IBPBass 2018 (ICES, 2018b).

Data revisions

2020 French data were used for this year's assessment.

Working Group issues

2020 age–length key (ALK) introduced bias in the last year's retrospective analysis due to an age reader change, already observed and discussed during the WGBIE 2019 and 2020 (ICES, 2019a; ICES, 2020).

14.1 General

14.1.1 Stock definition and ecosystem aspects

See Stock Annex.

14.1.2 Fishery description

Sea bass in the Bay of Biscay is targeted mainly by France with more than 98.8% of international landings in 2020 (Table 14.1). Spain is responsible for about 1.2% of the catches in 2020. A more detailed description of the fishery can be found in the Stock Annex.

Table 14.1. Summary of official and ICES commercial landings data in tonnes. The UK includes England, Wales, Northern Ireland, and Scotland.

Year	Belgium	France	NL	Spain	UK	Total Official	Total ICES
1985	0	2477	0	0	0	**2477**	**3420**
1986	0	2606	0	0	0	**2606**	**3549**
1987	0	2474	0	0	5	**2479**	**3417**
1988	0	2274	0	0	15	**2289**	**3217**
1989	0	2201	0	0	0	**2201**	**3144**
1990	0	1678	0	0	0	**1678**	**2621**
1991	0	1774	0	17	0	**1791**	**2734**
1992	0	1752	0	14	0	**1766**	**2709**
1993	0	1595	0	14	0	**1609**	**2552**

Year	Belgium	France	NL	Spain	UK	Total Official	Total ICES
1994	0	1708	0	17	0	**1725**	**2668**
1995	0	1549	0	0	0	**1549**	**2492**
1996	0	1459	0	0	0	**1459**	**2402**
1997	0	1415	0	0	0	**1415**	**2358**
1998	0	1261	0	27	0	**1288**	**2231**
1999	0	2081	0	11	0	**2092**	**2091**
2000	0	2080	0	67	0	**2147**	**2362**
2001	0	2020	3	68	0	**2091**	**2306**
2002	0	1937	0	176	0	**2113**	**2392**
2003	0	2812	0	119	0	**2931**	**2616**
2004	0	2561	0	96	0	**2657**	**2380**
2005	0	3184	0	74	0	**3258**	**2796**
2006	0	3318	0	167	2	**3487**	**2875**
2007	1	2984	0	74	1	**3060**	**2751**
2008	0	1508	0	145	0	**1653**	**2745**
2009	1	2339	0	194	0	**2534**	**2278**
2010	0	2322	0	165	2	**2489**	**2229**
2011	1	2536	0	311	0	**2848**	**2575**
2012	1	2325	0	204	5	**2535**	**2549**
2013	0	2504	0	156	0	**2660**	**2685**
2014	0	2926	0	89	0	**3015**	**2991**
2015	0	2216	0	71	0	**2287**	**2264**
2016	0	2121	0	85	0	**2206**	**2252**
2017	0	2146	0	72	0	**2218**	**2295**
2018	0	2204	0	84	0	**2288**	**2316**
2019	0	2090	0	97	0	**2187**	**2227**
2020	0	2032	0	24	0	**2056**	**2090**

For France, line fisheries (handlines and longlines) take place all year-round (especially during quarters 3 and 4), while nets, pelagic and bottom-trawl fisheries take place from November to April, the period when pre-spawning and spawning sea bass aggregate to reproduce. In 2020, nets represent 34.8% of the landings of the area, lines 34.8%, bottom-trawl 19.8%, pelagic trawl 6%, and other gears 4.6%.

In 2020, total landings decreased slightly compared to 2019. Landings were observed stable for liners, netters and other gears while a decrease for both pelagic and bottom-trawlers (Figure 14.1). Note that netters are very dependent on weather conditions (2014 was an exceptional year).

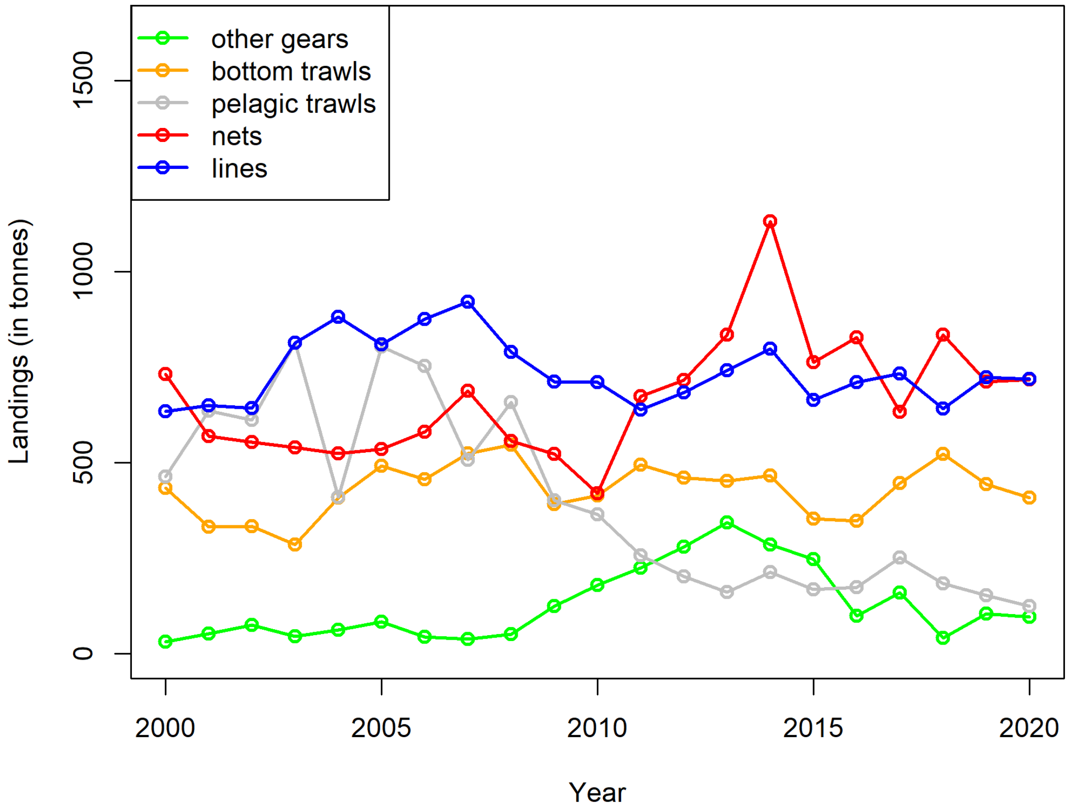


Figure 14.1. Figure 14.1. French landings per gear.

14.1.3 Summary of ICES advice for 2021 and management

14.1.3.1 ICES advice for 2021

ICES advises that when the EU multiannual plan for Western waters and adjacent waters is applied (MAP; EU, 2019), catches in 2021 that correspond to the F ranges in the MAP are between 2966 t and 3770 t. According to the MAP, catches higher than those corresponding to F_{MSY} (3108 t) can only be taken under conditions specified in the MAP, while the entire range is considered precautionary when applying the ICES advice rule (ICES, 2019b).

14.1.3.2 Management

Commercial fishery

Sea bass in the Bay of Biscay is not subject to EU TACs and quotas. However, sea bass is ruled by an EU multiannual plan since 2019 (EU, 2019). It aims to ensure that particular sea bass stocks are exploited sustainably and that the decisions on fishing opportunities are based on the most up-to-date scientific information. It allows certain flexibility in setting fishing opportunities by defining the target fishing mortality (F) as a range of values, which would result in a long-term F_{MSY} and would be based on the best available scientific advice. The plan does not include quantified reference points for F or biomass levels, which are instead provided by the latest scientific advice available, and used by the Council when fixing fishing opportunities. In addition to the F_{MSY} ranges, the plan introduces safeguard measures based on biomass levels, in order to restore the stocks when they fall below safe biological limits. Where recreational F has a significant impact on a stock managed on the basis of a MSY (which is the case of sea bass stocks), the Council should be able to set non-discriminatory limits for recreational fishers. The Council should use transparent and objective criteria when setting such limits. Where appropriate, Member States should make the necessary and proportionate arrangements for monitoring the stocks and data collection in order to make a reliable estimate of effective levels of recreational catches.

Commercial fishery at national level

Since 2012, a national professional quota system for sea bass fishing licences, defined and implemented by the Committees for Maritime Fisheries and Fish Farming (CNPMEM, 2020), has regulated French professional catches of the species both for the Bay of Biscay (divisions 8.a, 8.b, and 8.d) and the Northern stocks (divisions 4.b, 4.c, 7.a, 7.d–7.h).

In addition, a French national regulation was applied. From 2012 onwards, a national license, defined and implemented by the CNPMEM, supervises the French professional sea bass landings on both the Bay of Biscay (ICES divisions 8.a, 8.b, and 8.d) and the Northern stocks (ICES divisions 4.b, 4.c, 7.a, 7.d–7.h). Since 2017, a Minimum Landing Size (MLS) of 38 cm has been implemented in the Bay of Biscay (ICES divisions 8.a, 8.b, and 8.d). This MLS was revised to 40 cm in 2019 and applied in 2020. Moreover, all French professional fishing activities in the area have been subjected to an annual overall catch limit. It has been implemented in 2017, 2018, 2019 and 2020, and was set to 2490 t, 2241 t, 2150 t, and 2032 t, respectively. To manage the overall catch limit, annual and periodic individual limitations of fishing opportunities were implemented.

Recreational fishery

A series of management measures have been implemented for the French recreational fishery:

- A minimum conservation size of 42 cmwas implemented in 2013.
- A 5-fish bag limit was implemented in 2017.
- A 3-fish bag limit was implemented in 2018.
- A 2-fish bag limit was implemented in 2020.

14.2 Data

14.2.1 Commercial landings and discards

A detailed description of the commercial landings can be found in the Stock Annex. Landings time-series were reconstructed using the three main sources available (Figure 14.2):

1. Official statistics recorded in the FishStat database (FAO, 2020) since around the mid-1980s (total landings).
2. French landings for 2000–2020 from a separate analysis of logbook and auction data by Ifremer (SACROIS methodology; Demaneche *et al.*, 2010), which is used to answer the ICES annual InterCatch data call. Landings are available by *métier*.
3. Spanish landings for 2007–2011 from sale notes and for 2012–2018 from InterCatch statistics.

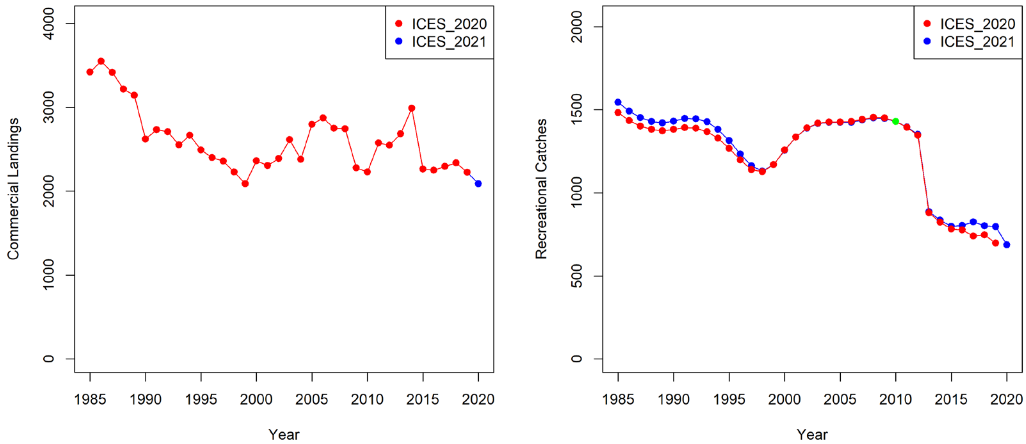


Figure 14.2. Commercial landings (left) and recreational removals (right) used in the 2020 and 2021 assessments. Weights are in tonnes.

The 2020 French data have been used for the assessment. There was no data revision (Figure 14.2).

Discarding of sea bass by commercial fisheries can occur when fishing takes place in areas where caught individuals are smaller than the MLS. For France, discards rates are low (Table 14.2). In 2020, the total discards percentage was estimated at 1.92% of the total French commercial catches, corresponding to an amount of 41 t. For Spain, observer data from Spanish vessels fishing in Area 8, have shown that no sea bass was discarded in 2003. No information in 2020 was available on discards for this year's WG. Discards are considered negligible and are not included in the stock assessment, despite the availability of this information. As it was observed that discards increased during the last 3 years of the series, landings predictions (from the assessment) were raised to provide the catch advice (Vigneau and Girardin, 2020).

Table 14.2. Estimated sea bass discards of French vessels in the Bay of Biscay. Weights are in tonnes.

Year	Commercial discards	Commercial landings	Total commercial catches	% commercial discards
2015	68	2264	2332	2.92
2016	65	2252	2317	2.81
2017	196	2295	2491	7.87
2018	155	2338	2493	6.22
2019	183	2227	2410	7.59
2020	41	2090	2131	1.92

14.2.2 Length and age sampling

The full description of the biological sampling is available in the Stock Annex.

14.2.2.1 French commercial fishery

The French sampling programme for sea bass landings length compositions covers sampling at sea and onshore. Data are available from 2000 onwards. French length compositions for 8.a–b across time and all gears combined are presented in Figure 14.3.

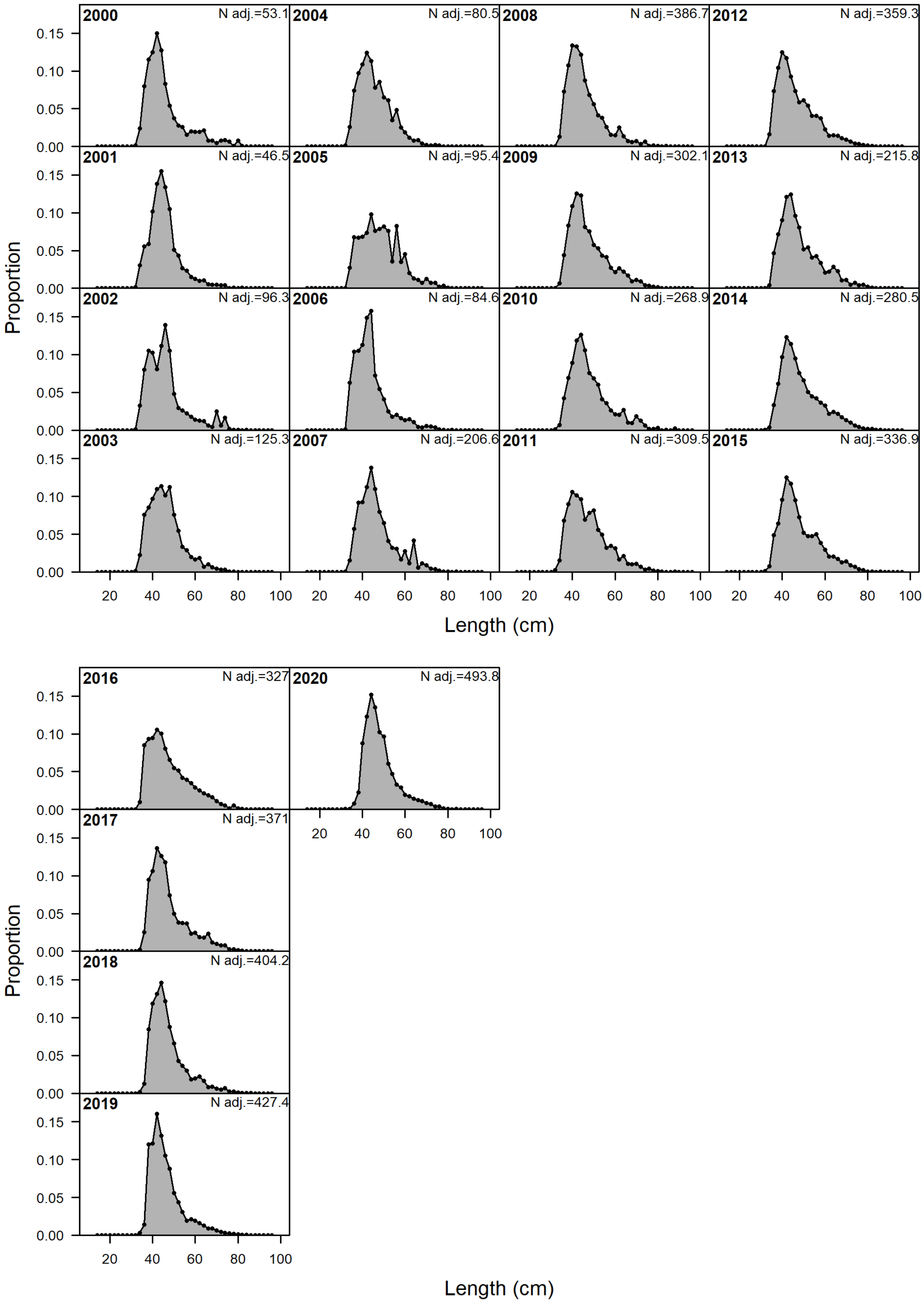


Figure 14.3. Length compositions of all French fleets combined from 2000 onwards.

The French sampling programme for sea bass age compositions is based on ALKs with fixed allocation. For the 8.a–b area, the information is available only from 2008. This year, as for years 2018–2019, it was observed that the 2020 ALK showed a pattern inconsistent with the historical data. The observed bias was related to a change in age readers over the years (Table 14.3). The group decided again not to include those age-at-length data.

Table 14.3. Proportion of scales read by each age reader over years 2008–2020

Year	Age readers			
	JH	KS	RE	SM
2008			100	
2009			100	
2010		71	29	
2011		100		
2012		100		
2013		100		
2014	13	78	9	
2015		31	69	
2016		89	5	6
2017		88	12	
2018			100	
2019			100	
2020			100	

A sensitivity analysis was performed to account for age readers' bias in the assessment (see section hereafter). An inter-calibration exercise was performed. It evaluated the bias and precision of the age readers, allowing 2 age error definitions that were included in an alternative assessment model. The historical age reader, KS, was considered as the reference age reader in the model, meaning that its age error definition has no bias and very high precision, while age error definition from the new age reader, RE, includes bias and imprecision (Figure 14.4)

14.2.2.2 Recreational fishery

The full description of the recreational catches is presented in the Stock Annex.

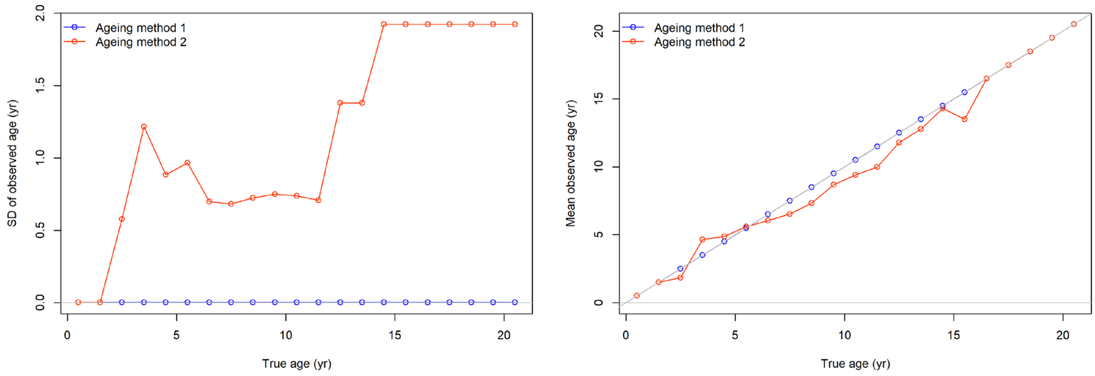


Figure 14.4. Ageing imprecision: Means and SD of observed age (year).

Recreational fishery catches reconstructed for the whole time-series

In a previous report (ICES, 2016b), partitioning French recreational data between the Biscay and Northern stock was only possible for the 2009–2011 study (Rocklin *et al.*, 2014). There are no historical estimates of the recreational catch over the entire time-series. IBPBass (ICES, 2014) considered it more plausible to treat recreational fishing as having more stable participation and effort over time than the commercial fishery. A decision was made during WKBASS 2018 benchmark meeting (ICES, 2018a) to apply a constant recreational F over time considering the same approach 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 value of 1430 t estimated in 2010. The implementation of new management measures should have led to a reduction in F as more and larger fish are released (Hyder *et al.*, 2018). This means that it is not appropriate to assume constant recreational F in the last years and, thus, it is necessary to re-estimate the recreational removals. This has been done using the estimated reductions generated from the assessment of the effect of different bag limit levels and MLSs (Armstrong *et al.*, 2014) in order to derive changes in recreational F. Also, the application of different management measures gave a recreational F multiplier for 2010–2012 of 1 and 0.684 for 2013–2016 (related to an increase in Minimum Conservation Reference Sizes (MCRS) to 42 cm). In 2017, with a 5-fish bag limit implementation, the multiplier was estimated to be unchanged. However, for 2018 with a 3-fish bag limit implementation, it was estimated to be 0.647. In 2020, a 2-fish bag limit was decided and the new multiplier used was estimated to be 0.584. Table 14.4 compiled figures used in the assessment for the recreational fishery.

Table 14.4. Time-series used in the SS model as commercial landings and recreational removals (in tonnes).

Year	Recreational removals	Commercial landings
1985	1544	3420
1986	1492	3549
1987	1452	3417
1988	1429	3217
1989	1421	3144
1990	1432	2621
1991	1448	2734

Year	Recreational removals	Commercial landings
1992	1446	2709
1993	1428	2552
1994	1382	2668
1995	1314	2492
1996	1234	2402
1997	1162	2358
1998	1130	2231
1999	1170	2091
2000	1257	2362
2001	1336	2306
2002	1389	2392
2003	1417	2616
2004	1424	2380
2005	1424	2796
2006	1425	2875
2007	1439	2751
2008	1451	2745
2009	1448	2278
2010	1430	2229
2011	1396	2575
2012	1352	2549
2013	887	2685
2014	835	2991
2015	799	2264
2016	803	2252
2017	825	2295
2018	801	2338
2019	797	2227
2020	686	2090

After the benchmark in 2018 (ICES, 2018a), an additional survey has been conducted in France by FranceAgriMer that provided estimates of the sea bass recreational removals in the Bay of Biscay. However, this survey has different associated uncertainty and bias than the one of 2010. It is not straightforward on how well to combine these data for use in the assessment and also ensure no significant departure or changes from the current approach. Hence, this should be done as part of the next benchmark and then peer-reviewed to ensure the robustness of the process. As a result, the current approach will be used until the next benchmark and recreational removals will be included on the issue list.

Recreational post-released mortality (PRM)

Based on the information provided by Hyder *et al.* (2018), WKBASS 2018 agreed on a figure of 5% for PRM in recreational fisheries for the Northern and the Bay of Biscay sea bass stocks (ICES, 2018a). This estimate was based on a published study (Lewin *et al.*, 2018).

Recreational length compositions

The estimate of removals was recalculated for the 2010 reference year as the sum of the 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 a WD from Hyder *et al.* (2018) and illustrated in Figure 14.5

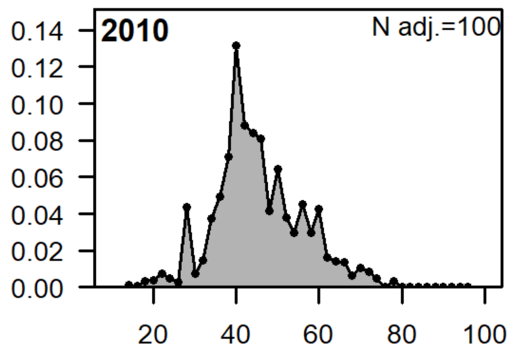


Figure 14.5. Length composition for the recreational fishery. Data available only for 2010.

14.2.3 Abundance indices from surveys

Currently, there is no survey providing relative indices of adult or juvenile sea bass abundance over time. A French study has been undertaken since 2013 to explore the possibility of creating recruitment indices in estuarine waters. Good results were obtained but it needs financial support to be routinely carried out (Le Goff *et al.*, 2017). Abundance indices have been calculated for years 2016–2020 in the Loire estuary and for years 2019–2020 for the Gironde estuary. These series of indices collection are planned to be continued. The ultimate objective would be to fund them in a sustainable manner through the Data Collection Framework (DCF).

14.2.4 Commercial landing-effort data

A full description of the LPUE and its estimation methods are presented in the Stock Annex and in a WD by Laurec and Drogou (2017). The absence of a relative index of abundance covering adult sea bass has been identified as a major issue for the assessment of the Bay of Biscay stock. There are no scientific surveys providing sufficient data on adult sea bass to develop an abundance index for the area. Hence, Ifremer investigated the potential of 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. A new LPUE index was presented at WKBASS 2018 (ICES, 2018a). This index was obtained by modelling the zeros and non-zeros values using a delta-GLM approach (Stefánsson, 1996) using the cuttlefish.model package (Gras and Robin, 2015) in R (R Core Team, 2020). A review of the study has been done by an external expert (M.C. Christman, MCC Statistical Consulting, Gainesville, Florida, USA) before WKBASS 2018 (ICES, 2018a). The reviewer recommended the use of the new LPUE index in the assessment of the Bay of Biscay sea bass stock. The new LPUE index has been incorporated in the Northern and the Bay of Biscay stocks assessment models. Results updated with 2020 data are presented in Figure 14.6.

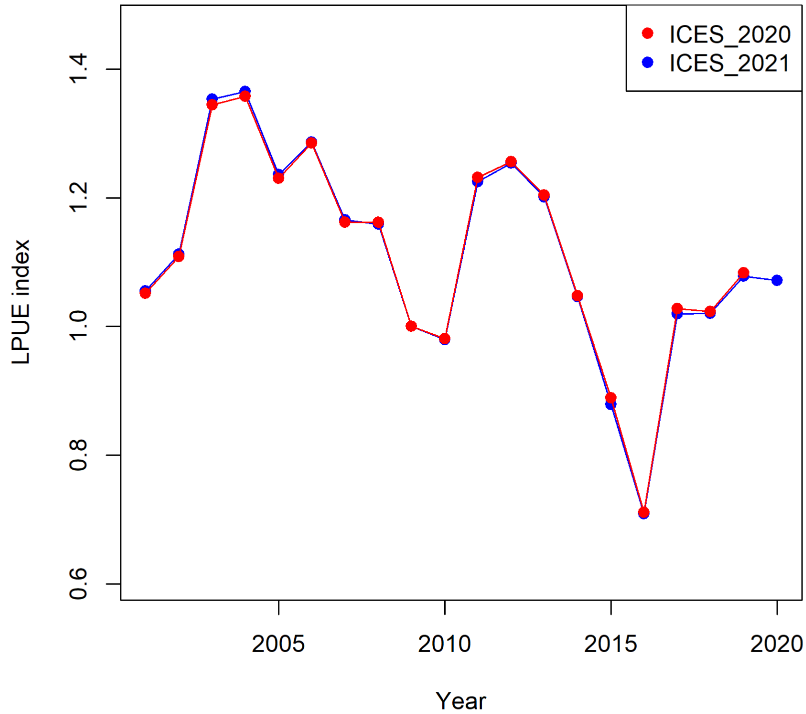


Figure 14.6. Comparison of the LPUE index used in the 2020 and 2021 assessments.

14.2.5 Biological parameters

The full description of the biological parameters is presented in the Stock Annex.

14.2.5.1 Growth

In the Bay of Biscay, studies on sea bass growth exist and have been published by Dorel (1986) and Bertignac (1987). To update these studies, sea bass was sampled by Ifremer during the years 2014–2015 along the coasts of France in areas 8.a and 8.b (Drogou *et al.*, 2018). The von Bertalanffy model parameters were estimated using an absolute error model minimizing $\sum(obs - exp)^2$ the lengths-at-age data used. L_{inf} was fixed to 80.4 cm (Bertignac, 1987). The standard deviation could be described by a linear model: SD = 0.1861 * age + 2.6955 (samples used from age 0 to age 15). The standard deviation of length-at-age increased with length as expected. K was estimated (see Stock Annex), but this value is not used as K is re-estimated by the assessment model.

14.2.5.2 Maturity

Sea bass maturity has been studied with samples collected by Ifremer in the Bay of Biscay. Samples were derived from French fisheries around the Bay of Biscay coast. The size at which 50%

of the females are mature is 42.14 cm (with a lower limit of 41.31 cm and an upper limit of 43.08 cm). The Pearson test (p-value = 0.597) identifies a good fit from the model to the data (Figure 14.7).

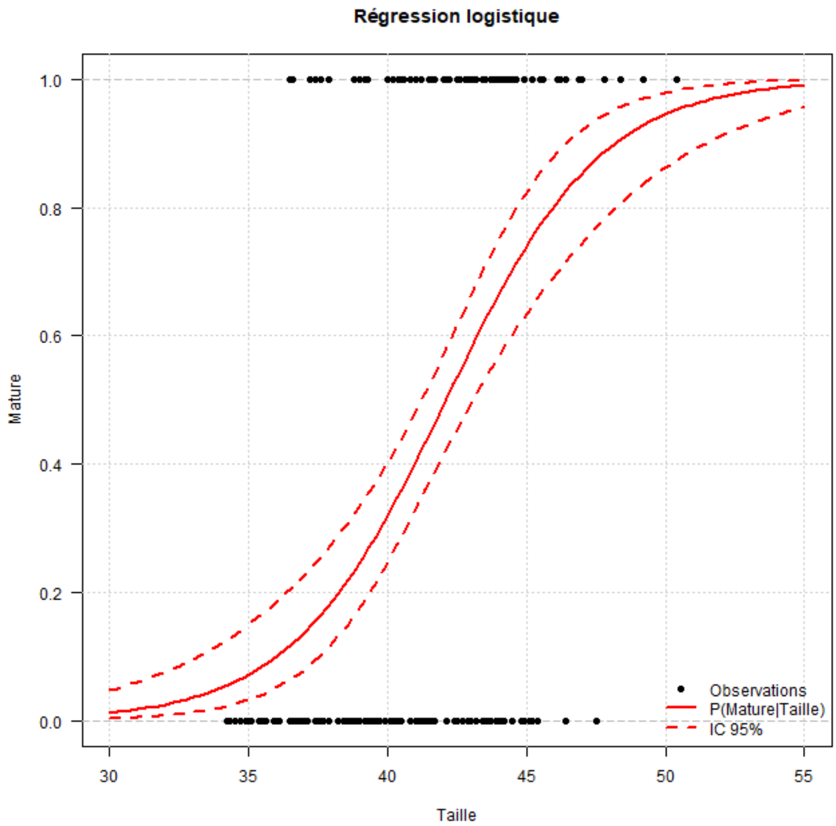


Figure 14.7. Maturity ogive for the Bay of Biscay sea bass stock.

14.2.5.3 Natural mortality

WKBASS 2017/2018 (ICES, 2018a) proposed to use the same value for both the northern and the Bay of Biscay sea bass stocks and set the natural mortality (M) to 0.24, the value predicted by Then *et al*. (2015) based on a t_{max} method which is considered more robust than inferences from any single study.

14.3 Assessment

This is an update assessment including the new data available for the year 2020 from WKBASS assessment. The COVID-19 pandemic has not affected the data quality for assessment and advice of the stock.

14.3.1 Input data

Input data are described in the Stock Annex (see under section “Input data for Stock Synthesis”).

14.3.2 Data Revisions

There were no data revisions for this update assessment.

14.3.3 Model

The SS assessment model (Methot and Wetzel, 2013) was selected for use in this assessment. Model description and settings are presented in the Stock Annex (under "Current assessment" for model description and "SS settings (input data and control files)" for model settings).

14.3.4 Assessment results

The assessment model includes estimation of size-based selectivity functions (selection pattern at length) for commercial and recreational fleets and for LPUE abundance index. Figure 14.8 presents selectivity functions by fleet estimated by the model. The inclusion of 2020 data did not change the selectivity pattern.

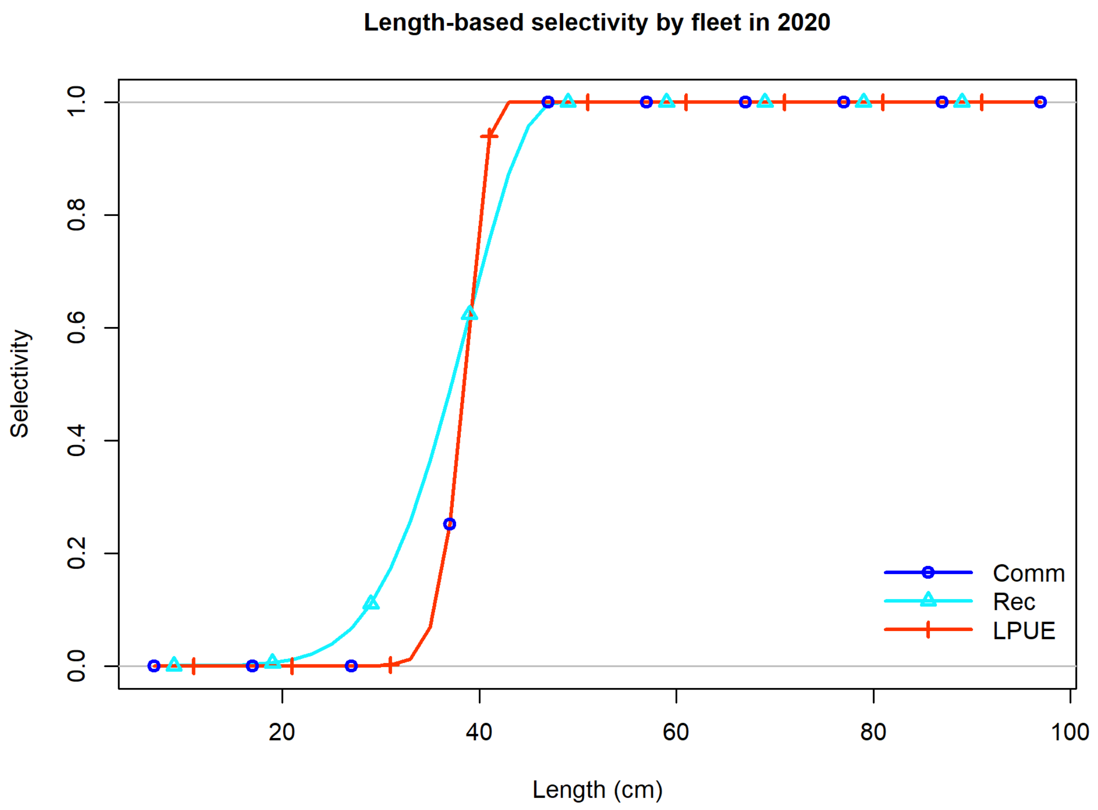


Figure 14.8. Selection patterns at length by commercial and recreational fleets estimated by the SS model. Selection pattern for the LPUE abundance index was assumed to follow the one from the commercial fleets.

The selection curve is assumed constant over the whole period for all the fleets. The selection curve for the LPUE abundance index was assumed identical with that of the commercial fleets. The assessment currently assumes that commercial fleets do not discard fish (negligible discards must be less than 5% of the total landings).

Model fit for the LPUE abundance index was good (Figure 14.9). The index was useful for the model to get the correct trend over time.

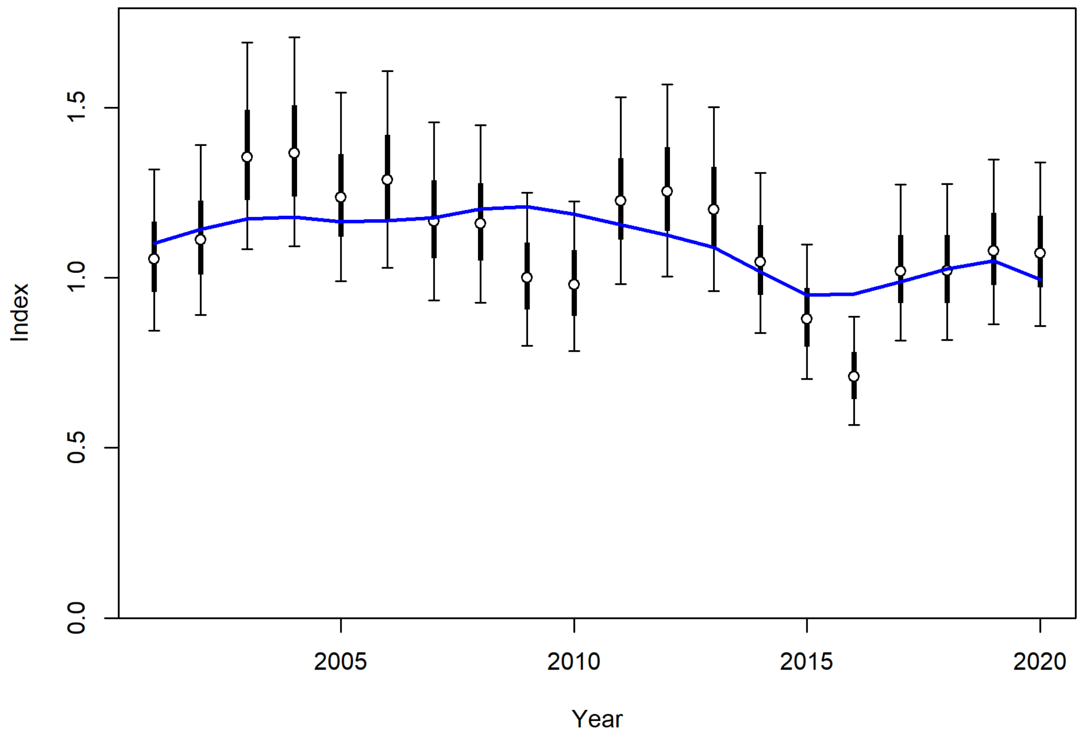
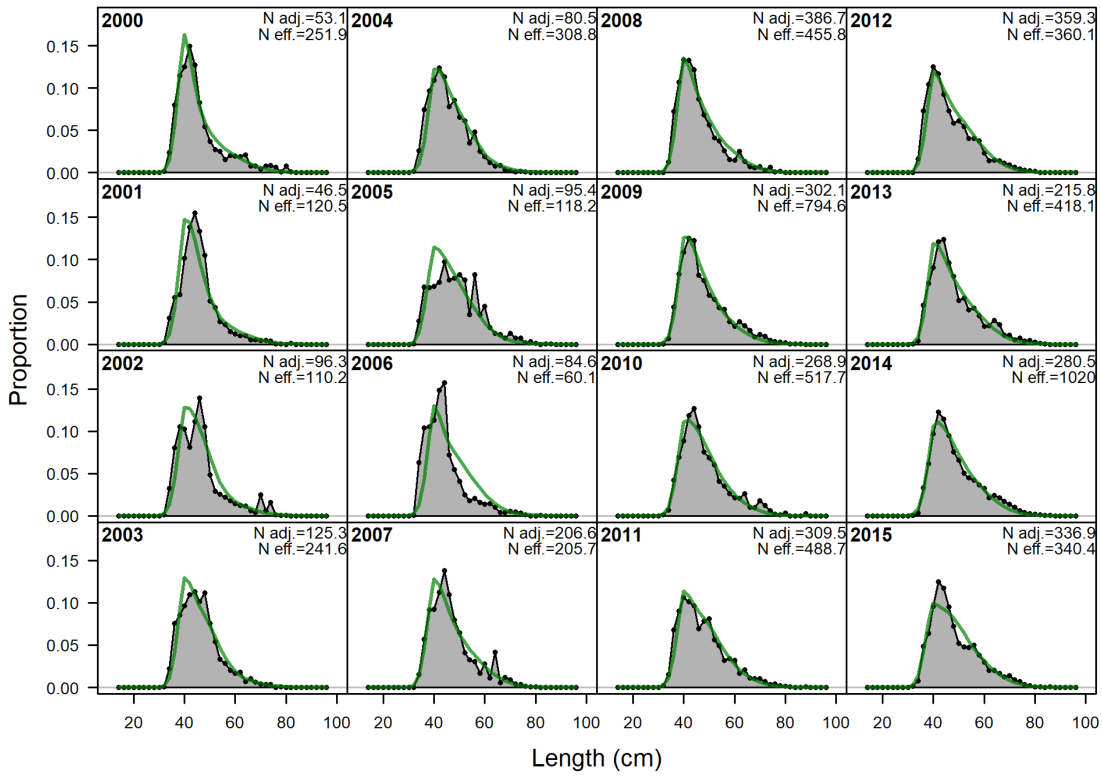


Figure 14.9. Fit to the LPUE abundance index.

Model fit for the commercial and recreational length composition data were good (Figures 14.10 and 14.11).



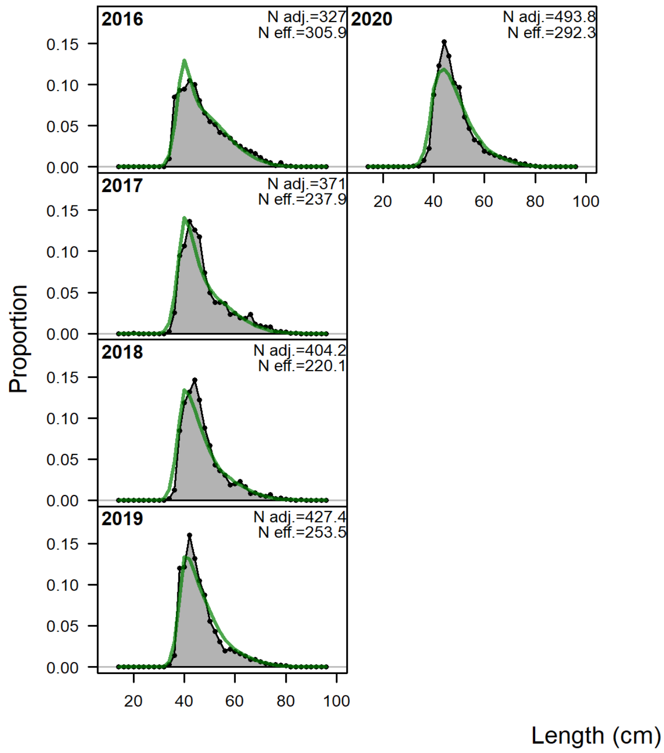


Figure 14.10. Fit to the commercial fishery length composition data.

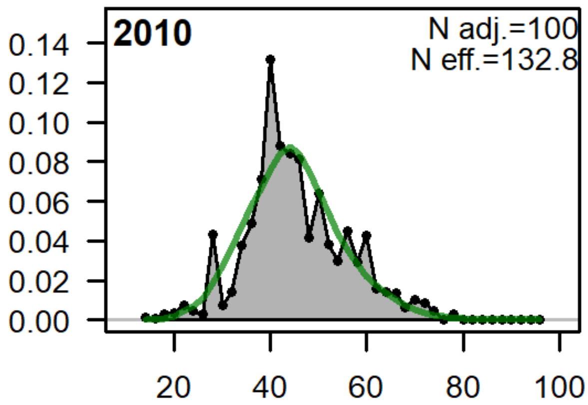
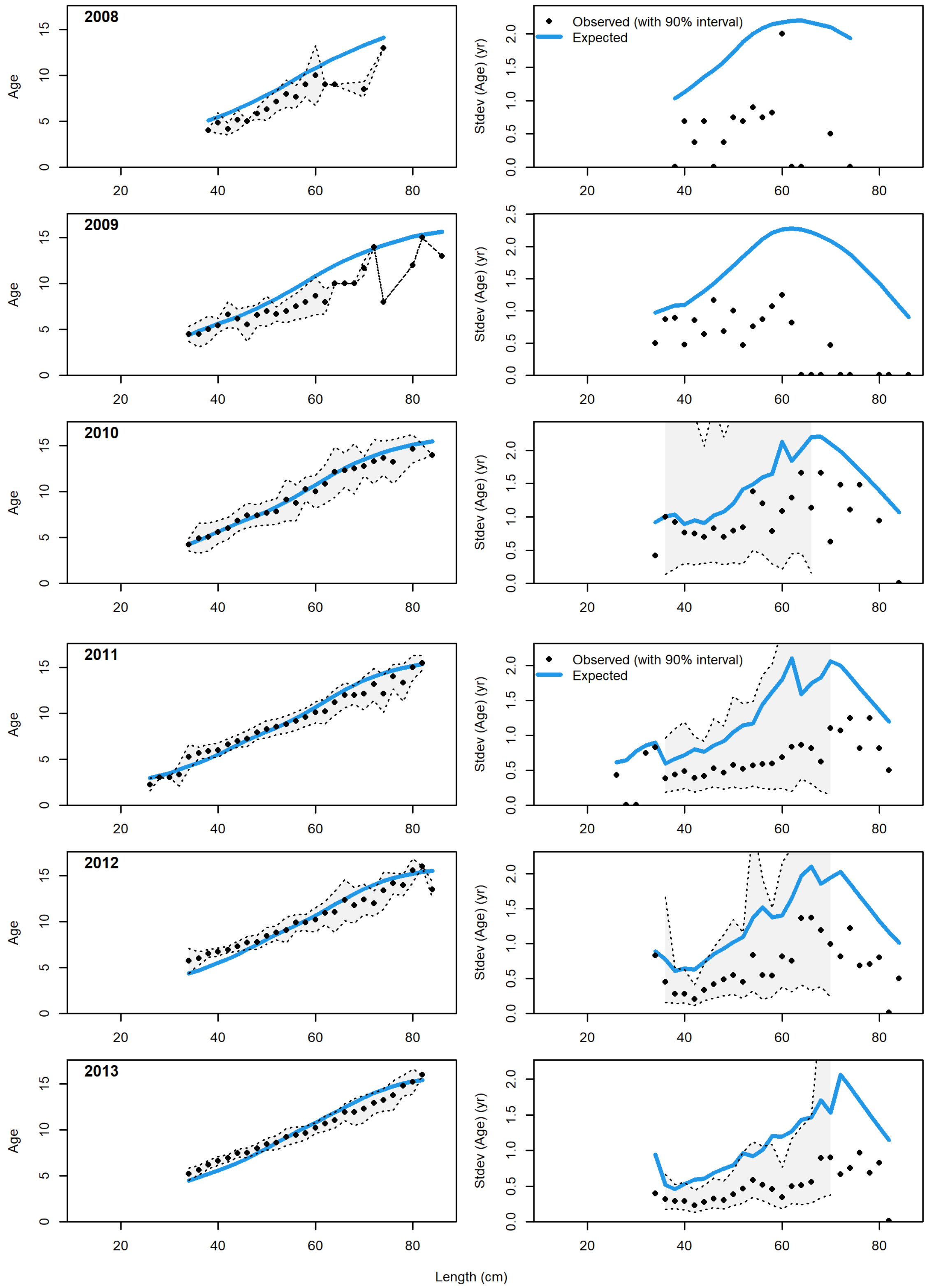


Figure 14.11. Fit to the recreational fishery length composition data.

Model fit for the aggregated fishery age-at-length composition data were good in average, but poor in standard deviation (Figure 14.12). The 2018, 2019, and 2020 age-at-length data were not included in the assessment as they showed a pattern incoherent with the historical data.

The fit was poor for the first 2 ALKs for years 2008 and 2009 as the sampling size during these two years was considered low.

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 14.13). Model and observations compared well despite the evident discrepancies for some years. For instance, in the years 2011–2014, the model overestimated the proportion of age ≤ 5 individuals compared to observations, or *vice versa*. Uncertainty in age reading or sampling bias may be considered as a potential explanation.



2008
2009
2010
2011
2012
2013
Age
Stdev (Age) (yr)
Observed (with 90% interval)
Expected
Length (cm)

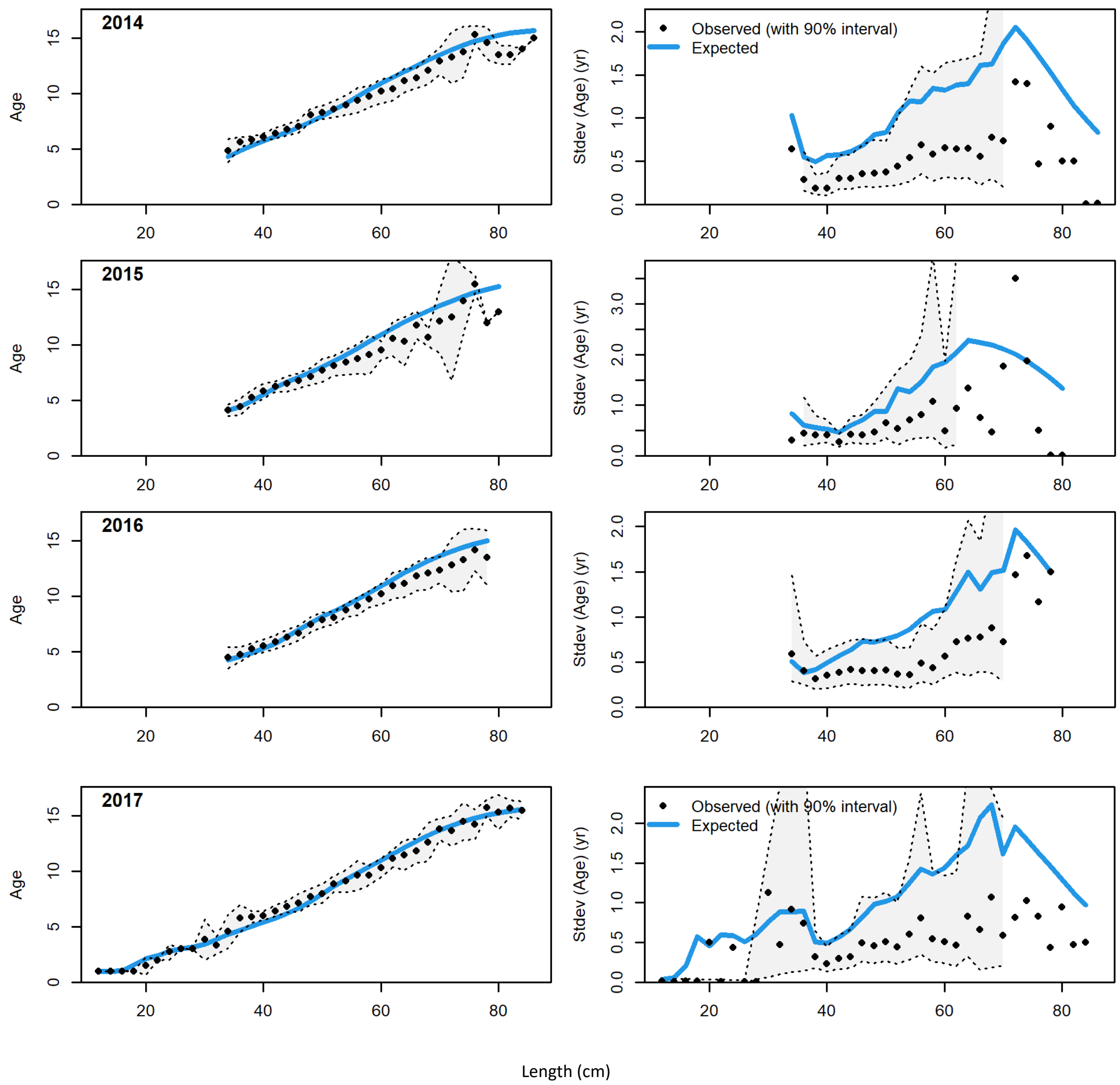


Figure 14.12. Fit to conditional age-at-length for commercial fishery.

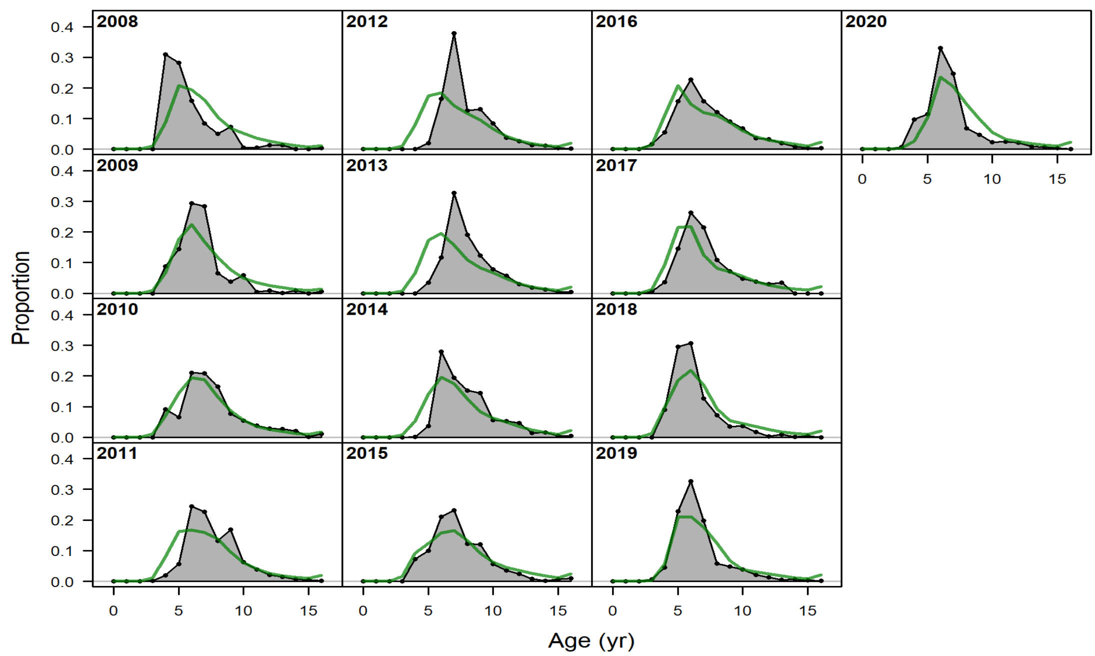


Figure 14.13. Observations and model predictions for age composition.

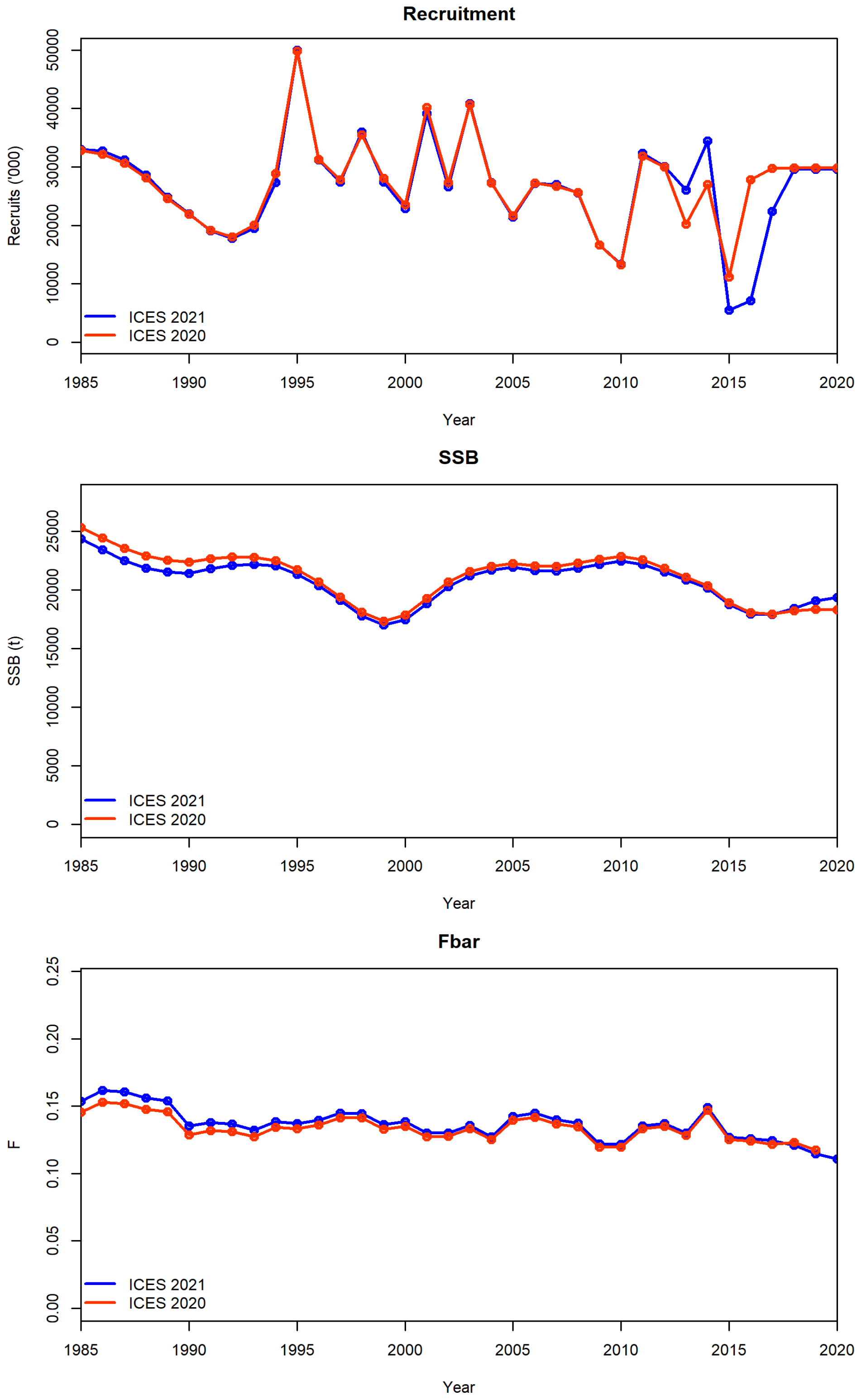


Figure 14.14. Comparison of the 2020 and 2021 assessment outputs (Recruitment, SSB, F_{bar}).

Figure 14.14 shows a comparison between the 2020 and 2021 assessments for the sea bass in the Bay of Biscay area. The recruitment series changes a lot, with two low values estimated in 2015–2016. The SSB increases slightly during recent years. F continues to decrease.

A retrospective analysis was performed (Figure 14.15) without the 2020 ALK. Recruitment, SSB and F series showed some variabilities. However, the stock trend is rather robust. In the last 5 years, the SSB is stable at around 20 000 t, while the F is below 0.15 with a decreasing trend.

Recruitment was poorly estimated in recent years and showed high variability during the last decade.

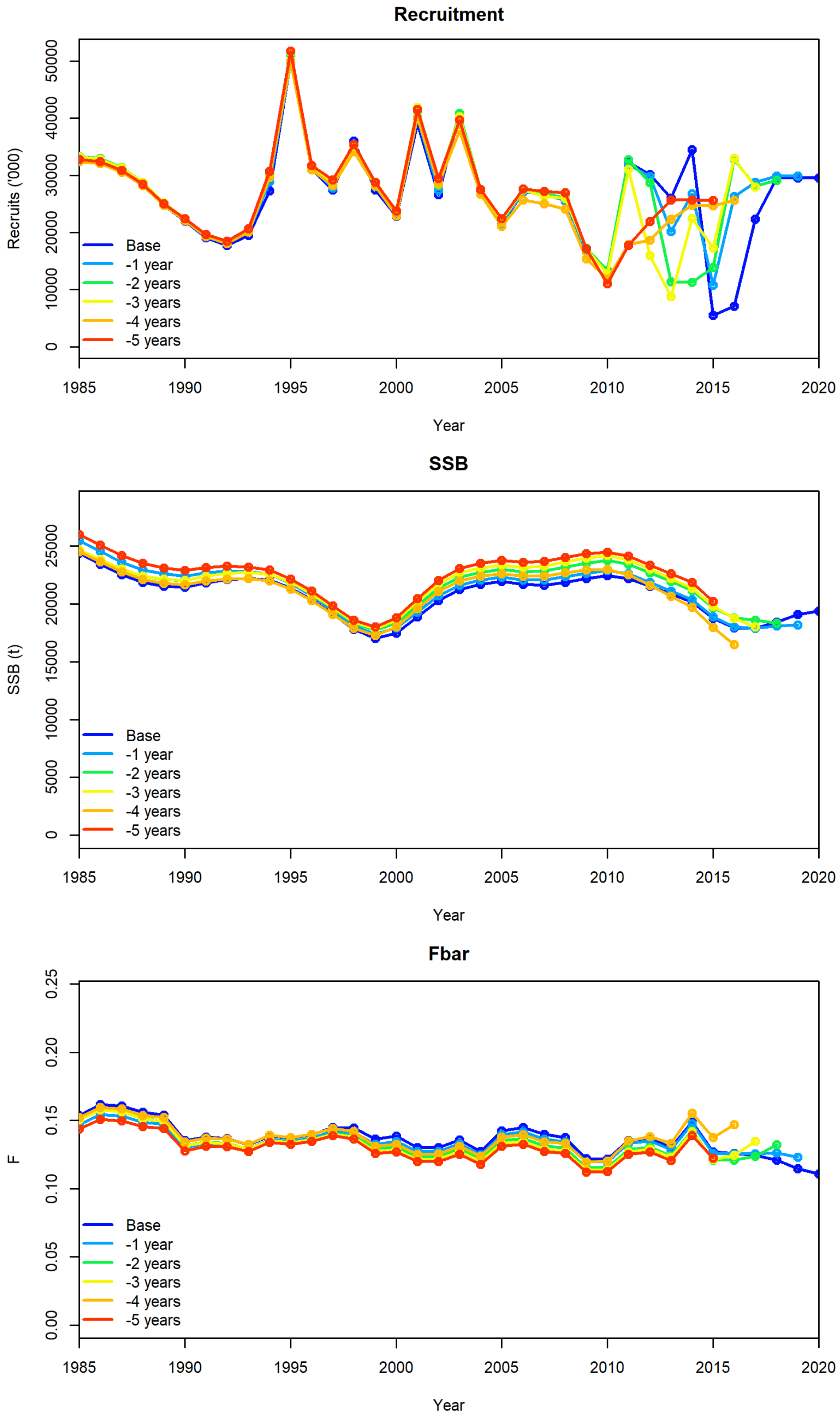


Figure 14.15. Retrospective plot without the 2020 ALK (i.e.the base assessment).

Inconsistencies between time-series of the retrospective analysis were quantified by Mohn's rho values (see Table 14.5; Mohn, 1999). The base assessment shows a high Mohn's rho value for the recruitment series, which is highly variable and uncertain.

Table 14.5. Mohn's rho values for the retrospective analysis.

Base assessment (without 2020 ALK)		
SSB	Rec	F_{bar}
−0.010	1.311	0.076

14.4 Alternative assessments

Two alternative assessments were performed:

- The first one implemented two blocks for the selectivity pattern as management measures on the MLS which have been adopted in 2017 and 2020.
- The second one used 2 age error definitions to account for the reader change in recent years.

14.4.1 Assessment with selectivity blocks

Two blocks were implemented for the selectivity of the commercial fleets to account for management measures. The fit shows an increase of selectivity for the most recent years, which correspond well with the increase of the MLS from 36 to 38 cm in 2017, and from 38 to 40 cm in 2020 (Figure 14.16).

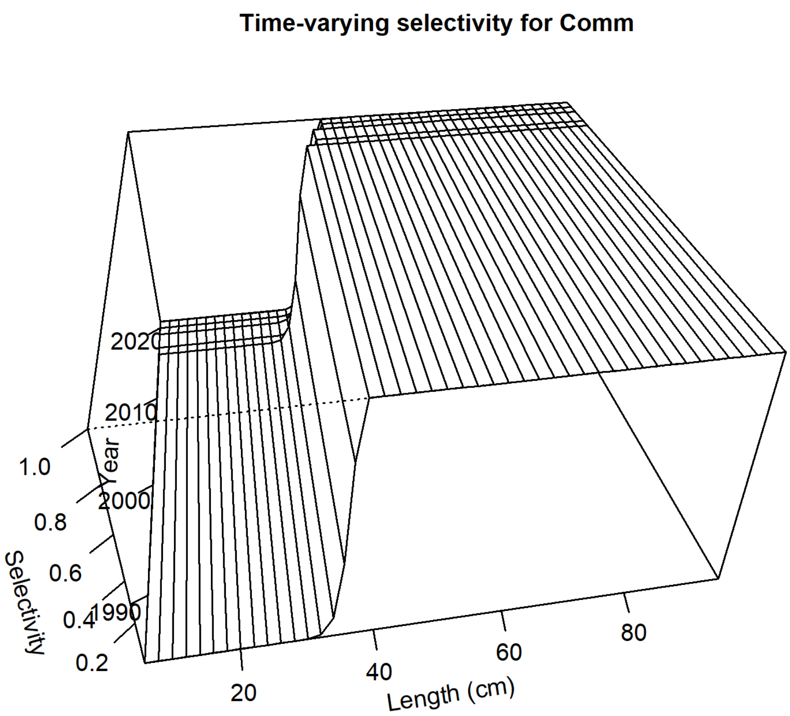
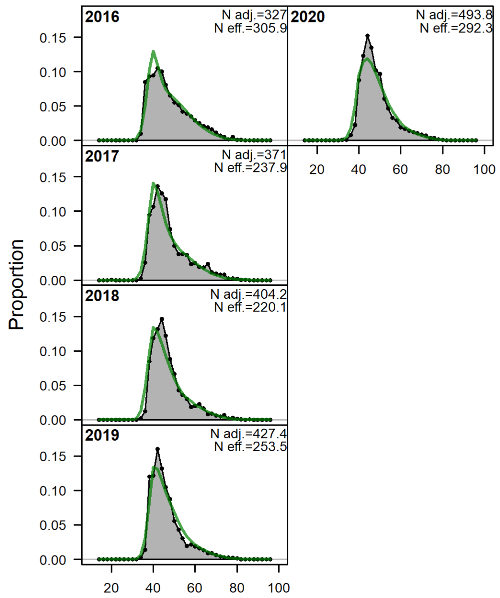


Figure 14.16. Surface plot of the time-varying selectivity for the commercial fleets.

Consequently, the fit to the commercial fishery length composition improved over the last years of the time-series (Figure 14.17).



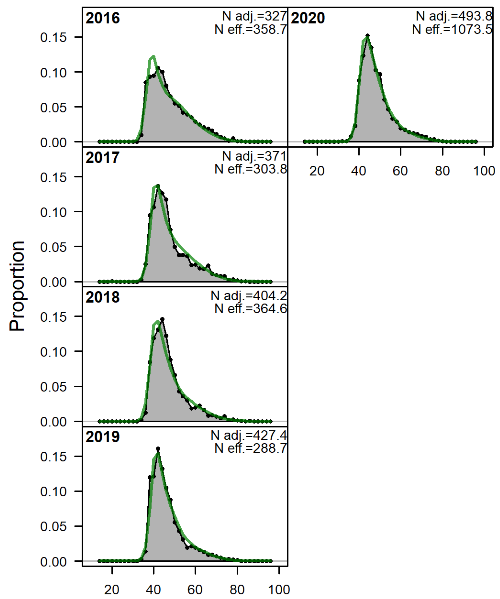


Figure 14.17. Fit to commercial fishery length composition data (Base assessmentvs.selectivity blocks assessment).

14.4.2 Assessment with 2 age error definitions

The use of 2 age error definitions within the SS model required the disaggregation of conditional age–length keys and ghost age composition according to readers in order to allow the model to account for bias and imprecisions between readers. In Figure 14.18, the fit of the model was illustrated on the ghost age composition according to readers (with a1 = KS and a2 = RE). The coherence between observations and model predictions was also improved for the last years of the time-series.

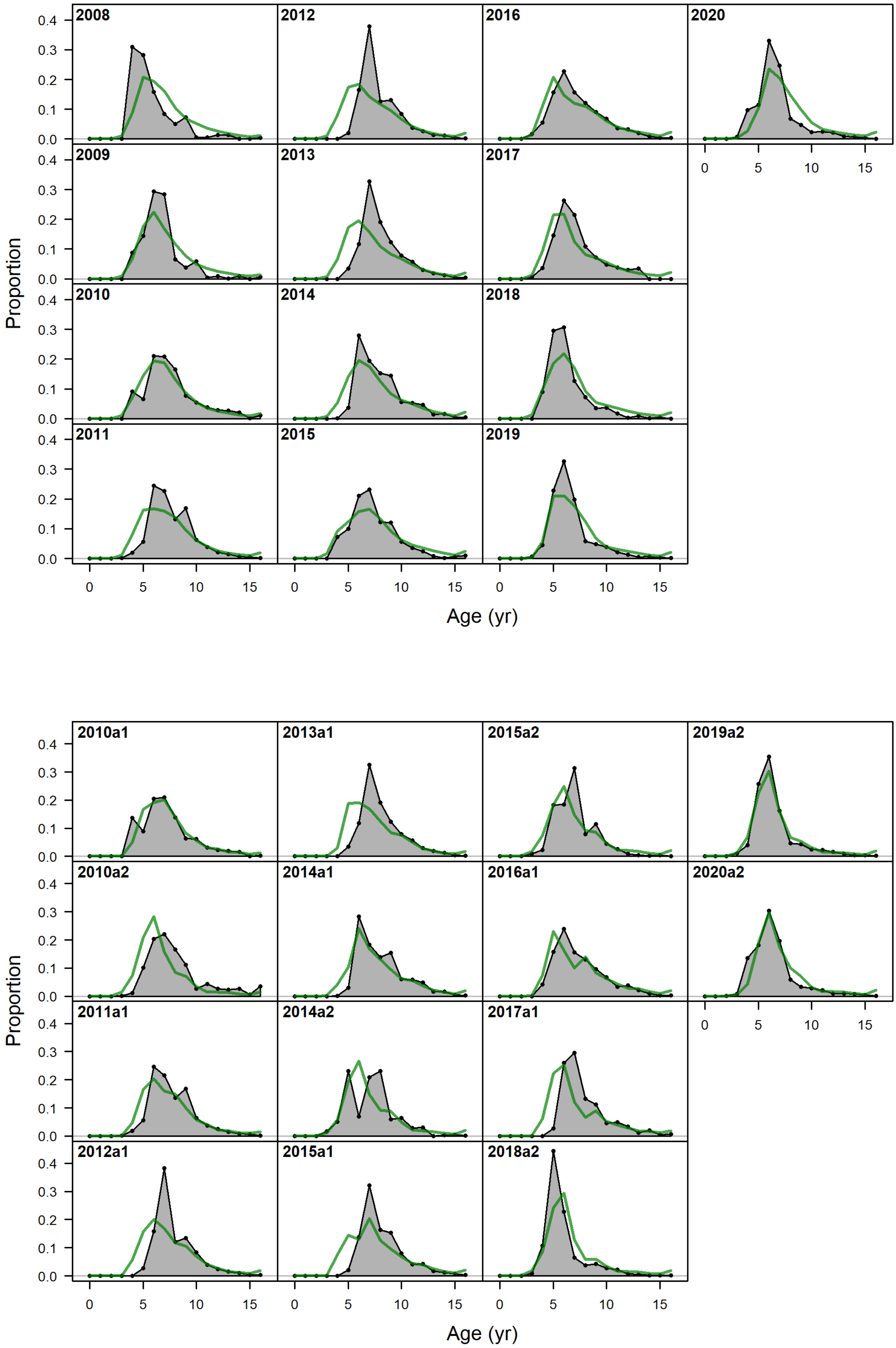


Figure 14.18. Yearly ghost age composition per age reader. Base assessment (above)vs.2 age error definitions assessment (below).

14.4.3 Sensitivity analysis

A sensitivity analysis was performed to compare the base assessment and the two alternative assessments. Figure 14.19 shows that the base assessment is in between the two alternative assessments. The selectivity blocks assessment estimates a higher SSB, a higher recruitment over recent years and a lower F, while the 2 age error definitions assessment shows no change of trends from the base assessment.

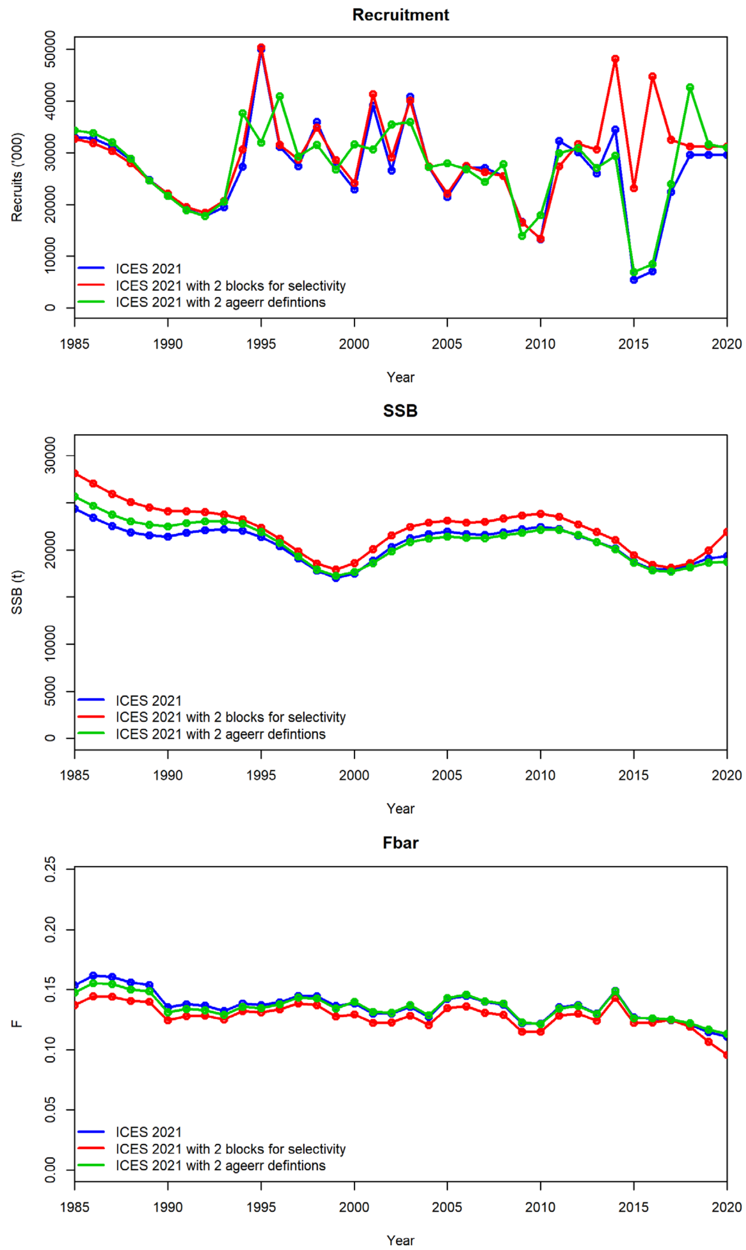


Figure 14.19. Base assessment compared to the two alternative assessments.

14.4.4 Retrospective analysis

The comparison of the retrospective analyses and of Mohn's rho indices shows that recruitment is much more stable in the case of the selectivity blocks assessment (Figure 14.20 and Table 14.6).

The retrospective analyses and Mohn's rho indices are at the same order for the base and the 2 age error definitions assessments.

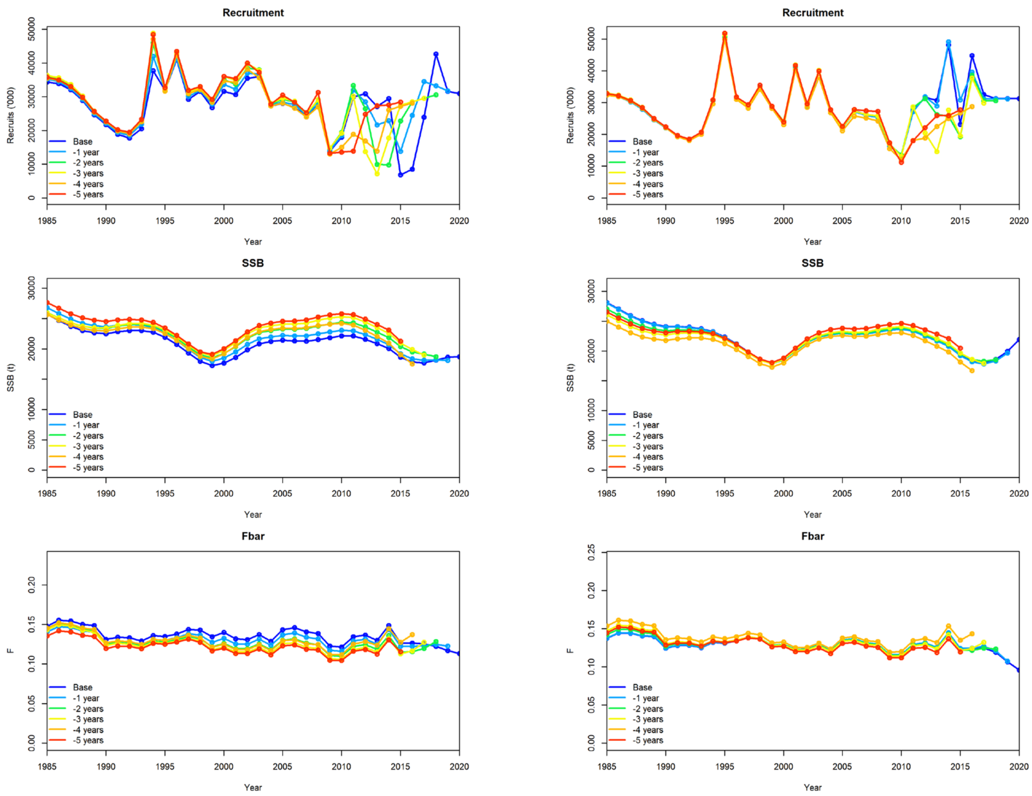


Figure 14.20. Retrospective plots for the two alternative assessments: the 2 age error definitions assessment (left) and the selectivity blocks assessment (right).

Table 14.6. Mohn's rho values for the retrospective analyses of the two alternative assessments.

selectivity blocks assessment			2 age error definitions assessment		
SSB	Rec	F_{bar}	SSB	Rec	F_{bar}
-0.014	-0.052	0.049	0.039	1.082	0.024

14.4.5 Alternative assessments conclusion

The WG decided that the two alternative assessments proposed during this year's WGBIE should be considered for a future benchmark on sea bass.

14.5 Historic trends in biomass, fishing mortality and recruitment

Fishing pressure on the stock is below F_{MSY} and spawning-stock size is above MSY $B_{trigger}$, B_{pa}, and B_{lim} (Figure 14.21).

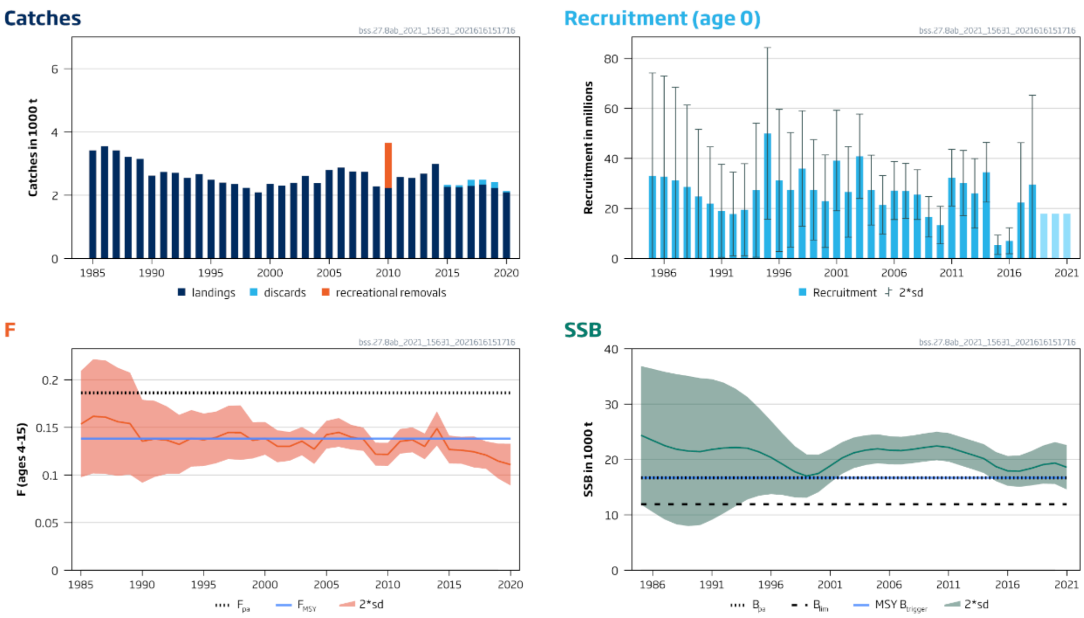


Figure 14.21. Summary of the stock assessment (weights in thousand tonnes). Commercial landings (with discards only included in 2016, 2017, 2018, 2019 and 2020), and recreational removals (only presented for 2010, where the data are available), including 5% mortality of released fish. Fishing mortality is shown for the combined commercial and recreational fisheries. Assumed recruitment values are not shaded. Recruitment and SSB are shown with 95% confidence intervals.

In 2020, F is below F_{MSY} (Table 14.7). SSB is above MSY $B_{trigger}$ and the stock is at full reproductive capacity.

Table 14.7. State of the stock and fishery relative to reference points.

	Fishing pressure				Stock size			
		2018	2019	2020		2019	2020	2021
Maximum sustainable yield	F_{MSY}	✓	✓	✓ Appropriate	MSY $B_{trigger}$	✓	✓	✓ Above trigger
Precautionary approach	F_{pa},F_{lim}	✓	✓	✓ Undefined	B_{pa},B_{lim}	✓	✓	✓ Full reproductive capacity
Management plan	F_{MGT}	–	–	– Not applicable	B_{MGT}	–	–	– Not applicable

Figure 14.22 presents the historical assessment results with the 3 final-year recruitment assumption included for each line. It shows that the recruitment series is highly variable and uncertain.

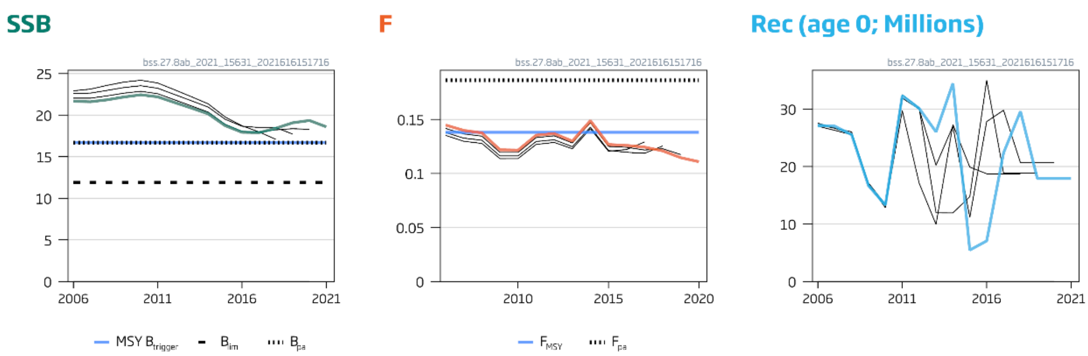


Figure 14.22. Historical assessment results (3 final-year recruitment assumption included for each line).

Table 14.8 compiles the assessment summary provided by the SS model.

14.6 Biological reference points

IBPBass (ICES, 2018b) set the biological reference points to be used for this stock. Table 14.9 compiles the biological reference points computed under type 6 stock–recruitment relationship as agreed during the IBPBass. In 2021, ICES ACOM asked the WGBIE to revise the computation basis for F_{pa}, as the F that leads to SSB ≥ B_{lim} with 95% probability (i.e. $F_{p0.5}$). F_{pa} was higher than the current F_{lim}. Consequently, F_{lim} was revised as "undefined". Consistent with the decision regarding $F_{pa} = F_{p05}$, F_{MSY} and MAP F_{MSY} was changed to the uncapped value from the IBPBass 2018 (ICES, 2018b). F_{MSY} value is now set to 0.138.

Table 14.9. Biological reference points accepted during the IBPBass (ICES, 2018b) for use in the ICES advice. All weights are in tonnes.

Framework	Reference point	Value	Technical basis
MSY approach	MSY $B_{trigger}$	16 688	B_{pa}
	F_{MSY}	0.138	The F that maximizes median long-term yield in stochastic simulations under constant F exploitation; constrained by the requirement that $F_{MSY} \leq F_{pa}$
Precautionary approach	B_{lim}	11 920	B_{pa} / exp (CV × 1.645)
	B_{pa}	16 688	Lowest observed SSB
	F_{lim}	Undefined	F_{lim} (0.172) is no longer considered appropriate given the estimate of F_{pa}
	F_{pa}	0.186	$F_{p.05}$ with AR: The F that provides a 95% probability for SSB to be above B_{lim}
Management plan	MAP MSY $B_{trigger}$	16 688	MSY $B_{trigger}$
	MAP B_{lim}	11 920	B_{lim}
	MAP F_{MSY}	0.138	F_{MSY}
	MAP range F_{lower}	0.117	Consistent with ranges provided by ICES (2018b), resulting in no more than 5% reduction in long-term yield compared with MSY.
	MAP range F_{upper}	0.151	Consistent with ranges provided by ICES (2018b), resulting in no more than 5% reduction in long-term yield compared with MSY.

14.7 Catch options and prognosis

14.7.1 Short-term projection

Forecast inputs used for the projections are compiled in Table 14.10. The recruitment used for the projection is the geometric mean (GM) calculated from 2008 to 2016. For the short-term projection, F-at-age averaged over the last three years (2018–2020) and scaled to 2020 value was used for both the commercial and recreational fleets (Table 14.10)

Table 14.10. Forecast inputs table.

Ages	N@age	Weight@age	Prop.mature@age	Commerical F	Commerical mean weight	Recreational F	Recreational mean weight	Natural mortality
0	17 924	0.0039	0.0000	0.000	0.0091	0.000	0.009	0.24
1	14 099	0.0197	0.0000	0.000	0.0443	0.000	0.051	0.24
2	11 090	0.0775	0.0002	0.000	0.2733	0.001	0.151	0.24
3	14 395	0.1811	0.0030	0.000	0.4478	0.004	0.299	0.24
4	8530	0.3287	0.0299	0.013	0.5974	0.010	0.483	0.24
5	2067	0.5144	0.1616	0.052	0.7373	0.019	0.686	0.24
6	1173	0.7304	0.4227	0.081	0.9065	0.025	0.899	0.24
7	5210	0.9685	0.6760	0.091	1.1183	0.029	1.125	0.24
8	2721	1.2211	0.8371	0.095	1.3602	0.030	1.367	0.24
9	2159	1.4812	0.9206	0.095	1.6161	0.031	1.621	0.24
10	1582	1.7433	0.9607	0.096	1.8750	0.031	1.878	0.24
11	442	2.0026	0.9797	0.096	2.1306	0.031	2.132	0.24
12	372	2.2554	0.9890	0.096	2.3788	0.031	2.380	0.24
13	383	2.4991	0.9937	0.096	2.6169	0.031	2.617	0.24
14	273	2.7315	0.9962	0.096	2.8433	0.031	2.844	0.24
15	185	2.9516	0.9976	0.096	3.0567	0.031	3.057	0.24
16	405	3.5568	0.9984	0.096	3.5904	0.031	3.590	0.24

Age 0,1,2 over-written as follows: 2021 yc -> 2021 age 0 replaced by 2008–2016 LTGM (17 924 thousand); 2020 yc -> 2021 age 1 from SS survivor estimate at-age 1, 2021 * LTGM / SS estimate of age 0 in 2019; 2019 yc -> 2021 age 2 from SS survivor estimate at-age 2, 2021 * LTGM / SS estimate of age 0 in 2018

Total landings forecasted for 2021 are 2555 t, with 1908 t for the commercial landings and 647 t for the recreational fishery. SSB for 2022 is forecasted to be at 16 676 t which is just below MSY $B_{trigger}$ (Table 14.11).

Table 14.11. The basis for the catch scenarios.

Variable	Value
$F_{ages\ 4\text{-}15}$ (2021)	Commercial fishery F = 0.083, Recreational fishery F = 0.028, Total F = 0.111
SSB (2022)	16 676 t
R_{age0} (2019,2020,2021)	17 924 thousands
Total catch (2021)	2555 t
Wanted commercial catch (2021)	1908 t
Unwanted commercial catch (2021)	3.6%
Recreational removals (2021)	647 t

Following the ICES advice rules, when the MSY approach is applied, the total catch (commercial and recreational removals) in 2022 should be no more than 3156 t (Table 14.12).

Table 14.12. Catch options table.

Basis	Total catches (in tonnes)	Commerical landings (in tonnes)	Recreational removals (in tonnes)	Commercial discards (in tonnes)	Total F_{bar}	Commercial F_{bar}	Recreational F_{bar}	SSB 2023	SSB change (%)	Advice change (%)
$F=F_{MSY}$	3156	2265	775	116	0.138	0.104	0.0340	15520	-6.900	1.550
$F=F_{MSY\_lower}$	2692	1932	661	99	0.117	0.088	0.0290	15869	-4.800	-9.200
$F=F_{MSY\_upper}$	3422	2455	840	126	0.151	0.113	0.0370	15321	-8.100	-9.200
F=0	0	0	0	0	0.000	0.000	0.0000	17907	+7.400	-100.000
$F=F_{pa}$	4160	2985	1023	153	0.186	0.140	0.0460	14770	-11.400	+34.000
SSB_2023 = B_{lim}	8034	5756	1982	296	0.400	0.300	0.0980	11920	-29.000	+158.000
SSB_2023 = B_{pa}	1605	1152	394	59	0.068	0.051	0.0169	16688	+0.0720	-48.000
SSB_2023 = MSY $B_{trigger}$	1605	1152	394	59	0.068	0.051	0.0169	16688	+0.0720	-48.000
SSB_2023=SSB_2022	1621	1164	398	60	0.069	0.052	0.0170	16676	0.000%	-48.000
$F=F_{2020}$	2567	1842	630	95	0.111	0.083	0.0280	15963	-4.300%	-17.400

14.8 Comments on the assessment

The assessment for the Bay of Biscay sea bass stock shows that since 2000, the spawning-stock biomass (SSB) fluctuated around 20 000 t.A low SSB was observed just before the 2000s, and a high SSB was observed around the year 2010. SSB is currently above MSY $B_{trigger}$. F showed a decreasing trend over the recent years and is currently below F_{MSY}. The recruitment is variable over time, and it was below average for the years 2010 and 2015–2016. Landings are stable over time around 2600 t.

The COVID-19 pandemic has not affected the data quality for assessment and advice of the stock.

14.9 Considerations for a benchmark

This assessment relies on a short data time-series: length composition time-series started in 2000; age-at-length time-series started only in 2008 (with a proper sampling after 2010); recreational data were surveyed for only one year, in 2010. In addition, there is no scientific survey for adult sea bass to scale the model to an appropriate level of abundance. There is no survey for recruits either. All these elements make this assessment uncertain. In order to improve future assessments and advice for this stock, several important limitations and deficiencies in data for the Bay of Biscay sea bass stock should be considered and addressed.

1. Recruitment indices are needed for the Bay of Biscay area. Estimation of recruitment is only based on commercial landings, and it may be smoothed by ageing errors (Laurec and Drogou, 2012). A French study has been undertaken in 2013–2018 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). Abundance indices have been calculated for years 2016–2020 in the Loire estuary, and for years 2019–2020 in the Gironde estuary and are planned for both estuaries for year 2021. The final objective is to make these surveys sustainable through DCF funding from 2022, implement and test these in the assessments then discuss the results and their pertinence during a benchmark.
2. 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 a drift model.
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. The actual assessment model should be revised according to the results of the undergoing tagging and genetic programs.
5. Studies are needed to investigate the accuracy and bias in ageing and errors due to historically aged sampling schemes.
6. Continued estimation of recreational removals and size compositions is needed across the stock range. Information to evaluate historical trends in recreational effort and removals 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 need also 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 and/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 assessment modelling as this prevents any evaluation of changes in selectivity that may have occurred, for example, due to changes in the proportion of different gear types and especially with the large decrease in numbers of pairtrawlers after 1995.

14.10 Management considerations

Sea bass is characterized by slow growth, late maturity, and low M on adults, which imply the need for comparatively low rates of F to avoid depletion of spawning potential in each year-class. In the well-known northern stock (4.b-c, 7.a,d-h) productivity of the stock is affected by extended periods of enhanced or reduced recruitment which appear to be related to changes in sea temperature (ICES, 2016a). Warm conditions facilitate northward penetration of sea bass in the Northeast Atlantic and enhance the growth and survival of young fish in estuarine and other coastal nursery habitats. In the Bay of Biscay, there is no reason to observe a difference in dynamics. In terms of numbers of recruits, the Bay of Biscay area looks more productive than in the North. If no management is put in place, and if a combination of increasing F and environmental conditions causing relative successive poor recruitments to occur, it could lead to a long-term and significant decline of biomass actually occurring in the Northern part.

The life-history behaviour of sea bass forming predictable aggregations for spawning in winter and moving inshore to feed at other times of the year, increases their vulnerability to exploitation by offshore and inshore fisheries. The effects of targeting offshore spawning aggregations of sea bass are poorly understood, particularly on how the fishing effort is distributed in relation to the mixing of fish from different nursery grounds or summer feeding grounds, considering the strong site fidelity of sea bass. Fisheries targeting offshore aggregation are mainly netters and, to a lesser extent, pelagic trawlers operating from December to March. Note that a high increase in the French landings for the nets fishery is observed since 2011. Indeed, as sea bass is currently a non-TAC species, there is potential for a displacement of fishing effort from other species with limiting quotas to this stock as observed with the netters in the Bay of Biscay that shifted their catches from sole to sea bass. With no effective control on the fishery to limit the increase of the landings as observed in 2014, risks are taken. Many small-scale artisanal fisheries, especially line fishing, have developed a high seasonal dependence on sea bass. There is also a significant recreational F in inshore waters. The importance of sea bass to recreational, artisanal and other inshore commercial and large-scale offshore fisheries in different regions means that resource sharing is an important management consideration.

14.11 Information from stakeholders

Since 2017, the French commercial fishing activities in the Bay of Biscay (ICES divisions 8.a, 8.b, and 8.d) have been subjected to national management measures. These are aimed at limiting both sea bass fishing effort and fishing capacity, at levels compatible with the ICES recommendations. These especially concern annual and periodic limitations of sea bass fishing opportunities, at the levels of both the whole fishery and at individual vessels (CNPMEM, 2020).

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15 Sea bass in divisions 8.c and 9.a (southern Bay of Biscay and Atlantic Iberian waters)

Dicentrarchus labrax – bss.27.8c9a

Type of assessment: no analytical assessment

Sea bass, *Dicentrarchus labrax,* stock in divisions 8.c and 9.a is considered a data-limited stock (DLS) and therefore classified as a category 5.2 stock (ICES, 2012a).

Advice basis: precautionary approach

The advice for this stock is biennial.

Data revision

Landings for years 1978 to 2000 were included with information available in the ICES historical database or in InterCatch.

15.1 General

15.1.1 Stock identity and substock structure

Sea bass is a widely distributed species in Northeast Atlantic shelf waters with a range from southern Norway, through the North Sea, the Irish Sea, the Bay of Biscay, the Mediterranean and the Black Sea to Northwest Africa. The species is at the northern limits of its range around the British Isles and southern Scandinavia. Further studies are needed on sea bass stock identity, using conventional and electronic tagging, genetics and other individual and population markers (e.g. otolith microchemistry and shape), together with data on spawning distribution, larval transport and VMS data for vessels tracking migrating sea bass shoals, to confirm and quantify the exchange rate of sea bass between areas that could form management units for this stock (ICES, 2012a; ICES, 2012b; ICES, 2012c).

The stock identity was assumed to be: Northern (ICES areas 4.b, 4.c, 7.a, 7.d–7.h); Southern Ireland and Western Scotland (ICES areas 6.a, 7.b and 7.j); Biscay (ICES areas 8.a and 8.b); Portugal and Northern Spain (ICES areas 8.c and 9.a) (Figure 15.1). Currently, stock identity has not been changed (ICES, 2017a), but research on population structure is in progress.

15.1.1 Biological reference points

No biological reference points are defined for this stock.

15.2 ICES advice on fishing opportunities

ICES advices that when a precautionary approach is applied, commercial catches in each of the years 2022 and 2023 should be no more than 382 t. ICES recommends that catches should not increase unless there is evidence that these will be sustainable. All commercial catches are assumed to be landed. Recreational removals cannot be quantified and therefore total catches cannot be calculated.

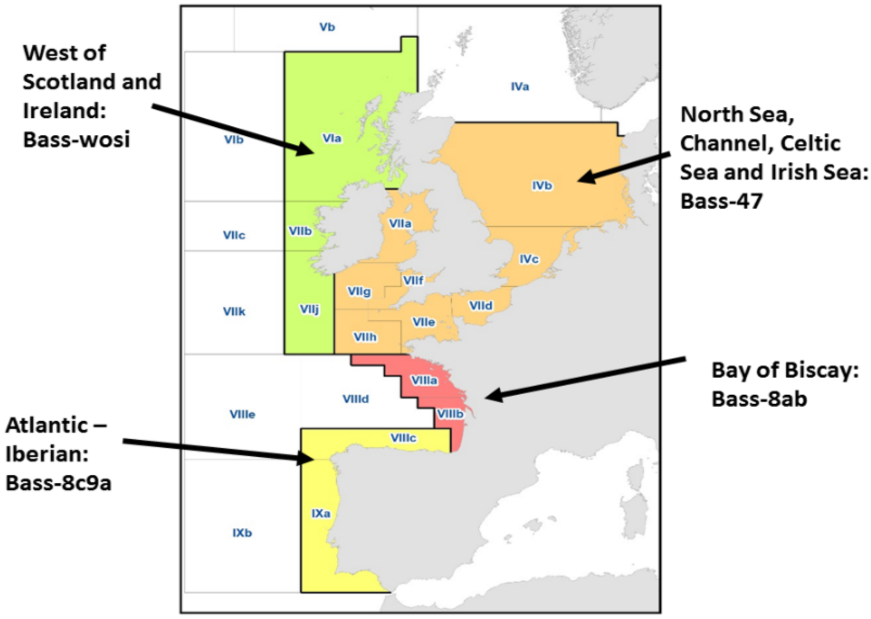

Figure 15.1. Current stock definitions for sea bass.

15.3 Management

15.3.1 Management applicable to 2017

Sea bass is not subjected to EU TACs and quotas. Under the EU regulation, the minimum landing size (MLS) for commercial fisheries of sea bass in the Northeast Atlantic is 36 cm total length. A variety of national restrictions on commercial sea bass fishing is also implemented.

The measures affecting recreational fisheries in Portugal include gear restrictions, a MLS equal to the commercial fishery (36 cm), the total catch of fish and cephalopods by each fishery must be less than 10 kg per day, and the sale of catch is prohibited.

15.3.2 Management applicable to 2018

No management measures are known in 8.c and 9.a for the year 2018.

15.3.3 Management applicable to 2019

A multiannual management plan (MAP; EU, 2019) has been published for the Western Waters (European Parliament and Council Regulation (EU) 2019/472). This plan applies to demersal stocks including sea bass in ICES divisions 8.c and 9.a.

15.3.4 Management applicable to 2020

European Parliament and the Council have published a multiannual management plan (MAP; EU, 2019) for the Western Waters (European Parliament and Council Regulation (EU) 2019/472). This plan applies to demersal stocks including sea bass in ICES divisions 8.c and 9.a.

15.4 Fisheries data

15.4.1 Commercial landings data

Landings series are given in Figure 15.1 and are derived from:

i) Official statistics recorded in the FishStat database (FAO, 2020) since around the mid-1970s.

ii) Spanish landings for 2007–2011 from sales notes.

iii) Portuguese estimated landings from 1986 to 2011 including the distinction between *Dicentrarchus labrax* and *D. punctatus*.

iv) Official landings from recent years (reviewed from 2012 onwards).

v) InterCatch.

Spanish and Portuguese vessels represent almost all of the total annual landings in the areas 8.c and 9.a. Commercial landings represent 896 t in 2019 (source InterCatch). A peak of landings was observed in the early 1990s and in 2013, reaching more than 1000 t while the lowest landings (637 t) have been observed in 2004. Artisanal fisheries are mainly observed in this area (Table 15.2). Landings from Portugal are only from Division 9.a, while the Spanish landings are distributed between divisions 8.c and 9.a (212.3 t and 212.5 t in 2020, respectively). Landings per country are given in Figure 15.2, and landings split by country, gear, and area are given in Table 15.2.

It should be noted that according to the Portuguese administration official landings from 2018 are probably overestimated due to a duplication in the calculations. Official landings were extracted from the ICES Official Statistics webpage for *D. labrax* (BSS) and divisions 8.c and 9.a. The difference between ICES statistics and the official statistics are primarily that, prior to 2006, most of the sea bass catches in the Portuguese statistics were registered under the code BSE which represents all *Dicentrarchus* spp. combined. After the implementation of the Data Collection Framework (DCF) there was a progressive increase in the correct identification of *D. labrax* in the official statistics (the number of BSS increased while BSE decreased) that consider *Dicentrarchus* spp. landings minus 2.3% of *Dicentrarchus punctatus* based on DCF market and onboard sampling between 2008 and 2012.

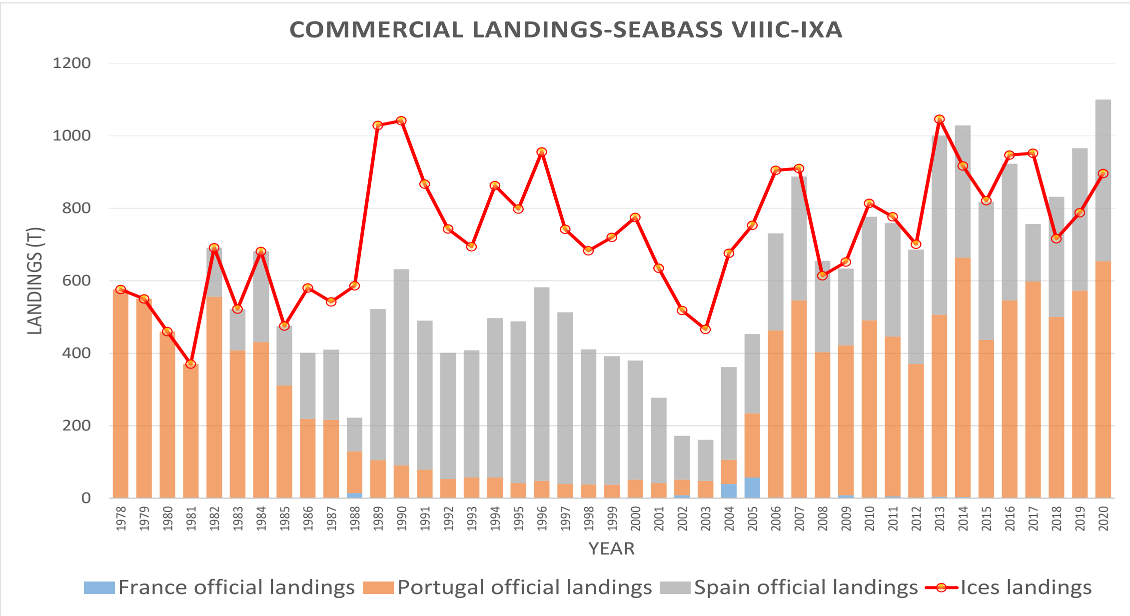

Figure 15.2. Commercial landings per country in divisions 27.7.8.c and 27.7.9.a (source: official landings and InterCatch).

15.4.2 Commercial length composition data

Quarterly length composition is available in Division 9.a (source: InterCatch) for commercial Portuguese fleet (MIS_MIS_0_0_0) in 2016–2020 (Figure 15.3) and for Spanish commercial fleet in 2017–2020 (Figure 15.4).

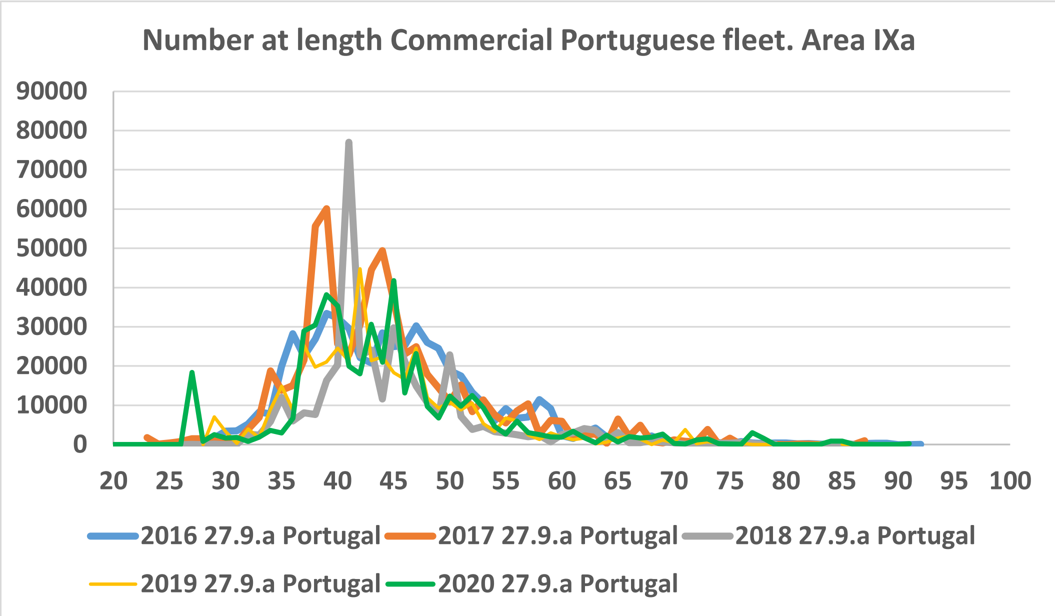

Figure 15.3. Commercial length composition in 2016–2018 for Portuguese fleet landings (source: InterCatch).

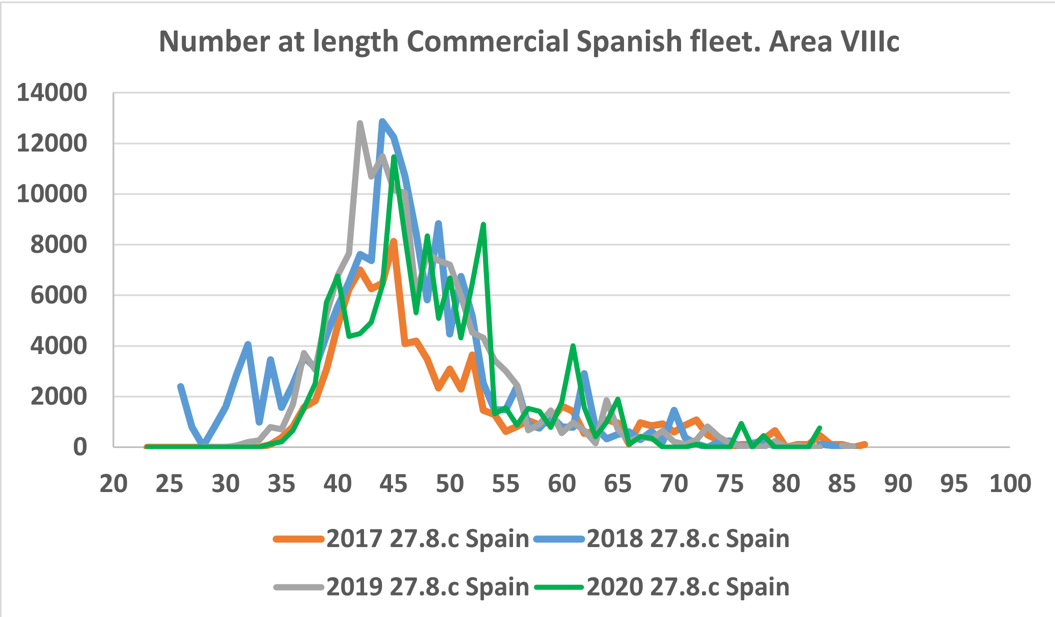

Figure 15.4. Commercial length composition in 2017–2018 for Spanish fleet landings (source: InterCatch).

15.4.3 Commercial discards

Portugal: Sea bass discards are recorded by the DCF onboard sampling program. The Portuguese onboard sampling does not cover the sea bass fishing area in divisions 8.c and 9.a where no discards were observed.

Spain: No sea bass discards were observed for any métier from 2003 to 2020.

15.4.4 Effort

Some effort data were available (source: InterCatch) for Spanish fleet from 2013 and for Portuguese fleet from 2015, showing a global decrease over time (Figure 15.5).

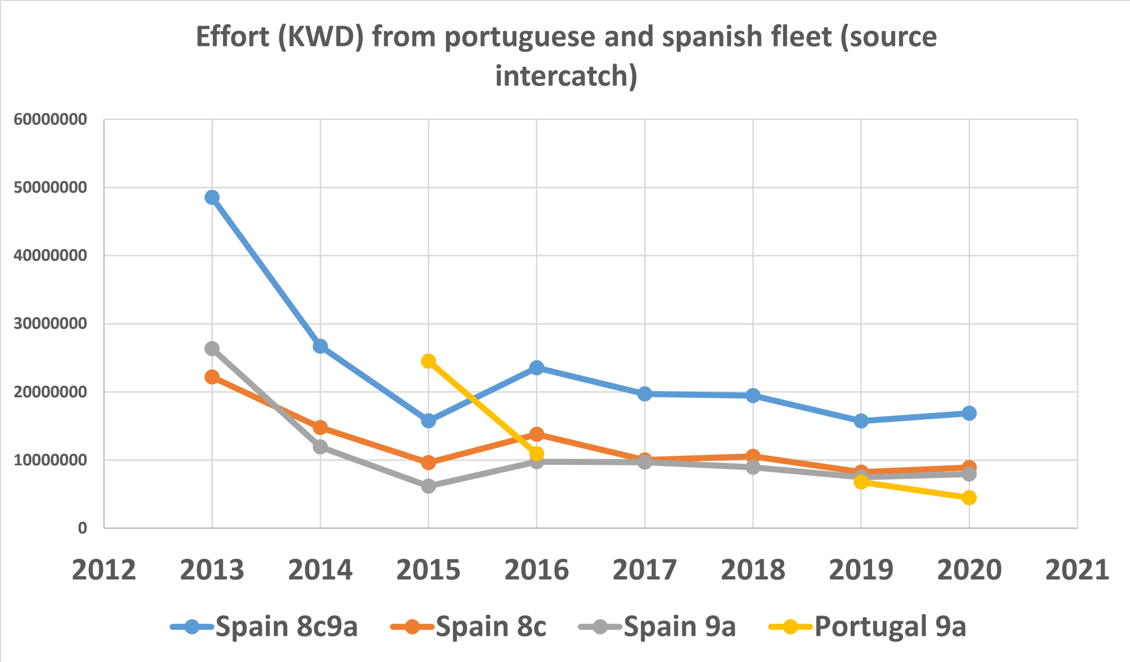

Figure 15.5. Effort (KWD) for Spanish and Portuguese fleets in divisions 8.c and 9.a (source: InterCatch).

15.4.5 Recreational removals

In 2015, a study was conducted in Spain titled: *Comparing different survey methods to estimate European sea bass recreational catches in the Basque Country* (Zarauz *et al*., 2015). This is the first study that estimates sea bass recreational removals in the Basque Country including fishers from shore, boat, and spearfishing. Three different offsite survey methods were used (e-mail, phone, and post) and their performance was compared. Estimates were different depending on the survey method used. Total catch estimates for shore fishing were 129, 156, and 351 t for e-mail, phone, and post surveys, respectively. For boat fishing, estimates varied from 5 (phone) to 13 t (e-mail and post). For spearfishing, only e-mail surveys were performed and total catch was estimated at 13 t. Potential representation and measurement bias of each survey method were analysed. It was concluded that post surveys assured a full coverage of the target population, but showed very low response rates. Telephone surveys presented the highest response rates, but lower coverage of the target population. E-mail surveys had a low coverage and a low response rate but was the cheapest method that provided the largest sample size. All surveys methods were affected by recall bias. Recommendations are made on how to improve the surveys (increasing coverage, reducing non-response and recall bias) to set up a routine cost-effective monitoring program for the Basque recreational fisheries. Results show that estimated sea bass recreational removals are comparable to commercial catches which emphasized the relevance of implementing a routine recreational fishing sampling and include the collected information in the stock assessment and management process.

In 2016, data for the sea bass capture estimation in recreational fisheries (117 t) provided by AZTI corresponded only to the Basque Country landings, and that despite being mostly categorized as species captured in Division 27.8.c, a portion may have been caught in Division 27.8.b (Source:

AZTI's estimation under the DCF). Further details can be found in the WGRFS 2017 report (ICES, 2017b).

Recreational removals of sea bass in divisions 8.c and 9.a are unquantified but are considered not negligible.

15.5 Assessment model, diagnostics and retrospectives

15.5.1 History of previous assessments

***Advice for 2014*:** Based on the ICES approach for DLSs, ICES advised that commercial catches should be no more than 598 t in 2014 (0.8*average landings 2009–2011). All commercial catches are assumed to be landed. Recreational removals cannot be quantified; therefore, total catches cannot be calculated.

***Advice for 2015*:** There are no new data available and the perception of the stock has not changed. Therefore, the ICES advice for this fishery in 2015 was similar to the advice provided in 2014 where commercial catches should be no more than 598 t. All commercial catches are assumed to be landed. Recreational removals cannot be quantified; therefore, total catches cannot be calculated.

***Advice for 2016 and 2017*:** the ICES framework for category 5 stocks was applied (ICES, 2012a). For stocks without information on abundance or exploitation, ICES considered that a precautionary reduction of catches should be implemented unless there is ancillary information clearly indicating that the current level of exploitation is appropriate to the stock. The precautionary buffer (0.80) was applied in 2013 for the 2014 advice. ICES advised that when the precautionary approach is applied, commercial catches should be no more than 598 t in each of the years 2016 and 2017.

***Advice for 2018 and 2019*:** The ICES framework for category 5 stocks was applied (ICES, 2012a). For stocks without information on abundance or exploitation, ICES considered that a precautionary reduction of catches should be implemented unless there is ancillary information clearly indicating that the current level of exploitation is appropriate to the stock. As the precautionary buffer was applied in 2013 for the 2014 advice, the precautionary buffer of 0.80 was again applied to result in advice that commercial catches should be no more than 478 t in each of the years 2018 and 2019.

In 2018, a precautionary approach (PA) has been adopted as the basis for advice on this stock in 2013 (−20%) based on the average of the 2009–2011 catches (ICES, 2018). The new buffer of 20% applied this year to the latest advice did not make sense for the WG in 2018 due to the previous period considered for the calculations, the relative stability in landings over time, the presence of very large individuals (up to 92 cm) in length composition of commercial landings and because sea bass is not a targeted species in this area compared to the northern stock. The application of the precautionary buffer (20% less) on the mean of the 2014–2016 catches that resulted in catch advice of 716 t would have been probably more appropriate.

Advice for 2020 and 2021: The ICES framework for category 5 stocks was applied (ICES, 2012a). For stocks without information on abundance or exploitation, ICES considered that a precautionary reduction of catches should be implemented unless there is ancillary information clearly indicating that the current level of exploitation is appropriate to the stock. ICES advises that when the precautionary approach is applied, commercial catches in each of the years 2020 and 2021 should be no more than 478 t. The precautionary buffer was not applied. All commercial catches are assumed to be landed. Recreational removals cannot be quantified and therefore total catches cannot be calculated.

15.5.2 Current assessment

Previous assessments were based on the period 2009–2011 for calculations where the buffer is consecutively applied every two years since 2015 resulting in decreasing commercial catch advice, which for the WG does not make sense when considering the stability of the stock. However, the precautionary buffer (0.8) was applied again this year. The ICES framework for category 5 stocks was again applied (ICES, 2012a) this year. ICES advises that when the precautionary approach is applied, commercial catches in each of the years 2022 and 2023 should be no more than 382 t. COVID-19 did not affect the data provided for an assessment or advice,

15.6 Recommendations for next benchmark assessment

In 2019, the WG encouraged the documentation of the sea bass data quality for the Iberian waters, and propose studies to better understand the stock dynamics and movements between the current stock areas (ICES, 2019). Sea bass in Iberian waters is still considered as a category 5.2. The ICES framework for category 5 stocks is applied (ICES, 2012a) for catch advice. Currently, no information is available to provide the status of this stock. A parallel can be done with the northern sea bass (bss27.7.8ab) stock assessed which used the same methodology until 2014. In 2015, a French LPUE index was estimated based on the logbook of French commercial vessels (> 10 m and < 10 m). This allowed the assessment of this stock using the ICES framework for category 3 stocks (ICES, 2012a). The French LPUE was applied as an index of stock biomass. The advice was based on a comparison of the two latest index values (index A) with the three preceding ones (index B) multiplied by the recent average landings. The analysed dataset correspond to Spanish and Portuguese logbooks from commercial vessels catching sea bass (< 10 m if possible, and > 10 m). This point has been discussed during the WGBIE 2021 (ICES, 2021), but landings in divisions 8.c and 9.a are mainly caught by artisanal fleets (vessel < 10 m) which do not fill the logbooks. Intersessional work before the next WG is proposed to explore the stock structure with other sea bass stocks (bss.27.8ab and bss.27.4bc7ad–h) and if promising results will be obtained, the WG would push for a new benchmark in 2024.

15.7 Management plan

The EU multiannual plan (MAP; EU, 2019) for stocks in the Western Waters and adjacent waters (Regulation (EU) 2019/472) applies to this stock. The MAP stipulates that when the F_{MSY} ranges are not available, fishing opportunities should be based on the best available scientific advice. This plan applies to demersal stocks including sea bass in ICES divisions 8.c and 9.a.

15.8 References

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15.9 Tables and figures

Table 15.1. Sea bass in divisions 8.c and 9.a. ICES and official landings (tonnes). NB: Official landings reviewed from 2012 onwards in 2019.

Year	France*	Portugal*	Spain*	Total*	Total ICES estimates**
1978	0	576	0	**576**	**576**
1979	0	550	0	**550**	**550**
1980	0	460	0	**460**	**460**
1981	0	370	0	**370**	**370**
1982	0	556	135	**691**	**691**
1983	0	408	114	**522**	**522**
1984	0	431	250	**681**	**681**
1985	0	311	164	**475**	**475**
1986	0	219	182	**401**	**580**
1987	0	216	194	**410**	**542**
1988	14	115	93	**222**	**586**
1989	0	105	417	**522**	**1029**
1990	1	90	541	**632**	**1042**
1991	2	77	411	**490**	**867**
1992	0	53	348	**401**	**743**
1993	0	57	351	**408**	**694**
1994	0	57	440	**497**	**863**

Year	France*	Portugal*	Spain*	Total*	Total ICES estimates**
1995	0	42	446	**488**	**798**
1996	0	48	534	**582**	**956**
1997	0	39	474	**513**	**742**
1998	0	38	373	**411**	**683**
1999	0	37	355	**392**	**720**
2000	2	49	329	**380**	**775**
2001	0	42	235	**277**	**635**
2002	8	43	121	**172**	**518**
2003	1	47	113	**161**	**466**
2004	39	67	256	**362**	**676**
2005	57	177	219	**453**	**753**
2006	2	461	268	**731**	**905**
2007	1	545	342	**888**	**910**
2008	0	403	252	**655**	**614**
2009	8	414	212	**634**	**652**
2010	2	489	286	**777**	**814**
2011	5	441	313	**759**	**777**
2012	2	368	316	**686**	**701**
2013	4	502	495	**1001**	**1046**
2014	3	661	365	**1026**	**917**
2015	0	437	381	**818**	**821**
2016*	0	546	377	**923**	**947**
2017	2	596	159	**757**	**952**
2018	0	500	332	**832**	**716**
2019	0	573	393	**966**	**788**
2020	0	654	446	**1100**	**896*** **

***Official landings have been extracted from the ICES official catch statistics web page (04 May 2015) for "BSS" (*D. labrax*) for divisions 8.c, 9.a, and 9 (9 has been retained for Portuguese catch statistics as data were reported as for 9.a prior to 2007).**

****Difference between ICES and official statistics are mainly due Portugal catch statistics prior to 2006. Most of the sea bass catches were registered under the code BSE (*Dicentrarchus* spp.) until 2005. After the DCF implementation, there was a progressive improvement on the correct identification of species in the official statistics (BSS increased**

while BSE decreased) where 2.3% of *Dicentrarchus punctatus* landings were deducted from the total *Dicentrarchus* spp. Landings. The deducted proportion was based on the DCF market and onboard sampling between 2008 and 2012.

***Preliminary.

Table 15.2. Commercial landings in Iberian waters per country, gear, and subarea.

	Source : intercatch2016-2019 and ices accessions 2020	landings 2016	landings 2017	landings 2018	landings 2019	landings 2020
Portugal	total IXa	565	598	366	415	471
	MIS_MIS_0_0_0	565	598	366	412.3	467.3
	OTB				0.52	0.4
	PS_SPF_0_0_0				2	3.3
	total VIIIc	0	0	0	0	0
	Total Portugal	565	598	366	415	471

	Source : intercatch	landings 2016	landings 2017	landings 2018	landings 2019	landings 2020
Spain	total IXa	165	171	168	187	213
	GNS_DEF_60-79_0_0	8	8	12.1	52.3	33
	GNS_DEF_80-99_0_0	0	0	0.04	0	0
	GTR_DEF_60-79_0_0	50	45	33.7	25.88	29
	LHM_DEF_0_0_0	3	3	3.38	0	0
	LLS_DEF_0_0_0	86	85	76.61	83.82	112
	MIS_MIS_0_0_0_HC	12	3	2.2	7.51	10
	OTB_DEF_>=55_0_0	0	0	0.08	0	0
	OTB_MCD_>=55_0_0	0	0	0.33	0	0
	PS_SPF_0_0_0	6	25.03	39.38	17.47	27
	total VIIIc	215	183	182	186	212
	GNS_DEF_>=100_0_0	0	0	0.04	0	0
	GNS_DEF_60-79_0_0	7	11	12.82048	37.4	33
	GNS_DEF_80-99_0_0	3	1	3.81	2.3	4
	GTR_DEF_60-79_0_0	38	26	26.76525	12.6	26
	LHM_DEF_0_0_0	2	0	1.02	0.03	1
	LHM_SPF_0_0_0			0.18	0	0
	LLS_DEF_0_0_0	139	130	115.19584	120.03	131
	MIS_MIS_0_0_0	0	3		0.95	0
	MIS_MIS_0_0_0_HC	3		1.85	0	1
	OTB_DEF_>=55_0_0	0	0.29	0.343	0.23	1
	OTB_MPD_>=55_0_0	1	0.25	0.49	0.05	0
	PS_SPF_0_0_0	21	12.81	19.5689	12.35	13
	PTB_MPD_>=55_0_0	0		0.3763	0.05	0
	total spain Ixa+VIIIc	380	353.86	350	373	425

16 Plaice in Subarea 8 and Division 9.a (Bay of Biscay and Atlantic Iberian waters)

Pleuronectes platessa – ple.27.89a

Type of assessment: no analytical assessment

The Bay of Biscay and Atlantic Iberian waters plaice, *Pleuronectes platessa,* is considered a data-limited stock (DLS) and classified as a category 5.2 stock (ICES, 2012; ICES, 2021).

Advice basis: precautionary approach

The advice for this stock is biennial.

Data revision

Landings for the years 1994 to 2000 were included with information available from the ICES historical database. Catches from 2014 to 2000 were extracted from InterCatch.

16.1 General

16.1.1 Stock identity

See Stock Annex.

16.1.2 Biological reference points

No biological reference points are defined for this stock.

16.1.3 Fishery description

See Stock Annex.

16.1.4 Summary of ICES advice and management

16.1.4.1 ICES advice for 2020 and 2021

ICES advises that when the precautionary approach is applied, landings should be no more than 155 t in each of the years 2022 and 2023. ICES cannot quantify the corresponding total catches.

16.1.4.2 Management plan

The EU Multiannual Plan for the Western Waters (MAP; EU, 2019) takes bycatch of this species into account.

16.2 Fisheries data

16.2.1 Commercial landings

Plaice (*Pleuronectes platessa*) is caught as bycatch by various fleets and gear types covering both small-scale artisanal and trawl fisheries. Portugal and France are the main countries exploiting the stock with Spain playing a minor role. Landings may contain misidentified flounder (*Platichthys flesus*) as they are often confounded at market auctions in Portugal. The official landings are given in Table 16.1 while the catches submitted to the working group are given in Table 16.2. The quantity of discarding is uncertain. Discards are likely relatively minor but the WG cannot conclude that discarding is less than 5% of the catch.

Plaice were not present in sufficient numbers in the survey to allow estimation of an abundance index. EVHOE-WIBTS-Q4 (G9527) is the only survey that covers the stock area and only 43 individuals were caught in Division 8 during the entire time-series (1997–2018). The survey may be considered adapted for providing an abundance index as this survey always caught considerable numbers of plaice in the Celtic Sea. No commercial index is currently available. However, the advice might benefit from commercial LPUE data if these were made available to the WG.

Biological information needs to be compiled. Issues concerning the quality of landing statistics in addition to the lack of survey or commercial abundance indices need to be resolved before an assessment can be made. As this species is at the southern extent of its range in the Bay of Biscay and Iberian Peninsula (Figure 16.1), perhaps merging the northern and southern stocks would provide a better opportunity to improve the assessment of the stock.

This stock is under the EU landing obligation since 2016.

16.3 Assessment model, diagnostics, and retrospectives

16.3.1 Previous assessment

ICES 2016 Advice (Published 30 June 2015)
ICES advises that when the precautionary approach is applied, the wanted catch should be no more than 194 t in each of the years 2016 and 2017. ICES cannot quantify the corresponding total catches. The ICES framework for category 5 stocks was applied (ICES, 2012). For stocks without information on abundance or exploitation, ICES considers that a precautionary reduction of catches should be implemented unless there is ancillary information clearly indicating that the current level of exploitation is appropriate to the stock. Given that this is the first time that ICES is providing quantitative advice, the precautionary buffer was applied (ICES, 2016).

ICES 2018 Advice (Published 30 June 2017)
ICES advises that when the precautionary approach is applied, wanted catches[1] in each of the years 2018 and 2019 should be no more than 194 t. ICES cannot quantify the corresponding total catches. The ICES framework for category 5 stocks was applied (ICES, 2012). For stocks without information on abundance or exploitation, ICES considers that a precautionary reduction of catches should be implemented unless there is ancillary information clearly indicating that the current level of exploitation is appropriate to the stock. The stock status relative to the reference points remains unknown. The precautionary buffer was applied in 2015 for the 2016 advice and is, therefore, not applied again this year (ICES, 2018).

[1]"Wanted catch" is used to describe the stock that would be landed in the absence of the EU landing obligation.

ICES 2020 and 2021 Advice (Published 28 June 2019)

The ICES framework for category 5 stocks was applied (ICES, 2012). ICES advises that when the precautionary approach is applied, wanted catches in each of the years 2020 and 2021 should be no more than 155 t. ICES cannot quantify the corresponding total catches. The stock status relative to reference points remains unknown. The precautionary buffer was not applied in 2017 for the 2018 and 2019 advice and is, therefore, applied this year.

16.3.2 Current assessment

The advice for this stock is biennial. In this WG, the stock catch data were updated. Advice is issued this year. COVID-19 has not affected the quality of data on which the advice is based.

16.4 References

EU. 2019b. Regulation (EU) 2019/472 of the European Parliament and of the Council of 19 March 2019 establishing a multiannual plan for stocks fished in the Western Waters and adjacent waters, and for fisheries exploiting those stocks, amending Regulations (EU) 2016/1139 and (EU) 2018/973, and repealing Council Regulations (EC) No 811/2004, (EC) No 2166/2005, (EC) No 388/2006, (EC) No 509/2007 and (EC) No 1300/2008. Official Journal of the European Union, L83: 1–17. http://data.europa.eu/eli/reg/2019/472/oj.

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16.5 Tables and figures

Table 16.1. Plaice in Subarea 8 and Division 9.a. Official landings by country in tonnes.

Year	Belgium	France	Portugal	Spain	Total
1994		365	33	1	**399**
1995		319		12	**331**
1996		248		14	**262**
1997		255		3	**258**
1998		219		6	**225**
1999	1			3	**4**
2000	15	193		22	**230**
2001		201		22	**223**
2002	1	167		11	**179**
2003	1	217	1	4	**223**
2004		229	163	7	**399**
2005	4	186	1	33	**224**
2006	2	248	1	5	**256**
2007	5	214	41	4	**263**
2008	2	98	89	4	**193**
2009	2	133	101	8	**244**
2010	2	200	112	12	**325**
2011	2	208	65	9	**283**
2012	3	183	63	4	**252**
2013	0	147	45	5	**197**
2014	1	164	51	6	**222**
2015	2	142	45	5	**194**
2016	1	121	49	4	**175**
2017	1	98	33	2	**134**
2018	0	90	39	3	**133**
2019	0	94	36	3	**133**
2020	0	76	46	4	**126**

Table 16.2. Plaice in Subarea 8 and Division 9.a. Catches submitted to InterCatch (tonnes).

Catch category	Country	Gear	2014	2015	2016	2017	2018	2019	2020
Discards	France	Nets	-	10.00	3.00	4.00	2.00	2.00	2.00
		Other	-	2.00	0	0	0	0	-
		Trawl	-	4.00	0	1.00	1.00	0	-
	Spain	Nets	0	-	-	-	0	-	-
		Trawl	0	-	-	-	0	-	-
	Portugal	Trawl		0*	0*	0*	0	-	-
Discards total			**0**	**15.00**	**3.00**	**5.00**	**3.00**	**2.00**	**2.00**
Landings	Belgium	Other	1.00	2.00	1.00	1.00	-	0.40	0.30
	France	Nets	42.00	46.00	48.00	42.00	41.00	38.00	37.00
		Other	38.00	21.00	12.00	24.00	6.00	7.00	4.00
		Trawl	82.00	74.00	62.00	33.00	44.00	49.00	36.00
	Portugal	Other	47.00	44.00	47.00	33.00	39.00	36.00	46.00
	Spain	Nets	4.00	3.00	3.00	1.00	2.00	2.00	2.20
		Other	1.00	1.00	1.00	0	0	0.20	0.60
		Trawl	1.00	1.00	1.00	1.00	1.00	0.06	0.63
Total landings			**217.00**	**193.00**	**174.00**	**135.00**	**133.00**	**133.00**	**126.00**
Total catches			**217.00**	**208.00**	**177.00**	**140.00**	**136.00**	**135.00**	**128.00**
Official Landings			**220.00**	**193.00**	**173.00**	**134.00**	**133.00****	**133.00****	**126.00****

*** Not available in InterCatch.**

**** Official provisional statistics from ICES website[2].**

[2] http://data.ices.dk/rec12/downloadData.aspx

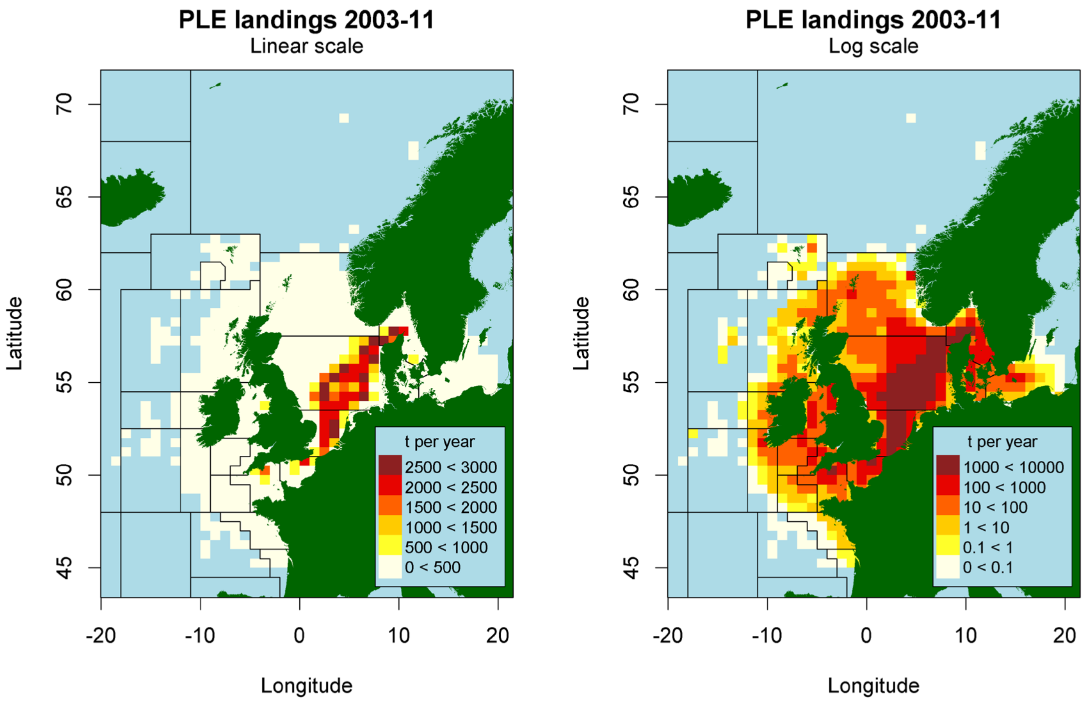

Figure 16.1. International landings of plaice by statistical rectangle from 2003–2011.

17 Pollack in Subarea 8 and Division 9.a (Bay of Biscay and Atlantic Iberian waters)

Pollachius pollachius – pol.27.89a

Type of assessment: no analytical assessment

The Bay of Biscay and Atlantic Iberian waters pollack, *Pollachius pollachius*, is considered a data-limited stock (DLS) and classified as a category 5.2 stock (ICES, 2012; ICES, 2021a). The stock was benchmarked in early 2021 (ICES, 2021b). However, the assessment was not approved and will therefore remain a category 5.2 stock.

Advice basis: precautionary approach

The advice for this stock is biennial.

Data revision

Landings for the years 1979 to 1984 were included with information available from the ICES historical database[1]. Time-series of landings, effort, and LPUE of the abundance index from the FR-GNS90-8a-2s commercial fleet was updated.

17.1 General

17.1.1 Stock identity and fishery description

See Stock Annex.

17.1.2 Summary of ICES advice for 2020 and 2021 and management for 2019 and 2020

17.1.2.1 ICES advice for 2020 and 2021

In 2019 ICES advised that when the precautionary approach is applied, commercial catches should be no more than 1131 t in each of the years 2020 and 2021.

17.1.2.2 Management applicable for 2019 and 2020

Pollack is managed under a TAC that was set at 1944 t for 2020 and 1851 t for 2021. The TAC for this stock was set separately for ICES divisions 8.a, 8.b, 8.d, 8.e, ICES Division 8.c, and subareas 9 and 10 (and Union waters of CECAF 34.1.1), and is provided in Table 17.1.

The reported landings for this stock in 2020 were 79% of the established TAC. The minimum landing size (MLS) for pollack is set at 30 cm by the European Member States (EU, 1998).

[1] http://www.ices.dk/marine-data/Documents/CatchStats/ICES1903-49.zip

17.2 Fisheries data

17.2.1 Commercial landings

Pollack is mainly exploited by France and Spain, with a minor contribution to landings from UK and Portugal. In the last ten years, France was responsible for 77% of commercial landings of the stock and Spain for 18% (Figure 17.1). The commercial landing statistics are given in Table 17.2. A detailed description of the fishery and biology of the species is provided in the Stock Annex.

The landings by gear submitted to the Working Group (WG) are given in Table 17.3. Note that these are not the landings figures used in the advice issued in 2015 and 2017 because there were many gaps in the data. A new series of French landings by *métier* from 2000 to 2014 was available from the ROMELIGO project (WD 05; ICES, 2018), and these data were used to update the pollack landings for these years. Data from this project have been used to complete the official information available for this stock.

Annual commercial landings have fluctuated between 1479 t and 2313 t since 2000, without a clear trend. Pollack landings slightly increased from 1481 t in 2017 to 1535 t in 2020, which is an increase of 4%. The TAC for 2020 was 1944 t, which means that commercial landings have not exceeded the total allowable catches.

Recreational removals might be considerable but have not been quantified.

17.2.2 Commercial discards

Discard estimates are available since 2003 for French fleets and the last five years for all other relevant fleets (Table 17.4). Discard information from 2003 to 2014 were compiled from data provided by the ROMELIGO project to the WG (*personal communication*). Most fleets did not report pollack in discards and for Spanish netters, discards are considered negligible (less than 0.5% of catch). In 2020, French netters and liners discarded about 1.2% and 0.1% of their catches, respectively.

17.2.3 Length composition

A recent time-series of commercial landings-at-length data for 2010–2020 (Figure 17.2). Length composition sampled were compiled from InterCatch (years > 2015) and the ROMELIGO project. From 2010 to 2015 the length composition information is only available for French *métiers*, from 2015 onwards Spain provides length information for its *métiers* through InterCatch, and from 2019 Portugal also uploads length information. The raising procedure used to obtain an aggregated-weighted length composition of landings follows the following strata: country, area, gear type, and year. The average percentage of the volume of sampled catches was 31%, with the highest values in 2019 (41%) and 2020 (58%).

17.2.4 Commercial landing-effort data

A commercial abundance index for pollack is available for the French gillnet fleet in Division 8.a. The index includes information for fishing sequences performed with gillnets of mesh size > 90 mm and fishing during the second semester of the year (FR-GNS >90mm-8a-2s). This index was identified as a task of the ROMELIGO project and it is described in the working document (WD) by Léauté *et al*. (2018) in a previous WGBIE report (ICES, 2018). A new methodology, based on a conditional decision tree, has been developed to select the information from fleet FR-GNS>90mm-8a-2s from logbook records (Caill-Milly *et al.*, 2020 in ICES, 2020). This methodology was used to update the abundance index last year. The updated time-series of landings, effort and LPUE were provided to the WG this year (*personal communication*) (Table 17.5). The FR-GNS >90mm-8a-2s index is available from 2005 to 2020 and represents an average of 7.5% of the stock's total landings. Landings of this fleet have fluctuated between 52 and 172 t recorded in 2006 and 2014, respectively (Figure 17.3). Since 2014, landings began decreasing reaching the lowest value of 110 t (2018) of the whole series. A slight increase to 154 t was observed in 2020. The effort unit is estimated using the fishing sequence, a combination of vessel, gear, statistical rectangle, and day of FR-GNS>90mm-8a-2s. Effort showed an increasing trend between 2011 and 2016 then decreased in 2017 and 2018, which was followed by an increase in the last two years. The LPUE showed a decreasing trend from 2011 to 2018, declining from 218 in 2011 to 101 kg/Fs in 2018.

17.3 Application of advice rule

Advices are based from 2014 on the previous three year's (2011–2013) average of the landings, with the precautionary buffer applied regularly. The latest advice was released in 2019 (ICES, 2019). ICES advised that commercial landings should be no more than 1131 t in each of the years 2020 and 2021.

The framework for category 5 stocks (ICES, 2021a) was followed to provide the advice for 2022 and 2023. The landings statistics for pollack do not show any remarkable changes since 2017, with an interannual variation on landings between −2% and 3%. The available scientific data for the stock are not sufficient to evaluate both the stock's abundance and exploitation status.

The precautionary buffer was last applied in 2017 and is, therefore, applied again this year. The two exceptions for the application of the precautionary approach buffer were evaluated using the available LPUE index (FR-GNS>90mm-8a-2s) and based on the evaluation, the conditions for the exception the buffer's application were not fulfilled:

- No consistent increase in stock size was observed.
- The stock size index ratio, following the 2-over-3 rule, was estimated as 1.15, below the target value of 1.5.

In this case, the proposed advice resulting from the application of the precautionary buffer (reduction of 20%) on the latest advice (1132 t), is 905 t for each of the years 2022 and 2023.

17.4 Biological reference points

No biological reference points are defined for this stock.

17.5 Management plans

No management plan is known for this stock in the area.

17.6 Current assessment and advice

There is no analytical assessment for this stock. The advice for this stock is biennial. In 2019, the stock was subjected to advice and is, thus provided again this year. In this WG, the stock catch data were updated. COVID-19 has not affected the quality of data on which the advice is based.

17.7 Recommendations for next benchmark

This stock was benchmarked during the WKMSYSPiCT in early 2021 (ICES, 2021b). Due to the short time-series of the abundance index and to the contrasting gaps in the input data, it was not possible to fit the information available to provide an acceptable assessment model using SPiCT (Pedersen and Berg, 2017). Hence, the stock remains as an ICES category 5 stock.

During the WKMSYSPiCT (ICES, 2021b), the following steps were recommended for a future benchmark:

- Standardize the abundance index FR-GNS >90mm-8a-2s with a statistical model as GAM or GLMM.
- Develop an integrated assessment model, e.g. stock synthesis (SS; Methot and Wetzel, 2013), for the stock. The model would integrate the biological information provided by the ROMELIGO project and the landings length composition estimated by the WG.

Other recommendations for the next benchmark include:

- Estimate the recreational removals which are supposed to be relevant and include these data in the assessment model.
- Review the stock's structure in the Northeast Atlantic based on literature and new evidence from ongoing studies.

Once sufficient progress has been achieved considering all the points enumerated above, the WG will push for a new benchmark for the stock.

17.8 References

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17.9 Tables and figures

Table 17.1. TAC for pollack for the two ICES divisions (8a, 8.b, 8.d, 8.e and 8.c) and two subareas (9 and 10) in 2021.

Species:	Pollack *Pollachius pollachius*	**Zone:**	8a, 8b, 8d and 8e (POL/8ABDE.)
Spain	252	Precautionary TAC	
France	1 230		
Union	1 482		
TAC	1 482		

Species:	Pollack *Pollachius pollachius*	**Zone:**	8c (POL/08C.)
Spain	187	Precautionary TAC	
France	21		
Union	208		
TAC	208		

Species:	Pollack *Pollachius pollachius*	**Zone:**	9 and 10; Union waters of CECAF 34.1.1 (POL/9/3411)
Spain	246 (1)	Precautionary TAC	
Portugal	8 (1) (2)		
Union	254 (1)		
TAC	254 (1)		

Table 17.2. Pollack in Subarea 8 and Division 9.a. Commercial landings (tonnes) by country as estimated by Working Group. Shaded values (in light grey) are from ICES/FAO* historical databases and the ROMELIGO project. Values from 2015 to 2020 were derived from the InterCatch database.

	Bay of Biscay (Subarea 8)				Atlantic Iberian waters (Division 9.a)				ICES
Year	Belgium	Spain	France	UK	Spain	Portugal	Total	Unallocated	estimates
1979	0	1021	2221	0	0	0	3242	0	3242
1980	1	1576	2158	0	0	0	3735	0	3735
1981	1	902	2326	0	0	0	3229	0	3229
1982	2	85	2185	2	32	0	2306	0	2306
1983	0	581	2652	0	203	0	3436	0	3436
1984	0	1606	2351	1	642	0	4600	0	4600
1985	0	2304	2769	23	636	0	5732	0	5732
1986	0	437	2127	5	237	0	2806	0	2806
1987	0	584	2022	1	308	3	2918	0	2918
1988	3	476	1761	6	329	7	2582	0	2582
1989	13	214	1682	4	57	3	1973	0	1973
1990	14	194	1662	2	27	1	1900	0	1900
1991	1	221	1867	1	76	2	2168	0	2168
1992	2	154	1735	0	65	2	1958	0	1958
1993	3	135	1327	0	47	1	1513	0	1513
1994	3	157	1764	0	28	3	1955	0	1955
1995	6	153	1457	2	59	2	1679	0	1679
1996	8	137	1164	0	43	2	1354	0	1354
1997	2	152	1167	1	54	2	1378	0	1378
1998	1	152	956	0	55	1	1165	0	1165
1999	0	120	n/a	0	36	1	157	0	157
2000	0	121	1294	0	49	15	1479	0	1479
2001	0	346	1278	0	81	41	1746	0	1746
2002	0	170	1722	0	35	45	1972	0	1972
2003	0	142	1450	1	39	31	1663	0	1663
2004	0	211	1343	0	90	12	1656	70	1726
2005	0	306	1552	0	132	0	1990	-4	1986
2006	0	251	1596	171	102	0	2120	6	2126
2007	0	198	1375	62	103	5	1743	104	1847
2008	0	265	1732	64	128	31	2220	93	2313
2009	0	218	1371	41	68	3	1701	111	1812
2010	0	265	1170	44	91	2	1572	110	1682
2011	0	322	1475	27	104	2	1930	102	2032
2012	0	159	1131	2	139	2	1433	87	1520
2013	0	251	1346	8	110	3	1718	93	1811
2014	0	185	1612	19	93	1	1910	49	1959
2015	0	195	1244	37	78	18	1573	37	1610
2016	0	186	1292	25	111	28	1642	19	1661
2017	0	128	1219	0	95	38	1480	1	1481
2018	0	135	1220	0	124	33	1513	0	1513
2019	0	174	1189	0	143	57	1562	0	1562
2020	0	171	1174	0	136	54	1535	0	1535

Table 17.3. Pollack in Subarea 8 and Division 9.a. Landings (tonnes) from France, Spain, and Portugal by country and gear as submitted to the Working Group. Shaded values come from ICES/FAO historical database and ROMELIGO project. Non-shaded figures, from 2015 to 2020, were derived from the InterCatch database.

	France				Spain			Portugal	
Year	Nets	Trawl	Lines	Others	Lines	Nets	Others	Others	Trawl
2000	671	353	176	94	-	-	-	-	-
2001	794	271	133	80	31	53	169	-	-
2002	1151	321	170	79	26	28	134	-	-
2003	990	215	182	64	31	35	146	-	-
2004	679	298	292	73	47	36	222	16.5	0.1
2005	801	364	326	62	90	36	161	7.8	0.6
2006	882	395	245	74	48	29	243	6.7	0.3
2007	797	301	228	49	72	51	210	4.5	0.4
2008	1055	267	351	59	147	95	163	33.3	0
2009	829	185	328	30	101	76	97	2.4	0.5
2010	719	128	249	74	167	162	93	1.7	0.1
2011	850	180	357	88	207	199	20	1.2	0.3
2012	631	148	305	46	123	122	53	-	-
2013	756	210	327	52	-	-	-	-	-
2014	925	288	345	55	110	147	103	1	0
2015	766	178	258	42	145	114	14	18	0.2
2016	735	128	399	30	185	87	26	28	0
2017	596	100	486	37	123	91	9	38	0
2018	684	78	405	54	134	120	6	32	0.8
2019	683	76	387	43	152	162	3	55	1.8
2020	670	71	409	24	168	133	7	49	5

Table 17.4. Pollack in Subarea 8 and Division 9.a. Annual discards estimates (tonnes) from France, Spain, and Portugal by gear as submitted to the Working Group. Shaded values (in light gray) are from the ROMELIGO project. Values from 2015 to 2020 were derived from the InterCatch database.

	France			Spain			Portugal
Year	Nets	Trawl	Lines	Lines	Nets	Trawl	Trawl
2003	0	0	-	-	-	-	-
2004	0	0.2	-	-	-	-	-
2005	11	0	-	-	-	-	-
2006	1.4	13.9	-	-	-	-	-
2007	5.7	0	-	-	-	-	-
2008	35.5	0	0	-	-	-	-
2009	3.2	0	1.5	-	-	-	-
2010	9	0	0	-	-	-	-
2011	2.9	0	6.2	-	-	-	-
2012	13	0	1.2	-	-	-	-
2013	19.4	0.3	6.8	-	-	-	-
2014	63.6	0	1.1	-	-	-	-
2015	28.1	0	0	0	3.5	0	0
2016	83.1	5.4	4.3	0	0.4	0	0
2017	18.6	0	0	0	0	0	0
2018	38.7	0	0	0	0	2.8	0
2019	8.2	0	6.1	0	0	0	0
2020	8.5	0	0.6	0	0	0	0

Table 17.5. Pollack in Subarea 8 and Division 9.a. Data for commercial index FR-GNS>90mm-8a-2s as submitted to the Working Group in 2021. The representativeness of the index related to the total annual stock landings (in %) is indi-cated in the last column.

Year	Landings (kg)	Effort (fishing sequence)	LPUE (kg/fs)	% Stock
2005	97484	829	117.6	4.9
2006	51794	669	77.4	2.4
2007	120701	895	134.9	6.5
2008	139003	1036	134.2	6.0
2009	104658	810	129.2	5.8
2010	81178	721	112.6	4.8
2011	142528	654	217.9	7.0
2012	149691	746	200.7	9.8
2013	148872	876	169.9	8.2
2014	171901	1045	164.5	8.8
2015	168819	1051	160.6	10.5
2016	149391	1335	111.9	9.0
2017	133548	1204	110.9	9.0
2018	110553	1095	101.0	7.3
2019	155317	1163	133.5	9.9
2020	154148	1348	114.4	10.0

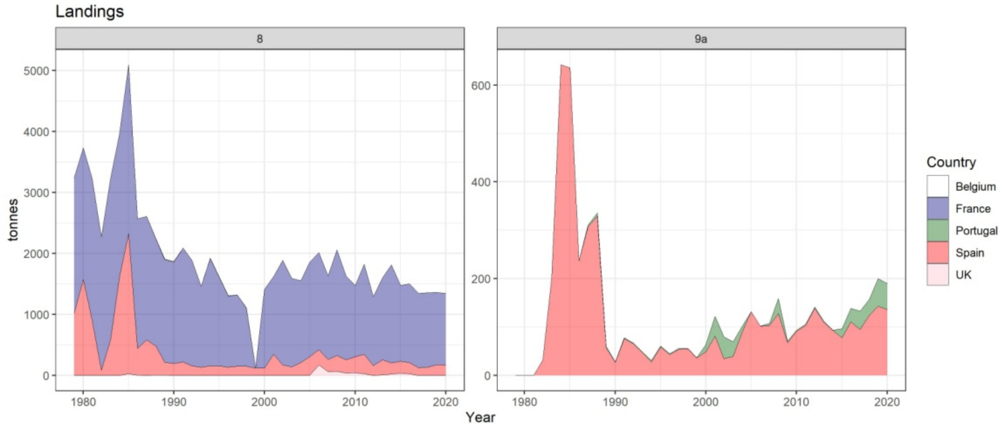

Figure 17.1. Pollack in Subarea 8 and Division 9.a. Commercial landings by country. French data are missing for 1999.

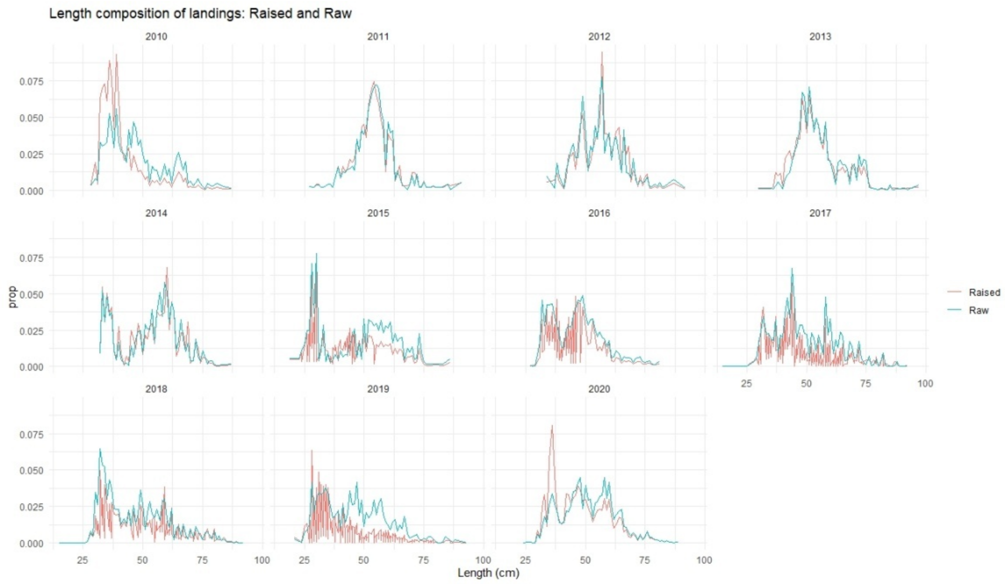

Figure 17.2. Pollack in Subarea 8 and Division 9.a. Length composition of landings (in proportion) showing the raw data (blue) and raised (red) values for the period 2010–2020.

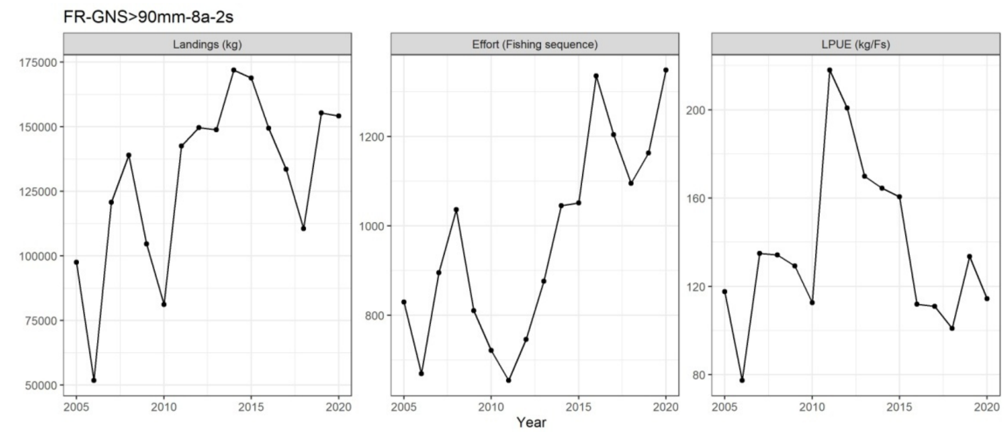

Figure 17.3. Pollack in Subarea 8 and Division 9.a. Landings, effort, and LPUE were estimated from FR-GNS>90mm-8a-2s commercial fleet.

18 Whiting in Subarea 8 and Division 9.a (Bay of Biscay and Atlantic Iberian waters)

Merlangius merlangus – whg.27.89a

Type of assessment in 2021

Length-based indicator method (LBI) as fishing pressure indicator (ICES, 2017; ICES, 2018a; ICES, 2018b).

Data revision in 2021

InterCatch data were compiled for 2020.

18.1 General

ICES advises that when the precautionary approach is applied, catches should not be more than 2276 t in each of the years 2022 and 2023. The rationale for catch option was the following:

The ICES framework for category 5 stocks was applied (ICES, 2012; ICES, 2021). For stocks without information on abundance or exploitation, ICES considers that a precautionary reduction of catches should be implemented unless there is ancillary information clearly indicating that the current level of exploitation is appropriate to the stock. The precautionary buffer was applied in 2015 and was applied again in 2018 as the stock size was unknown in relation to the reference points.

The COVID-19 pandemic affected onboard sampling and discard estimates. Discard and length structures were raised on a six-month basis in order to mitigate low sampling levels. Low sampling levels and the larger time-scale used to raise discards might be the reason for the lowest estimated discard rate of the time-series [DR_{2020} = 0.21, $average_{2016–2019}$ = 0.29, $max_{2016–2019}$ = 0.32].

Discards estimates were, however, considered relevant to provide the advice and the discard rate in the catch option table was computed over 2016–2020.

18.2 Data

Whiting (*Merlangius merlangus*) are caught in mixed demersal fisheries primarily by France and Spain (Table 18.1 and Figure 18.1). There are concerns about the reliability of the French data from 2008–2009 which appear to be incomplete. There is some misidentification of whiting in the Portuguese markets with pollack due to the common names used for both stocks. This resulted in most pollack landings being recorded as whiting from 2004 onwards. Based on this information, pollack landings were deducted from the whiting landings during this period and were then considered as unallocated (Table 18.1). Sampling data since 2012 indicate that Portuguese landings of whiting and pollack from Division 9.a consisted of 2% whiting and 98% pollack (EC, 2015). Whiting landed by Portuguese vessels makes up an insignificant proportion of the total whiting landings in this area.

18.2.1 Commercial catches and discards

InterCatch data from 2016–2018 were processed in 2019 to compute discards estimates (ICES, 2019). In 2021, 2020 InterCatch data were processed to compute landings and discards estimates.

The standard procedure to estimate discards is to use the discard data provided for the different combinations of countries/gears/seasons/areas ("strata") and to raise the available discard data to the total landings for the strata with limited available data.

However, in 2020 COVID-19 affected onboard samplings and discards estimates. Fewer strata (i.e. countries/gears/seasons/areas) were sampled compared to previous years (see Table 18.2). This low sampling level induced some changes in the raising procedures from merging quarters to semesters (merging quarters 1 and 2, and 3 and 4).

In 2020, the estimated discard rate is the lowest of the time-series (see Table 18.3) [DR_{2020} = 0.21, $average_{2016–2019}$ = 0.29, $max_{2016–2019}$ = 0.33]. Low sampling levels and the larger time-scale used to raise discards might be the reason for the lowest estimated rate. Landing Obligation (LO) might also have affected the discard rate even if there is currently no real evidence of this impact. However, the small number of observations and the change in the raising method for discards increased the uncertainty around these estimates and raised the question of whether it should be considered relevant to provide advice. It is not possible to derive any conclusion from the decrease of the discard rate in 2020.

18.2.2 Length structure of commercial catches

For landings, 51, 41, 46, 44, and 63% of the landings (in volume) had a length structure associated in 2020, 2019, 2018, 2017, and 2016, respectively.

For discards, the percentage of the total discards (after raising) with a length distribution provided are 17, 30, 44, 43, and 60% in 2020, 2019, 2018, 2017, and 2016, respectively. See Table 18.4 through Table 18.8 for details.

Length distribution of landings and discards before and after raising are shown in Figure 18.2 through Figure 18.6. Final distributions (pink dots) are similar to the sampled (provided) distribution, showing the limited impact of the raising procedures on length compositions. Due to the low sampling level in 2020, the discard length structure is much noisier than in the previous years. However, landings length structures are of similar quality compared to previous years. Given the structure of the number at length mostly driven by landings, the uncertainty of the discard length structure should not affect the conclusion of the LBI.

The length distributions of the landings are truncated below 27 cm due to the Minimum Conservation Reference Size set at 27 cm in this area.

18.2.3 Survey data and commercial cpues

Whiting is present in the French survey (EVHOE-WIBTS-Q4 (G9527) from the Bay of Biscay. In 2017, WGBIE investigated if this survey could provide an index of recruitment and/or biomass (ICES, 2017). The survey regularly catches whiting on inshore stations but the catch rates are highly variable, resulting in very wide confidence limits. WGBIE does not propose to use these as a basis for the advice.

This species is at the southern extent of its range in the Bay of Biscay and Iberian Peninsula (Figure 18.7). It is not clear whether this is a separate stock from a biological point of view.

Two commercial cpue indices were identified which were provided by the ROMELIGO project carried out by Ifremer (France) and are described in the working document by Léauté *et al*. (2018) in the WGBIE 2018 report (ICES, 2018c). These cpues, estimated based on two trawler fleets in the south and north of the Bay of Biscay, were updated this year.

None of these cpues was used to provide advice as they were not assessed during a benchmark and will need further development. However, none of them showed any clear trends (Figure 18.8).

18.2.4 Length-based indicators

Whiting length samples (sex combined) from commercial catches were provided in InterCatch format for the years 2016–2020. Length structures of the catches were estimated from these samples and were used for the analyses of MSY proxies applying the LBI method (ICES, 2017; 2018a; 2018b). The length distributions were binned to 40 mm length classes (Figure 18.9). The method also requires growth and maturity parameters which were taken from FishBase (Fröese and Pauly, 2020; Table 18.9).

The results of the LBI method showed that all indicators except L_c/L_{mat} in 2019 are above the reference points (Table 18.10. and Figure 18.10–Figure 18.12).

From these results, it was concluded that whiting is currently exploited below F_{MSY} as $L_{mean}/L_{F=M}$ is above 1 from 2016 onwards.

18.3 Issues list

Issue	Problems/Aims	Work needed / possible direction of a solution	Data needed to be able to do this. Are these available/ where should these come from?	External expertise needed at benchmark Type of expertise needed/ proposed names
Data to be considered and/or quantified	Time-series of catch data.	5 years of data have been consolidated in InterCatch. A longer time-series needs to be consolidated.	France, Spain and Portugal need to consolidate their InterCatch data provision to get a longer time-series as possible.	
	Time-series of length structures. Samplings may not be sufficient in all areas.	Assess the representativeness of the samplings in Subarea 8 and evaluate the possibilities for use to raise data in Division 9 where very few samples are available.	Raw sampling data.	
	Time-series of age structures. Samplings may not be sufficient in all areas.	Assess the representativeness of the sampling in Subarea 8 and evaluate the possibilities for use to raise data in Division 9 where very few samples are available.	Raw sampling data.	
Data to be produced				

Issue	Problems/Aims	Work needed / possible direction of a solution	Data needed to be able to do this. Are these available/ where should these come from?	External expertise needed at benchmark Type of expertise needed/ proposed names
Tuning series	Commercial cpues. A short time-series using French otter trawls already exists.	The time-series needs to be consolidated and/or use a statistical model to provide commercial cpues (GLM-GAM).	Data are available but need processing.	
Discards	Time-series of discards has to be consolidated.	5 years of data have been raised in InterCatch. A longer time-series needs to be consolidated.	France, Spain and Portugal need to consolidate their InterCatch data provision to get a longer time-series as possible.	
Stock ID	This species is at the southern extent of its range in the Bay of Biscay and Iberian Peninsula. It is not clear whether this is a separate stock from a biological point of view.	Review of literature.		
Biological parameters	Maturity.	Little information about maturity is currently available for assessment but some information should have been collected during scientific surveys and DCF collections in France, Spain and Portugal.	France, Spain and Portugal should provide all individual biological data to assess if some maturity ogive can be derived for this stock.	
Assessment method	SPiCT (Pedersen and Berg, 2017) is the priority as no age/length data are currently available. However, some ongoing works exist which aim to provide these data. If so, an a4a model can be envisaged.			
Biological reference points				

- No discard information is provided for Subarea 8.c and Division 9.a.
- Very little information is available about stock distribution.
- Surveys should be investigated further to check for data availability.

18.4 References

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18.5 Tables and figures

Table 18.1. Whiting in Subarea 8 and Division 9.a. Official landings in tonnes (2020 provisional). ICES estimates are based on a correction of mixed species (whiting and pollack) landings records in the Portuguese landings from Division 9.a.

Year	Belgium	France	Portugal	Spain	Total	Unallocated *	ICES estimates
1994		3496	15	136	**3647**	0	**3647**
1995		2645	2	1	**2648**	0	**2648**
1996		1544	4	13	**1561**	0	**1561**
1997		1895	3	47	**1945**	0	**1945**
1998		1750	3	105	**1858**	0	**1858**
1999			1	211	**212**	0	**212**
2000	2	1106	2	338	**1448**	0	**1448**
2001	3	1989	1	288	**2281**	0	**2281**
2002	3	1970	1	230	**2204**	0	**2204**
2003	1	2275	4	171	**2451**	0	**2451**
2004		1965	77	249	**2291**	−70	**2221**
2005	3	1662	2	416	**2083**	−2	**2081**
2006	2	1420	7	433	**1862**	−6	**1856**
2007	4	1617	107	296	**2024**	−104	**1920**
2008	1	772	98	187	**1058**	−93	**965**
2009	2	1303	114	54	**1473**	−111	**1362**
2010	3	2234	114	101	**2452**	−110	**2342**
2011	1	2029	105	108	**2243**	−102	**2141**
2012	3	1791	90	110	**1994**	−87	**1907**
2013	1	1943	95	55	**2094**	−93	**2001**
2014	1	1579	65	55	**1700**	−49	**1651**
2015	2	2138	38	56	**2234**	−35	**2199**
2016	1	2441	20	40	**2502**	23	**2525**
2017	0	1871	18	20	**1909**	16	**1925**
2018	2	1524	15	26	**1565**	0	**1565**
2019	1	1348		13	**1362**	34	**1396**
2020	1	1094		1	**1096**	25	**1121**

*Unallocated are mostly coming from landings taken off from pollock.89a.

Table 18.2. Whiting landings with associated discards (same strata) submitted to InterCatch (in percent).

Year	Landings with associated discards*
2016	88%
2017	72%
2018	70%
2019	49%
2020	33%

*Similar combinations of countries/gears/seasons/areas.

Table 18.3. Whiting landings and discards after raising procedures (in tonnes).

Year	Landings (imported)	Discards (imported)	Discards (raised)	Total Discards	Overall Discard Rate
2016	2525.00	828.40	98.38	**926.78**	**0.268**
2017	1925.00	617.60	320.20	**937.80**	**0.328**
2018	1565.00	376.00	279.50	**655.50**	**0.295**
2019	1396.00	243.90	291.20	**535.10**	**0.280**
2020	1122.00	92.50	206.20	**298.70**	**0.210**

Table 18.4. Whiting in Subarea 8 and Division 9.a. Summary of the structures provided in 2020 (Imported_Data refers to data imported to InterCatch, Raised_Discards refers to discard raised based on observed data for other strata, Sampled_Distribution refers to landings or discards with length structures provided, Estimated_Distribution refers to length distribution estimated from the provided strata).

CatchCategory	RaisedOrImported	SampledOrEstimated	CATON	perc
Landings	Imported_Data	Estimated_Distribution	577.3	51
Landings	Imported_Data	Sampled_Distribution	544.2	49
Discards	Raised_Discards	Estimated_Distribution	206.2	69
Discards	Imported_Data	Sampled_Distribution	50.84	17
Discards	Imported_Data	Estimated_Distribution	41.66	14

Table 18.5. Whiting in Subarea 8 and Division 9.a. Summary of the structures provided in 2019 (Imported_Data refers to data imported to InterCatch, Raised_Discards refers to discard raised based on observed data for other strata, Sampled_Distribution refers to landings or discards with length structures provided, Estimated_Distribution refers to length distribution estimated from the provided strata).

CatchCategory	RaisedOrImported	SampledOrEstimated	CATON	perc
Landings	Imported_Data	Estimated_Distribution	826	59
Landings	Imported_Data	Sampled_Distribution	570.1	41
Discards	Raised_Discards	Estimated_Distribution	291.2	54
Discards	Imported_Data	Sampled_Distribution	163.2	30
Discards	Imported_Data	Estimated_Distribution	80.77	15

Table 18.6. Whiting in Subarea 8 and Division 9.a. Summary of the structures provided in 2018 (Imported_Data refers to data imported to InterCatch, Raised_Discards refers to discard raised based on observed data for other strata, Sampled_Distribution refers to landings or discards with length structures provided, Estimated_Distribution refers to length distribution estimated from the provided strata).

CatchCategory	RaisedOrImported	SampledOrEstimated	CATON	perc
Landings	Imported_Data	Estimated_Distribution	846.2	54
Landings	Imported_Data	Sampled_Distribution	718.6	46
Discards	Imported_Data	Sampled_Distribution	290.5	44
Discards	Raised_Discards	Estimated_Distribution	279.5	43
Discards	Imported_Data	Estimated_Distribution	85.51	13

Table 18.7. Whiting in Subarea 8 and Division 9.a. Summary of the structures provided in 2017 (Imported_Data refers to data imported to InterCatch, Raised_Discards refers to discard raised based on observed data for other strata, Sampled_Distribution refers to landings or discards with length structures provided, Estimated_Distribution refers to length distribution estimated from the provided strata).

CatchCategory	RaisedOrImported	SampledOrEstimated	CATON	perc
Landings	Imported_Data	Estimated_Distribution	1080	56
Landings	Imported_Data	Sampled_Distribution	844.4	44
Discards	Imported_Data	Sampled_Distribution	404.7	43
Discards	Raised_Discards	Estimated_Distribution	320.2	34
Discards	Imported_Data	Estimated_Distribution	212.9	23

Table 18.8. Whiting in Subarea 8 and Division 9.a. Summary of the structures provided in 2016 (Imported_Data refers to data imported to InterCatch, Raised_Discards refers to discard raised based on observed data for other strata, Sampled_Distribution refers to landings or discards with length structures provided, Estimated_Distribution refers to length distribution estimated from the provided strata).

CatchCategory	RaisedOrImported	SampledOrEstimated	CATON	perc
Landings	Imported_Data	Sampled_Distribution	1585	63
Landings	Imported_Data	Estimated_Distribution	939.9	37
Discards	Imported_Data	Sampled_Distribution	553.1	60
Discards	Imported_Data	Estimated_Distribution	275.2	30
Discards	Raised_Discards	Estimated_Distribution	98.38	11

Table 18.9. Whiting in Subarea 8 and Division 9.a. Parameters used as input for the LBI method.

Table 1: Table continues below

Data Type	Value/Year
Length at maturit	261 261 261
von Bertalanffy growth parameter	443 443 443
Catch at length by year	2014 2020
Length-weight relationship parameters for landings and discards	2014 2020

Source
https://www.fishbase.in/Reproduction/MaturityList.php?ID=29
https://www.fishbase.in/Reproduction/MaturityList.php?ID=29
Length data from IC
Mean weight at length from IC

Table 18.10. Whiting in Subarea 8 and Division 9.a. Results from LBI method and reference values for each indicator.

Year	Lc_Lmat	L25_Lmat	Lmax5_Linf	Pmega	Lmean_Lopt	Lmean_LFeM
2016	**1.15**	**1.07**	**1.15**	0.55	**1.25**	**1.1**
2017	1	**1.03**	**1.18**	0.52	**1.22**	**1.18**
2018	**1.15**	**1.15**	**1.11**	0.53	**1.2**	**1.05**
2019	0.84	**1.03**	**1.17**	0.49	**1.13**	**1.21**
2020	1	**1.11**	**1.18**	0.49	**1.18**	**1.14**

Table 3: Refs

Lc/Lmat	L25%/Lmat	Lmax5%/Linf	Pmega	Lmean/Lopt	Lmean/Lf=m
>1	>1	>0.8	>30%	~1 (>0.9)	>=1

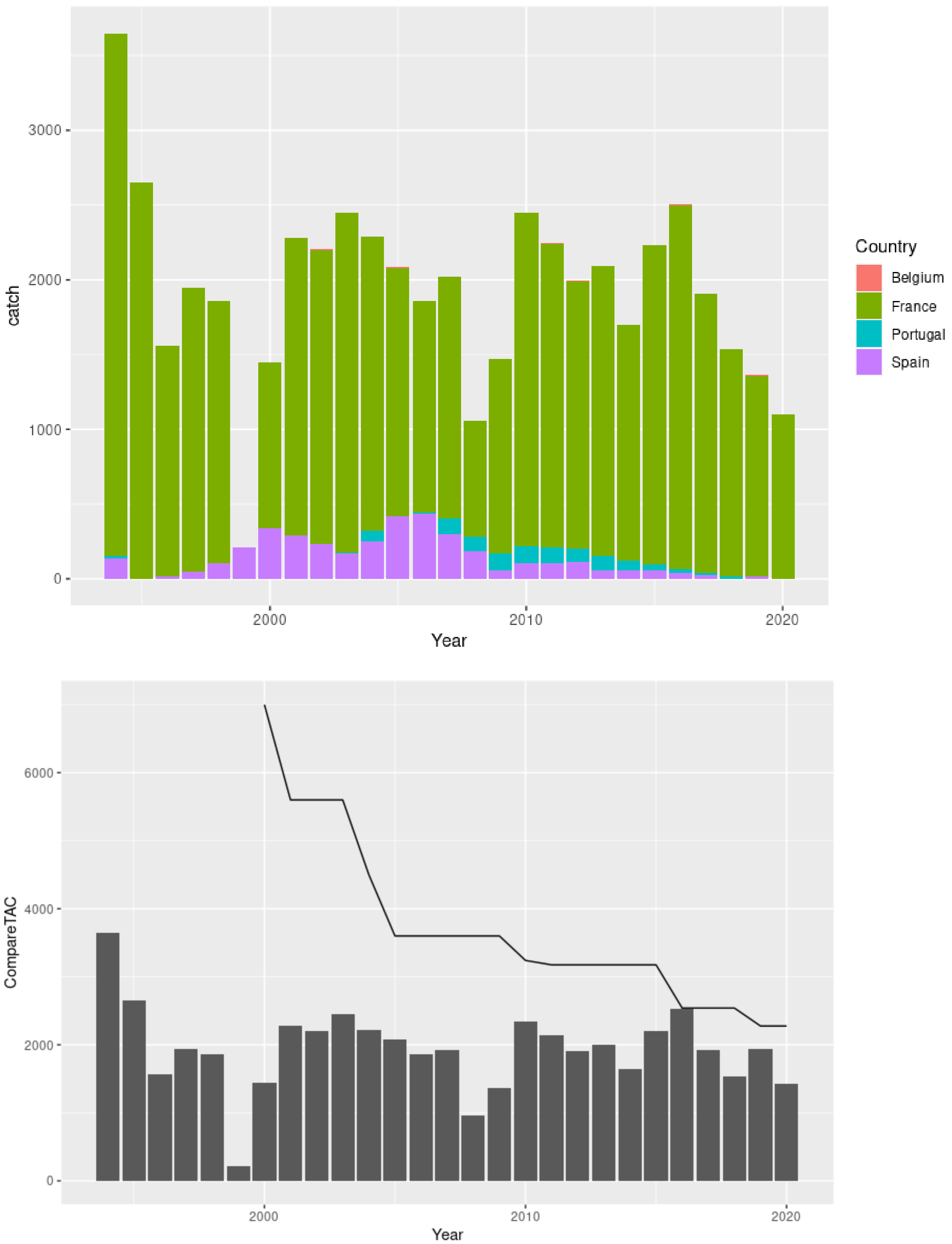

Figure 18.1. Landings per country (upper panel), landings before 2019 (lower panel), and catches after 2019 compared to TAC (solid line).

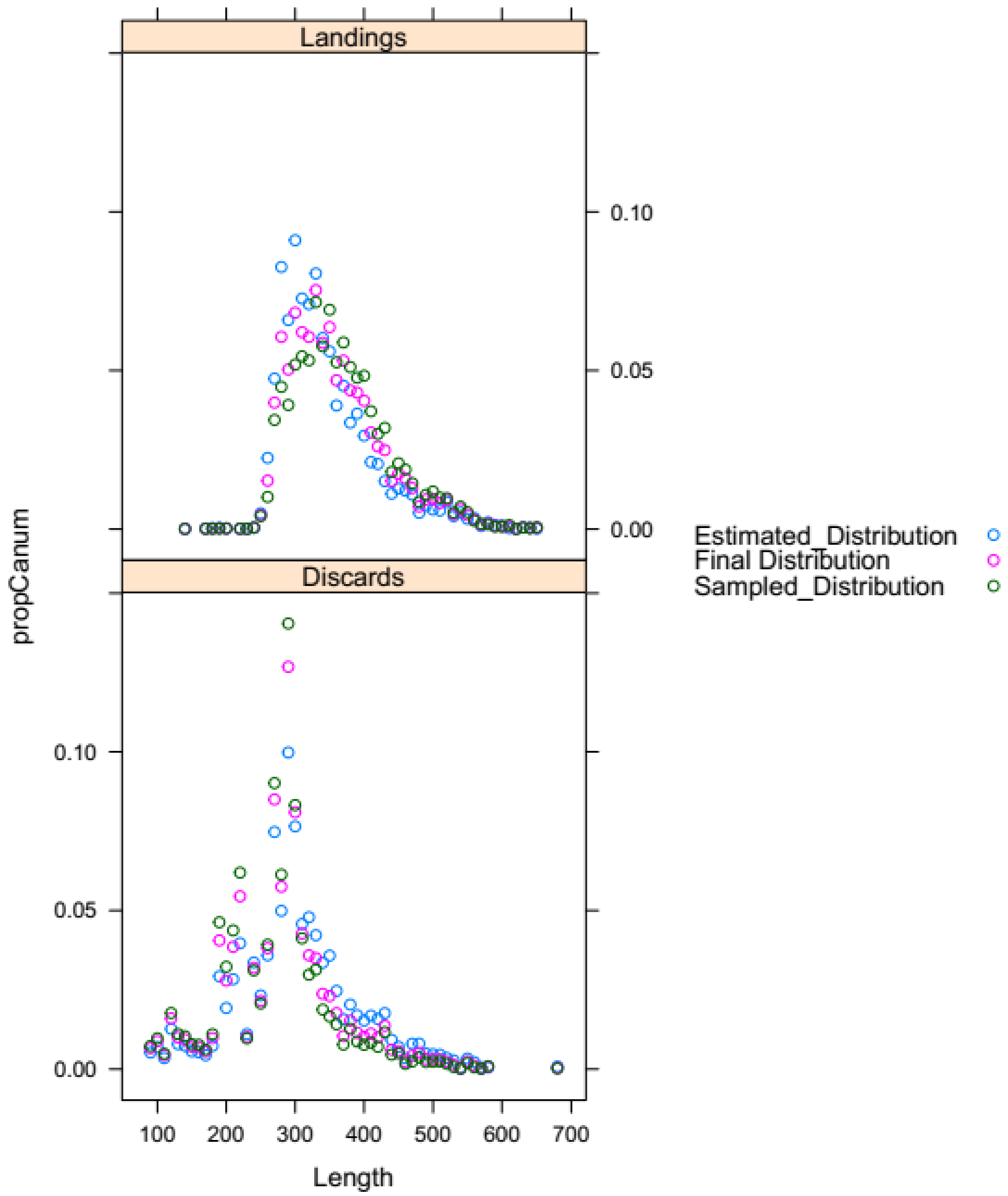

Figure 18.2. Length distribution of landings (top) and discards (bottom) for 2016.

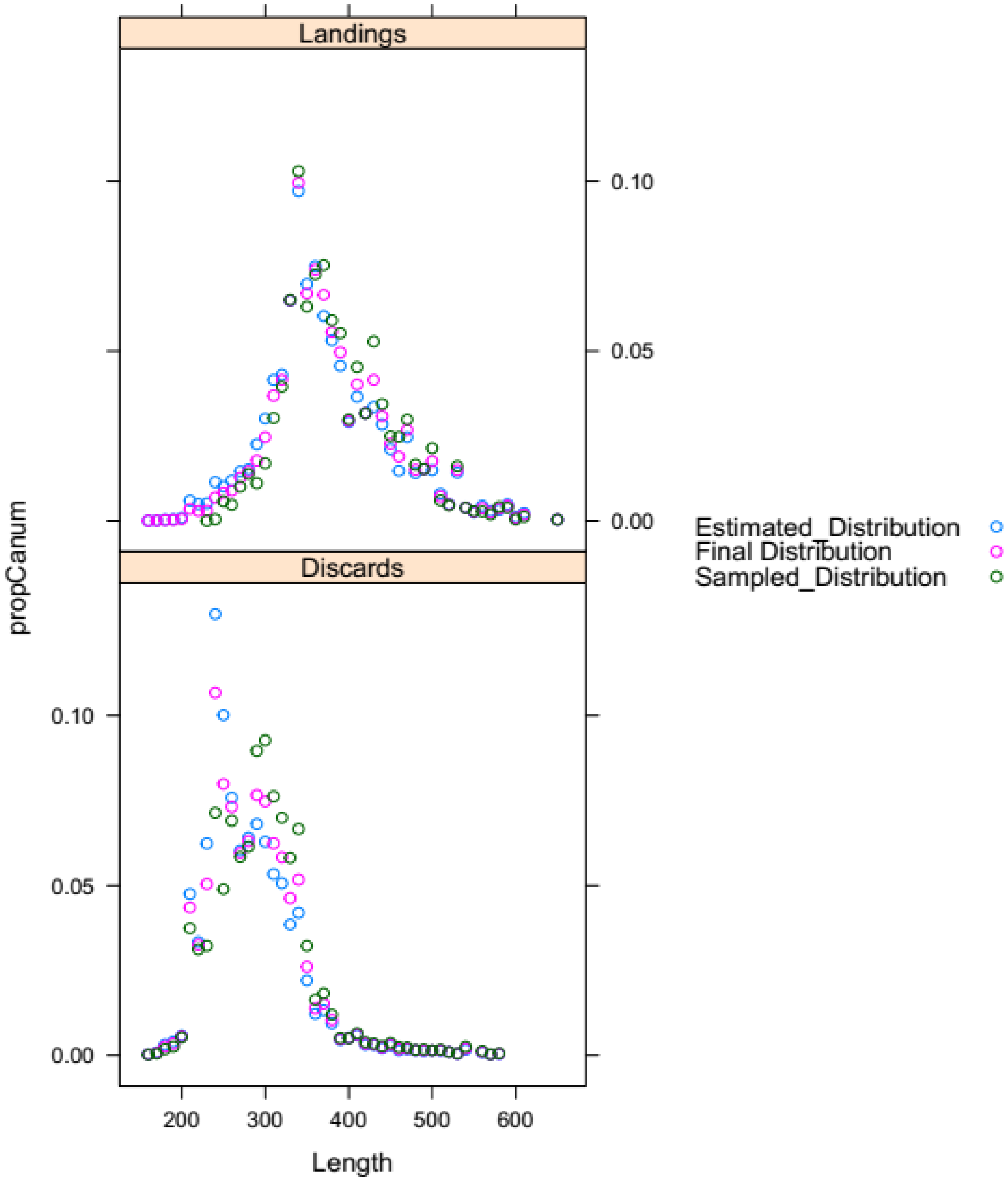

Figure 18.3. Length distribution of landings (top) and discards (bottom) for 2017.

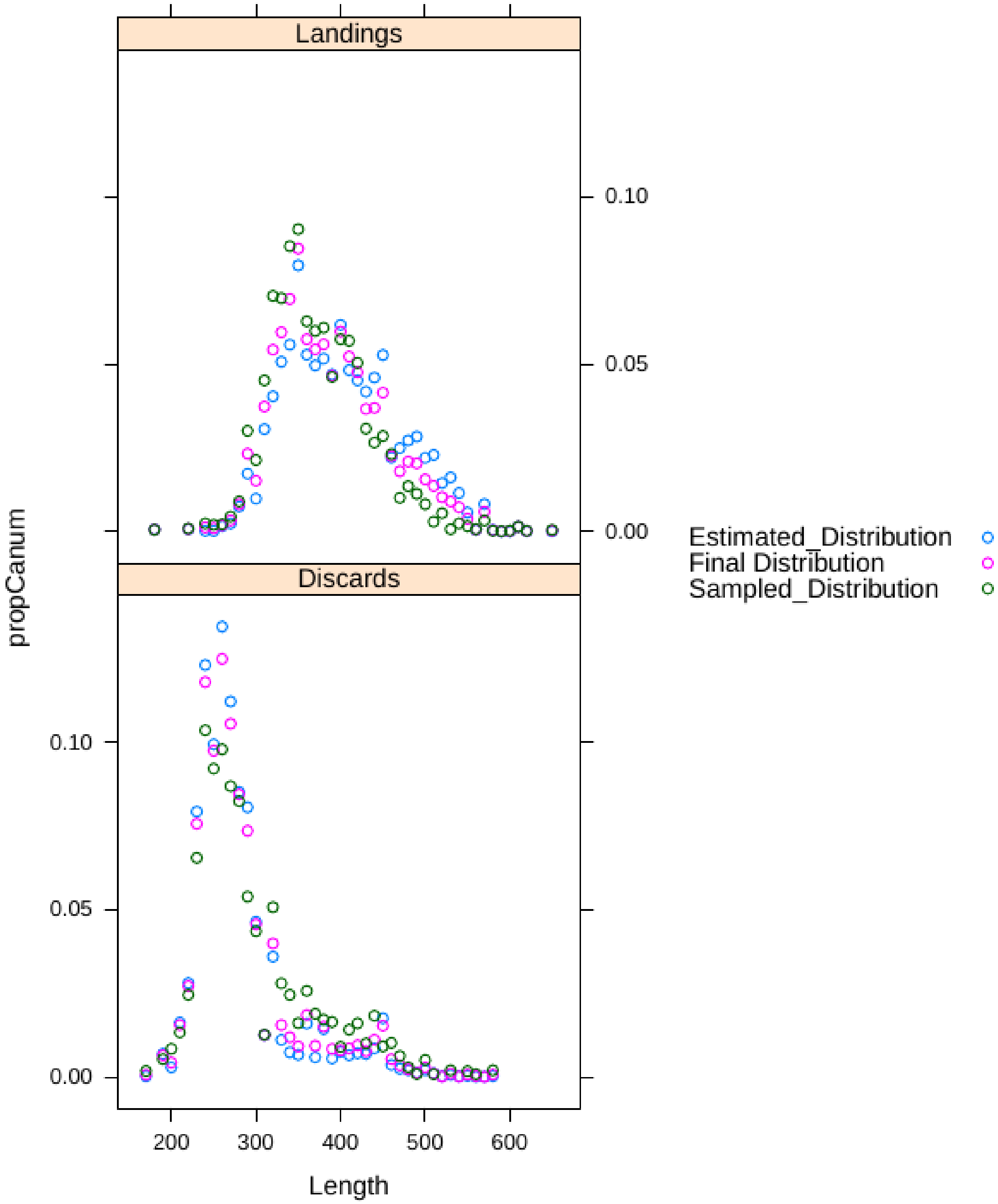

Figure 18.4. Length distribution of landings (top) and discards (bottom) for 2018.

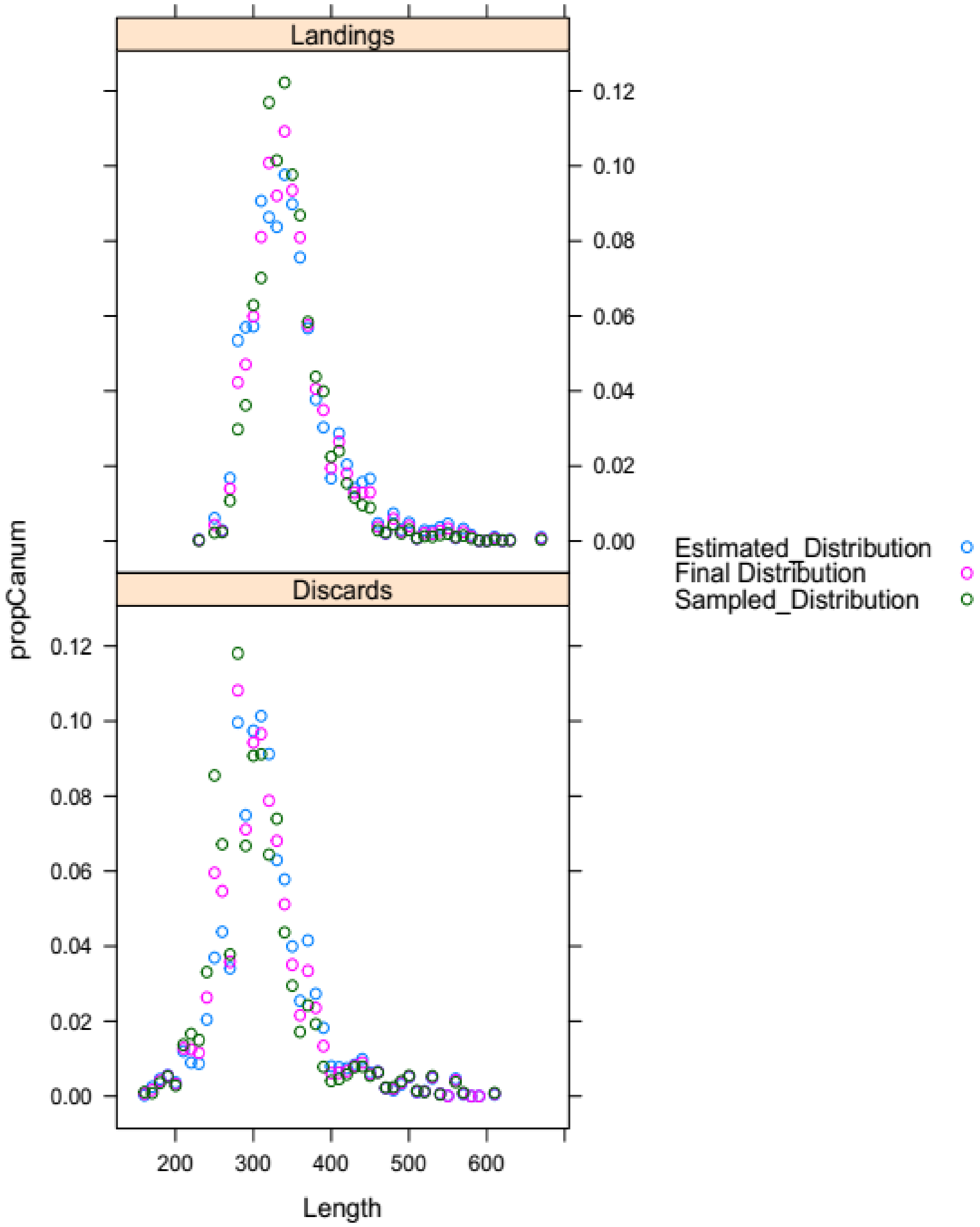

Figure 18.5. Length distribution of landings (top) and discards (bottom) for 2019.

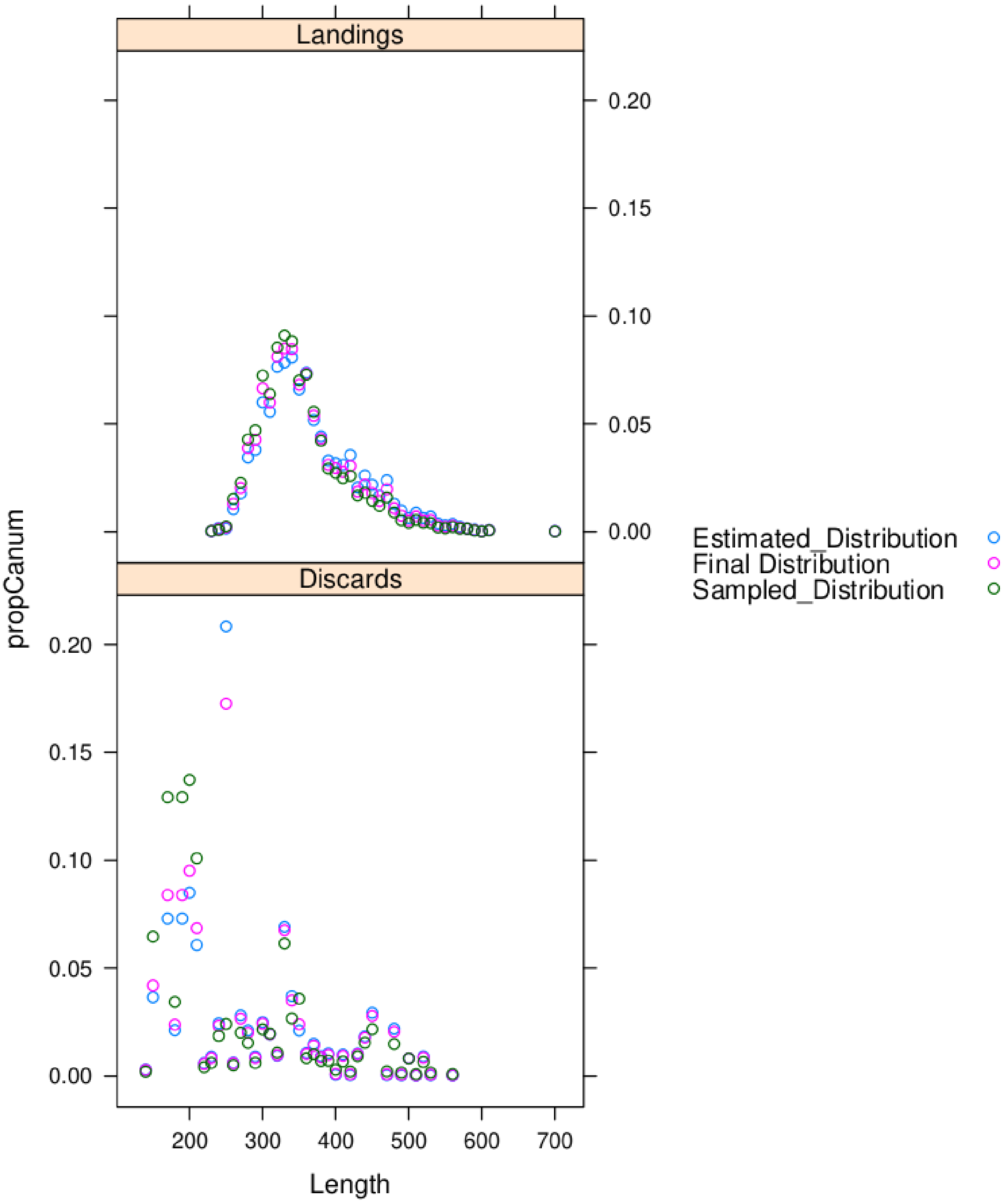

Figure 18.6. Length distribution of landings (top) and discards (bottom) for 2020.

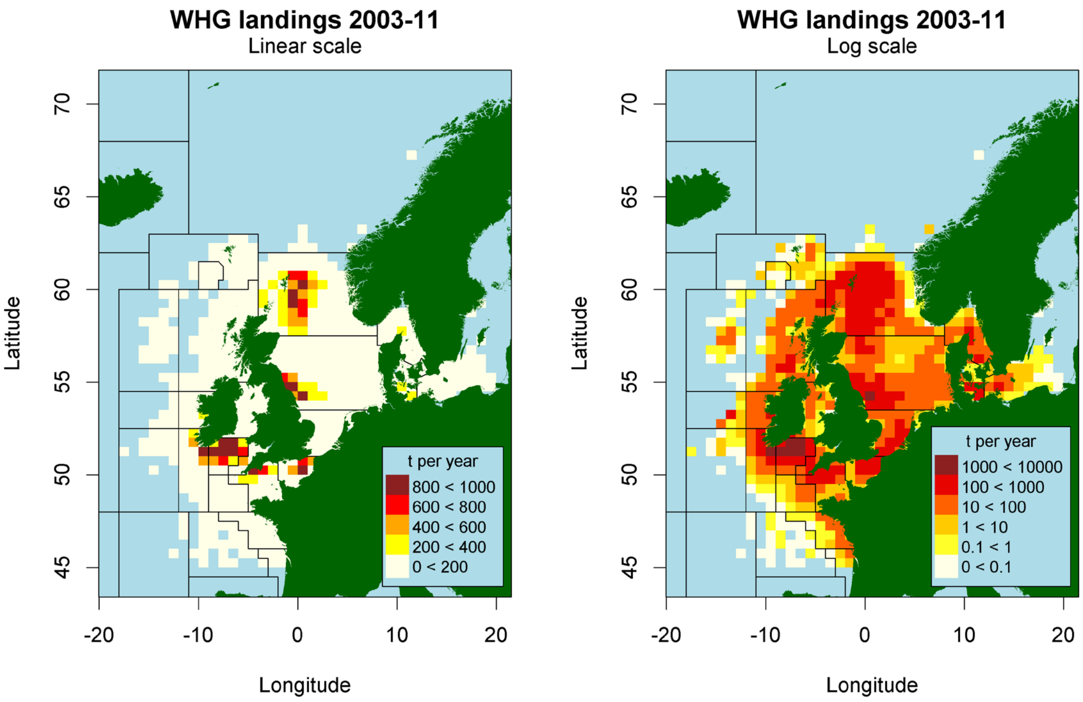

Figure 18.7. Spatial distribution of whiting landings.

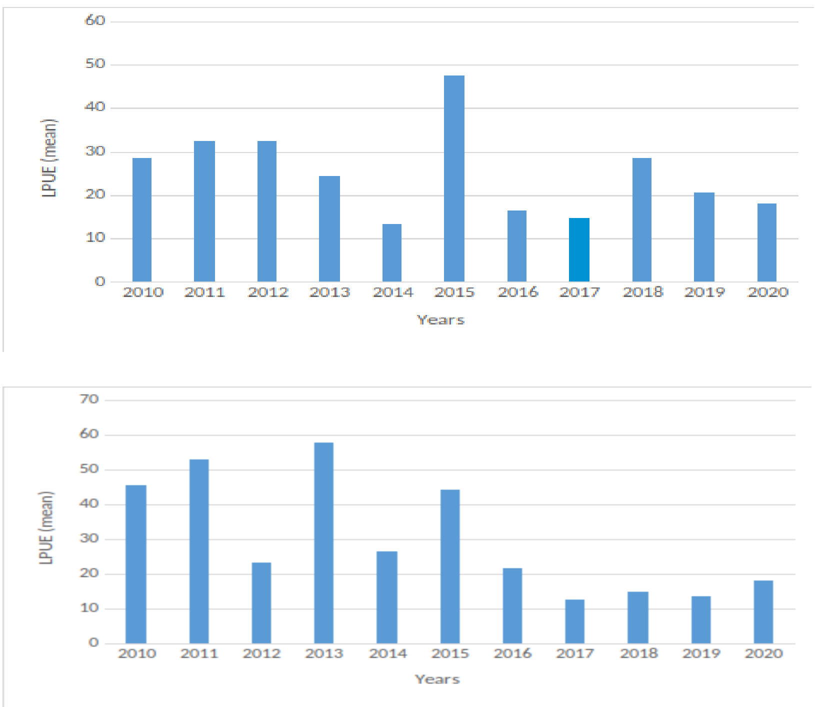

Figure 18.8. Time-series of whiting landings per unit of effort (LPUEs in kg/day) for two otter trawl fleets fishing in divisions 8.a, 8.b, and 8.d in the period 2010–2020. Otter trawl fleet fishing in the south (upper panel) and otter trawl fleet fishing in the north (bottom panel).

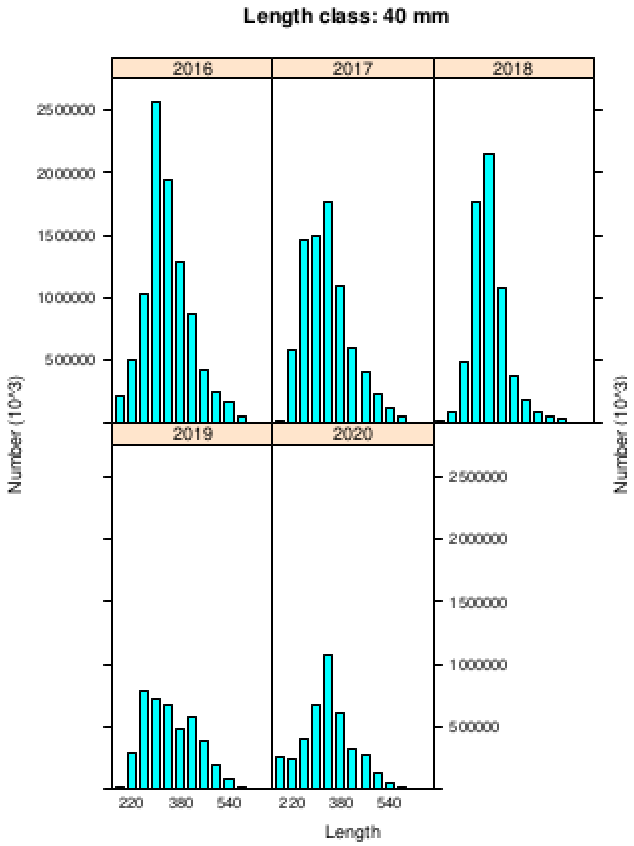

Figure 18.9. Length composition of whiting catches binned at 40 mm.

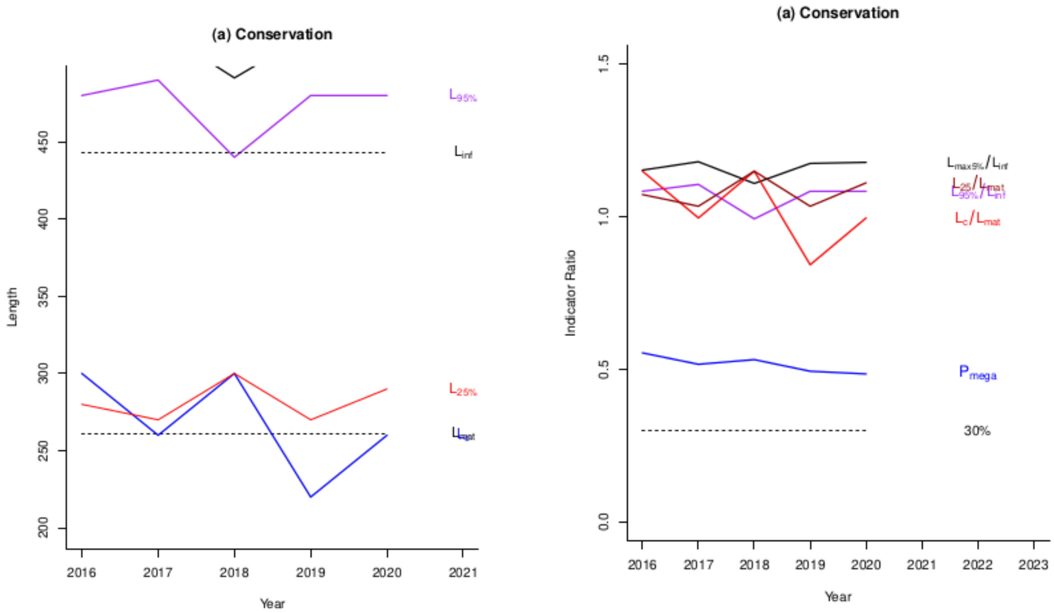

Figure 18.10. Conservation results from the LBI analyses.

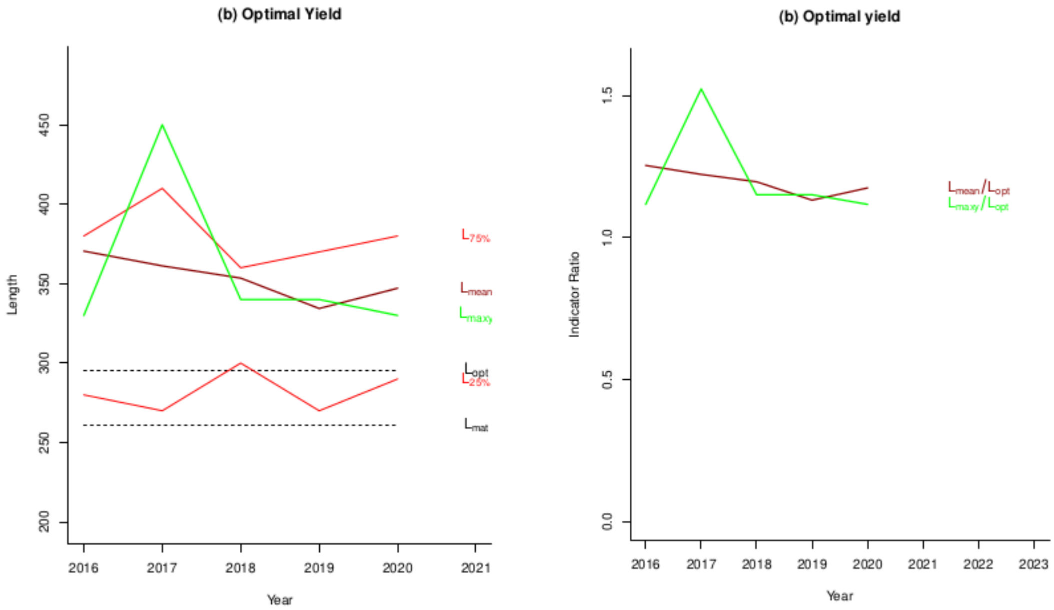

Figure 18.11. Optimal yield results from LBI analyses.

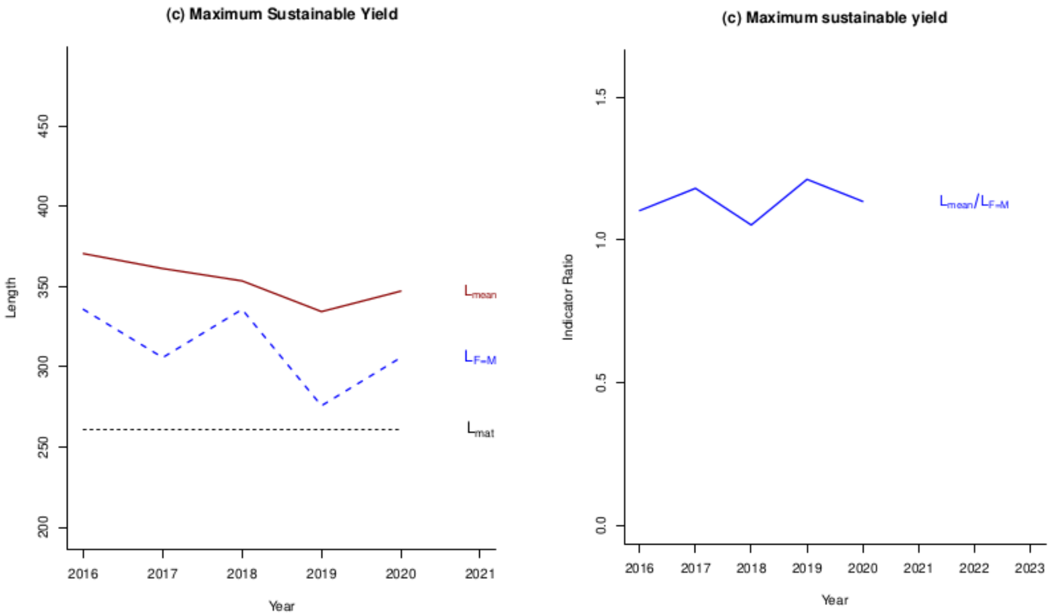

Figure 18.12. Maximum yield results from LBI analyses.

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Bárbara Serra-Pereira	Portugal
Cristina Silva (chair)	Portugal
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Annex 2: Resolutions

WGBIE– Working Group for the Bay of Biscay and Iberian waters Ecoregion

This resolution was approved 3 November 2020

2020/2/FRSG08 The **Working Group for the Bay of Biscay and Iberian waters Ecoregion** (WGBIE), chaired by Ching Villanueva, France, and Cristina Silva, Portugal, will meet in Copenhagen, Denmark, 5–12 May 2021 to:

a) Address generic ToRs for Regional and Species Working Groups;

b) Review progress on evaluating the potential for assessing FU29 and FU30 as one stock;

c) Review results and recommendations from benchmark and other interim workshops to review the assessment methods for sole, hake, megrims and anglerfish stocks

The assessments will be carried out on the basis of the stock annex. The assessments must be available for audit on the first day of the meeting.

Material and data relevant for the meeting must be available to the group on the dates specified in the 2020 ICES data call.

WGBIE will report by 21 May 2021 for the attention of ACOM.

Only experts appointed by national Delegates or appointed in consultation with the national Delegates of the expert's country can attend this Expert Group

Annex 3: Stock annexes

Stock Annex: Black anglerfish (*Lophius budegassa*) in Divisions 8.c and 9.a (Cantabrian Sea and Atlantic Iberian waters)

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	Southern black anglerfish (ank.27.8c.9a)
Working group:	Working Group for the Bay of Biscay and the Iberic waters Ecoregion (WGBIE)
Created:	
Authors:	
Last updated:	5 May 2021
Last updated by:	Teresa Moura (WGBIE 2021)

A. General

A.1 Stock definition

The two species of anglerfish (the white, *Lophius piscatorius*, and the black, *L. budegassa*) are North-eastern Atlantic species. However black anglerfish has a more southerly distribution. White anglerfish is distributed from Norway (Barents Sea) to the Straits of Gibraltar (and including the Mediterranean and the Black Sea) and black anglerfish from the British Isles to Senegal (including the Mediterranean and the Black Sea). Anglerfish occur in a wide range of depths, from shallow waters to at least 1000 m. Information about spawning areas and seasonality is scarce, therefore the stock structure remains unclear. This lack of information is due to their particular spawning behaviour. Anglerfish eggs and larvae are rarely caught in scientific surveys.

ICES gives advice for the management of several anglerfish stocks in European waters: one stock on the Northern Shelf area, that includes anglerfish from the Norwegian Sea - Division 2.a, Northern Shelf - Division 3.a, Subareas 4 and 6, and the stocks on the Southern Shelf area, one in Divisions 7.b-k and 8.a,b and d and the Southern stocks in Divisions 8.c and 9.a. The stock under this Annex is called Southern Black Anglerfish and is defined as black anglerfish in Divisions 8.c and 9.a. The boundaries of anglerfish in Divisions 7.b-k and 8.a,b and d and Southern Anglerfish stocks were established for management purposes and they are not based on biological or genetic evidences (GESSAN, 2002; Duarte *et al*., 2004; Fariña *et al*., 2004).

White and black anglerfish are caught and landed together and there is a unique TAC for both species. However, the stock assessment is carried out separately and the advice is given for individual species.

A.2 Fishery

Anglerfish in ICES Divisions 8.c and 9.a is mainly exploited by Spanish and Portuguese vessels, since 2000 the Spanish landings being approximately 80% for both anglerfish total reported landings. France have reported catches of this stock since 2002, that represent an average of 2% of total landings. International catches for these two stocks have increased since the beginning of the 1980s, until a maximum was reached in 1988

(10 022 t). They have decreased to 1 801 t–1 901 t in 2001–2002. In the 2003–2011 period the catches were between 2 105 t and 4 757 t. From 2012 to 2017 landings varied between 2307 and 3030 t, but decreased to 1577 t in 2019.. Both species are caught on the same grounds by the same fleets and are marketed together.

White and black anglerfish are caught together by Spanish, Portuguese and French bottom-trawlers and gillnet fisheries. Spanish and Portuguese bottom trawlers are mixed fisheries. The Spanish bottom-trawl fleet predominantly targets hake, megrim, Norway lobster and anglerfish. Since 2003 the alternative use of a trawl gear with High Vertical Opening (HVO) has taken place in larger proportion relative to previous years. This gear targets horse mackerel and mackerel with very few anglerfish catches.

The species proportion in landings has changed since 1986. In the beginning of the time-series (1980-1986), *L. piscatorius* represented more than 70% of the total anglerfish landings. After 1986, the proportion of *L. piscatorius* decreased, and in 1999-2002 both species had approximately the same weight in the annual landings. Since then, the *L. piscatorius* proportion increased. The mean proportion of *L. piscatorius* in landings from 2008 to 2018 is 63%.

Since 2008, the Spanish black anglerfish landings were on average 66% from the trawl fleet, 29 % from the gillnet fishery and 5% from other fisheries. The Spanish gillnet fishery can use different artisanal gears, but most catches come from “Rasco”, a specific gear targeting anglerfish.

Black anglerfish are caught by Portuguese fleets in trawl and artisanal mixed fisheries. Portuguese landings were on average, from 2008, 29 % from trawlers and 71 % from artisanal fisheries. The trawl fleet has two components, the trawl fleet targeting demersal fish and trawl fleet targeting crustaceans. From 2005 to 2011 Portuguese combined species landings were TAC constrained in some years and very low landings were registered during the 4th quarter.

French catches of black anglerfish are attributed, on average (since 2008) to gillnet (35%) and trawl fisheries (64%).

Discarding in black anglerfish is considered low for the trawl fishery, based on estimated data for Spanish trawl fleet (ICES, 2011) and information from the Portuguese trawl fleet (ICES, 2012).

Each year, the European Union sets a combined TAC and quota for white and black anglerfish. There is no minimum landing size for anglerfish, but in order to ensure marketing standards a minimum landing weight of 500 g was fixed in 1996 by the Council Regulation (EC) No.2406/96.

As part of the Recovery Plan for the Southern hake and Iberian *Nephrops* stocks (Council Regulation (EC) No.2166/2005), in force since January of 2006, the fishing effort regulations are affecting the Spanish and Portuguese mixed trawl fisheries. As anglerfish are taken in these mixed trawl fisheries, these stocks are also affected by the recovery plan effort limitation.

Since 2012 that Portuguese vessels cannot land *Lophius* specimens in January and February. This national regulation was set to avoid target fisheries to these species during the reproductive season.

A.3 Ecosystem aspects

Black anglerfish is a benthic species that occur on muddy to gravelly bottoms. It is usually caught at sizes <100 cm but there are reported sizes around 110 cm.

Historically, black anglerfish has been considered a slow growing species, with a late maturation (Duarte *et al.*, 2001). Nevertheless, new evidences from mark-recapture experiments indicate that the anglerfish are likely to grow faster (Landa *et al.*, 2008).

The ovarian structure of anglerfish differs from most other teleosts. It consists of very long ribbons of a gelatinous matrix, within individual mature eggs floating in separate chambers (Afonso-Dias and Hislop, 1996). The spawning of the *Lophius* species is very particular, with eggs extruded in a buoyant, gelatinous ribbon that may measure more than 10 m and contain more than a million eggs (Afonso-Dias and Hislop, 1996; Hislop *et al.*, 2001a; Quincoces, 2002). Eggs and larvae drift with ocean currents and juveniles settle on the seabed when they reach a length of 5-12 cm. This particular spawning leads to highly clumped distributions of eggs and newly emerged larvae (Hislop *et al.*, 2001b) and favourable or unfavourable ecosystem conditions can therefore have major impacts on recruitment.

Due to their particular reproduction aspects (that shows a high parental investment in the offspring) the population dynamics of these species is expected to be highly sensitive to external biological/ecosystem factors.

Vertical displacements of immature and mature white anglerfish from the seabed to the near surface have been recorded in the Northeast Atlantic (Hislop *et al.*, 2001a) and are suggested to be related to spawning or feeding.

Improvement of knowledge regarding growth, spawning behaviour, migratory behaviour and juvenile drift are essential to present and future assessment and management of both Southern Anglerfish stocks.

B. Data

B.1 Commercial Catch

Landing's data are provided by National Governments and research institutions of Spain, Portugal and France. Quarterly landings by country, gear and ICES Division are available since 1978. There were unrecorded landings in Division 8.c between 1978–1979, and it was not possible to obtain the total landings in those years. Portuguese landings were TAC constrained from 2005 to 2011, with very low landings registered during the 4th quarters. France landings are only available for the period 2002–2016.

The two species are not usually landed separately, for the majority of the commercial categories and misidentification issues are known to occur. Therefore, estimates of each species in Spanish landings from Divisions 8.c and 9.a and Portuguese landings of Division 9.a are derived from their relative proportions in market samples.

After 1980, black anglerfish landings increased and reached a peak of 3 832 t in 1987. Since then, landings decreased and reached 810 t in 2002. From 2002 to 2007 landings increased to 1 306 t, decreasing afterwards to levels between 754–774 t in 2009–2010. From 2011 to 2016 catches fluctuated from 948 t to 1 141 t but decreased to 669 t in 2019.

Discards

The Spanish Discard Sampling Programme, in the ICES Divisions 8.c and 9.a, is being carried out for trawl fleets since 1994 and for gillnets fleets since 2011. However, the trawl time-series is not complete and years with discard data are 1994, 1997, 1999, 2000 and from 2003–2017. The raising procedure used to estimate discards was based on effort. With exception of 2006 and 2010, discards for the trawl and gillnet fleets represent very low proportions of the total catches in each year. The Portuguese Discard

Sampling Programme recorded anglerfish data from 2004. The frequency of occurrence of black anglerfish in discard samples is very low and their discard is considered negligible.

B.2 Biological

Landing numbers at length

Since 2009 the quarterly Spanish and Portuguese sampling for length compositions is by métier and ICES Division. Length data from sampled vessels are summed and the resulting length composition is applied to the quarterly landings of the corresponding métier and ICES Division. The sampled length compositions were raised for each country and SOP corrected to total landings on a quarterly or half yearly basis (when the sampling levels by quarter were low). Since 2009, when the métier-based sampling was implemented in the DCF, the length compositions of Portuguese fleets and particularly of the artisanal fleet, are estimated with a small number of samples. The average lengths of trawl caught anglerfish are lower compared to the artisanal fleets.

Catch numbers-at-age

No catch numbers-at-age are provided to the Working Group. At the WGHMM 2007 meeting (ICES, 2007), age length keys, based on *illicia* readings, were used to obtain catch number-at-age for each species. The exploratory analysis of estimates indicated that the biased age reading criterion does not allow following cohorts along years in either of the two species. The last research about white anglerfish ageing, *White Anglerfish Illicia and Otoliths Exchange 2011* (ICES, 2012), highlighted that neither *illicia* or otolith age readings have not been validated and, in the case of *illicia* studies, the agreement among readers and the precision were not acceptable. Therefore, it was concluded that the available age reading criteria for white anglerfish southern stock is not valid to build an ALK.

Growth curve

An agreed growth model is not available for black anglerfish *in* Divisions 8.c and 9.a.

Maturity-at-length

Different estimates of maturity ogive at length are available for *Lophius budegassa* (Duarte *et al*., 2001, Quincoces, 2002, Landa *et al*., 2008, , Landa *et al*., 2012). The last study (Landa *et al*., 2014) indicates, for ICES Div. 8.c-9.a, a sex ratio of 1:1.01 (50.30% of females) and L50 values of 38.2 cm for combined sexes, 36 cm for males and 53 cm for females. These values of sex ratio and L50 are within the range given for this species in previous studies.

Natural mortality

Trial assessment, in the past, of the black anglerfish stock used a natural mortality rate of 0.15 yr-1. This value was adopted for all ages and years in the absence of any direct estimates. More recently, a value of 0.2 yr-1 was also considered.

Length-weight relationship

The weight at length relationship was calculated using data from an international project with a sampling that spatially covered a large proportion of the stock and which number of samples (BIOSDEF, 1998):

$W= 2.11x10^{-5} \cdot L^{2.9198}$

where W = weight in kilograms and L = length in centimetres.

B.3 Surveys

SpGFS-WIBTS-Q4 (code G2784)

The Spanish Groundfish Survey aims to collect data on the distribution and relative abundance, and biological information of commercial fish in ICES Divisions 8.c and Northern 9.a. Since 1983 that the survey is annually carried out in the fourth quarter (September/October), except in 1987. Time-series of abundance indices, in weight and in number, and correspondent length composition, are available for both anglerfish species.

This survey is not used in the current assessment of black anglerfish.

SP-ARSA (SpGF-Cspr-WIBTS-Q1, code G7511; SpGF-Caut-WIBTS-Q4, code G4309)

The Southern Spanish Groundfish Survey on the Gulf of Cádiz is conducted in the southern part of ICES Division 9a, the Gulf of Cádiz. The covered area extends from 15 m to 800 m depth, during spring and autumn. This survey was identified during the WKANGLER-Data Evaluation meeting as a potential abundance index for *L. budegassa* in Divisions 8c9a. The series covers the period 1993-2018, two surveys by year (Q1 and Q4), and the biomass and abundance indices and the respective variance and length compositions are available.

This survey is not used in the current assessment of black anglerfish.

PtGFS-WIBTS-Q4 (code G8899)

Portuguese Autumn Groundfish Survey has been carried out in Portuguese continental waters since 1979 in the fourth quarter of the years. Abundance indices for both anglerfish species are available since 1989. This survey was not performed in 2012. The abundance values detected by this survey are very low for the whole time-series, being insignificant for some years.

This survey is not used in the current assessment of black anglerfish.

PtGFS-WIBTS-Q1

Portuguese Winter Groundfish Survey has been carried out in Portuguese continental waters from 2005 till 2008 in the first quarter. Time-series of abundance indices, in weight and in number, and correspondent length composition are available for both anglerfish species. The abundance values detected by this survey are very low for the whole time-series.

This survey is not used in the current assessment of black anglerfish.

PT-CTS (UWTV (FU 28–29)) Portuguese Crustacean Survey has been carried out in south of the Portuguese coast since 1997 in the second quarter. This survey was not performed in 2012. Time-series of abundance indices, in weight and in number, and correspondent length composition are available for both anglerfish species. This survey detects better anglerfish (especially *L. budegassa*) but the area cover is very small compared with the anglerfish stocks distribution.

This survey is not used in the current assessment of black anglerfish.

PtGFS-WIBTS-Q3

Portuguese Summer Groundfish Survey has been carried out in Portuguese continental waters from 1990–2001 (except 1994, 1996) in the third quarter. Time-series of abundance indices, in weight and in number, and correspondent length composition are available for both anglerfish species. The abundance values detected by this survey are very low for the whole time-series, being insignificant for some years.

This survey is not used in the current assessment of black anglerfish.

Portuguese deep-water fish survey

Portuguese deep-water fish Survey has been carried out in Portuguese continental waters from 1997–2002. No indices are available, only raw data.

This survey is not used in the current assessment of black anglerfish.

B.4 Commercial CPUE

Six commercial series of landing-effort are available to the WG. Four of them are Spanish fleets in the ICES Division 8.c and two Portuguese fleets in the ICES Division 9.a. The Portuguese trawl fleet was split into fish trawlers and crustacean trawlers (WD12, Duarte *et al.*, 2007 in ICES, 2007) according to the fleet segmentation proposed by the IBERMIX project (WD06, Castro *et al.*, 2007 in ICES, 2007).

SP-CORTR8C – fleet series

A Coruña trawl fleet fishing in Division 8.c is available for years 1982-2012. Data provided for A Coruña trawlers comprise quarterly effort (fishing days per 100 horse power), landings and length composition of landings. This fleet represents an average of 18% of international catches of black anglerfish along the time-series. A standardized series from 1994–2006 is also available for this fleet with annual effort data (in fishing days) and annual LPUE. Comparison between standardized and nominal LPUE showed no major differences between series (Cardador *et al.*, 2008) and the non-standardized series was used in the black anglerfish assessment from 2012 to 2019.

SP-CORTR8C – port series

The change in the source of the information and the methodology used to estimate the LPUE prevented the update of the SP-CORTR8C – fleet series from 2012 onwards. The main difference between the methods used to estimate the LPUE for the Coruña Trawl Fleet in Division 8c (previous and after 2012) is related with the quantification of the effort. Until 2012, the duration of the fishing trips was a fix value of 1.5 or 2 days depending on the target species. Since 2012, the logbook's information was used to estimate the exact duration of each trip, being the effort more precisely estimated. Also, the new series of LPUE – A Coruña Port - is calculated using only the information from vessels whose official base port is A Coruña. Previously, all vessels operating regularly in A Coruña were included in the calculations.

This survey is not used in the current assessment of black anglerfish.

SP-CEDGNS8C

Cedeira gillnet fleet fishing in Division 8.c is available for years 1999–2011. Data provided for Cedeira gillnets comprise quarterly standardized effort (in soaking days), landings and length composition of landings. This fleet represents an average of 1% of international catches of black anglerfish since 1999.

Information from this commercial series is not used in the current assessment of black anglerfish.

PT-TRF9A

Portuguese trawlers targeting fish: since 1989. Data provided for Portuguese trawlers targeting fish comprise quarterly effort (1000 hours trawling with occurrence of anglerfish), landings and length composition of landings. This fleet represents an average of 5% of international catches of black anglerfish along the time-series. This series was standardized for WKMSYSPiCT 2021, using a generalized linear mixed model and considering as independent variables the Year, Quarter and Area (centre and south). The vessel identity (Vessel) was considered as the random variable..

Data from this commercial LPUE has been used in the black anglerfish assessment since 2007.

PT-TRC9A

Portuguese trawlers targeting crustacean: since 1989. Data provided for Portuguese trawlers targeting fish comprise quarterly effort (1000 hours trawling with occurrence of anglerfish), landings and length composition of landings. This fleet represents an average of 3% of international catches of black anglerfish along the time-series. This series was standardized for WKMSYSPiCT 2021, using a generalized linear mixed model and considering as independent variables the Year, Quarter and Area (centre and south). The vessel identity (Vessel) was considered as the random variable.Data from this commercial LPUE was used in the black anglerfish assessment from 2007 to 2019.

SP-AVITR8C

Avilés trawl fleet fishing in Division 8.c is available for years 1986–2003. Data provided for Avilés trawlers comprise quarterly effort (fishing days per 100 horse power), landings and length composition of landings. This fleet represents an average 3% of international catches of black anglerfish along the time-series. The effort series was interrupted in 2003.

SP-SANTR8C

Santander trawl fleet fishing in Division 8.c is available for years: years 1986–2010. Data provided for Santander trawlers comprise quarterly effort (fishing days per 100 horse power), landings and length composition of landings. This fleet represents an average of 3% of international catches of black anglerfish along the time-series. Effort data for 2008 was not provided to the WG.

C. Assessment Methods and Settings

Until 2011 black anglerfish stock was assessed with a non-equilibrium production model (ASPIC, Prager, 1994; 2004). At WKFLAT 2012 (ICES, 2012) a new formulation, of the ASPIC, including 3 tuning indices (A Coruña, Portuguese Trawler fleet directing to crustaceans, Portuguese Trawler fleet directing to ground-fish) was considered more stable. From 2012 to 2017 this formulation of ASPIC was used, but from 2014-2017 B1/K was fixed 0.6 to stabilize the model. A new assessment model, stochastic surplus production model in continuous time (SPiCT; Pedersen and Berg, 2016), was accepted during WKANGLER 2018 (ICES, 2018a). The accepted configuration used the same data as ASPIC. This model was considered more reliable since it did not require the fixation of parameters such as B1/K to be stable and was accepted as the basis for advice. The benchmarked approach gave comparable trends, but the estimates of stock biomass were notably higher, and fishing mortality lower compared with the previous assessment method. If fishing at F_{MSY}, catches should be increased to ~5500 tonnes, values never reached in this fishery. A stepwise procedure to achieve F_{MSY} was recommended by WKANGLER, proposed by WGBIE 2018 but later rejected by ACOM (ICES, 2018b). Given the uncertainties regarding the absolute levels of biomass and fishing pressure, the assessment was considered as indicative of trends only, and it was decided to present the advice as a category 3.2 stock with proxy reference points, using SPiCT results (ICES, 2018b).

Default parameters were used, only the shape of the production curve was fixed to Schaefer. Model diagnostics showed some autocorrelation for index PT-OTB-crust which has been considered not meaningful. This auto-correlated residual pattern could reflect spatiotemporal changes in the distribution or indicate transitory changes in catchability (ICES, 2018a).

Given the above, the stock was benchmark in 2021, under WKMSYSPiCT, with SPiCT. Th new model uses as input data landings since 1980 and the PT- TRF9A commercial fleet standardized index. No issues in diagnostics were detected and Mohn´s rho for B/Bmsy and F/Fmsy are within the acceptable values. Black-bellied anglerfish in divisions 8c and 9a is assessed as category 2 stock.

Model:

Stock: black anglerfish (*L. budegassa)*

Assessment Model: stochastic surplus production model in continuous time - SPiCT (Pedersen and Berg, 2017)

Software: SPiCT (R package)

Input data:

Total landings since 1980 (discards are considered negligible).

Portuguese trawl fleet targeting fish, since 1989 (Index1)

Settings:

- Euler time step (years): 1/16 (default)
- Production curve shape: assume Schaefer (n=2).
- Alpha (Biomass observation and process errors ratio): estimated by the model (default priors for all indices).
- Beta Catch observation and process errors ratio): estimated by the model (default priors).
- B/K: logbkratio = c(log(0.5),0.5,1)
- Other parameters: default (estimated by the model).
- CPUE index assigned to the middle of the year;

D. Short-term projection

Stock catch forecasts consider the fishing mortality in the intermediate year as the estimated F at the time step of the last observation and the estimated seasonal F process.

E. Medium term projections

SPiCT is not adequate for medium or long-term projections.

F. Yield and biomass per recruit / long-term projections

SPiCT is not adequate for medium or long-term projections.

G. Biological reference points

WKMSYSPiCT (ICES, 2021) reiterated the use of MSY reference points previously assumed by ICES (2018a). Reference points are shown in Table 1.

Table 1. Reference points.

Framework	Reference point	Relative value	Technical basis	Source
MSY approach	MSY $B_{trigger\ proxy}$	$0.5 \times B_{MSY\ proxy} = 0.25 \times K$*	Relative value. B_{MSY} proxy is estimated directly from the assessment model and changes when the assessment is updated.	ICES (2018a, 2018b)
	$F_{MSY\ proxy}$	r/2*	Relative value. The F_{MSY} proxy is estimated directly from the assessment model and changes when the assessment is updated.	ICES (2018a, 2018b)
Precautionary approach	$B_{lim\ proxy}$	$0.3 \times B_{MSY\ proxy}$*	Relative value (equilibrium yield at this biomass is 50% of the MSY proxy).	ICES (2018a, 2018b)
	B_{pa}	Not defined		
	$F_{lim\ proxy}$	$1.7 \times F_{MSY\ proxy}$*	Relative value (the F that drives the stock to the proxy of B_{lim}).	ICES (2018a, 2018b)
	F_{pa}	Not defined		
Management plan	SSB_{mgt}	Not applicable		
	F_{mgt}	Not applicable		
	MAP MSY $B_{trigger}$	$0.5 \times B_{MSY\ proxy} = 0.25 \times K$*	MSY $B_{trigger\ proxy}$	EU (2019)
	MAP B_{lim}	$0.3 \times B_{MSY\ proxy}$ *	$B_{lim\ proxy}$	EU (2019)
	MAP F_{MSY}	r/2*	$F_{MSY\ proxy}$	EU (2019)
	MAP range F_{lower}	$0.78\ F_{MSY\ proxy}$	Consistent with ranges resulting in no more than 5% reduction in long-term yield compared with the MSY (ICES, 2018a).	ICES (2018a) and EU (2019)
	MAP range F_{upper}	$F_{MSY\ proxy}$ ($F_{2018} \times 3.631$)	Consistent with ranges resulting in no more than 5% reduction in long-term yield compared with the MSY (ICES, 2018a).	ICES (2018a) and EU (2019)

H. Other Issues

H.1. Historical Development of Assessment

Southern Anglerfish stocks were assessed for the first time in the 1990 ICES WG meeting. Different assessment trials were performed during the subsequent 8 years but analytical assessments indicated unrealistic results. The database (both biological and fisheries data) were improved along these years trying to apply an analytical assessment model. Since 1998 a non-equilibrium surplus production model ASPIC (Prager, 1994) was applied to each stock or to the combined stock data. These stock assessments were accepted by the ACFM and used to provide management advice. The assessment of black anglerfish as a separate stock has been carried out continuously from 2007. In 2012 during the benchmark (WKFLAT2012) it was agreed to include a third series in the assessment. Since WGBIE2014 B1/K was fixed at 0.6. A new assessment model, stochastic surplus production model in continuous time (SPiCT; Pedersen and Berg, 2016), was accepted during WKANGLER 2018 and revised at WKMSYSPiCT 2021. The history of black anglerfish assessment from 2007–2019 is presented in Table 2.

Table 2. History of southern black anglerfish assessment from 2007–2021.

WG	2007	2008	2009	2010	2011	2012–2013	2014–2017
Assessment Model	Non-equilibrium Surplus production model (Prager, 1994a)	No updated	Non-equilibrium Surplus production model (Prager, 1994a)	Non-equilibrium Surplus production model (Prager, 1994a)	Non-equilibrium Surplus production model (Prager, 1994a)	Non-equilibrium Surplus production model (Prager, 1994a)	Non-equilibrium Surplus production model (Prager, 1994a)
Software	ASPIC (v. 5.16)	No updated	ASPIC (v. 5.24)	ASPIC (v. 5.34)	ASPIC (v. 5.34.9)	ASPIC (v. 5.34.9)	ASPIC (v. 5.34.9)
Catch data range	1980-2006		1980-2008	1980-2009	1980-2010	Since 1980	Since 1980
cpue Series 1 (years)	PT-TRF9a (1989-2006)		PT-TRF9a (1989-2008)	PT-TRF9a (1989-2009)	PT-TRF9a (1989-2010)	PT-TRC9a (since 1989)	PT-TRC9a (since 1989)
cpue Series 2 (years)						PT-TRF9a (since 1989)	PT-TRF9a (since 1989)
Index of Biomass (years)	PT-TRC9a (1989-2006)		PT-TRC9a (1989-2008)	PT-TRC9a (1989-2009)	PT-TRC9a (1989-2010)	SPCORTR8c (1982-2010)	SPCORTR8c (1982-2012)
Error Type	Condition on yield		Condition on yield	Condition on yield	Condition on yield	Condition on yield	Condition on yield
Number of bootstrap	500		500	1000	1000	1000	1000
Maximum F	8.0 (y-1)		8.0 (y-1)	8.0 (y-1)	8.0 (y-1)	8.0 (y-1)	8.0 (y-1)
Statistical weight B1/K	1		1	1	1	1	1
Statistical weight for fisheries	1,1		1,1	1,1	1,1	8.59E-01, 1.20E+00, 9.81E-01	8.59E-01, 1.20E+00, 9.81E-01
B1/K -ratio (starting guess)	0.5		0.5	0.5	0.5	0.6	Fixed 0.6
MSY (starting guess)	3000 t		3000 t	3000 t	3000 t	1811.26 t	1811.26 t
K (starting guess)	20 000 t		20 000 t	20 000 t	20 000 t	18 112.6 t	18 112.6 t
q1 (starting guess)	1d-5		1d-5	1d-5	1d-5	8.2523E-04	8.2523E-04
q2 (starting guess)	1d-4		1d-4	1d-4	1d-4	1.1196E-07	1.1196E-07
q3 (starting guess)						2.7279E-07	2.7279E-07

WG	2007	2008	2009	2010	2011	2012–2013	2014–2017
Estimated parameter	All		All	All	All	All	All
Min and Max allowable MSY	2000 (t) -10000 (t)		2000 (t) -11500 (t)	2000 (t) -10000 (t)	2000 (t) -10000 (t)	181.126 (t) -3622.52 (t)	181.126 (t) -3622.52 (t)
Min and Max K	5000 (t) -500000 (t)		5000 (t) - 112000 (t)	5000 (t) -100000 (t)	5000 (t) -100000 (t)	1811.26 (t) -362252 (t)	1811.26 (t) -362252 (t)
Random Number Seed	1964185		1964185	1964185	1964185	1025957	1025957

Table 2. History of southern black anglerfish assessment from 2018 onwards.

WG	WKAngler2018	WKMSYSPiCT 2021
Assessment Model	A Stochastic Surplus Production Model in Continuous TIme (Pedersen and Berg, 2017)	A Stochastic Surplus Production Model in Continuous TIme (Pedersen and Berg, 2017)
Software	SPiCT (1.2.1)	SPiCT
Catch data range	1980-2016	1980-2019
LPUE I1 (years)	SPCORTR8c (1982-2012)	PT-TRC9a (1989-2019)
LPUE I2 (years)	PT-TRC9a (1989-2016)	
LPUE I3 (years)	PT-TRF9a (1989-2016)	
Iput data	all assumed at the beginning of the year	all assumed at the middle of the year
Euler time step (years)	1/16 (default)	1/16 (default)
Production curve shape: Prior logn	Disable Fixed at 2. Assume Schaefer	Disable Fixed at 2. Assume Schaefer
Prior logalpha (Index1)	dnorm [log(1), 2^2]	dnorm [log(1), 2^2]
Prior logalpha (Index2)	dnorm [log(1), 2^2]	dnorm [log(1), 2^2]
Prior logalpha (Index3)	dnorm [log(1), 2^2]	dnorm [log(1), 2^2]
Prior logbeta	dnorm [log(1), 2^2]	dnorm [log(1), 2^2]
Prior B/K		c(log(0.5),0.5,1)
Other parameters	default (estimated by the model)	default (estimated by the model

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Stock Annex: Sea bass (*Dicentrarchus labrax*) in division 8ab (Bay of Biscay)

Stock-specific documentation of standard assessment procedures used by the International Council for Exploration of the Sea (ICES).

Stock:	Sea bass (*Dicentrarchus labrax)* in division 8ab
Working Group:	Working Group for the Bay of Biscay and the Iberian Waters Ecoregion (WGBIE)
Revised by:	WKBass 2018 and IBPBass 2018
Last updated:	August 2018
Last Benchmarked:	WKBASS and IBPBass 2018

General

1.1.1 Stock definition

Sea bass Dicentrarchus labrax is a widely distributed species in Northeast Atlantic shelf waters with a range from southern Norway, through the North Sea, the Irish Sea, the Bay of Biscay, the Mediterranean and the Black Sea to North-west Africa. The species is at the northern limits of its range around the British Isles and southern Scandinavia. Further studies are needed on sea bass stock identity, using conventional and electronic tagging, genetics and other individual and population markers (e.g. otolith microchemistry and shape), together with data on spawning distribution, larval transport and VMS data for vessels tracking migrating sea bass shoals, to confirm and quantify the exchange rate of sea bass between areas that could form management units for this stock (ICES, 2012).

The stock identity was assumed to be: Northern (ICES areas 4.b-c, 7.a,d-h); Southern Ireland and Western Scotland (ICES areas 6.a, 6.b and 7.j); Biscay (ICES areas 8.a-b); Portugal & Northern Spain (ICES areas 8.c & 9.a) (Figure 1). Since then, stock identity has not changed (ICES, 2018), but research on population structure are under progress.

Two large tagging programmes are underway that will provide significant 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 seabass 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 10 locations in the Channel and Bay of Biscay. So far, 414 tags have been returned (January 2018) and the movements of individual fish are being reconstructed.

Cefas and Ifremer are working together to compare geolocation algorithms.

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 sub-population.

Genetic studies have also been reported by Museum d'Histoire Naturelle (France) in the GenStock project ended in May 2018.

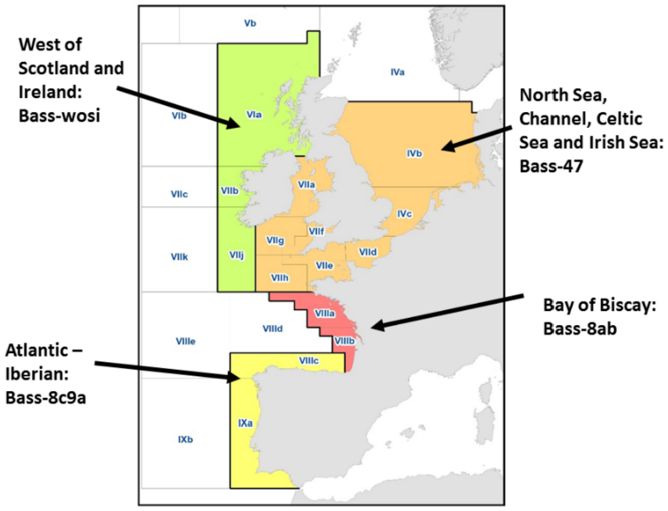

Figure 1. Main spawning and nursery areas. Spawning areas sloping downwards from left to right; Nursery areas sloping downwards from right to left. (from Casey and Pereiro, 1995)

A further study has been done using stable isotope 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 sub-populations of sea bass may exist in Welsh waters, using separate feeding grounds (south vs. mid/north Wales) (Cambiè *et al.*, 2016). Further details of this study have been provided for the benchmark workshop for sea bass led in February 2017.

Ecosystem aspects

In the well-known north stock (6.bc, 7.a,d-h) productivity of the stock is affected by extended periods of enhanced or reduced recruitment which appear to be related to changes in sea temperature (ICES, 2016). Warm conditions facilitate northward penetration of sea bass in the Northeast Atlantic, and enhance the growth and survival of young fish in estuarine and other coastal nursery habitats. In the Bay of Biscay there is no reason to observe different dynamics. In terms of numbers of recruits the Bay of Biscay area looks more productive than in the North.

In the north-eastern Atlantic, adult sea bass (*Dicentrarchus labrax)* is one of largest fish living on the shelf. In autumn and winter, sea bass seems to primarily target small pelagic fish (Spitz *et al*., 2013), most notably mackerel (*Scomber scombrus*), scads (*Trachurus* spp.), anchovy (*Engraulis encrasicolus*), and sardine (*Sardina pilchardus*). These four species also dominated the diets of common dolphins (*Delphinus delphis*). This overlap in feeding preferences could increase the risk of dolphins being caught by pelagic trawls while feeding among sea bass, and may be an underlying mechanism to explain the high rate of common dolphin bycatch observed in the pelagic trawl fishery for sea bass in the Bay of Biscay (Spitz *et al.*, 2013).

Management

Sea bass are not subject to EU TACs and quotas. Under EU regulation, the minimum landing size (MLS) of sea bass in the Bay of Biscay is 38 cm total length from 2017[1], a variety of national restrictions on commercial sea bass fishing are also in place. These include:

- An historical landings limit of 5 t/boat/week for French and UK trawlers landing sea bass (which was not based on a biological point of reference). In France from 2012, following the implementation of a national licensing system for commercial gears targeting sea bass, the landings limits have slightly changed, from 1.5t/week to 5t/week depending on season and gear used[2]
- A licensing system from 2012 in France for commercial gears targeting sea bass in order to fix the level of the French commercial fishery
- A MLS of 38cm has been implemented in 2017 instead of 36cm for commercial fisheries
- A MLS of 42 cm for the French recreational fisheries has been implemented in 2013 (French association of anglers)
- A Voluntary closed season from February to mid-March for longline and handline sea bass fisheries in Brittany, France;

No management plan exists for this stock applicable to 2017, beside the regulations mentioned here before.

Fishery description

Sea bass in the Bay of Biscay are targeted mainly by France (more than 97% of international landings in 2017), followed by Spain (responsible for 3% of the commercial landings in area 8.b mainly, in 2017).

French fishery

From 2000 to 2008 in France, pelagic trawlers used to catch around 25% of the landings of the area Bss.8ab: they have reallocated their effort partly in the Channel Bss 47 because of the anchovy fishery closure in 2005. The pelagic fishery took place essentially in the Channel until 2015 (but with recent implementation of management measures in the "north" stock Bss 47, pelagic fishery doesn't occur any more in Bss 47).

Lines fishery (handlines and longlines) takes place all the year, while nets, pelagic and bottom trawls fisheries take place from November to April on pre spawning and spawning grounds when seabass is aggregated. In 2017, nets represent 28% of the landings of the area, lines 33%, bottom trawl 20%, and pelagic trawl 11%.

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[1] *http://eur-lex.europa.eu/legal-content/FR/TXT/?uri=OJ:L:2018:027:TOC*

[2] *http://www.comite-peches.fr/wp-content/uploads/B87-2017-Db-BAR-GdG-2018.pdf*

In Bss 8ab a high increase in the French landings for the net fishery is observed from 2011. An average of 585 tons during the period 2000-2012 is landed. In 2013, 834 tons have been landed, and 1131 tons in 2014. The main reason is the decrease of sole quotas from 2011 and an effort report on seabass which become more targeted, combined with good weather condition in 2014 and an increase in fishing technicality

In 2017 an increase in landings for all gear except netters is observed in Figure 2.

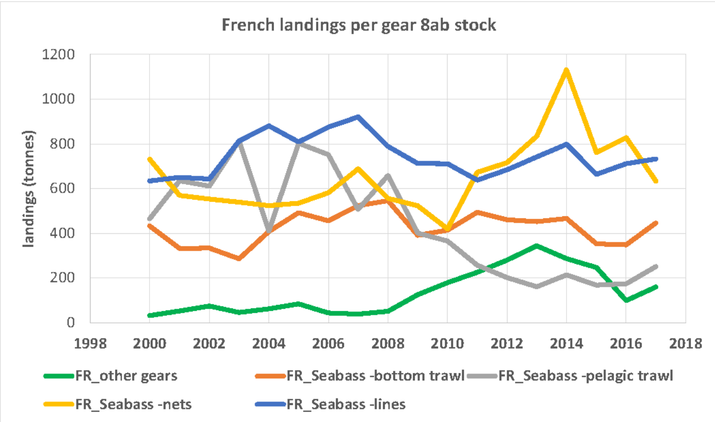


Figure 2 : French landings per gear from 2000 onwards (source Sacrois, DPMA)

Note: Historical landings (period 1985–2000) has been mainly driven by the pelagic trawlers particularly during the period 1985–1995. During this period up to 60 pairs trawlers could be observed. Nevertheless quality of data for this period is very poor.

Spanish fishery

Spain is responsible for 3% of the catches of the area (8.b essentially) in 2017, mainly with bottom trawlers. Spanish bass landings from Division 8.a,b,d have increased to around 20 tons in the 90's to around 150 tons in the middle of the 2000's, then a peak to 317 tons in 2011. 72 tons have been landed in 2017.

Data

Commercial landings

French Estimates

Landings series are available from different sources:

- Official statistics recorded in the Fishstat database since the mid-1980s (total landings).
- French landings for 2000–2017 from a separate analysis made by Ifremer of logbook and auction data. Landings are available per metier.

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 3**Error! Reference source not found.**).

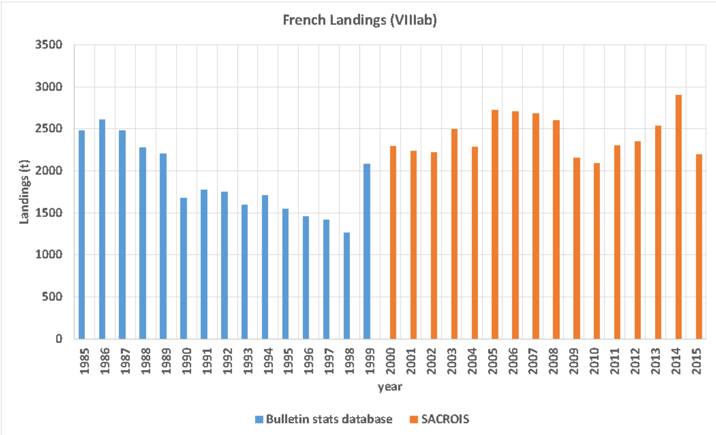


Figure 3. French Landings (Bulletin stats 1985–1999; Sacrois 2000–2015).

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 4

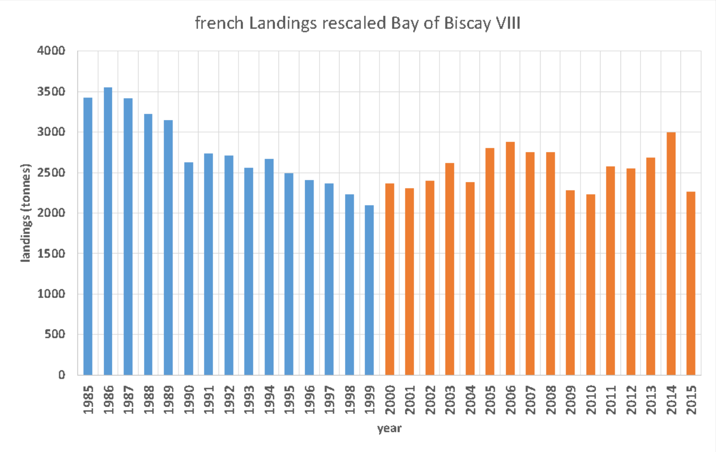


Figure 4 : French Landings (Bulletin stats 1985-1999; Sacrois 2000–2015) rescaled on the period 1985–1998.

Landings coverage and quality

Quality of French official landings data can be considered more robust from 2000 onwards. Ices estimates also corresponds to official estimates from 2014

Spanish estimates

Landings series are available from for 2007-2011 from sale notes and for 2012-2017 from official statistics

Commercial discards

Observer data from Spanish vessels fishing in Areas 8, have shown there was no seabass discard from 2003. No information from 2015 onwards were available on discards for WGBIE 2018. This section also presents only French data.

French survey design and analysis

The French sampling schemes use a vessel-list sampling frames and random selection of vessels within strata defined by area and fleet sector. From the activity calendars of French vessels for year n-1, vessels are grouped by métier. Thus, a vessel may belong to multiple groups if practicing several metiers in the period. If the metier has to be sampled as priority, the vessel to be boarded is chosen randomly within this group of vessels. The observer then chooses to go on board for a trip. During the trip, the fishing operations corresponding to metier are sampled. Optionally, if the vessel practices several metiers during the trip, fishing operation of the other metiers will also be sampled if the metier is included in the annual sampling plan. If the metier is not part of the plan, it is requested to sample at least one fishing operation of this metier in the trip. (see the complete documentation of the discard sampling protocol :http://sih.ifremer.fr/content/download/5587/40495/file/Manuel_OBSMER_V2_2_2012.pdf). The objective of COST design based estimates for discards is to provide discards sampling users with methods that are practical, convenient and unbiased. The option used is a method for raising to an auxiliary variable that are based on landings (Vigneau 2006).

Discards coverage and quality

Discards data are available for French fleets from 2003 onwards. Discarding of sea bass by commercial fisheries can occur where fishing takes place in areas with bass smaller than the minimum landing size. Discards rates in France are relatively low. In 2016 total discards percentage is estimate at 3% of the total catches with an amount of 62 tonnes. In 2017 total discards percentage is estimate at 3% of the total catches with an amount of 74t (Table 1)

Table 1 : French discards estimates from 2015 onwards

YEAR	discards	landings	percentage of discards
2017	**74**	**2223**	**3.22%**
2016	**65**	**2160**	**2.92%**
2015	**69**	**2193**	**3.05%**

Length and age

Sampling methods and analysis

The French sampling programme for length compositions of sea bass landings covers sampling at sea and on shore. Since 2009, both sampling types are based on métiers composition and their relative importance to each fishing harbour and month. Both are also designed to sample the whole catch following a concurrent sampling of species, potentially leading to low sea bass sample size. In order to complement this effort, specific sampling for sea bass at the market is added at times and harbours when higher landings are occurring, especially from métiers targeting sea bass. The sampling frame is based on the main harbours, gear types (or grouping of métiers) and month and is available to all samplers on a dedicated website. Real-time follow-up of the plan, refusal rates and their reasons, and time taken to sample is also available from the website, together with sampling protocol (http://sih.Ifremer.fr/content/download/5587/40495/file/Manuel_OB-SMER_V2_2_2012.pdf). Before 2009, only market specific sampling was in place, and the sampling plan was designed and followed by the stock coordinator.

The French sampling programme for age compositions of sea bass is based on age–length keys with fixed allocation. For BSS-8.ab, the information is available only from 2008. All length samples are stored in a central database (Harmonie) and regular extracts are available in the COST format, with raising to the population done using COST.

Data coverage and quality

Length compositions of French sea bass commercial landings are available from 2000 for the area 8.ab by gear. These are grouped into 2 cm length bins as input data for Stock Synthesis and represent the fleet-aggregated length compositions in 2 cm classes (20–21.9, 22–23.9, etc.) for each year from 2000 onwards.

The statistical design of fishery sampling schemes has undergone change in recent years in the European countries, following recommendations from ICES workshops on sampling survey design, with a move towards more representative sampling across trips within fleet segments. This can result in sampling more trips that have small catches of sea bass. This is one reason for the increase in numbers of sampled trips with sea bass since 2009 in France, which does not imply an increase of the proportion in numbers of fish measured per trip (this is also observed for other countries). Numbers of trips and numbers of fish sampled are presented in Table 2

Table 2 : Number of trip and number of fish sampled in French sampling program from 2000 onwards

year	Number of trip sampled	Number of fish sampled
2000	64	1611
2001	56	1793
2002	116	2209
2003	151	3417
2004	97	1833
2005	115	1968
2006	102	2591
2007	249	2962
2008	466	5403
2009	364	3800
2010	324	2873
2011	373	5297
2012	433	5393
2013	260	3645
2014	338	5568
2015	406	6022
2016	394	5758
2017	417	3183

As in SS3 model used for the assessment of the sea bass stock in areas 4 and 7 (BSS-47), the input sample size for annual estimates of length composition should reflect the relative precision of the length compositions from year to year. It is a proxy for effective sample size which is typically much less than the total number of fish measured or aged due to cluster sampling effects. In the BSS-47 assessment, input sample sizes for the length compositions are first computed using the number of trips sampled for length as a proxy for effective sample size, and the input sample sizes are iteratively rescaled a few times (while maintaining the relative values between years) using the Francis method based on the SS3 output estimates of effective sample size.

WGBIE 2018 were made aware of an issue with the sampling level in Q1 and Q2 of 2017 from France (The full explanation of it can be found in the working document from Quemar, Vigneau *et al* "Estimation of quarterly length distribution of landings in the context of a 6-months disruption in the French on-shore sampling"). Because of the lack of market sampling for length (biological and onboard sampling was unaffected), efforts were made to try and fill the deficiency in the number of samples by use of simulation techniques. Both simulated data and actual data were uploaded to InterCatch combined making it impossible to distinguish true samples from simulated ones. The simulation was based on commercial landings market categories (Figure 5)

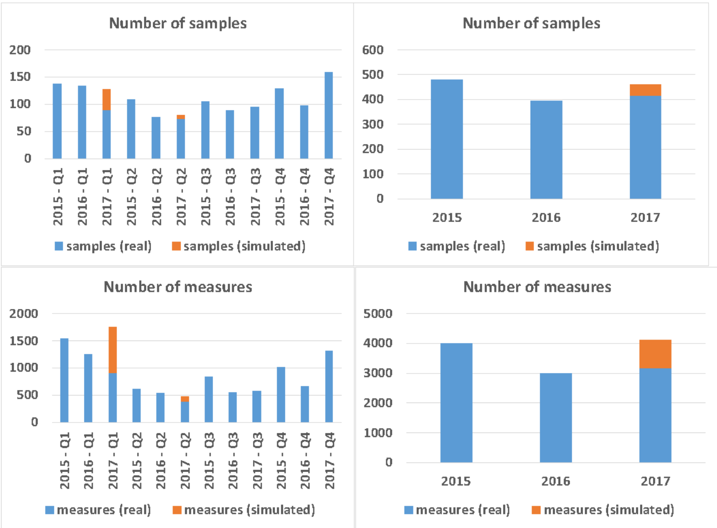


Figure 5: numbers of samples and measures simulated in French sampling scheme in 2017 compared to the previous years.

Recreational fishery catches, length compositions and post-release mortality

Recreational post released mortality

Recreational fisheries on European seabass are characterised by relatively high release rates, which appear to have increased following an increase of the MCRS from 36cm to 42cm 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 seabass 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 north west 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 details at the WKBASS 2018 assessment meeting (see working document from Hyder *et al.*, 2018 – Annex 2). **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 seabass 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 10 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 seabass caught by recreational sea anglers in 2012 was set at 5.0% (95% CI=1.7–14.4%) for the Northern seabass stock (Lewin *et al.*, 2018). The WKBASS 2018 group agreed that this value applies also to the Bay of Biscay seabass 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 2011–12 study (Levrel *et al.*, 2013) provided separate estimates for the Bay of Biscay and the Northern stocks (Estimates of recreational catches of seabass 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.). A total weight of 3,173 t in 2009-11 and 3,922 in 2011–12 were estimated, with a much higher proportion from the Northern stock in 2011–12 (Table 3). This may be due to differences in the survey design and the low sampling effort deployed in the Bay of Biscay in the 2011–12 (Table 3).

Country	Year	Area	Numbers (thousands)							Weight (tonnes)							Source
			Retained	RSE	Released	RSE	Total	RSE	% released	Retained	RSE	relapsed	RSE	Total	RSE	% released	
France	2009–11	4 & 6	781		796		1,578	>26	50	940		332		1,272	>26	26	ICES (2014b)
	2009–11	Biscay	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	4 & 6	2,043		1,581		3,624		44	2,458		659		3,117		21	IFREMER
	2011–12	Biscay	572		281		852		33	688		117		805		15	IFREMER
	2011–12	All	2,615		1,861		3,935		47	3,146		776		3,922		20	IFREMER

Table 3. Estimates of recreational catches of seabass 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.

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 hasn't been enough reviewed by scientific experts as the first study.

Estimation of the catches in the 2009-2011 study (1,405 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 (**Error! Reference source not found.**) 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 seabass stock, catches in the reference year 2010 was estimated to be 1,405 t + 25 t (5%) = 1,430 t.

Recreational fishery catches reconstructed for the whole time serie

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 1,430 t estimated in 2010.

The implementation of new management measures should have lead 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 4) in order to derive changes in recreational fishing mortality (Hyder *et al*., 2018).

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 5 fish bag limit implementation, the multiplier was estimated to be unchanged. For 2018 with a 3 fish bag limit implementation, it was estimated to be 0.647.

Table 4 : Time series of commercial and recreational catches used in the SS3 final model run.

year	commercial landings (t)	recreational landings (t)
1985	3420	1431
1986	3549	1384
1987	3417	1350
1988	3217	1331
1989	3144	1323
1990	2621	1331
1991	2734	1342
1992	2709	1338
1993	2552	1317
1994	2668	1277
1995	2492	1215
1996	2402	1147
1997	2358	1089
1998	2231	1079
1999	2091	1124
2000	2362	1217
2001	2306	1295
2002	2392	1350
2003	2616	1380
2004	2380	1395
2005	2796	1408
2006	2875	1427
2007	2751	1448
2008	2745	1461
2009	2278	1451
2010	2229	1430
2011	2575	1392
2012	2549	1341
2013	2685	875
2014	2991	819
2015	2264	769
2016	2252	733
2017	2295	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 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 : 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

Abundance indices from surveys

Currently, there is no survey providing relative indices of adult or juvenile sea bass abundance over time. A French study is undertaken from 2013 to explore the possibility of creating recruitment indices in estuarine waters. There were good results, but it needs support to be routinely carried out. Abundance indices have been calculated for year 2016 and 2017 in the Loire estuary and are planned for year 2018. The study has been submitted to FEAMP for year 2019-2021, including also the Gironde estuary in order to get two abundance index for the stock Bss 8ab. Final objective would be to make it sustainable through DCF from 2022.

Commercial landings-effort data

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

There are no scientific surveys providing sufficient data on adult seabass 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 < 10m) 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 6 and 8 were presented through a Working Document (Laurec, Woillez and Drogou). A review of this second document has been done by an external expert (M. Christman) during summer 2017 and before WKBASS 2018.

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 seabass stock.

Two main issues were highlighted by the reviewer:

1) The alleged false positive pollution of the data set 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.
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 seabass (i.e. hyperstability) during the spawning season.

The new LPUE index has been incorporated in the Northern and the Bay of Biscay stocks assessment models (Figure 6**Error! Reference source not found.**).

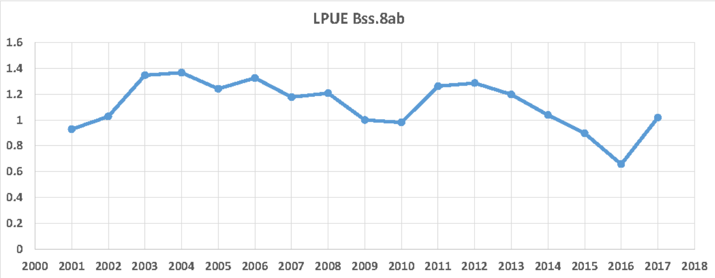


Figure 6. The "new" LPUE index series for the Bay of Biscay stock presented at WKBASS 2018 assessment meeting.

Figure 7 shows the comparison between the "old" index used to assess the Bay of Biscay seabass stock in WGBIE 2017 and the new index presented during WKBASS 2018 used in the SS3 final model run

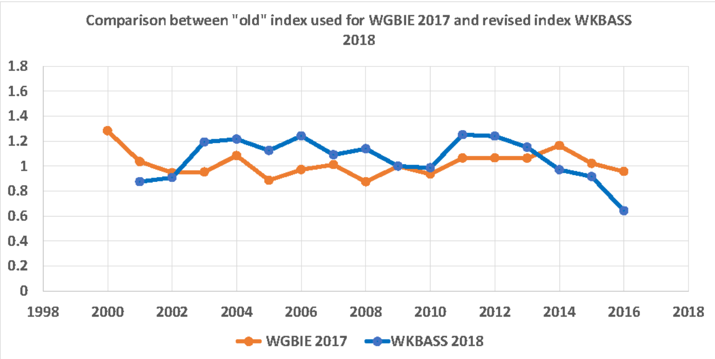


Figure 7. Comparison between the "old" index used for WGBIE 2017 and the "new" index from WKBASS 2018 assessment WK.

Biological parameters

Growth

Von Bertalanffy growth parameters were calculated for seabass sampled by Ifremer around the coasts of France in area 8.a and 8.b (Ices WKBASS 2017). 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. L_{inf} has been fixed to 80.4cm (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.

Maturity

Maturity has been studied for seabass sampled by France in the Bay of Biscay. Data are derived from samples of French fishery around the Bay of Biscay coast (very few seabass 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 41.31cm and upper limit 43.08 cm). The Pearson test (pvalue = 0.597) revealed a good model fit of the data (Figure 8)

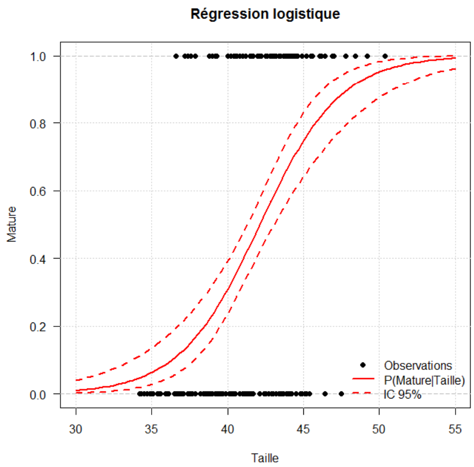


Figure 8. Maturity ogive for seabass in Bay of Biscay.

The study has been conducted on a short period (2 years) but nevertheless, it indicates similar results compared to Dorel (1986) (i.e. 42cm for females). Stequert (1972) also reported a similar value of $L_{50\%}$ for this area.

Natural mortality

There are no direct estimates of M for seabass. 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 fishes 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 seabass stock.

Because of the short time series for the French biological data (no biological data before 2000's, 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 seabass stock was conducted. M estimates have been computed from different methods based on life history information (Figure 9 left). A composite M median value from all the methods explored was 0.178 Figure 9 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.

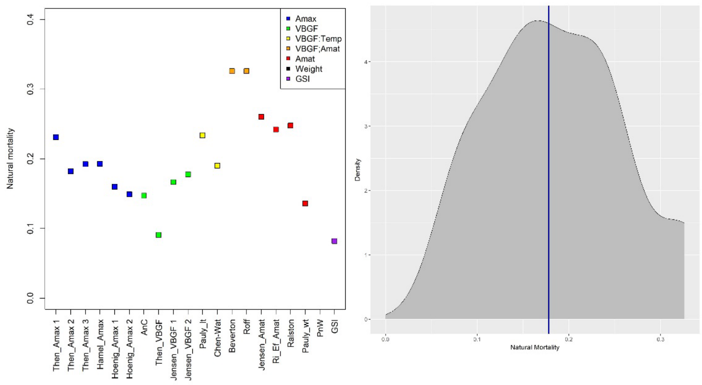


Figure 9. Left) Natural mortality estimates and methods applied. Right) Composite natural mortality value.

Assessment

The assessment has been developed in three stages during WKBASS 2017, WKBASS 2018 and IBPBASS 2018 which focused on reference points.

Assessment model development during WKBASS 2017 and 2018

Input data and model specifications

The Stock Synthesis (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 seabass, 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 (Ices WKBASS 2017). 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 has been selected as final model.

During the WKBASS benchmark 2018, the assessment model development focused on improving the 2017 final base model. 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

SS3 Data and Control files developed for WGBIE 2018 can be found in Annex 1.

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

In 2018, 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 (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 data set (e.g., year) as a data point 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 seabass 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.

Final assessment model, diagnostics and retrospective

The final assessment model considered two fleets: a commercial fishing fleet and a recreational fleet (Figure 10). Commercial fleet includes French and Spanish fleets, even though the latter only accounts for 3% percent of the total landings in 8.ab area. Catch data were considered for years 1985-2016. Historical data (years 1985–1999) were reported from a different database than the modern data (years 2000–2015). A correction was applied to merge both series. A LPUE abundance index were 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.

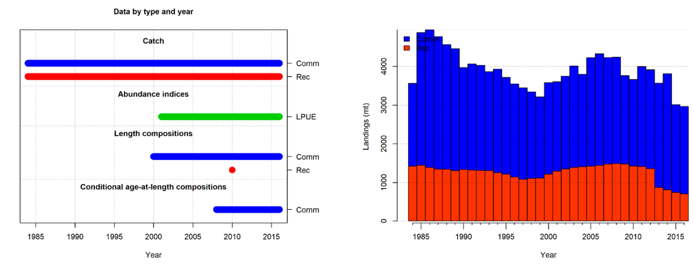


Figure 10. Left: Datasets used in the final assessment model. Right: Landings series for the two fleets.

Selectivity were mainly driven by length rather than age (Figure 11). 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.

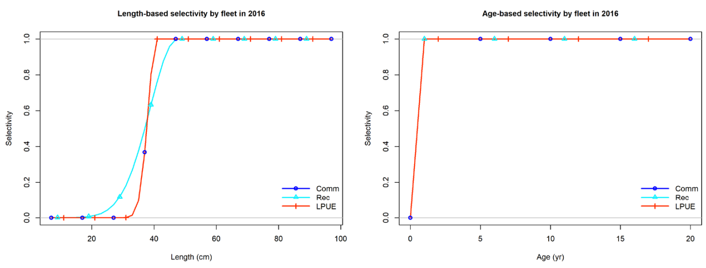


Figure 11. Final Bay of Biscay seabass stock assessment model: fitted length-based and age-based selectivity curves.

Model fit for the commercial length composition data were good (Figure 12**Error! Reference source not found.**).

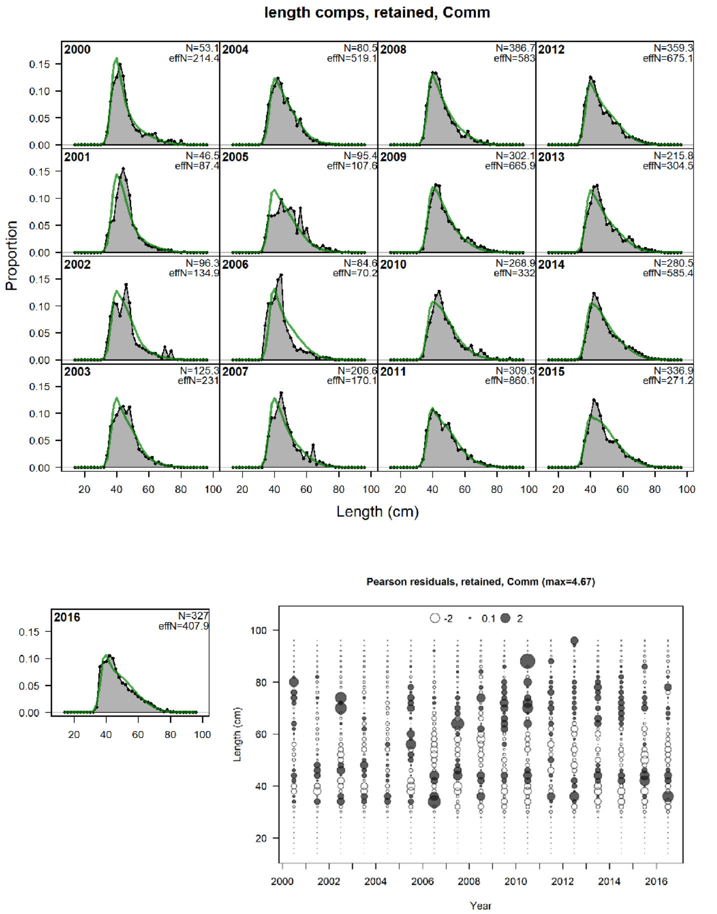


Figure 12. Final Bay of Biscay seabass stock assessment model: fit to commercial fishery length composition data and residuals.

Model fit for the recreational length composition data were good and better than for the 2017 final model (Figure 13). 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.

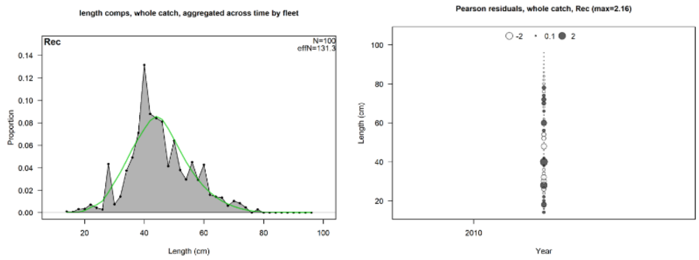


Figure 13. Final Bay of Biscay seabass stock assessment model: fit to recreational fishery length composition data and residuals.

The model fit for the commercial length composition data aggregated across time were satisfactory (Figure 14).

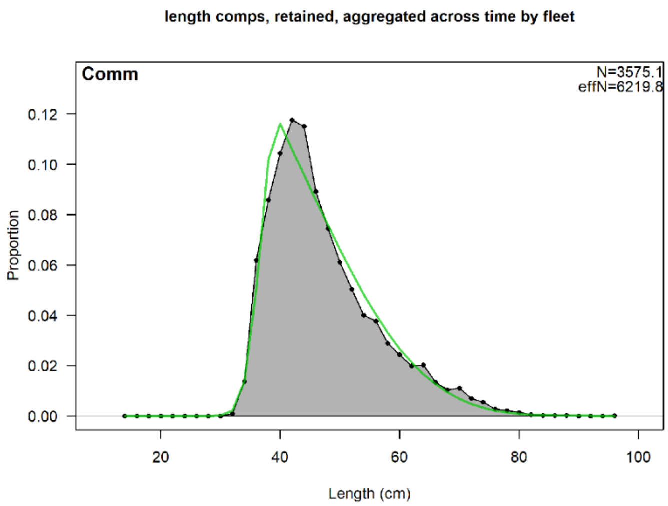
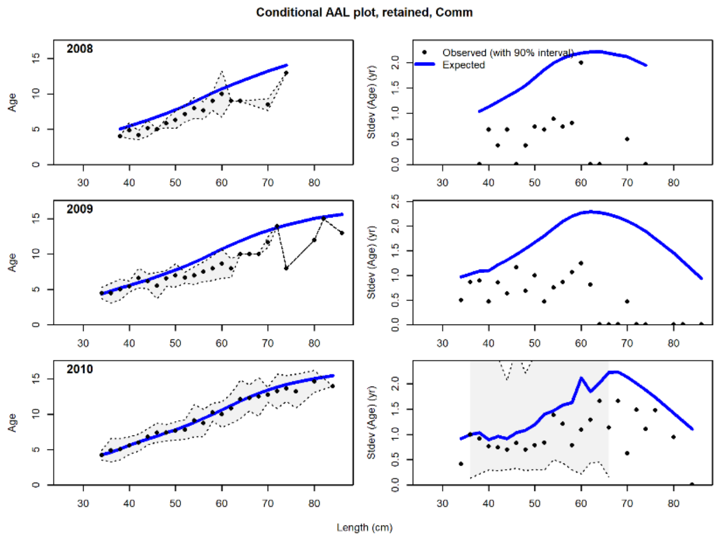
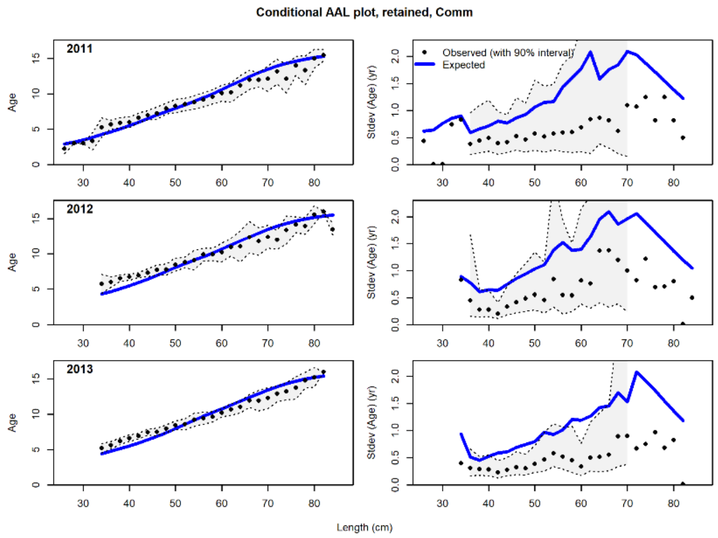


Figure 14. Final Bay of Biscay seabass stock assessment model: fit to length composition data by fishery aggregated across time.

Model fit for the aggregated fishery age-at-length composition data were good (Figure 15 and Figure 16). The fit were poor for first 2 years (2008 and 2009). However, for these years the sampling size was low.


Conditional AAL plot, retained, Comm
2008
2009
2010
Age
Stdev (Age) (yr)
Observed (with 90% interval)
Expected
Length (cm)


Conditional AAL plot, retained, Comm
2011
2012
2013
Age
Stdev (Age) (yr)
Observed (with 90% interval)
Expected
Length (cm)

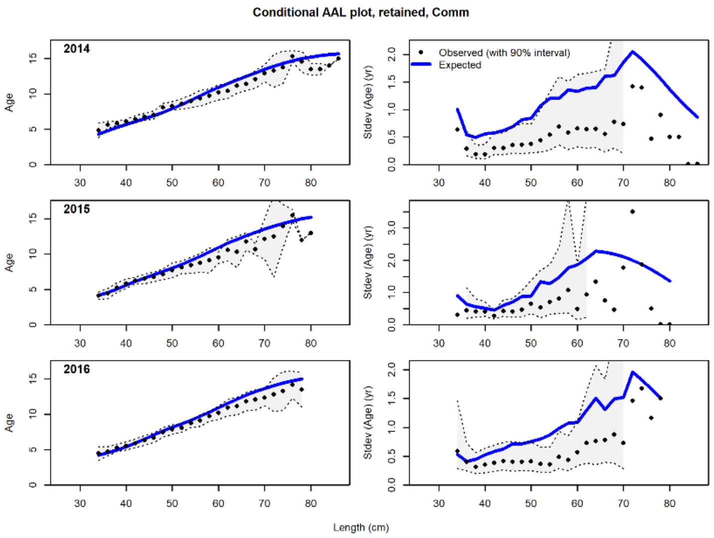


Figure 15. Final Bay of Biscay seabass stock assessment model: fit to conditional age-at-length for commercial fishery.

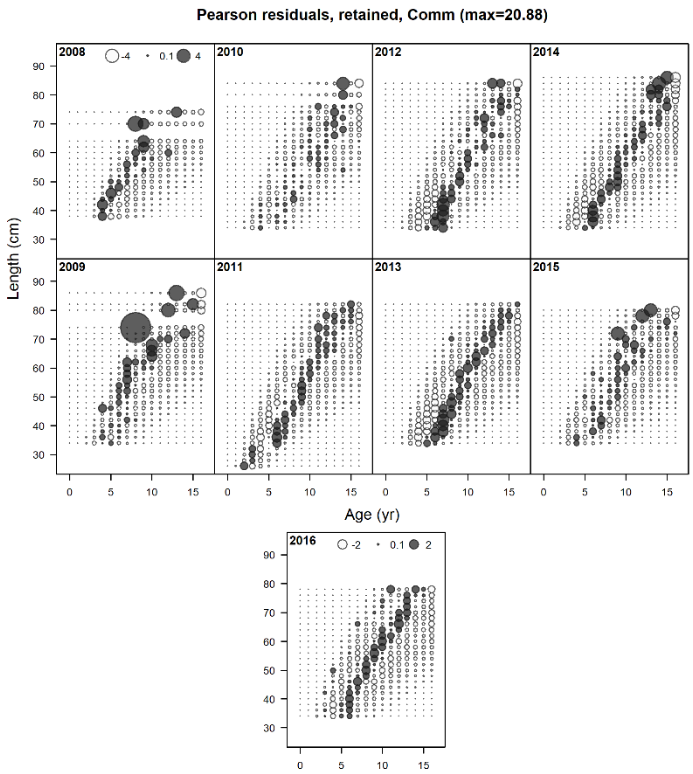


Figure 16. Final Bay of Biscay seabass stock assessment model: fit to conditional age-at-length for commercial fishery and residuals.

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 17). Model and observations compared well, even though 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.

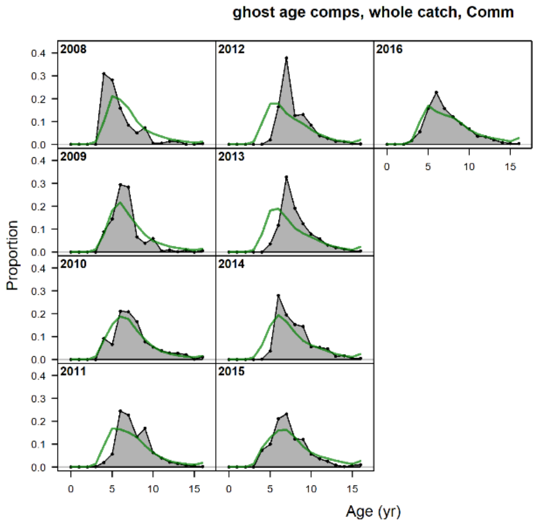


Figure 17. Final Bay of Biscay seabass stock assessment model: fit to ghost age composition data for commercial fishery.

Fit of the LPUE abundance index was good (Figure 18).

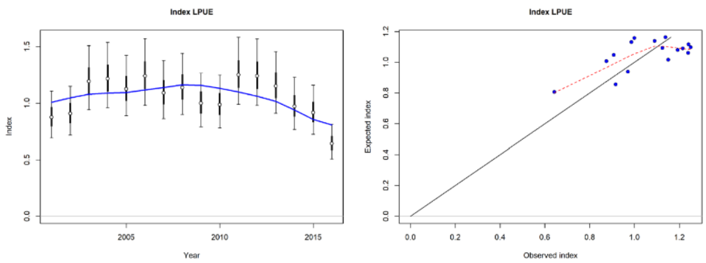


Figure 18. Final Bay of Biscay seabass stock assessment model: fit to LPUE abundance index.

The Bay of Biscay seabass stock showed a narrow dynamic range of SSB and no evidence of past or present impaired recruitment (Figure 19)

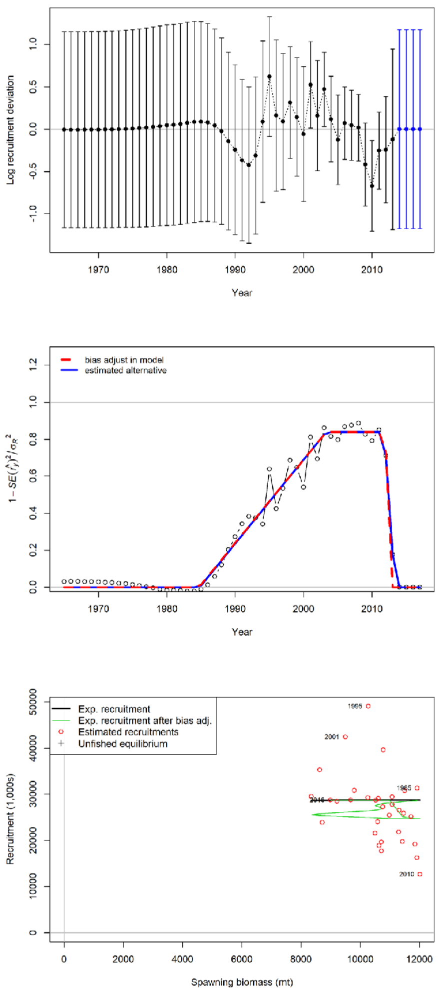


Figure 19 : Final Bay of Biscay seabass stock assessment model: Top) time-series of log recruitment deviations (deviations for 1965–1984 present the period of input catch data). Middle) Adjustment for bias due to variability of estimated recruitments in fishery. Red line shows current settings for bias adjustment. Blue line shows least squares estimate of alternative bias adjustment relationship for recruitment deviations. Bottom) Stock–recruitment scatter plot (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 (**Error! Reference source not**

found.). 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 20)

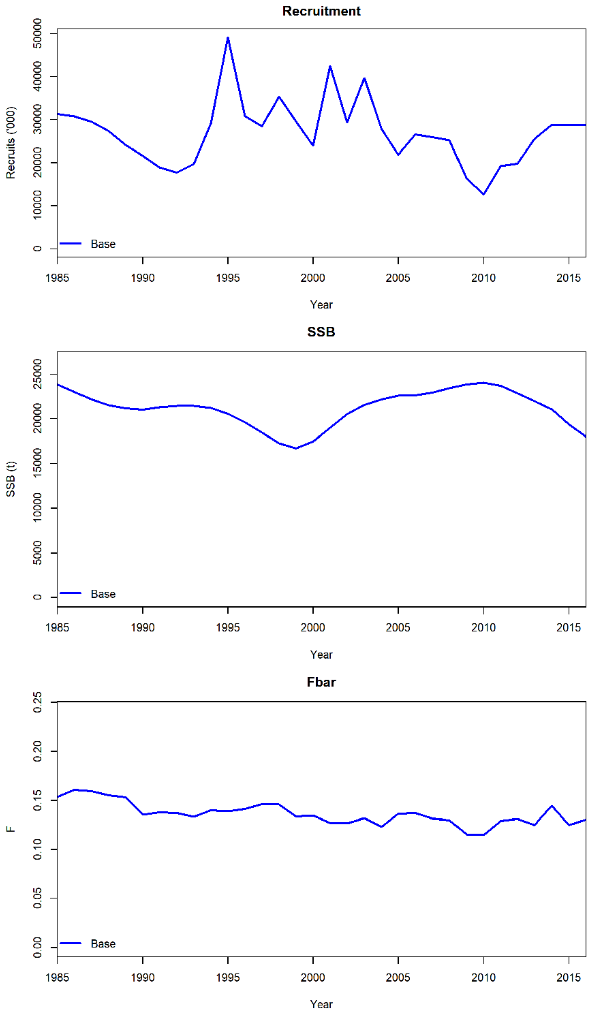


Figure 20. Final Bay of Biscay seabass stock assessment model: Recruitment, SSB and F (computed from ages 4-15) time-series.

A retrospective analysis was conducted (**Error! Reference source not found.**). Recruitment, SSB and F series showed some variability, however the stock trend is rather robust. In the last 5 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 21)

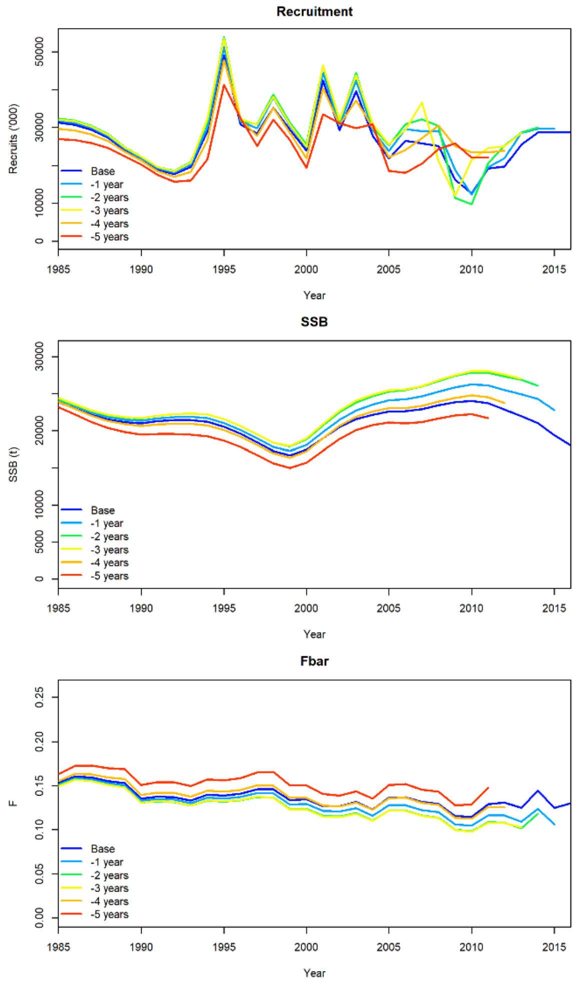


Figure 21. Retrospective analysis of the final Bay of Biscay seabass stock assessment model: Recruitment, SSB and F time-series.

Biological Reference Points and forecast (IBPBASS 2018)

Current reference points

There is no current Biological Reference Points for the Seabass (*Dicentrarchus labrax*) in Divisions 8.ab (Bay of Biscay North and Central). Reference points presented have been accepted during IBPBass 2018.

Source of data

The Seabass 8.ab 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 the benchmark meeting ICES WKBASS 2018.

Methods used

All analyses were conducted with EQSIM in R. To do so, 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 6.

Table 6 : Model and data selection settings

DATA AND PARAMETERS	SETTING	COMMENTS
SSB-recruitment data	Full data series (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

Results

Stock-Recruitment relationship

The S-R relationship was explored using age 0 as age of recruitment. As no fishing mortality occurs for most fish below or equal to age 3, we assumed that considering age 3 as age of recruitment rather than age 0 would not provide any better information. Several models were fitted to the S-R relationship (Figure 22). The most statistically appropriate model seems to be a Ricker model, which model some density dependence at high SSB. However a segmented regression was considered as an appropriate S-R model given the lack of biologically understandable trends in S-R that would justify a density-dependent process occurring at current stock state.

Based on the S-R relationship classification proposed by ICES (2017), the seabass stock can be categorised as a type 6 S-R plot. This is a stock with a narrow dynamic range of

SSB and showing no evidence of past or present impaired recruitment. Thus, it is justified to consider B_{pa} at the breakpoint of a segmented regression (Figure 22).

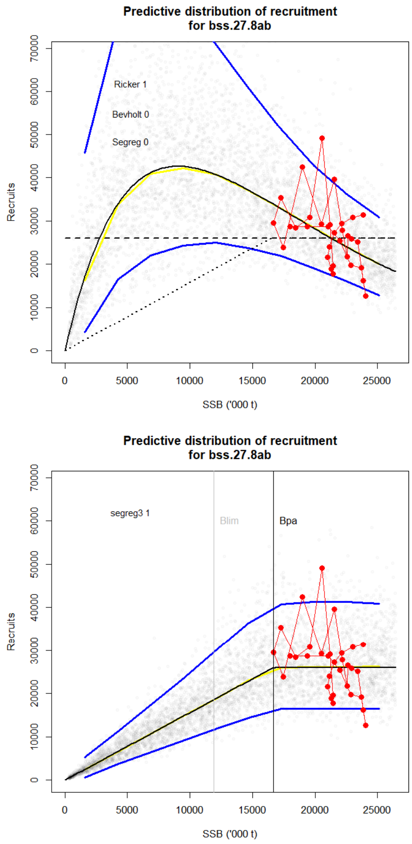


Figure 22: Stock recruitment relationship for the seabass in divisions 8.ab.

B_{pa} is estimated to be equal to B_{loss}. This implies a B_{pa} of 16,688 tonnes with a $B_{lim} = B_{pa}$ / exp(CV * 1.645) = B_{pa} / 1.4 = 11,920 tonnes, with CV taken equal to 0.2045 (default value recommended by ICES).

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.

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 0.172, and F_{pa} is estimated to be 0.123 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 Btrigger). 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 $F_{pa} = 0.123$, see Figure 23 and Figure 24. In such a case, F_{MSY} is reduced to F_{pa} (i.e. F_{MSY} can not exceed F_{pa}).

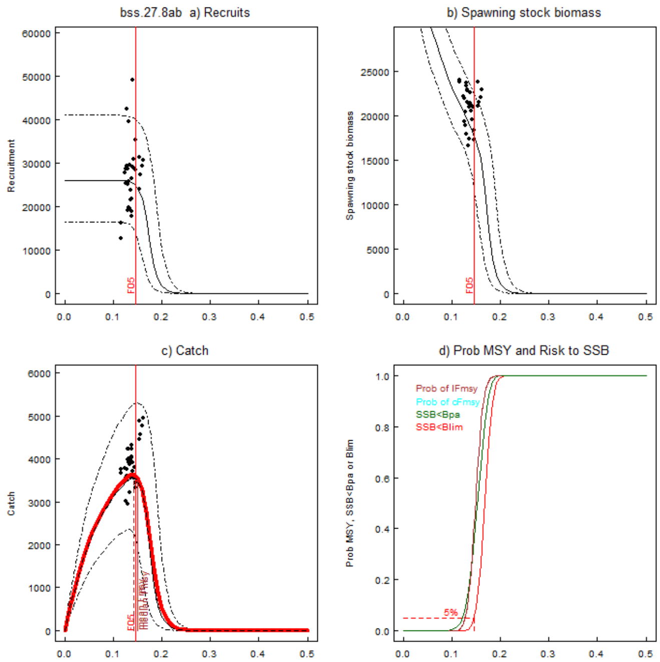
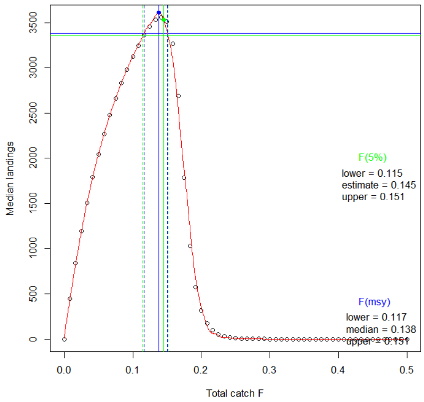


Figure 23 : Eqsim summary plot without $B_{trigger}$. Panels a to c: historic values (dots) median (solid black) and 90% intervals (dotted black) recruitment, SSB and landings for exploitation at fixed values of F. Panel c also shows mean landings (red solid line). Panel d shows the probability of SSB<B_{lim} (red), SSB<B_{pa} (green) and the cumulative distribution of F_{MSY} based on yield as landings (brown).



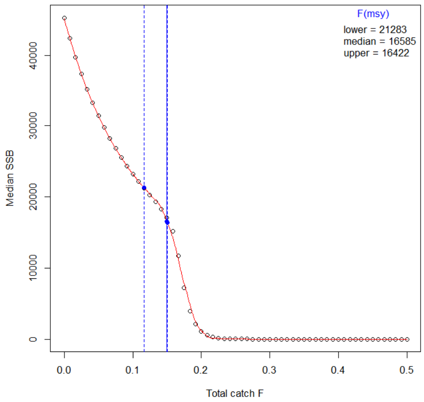


Figure 24: Left) Eqsim median landings yield curve with estimated reference points without $B_{trigger}$. Blue lines: F_{MSY} estimate (solid) and range at 95% of maximum yield (dotted). Green lines: F (5%) estimate (solid) and range at 95% of yield implied by F (5%) (Dotted). Right) Eqsim median SSB 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}, as in this case, then MSY $B_{trigger}$ is set to B_{pa}.

For this final run, assessment/advice error were included using the same default values and MSY $B_{trigger}$ was set to 16,688 tonnes. As shown in Figure 25, EqSim output $F_{p.05}$ (fishing mortality that gives 5% probability of SSB below B_{lim}) equals 0.186. As F_{MSY} estimated in the first run is below $F_{p.05}$, then F_{MSY} is kept to 0.123.

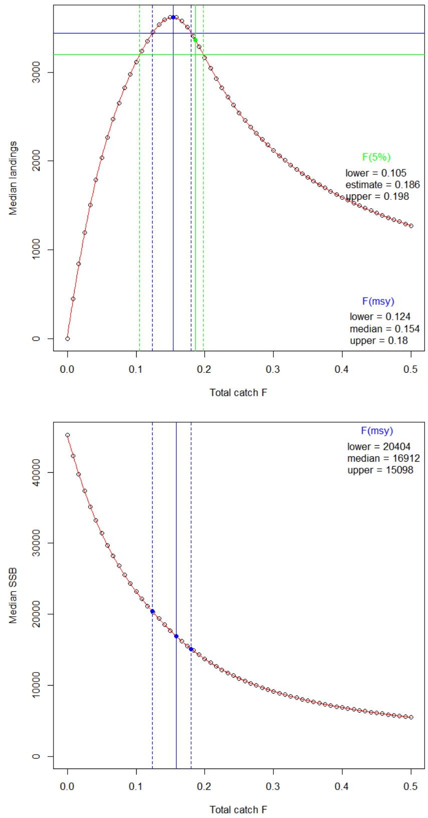


Figure 25: Eqsim median landings yield curve with estimated reference points with $B_{trigger}$. Blue lines: F_{MSY} estimate (solid) and range at 95% of maximum yield (dotted). Green lines: F (5%) estimate (solid) and range at 95% of yield implied by F (5%) (Dotted).

Proposed reference points

For the seabass in division 8ab stock, the proposed reference points are reported in the Table 7. Those proposed reference points are then displayed on the diagnostic plots of the final assessment (Figure 26 : Recruitment, SSB and Fbar time-series with IBP2018 biological reference points), i.e. the recruitment, the SSB and the F_{bar} (computed from ages 4–15) time-series.

Table 7 : Summary table of proposed stock reference points for method Eqsim.

STOCK	Seabass divisions 8ab		
PA Reference points	Value	Rational	
B_{lim}	11,920 t	B_{pa} / 1.4	
B_{pa}	16,688 t	Lowest observed SSB	
F_{lim}	0.172	In equilibrium gives a 50% probability of SSB>B_{lim}	
F_{pa}	0.123	$F_{pa} = F_{lim}$ / 1.4	
MSY Reference point	Value		
F_{MSY} without $B_{trigger}$	0.138		
F_{MSY} lower without $B_{trigger}$	0.117		
F_{MSY} upper without $B_{trigger}$	0.150		
$F_{P.05}$ (5% risk to B_{lim} without $B_{trigger}$)	0.145		
F_{MSY} upper precautionary without $B_{trigger}$	0.151		
MSY $B_{trigger}$	16,688 t	Value reduced to B_{pa}. Never fished at F_{MSY} before. (originally equals to 17,715 t)	
$F_{P.05}$ (5% risk to B_{lim} with $B_{trigger}$)	0.186		With WKMSYREF4 default values for assessment/advice error
F_{MSY} with $B_{trigger}$	0.123	Reduced value (originally equals to 0.154)	
F_{MSY} lower with $B_{trigger}$	0.123		
F_{MSY} upper with $B_{trigger}$	0.180		
F_{MSY} upper precautionary with $B_{trigger}$	0.180		
Median SSB at F_{MSY}	20,528 t		
Median SSB lower precautionary (median at F_{MSY} upper precautionary)	15,123 t		
Median SSB upper (median at F_{MSY} lower)	20,528 t		

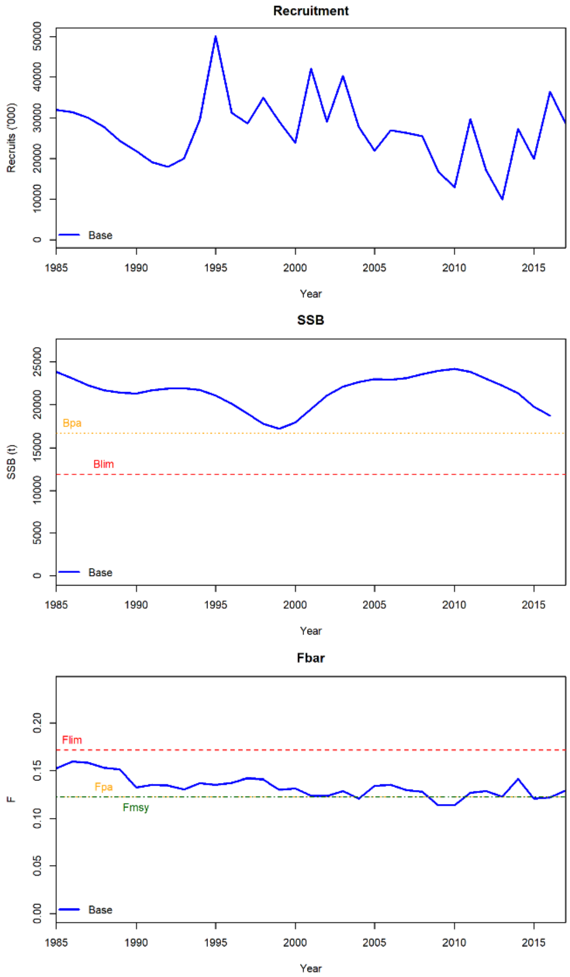


Figure 26 : Recruitment, SSB and F_{bar} time-series with IBP2018 biological reference points

Revision of the proposed reference points

In 2021, ICES decided to revise the basis of calculation for F_{pa}, as the F that leads to SSB ≥ Blim with 95% probability with $B_{trigger}$, i.e. $F_{pa} = F_{p0.5} = 0.186$. As the revised value of $F_{pa} \geq F_{lim}$, F_{lim} was not defined. Those values replaced the ones presented in Table 7 and were used in the assessment since 2021.

Short-Term projection, catch options and prognosis

The recruitment used for projections is the geometric mean (GM) calculated from 2008 to 2014. For the short-term projection, scaled F-at-age to the average of the last 3 years

(2015-2017) were used for commercial and recreational fleets. For illustration purpose, forecasting inputs used for projections in 2017 are compiled in **Error! Reference source not found.** and Table 9.

Table 8. Seabass in Division 8.a-b. Forecast inputs table.

Age	Numbers at age	Weight in stock	Proportion mature	Commercial F	Commercial mean weights	Recreational F	Recreational mean weight	M
0	18584	0,004	0,000	0,000	0,009	0,000	0,009	0,24
1	14618	0,020	0,000	0,000	0,044	0,000	0,051	0,24
2	11498	0,078	0,000	0,000	0,295	0,001	0,151	0,24
3	9675	0,183	0,003	0,001	0,460	0,004	0,300	0,24
4	10400	0,332	0,031	0,019	0,592	0,011	0,485	0,24
5	2879	0,519	0,167	0,066	0,726	0,020	0,690	0,24
6	3578	0,737	0,431	0,096	0,900	0,027	0,906	0,24
7	4328	0,977	0,683	0,105	1,120	0,031	1,134	0,24
8	1283	1,232	0,842	0,107	1,368	0,032	1,378	0,24
9	1149	1,494	0,923	0,108	1,628	0,033	1,633	0,24
10	1176	1,757	0,962	0,108	1,889	0,033	1,892	0,24
11	825	2,018	0,980	0,108	2,146	0,033	2,148	0,24
12	580	2,271	0,989	0,108	2,395	0,033	2,396	0,24
13	324	2,516	0,994	0,108	2,634	0,033	2,634	0,24
14	283	2,749	0,996	0,108	2,861	0,033	2,861	0,24
15	281	2,969	0,998	0,108	3,074	0,033	3,074	0,24
16	471	3,534	0,998	0,108	3,593	0,033	3,593	0,24

Age 0,1,2 over-written as follows:

2018 yc 2018 age 0 replaced by 2008–2014 LTGM (18 584 thousand);

2017 yc 2018 age 1 from SS3 survivor estimate at-age 1, 2018 * LTGM / SS3 estimate of age 0 in 2016;

2016 yc 2018 age 2 from SS3 survivor estimate at-age 2, 2018 * LTGM / SS3 estimate of age 0 in 2015.

Table 9. Seabass in Division 8.a-b. The basis for the catch scenarios.

Variable	Value	Notes
F ages 4–15 (2018)	0.124	F_{sq}; $F_{average(2015\text{-}2017)}$ scaled to 2017; commercial fishery F= 0.096; recreational fishery F=0.028 (reduced to account for 2018 management measures; $F_{recreational(2018)} = F_{recreational(2017)} * 0.945$)
SSB (2019)	15573 t	Short-term forecast
R_{age0} (2016, 2017, 2018)	18584 thousands	Geometric mean (2008-2014)
Total catch (2018)	2718 t	Fishing at F_{sq} with $F_{recreational(2018)}$ reduced
Wanted commercial catch (2018)	2092 t	Short-term forecast
Unwanted commercial catch (2018)	negligible	
Recreational Catch (2018)	626 t	Short-term forecast with management measures taken into account and full compliance assumed

Depending of the level of SSB of year N+2, ICES basis rules should be followed.

For assessment year 2017, we had Blim < SSB_{2019} < Bpa, so the MSY approach recommended to have F=Fmsy * SSB_2019 / MSY_Btrigger

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Annexe 1: Stock Synthesis 3 Model data and control files for seabass 8.ab stock

SS3 control file

C Sea bass 8 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=Lorenzen;_3=agespecific;_4=agespec_withseasinterpolate

#0.150 0.150 0.150 0.152 0.163 0.209 0.247 0.256 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 implemented; 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-maturity 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 parameters
#
#_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 parameters
#
#-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 max-phase+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 # SizeSel_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 # SizeSel_2P_3_FROTB #Asc_width

-8.5 6.0 4.4 4.4 -1 0.05 -3 0 0 0 0 0 0 0 # SizeSel_2P_4_FROTB #Desc_width

-999.0 9.0 -999 -999 -1 0.05 -2 0 0 0 0 0 0 0 # SizeSel_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 # SizeSel_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%CPUE-index

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

SS3 control 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: 2018-04-09 15:43:16

#

1985 #_styr

2017 #_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

33 #_N_lines_of_catch_to_read

#_Comm Rec year seas

3420 1431.2399 1985 1

3549 1383.5521 1986 1

3417 1349.9494 1987 1

3217 1330.7479 1988 1

3144 1322.8046 1989 1

2621 1331.0681 1990 1

2734 1341.8414 1991 1

2709 1337.6787 1992 1

```
  2552 1317.3367 1993    1
  2668 1277.3742 1994    1
  2492 1215.4993 1995    1
  2402 1147.1736 1996    1
  2358 1089.3784 1997    1
  2231 1079.3955 1998    1
  2091 1123.9005 1999    1
  2362 1216.7399 2000    1
  2306 1295.1030 2001    1
  2392 1350.0833 2002    1
  2616 1380.0698 2003    1
  2380 1395.2080 2004    1
  2796 1407.6398 2005    1
  2875 1426.7797 2006    1
  2751 1447.5792 2007    1
  2745 1461.4891 2008    1
  2278 1451.3784 2009    1
  2229 1430.0000 2010    1
  2575 1392.4568 2011    1
  2549 1341.1073 2012    1
  2685  874.9097 2013    1
  2991  818.6358 2014    1
  2264  768.7657 2015    1
  2252  732.7570 2016    1
  2295  712.7570 2017    1
17 #_N_cpue
 #_Fleet Units Errtype
     1    1      0
     2    1      0
     3    1      0
 #_year seas index      obs se_log
```

2001	1	3	0.9279832	0.05
2002	1	3	1.0274510	0.05
2003	1	3	1.3462521	0.05
2004	1	3	1.3669888	0.05
2005	1	3	1.2413025	0.05
2006	1	3	1.3258824	0.05
2007	1	3	1.1774006	0.05
2008	1	3	1.2075574	0.05
2009	1	3	1.0000000	0.05
2010	1	3	0.9815574	0.05
2011	1	3	1.2624538	0.05
2012	1	3	1.2862521	0.05
2013	1	3	1.1969608	0.05
2014	1	3	1.0384118	0.05
2015	1	3	0.8974790	0.05
2016	1	3	0.6576134	0.05
2017	1	3	1.0180700	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

19 #_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 0.0000 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 0.0000 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 0.0000 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 0.0000 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 0.0000 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 0.0000 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 0.0000 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 0.0000 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 0.0000 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 0.0000 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 0.0000 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 0.0000 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 0.0000 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 0.0000 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 0.0000 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 0.0000 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 0.0000 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

2017 1 1 0 2 447 0.000 0.000 0.000 322.4597 0.000 0.000 0.000 0.00 0.00000 108.3776 3024.805 29792.31 111825.48 126008.0 161278.1 149349.5 139217.6 87973.89 58592.50 44959.03 44766.27 43567.95 28037.16 29087.70 22712.89 21925.51 27472.327 13885.842 11465.614 9530.569 9448.126 3275.8418 3403.5207 1826.9066 946.99782 453.5681 0.00000 0.0000 0.00000 0.000 0.00000 0.0000

2010 1 2 0 0 100 1396.693 980.001 4062.675 4358.4690 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

279 #_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

 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

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

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

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

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

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0.0 7.0 23.0 19.00 7.00 0.000 0.00 0.0000 0.000 0.0000 0.000

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0.0 6.0 12.0 18.00 7.00 0.000 0.00 0.0000 0.000 0.0000 0.000

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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

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1.0 0.0 0.0 0.00 0.00 0.000 0.00 0.0000 0.000 0.0000 0.000

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26.0 1.0 0.0 0.00 0.00 0.000 0.00 0.0000 0.000 0.0000 0.000

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46.0 2.0 0.0 0.00 0.00 0.000 0.00 0.0000 0.000 0.0000 0.000

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16.0 30.0 6.0 0.00 0.00 0.000 0.00 0.0000 0.000 0.0000 0.000

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8.0 27.0 14.0 0.00 0.00 0.000 0.00 0.0000 0.000 0.0000 0.000

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0.0 1.0 8.0 17.00 3.00 3.000 0.00 0.0000 0.000 0.0000 0.000

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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

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0.0 0.0 1.0 8.00 10.00 7.000 5.00 0.0000 0.000 0.0000 0.000

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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
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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

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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

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3.0 13.0 8.0 14.00 1.00 0.000 0.00 0.0000 0.000 0.0000 0.000

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1.0 5.0 8.0 8.00 6.00 0.000 0.00 0.0000 0.000 0.0000 0.000

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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

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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

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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

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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
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2016 1 1 0 2 1 64 64 27 0 0 0.0000 0.0000 0.0000 0.00
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2016 1 1 0 2 1 66 66 34 0 0 0.0000 0.0000 0.0000 0.00
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2016 1 1 0 2 1 68 68 24 0 0 0.0000 0.0000 0.0000 0.00
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2016 1 1 0 2 1 70 70 21 0 0 0.0000 0.0000 0.0000 0.00
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2016 1 1 0 2 1 72 72 11 0 0 0.0000 0.0000 0.0000 0.00
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2017 1 1 0 2 1 14 14 14 0 14 0.0000 0.0000 0.0000 0.00
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2017 1 1 0 2 1 16 16 8 0 8 0.0000 0.0000 0.0000 0.00
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2017 1 1 0 2 1 20 20 2 0 1 1.0000 0.0000 0.0000 0.00
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2017 1 1 0 2 1 22 22 7 0 0 7.0000 0.0000 0.0000 0.00
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2017 1 1 0 2 1 24 24 4 0 0 1.0000 3.0000 0.0000 0.00
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2017 1 1 0 2 1 26 26 12 0 0 0.0000 12.0000 0.0000 0.00
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2017 1 1 0 2 1 28 28 10 0 0 0.0000 10.0000 0.0000 0.00
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2017 1 1 0 2 1 30 30 5 0 0 0.0000 4.0000 1.0000 0.00
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2017 1 1 0 2 1 34 34 6 0 0 0.0000 0.0000 6.0000 0.00
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2017 1 1 0 2 1 40 40 20 0 0 0.0000 0.0000 0.0000 2.00
13.0 5.0 0.0 0.00 0.00 0.000 0.00 0.0000 0.000 0.0000 0.000

2017 1 1 0 2 1 42 42 16 0 0 0.0000 0.0000 0.0000 0.00
8.0 8.0 0.0 0.00 0.00 0.000 0.00 0.0000 0.000 0.0000 0.000

2017 1 1 0 2 1 44 44 7 0 0 0.0000 0.0000 0.0000 0.00
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2017 1 1 0 2 1 46 46 9 0 0 0.0000 0.0000 0.0000 0.00
1.0 6.0 2.0 0.00 0.00 0.000 0.00 0.0000 0.000 0.0000 0.000

2017 1 1 0 2 1 48 48 11 0 0 0.0000 0.0000 0.0000 0.00
0.0 3.0 6.0 2.00 0.00 0.000 0.00 0.0000 0.000 0.0000 0.000

2017 1 1 0 2 1 50 50 13 0 0 0.0000 0.0000 0.0000 0.00
0.0 3.0 8.0 2.00 0.00 0.000 0.00 0.0000 0.000 0.0000 0.000

2017 1 1 0 2 1 52 52 11 0 0 0.0000 0.0000 0.0000 0.00
0.0 0.0 4.0 5.00 1.00 1.000 0.00 0.0000 0.000 0.0000 0.000

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2017 1 1 0 2 1 56 56 12 0 0 0.0000 0.0000 0.0000 0.00
0.0 0.0 2.0 4.00 3.00 2.000 1.00 0.0000 0.000 0.0000 0.000

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2017 1 1 0 2 1 72 72 6 0 0 0.0000 0.0000 0.0000 0.00
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2017 1 1 0 2 1 80 80 2 0 0 0.0000 0.0000 0.0000 0.00
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2017 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

2017 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 0.000 0.0000 1.000

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

2017 1 -1 0 0 1 -1 -1 335 0 0 0.0000 6594.0453 40668.5407 161225.30 289219.2 235707.5 120565.8 78451.32 53343.52 41669.593 33832.19 39142.2318 0.000 0.0000 0.000

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Stock Annex: Four-spot megrim (*Lepidorhombus boscii*) in divisions 8.c and 9.a (southern Bay of Biscay and Atlantic Iberian waters East)

Stock-specific documentation of standard assessment procedures used by ICES

Stock	Southern four spot megrim (Division 8c, 9a)_ ldb.27.8c9a
Working Group:	Working Group for the Bay of Biscay and Iberian Waters Ecoregion (WGBIE)
Date:	13 May 2014
Revised by	WGBIE 2021

A. General

A.1. Stock definition

The genus Lepidorhombus is represented in eastern Atlantic waters by two species, megrim (*L. whiffiagonis*) and four-spot megrim (*L. boscii*). Three stocks of megrims are assessed by ICES: megrim in ICES Subareas 4 and 6, megrim in Divisions 7b-k and 8abd and megrim in Divisions 8c and 9a.

Four-spot megrim (*L. boscii*) is distributed in both ICES Divisions (8c and 9a), being more southerly present than megrim (Sánchez *et al*., 2002). There is a certain bathymetric segregation between the two species of megrim. *L. boscii* has a preferential depth range of 100 to 450 m and *L. whiffiagonis* of 50 to 300 m (Sanchez *et al*, 1998).

A.2. Fishery

Management of megrim is both by TAC and technical measures. The two species (*L. whiffiagonis* and *L. boscii*) are managed under a common TAC. They are caught and recorded together in the landings statistics. It is impossible to manage each species separately under a common TAC. The spatial distribution of the two stocks shows some differences that could be utilized for separate management of the two stocks.

The minimum mesh size for towed gears ranges between 55–70 mm, depending on catch species composition. Minimum landing size for the two species changed from 25 to 20 cm in year 2000 (Council Regulation EC 850/98).

Both megrim species are included in the landings from ICES Divisions 8c and 9a. The percentage of megrim (*L. boscii*) in landings of both species by weight was between 94% and 63% over the whole period for which data are available.

Both species of megrims are taken as by-catch in the mixed bottom trawl fisheries targeting "white fish" by Portuguese and Spanish fleets, and also in small quantities by the Portuguese artisanal fleet. The majority of the catches are taken by Spanish trawlers. No landings data are available for these stocks before 1986, although some Spanish harbours have longer landings series. Total international landings for both stocks of megrims increased sharply from 1986 to 1989, when they reached 3340 t, and then showed a continuous declining trend until their lowest level of 837 t in 2002. There has been some increase in landings since that year, being 1531 t in 2014, the maximum value of the last decade.

Since the early 1990's the Spanish bottom trawl fleet has diversified its fishing strategy, introducing a new trawl gear which targets primarily pelagic species (as horse mackerel and mackerel) (Punzón *et al*, 2010; Castro *et al*, 2011). This gear affects catches of *L. boscii* more than those of *L. whiffiagonis*, probably due to differences between the distribution area of both species. Also, the fishing ban for all trawlers in grounds within 100 m depth (RD 1441/1999, 10 sept) may affect in the proportion of both species in catches due to their different bathymetric distribution.

The Prestige oil spill in the northwest Spanish coast (November 2002) prompted a redistribution of fishing effort, particularly in the Galician area. Some regulation measures, such as spatial and seasonal closures, were adopted in order to minimise the oil spill impact on fisheries. Some trawl fleets display lower effort in 2003 in relation to later years (Abad *et al*, 2010).

Horse mackerel, Atlantic mackerel, blue whiting, anglerfish, hake, megrim, different cephalopods and *Nephrops* account for a high percentage (around 90%) of all retained species in this multispecies trawl fishery (Castro *et al*, 2011, Abad *et al*, 2020). A great number of species are caught as by-catch.

Discards are important, particularly for younger ages of both megrim species. Around 10-65% of the individuals caught are discarded by trawlers (Pérez *et al*, 2011). Lack of commercial interest, variations in market price, fish size (MLS or market size), storage capacity as well as distance to home port are the main reasons for discarding. Artisanal fleets catch few megrims and discards of all species in these fleets are very low.

Megrims have been affected by the Recovery Plan for the Southern hake and Iberian *Nephrops* stocks (Council Regulation EC 2166/2005), since January of 2006, with the fishing effort limitation measurements in the Spanish and Portuguese mixed trawl fisheries.

A.3. Ecosystem aspects

The Iberian Region along the eastern Atlantic shelf (Divisions 8c and 9a) is an upwelling area with high productivity, especially along the Portuguese and Galician coasts; upwelling takes place during late spring and summer (Álvarez-Salgado *et al*., 2002; Serrano *et al*., 2008). The region is characterized by a large number of commercial and non-commercial fish species caught for human consumption.

Many flatfish species show a gradual offshore movement of juveniles as they grow. This might indicate that habitat quality for flatfish is size-dependent. Another common pattern is the annual micro- and macroscale movements and migrations between spawning, feeding and wintering areas (Gibson 1994). Also, most flatfishes are associated with finer sediments, rather than with hard substrata because burying themselves provides some protection from predators and reduces the use of energy (van der Veer *et al*., 1990, 2000; Beverton and Iles 1992; Bailey 1994; Wennhage and Pihl 2001).

Previous studies on megrim species show that they generally occurred outside zones with hydrographical instabilities that foster the vertical interchange of organic matter (Sánchez and Gil, 1995) and disappear at the mouth of the most important rivers (Sánchez *et al*., 2001). Both species appear to show a gradual expansion in their bathymetric distribution throughout their lifetimes, with the larger individuals tending to occupy shallower waters than the juveniles.

Bearing in mind that the two species have similar characteristics, a certain degree of interspecific competition may be assumed (Sanchez *et al*, 1998).

Juveniles of these species feed mostly on detritivore crustaceans inhabiting deep-lying muddy bottoms. Adult *L. boscii* feeds mainly on crustaceans inhabiting muddy surfaces (Rodriguez-Marín and Olaso, 1993; Rodriguez-Marín, 2002). None of the two species represent an important part of the diet for the main fish predators in the area. However, Velasco (IEO, Santander, Spain, pers. comm.) observed that they are occasionally present in stomach contents of hake, anglerfish and rays.

The spawning period of these species is short. In southern areas megrims spawn from January to April, but spawning peaks in March (BIOSDEF, 1998; study contract 95/038).

The growth rate also varies (Landa *et al*, 1996; Landa, 1999), growth is quicker in the southern area for both species but the maximum length attained is smaller than in the north. The maximum age for four-spot megrim in Divisions 8c and 9a is 11 years (Landa *et al*, 2002, Landa, pers. com.).

B. Data

B.1. Commercial catch

Landings

Landings data are provided by National Government and research institutions of Spain and Portugal. The available series began in 1986.

The proportions of each megrim species in Portuguese and Spanish landings are estimated using the relative abundances of the two species of megrim in the sampled landings.

For *L. boscii,* landings present an increase at the beginning of the time series; after that, they have generally declined to their lowest value in 2002 and, since then, the general trend is to increase smoothly.

Discards

Discards estimates are available for Spanish trawlers in some years and are used in this assessment, where discards are missing, mainly in the historic data these have been estimated using the mean of the time-series for each age. A discarding sampling programme runs regularly since the establishment of the European Data Collection Programme in 2003. Before this year, Spanish discards data are available only for 1994, 1997, 1999 and 2000. The raising procedure used to estimate Spanish discards for the sampled years was based on effort.

In order to include discards data in the assessment, discards estimates from the average by period have been used for imputing missing data. For the first period (1986-1999), the average of available years 1994, 1997 and 1999 were used and for the second period (2000-2012) the absence of data in 2001 and 2002 was replaced by the average of the closest years. The raison of using these two periods is the change of the Minimum landing size (MLS) in 2000 that could bring a shift in the discarding behaviour. The whole time series of discards have been added to the landings data to calculate catch data.

B.2. Biological

Landings numbers at length

For *L. boscii*, annual length distributions are available for Spanish and Portuguese landings since 1986 and 1998, respectively.

There has been a strong decrease in landings of fish under 15 cm in length since 1994 and under 20 cm in recent years for both species. This change probably results from stricter enforcement of the minimum landing size and a mesh size increase regulation in year 2000.

Catch numbers at age

Age compositions of landings are based on annual Spanish ALKs since 1990, whereas a survey ALK from 1986 combined with an annual ALK from 1990 was applied to years 1986–1989. Landings weights-at-age are also used as the weights-at-age in the stock. The following parameter values were used in the length-weight relationship (BIOSDEF, 1998):

	L. boscii
a	0.00431
b	3.1904

Natural mortality is set to 0.2 and assumed constant over all ages and years.

The sex combined maturity ogive (BIOSDEF, 1998) is assumed constant over time, with the following proportions of fish mature at each age:

Age	0	1	2	3	4	5+
L. Boscii	0	0.55	0.86	0.97	0.99	1

B.3. Surveys

The Portuguese October groundfish survey (PtGFS-WIBTS-Q4) and the Portuguese Crustacean survey (PT-CTS (UWTV (FU 28-29))) and one Spanish groundfish survey (SpGFS-WIBTS-Q4) series are available since 1990, 1997 and 1983, respectively.

It should be taken into consideration that during years 1996, 1999, 2003, 2004 and 2012 the October Portuguese survey was carried out with a different vessel and gear from the one used in the rest of the series. The Crustacean survey was performed with different vessels in different years and covers a partial area; in 2004 it had many operational problems.

For these reasons and because indices from these surveys are not considered to be representative of megrim abundance, due to the very low catch rates, only the Spanish survey (SpGFS-WIBTS-Q4) is used in the assessment of the two species. The survey covers the distribution area and depth strata of these species in Spanish waters (covering both 8c and 9a). The survey appears to be quite good at tracking some cohorts through time.

B.4. Commercial CPUE

LPUE and Fishing Effort data are available for the following fleets: Spanish trawlers targeting demersal fish based in A Coruña port (SP-LCGOTBDEF) and in Avilés port (SP-AVSOTBDEF) fishing in Division 8c since 1986 and Portuguese trawlers fishing in Division 9a since 1988. Effort from the Portuguese fleet is estimated from a sample of logbooks from sea trips where megrim occurred in the catch.

Commercial fleets used in the assessment of *L.boscii* to tune the model

SP-LCGOTBDEF: This fleet contributed with data of effort (fishing days per 100 horse power), LPUE (as kg per fishing day per 100 horse power) and length composition of landings. Because of trends in the residuals, this fleet has been split in two periods, 1986-1999 (SP-LCGOTBDEF-1) and 2000-current year (SP-LCGOTBDEF-2).

B.5. Other relevant data

C. Assessment: data and method

Model used: Extended Survivors Analysis (XSA), (Shepherd, 1992)

- Software used: VPA95 Lowestoft suite.

Model Options chosen *L. boscii*:

- Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year
Caton	Catch in tonnes	1986–present	0–7+	Yes
Canum	Catch at age in numbers	1986–present	0–7+	Yes
Weca	Weight at age in the commercial catch	1986–present	0–7+	Yes
West	Weight at age of the spawning stock at spawning time.	1986–present	0–7+	Yes
Mprop	Proportion of natural mortality before spawning	1986–present	0–7+	No
Fprop	Proportion of fishing mortality before spawning	1986–present	0–7+	No
Matprop	Proportion mature at age	1986–present	0–7+	No
Natmor	Natural mortality	1986–present	0–7+	No

- Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1	SP-LCGOTBDEF1	1986–1999	3–6
Tuning fleet 2	SP-LCGOTBDEF2	2000–present	3–6
Tuning survey 1	SpGFS-WIBTS-Q4	1988–present	0–6

- Model options:

TYPE	SETTING
Taper	No
Tuning range	
Ages catch dep. on stock size	Independant
Q plateau	5
F shrinkage s.e.	1.5
Shrinkage year range	5
Shrinkage age range	3
Fleet s.e.threshold	0.3
F bar range	2–4

D. Short-Term Projection

- *L. boscii*
- Model used: Age structured

Software used: MFDP prediction with management option table and yield per recruit routines.

Initial stock size: Taken from the XSA survivors.

- Recruitment-at-age 0 assumed equal in all projection years (GM from 1990 to final assessment year minus 2).
- If if the XSA last year recruitment is considered poorly estimated, age 1 is replaced by GM90-final assessment year minus 2 reduced by total estimated mortality, obtained from the fishing mortality of age 0 of the last year and the natural mortality.

Maturity: Average maturity ogive for the last three years.

F and M before spawning: Set to 0 for all ages in all years.

- Weight at age in the stock: Average stock weights for the last five years or an appropriate number of years selected by the working group.
- Weight at age in the catch: Average of the last five years or an appropriate number of years selected by the working group.
- Exploitation pattern: Scale F-at-age within each year, then average the scaled last five years weighted to the final year or an appropriate number of years selected by the working group.
- Intermediate year assumptions: Average Fbar for the last three years.
- Stock recruitment model used: Stock recruitment model used: None. Recruitment-at-age 0 assumed equal in all projection years (GM from 1990 to final assessment year minus 2).
- Procedures used for splitting projected catches: Forecast catch numbers-at-age are divided into landings and discards (at age) based on the proportions given as inputs to the projection software; the software does it automatically. These proportions were tak-

en (for each age) to be those corresponding to the observed average of the most recent 5 years.

E. Medium-Term Projections

Medium term projections are not conducted for these stocks.

F. Long-Term Projections

Model used: yield and biomass per recruit over a range of F values.

Software used: MFYPR.

Yield per recruit calculations are conducted using the same input values as those used for the short term forecasts.

G. Biological Reference Points

During the 2015 WKMSYREF4, the software EqSim was used to define biological reference points for this stock. The methodology is described in the report of the workshop (ICES, 2015). Also, an ICES special request adviced was published with F_{MSY} ranges (ICES, 2016).

L. boscii

	Type	Value	Technical basis
MSY Approach	MSY $B_{trigger}$	4600 t	Bpa
	F_{MSY}	0.193	
	F_{MSY} lower	0.125	based on 5% reduction in yield
	F_{MSY} upper (with advice rule)	0.29	based on 5% reduction in yield
	F_{MSY} upper (without advice rule)	0.29	based on 5% reduction in yield
	$F_{P.05}$	0.58	5% risk to B_{lim} witht $B_{trigger}$.
Precautionary Approach	B_{lim}	3300 t	B_{loss} estimated in 2015
	B_{pa}	4600 t	1.4 B_{lim}
	F_{lim}	Undefined	
	F_{pa}*	0.58	F $_{p0.5}$: F that provides a 95% probability for SSB to be above Blim

* Fpa was defined as Fp0.5 by ACOM in 2020.

H. Other Issues

H.1. Historical overview of previous assessment methods

WG YEAR	2016	2017	2018	2019	2020	2021
Model	XSA	XSA	XSA	XSA	XSA	XSA
Software	VPA95 Lowestoft suite	VPA95 Lowestoft suite	VPA95 Lowestoft suite	VPA95 Lowestoft suite	VPA95 Lowestoft suite	VPA95 Lowestoft suite
Stock	*L.boscii*	*L.boscii*	*L.boscii*	*L.boscii*	*L.boscii*	*L.boscii*
Catch data range	Landings and Discards 1986-2015	Landings and Discards 1986-2016	Landings and Discards 1986-2017	Landings and Discards 1986-2018	Landings and Discards 1986-2019	Landings and Discards 1986-2020
Age range in catch data	0-7+	0-7+	0-7+	0-7+	0-7+	0-7+
SP-CORUTR8c						
SP-LCGOTBDEF1	1986–1999 Ages 3–6	1986–1999 Ages 3–6	1986–1999 Ages 3–6	1986–1999 Ages 3–6	1986–1999 Ages 3–6	1986–1999 Ages 3–6
SP-LCGOTBDEF2	2000–2015 Ages 3–6	2000–2016 Ages 3–6	2000–2017 Ages 3–6	2000–2018 Ages 3–6	2000–2019 Ages 3–6	2000–2019 Ages 3–6
SP-GFS survey	1988–2015 (2003 and 2013 not included) Ages 0–6	1988–2016 (2003 and 2013 not included) Ages 0–6	1988–2017 (2003 and 2013 not included) Ages 0–6	1988–2018 (2003 and 2013 not included) Ages 0–6	1988–2019 (2003 and 2013 not included) Ages 0–6	1988–2020 (2003 and 2013 not included) Ages 0–6
Taper	No	No	No	No	No	No
Tuning range	30	31	32	33	34	35
Ages catch dep. Stock	Independent	Independent	Independent	Independent	Independent	Independent
Q plateau	5	5	5	5	5	5
F shrinkage se	1.5	1.5	1.5	1.5	1.5	1.5
Year range	5	5	5	5	5	5

WG YEAR	2016	2017	2018	2019	2020	2021
Age range	3	3	3	3	3	3
Fleet se threshold	0.3	0.3	0.3	0.3	0.3	0.3
F bar range	2-4	2-4	2-4	2-4	2-4	2-4

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Stock Annex: Megrim (*Lepidorhombus whiffiagonis*) in divisions 8.c and 9.a (Cantabrian Sea and Atlantic Iberian waters)

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Southern megrim (Division 8c, 9a)_meg.27.8c9a
Working Group:	Working Group for the Bay of Biscay and Iberian Waters Ecoregion (WGBIE)
Date:	13 May 2014
Revised by	WGBIE2021

A. General

A.1. Stock definition

The genus Lepidorhombus is represented in eastern Atlantic waters by two species, megrim (*L. whiffiagonis*) and four-spot megrim (*L. boscii*). Three stocks of megrims are assessed by ICES: megrim in ICES Subareas 4 and 6, megrim in Divisions 7b-k and 8a,b,d and megrim in Divisions 8c and 9a.

Megrim (*L. whiffiagonis*) is in both ICES Divisions (8c and 9a), with its highest abundance in Division 8c (Sánchez *et al.*, 2002). There is a certain bathymetric segregation between the two species of megrim. *L. boscii* has a preferential depth range of 100 to 450 m and *L. whiffiagonis* of 50 to 300 m (Sanchez *et al*, 1998).

A.2. Fishery

Management of megrim is both by TAC and technical measures. The two species (*L. whiffiagonis* and *L. boscii*) are managed under a common TAC. They are caught and recorded together in the landings statistics. It is impossible to manage each species separately under a common TAC. The spatial distribution of the two stocks shows some differences that could be utilized for separate management of the two stocks.

The minimum mesh size for towed gears ranges between 55 and 70 mm, depending on catch species composition. Minimum landing size for the two species changed from 25 to 20 cm in year 2000 (Council Regulation EC 850/98).

Both megrim species are included in the landings from ICES Divisions 8c and 9a. The percentage of megrim (*L. whiffiagonis*) in landings of both species by weight was between 6% and 37% over the whole period for which data are available.

Both species of megrims are taken as by-catch in the mixed bottom trawl fisheries targeting "white fish" by Portuguese and Spanish fleets, and also in small quantities by the Portuguese artisanal fleet. The majority of the catches are taken by Spanish trawlers. No landings data are available for these stocks before 1986, although some Spanish harbours have longer landings series. Total international landings for both stocks of megrims increased sharply from 1986 to 1989, when they reached 3340 t, and then showed a continuous declining trend until their lowest level of 837 t in 2002. There has been some increase in landings since that year, being 1531 t in 2014, the maximum value of the last decade.

Since the early 1990's the Spanish bottom trawl fleet has diversified its fishing strategy, introducing a new trawl gear which targets primarily pelagic species (as horse mackerel and mackerel) (Punzón *et al*, 2010; Castro *et al*, 2011). This gear affects catches of *L. boscii* more than those of *L. whiffiagonis*, probably due to differences between the distribution area of both species. Also, the fishing ban for all trawlers in grounds within 100 m depth (RD 1441/1999, 10 sept) may affect in the proportion of both species in catches due to their different bathymetric distribution.

The Prestige oil spill in the northwest Spanish coast (November 2002) prompted a redistribution of fishing effort, particularly in the Galician area. Some regulation measures, such as spatial and seasonal closures, were adopted in order to minimise the oil spill impact on fisheries. Some trawl fleets display lower effort in 2003 in relation to later years (Abad *et al*, 2010).

Horse mackerel, Atlantic mackerel, blue whiting, anglerfish, hake, megrim, different cephalopods and *Nephrops* account for a high percentage (around 90%) of all retained species in this multispecies trawl fishery (Castro *et al*, 2011, Abad *et al*, 2020). A great number of species are caught as by-catch.

Discards are important, particularly for younger ages of both megrim species. Around 10-65% of the individuals caught are discarded by trawlers (Pérez *et al*, 2011). Lack of commercial interest, variations in market price, fish size (MLS or market size), storage capacity as well as distance to home port are the main reasons for discarding. Artisanal fleets catch few megrims and discards of all species in these fleets are very low.

Megrims have been affected by the Recovery Plan for the Southern hake and Iberian *Nephrops* stocks (Council Regulation EC 2166/2005), since January of 2006, with the fishing effort limitation measurements in the Spanish and Portuguese mixed trawl fisheries.

A.3. Ecosystem aspects

The Iberian Region along the eastern Atlantic shelf (Divisions 8c and 9a) is an upwelling area with high productivity, especially along the Portuguese and Galician coasts; upwelling takes place during late spring and summer (Álvarez-Salgado *et al*., 2002; Serrano *et al*., 2008). The region is characterized by a large number of commercial and non-commercial fish species caught for human consumption.

Many flatfish species show a gradual offshore movement of juveniles as they grow. This might indicate that habitat quality for flatfish is size-dependent. Another common pattern is the annual micro- and macroscale movements and migrations between spawning, feeding and wintering areas (Gibson 1994). Also, most flatfishes are associated with finer sediments, rather than with hard substrata because burying themselves provides some protection from predators and reduces the use of energy (van der Veer *et al*., 1990, 2000; Beverton and Iles 1992; Bailey 1994; Wennhage and Pihl 2001).

Previous studies on megrim species show that they generally occurred outside zones with hydrographical instabilities that foster the vertical interchange of organic matter (Sánchez and Gil, 1995) and disappear at the mouth of the most important rivers (Sánchez *et al*., 2001). Both species appear to show a gradual expansion in their bathymetric distribution throughout their lifetimes, with the larger individuals tending to occupy shallower waters than the juveniles. Bearing in mind that the two species have similar characteristics, a certain degree of interspecific competition may be assumed (Sanchez *et al*, 1998).

Juveniles of these species feed mostly on detritivore crustaceans inhabiting deep-lying muddy bottoms. Adults *L. whiffiagonis* are more ichthyophagous and rates of crustacean in diet decrease with fish size (Rodriguez-Marín, 2002). None of the two species represent an important part of the diet for the main fish predators in the area. However, Velasco (IEO, Santander, Spain, pers. comm.) observed that they are occasionally present in stomach contents of hake, anglerfish and rays.

The spawning period of these species is short. In southern areas megrims spawn from January to April, but spawning peaks in March (BIOSDEF, 1998; study contract 95/038).

The growth rate also varies (Landa *et al*, 1996; Landa, 1999), growth is quicker in the southern area for both species but the maximum length attained is smaller than in the north. The maximum age for megrim also varies with latitude. In Subarea 7 the maximum age of megrim is 14 years, this decreases to 12 years in Divisions 8c and 9a (BIOSDEF, 1998; Landa et. al, 2000).

B. Data

B.1. Commercial catch

Landings

Landings data are provided by National Government and research institutions of Spain and Portugal. The available series began in 1986.

The proportions of each megrim species in Portuguese and Spanish landings are estimated using the relative abundances of the two species of megrim in the sampled landings.

For *L. whiffiagonis*, landings present an increase for a few years at the beginning of the time series and a general declining trend till 2011. Since then, the stock is increasing again.

Discards

Discards estimates are available for Spanish trawlers in some years and are used in this assessment, where discards are missing, mainly in the historic data these have been estimated using the mean of the time-series for each age. A discarding sampling programme runs regularly since the establishment of the European Data Collection Programme in 2003. Before this year, Spanish discards data are available only for 1994, 1997, 1999 and 2000. The raising procedure used to estimate Spanish discards for the sampled years was based on effort.

In order to include discards data in the assessment, discards estimates from the average by period have been used for imputing missing data. For the first period (1986-1999), the average of available years 1994, 1997 and 1999 were used and for the second period (2000-2012) the absence of data in 2001 and 2002 was replaced by the average of the closest years. The raison of using these two periods is the change of the Minimum landing size (MLS) in 2000 that could bring a shift in the discarding behaviour. The whole time series of discards have been added to the landings data to calculate catch data.

B.2. Biological

Landings numbers at length

For *L. whiffiagonis*, annual length distributions were available for both Spanish and Portuguese landings until 1998, when Portuguese length frequency data were mainly based on samples from Aveiro. Due to the uncertainties of this port since 1999, Spanish length distributions were raised to the total international landings for all subsequent years. Portuguese landings only represent 10% of the total landings on average.

There has been a strong decrease in landings of fish under 15 cm in length since 1994 and under 20 cm in recent years for both species. This change probably results from stricter enforcement of the minimum landing size and a mesh size increase regulation in year 2000.

Catch numbers at age

Age compositions of landings are based on annual Spanish ALKs since 1990, whereas a survey ALK from 1986 combined with an annual ALK from 1990 was applied to years 1986-1989. Landings weights-at-age are also used as the weights-at-age in the stock. The following parameter values were used in the length-weight relationship (BIOSDEF, 1998):

	L. whiffiagonis
a	0.006488
b	3.0114

Natural mortality is set to 0.2 and assumed constant over all ages and years. This is the same value used for *L. whiffiagonis* in Divisions 7b-k and 8abd.

The sex combined maturity ogive (BIOSDEF, 1998) is assumed constant over time, with the following proportions of fish mature at each age:

Age	0	1	2	3	4	5+
L. whiffiagonis	0	0.34	0.90	1	1	1

B.3. Surveys

The Portuguese October groundfish survey (PtGFS-WIBTS-Q4) and the Portuguese Crustacean survey (PT-CTS (UWTV (FU 28-29))) and one Spanish groundfish survey (SpGFS-WIBTS-Q4) series are available since 1990, 1997 and 1983, respectively.

It should be taken into consideration that during years 1996, 1999, 2003, 2004 and 2012 the October Portuguese survey was carried out with a different vessel and gear from the one used in the rest of the series. The Crustacean survey was performed with different vessels in different years and covers a partial area; in 2004 it had many operational problems.

For these reasons and because indices from these surveys are not considered to be representative of megrim abundance, due to the very low catch rates, only the Spanish survey (SpGFS-WIBTS-Q4) is used in the assessment of the two species. The survey covers the distribution area and depth strata of these species in Spanish waters (covering both 8c and 9a). The survey appears to be quite good at tracking cohorts through time *for L. whiffiagonis*.

B.4. Commercial CPUE

LPUE and Fishing Effort data are available for the following fleets: Spanish trawlers targeting demersal fish based in A Coruña port (SP-LCGOTBDEF) and in Avilés port (SP-AVSOTBDEF) fishing in Division 8c since 1986 and Portuguese trawlers fishing in Division 9a since 1988. Effort from the Portuguese fleet is estimated from a sample of logbooks from sea trips where megrim occurred in the catch.

Commercial fleets used in the assessment of L.whiffiagonis to tune the model

SP-LCGOTBDEF: This fleet contributed with data of effort (fishing days per 100 horse power), LPUE (as kg per fishing day per 100 horse power) and length composition of landings.

SP-AVSOTBDEF: This fleet contributed with data of effort (fishing days per 100 horse power), LPUE (as kg per fishing day per 100 horse power) and length composition of landings.

B.5. Other relevant data

C. Assessment: data and method

Model used: Extended Survivors Analysis (XSA), (Shepherd, 1992)

- Software used: VPA95 Lowestoft suite.

Model Options chosen *L. whiffiagonis*:

- Input data types and characteristics

Type	Name	Year range	Age range	Variable from year to year
Caton	Catch in tonnes	1986–present	1–7+	Yes
Canum	Catch at age in numbers	1986–present	1–7+	Yes
Weca	Weight at age in the commercial catch	1986–present	1–7+	Yes
West	Weight at age of the spawning stock at spawning time.	1986–present	1–7+	Yes
Mprop	Proportion of natural mortality before spawning	1986–present	1–7+	No
Fprop	Proportion of fishing mortality before spawning	1986–present	1–7+	No
Matprop	Proportion mature at age	1986–present	1–7+	No
Natmor	Natural mortality	1986–present	1–7+	No

- Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1	SP-LCGOTBDEF	1986–present	3–6
Tuning fleet 2	SP-AVSOTBDEF	1986–present	3–6
Tuning survey 1	SpGFS-WIBTS-Q4	1990–present	1–6

- Model options:

Type	Setting
Taper	No
Tuning range	
Ages catch dep. on stock size	1–2
Q plateau	5
F shrinkage s.e.	1.5
Shrinkage year range	5
Shrinkage age range	3
Fleet s.e.threshold	0.2
F bar range	2–4

D. Short–Term Projection

- *L. whiffiagonis*
- Model used: Age structured

Software used*:* MFDP prediction with management option table and yield per recruit routines.

Initial stock size: Taken from the XSA survivors.

- Recruitment-at-age 1 assumed equal in all projection years (GM from 1998 to final assessment year minus 2).
- If if the XSA last year recruitment is considered poorly estimated, age 2 is replaced by GM98- final assessment year minus 2 reduced by total estimated mortality, obtained from the fishing mortality of age 1 of the last year and the natural mortality.

Maturity: Average maturity ogive for the last three years

F and M before spawning: Set to 0 for all ages in all years.

Weight at age in the stock: Average stock weights for the last five years or an appropriate number of years selected by the working group.

Weight at age in the catch: Average of the last five years or an appropriate number of years selected by the working group.

- Exploitation pattern: Scale F-at-age within each year, then average the scaled last five years weighted to the final year or an appropriate number of years selected by the working group.
- Intermediate year assumptions: Average Fbar for the last three years.
- Stock recruitment model used: None.
- Procedures used for splitting projected catches: Forecast catch numbers-at-age are divided into landings and discards (at age) based on the proportions given as inputs to the projection software; the software does it automatically. These proportions were taken (for each age) to be those corresponding to the observed aver-age of the most recent 5 years.

E. Medium-Term Projections

Medium term projections are not conducted for these stocks.

F. Long-Term Projections

Model used: yield and biomass per recruit over a range of F values.

Software used: MFYPR.

Yield per recruit calculations are conducted using the same input values as those used for the short term forecasts.

G. Biological Reference Points

During the 2015 WKMSYREF4, the software EqSim was used to define biological reference points for this stock. The methodology is described in the report of the workshop (ICES, 2015). Also, an ICES special request adviced was published with F_{MSY} ranges (ICES, 2016).

L. whiffiagonis

	Type	Value	Technical basis
MSY Approach	MSY $B_{trigger}$	980 t	B_{pa}
	F_{MSY}	0.191	
	F_{MSY} lower	0.122	based on 5% reduction in yield
	F_{MSY} upper (with advice rule)	0.29	based on 5% reduction in yield
	F_{MSY} upper (without advice rule)	0.24	based on 5% reduction in yield
	$F_{P.05}$	0.40	5% risk to B_{lim} witht $B_{trigger}$.
Precautionary Approach	B_{lim}	700 t	B_{loss} estimated in 2015
	B_{pa}	980 t	1.4 B_{lim}
	F_{lim}	0.45	Based on segmented regression simulation of recruitment with B_{lim} as the breakpoint and no error
	F_{pa}*	0.40	$F_{p0.5}$: F that provides a 95% probability for SSB to be above Blim

* Fpa was defined as Fp0.5 by ACOM in 2020.

H. Other Issues

H.1. Historical overview of previous assessment methods

WG YEAR	2016	2017	2018	2019	2020	2021
Model	XSA	XSA	XSA	XSA	XSA	XSA
Software	VPA95 Lowestoft suite	VPA95 Lowestoft suite	VPA95 Lowestoft suite	VPA95 Lowestoft suite	VPA95 Lowestoft suite	VPA95 Lowestoft suite
Stock	*L.whiffiagonis*	*L.whiffiagonis*	*L.whiffiagonis*	*L.whiffiagonis*	*L.whiffiagonis*	*L.whiffiagonis*
Catch data range	Landings and Discards 1986–2015	Landings and Discards 1986–2016	Landings and Discards 1986–2017	Landings and Discards 1986–2018	Landings and Discards 1986–2019	Landings and Discards 1986–2020
Age range in catch data	1–7+	1–7+	1–7+	1–7+	1–7+	1–7+
SP-LCGOTEBDEF	1986–2015 Ages 3–6	1986–2016 Ages 3–6	1986–2017 Ages 3–6	1986–2018 Ages 3–6	1986–2019 Ages 3–6	1986–2019 Ages 3–6
SP-AVSOTBDEF	1986–2015 Ages 3–6	1986–2016 Ages 3–6	1986–2017 Ages 3–6	1986–2018 Ages 3–6	1986–2019 Ages 3–6	1986–2019 Ages 3–6
SpGFS-WIBTS-Q4 survey	1990–2015 Ages 1–6	1990–2016 Ages 1–6	1990–2017 Ages 1–6	1990–2018 Ages 1–6	1990–2019 Ages 1–6	1990–2020 Ages 1–6
Taper	No	No	No	No	No	No
Tuning range	26	27	28	29	30	31
Ages catch dep. stock size	1–2	1–2	1–2	1–2	1–2	1–2
Q plateau	5	5	5	5	5	5
F shrinkage s.e.	1.5	1.5	1.5	1.5	1.5	1.5
Shrinkage year range	5	5	5	5	5	5
Shrinkage age range	3	3	3	3	3	3
Fleet s.e. threshold	0.2	0.2	0.2	0.2	0.2	0.2
F bar range	2–4	2–4	2–4	2–4	2–4	2–4

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Annex E Stock Annex–Megrim (*Lepidorhombus whiffiagonis*) in Divisions 7b–k and 8a,b,d

Quality Handbook	Stock specific documentation of standard assessment procedures used by ICES.
Stock	Megrim (*Lepidorhombus whiffiagonis*) in Divisions 7b–k and 8a,b,d
Working Group	Working Group for the Bay of Biscay and the Iberian waters Ecoregion (WGBIE)
Date	Updated May 2021
Revised by	Ane Iriondo

General

A.1. Stock definition

Since the end of the 1970s ICES has assumed three different stocks for assessment and management purposes: megrim in ICES Subarea 6, megrim in Divisions 7b–k and 8a,b,d and megrim in Divisions 8c and 9a. The stock under this Annex is called northern Megrim and defined as megrim in Divisions 7b–k and 8a,b,d.

A.2. Fishery

Megrim in the Celtic Sea, west of Ireland, and in the Bay of Biscay are caught in a mixed fishery predominantly by French followed by Spanish, UK and Irish demersal vessels. In 2014, the four countries together reported around 96% of the total landings

French benthic trawlers operating in the Celtic Sea and targeting benthic and demersal species catch megrim as a bycatch.

Spanish fleets catch megrim targeting them and in mixed fisheries for hake, anglerfish, *Nephrops* and others. Otter trawlers account for the majority of Spanish landings from Subarea 7, the remainder, very low quantities, being taken by netters prosecuting a mixed fishery for anglerfish, hake and megrim on the shelf edge around the 200 m contour to the south and west of Ireland. The catches made by otter trawlers from the port of Vigo comprise around 50% of the total catches.

Most UK landings of megrim are made by beam trawlers fishing in ICES Divisions 7e,f,g,h.

Irish megrim landings are largely made by multi-purpose vessels fishing in Divisions 7b,c,g for gadoids as well as plaice, sole and anglerfish.

Countries	ICES area	% landings (based on 2014 landings data)	Fisheries
Spain	Divisions 7b,c,e–k and 8a,b,d	25%	Otter trawls targeting mixed groups of species (hake, anglerfish, Nephrops and other). Netters targeting also mixed species (anglerfish, hake and megrim)
France	Subarea 7	32%	Benthic trawlers targeting benthic and demersal species
Ireland	Divisions 7b,c,g	18%	Multipurpose vessels targeting gadoids, plaice, sole and anglerfish
UK (England and Wales)	ICES Divisions 7e,f,g,h	22%	Beam trawlers
Belgium	Divisions 7b,c,e–k and 8a,b,d	1%	Beam trawlers

A.3. Ecosystem aspects

There are two megrim species in the North eastern Atlantic: megrim (*Lepidorhombus-whiffiagonis*) and four spot megrim (*Lepidorhombus boscii*).

Megrim (*L.whiffiagonis*, Walbaum, 1792) is a pleuronectiform fish distributed from the Faroe Islands to Mauritania (from 70°N to 26°N) and the Mediterranean Sea, at depths ranging from 50 to 800 metres but more precisely around 100–300 metres (Aubin-Ottenheimer, 1986).

Four spot megrim (*L. boscii*, Risso 1810) is distributed from the Faroe Islands (63°N) to Cape Bojador and all around the Mediterranean Sea. It is found between 150–650 m, but mostly between 200–600 m.

Although, there is no evidence of multiple populations in the Northeast Atlantic, since the end of the 1970s ICES has assumed three different stocks for assessment and management purposes: megrim in Subarea 6, megrim in Divisions 7b,c,e–k and 8a,b,d and megrim in Divisions 8c and 9a.

Spawning period of these stocks goes from January to March. Megrim spawning peak occurs in February (8a,b,d) and March (7) along the shelf edge. Males reach the first maturity at a lower length and age than females. For both sexes combined, fifty percent of the individuals mature at about 20 cm and about 2.5 year old (BIOSDEF, 1998; Santurtún *et al.*, 2000). Their eggs are spherical, pelagic, with a furrow (stria) in the internal part of the membrane and with a fat globule.

Megrim is a demersal species of small-medium size with a maximum size about 60 cm. It is believed that it has a medium-large lifespan, with a maximum age of about 14–15 years. It lives mainly in muddy bottoms, showing a gradual expansion in bathymetric distribution throughout their lifetimes, where mature males and juveniles tend to occupy deep waters, immature females shallower waters and, during the very short period when females are mature, the dynamics remain unclear.

The Bay of Biscay and Iberian shelf are considered as a single biogeographic ecotone (a zone of transition between two different ecosystems) where southern species at the northern edge of their range meet northern species at the southern edge of their range as well as for some other Mediterranean species. Since species at the edge of their range may react faster to climate changes, this area is of particular interest in accounting for effects of climate change scenarios, for instance, in the food-web models (BECAUSE, 2004).

Megrim belongs to a very extended and diverse community of commercial species and it is caught in mixed fisheries by different gears and in different sea areas. Some of the commercial species that exist in the same ecosystem are hake and anglerfish, however many other species are also found. From the northern to southern areas of the extent of the stock these species include: Octopus, *Rajidae, Ommastrephidae, Nephropsnorvegicus, Phycisblennoides, Molva molva, Pollachius virens, Trisopterus* spp (mainly *Trisopterusluscus*), *Trachurus* spp, *Sepia officinalis*, Loligidae, *Micromesistius poutassou, Merlangius merlangus, Scyliorhynus canicula* and *Pollachius pollachius*.

Demersal fish prey on megrim. Megrims are very voracious predators. Prey species include flatfish, sprat, sandeels, dragonets, gobies, haddock, whiting, pout and several squid species.

Adult megrim feed on small bottom dwelling fish, cephalopods and small benthic crustaceans; juvenile megrim feed on small fish and detritivore crustaceans inhabiting deep-lying muddy bottoms (Rodriguez-Marín and Olaso, 1993).

It is believed that megrim movements are more aggregation and disaggregation movements in the same area instead of highly migratory movements between areas (Perez, pers. comm.).

Although a comprehensive study on the role of megrim in the ecosystem of the complete sea area distribution has not been carried out, some general studies are available.

Fisheries modify ecosystems through more impacts on the target resource itself, the species associated to or dependent on it (predators or preys), on the tropic relationships within the ecosystem in which the fishery operates, and on the habitat.

At present, both the multi species aspect of the fishery and the ecological factors or environmental conditions affecting megrim population dynamics are not taken into account in assessment and management. This is due to the lack of knowledge of these issues.

Data

Data are supplied from databases maintained by national Government Departments and research institutions. The figures used in assessment are considered as the best available data at the Working Group time of the year. From year to year, and before the Working Group, small revisions of data could occur. In that case, revised data are explained and incorporated into the historical data series for assessment.

Data are supplied on electronic files to a stock coordinator nominated by the ICES Working Group for the Bay of Biscay and the Iberian Waters Ecoregion (formerly Hake, Monk and Megrim Working Group), who compiles the international landings, discards and catch-at-age data, and maintains the time-series of such data with the amendments proposed by countries.

B.1. Commercial catch

Landings data are supplied from databases maintained by national Government Departments and research institutions. Countries providing landing data by quarter and ICES division are Spain, France, Ireland, United Kingdom and Belgium.

B.2. Discard data

In many fisheries, discards constitute a major contribution to fishing mortality in younger ages of commercial species. However, relatively few assessments in ICES stock working groups take discards into consideration. This happens mostly due to the long time-series needed (not available for all the fleets involved in the exploitation of most stocks) but also to the large amount of research effort needed to obtain this kind of information (Alverson *et al.*, 1994; Kulka, 1999). The knowledge of discards and their use in stock assessment may also contribute, in cooperation with the industry, to refine fishing and management strategies (Kulka, 1999).

Spain started sampling discards on board commercial vessels in 1988, more specifically the Spanish trawl fleet operating in Subareas 6 and 7 was firstly target. During 1994, discard sampling was undertaken for other fleets (longliner (EC Project: Pem/93/005)). Sampling discards continued during 1999, 2000 for 4, 7, 8 and 9 (EC Project: 98/095) and in 2001, partly just for cephalopods and during the first and last quarter of the year (Bellido *et al.*, 2003; Santurtun *et al.*, 2004). Since 2002 and under the National Sampling Programs, Spain continues sampling discards on board commercial fleets.

Until 2003, the standard procedure used for calculation of the Spanish discards estimators was based on a haul basis as described by Trenkel (2001). However, although these procedures were applied, there was not an estimate of the error and variance in every step of the analysis. Errors were only estimated on a haul basis.

From 2003 onwards and following the recommendation of the Workshop on Discard Sampling Methodology and Raising Procedures held in Charlottenlund (Denmark) in 2003 (Anon, 2003), general guidelines on appropriate sampling strategies and methodologies were described and then, the primary sampling unit was defined as the fishing trip instead of haul.

From 2000 to 2001 the minimum legal size (MLS) was reduced from 25 to 20 cm.

Since using the French discards from the 1991 survey to obtain estimates for 1999 and subsequent years was considered unreliable, only the Spanish data were used for these years, applied only to the Spanish fleets. This has led to an artificial decrease in the amount of total discards, since no estimates for French fleets were available.

The lack of discards data was considered the main problem with megrim assessment. This fact resulted in an underestimation of the international catch matrix occurs as some main countries (mostly France) involved in the fishery have not provide discard data. The lack of consistency of the catch series, which could cause great bias in assessment, was also a result of only one country (Spain) providing discard data since 1999.

During the WKFLAT (2012), Spain, United Kingdom (England and Wales) and Ireland provided discard data since 2000. Still France did not provide these data, which led to an artificial decrease in the amount of total discards. Discard data deficiencies were partly overcome as United Kingdom (England and Wales) provided discard raised data from 2000 to 2010. Irish discard data were revised and updated and a new data series were provided since 1995. Spain provided some minor revised values of discards.

France did not provided discard data since 1999, as data appear to be very uncertain in relation to sampling level affecting their representatively.

In Inter-Benchmark 2016 the main aim was to obtain discard information from France which was lacking from 1991 onwards. Finally, an updated discard data from 2004 to 2014 from France was delivered based on the WD presented by IFREMER (WD XX Joel Vigneau).

Discard data available by country and the procedure to derivate them are summarised in Table B.2.1.

Table B.2.1. Megrim (*L.whiffiagonis*) in 7b–k and 8a,b,d. Discards information and derivation.

	FR	SP	IR	UK
1984	FR84-85	-	-	-
1985	FR84-85	-	-	-
1986	(FR84-85)	(SP87)	-	-
1987	(FR84-85)	SP87	-	-
1988	(FR84-85)	SP88	-	-
1989	(FR84-85)	(SP88)	-	-
1990	(FR84-85)	(SP88)	-	-
1991	FR91	(SP94)	-	-
1992	(FR91)	(SP94)	-	-
1993	(FR91)	(SP94)	-	-
1994	(FR91)	SP94	-	-
1995	(FR91)	(SP94)	IR	-
1996	(FR91)	(SP94)	IR	-
1997	(FR91)	(SP94)	IR	-
1998	(FR91)	(SP94)	IR	-
1999	-	SP99	IR	-
2000	-	SP00	IR	UK
2001	-	SP01	IR	UK
2002	-	(SP01)	IR	UK
2003	-	SP03	IR	UK
2004	**FR04**	**SP04**	IR	UK
2005	**FR05**	**SP05**	IR	UK
2006	**FR06**	**SP06**	IR	UK
2007	**FR07**	**SP07**	IR	UK
2008	**FR08**	**SP08**	IR	UK
2009	**FR09**	**SP09**	IR	UK
2010	**FR10**	**SP10**	IR	UK
2011	**FR11**	**SP11 (*)**	IR	UK
2012	**FR12**	**SP12 (*)**	IR	UK
2013	**FR13**	**SP13 (*)**	IR	UK

2014	**FR14**	**SP14 (*)**	IR	UK

- In bold: years where discards sampling programs provided information.

- In (): years for which the length distribution of discards has been derived.

B.3. Biological

Quarterly/annually length/age composition data are supplied from databases maintained by national Government Departments and research institutions. These figures are used as the best available data to carry out the assessment.

France has provided quarterly length distribution by fishery unit and by sex since 1984. For 2002, 2003, 2004 and 2006 French data (length distributions, catch-at-age by FU and ALKs) were not available for the assessment. In 2005 and 2006, length distributions, catch-at-age data by quarter and sex were available. In 2007 and 2008, annual length distributions by sexes were provided. For 2010, no French data were provided to the group. In 2012 (ICES, 2012) France provided revised ALKs and consequently completed number and weights-at-age since 1999.

Annual length compositions of landings are available by country and fishery unit, for the period 1984–1990 by sex. Since 1991, annual length composition has been available for sexes combined for most countries except for France. Since 1999, the length compositions have been available on a quarterly or half-year basis. For Spain, data are available for sexes combined, except in 1993, when data were presented for separate sexes and on an annual basis. As in previous years, derivations were used to provide length compositions where no data other than weights of landings were available.

No ALKs were available for the period 1984–1986, and age compositions for these years were derived from a combined-sex ALK based on age readings from 1987 to 1990.

Quarterly ALKs for separate sexes were available for UK (E&W). Combined Annual ALKs were applied to their length distributions. Annual age composition of discards and half-year landings per fleet, based on half-year ALKs for both sexes combined, were available and applied from Spain in Subarea 7 and in Divisions 8a,b,d. Annual age composition of discards was available based on annual ALKs for both sexes combined were available and applied to Irish and UK (England and Wales) discards. Quarterly age compositions for sexes combined were available for Irish catches for Divisions 7b,c,e–k.

The following table gives the source of length frequencies and ages for Northern Megrim:

	France		Ireland		Spain		UK	
	Length distribution	**ALK**	**Length distribution**	**ALK**	**Length distribution**	**ALK**	**Length distribution**	**ALK**
1984–1990	Quarter, by sex	(1984–1986) Synthetic ALKs using age reading from 1987–1990	Annual, by sex	(1984–1986) Synthetic ALKs using age reading from 1987–1990	Annual, by sex	(1984–1986) Synthetic ALKs using age reading from 1987–1990	Annual by sex	(1984–1986) Synthetic ALKs using age reading from 1987–1990
1991	Quarter, by sex	Quarter, combined	Annual, combined	Quarter, by sexes	Annual, combined	Half-year, combined	Annual, combined	Quarter, combined
1992	Quarter, by sex	Quarter, combined	Annual, combined	Quarter, by sexes	Annual, combined	Half-year, combined	Annual, combined	Quarter, combined

1993	Quarter, by sex	Quarter, combined	Annual, combined	Quarter, by sexes	Annual, by sexes	Half-year, combined	Annual, combined	Quarter, combined
1994	Quarter, by sex	Quarter, combined	Annual, combined	Quarter, by sexes	Annual, combined	Half-year, combined	Annual, combined	Quarter, combined
1995	Quarter, by sex	Quarter, combined	Annual, combined	Quarter, by sexes	Annual, combined	Half-year, combined	Annual, combined	Quarter, combined
1996	Quarter, by sex	Quarter, combined	Annual, combined	Quarter, by sexes	Annual, combined	Half-year, combined	Annual, combined	Quarter, combined
1997	Quarter, by sex	Quarter, combined	Annual, combined	Quarter, by sexes	Annual, combined	Half-year, combined	Annual, combined	Quarter, combined
1998	Quarter, by sex	Quarter, combined	Annual, combined	Quarter, by sexes	Annual, combined	Half-year, combined	Annual, combined	Quarter, combined
1999	Quarter, by sex	Quarter, combined	Quarter, combined	Quarter, combined	Half-year, combined	Half-year, combined	Quarter, combined	Quarter, by sexes
2000	Quarter, by sex	Quarter, combined	Quarter, combined	Quarter, combined	Half-year, combined	Half-year, combined	Quarter, combined	Quarter, by sexes
2001	Quarter, by sex	Quarter, combined	Quarter, combined	Quarter, combined	Half-year, combined	Half-year, combined	Quarter, combined	Quarter, by sexes
2002	NA	NA	Quarter, combined	Quarter, combined	Half-year, combined	Half-year, combined	Quarter, combined	Quarter, by sexes
2003	NA	NA	Quarter, combined	Quarter, combined	Half-year, combined	Half-year, combined	Quarter, combined	Quarter, by sexes
2004	NA	NA	Quarter, combined	Quarter, combined	Half-year, combined	Half-year, combined	Quarter, combined	Quarter, by sexes
2005	Quarter, by sex	Quarter, by sex	Quarter, combined	Quarter, combined	Half-year, combined	Half-year, combined	Quarter, combined	Quarter, by sexes
2006	Quarter, by sex	Quarter, by sex	Quarter, combined	Quarter, combined	Half-year, combined	Half-year, combined	Quarter, combined	Quarter, by sexes
2007	Annual, by sex	NA	Quarter, combined	Quarter, combined	Half-year, combined	Half-year, combined	Quarter, combined	Quarter, by sexes
2008	Annual, by sex	NA	Quarter, combined	Quarter, combined	Half-year, combined	Half-year, combined	Quarter, combined	Quarter, by sexes
2009	Quarter, by sex	Quarter, by sex	Quarter, combined	Quarter, combined	Half-year, combined	Half-year, combined	Quarter, combined	Quarter, by sexes
2010	Quarter, by sex	Quarter, by sex	Quarter, combined	Quarter, combined	Half-year, combined	Half-year, combined	Quarter, combined	Quarter, by sexes
2011	Quarter, by sex	Quarter, by sex	Quarter, combined	Quarter, combined	Half-year, combined	Half-year, combined	Quarter, combined	Quarter, by sexes
2012	Quarter, by sex	Quarter, by sex	Annual, combined, bymetier	Annual, combined, bymetier	Quarter, combined	Quarter, combined	Quarter, combined	Quarter, by sexes
2013	Half-year, combined	Half-year, combined	Annual, combined, bymetier	Annual, combined, bymetier	Quarter, combined	Quarter, combined	Quarter, combined	Quarter, by sexes
2014	Half-year, combined	Half-year, combined	Annual, combined, bymetier	Annual, combined, bymetier	Quarter, combined	Quarter, combined	Quarter, combined	Quarter, by sexes

A fixed natural mortality of 0.2 is used for all age groups and all years both in the assessment and the forecast.

The maturity ogive, obtained by macroscopy, for sexes combined calculated for Subarea 7 (BIOSDEF, 1998), has been applied every year. It is as follows:

Age	0	1	2	3	4	5	6+
Maturity	0.00	0.04	0.21	0.60	0.90	0.98	1.00

As in previous years, SSB is computed at the start of each year, and the proportions of M and F before spawning were set to zero.

B.4 Surveys

UK survey Deep Waters (UK-WCGFS-D, Depth >180 m) and UK Survey Shallow Waters (UK-WCGFS-S, Depth <180 m) indices for the period 1987–2004 and French EVHOE survey (EVHOE-WIBTS-Q4) results for the period 1997–present are available.

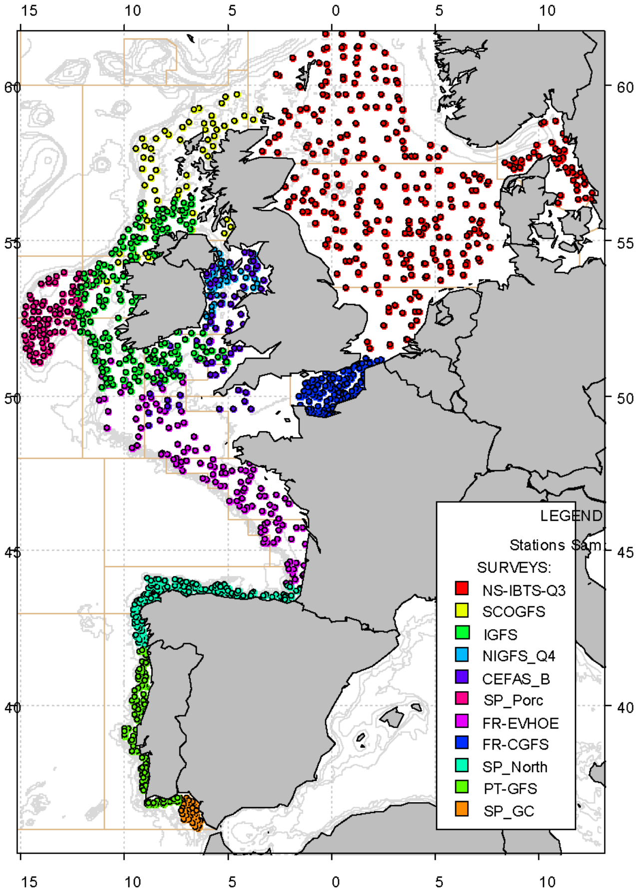
An abundance index was provided for the Spanish Porcupine Ground Fish Survey from 2001 to present.

Irish Ground Fish Survey (IGFS-WIBTS-Q4) is also from 2003 to present.

Surveys available for the assessment:

Type	Name	Year range	Age range	Used in the assessment
UK Survey Deep Water	UK-WCGFS-D	1987–2004	1–10+	No
UK Survey Shallow Water	UK-WCGFS-S	1987–2004	1–10+	No
French EVHOE groundfish survey	EVHOE-WIBTS-Q4	1997–present	1–9	Yes
Spanish Porcupine groundfish survey	SPGFS-WIBST-Q4	2001–present	0–10+	Yes
Irish groundfish survey	IGFS-WIBTS-Q4	2003–present	0–10+	No

It must be noted that the area covered by the three current surveys does not overlap, just the northern component of EVHOE-WIBTS-Q4 and the southern coverage of IGFS-WIBTS-Q4. (Map B.4).



Map B.4. Station positions for the IBTS Surveys carried out in the Western and North Sea area in the autumn/winter of 2008. (From IBTSWG 2009 Report). Just to be used as general location of the Surveys.

B.5 Commercial CPUE

Commercial series of fleet-disaggregated catch-at-age and associated effort data were available for three Spanish fleets in Subarea 7: A Coruña (SP-CORUTR7), Cantábrico (SP-CANTAB7) and Vigo (SP-VIGOTR7).

From 1985 to 2008, lpue s from four French trawling fleets: FR-FU04, Benthic Bay of Biscay, Gadoids Western Approaches and *Nephrops* Western Approaches are available. No update for the French lpues series has been provided from 2008 onwards as effort deployed by these fleets was considered, at the time of the analysis, unreliable.

In 2012, during the WKFLAT (ICES, 2012), a new Irish trawler index was provided as the result of the revision carried out for the Irish Otter trawl fleet. Irish beam trawl (TBB) data are limited to TBB with mesh sizes of 80–89 mm, larger mesh sizes are disused since 2006.

Type	Name	Year range	Used in the assessment
A Coruña otter trawl	SP-CORUTR7	1984–present	No
Cantábrico otter trawl	SP-CANTAB7	1984–2010	No
Vigo otter trawl	SP-VIGOTR7	1984–present	Yes
Irish beam trawl	IR-TBB	1995–present	Yes
French (single and twin bottom trawls	Benthic Bay of Biscay	1985-2008	No
	Benthic Western Approaches	1985-2008	No
	Gadoids Western Approaches	1985-2008	No
	Nephrops Western Approaches	1985-2008	No

B.6 Other relevant data

The estimates of discard data from France have been incorporated to the assessment in IBP Megrim 2016. The aim was to obtain consistent data along the whole data series and also to detect possible recruitment processes that were not previously completely registered in the catch-at-age matrix and lpue.

C. Assessment: data and methods

<u>Summary of the data used for the Inter Benchmark Megrim 2016</u>

Catch, landings and discard numbers-at-age data that were used to carry out the assessment:

i) From 1984 to 1990, international catches-at-age.

ii) From 1990 to present, total international landings-at-age (separately from discards).

iii) From 1990 to 1998 total international discards at age (separately from landings).

Discards in this period were originally available just for two countries: France and Spain. Total international discards from 1990 to 1998 were calculated raising the Spanish and French discards based on the international landings. However, the discard raising method used (which came from many years ago) has not been exactly clarified.

iv) For 1999, only Spanish and Irish discards-at-age are available. Discards-at-age are available for Ireland, Spain and UK from 2000 onwards and for France from 2004 onwards. There was no information for Belgium and Northern Ireland. However, missing discards are supposed to be small as the contribution of these two nations to the stock landings is very small.

The table below summarizes the information of the tuning fleets used in the assessment.

FLEET	ACRONYMS	PERIOD	AGE RANGE
Spanish Survey	SPGFS-WIBTS-Q4	2001–assessment year-1	1–8
French Survey	EVHOE-WIBTS-Q4	1997–assessment year-1	1–9
Spanish Vigo Trawl 7	VIGO84	1984–1998	2–9
	VIGO99	1999–assessment year-1	2–9
Irish Beam trawlers 7	IRTBB	1995–assessment year-1	2–9

Model used in Inter Benchmark 2016

The model explored during the benchmark is an adaptation of one developed originally for the southern hake stock, published in Fernández *et al.* (2010). It is a statistical catch-at-age model that allows incorporating data at different levels of aggregation in different years and also allows for missing discards data by certain fleets and/or in some years. These are all relevant features in the megrim stock. This model was proposed in WKFLAT 2012 and was adapted in IBP 2016 to include French discards data. The model is fitted in a Bayesian context, using the freely available software JAGS (Martyn Plummer, 2007).

Population dynamics

$N(y,a)$denotes the number of fish of age$a$ at the beginning of year y. In this general model description, the assessment years are labelled as$y = 1, \dots, Y$and ages as $a = 1, \dots, A+$, where A–1 is the last true age and the A+ group consists of fish aged A or older. For the megrim stock, the first assessment year is 1984 and the age plus group corresponds to 10+.

Population dynamics follow the usual equations for closed populations. For $y \geq 2$:

$$N(y,a) = N(y-1, a-1)\exp[-Z(y-1, a-1)], \quad if\ 2 \leq a \leq A-1 \qquad (1)$$

$$N(y, A+) = N(y-1, A-1)\exp[-Z(y-1, A-1)] + N(y-1, A+)\exp[-Z(y-1, A+)] \qquad (2)$$

where $Z(y,a) = F(y,a) + M$ and$F(y,a)$and$M$ are the rates of fishing and natural mortality, respectively. $M = 0.2$is assumed for all ages and years. Annual recruitment of megrim (at age 1), $N(y,1)$, and numbers-at-age in the initial assessment year, $N(1,a)$, are unknown parameters.

Modelling $F(y,a)$ taking account of discards

The rate of fishing mortality is decomposed into disjoint terms as follows:

$F(y,a) = F_L(y,a) + \sum_{j=1}^{J} F_{D,j}(y,a)$ (3) where $F_L(y,a)$ and $F_{D,j}(y,a), j = 1, \dots, J$ relate to the total stock landings and discards from each of the J fleets fishing the stock, respectively. The fleets used for the megrim stock correspond to the countries fishing it and are: Spain, Ireland, United Kingdom, France and Others, where "Others" comprises countries with minor stock catches.

The terms making up the fishing mortality are modelled as follows:

$$F_L(y,a) = f(y)r_L(y,a), F_{D,j}(y,a) = f(y)r_{D,j}(y,a), j = 1, \dots, J \qquad (4)$$

where $f(y)$ is an overall annual factor relating to total fishing effort on the stock and $r_L(y,a)$ and $r_{D,j}(y,a)$ for $j = 1, \dots, J$ determine the exploitation pattern or, in other words, the distribution of F among ages and among landings and discards of different fleets. All factors in formulation (4) are positive and for identifiability, $r_L(y,a)$ is set to 1 for an age chosen arbitrarily. This was set as age 9 in the megrim model implementation, an age for which discards are assumed to be 0, i.e. $r_{D,j}(y,9)$ for all fleets; therefore,$f(y)$ is interpreted as the total fishing mortality-at-age 9). Each of the $r(y,a)$ factors, whether it corresponds to landings or discards, is assumed to have the same values for ages A–1 and A+ , so that the fishing mortality of the + group is the same as the fishing mortality of the last true age.

A Normal random walk for $\log[r_L(y,a)]$ is assumed for each age separately. In original (non-logged) scale, this means:

$$r_L(y,a) \sim LN(r_L(y-1, a-1), CV_{rcond}), \qquad (5)$$

where the log-Normal (LN) distribution is parametrized using the median (first parameter) and coefficient of variation (second parameter). As megrim discarding is believed to have increased over the assessment period, the non-stationary random walk model in Equation (5) is considered appropriate. For each age, the value in the first year of the assessment period, $r_L(1,a)$, is an unknown parameter, whereas CV_{rcond}has been fixed at 20%. The same modelling procedure is applied to $r_{D,j}(y,a)$, separately for each age and fleet $j=1,\dots,J$, where the values in the first assessment year, $r_{D,j}(1,a)$, are unknown parameters and $CV_{rcond}$is fixed at the same value as for $r_L(y,a)$.

The annual factor $f(y)$ [Equation (4)] common to all components of F is also unknown. As $f(y)$ is expected to vary slowly in time with no particular trend *a priori*, a stationary process with time autocorrelation seems appropriate. This is modelled as a multivariate Normal distribution for $(\log[f(1)],\dots,\log[f(Y)])$ $(\log[f(1)],\dots,\log[f(Y)])$ *a priori*, with the same mean and variance in all years and correlation ρ^n between $\log[f(y)]$ values that are n years apart. The resulting marginal prior distribution in original (non-logged) scale every year is log-Normal:

$$f(y) \sim LN(med_f, CV_f), \qquad (6)$$

with median and CV denoted as med_f and CV_f, respectively. Considering only non-negative correlations, the extreme $\rho=0$ corresponds to independence between $f(y)$ values over time, whereas $\rho=1$ leads to the same $f(y)$ value in all years. The values med_f and CV_f are fixed and ρ is treated as unknown.

Observation equations for commercial catch, landings and/or discards data in numbers-at-age

The commercial catch data for the megrim stock have different levels of aggregation depending on the year. Three main time periods can be distinguished in terms of data availability and how they are used in the assessment: (1) years 1984–1989: stock catch numbers-at-age in all years, without any disaggregation into landings and discards or by fleet; (2) years 1990–1998: stock landed numbers-at-age and stock discarded numbers-at-age in all years, without any disaggregation by fleet; (3) years 1999–present: stock landed numbers-at-age in all years and discarded numbers-at-age disaggregated by fleet for the fleets mentioned earlier, i.e. Spain, Ireland, UK (missing in 1999), France (missing in 1999-2003) and Others (but all years missing). The fact that discards of the Others fleet (composed of countries with minor stock catches) are not available means that the stock discards data from 1999 to present are incomplete.

Each of these sources of information is assigned its own observation equations, with a separate equation for each age. For the catch numbers-at-age (years 1984–1989), these are:

$$\log[C^{obs}(y,a)] \sim N\left(\log\left[\hat{C}(y,a)\right], \tau_C(a)\right), \qquad (7)$$

where$C^{obs}(y,a)$ is the observed and

$$\hat{C}(y,a) = N(y,a)\{1-\exp[-Z(y,a)]\}\,F(y,a)/Z(y,a) \qquad (8)$$

the model estimated catch numbers-at-age. For the landed numbers-at-age (years 1990–present):

$$\log[L^{obs}(y,a)] \sim N\left(\log\left[\hat{L}(y,a)\right], \tau_L(a)\right), \qquad (9)$$

where$L^{obs}(y,a)$ is the observed and

$$\hat{L}(y,a) = N(y,a)\{1-\exp[-Z(y,a)]\}\,F_L(y,a)/Z(y,a) \qquad (10)$$

the model-estimated landed numbers-at-age, obtained by applying the Baranov catch equation and using the landings component of F.

The observation equations for discarded numbers-at-age for the stock total (years 1990–1998) or by fleet (years 1999–present) are defined in a similar fashion as Equations (9) and (10), considering the appropriate component of the fishing mortality, i.e. replacing $F_L(y,a)$ by $F_{SPD}(y.a)$ (Spanish discards), $F_{IRD}(y.a)$ (Irish discards), $F_{UKD}(y.a)$ (UK discards), $F_{FRD}(y.a)$(French discards) and $F_D(y.a) = F_{SPD}(y.a) + F_{IRD}(y.a) + F_{UKD}(y.a) + F_{FRD}(y.a) + F_{OTD}(y.a)$ (total stock discards). There are no observation equations involving $F_{OTD}(y.a)$ alone, given that discards of the Others fleets are missing in all years from 1999 to present. This means that information for fitting the $F_{OTD}(y.a)$ component of the total fishing mortality is very indirect as this component of fishing mortality only in the observation equations for total stock catch-at-age during 1984–1989 and total stock discards-at-age during 1990–1998. In preliminary trial runs of this models it became apparent that it was not possible to get sensible estimates of $F_{OTD}(y.a)$ for years 1999 and onwards. To circumvent this difficulty it was decided to fix the evolution of $r_{OTD}(y.a)$from 1999 according to the formula:

$$r_{OTD}(y.a) = r_{OTD}(y-1.a)\frac{OTLW(y)/LW(y)}{OTLW(y-1)/LW(y-1)} \qquad (11)$$

where $LW(y)$ and $OTLW(y)$ denote the total stock landings in weight and the landings of the Others fleet in weight in year y, which are both known. The idea here is to say that the discarding pattern-at-age of the Others fleet has not changed since 1998 and that its change in overall level (with the same change in level for all ages) between years can be approximated by the change in overall landings of this fleet with respect to total stock landings. Clearly, this assumption can be debated, but it was the most reasonable way found to constrain the model to produce sensible fits. If discards data become available for the Others fleet, it would be recommendable to remove this assumption from the model and let $r_{OTD}(y.a)$ continue to evolve in time as a random walk (in log-scale) after 1998 too, as originally modelled.

The precision (inverse of variance) parameters of the observation equations, namely, $\tau_c(a)$ (catch numbers-at-age), $\tau_L(a)$ (landed numbers-at-age), $\tau_D(a)$ (discarded numbers-at-age) and $\tau_{D,j}(a), j = 1, \ldots, J$ (discarded numbers-at-age for fleet$j = 1, \ldots, J$), reflect the precision of the catch, landings and discards data and are treated as unknown and estimated when fitting the assessment model. In setting prior distributions for these parameters, the well-known relationship between the precision τ of a Normal prior distribution for the log of a variable and the CV of the corresponding log-Normal distribution for the original variable (in non-log scale) will be used. This relationship is as follows: if$\log(X) \sim N(\mu, \tau)$, where τ denotes precision (inverse of variance), then $CV(X) = (\exp(1/\tau) - 1)^{1/2}$.

Observation equations for relative indices of stock abundance

Relative indices of abundance-at-age may be obtained from research surveys or correspond to values of catch per unit of effort of commercial fleets. Let $I_k^{obs}(y,a)$ denote the index corresponding to series k, which relates to a certain time portion of the year$[\alpha_k, \beta_k] \subseteq [0,1]$. For each year and age for which the index is available, the following observation equation is assumed:

$$\log\left[I_k^{obs}(y,a)\right] \sim N\left(log\left[q_k(a)N(y,a)\frac{\exp[-\alpha_k Z(y,a)] - \exp[-\beta_k Z(y,a)]}{(\beta_k - \alpha_k)Z(y,a)}\right], \tau_k(a)\right) \quad (12)$$

(12)

The mean of the Normal distribution is the logarithm of the product of the average stock abundance during the period of the year to which the index relates and the catchability $q_k(a)$, which is unknown. The index precision, $\tau_k(a)$, is considered unknown for all indices explored in the assessment. As explained above, the relationship between the precision of a Normal distribution for the log of a variable and the CV of the corresponding log-Normal distribution for the variable in original scale will be used when setting prior distributions for the precision parameters.

Data, priors, and computational method

Catch numbers-at-age data correspond to: total stock catch (years 1984–1989), total stock landings (1990–present), total stock discards (1990–1998), Spanish discards (1999–present), Irish discards (1999–present), French discards (2004-present), UK discards (2000–present, with year 1999 missing). Discards of Others (countries with minor stock catches) from 1999–present are missing in all years. Catch and landings correspond to ages 1–10+. Discards of ages 8 and older are minimal and assumed to be exactly 0 for ease of modelling (except for Spain, for which the very low number of discards from age 7 make it more convenient to assume that discards are 0 already from age 7).

After considering various potential abundance indices available at the benchmark, with the corresponding ranges of available ages, the ones finally explored within the assessment model correspond to the following indices, years and ages: EVHOE-WIBTS-Q4 survey (1997–present, ages 1–5), Porcupine survey (2001–present, ages 1–8), Vigo bottom-trawl cpue (split into two parts: 1984–1998, ages 2–9; 1999–present, ages 1–9; this splitting was done because of the strong increase in cpue shown by this fleet around the late 1990s and early 2000s, which, after exploration, was considered much more likely to be caused by an increase in catchability rather than be reflective of a strong increase in megrim abundance) and Irish beam trawl lpue (1995–present, ages 2–7).

In a Bayesian context, all unknown parameters are assigned prior distributions, which are meant to reflect the knowledge available before observing the data. The prior distributions considered are centred at values deemed reasonable according to current knowledge of the stock and the fishery while trying to ensure they are not too narrow, so as not to influence unduly the assessment results. Table C.1. lists all the prior choices made for the final run. The parameters of the Gamma prior distribution for the precisions of all observation equations (the τ parameters towards the bottom of Table 9.9.1.1), were chosen using the well-known statistical fact that if $\log(X) \sim N(\mu, \tau)$, then $CV(X) = (\exp(1/\tau) - 1)^{1/2}$, as already mentioned, because it seems easier to think in terms of CVs of the observations than to think in terms of the inverse variance in logarithmic scale. With a $\Gamma(4{,}0.345)$ prior distribution on τ, the resulting prior distribution for the *CV*s of the observations in original (non-logged) scale has median 0.31 and (0.20, 0.61) as the 95% central probability interval. These values become 0.10 and (0.08, 0.15), when a $\Gamma(10{,}0.1)$ prior distribution is used for τ. The prior distributions for the exploitation pattern parameters in the first assessment year ($y = 1$, which corresponds to 1984) reflect the idea that discards were very low at that time. When setting the prior distribution for these parameters, it is useful to remember that $r_L(y, 9) = r_L(y, 10+) = 1$has been set, so that all other selection-at-age parameters for landings and discards should be interpreted as departures from the fishing exploitation at ages 9 and 10+.

Model fitting was done using MCMC to simulate the posterior distribution (Gilks *et al.*, 1996, provide an accessible introduction to MCMC). This was programmed in the free software JAGS and run from R (R Development Core Team, 2015).MCMC simulates the posterior distribution with each draw depending on the one immediately preceding it. As a consequence of this dependence, many iterations are typically needed to obtain a representative sample from the posterior distribution, particularly when this is highly dimensional and strong correlations between some of its dimensions exist. The results for the main runs conducted during the benchmark are based mostly on chains of 250 000 iterations. The first 50 000 were discarded to eliminate the effect of start-up values, and 2000 equally spaced iterations out of the other 200 000 iterations were kept. This was considered enough to provide a good representation of the posterior distribution.

Sensitivity analysis

Current assessment settings were decided on the benchmark IBP Megrim (ICES, 2016). This is an update of WKFLAT 2012 benchmark setting where a sensitivity analysis to the various model configurations was conducted. The report of that workshop provides a detailed description of that work.

Table C.1. IBP 2016 Prior distributions of final run. $LN(\mu,\psi)$ denotes the lognormal distribution with median μ and coefficient of variation ψ, and $\Gamma(u,v)$ denotes the Gamma distribution with mean u/v and variance u/v^2.

Parameter and prior distribution	Values used in prior settings
$N(y,1) \sim LN(medrec,2)$	$medrec = 250000$
$N(1984,a) \sim LN(medrec \exp[-(a-1)M - \sum_{j=1}^{a-1} medF(j)],2), a = 2,...,9$	$medrec$ as above, $M = 0.2$, $medF = (0.05,0.1,0.3,0.3,0.3,0.3,0.3,0.3,0.3)$
$N(1984,10+) \sim LN(medrec \exp[-9M - \sum_{j=1}^{9} medF(j)]/\{1-\exp[-M - medF(9)]\}, 2)$	$medrec, M, medrecF$ as above
$f(y) \sim LN(med_f, CV_f)$	$med_f = 0.3, CV_f = 1$
$\rho \sim Uniform(0,1)$	
$r_L(1984,a) \sim LN(medr_L(a),1), a = 1,...,8$	$medr_L = (0.0005,0.05,1,1,1,1,1,1)$
$r_L(y,9) = r_L(y,10+) = 1$	
$r_{SPD}(1984,a) \sim LN(medr_{SPD}(a),1), a = 1,...,7$	$medr_{SPD} = (0.002,0.02,0.02,0.02, 0.01,0.01,0.01)$
$r_{IRD}(1984,a) \sim LN(medr_{IRD}(a),1), a = 1,...,8$	$medr_{IRD} = (0.001,0.01,0.01,0.01, 0.005,0.005,0.005,0.001)$
$r_{UKD}(1984,a) \sim LN(medr_{UKD}(a),1), a = 1,...,8$	$medr_{UKD} = (0.00001,0.001,0.001,0.001, 0.001,0.001,0.001,0.001)$

$r_{FRD}(1984,a) \sim LN(medr_{FRD}(a),1), a=1,\ldots,8$	$medr_{FRD} = (0.002,0.02,0.02,0.02, 0.01,0.01,0.01,0.01)$
$r_{OTD}(1984,a) \sim LN(medr_{OTD}(a),1), a=1,\ldots,8$	$medr_{OTD} = (0.002,0.02,0.02,0.02, 0.01,0.01,0.01,0.002)$
$r_{SPD}(y,7) = r_{SPD}(y,a) = r_{IRD}(y,a) = r_{UKD}(y,a) = r_{FRD}(y,a) = r_{OTD}(y,a) = 0,\ a = 8,9,10+$	
$\tau_C(a), \tau_L(a), a=1,2,3; \tau_D(a), a=1,\ldots,8$	$\Gamma(4,0.345)$
$\tau_C(a), \tau_L(a), a=4,\ldots,10+$	$\Gamma(10,0.1)$
$\tau_{SPD}(a), a=1,\ldots,7; \tau_{IRD}(a), \tau_{UKD}(a), \tau_{FRD}(a) a=1,\ldots,8$	$\Gamma(4,0.345)$
$\log[q_k(a)] \sim N(\mu_{Ik}, \tau_{Ik}), a \le 8,$ index $k=1,\ldots,5$	$\mu_{Ik} = -7,\ \tau_{Ik} = 0.2$
$q_k(a) = q_k(8), a > 8,$ indices k with ages > 8	
$\tau_k(a),$ index $k=1,\ldots,5$	$\Gamma(4,0.345)$

D. Short-term projection

Model used: Age structured.

Software used*:* Rscript developed by Fernández et al. (2010).

Type of projection: stochastic.

Initial stock size: Survivors of ages 2 to 10+ from the assessment. All the MCMC draws are used, so that uncertainty from the assessment is taken forward to the projection.

Number of years of projections: 3 years (interim year and 2 additional years).

Recruitment-at-age 1: It is assumed equal in all projection years. It is calculated as the geometric mean of all the recruitments since 1984 except the last two years. If the last year recruitment data is not considered credible, it could also be changed by the geometric mean of all the recruitments since 1984 except the last two years. It includes uncertainty from the assessment, as recruitment is calculated for each MCMC draw. Note that this assumption makes recruitment independent of the current SSB level. Other recruitment scenarios, based on bootstrapping recruitment and/or selecting specific years are also available.

F-at-age, the proportion landed-at-age, weight-at-age and maturity-at-age are taken as the average of the last three years.

Exploitation pattern: If there is a decreasing trend of F in the results of the assessment time series, F status quo should be scaled to Fbar of the final assessment year (default option). Otherwise, this is not necessary.

E. Medium-term projections

No medium-term projections are proposed for this stock.

F. Long-term Projections (until 2006)

No long-term projections are proposed for this stock.

G. Biological reference points

They have been last updated in WGBIE 2016.

From the IBP megrim (ICES, 2016):	Type	Value	Technical Basis
MSY approach	MSY Btrigger	41 800	BPA, because the fishery has not been at FMSY in the last 10 years
	FMSY	0.191	F giving maximum yield at equilibriumComputed using Eqsim.
	FMSY ranges	0.122-0.289	
Precautionary approach	Blim	37 100	B_{loss}, which is the lowest biomass observed corresponding to year 2006
	Bpa	41 800	$B_{lim}e^{1.645\,\sigma}$ where σ = 0.07isthe standard deviation of the logarithm of SSB in 2014
	Flim	0.533	It is the F that gives 50% probability of SSB being above B_{lim} in the long term. It is computed using Eqsim based on segmented regression with the breakpoint fixed at Blim, without advice/assessment error and without Btrigger
	Fpa*	0.417	$F_{p0.5}$: F that provides a 95% probability for SSB to be

above Blim.

* Fpa was defined as Fp0.5 by ACOM in 2020.

H. Other issues

Historical development

Data improvement during the Benchmark 2012

i) A new Irish trawler index was provided as the result of the revision carried out for the Irish Otter trawl fleet. Irish beam trawl (TBB) data are limited to TBB with mesh sizes of 80–89 mm, larger mesh sizes are disused since 2006.

ii) France provided revised ALKs and consequently completed number and weights-at-age since 1999.

iii) Spain, United Kingdom (England and Wales) and Ireland provide discard data since 2000.

iv) Irish discard data were revised and updated and a new dataseries was provided since 1995.

v) Spain provided some minor revised values of discards.

vi) Some minor revisions were carried out for SP-VIGOTR7 due to the incorporation of catches previously not recorded.

Data deficiencies after Benchmark 2012

vii) France did not provided discard data since 1999, as data appear to be very uncertain in relation to sampling level affecting their representatively.

viii) No update for the French lpues series has been provided to the Benchmark group for 2009 and 2010 as effort deployed by this fleet was considered, at the time of the analysis, unreliable.

Software change in WGBIE 2014

Until last year working group, the model was fitted in a Bayesian context, using the freely available software WinBUGS (Lunn *et al.*, 2009). Due to the high amount of time needed to run the model in this software (3 days to run the final assessment) and the low effectiveness that it implicates to make trial runs with different inputs during the group, another freely available software JAGS (Martyn Plummer, 2007) was tested. In JAGS software the final run took 1.5 hours to run. A comparison of the results of both software was done in order to check the outputs. As the results obtained where nearly the same (Figure 5.3.2.1) it was decided to used JAGS software for the assessment.

Updates during IBP Megrim 2016

During IBP Megrim these are the main updates executed:

-French discard estimates are provided from year 2004 to 2014 and included in the assessment.
-Short term forecast script was revised and projections are presented.
-Biological reference points are defined for this stock.

Update of Fpa reference point WGBIE 2021

- F_{pa} that was derived from F_{lim} as follows:

$$F_{pa} = F_{lim} e^{-1.645\,\sigma},$$

where σ is the standard deviation of ln(F) in the final assessment year. Fpa is replaced by $F_{p0.5}$ the F that provides a 95% probability for SSB to be above Blim.

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Stock Annex: White anglerfish (*Lophius piscatorius*) in divisions 8.c and 9.a (Cantabrian Sea and Atlantic Iberian waters)

Stock specific documentation of standard assessment procedures used by ICES

Stock	White anglerfish_mon.27.8c.9a
Working Group	Working Group for the Bay of Biscay and the Iberian waters Ecoregion (WGBIE)
Created	
Authors	
Last updated	10 May 2021
Last updated by	Paz Sampedro (WGBIE2021)

A. General

A.1 Stock definition

The two species of anglerfish (the white, *Lophius piscatorius*, and the black, *L. budegassa*) are Northeastern Atlantic species; however black anglerfish has a more southerly distribution. White anglerfish is distributed from Norway (Barents Sea) to the Strait of Gibraltar (and including the Mediterranean and the Black Sea) and black anglerfish from the British Isles to Senegal (including the Mediterranean and the Black Sea). Anglerfish occur in a wide range of depths, from shallow waters to at least 1000 m. Information about spawning areas and seasonality is scarce, therefore the stock structure remains unclear. This lack of information is due to their particular spawning behaviour. Anglerfish eggs and larvae are rarely caught in scientific surveys.

ICES gives advice for the management of several anglerfish spp. stocks in European waters: one stock on the Northern Shelf area, that includes anglerfish from the Northern Shelf, Division 3.a, subareas 4 and 6, and the stocks on the Southern Shelf area, one in divisions 7.b–k and 8.a,b and d and the Southern stocks in divisions 8.c and 9.a. The stock under this Annex is called Southern White Anglerfish and is defined as white anglerfish in divisions 8.c and 9.a. The boundaries of anglerfish in divisions 7.b–k and 8.a,b and d and Southern Anglerfish stocks were established for management purposes and they are not based on biological or genetic evidences (GESSAN, 2002; Duarte *et al.*, 2004; Fariña *et al.*, 2004; Cañás, 2012).

White and black anglerfish are caught and landed together and there is a unique TAC for both species. However, the stock assessment is carried out separately for each species and the advice is given for individual species.

A.2 Fishery

Anglerfish in ICES divisions 8.c and 9.a is mainly exploited by Spanish and Portuguese vessels, since 2000 the Spanish landings being more than 80% for both anglerfish total reported landings. France have reported catches of this stock for the period 2002–2020, that represent an average of 2% of total landings. International catches for these two stocks have increased since the beginning of the 1980s, until a maximum was reached in 1988 (10 021 t). They have decreased to 1801 t–1900 t in

2001–2002. In the 2005–2011 periods the catches were between 2179 t and 4757 t. From 2014 to 2020 landings have decreased from 3130 t to 1515 t. Both species are caught on the same grounds by the same fleets and are marked together.

White and black anglerfish are caught together by Spanish and Portuguese bottom trawlers and gillnet fisheries. Spanish and Portuguese bottom trawlers are mixed fisheries. The Spanish bottom-trawl fleet predominantly targets hake, megrim, Norway lobster and anglerfish. Since 2003 the alternative use of a trawl gear with High Vertical Opening (HVO) has taken place in larger proportion relative to previous years. This gear targets horse mackerel and mackerel with very few anglerfish catches. Since 2004, the Spanish landings were on average 51% from the trawl fleet and 49% from the gillnet fishery. The Spanish gillnet fishery can use different artisanal gears, but most catches come from "Rasco" that is a specific gear targeting anglerfish.

Anglerfish are caught by Portuguese fleets in trawl and artisanal mixed fisheries. Portuguese landings were on average, from 2002, 11% from trawlers and 89% from artisanal fisheries. The trawl fleet has two components, the trawl fleet targeting demersal fish and trawl fleet targeting crustaceans.

Discarding in white anglerfish is considered low for the trawl fishery, based on estimated data for Spanish trawl fleet (ICES, 2011) and information from Portuguese trawl fleet (ICES, 2012a).

Each year, the European Union sets a combined TAC and quota for white and black anglerfish. There is no minimum landing size for anglerfish, but in order to ensure marketing standards a minimum landing weight of 500 g was fixed in 1996 by the Council Regulation (EC) No.2406/96.

As part of the Recovery Plan for the Southern hake and Iberian *Nephrops* stocks (Council Regulation (EC) No.2166/2005), in force from January of 2006 to March of 2019, the fishing effort regulations affected the Spanish and Portuguese mixed trawl fisheries. As anglerfish were taken in these mixed trawl fisheries, these stocks were also affected by the recovery plan effort limitation.

A.3 Ecosystem aspects

White anglerfish is a benthic species that occur on muddy to gravelly bottoms. It attains a maximum size of around 175 cm corresponding to a weight of approximately 63 kg. Historically white anglerfish has been considered a slow growing species, with a late maturation (Duarte *et al*., 2001). Nevertheless, new evidences from mark–recapture experiments indicate that the anglerfish growth could be faster (Landa *et al*., 2008).

The ovarian structure of anglerfish differs from most other teleosts. It consists of very long ribbons of a gelatinous matrix, within individual mature eggs floating in separate chambers (Afonso-Dias and Hislop, 1996). The spawning of the *Lophius* species is very particular, with eggs extruded in a buoyant, gelatinous ribbon that may measure more than 10 m and contain more than a million eggs (Afonso-Dias and Hislop, 1996; Hislop *et al*., 2001; Quincoces, 2002). Eggs and larvae drift with ocean currents and juveniles settle on the seabed when they reach a length of 5–12 cm. This particular spawning leads to highly clumped distributions of eggs and newly emerged larvae (Hislop *et al*., 2001) and favourable or unfavourable ecosystem conditions can therefore have major impacts on recruitment.

Due to their particular reproduction aspects (that shows a high parental investment in the offspring) the population dynamics of these species is expected to be highly sensitive to external biological/ecosystem factors.

Vertical displacements of immature and mature white anglerfish from the seabed to the near surface have been recorded in the Northeast Atlantic (Hislop *et al*., 2001) and are suggested to be related to spawning or feeding.

Improvement of knowledge regarding growth, spawning behaviour, migratory behaviour and juvenile drift are essential to present and future assessment and management of both Southern Anglerfish stocks.

B. Data

B.1 Commercial catch

Landings data are provided by National Government and research institutions of Spain, Portugal and France. Quarterly landings by country, gear and ICES division are available from 1978. There were unrecorded landings in Division 8.c between 1978 and 1979, and it was not possible to obtain the total landings in those years. Portuguese landings were TAC constrained since 2005. Very low landings have been registered during the 4th quarters since then. The Portuguese landings were relatively stable during the first two years, but have decreased substantially from 2004 to 2010. In 2018 Portuguese landings were at its minimum value of the series. France landings are only available for the period 2002–2020.

The two species are not usually landed separately, for the majority of the commercial categories, and they are recorded together in the ports' statistics. Therefore, estimates of each species in Spanish landings from divisions 8.c and 9.a and Portuguese landings of Division 9.a are derived from their relative proportions in market samples.

For white anglerfish the maximum landing of the available series was recorded in 1986 at 6870 t. After that, a general decline to 788 t in 2001 was observed, reaching the minimum of the available series. From 2002–2005 landings increased reaching 3824 t. Since 2005 landings have slowly decreased to 1157 t in 2011. In the last 7 years landings have decreasing from 2032 t in to 722 t.

Discards

Since 1994 a Spanish Discard Sampling Programme is being carried out for trawl fleets operating in the ICES divisions 8.c and 9.a. However, the time-series is not complete and years with discard data are 1994, 1997, 1999, 2000 and from 2003–2020. The raising procedure used to estimate discards was based on effort. A short time-series, 2013–2020, of discards estimates is available for the Spanish gillnet fleets. The Portuguese Discard Sampling Programme recorded anglerfish data from 2004. The frequency of occurrence of white anglerfish in discard samples is very low and its discard is considered negligible.

B.2 Biological

Landing numbers-at-length

Since 2009 the quarterly Spanish and Portuguese sampling for length compositions is by métier and ICES division. Length data from sampled vessels are summed and the resulting length composition is applied to the quarterly landings of the corresponding métier and ICES division. The sampled length compositions were raised for each country and SOP corrected to total landings on a quarterly or half yearly basis (when the sampling levels by quarter were low). The average lengths of trawl caught anglerfish are lower compared to the artisanal fleets.

Catch numbers-at-age

No catch numbers-at-age are provided to the Working Group. At the WGHMM 2007 meeting (ICES, 2007), age–length keys, based on *illicia* readings, were used to obtain catch number-at-age for each species. The exploratory analysis of estimates indicated that the biased age-reading criterion does not allow following cohorts along years in either of the two species. The last research about white anglerfish ageing, *White Anglerfish Illicia and Otoliths Exchange 2011* (ICES, 2012b), highlighted that neither *illicia* nor otolith age readings have been validated and, in the case of *illicia* studies, the agreement among readers and the precision were not acceptable. Therefore, it was concluded that the available age-reading criteria for white anglerfish southern stock is not valid to build an ALK.

Growth curve

The most recent study about white anglerfish growth in Atlantic integrates results for different growth researches (tag–recapture study, length–frequency of catches, and microstructure analysis of hard parts) (Landa *et al*., 2008). A von Bertalanffy growth curve fitted to all data provided the parameter values L_{inf} = 140 cm and K = 0.11. This growth rate is faster than estimated recently using *illicia* for age estimation.

Maturity-at-length

Different estimates of maturity ogive based on macroscopic maturity staging are available for white anglerfish (Duarte *et al*., 2001; Landa *et al*., 2012). In these studies the difficulty of finding mature females in the field resulted in samplings with low coverage of mature individuals. Besides, the inadequacy in same instances of the macroscopic examination to determine maturity stage let it to consider a maturity ogive of white anglerfish from other areas. The available study was carried out in ICES divisions 8abd and determined microscopically the maturity stage (Quincoces, 2002). The parameters of maturity ogive are 50% maturity at 61.84 cm and a slope at 0.1001.

Natural mortality

No specific studies about natural mortality of white anglerfish were available. However, taking into consideration its growth rate and the high size that can attain, a constant annual instantaneous natural mortality rate (M) of 0.2 yr^{-1}, for all ages and years, is assumed.

Length–weight relationship

The weight–length relationship was calculated using data from an international project that spatially covered a large proportion of the stock and which a large number of samples and from samples collected through years 2002–2016 (Landa and Antolínez, 2017):

$$W = 2.5\times10^{-5}\cdot L^{2.853}$$

where W = weight in kilograms and L = length in centimetres.

B.3 Surveys

SP-NSGFS-Q4

The Spanish Groundfish Survey aims to collect data on the distribution and relative abundance, and biological information of commercial fish in ICES divisions 8.c and Northern 9.a. Since 1983 it is annually carried out in the fourth quarter (September/October) of the years, except for 1987. Time-series of abundance indices, in weight and in number, and correspondent length composition are available for both anglerfish species. The full time-series of this survey is used in the assessment of white anglerfish since 2012.

SP-GCGFS-Q1,4

The Southern Spanish Groundfish Survey on the Gulf of Cádiz (SP-GCGFS) is conducted in the southern part of ICES Division 9a, the Gulf of Cádiz. The covered area extends from 15 m to 800 m depth, during spring and autumn. This survey was identified during the WKAngler DataEvaluation meeting as a potential abundance index for anglerfish in divisions 8c9a. The time-series data were requested to Spain. The series covers the period 1993–2017, two surveys by year, and the abundance index (in number and in weight) and their associated variance, and length compositions are available. The abundance values of *L. piscatorius* in this survey are very low, being zero in some cases. This survey index is not used in the assessment.

PT-PGFS- Q4

Portuguese Autumn Groundfish Survey has been carried out in Portuguese continental waters since 1979 in the fourth quarter of the years. Abundance indices for both anglerfish species are available from 1989–2018. The abundance values detected by this survey are very low for the whole time-series, being insignificant for some years.

This survey is not used in the assessment of white anglerfish.

B.4 Commercial cpue

Six commercial series of landing effort are available to the WG. Four of them are Spanish fleets in the ICES Division 8c and two Portuguese fleets in the ICES Division 9a. The Portuguese trawl fleet was split into fish trawlers and crustacean trawlers (WD12, Duarte *et al.*, 2007 in ICES, 2007) according to the fleet segmentation proposed by the IBERMIX project (WD06, Castro *et al.*, 2007 in ICES, 2007).

SP-CORTR8C

A Coruña trawl fleet fishing in Division 8c is available for years 1982–2012. Data provided for A Coruña trawlers comprise quarterly effort (fishing days per 100 horse power), landings and length composition of landings. This fleet represents an average of 15% of international catches of white anglerfish along the time-series. A standardized series from 1994 to 2006 is also available for this fleet with annual effort data (in fishing days) and annual lpue.

Data from this commercial lpue series have been used in the white anglerfish assessment since 2007.

SP-CEDGNS8C

Cedeira gillnet fleet fishing in Division 8.c is available for years 1999–2011. Data provided for Cedeira gillnets comprise quarterly standardized effort (in soaking days), landings and length composition of landings. This fleet represents an average of 11% of international catches of white anglerfish since 1999. Due to the reduction in the number of vessels of Cedeira fleet, this tuning series could not be considered as a representative abundance index of the stock and since 2012 it is no longer recorded.

Data from this commercial lpue series have been used in the white anglerfish assessment since 2007.

Other available commercial series of lpues that have never been employed in the assessment are:

PT-TRF9A

Portuguese trawlers targeting fish: years 1989–2018. Data provided for Portuguese trawlers targeting fish comprise quarterly effort (1000 hours trawling with occurrence of anglerfish), landings and length composition of landings. This fleet represents an average of 1% of international catches of white anglerfish along the time-series. A standardized series from 1989 to 2008 is also available for this fleet with annual effort data (in 1000 hauls) and annual lpue.

PT-TRC9A

Portuguese trawlers targeting crustacean: years 1989–2018. Data provided for Portuguese trawlers targeting fish comprise quarterly effort (1000 hours trawling with occurrence of anglerfish), landings and length composition of landings. This fleet represents an average of 1% of international catches of white anglerfish along the time-series. A standardized series from 1989 to 2008 is also available for this fleet with annual effort data (in 1000 hauls) and annual lpue.

SP-AVITR8C

Avilés trawl fleet fishing in Division 8.c is available for years 1986–2003. Data provided for Avilés trawlers comprise quarterly effort (fishing days per 100 horse power), landings and length composition of landings. This fleet represents an average of 6% of international catches of white anglerfish along the time-series. The effort series was interrupted in 2003.

SP-SANTR8C

Santander trawl fleet fishing in Division 8.c is available for years: years 1986–2010. Data provided for Santander trawlers comprise quarterly effort (fishing days per 100 horse power), landings and length composition of landings. This fleet represents an average of 7% of international catches of white anglerfish along the time-series. Effort data for 2008 were not provided to the WG.

C. Assessment: data and method

Until 2011 white anglerfish stock was assessed with a non-equilibrium production model (ASPIC software). Results from growth studies provide a growth pattern for this stock allowing the application of a length-based assessment model. Stock Synthesis (SS) was considered a suitable model to assess this stock by WKFLAT (ICES, 2012a). During the WKAngler 2018, some settings and input data of SS assessment model for white anglerfish were modified.

The assessment method:

Model

Model used: Stock Synthesis (SS) (Methot, 2000)

Software used: Stock Synthesis v3.30.10 (Methot *et al*., 2018)

Stock Synthesis is an integrated assessment model. SS has been used for stock assessment all around the world. The area of highest used is on the US Pacific Coast. SS is coded in C++ using Auto-Differentiation Model Builder (http://www.admb-project.org) and available at the NOAA Virtual Laboratory (https://vlab.ncep.noaa.gov/). SS has three main characteristics that differentiate it from classical assessment models:

- SS model structure allows for building of simple to complex models depending upon the data available. It is capable to build models with age and/or length structure and spatial structure.
- It is capable to use different sources of information.
- All parameters have a set of controls to allow prior constraints, time-varying flexibility, and linkages to environmental data.

The overall SS model is subdivided into 3 submodels. The first submodel simulates the population dynamics, where the basic abundance, mortality and growth functions create a synthetic representation of the true population. The second submodel is the observation submodel. This contains the processes and filters designed to derive expected values for the various types of data. The last submodel is the statistical that quantifies the magnitude of the difference between observed and expected data and employs an algorithm to find the set of parameters that maximizes the goodness-of-fit.

The SS model developed for white anglerfish during the WKAngler 2018 has been designed for a particular set of data and specifications. White anglerfish is harvested by four fleets, and two commercial lpue series and one fishery-independent survey provide information about relative abundance. No discard information is considered. Length composition data are available from both the fisheries and surveys. No age information is available for this stock.

Input data

Years: 1980–2020.

Model structure:

- Temporal unit: quarterly based data (landings, lpue and length–frequency) were used in SS calculations.
- Spatial structure: One area.
- Sex: Both sexes combined.

Fleet definition:

Four *fleets* were defined attending to the gear type and country:

- Spanish trawlers in ICES divisions8.c–9.a (SPTR8C9A)
- Spanish artisanal in ICES Division 8.c (SPART8C)
- Portuguese trawlers in ICES Division 9.a (PTTR9A)
- Portuguese artisanal in ICES Division 9.a (PTART9A)

Landed catches:

Quarterly landings entered the model as biomass (in weight) for the four fleets. Landings data for January 1980 to December 2020 were used to conduct the stock assessment of white anglerfish.

From 1980 to 1988 quarterly landings were estimated using the average proportion for the further five years (1989–1993) by fleet. In the case of SPART8C quarterly landings were estimated from 1980 to 1993 using the average proportion for the further five years (1994–1998).

Abundance indices:

- A Coruña trawlers (SPCORTR8C): Quarterly lpue in weight from 1982 to 2012. It is entered as four separate indices, one index per quarter.
- Cedeira gillnetters (SPCEDGN8C): Quarterly lpue in weight from 1999 to 2011. It is entered as four separate indices, one index per quarter.
- Spanish Groundfish Survey (SPGFS): Abundance index in numbers from 1983 to 2020, except for 1987.

Length composition of data:

The length bin was set by 2 cm, from 4 to 100 cm, by 10 cm from 100 to 160 cm and by 40 cm from 160 to 200 cm. Length composition for the four fishing fleets and the three abundance indices were used. The available length data and their disaggregated level differ among fleets:

Length composition of Fleets:

- SPTR8C9A: 1986–2019, quarterly basis. From 1986 to 1988 quarterly length proportions were estimated from an annual proportion using the Data Super-Period approach available in SS.
- SPART8C: 1986–2020, quarterly basis. From 1986 to 1994 quarterly length proportions were estimated from an annual proportion using the Data Super-Period approach available in SS.
- PTTR9A: 1986–2009, quarterly basis. From 1986 to 1988 quarterly length proportions were estimated from an annual proportion using the Data Super-Period approach presented in SS.
- PTART9A: 1986–2009, quarterly basis. From 1986 to 1988 quarterly length proportions were estimated from an annual proportion using the Data Super-Period approach present in SS.

Length composition of Abundance Indices:

- SPCORTR8C: 1982–2012, quarterly basis. Gaps are presented in years 1982, 1984, 1985 and 1986.
- SPCEDGN8C: 1999–2011, quarterly basis.
- SPGFS: length composition for fourth quarter, from 1983–2020. 1987 length composition is missing.

Model assumptions and parameters

- Natural mortality: M=0.2 for all ages and years.
- Growth: vonBertalanffy function: K=0.11 fixed, L_{max} and mean length-at-age 0.75 are estimated.

- Maturity ogive: length-based logistic, L_{50}=61.84 and slope=-0.1001, constant over time.
- Weight-at-length: a=2.5×10-5 b=2.853, not estimated.
- Recruitment allocation in Quarter 3.
- Stock–recruitment relationship: Beverton–Holt model: steepness h=0.999, sigmaR=0.4, R0 estimated.
- Selectivity: For all fleets selectivity was only length-based and was modelled as a double normal function. Selectivity for fishery PTART9A was set to be flattop. Selectivity varies among fleets, but is assumed to be time-invariant.

D. Short-term projection

Model used: Stock Synthesis.

Software used: *ad hoc* R code.

Initial stock size: SS outputs in the last assessment year.

Natural mortality: Set to 0.2 for all ages in all years.

Growth model: von Bertalanffy function, with parameters estimated in the assessment model.

Maturity-at-length: The same ogive as in the assessment is used for all years.

Weight-at-length in the stock and in the catch: The same length–weight relationship as in the assessment model.

Exploitation pattern: Average of the final three assessment years (with the possibility of scaling to final year F).

Intermediate year assumptions: *status quo* F.

Recruitment: geometric mean of estimated recruitment from 1980 until the final assessment year. If trends in recruitment become evident a shorter range of years could be selected.

E. Medium-term projections

No medium-term projections are conducted for white anglerfish stock.

F. Yield and biomass per recruit/long-term projections

Yield-per-recruit calculations are conducted using the same input values as those used for the short-term forecasts.

Model used: yield and biomass-per-recruit over a range of F values.

Software used: *ad hoc* R code.

G. Biological reference points

In the WKAngler 2018 (ICES, 2018) biological reference points were revised for this stock. The updated reference points and their technical bases are as follows:

Framework	Type	Value	Technical basis	Source
MSY approach	MSY Btrigger	6283 t	5th percentile of SSB when fishing at F_{MSY}	ICES (2021)
	F_{MSY}	0.24	F that maximises median equilibrium yield	
	F_{MSY} ranges [Flower, Fupper]	0.164, 0.33	5% reduction in long-term yield compared with MSY	
Precautionary approach	Blim	1993 t	Bloss (lowest observed SSB)	ICES (2021)
	Bpa	2769 t	Blim * exp(1.645 * σ), where σ = 0.2	
	Flim*		not defined	
	Fpa*	0.87	Fp0.5; the F that leads to SSB ≥ Blim with 95% probability, calculated using Btrigger.	
Management Plan	Flower	0.164	5% reduction in long-term yield compared with MSY	ICES (2021)

* Following the ACOM decision in 2020 (ICES, 2020), Fpa is defined as Fp0.5 and Flim is not defined.

H. Other issues

H.1 Historical development of assessment

Southern Anglerfish stocks were assessed for the first time in the 1990 ICES WG meeting. Different assessment trials were performed during the subsequent eight years, but analytical assessments indicated unrealistic results. The database (both biological and fisheries data) was improved along these years trying to apply an analytical assessment model. Since 1998, a non-equilibrium surplus production model ASPIC (Prager, 1994) was applied to each stock or to the combined stock data. These stock assessments were accepted by the ACFM and used to provide management advice. The assessment of white anglerfish as a separate stock has been carried out continuously from 2007. The history of white anglerfish assessment from 2007 to 2021 is presented in Table 1.

Table 1. History of southern white anglerfish assessment from 2007–2018.

WG	2007	2008	2009	2010	2011		2012	2013
Assessment Model	Non-equilibrium Surplus production model (Prager, 2004)	No updated	Non-equilibrium Surplus production model (Prager, 2004)	Non-equilibrium Surplus production model (Prager, 2004)	Non-equilibrium Surplus production model (Prager, 2004)	Assessment Model Model Structure	Stock Synthesis 3 (Methot, 2000) Length-based Quarterly based data	Stock Synthesis 3 (Methot, 2000) Length-based Quarterly based data
Software	ASPIC (v. 5.16)	No updated	ASPIC (v. 5.16)	ASPIC (v. 5.34)	ASPIC (v. 5.34.9)	Software	SS3v23b	SS3v23b
Catch data range	1980–2006		1980–2008	1980–2009	1980–2010	Catch data range Fleets	1980–2010 SPTR8C9A SPART8C PTTR9A PTART9A	1980–2012 SPTR8C9A SPART8C PTTR9A PTART9A
Cpue Series 1 (years)	SP-CORUTR8c (1986–2006)		SP-CORUTR8c (1986–2008)	SP-CORUTR8c (1986–2009)	SP-CORUTR8c (1986–2010)	Abundance Index 1 (by quarter)	SPCORUTR8c (1982–2010)	SPCORUTR8c (1982–2012)
Index of Biomass (years)	SP-CEDGNS8c (1999–2006)		SP-CEDGNS8c (1999–2008)	SP-CEDGNS8c (1999–2009)	SP-CEDGNS8c (1999–2010)	Abundance Index 2 (by quarter)	SPCEDGN8C (1999–2010)	SPCEDGN8C (1999–2011)
Error Type	Condition on yield		Condition on yield	Condition on yield	Condition on yield	Abundance Index 3 (4rd quarter)	SPGFS (1983–2010)	SPGFS (1983–2012)
Number of bootstrap	500		500	1000	1000	Natural mortality	M=0.2 for all ages and years	M=0.2 for all ages and years
Maximum F	8.0 (y-1)		8.0 (y-1)	8.0 (y-1)	8.0 (y-1)	Growth	von Bertalanffy K=0.11 fixed Lmax estimated	von Bertalanffy K=0.11 fixed Lmax estimated

WG	2007	2008	2009	2010	2011		2012	2013
Statistical weight B1/K	1		1	1	1	Maturity ogive	length-based logistic L50=61.84 slope=-0.1001	length-based logistic L50=61.84 slope=-0.1001
Statistical weight for fisheries	1,1		1,1	1,1	1,1	Weight-at-length	a=2.70×10-5 b=2.839	a=2.70×10-5 b=2.839
B1-ratio (starting guess)	0.5		0.5	0.5	0.5	Recruitment allocation	Quarter 3	Quarter 3
MSY (starting guess)	5000 t		5000 t	5000 t	5000 t	Stock–Recruitment	Beverton–Holt model h=0.999 sigmaR=0.4 R0 estimated	Beverton–Holt model h=0.999 sigmaR=0.4 R0 estimated
K (starting guess)	50 000 t		50 000 t	50 000 t	50 000 t	Selectivity	All fleets: length-based double normal function Varies among fleets Time-invariant	All fleets: length-based double normal function Varies among fleets Time-invariant
q1 (starting guess)	1d-5		1d-5	1d-5	1d-5			
q2 (starting guess)	1d-6		1d-6	1d-6	1d-6			
Estimated parameter	All		All	All	All			
Min and Max allowable MSY	2000 (t)–10 000 (t)		2000 (t)–10 000 (t)	2000 (t)–11 500 (t)	2000 (t)–11 500 (t)			
Min and Max K	5000 (t)–500 000 (t)		5000 (t)–100 000 (t)	5000 (t)–112 000 (t)	5000 (t)–112 000 (t)			

WG	2007	2008	2009	2010	2011		2012	2013
Random Number Seed	1 964 18 5		1 964 18 5	1 964 18 5	1 964 18 5			

WG	2014	2015	2016	2018	2019
Assessment Model	Stock Synthesis 3 (Methot, 2000)	Stock Synthesis 3 (Methot, 2000)	Stock Synthesis 3 (Methot, 2000)	Stock Synthesis (Methot, 2018)	Stock Synthesis (Methot, 2018)
Model Structure	Length-based Quarterly based data	Length-based Quarterly based data	Length-based Quarterly based data	Length-based Quarterly based data	Length-based Quarterly based data
Software	SS3v23b	SS3v23b	SS3v23b	SS v30.10	SS v30.10
Catch data range	1980–2013	1980–2014	1980–2015	1980–2017	1980–2018
Fleets	SPTR8C9A SPART8C PTTR9A PTART9A	SPTR8C9A SPART8C PTTR9A PTART9A	SPTR8C9A SPART8C PTTR9A PTART9A	SPTR8C9A SPART8C PTTR9A PTART9A	SPTR8C9A SPART8C PTTR9A PTART9A
Abundance Index 1 (by quarter)	SPCORUTR8c (1982–2012)	SPCORUTR8c (1982–2012)	SPCORUTR8c (1982–2012)	SPCORUTR8c (1982–2012)	SPCORUTR8c (1982–2012)
Abundance Index 2 (by quarter)	SPCEDGN8C (1999–2011)	SPCEDGN8C (1999–2011)	SPCEDGN8C (1999–2011)	SPCEDGN8C (1999–2011)	SPCEDGN8C (1999–2011)
Abundance Index 3 (4rd quarter)	SPGFS (1983–2013)	SPGFS (1983–2014)	SPGFS (1983–2015)	SPGFS (1983–2017)	SPGFS (1983–2018)
Natural mortality	M=0.2 for all ages and years	M=0.2 for all ages and years	M=0.2 for all ages and years	M=0.2 for all ages and years	M=0.2 for all ages and years
Growth	von Bertalanffy K=0.11 fixed Lmax estimated	von Bertalanffy K=0.11 fixed Lmax estimated	von Bertalanffy K=0.11 fixed Lmax estimated	von Bertalanffy K=0.11 fixed Lmax estimated	von Bertalanffy K=0.11 fixed Lmax estimated
Maturity ogive	length-based logistic L50=61.84 slope=-0.1001	length-based logistic L50=61.84 slope=-0.1001	length-based logistic L50=61.84 slope=-0.1001	length-based logistic L50=61.84 slope=-0.1001	length-based logistic L50=61.84 slope=-0.1001
Weight-at-length	a=2.70×10-5 b=2.839	a=2.70×10-5 b=2.839	a=2.70×10-5 b=2.839	a=2.50×10-5 b=2.853	a=2.50×10-5 b=2.853
Recruitment allocation	Quarter 3	Quarter 3	Quarter 3	Quarter 3	Quarter 3
Stock–recruitment	Beverton–Holt model h=0.999 sigmaR=0.4 R0 estimated	Beverton–Holt model h=0.999 sigmaR=0.4 R0 estimated	Beverton–Holt model h=0.999 sigmaR=0.4 R0 estimated	Beverton–Holt model h=0.999 sigmaR=0.4 R0 estimated	Beverton–Holt model h=0.999 sigmaR=0.4 R0 estimated

WG	2014	2015	2016	2018	2019
Selectivity	All fleets: length-based double normal function Varies among fleets Time-invariant	All fleets: length-based double normal function Varies among fleets Time-invariant	All fleets: length-based double normal function Varies among fleets Time-invariant	All fleets: length-based double normal function PTART9A flat top Varies among fleets Time-invariant	All fleets: length-based double normal function PTART9A flat top Varies among fleets Time-invariant

WG	2020	2021
Assessment Model	Stock Synthesis (Methot, 2018)	Stock Synthesis (Methot, 2018)
Model Structure	Length-based Quarterly based data	Length-based Quarterly based data
Software	SSv3.30.10	SS3v3.30.10
Catch data range	1980–2019	1980–2020
Fleets	SPTR8C9A SPART8C PTTR9A PTART9A	SPTR8C9A SPART8C PTTR9A PTART9A
Abundance Index 1 (by quarter)	SPCORUTR8c (1982–2012)	SPCORUTR8c (1982–2012)
Abundance Index 2 (by quarter)	SPCEDGN8C (1999–2011)	SPCEDGN8C (1999–2011)
Abundance Index 3 (4rd quarter)	SPGFS (1983–2019)	SPGFS (1983–2020)
Natural mortality	M=0.2 for all ages and years	M=0.2 for all ages and years
Growth	von Bertalanffy K=0.11 fixed Lmax estimated	von Bertalanffy K=0.11 fixed Lmax estimated
Maturity ogive	length-based logistic L50=61.84 slope=-0.1001	length-based logistic L50=61.84 slope=-0.1001
Weight-at-length	a=2.50×10-5 b=2.853	a=2.50×10-5 b=2.853
Recruitment allocation	Quarter 3	Quarter 3
Stock–recruitment	Beverton–Holt model h=0.999 sigmaR=0.4 R0 estimated	Beverton–Holt model h=0.999 sigmaR=0.4 R0 estimated

WG	2020	2021
Selectivity	All fleets: length-based double normal function PTART9A flat top Varies among fleets Time-invariant	All fleets: length-based double normal function PTART9A flat top Varies among fleets Time-invariant

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Stock Annex

Quality Handbook ANNEX: K

Stock specific documentation of standard assessment procedures used by ICES.

Stock	North Galicia (Division VIIIc, FU 25).
Working Group:	WGBIE
Date:	3 May 2021 (update)
Revised by	Isabel González Herraiz

A. General

A.1. Stock definition

Nephrops stock from FU 25 stretches along the Atlantic area off the northwest Spanish coast, located between Cap Finisterre and San Andrés de Teixido (statistical rectangles 15E0-1 and 16E1). WGBIE 2021 decided to add rectangles 16E0 and 17E1 to FU 25.

A.2. Fishery

Nephrops is caught in the mixed bottom trawl fishery (métier OTB_DEF≥55) in the North and Northwest Iberian Atlantic. Bottom trawl in this area must be carried out by vessels with at least 24 m of length and at a depth over 100 m (BOE, 1999, BOE, 2013). The daily maximum period of activity is 18 hours and there must be a break by week of 48 hours consecutive. Minimum mesh size for trawling is 70 mm (BOE, 1999). OTB_DEF≥55 métier targets hake, megrim, horse mackerel and anglerfish. Blue whiting, hake, anglerfish and megrim are the species with more landings in the trips of OTB_DEF≥55 in FU 25 with *Nephrops* catch (logbooks 2008-2016). The *Prestige* oil spill in November 2002, which started in the rectangle 15E0, resulted in a reduction in fishing effort until June 2003 and the closure of the fishery from January to April 2003. A recovery plan for 8c and 9a hake and *Nephrops* stocks (except FU 30) was implemented and enforced since 2006 (EC, 2005) to 2019. The increasing use of pair trawlers and HVO trawlers has reduced the fishing effort on the species.

Nephrops is managed by aTAC (applying to the whole ICES Division 8c) and technical measures. The TAC is zero for the periods 2017-2019 and 2020-2022. A *Nephrops* Sentinel fishery has been carried out in FU 25 since 2017. European Union regulations establish 20 mm carapace length (CL) as a minimum landing size. Few animals are caught under size. The *Nephrops* fishery takes place throughout the year, with the highest LPUE in July, as in other FUs.

Although *Nephrops* represented a very low percentage of the total weight landed (Fariña, 1996), the species is a very valuable component of the landings due to its high market price. The emergence patterns of the *Nephrops* females during the incubation period results in a different exploitation pattern for each sex. The decline of the FUs 25, 31 and 26-27 *Nephrops* fishery from 1975 to 2000 is described in Fariña & González Herraiz, 2003.

A.3. Ecosystem aspects

This geographical area is characterized by seasonal upwelling of North Atlantic Central Water during spring and summer caused by northeast wind. The upwelling and fluvial flows are the main sources of nutrients in the region (Bode et al., 2012).

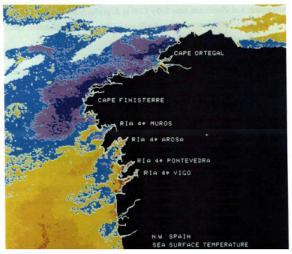

Figure 1. Upwelling in the area of FU 25. Cold waters in purple and dark blue and warm waters in yellow and red. Image from 25 of June of 1984 (Fariña, 1996).

Unlike other functional units (González Herraiz et al., 2009), a link between the North Atlantic Oscillation (NAO) and low *Nephrops* LPUEs has not been observed in FU 25 (González Herraiz et al., 2015). From 1970 to 2002 there were seven spills of toxic substances in the FU 25 area (in 1970, 1976, 1978, 1987, 1992, 1996 and 2002).

There have been several earthquakes in the FU 25, in May 1997 in the Northwest of Spain with a magnitude of 5.3 on the Richter scale, in November 2016 in the rectangle 15E1 of the FU 25, in January 2019 in the rectangle 16E1 of the FU 25 of 2.7 and in April 2019 two in areas adjacent to FU 25, one in rectangle 16E0, of 3.0, at 6 km depth and other in rectangle 17E1, of 3.5, at 40 km depth.

Nephrops is a burrowing species and occurs on muddy sea bed on the continental shelf and upper slope. The distribution of *Nephrops* in this area is limited to depths ranging from 90-600 m in a patchwork configuration where the substrate is suitable. Its distribution is more determined by ground type and sea temperature than by depth. *Nephrops* are sedentary but they can leave their burrows in search of food and for reproduction.

After reaching sexual maturity, males molt more frequently than females, consequently growing faster. Mating in FU 25 takes place from May to July (González Herraiz et al., 2011) just after the females molt. Eggs are fertilized when they are laid and they attach under the female abdomen. Berried *Nephrops* stay in the incubation period from September to April inside their burrows. Egg loss is significant during incubation. Eggs hatch in April-May, larvae are pelagic for one month around June, after metamorphosis the small *Nephrops* settle on the sea bed.

Nephrops are omnivorous, but polychetes, crustaceans, molluscs and echinoderms are their favourite preys. There are not reports on *Nephrops*' predators in the area.

B. Data

B.1. Commercial catch

Landings

Landings are reported only by Spain, with the data based on Spanish sales notes and Owners Associations data compiled by IEO since 1975. Fisheries statistics are believed to be reliable. However, during the periods 1998-2001 and 2004-2008 the information sources failed and landings data were obtained from the biological sampling programme, instead of directly from the sale sheets, which makes the quality of estimates more questionable. Since 2008 logbooks information is added.

Discard

Nephrops discards are negligible in this fishery. Generally, only soft and damaged individuals are discarded (Pérez et al., 1996) and the information is obtained via the discard sampling programme that is carried out by observers onboard. Since 2018 (TAC zero started in 2017) there are also some discards registered in logbooks in the FU 25 ($\leq$1 ton by year).

B.2. Biological

Landing numbers at length

Annual length compositions of the commercial landings of *Nephrops* for both males and females are available since 1981 to 2016 for the trawl fleet that sells in the port of A Coruña. The sampling data were raised to the total landings by market category and month. There are also length distributions by sex from the SP-NSGFS survey since 1983 (October) and from the FU 25 Nephrops Sentinel fishery since 2017 (July & August).

Catch numbers at age

An agreed method to determine age is not available for *Nephrops*.

Maturity at length

The carapace length at which the 50% of the females are mature according with the criterion of ovary stage or eggs presence is 28.3 mm (Fariña, 1996).

Natural mortality

Nephrops assessments in the past used a natural mortality rate of 0.2 yr^{-1} assumed from Morizur (1982). This value was adopted for all ages and years in the absence of any direct estimates.

Length-weight relationship

The weight at length relationship was calculated using data from the survey Sisargas 1983 (Fariña, 1984):

Weight in grams = 0.00043 x carapace length in $mm^{3.160}$

B.3. Surveys

The SP-NSGFS survey, carried out in October to collect information on abundance of demersal species, provides an abundance index of *Nephrops* FU 25. This index is obtained with the hauls within the *Nephrops* area of the FU. The FU 25 *Nephrops* area has been calculated with the hauls with *Nephrops* catch in the SP-NSGFS (1983-2020), in the discards programme (1994-2020) and in the Sentinel Fishery (2017-2020). SP-NSGFS has half hour hauls and covers the northwest area of Spain, from Portugal to France, during September/October since 1983 (except 1987). Data for 2003 are not considered reliable. Despite SP-NSGFS survey was not designed for *Nephrops*, the SP-NSGFS *Nephrops* abundance index has been considered suitable for the assessment (ICES, 2021). The survey provides also *Nephrops* length distributions by sex.

B.4. Commercial CPUE

Fishing effort and LPUE data are available for the trawl fleet that sells in A Coruña port since 1975. The fishing effort corresponds to the bottom trawl fleet that fish in a mixed fishery for demersal species (not specifically directed to *Nephrops*). Fishing effort and LPUE data since 1999 exclude the fishing trips that operate with HVO, as this gear (which catches mostly mackerel and horse mackerel) does not catch *Nephrops*.

B.5. Other relevant data

The spatial information from SP-NSGFS survey (1983-2020), Discards Programme (1994-2020) and Sentinel Fishery (2017-2020) shows a contraction of the FU 25 *Nephrops* area by 63% from 1983 to 2020.

C. Historical Stock Development

Nephrops FU 25 has been regularly assessed since 1990 (ICES, 1990). The last analytical assessment was carried out by the WGHMM in 2006 (ICES, 2006). XSA was applied, using "catch-at age" data generated by the slicing of length distributions employing the L2AGE program. This procedure, introduced in the 1991 *Nephrops* WG, uses von Bertalanffy growth parameters to determine limits between age classes. The use of slicing to convert length compositions into age compositions is controversial, especially for older age groups (3 and older). An assessment for both sexes combined was carried out, although slicing was applied by sex and the results combined to obtain a single catch-at-age matrix for both sexes.

The 2006 XSA assessment was calibrated using data from a single commercial LPUE series, where the definition of fishing effort was based on nominal effort. The results were only accepted as indicative of stock trends.

Model used (until 2006): XSA

Software used: Lowestoft VPA Suite (VPA95.exe), Retvpa02.exe

Input data types and characteristics:

Parameter	**Value**	**Source**
Discard survival	NA	Not applicable _ Few discards (<1% on average)
MALES		
Growth-K	0.160	(ICES, 1994)
Grouth-L(inf)	70	"
Natural mortality-M	0.2	"
Lenght/weight-a	0.00043	(Fariña, 1984)
Lenght/weight-b	3.160	"
FEMALES		
Inmature Growth		
Growth-K	0.160	(ICES, 1994)
Growth-L(inf)	70	"
Natural mortality-M	0.2	"
Size at maturity (mm CL)	28	(Fariña, 1996)
Mature Growth		

Growth-K	0.080	(ICES, 1994)
Grouth-L(inf)	60	“
Natural mortality-M	0.2	Assumed from Morizur (1982)
Lenght/weight-a	0.00043	(Fariña, 1984)
Lenght/weight-b	3.160	“

XSA run:

Males+Females	**2006 WGHMM**	
Tuning Fleets used SP-CORUTR-8c	Assessment Years 1982-2005	Assessment Ages 2 - 9
First age for normal catchability independent analysis	All ages independent	
First age at which q is considered independent of age	7	
Taper	Tricube over 20 yrs	
F shrinkage (SE for mean F)	1.5	
F Shrinkage	Final 5 yrs	3 oldest ages
Minimum Log SE for terminal population estimates	0.3	
Fbar (age)	4 - 7	
Recruitment Age	2	

No improvements in relation to the methodological assessment have been achieved after 2006 and the WG has not attempted any further analytical assessment for this stock. The time series of fisheries data are updated annually and LPUE series used to depict the stock trend.

Since 2012, the advice for this stock was based on fishery LPUE and effort trend, according to the ICES data-limited approach (ICES, 2012). This stock is classified in the category 3.1.4. of Data Limited Stocks (DSL): stocks with extremely low biomass, a recovery plan and possible zero catch is advised (ICES, 2017).

A new assessment model, stochastic Surplus Production model in Continuous Time (SPiCT; Pedersen & Berg, 2016) was accepted during the benchmark WKMSYSPiCT (ICES, 2021). The accepted configuration uses a reviewed catch time series (1975-2020) and the SP-NSGFS *Nephrops* abundance index (1983-2020). This model was considered more reliable than other Data Limited Stocks (DLS) methods since takes into account the history of the fishery and does not need a long list of life cycle parameters most of them unknown or with very high uncertainty. Priors about the level of exploitation of the stock before the beginning of the time series, the shape parameter ‘n’, the intrinsic growth rate parameters ‘r’, the coefficient of variation of the catches and the F diffusion process and about the uncertainty of the catches after the TAC zero were used to obtain satisfactory diagnostics. The result was 2020 biomass was the 11% of the B_{MSY} and the 22% of the $B_{trigger}$ and 2020 fishing mortality was the 8% of the F_{MSY}.

D. Short-Term Projection

During the benchmark WKMSYSPiCT, four different scenarios were selected as the most relevant options for the short-term catch forecast:

1. No fishing mortality (F=0),

2. Status quo fishing mortality ($F=F_{sq}$),

3. Hockey-stick MSY rule: $F=F_{MSY}$ when biomass is higher than $B_{trigger}$, but F is reduced linearly to zero when the biomass is less than $B_{trigger}$, as it happens in FU 25,

4. Hockey-stick MSY rule with the catch fractile: in order to take into account, the estimated uncertainties, the 35th percentile of the catch distribution is used instead of the median. The F assumption is the same as in 3 (in the case of FU 25 reduction to zero).

The predicted catch and states for 2023 was:

	C (tonnes)	B/B_{MSY}	F/F_{MSY}
F=0	0.0	0.15 (0.03-0.69)	0.00 (0.00-0.00)
$F=F_{sq}$	3.2	0.15 (0.03-0.69)	0.08 (0.01-0.80)
$F=F_{MSY}$	0.0	0.15 (0.03-0.69)	0.00 (0.00-0.00)
$F=F_{MSY}$_C_fractile	0.0	0.15 (0.03-0.69)	0.00 (0.00-0.00)

E. Medium-Term Projections

SPiCT is not adequate for medium or long-term projections.

F. Long-Term Projections

SPiCT is not adequate for medium or long-term projections.

G. Biological Reference Points

Biomass $2020/B_{MSY} = 0.11$

Biomass $2020/B_{trigger} = 0.22$

Fishing mortality $2020/F_{MSY} = 0.08$.

H. Other Issues

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Stock Annex

Quality Handbook ANNEX: K

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Cantabrian Sea (Division VIIIc, FU 31).
Working Group:	WGBIE
Date:	04 May 2021 (update)
Revised by	Isabel González Herraiz

A. General

A.1. Stock definition

Nephrops stock from FU 31 extends in patches located in the central and in the easternmost Cantabrian Sea (statistical rectangles 16E4-7).

A.2. Fishery

Nephrops is caught mostly in the mixed bottom trawl fishery (métier OTB_DEF≥55) in the North and Northwest Iberian Atlantic. Also, in, the 7% of the Spanish landings of *Nephrops* were obtained from crustacean pots (métier FPO_CRU), and 1% from other pots or traps (métier FPO_FIF) (logbooks 2008-2016). Bottom trawl in this area must be carried out by vessels with at least 24 m of length and at a depth over 100 m (BOE, 1999, BOE, 2013). The daily maximum period of activity is 18 hours and there must be a break by week of 48 hours consecutive. Minimum mesh size for trawling is 70 mm (BOE, 1999). OTB_DEF≥55 targets hake, megrim, horse mackerel and anglerfish. Anglerfish, hake, forkbeards and megrim are the species with more landings in the trips of OTB_DEF≥55 in FU 31 with *Nephrops* catch (logbooks, 2008-2016). The increase in the use of other gears (HVO and pair trawl) resulted in the reduction in effort by the metier OTB_DEF≥55. A recovery plan for 8c and 9a hake and *Nephrops* stocks (except FU 30) was implemented and enforced since 2006 (EC, 2005) to 2019.

Nephrops is managed by a TAC (applying to the whole ICES Division 8c) and technical measures. The TAC is zero for the periods 2017-2019 and 2020-2022. A *Nephrops* Sentinel fishery has been carried out in FU 31 since 2019. European Union regulations establish 20 mm carapace length (CL) as a minimum landing size. Few animals are caught under size. The *Nephrops* fishery takes place throughout the year, with the highest LPUE in July, as in other FUs.

Although *Nephrops* represented a very low percentage of the total weight landed (6% in OTB_DEF≥55, logbooks 2008-2016), the species is a very valuable component of the landings due to its high market price. The emergence patterns of the *Nephrops* females during the incubation period results in a different exploitation pattern for each sex. The decline of the FUs 25, 31 and 26-27 *Nephrops* fishery from 1975 to 2000 is described in Fariña & González Herraiz, 2003.

A.3. Ecosystem aspects

This geographical area is characterized by seasonal upwelling of North Atlantic Central Water during spring and summer caused by east wind. The upwelling and fluvial flows are the main sources of nutrients in the region (Bode et al., 2012).

Nephrops is a burrowing species and occurs on muddy sea bed on the continental shelf and upper slope. The distribution of *Nephrops* in this area is limited to depths ranging from 90-600 m in a patchwork configuration where the substrate is suitable. It distribution is more determined by ground type and sea temperature than depth. They are sedentary but they can leave this burrow to look for food and for the reproduction.

After reaching sexual maturity, males molts more frequently than females, consequently growing faster. Mating takes place just from May to July (González Herraiz et al., 2011) after the females molt. Eggs are fertilized when they are laid and they attach under the female abdomen. Berried *Nephrops* stay most of the time in the egg's incubation period from September to April in their burrows. Egg loss is significant during incubation. Eggs hatch in April-May, larvae are pelagic for one month around June, after metamorphosis the small *Nephrops* settle on the sea bed.

Nephrops are omnivorous but polychetes, crustaceans, molluscs and echinoderms are its favourite prey. There are not reports on *Nephrops*' predators in the area.

B. Data

B.1. Commercial catch

Landings

Landings were reported only by Spain and they are available since 1983. Data used in FU 31 are based on Spanish sales notes and Owners Associations data compiled by IEO. Since 2008 logbooks information is added.

Discard

Nephrops discards were negligible in this fishery. Generally, only soft and damaged individuals were discarded (Pérez et al., 1996) and the information is obtained via the discard sampling programme that is carried out by observers onboard. Since 2018 (TAC zero started in 2017) there are also relatively high discards registered in logbooks in the FU 31 (≤10 ton by year).

B.2. Biological

Landing numbers at length

Annual length frequencies by sex of *Nephrops* landings are collected by the sampling program since 1988 to 2016. The sampling data of Avilés and Santander fleet were raised to the total landings by market category and month. There are also length distributions by sex from the SP-NSGFS survey (October) since 1983 and from the FU 31 Nephrops Sentinel fishery (July) since 2019.

Catch numbers at age

An agreed method to determine age is not available for *Nephrops*.

Maturity at length

The carapace length at which the 50% of the females are mature according with the criterion of ovary stage or eggs presence is 28.3 mm (Fariña, 1996).

Natural mortality

Nephrops assessments in the past used a natural mortality rate of 0.2 yr^{-1} assumed from Morizur (1982). This value was adopted for all ages and years in the absence of any direct estimates.

Length-weight relationship

The weight at length relationship was calculated using data from the survey Sisargas 1983 (Fariña, 1984):

Weight in grams = 0.00043 x carapace length in $mm^{3.160}$

B.3. Surveys

The SP-NSGFS survey, carried out in October to collect information on abundance of demersal species, provides an abundance indices of *Nephrops* FU 31. This index is obtained with the hauls within the four statistical rectangles of the FU. SP-NSGFS has half hour hauls and covers the northwest area of Spain, from Portugal to France, during September/October since 1983 (except 1987). Data for 2003 are not considered reliable. Despite SP-NSGFS survey was not designed for *Nephrops*, the SP-NSGFS *Nephrops* abundance index has been considered suitable for the assessment (ICES, 2021). The survey provides also *Nephrops* length distributions by sex.

B.4. Commercial CPUE

Landings per unit effort data series correspond to two bottom trawl fleets operating in the Cantabrian Sea with ports of selling Avilés, Santander and Gijón. No effort information for Aviles is available after 2003. In 2008 and 2009 fishing effort data are not available for Santander either.

B.5. Other relevant data

The spatial information from SP-NSGFS survey (1983-2020), Discards Programme (1994-2020) and Sentinel Fishery (2019-2020) shows a diminution of the FU 31 *Nephrops* area by 19% from 1983 to 2020.

C. Historical Stock Development

The last analytical assessment of FU31 was conducted in 2002 (ICES, 2002). XSA was applied, using "catch-at age" data generated by the slicing of length distributions employing the L2AGE program. This procedure, introduced in the 1991 *Nephrops* WG, uses von Bertalanffy growth parameters to determine limits between age classes. The use of slicing to convert length compositions into age compositions is controversial, especially for older age groups (3 and older). An assessment for both sexes combined was carried out, although slicing was applied by sex and the results combined to obtain a single catch-at-age matrix for both sexes. After, the low levels of landings and fishing effort were insufficient to carry out an adequate analytical assessment. The time series of fisheries data were updated annually and LPUE series used to depict the stock trend.

Since 2012, the advice for this stock was based on fishery LPUE and effort trend, according to the ICES data-limited approach (ICES, 2012). This stock is classified in the category 3.14. of Data Limited Stocks (DSL), stocks with extremely low biomass, a recovery plan and possible zero catch is advised (ICES, 2017).

A new assessment model, stochastic Surplus Production model in Continuous Time (SPiCT; Pedersen & Berg, 2016) was accepted during the benchmark WKMSYSPiCT (ICES, 2021). The accepted configuration uses the catch time series (1983-2020) and the FU 31 SP-NSGFS *Nephrops* abundance index (1983-2020). This model was considered more reliable than other Data Limited Stocks (DLS) methods since takes into account the history of the fishery and does not need a long list of life cycle parameters most of them unknown or with very high uncertainty. Priors about the level of exploitation of the stock before the beginning of the time series, the shape parameter 'n', the intrinsic growth rate parameters 'r', the coefficient of variation of the catches and the F diffusion process and about the uncertainty of the catches after the TAC zero were used to obtain satisfactory diagnostics. The result was 2020 biomass was the 44% of the B_{MSY} and the 88% of the $B_{trigger}$ and 2020 fishing mortality was the 34% of the F_{MSY}.

D. Short-Term Projection

During WKMSYSPiCT, four different scenarios were selected as the most relevant options for the short-term catch forecast:

1. No fishing mortality (F=0),

2. Status quo fishing mortality ($F=F_{sq}$),

3. Hockey-stick MSY rule: $F=F_{MSY}$ when biomass is higher than $B_{trigger}$, but F is reduced linearly to zero when the biomass is less than $B_{trigger}$, as it happens in FU 31,

4. Hockey-stick MSY rule with the catch fractile: in order to take into account the estimated uncertainties, the 35th percentile of the catch distribution is used instead of the median. The F assumption is the same as in 3 (in the case of FU 31 reduction to zero).

The predicted catch and states for 2023 was:

	C (tonnes)	B/B_{MSY}	F/F_{MSY}
F=0	0.0	0.54 (0.16-1.87)	0.00 (0.00-0.00)
$F=F_{sq}$	12.2	0.53 (0.15-1.85)	0.44 (0.07-2.84)
$F=F_{MSY}$	26.3	0.50 (0.14-1.84)	0.97 (0.15-6.22)
$F=F_{MSY}$_C_fractile	20.2	0.51 (0.14-1.84)	0.74 (0.11-4.73)

E. Medium-Term Projections

SPiCT is not adequate for medium or long-term projections.

F. Long-Term Projections

SPiCT is not adequate for medium or long-term projections.

G. Biological Reference Points

Biomass 2020/B_{MSY} = 0.44

Biomass 2020/$B_{trigger}$ = 0.88

Fishing mortality 2020/ F_{MSY} = 0.34.

H. Other Issues

I. References

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Stock Annex: Norway lobster (*Nephrops norvegicus*) in Division 9.a, functional units 26–27 (Atlantic Iberian waters East, western Galicia, and northern Portugal)

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	Norway lobster (Division 9a, FU26-27)
Working Group:	Working Group for the Bay of Biscay and the Iberian waters Ecoregion (WGBIE)
Last updated:	May 2021
Last updated by:	Yolanda Vila
Last Benchmarked	WKMSYSPiCT, 2021

A. General

A.1. Stock definition

The *Nephrops* stock from FU 26 extends along the Atlantic area off the northwestern Spanish coast, south of Cape Finisterre, whereas FU 27 covers the Atlantic area off northern Portugal.

A.2. Fishery

Nephrops is caught in a mixed bottom-trawl fishery, which takes place throughout the year, with the highest *Nephrops* landings in spring and summer. The overall decline of some bottom commercial species in the area has influenced the fishing strategies of the trawl fleets in terms of gear modalities and target species. Targeted species include hake, anglerfish, megrim, horse mackerel, mackerel and a variety of other fish and cephalopods.

The bottom-trawl fleet comprises three main components: baca trawl, high vertical opening trawl (HVO) and pair trawl, each targeting different species. Only the baca trawl catches *Nephrops*. The description of these fisheries was updated and reported in STECF (2003). Trawl vessels can change gear from year to year and, consequently, target species and fishing effort applied vary. The increasing use of pairtrawlers and HVO (fishing for mackerel and horse mackerel) that do not catch *Nephrops*, has reduced fishing effort on the species in recent years.

The Prestige oil spill off the northwest Spanish coast (November 2002) resulted in the adoption of several temporary regulations to minimize the impact on the fisheries, such as spatial and seasonal closure for fishing fleets. The fishery remained partially closed from January to April 2003, causing a reduction in fishing effort.

Nephrops is managed in the area by an annual TAC (applying to the whole of ICES Division 9.a) and technical measures. European Union regulations establish 20 mm carapace length (CL) as a minimum landing size. Few animals are caught under size. Although *Nephrops* represents less than 2% of the total weight landed by the bottom-trawl fishery (Fariña, 1996), the species is a very valuable component of the landings.

A recovery plan for southern hake and Iberian *Nephrops* stocks has been in force since the end of January 2006. The aim of the recovery plan is to rebuild the stocks within 10 years, with a reduction of 10% in F relative to the previous year and the TAC set accordingly (Council Regulation (EC) No. 2166/2005). Although no clear targets were defined for Norway lobster stocks in the plan, the same 10% reduction has been applied to these stocks effort and TAC. The number of allowed fishing days is set in each year regulations. However, the number of fishing days included in these regulations is not applicable to the Gulf of Cadiz (FU 30), which has a different effort management regime. ICES has not evaluated the recovery plan for *Nephrops* in relation to the precautionary approach. This plan was based on precautionary reference points for southern hake that are no longer appropriate.

In order to reduce F on *Nephrops* stocks in this Division even further, a seasonal ban was introduced in the trawl and creel fishery for two boxes, located in FU 26 and 28, in the peak of the *Nephrops* fishing season. These boxes are closed for *Nephrops* fishing in June–August and in May–August, respectively (Council Regulation (EC) No 850/98).

A Fishing Plan for the Northwest Cantabrian ground was established in 2013 (AAA/1307/2013). This new regulation establishes an assignation of the quotas by vessel including *Nephrops*.

A new Management Plan for Western Waters was established in 2019 for demersal species including *Nephrops* in these FUs (Regulation (EU) 2019/472, of 19 March 2019). In the current Management Plan for Western Waters, applied to 2020 onwards, no effort limitations were established

Unwanted catches from *Nephrops* are legislated by the discard plan for demersal fisheries in South-Western waters for the period 2019-2021 (Council Regulation (EC) No 2018/2033), under which they are exempted from the landing obligation based on the species' high survival rates. This exemption applies to all catches of Norway lobster from ICES subareas 8 and 9 with bottom trawls, and the discards shall be released whole, immediately and in the area where they were caught.

A.3. Ecosystem aspects

Nephrops is a burrowing species and occurs on muddy seabed on the continental shelf and upper slope. The distribution of *Nephrops* in this area is limited to depths ranging from 90-500 m. Main patch configurations are evident in shallower waters (80–140 m) in the west coast of Galicia. The distribution of *Nephrops* is more determined by ground type and sea temperature than depth. They are sedentary but they can leave their burrows to look for food and for reproduction purposes.

After reaching sexual maturity, males moult more frequently than females, consequently growing faster. Mating takes place just after the females moult. Eggs are fertilized when they are laid and they attach under the female abdomen. Berried *Nephrops* stay most of the time in their burrows. Larvae are pelagic for one month after hatching, then after metamorphosis the small *Nephrops* settle on the seabed. The emergence patterns of females during the incubation period results in a different exploitation pattern for each sex.

Nephrops are omnivorous but polychetes, crustaceans, molluscs and echinoderms are their favourite preys. There are not reports on *Nephrops*' predators in the area.

B. Data

B.1. Commercial catch

Landings

Landings are reported by Spain and minor quantities by Portugal. The catches are taken by Spanish fleets fishing on the Galicia (FU 26) and North Portugal (FU 27) fishing grounds and by the Portuguese artisanal fleet fishing with traps in FU 27. Prior to 1996 no distinction was made between the two FUs and, therefore, the Spanish landings for that early period are given for the two FUs together.

Spanish landings are based on sales notes which are compiled and standardized by IEO. Since 2013, trips from sales notes are also combined with their respective logbooks, which allow georeferencing the catches. Since 2013, the Spanish concurrent sampling is used to raise the FU26-27 observed landings to total effort by *métier*. When the estimated landings exceed the official landings, the difference is provided to InterCatch as non-reported landings.

Landings data are available since 1975 although landings by sex are only available from 1988 onwards.

Discard

Nephrops discards are negligible in this fishery. Generally, only soft and damaged individuals are discarded (Pérez *et al*., 1996) and the information is obtained via the onboard discard sampling program.

B.2. Biological

Length frequencies by sex of the *Nephrops* landings are collected monthly by the biological sampling program since 1988. The sampling data from the Marín and Vigo fleets are raised to the total landings by market category and month. Starting from 2009 concurrent sampling is carried out, as required by the new DCR (Reg. EC 1343/2007). With the new sampling strategy, fishing trips of the bottom-trawl métier are sampled at the auction markets of Riveira (FU 26), Marin (FU 26) and Vigo (FU 27) ports, with 3, 4 and 2 sampling events per month, respectively. Information on discards is not taken into account in the estimation of the total catch length distribution due to the low level of discards.

B.3. Surveys

International Bottom Trawl Surveys

The **Spanish International Trawl Survey Q4 (G2784)** covers the northern Spanish shelf comprised in ICES Division 8c and the northern part of 9a, including the Cantabrian Sea and off Galicia waters. This survey usually starts at the end of the 3rd quarter (September) and finishes in the 4th quarter. Time series is available for 1984-2019 period. No survey was carried out in 1987. It is a bottom trawl survey with a random stratified by depth strata sampling design. Total area is divided in 5 sectors (Miño-Finisterre, Finisterre-Estaca, Estaca-Peñas, Peñas-Ajo and Ajo-Bidasoa) (Figure 1). Miño-Finisterre sector corresponds to statistics rectangles that compound *Nephrops* FU 26 stock (Western Galicia). The area of this sector is 4 327 Km^2. Therefore, hauls conducted in this sector can be used to derive a biomass index in this FU taken into account depth stratification (70-120 m, 121-200 m, 201-500m, 501-800m). Prior 1997, the lowest stratum covered since 30 m depth. However, hauls at depth lower than 70 m are not used as *Nephrops* is not distributed at this deep.

Portuguese International Bottom Trawl Survey Q4 (G8899) is carried out in Portuguese continental waters in the 4th quarter of the years. *Nephrops* data are available for 1984-2017 periods. No survey could conduct in 2019 and 2020. Survey extends from latitude 41°20′ N to 36°30′ N (ICES Division 9a) and from 20–750 m depth following 20-100 m, 101-200 m, 201-500 m and 501-750 m strata design. This survey is divided in 11 sectors (Figure 1), 6 of them correspond to FU 27 (Caminha (CAM), Matosinhos (MAT), Aveiro (AVE), Figueira (FIG), Berluga (BER) and Lisbon (LIS)) covering a total area of 19 055 Km² (Figure 1). So, hauls conducted in those sectors can be used to derive a stratified index in this FU.

Combined index in FU26-27 from Spanish and Portuguese IBTS surveys (G2784+ G8899)

A **new depth stratified biomass index** for the total area covering FU26-27 (23 382 Km²) was estimated during WKMSYSPiCT (ICES, 2021) considering the following sectors: Miño-Finisterre (GAL), Caminha (CAM), Matosinhos (MAT), Aveiro (AVE), Figueira (FIG), Berluga (BER) and Lisbon (LIS) from Spanish and Portuguese IBTS surveys (Figure 1), as parts of a unique survey and taking into account the area corresponding to each stratum of depth. *Nephrops* weight by haul was standardized to 1 hour.

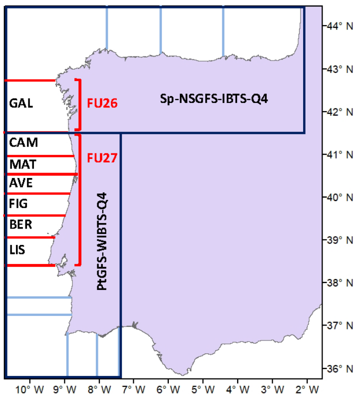
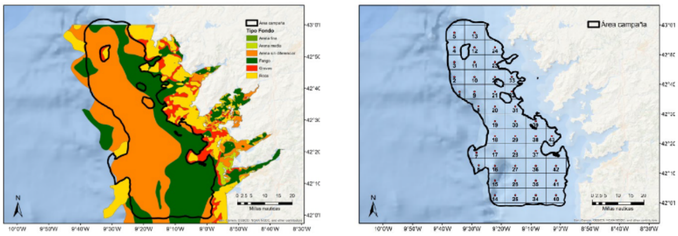


Figure 1. Area and different sectors covered by Spanish IBTS survey (Sp-NSGFS-IBTS-Q4) and Portuguese IBTS survey (PtGFS-WIBTS-Q4). Sectors in red correspond to FU26 (GAL) and FU27 (CAM, MAT, AVE, FIG, BER, LIS).

Trawl Surveys directed to *Nephrops*

GANEP26 survey in FU26

The **GALNEP26** is a survey promoted by Marin Fishing Industry (OPROMAR, Productores de Pesca Fresca del Puerto y la Ría de Marín) in 2019 and carried out yearly in August since then. This survey is conducted onboard a commercial vessel in order to estimate *Nephrops* abundance index in FU 26 (Vila et al., 2020). An observer is onboard during the survey and it is supervised by the IEO. This time series is very short yet. Design follows a systematic sampling over a 5x5 nm grid. Usually, 43 hauls are carried out (one in each cell) (Figure 2). Depth ranged between 110 m and 480 m. Area survey was established on the base on the VMS analysis together the bottom trawl logbooks in the 2009-2017 period. Additionally, sediment composition was taken account and gravel and rocky bottoms were eliminated in the area delimited by VMS. Survey was carried by a unique commercial vessel (27.9 m Length, 109.17 TRB, 430 hp & 70 mm mesh size).



***Nephrops* area distribution in FU26 (Western Galicia). VMS (Vessels Monitoring System) vs (logbooks) bottom trawl 2009-2017 and sediment composition overlapped (left panel). GALNEP26 survey area and survey design (right panel).**

B.4. Commercial cpue

Fishing effort and LPUE data series are available for Marín trawl fleet (SP-MATR) starting from 1990. This fleet accounts for more than 40% of the landings from these FUs. Time-series of fishing effort and LPUE of the bottom-trawl fleets with home ports of Muros (1984–2003), Riveira (1984–2004) and Vigo (1995–2010) are also available.

B.5. Other relevant data

A Bayesian hierarchical model was used in order to obtain a combined survey index for *Nephrops* in FU26-27 stock from G2784 survey in FU26 and G8899 in FU27 in WKMSYSPiCT (ICES, 2021). However, a spatial-time interaction factor was not included in the model. The model-based index used an autoregressive process to estimate the time-trend (years). This implies that the resulting indices by year are not independent of each other, and the time-series will appear smoother as opposed to when year effects are treated independently. This is undesirable when the index is used as data in an assessment model that assumes that each datapoint is independent of the others. WKMSYSPiCT experts recommended using independent year effects in model-based approaches in a further work. Exploratory SPiCT assessments using the bayesian hierarchical model-based combined index were performed, but model convergence could not be achieved with this index for any of the runs tried.

C. Historical Stock Development

The species has been regularly assessed since 1990 (ICES, 1990). The last analytical assessment for this FU was carried out by the WGHMM in 2006 (ICES, 2006). XSA was used with "catch-at age" data generated by slicing length distributions employing the L2AGE program. This procedure, introduced at the 1991 *Nephrops* WG, uses von Bertalanffy growth parameters to determine limits between age classes. The use of slicing to convert length compositions into age composition is controversial, especially for older age groups (3 and older). An assessment with combined sexes was carried out, although the slicing was applied for each sex separately and the resulting catch-at-age matrices by sex added up for the assessment. Prior to 2005 an assessment by sex was carried out but the WG proposed to carry out an assessment for both sexes combined, considering the advantages for management.

The 2006 assessment was calibrated using data from a single commercial LPUE series, where the definition of fishing effort was based on nominal effort. The results were accepted only as indicative of stock trends and not used for projections.

Model used (until 2006): XSA

Software used: Lowestoft VPA Suite (VPA95.exe), Retvpa02.exe

Input data types and characteristics

Parameter	Value	Source
Discards survival	NA	Not applicable-Few discards (<1% on average)
MALES		
Growth-K	0.150	(Fernandez *et al.*, 1986)
Grouth-L(inf)	80	"
Natural mortality-M	0.2	"
Lenght/weight-a	0.00043	(Fariña, 1984)
Lenght/weight-b	3.160	"
FEMALES		
Inmature Growth		
Growth-K	0.160	(ICES, 1994)
Growth-L(inf)	70	"
Natural mortality-M	0.2	"
Size at maturity (mm CL)	26	(Fariña, 1996)
Mature Growth		
Growth-K	0.080	(ICES, 1994)
Grouth-L(inf)	65	"
Natural mortality-M	0.2	"
Lenght/weight-a	0.00043	(Fariña, 1984)
Lenght/weight-b	3.160	"

XSA run:

MALES+FEMALES	2006 WGHMM	
TUNING FLEETS USED	ASSESSMENT YEARS	ASSESSMENT AGES
SP-MATR	1994–2005	2 – 9
First age for normal catchability independent analysis	All ages independent	
First age at which q is considered independent of age	6	
Taper	Tricube over 20 yrs	
F shrinkage (SE for mean F)	1.5	
F Shrinkage	Final 5 yrs	3 oldest ages
Minimum Log SE for terminal population estimates	0.3	
F_{bar} (age)	3 –7	
Recruitment Age	2	

After 2006, no improvements in relation to a methodological assessment were achieved and the WG did not attempt any further analytical assessment for this stock. The time-series of fisheries data are updated every year and LPUE series used to depict the stock trends.

Since 2012, the advice for this stock was based on fishery LPUE and effort trend, according to the ICES data-limited approach (ICES, 2012). This stock is classified according to Data Limited Stocks (DSL) category 3.1.4.: stocks with extremely low biomass.

D. Assessment methods and settings

D.1 Choice of stock assess model

Nephrops in FU2627 is considered a DLS stock. The Surplus Production in Continuous Time (SPiCT) model (Pedersen and Berg, 2017) was proposed during WKMSYSPiCT (ICES, 2021) to produce MSY advice.

D.2 Model used of basis for advice

Model used: SPiCT

Software used*:* SPiCT package, R version 1.3.4 (R Core Team, 2020) available at https://github.com/DTUAqua/spict.

The analyses were made following the Handbook and Guidelines developed for this package (Pedersen *et al*., 2020; Mildenberger *et al*., 2020).

Input data:

- Total landings since 1975 (discards are considered negligible).
- Spanish and Portuguese International Botom Trawl surveys Q4 combined index (G2784+ G8899), since 1983 (no data in 1987).

D.3. Assessment model configuration

The configuration of the SPiCT model chosen for the *Nephrops* in FU26-27 assessment was EXTRA RUN 2 (ICES, 2021).

Settings are:

a) The biomass index time series was scaled to mean 1 in order to obtain a better numerical stability
b) An extra uncertainty was applied to landings from 1975 to 1980 as during this period is possible that a wrong gear identification of some trips could occur and as consequence *Nephrops* landing were lower.
c) Moreover, the uncertainty of the survey index for 1983-1990 was also increased.
d) Priors:

- The initial biomass depletion level, b/k prior: 0.5 with a low CV (medium level).
- The intrinsic growth rate, r prior: 0.2 with a low CV in order to increase model stability
- The production curve, n prior: using the Tighter Shaefer prior.

In order to decrease the confidence intervals of the results, priors for the observation error of (logsdf) and (logsdc) are used. Priors for the ratios of process to observation errors (logalpha) and (logbeta) are removed as it is required.

Below is shown the R code used:

```
## Scale index to mean 1 (for better numerical stability)
mstd <-function(x) x/mean(x,na.rm=TRUE)
data$DEM = mstd(data$DEM)

## CREATE THE inp OBJECT FOR THE MODEL
inp <- list(timeC=data$TC, obsC=data$C,
        obsI=list(obsI=data$DEM),
        timeI=list(timeI=data$TDEM+0.8333333))
inp$dteuler=1/16 ## Obs, this needs to be set BEFORE calling check.inp
inp=check.inp(inp)
inp$dtc

##Check list
check.inp(inp)

## Extra uncertainty in 1975-1980 period Catch
inp$stdevfacC <- rep(1, length(inp$obsC))
inp$stdevfacC[1:6] <- 3

## Extra uncertainty in 1983-1990 period survey index
inp$stdevfacI <- list(c(rep(2, 7), rep(1, length(inp$timeI[[1]]) - 7)))

##To increase n.iter
inp$optimiser.control= list(iter.max = 1e6, eval.max = 1e6)

## Setting priors
inp$priors$logbkfrac <-c(log(0.5),0.2,1) ## Initial DEPLETION level prior (B/K)_medium level
inp$priors$logr <-c(log(0.2),0.2,1) ### r Prior
inp$priors$logn <- c(log(2),0.5,1) ## SHAPE of the Shaefer production curve (Tighter Shaefer prior)
inp$priors$logalpha <- c(0,0,0)   # deactivate
inp$priors$logbeta <- c(0,0,0)   # deactivate
inp$priors$logsdf <- c(log(3), 0.5, 1) # decrease F sd
inp$priors$logsdc <- c(log(0.1), 0.2, 1) # Control catch error sd
```

E. Short-Term Projection

Catch forecast is carried out using SPiCT version 1.3.4 and R code presented during the Benchmark Workshop WKMSYSPiCT 2021 (ICES, 2021).

Four different scenarios were selected as the most relevant options for the short-term catch forecast:

1. No fishing mortality (F = 0).
2. Status quo fishing mortality ($F = F_{sq}$).
3. Hockey-stick MSY rule: $F = F_{MSY}$ when biomass is higher than $B_{trigger}$ ($=0.5\ B_{MSY}$), but F is reduced linearly to zero when the biomass is less than $B_{trigger}$.
4. Hockey-stick MSY rule with the catch fractile: in order to take into account the estimated uncertainties, the 35th percentile of the catch distribution is used instead of the median (50th percentile). The fishing mortality assumption is the same as in 3.

F. Medium-Term Projections

Not used.

G. Long-Term Projections

Not Used.

H. Biological Reference Points

Proxies of MSY reference points have been defined using the methods developed in WKLIFE and WKProxy (ICES, 2015, 2016) during WGBIE 2020. $F_{0.1}$, taken as proxy of F_{MSY}, from length–based analysis for the period 1988–2014 was 0.137 for both sexes combined but the value of MSY Bt_{rigger} proxy is not available.

New stochastic reference points were estimated using the Surplus Production in Continuous Time (SPiCT) Model during WKMSYSPiCT in February 2021 (ICES 2021). In this model, stock status evaluation and stock catch forecast options are based on relative reference points. The reference points are re-estimated every time the model is applied as opposed to many other assessments, where the reference points remain fixed until next benchmark.

The following reference points are used:

- F_{fy}/F_{MSY}: where F_{fy} is the estimated F in the final assessment year and F_{MSY} is the F that maximizes the equilibrium curve of yield versus F
- B_{fy}/B_{MSY}: where B_{fy} is the estimated exploitable biomass in the final assessment year and B_{MSY} is the exploitable biomass corresponding to MSY in the equilibrium curve of yield versus stock biomass
- $B_{fy}/B_{trigger}$: where $B_{trigger}$ is 0.5*B_{MSY}
- B_{fy}/B_{lim}: where B_{lim} is 0.3*B_{MSY}.

WKMSYSPiCT (ICES, 2021) reiterated the use of MSY reference points previously assumed by ICES (2018a). Reference points are shown in Table below.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$	0.5	Relative value. Bmsy is estimated directly from the assessment model and changes when the assessment is updated.	ICES (2021)
	F_{MSY}	1	Relative value. F_{MSY} is estimated directly from the assessment model and changes when the assessment is updated.	ICES (2021)
Precautionary approach	B_{lim}	0.3 × B_{MSY}	Relative value (equilibrium yield at this biomass is 50% of the MSY proxy).	ICES (2021)
	B_{pa}	Not defined		
	F_{lim}	1.7 × F_{MSY}	Relative value (the F that drives the stock to the proxy of B_{lim})	ICES (2021)
	F_{pa}	Not defined		
Management Plan	B_{MGT}	Not defined		
	F_{MGT}	Not defined		
	MAP MSY $B_{trigger}$	0.5 × B_{MSY}	MSY $B_{trigger\ proxy}$	ICES (2021c), EU (2019)
	MAP B_{lim}	0.3 × B_{MSY}	$B_{lim\ proxy}$	ICES (2021c), EU (2019)
	MAP F_{MSY}	1 × F_{MSY}	$F_{MSY\ proxy}$	ICES (2021c), EU (2019)
	MAP range F_{lower}	0.78 × F_{MSY}		ICES (2016), EU (2019)
	MAP range F_{upper}	1 × F_{MSY}	The upper bound is set to the same level as FMSY	ICES (2016), EU (2019)

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Stock Annex: Norway lobster (*Nephrops norvegicus*) in Division 9.a, functional units 28-29 (Atlantic Iberian waters East and south-western and southern Portugal)

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	Norway lobster
Working Group:	Working Group for the Bay of Biscay and the Iberic waters Ecoregion (WGBIE)
Created:	07 May 2009
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Last updated by:	Bárbara Serra Pereira and Cristina Silva

A. General

A.1. Stock definition

The Norway lobster (*Nephrops norvegicus*) is distributed along the continental slope off the southwest and south Portuguese coast, at depths ranging from 200–800 m. Its distribution is limited to muddy sediments and requires sediment with a silt and clay content of between 10–100% to excavate its burrows, and this means that the distribution of suitable sediment defines the species distribution. Although FUs 28 and 29 are different stocklets, landings records are not differentiated, and they are assessed together.

A.2. Fishery

The fishery in FUs 28 and 29 is mainly conducted by Portugal. For the last 25 years, this species has been a very important resource for the demersal trawl fisheries operating in the region. With exception of the years when the abundance of rose shrimp (*Parapenaeus longirostris*) is extremely high, *Nephrops* constitutes the main target species of the majority of the crustacean trawl fleet and is not generally caught as bycatch of other fleets.

The Portuguese trawl fleet comprises two components, namely the trawl fleet fishing for fish and the trawl fleet fishing for crustaceans. The trawl fleet fishing for fish operates off the entire coast while the trawl fleet directed to crustaceans operates mainly in the Southwest and South Portugal, in deep waters, where crustaceans are more abundant. The fish trawlers are licensed to use a mesh size >= 65 mm and the crustacean trawlers are licensed for two different mesh sizes, 55 mm for catching shrimp and >= 70 mm for Norway lobster. Demersal fish trawlers that regularly land *Nephrops*, do in fact target this resource, which in terms of overall profit, represents a significant additional income.

The number of trawlers targeting crustaceans has been fixed at 35 since the early 1990s. However, since the late 1990s, some vessels have been replaced by new ones, better equipped and with a more powerful engine. In 2008, the number of licensed fish trawlers was 69 with an average of 645 HP, 182 GRT and 26 m of overall length, whereas the number of crustacean trawlers was 30, with an average of 562 HP, 177 GRT and 25 m of overall length.

There are two main target species in the crustacean fishery, which are the Norway lobster and the deep-water rose shrimp. These two species have a different but overlapping depth distribution. Rose shrimp occurs from 100–350 meters of depth whereas Norway lobster is distributed from 200–800 meters. The number of fishing trips directed to one species or to the other depends on the abundance of these species each year. The number of fishing trips directed to *Nephrops* increased in 2004–2005, dropping again in recent years.

The fishery takes place throughout the year, with the highest landings usually being made in spring and summer.

A Recovery Plan for the southern hake and Iberian *Nephrops* stocks has been in force since the end of January 2006 (Council Regulation (EC) No. 2166/2005). The aim of the recovery plan is to rebuild the stocks within 10 years, with a reduction of 10% in F relative to the previous year and the TAC set accordingly. In order to reduce fishing mortality on *Nephrops* stocks in this area even further, the Recovery Plan introduced a seasonal ban in the trawl and creel fishery in a box, located in FU 28, for four months in the peak of the *Nephrops* fishing season (May–August).

Every year, the TAC and the number of fishing days per vessel is regulated.

A Portuguese national regulation (Portaria no. 1142/2004, 13th September 2004) enforced a complete closure of the deep-water crustacean trawl fishery in January–February 2005 and established a ban on *Nephrops* fishing from 15 September to 15 October. The ban in September–October was already implemented in 2004. This regulation was revoked in January 2006 after the implementation of the Recovery Plan, keeping only one month of closure of the crustacean fishery in January (Portaria no. 43/2006, 12th January 2006). Although these periods do not correspond to the main fishing season for *Nephrops*, these measures resulted in a reduction of effort.

The minimum landing size (MLS) for *Nephrops norvegicus* is 20 mm of carapace length (CL) or 70 mm of total length (TL). Discards are negligible and are mainly related to quality (broken or soft shells).

The main bycatch species are blue whiting, hake and anglerfish.

A.3. Ecosystem aspects

The Norway lobster (*Nephrops norvegicus*) is distributed along the southwest and south Portuguese coast, at depths ranging from 200–800 m. Its distribution along the continental slope is patchy and high abundance areas have been clearly identified.

Differences in the length composition of catches originating in FU28 (SW Portugal) and those originating in FU29 (S Portugal) were observed during the surveys. At present there is no scientific evidence to separate these stocks and consider them two subpopulations. Further work in this area is needed to improve our knowledge of this stock.

Another topic that should be further investigated, is the possible interaction between the stocks found in FU29 and FU30 (Cadiz). Exchanges between the two populations are likely to occur since there are no known physical/geographical constraints limiting this exchange. Aiming for a better understanding of the *Nephrops* population dynamics, tagging experiments and genetic studies would provide valuable information, which would help to support the issues dealt with during the assessment working groups.

Norway lobster is a benthic species that attains a maximum size of around 80mm (CL) corresponding to a weight of approximately 400g. Lobsters spawn from August through to November off-the-shelf edge in deep waters. After spawning, females carry the eggs for a 3 to 4 month period after which the larvae hatch and become pelagic free swimmers. Larvae move freely in the water column for a short period before settling into the mud grounds. Females reach the first maturity at 30 mm and males around 28 mm of carapace length (CL) (ICES, 2006).

A comprehensive study into the role of Norway lobsters in the ecosystem has not yet been carried out. It would be particularly useful to have such information, as *Nephrops* is part of an extended and dynamic community of highly valuable commercial species.

B. Data

B.1. Commercial catch

Up to 1992 the estimated landings from FUs 28 and 29 have fluctuated between 450 and 530 t, with a long-term average of about 480 t. Between 1990–1996, the landings fell drastically to 132 t. From 1997–2005 landings have increased to levels observed during the early 1990s but decreased again in recent years.

Males are the dominant component in all landings with exception of 1995 and 1996 when total female landings exceeded male landings (ICES, 2006a). Male to female sex-ratio has been close to 1.5:1.

A discard sampling program on board the Portuguese crustacean trawlers started in 2004. Discards of *Nephrops* are considered negligible in this fishery and mostly due to quality.

B.2. Biological

Length distributions for both males and females for the Portuguese trawl landings are obtained from samples taken weekly at the main auction port, Vila Real de Santo António. The sampling data are raised to the total landings by market category, vessel and month. Information on discards is not taken into account in the estimation of the total catch length distributions due to the low level of discards and the lack of defined raising procedures. However, the length distribution of discards confirms the idea that *Nephrops* is not rejected because of its MLS (20 mm of CL) but mainly due to quality problems.

Mean weights-at-age for this stock are estimated from fixed weight-length.

A natural mortality rate of 0.3 was assumed for all age classes and years for males and immature females, with a value of 0.2 for mature females based in Morizur (1982). The lower value for mature females reflects the reduced burrow emergence while ovigerous and hence an assumed reduction in predation.

The size at maturity for females was recalculated at ICES-WKNEPH 2006 to be 30 mm being the same as used in assessments prior to 2008 (ICES, 2006). An asymmetrical log-log relationship was used to estimate the maturity ogive and L_{50}.

A segmented regression was used to estimate the size at maturity for males as the breakpoint in the growth relationship between the appendix masculina and the carapace length. The value estimated for FU 29 was 28.4 mm of CL (ICES, 2006).

Growth parameters were estimated using the Bhattacharya method and tagging experiments (Figueiredo, 1989).

Several factors were considered to potentially affect survival, including duration of the tow and season, and biological characteristics of the individuals (e.g. size, sex and ovigerous condition). Survival was only affected by season (increased mortality in warm months). A global estimate of survival of released lobsters, taking into consideration survival and proportion of the catches for each season, was 35% (Castro *et al.*, 2003).

Table 1. Summary of the life history parameters for *Nephrops* FU 28-29.

INPUT PARAMETERS		
Parameter	Value	Source
Discard Survival	0.35	
MALES		
Growth - K	0.200	Portuguese data (Bhattacharya method) ; tagging (ICES, 1990a)
Growth - L(inf)	70	"
Natural mortality - M	0.3	Figueiredo (1989)
Size at maturity (mm CL)	28.4	ICES (2006)
Length/weight - a	0.00028	Figueiredo (pers. comm., 1986)
Length/weight - b	3.2229	"
FEMALES		
Immature Growth		
Growth - K	0.200	Portuguese data (Bhattacharya method) ; tagging (ICES, 1990a)
Growth - L(inf)	70	"
Natural mortality - M	0.3	Figueiredo (1989)
Size at maturity (mm CL)	30	ICES (1994)
Mature Growth		
Growth - K	0.065	Portuguese data (Bhattacharya method) ; tagging (ICES, 1990a)
Growth - L(inf)	65	"
Natural mortality - M	0.2	Figueiredo (1989)
Length/weight - a	0.00056	Figueiredo (pers. comm., 1986)
Length/weight - b	3.0288	"

B.3. Surveys

The Portuguese crustacean surveys started in 1981. The surveys were carried out with the research vessels «Mestre Costeiro» and «Noruega» and the main areas covered were the southwest coast (Alentejo or FU 28) and the south coast (Algarve or FU 29).

The main objectives were to estimate the abundance, to study the distribution and the biological characteristics of the main crustacean species, namely *Nephrops norvegicus* (Norway lobster), *Parapenaeus longirostris* (rose shrimp) and *Aristeus antennatus* (red shrimp).

In 1997, a stratified sampling design was adopted, based on the design for the demersal resources. The sectors and depth strata were the same used for the groundfish surveys, from 200–750 meters in the southwest coast and from 100–750 meters in the south coast. The number of hauls in each stratum was dependent on *Nephrops* and rose shrimp abundance variance, with a minimum of 2 stations per stratum. The average total number of stations in the period 1997–2004 was 60. These surveys were carried out in May-July and had a total duration of 20 days.

Since 2005, sampling was based on a regular grid superimposed on the area of *Nephrops* distribution. This sampling procedure allows a more powerful use of data, especially considering the use of geostatistical tools. The total duration of the survey was the same (20 days) and the haul duration had to be reduced from 60–30 minutes in order to cover all the rectangles (77) of the grid.

Sediment samples have been collected since 2005 with the aim to study the characteristics of the *Nephrops* fishing grounds.

In 2008, the crustacean trawl survey conducted in Functional Units 28 and 29, was combined with an experimental video sampling. The collection of images was limited to 10 stations in FU 28.

A SeaCorder, composed of an MD4000 high resolution colour camera, an MP4 video recorder and a 30 Gb hard drive, was hung at the central point of the headline, pointing forward onto the seabed with an angle of 45 degrees, approximately (ICES, 2007). A 2-beam laser pointer is attached to the SeaCorder, for measuring purposes (estimation of the width of view and *Nephrops* and burrows sizes).

The collection of video footage was routinely carried out in each trawl station in the 2009 survey. This methodology was evaluated to see if the data could be used for biomass estimation, length distribution and *Nephrops* catchability by the trawl gear (ICES, 2009). The observation of the collected footages shows that the trawling speed and the turbidity were the main problems affecting the clarity of the image and that the high variation of the height of the camera to the ground resulted in a variable field of view. It is not guaranteed that this method can be used for abundance estimation (ICES, 2012a).

B.4. Commercial CPUE

A standardization of the CPUE series was presented to WGHMM in 2008 (Silva, C. – WD 25) and reviewed in 2009, applying the generalized linear models (GLMs). The data used for this standardization were the crustacean logbooks for the period 1988–2008. The factors retained for the final model (year, month and vessel category) were those which contribute more than 1% to the overall variance. The model explains 17–19% of the variability, when using the CPUE in kg/day or kg/haul respectively. The CPUE series was standardized, and the effort estimated correspondingly.

The issue of effort estimation using standardized CPUE from GLMs or other methods considering the flexibility of the fleet in relation to target species was further developed in the WGHMM 2010 (ICES, 2010a) and during WKSHAKE2 (ICES, 2010b). Crustacean vessels are targeting two main species, rose shrimp and Norway lobster, which have different market value. Depending on their abundance/availability, the effort is directed at one species or the other.

The model of CPUE standardization used until 2010 never explained more than 20% of the variability (ICES, 2010a). The explanatory variables used were *year*, *month* and *vessel-category*. Considering the behaviour of the fleet in periods of high abundance of rose shrimp, new variables related to the catches of this species and the proportion of *Nephrops* in the total catch were incorporated. As the distributions of rose shrimp and *Nephrops* are fishing ground and depth dependent, the availability and use of VMS data were suggested to improve the standardization model (Silva and Afonso-Dias, 2011, WD to WKcpueFFORT).

Taking all this into account, new variables as the fishing depth, the catches of rose shrimp and the proportion of *Nephrops* in the total crustacean catches were incorporated in the new model for CPUE standardization and presented to IBP *Nephrops* 2012 (Inter-Benchmark Protocol for *Nephrops* 2012).

The IBP *Nephrops* (ICES, 2012b) did not come to a conclusion about the stock assessment method but the WG has agreed to use this new CPUE standardization for the trends-based assessment and standardized effort estimation.

VMS data are only available since 1998 and the use of this method has shortened the length of the time-series. In the models presented before, the CPUE was expressed in kg/day and the time-series started in 1988. The CPUE in the new model is expressed in kg/hour, the time-series starts 10 years later but the estimation of CPUE is based on more reliable effort data.

The overall analysis of the geo-referenced catches confirmed the general preference of rose shrimp and *Nephrops* for grounds shallower and deeper than 400 m, respectively. These data also confirmed that, in years of higher abundance of rose shrimp, a greater effort is allocated to depths shallower than 400 m. In what concerns the distribution of the fishing effort between the two Functional Units, FU29 represents in average 83% of the total effort. However, the FUs were found not significantly different and therefore removed from the model.

The factors and levels retained in the final model presented to IBP 2012 were updated to include more recent data:

- year: 1998–2015
- month: 1–12
- depth interval: [100, 400[, [400, 800[, [800, 1500]
- log catch of rose shrimp: [0, 2[, [2, 5]
- proportion of *Nephrops* in the total catch of crustaceans: [0, 0.25[, [0.25, 1]

- and vessel category: A (standard), B and C. These two categories correspond to vessels less or more productive than the standard type.

The choice of the final model was based on the highest value of explained variance and the smallest AIC. The model explained 47% in 2013 of the total variability and 51.3% in 2020. The proportion of *Nephrops* in the crustacean catches has been the most important factor. The depth interval class [400, 800[, the log catch of rose shrimp class [0, 2[, the category of proportion of *Nephrops* [0.25, 1] and the vessel category A were used as the reference factors for *Nephrops* target CPUE.

In late 2020, a new approach for the standardization of the CPUE series was presented in the WKMSYSPiCT (ICES, 2021), also based on crustacean trawlers logbooks and VMS records but, differently from the previous model, including both positive and null catches. The new formulation was also improved by incorporating:

- a new variable, 'fishing ground', to take into account the spatial dimension of the *Nephrops* distribution; eight levels were considered in this factor, which includes two fishing grounds in FU28 and six in FU29 (Figure 1);
- the 'depth' as a continuous variable, instead of using depth intervals;
- a new variable for 'target fishing' with four cluster levels, obtained from a non-hierarchical clustering technique, CLARA (Kaufman and Rousseeuw, 1990; Struyf et al., 1996), applied to the catch composition matrix with the proportion in weight per hour of the five main crustacean species (Norway lobster, deepwater rose shrimp, blue and red shrimp (*Aristeus antennatus*), giant red shrimp (*Aristaeomorpha foliacea*) and scarlet shrimp (*Plesiopenaeus edwardsianus*)) caught by the fishery in each record in relation to the total weight per hour of crustaceans; one cluster (cluster 1) contains more deepwater species like blue and red shrimp (56%) and scarlet shrimp (11%), other with a mixture of deepwater rose shrimp and *Nephrops* but with higher proportion of the former (66%, cluster 2), another cluster mostly with deepwater rose shrimp (100%, cluster 3) and one can be considered a *Nephrops* cluster (86%, cluster 4) (Figure 2); the variables used to mimic the target fishing in the previous model, as the proportion of *Nephrops* and classes of deepwater rose shrimp catch, were considered not truly independent from the response variable and were dropped;
- the 'vessel' as random effect.

The best model selected, with 59.6% explained deviance and the lowest AIC, was a Generalized Additive Model (GAM), assuming a Tweedie distribution with a log link function, given that the response variable is a continuous variable with a discrete mass at 0. The explanatory variables included in the final model were: year, month, fishing ground, depth as a continuous variable with a smooth function and target fishing defined by 4 clusters as fixed terms, and vessel as a random effect. The mean estimates of the standardized CPUE series of *Nephrops* from each model were obtained with the least-squares means (Lenth, 2016).

Standardized effort in trawling hours is estimated based on the latest modeled series, dividing the total catch by the standardized CPUE.

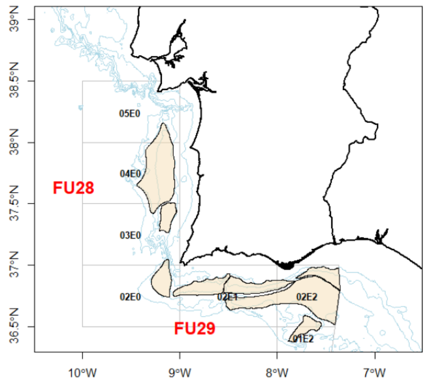

Figure 1. ***Nephrops*** **in FUs 28-29 (SW and S Portugal). Fishing grounds overlaying ICES statistical rectangles.**

Figure 2. ***Nephrops*** **in FU 28-29 (SW and S Portugal). Proportion in weight of the five crustacean species by cluster, considering four clusters. ARA: blue and red shrimp (*Aristeus antennatus*), ARS: giant red shrimp (*Aristaeomorpha foliacea*), DPS: deepwater rose shrimp (*Parapenaeus longirostris*), NEP: Norway lobster (*Nephrops norvegicus*), SSH: scarlet shrimp (*Plesiopenaeus edwardsianus*).**

B.5. Other relevant data

C. Assessment methods

C.1. Historical Stock Development

In the past, LCA assessments were carried out for males and females separately over a 3–year reference period, in which the stock was considered to be in a steady state. The steady state assumption was questioned due to the decrease of the stock and this method was abandoned (ICES, 2002).

Software used: Lba99g.exe

Age structured XSA assessments have been carried out recently for *Nephrops*, males and females separately (ICES, 2008), with two tuning fleets: the crustacean fleet and the crustacean survey. The results were considered unreliable for several reasons most importantly, growth and natural mortality assumptions and the use of age-converted groups by slicing. However, the results have been taken as indicative of stock trends.

Software used:

- For conversion of the length compositions in ages with slicing: L2AGE4.exe
- XSA: Lowestoft VPA Suite (VPA95.exe), Retvpa02.exe, FLR package

MALES	2006 – 2010 WGHMM	
Tuning Fleets used (First - Last year ; Ages used)	Period	Ages
P-TR: Crustacean Trawl Fleet	1988–2005	2–7
P-CTS: Crustacean Trawl Survey	1997–2005	2–7
First age for normal catchability independent analysis	All ages independent	
First age at which q is considered independent of age	6	
Taper time weight applied?	Tricube over 20 yrs	
F shrinkage (SE for mean F)	1.5	
F Shrinkage	Final 5 yrs	3 oldest ages
Minimum Log SE for terminal population estimates	0.3	
F_{bar} (age)	2–7	
Recruitment Age	2	

FEMALES	2006 – 2010 WGHMM	
Tuning Fleets used (First - Last year ; Ages used)	Period	Ages
P-TR: Crustacean Trawl Fleet	1988–2005	2–12
P-CTS: Crustacean Trawl Survey	1997–2005	2–5
First age for normal catchability independent analysis	All ages independent	
First age at which q is considered independent of age	11	
Taper time weight applied?	Tricube over 20 yrs	
F shrinkage (SE for mean F)	1.5	

F Shrinkage	Final 5 yrs	5 oldest ages
Minimum Log SE for terminal population estimates	0.3	
F_{bar} (age)	4–10	
Recruitment Age	2	

Other indicators, such as CPUE from the fleet, abundance index from crustacean trawl survey and mean sizes in landings and in surveys have also been used when analysing trends.

These FUs were assessed using XSA until 2010, but the results were only accepted for trends analysis.

IBP Nephrops 2012 had not come to conclusions at the deadline set in the Terms of Reference (31st March), but noted that, although there were some significant improvements in the tuning fleet data and different XSA model settings have been looked into, there were still some problems of internal consistency (ICES, 2012b).

In 2012, WGHMM considered that XSA shall be abandoned and other methods be tried. Since this year, the advice for these stocks was based on survey and fishery CPUE and effort trends, according to the ICES data-limited approach (ICES, 2012c).

C.2. Current assessment method

This stock is classified in the category 3.2.0 of Data-Limited Stocks (DLS), based on the trends of the standardized commercial CPUE series (since 1998), used as the index of stock development.

The fishing pressure is determined by sex, using the Mean Length Z with effort (THoG; Then et al., 2017), defined in WKLIFE V (ICES, 2015) and WKProxy (ICES, 2016), and reviewed in WKNephrops (ICES, 2020). The input data for this method are the length composition of the catches, the effort series derived from the standardized commercial CPUE and the life history parameters defined in Table 1 (L_∞, k, a, b, L_{50} and M). F trends and values obtained are compared with the F_{MSY} proxy ($F_{0.1}$).

Other indicators are used as auxiliary information for the assessment of *Nephrops* FU28-29, including:

- the trend of the Portuguese crustacean survey (since 1998);
- the mean length by sex obtained from the survey (since 1998);
- the mean length by sex obtained from the commercial catches (since 1984);
- and other length-based methods defined in WKLIFE V (ICES, 2015) and WKProxy (ICES, 2016), and reviewed in WKNephrops (ICES, 2020):
  - Length-Based Indicators, LBI (Cope and Punt, 2009);

- Length-based Stock Potential Ratio (LBSPR) (Hordyk et al., 2015).

The LBI determined by sex, uses as input data the length composition of the catches, the mean weight by length class and the life history parameters L_∞ and L_{50} (Table 1). The indicator ratios presented every year to WGBIE are those informing on:

- the conservation of immatures - L_c/L_{mat} and $L_{25\%}/L_{mat}$;
- the conservation of adults - $L_{max5\%}/L_\infty$ and P_{mega};
- the optimizing yield – L_{mean}/L_{opt}; and
- the MSY - $L_{mean}/L_{F=M}$.

The LBSPR is used to estimate the values of relative fishing mortality (F/M), selectivity-at-length, and the resulting SPR, using the length composition of the catches, life history parameters in Table 1 (M, k, and the resulting M/k, L_∞ and L_{50}), and L_{95} (37.5 mm) as input data. As one of the assumptions of the model is parity of the sex ratio of the catch, and for *Nephrops* FU 28-29 males are more abundant in catches than females, the recommendation is to only consider the model for females (Hordik et al. 2015). The resulting SPR for females is then compared with the SPR target=30-40%, which indicates that the spawning stock biomass (SSB) is maintained at a sustainable level (ICES, 2015).

The ICES framework for category 3 stocks is applied to provide advice for *Nephrops* FU 28-29, based on a comparison of the average of the two latest biomass index values with the average of the three preceding values, multiplied by the recent advised catch (ICES, 2012c).

D. Short-Term Projection

E. Medium-Term Projections

F. Long-Term Projections

G. Biological Reference Points

Proxies of MSY reference points were reviewed in WGBIE 2017 (ICES, 2017) using the methods developed in WKLIFE V and WKProxy (ICES, 2015, 2016a). The $F_{0.1}$ was estimated at 0.23 for males and 0.24 for females, as proxies of F_{MSY}, estimated from the length-based yield-per-recruit analysis, based on external M (Table 1). No proxy for B_{MSY} was identified (ICES, 2017).

H. Other Issues

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Annex F – Stock Annex Bay of Biscay Sole

Quality Handbook	Stock specific documentation of standard assessment procedures used by ICES.
Stock	Sole (division 8ab)
Working Group:	Assessment of Bay of Biscay and the Iberian waters Ecoregion
Date:	WGBIE 2021
Revised by:	M. Lecomte

A General

A.1 Stock definition

The Bay of Biscay sole stock extends on shelf that lies along Atlantic French coast from the Spanish boarder to the West point of Brittany. This shelf forms a geographical unit, being narrow at its two extreme parts, particularly in the south. As sole is chiefly present at less than 150 m, this geography of the living area gives some supports to the absence or only limited exchanges with other southern or northern stocks. However, a tagging experiment carried out in 1992 on two nursery areas has shown that fish may move from southern coast of Brittany to the Iroise sea, in the West of Brittany (KoutsiKopoulos et *al*., 1993).

Several spawning grounds are known at depth from 30 to 100 m, from south to north (Arbault et *al*., 1986):

- in the north of Capbreton, off the Landes coast,
- between Arcachon and the Gironde estuary,
- in front of La Rochelle,
- in front of the Loire estuary,
- in several but limited areas off the southern coast of Brittany.

Nursery grounds are located in the coastal waters, in bays (Pertuis d'Antioche, Pertuis Breton, Baie de Bourgneuf) and estuaries (Gironde, Loire, Vilaine) (Le Pape et *al*., 2003a).

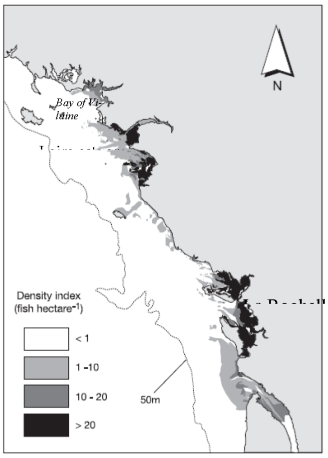


Figure 1: Fitted 0-group sole density (number of fish per hectare) in the Bay of Biscay (Le Pape et *al*., 2003a).

A.2 Fishery

The French fleet is the major participant in the Bay of Biscay sole fishery with landings being about 90% of the total official international landings over the historical series. Most of the remaining part is usually landed by the Belgian fleet.

The fishery is largely a fixed net fishery directed on sole, particularly in the first term on the year. The other component is a French and Belgian trawl fishery. The French trawlers are otter trawlers with mixed species catches (sole, cuttlefish, squid, hake, pout, whiting….). The Belgium trawlers are beam trawlers directed at sole, but monkfish is an important part of its catch. The French coastal boats of these two fisheries have a larger proportion of young fish in their catch than offshore boats. These boats which are less than 12 m long contribute to the landings by about one-third from 2000 onwards. Sole is a major resource for all these boats, given the price of this species on the market. Although the species is taken throughout the year, the catch of coastal netters is less important in autumn, those of coastal trawlers in winter and those of offshore French boats are heaviest in the first quarter.

Otter trawling predominated until the late 1980s, including a small-mesh shrimp fishery which decreased markedly in the beginning of the 1990s. The fixed fishery begun in the 1980s and it have expanded in the 1990 to account for two third to three quarters of the French landings in the beginning of 2000s. The beam trawl effort increased also rapidly and continuously in the 1990s. It has decreased after 1999 until 2004 but it has returned to its previous 2001-2002 level in 2006-2007. In 2010 it had increased until 11 % (his max until 1999). On the opposite, the otter trawl effort shows a decreasing trend until 1999 but it is stable since then.

Catches have increased continuously since the beginning of the 1980s, until a maximum was reached in 1994 (7 400 t). They have decreased afterwards to 3600-4800t in 2003-2010. The year 2009 is the lower and the year 2011 is the higher since 2006 (4600 t).

A.3 Ecosystem aspects

The quality and the extent of the nursery grounds have likely a major effect in the dynamic of sole recruitment. Studies in Vilaine bay showed a significant positive relationship between the fluvial discharges in winter-spring and the size of the nursery (Le Pape et *al.*, 2003b). The extent of the river plume influences both the larval supply and the size and biotic capacity of habitats in estuarine nursery grounds and determines the number of juveniles produced.

The WGSSDS looked at the possibility of such effect for the whole Bay of Biscay stock during its 2006 meeting. The relationship between recruitment and river flows was investigated using the Loire river flow in the first half of the year which is considered to be a representative index of the water discharge influences on nursery areas in the Bay of Biscay. Unfortunately, no relationship can be seen between this index and the recruitment at age 2 (Figure 2). The environmental effect is likely to be more complex at the Bay of Biscay scale.

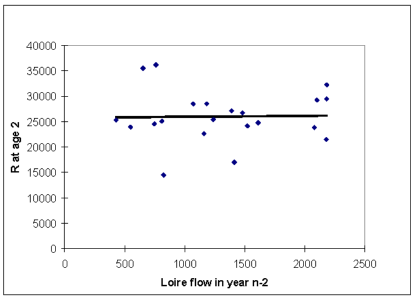


Figure 2: relationship between recruitment at age 2 (as estimated by WGSSDS in 2006) and mean Loire flow in first half year

B. Data

B.1 Commercial Catch

B.1.1 Discards estimates

Discard data are not included in the assessment because the available discards estimates are limited and, furthermore, may be biased (see thereafter).

Discards data collected within the DCF regulation framework:

These observations have shown that discards of beam trawlers and gillnetters are generally low but that the inshore trawlers fleet may have occasionally high discards of sole. Unfortunately, they are difficult to estimate because the effort data of inshore trawlers are not precise enough to allow estimating them by relevant areas. However, if one considers the discards have probably been high in 2009 because the 2007 year class seems to have been above the mean according to the ORHAGO survey (B1706), and if one uses the observed ratio of discards on landings of the inshore trawler fleet in 2009, which is likely to be an overestimate because the observed trips were mainly in nursery areas, the discards of the inshore trawlers are no more than 5 % of the landings in number.

The French fishing industry agreed with the data used in the assessment but suggested that the use of the discards might improve the assessment because the development of high-grading in some areas. The discards data are available since 2010 but total discards cannot be estimated because we have not an historical series (lack of data between 2004 and 2009).

<u>Discards estimates of the French offshore trawlers provided by the RESSGASC surveys from 1987 to 2003:</u>

Discards estimates of the French offshore trawlers were provided by the French trawl surveys FR-RESSGASC-S from 1987 to 2002. These surveys were carried out each quarter until 1997 and in the second and last quarter from 1998 to 2002.

In 2002, this survey was discontinued because the discards estimates that it provides were estimated to depend on the following questionable assumptions:

1) Trawls of the Gwen Drez R/S and the offshore trawlers have the same selectivity,
2) Gwen Drez R/S operate in the same area and in the same conditions than the offshore trawlers during the quarter (up to 1997) or the semester of the survey (quarter 4 year n + quarter 1 year n+1 for November survey year n; quarter 2 and 3 for may survey).

These discards estimates have been included several years in the assessments. They have represented about 1 to 3 % of the total catches from 1991 to 2003 and less than 0.5% since in 2002 and 2003. Given their low contribution to the total catch and the uncertainty due to the assumptions on which they are based, they are no longer used in the assessment, as recommended by ACFM, since 2005.

Their estimation method may be found in the annexes appended to the 2005 and 2006 WGSSDS reports or in the WGHMM stock annexes from 2007 to 2010 (Bay of Biscay sole stock was moved from WGSSDS to WGHMM in 2007).

B.1.2 Landing numbers at length

The quarterly French sampling for length compositions is by gear (trawl or fixed net) and boat length (below or over 12 m long). The contributions of each of these components of the French fleet to the landings are estimated by quarter from logbook data, assuming that the landings associated with logbooks are representative of the whole landings. In 2000-2002, surveys on fishing activities by month have provided a likely less biased estimate of landing split by gear than logbooks, which are filled in only by a part of the fleet (50-60% of the landings in 2000-2002). As logbooks are often recorded in the file with delay, the percentage of landings associated with logbooks may be well below preceding years, particularly in the last quarter. In that case, the process is to use logbooks to get a landing split in the last year if it is close to the mean over the three preceding years otherwise the quarterly mean over the three preceding years is used.

B.1.3 Catch number at age

Age reading method

From 1984 to 2008, the ages in the French landings have been determined by reading otoliths which have been burnt and manually cut. From 1996 onwards, the ages in Belgian landings begun to be determined by reading the age on thin slices of otolith.

In 2005, the ages in French landings begun to be also determined by using this latter method which is the more commonly used for sole age reading. However, in order to estimate the effect of the change in age reading method, from 2005 to 2008 the age reading of French sampled fishes were carried out using the two methods. One otolith was burnt and the second was collected to get thin slices.

Two catch and weight-at-age 1984-2008 time-series can thus be used to carry out two assessments, the set of data differing one from the other in the four terminal years. A comparison of these two assessments was presented to the 2010 WGHMM. It shows only limited differences in the outputs. Consequently, the French catch and weight-at-age were revised from 2005 onwards at the 2010 WGHMM to use the 2005-2009 data set provided by age reading on otolith slices, which is now the unique age reading method for the Bay of Biscay sole stock.

ALKs use to get catch at age estimates

Age compositions of the French landings and discards (up to 2003) are estimated using quarterly ALKs. Up to 1998, it is only FR-RESSGASC-S surveys ALKs. From the second half of the 1998 year and up to 2002, the first and third quarters ALKs are obtained from commercial landings samples. In 2003, commercial landing samples are completed by fish caught during a survey which was planned to design gear and methodology for the future survey ORHAGO aiming at a sole abundance index series in the Bay of Biscay. In 2004 and 2005, only market samples are used. From 2006 onwards, market samples are mainly used but the ORHAGO survey series provides age estimates at length for a large part of the landing length distribution in the last quarter of the year. Another survey (Langolf) can provide also some fish in the second quarter. Market samples are used to complete these ALKs for the upper part of the distribution.

Prior to 1994, the age composition of the French offshore trawler catches is raised to include Belgian landings. In 1994 and 1995, FR-RESSGASC-S ALKs are applied to Belgian length distributions. From 1996 ahead, catch numbers-at-age of the Belgian fleet are estimated with Belgian ALKs. French and Belgian age composition are added before being raised to the total international catch except in 2001 where the Belgian age compositions were raised to the total of Belgian and Dutch landings.

B.2 Biological

Weights-at-Age

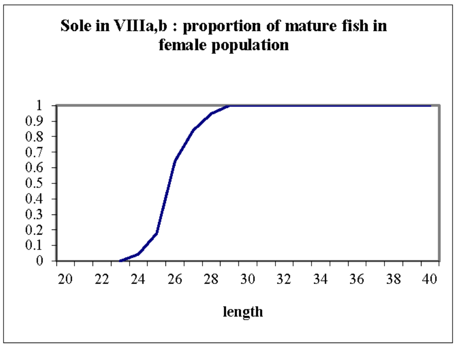
French mean weights-at-age are estimated using quarterly length-weight relationships in which weight are gutted weight multiplicated by the fresh/gutted transformation coefficient of French landing. This latter was changed from 1.11 to 1.04 in 2007. The French mean weights-at-age in catches are consequently estimated with a fresh/gutted transformation coefficient which is 1.11 up to 2006 and 1.04 from 2007 onwards.

Belgian mean weights-at-age are straight estimates. International mean weights-at-age are French-Belgian quarterly weighted mean weights.

Stock weights are set to the catch weights but always using the old fresh/gutted transformation coefficient of French landing (1.11) to have the predicted spawning biomass comparable to the biomass reference point of the management plan (Bpa as estimated in 2006 using mean weights in the stock which were mean weights in the catches).

Maturity ogive

In assessments up to the 2000 Working Group, a knife-edge maturity was used, assuming a full maturity at age 3.



During the 4 first months in 2000, the maturity-at-length and at-age was observed on 296 female fish, 112 being between 24 cm and 28 cm long, which is the observed length range for maturity occurrence of sole in Bay of Biscay. The sampling was assumed to be at random within a length class of 1 cm. The maturity ogive was then estimated applying a maturity/age/length key thus obtained to the length distribution of the first quarter in 2000.

The maturity at age was so estimated to be:

Age	≤ 1	2	3	4	≥ 5
Mature	0	0.32	0.83	0.97	1

Natural Mortality

Natural mortality is assumed to be 0.1 for all age groups and all years.

B.3 Surveys

RESSGASC surveys

Quarterly RESSGASC survey series are available from 1987 to 2002 but it worth noting that these surveys were carried out to provide hake discard estimates and, consequently, not well designed for providing sole abundance indices. Each quarter from 1987 to 1998, and thereafter each second and fourth quarter of the year, the survey aimed to catch as commercial fishing boats in the same areas. These series were disrupted in 2003. They have been withdrawn from the assessment by the 2011 WKFLAT because they no longer contribute to the estimates of the terminal population numbers.

ORHAGO survey (B1706)

The ORHAGO survey was launched in 2007. The fishing gear is a beam trawl with 40 mm codend. This survey is carried out in November-December in order to have a good catchability of sole at the age 1. The sampling plan is systematic. 50 hauls are distributed in 10' latitude by 10' longitude rectangles all over the sole habitat in the Bay of

Biscay. The haul positions are kept unchanged from year to year. This beam trawl survey is coordinated by the WGBEAM to which the results are reported each year since its beginning.

At the 2013 meeting of the WGBEAM 2013, several CPUE series were compared to investigate the effect of missing values for some stations in some years (0 to 20 %, depending on the year and the day fishing period) and whether fishing at night might provide a better abundance index. The WGBEAM concluded from that analysis that the CPUE times-series based on all the reference stations and on hauls carried out by daylight can be retained to provide a survey abundance index for the Bay of Biscay sole stock. An interim benchmark by correspondence was held consecutively. It agrees the inclusion of the ORHAGO survey time-series in the tuning fleets of the Bay of Biscay sole assessment, considering the need of an independent tuning index, the length of the time-series (6 years) and its ability to track year class strength in following years.

The ORHAGO survey time-series was consequently included in the assessment at the WGHMM 2013.

B.4 Commercial CPUE

Four commercial CPUE series are used in the assessment: La Rochelle offshore trawlers (FR-ROCHELLE), Les Sables d'Olonne offshore trawlers (FR-SABLES), the Bay of Biscay offshore trawlers in the second quarter (FR-BB-OFF-Q2) and the Bay of Biscay inshore trawlers in the last quarter (FR-BB-IN-Q4).

These series are provided by boats which are selected to form homogeneous groups and to limit year-to-year changes in fleet compositions. The following methods were adopted:

- The La Rochelle and the Les Sables d'Olonne offshore trawler fleets are two fixed groups of fishing boats. These fleets were first included in the tuning fleets at the 2005 WGSSDS. They were formed by boats which have landed sole either in La Rochelle (or near La Rochelle) or in Les Sables and for which CPUE data (with sole and *Nephrops* percentage in catches thresholds indicated thereafter) are available for a minimum number of years (10 from 1984 or 7 from 1995 to 2004). The criterion of skippers having declared to have looked for sole in 2003-2004 (IFREMER annual activities survey) was added to avoid inclusion of boats fishing sole sporadically. The La Rochelle vessels are 14 to 20 meters long and the Les Sables vessels are 12 to 23 meters long.
- The Bay of Biscay offshore trawler fleet in the second quarter and the Bay of Biscay inshore trawler fleet in the fourth quarter are formed by fishing boats which have caught sole in Bay of Biscay and for which CPUE data (with sole and *Nephrops* percentage in catches thresholds indicated thereafter) are available for five years over the ten last years. Furthermore, to limit effect of changes in fishing area, the CPUE were calculated by selecting the statistical rectangles which have provided a CPUE for more than 5 years from 2000 onwards. After the selection of rectangles, we keep the fishing boats which have caught sole for five years over the ten last years. These tuning series were first included in the tuning process at the 2011 WKFLAT. They were added to the tuning series because the decrease in number of trawlers in La Rochelle or Les Sables fleets due to the decommissioning measures or the change in gear. The inshore vessels are 10 to 12 meters long and the offshore vessels are 14 to 18 meters long.

To take into account changes in fishing areas due to change in targeting species, a minimum percentage of sole in total landing of a trip (data from 1984 to 1998) or of a day (from 1999 onwards) was selected to avoid effects of a shift in target species from sole to cephalopods in recent years. This percentage has been set to 10 % in 2005 for selecting relevant fishing periods for the La Rochelle and Les Sables tuning fleets. It resulted from the advice of fishermen given at a meeting. For defining new tuning fleets in 2011, it was necessary to reduce this percentage to 6 % for increasing the number of available data. This requirement is due to the choice to carry out the work on a more reduced time period than previously (quarter instead of year) and to pay attention to the spatial distribution of effort.

A second threshold was fixed on the percentage of *Nephrops* in total landing (below or equal to 10%) to avoid the inclusion of trips or days during which a large part of effort is devoted to this species.

The effort is in hours. It is not corrected for horse power (H x 100 kW) because this correction is considered introducing more noise, because of the quality of the measurement of horse power, than any improvement in fleets which are constructed to be homogeneous and with limited change in composition over the time period.

Because of the decreasing on the numbers of vessels for Les Sables and the large decreasing on the fishing effort for La Rochelle for 2010, the WGHMM decision is to withdraw the 2010 CPUE value for the Les Sables and La Rochelle.

C. Assessment: Data and method

Model used: XSA

Software used: Lowestoft VPA program

The XSA settings to be used were set by the WKFLAT 2011 and revised by the WGHMM are given in the following text table.

	WGBIE 2021
Catch data range	84- last year
Catch age range	2-8+
Sables d'Olonne offshore trawlers fleets tuning fleet (FR – SABLES)	1991 – 2009 2-7
La Rochelle offshore trawlers fleets tuning fleet (FR – ROCHELLE)	1991 – 2009 2-7
Bay of Biscay offshore trawlers in the second quarter tuning fleet (FR-BB-OFF-Q2)	2000 – 2012 2-6
Bay of Biscay inshore trawlers in the fourth quarter tuning fleet (FR-BB-IN-Q4)	2000 – last year 3-7
Bay of Biscay beam trawler survey in the fourth quarter (FR-ORHAGO)	2007 – last year 2-8
Taper	No
Ages catch dep. Stock size	No
Q plateau	6
F shrinkage se	1.5
Year range	5
age range	3
Fleet se threshold	0.2

F bar range	3-6

Historical review of changes in XSA settings (see text table thereafter):

Age range in the assessment was changed from 0-8+ to 1-8+ in 1998, and to 2-8+ in 2004. In both cases, this change is largely due to the uncertainties in discards estimates.

Because French 1999 catches were not available at the 2000 WG, the 2000 XSA was identical to the 1999 XSA.

The age range of F bar was change from 2-6 to 3-6 at the 2004 WG because the age 2 is not fully recruited. This age range was turned back to 2-6 by ACFM because its implication on reference points. The Review Group asked nevertheless to investigate changing it again to 3-6 in 2005 and ACFM accepted the change to 3-6 in 2006.

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WG year XSA	1998 XSA	1999 & 2000 XSA	2001 XSA	2002 XSA	2003 XSA	2004 XSA	2005 XSA	2006 XSA	2007 XSA
Catch data range	1984-1997	1984-1998	1984-2000	1984-2001	1984-2002	1984-2003	1984-2004	1984-2005	1984-2006
Age range in catch data	1-8+	1-8+	1-8+	1-8+	1-8+	2-8+	2-8+	2-8+	2-8+
FR – SABLES	88-97 1-7	89-98 1-7	84-00 2-7	84-01 2-7	84-02 2-7	84-03 2-7	91-04 revised 2-7	91-05 2-7	91-06 corrected 2-7
FR – ROCHELLE	88-97 1-7	89-98 1-7	84-00 2-7	84-01 2-7	84-02 2-7	removed	95-04 revised 2-7	91-05 corrected 2-7	91-06 corrected 2-7
FR – ROCHELLE1	Not used	Not used	Not used	Not used	Not used	84-92 2-7	removed	removed	removed
FR – ROCHELLE2	Not used	Not used	Not used	Not used	Not used	93-03 2-7	removed	removed	removed
FR – OTHER	Not used	Not used	Not used	Not used	Not used	Not used	95-04 2-7	removed	removed
FR – RESSGASC-S	88-97 1-7	89-98 1-7	removed	removed	removed	removed	removed	removed	removed
FR – RESSGASC-S 2	Not used	Not used	87-00 2-6	87-01 2-6	87-02 2-6	87-02 2-6	87-02 2-6	87-02 2-6	87-02 2-6
FR – RESSGASC-S 3	Not used	Not used	87-97 2-6	removed	removed	removed	removed	removed	removed
FR – RESSGASC-S 4	Not used	Not used	87-00 1-6	87-01 1-6	87-02 1-6	87-02 2-6	87-02	87-02 2-6	87-02 2-6
FR-BB-IN-Q4	Not used	Not used	Not used	Not used	Not used	Not used	Not used	Not used	Not used
FR-BB-OFF-Q2	Not used	Not used	Not used	Not used	Not used	Not used	Not used	Not used	Not used
FR-ORHAGO	Not used	Not used	Not used	Not used	Not used	Not used	Not used	Not used	Not used
Taper	No	No	Yes	Yes	Yes	No	No	No	No
Tuning range	10	10	17	18	19	20	14	15	16
Ages catch dep. Stock size	No	No	No	No	No	No	No	No	No
Q plateau	6	6	6	6	6	6	6	6	6
F shrinkage se	1.0	1.0	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Year range	5	5	5	5	5	5	5	5	5
age range	3	3	3	3	3	3	3	3	3
Fleet se threshold	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
F bar range	2-6	2-6	2-6	2-6	2-6	3-6	2-6	3-6	3-6

WG year XSA	2008 XSA	2009 XSA	2010 XSA	2011 XSA	2012 XSA	2013 XSA	2014 XSA	2015 XSA
Catch data range	1984-2007	1984-2008	1984-2009	1984-2010	1984-2011	1984-2012	1984-2013	1984-2014
Age range in catch data	2-8+	2-8+	2-8+	2-8+	2-8+	2-8+	2-8+	2-8+
FR – SABLES	91-07 2-7	91-08 2-7	91-09 2-7	91-09 2-7	91-09 2-7	91-09 2-7	91-09 2-7	91-09 2-7
FR – ROCHELLE	91-07 2-7	91-08 2-7	91-09 2-7	91-09 2-7	91-09 2-7	91-09 2-7	91-09 2-7	91-09 2-7
FR – ROCHELLE1	Removed	Removed	Removed	Removed	Removed	Removed	Removed	Removed
FR – ROCHELLE2	Removed	Removed	Removed	Removed	Removed	Removed	Removed	Removed
FR – OTHER	Removed	Removed	Removed	Removed	Removed	Removed	Removed	Removed
FR – RESSGASC-S	Removed	Removed	Removed	Removed	Removed	Removed	Removed	Removed
FR – RESSGASC-S 2	87-02 2-6	87-02 2-6	87-02 2-6	Removed	Removed	Removed	Removed	Removed
FR – RESSGASC-S 3	Removed	Removed	Removed	Removed	Removed	Removed	Removed	Removed
FR – RESSGASC-S 4	87-02 2-6	87-02 2-6	87-02 2-6	Removed	Removed	Removed	Removed	Removed
FR-BB-IN-Q4	Not used	Not used	Not used	00-10 3-7	00-11 3-7	00-12 3-7	00-13 3-7	00-14 3-7
FR-BB-OFF-Q2	Not used	Not used	Not used	00-10 2-6	00-11 2-6	00-12 2-6	00-12 2-6	00-12 2-6
FR-ORHAGO	Not used	Not used	Not used	Not used	Not used	07-12 2-8	07-13 2-8	07-14 2-8
Taper	No	No	No	No	No	No	No	No
Tuning range	17	18	19	20	21	22	23	24
Ages catch dep. Stock size	No	No	No	No	No	No	No	No
Q plateau	6	6	6	6	6	6	6	6
F shrinkage se	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Year range	5	5	5	5	5	5	5	5
age range	3	3	3	3	3	3	3	3
Fleet se threshold	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
F bar range	3-6	3-6	3-6	3-6	3-6	3-6	3-6	3-6

WG year XSA	2016 XSA	2017 XSA	2018 XSA	2019 XSA	2020 XSA
Catch data range	1984-2015	1984-2016	1984-2017	1984-2018	1984-2019
Age range in catch data	2-8+	2-8+	2-8+	2-8+	2-8+
FR – SABLES	91-09 2-7	91-09 2-7	91-09 2-7	91-09 2-7	91-09 2-7
FR – ROCHELLE	91-09 2-7	91-09 2-7	91-09 2-7	91-09 2-7	91-09 2-7
FR-BB-IN-Q4	00-15 3-7	00-16 3-7	00-17 3-7	00-18 3-7	00-19 3-7
FR-BB-OFF-Q2	00-12 2-6	00-12 2-6	00-12 2-6	00-12 2-6	00-12 2-6
FR-ORHAGO	07-15 2-8	07-16 2-8	07-17 2-8	07-18 2-8	07-19 2-8
Taper	No	No	No	No	No
Tuning range	25	25	25	25	25
Ages catch dep. Stock size	No	No	No	No	No
Q plateau	6	6	6	6	6
F shrinkage se	1.5	1.5	1.5	1.5	1.5
Year range	5	5	5	5	5
age range	3	3	3	3	3
Fleet se threshold	0.2	0.2	0.2	0.2	0.2
F bar range	3-6	3-6	3-6	3-6	3-6

D. Short term projection

Model used: Age structured deterministic projection

Software used: MFDP

Inputs

Initial stock size:

- Recruitment is the geometric mean of recruitment values XSA over 2016 to one year before the assessment (short mean because recruitment values are lower since 2016) or three years if the XSA last year recruitment is considered poorly estimated according to the retrospective pattern.
- Age group above recruitment is derived from the GM.

Natural mortality: Set to 0.1 for all ages in all years

Maturity: Same ogive used for all years (given in section B.2)

F and M before spawning: None

Weight at age:

- Weights at age in the landings are the unweighted means over the last 3 years using the new fresh/gutted transformation coefficient of French landing which was changed from 1.11 to 1.04 in 2007.
- Weights at age in the stock are the unweighted means over the last 3 years using the old fresh/gutted transformation coefficient of French landing (1.11). The predicted spawning biomass is consequently comparable to the precautionary biomass reference point (Bpa) set before the change in fresh/gutted transformation coefficient of the French landing.

Exploitation pattern:

- Fishing mortality at recruiting age is the arithmetic mean over the 2 years before the terminal year if the XSA recruitment estimate is overwritten by a GM.
- Fishing mortalities above recruiting age is the arithmetic mean over the 3 last years of the assessment,
- Unscaled if no trend is detected,
- Scaled to the last year's Fbar if a trend is detected.

Intermediate year assumptions:

Status quo F except if there is some information about the possibility that the TAC may be limiting.

F. Yield and biomass per recruit / long term projections

Yield per recruit calculations are conducted using the same input values as those used for the short term forecasts.

G. Biological reference points

	Type	Value	Technical basis	Source
MSY	MSY Btrigger	10600 t	Bpa	ICES (2016a)
Approach	FMSY	0.33	FMSY without Btrigger	ICES (2016a)
	Blim	7600 t	Blim = Bpa / exp(σ x 1.645)	ICES (2016b)
Precautionary Approach	Bpa	10600 t	The third lowest value	ICES (2016b)
	Flim	Undefined		
	Fpa	0.88	Fpa = $F_{P.05}$ (5% risk to Blim with Btrigger)	ICES (2016b)

H. Other Issues

None

I. References

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Stock Annex: Sole (*Solea spp.*) in divisions 8.c and 9.a (Cantabrian Sea and Atlantic Iberian waters)

Stock specific documentation of standard assessment procedures used by ICES.

Stock: Sole

Group: Working Group for the Bay of Biscay and Iberian Waters Ecoregion (WGBIE)

Created: Maria de Fatima Borges (WGBIE) May 2014

Last updated: May 2021

Last updated by: Maria Grazia Pennino and Catarina Maia

A. General

A.1. Stock definition

Solea Solea is a widely distributed species in Northeast Atlantic shelf waters with a range from southern Norway including North Sea and western Baltic and Mediterranean Sea, to the Northwest of Africa inhabiting sandy and muddy bottoms at depths near to 100 and 200 meters (Quero *et al.*, 1986). At present there is no information on stock unit definition for common sole in ICES divisions 8.c and 9.a. It was considered that in the absence on specific information on stock structure, the divisions 8.c and 9.a may be used as a management unit.

A.2. Fishery

The management unit of the common sole stock in the Iberian Atlantic waters includes the ICES divisions 8.c and 9.a. where both the Portuguese and Spanish fleets operate. In this area common sole is target mainly by multi-species fleets using as main fishing gears trammel and gill nets. The minimum landing size of sole species is 24 cm. There are other regulations regarding the mesh size for trammel and trawl nets, fishing grounds and vessel's size. Sole species are under the Landing Obligation in Divisions 8.abde (all bottom trawls, mesh sizes between 70 mm and 100 mm, all beam trawls, mesh sizes between 70 mm and 100 mm and all trammel and gill nets, mesh size larger or equal to 100 mm) and in Division 9.a (all trammel nets and gill nets, mesh size larger or equal to 100 mm). In Portugal all catches of sole species from all gears and mesh sizes are under the Landing Obligation (more restrictively than required by European regulations).

The EU multiannual plan (MAP; EU, 2019) for stocks in the Western Waters and adjacent waters applies to this stock. The MAP stipulates that when the F_{MSY} ranges are not available, fishing opportunities should be based on the best available scientific advice.

A.3. Ecosystem aspects

The life cycle of common sole is complex and presents different ontogenetic migrations (Tanner et al., 2017). Common sole spawn in coastal waters at depths ranging from 30 to 100 m (Van der Land, 1991). The spawning period is commonly between February and May, although it can occur in early winter in warmer areas. The development of the larvae is temperature-dependent and takes place in shallow waters (Tanner et al., 2017). It is during transport from spawning areas to coastal nurseries that the larvae metamorphose into benthic life (Marchand, 1991). Nursery areas are generally located within estuaries where juveniles of common sole spend up to 2 years in a residence phase before returning to the adult feeding and spawning areas on the continental shelf (e.g., Vasconcelos et al., 2010).

B. Data

B.1. Commercial catch

During the WGBIE2020, Portuguese's colleagues highlighted that catches from Portugal have a problem of misidentification in some ports with the three species (i.e. *Solea solea, Solea senegalensis, Pegusa lascaris* and *Solea* spp.) (Dinis et al., 2020).

For the WKWEST2021 benchmark, using data from the Data Collection Framework (DCF) sampling, Portuguese catches were proportionally divided by sole species applying the species weight proportion to the total weight of Soleidae in each year, landing port, and semester and using a simple random sampling estimator, following Figueiredo et al. (2020). Details on data available and catch estimation procedures can be found in Annex 2 of the working document Pennino et al. (2021). At the moment the new Portuguese catches are considered reliable.

In addition, from the WKWEST2021 data call, catches for *S. solea* were also reported by France and now are available in InterCatch from 2009 to 2020 (Figure 1). Information on discards indicates that discarding can be considered negligible (< 1%).

For the years 2009-2010, only catches from Spain and France are available, while for the period 2011-2020 catches are available for the three countries (i.e., Portugal, Spain and France) (Figure 2).

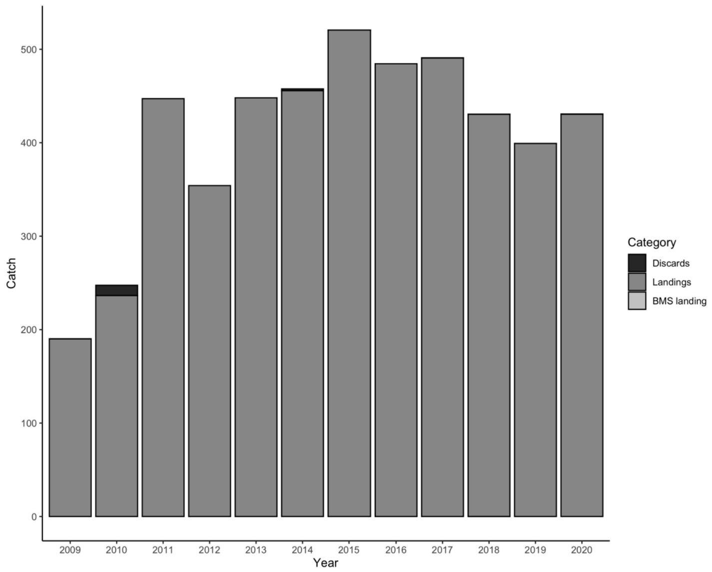

Figure 1: Catches for *Solea solea* by category (landings, discards and BMS landing) in the ICES divisions 8c9a for Portugal, Spain and France from 2009 to 2020. Source data: InterCatch. No Portuguese catches in 2009 and 2010.

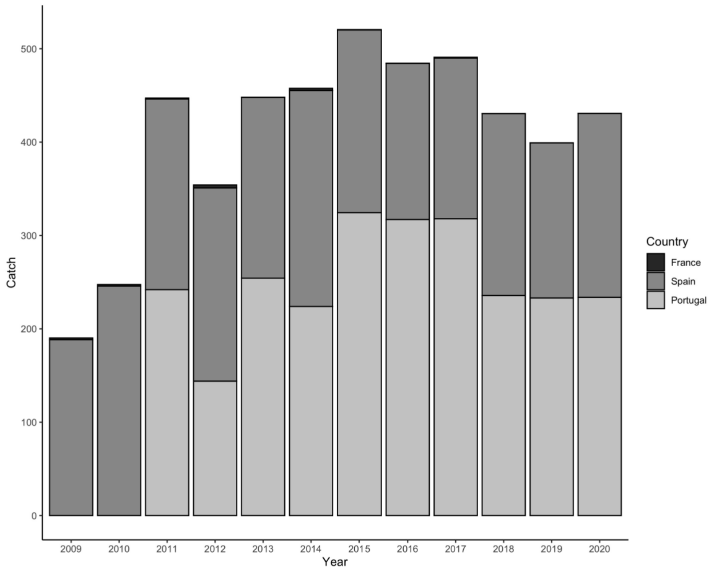

Figure 2: Catches for *Solea solea* in the ICES divisions 8c9a by country from 2009 to 2020. Source data: InterCatch.

When catches are analysed by division it is possible to see that the majority of them are in the ICES Division 9a and that, although different fleets fish this stock, the two main ones are the polyvalent fleet from Portugal (i.e. "MIS_MIS_0_0_0") and the trammel net fleet from Spain (i.e. "GRT_DEF_60-79_0_0") (Figure 3). The distribution of the catches is almost homogenous along the year for the two main countries (i.e. Portugal and Spain), as well as for the main fleets (Figure 4).

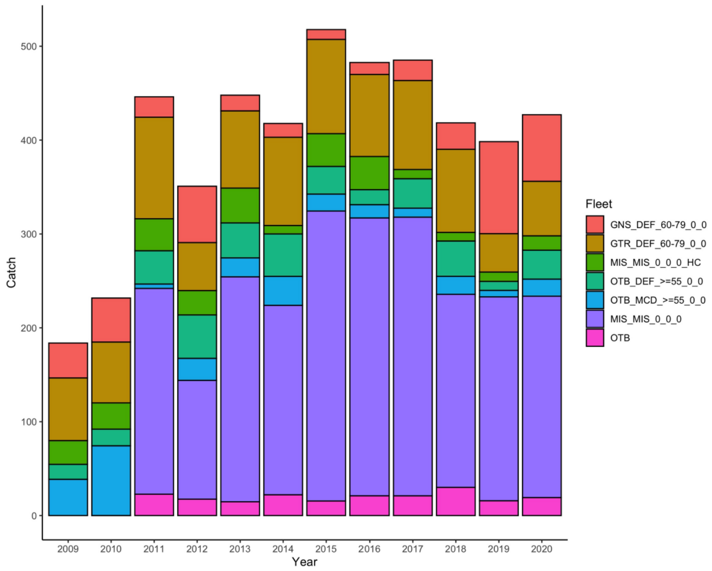

Figure 3: Catches for *Solea solea* by the main fleet in the ICES divisions 8c9a for Portugal, Spain and France from 2009 to 2020. Source data: InterCatch. No Portuguese catches in 2009 and 2010.

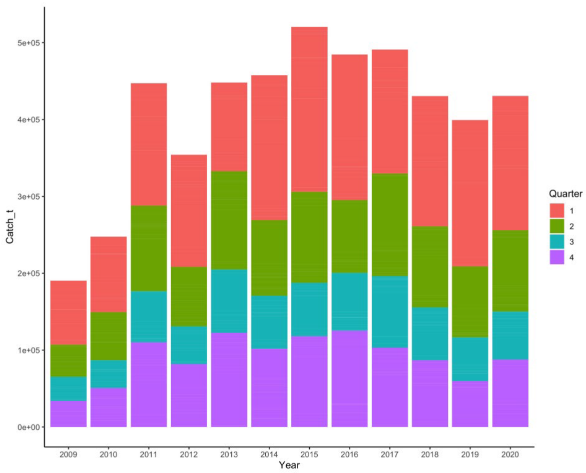

Figure 4: Catches for *Solea solea* by quarter in the ICES divisions 8c9a for Portugal, Spain and France from 2009 to 2020. Source data: InterCatch. No Portuguese catches in 2009 and 2010.

It is important to note that market sampling in Portuguese ports during 2020 was affected by the CoVid-19 pandemic, resulting in the sampling suspension during the period March-June and resumption after that. In order to overcome the decrease in the amount of data collected by the National sampling program PNAB/DCF, samples collected under Project "*Pequena Pesca na Costa Ocidental Portuguesa* - PPCEN-TRO" (ref: MAR-01.03.02-FEAMP-0007) were also used to estimate landings by species and length frequency distribution.

Length frequency distribution

In InterCatch, data on length frequency distribution are available for the years 2011-2020 (Figure 5). The majority of the data are of the polyvalent fleet (i.e. metier "MIS_MIS_0_0_0") from Portugal.

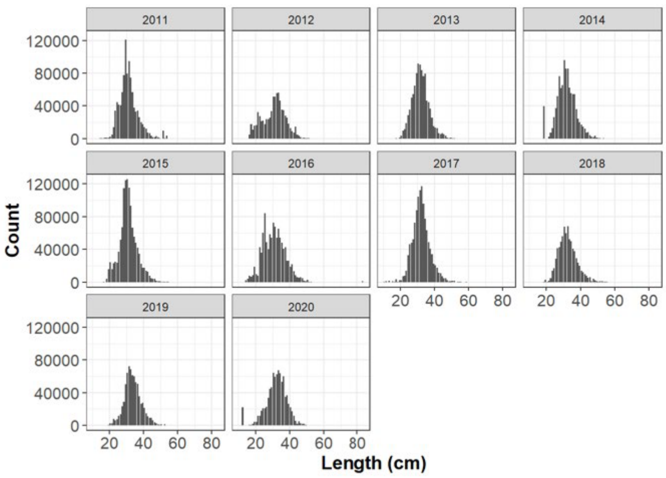

Figure 5: Length frequency distribution of catches for *Solea solea* in the ICES divisions 8c9a by year (from 2011 to 2020) for Portugal, Spain and France. Source data: InterCatch.

Other sole species

For the WKWEST21 an official data call was requested for this stock to get all the possible data, not only for the common sole (*S. Solea*) but also for the other sole species *Solea senegalensis*, *Pegusa lascaris* and *Solea spp*. (Figure 6, Tables 1 and 2).

For Portugal, *S. Senegalensis*, *P. lascaris* and *Solea spp*. landings are available for the period 2011-2020. For Spain, *S. Senegalensis*, *P. lascaris* and *Solea spp*. landings are available for the period 2009-2020. No French data on these species were available.

These new time series were revised using data from the Data Collection Framework (DCF) sampling and proportionally divided by sole species applying the species weight proportion to the total weight of Soleidae in each year, landing port, and semester and using a simple random sampling estimator, following Figueiredo et al. (2020).

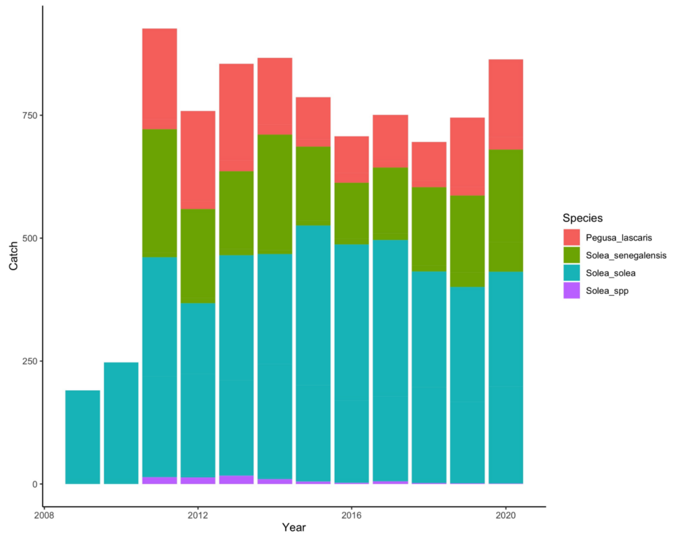

Figure 6: Sole species landings for the Division 8c9a. Data are from Spain and Portugal together. No Portuguese catches in 2009 and 2010.

Table 1: Catches (in tonnes) of *S. Solea*, *S. senegalensis*, *Pegusa lascaris* and *Solea spp*. from 2009-2020. Please note that in 2009-2010 no Portuguese data were available.

Year	*S. solea*	*S. senegalensis*	*P. lascaris*	*Solea spp.*	total catch
2009	190.26				190.26
2010	247.47				247.47
2011	447.17	260.6	205.94	14.1	927.81
2012	354.17	191.29	199.67	13.61	758.74
2013	448.08	170.88	218.6	17.04	854.60
2014	457.63	243.13	156.03	10.03	866.82
2015	520.56	160.6	100.75	5.01	786.88
2016	484.55	125.6	94.38	2.47	707.01
2017	490.90	147.12	107.07	5.48	750.56
2018	430.56	171.2	92.13	4.58	698.47
2019	399.24	186.09	158.66	1.37	745.37
2020	430.78	248.23	183.49	1.111	863.61

Table 2: Percentage of catches of *S. Solea, S. senegalensis, Pegusa lascaris* and *Solea spp*. in the total landed weight of sole species from 2009-2020. Please note that in 2009-2010 no Portuguese data were available.

Year	*S. solea*	*S. senegalensis*	*P. lascaris*	Solea spp
2009	100	0	0	0
2010	100	0	0	0
2011	48	28	22	2
2012	47	25	26	2
2013	52	20	26	2
2014	53	28	18	1
2015	66	20	13	1
2016	69	18	13	0
2017	65	20	14	1

2018	62	25	13	1
2019	54	25	21	0
2020	50	29	21	0

B.2. Biological

Growth studies based on *S. solea* otoliths readings in the Portuguese coast indicate L_{inf}=52.1 cm for females and 45.7 cm for males while the growth coefficient (K) estimate of females (K=0.23) was slightly higher than for males (K=0.21) and t_0 estimates were -0.11 and 1.57 for females and males respectively (Teixeira and Cabral, 2010). Common sole length of first maturity was estimated as 25 cm for males and 27 cm for females (Jardim, et al., 2011).

The natural mortality parameter M is not known for this stock but for the stock of common sole ICES division 8a, is used a M of 0.2. A recent study of Cerim et al. (2020) defined the M of the common sole as M= 0.31 yr-1.

L_{95} is not known for this stock but for the common sole ICES division 8a, b is 27.5 cm (see stock annex sol-bisc division 8a,b).

Bayesian length-weight: a=0.00759 (0.00629 - 0.00915), b=3.06 (3.00 - 3.12), in cm Total Length, based on LWR estimates for this species (Froese et al., 2014).

B.3. Surveys

Common sole data was collected during the scientific survey series G2784 performed by the *Instituto Español de Oceanografía* (IEO) in autumn (September and October) between 2000 and 2020. Surveys were conducted on the northern continental shelf of the Iberian Peninsula (ICES divisions 8c and the northern part of 9a) which has a total surface area of almost 18,000 km^2 (Figure 7).

Surveys were performed using a stratified sampling design based on depth with three bathymetric strata: 70–120 m, 121–200 m and 201–500 m. Sampling stations consisted of 30 min trawling hauls located within each stratum at the beginning of the design. The gear used is the baka 44/60 and the survey follow the protocol of the International Bottom Trawl Survey Working Group (IBTSWG) of ICES (ICES, 2017).

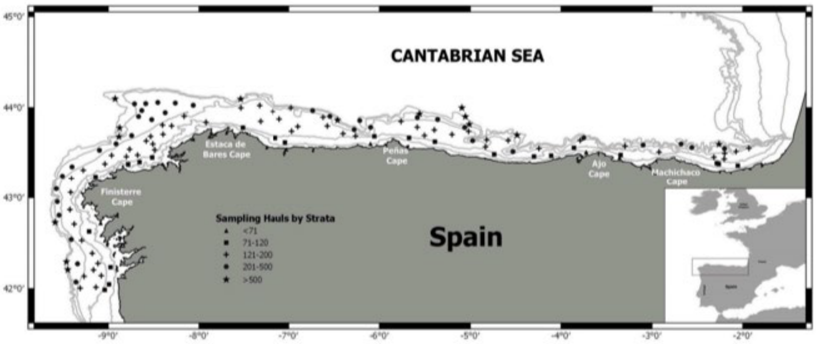

Figure 7: Map of the study area. Black dots represent annual sampling locations.

However, the common sole is a species with a biological bathymetric range between 0 and 200 meters in the Iberian Atlantic waters. The G2784 only covers partially the common sole bathymetric range and the resultant abundance index is probably underestimated. For this reason, and with the aim to correct this sampling bias, a hurdle Bayesian spatiotemporal was applied to this dataset.

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

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

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

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

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

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

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

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

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

where π_{st} represents the probability of occurrence at location *s* at time *t* and μ_{st} and ϕ are the mean and dispersion of common sole conditional-to-presence abundance. The linear predictors, which contain the effects that link the parameters π_{st} and μ_{st}, include: $\alpha(Y)$ and $\alpha(Z)$, terms that represent the intercepts of each variable respectively; ds corresponds to the depth at location *s*, being f(ds) the bathymetric effect modelled as a second order random walk (RW2) smooth function parametrised as unknown values $f = (f_0, \ldots f_{i-1})_t$ at $i = 14$ equidistant values of ds, with hyperparameter σ representing the variance of the f(ds) model. In the same way, g(t) corresponds to the temporal trend fitted through a RW2 effect over the years. The terms f(ds) and g(t) are shared between both predictors and multiplied by θ and η in the conditional-to-presence abundance model to allow for differences in scales between both predictors (i.e. the logit transformed probability and the logarithm of the conditional-to-presence abundance); $U_{st}(Y)$ and $U_{st}(Z)$ refer to the progressive spatiotemporal structures of common sole occurrence and conditional-to-presence abundance respectively.

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

From this analysis, the most important results that we obtained were the predicted distribution of the species (Figure 8), and a new spatio-temporal abundance index (Figure 9).

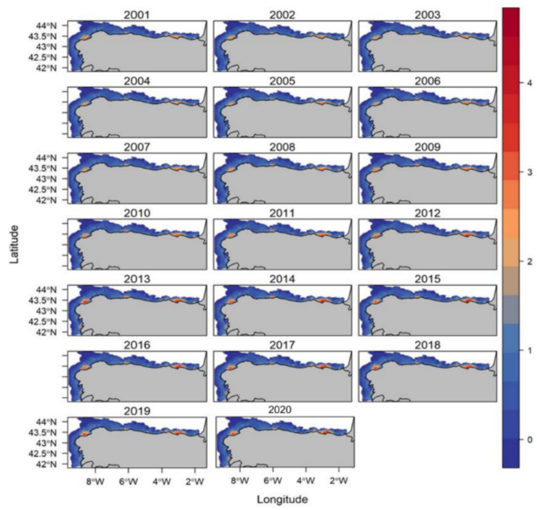

Figure 8: Prediction maps (2001-2020) of the common sole conditional-to-presence median abundance estimated by the hurdle Bayesian spatiotemporal model.

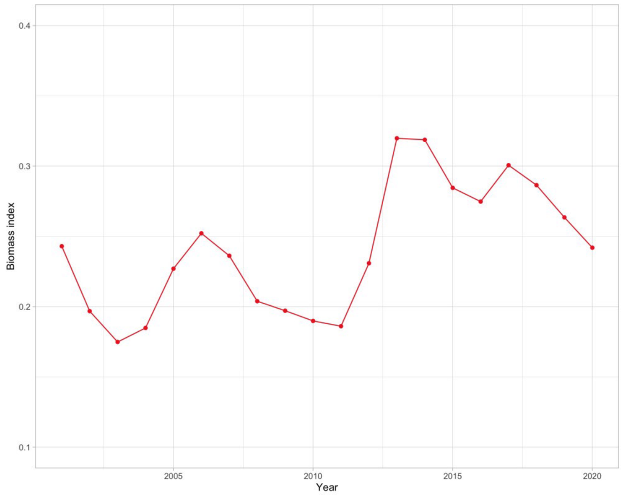

Figure 9: Temporal trend of the spatiotemporal abundance index for the G2784.

B.4. Commercial LPUE

Portuguese LPUE estimates relied on fishery dependent data derived from the polyvalent fleet and are based on the estimated *S. solea* landed weight by fishing trip. The analysis was restricted to the most important landing ports in terms of *S. solea* landed weight: Viana do Castelo, Matosinhos, Aveiro, Peniche and Setúbal. The Portuguese polyvalent fleet segment comprises multi-gear/multi-species fisheries, usually licensed to operate with more than one fishing gear (most commonly gill and trammel nets, longlines and traps), that can be deployed in the same trip, targeting different species. The time period considered in the present study extends from 2011 to 2020.

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

All the explanatory variables were considered as categorical variables. The function "bestglm" implemented in R software was used to select the best subset of explanatory variables (McLeod and Xu, 2010). The selection of the set explanatory variables to enter into the model is done following McLeod and Xu (2010) procedure, which is based on a variety of information criteria and their comparison following a simple exhaustive search algorithm (Morgan and Tatar, 1972). The diagnostic plots, distribution of residuals and the quantile-quantile (Q-Q) plots, were used to assess model fitting. Changes in deviance explained by the selected model and the proportions of deviance explained to the total explained deviance was determined and used as indicative of r2. Finally, annual estimates of LPUE and the corresponding standard error were determined using estimated marginal means (R package: emmeans).

The final model explained 86% of the variability and included as explanatory variables the year, the month, the landing port and the vessel size. The final LPUE index is presented in Figure 10. Finally, it worth to be mentioned that sensitivity tests were carried out to this dataset to assess the sensibility of the model to a possible increase or reduction of the weight per trip by 25% for data from 2020. Results highlighted that the model performed well and consequently obtained consistent outputs with the original dataset.

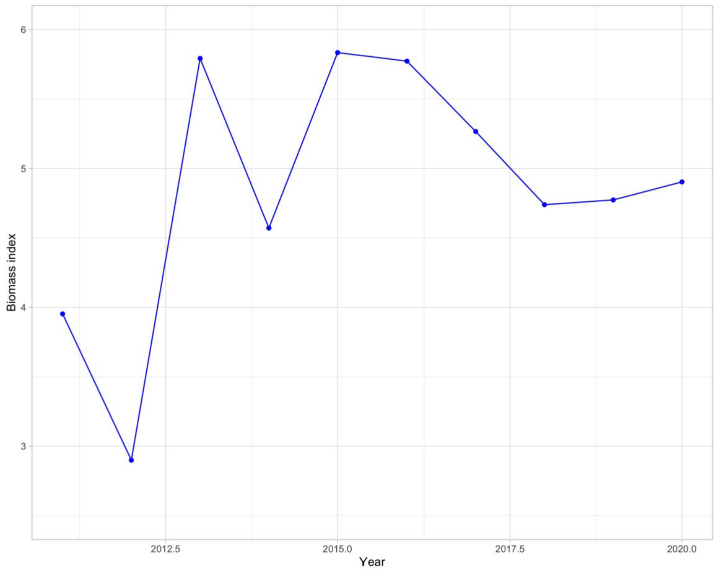

Figure 10. LPUE index by year of *Solea solea* in the in Portuguese waters (Division 9a).

B.5. Other relevant data

The Portuguese Groundfish Survey dataset was analysed for this stock during the WKWEST2021 but due to the very few catches of this species and the low spatial coverage, the survey was not further considered. However, from December 2020 a new gear will be used in this survey that probably could have a better catchability of the common sole. This data needs to be monitored in the future. Similarly, during the WKWEST2021 it was computed a commercial CPUE using data of observer on board the artisanal fleet that operate in the Galician waters (Spain). For the moment this CPUE was considered no representative for the stock but need to be monitored in future years.

C. Assessment: data and method

Before the WKWEST2021 benchmark, the common sole stock was considered as a data-limited stock and was classified as a category 5 stock, as only catch data was available. There was no analytical assessment for sole in this area. Since 2012, ICES provides scientific advice for this stock applying the precautionary approach. A precautionary buffer was applied in 2018 (≥20% reduction in catch relative to 2014-2016 average) and in 2019 (same catch value advised as 2018) with an advice that catches should be no more than 502 tones (2020-2021). The advice and assessment were provided only for common sole. The management of all sole species was provided under a unique combined Total Allowable Catch (TAC). It worth to be mentioned that the 502 tones advised in 2020-2021 were computed on catches that were successively corrected at species level during the benchmark in 2021.

During the WKWEST2021 different data-poor methods were implemented, such as Length based indicators (LBI), Length-based spawning potential ratio (LBSPR), Mean length-based mortality estimators (MLZ) and stochastic surplus production model in continuous time (SPiCT) (ICES, 2018a). Among them it was agreed that the LBI approach was currently the most adequate for this stock.

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

- M/K=1.41, derived from the M=0.31 (from Cerim et al., 2020), K=0.22 (from Teixeira and Cabral (2010) we have that K=0.23 for females and K=0.21 for males, then we consider the mean of both sexes).
- L_{inf} =48.9 cm (from Teixeira and Cabral (2010) we have that L_{inf} = 52.1 cm for females and L_{inf} = 45.7 cm for males, and hence we compute the mean of both sexes).
- L_{mat} =26 cm (from Jardim et al. (2011) we have that L_{mat} =25 cm for males and L_{mat} =27 cm for females, and then the mean of both sexes is computed).
- Length–weight relationship parameters a=0.00759 and b=3.06 (Bayesian length-weight model based on LWR estimates for this species Froese et al., 2014).

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

From the reference model we can conclude that the stock is exploited at MSY level and the optimal yield is attained (Table 3 and Figure 13). The immatures are good preserved whereas the proportion of megaspawners is low, although it has been increased in the last years.

Table 3: Traffic light indicator table for the LBI analysis.

	Conservation				Optimizing Yield	MSY
Year	Lc/Lmat	L25%/Lmat	Lmax5%/L∞	Pmega	Lmean/Lopt	Lmean/LF=M
2011	1.10	1.10	0.94	0.13	1.00	0.99
2012	0.83	1.02	0.90	0.17	0.96	1.12
2013	1.02	1.10	0.89	0.14	0.99	1.01
2014	1.02	1.10	0.91	0.15	0.99	1.02
2015	1.06	1.10	0.88	0.12	0.98	0.98
2016	0.87	0.98	0.93	0.17	0.95	1.08
2017	1.10	1.13	0.91	0.15	1.02	1.00
2018	1.02	1.10	0.93	0.18	1.00	1.03
2019	1.13	1.17	0.94	0.23	1.05	1.01
2020	1.06	1.10	0.89	0.20	1.03	1.03

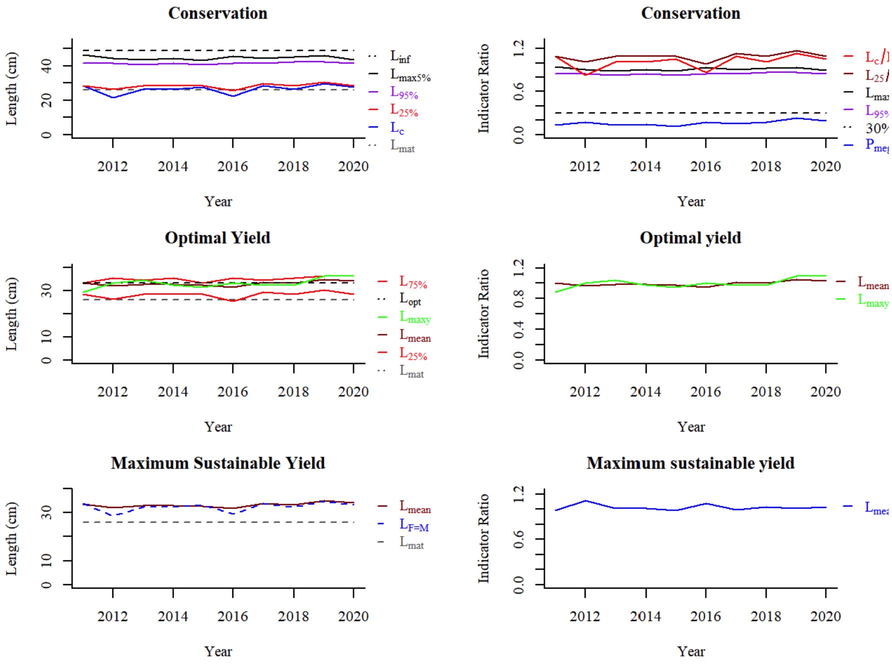

Figure 13: LBI indicators for the common sole 8c9a, data 2011-2020.

Finally, the sensitivity analysis (Figure 14) shows that:

- L_{inf}: overestimation of this parameter leads to a decrease in the proportion of mega-spawners and also affects the MSY indicator, although this indicator is in red for some years it is not worrisome since its values are close to 1. Underestimation leads to the opposite situation, the proportion of mega-spawners increased attaining values above the threshold of 0.3.
- M/K: the conclusions are similar to the ones derived from the reference model (although of course under overestimation the proportion of mega-spawners increased and was larger or close to the threshold of 0.3).
- L_{mat}: overestimation leads to a decrease in the values of the indicators related to the conservation of immatures, in spite of this the conclusion derived from the last year still maintain that conservation is correct.

From the above explanations we conclude that the stock status is good but attention to the conservation of mega-spawners is required.

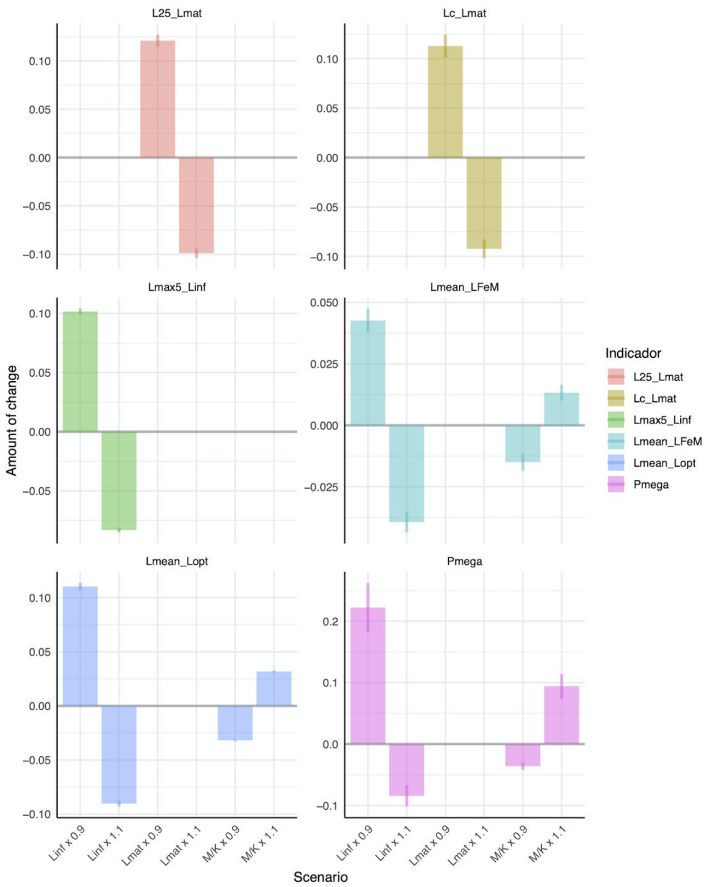

Figure 14: LBI sensitive analysis using understimation and overestimation of Linf, M/K and L50 parameters at the 5 and 10 of the reference model's values. For each setting, the annual average of change defined as the mean of the annual vector of differences among the values of the indicator in the corresponding setting and such values in the reference setting is plotted as a barplot. Furthermore, the associated standard deviation is represented trough vertical line whose extremes are the mean minus two times the standard deviation and plus such quantity.

Although in the WKWEST2021 benchmark it was advised that the LBI is the preferred method for this stock, the LBSPR and MLZ are routinely computed for this stock to check if all the data-poor methods agree in the stock status.

Length-based spawning potential ratio (LBSPR)

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

- M=0.31 (by Cerim et al., 2020), and K=0.22 (from Teixeira and Cabral, 2010, we have that K=0.23 for females and K=0.21 for males then we consider the mean of both sexes). Finally, M/K=1.41.
- L_{inf}=48.9 cm (growth studies based on *S. solea* otolith readings in the Portuguese coast indicate that L_{inf}=52.1 cm for females and L_{inf}=45.7 cm for males, and hence we compute the mean of both sexes).
- L_{50}=26 cm (from Jardim, et al., 2011, we have that L_{50}=25 cm for males and L_{50}=27 cm for females, and then the mean of both sexes is computed).
- L_{95}=27.5 cm (derived from stock annex sol-bisc division 8a, b).

The LFD used is the same implemented for the LBI method.

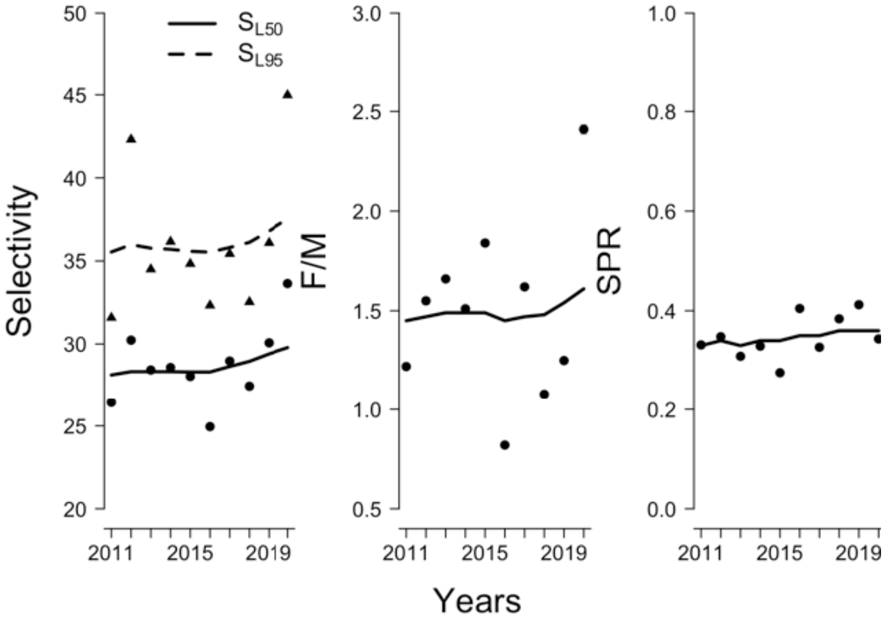

Figure 15: Results of the LBSPR methods for the *S.solea* 2011-2020.

The SPR values for this stock vary from a minimum of 0.28 in the 2015 to a maximum of 0.41 in 2019 (Figure 15). The SPR value for 2020 is 0.34. Overall the trend of the SPR is an increasing trend and are between the recommended range of 0.30-0.40.

Mean length-based mortality estimators (MLZ)

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

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

- K=0.22 (from Teixeira and Cabral, 2010, we have that K=0.23 for females and K=0.21 for males then we consider the mean of both sexes).

- L_{inf}=48.9 cm (growth studies based on *S. solea* otolith readings in the Portuguese coast indicate that L_{inf}=52.1 cm for females and L_{inf}=45.7 cm for males, and hence we compute the mean of both sexes).

The effort time-series is derived from the ratio of the catch and a LPUE series of Portugal.

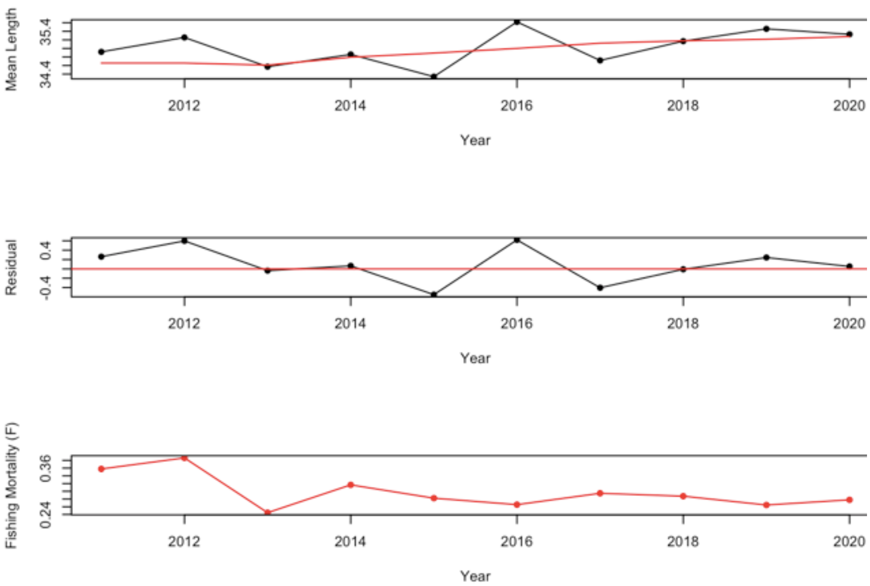

Figure 16: Fishing mortality trend computed using the MLZ model for *S. solea* 2011-2020.

The fishing mortality estimates range from a maximum of 0.38 at the beginning of the time series (2012) to a minimum of 0.24 in 2013 (Figure 16). The value of F for 2020 is 0.27. Overall the F time series showed a decreasing pattern.

In addition, the Yield-Per-Recruits (YPR) estimations show a F_{max} of 1.04 and F_{01} of 0.32 (Figure 17).

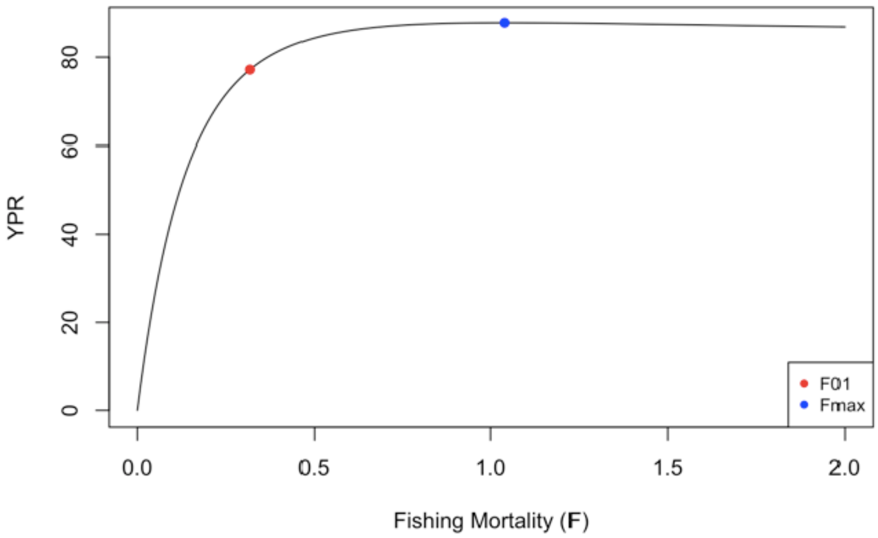

Figure 17: Yield per recruits approximation obtained with the MLZ methods for the *S.solea* 2011-2020.

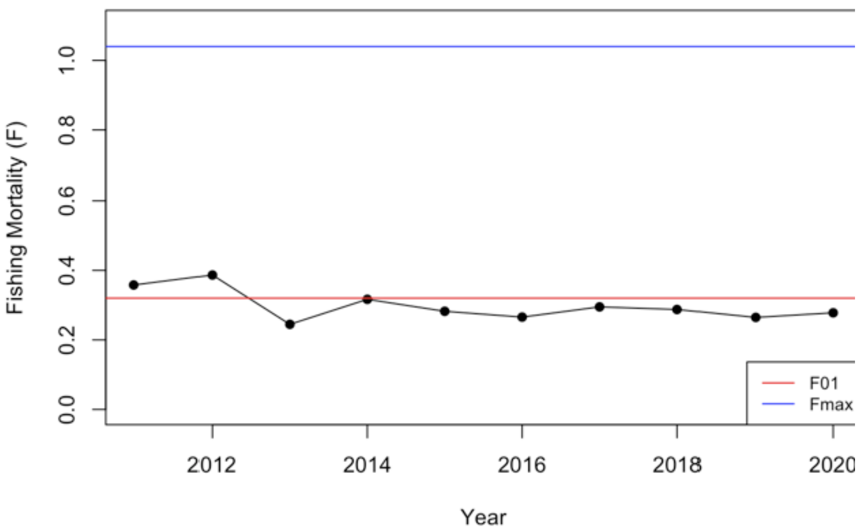

Figure 18: Fishing mortality trend for the *S.solea* 2011-2020 with the estimated F_{max} and F_{01}.

Advice rules for harvest control rules for length-based approaches

During the WKWEST2021 benchmark, it was decided that the LBI was the best suited to reflect the status of the stock. Using this method as basis, the catch advise will be provided with the 2-over-3 HCR (Method 2.1, Annex III, WKLIFE VIII, ICES 2020). As for the 2-over-3 HCR an index of biomass is required, among the all possible options it was agreed to use a weighted sum of the Portuguese LPUE and the Spanish Bayesian survey index (Figure 19) with weights varying by year according to the percentage of catches of each of the countries (i.e. Spain and Portugal). In this setting the two indices are standardized before their application:

$$Index_{year} = ½ * [S\text{-}BayesianIndex_{year}/mean(S\text{-}BayesianIndex) + P\text{-}LPUE_{year}/(mean(P\text{-}LPUE)]$$

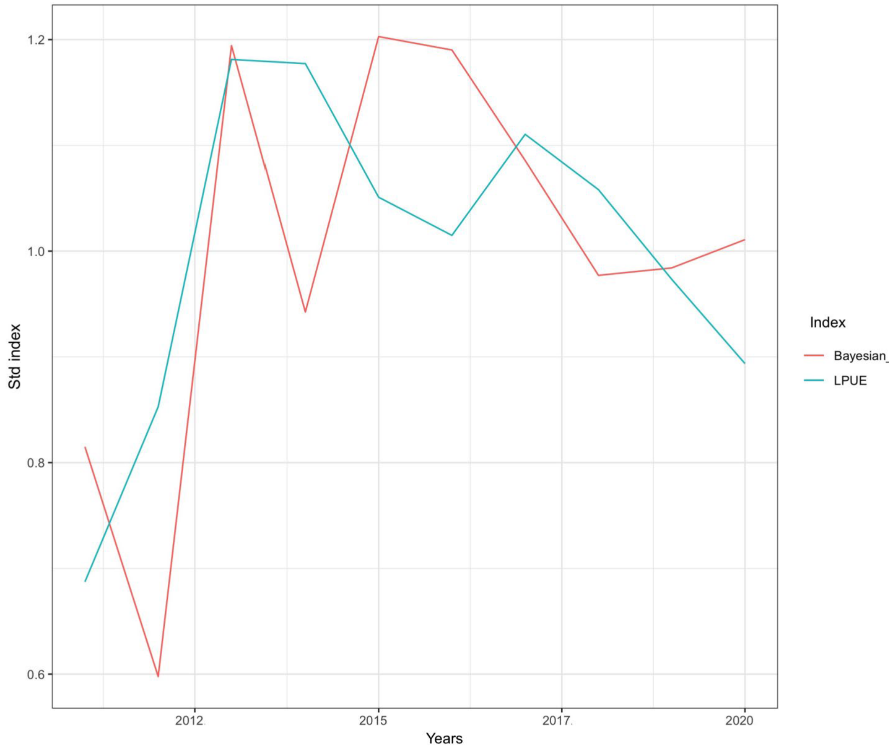

Figure 19: Standardized indices used in the 2-over-3 HCR. The Portuguese LPUE (blue) and the Spanish Bayesian survey index (red).

The catch rule is defined as:

$$C_{y+1}=m*C_y*r*f*b,$$

where the advised catch for next year y+1 is based on the average of real catches corresponding to the three most recent years adjusted by the following components:

- **r**: The rate of change in the index, based on the average of the two most recent years of data (y−2 to y−1, i.e, 2019 to 2020) relative to the average of the three years prior to the most recent two (y−3 to y−5, i.e., 2016-2018), and termed the "2-over-3" rule.
- **f**: The ratio of the mean length in the observed catch that is above the length of first capture relative to the target reference length (mean length/target reference length). The target refer-

ence length is $L_{F=M}=(1-a)*L_c+a*L_{inf}$, being $a=1/(2*(M/k)+1)$ and L_c the length at 50% of modal abundance. Note that the "mean length" (numerator of the ratio) is derived from LBI estimate of L_{mean} (mean length of individuals > L_c) in the year y-1, that is, 2020. $L_{F=M}$ value is also equal to the LBI estimate for year y-1=2020.

- **b**: Adjustment to reduce catch when the most recent index data $I_{y-1}=I_{2020}$ is less than $I_{trigger}=1.4*I_{loss}$ such that b is set equal to $I_{2020}/I_{trigger}$. I_{loss} is generally defined as the lowest observed index value for that stock (minimum of the hold time series index).
- **m**: Multiplier applied to the harvest control rule to maintain the probability of the biomass declining below B_{lim} to less than 5%. May range from 0 to 1.0. *Medium-lived stocks with k between 0.20 and 0.32 (our case) should apply a multiplier of 0.80 to next year's estimated catch.*

Applying this rule, the advice is of 284t for 2022 and 2023.

D. Short-term projection

No fishing possibilities can be projected.

E. Medium-term projections

No medium-Term projections can be projected.

F. Long-term projections

No long-term projections can be projected.

G. Biological Reference Points

No biological references points were available.

H. Other Issues

I. References

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Annex 4: Audit reports

Audit of assessments made by expert group members

Audit of Sea bass (*Dicentrarchus labrax*) in divisions 8.c and 9.a (southern Bay of Biscay and Atlantic Iberian waters)

Date: 30/05/2021

Auditor: Andreia Silva

General

There is no sufficient information to provide catch options. Discarding is assumed to be negligible and recreational removals are unknown, therefore ICES cannot quantify the corresponding total catch.

For single stock summary sheet advice:

1) **Assessment type:** No assessment
2) **Assessment**: No assessment.
3) **Forecast**: No forecast
4) **Assessment model**: No model is used in the assessment
5) **Data issues:** Last assessments were based on the period 2009-2011 for calculation which are not in agreement with the stability of the stock. At this stage is not possible to define the details of an approach suitable for this area.
6) **Consistency**: No comment
7) **Stock status**: The available scientific data for the stock is insufficient to evaluate its status.
8) **Management Plan**: There is no management plan for this stock.

General comments

The report is well written, and data was correctly updated.

Technical comments

Assessment and advice have been carried out following ICES procedures.

Conclusions

The assessment has been performed correctly.

Checklist for audit process

General aspects

- Has the EG answered those TORs relevant to providing advice?
  Yes.
- Is the assessment according to the stock annex description?
  Yes.
- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary?
  Not applicable.
- Have the data been used as specified in the stock annex?
  Yes.
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex?
  Not applicable.
- Is there any **major** reason to deviate from the standard procedure for this stock?

Commercial landings and recreational catches of seabass are unknown which are requirements from the commission.

- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice?
  Not applicable.

Audit of hke.27.3a46-8abd

Date: 18/05/2021
Auditor: Hans Gerritsen

General

Advice

- I have added a few comments to the advice sheets, below is some more detail
- Table 1: SSB(2022) – this is the wrong value, I think it should be 218 924.
- Last year the MSY advice was for 99kt. This year the advice is for 75kt (a 24% decrease). This can be partially explained by the retro but the 2020 SSB was revised by 15% and the assumed 2021 SSB was revised by only 7% so there is something else as well. The SSB is projected to decrease (239kt in 2021; assumed 219kt in 2022 and projected 207kt in 2023 under Fmsy). I presume that this projected decline is due to a lack of particularly strong recruitment in recent years. At the moment the advice sheet explains the decrease in advice as follows "*The advice for 2022 is about 24% lower than the advice for 2021 because the perception of the stock has been revised downwards.*" During the additional plenary on 17/05/21 we decided not to add anything else to this but looking at the numbers I think we should explain better why the advice is so much lower than last year. I propose "*Additionally, the stock size is projected to decrease in 2022 and 2023 because there has been no particularly high recruitment in recent years*". The ADG can always delete it if they do not think it is informative.
- The footnote under table 2 reads "*** Total catch advice in 2022 relative to the catch advice for 2021 (tonnes).*" The catch advice for 2021 is not in the table so I would add it to the footnote: change to: "*... catch advice for 2021 (98 657 tonnes)*" (or whatever the updated value will be)
- The first footnote of table 8 is a bit unclear (see comment in advice sheet). However it is the same as before so must have been acceptable to the ADG.
- The totals of table 9 do not add up to those in table 8 (except for 2017-19). Either this is a mistake or it needs to be explained.

Report

- I added some comments in the report and made some very minor edits (spelling).
- The main issue is that the catch values in table 9.1 of the report do not correspond to those in table 8 of the advice for some years.
- Also, I think it is useful to describe exactly how the WKFORBIAS decision tree was followed.

For single stock summary sheet advice:

1) **Assessment type:** *update*
2) **Assessment**: *analytical*
3) **Forecast**: *presented*
4) **Assessment model**: *SS*
5) **Data issues:** *Some minor issues due to covid and administrative issues. Not thought to affect the quality of the assessment significantly.*
6) **Consistency**: *The assessment has not been rejected in recent years; however, the retrospective pattern is of concern and leads to inconsistencies in the advice. Catches have been considerably below the MSY advice since 2018 but F has been at or above MSY in those years, indicating that the advice has been overly optimistic. However, following the guidelines from WKFORBIAS it is acceptable to give advice.*
7) **Stock status**: *B>>Btrigger; F close to Fmsy, R often subject to retrospective revisions in first 2 years, therefore highly uncertain in 2019-20 (although the confidence limits are narrow). WGBIE decided to replace those values with GM.*
8) **Management Plan**: *EU MAP (old management plan no longer relevant)*

General comments

All the code is documented in TAF, which is a major achievement considering the complexity of the assessment. However, I did not try to re-run the assessment or forecast or check the input and set-up files because I would not know how to find any mistakes there. I am reasonably familiar with SS but it would take a lot more insight than I have to discover any mistakes. I can only assume that the assessment was performed correctly and I have checked the tables for consistency with previous years, checked advice tables against report tables and checked for values that appear in more than one table.

Technical comments

See 'General' section

Conclusions

The assessment has been performed correctly

Checklist for audit process

General aspects

- Has the EG answered those TORs relevant to providing advice? Yes
- Is the assessment according to the stock annex description? Yes
- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary? MAP
- Have the data been used as specified in the stock annex? Yes
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex? Yes
- Is there any **major** reason to deviate from the standard procedure for this stock? No
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice? Yes

Template for audit of assessments made by EG members

Audit of Four spot megrim (*Lepidorhombus boscii*) in Divisions 7.b-k and 8.a,b,d

Date: 18/05/2021

Auditor: Catarina Maia

General

This is a Category 5 stock and no quantitative stock assessment is carried out. The precautionary buffer is applied this year to recent average catches from 2017, 2018 and 2019.

For single stock summary sheet advice:

1) **Assessment type:** No assessment (ICES category 5 stock)
2) **Assessment**: No assessment.
3) **Forecast**: No forecast
4) **Assessment model**: No model is used in the assessment
5) **Data issues:** Data submitted only for the last 4 years. France could not estimate catches for 2020. Length frequency distributions for landings and discards were not available from all countries in 2020, but average discards from 2017 to 2019 were estimated to be 27% of the total catch.
6) **Consistency**: No comment
7) **Stock status**: The available scientific data for the stock are not sufficient to evaluate its status.
8) **Management Plan**: There is no management plan for this stock.

General comments

The report is well written and data was correctly updated.

Technical comments

Assessment and advice have been carried out following ICES procedures.

Conclusions

The assessment has been performed correctly.

Template for audit of assessments made by EG members

Checklist for audit process

General aspects

- Has the EG answered those TORs relevant to providing advice?
  Yes.
- Is the assessment according to the stock annex description?
  Yes.
- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary?
  Not applicable.
- Have the data been used as specified in the stock annex?
  Yes.
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex?
  Not applicable.
- Is there any **major** reason to deviate from the standard procedure for this stock?
  Short time series to evaluate stock status as required by the commission.
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice?
  Not applicable.

Audit of ldb.27.8c9a

Date: 19/05/2021
Auditor: Jean-Baptiste Lecomte and Isabel González Herraiz

General

- Category 1 stock.
- This stock was assessed and projections were performed without no particular issues.
- This year, there is a retrospective pattern.
- The assessment has been performed correctly according to the stock annex.
- The stock annex has been updated with an update of the biological reference points (Fpa)
- Both species of megrim are subject to a common TAC [Megrim (*Lepidorhombus whiffiagonis*) and Four-spot megrim (*Lepidorhombus boscii*)]

For single stock summary sheet advice:

1) **Assessment type:** Update
2) **Assessment:** Analytical assessment
3) **Forecast**: Presented. The advice for this stock follows the ICES rules for category 1 stocks.
4) **Assessment model**: XSA + 1 survey and 2 LPUEs
5) **Data issues:**
    a. The data are as described in Stock Annex.
    b. The collection of data from the commercial fishery and research surveys during 2020 has been impacted by COVID-19 restrictions to a varying degree across member states. It did not impact the quality of the advice.
6) **Consistency:** Results are consistent and the assessment and forecast were accepted.
7) **Stock status** SSB has been increasing in recent years and is above MSY Btrigger and Bpa. Fishing mortality (F) has constantly decreased since 1990 and it is below FMSY since 2018. Recruitment is stable since 2010 with some variability.
8) **Management Plan**: A multiannual plan for demersal stocks (which includes this stock) and their fisheries in the Western Waters and adjacent waters was published (EU Parliament and Council Regulation no. 2019/472, of 19 March 2019). This plan defines the target fishing mortality within the range of F_{MSY}.
9) **General comments:** The section was well structured, properly documented and it is easy to follow. We detected no inconsistencies in the text or in tables or figures. The data, assessment and forecast were used/realized according to the Stock Annex.

Technical comments

- Recruitment 2021 was replaced by the historical geometrical mean (GM1990-2018). for short-term projections.
- F_{2021} was set as average F (years 2018-2020).

Conclusions

The assessment has been performed correctly

Checklist for audit process

General aspects

- Has the EG answered those TORs relevant to providing advice?
  - Yes
- Is the assessment according to the stock annex description?
  - Yes
- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary?
  - The management plan has been agreed to by relevant parties and ICES has evaluated the multiannual management in a single stock basis.
- Have the data been used as specified in the stock annex?
  - Yes
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex?
  - Yes
- Is there any **major** reason to deviate from the standard procedure for this stock?
  - No
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice?
  - Yes

Audit of meg.27.8c9a

Date: 17/05/2021

Auditor: Youen Vermard and Jean-Baptiste Lecomte

General

- Category 1 stock since the 2016 benchmark workshop.
- This stock was assessed and projections were performed without no particular issues.
- This year, there is a retrospective pattern.
- The assessment has been performed correctly according to the stock annex.
- Both species of megrim are subject to a common TAC [Megrim (*Lepidorhombus whiffiagonis*) and Four-spot megrim (*Lepidorhombus boscii*)]

For single stock summary sheet advice:

1) **Assessment type:** Update
2) **Assessment**: Analytical assessment
3) **Forecast**: Presented. The advice for this stock follows the ICES rules for category 1 stocks.
4) **Assessment model**: XSA + 1 survey and 2 LPUEs
5) **Data issues:**
   a. The data are as described in Stock Annex.
   b. The collection of data from the commercial fishery and research surveys during 2020 has been impacted by COVID-19 restrictions to a varying degree across member states. It did not impact the quality of the advice.
6) **Consistency**: The assessment was accepted for the third consecutive year.
7) **Stock status**: Stock biomass has been above MSY $B_{trigger}$ since 2016; F has been decreasing and is below F_{MSY} in 2020.
8) **Management Plan**: A multiannual plan for demersal stocks (which includes this stock) and their fisheries in the Western Waters and adjacent waters was published (EU Parliament and Council Regulation no. 2019/472, of 19 March 2019). This plan defines the target fishing mortality within the range of F_{MSY}.

General comments

The section was well structured, properly documented and it is easy to follow. We detected no inconsistencies in the text or in tables or figures. The data, assessment and forecast were used/realized according to the Stock Annex.

Technical comments

- Recruitment is decreasing since 2019, after an above average recruitment for the years 2015 to 2019.
- Recruitment 2021 was replaced by the historical geometrical mean (GM1998-2018) for short-term projections.
- F_{2021} was set as average F (years 2017-2020)
- SSB has been increasing in recent years and is above MSY Btrigger.
- Fishing mortality (F) has decreased in the last years and it is below F_{MSY} in 2020.

Conclusions

The assessment has been performed correctly.

Checklist for audit process

General aspects

- Has the EG answered those TORs relevant to providing advice?
    - Yes
- Is the assessment according to the stock annex description?
    - Yes
- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary?
    - The management plan has been agreed to by relevant parties and ICES has evaluated the multiannual management in a single stock basis.
- Have the data been used as specified in the stock annex?
    - Yes
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex?
    - Yes
- Is there any **major** reason to deviate from the standard procedure for this stock?
    - No
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice?
    - Yes

Audit of (Stock name)

Date: 2021/05/14
Auditor: Dorleta Garcia

General

The assessment has been carried out according to the stock annex. The only deviation is related with some missing data due to the covid. However, the assessment model was able to work with missing data, in case of LPUEs, and in the case of length frequency distribution the data was raised using other available strata.

For single stock summary sheet advice:

1) **Assessment type:** **update**
2) **Assessment**: analytical
3) **Forecast**: presented
4) **Assessment model**: VPA Bayesian assess – tuning by 3 comm + 2 surveys
5) **Data issues:** Missing length frequency data from Spain in some quarters. Solved using data form other quarters. LPUE-s not available for Spain in 2020 but not strictly necessary in the assessment model.
6) **Consistency**: Consistent with previous years
7) **Stock status**: SSB>>>Btrigger, F<Fmsy
8) **Management Plan**: *Multiannual mixed-fisheries management plan with Franges, Fmsy and Btrigger.*

General comments

The report is well written and documented.

Technical comments

Several comments were made to the report and advice sheet that were corrected by the stock coordinator.

Conclusions

The assessment has been performed correctly

Checklist for audit process

General aspects

- Has the EG answered those TORs relevant to providing advice?
  YES

- Is the assessment according to the stock annex description?
  YES. The only deviation is the raising of data that ….

- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary?
  The MAP was not evaluated by ICES. But, the reference points used by the MAP for this stock were calculated by ICES and evaluated to be precautionary.

- Have the data been used as specified in the stock annex?
  NO.

- Has the assessment, recruitment and forecast model been applied as specified in the stock annex?
  YES

- Is there any **major** reason to deviate from the standard procedure for this stock?

  The impacts include the lack of Spanish length distribution data and discards data for the first semester of Spanish metier OTB_DEF_70-99_0_0 in Subarea 7 were missing. The existing LD of the metier were raised to the total catch of the metier. Discards data for the first semester was raised based on second semester discard data taking into account the exerted effort. The procedure was considered appropriate to conduct the assessment.

  Spanish LPUEs data of the Commercial indices: SP-VIGOTR7 (VIGO84, VIGO99) were missing for year 2020 and the LPUE was not updated. The model can work with missing data in abundance indices, so not having this data was not considered a problem by the EG.

- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice?

YES

Audit of mon.27.78abd

Date: 19/05/2021

Auditor: Paz Sampedro and Spyros Fifas

General

- Very minor changes were made (typos, spaces...) in the report.
- Assessment and advice 2022 performed in spite of some noisy retrospective patterns although inside the range of standard deviations

The following proposals of change are also sent to the stock coordinator:

Assessment and advice 2022 performed in spite of noisy

Report

- Figure 3.1.3. is duplicated. Also, it seems that it was not updated with 2020 data.

- Pag. 12: "Table 3.2.3 gives the catch options. Figure 3.2.14 shows the contributions of the cohorts to the 2021 and 20221 forecasted landings and 2021 and 2022 SSB. The 2020 assumed GM recruitment contributes 9% to the forecasted landings."

Change to: "Table 3.2.3 gives the catch options. Figure 3.2.14 shows the contributions of the cohorts to the 2022 forecasted landings and 2023 SSB. The 2021 assumed GM recruitment contributes 9% to the forecasted landings."

-Pag.27: "Table 3.2.3. *Lophius piscatorius* in 27.78abd. Catch options: Catch, landings and discards in 2019 in tonnes; F of the catch, landings and discards in 2019; SSB in 2020 in kilotonnes; dSSB, dLand and dCatch are the change in SSB, landings and catch with the previous year (%)."

Change to : Table 3.2.3. *Lophius piscatorius* in 27.78abd. Catch options: Catch, landings and discards in 2021 in tonnes; F of the catch, landings and discards in 2021; SSB in 2023 in kilotonnes; dSSB, dLand and dCatch are the change in SSB, landings and catch with the previous year (%).

Advice

Tabla1. SSB(2021) should be SSB(2022). And "value" 64190 should be also changed to value of SSB (2022) = 70972 t

Table 2. For scenario "MSY approach = FMSY", column "% Advice change" is "9" and should be "-0.9"

Table 2. For scenario "F = F2021", column "% Advice change" is "-.9" and should be "-9"

For single stock summary sheet advice:

1) **Assessment type:** *update*
2) **Assessment**: *analytical*
3) **Forecast**: *presented*
4) **Assessment model**: *a4a*
5) **Data issues:** *Due to the covid-19 and administrative issues, sampling has been limited and the number of samples of landings as well as discards has decreased in comparison to previous years. There were not discards data from Spain the first semester in the division 7. No high impact on the quality of the assessment is expected.*

6) **Consistency:** *There is a moderate-high retrospective pattern for F and SSB. The retrospective patterns were also detected in assessment 2019 and 2020, and it is increasing. Nevertheless, following the guidelines from WKFORBIAS the assessment was accepted to give advice.*

7) **Stock status**: *SSB_{2021} is above Btrigger currently equal to the maximum level of the time series and F_{2020} is below F_{MSY}.*
8) **Management Plan**: *EU - Western Waters Multiannual Plan*

General comments

The current model assessment is considered an interim solution to give advice until a more appropriate model is developed. This stock is going to be benchmarked in 2021-2022, and a new model will substitute the current one next year.

Technical comments

Conclusions

This year assessment has been performed correctly.

Checklist for audit process

General aspects

- Has the EG answered those TORs relevant to providing advice? Yes
- Is the assessment according to the stock annex description? Yes
- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary? Yes
- Have the data been used as specified in the stock annex? Yes
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex? Yes
- Is there any **major** reason to deviate from the standard procedure for this stock? No
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice? Yes

Audit of sol.27.8ab

Date: 21/05/2021

Auditor: Esther Abad and Paz Sampedro

General

- Category 1 stock.
- This stock was assessed and projections were performed without any particular issues.
- This year, the retrospective analyses show that the recruitment was well estimated by the XSA model.
- The assessment has been performed correctly according to the stock annex.

For single stock summary sheet advice:

1) **Assessment type:** Update
2) **Assessment**: Analytical assessment. The assessment was carried out using FLXSA and has been included in the TAF environment.
3) **Forecast**: Presented. The advice for this stock follows the ICES rules for category 1 stocks.
4) **Assessment model**: FLXSA + 1 survey and 4 LPUEs
5) **Data issues:**
   a. The data are as described in Stock Annex.
   b. The collection of data from the commercial fishery and research surveys during 2020 has been impacted by COVID-19 restrictions to a varying degree across member states. It did not impact the quality of the advice.
6) **Consistency**: The assessment was accepted.
7) **Stock status**: Stock biomass is below MSY $B_{trigger}$ and between B_{pa} and B_{lim}; F has increased and is above F_{MSY} in 2020.
8) **Management Plan**: There are two management plans and ICES advice is according to the EU multiannual plan (MAP):
   • The EU multiannual plan (MAP) for stocks in the Western Waters and adjacent waters applies to this stock. The plan specifies conditions for setting fishing opportunities depending on stock status and making use of the FMSY range for the stock.
   • The (EC) 388/2006 management plan is agreed for the Bay of Biscay sole but a long-term F target has not yet been set. This plan has not been evaluated by ICES.

General comments

The section was well structured, properly documented and it is easy to follow. We detected no inconsistencies in the text or in tables or figures. The data, assessment and forecast were used/realized according to the Stock Annex. The stock assessment was included in TAF this year and input data, code of the assessment and assessment's results are available on https://github.com/ices-taf/2021_sol.27.8ab_assessment.

Technical comments

- Recruitment has been declining over the time series and in 2020 is estimated to be the lowest level.
- Recruitment in 2021 was replaced by the historical geometrical mean (GM2016-2020) for short-term projections. In 2020, the WGBIE was concerned by the decrease in recruitment over the past two decades. For this reason, the WG2020 decided to shorten the period used to estimate recruitment for projections from 1993-2017 to 2004-2017. This deviation from the Stock Annex was not rejected by the ADG and ACOM.

- In 2021, the retrospective analysis indicates that the recruitment is well estimated in recent years, but still decreasing. In order to account for lower recruitment in recent years, the geometric mean of the recruitment was then shortened and computed over the time period 2016-2020; this new option was included in the Stock Annex this year.
- F_{2021} was set as average F (years 2018-2020) scaled to the last year F.
- SSB has been decreasing in recent years and is below MSY Btrigger.
- Fishing mortality (F) has increased in the last years and is above F_{MSY}.

Conclusions

The assessment has been performed correctly.

Checklist for audit process

General aspects

- Has the EG answered those TORs relevant to providing advice?
    - Yes
- Is the assessment according to the stock annex description?
    - Yes
- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary?
    - The management plan has been agreed to by relevant parties and ICES has evaluated the multiannual management in a single stock basis.
- Have the data been used as specified in the stock annex?
    - Yes
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex?
    - Yes
- Is there any **major** reason to deviate from the standard procedure for this stock?
    - No
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice?
    - Yes

Audit of Sole (*Solea solea*) in divisions 8.c and 9.a (Cantabrian Sea and Atlantic Iberian waters)

Date: 19/05/2021

Auditor: Isabel González Herraiz

General

Sole (Solea solea) in divisions 8.c and 9.a (Cantabrian Sea and Atlantic Iberian waters) stock is considered as a data-limited stock and it is classified as category 3.

The stock has been benchmarked in 2021 (WKWEST) and the time series of catches from 2011 to 2020 was revised.

Management of catches of all sole species under a combined TAC prevents effective control of each single-species exploitation rate and could potentially lead to overexploitation of all of the species.

For single stock summary sheet advice:

1) **Assessment type:** update
2) **Assessment**: Trends from combined biomass index (LPUE and survey), LBI (Length Based Indicator) for F_{msy} proxy
3) **Forecast**: not presented
4) **Assessment model**: "2 over 3 rule" for data-limited stocks (Method 2.1, the rfb rule, WKLIFE X)
5) **Data issues:** 2011 to 2020 catch data were revised. The "2 over 3 rule" require to apply the most recent year's advised catch Cy but, as catches were corrected in the benchmark, the average of the last 3 years was used instead.
6) **Consistency**: The stock was benchmarked in 2021 and the 2011-2020 catches revised. Respect to COVID impact in data, the assessment diagnostics were considered acceptable and the impact in advice minimal.
7) **Stock status**: Exploitation status in year 2020 < F_{MSY} proxy
8) **Management Plan**: 2019 EU multiannual plan for the Western Waters. If F_{MSY} ranges are not available, fishing opportunities should be based on the best available scientific advice.

General comments

This was a well documented and well ordered section in the report, stock annex and advice sheet.

Technical comments

Conclusions

The assessment has been performed correctly.

Checklist for audit process

General aspects

- Has the EG answered those TORs relevant to providing advice? Yes
- Is the assessment according to the stock annex description? Yes
- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary? Yes
- Have the data been used as specified in the stock annex? Yes
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex? Yes in the case of the assessment. There is no forecast and recruitment is not relevant for this assessment.
- Is there any **major** reason to deviate from the standard procedure for this stock? No
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice? Yes

Audit of (Stock name)

Date:
Auditor:

- *Audience to write for: ADG, ACOM, benchmark groups and EG next year.*
- *Aim is to audit (check if correct):*
  - *the stock assessment– concentrate on the input data, settings and output data from the assessment*
  - *the correct use of the assessment output in the forecast, and check if forecast settings are applied correctly*
- *Any deviations from the stock annex should be described sufficiently.*
- *By the conclusion of the working group, all update assessments should be audited successfully.*
- *Store all audits on SharePoint for future reference.*

General

Use bullet points and subheadings (Recommendations, General remarks, etc.) if needed

For single stock summary sheet advice:

Short description of the assessment: extremely useful for reference of ACOM.

1) **Assessment type: update/SALY**
2) **Assessment**: analytical /trends / not presented
3) **Forecast**: presented / not presented
4) **Assessment model**: *XSA + VPA Bayesian assess – tuning by 3 comm + 2 surveys*
5) **Data issues:** *are the data available as described in stock annex or have there been any issues with specific data / new data ?*
6) **Consistency**: *Last yr assess rejected – this accepted, the view of the RG was that last yrs assess should have been accepted*
7) **Stock status**: *B<Blim for a while, Flim<F<Fpa, R uncertain, seem to be high recent years*
8) **Management Plan**: *Agreed 2006: SSB above 35 000 t within 10 years and to reduce fishing mortality to 0.27. The main elements in the plan are a 10% annual reduction in F and a 15% constrain on TAC change between years. Plan is* ***not*** *evaluated by ICES*

General comments

This was a well documented, well ordered and considered section. It was easy to follow and interpret…. etc

Technical comments

(Include comments on points where the draft report contains errors, is unclear and if the assessment is done according to the stock annex)

Conclusions

The assessment has been performed correctly

(If needed describe if relevant what extra things need to be done for a correct final assessment)

(Include suggestions for future benchmarks, and things to be done before ADG)

Checklist for audit process

General aspects

- Has the EG answered those TORs relevant to providing advice?
- Is the assessment according to the stock annex description?
- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary?
- Have the data been used as specified in the stock annex?
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex?
- Is there any **major** reason to deviate from the standard procedure for this stock?
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice?

Audit of (Stock name)

Date: 19/5/21

Auditor: Santiago Cerviño (santiago.cervino@ieo.es) / Maria Grazia Pennino

General

Use bullet points and subheadings (Recommendations, General remarks, etc.) if needed

For single stock summary sheet advice:

Short description of the assessment: extremely useful for reference of ACOM.

1) **Assessment type:** Category 2
2) **Assessment**: Analytical
3) **Forecast**: Presented
4) **Assessment model**: SPiCT
5) **Data issues:** minor impact of COVID data issues.
6) **Consistency**: First assessment after benchmark (WKMSYSPICT 2021)
7) **Stock status**: B>MSYBtrigg the whole time series and above Bmsy in recent years. Blim for a while, Flim<F in recent years.
8) **Management Plan**: included in the western waters MAP (EU, 2019)

General comments

Well documented and clearly understandable

Technical comments

1) minor impact of COVID data issues. Lower samples in 2020 compared with previous years, but mainly affect length distribution, not used in Production model. SPiCT diagnosis are fine.
2) Minor Mohns Rho figures (<0.05) but retro diverges in the past.

Conclusions

The assessment has been performed correctly following stock annex.

There is a confusion with the lower range in the Catch option table (F/Fmsy = 0.7) and the reference points table (F/Fmsy=0.78)

Only one calibration index is used. Additional information would help to calibrate the model in a future benchmark.

Checklist for audit process

General aspects

- Has the EG answered those TORs relevant to providing advice? Yes
- Is the assessment according to the stock annex description? Yes
- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary? Yes
- Have the data been used as specified in the stock annex? Yes
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex? Yes
- Is there any **major** reason to deviate from the standard procedure for this stock? No

Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice? Yes

Audit of Norway lobster (Nephrops norvegicus) in Division 9.a

Date: 19th May 2021
Auditor: Eoghan Kelly

General

- Report and advice sheet were reviewed and comments were added to documents using track changes and communicated to stock coordinator via email.

For single stock summary sheet advice:

1) **Assessment type:** New assessment (SPiCT following upgrade to category 2, benchmarked at WKMSYSPiCT 2021)
2) **Assessment**: Analytical
3) **Forecast**: Presented
4) **Assessment model**: SPiCT, 1 survey index (scaled)
5) **Data issues:** Minor impact of COVID data issues, mainly affected length distribution and commercial LPUE, not used in SPiCT model.
6) **Consistency**: This stock was considered as category 3.1.4 according to the ICES data-limited approach since 2012 and was upgraded to category 2 in 2021. This year is the first assessment after benchmark (WKMSYSPiCT 2021). So, it cannot be compared with last year's assessment. The new assessment using SPicT was carried out using settings accepted in WKMSYSPiCT and specified in the stock annex.
7) **Stock status**: Fishing pressure on the stock is below F_{MSY} and stock size is below MSY $B_{trigger}$ and B_{lim}.
8) **Management Plan**: The EU multiannual plan (MAP; EU, 2019) for stocks in the Western Waters and adjacent waters applies to this stock. The MAP stipulates that when the FMSY ranges are not available, fishing opportunities should be based on the best available scientific advice.

General comments

I have checked advice tables against report tables and checked for values that appear in more than one table. However, I did not try to re-run the assessment or forecast or check the input and set-up files because I would not know how to find any mistakes there. I am reasonably familiar with SPiCT but it would take a lot more insight than I have to discover any mistakes. I can only assume that the assessment was performed correctly.

Technical comments

See 'general comments' section.

Conclusions

The assessment has been performed correctly.

Checklist for audit process

General aspects

- Has the EG answered those TORs relevant to providing advice? Yes
- Is the assessment according to the stock annex description? Yes
- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary? Yes
- Have the data been used as specified in the stock annex? Yes
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex? Yes

- Is there any **major** reason to deviate from the standard procedure for this stock? No
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice? Yes

Audit of nepFU25

Date: 21/5/21
Auditor: Maria Grazia Pennino

General

- Report and advice sheet were reviewed and comments were added to documents using track changes and communicated to stock coordinator via email.

For single stock summary sheet advice:

Short description of the assessment: extremely useful for reference of ACOM.

1) **Assessment type:** New assessment (SPiCT following upgrade to category 2, benchmarked at WKMSYSPiCT 2021)
2) **Assessment**: Analytical
3) **Forecast**: Presented
4) **Assessment model**: SPiCT
5) **Data issues:** No COVID-19 impact on data quality.
6) **Consistency**: First assessment assessment using SPiCT carried out using settings accepted in WKMSYSPiCT and specified in the stock annex.
7) **Stock status**: Fishing pressure on the stock is below FMSY and total biomass is below BMSY, Btrigger and Blim.
8) **Management Plan**: ICES is not aware of any agreed precautionary management plan for Norway lobster in this area.

General comments

Well documented and clearly understandable

Technical comments

The input data, catch and Spanish IBTS Q4 bottom trawl survey (G2784) abundance index time series, and the model were accepted by the WKMSYSPiCT benchmark and are reported in the report and stock annex.

No COVID-19 impact on data quality.

Conclusions

The assessment has been performed correctly following stock annex.

Checklist for audit process

General aspects

- Has the EG answered those TORs relevant to providing advice? Yes
- Is the assessment according to the stock annex description? Yes
- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary?
- Have the data been used as specified in the stock annex? Yes
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex? Yes
- Is there any major reason to deviate from the standard procedure for this stock? No
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice? Yes

Audit of nepFU31

Date: 21/5/21
Auditor: Maria Grazia Pennino

General

- Report and advice sheet were reviewed and comments were added to documents using track changes and communicated to stock coordinator via email.

For single stock summary sheet advice:

Short description of the assessment: extremely useful for reference of ACOM.

1) **Assessment type:** New assessment (SPiCT following upgrade to category 2, benchmarked at WKMSYSPiCT 2021)
2) **Assessment**: Analytical
3) **Forecast**: Presented
4) **Assessment model**: SPiCT
5) **Data issues:** No COVID-19 impact on data quality.
6) **Consistency**: First assessment assessment using SPiCT carried out using settings accepted in WKMSYSPiCT and specified in the stock annex.
7) **Stock status**: Fishing pressure on the stock is below FMSY and total biomass is below BMSY and Btrigger but above Blim.
8) **Management Plan**: ICES is not aware of any agreed precautionary management plan for Norway lobster in this area.

General comments

Well documented and clearly understandable

Technical comments

The input data, catch and Spanish IBTS Q4 bottom trawl survey (G2784) abundance index time series, and the model were accepted by the WKMSYSPiCT benchmark and are reported in the report and stock annex.

No COVID-19 impact on data quality.

Conclusions

The assessment has been performed correctly following stock annex.

Checklist for audit process

General aspects

- Has the EG answered those TORs relevant to providing advice? Yes
- Is the assessment according to the stock annex description? Yes
- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary?
- Have the data been used as specified in the stock annex? Yes
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex? Yes
- Is there any major reason to deviate from the standard procedure for this stock? No
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice? Yes

Template for audit of assessments made by EG members

Audit of whg.27.89a

Date: 21/05/2021
Auditor: Teresa Moura and Francisco Izquierdo

General

- Commercial landings in the period 1994-2020 were presented.
- Intercatch data from 2016-2020 was used to compute discards estimates and raise length distribution of landings and discards
- COVID-19 affected onboard sampling and discard estimates; discards and length structure were raised on a semestrial basis in order to mitigate low sampling levels.
- Landings have been reasonably stable over the time period.
- The stock definition of whiting in this area is not clear. This species is at the southern extent of its range in the Bay of Biscay and Iberian Peninsula.
- Length-based indicators were estimated for the period 2016-2020 and results suggest that whiting is currently exploited below FMSY (all indicators above refence values except Lc/Lmat in 2019)
- A comprehensive issues list was presented for this stock highlighting problems, work to be carried out and data needed.

For single stock summary sheet advice:

1) **Assessment type:** Update.
2) **Assessment**: Not presented.
3) **Forecast**: Not presented.
4) **Assessment model**: No assessment.
5) **Data issues:** Landings, discards and TL distribution are available for this stock but improvements can be made. Other data issues are listed in “issues list”.
6) **Consistency**: No assessment was presented for this species.
7) **Stock status**: Unknown. F is below F_{MSY} proxy (Length-based Indicators)
8) **Management Plan**: The multiannual plan for the stocks in the Western Waters and adjacent waters applies to this stock.

General comments
Report is well documented. Some minor issues were reported to the author.

Technical comments
Assessment and advice were carried out following ICES procedures.

Conclusions
The assessment has been performed correctly.

Template for audit of assessments made by EG members

Checklist for audit process

General aspects

- Has the EG answered those TORs relevant to providing advice? Yes.
- Is the assessment according to the stock annex description? Yes.
- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary? Not concerned.
- Have the data been used as specified in the stock annex? Yes.
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex? Not concerned.
- Is there any **major** reason to deviate from the standard procedure for this stock? No
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice? Yes, it does.

WGBIE audit of assessments made by EG members

Audit of ank.27.78abd – Black-bellied anglerfish in Subarea 7 and divisions 8.a-b and 8.d.

Date: 20/05/2021

Auditor: L Readdy and A. Iriondo

General

- *Category 3 stock assessment using the combined Irish and French survey indices.*
- *Advice is based on the precautionary approach using the 2 over 3 rule applied according to the guidance published in 2012 and not the recent guidance published in WKLIFE X.*
- *Uncertainty cap was applied as the index ratio was above 1.2.*
- *Precautionary buffer was not applied this year as it was last applied in 2018.*
- *MSY proxy reference points are only available for Fishing mortality using the Mean-Length Z method.*
- *Discard estimates are only available since 2003 and are around 9% of total catch, using the average of the last three years data. Issues found with sampling levels of discards and 2020 estimates replaced using the average of 2015-2019.*
- *This stock and white anglerfish in the same stock unit area are managed under a combined species total allowable catch. They are landed together as Lophius spp. and separated for assessment purposes using sampling data from port and onboard observer trip samples.*

For single stock summary sheet advice:

1) **Assessment type:** *Update*
2) **Assessment**: *Trends – category 3.2*
3) **Forecast**: *Not presented*
4) **Assessment model**: *Category 3 trends-based assessment using and index of biomass from combining two survey series which covers a large proportion of the stock area.*
5) **Data issues:** *Although COVID-19 preventing some surveys and commercial sampling for some member states from being completed, data used in the update assessment for the trend analysis was available this year, with the exception of discard sampling. Estimates for 2020 posed an issue and was replaced with the average of 2015-2019.*
6) **Consistency**: *This year's assessment was completed according to the stock annex and consistent with last year's assessment. However, the calculation of discard estimates for 2020 was replaced with the average of 2015-2019.*
7) **Stock status**: *The biomass index shows an increasing trend with recruitment estimated to be the highest of the timeseries in 2020. Fishing pressure is estimated to be below F proxy reference points, calculated using the mean-length Z method.*
8) **Management Plan**: *Published 2019: The EU multiannual plan (MAP; EU, 2019) for stocks in the Western Waters and adjacent waters applies to this stock. The MAP stipulates that when the FMSY ranges are not available, fishing opportunities should be based on the best available scientific advice.*

General comments

This was a well documented, well ordered and considered section. It was easy to follow and interpret.

Technical comments

Further clarification needed to explain how the 2015-2019 discard estimates were applied to 2020 catch data. The explanation in the report is unclear and could cause confusion with the discard rate calculations used to split catch advice into landings and discards.

Conclusions

WGBIE audit of assessments made by EG members

The assessment has been performed according to the stock annex.

WGBIE audit of assessments made by EG members

Checklist for audit process

General aspects

- Has the EG answered those TORs relevant to providing advice? Yes
- Is the assessment according to the stock annex description? Yes
- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary? Yes
- Have the data been used as specified in the stock annex? Yes
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex? Yes
- Is there any **major** reason to deviate from the standard procedure for this stock? No
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice? Yes

Audit of assessments made by EG members

Audit of hke.27.8c9a – Hake in divisions 8.c and 9.a, Southern stock.

Date: 19/05/2021
Auditor: L. Readdy and T. Moura

General

- *Category 3 stock since 2020 owing to rejection of category 1 stock assessment.*
- *Advice is based on the precautionary approach using the 2 over 3 rule applied according to the guidance published in 2012 and not the guidance published in WKLIFE X.*
- *The uncertainty cap was not applied as the index ratio was between 0.8 and 1.2.*
- *A precautionary buffer was applied in 2020 as Proxy reference points were not available. Therefore, it is not considered for application this year.*
- *A SPiCT assessment model and length-based indicators were developed and run for this year for the first time to assess the status of the stock in relation to reference points. This work is scheduled for external review before acceptance for use in the provision of advice.*

For single stock summary sheet advice:

1) **Assessment type:** *update*
2) **Assessment**: *trends – category 3.2*
3) **Forecast**: *not presented*
4) **Assessment model**: *Category 3 stock assessment using the combined survey and standardised commercial LPUE indices of abundance. The SPiCT assessment is used as an indicator this year to provide stock and fishing pressure status relative to proxy reference points.*
5) **Data issues:** *Although not all data were available owing to COVID-19 preventing some surveys and commercial sampling for some member states from being completed, data used in the update assessment for the trend analysis was available this year.*
6) **Consistency**: *The trends analysis was introduced in 2020 to provide advice for this stock owing to the GADGET model being rejected. The same trends analysis was carried out this year, using the same two series including 2020 data, a commercial LPUE and a survey index combined. Additionally, SPiCT and LBI's were run this year to estimate proxy reference points but are due to be externally reviewed before they can be accepted.*
7) **Stock status**: *SPiCT and LBI's give conflicting results showing both a healthy stock and one that is depleted, respectively. The trend-based analysis using the survey and LPUE series combined shows a decreasing trend since 2015 which is confirmed by the SPiCT estimate of biomass. Effort and F both show a decreasing trend.*
8) **Management Plan**: *Agreed 2019: The EU multiannual plan (MAP; EU, 2019) for stocks in the Western Waters and adjacent waters applies to this stock. The MAP stipulates that when the FMSY ranges are not available, fishing opportunities should be based on the best available scientific advice.*

General comments

With the change from a category 1 to a category 3 and development of both a category 1 and category 3 assessment method the report and stock annex needs updating to remove less relevant information. The report documents well the development work that has been carried out.

Audit of assessments made by EG members

Technical comments

The Assessment is based on category 3 methodology using a combined survey and commercial LPUE series as a biomass indicator. This year proxy reference points were presented using both SPiCT and LBI methods which showed conflicting stock status. An integrated stock assessment has been developed using Stock Synthesis which shows promising results and should be considered for a benchmark as soon as possible.

Conclusions

The assessment has been performed the same as last year applying category 3 methods to a biomass index from the combined survey and commercial LPUE series.

Audit of (nep.fu.2829)

Date: 12/05/2021
Auditor: Yolanda Vila

General

- According to the ICES data limited approach, this stock is classified as category 3.2.0.
- The advice for this stock is biennial.
- Last advice was carried out in 2019
- The standardized commercial CPUE is used as index of biomass.
- Advice based on a comparison of the average of the two latest biomass index values with the average of the three preceding values, multiplied by the recent advised catch

For single stock summary sheet advice:

1) **Assessment type: update**
2) **Assessment**: trends from standardized commercial CPUE and length-based indicators
3) **Forecast**: not presented
4) **Assessment model**: None.
5) **Data issues:** A new standardization of commercial CPUE model, based on Portuguese crustacean trawlers, was adopted, by including both positive and null *Nephrops* catches. Length frequency sampling was affected by COVID-19 pandemic. *Nephrops* could not sampled during the main fishing season. The length composition for the missing months was based on the mean length composition of the last three years (2017-2019) in each of those months raised to the corresponding catch in 2020. Onboard discard sampling programme was also impacted by the pandemic but discard is considered negligible in these stocks.
6) **Consistency**: The assessment this year is performed as it was in 2019. The difference from last year advice is the use of the new standardized commercial CPUE. The Stock annex was updated.
7) **Stock status**: Fishing mortality on the stock is below F_{MSY} proxy. No reference points for stock size have been defined for this stock but it is thought to be above possible reference points.
8) **Management Plan**: The EU multiannual plan (MAP; EU, 2019) for stocks in the Western Waters and adjacent waters applies to this stock. No effort limitations were established.

General comments

The report is well written, easy to follow and interpret.

Technical comments

The information necessary for the assessment was available and it was done according the Stock Annex.

Conclusions

The assessment has been performed correctly.

Checklist for audit process

General aspects

- Has the EG answered those TORs relevant to providing advice?
- Is the assessment according to the stock annex description?
- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary?
- Have the data been used as specified in the stock annex?
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex?
- Is there any **major** reason to deviate from the standard procedure for this stock?
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice?

Audit of (ple.27.89a)

Date: 18th May 2021

Auditor: Spyros FIFAS and Mathieu Woillez

General

Plaice (*Pleuronectes platessa*) is caught as a by-catch by various fleets and gear types covering small-scale artisanal and trawl fisheries (mainly Portugal and France, secondarily Spain). The species was not present in sufficient numbers to provide survey abundance indices. ICES cannot assess the stock and exploitation status relative to MSY and precautionary approach reference points because information to define reference points is not available. The ICES framework for category 5 stocks was applied.

For single stock summary sheet advice:

1) **Assessment type: update**
2) **Assessment**: not presented
3) **Forecast**: not presented
4) **Assessment model**: Precautionary reduction of catches should be implemented unless there is ancillary information indicating that the current exploitation level is appropriate for the stock: this is the first time that ICES is providing a quantitative advice, the precautionary buffer was applied.
5) **Data issues:** Landings may contain misidentified flounder (*Platichthys flesus*) because of usual confusion at sales auctions in Portugal. The discarded fraction seems to be relatively minor but the WG cannot conclude that discarding is less than 5% of the catch.
6) **Consistency**: Consistency taking into account the overall available dataset and current knowledge about this stock.
7) **Stock status**: The stock status relative to reference points remains unknown.
8) **Management Plan**: The EU Multi-annual Plan for the Western Waters (MAP; EU, 2019) takes by-catch of this species into account.

General comments

Report well written with some minor comments in order to improve the text. Stock Annex currently missing.

Technical comments

No specific relevant point apart from necessity to investigate the actual proportion of by-catch flounder (*Platichthys flesus*).

Conclusions

The assessment has been performed correctly.

General aspects

- Has the EG answered those TORs relevant to providing advice? YES
- Is the assessment according to the stock annex description? YES
- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary? NOT INVOLVED
- Have the data been used as specified in the stock annex? STOCK ANNEX NOT YET AVAILABLE
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex? NOT INVOLVED
- Is there any **major** reason to deviate from the standard procedure for this stock? NO
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice? YES

Audit of (pol.27.89a)

Date: 05/05/2021
Auditor: Mickael Drogou and Francisco Izquierdo

General

The Bay of Biscay and Atlantic Iberian Waters Pollack stock is considered as a data-limited stock and it is classified as category 5.2 stock despite it has been benchmarked in 2021. The short time series of the abundance index and the gap of contrast in the input data didn't allowed to fit an acceptable assessment model. Recreational catches may be considerable but have not been quantified.

For single stock summary sheet advice:

1) **Assessment type:** *update*
2) **Assessment**: *not presented*
3) **Forecast**: *not presented*
4) **Assessment model**: *This year the stock was benchmarked in the WKMSYSPiCT (ICES, 2021b) but the assessment through SPiCT was not accepted due to its strong dependence on the priors regarding model convergence. Stock remains in category 5. Advices are based from 2014 on the previous three year's average landings 2011-2013 with buffer -20% applied in 2015, 2017 and 2021.*
5) **Data issues:** *Lack of sufficient data. Recreational removals unknown. Main data sources are the commercial landings. The Length Frequency Distributions are available from 2010 onwards, but from 2010 to 2015 only French data available.*
6) **Consistency**: *No analytical assessment was presented.*
7) **Stock status**: *The available scientific data for the stock are not sufficient to evaluate its abundance and exploitation status.*
8) **Management Plan**: *There is no management plan for this stock. Advice based on commercial landings.*

General comments:

The report is well written. Some minor comments have been made in order to improve the report which were included in the text and communicated to the stock coordinator.

Technical comments

Assessment and advice have been carried out following ICES procedures.

Conclusions

The assessment has been performed correctly

Checklist for audit process

General aspects

- Has the EG answered those TORs relevant to providing advice? *Yes*
- Is the assessment according to the stock annex description? *Yes*
- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary? *Not concerned*
- Have the data been used as specified in the stock annex? *Yes*
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex? *Not concerned*
- Is there any **major** reason to deviate from the standard procedure for this stock? *No*
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice? *Yes, it does.*

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

Working Group: WGBIE **Stock Name: bss.27.8ab**

Date: 19/05/2021
Auditor: Agurtzane Urtizberea

- *Audience to write for: ADG, ACOM, benchmark groups and EG next year.*
- *Aim is to audit (check if correct):*
  - *the stock assessment– concentrate on the input data, settings and output data from the assessment*
  - *the correct use of the assessment output in the forecast, and check if forecast settings are applied correctly*
- *Any deviations from the stock annex should be described sufficiently.*
- *By the conclusion of the working group, all update assessments should be audited successfully.*
- *Store all audits on SharePoint for future reference.*

General

- In the assessment of 2020 the assessment model did not consider the length at age data estimated from the ololith in 2018 and 2019 and this year with the data of 2020 the issue is the same so it will also not be considered.
- The mohn's rho values of SSB and F are within the range but the mohn's rho of recruitment is very high, however, in a sensitivity analysis it was shown that the mohn's rho was improved significantly when two time blocks were included considering the changes stablished in the minimum landings size on 2017 and 2020.

For single stock summary sheet advice:

Short description of the assessment: extremely useful for reference of ACOM.

1) **Assessment type:** Update
2) **Assessment**: Analytical assessment
3) **Forecast**: presented
4) **Assessment model**: Stock Synthesis 3 model with Commercial landings and recreational removal, the length frequencies of both as input data and French commercial LPUE series as tuning index.
5) **Data issues:** No data issues
6) **Consistency**: The assessment is consistent with the stock annex.
7) **Stock status**: Fishing pressure on the stock is below FMSY and spawning-stock size is above MSYBtrigger, Bpa,and Blim.
8) **Management Plan**: The European Parliament and the Council have published a multiannual management plan (MAP) for the Western Waters (EU, 2019). This plan applies to demersal stocks including seabass in ICES divisions 8ab.

General comments

The report and the advice are well written. However, some comments in order to improve the advice, the report and the stock annex were included in the text and communicated to the stock coordinator.

Technical comments

The main issue in the assessment is the differences in the ALK due to a different otolith reader as in 2020. A WD is needed to explain and quantify the differences between the age estimates in order to include them in the assessment model.
It was agreed during the meeting that the value of the recruitment of the last 3 years should be from 2008 until 4 years before the last year of data, because the youngest fish catch are 4 years old.
Otherwise, the assessment is done according to the stock annex.
(Include comments on points where the draft report contains errors, is unclear and if the assessment is done according to the stock annex)

Conclusions
The assessment has been performed correctly.

Checklist for audit process

General aspects

Has the EG answered those TORs relevant to providing advice?

- Yes

Is the assessment according to the stock annex description?

- The reference points of the stock annex are updated, the new management measure implemented for the French recreational fishery in 2020 needs to be explained in the stock annex and the new multiplier to estimate recreational catches, although it is explained in the report.

If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary?

- The European Parliament and the Council have published a multiannual management plan (MAP) for the Western Waters (EU, 2019). This plan applies to demersal stocks including seabass in ICES divisions 8ab.

Have the data been used as specified in the stock annex?

- Yes, but the ALK of the last year due to some possible biased reading the otoliths is not used in the assessment model, although this is explained in the report.
- The recruitment deviates not clear when is the last year. This has been communicated to the stock coordinator.
- Not clear if the advance option is it updated every year. This has been communicated to the stock coordinator.

Has the assessment, recruitment and forecast model been applied as specified in the stock annex?

- Yes

Is there any **major** reason to deviate from the standard procedure for this stock?

- It was decided to don't include the ALK estimates of 2018 and 2020, due to the possible biased reading the otoliths (new reader) and the retrospective pattern that this biased implied.

Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice?

- Yes

It is useful to print previous year advice sheet for comparison purposes it will make it easier to find potential errors and or inconsistencies.

Along with the spelling and structure of the text ensure that any values referenced in the text match the values or percentages shown in the tables.

All the values presented in the advice sheet should not be rounded at the WG. All rounded will be done at the ADG.

The check list below is given by section and it results from a compilation of the most frequent errors but by no means is it a complete list.

ICES stock advice

☒ Ensure the basis of the advice used is the correct one i.e Management plan; MSY approach; precautionary approach. The same as stated in the basis of advice table and history of advice table.

☒ The advised value of catches should be the same as presented in the catch options table.

☒ Check the years for which the advice is given.

Stock development over time

☒ Ensure all units used in the plots are correct (compare with previous year advice sheet).

☒ Ensure all titles of the plots are correct i.e caches; landings, recruitment age (0, 1, 2…); relative index

☒ Recruitment plot: if the intermediate years is an outcome of a model the value should be unshaded.

☒ Ensure the F and SSB reference points (RP) in the plots are the same as in the reference points table. Also, check the respective labels if they correspond with the RP.

☒ Check if the legend of the plots is consistent with what is shown in the plots.

☒ Check that the graphs match the data in table of stock assessment results.

Stock and exploitation status

☒ Compare with the previous year's advice sheet. The years in common should have the same status (symbol).

☒ Check if the labels for the years are correct.

☒ Compare the status table with the F and SSB plots they should show the same information.

☒ Does the stock have a management plan? If yes than the row for the management plan should be filled as well otherwise will read not applicable.

Catch options

Basis of catch options table:

For each of the rows in the table ensure that:

☒ The year is correct,

☒ The value is correct,

☒ The notes are correct and

☒ The sources are correct.

Catch options table:

☐ The forecast should be re-run to ensure all values are correct.

- Not available

☐ Compare the input data with previous year run (previous year should be in the share point under the data folder)

- Not available the input data

☒ The wanted catch and SSB values should be given in tonnes (t);

☒ Confirm if the F values for the options F_{lim}; F_{pa}; are correct.

☒ For the options where the value of F will take SSB of the forecast year to be equal to B_{lim}; B_{pa}; $MSY_{Btrigger}$ confirm if the SSB value for the forecast year is equal or close to the reference points.

☒ For the options where a percentage is added or taken (i.e +10%; 15%, etc.) from the current TAC. Ensure that the calculated values are correct.

- Not available the data

☐ For all the options given in the table calculate the percentage of change in SSB and TAC.

- Not available the data

☒ In the first column (Rationale) ensure the rational of the first line is the correct basis for the advice. All other options should be under “Other options”.

☒ Compare different catch options; higher F should result in lower SSB

☒ Check if SSB change is in line with F.

Basis of the advice

☒ Ensure the basis of the advice is correct and if the same is used in the catch option table and in the ICES stock advice section.

☒ Is there a management plan? If there is one it should be stated if it has been evaluated by ICES and considered precautionary or not and also if it has been sign off by the clients(EU; Norway, Faroe Islands, etc.)

Quality of the assessment

☒ Are the units in plots correct?

☒ Are the titles in the plots correct including F (age range) recruitment (age).

☒ The red line correspond to the year of assessment (except F which is year of assessment -1)

☒ Each plot should have five lines.

This is the second year with an advice in category 1.

☒ Ensure the reference points lines (in the SSB and F plots) are correct and match with the values in the reference point table and summary plots.

Issues relevant for the advice

☒ Along with the spelling and structure in the text ensure that any values referenced in the text match the values or percentages in the tables within the advice sheet.

Reference points

☒ Ensure all the values, technical basis and sources are correct. If new values were not calculated the table should be the same as previous year.

Basis of the assessment

☒ If there is no change from the previous year the table should be the same.

☒ Ensure there is no typos wrong acronyms for the surveys.

☒ Assessment type- check that the standard text is used.

Information from stakeholders

☒ If no information is available the standard sentence should be "There is no available information"

History of advice, and management

☒ This table should only be updated for the assessment year and forecast year except if there was revision to the previous years.

☒ Ensure that the forecast year "predicted landings or catch corres. to advice" column match the advice given in the ICES stock advice section (usually given in thousand tonnes).

History of catch and landings

Catch distribution by fleet table:

☒ Ensure the legend of the table reflects the year for the data given in the table.

☒ Ensure that the sum of the percentage values in each of the components (landings and discards) amount to 100%

☒ Ensure that the sum of the values for discards and landings are equal to the value in the catch column. However, if only landings or discards components are shown, then total catch should be unknown.

History of commercial landings table:

☒ Ensure that the values for the last row are correct check against the preliminary landings (link to be added)

Summary of the assessment

☒ This table is an output from the standard graphs. If there was any errors picked up with any of the plots, then this table should be replaced by a new version once the errors are corrected.

☒ Check if the column names are correct mainly recruitment age and age range for F.

☐ If the stock is category 5 or 6 then it should read "There is no assessment for this stock"

Sources and references

☒ Ensure all references are correct.

☒ Ensure all references in the advice sheet are referenced in this section.

Annex 5: Working documents

Abstracts of 2021 WGBIE working documents

WD01: Maturity-at-age estimates for Irish demersal stocks in 6.a and 7.b-k between 2004-2020.

S.-J. Moore and H. Gerritsen

This document provides maturity-at-age estimates for stocks assessed by the WGCSE and WGBIE. All data are obtained on surveys and commercial sampling carried out by the Marine Institute. Because overall there was no clear evidence of trends in maturity over time for any stock, data from all years (2004-2020) were combined. Overall, the perception of age at maturity has not changed from previous years working documents. Results show for most stocks considered in the study there are no clear trends in the L_{50} over time. . It is possible that the lack of full spatial coverage can explain some of the differences.

WD02: Review of the population structure of hake, megrim, white and black anglerfish, and sardine in the Northeast Atlantic waters

P. Sampedro, E. Abad, S. Cerviño, D. García, A. Iriondo, M.G. Pennino, M. Pérez, I. Riveiro, and A. Urtizberea

Understanding the stock structure of a species is an essential requirement for stock assessment and to achieve an optimal management of the resources. We reviewed the scientific articles and technical reports providing information about spatial structure and stock identification of *Merluccius merluccius*, *Lophius piscatorius* and *L. budegassa, Lepidorhombus whiffiagonis* and *Sardina pilchardus* along the Northeast Atlantic. No biological evidence, neither genetic nor phenotypic, supports the separation between the current stocks of white anglerfish. In the case of black anglerfish, a genetic study including samples from northern shelf is still required to define the stock structure. With the current information, it is not possible to argue that the northern and southern stocks of megrim should be joined and an in-depth genetic study is necessary to resolve all existing doubts on this issue. The multidisciplinary results obtained so far indicated that there is no sufficient evidence to modify the current boundaries of sardine, although there are signs of regional structuring, especially in the area of Gulf of Cádiz, despite no genetic differences have been found. The current ICES stock structure for hake, considering two stocks (the northern stock and southern stock) is not supported by any of the genetic and non-genetic studies reviewed.

WD 03. Development of a new stock assessment model with Stock Synthesis 3 (SS3) for hake (*Merluccius merluccius*) in divisions 8.c and 9.a: Southern stock

F. Izquierdo, S. Cerviño, M. Cardinale, C. Silva, A. Silva and H. Mendes

Since 2010, the stock assessment model for the southern hake stock has been GADGET. However, in 2020 this model was rejected mainly due to convergence problems and there was a change to other data poor methods. Within this frame, there is a need of looking for alternative models, especially to one of the current and most used stock assessment models which are Stock Synthesis 3 (SS3). The present working document shows the progression of the SS3 southern hake model fitting since last November of 2020 to the WGBIE 2021 regarding the main advances, model issues and future work towards a benchmark in 2022. The modelling strategy consists in fitting a set of plausible models with different configurations and selecting the best one with the r4ss and ss3diags libraries in RStudio.

WD 04. Estimation of MSY proxies for Southern hake category 3 assessment.

S. Cerviño, M. Cousido-Rocha, F. Izquierdo and A. Silva.

Southern hake reference points methods for category 3 stocks were explored following ICES guidelines. Among the 4 methods suggested, 3 are based on length distributions and life-history parameters and one is based on time-series trends of catch and biomass indices (SPiCT). The methods based on length distributions provide a view of an overexploited stock (with few exceptions) meanwhile SPiCT provides a view of a stock inside safe references. Length based model assumptions include equilibrium, known growth and logistic or knife edge selectivity, all of them hard to hold for this stock. SPiCT results provide wide confidence intervals although all the converged runs performed (~100) show similar results in terms of reference points (Prob ($B<B_{lim}$) < 5%; B/B_{MSY} > 0.5 and F/F_{MSY} <1), suggesting that results are robust to alternative data and setting. SPiCT is proposed as the model to estimate relative reference points each year.

WD 05. At-sea-sampling in Ireland for 2020

S.-J. Moore and H. Gerritesen

In 2020, normal at-sea sampling ceased after quarter 1 and the MI moved towards an at-sea-self-sampling scheme to collect catch data at-sea. This document is a guide to the sampling levels that occurred in 2020. Seven at-sea sampling trips were carried out in Quarter 1 and 35 at-sea self-sampling trips were carried out in Quarters 2-4. A total of 351 hauls were sampled and although sampling was reduced (780 hauls were sampled in 2019) coverage was similar to previous years. The biggest impact of reduced sampling is in 7a although sampling numbers have been reduced in this sampling frame in recent years and this reduction has negatively impacted the sampling levels and discard estimates for some stocks in divisions 7a, 6ab and 7bk.

WD 06. Inference of fish population structure and connectivity using a combination of individual markers and a modelling approach: application to the European sea bass

M. Woillez M., C. Dambrine, M. Huret, P.A., Gagnaire, F. Daverat, E. Le Luherne E., H. de Pontual

Understanding population structure and connectivity is critical for reliable fish stock assessment and management. Mismatches between biological populations and stock units largely increase the risk of decline of exploited populations. In the past decades, biological markers (genetic, biogeochemical) and artificial ones (electronic tags) have been developed and applied to investigate these questions However, integrated studies combining individual markers and a modelling approach still remain very scarce although they should provide high level information and lead to better validation and accuracy. Given the different nature of the information provided by each type of markers, appropriate models and inference methods also have to be considered. We aimed at applying such an integrated approach to the European sea bass in the Northeast Atlantic. This species of high ecological and economical interest recently showed strong signs of over exploitation, at least regionally, while its spatial structure remains poorly understood. Here we present the current state of an integrated approach investigating movements/migrations between essential habitats at different stages (egg and larvae, juveniles, adults). Individual markers consisted in 1) Data Storage Tag data (1466 fish tag and a recovery rate > 30%) which corroborated strong fidelity to summer feeding areas and to winter spawning areas for the migrant contingent, 2) otolith trace elements and oxygen isotope ratio ($\delta^{18}O$) analyses aiming at confirming such fidelity processes and exploring the homing hypothesis and 3) genetic markers (SNPs) to help determining the effect of fidelity to functional areas on the genetic structure of the population. Lastly, a coupled mechanistic bioenergetics (DEB based) IBM model and hydrodynamical model has been developed to quantify connectivity between spawning and nursery areas. It has been used to assess connectivity between spawning grounds and nurseries using realistic drifts of eggs and larvae from spawning areas characterized using geolocated fishery data (VMS). The studies showed convergent results supporting the hypothesis of a structure in the Atlantic sea bass population. The English Channel would home two demographically independent populations that separate at the Cotentin Peninsula. This new knowledge suggests the need of revisiting the delineation of sea bass stocks as currently considered by ICES, which may have significant consequences on its management.

WD 07. Discards of WGBIE species by the Portuguese bottom-otter trawl operating in ICES Division 27.9.a.

A.C. Fernandez

The information on discards produced by Portuguese vessels operating with bottom otter trawl fleet in Portuguese ICES Division 27.9.a is compiled. The sampling effort, species frequencies of occurrence and discard estimates are presented, for the period 2016-2019. The species included in the WGBIE are the European hake (*Merluccius merluccius*), Norway lobster (*Nephrops norvegicus*), megrim (*Lepidorhombus whiffiagonis*), four-spot megrim (*Lepidorhombus boscii*), common sole (*Solea solea*), plaice (*Pleuronectes platessa*), pollack (*Pollachius pollachius*), whiting (*Merlangius merlangus*) and European sea bass (*Dicentrarchus labrax*). The samples were collected by the Portuguese onboard sampling programme (PNAB/EU DCF). The low frequency of occurrence registered by most of these species in OTB fisheries for the whole sampling period 2004-2019 indicates that discards can be considered negligible for assessment purposes, with exception of the European hake that is frequently discarded by this fleet. In 2020, the Portuguese on-board sampling programme was compromised by the pandemic situation due to COVID-19 and the sampling only occurred in the first quarter of the year. For this reason, the sampling effort was not representative of the fishing effort of the bottom otter trawl fleet (OTB) and the algorithm usually used for discards estimation could not be applied. The less frequent species were then considered to have also null or negligible discards in 2020. In the case of European hake, discarded volumes by fleet were calculated from the 2017-2019 discard estimates.

WD 08. Data compilation and application of SPiCT model for the assessment of *Nephrops* in Functional Units 28-29

C. Silva and B. Pereira

This Working Document summarizes the information and data available from *Nephrops* stock in FU 28-29 to be used at the WKMSYSPiCT benchmark. A short description of the fishery is also provided. The standardization of the crustacean fleet cpue is described based on logbook data linked with VMS and depth information. The modelled standardized cpue, the corresponding fishing effort, a survey-based biomass index and the commercial catches are used as input series for Surplus Production in Continuous Time (SPiCT, Pedersen and Berg, 2017) exploratory runs.

Working document

ICES Working Group for the Celtic Seas Ecoregion
5–14 May 2021
By Correspondence

ICES Working Group for the Assessment of the Bay of Biscay and the Iberic waters Ecoregion
5–12 May 2021
By Correspondence

Maturity-at-age estimates for Irish Demersal Stocks in 6.a and 7.b-k between 2004-2020

Sara-Jane Moore and Hans Gerritsen
Marine Institute
Galway
Ireland

Introduction
This document provides maturity-at-age estimates for stocks assessed by the WGCSE and WGBIE. All data are obtained on surveys and commercial sampling carried out by the Marine Institute.

Methods
Data was used from the Marine Institute Q1 Biological sampling programme (2010-2020), At-Sea Observer programme (2010-2020), Irish Anglerfish and megrim survey (2016-2020), the Irish beam trawl Ecosystem survey (2016-2018) and the MI Biological sampling survey (2004-2009). Sampling levels were reduced in 2020 as a result of COVID 19 and diminished access to at-sea samples and also port samples. Proportions mature-at-age were estimated by constructing a matrix containing the sample numbers by age, sex and maturity state (mature/immature) at each length class. Unsexed individuals (usually small fish with undeveloped gonads) were assigned in equal numbers to both sexes. This Age-Sex-Maturity-Length Key (ASMLK) was applied to the length-frequency data to estimate the proportions mature-at-age for either sex and both sexes combined. Any gaps in the ASMLK were filled in using a multinomial model (Gerritsen et al., 2006). Estimates for 7a stocks are not included in this document as there was no sampling in 2020.

Results
Because overall there was no clear evidence of trends in maturity over time for any stock, data from all years (2004-2020) were combined. Overall, the perception of age at maturity has not changed from previous years working documents. Figure 1 shows that for most stocks there are no clear trends in the L_{50} over time. Estimates for cod in area 7e-k varied from around 40cm to 60cm, however the sample sizes for this stock were generally very low at the

start of the time-series; in recent years the estimates are quite variable (around 40cm) with a slight increase in 2019. Sole in area 7 also exhibited variable estimates in recent years. Plaice in area 7 shows two outlying estimates in 2013 and 2019 but these was estimated with low precision. Whiting in 7b-k shows a decline in L_{50} in 2019 but the data is based on low sample levels. In 2020, the L_{50} increased again.

Table 1(a) shows the estimated proportions mature-at-age. "All" sexes is a weighted maturity ogive and included unsexed individuals most likely to be immature. Following from the submission of an updated version of this document for WKCELTIC, 2020 changes to the maturity ogives were made to Cod 7e-k, Haddock 7b-k and Whiting 7e-k stocks.
For Megrim 7&8, maturity at age is slightly lower than that used by WGBIE. Estimated proportions mature for plaice and sole were also slightly lower than those used by the working group. Whiting and Haddock estimates for 6a are variable over time.

Discussion
Some (relatively minor) differences were found between the ogives used by the working groups and the current findings. Because Irish sampling generally does not cover the full extent of the stocks, it is difficult to determine whether the Irish estimates are unbiased. It is possible that the lack of full spatial coverage can explain some of the differences.

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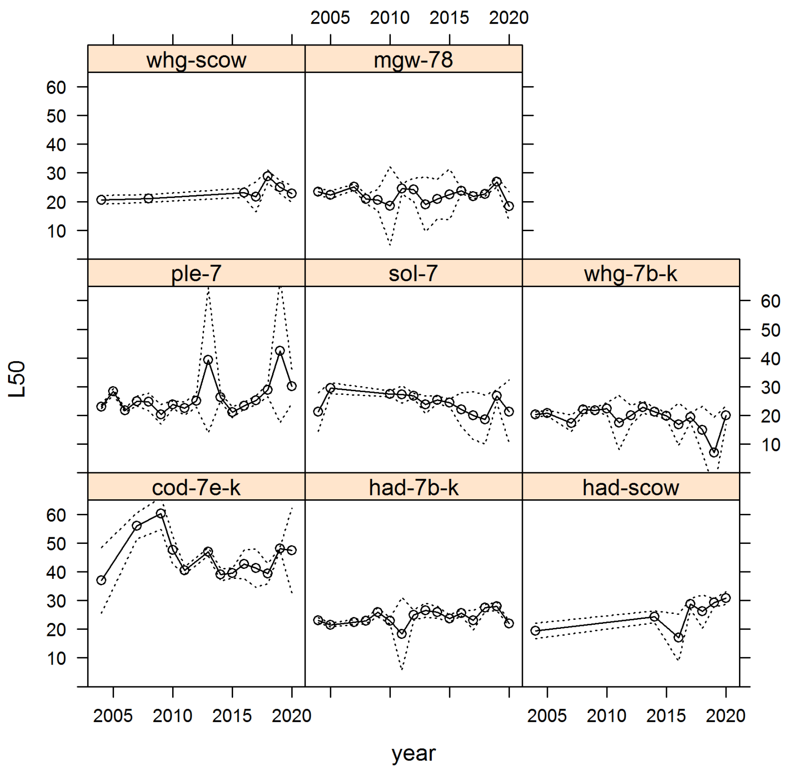

Figure 1. Length at 50% maturity (L50; cm) for females by stock and year.

Table 1 (a). Estimated proportions mature (sample numbers in table below) by stock, sex and age. Maturity ogives used by the WG are also given.

Stock	Sex/WG	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
cod-7e-k	All	0.01	0.39	0.69	1	1	1	1											
	F	0.02	0.49	0.90	1	1	1	1											
	M	0.01	0.56	0.96	1														
	WKCELTIC	0	0.54	0.93	1	1	1	1	1	1	1								
had-7b-k	All	0.21	0.85	0.94	0.94	0.96	0.98	1	1	1	1	0	0						
	F	0.01	0.90	0.98	0.98	0.97	0.99	1	1	1	1	1							
	M	0.28	0.80	0.89	0.90	1	0.95	0.95	1	1			1						
	WKCELTIC	0.04	0.91	0.97	0.98	1	1	1	1										
had 6.a	All	0.08	0.65	0.66	0.76	0.72	0.76	0.92	0.83	0.79	1.00								
	F	0.03	0.81	0.76	0.80	0.85	0.89	0.98	1	0.91	1								
	M	0.08	0.67	0.65	0.71	0.44	0.37	0.64	0.34	0.43									
	WGNSSK	0	0	1	1	1	1	1	1	1	1								
mgw-78	All	0.30	0.34	0.63	0.82	0.81	0.82	0.82	0.84	0.86	0.83	0.87	0.88	0.93	0.91	0.93	0.97	1.00	1
	F	0.11	0.29	0.68	0.86	0.86	0.86	0.82	0.81	0.87	0.86	0.88	0.87	0.91	0.89	0.93	0.96	1.00	1
	M	0.64	0.35	0.55	0.70	0.72	0.77	0.84	0.89	0.88	0.78	0.75	0.88	1.00			1		
	WGBIE	0.04	0.21	0.6	0.9	0.98	1	1	1	1	1								
ple-7	All	0	0.31	0.57	0.73	0.81	0.91	0.91	0.86	0.81	0.93	0.7159	0.7433						
	F	0	0.14	0.44	0.65	0.77	0.89	0.89	0.82	0.78	0.86	0.7621	0.8447						
	M	0	0.32	0.58	0.72	0.81	0.87	0.88	0.91	0.84	1	1	1						
ple 7.a	WGCSE	0	0.24	0.57	0.74	0.93	1.00	1.00	1.00	1.00	1								
ple 7.fg	WGCSE	0	0.26	0.52	0.86	1	1	1	1	1	1								
sol-7	All	0	0.15	0.41	0.59	0.83	0.84	0.86	0.86	0.87	0.89	0.9064	0.9079	0.9437	0.9172	0.8508	0.9765	0.9787	0.9558
	F	0	0.16	0.46	0.64	0.87	0.92	0.96	0.98	0.95	0.96	0.9484	0.9516	0.9384	1	0.899	1	1	1
	M		0.22	0.38	0.50	0.58	0.71	0.69	0.76	0.70	0.71	0.8504	0.7222	0.8375	0.7843	1	0.7796	0.8111	0.7027
sol 7.fg	WGCSE	0.00	0.14	0.45	0.88	0.98	1.00	1.00	1.00	1.00	1.00								
whg 7b-k	All	0.50	0.53	0.92	0.96	0.92	0.889	1	1	1									
	F	0.30	0.30	0.96	0.98	0.9864	1	1	1	1									
	M	0.49	0.50	0.83	0.94	0.85	0.801	1	1	1									
	WKCELTIC	0.61	0.94	0.97	0.97	1	1	1											
whg 6.a	All	0.43	0.73	0.70	0.81	0.88	0.82	0.90	1										
	F	0.44	0.89	0.93	0.91	0.96	1	1	1										
	M	0.48	0.59	0.47	0.62	0.65	0.46	0.73	1										
	WGCSE	0	1	1	1	1	1	1	1										

Table 1 (b). Sample numbers by stock, sex and age for associated maturity in Table 1(a) above.

Stock	Sex/WG	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
cod-7e-k	All	1642	1657	130	23	2	2	3											
	F	730	747	58	12	2	2	3											
	M	837	903	72	11														
had-7b-k	All	42	1170	2026	1323	508	256	142	89	36	17	4	1	1					
	F	20	462	1148	784	300	159	98	58	21	13	4	1						
	M	17	555	870	537	208	96	44	31	15	4			1					
had-scow	All	129	476	397	302	282	156	64	47	32	8								
	F	55	255	240	201	196	119	52	36	25	7								
	M	63	219	157	101	86	37	12	11	7									
mgw-78	All	54	1217	1960	1399	886	619	387	260	191	156	140	114	60	53	44	30	24	9
	F	32	593	1200	974	631	428	239	178	153	133	135	107	58	53	44	29	24	9
	M	21	618	748	424	255	191	148	82	38	23	5	7	2			1		
ple-7	All	28	511	1304	972	654	296	164	93	38	25	10	6						
	F	13	225	745	564	430	182	108	52	24	17	9	5						
	M	14	261	533	395	218	114	55	40	14	8	1	1						
sol-7	All	2	71	620	911	597	421	297	216	157	87	66	55	46	23	13	12	9	8
	F	2	43	511	767	494	284	176	102	83	41	22	26	24	10	8	8	4	5
	M		23	108	143	102	136	120	114	73	44	43	29	22	13	4	4	5	3
sol 7.fg																			
whg-7b-k	All	1257	1270	790	349	116	26	4	2										
	F	577	723	430	186	60	10	2	1										
	M	629	544	360	163	55	16	2	1										
whg-scow	All	198	385	384	252	132	43	11	3										
	F	94	208	224	163	97	26	5	2										
	M	103	177	160	89	35	17	6	1										

Working Document to ICES Working Group for the Assessment of the Bay of Biscay and the Iberian waters Ecoregi
on, 5-12 May 2021. By correspondence

Review of the population structure of hake, megrim, white and black anglerfish, and sardine in the Northeast Atlantic waters

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1 Introduction

Understanding the stock structure of a species is an essential requirement for stock assessment and to achieve an optimal management of the resource (Cadrin, 2020). Despite this requisite is widely acknowledged, inconsistencies between the stock structure of the biological populations and the units used for assessment and management are frequent (Kerr et al. 2017).

Most stock assessment models assume that the resource is a single population and inappropriate assumptions of the stock structure, assuming more or less conservative parameters, might lead the stock to be under- or over-fished. Punt et al. (2020) indicates that novel assessment models, in which space is explicitly represented in the population dynamics, present a better representation of the spatial structure for the stocks that do not fulfill the assumption of single stock. On the other hand, the definition of the fishery management units involves other considerations such as fishery exploitation patterns and administrative and jurisdictional interests. A general recommendation is that management units should ensure the matching of biologically relevant processes and management measures (Reiss et al. 2009). Accordingly, a good definition of the stocks being exploited, their spatial distribution and biological characteristics are required.

The current stock assessment of European hake, *Merluccius merluccius*, assumes the occurrence of two stocks, the northern and southern stock, with the boundary located at the Canyon of Cape Breton (Table 1). For white and black anglerfish, *Lophius piscatorius* and *L. budegassa*, three stocks are considered: the northern and southern stocks of the Southern Shelf, which are separated by the Canyon of Cape Breton, and a third stock for both species of anglerfish combined at the Northern Shelf. Six stocks of megrims (*Lepidorhombus spp*) are assessed by ICES: megrims in ICES divisions 4a and 6a, megrims in ICES division 6b; megrim (*L. whiffiagonis*) in division's 7b-k and 8abd and in divisions 8c and 9a; and four-spot megrim (*L. boscii*) in divisions 7b-k and 8abd and in divisions 8c and 9a. Since 2017, ICES assesses sardine, *Sardina pilchardus*, as three stocks: sardine in Subarea 7 and the two stocks separated by Cape Breton Canyon, sardine in divisions 8a,b and 8d and sardine in divisions 8c and 9a.

Defining the stock structure of a species subject to exploitation is a complex task that requires an interdisciplinary approach. Genetic and non-genetic evidence are required to define the stock structure of a species. The aim of this study is to update the current knowledge about the stock structure of hake, megrim, anglerfishes, and sardine in the North East Atlantic. The results of different genetic and non-genetic stock identification studies are jointly analysed providing a synthesis of the definition of the stock structure for each species. Likewise, the uncertainties and the needs of further studies for defining the stock structure for each species are identified.

2 Methods

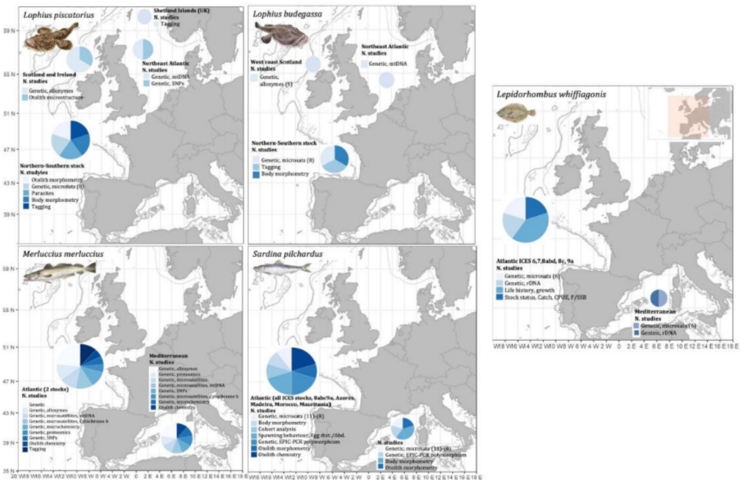
We reviewed the scientific articles and technical reports providing information about spatial structure and stock identification of the five species along the Northeast Atlantic (Figure 1).

Table 1. Stocks used for assessment and Management units for the species included in the study.

Species	ICES current stocks	ICES advice 2021 (t)	TAC - Management Units	TAC 2021 (t)
Lepidorhombus whiffiagonis	Lepidorhombus spp. 4a6a	7300	Lepidorhombus spp. - Subarea 4+Div 2a	731 *
Lepidorhombus boscii	Lepidorhombus spp. 6b	? 512	Lepidorhombus spp. - Subareas 6,12,14+Div 5b	1476 *
	L. whiffiagonis 7b-k8abd	19184	Lepidorhombus spp - Subarea 7	4683 *
	L. boscii 7b-k8abd	np	Lepidorhombus spp - Divisions 8abde	448 *
	L. whiffiagonis 8c9a	468	Lepidorhombus spp - 8c, 9 and 10; UW CECAF 34.1.1	
	L. boscii 8c9a	1690		
Lophius piscatorius	Lophius spp. 463a	17645	Lophiidae - Subarea 4+Div 2a	3522 *
Lophius budegassa			Lophiidae- Norwegian waters Subarea 4	425 *
			Lophiidae - Subareas 6,12,14+Div 5b	1993 *
	L. piscatorius 78abd	34579	Lophiidae - Subarea 7	15885 *
	L. budegassa 78abd	15551	Lophiidae - Divisions 8abde	2252 *
	L. piscatorius 8c9a	1872	Lophiidae - 8c, 9 and 10; UW CECAF 34.1.1	
	L. budegassa 8c9a	1800		
Merluccius merluccius	M. merluccius Sub 4,6,7 Div 3a, 8a-b, 8d	98657	M.merluccius - Subarea 4+Div 2a	3940 *
			M.merluccius- Div 3a	3403 *
			M.merluccius - Subareas 6,7,12,14+Div 5b	63325 *
			M.merluccius - Divisions 8abde	8206 *
	M. merluccius 8c9a	7825	M.merluccius - 8c, 9 and 10; UW CECAF 34.1.1	8517
Sardina pilchardus	S. pilchardus in Subarea 7 (southern Celtic Seas and the English Channel)	na	S. pilchardus in Subarea 7	No official TAC
	S. pilchardus in divisions 8.a–b and 8.d (Bay of Biscay)	27858	S. pilchardus in divisions 8.a–b and 8.d	No official TAC
	S. pilchardus in divisions 8.c and 9.a (Cantabrian Sea and Atlantic Iberian waters)	10871	S. pilchardus in divisions 8.c and 9.a	No official TAC

na: not available; np: not provided; * brexit pending

Figure 1. Map representing the location of stock identification studies available for hake, megrim, anglerfishes and sardine.



3 Results

3.1. *Lepidorhombus whiffiagonis*

The genus Lepidorhombus is represented in eastern Atlantic waters by two species, megrim (*L. whiffiagonis*) and four-spot megrim (*L. boscii*). Six stocks of megrims are assessed by ICES: megrim in ICES divisions 4a and 6a, megrim in ICES division 6b, megrim in divisions 7b-k and 8abd, four-spot megrim in divisions 7b-k and 8abd, megrim in divisions 8c and 9a and four-spot megrim in divisions 8c and 9a (Figures 2, 3).

The stocks of Lepidorhombus whiffiagonis in 7b-k and 8abd and in 8c9a are analytically assessed in the ICES working group for the Bay of Biscay and the Iberian Waters Ecoregion (WGBIE). The other assessed species of Genus Lepidorhombus in these areas is *L. boscii*. There is a common TAC for both species of megrim (*L. whiffiagonis* and *L. boscii*), so the joint status of the two species should be taken into consideration when formulating management advice.

During an ICES Benchmark for *L. whiffiagonis* in 2014 (ICES, 2014a), it was suggested that 8c9a stock could be just “the tail” of the much larger stock of megrim in ICES subarea 7 and divisions 8abd and proposed to reconsider the stock limits and the inclusion of this stock in the Northern megrim stock from ICES subarea 7 and divisions 8abd. This option was presented to the ICES Stock Identification Methods Working Group in 2015 (ICES, 2015a) and these were their findings: "SIMWG does not find biological support for combining the northern (ICES divisions VIIb-k and VIIIabd) and southern (ICES divisions VIIIc and IXa) stocks of megrim together and contends that the current stock separation stands. A key paper on population structure of megrim showed a peculiar degree and pattern of genetic separation which merits further review."

Figure 2. Current stocks of *Lepidorhombus* spp. Southern stocks-Div 8c.9a (dark green); Northern stocks – Div 7b-k.8abd (lime) and Northern shelf stock Div 6a.4a (brown).

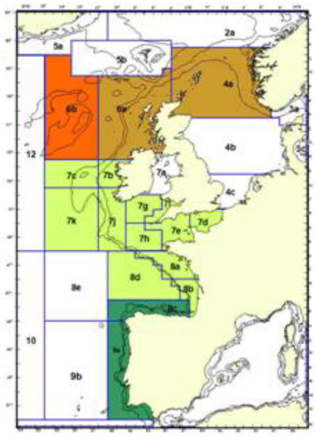
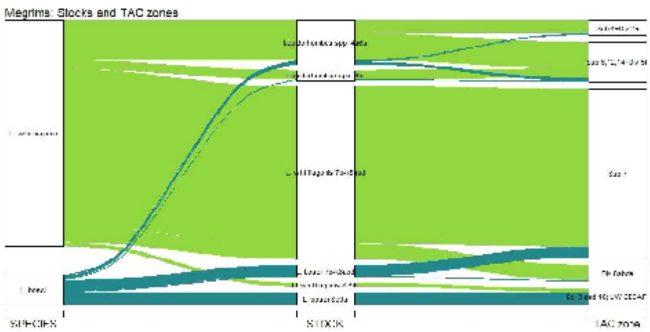


Figure 3. *L. whiffiagonis* and *L. boscii* in NE Atlantic. Stocks presently defined for assessment purposes and TAC zones. The dimension of rectangles and flow lines is proportional to catches.

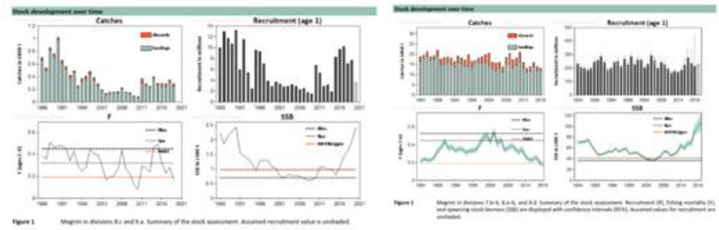


Stock identification studies

Stock status

ICES advice for both stocks in June 2020, shows the stocks development over time. For both stocks, fishing mortality shows a decreasing trend and spawning stock biomass shows an increasing trend (Figure 4).

Figure 4. *Lepidorhombus whiffiagonis*. Stock status of meg8c9a (left) and meg78abd (right).



Catch data

In Table 2, time series of landings and discards are shown for both stocks. Catches in megrim stock 78abd are much higher than in megrim stock 8c9a, and this is one of the reasons why it was thought that the southern stock could be part of the northern one.

In Figure 5 the time series of catches and landings of both megrims are shown in different axes and scales. Catches and landings trends in both stocks show similar patterns. Coincident rises and falls are observed but a slight time lag is observed in those trends.

CPUEs trend

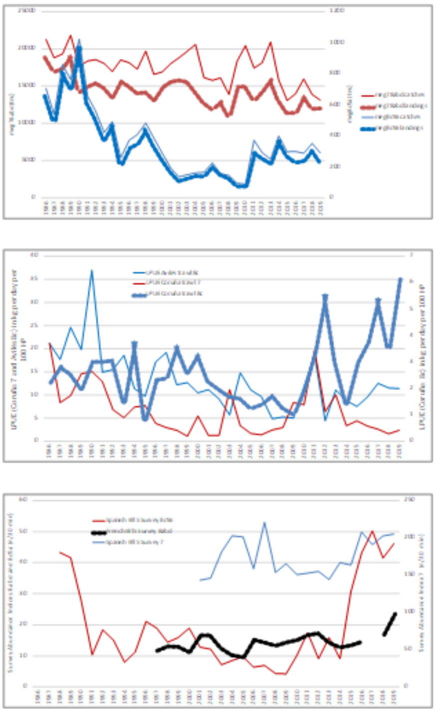
Regarding LPUEs from commercial fleets, there are differences in trends between ports in the same area and in the same port in different areas (Figure 5). However, it must be said that they are different fleets and establishing a direct comparison may not be appropriate for this kind of study.

Three megrim abundance indices from research surveys are compared, one in subarea 7, the other in divisions 8abd and the third one in division 8c9a. Research surveys of the species show similar trends in the central and southern zones. However, to match the trend of the northern area (subarea 7) with the other two, an increasing trend is observed in recent years for the 3 abundance indices.

Table 2. *Lepidorhombus whiffiagonis*. Times series of landings and discards for both stocks.

	meg8c9a				meg78abd			
Year	Landings	Discards	Captura	TAC	Landings	Discards	Captura	TAC
1986	659	46	705		18927	2321	21248	
1987	497	40	537	13000	17114	1705	18819	16460
1988	817	42	859	13000	17577	1725	19302	18100
1989	714	47	761	13000	19233	2582	21815	18100
1990	977	45	1022	13000	14370	3284	17654	18100
1991	614	41	655	14300	15094	3282	18376	18100
1992	516	42	558	14300	15600	2988	18588	18100
1993	383	38	421	8000	14929	3108	18037	21460
1994	479	13	492	6000	13684	3284	16968	20330
1995	218	40	258	6000	15862	2652	18514	22590
1996	329	44	373	6000	15109	3026	18135	21200
1997	356	52	408	6000	14230	3066	17296	25000
1998	446	36	482	6000	14345	5371	19716	25000
1999	343	43	386	6000	13305	3297	16601	20000
2000	253	35	288	5000	15031	1870	16901	20000
2001	175	19	193	5000	15778	2262	18040	16800
2002	117	19	137	4000	15987	2813	18800	14900
2003	134	15	148	2400	15711	4008	19719	16000
2004	149	11	160	1336	14358	6243	20602	20200
2005	147	19	166	1336	12888	3275	16163	21500
2006	210	16	226	1269	12037	3751	15788	20400
2007	155	0	155	1440	13060	3033	16092	20400
2008	133	11	144	1430	11048	2860	13908	20400
2009	84	11	94	1430	15064	3278	18342	20400
2010	83	5	88	1287	15101	5343	20444	20106
2011	302	69	371	1094	13226	4187	17413	20106
2012	262	31	293	1214	14433	3704	18137	19101
2013	231	18	250	1214	16025	4885	20910	19101
2014	377	23	399	2257	13277	2569	15846	19101
2015	276	21	297	1377	11569	1507	13076	19101
2016	235	63	298	1363	11548	2445	13992	20056
2017	247	41	288	1159	13784	2173	15957	15043
2018	315	37	352	1387	12147	1738	13885	13528
2019	239	51	289	1872	12164	989	13153	19836

Figure 5. *Lepidorhombus whiffiagonis.* Comparison of catches (top), LPUEs (medium) and survey indices (bottom) of southern and northern stocks.



Life history parameters

The growth rate also varies in both stocks (Landa et al. 1996). Growth is quicker in the southern area but the maximum length attained is smaller than in the northern area. The maximum age for megrim also varies with latitude. In subarea 7 the maximum age of megrim is 14 years, this decreases to 12 years in divisions 8c9a (BIOSDEF, 1998; Landa and Piñeiro, 2000). This latitudinal variation in growth, with a greater age range and maximum lengths in the north (division 7chjk), intermediate in the Bay of Biscay (division 8a,b,c2), less in the north of the Galician continental shelf (division 8c1) and least in the south of the Galician continental shelf (division 9a2), where the species is very scarce (Landa and Piñeiro, 2000), can sustain the existence of several populations but does not justify the division in stocks.

Genetic studies

The results of the genetic studies in the area are not very clarifying. Danancher and García-Vázquez (2009) concluded that there are two populations of *L. whiffiagonis* in the Atlantic, fishes from division 6 corresponded to one stock and those from divisions 8c and 9 to a second one. However, the boundaries of these two stocks are not clear, 8abd was clustering with up North sample (6), whereas samples from area 7 clustered with South ones. As no further results have been found, it is difficult to determine if finally the southern stock is more like 8abd division, 7 division or both. Detailed investigations in order to describe megrim population structure and to explain the strange divergences observed in the results are needed.

Conclusion

Although it has been suggested that the southern stock may be the tail of the northern stock, there are issues that still cannot fully support this idea. Figures clearly indicate that LPUEs of megrim are different in ports and areas, suggesting that the productivity and abundance of megrim varies across subareas. It could be that the combination in a single stock will lead to the overexploitation of the less productive populations of megrim.

Furthermore, the differences in growth rates between the areas of the two stocks suggest that there is the probability of different responses to exploitation and environmental changes.

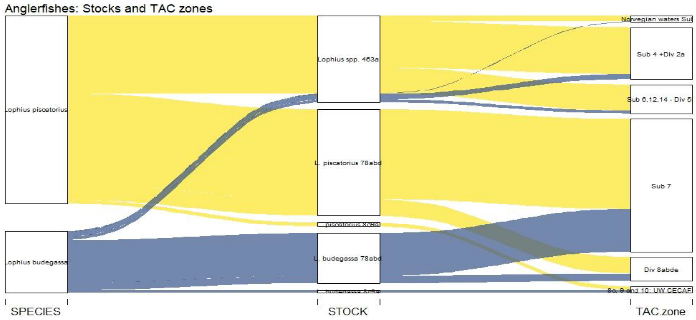
With the current information it is not possible to argue that the two stocks should be joined. In any case, it is necessary to carry out in-depth genetic studies to resolve all existing doubts on this issue in this species, as has already been done for other species that are exploited by the same fleets. The restructuring of the limits of the stocks must be done globally since the management is common to several species.

3.2. ***Lophius piscatorius* and *L. budegassa***

Two species of anglerfish (the white *Lophius piscatorius* and the black *L. budegassa*) are found in the Northeast Atlantic; however *L. budegassa* has a more southerly distribution than *L. piscatorius*. Both species can be distinguished primarily by the colour of the peritoneum (white or black, from here on the common names, white anglerfish, *L. piscatorius*, and black anglerfish, *L. budegassa* will be used) (Caruso 1986). However, genetic studies show that this method can lead to misidentification of the species due to the lack of colour in the peritoneum in the *L. budegassa* (Aguirre-Sarabia et al. 2021). So, alternative characteristics for species identification such us dorsal and anal fin ray counts or length of the cephalic dorsal fin spines could be also important to consider distinguishing both species (Caruso, 1986). In addition, genetic studies also showed that some hybrids of both species can be found in the Northeast Atlantic (Aguirre-Sarabia et al. 2021).

Both species are managed by a common TAC and quota system as it is not possible to distinguish species in landings (Table 1; Figure 6).The combined landings are split into species at national level, based on the species composition in the sampling data. Some countries use annual proportions of the two species, others estimate proportions by fleet, port and/or quarter.

Figure 6. *Lophius piscatorius* and *L. budegassa* in NE Atlantic. Stocks presently defined for assessments purposes and TAC zones. The dimension of rectangles and flow lines is proportional to catches.



Lophius piscatorius

In the Atlantic northeast, ICES delimits three areas for assessment of white anglerfish: Northern Shelf stock, as combined stock together with black anglerfish (ICES subareas 4 and 6 and division 3a), northern stock (of Southern Shelf) (ICES subarea 7 and divisions 8abd), and southern stock (of Southern Shelf) (ICES divisions 8c and 9a) (Figure 6) (ICES, 2020, 2021). These stocks are considered to be distinct to facilitate the management of the fishery of the species.

In the past two decades, the stock structure of white anglerfish has been studied following different genetic and non genetic approaches (Figure 1). Since 1995, various programs of mark-recapture were carried to characterize the movements and spatial structure of northern and southern white anglerfish stocks (Fariña et al. 2002; Landa et al. 2008; Pereda and Landa, 1997). The displacements observed point to some degree of migratory behaviour of this species and movements of juveniles and adults between the northern and southern stocks. These findings put into question that Canyon of Cape Breton is a geographical barrier for these two stocks. The large-scale movements of adults recorded between Shetland Islands and Faroe and Iceland raised the idea of stock mix (Laurenson et al. 2005).

The morphological study of the otoliths revealed that they were not sufficient evidence to sustain the separation between northern and southern stocks (Cañás et al. 2012). However, this study showed indications of the existence of subpopulations in this area, so a totally panmictic population is not expected. In addition, the meta-analysis of the abundance and prevalence of parasites populations, pointed that there was certain variability between the northern and southern stocks but differences were not enough to discriminate between two stocks (Cañás, 2012). Although morphometric analysis provided reasonable discrimination among populations from western and southern European waters (Duarte et al. 2004), the number samples analysed was considered low to produce robust conclusions. The study of the microstructure of the otoliths suggested that for early life stages the exchange between areas is very limited (Swan, 2004).

The molecular approaches for studying the stock structure of white anglerfish made use of various marker types. Using allozymes, low genetic variation has been detected off the west coast of Scotland (Crozier, 1988) and between populations from the Irish Sea and the west of Scotland (Crozier, 1987). The mitochondrial DNA study of Charrier et al. (2006) revealed a limited genetic structure and lack of isolation by distance. A genetic analysis using polymorphic microsatellite markers (Blanco et al. 2008) strongly concluded that the boundary between northern and southern stocks was not genetically supported. The proportion of total genetic variation between stocks was relatively small (0.35%) and more than 98% of the total genetic variation was attributed to differences within populations, which suggest high gene flow among populations (Blanco et al. 2008). O'Sullivan et al. (2006) means screening adults for nine DNA microsatellites, revealed that there was no evidence of spatial or temporal differences in ICES divisions 4a, 6ab and 7b, deriving from a single panmictic population. Finally, the most recent genetic analysis following a genome-wide approach to identify Single Nucleotide Polymorphisms markers, also pointed at white anglerfish is composed by a single panmictic population throughout the Northeast Atlantic (Aguirre-Sarabia et al. 2021).

Conclusion

Based on the results of genetic and non-genetic studies, it can be concluded that there is no biological evidence, neither genetic nor phenotypic, that supports the separation between stocks presently established. However, phenotypic studies as otolith morphometry and parasites composition, point that the Atlantic population of *Lophius piscatorius* is probably made up of subpopulations.

The spawning mode of white anglerfish, where eggs are enclosed in a gelatinous ribbon that drifts passively on the sea surface, could have a strong effect on dispersal distance and population connectivity (Fariña et al. 2008). Also, the long pelagic larval phase, which is extended during four months, is considered as indicative of the high dispersal potential of the species (Hislop et al. 2001). The eggs and larvae dispersal capacities and the displacements of adults and juveniles support the conclusion of the existence of a panmictic population, and also confirm that Cape Breton Canyon is not a geographical barrier between northern and southern stocks.

The mismatch between the population structure, the stock structure defined for the assessment and the management units defined for white anglerfish must be led to question the appropriateness of these assessment/management units. One of the main assumptions to establish the northern and southern stocks was that the Canyon of Cape Breton constituted a geographical barrier for population interchanges. The results of the main stock identification studies refute this hypothesis, holding up the presence of a unique panmictic population in the Atlantic Ocean. The management units are usually defined by managers as a group of fish exploited in a specific area or by a specific method, and also taking in consideration administrative and political reasons. As for many other species, the management units of white anglerfish do not reflect the real spatial structure of the species. The impact of this divergence in an efficient management of the resource should be explored and, also, it should be tried to find a balanced definition of stock that includes biological, environmental, and political factors.

Lophius budegassa

ICES delimits three areas for assessment of black anglerfish, the same areas defined previously for white anglerfish (ICES, 2020, 2021) (Table 1).

The studies on the population structure of black anglerfish in the NE Atlantic included genetic studies using allozymes, mitochondrial DNA and microsatellites as markers, tagging experiences and morphometric analysis (Figure 1). Tagging studies detected movements of the black anglerfish between northern and southern populations (Landa et al. 2008). Charrier et al. (2006) found that black anglerfish in the NE Atlantic presented a limited genetic structure and lack of significant relationship between genetic distance and geographic distance (lack of isolation by distance), that are suggesting a high larval dispersal capacity. A low genetic variation of black anglerfish off the west coast of Scotland was also confirmed (Crozier, 1988). Besides, the microsatellite study suggested the existence of differences between populations of different areas, even though the genetic variability is very low (0.21%) and does not support the current separation between northern and southern stock (Blanco et al. 2008). In contrast with previous results, the morphometric analysis showed a high segregation of the Portuguese coast (division 9a) and a north-south gradient, pointing to a more complex population structure than the current one.

Conclusion

Except for morphometric analysis, the stock identification studies support that there is no biological reason for the separation between northern and southern stocks of black anglerfish. However, more studies with samples from the Northern shelf stock are needed to confirm that black anglerfish in NE

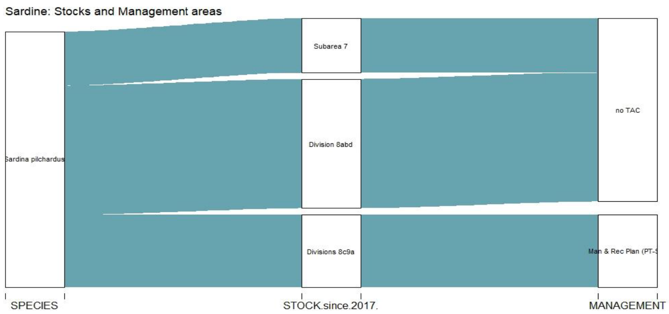
Atlantic is a panmictic population. As it happens for white anglerfish, the high dispersal capacity of the larval pelagic phase, that are passively transported by the currents (Hislop et al. 2001; Leslie and Grant, 1990), would support the presence of a panmictic population in the NE Atlantic.

The impact of the current mismatch between the northern and southern stocks established for assessment, management purposes, and the population structure supported by the stock identification studies should be analysed.

3.3. *Sardina pilchardus*

Three stocks of sardine (*Sardina pilchardus*) are assessed by ICES: Sardine in Subarea 7 (southern Celtic Seas and the English Channel), Sardine in divisions 8.a–b and 8.d (Bay of Biscay) and Sardine in divisions 8.c and 9.a (Cantabrian Sea and Atlantic Iberian waters) (Table 1; Figure 7).

Figure 7. *Sardina pilchardus* in NE Atlantic. Stocks presently defined for assessments purposes. The dimension of rectangles and flow lines is proportional to catches.



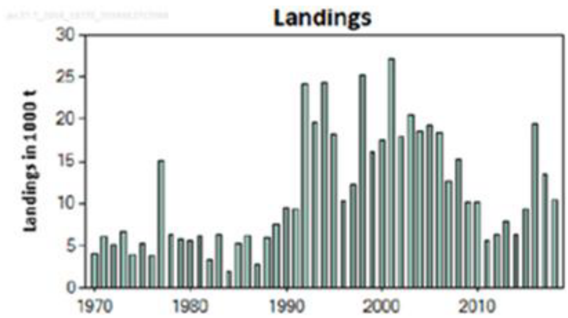
The stock of the Iberian Peninsula (8c, 9a) has always been evaluated separately, but in the case of the northern stocks, they were evaluated jointly until 2017, when the last benchmark takes place. This workshop concluded (Duhamel et al. 2017) that in the absence of evidence of connectivity between the Bay of Biscay and Subarea 7 sardine populations, and taking into account the indications of shelf sustained populations in each area it would be preferable to deal with the Bay of Biscay and Subarea 7 separately.

Stock identification studies

Stock status

In the case of sardine in the southern Celtic Seas and the English Channel (Figure 8), the lack of reliable data makes it impossible to provide advice on fishing opportunities for 2020 and 2021 for this stock. For the other two stocks, ICES advice published in 2020 shows the stocks development over time.

Figure 8. Official landings (1000 t) of sardine in subarea 7 from 1970 to 2018 (ICES, 2019).



The population of Iberian sardine (sardine in 8c and 9a subdivisions), after a period of crisis, shows signs of recovery. The biomass of age 1 and older fish (biomass 1+ or B1+) is above MSY Btrigger for the first time since 2009. Recruitment in 2019 is the highest since 2004 and above the long-term geometric mean. Fishing mortality has been declining since 2012 and is the lowest in the time-series, but still above F_{MSY} (Figure 9).

The spawning–stock biomass (SSB) of sardine in the Bay of Biscay (Sardine in divisions 8.a–b and 8.d) is above MSY Btrigger. SSB has decreased from 2010 to 2012 to the lower value of the series and has been since then stable. Fishing mortality is now estimated to be below FMSY and recruitment in 2019 is around the time-series average (Figure 10).

Figure 9. Summary of the stock assessment for sardine in divisions 8c and 9a. Assumed recruitment is unshaded. Recruitment, fishing mortality and biomass are indicated with 95% confidence intervals (ICES, 2020a).

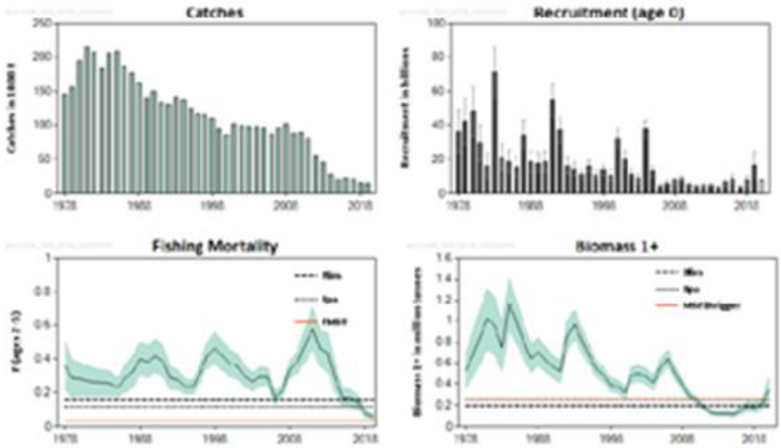


Figure 10. Summary of the stock assessment for sardine in divisions 8a-b and 8d. Recruitment and SSB are estimated at the beginning of the year. The lighter blue 2020 bar in the recruitment graph represents the geometric mean 2000-2019 (ICES, 2020b).

Figure 1 Sardine in divisions 8.a–b and 8.d. Summary of the stock assessment. Recruitment and SSB are estimated at the beginning of the year. The lighter blue 2020 bar in the recruitment graph represents the geometric mean (2000–2019).

Catch data

Catches in the Iberian sardine stock have experienced a drastic reduction from the beginning of the historical series to the present, as a consequence of the significant reduction in biomass and the management measures applied in recent years. In the case of Bay of Biscay stock, catches have been stable since 2000, with a slight rebound since 2012. By contrast, landings in the Celtic Sea have experienced significant fluctuations since 1970, with the highest values recorded in the years 90-2000.

Spawning behaviour and egg and larval dispersion

Several studies on ichthyoplankton phases and sardine reproduction (Bernal et al. 2007; Stratoudakis et al. 2007) have demonstrated overlap in spawning period and continuous egg distribution of sardine along the Atlantic Iberian and French coast with only a persistent gap at the north-western corner of the Iberian Peninsula.

Simulation of egg and larval dispersion (Santos et al. 2018) have shown a high level of larval retention of individuals on local spawning areas, with low transportation between neighbour regions, but with some level of connectivity, especially between western Iberian area and Cantabrian Sea. This study also showed that the existing connectivity between Iberian stock and Mediterranean and Morocco areas was low.

Morphometry

Morphometric studies (Silva 2003; Silva et al. 2008) support the eastern limit of the Atlanto-Iberian stock in the Strait of Gibraltar. For conclusive results, especially in the limits of the stocks (Celtic Channel and Cadiz), more samples are needed.

Otolith shape and microchemistry

Otolith shape differences, due to changes in environmental conditions affecting growth, failed to detect significant structuring between Atlantic and Mediterranean sardine samples (Jemaa et al. 2015). This study found three different groups among the analysed samples: Mediterranean and Gulf of Gabes (Tunisia), Northern Atlantic Morocco to South Alboran, and European Atlantic Coast.

Data on otolith microchemistry (Castro 2007; Correia et al. 2014) support the hypothesis of a metapopulation around the Iberian Peninsula, where sardine stray from western Iberian to North Galicia and the Cantabrian Sea during their first 2–3 years of life.

Cohort track analysis

The analysis of survey data by sub-area inside Iberian area shows recruitment is localized in a few areas and generally asynchronous among areas, although some recruitment peaks are noticeable across wide regions (Silva et al. 2009). A recent modelling study, using number-at-age data of acoustic surveys between 2000 and 2016 from Bay of Biscay to Cadiz, shows that movement was relatively low between three recruitment areas (Bay of Biscay, northern Spain and Portuguese waters). This connectivity pattern does not invalidate the limit between Bay of Biscay and Iberian stock but suggest that the Gulf of Cadiz population should be treated as a separate stock (Silva et al. 2019).

Other studies have demonstrated that migration directions may change over time. These movements seem however to be rather limited and do not indicate any large-scale migration but rather a connectivity between sub-populations (Carrera and Porteiro, 2003; Silva et al. 2009).

Genetic studies

This species has been the subject of numerous genetic studies, using different molecular markers, both in the Iberian stock and in adjacent areas to the North, in Morocco or in the Mediterranean (Atarhouch et al. 2007; Gonzalez & Zardoya 2007; Kasapidis et al. 2012). In general, results question the northern (Cantabrian Sea-southern France) and southern stock limits (Gulf of Cadiz-northern Morocco) because they do not appreciate evident genetic structure (see Kasapidis, 2014 for a review).

Conclusion

Most of the studies have focused on the limits of the Atlantoiberian area. With the multidisciplinary results obtained so far, there is no sufficient evidence to modify the current boundaries of the stock, although there are signs of regional structuring, especially in the area of Gulf of Cadiz, despite no genetic differences have been found.

Dynamics of the Southern stock is not significantly affected by the dynamics of the Northern stock.

3.4. *Merluccius merluccius*

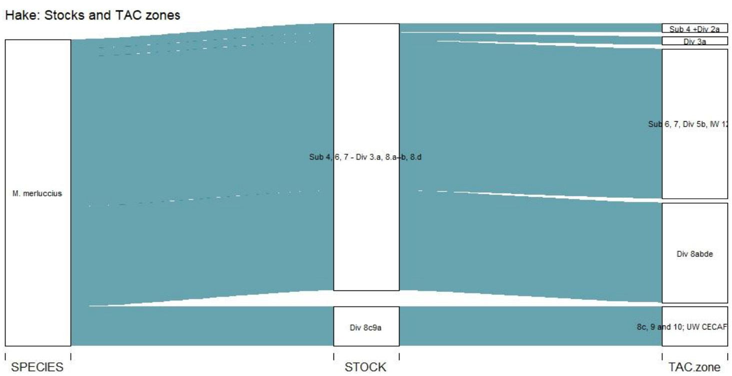
European hake, *Merluccius merluccius,* is widely distributed along the North East Atlantic, from Mauritanian in the North to Norway in the North, and the Mediterranean. ICES identifies two stocks of *M. merluccius* in the Atlantic area: the northern stock distributed in ICES subareas 4, 6, and 7, and in divisions 3.a, 8.a–b, and 8.d, and the Southern stock in ICES Divisions 8c and 9a. The definition of the two Atlantic stocks (Northern and Southern) separated by the 8c-8abd boundary, was decided in 1979 (ICES, 1979). Previously their population was split in 3 parts, in 1979 the ICES working group that assessed the stocks had a ToR asking if the two stocks in the Bay of Biscay in the French and Spanish coast were a common stock. However, it was decided to join the two areas in the North corresponding to the fish caught in Community waters and leaving as a separate stock the Southern stock, those caught outside community waters (at that time) in the coast of Spain and Portugal. The reason was based on:

1. Lack of biological basis for existence of sub-stocks
2. Imprecise allocation of catches in ICES sub-areas and divisions
3. No evidence of juveniles in 4a and 6a, assuming that catches there were derived from nursery grounds further south.
4. Evidences from Spain and Portugal of recruitment failure, not apparent in the Northern stock

There are some contradictory reasons here since the imprecise allocation of catches mainly referred to Spain whose statistics were based on the port were the catches were landed instead of origin of catches. Then, catches in Sub area 8 were reported jointly without considering the division they belonged to, and catches in 9a included catch from the North of Africa, a quite important hake fishery at that time. However, the conclusion on the recruitment failure in the Southern stock was based on this imprecise catches and their length structure that included catches in all the Bay of Biscay and also in the North of Africa.

The next ICES WG on Hake (ICES, 1980) supported the new stock distribution with the following arguments: "This arrangement has been based primarily on the distribution of nursery grounds and apparent differences in recruitment trends between the two areas. In addition, the narrow continental shelf along the northern coast of Spain and the Cap Breton depression also serve as a geographical barrier. ... noting that different arrangements may be more appropriate when additional data become available".

Figure 11. *Merluccius merluccius* in NE Atlantic. Stocks presently defined for assessments purposes and TAC zones. The dimension of rectangles and flow lines is proportional to catches.



Stock identification studies

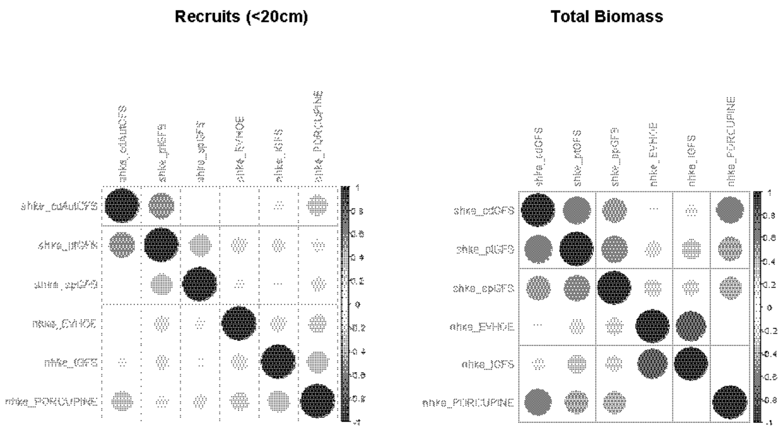
Stock status

In the last part of the 20th century and the beginning of the current one, the biomass level of both stocks followed similar trends. At the beginning of 2000s' the depletion of both stocks was high which led to the implementation of two of the first recovery plans in the CFP (COM 2003, 2004). Both stocks showed signals of good recruitments around 2005-10 and eventually increased the SSB. However, the fishing mortality in the Northern stock decreased meanwhile that in the Southern stock remained high which led to a different stock status. Around 2010 both stocks were considered to be recovered, although the increase in the biomass in the northern stocks was considerably higher which led the stock to a better state. The high increase in the biomass of Northern stock produced a north east expansion of the stock (ICES, 2017). The expansion has been a matter of concern for the fishing fleets in the North Sea because the high abundance together with the landing obligation and the low catch quotas produced a choke effect for the mixed fisheries (Baudron and Fernandes, 2015). The big retrospective pattern in the assessment of the Southern stock of hake motivated the rejection of the assessment ICES (2020). Thus, the current biological state in relation to reference points is unknown.

Surveys trend

The correlation between survey estimates of recruitment and total biomass in the Bay of Biscay and Iberian peninsula was analysed using the time series available to the group and considering as recruits individuals below 20 cm. The obtained correlations are shown in Figure 12, the order of the surveys in the figure follows their spatial distribution from north to south. The correlations were stronger at biomass level probably motivated by the differences in length frequency distributions at spatio-temporal level. For instance, there is an strong positive correlation between nhke_EVHOE and nhke_GFS surveys at biomass level but for recruitment the correlation is negative. In the recruitment surveys in the south, there was a correlation between adjacent surveys. Surprisingly, there was a positive correlation between the survey further south (shke_cdAutGFS) and that further north (nhke_PORCUPINE). The nhke_PORCUPINE surveys also had a positive correlation between the Irish survey (nhke_IGFS). At biomass level, nhke_PORCUPINE index did not have any correlation with the other two surveys that correspond with the northern stock. However, there was a strong correlation with those in the South. The population segment sampled by nhke_PORCUPINE and the other two northern hake surveys are very different, with the nhke_IGFS and nhke_EVHOE more focused in younger individuals.

Figure 12. *Merluccius merluccius* in NE Atlantic. Correlation between abundance estimated from scientific surveys in Bay of Biscay. The left hand plot corresponds with the correlation of number of individuals smaller than 20 cm over time and the right hand side with total biomass.



Life history parameters

There are many life history studies published on growth, reproduction or natural mortality for European hake in Atlantic water. A good summary can be found in Korta et al. (2015). Growth studies are not conclusive regarding stock structure because problems identifying otolith rings and lack of other kind of data. Extensive tagging experiences were only developed in French Brittany waters. Natural mortality studies are not conclusive for similar reasons. Reproductive studies show that length at maturity increases with latitude and also that the reproductive season is more extended in the South than in the North (Korta et al. 2015). Significance differences between Galician coast and French coast reproductive parameters were found by Korta et al. (2010) although the authors explain that these can be caused by phenotypic plasticity driven by environmental or fishing differences. Domínguez et al. (2008) also found reproductive differences between areas (Galician and French desks) getting similar conclusions and suggesting that there is no reason to split both stocks although some kind of substock structure may be in play.

Tagging experiences

Two tagging experiences were performed in Northern stock (de Puntual et al. 2003 and 2013) and the Southern stock (Piñeiro et al. 2007). 27 690 were tagged in French Brittany waters between 2002 and 2007 and 1199 (4.3%) have been recovered (de Puntual et al. 2013) with a maximum time before recovery of 1555 days. Data did not reveal seasonal movements of hake and none of these tagged hake in Northern stock area was recovered in the Southern stock one. Most fish were recovered near their release locations although a few of them travelled long distances (around 150 miles), suggesting that some exchange at a population level would be possible. However none was recovered outside their original stock area.

A similar tagging experience was developed in the Northwest of Spain following the procedure designed by de Puntual et al. (2003) although the amount of tagged and recovered fish was lower. 527 live tagged individuals were release and fifteen months after tagging, seven individuals (1.3%) had been recaptured with times at liberty ranging from 29 to 466 days. None of them was recovered far away from the release area. The maximum distance recorded was around 15 miles from release location after 347 days.

Results from both analyses revealed homing behaviour and/or inshore residency. None of the hake tagged in Northern or Southern waters was recaptured out of their original stock area.

Genetic studies

We have made an extensive analysis of all genetic data of European hake published up to date. The approach of the genetic studies has been different regarding the genetic markers, spatial coverage, time series, sampling procedure or statistical tests used. In general, all the genetic information shows a pattern of connectivity among Atlantic populations of hake regardless of the subdivision in stocks by the ICES, although the level of connectivity is different depending on the type of data.

The genetic structure of the Atlantic population has been addressed in the last decades using different genetic markers such as allozymes (Roldán et al 1998; Cimmaruta et al. 2005), mtDNA (Lundy et al. 1999; Pita et al. 2010, 2017) or microsatellites (Lundy et al. 1999; Castillo et al. 2004; Pita et al. 2014; 2016; 2017). In all cases, the results suggested that this two stocks model does not reflect the actual population dynamic between these areas, which seems to be more complex than that established by ICES.

The data obtained from North and South stocks shows higher genetic homogeneity than those expected for two independent populations. A heterozygote deficit was observed for genetic markers in most areas (Lundy et al. 1999; Castillo et al. 2004) and recent spatiotemporal studies suggest the wide genetic connectivity within the North-eastern Atlantic metapopulation (Pita et al. 2011, 2014, 2016). The migration hypothesis proposed by Pita et al. 2011 suggests that no barriers to migration seem to exist between the main Atlantic hake stocks, and there is a migrant flow of adult hakes from Porcupine Bank and Great Sole to the Bay of Biscay, the Cantabrian Sea and the Iberian Atlantic waters. These results are congruent with the observations on the dynamics of egg and larvae in the Bay of Biscay (Álvarez et al. 2004) as well as with a migration between “stocks" mediated by the passive drift of larvae and pre-recruits (Bartsch et al. 1996). However, other studies suggested the existence of a more complex population structure within each ICES stock in the North-eastern Atlantic than just a single panmictic population. For instance, significant genetic differences were reported in the Northern stock between Norwegian and Celtic samples using six microsatellites (Lundy et al. 1999; Castillo et al. 2004), or between Irish and French samples using 21 allozymes (Roldán et al. 1998). Recent analyses of SNP Outlier loci showed differentiation between the Bay of Biscay and the North Sea and the Norwegian Sea samples (Milano et al. 2014; Westgaard et al. 2017). According to Leone et al. (2019) additional analyses are needed to consider the Norwegian Sea and possibly the North Sea as a separate stock. In addition, proteomics surveys showed two different cluster when samples from the Bay of Biscay and the Cies Island were compared (González et al. 2010), and the genetic differentiation increases progressively as the samples are taken from southern waters off the Portugal coast (Lundy et al. 1999). In the Gulf of Cádiz (SW of Iberian Peninsula), the genetic structure seems to be more related with the Mediterranean population rather than the North-East Atlantic stocks (Tanner et al. 2014). Pita et al. (2017) using microsatellites conclude that the Southern Stock is formed by a single gene pool provided its wide Atlantic connectivity.

Combination of markers and methods

The combination of genetic markers and other methodological approaches, such otolith chemistry, improves the overall accuracy in the determination of the fishery units (Tanner et al. 2014), and represents a useful tool to establish the exploitation and biological status of the stock. However, the choice of one genetic parameter to integrate this information is not a simple question, due to the high variability in time and space scales among the sampling procedures.

In general, all genetic data show a pattern of connectivity among Atlantic populations of hake regardless of the subdivision in stocks by the ICES. The Bayesian inference made on multilocus genotypic data (microsatellites) of *Merluccius merluccius* populations provides evidence that a large genetic connectivity exists among Atlantic grounds and is mediated by significant migration rates stepping up from the Celtic Sea towards its adjacent Atlantic grounds. SNPs analysis shows similar results.

Conclusion

The original ICES scientific support for splitting both stocks in 1977 were not consistent. Imprecise catch data and flaw scientific evidence were the basis to take this decision that remains since then.

Genetic studies show a pattern of connectivity among Atlantic populations of hake regardless of the division of the population in two stocks by the ICES. Genetic differences between 8c (Southern stock) and 8abd (Northern stock) are lower than those between 8c and 9a (both in the Southern stock).

Tagging studies show that hake migrations are not large. However there is a continuity in the hake distribution along the coast of both stocks without any clear barrier impeding movements along.

Life history studies show differences between reproductive traits in both stocks. However there are environmental and fishing pressure differences that can explain these phenotypic differences.

Current ICES stock structure with two stocks is not supported by any of the studies reviewed.

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5.1. *Lepidorhombus whiffiagonis*

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hke.27.8c9a WGBIE 2021

Development of a new stock assessment model with Stock Synthesis 3 (SS3) for hake (*Merluccius merluccius*) in divisions 8.c and 9.a; Southern stock (Cantabrian Sea and Atlantic Iberian waters).

Working document to the Working Group for the Bay of Biscay and the Iberian Waters Ecoregion (WGBIE), 5-12 May 2021.

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Abstract

Since 2010, the stock assessment model for the southern hake stock has been GADGET. However, in 2020 this model was rejected mainly due to convergence problems and there was a change to other data poor methods. Within this frame, there is a need of looking for alternative models, especially to one of the current and most used stock assessment models which are Stock Synthesis 3 (SS3). The present working document shows the progression of the SS3 southern hake model fitting since last November of 2020 to the WGBIE 2021 regarding the main advances, model issues and future work **towards a benchmark in 2022**. The modelling strategy consists in fitting a set of plausible models with different configurations and selecting the best one with the *r4ss* and *ss3diags* libraries in RStudio.

1. Reasons for moving from GADGET to SS3

Southern hake stock assessment has been carried out through GADGET (length based) since 2010. However some problems were indentified with this assessment model in latest years resulting in a rejection of the model by WGBIE to be used for TAC advice. The main problem is the strong retrospective pattern, but also some convergence difficulties. The causes of the retrospective problem were analyzed without a clear solution (ICES, 2020) and we decided to explore the use of Stock Synthesis 3 (SS3) (Methot, 2009) as an alternative. The main reasons are:

- SS3 has multiple modeling options for stock assessment as it's focused on that.
- SS3 allows including and to estimate the error of each model parameter all together giving a more easy and complete measure of uncertainty.
- Northern hake stock is already assessed with SS3, and there is no ecological reason to Split both stocks. Regarding future aims, it would be quite interesting to try a multi area single stock model and to investigate this issue.

About data

A general data review is currently in progress. There are landings spitted in 5 fleets, discards and 5 fleets' indices corresponding to Spain and Portugal: 2 CPUE's and 3 surveys (see Fig.1).

There is a review in progress due to the bad quality of the catch data before 1994 (only yearly, no discards) and also before 1982 (hake catch mixed with catches from North Africa). Moreover, there is also a parallel study on biological data in progress and some information on growth and maturity priors are already available.

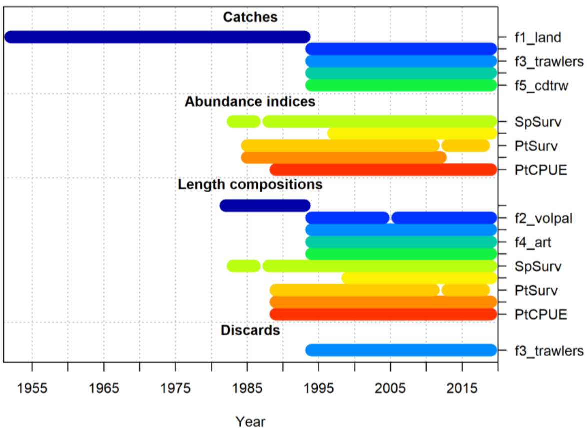

Fig1. Input catch, abundance and length composition from fishing fleets, surveys and discards.

2. SS3 Model configuration

This is a summary of one of the last SS3 *model* configurations (28/04/2021) for the southern hake stock (Fig.2). The model inputs are described below.

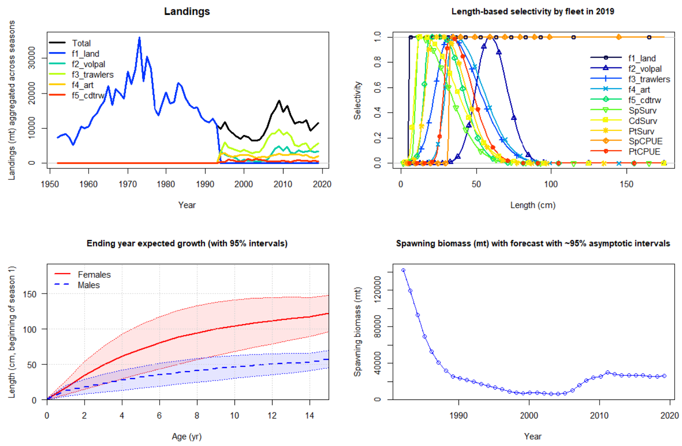

Fig 2. Sex separated model summary plot.

Data file

- Period 1953-2019
- 4 Seasons (3 months per season)
- Spawning month 1st January (default in SS3)
- Ngenders = 2
- Nages = 15 years
- Nfleets = 10 (land, volpal, trawlers, art, cdTrw, spSurv, ptSurv, cdSurv, ptCPUE and ~~spCPUE~~)
- Discards = 1 fleet associated to trawlers fleet
- Length bins input is 67 (from 4 to 40 by 1 cm and from 40 to 100 by 2 cm)
- Len mintail compression = 11 for land (LFD up to 80 cm) and 0 for the rest
- Nsample from ICES reports for an adequate weighting of LFDs

Control file

- Growth patterns = 1
- Recruitment settlement assignments = 3 (In months 1, 4 and 7). RW2 in month 4 applied
- Nat Mortality type 3, Lorenzen's M=0.28 at age 4
- Age post settlement = 0.75, linear growth bellow this value
- Maturity option = 1 (length logistic)
- First mature age = 2

- Females Lmax = 130 cm males Lmax = 66 cm
- K von Bertlanffy females = 0.165, males = 0.110
- Lmin is estimated for both sexes
- Stock-Recruit Beverton-Holt, estimates for LN(R0) and and steepness
- Recruitment deviations start in 1982 (first year of LFDs) up to 2019
- F method = 2 Pope
- Selectivity double normal for all fleets. Fleet land 1 (all fleets mixed from 1953-1982) has implemented the RW time varying selectivity option.

3. SS3 modelling progress

It is worth to mention that from the first model to the current one, the main fitting issues have been the huge B0, the biomass trend (Fig.3) and the low SPR. Regarding SPR, we argue that it cannot be almost 0 along the period 1982-2020 because in that case the stock must have collapsed many years ago. Further work on modelling needs to be done in order to solve these issues.

The **modelling strategy** consists in fitting different model configurations and once we have them all, we will perform a model selection by using the *ss3diags* package (Carvalho et al., 2021).

In this section we sum up the most important steps (each step corresponds to the trials of one month) that have been carried out in order to fit the southern hake SS3 model:

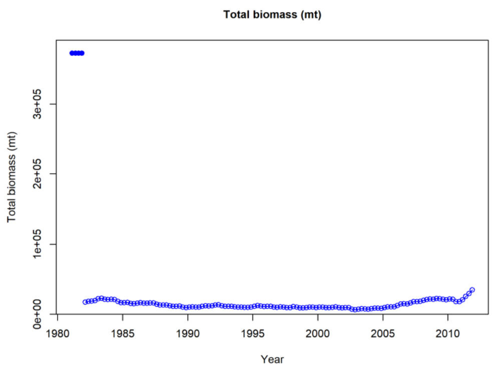

Fig 3. Plot of the biomass trend from the first fitted model.

Step 1

1. Starting point in December of 2020 from a simple SS3 v3.24 (old version) model copying the Northern hake SS3 configuration. Data period from 1982 to 2010. Model with 7 fleets (2 commercial mixed fleets, 3 surveys and 2 cpues): land landCd, ptGFS-WIBTS-Q4, Sp-GFS-aut, Sp-GFS-caut, Sp-CORTUR, pt-Trawl.

2. First WKTADSA: SS3 v3.24 model files transformed to SS3 v3.30 with the help of Rick Methot. Learnt how to work SS from R (r4ss package) in order to edit, run and plot results. As suggested by the experts, recruitment deviation advanced options were implemented (values from r4ss) (Fig.4).

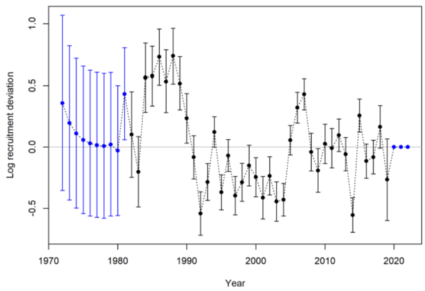

Fig 4. Plot of the log recruitment deviations implemented in one of the first models.

3. Updated catch data from the year 1972 to 2019. Changed upper and lower bounds of parameters as suggested in the model diagnostic tables. This model had only one initial F value, whereas catch values were input seasonally.

Step 2

1. Second WKTADSA: As suggested by Massimiliano Cardinale, we collected historical catch data previous to 1972 from ICES reports in order to improve the model recruitment deviation ramp.

2. As suggested also in the group, initial F parameter values were changed from 1 to 4 and equilibrium catch values were properly settled in 4 seasons.

3. Inclusion of NSample data (ICES reports) in order to properly control the model Length Frequency Distribution weighting issue for each fleet.

4. Recruitment and selectivity blocks coming from Northern hake model structure were eliminated from the shake model.

5. Included double normal distributions for all the fleets. In addition, time-vary selectivity's for fleet land1 and landCd were applied through a Random Walk fit (Fig.5).

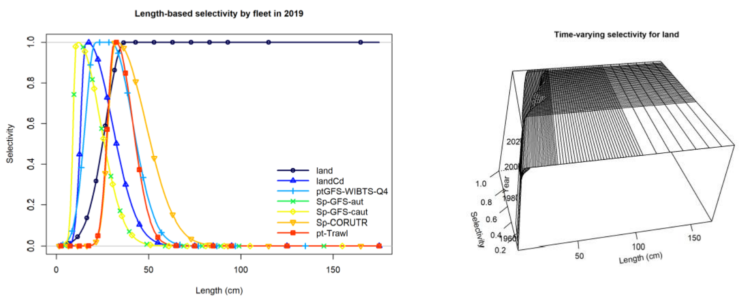

Fig 5. Double normal length-based selectivity option for all fleets (left) and time-varying Random walk logistic selectivity option for land fleet (right).

6. Recruitment distribution settlements were analysed. In SS3, the spawning peak occurs on the first month of the year and we settled 4 recruitment patterns in order to simulate 4 different growth starting points (as shake is a batch spawner species). After trying settlements in months 1, 4, 7 and 10, the one in month 10 was discarded (negligible effect). In addition, a random walk was applied to the settlement in month 4.

7. Natural mortality trial performed by changing M from single value of 0.4 for all ages to 1.06, 0.56, 0.27, and 0.15 at the ages of 0.5, 1.5, 5.5, 15.5. Important changes observed in Biomass with a softer trend compared to the single M value models (Fig 6).

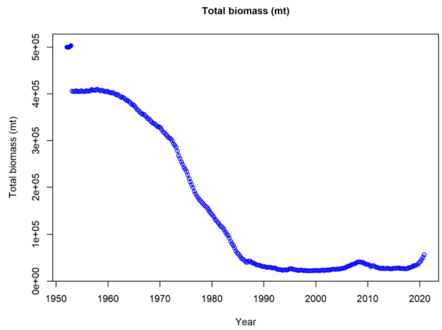

Fig 6. Plot of biomass trend for the model estimating M at age values.

Step 3

1. The model spawner-recruit relationship has been always Beverton-Holt estimating steepness (around 0.98) and ln(R0). Some trials were made by fixing it to 0.6. After all we kept estimating steepness, however, the fitted SR relationship needs further investigation (Fig. 7).

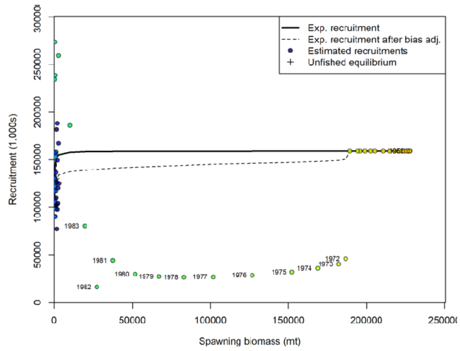

Fig 7. Spawner-recruit curve for Beverton-Holt.

2. An exhaustive fleets separated data sensitivity analysis was performed (Fig 8). After that, we decided to group the fleets in: f1_land1 (all mixed from 1953-1982), and from 1982-2019 we have f2_volpal (volanta, palangre), f3_trawlers (Sp and Pt trawlers, parejas), f4_mixture (artisanal Sp and Pt and cdTrw), spSurvey, ptSurvey, cdSurvey, spCPUE, ptCPUE. In addition, f4 mixture was settled as a Random Walk (time varying selectivity).

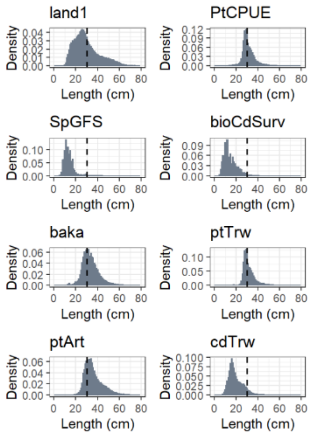

Fig 8. Length frequency distribution summary plot of each separated fleet.

3. Advances in the use of R4ss tools using SS_Jitter, SS_retrospective, SS_diags (it is worth to mention that model was not stable enough to properly analyse the results with these tools).

4. After some trials fleet f4_mixture was separated in f4_artisanal and f5_cdTrw, as they had a different LFD (Fig 9). More weight was given to the indices specifically for the most recent years.

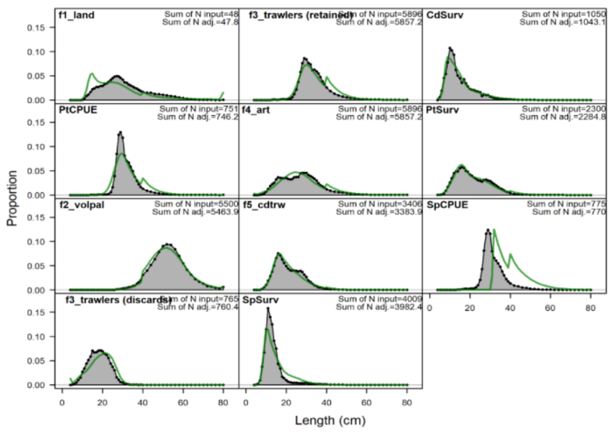

Fig 9. Summary LFD plot for all model fleets. Note that spCPUE is included in the plot but not being fitted.

Step 4

1. The current Beverton-Holt model was compared to the Ricker model as it could be a reasonable option due to hake cannibalism. The Ricker model gives lower B0 values and seems to catch well the 2010 population high biomass (Fig 10).

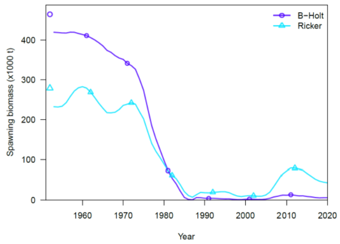

Fig 10. Biomass trend comparison between B-Holt and Ricker.

2. Previous work in shake invariants. Meta-analysis from which we derived values for biological parameters and the corresponding errors (Tab. 1).

parameter	function	Northern Parameters	Southern Parameters
L 50% maturity	normal	mean=42.29; sd=2.24	mean=37.95; sd=3.09
Linf (Von Bertalanffy)	normal	Mean=116.39.42; sd=21.54	Mean=100.17; sd=18.62
k (Von Bertalanffy)	lognormal	median=0.14; CV=0.31	median=0.17; CV=0.30
M	lognormal	median=0.23; CV=13.58	median=0.28; CV=15.33
Linf/Lmat	normal	mean=2.75; sd=0.49	
k/M	lognormal	median=0.63; CV=0.39	

Tab 1. Summary of the developed priors from invariants work regarding Lmat, Linf, k and M.

3. A sensitivity analysis for Biological parameter values was performed. Models with GADGET values were tried by keeping all parameter fixed unless one biological parameter each time. When estimating this single parameter, a new parameter value (from invariants work) was settled as prior (Fig 11 and Tab 2).

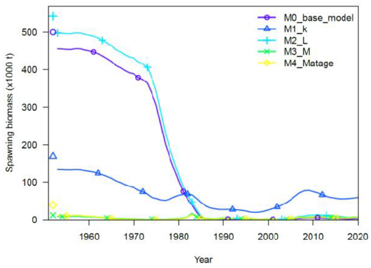

Fig 11. Biomass trend models comparison for biological parameter analysis

	Lmin	*Steepness*	*K VonB.*	*M*	*Lmax*
M0 base	14.8	0.99	-	-	-
M1 k	10.52	0.68	0.03	-	-
M2 L	15	0.99	-	-	138
M3 M	14.6	0.87	-	2.58	-
M4 Matage	14.23	0.98	-	3.26 2.26, 0.16, 0.17	

Tab 2. Estimated parameter values comparison for biological parameter analysis.

4. Trials setting as fixed the new biological parameter values from invariants work into the model were performed, but bad results were obtained. It seems the model had not enough information to analyse these components (it was still too sensible).

5. Installed SS3 stable version 3.30.16 at the supercomputer CESGA server. Established workflow for running up to 200 models simultaneously.

6. The steepness estimated has been highly variable depending on the rest of fixed parameter settled. A profiling was performed for a range of values of sigmaR and steepness with SS profile() function (Fig 12).

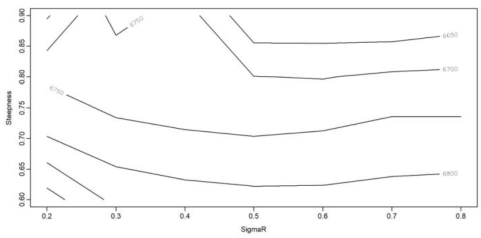

Fig 12. Plot of the profiling results for steepness and sigmaR.

7. As alternative, a sex separated model was fitted. Hake is a quite dimorphic species where males are rarely higher than 66 cm but females grow up to 130 cm (Cerviño, 2014) (Fig.13). Due to this reason, we argue that this model makes full sense for southern hake but more sex data will be needed (current sex separated data is only from the SpSurvey).

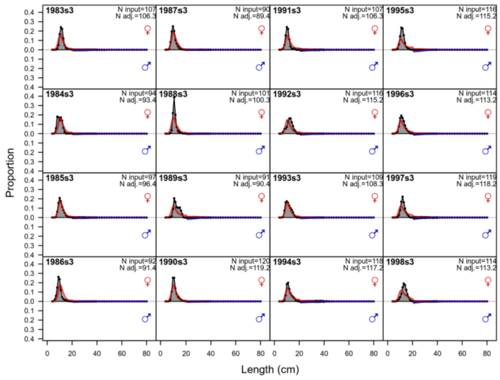

Fig 13. Model plot for males and females LFD's of the Spanish survey.

8. In this step we tried estimating natural mortality trough the Lorenzen's Mortality option for an M=0.28 at a reference age of 4 years (Fig. 14).

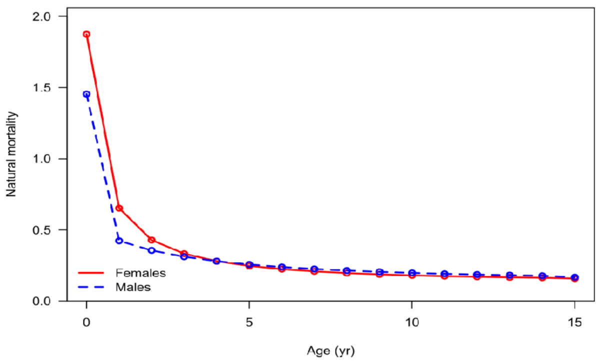

Fig 14. Model plot Lorenzen's mortality at age option for females and males.

4. Conclusions

Further research and performance improvement of the models needs to be done before doing the model selection. Different configurations will be tested in order to reach the best plausible models for this species.

Achieved aims

- ✓ Included historical data 1953-2020
- ✓ Workflow for SS3 from r4ss in RStudio
- ✓ Performed analysis about recruitment settlements
- ✓ Included sample size data to weight LFDs
- ✓ Split fleets, sensitivity analysis performed and new fleets selectivity implemented
- ✓ Tried Beverton-Holt and Ricker growth options. Current is BH.
- ✓ Understand better model options and diagnostics (still in progress)
- ✓ Sex separated provisional model (needs more sex separated fleets input)
- ✓ Some alternative values for biological parameter already tested
- ✓ M at age Lorenzen option inmplemented

Future aims

- Continue improving B0, SPR and SR parameters performance
- Indices
  - Standardization Spanish CPUE (in progress)
  - New standardization of Portuguese CPUE (in progress)
  - Sex separated data from Portuguese survey (in progress)
- Continue exploring biological parameter estimation on new sex separated model (k, Linf, M, recruitment)
  - Maturity each year including Portuguese data
  - Estimate growth parameters
  - Spawner Recruit relationship
- Later
  - Select the best models among a bunch of model configurations through *ss3diags* (i.e. single sex, sex separated).
  - Try spatial (multi area) model.

References

Cerviño, S. (2014). Estimating growth from sex ratio-at-length data in species with sexual size dimorphism. *Fisheries Research*, *160*, 112-119.

Carvalho, F., Winker, H., Courtney, D., Kapur, M., Kell, L., Cardinale, M., ... & Methot, R. D. (2021). A cookbook for using model diagnostics in integrated stock assessments. *Fisheries Research*, *240*, 105959.

Methot, R. D. (2009). User manual for stock synthesis. *NOAA Fisheries, Seattle, USA*.

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Estimation of MSY proxies for Southern hake category 3 assessment.

S. Cerviño, M. Cousido-Rocha, Fran Izquierdo and A. Silva.

All these runs with R code and output diagnostics in HTLM files are available in the sharepoint (data/shke/Refpts/)

Summary

Southern hake reference points methods for category 3 stocks were explored following ICES guidelines. Among the 4 methods suggested, 3 are based on length distributions and life history parameters and one is based on time series trends of catch and biomass indices (SPiCT). The methods based on length distributions provide a view of an overexploited stock (with few exceptions) meanwhile SPiCT provides a view of a stock inside safe references. Length based model assumptions include equilibrium, known growth and logistic or knife edge selectivity, all of them hard to hold for this stock. SPiCT results provide wide confidence intervals although all the converged runs performed (~100) show similar results in terms of reference points (Prob (B<Blim) < 5%; B/Bmsy > 0.5 and F/Fmsy <1), suggesting that results are robust to alternative data and setting. SPiCT is proposed as the model to estimate relative reference points each year.

Introduction

Southern hake was evaluated with a length based model (GADGET) since 2010. A recent increase in retrospective pattern as well as convergence issues precluded their use for advice and WGBIE (2020) decided to change the advice method to a Category 3 stocks that uses 2 combined indices to estimate a ratio of 2 over last 3 years. These requirements are needed to provide the best advice and to implement different management rules in the context of multiannual plan for stocks fished in the Western Waters.

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

- Length based indicators (LBI)
- Mean length Z (MLZ)
- Length based spawner per recruit (LBSPR)
- Surplus Production model in Continuous Time (SPiCT)

The first 3 are based on length distribution data meanwhile the last one is based on time series of catches and biomass indices. **ICES (2018) recommends that all methods should be explored**, if possible, because agreement between different models strengthens inference while disagreements among methods can highlight problems with data or model assumptions. The adopted method will depend on data quality, preliminary model diagnostics, and understanding of exploitation history and perceptions of stock development by the relevant ICES stock co-ordinator(s).

However, **ICES (2018) also recommends that if SPiCT diagnostics are acceptable, then SPiCT should be used as the basis for further analyses**; if unacceptable, analyses based on length data only should the considered instead. SPiCT is based on a biomass dynamics model. These models internally estimate F_{msy} and B_{msy} as part of the model fitting. For stocks for which these models have been applied, ICES set MSY $B_{trigger}$ at B_{msy}/ 2.

ICES guides for advice in 2021 states relative to reference points in Cat 3:

4.4.1.3.

Insert a Figure 2 to justify the stock status evaluation under the table 2.

4.8.1 Category 3 and 4

These will have a reference points table (but please see d) below).

b) Include the source for these values and any relevant information on the technical basis. **For stocks with reference points estimated by the EG, include the EG report in the "Sources**"-column. If the values were estimated under, e.g. WKMSYREF4, include that as the reference under sources, etc.

c) If the assessment is relative, consider including a footnote. For example: "* No reference points are defined for this stock in terms of absolute values. The SPiCT-estimated values of the ratios F/F_{msy} and B/B_{msy} are used to estimate stock status relative to the MSY reference points."

Data

The data required to perform all these 4 methods are available for Southern hake since last benchmark (ICES, 2014) and were updated every year since them. All the methods can be analyzed.

Catch data include discards. Data were updated with 2020 catch. 2020 sampling was less intensive than other years affecting discards estimation (probably underestimated) and unallocated Spanish landings. Catch length distributions in 2020 also flaw for the same reason although the existing data was raised to each metier and quarter based on total catch for each metier and quarter and length weight relationship. Figure 1 shows the length frequency composition of catches from 2004-2020.

Figure 1: Length frequency composition of catches from 2004-2020.

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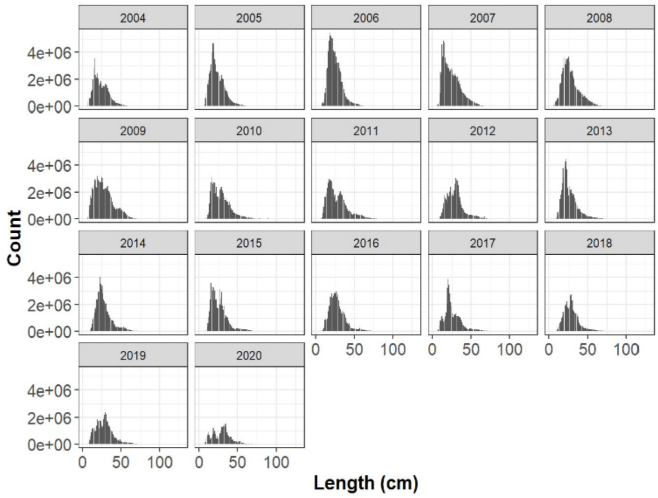


Length based methods also requires biological parameters on maturity, growth and natural mortality. For this purpose, the biological parameters already implemented in the GADGET model were used. Additional parameters coming from a study based on life history invariants and hierarchical Bayesian models with data from all hakes around the world, presented in the hake benchmark in 2014 (ICES WKSOUTH, 2014) were also implemented as a sensitivity test. Table 1 shows the values of the life history parameters implemented in the GADGET model and also the ones derived from life history invariants (LHI) and hierarchical Bayesian models.

Table 1: Life history parameters (L_{inf}, L_{50}, L_{95}, M/k, k, M and a and b). For each of the length based methods (LBI, LBSPR and MLZ) we specify which of the life history parameters are required. (*) Means that such parameter is also used to computed the corresponding YPR curve.

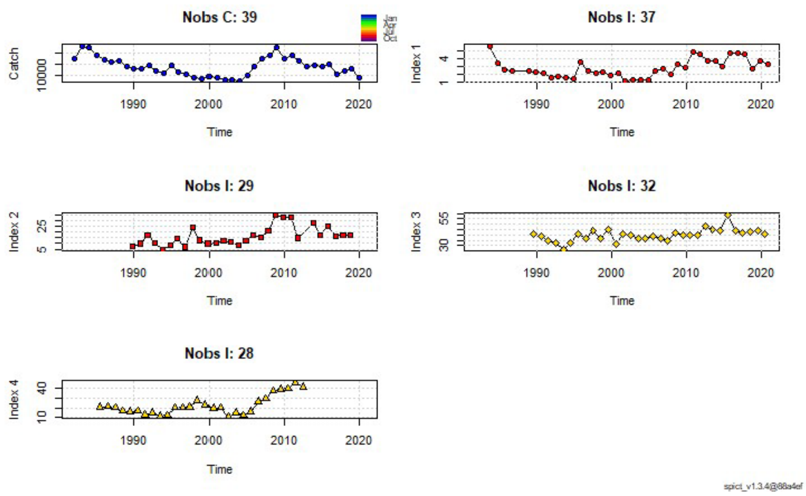
Parameters	Value	Source	Methods		
			LBI	LBSPR	MLZ
L_{inf}	130 cm	GADGET	✓	✓	✓
L_{50}	33 cm	GADGET	✓	✓	
L_{95}	50 cm	GADGET		✓	
M/k	2.42	GADGET	✓	✓	
k	0.165	GADGET			✓
M	0.4	GADGET			✓
a and *b*	a = 0.00000659; *b*= 3.01721	GADGET	✓		✓(*)
L_{inf}	100 cm	LHI	✓	✓	✓

L_{50}	38 cm	LHI	✓	✓	
L_{95}	55 cm	LHI		✓	
M/k	1.65	LHI	✓	✓	
k	0.17	LHI			✓
M	0.28	LHI			✓

For SPiCT calibration purposes 4 indices were considered. There are two CPUEs indices and 2 survey indices. All these indices were already accepted for their use in the hake assessment with GADGET. The Portuguese survey could not be updated in 2019-20. The survey indices use a smaller mesh size than those in the commercial catches catching length classes smaller than those caught by commercial fleet. SPiCT assumes that the biomass refers to the fishable biomass and biomass indices targeting these catches are more accurate for SPiCT calibration purposes. For this reason, in order to have a biomass index of fishable biomass for both surveys, fish with less than 20 cm was removed from the biomass index because this length classes are scarce in commercial catch. Figure 2 shows the four indices and the catches time series.

Method description and results are presented as follow: LBI, MLZ, LBSPR and SPiCT.

Figure 2: Left panel shows the catches time series, the Portuguese survey, and the Spanish CPUE whereas the right panel shows the Spanish survey and Portuguese CPUE.



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Length Based Indicators (LBI)

A set of length-based indicators was selected for screening catch/landings–length composition and classify the stocks according to conservation/sustainability, yield optimization and MSY considerations. These indicators require data on the stock catch/landings–length composition and life-history parameters. The methodology was developed by WKLIFE V (2015), although it had already been previously defined by Froese (2004).

Data

Length distributions include catch from 2004 to 2020 (see Figure 1). Discards length distribution was not sampled regularly before 2004.

Biological parameters tested are presented in Table 1. GADGET biological parameters are used as reference ones, hence the results reported below are derived using such values.

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

Table 2. Set of length-based indicators, their references, the corresponding indicator ratios and their expected values grouped in terms of conservation/sustainability, optimal yield and MSY considerations.

Indicator	Calculation	Reference point	Indicator ratio	Expected Value	Property
$L_{max5\%}$	Mean length of largest 5%	L_{inf}	$L_{max5\%}$ / L_{inf}	> 0.8	Conservation (large individuals)
$L_{95\%}$	95th percentile	L_{inf}	$L_{95\%}$ / L_{inf}	> 0.8	Conservation (large individuals)
P_{mega}	Proportion of individuals above L_{opt} + 10%	0.3-0.4	P_{mega}	> 0.3	Conservation (large individuals)
$L_{25\%}$	25th percentile of length distribution	L_{mat}	$L_{25\%}$ / L_{mat}	> 1	Conservation (immatures)
L_c	Length at first catch (length at 50% of mode)	L_{mat}	L_c / L_{mat}	> 1	Conservation (immatures)
L_{mean}	Mean length of individuals >L_c	L_{opt} = 3* L_{inf} / (3+(M/k))	L_{mean}/L_{opt}	≈1	Optimal yield
L_{maxy}	Length class with maximum biomass in catch	L_{opt} = 3L_{inf} / (3+(M/k))	L_{maxy} / L_{opt}	≈1	Optimal yield
L_{mean}	Mean length of	$L_{F=M}$ = (1-a) L_c + a	L_{mean} /	≥1	MSY

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	individuals >L_c	L_{inf}; a=1/(2(M/k)+1)	$L_{F=M}$		

LBI results are shown below in Table 3 and Figure 3. Note that red colour in Table 3 shows that the indicator is under its reference value.

Table 3: Traffic light indicator table for the LBI analysis.

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

Figure 3: Temporal trends of the LBI indicator ratios estimates.

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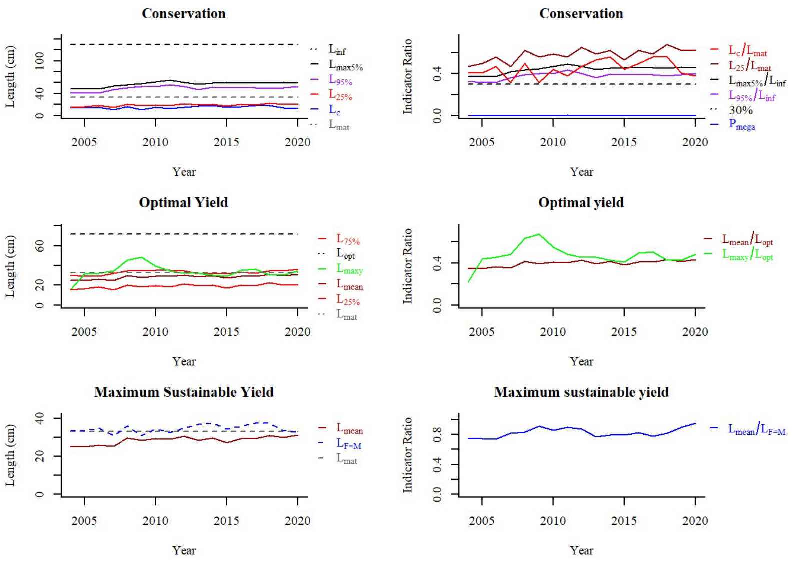

All the indicators presented in Table 2 showed that conservation, optimal yield and MSY stock references were outside of its optimal values. Alternative tests were provided, grouping length classes (1, 2 , 3 and 4 cm length bins), using the LHI life history parameter values instead of GADGET ones (see Table 1), and also using M/k=1.5. Although the results were sensitive to these changes, the main conclusions do not change and all the indicators, for all the years, remained out of safe bounds.

The main assumptions of applicability of LBI are: equilibrium conditions (total mortality and recruitment have been constant for a period as long as the lifetime of the time-series); natural mortality and growth are known; selectivity follows a logistic curve; a length-based proxy for MSY is $L_{F=M}$ = (1-a)L_c + a L_{inf} being a=1/(2(M/k)+1) (where L_c is the length at first capture) and the length of optimal yield is L_{opt} = 3L_{inf} / (3+(M/k)).

The method assumes that input parameters are known, but hake life-history parameters such as L_{inf}, k or M are uncertain. Furthermore, it is known that European hake is a dimorphic species where males do not reach 70 cm meanwhile females can achieve 140 cm. This presuppose that halve of the population rarely reach 0.5L_{inf}. Furthermore, L_{50} (or L_{mat}) is also used as a reference and hake is really different than other species in the relationship between L_{mat} and L_{inf}. Hake is caught by different gear types (trawl, gillnet and longliners) with different mesh sizes. Trawls and small gillnets catch a lot of small fish below size at maturity, meanwhile large gillnets and longliners catch larger fish. These gears are quite selective on length, with a dome shape selection. Gear size preferences (mesh size or hooks) defined to target the most abundant length groups, avoiding the larger and less abundant length classes. Hake larger than

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90 cm are scarce in the catches. A combination of uncertain growth and natural mortality together with dome shape selection for larger fish can cause wrong indicators.

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Mean Length Mortality (MLZ)

The mean length of animals that are fully vulnerable to the sampling gear can be used to estimate total mortality from basic growth parameters and a known length at first capture. This approach may in some cases represent the best opportunity to reconstruct the mortality history of a stock. The idea was first developed by Beverton-Holt based on the length-based mortality estimator; however, the method requires equilibrium conditions. It assumes equilibrium length composition such that the mean length reflects the current Z rate experienced by the stock. Gedamke and Hoenig (2006) modified the Beverton and Holt estimator by relaxing the strict assumption of equilibrium population. This was done by modelling the transition of mean length from an equilibrium period to the next, following step-wise changes in Z. Using a time series of mean length observations, the Gedamke- Hoenig estimator yields period-specific estimates of Z and the corresponding years of change in mortality. Then et al. (2018) developed a new formulation of the Gedamke-Hoenig estimator that utilizes additional information from a time-series of fishing effort to estimate the catchability coefficient q and the natural mortality rate M and thus year-specific total and fishing mortality rates.

Both methods use maximum likelihood estimation and provide asymptotic variances and covariance of the parameter estimates.

Data

The data required to estimate MLZ are a time series of catch length measurements (same used as with LBI data, see Figure 1); biological parameters such as von Bertalanffy growth parameters L_{inf} and k for the stock (same as for LBI data; see Table 1), time-series of fishing effort (only for Then et al. 2018) and the so-called length of first capture (L_c, i.e., the smallest size at which animals are fully vulnerable to the fishery and to the sampling gear). The effort time-series was calculated as the ratio of the catch series and the combined index (Portugues CPUE and Spanish survey) already estimated for current Southern hake assessment (ICES, 2020). Note that the value of natural mortality (M) in Table 1 is also used since Then et al. (2018) has been applied fixing M instead of estimating such parameter.

Gedamke-Hoenig method

The mean length distribution of hake above size of first capture (L_c=20.5 cm) together with GADGET biological parameters were used to fit the model. From the time-series of mean length data, total mortality rates (Z) are estimated in blocks of time as well as the years in which the mortality changed. The model uses a likelihood approach to obtain parameters that maximize goodness-of-fit to the mean length data. With an external estimate of the natural mortality rate (M), the fishing mortality rate (F) can be derived. The best fit was achieved with 3 year breaks in 2007, 2015 and 2017, estimating mean Z for years 2004-05, 2006-2010, 2011-17 and 2018-20. The Figure 4 shows the fit of mean length from 2004-20 with Z estimated for the 4 year groups. Furthermore, Table 4 reports the outputs of MLZ fit using both sets of life history parameters, GADGET and LHI (Table 1). Figure 5 also reports the YPR curve and the estimated values for $F_{0.1}$ (0.17) and F_{max} (0.25).

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Figure 4: Fitted values for the time-series of mean length data and the corresponding residuals (GADGET life history parameter values).

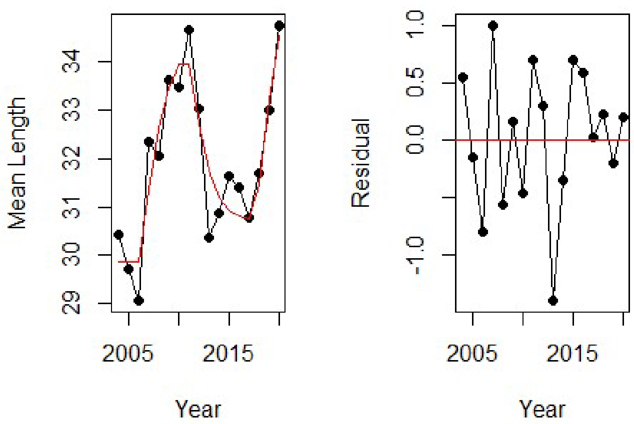

Table 4: Outputs of MLZ fit using both sets of life history parameters, GADGET and LHI (Table 1).

	GADGET data		LHI Data	
Parameter	Estimate	StdErr	Estimate	StdErr
Z1	0.96	0.03	0.77	0.03
Z2	0.71	0.02	0.52	0.03
Z3	0.91	0.02	0.73	0.02
Z4	0.62	0.05	0.43	0.07
Y1	2006.03	0.44	2005.92	0.41
Y2	2010.74	0.40	2010.27	0.51
Y3	2017.57	0.37	2017.37	0.49
sigma	0.60	NA	0.65	NA
AIC	15.58	NA	18.23	NA

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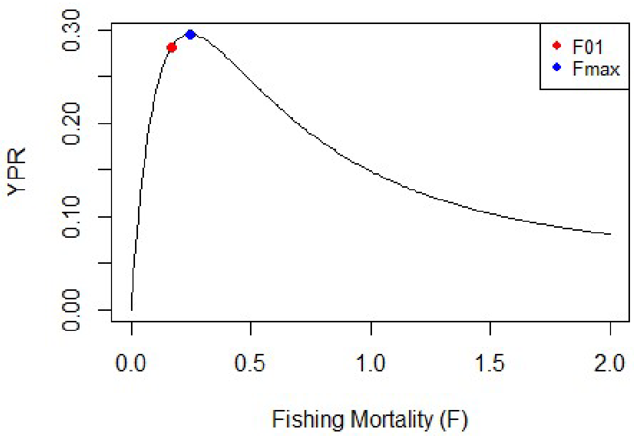
Figure 5: Yield-per-recruit (YPR) curve, and the estimated values for $F_{0.1}$ and F_{max}.



As mentioned above, the analysis was performed with biological parameters coming from LHI analysis, instead of GADGET ones, getting similar breaks and results in terms of exploitation status (see summary in Table 4).

Then Method

Then et al. (2018) developed a new formulation of the Gedamke-Hoenig estimator that utilizes additional information from a time-series of fishing effort to estimate the catchability coefficient q and the natural mortality rate M and thus year-specific fishing mortality rates

Hake models estimating M did not converged and hence two runs, with M fixed, using the parameters from GADGET and LHI were performed. Both provide similar results, with a F decreasing trend always above F_{max} although near this reference in 2020 (see Figure 6).

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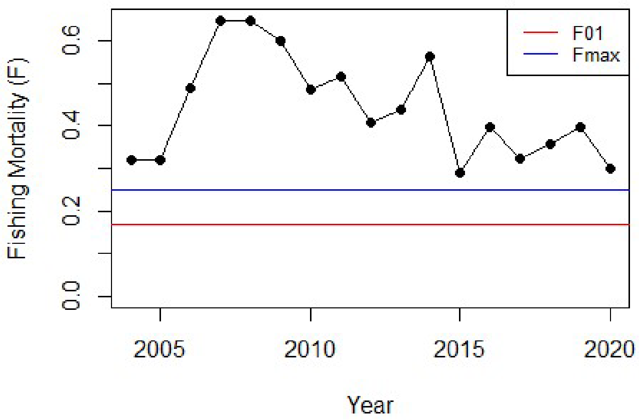
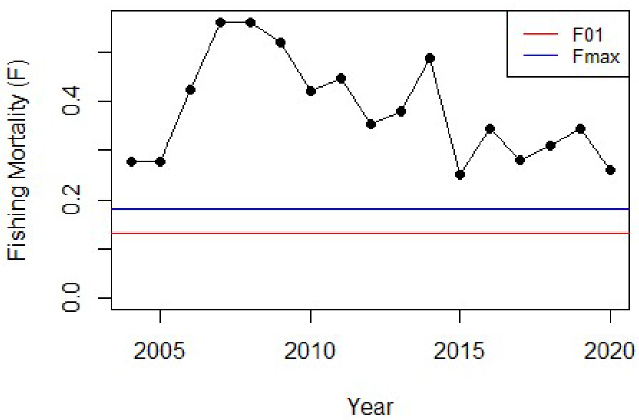
Figure 6: Estimated F trends using Then method based on GADGET and LHI parameters values, upper and lower plots, respectively. The plots also include the reference values of $F_{0.1}$ and F_{max}.





The estimated F trends in Figure 6 are quite similar with both sets of parameters, although the absolute values change. However the relative F values show a stock that is being overexploited.

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Table 5 shows the comparative performance of Gedame-Hoenig and Then models. GH models present a stock that has been exploited slightly below F_{max} in latest years, meanwhile Then models provide an exploitation level in 2020 above F_{max}.

Table 5: Values of F_{last} for Gedame-Hoenig (GH) and Then models based on the two set of life history parameters (GADGET and LHI), reference points $F_{0.1}$ and F_{max} and the corresponding ratios. Note that F_{last} refers to the estimated F in the last period of time, that is 2017-20 for GH models and 2020 for Then models.

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

The main assumptions for Gedamke and Hoenig (2006) mean-length Z method and Then et al. (2018) expansion of the method are the following:

- Recruitment is constant over time or variation over time are small and without trend.
- Growth is deterministic, following a von Bertalanffy growth equation time-invariant.
- Selectivity is knife-edge above the length of full selectivity (L_c).
- Length of full selectivity (L_c - taken from the data); 100% of individuals are vulnerable to capture.
- Constant catchability for the effort – F relationship.

Mean length in a population is determined by the mortality history and the recruitment history experienced by the population. Without further information, the effects of changing recruitment and mortality are confounded. It is recognized that this stock had good recruitments in years 2005-2009.

Growth, M and selectivity assumptions can undermine results in a similar way than explained for LBI method.

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Length based Sawning Potential Ratio (LB-SPR)

Spawning Potential ratio (SPR) is defined as the proportion of Spawning Biomass per recruit (SBPR) in an exploited stock with regards to SBPR in an unfished (virgin) stock. The rationale behind this indicator is that the abundance at length in the population decreases with ageing (length) because of the mortality (M and F). A virgin population will have a larger amount of large mature individuals than an exploited population. The SPR ranges between 1 (virgin population) and 0. A SPR in the Range of 0.35-0.4 are usually considered a population around MSY level although this is a quite variable parameter. A population with SPR below 0.1-0.15 are considered collapsed.

Data

The LBSPR method has been developed for data-limited fisheries. Data requested for the method are a representative sample of the size structure of the catch (see Figure 1), and the life history parameter values reported in Table 1 (two set of values are considered; GADGET and LHI).

The LBSPR method does not require knowledge of the natural mortality rate (M), but instead uses the ratio of natural mortality and the von Bertalanffy growth coefficient (k) (M/k), which is believed to vary less across stocks and species than M (Prince et al. 2015).

Results

Figures 7 and 8 show the estimated values for selectivity, F/M and SPR from 2004 to 2020 for LBSPR method based on GADGET and LHI biological parameter values , respectively.

Both fits provide quite similar results. There is a trend in the selectivity estimated increasing from 2004 until 2020. F/M is quite variable the first years (2004-10) and afterwards it stabilises between 2.5 and 3. SPR increases until 2010, getting a maximum around 0.1 and decreases slightly again afterwards. These low SPR values would correspond to a collapsed stock.

There are a number of caveat which concerns the validity of this analysis assumptions regarding growth, natural mortality and selectivity are the main source of uncertainty to accept these results, in a similar way than in the previous analysis (LBI and MLZ). Apart of the equilibrium assumptions, uncertainty in growth and M (including sex dimorphism) could compromise the results. Selection dominated by different gears with trawls catching small fish and dome shaped gears (gillnets and longliners) catching larger fish can also contributed to violation of assumptions.

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Figure 7: Estimated values for selectivity, F/M and SPR using GADGET biological parameter values.

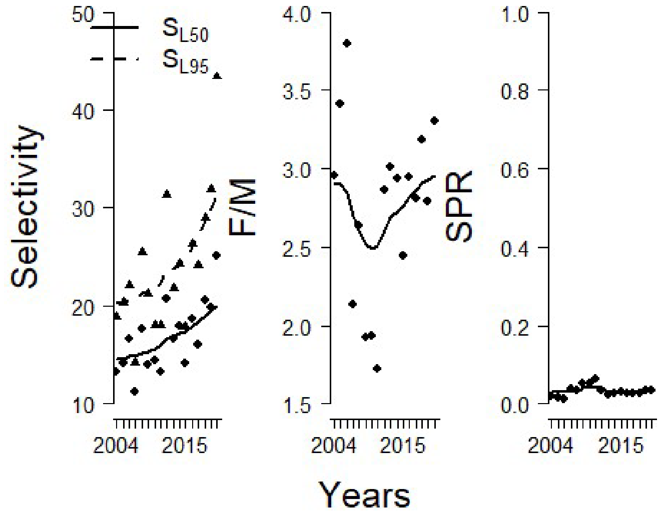
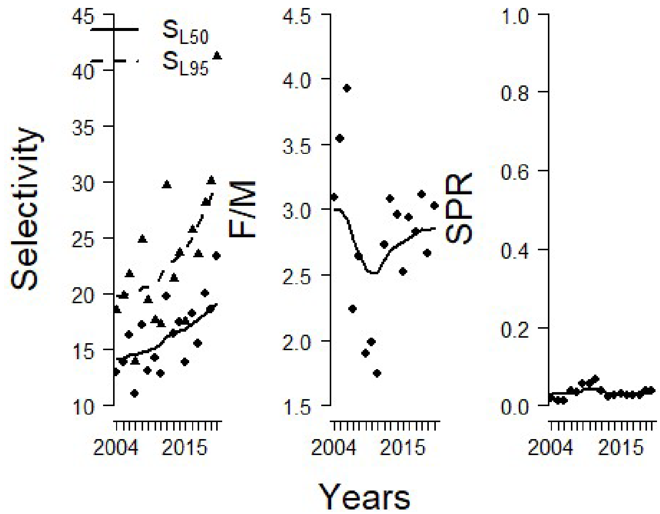


Figure 8: Estimated values for selectivity, F/M and SPR using LHI biological parameter values.



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SPiCT

A base run model was first performed using catches from 1982 to 2020 and the 4 biomass indices as the data accepted for the GADGET model. In some runs the CPUE's are combined assuming equal weight. Furthermore, an effort index was tested. This index was derived combining the series defined as catch divided by Spanish CPUE with the series of catch divided by Portugues CPUE.

SPiCT settings follow the default option. Additional runs considering different years, biomass indices, priors and settings were also performed to try to improve the model performance of the base run.

Criteria to evaluate the model performance to the alternative model configuration were the usual SPiCT ckeck list. However we have to take in consideration that the goal of this analysis is to estimate the reference points for Category 3 stocks which are B/B_{msy} (MSY $B_{trigger}$ reference value = 0.5) and F/F_{msy} (reference value = 1). So comparative among different runs, Table 6, also consider this values.

Checklist for the acceptance of a SPiCT assessment:

1. The assessment converged (fitoptconvergence equals 0).
2. All variance parameters of the model parameters are finite (all(is.finite(fit$sd)) should be TRUE).
3. No violation of model assumptions based on one-step-ahead residuals (bias, auto-correlation, normality). This means, that p-values are insignificant (> 0.05), indicated by green titles in the graphs of plotspict.diagnostic(fit). Slight violations of these assumptions do not necessarily invalidate model results.
4. Consistent patterns in the retrospective analysis (fit <- retro(fit)). This means that there is no tendency of consistent under- or overestimation of the relative fishing mortality (F/F_{msy}) and relative biomass (B/B_{msy}) in successive assessment. The retrospective trajectories of those two quantities should be inside the credible intervals of the base run.
5. Realistic production curve. The shape of the production curve should not be too skewed (B_{msy}/k should be between 0.1 and 0.9). Low values of B_{msy}/k allow for an infinite population growth rate (calc.bmsyk(fit)).
6. High assessment uncertainty can indicate a lack of contrast in the input data or violation of the ecological model assumptions.
    a. The main variance parameters (logsdb, logsdc, logsdi, logsdf) should not be unrealistically high.
    b. Credible intervals for B/B_{msy} and F/F_{msy} should not span more than 1 order of magnitude (calc.om(fit)).
7. Initial values do not influence the parameter estimates (fit <- check.ini(fit)). The estimates should be the same for all initial values (fit$check.ini$resmat). Runs which did not converge should not be considered in this regard.

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Results

Table 6 reports a summary of the main runs performed after the base run (Run 1). Annex I shows additional runs performed in this analysis. *NOTICE that all the runs in Table 6 (and others) with R code and output diagnostics in HTLM files are available in the sharepoint (data/shke/refpts/SPICT).*

Table 6: Summary of the main runs performed after the base run (Run 1). Bold type highlights differences regarding Run 1.

Run number	**Indices**	**Years**	**Settings (only non default)**	**Convergence**	**B/B_{msy} (90% IC) F/F_{msy} (90% IC)**	**Checklist for acceptance (only fails)**	**AIC**
1	Portugues survey and CPUE, Spanish survey and CPUE	1982-2020	-----------------	Yes	1.375 (0.489.3.870) 0.429 (0.088,2.076)	Ljung-Box signifficant tests for 3 indices.	68.17704
2	Portugues survey and CPUE, Spanish survey and CPUE	**1972**-2020	-----------------	Yes	1.588 (0.497,5.073) 0.351 (0.049,2.524)	Ljung-Box signifficant tests for 2 indices.	74.13231
3	Portugues survey and CPUE, Spanish survey and CPUE	1982-2020	**logbkfrac<-c(log(0.6),0.5,1)**	Yes	1.356 (0.512,3.589) 0.443 (0.113,1.747)	Ljung-Box signifficant tests for 2 indices.	62.36061
4	Portugues survey, Spanish survey and **mean effort index**	1982-2020	-----------------	Yes	1.490 (0.641,3.466) 0.371 (0.092,1.483)	Ljung-Box signifficant tests for 1 index. One problematic run in the check of robustness to initial parameter values	28.76575
5	Portugues survey, Spanish survey and **mean effort index**	1982-2020	**logbkfrac<-c(log(0.6),0.5,1)**	Yes	1.475 (0.633,3.439) 0.389 (0.123,1.234)	Two problematic runs in the check of robustness to initial parameter values	23.21347

In general, the additional runs performed improve the Run 1 in terms of diagnostics and reducing standard errors. However none of the alternative models change our perception of stock or fishery status relative to reference points. This result is the most significative one to check that B/B_{msy} and F/F_{msy} are robust to alternative model configuration. Additional runs are also presented in the Annex I and all of them also confirm this robustness.

A sensitivity analysis for possible underestimation of catch in 2020 was also performed running again the 5 Runs in the table above. Results confirm that relative reference points are not sensitive to this.

Given the high CI associated with F/Fmsy and B/Bmsy. A sensitivity analysis using one index each time was also performed. The idea was to check whether the wide confidence intervals are caused by the implementation of 4 indices with differences among them. The results show that, in general, the CIs are not reduced considerably, suggesting that the combination of different indices is not the cause of wide CIs. However, for the converged runs (most of them) the results regarding the reference points dot change, making the initial results more robust.

Column 6 (B/B_{msy} and F/F_{msy}) includes 90% confidence intervals. Recent WKSPiCT (ICES, 2021) set B_{lim} as 0.3Bmsy. This additional reference point is not yet in the ICES guidelines for category 3 stocks. However lower CI, which represents 95% probability is always well above $0.3B_{msy}$(also in Annex I runs).

Discusion and conclusions

The four data-limited models implemented present different results in term of stock and exploitation status. Models that depend on length distribution (LBI, MLZ and LBSPR) show an overexploited stock although MLZ (GH model) shows that the estimated F is below F_{max}. SPiCT, which do not use length distributions but time series of catches and biomass indices, presents a healthy stock and exploitation level inside MSY boundaries.

Why these strong differences among methods? ICES (2018) recommends to explore all methods because agreement between different models strengthens inference while disagreements among methods can highlight problems with data or model assumptions. The key of differences here seems to be the different information used and models assumptions. The methods using length distributions understand that these length distributions correspond to a quite depleted hake stock. This extremely depleted in the case of LBSPR were SPR never reaches 0.1, even around 2010, when the stock was at high SSB (considered recovered) and producing high yields. However this is based on some arguable model assumptions. The more controversial assumptions in the case of hake are: equilibrium assumptions (constant recruitment), logistic selection (or, at least flat selection between lower size references, e.g. L_c or $L_{25\%}$, and higher size references e.g. L_{inf} in the case of LBI); known growth and known natural mortality.

Equilibrium assumption is clearly violated by the periods of different recruitment. 2005-10 was considered a period of quite good recruitments. Afterwards recruitment is lower although quite variable.

Southern hake selection is compound of catches from different gears. Small hake is catch by trawlers and artisanal boats, mainly small gillnetters and large hake is catch by longliners and large gillnetters. Both are quite selective fishermen can play with the size of hooks and nets mesh size. However they set these gears to target the more profitable fraction of the population that is a trade-off between larger expensive hakes and their decreasing abundance.

Hake growth is quite uncertain because there are not criteria to read otholits and tagging experiences are not complete enough to build a growth model. Hake benchmark (ICES, 2014) deal with this assuming a L_{inf}=130 cm and estimating k inside the models (Northern hake with SS3 and Southern hake with GADGET), resulting in a k≈0.17. However hake is a quite dimorphic species with females that can reach 140 cm and males that never achieves 70 cm. This mean that a theoretical depleted length structure can be caused by the fact that half of the population cannot achieve 70 cm (half of maximum size). However the model understands that this is caused by fishing intensity corresponding to an overexploited population.

Uncertainty on M is also an issue, as in most stocks. Now it is assumed to be 0.4 and constant for all ages and years. However hake is a quite cannibal species with age 0 being the main prey for older hake. Furthermore cetaceans are the main predators, with age 1 being the main prey. This suggest that higher Ms should be set, at least for ages 0 and 1, but uncertainty also remains in older fish M. Sex dimorphism is also an issue because maturity process triggers an increase in mortality and males mature at lower size than females (30 cm vs 40 cm aprox.).

It is also remarkable that the relation between MSY and SPR reference points is quite different for hake than for other species. Theoretical studies shown that SPR around 0.35-0.4 are the usual proxy for MSY, i.e. that F that produces a SPR around 0.4 is that F than produces MSY. However, Cerviño et al (2014), with the GADGET accepted model for Southern hake, show that MSY is achieved with a 0.2 SPR with Beverton-Holt recruitment model and even below this with the Ricker model, showing that the usual assumptions for SPR proxies do not hold for hake (assuming L_{inf}=130, k=0.17 and M=0.4).

On the other side biomass dynamic models like SPiCT assumes that all production parameters (growth, natural mortality and recruitment) are grouped in one parameter that defines the population growth rate. The other main model parameters are the carrying capacity (K) and the shape of the production curve (n). These parameters are not forced to be constant in time since error process is considered in SPiCT. These parameters shape the relationship between production and exploitable biomass. Model assumes that selectivity do not varies in time. This biomass is calibrated with abundance indices and the model assumes that catchability abundance indices are also constant in time.

Main problem with hake SPiCT model is the high uncertainty in the estimations and also some ticks in some of the quality test, in particular autocorrelation in residuals of some biomass indices. Both problems are related and depend on the different signals coming from biomass indices. Although all of them follow up and down trends, the intensity of the change in these trends is quite different causing high variability as well as autocorrelations in some residuals. These problems can be reduced adding complexity to the model in form on priors for the B/K ratio or making an effort index from CPUEs. Although this improve the diagnostics and reduce uncertainty, none of this models changes substantially the view of the reference points which ranges between 1.36 and 1.49 (ICES MSY $B_{trigger}$ is 0.5); and between 0.35 and 0.44 for F, when ICES F_{msy} proxy is 1. The hake MSY proxies are insensitive to changes in the model configuration. Furthermore, B_{lim} was set as $0.3B_{msy}$ (ICES, 2021) and all the runs also shows that the stock is above B_{lim} with a probability higher that 95%.

For this reason the case base (run 1), the simpler one, could be our reference model for SPiCT. In terms of accepting the model to make predictions and catch recommendations (Categories 1 and 2), the high variability seems to preclude this use. However, if confident intervals for Run 1 are considered high, any of the alternative runs can be used instead. Run 5, with one effort series instead of the two CPUEs, is the better one in terms of quality diagnostics.

ICES (2018), about guidelines for reference points in category 3 and 4, recommends that if SPiCT diagnostics are acceptable, then SPiCT should be used as the basis for further analyses. In order to define relative reference points (B/B_{msy} and F/F_{msy}) the model seems quite stable an insensitive to changes in data or model settings. So SPiCT seems to be the best model to use for Southern hake reference points.

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Annex 1. Additional runs summary. Bold type highlights changes regarding Base case

Run number	Indices	Years	Settings	Convergence	B/B_{msy} (90% IC) F/F_{msy} (90% IC)	Checklist for acceptance	AIC
1	Portugues survey and CPUE, Spanish survey and CPUE	1982-2020	**Scaling first values of catch series until 1994**	Yes	1.374 (0.519,3.643) 0.412 (0.096,1.763)	Ljung-Box signifficant tests for 3 indices. Retropective trajectory -5 far from the remaning	70.03942
2	Portugues survey and CPUE, Spanish survey and CPUE	**1972-2020**	**Scaling first values of catch series until 1994**	Yes	1.587 (0.508,4.961) 0.332 (0.043,2.545)	Ljung-Box signifficant tests for 2 indices. Retropective trajectory -5 far from the remaning	73.42909
3	Portugues survey and CPUE, Spanish survey and CPUE	**1972-2020**	**logbkfrac <- c(log(0.7),0.5,1)**	Yes	1.366 (0.487,3.827) 0.449 (0.111,1.811)	Ljung-Box signifficant tests for 2 indices.	68.75358
4	**Portugues and Spanish surveys**	1982-2020	------------------	No	------------------	------------------	------------------
5	**Portugues and Spanish surveys**	1982-2020	**logbkfrac <- c(log(0.6),0.5,1)**	No	------------------	------------------	------------------
6	**Portugues and Spanish surveys, and Portugues CPUE**	1982-2020	------------------	Yes	2.401 (0.803,7.179) 0.0254 (2.670e-05,24.232)	Ljung-Box signifficant tests for 2 indices. Problems in the check of robustness to initial parameter values.	48.84826
7	**Portugues and Spanish surveys, and weighted CPUE**	1982-2020	------------------	Yes	1.653 (0.556,4.910) 0.319 (0.041,2.507)	Ljung-Box signifficant tests for 1 index.	29.0529
8	**Portugues and Spanish surveys, and weighted**	1982-2020	**logbkfrac <- c(log(0.6),0.5,1)**	No	------------------	------------------	------------------

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Annex II. SPiCT runs one with only one index.

Run number	Indices	Years	Settings	Convergence	B/B_{msy} (90% IC) F/F_{msy} (90% IC)	Checklist for acceptance	AIC
1	Spanish survey	1982-2020	----------------	NO			
2	Spanish survey	1972-2020	----------------	Yes	1.37 (0.49-3.82) 0.44 (0.10-0.89)	Retros > 20%	30.31
3	Spanish survey	1982-2020	logbkfrac <- c(log(0.6),0.5,1)	NO			
4	Portuguese survey	1982-2020	----------------	Yes	1.27 (0.35-4.63) 0.47 (0.08-2.57)	Wide F CI Retro (-0.31, 0.48)	34.96
5	Portuguese survey	1972-2020	----------------	Yes	1.53 (0.51-4.59) 0.35 (0.08-1.68)	Wide F CI Retro (-0.17, 0.28)	40.30
6	Portuguese survey	1982-2020	logbkfrac <- c(log(0.6),0.5,1)	Yes	1.35 (0.37-4.95) 0.43 (0.063-2.92)	Wide F CIs Retro (-0.34, 0.54)	29.46
7	Spanish CPUE	1982-2020	----------------	Yes	1.41 (0.51-3.88) 0.37 (0.10-1.40)	Weird retro but inside bounds 4 / 30 Jitter	8.31
8	Spanish CPUE	1972-2020	----------------	Yes	1.64 (0.60-4.52) 0.30 (0.07-1.27)	Wide F CIs	12.75
9	Spanish CPUE	1982-2020	logbkfrac <- c(log(0.6),0.5,1)	Yes	1.51 (0.43-5.37) 0.34 (0.05-2.30)	Retro (-0.17, 0.21) 3 / 30 Jitter	2.88564
10	Portuguese CPUE	1982-2020	----------------	Yes	2.67 (0.68-10.43) 0.01 (0.00006-11.06)	Wide CI Bad Jitter	-29.
11	Portuguese CPUE	1972-2020	----------------	Yes	2.82 (0.79-10.24) 0.02 (0.00004-13.62)	Wide CI Retro (-0.04, 0.65)	-23.12
12	Portuguese CPUE	1982-2020	logbkfrac <- c(log(0.6),0.5,1)	Yes	0.70 (2.63-9.87) 2.63 (0.70-9.87)	Wide CI	-34

Annex III. SPiCT main runs

Stochastic surplus production model in continuous time (SPiCT)

Southern Hake April 2021 by Santiago Cerviño

2021-04-28

First charge library in the workspace.

```
#remotes::install_github("tokami/spict/spict", ref="fix130")
library(spict)
library(readxl)
```

Load data.

```
set.seed(1234)


data=read.csv("ShkeTimeSeries20.csv")

C_hake <- data.frame(obsC = data$catch, timeC = data$year)

I_S <- data.frame(obsI = c(data$spsurv), timeI = data$year + 0.83)
I_P <- data.frame(obsI = c(data$ptsurv), timeI = data$year + 0.83)

CPUE_P <- data.frame(obsI = c(data$ptcpue), timeI = data$year)

CPUE_S <- data.frame(obsI = c(data$spcpue), timeI = data$year)
```

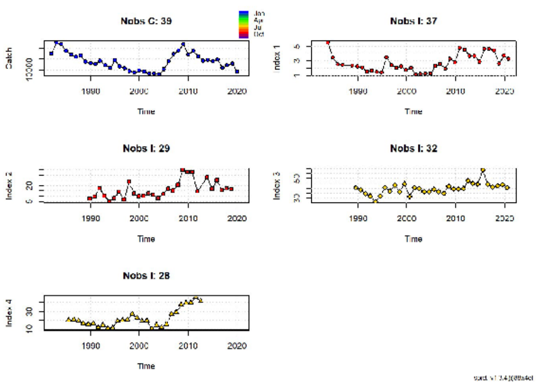
1 Run 1: Using four abundance indices: Portugues survey,Spanish survey, Spanish CPUE and Portugues CPUE. Default priors. CATCH SERIES FROM 1982 TO 2020.

```
ind=which(C_hake$timeC==1982)
ind2=which(C_hake$timeC==2020)



inp1 <- list(timeC = C_hake$timeC[ind:ind2], obsC = C_hake$obsC[ind:ind2],
             timeI = list(I_S$timeI, I_P$timeI,
                          CPUE_P$timeI+0.5, CPUE_S$timeI+0.5),
             obsI = list(I_S$obsI, I_P$obsI,
                         CPUE_P$obsI, CPUE_S$obsI))
inp1=check.inp(inp1)
```

```
## Removing zero, negative, and NAs in  I  series  1
## Removing zero, negative, and NAs in  I  series  2
## Removing zero, negative, and NAs in  I  series  3
## Removing zero, negative, and NAs in  I  series  4
```

The data can be plotted using the command:

```
plotspict.data(inp1)
```



The model is fitted to data by running:

```
res1 <- fit.spict(inp1)
```

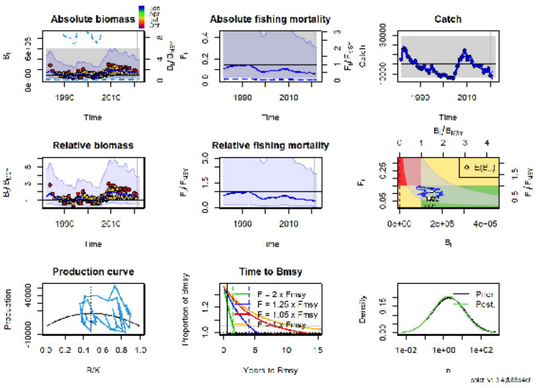
The results are summarized using:

```
capture.output(summary(res1))
```

```
##  [1] "Convergence: 0  MSG: both X-convergence and relative convergence (5)"
##  [2] "Objective function at optimum: 20.0885215"
##  [3] "Euler time step (years):  1/16 or 0.0625"
##  [4] "Nobs C: 39,  Nobs I1: 37,  Nobs I2: 29,  Nobs I3: 32,  Nobs I4: 28"
##  [5] ""
##  [6] "Priors"
##  [7] "     logn  ~  dnorm[log(2), 2^2]"
##  [8] " logalpha  ~  dnorm[log(1), 2^2]"
##  [9] "  logbeta  ~  dnorm[log(1), 2^2]"
## [10] ""
```

```
## [11] "Model parameter estimates w 95% CI "
## [12] "            estimate        cilow        ciupp     log.est  "
## [13] " alpha1 1.523321e+00 8.790234e-01 2.639870e+00   0.4208928  "
## [14] " alpha2 1.967613e+00 1.178943e+00 3.283872e+00   0.6768210  "
## [15] " alpha3 1.577583e+00 1.011691e+00 2.460008e+00   0.4558940  "
## [16] " alpha4 1.157090e+00 5.696362e-01 2.350372e+00   0.1459081  "
## [17] " beta   4.647381e-01 1.309579e-01 1.649243e+00  -0.7662814  "
## [18] " r      2.796904e-01 1.246030e-02 6.278096e+00  -1.2740721  "
## [19] " rc     3.122645e-01 5.803720e-02 1.680114e+00  -1.1639048  "
## [20] " rold   3.534262e-01 9.201000e-04 1.357641e+02  -1.0400806  "
## [21] " m      1.668639e+04 7.463252e+03 3.730754e+04   9.7223487  "
## [22] " K      2.232558e+05 3.391150e+04 1.469801e+06  12.3160737  "
## [23] " q1     1.940000e-05 1.500000e-06 2.434000e-04 -10.8501708  "
## [24] " q2     1.159000e-04 9.200000e-06 1.462400e-03  -9.0631834  "
## [25] " q3     3.091000e-04 2.460000e-05 3.887400e-03  -8.0818244  "
## [26] " q4     1.745000e-04 1.380000e-05 2.211900e-03  -8.6534653  "
## [27] " n      1.791369e+00 4.020140e-02 7.982303e+01   0.5829799  "
## [28] " sdb    1.602341e-01 1.073885e-01 2.390850e-01  -1.8311194  "
## [29] " sdf    1.057335e-01 6.286130e-02 1.778453e-01  -2.2468331  "
## [30] " sdi1   2.440880e-01 1.803722e-01 3.303112e-01  -1.4102265  "
## [31] " sdi2   3.152787e-01 2.380057e-01 4.176397e-01  -1.1542984  "
## [32] " sdi3   2.527826e-01 1.716364e-01 3.722932e-01  -1.3752254  "
## [33] " sdi4   1.854052e-01 1.168670e-01 2.941388e-01  -1.6852113  "
## [34] " sdc    4.913840e-02 1.856500e-02 1.300607e-01  -3.0131145  "
## [35] " "
## [36] "Deterministic reference points (Drp)"
## [37] "           estimate        cilow        ciupp   log.est  "
## [38] " Bmsyd 1.068734e+05 1.190515e+04 9.594112e+05 11.579401  "
## [39] " Fmsyd 1.561322e-01 2.901860e-02 8.400571e-01 -1.857052  "
## [40] " MSYd  1.668639e+04 7.463252e+03 3.730754e+04  9.722349  "
## [41] "Stochastic reference points (Srp)"
## [42] "           estimate        cilow        ciupp   log.est rel.diff.Drp  "
## [43] " Bmsys 1.017884e+05 1.215750e+04 8.522206e+05 11.530651  -0.04995716  "
## [44] " Fmsys 1.510891e-01 2.227270e-02 1.024928e+00 -1.889886  -0.03337857  "
## [45] " MSYs  1.535347e+04 7.094944e+03 3.322492e+04  9.639097  -0.08681573  "
## [46] ""
## [47] "States w 95% CI (inp$msytype: s)"
## [48] "                    estimate        cilow        ciupp    log.est  "
## [49] " B_2020.94      1.396882e+05 1.161727e+04 1.679636e+06 11.8471681  "
## [50] " F_2020.94      6.476690e-02 5.307600e-03 7.903293e-01 -2.7369613  "
## [51] " B_2020.94/Bmsy 1.372339e+00 3.985374e-01 4.725568e+00  0.3165168  "
## [52] " F_2020.94/Fmsy 4.286667e-01 6.548460e-02 2.806081e+00 -0.8470755  "
## [53] ""
## [54] "Predictions w 95% CI (inp$msytype: s)"
## [55] "                  prediction        cilow        ciupp    log.est  "
## [56] " B_2022.00      1.440644e+05 1.280132e+04 1.621282e+06 11.8780155  "
## [57] " F_2022.00      6.476700e-02 5.259500e-03 7.975540e-01 -2.7369586  "
## [58] " B_2022.00/Bmsy 1.415332e+00 4.353659e-01 4.601107e+00  0.3473643  "
## [59] " F_2022.00/Fmsy 4.286679e-01 6.469720e-02 2.840249e+00 -0.8470729  "
## [60] " Catch_2021.00  9.193340e+03 6.672066e+03 1.266737e+04  9.1262346  "
## [61] " E(B_inf)       1.532850e+05           NA           NA 11.9400541  "
```

```
plot(res1,CI = 0.9)
```



Checklist for the acceptance of a SPiCT assessment

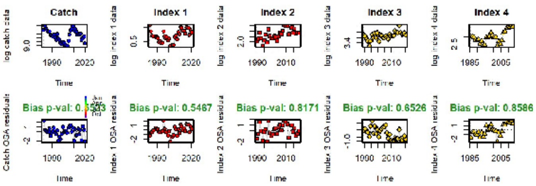
```
res1$opt$convergence
```

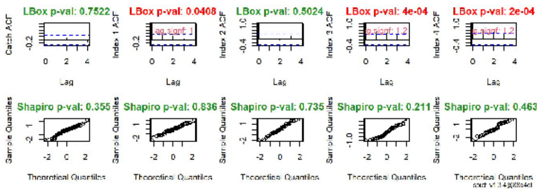
```
## [1] 0
```

```
all(is.finite(res1$sd))
```

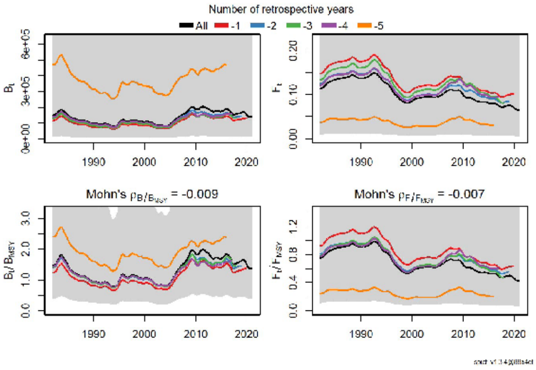
```
## [1] TRUE
```

```
r1 <- calc.osa.resid(res1)
plotspict.diagnostic(r1)
```



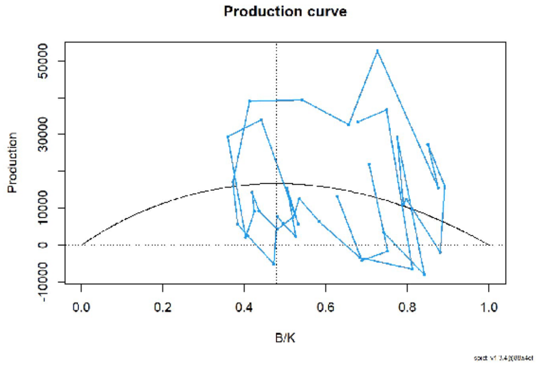



```
rl<- fit.spict(inpl)
repl=retro(rl, nretroyear=5)
plotspict.retro(repl)
```




```
## FFmsy BBmsy
## -0.006816319 -0.008671366
```

```
plotspict.production(resl)
```




```
set.seed(1234)
a=check.ini(inpl, ntrials=30,verbose = FALSE)
```

```
## Warning in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control): NA/
## NaN function evaluation
```

```
## Error in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control) :
##   gradient function must return a numeric vector of length 14
## obj$par:
##        logm        logK        logq        logq        logq        logq
##   9.4348351   9.3355493 -10.7870243 -10.6051867  -9.6720196 -11.1742752
##        logn      logsdb      logsdf      logsdi      logsdi      logsdi
##   2.2190475  -0.4136104  -2.9852415  -2.7201597   0.6569985  -0.1940281
##      logsdi      logsdc
##  -1.3638277  -0.9352129
## obj$fn:
## [1] NaN
## obj$gr:
## [1] NaN
## Error in fit.spict(inpsens) :
##   Could not fit model. Error msg:Error in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.
control) :
##   gradient function must return a numeric vector of length 14
```

```
## Warning in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control): NA/
## NaN function evaluation

## Warning in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control): NA/
## NaN function evaluation
```

```
## Warning in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control): NA/
## NaN function evaluation

## Warning in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control): NA/
## NaN function evaluation

## Warning in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control): NA/
## NaN function evaluation

## Warning in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control): NA/
## NaN function evaluation

## Warning in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control): NA/
## NaN function evaluation

## Warning in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control): NA/
## NaN function evaluation
```

```
a$check.ini$resmat
```

```
##            Distance        m        K  q  q  q  q    n  sdb  sdf  sdi  sdi  sdi
## Basevec        0.00 16686.39 223255.8  0  0  0  0 1.79 0.16 0.11 0.24 0.32 0.25
## Trial 1        0.71 16686.39 223256.5  0  0  0  0 1.79 0.16 0.11 0.24 0.32 0.25
## Trial 2        0.13 16686.37 223256.0  0  0  0  0 1.79 0.16 0.11 0.24 0.32 0.25
## Trial 3        0.00       NA       NA NA NA NA NA   NA   NA   NA   NA   NA   NA
## Trial 4        0.01 16686.39 223255.8  0  0  0  0 1.79 0.16 0.11 0.24 0.32 0.25
## Trial 5        0.32 16686.38 223255.5  0  0  0  0 1.79 0.16 0.11 0.24 0.32 0.25
## Trial 6        0.35 16686.37 223255.5  0  0  0  0 1.79 0.16 0.11 0.24 0.32 0.25
## Trial 7        0.19 16686.40 223256.0  0  0  0  0 1.79 0.16 0.11 0.24 0.32 0.25
## Trial 8        0.01 16686.39 223255.9  0  0  0  0 1.79 0.16 0.11 0.24 0.32 0.25
## Trial 9        0.01 16686.39 223255.9  0  0  0  0 1.79 0.16 0.11 0.24 0.32 0.25
## Trial 10       0.60 16686.41 223256.4  0  0  0  0 1.79 0.16 0.11 0.24 0.32 0.25
## Trial 11       0.09 16686.39 223255.8  0  0  0  0 1.79 0.16 0.11 0.24 0.32 0.25
## Trial 12       0.21 16686.39 223255.6  0  0  0  0 1.79 0.16 0.11 0.24 0.32 0.25
## Trial 13       0.20 16686.39 223256.0  0  0  0  0 1.79 0.16 0.11 0.24 0.32 0.25
## Trial 14       0.00       NA       NA NA NA NA NA   NA   NA   NA   NA   NA   NA
## Trial 15       0.11 16686.38 223255.7  0  0  0  0 1.79 0.16 0.11 0.24 0.32 0.25
## Trial 16       0.52 16686.39 223256.4  0  0  0  0 1.79 0.16 0.11 0.24 0.32 0.25
## Trial 17       0.51 16686.39 223255.3  0  0  0  0 1.79 0.16 0.11 0.24 0.32 0.25
## Trial 18       0.05 16686.39 223255.8  0  0  0  0 1.79 0.16 0.11 0.24 0.32 0.25
## Trial 19       0.16 16686.38 223255.7  0  0  0  0 1.79 0.16 0.11 0.24 0.32 0.25
## Trial 20       0.02 16686.39 223255.9  0  0  0  0 1.79 0.16 0.11 0.24 0.32 0.25
## Trial 21       0.58 16686.39 223256.4  0  0  0  0 1.79 0.16 0.11 0.24 0.32 0.25
## Trial 22       0.12 16686.41 223255.7  0  0  0  0 1.79 0.16 0.11 0.24 0.32 0.25
## Trial 23       0.37 16686.36 223255.5  0  0  0  0 1.79 0.16 0.11 0.24 0.32 0.25
## Trial 24       0.04 16686.39 223255.9  0  0  0  0 1.79 0.16 0.11 0.24 0.32 0.25
## Trial 25       0.00       NA       NA NA NA NA NA   NA   NA   NA   NA   NA   NA
## Trial 26       0.31 16686.39 223256.1  0  0  0  0 1.79 0.16 0.11 0.24 0.32 0.25
## Trial 27       0.02 16686.39 223255.8  0  0  0  0 1.79 0.16 0.11 0.24 0.32 0.25
## Trial 28       0.11 16686.39 223256.0  0  0  0  0 1.79 0.16 0.11 0.24 0.32 0.25
## Trial 29       0.17 16686.40 223256.0  0  0  0  0 1.79 0.16 0.11 0.24 0.32 0.25
## Trial 30       0.16 16686.38 223255.7  0  0  0  0 1.79 0.16 0.11 0.24 0.32 0.25
##             sdi  sdc
## Basevec  0.19 0.05
## Trial 1  0.19 0.05
## Trial 2  0.19 0.05
## Trial 3    NA   NA
## Trial 4  0.19 0.05
## Trial 5  0.19 0.05
## Trial 6  0.19 0.05
## Trial 7  0.19 0.05
## Trial 8  0.19 0.05
## Trial 9  0.19 0.05
## Trial 10 0.19 0.05
## Trial 11 0.19 0.05
## Trial 12 0.19 0.05
## Trial 13 0.19 0.05
## Trial 14   NA   NA
## Trial 15 0.19 0.05
## Trial 16 0.19 0.05
## Trial 17 0.19 0.05
## Trial 18 0.19 0.05
## Trial 19 0.19 0.05
## Trial 20 0.19 0.05
## Trial 21 0.19 0.05
## Trial 22 0.19 0.05
## Trial 23 0.19 0.05
## Trial 24 0.19 0.05
## Trial 25   NA   NA
## Trial 26 0.19 0.05
## Trial 27 0.19 0.05
## Trial 28 0.19 0.05
## Trial 29 0.19 0.05
## Trial 30 0.19 0.05
```

```
fit=res1
get.par("logBmBmsy", fit, exp=TRUE, CI = 0.9)
```

```
##                  ll      est       ul        sd       cv
## logBmBmsy 0.4887021 1.375083 3.869135 0.6289414 0.696582
```

```
get.par("logFmFmsy", fit, exp=TRUE, CI = 0.9)
```

```
##                   ll       est       ul        sd       cv
## logFmFmsy 0.08852523 0.4286667 2.075738 0.9589863 1.228179
```

I also compute AIC value:

```
get.AIC(res1)
```

```
## [1] 68.17704
```

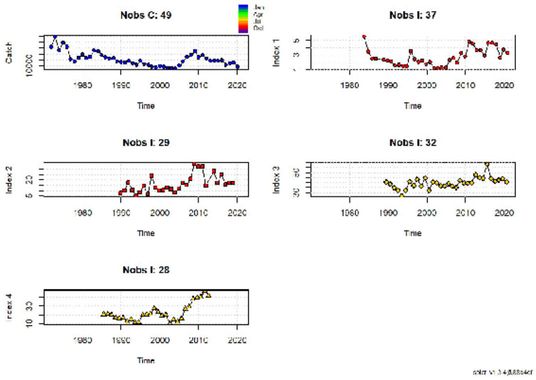
2 Run 2: Using four abundance indices: Portugues survey,Spanish survey, Spanish CPUE and Portugues CPUE. Default priors. CATCH SERIES FROM 1972 TO 2020.

```
ind=which(C_hake$timeC==1972)
ind2=which(C_hake$timeC==2020)



inp2 <- list(timeC = C_hake$timeC[ind:ind2], obsC = C_hake$obsC[ind:ind2],
            timeI = list(I_S$timeI, I_P$timeI,
                         CPUE_P$timeI+0.5, CPUE_S$timeI+0.5),
            obsI = list(I_S$obsI, I_P$obsI,
                        CPUE_P$obsI, CPUE_S$obsI))
inp2=check.inp(inp2)
```

```
## Removing zero, negative, and NAs in  I  series  1
## Removing zero, negative, and NAs in  I  series  2
## Removing zero, negative, and NAs in  I  series  3
## Removing zero, negative, and NAs in  I  series  4
```

The data can be plotted using the command:

```
plotspict.data(inp2)
```



The model is fitted to data by running:

```
res2 <- fit.spict(inp2)
```

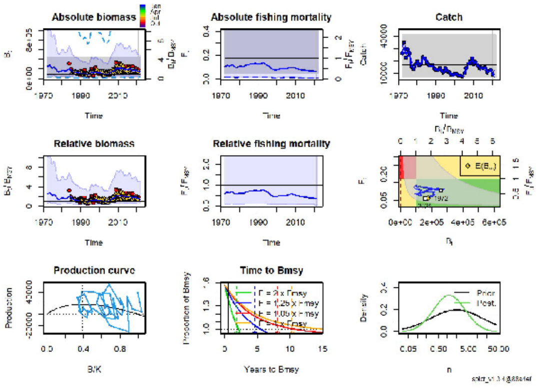
The results are summarized using:

```
capture.output(summary(res2))
```

```
##  [1] "Convergence: 0  MSG: relative convergence (4)"
##  [2] "Objective function at optimum: 23.0661559"
##  [3] "Euler time step (years):  1/16 or 0.0625"
##  [4] "Nobs C: 49,  Nobs I1: 37,  Nobs I2: 29,  Nobs I3: 32,  Nobs I4: 28"
##  [5] ""
##  [6] "Priors"
##  [7] "     logn  ~  dnorm[log(2), 2^2]"
##  [8] " logalpha  ~  dnorm[log(1), 2^2]"
##  [9] "  logbeta  ~  dnorm[log(1), 2^2]"
## [10] ""
## [11] "Model parameter estimates w 95% CI "
## [12] "           estimate       cilow        ciupp     log.est  "
## [13] " alpha1 1.458025e+00 8.077086e-01 2.631937e+00   0.3770830  "
## [14] " alpha2 1.884193e+00 1.088057e+00 3.262864e+00   0.6334997  "
## [15] " alpha3 1.515872e+00 9.513427e-01 2.415395e+00   0.4159911  "
## [16] " alpha4 1.104703e+00 5.166562e-01 2.362052e+00   0.0995766  "
## [17] " beta   7.364044e-01 2.654940e-01 2.042575e+00  -0.3059759  "
## [18] " r      1.984116e-01 4.176350e-02 9.426212e-01  -1.6174119  "
## [19] " rc     3.483975e-01 7.631040e-02 1.590620e+00  -1.0544111  "
## [20] " rold   1.427471e+00 0.000000e+00 1.080335e+08   0.3559043  "
## [21] " m      1.791701e+04 6.305405e+03 5.091176e+04   9.7935058  "
## [22] " K      2.623414e+05 5.974261e+04 1.151992e+06  12.4774020  "
## [23] " q1     1.770000e-05 1.500000e-06 2.109000e-04 -10.9392396  "
## [24] " q2     1.059000e-04 8.900000e-06 1.267500e-03  -9.1526072  "
## [25] " q3     2.825000e-04 2.370000e-05 3.366900e-03  -8.1717893  "
## [26] " q4     1.596000e-04 1.330000e-05 1.916300e-03  -8.7428610  "
## [27] " n      1.138995e+00 1.077952e-01 1.203495e+01   0.1301464  "
## [28] " sdb    1.671265e-01 1.077170e-01 2.593023e-01  -1.7890043  "
## [29] " sdf    1.047576e-01 5.916770e-02 1.854754e-01  -2.2561059  "
## [30] " sdi1   2.436747e-01 1.789354e-01 3.318368e-01  -1.4119213  "
## [31] " sdi2   3.148986e-01 2.371902e-01 4.180659e-01  -1.1555046  "
## [32] " sdi3   2.533424e-01 1.710275e-01 3.752753e-01  -1.3730132  "
## [33] " sdi4   1.846252e-01 1.146360e-01 2.973452e-01  -1.6894276  "
## [34] " sdc    7.714400e-02 4.007170e-02 1.485135e-01  -2.5620818  "
## [35] " "
## [36] "Deterministic reference points (Drp)"
## [37] "          estimate       cilow        ciupp   log.est  "
## [38] " Bmsyd 1.028538e+05 1.580240e+04 6.694496e+05 11.541064  "
## [39] " Fmsyd 1.741988e-01 3.815520e-02 7.953099e-01 -1.747558  "
## [40] " MSYd  1.791701e+04 6.305405e+03 5.091176e+04  9.793506  "
## [41] "Stochastic reference points (Srp)"
## [42] "          estimate      cilow        ciupp   log.est rel.diff.Drp  "
## [43] " Bmsys 98277.637525 15833.05498 6.100209e+05 11.495552 -0.04656390l  "
```

```
## [44] " Fmsys     0.173237     0.03469 8.651225e-01 -1.753095 -0.005551733  "
## [45] " MSYs  17020.924231   5931.78648 4.884057e+04  9.742199 -0.052646118  "
## [46] ""
## [47] "States w 95% CI (inp$msytype: s)"
## [48] "                    estimate        cilow        ciupp    log.est  "
## [49] " B_2020.94      1.558085e+05 1.368481e+04 1.773960e+06 11.9563832  "
## [50] " F_2020.94      6.074290e-02 5.234300e-03 7.049120e-01 -2.8011049  "
## [51] " B_2020.94/Bmsy 1.585392e+00 3.961158e-01 6.345282e+00  0.4608314  "
## [52] " F_2020.94/Fmsy 3.506347e-01 3.338390e-02 3.682751e+00 -1.0480103  "
## [53] ""
## [54] "Predictions w 95% CI (inp$msytype: s)"
## [55] "                  prediction        cilow        ciupp    log.est  "
## [56] " B_2022.00      1.596343e+05 1.489696e+04 1.710624e+06 11.9806406  "
## [57] " F_2022.00      6.074310e-02 5.186800e-03 7.113668e-01 -2.8011020  "
## [58] " B_2022.00/Bmsy 1.624319e+00 4.245390e-01 6.214772e+00  0.4850889  "
## [59] " F_2022.00/Fmsy 3.506357e-01 3.306840e-02 3.717911e+00 -1.0480075  "
## [60] " Catch_2021.00  9.584022e+03 6.789807e+03 1.352814e+04  9.1678526  "
## [61] " E(B_inf)       1.753951e+05           NA           NA 12.0747966  "
```

```
plot(res2,CI = 0.9)
```



Checklist for the acceptance of a SPiCT assessment

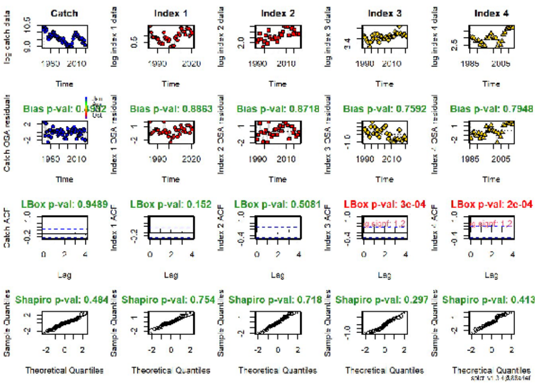
```
res2$opt$convergence
```

```
## [1] 0
```

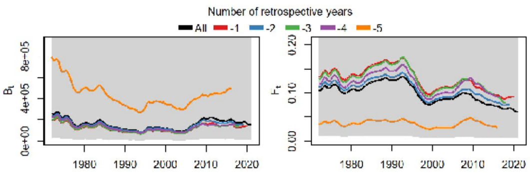
```
all(is.finite(res2$sd))
```

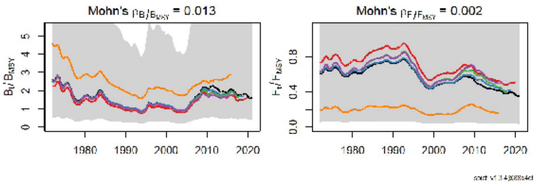
```
## [1] TRUE
```

```
r2 <- calc.osa.resid(res2)
plotspict.diagnostic(r2)
```



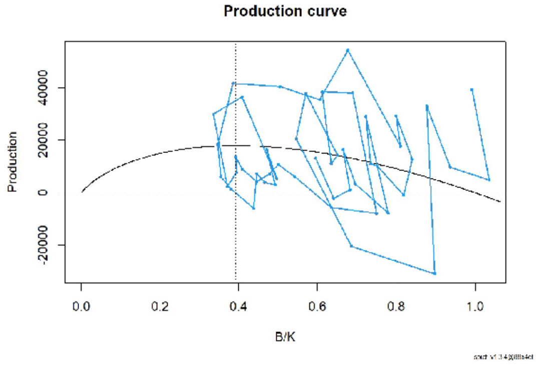

```
r2<- fit.spict(inp2)
rep2=retro(r2, nretroyear=5)
plotspict.retro(rep2)
```






```
##        FFmsy       BBmsy
## 0.001504673 0.013472765
```

```
plotspict.production(res2)
```




```
set.seed(1234)
a=check.ini(inp2, ntrials=30,verbose = FALSE)
```

```
## Warning in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control): NA/
## NaN function evaluation
```

```
## Error in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control) :
##   gradient function must return a numeric vector of length 14
## obj$par:
##        logm        logK        logq        logq        logq        logq
##   9.4348351   9.7518618 -11.2033368 -11.0214992 -10.0883321 -11.5905877
##        logn      logsdb      logsdf      logsdi      logsdi      logsdi
##   2.2190475  -0.4136104  -2.9852415  -2.7201597   0.6569985  -0.1940281
##      logsdi      logsdc
##  -1.3638277  -0.9352129
## obj$fn:
## [1] NaN
## obj$gr:
## [1] NaN
## Error in fit.spict(inpsens) :
##   Could not fit model. Error msg:Error in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.
control) :
##   gradient function must return a numeric vector of length 14
```

```
## Warning in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control): NA/
## NaN function evaluation

## Warning in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control): NA/
## NaN function evaluation

## Warning in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control): NA/
## NaN function evaluation

## Warning in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control): NA/
## NaN function evaluation

## Warning in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control): NA/
## NaN function evaluation

## Warning in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control): NA/
## NaN function evaluation

## Warning in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control): NA/
## NaN function evaluation

## Warning in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control): NA/
## NaN function evaluation

## Warning in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control): NA/
## NaN function evaluation
```

```
## Error in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control) :
##   NA/NaN gradient evaluation
## obj$par:
##         logm         logK         logq         logq         logq         logq
##  11.56437121  11.51786084  -8.81252521  -9.02672680 -11.13156085 -10.32080220
##         logn       logsdb       logsdf       logsdi       logsdi       logsdi
##   0.09068018  -2.58786323  -0.70548414  -0.13230057  -0.89492949  -2.00776359
##       logsdi       logsdc
##   0.47131344  -2.79246257
## obj$fn:
```

```
## [1] -Inf
## attr(,"logarithm")
## [1] TRUE
## obj$gr:
##  [1] NaN NaN NaN NaN NaN NaN NaN NaN NaN NaN NaN NaN NaN NaN
## Error in fit.spict(inpsens) :
##   Could not fit model. Error msg:Error in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.
control) :
##   NA/NaN gradient evaluation
```

```
## Warning in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control): NA/
## NaN function evaluation

## Warning in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control): NA/
## NaN function evaluation

## Warning in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control): NA/
## NaN function evaluation

## Warning in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control): NA/
## NaN function evaluation

## Warning in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control): NA/
## NaN function evaluation

## Warning in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control): NA/
## NaN function evaluation

## Warning in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control): NA/
## NaN function evaluation

## Warning in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control): NA/
## NaN function evaluation

## Warning in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control): NA/
## NaN function evaluation

## Warning in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control): NA/
## NaN function evaluation

## Warning in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control): NA/
## NaN function evaluation
```

```
a$check.ini$resmat
```

```
##          Distance        m        K  q  q  q  q    n  sdb sdf  sdi  sdi  sdi
## Basevec      0.00 17917.01 262341.4  0  0  0  0 1.14 0.17 0.1 0.24 0.31 0.25
## Trial 1      0.44 17916.98 262341.0  0  0  0  0 1.14 0.17 0.1 0.24 0.31 0.25
## Trial 2      0.54 17916.97 262340.9  0  0  0  0 1.14 0.17 0.1 0.24 0.31 0.25
## Trial 3      0.00       NA       NA NA NA NA NA   NA   NA  NA   NA   NA   NA
## Trial 4      0.41 17917.00 262341.0  0  0  0  0 1.14 0.17 0.1 0.24 0.31 0.25
## Trial 5      0.00 17917.01 262341.4  0  0  0  0 1.14 0.17 0.1 0.24 0.31 0.25
## Trial 6      0.24 17917.03 262341.6  0  0  0  0 1.14 0.17 0.1 0.24 0.31 0.25
## Trial 7      0.58 17917.05 262342.0  0  0  0  0 1.14 0.17 0.1 0.24 0.31 0.25
## Trial 8      0.27 17917.02 262341.7  0  0  0  0 1.14 0.17 0.1 0.24 0.31 0.25
## Trial 9      0.11 17917.00 262341.3  0  0  0  0 1.14 0.17 0.1 0.24 0.31 0.25
## Trial 10     0.02 17917.00 262341.4  0  0  0  0 1.14 0.17 0.1 0.24 0.31 0.25
## Trial 11     0.01 17917.00 262341.4  0  0  0  0 1.14 0.17 0.1 0.24 0.31 0.25
## Trial 12     0.32 17916.99 262341.7  0  0  0  0 1.14 0.17 0.1 0.24 0.31 0.25
## Trial 13     0.59 17916.98 262340.8  0  0  0  0 1.14 0.17 0.1 0.24 0.31 0.25
## Trial 14     0.26 17917.00 262341.2  0  0  0  0 1.14 0.17 0.1 0.24 0.31 0.25
## Trial 15     0.08 17917.00 262341.3  0  0  0  0 1.14 0.17 0.1 0.24 0.31 0.25
## Trial 16     0.16 17917.00 262341.2  0  0  0  0 1.14 0.17 0.1 0.24 0.31 0.25
## Trial 17     0.19 17917.00 262341.2  0  0  0  0 1.14 0.17 0.1 0.24 0.31 0.25
## Trial 18     0.12 17917.00 262341.3  0  0  0  0 1.14 0.17 0.1 0.24 0.31 0.25
## Trial 19     0.46 17917.07 262341.9  0  0  0  0 1.14 0.17 0.1 0.24 0.31 0.25
## Trial 20     0.04 17917.00 262341.5  0  0  0  0 1.14 0.17 0.1 0.24 0.31 0.25
## Trial 21     0.00       NA       NA NA NA NA NA   NA   NA  NA   NA   NA   NA
## Trial 22     0.66 17917.00 262342.1  0  0  0  0 1.14 0.17 0.1 0.24 0.31 0.25
## Trial 23     0.16 17917.04 262341.2  0  0  0  0 1.14 0.17 0.1 0.24 0.31 0.25
## Trial 24     0.23 17916.99 262341.2  0  0  0  0 1.14 0.17 0.1 0.24 0.31 0.25
## Trial 25     0.00       NA       NA NA NA NA NA   NA   NA  NA   NA   NA   NA
## Trial 26     0.24 17916.99 262341.2  0  0  0  0 1.14 0.17 0.1 0.24 0.31 0.25
## Trial 27     0.58 17917.00 262340.8  0  0  0  0 1.14 0.17 0.1 0.24 0.31 0.25
## Trial 28     0.23 17917.01 262341.2  0  0  0  0 1.14 0.17 0.1 0.24 0.31 0.25
## Trial 29     0.42 17917.03 262341.8  0  0  0  0 1.14 0.17 0.1 0.24 0.31 0.25
## Trial 30     0.16 17917.01 262341.6  0  0  0  0 1.14 0.17 0.1 0.24 0.31 0.25
##           sdi  sdc
## Basevec  0.18 0.08
## Trial 1  0.18 0.08
## Trial 2  0.18 0.08
## Trial 3    NA   NA
## Trial 4  0.18 0.08
## Trial 5  0.18 0.08
## Trial 6  0.18 0.08
## Trial 7  0.18 0.08
## Trial 8  0.18 0.08
## Trial 9  0.18 0.08
## Trial 10 0.18 0.08
## Trial 11 0.18 0.08
## Trial 12 0.18 0.08
## Trial 13 0.18 0.08
## Trial 14 0.18 0.08
## Trial 15 0.18 0.08
## Trial 16 0.18 0.08
## Trial 17 0.18 0.08
## Trial 18 0.18 0.08
## Trial 19 0.18 0.08
## Trial 20 0.18 0.08
## Trial 21   NA   NA
## Trial 22 0.18 0.08
## Trial 23 0.18 0.08
## Trial 24 0.18 0.08
## Trial 25   NA   NA
## Trial 26 0.18 0.08
## Trial 27 0.18 0.08
## Trial 28 0.18 0.08
## Trial 29 0.18 0.08
## Trial 30 0.18 0.08
```

```
fit=res2
get.par("logBmBmsy", fit, exp=TRUE, CI = 0.9)
```

```
##                  ll      est       ul        sd        cv
## logBmBmsy 0.4970286 1.587872 5.072821 0.7061433 0.8040385
```

```
get.par("logFmFmsy", fit, exp=TRUE, CI = 0.9)
```

```
##                   ll       est       ul      sd       cv
## logFmFmsy 0.04870058 0.3506347 2.524502 1.20014 1.795024
```

I also compute AIC value:

```
get.AIC(res2)
```

```
## [1] 74.13231
```

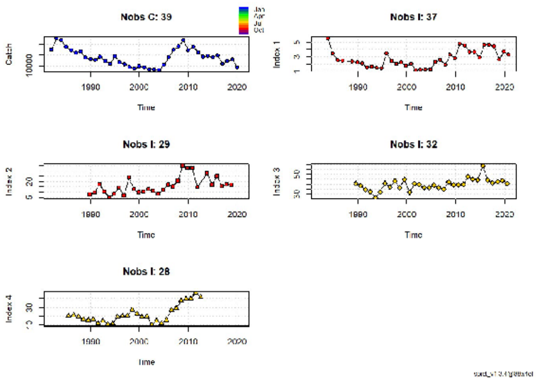
3 Run 3: Using four abundance indices: Portugues survey,Spanish survey, Spanish CPUE and Portugues CPUE. Default priors except logbkfrac. CATCH SERIES FROM 1982 TO 2020.

```
ind=which(C_hake$timeC==1982)
ind2=which(C_hake$timeC==2020)


inp3 <- list(timeC = C_hake$timeC[ind:ind2], obsC = C_hake$obsC[ind:ind2],
            timeI = list(I_S$timeI, I_P$timeI,
                         CPUE_P$timeI+0.5, CPUE_S$timeI+0.5),
            obsI = list(I_S$obsI, I_P$obsI,
                        CPUE_P$obsI, CPUE_S$obsI))
inp3$priors$logbkfrac <- c(log(0.6),0.5,1)
inp3=check.inp(inp3)
```

```
## Removing zero, negative, and NAs in  I  series  1
## Removing zero, negative, and NAs in  I  series  2
## Removing zero, negative, and NAs in  I  series  3
## Removing zero, negative, and NAs in  I  series  4
```

The data can be plotted using the command:

```
plotspict.data(inp3)
```



The model is fitted to data by running:

```
res3 <- fit.spict(inp3)
```

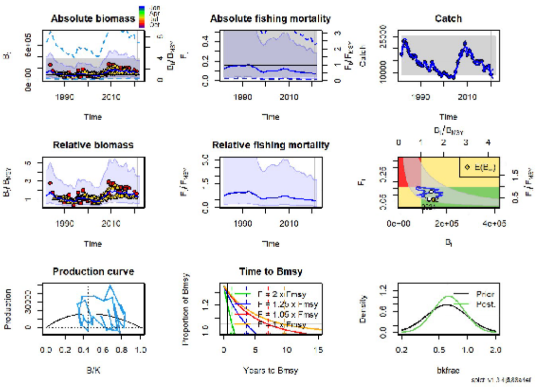
The results are summarized using:

```
capture.output(summary(res3))
```

```
##  [1] "Convergence: 0  MSG: relative convergence (4)"
##  [2] "Objective function at optimum: 17.1803073"
##  [3] "Euler time step (years):  1/16 or 0.0625"
##  [4] "Nobs C: 39,  Nobs I1: 37,  Nobs I2: 29,  Nobs I3: 32,  Nobs I4: 28"
##  [5] ""
##  [6] "Priors"
##  [7] " logbkfrac  ~  dnorm[log(0.6), 0.5^2]"
##  [8] "      logn  ~  dnorm[log(2), 2^2]"
##  [9] "  logalpha  ~  dnorm[log(1), 2^2]"
## [10] "   logbeta  ~  dnorm[log(1), 2^2]"
## [11] ""
## [12] "Model parameter estimates w 95% CI "
## [13] "           estimate        cilow        ciupp     log.est  "
## [14] " alpha1 1.523350e+00 8.811850e-01 2.633495e+00   0.4209121  "
## [15] " alpha2 1.964244e+00 1.179826e+00 3.270188e+00   0.6751073  "
## [16] " alpha3 1.583993e+00 1.017617e+00 2.465598e+00   0.4599490  "
## [17] " alpha4 1.150858e+00 5.706501e-01 2.320994e+00   0.1405081  "
## [18] " beta   4.667370e-01 1.315709e-01 1.655711e+00  -0.7619894  "
## [19] " r      2.562095e-01 1.356250e-02 4.840067e+00  -1.3617597  "
```

```
## [20] " rc     3.302655e-01 7.887360e-02 1.382912e+00  -1.1078585  "
## [21] " rold   4.645375e-01 4.363000e-04 4.946366e+02  -0.7667130  "
## [22] " m      1.613331e+04 8.823531e+03 2.949881e+04   9.6886413  "
## [23] " K      2.166526e+05 4.176339e+04 1.123912e+06  12.2860506  "
## [24] " q1     2.150000e-05 3.000000e-06 1.560000e-04 -10.7478496  "
## [25] " q2     1.283000e-04 1.750000e-05 9.385000e-04  -8.9610431  "
## [26] " q3     3.423000e-04 4.700000e-05 2.494900e-03  -7.9797342  "
## [27] " q4     1.934000e-04 2.640000e-05 1.415600e-03  -8.5509221  "
## [28] " n      1.551537e+00 5.251000e-02 4.584399e+01   0.4392459  "
## [29] " sdb    1.602805e-01 1.075202e-01 2.389304e-01  -1.8308298  "
## [30] " sdf    1.052935e-01 6.262080e-02 1.770451e-01  -2.2510041  "
## [31] " sdi1   2.441634e-01 1.806643e-01 3.299808e-01  -1.4099178  "
## [32] " sdi2   3.148300e-01 2.378276e-01 4.167638e-01  -1.1557225  "
## [33] " sdi3   2.538832e-01 1.736601e-01 3.711659e-01  -1.3708808  "
## [34] " sdi4   1.844602e-01 1.169306e-01 2.909894e-01  -1.6903217  "
## [35] " sdc    4.914430e-02 1.857920e-02 1.299931e-01  -3.0129935  "
## [36] " "
## [37] "Deterministic reference points (Drp)"
## [38] "           estimate        cilow        ciupp   log.est  "
## [39] " Bmsyd 9.769904e+04 1.747759e+04 5.461339e+05 11.489647  "
## [40] " Fmsyd 1.651327e-01 3.943680e-02 6.914562e-01 -1.801006  "
## [41] " MSYd  1.613331e+04 8.823531e+03 2.949881e+04  9.688641  "
## [42] "Stochastic reference points (Srp)"
## [43] "           estimate        cilow        ciupp   log.est rel.diff.Drp  "
## [44] " Bmsys 9.335170e+04 17581.517575 4.956649e+05 11.444129  -0.04656940  "
## [45] " Fmsys 1.616192e-01     0.033569 7.781207e-01 -1.822512  -0.02173961  "
## [46] " MSYs  1.507215e+04  8212.023155 2.766308e+04  9.620604  -0.07040505  "
## [47] ""
## [48] "States w 95% CI (inp$msytype: s)"
## [49] "                     estimate        cilow        ciupp    log.est  "
## [50] " B_2020.94      1.263275e+05 1.790303e+04 8.913931e+05 11.7466332  "
## [51] " F_2020.94      7.169350e-02 1.005490e-02 5.111912e-01 -2.6353549  "
## [52] " B_2020.94/Bmsy 1.353243e+00 4.231773e-01 4.327420e+00  0.3025038  "
## [53] " F_2020.94/Fmsy 4.435953e-01 8.666760e-02 2.270476e+00 -0.8128426  "
## [54] ""
## [55] "Predictions w 95% CI (inp$msytype: s)"
## [56] "                   prediction        cilow        ciupp    log.est  "
## [57] " B_2022.00      1.306748e+05 1.946387e+04 8.773133e+05 11.7804674  "
## [58] " F_2022.00      7.169370e-02 9.940100e-03 5.170948e-01 -2.6353525  "
## [59] " B_2022.00/Bmsy 1.399812e+00 4.570623e-01 4.287104e+00  0.3363380  "
## [60] " F_2022.00/Fmsy 4.435964e-01 8.548040e-02 2.302021e+00 -0.8128402  "
## [61] " Catch_2021.00  9.217424e+03 6.709937e+03 1.266195e+04  9.1288508  "
## [62] " E(B_inf)       1.437458e+05           NA           NA 11.8758019  "
```

```
plot(res3,CI = 0.9)
```



Checklist for the acceptance of a SPiCT assessment

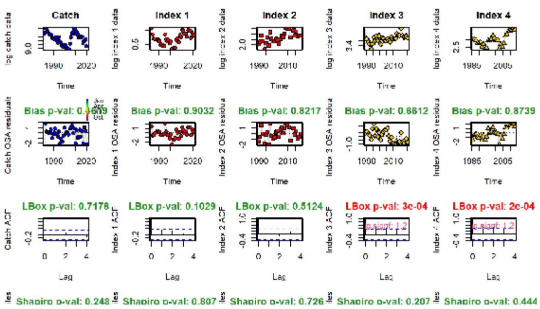
```
res3$opt$convergence
```

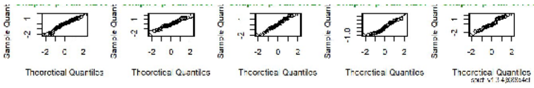
```
## [1] 0
```

```
all(is.finite(res3$sd))
```

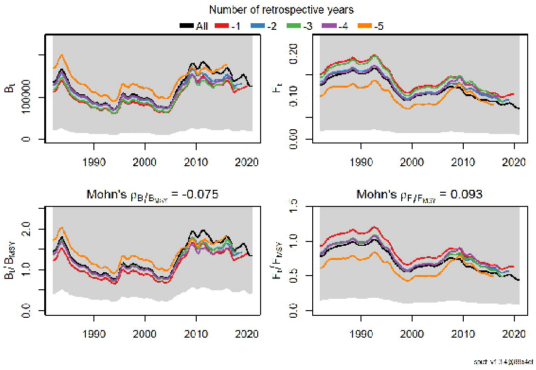
```
## [1] TRUE
```

```
r3 <- calc.osa.resid(res3)
plotspict.diagnostic(r3)
```



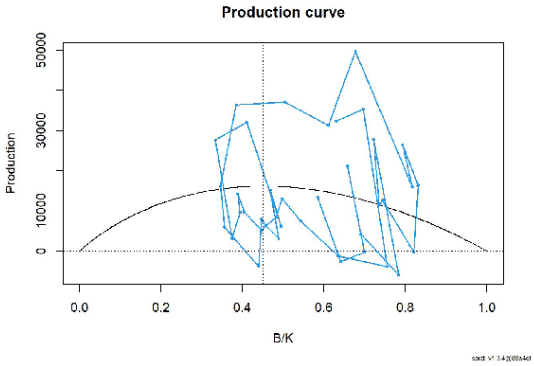



```
r3<- fit.spict(inp3)
rep3=retro(r3, nretroyear=5)
plotspict.retro(rep3)
```




```
##        FFmsy       BBmsy
##   0.09278796 -0.07538972
```

```
plotspict.production(res3)
```




```
set.seed(1234)
a=check.ini(inp3, ntrials=30,verbose = FALSE)
```

```
## Warning in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control): NA/
## NaN function evaluation
```

```
## Error in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control) :
##   gradient function must return a numeric vector of length 14
## obj$par:
##        logm        logK        logq        logq        logq        logq
##   9.4348351   9.3355493 -10.7870243 -10.6051867  -9.6720196 -11.1742752
##        logn      logsdb      logsdf      logsdi      logsdi      logsdi
##   2.2190475  -0.4136104  -2.9852415  -2.7201597   0.6569985  -0.1940281
##      logsdi      logsdc
##  -1.3638277  -0.9352129
## obj$fn:
## [1] NaN
## obj$gr:
## [1] NaN
## Error in fit.spict(inpsens) :
##   Could not fit model. Error msg:Error in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.
control) :
##   gradient function must return a numeric vector of length 14
```

```
## Warning in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control): NA/
## NaN function evaluation

## Warning in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control): NA/
## NaN function evaluation

## Warning in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control): NA/
## NaN function evaluation

## Warning in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control): NA/
## NaN function evaluation

## Warning in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control): NA/
```

```
## NaN function evaluation

## Warning in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control): NA/
## NaN function evaluation

## Warning in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control): NA/
## NaN function evaluation

## Warning in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control): NA/
## NaN function evaluation

## Warning in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control): NA/
## NaN function evaluation

## Warning in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control): NA/
## NaN function evaluation
```

```
a$check.ini$resmat
```

```
##          Distance        m        K  q  q  q  q    n  sdb  sdf  sdi  sdi  sdi
## Basevec      0.00 16133.31 216652.6  0  0  0  0 1.55 0.16 0.11 0.24 0.31 0.25
## Trial 1      0.14 16133.29 216652.5  0  0  0  0 1.55 0.16 0.11 0.24 0.31 0.25
## Trial 2      1.85 16133.38 216654.5  0  0  0  0 1.55 0.16 0.11 0.24 0.31 0.25
## Trial 3      0.00       NA       NA NA NA NA NA   NA   NA   NA   NA   NA   NA
## Trial 4      0.08 16133.30 216652.6  0  0  0  0 1.55 0.16 0.11 0.24 0.31 0.25
## Trial 5      1.16 16133.28 216651.5  0  0  0  0 1.55 0.16 0.11 0.24 0.31 0.25
## Trial 6      0.21 16133.30 216652.9  0  0  0  0 1.55 0.16 0.11 0.24 0.31 0.25
## Trial 7      0.29 16133.31 216652.4  0  0  0  0 1.55 0.16 0.11 0.24 0.31 0.25
## Trial 8      0.23 16133.31 216652.9  0  0  0  0 1.55 0.16 0.11 0.24 0.31 0.25
## Trial 9      0.03 16133.30 216652.7  0  0  0  0 1.55 0.16 0.11 0.24 0.31 0.25
## Trial 10     0.07 16133.31 216652.7  0  0  0  0 1.55 0.16 0.11 0.24 0.31 0.25
## Trial 11     0.08 16133.30 216652.7  0  0  0  0 1.55 0.16 0.11 0.24 0.31 0.25
## Trial 12     0.25 16133.31 216652.4  0  0  0  0 1.55 0.16 0.11 0.24 0.31 0.25
## Trial 13     0.18 16133.31 216652.8  0  0  0  0 1.55 0.16 0.11 0.24 0.31 0.25
## Trial 14     0.00       NA       NA NA NA NA NA   NA   NA   NA   NA   NA   NA
## Trial 15     0.05 16133.31 216652.6  0  0  0  0 1.55 0.16 0.11 0.24 0.31 0.25
## Trial 16     0.05 16133.31 216652.7  0  0  0  0 1.55 0.16 0.11 0.24 0.31 0.25
## Trial 17     0.03 16133.31 216652.7  0  0  0  0 1.55 0.16 0.11 0.24 0.31 0.25
## Trial 18     0.14 16133.31 216652.8  0  0  0  0 1.55 0.16 0.11 0.24 0.31 0.25
## Trial 19     0.23 16133.31 216652.9  0  0  0  0 1.55 0.16 0.11 0.24 0.31 0.25
## Trial 20     0.31 16133.31 216653.0  0  0  0  0 1.55 0.16 0.11 0.24 0.31 0.25
## Trial 21     0.33 16133.30 216653.0  0  0  0  0 1.55 0.16 0.11 0.24 0.31 0.25
## Trial 22     0.24 16133.33 216652.9  0  0  0  0 1.55 0.16 0.11 0.24 0.31 0.25
## Trial 23     0.03 16133.30 216652.7  0  0  0  0 1.55 0.16 0.11 0.24 0.31 0.25
## Trial 24     0.19 16133.31 216652.8  0  0  0  0 1.55 0.16 0.11 0.24 0.31 0.25
## Trial 25     0.00       NA       NA NA NA NA NA   NA   NA   NA   NA   NA   NA
## Trial 26     0.15 16133.30 216652.8  0  0  0  0 1.55 0.16 0.11 0.24 0.31 0.25
## Trial 27     0.09 16133.30 216652.5  0  0  0  0 1.55 0.16 0.11 0.24 0.31 0.25
## Trial 28     0.72 16133.32 216653.4  0  0  0  0 1.55 0.16 0.11 0.24 0.31 0.25
## Trial 29     0.52 16133.32 216653.2  0  0  0  0 1.55 0.16 0.11 0.24 0.31 0.25
## Trial 30     0.43 16133.30 216652.2  0  0  0  0 1.55 0.16 0.11 0.24 0.31 0.25
##           sdi  sdc
## Basevec  0.18 0.05
## Trial 1  0.18 0.05
## Trial 2  0.18 0.05
## Trial 3    NA   NA
## Trial 4  0.18 0.05
## Trial 5  0.18 0.05
## Trial 6  0.18 0.05
## Trial 7  0.18 0.05
## Trial 8  0.18 0.05
## Trial 9  0.18 0.05
## Trial 10 0.18 0.05
## Trial 11 0.18 0.05
## Trial 12 0.18 0.05
## Trial 13 0.18 0.05
## Trial 14   NA   NA
## Trial 15 0.18 0.05
## Trial 16 0.18 0.05
## Trial 17 0.18 0.05
## Trial 18 0.18 0.05
## Trial 19 0.18 0.05
## Trial 20 0.18 0.05
## Trial 21 0.18 0.05
## Trial 22 0.18 0.05
## Trial 23 0.18 0.05
## Trial 24 0.18 0.05
## Trial 25   NA   NA
## Trial 26 0.18 0.05
## Trial 27 0.18 0.05
## Trial 28 0.18 0.05
## Trial 29 0.18 0.05
## Trial 30 0.18 0.05
```

```
fit=res3
get.par("logBmBmsy", fit, exp=TRUE, CI = 0.9)
```

```
##                  ll      est       ul       sd        cv
## logBmBmsy 0.5124627 1.356206 3.589131 0.591675 0.6474412
```

```
get.par("logFmFmsy", fit, exp=TRUE, CI = 0.9)
```

```
##                 ll       est       ul        sd      cv
## logFmFmsy 0.112608 0.4435953 1.747449 0.8335088 1.00159
```

I also compute AIC value:

```
get.AIC(res3)
```

```
## [1] 62.36061
```

3.1 Sensitivity Analysis for prior values of Run 3

```
BKPrior <- list ("Baseline" = c(log(0.6),0.5, 1), "HighMean" = c(log(0.8),0.5,1), "LowMean" = c(log(0
```

```
.4),0.5,1),"HighSD" = c(log(0.6),1,1))

warn<-options(warn=-1)
options(warn)

out2 <- data.frame()
for (i in 1:length (BKPrior))
  {
      hakeSens <- inp1
      hakeSens$priors$logbkfrac <- BKPrior[[i]]
      res <- tryCatch(fit.spict(hakeSens),
             error = function()  next)
      out <- cbind(names(BKPrior[i]), as.numeric(as.character(res$opt$convergence)), res$opt$message,
as.numeric(as.character(round(res$opt$objective,3))),as.numeric(as.character(round(res$report$MSY,0))
),as.numeric(as.character(round(res$value["Fmsy"],2))),as.numeric(as.character(round(res$value["Bmsy"
],0))),calc.bmsyk(res), as.numeric(as.character(res$value["K"])), round(sumspict.parest(res)["n",1],2
), get.par("logBmBmsy", res, exp=TRUE, CI = 0.90)[2],get.par("logBmBmsy", res, exp=TRUE, CI = 0.90)[1
],get.par("logBmBmsy", res, exp=TRUE, CI = 0.90)[3],get.par("logFmFmsy", res, exp=TRUE, CI = 0.90)[2]
,get.par("logFmFmsy", res, exp=TRUE, CI = 0.90)[1],get.par("logFmFmsy", res, exp=TRUE, CI = 0.90)[3])

    out2 <- rbind(out2, out)


  }

names(out2) <- c("BKPrior", "Convergence", "TypeConve", "ObjectiveFunction", "MSY", "Fmsy", "Bmsy", "
BKfrac", "K", "n", "BBmsy", "BBmsycilow","BBmsyciupp","FBmsy", "FBmsycilow","FBmsyciupp")

rownames(out2) <- NULL
out2
```

```
##    BKPrior Convergence                TypeConve ObjectiveFunction   MSY Fmsy
## 1 Baseline           0 relative convergence (4)             17.18 15072 0.16
## 2 HighMean           0 relative convergence (4)            17.192 15729 0.14
## 3  LowMean           0 relative convergence (4)             17.35 15041 0.18
## 4   HighSD           0 relative convergence (4)            17.812 15228 0.16
##     Bmsy            BKfrac                K    n            BBmsy
## 1  93352 0.450947811053079  216652.64528554 1.55 1.35620644792657
## 2 114735  0.50154451842007 241132.635320249 2.02 1.40085577481698
## 3  81091  0.34525714564271 244435.346798214 0.88 1.27248430140332
## 4  97890 0.467772756820755 219413.817096434 1.69 1.36676658361092
##          BBmsycilow       BBmsyciupp             FBmsy         FBmsycilow
## 1 0.512462722136467 3.58913116983328 0.443595295860768  0.112607998163333
## 2 0.438225960360909 4.47804803764232 0.410067295740994 0.0608956873389662
## 3 0.462693632379866 3.49954307559726 0.492829453767571  0.148065016298217
## 4 0.501898391560286 3.72197027423842 0.435156913846327 0.0995919812471287
##         FBmsyciupp
## 1 1.74744946823747
## 2 2.76136446412573
## 3 1.64036635103364
## 4 1.90137335653938
```

4 Run 4: Using two abundance indices: Portugues survey, Spanish survey, and a mean effort index. Default priors. CATCH SERIES FROM 1982 TO 2020.

Defining the effort using (catch/CPUE):

```
EP=CPUE_P;colnames(EP)=c("obsE","timeE")
ES=EP

EP$obsE=C_hake$obsC/CPUE_P$obsI
ES$obsE=C_hake$obsC/CPUE_S$obsI
```

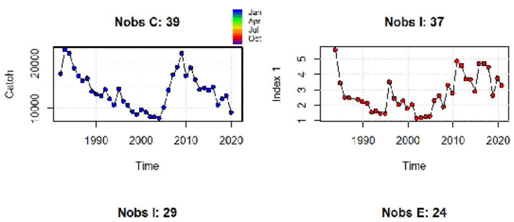
The model only allows us to introduce one of the indices. For this reason we define an average index.

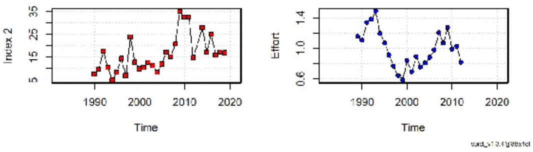
```
EG=EP

EG$obsE=((EP$obsE/mean(EP$obsE,na.rm=TRUE)) + (ES$obsE/mean(ES$obsE,na.rm = TRUE)))/2

ind=which(C_hake$timeC==1982)
ind2=which(C_hake$timeC==2020)

inp4 <- list(timeC = C_hake$timeC[ind:ind2], obsC = C_hake$obsC[ind:ind2],
           timeI = list(I_S$timeI, I_P$timeI),
           obsI = list(I_S$obsI, I_P$obsI),
           timeE = EG$timeE,
           obsE = EG$obsE)


inp4=check.inp(inp4)
```

```
## Removing zero, negative, and NAs in  I  series  1
## Removing zero, negative, and NAs in  I  series  2
## Removing zero, negative, and NAs in  E  series
```

The data can be plotted using the command:

```
plotspict.data(inp4)
```





The model is fitted to data by running:

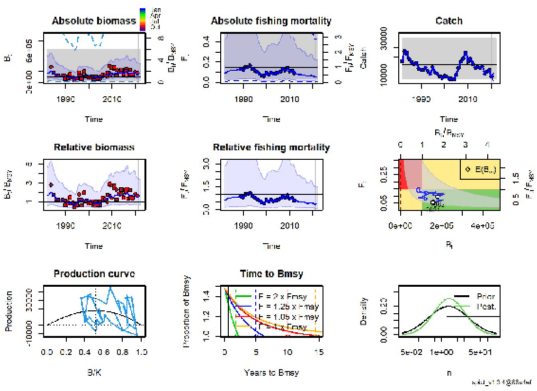
```
res4 <- fit.spict(inp4)
```

The results are summarized using:

```
capture.output(summary(res4))
```

```
##  [1] "Convergence: 0  MSG: relative convergence (4)"
##  [2] "Objective function at optimum: 2.3828726"
##  [3] "Euler time step (years):  1/16 or 0.0625"
##  [4] "Nobs C: 39,  Nobs I1: 37,  Nobs I2: 29,  Nobs E: 24"
##  [5] ""
##  [6] "Priors"
##  [7] "     logn  ~  dnorm[log(2), 2^2]"
##  [8] " logalpha  ~  dnorm[log(1), 2^2]"
##  [9] "  logbeta  ~  dnorm[log(1), 2^2]"
## [10] ""
## [11] "Model parameter estimates w 95% CI "
## [12] "           estimate        cilow        ciupp     log.est  "
## [13] " alpha1 1.386340e+00 8.401490e-01 2.287618e+00   0.3266675  "
## [14] " alpha2 2.070556e+00 1.284778e+00 3.336919e+00   0.7278170  "
## [15] " beta   2.295474e-01 4.464500e-02 1.180244e+00  -1.4716456  "
## [16] " r      3.401836e-01 2.483670e-02 4.659432e+00  -1.0782697  "
## [17] " rc     3.133315e-01 6.031520e-02 1.627727e+00  -1.1604934  "
## [18] " rold   2.904084e-01 6.585100e-03 1.280721e+01  -1.2364670  "
## [19] " m      1.744424e+04 7.655644e+03 3.974863e+04   9.7667646  "
## [20] " K      2.158469e+05 3.139508e+04 1.483987e+06  12.2823248  "
## [21] " q1     1.880000e-05 1.600000e-06 2.215000e-04 -10.8799465  "
## [22] " q2     1.146000e-04 9.700000e-06 1.355600e-03  -9.0740540  "
## [23] " qf     1.107072e-01 9.349600e-03 1.310875e+00  -2.2008660  "
## [24] " n      2.171397e+00 9.837120e-02 4.793036e+01   0.7753709  "
## [25] " sdb    1.649140e-01 1.124730e-01 2.418059e-01  -1.8023309  "
## [26] " sdf    1.394660e-01 9.578770e-02 2.030611e-01  -1.9699345  "
## [27] " sdi1   2.286270e-01 1.728033e-01 3.024844e-01  -1.4756634  "
## [28] " sdi2   3.414637e-01 2.599361e-01 4.485620e-01  -1.0745139  "
## [29] " sde    8.199150e-02 5.183890e-02 1.296827e-01  -2.5011397  "
## [30] " sdc    3.201410e-02 6.949100e-03 1.474878e-01  -3.4415801  "
## [31] " "
## [32] "Deterministic reference points (Drp)"
## [33] "          estimate        cilow        ciupp   log.est  "
## [34] " Bmsyd 1.113468e+05 1.232493e+04 1.005938e+06 11.620405  "
## [35] " Fmsyd 1.566658e-01 3.015760e-02 8.138634e-01 -1.853641  "
## [36] " MSYd  1.744424e+04 7.655644e+03 3.974863e+04  9.766765  "
## [37] "Stochastic reference points (Srp)"
## [38] "          estimate        cilow        ciupp   log.est rel.diff.Drp  "
## [39] " Bmsys 1.055818e+05 12527.334749 8.898551e+05 11.567241  -0.05460268  "
## [40] " Fmsys 1.487588e-01     0.022235 9.952429e-01 -1.905429  -0.05315297  "
## [41] " MSYs  1.566063e+04  7205.507185 3.403722e+04  9.658905  -0.11389090  "
## [42] ""
## [43] "States w 95% CI (inp$msytype: s)"
## [44] "                   estimate        cilow        ciupp    log.est  "
## [45] " B_2020.94      1.571197e+05 1.394635e+04 1.770112e+06 11.9647631  "
## [46] " F_2020.94      5.513650e-02 4.813900e-03 6.315125e-01 -2.8979429  "
## [47] " B_2020.94/Bmsy 1.488133e+00 5.424477e-01 4.082492e+00  0.3975220  "
## [48] " F_2020.94/Fmsy 3.706438e-01 7.109290e-02 1.932358e+00 -0.9925138  "
## [49] ""
## [50] "Predictions w 95% CI (inp$msytype: s)"
## [51] "                 prediction        cilow        ciupp    log.est  "
## [52] " B_2022.00      1.603437e+05 1.520026e+04 1.691425e+06 11.9850748  "
## [53] " F_2022.00      5.513670e-02 4.736500e-03 6.418402e-01 -2.8979398  "
## [54] " B_2022.00/Bmsy 1.518668e+00 5.821235e-01 3.961965e+00  0.4178337  "
## [55] " F_2022.00/Fmsy 3.706450e-01 6.941670e-02 1.979029e+00 -0.9925107  "
## [56] " Catch_2021.00  8.755587e+03 6.248867e+03 1.226787e+04  9.0774473  "
## [57] " E(B_inf)       1.580323e+05           NA           NA 11.9705545  "
```

```
plot(res4,CI = 0.9)
```



Checklist for the acceptance of a SPiCT assessment

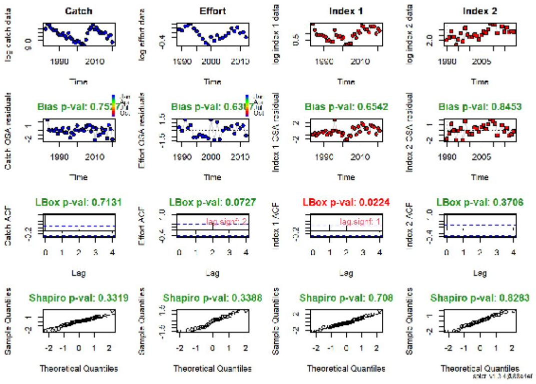
```
res4$opt$convergence
```

```
## [1] 0
```

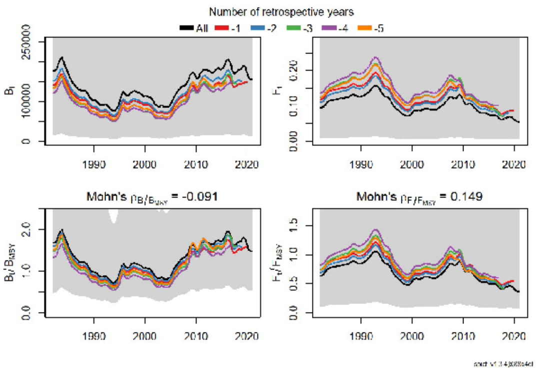
```
all(is.finite(res4$sd))
```

```
## [1] TRUE
```

```
r4 <- calc.osa.resid(res4)
plotspict.diagnostic(r4)
```

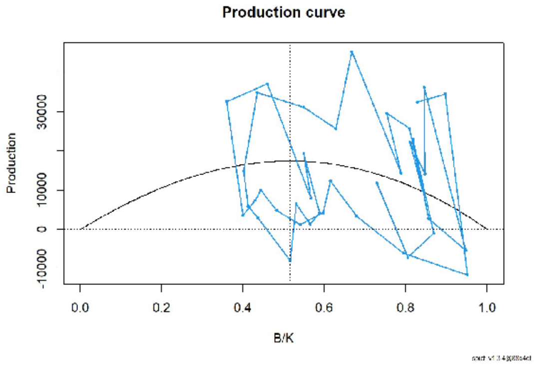



```
r4<- fit.spict(inp4)
rep4=retro(r4, nretroyear=5)
plotspict.retro(rep4)
```




```
##        FFmsy       BBmsy
##  0.14899125 -0.09121153
```

```
plotspict.production(res4)
```




```
set.seed(1234)
a=check.ini(inp4, ntrials=30,verbose = FALSE)
```

```
## Warning in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control): NA/
```

```
## NaN function evaluation

## Warning in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control): NA/
## NaN function evaluation
```

```
## Error in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control) :
##   gradient function must return a numeric vector of length 12
## obj$par:
##        logm        logK        logq        logq       logqf        logn
##   8.7951340   9.3175293 -11.9449332 -10.9074999   0.1503767   2.3732691
##      logsdb      logsdf      logsdi      logsdi      logsde      logsdc
##  -2.4931942  -1.5700749  -3.6741815  -1.3120828   0.1996405  -3.3525861
## obj$fn:
## [1] NaN
## obj$gr:
## [1] NaN
## Error in fit.spict(inpsens) :
##   Could not fit model. Error msg:Error in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.
control) :
##   gradient function must return a numeric vector of length 12
```

```
## Warning in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control): NA/
## NaN function evaluation

## Warning in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control): NA/
## NaN function evaluation

## Warning in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control): NA/
## NaN function evaluation

## Warning in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control): NA/
## NaN function evaluation

## Warning in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control): NA/
## NaN function evaluation

## Warning in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control): NA/
## NaN function evaluation

## Warning in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control): NA/
## NaN function evaluation

## Warning in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control): NA/
## NaN function evaluation

## Warning in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control): NA/
## NaN function evaluation

## Warning in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control): NA/
## NaN function evaluation
```

```
a$check.ini$resmat
```

```
##           Distance         m        K  q  q   qf    n  sdb  sdf  sdi  sdi  sde
## Basevec       0.00  17444.24 215846.9  0  0 0.11 2.17 0.16 0.14 0.23 0.34 0.08
## Trial 1       0.49  17444.27 215847.4  0  0 0.11 2.17 0.16 0.14 0.23 0.34 0.08
## Trial 2       0.50  17444.27 215847.4  0  0 0.11 2.17 0.16 0.14 0.23 0.34 0.08
## Trial 3       0.81  17444.28 215847.8  0  0 0.11 2.17 0.16 0.14 0.23 0.34 0.08
## Trial 4       0.78  17444.28 215847.7  0  0 0.11 2.17 0.16 0.14 0.23 0.34 0.08
## Trial 5       0.69  17444.28 215847.6  0  0 0.11 2.17 0.16 0.14 0.23 0.34 0.08
## Trial 6       0.00        NA       NA NA NA   NA   NA   NA   NA   NA   NA   NA
## Trial 7       0.73  17444.27 215847.7  0  0 0.11 2.17 0.16 0.14 0.23 0.34 0.08
## Trial 8       0.76  17444.28 215847.7  0  0 0.11 2.17 0.16 0.14 0.23 0.34 0.08
## Trial 9       0.90  17444.28 215847.8  0  0 0.11 2.17 0.16 0.14 0.23 0.34 0.08
## Trial 10      0.00        NA       NA NA NA   NA   NA   NA   NA   NA   NA   NA
## Trial 11      0.95  17444.29 215847.9  0  0 0.11 2.17 0.16 0.14 0.23 0.34 0.08
## Trial 12      0.93  17444.28 215847.9  0  0 0.11 2.17 0.16 0.14 0.23 0.34 0.08
## Trial 13      0.84  17444.28 215847.8  0  0 0.11 2.17 0.16 0.14 0.23 0.34 0.08
## Trial 14      0.71  17444.28 215847.7  0  0 0.11 2.17 0.16 0.14 0.23 0.34 0.08
## Trial 15      0.79  17444.28 215847.7  0  0 0.11 2.17 0.16 0.14 0.23 0.34 0.08
## Trial 16      0.91  17444.29 215847.9  0  0 0.11 2.17 0.16 0.14 0.23 0.34 0.08
## Trial 17      0.79  17444.28 215847.7  0  0 0.11 2.17 0.16 0.14 0.23 0.34 0.08
## Trial 18      0.20  17444.27 215847.1  0  0 0.11 2.17 0.16 0.14 0.23 0.34 0.08
## Trial 19      0.72  17444.28 215847.7  0  0 0.11 2.17 0.16 0.14 0.23 0.34 0.08
## Trial 20      0.79  17444.28 215847.7  0  0 0.11 2.17 0.16 0.14 0.23 0.34 0.08
## Trial 21      0.76  17444.28 215847.7  0  0 0.11 2.17 0.16 0.14 0.23 0.34 0.08
## Trial 22      0.95  17444.28 215847.9  0  0 0.11 2.17 0.16 0.14 0.23 0.34 0.08
## Trial 23 963856.86 979984.08 266216.6  0  0 0.05 0.31 1.03 0.11 0.26 0.32 0.12
## Trial 24      0.88  17444.28 215847.8  0  0 0.11 2.17 0.16 0.14 0.23 0.34 0.08
## Trial 25      2.95  17444.31 215849.9  0  0 0.11 2.17 0.16 0.14 0.23 0.34 0.08
## Trial 26      0.47  17444.27 215847.4  0  0 0.11 2.17 0.16 0.14 0.23 0.34 0.08
## Trial 27      0.80  17444.28 215847.7  0  0 0.11 2.17 0.16 0.14 0.23 0.34 0.08
## Trial 28      0.94  17444.28 215847.9  0  0 0.11 2.17 0.16 0.14 0.23 0.34 0.08
## Trial 29      0.00        NA       NA NA NA   NA   NA   NA   NA   NA   NA   NA
## Trial 30      0.52  17444.28 215847.5  0  0 0.11 2.17 0.16 0.14 0.23 0.34 0.08
##           sdc
## Basevec  0.03
## Trial 1  0.03
## Trial 2  0.03
## Trial 3  0.03
## Trial 4  0.03
## Trial 5  0.03
## Trial 6    NA
## Trial 7  0.03
## Trial 8  0.03
## Trial 9  0.03
## Trial 10   NA
## Trial 11 0.03
## Trial 12 0.03
## Trial 13 0.03
## Trial 14 0.03
## Trial 15 0.03
## Trial 16 0.03
## Trial 17 0.03
## Trial 18 0.03
## Trial 19 0.03
## Trial 20 0.03
## Trial 21 0.03
```

```
## Trial 22 0.03
## Trial 23 0.03
## Trial 24 0.03
## Trial 25 0.03
## Trial 26 0.03
## Trial 27 0.03
## Trial 28 0.03
## Trial 29   NA
## Trial 30 0.03
```

```
fit=res4
get.par("logBmBmsy", fit, exp=TRUE, CI = 0.9)
```

```
##                 ll      est       ul        sd        cv
## logBmBmsy 0.640684 1.490131 3.465814 0.5131662 0.5488793
```

```
get.par("logFmFmsy", fit, exp=TRUE, CI = 0.9)
```

```
##                   ll       est       ul        sd       cv
## logFmFmsy 0.09259904 0.3706438 1.483567 0.8432135 1.017863
```

I also compute AIC value:

```
get.AIC(res4)
```

```
## [1] 28.76575
```

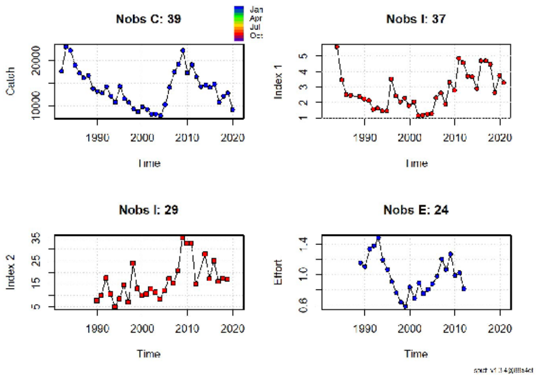
5 Run 5: Using two abundance indices: Portugues survey, Spanish survey, and a mean effort index. Default priors except logbkfrac. CATCH SERIES FROM 1982 TO 2020.

```
ind=which(C_hake$timeC==1982)
ind2=which(C_hake$timeC==2020)

inp5 <- list(timeC = C_hake$timeC[ind:ind2], obsC = C_hake$obsC[ind:ind2],
             timeI = list(I_S$timeI, I_P$timeI),
             obsI = list(I_S$obsI, I_P$obsI),
             timeE = EG$timeE,
             obsE = EG$obsE)

inp5$priors$logbkfrac <- c(log(0.6),0.5,1)
inp5=check.inp(inp5)
```

```
## Removing zero, negative, and NAs in  I  series  1
## Removing zero, negative, and NAs in  I  series  2
## Removing zero, negative, and NAs in  E  series
```

The data can be plotted using the command:

```
plotspict.data(inp5)
```



The model is fitted to data by running:

```
res5 <- fit.spict(inp5)
```

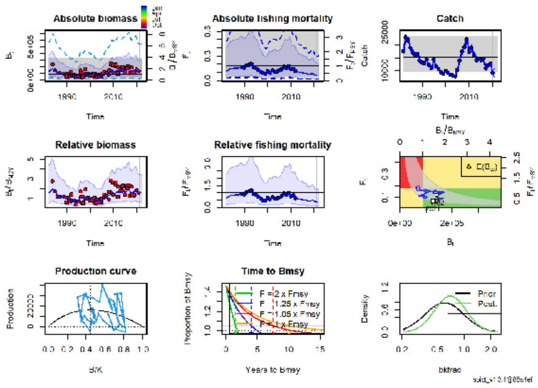
The results are summarized using:

```
capture.output(summary(res5))
```

```
##  [1] "Convergence: 0  MSG: both X-convergence and relative convergence (5)"
##  [2] "Objective function at optimum: -0.393264"
##  [3] "Euler time step (years):  1/16 or 0.0625"
##  [4] "Nobs C: 39,  Nobs I1: 37,  Nobs I2: 29,  Nobs E: 24"
##  [5] ""
##  [6] "Priors"
##  [7] " logbkfrac  ~  dnorm[log(0.6), 0.5^2]"
##  [8] "      logn  ~  dnorm[log(2), 2^2]"
##  [9] "  logalpha  ~  dnorm[log(1), 2^2]"
## [10] "   logbeta  ~  dnorm[log(1), 2^2]"
## [11] ""
## [12] "Model parameter estimates w 95% CI "
```

```
## [13] "              estimate        cilow        ciupp     log.est  "
## [14] " alpha1 1.382318e+00 8.366364e-01 2.283910e+00   0.3237615  "
## [15] " alpha2 2.064838e+00 1.280510e+00 3.329575e+00   0.7250516  "
## [16] " beta   2.276678e-01 4.383030e-02 1.182574e+00  -1.4798678  "
## [17] " r      2.713874e-01 1.366020e-02 5.391654e+00  -1.3042081  "
## [18] " rc     3.588772e-01 9.076280e-02 1.419005e+00  -1.0247751  "
## [19] " rold   5.296140e-01 3.128000e-04 8.967887e+02  -0.6356069  "
## [20] " m      1.615126e+04 9.286283e+03 2.809125e+04   9.6897534  "
## [21] " K      2.018018e+05 4.357332e+04 9.346081e+05  12.2150414  "
## [22] " q1     2.350000e-05 4.100000e-06 1.347000e-04 -10.6575259  "
## [23] " q2     1.431000e-04 2.480000e-05 8.263000e-04  -8.8519223  "
## [24] " qf     1.383362e-01 2.401300e-02 7.969387e-01  -1.9780682  "
## [25] " n      1.512425e+00 4.977950e-02 4.595120e+01   0.4137142  "
## [26] " sdb    1.653739e-01 1.127138e-01 2.426369e-01  -1.7995465  "
## [27] " sdf    1.387076e-01 9.551270e-02 2.014371e-01  -1.9753873  "
## [28] " sdi1   2.285992e-01 1.728197e-01 3.023821e-01  -1.4757850  "
## [29] " sdi2   3.414702e-01 2.598855e-01 4.486664e-01  -1.0744949  "
## [30] " sde    8.225170e-02 5.197720e-02 1.301596e-01  -2.4979718  "
## [31] " sdc    3.157920e-02 6.766000e-03 1.473918e-01  -3.4552551  "
## [32] " "
## [33] "Deterministic reference points (Drp)"
## [34] "             estimate        cilow        ciupp   log.est  "
## [35] " Bmsyd 9.000997e+04 1.752655e+04 4.622583e+05 11.407676  "
## [36] " Fmsyd 1.794386e-01 4.538140e-02 7.095023e-01 -1.717922  "
## [37] " MSYd  1.615126e+04 9.286283e+03 2.809125e+04  9.689753  "
## [38] "Stochastic reference points (Srp)"
## [39] "             estimate        cilow        ciupp   log.est rel.diff.Drp  "
## [40] " Bmsys 8.605201e+04 1.759950e+04 4.207476e+05 11.362707  -0.04599500  "
## [41] " Fmsys 1.759691e-01 3.912390e-02 7.914640e-01 -1.737447  -0.01971640  "
## [42] " MSYs  1.512876e+04 8.985484e+03 2.547213e+04  9.624353  -0.06758642  "
## [43] ""
## [44] "States w 95% CI (inp$msytype: s)"
## [45] "                     estimate        cilow        ciupp    log.est  "
## [46] " B_2020.94      1.267269e+05 2.237469e+04 7.177619e+05 11.7497893  "
## [47] " F_2020.94      6.846900e-02 1.193770e-02 3.927049e-01 -2.6813741  "
## [48] " B_2020.94/Bmsy 1.472678e+00 5.362239e-01 4.044539e+00  0.3870821  "
## [49] " F_2020.94/Fmsy 3.890968e-01 9.851040e-02 1.536855e+00 -0.9439273  "
## [50] ""
## [51] "Predictions w 95% CI (inp$msytype: s)"
## [52] "                   prediction        cilow        ciupp    log.est  "
## [53] " B_2022.00      1.304372e+05 2.401828e+04 7.083721e+05 11.7786475  "
## [54] " F_2022.00      6.846920e-02 1.167410e-02 4.015746e-01 -2.6813716  "
## [55] " B_2022.00/Bmsy 1.515796e+00 5.686673e-01 4.040387e+00  0.4159404  "
## [56] " F_2022.00/Fmsy 3.890977e-01 9.576290e-02 1.580958e+00 -0.9439247  "
## [57] " Catch_2021.00  8.808410e+03 6.309926e+03 1.229619e+04  9.0834622  "
## [58] " E(B_inf)       1.394401e+05           NA           NA 11.8453906  "
```

```
plot(res5,CI = 0.9)
```



Checklist for the acceptance of a SPiCT assessment

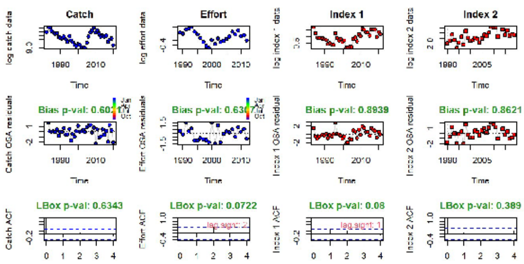
```
res5$opt$convergence
```

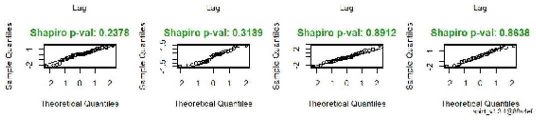
```
## [1] 0
```

```
all(is.finite(res5$sd))
```

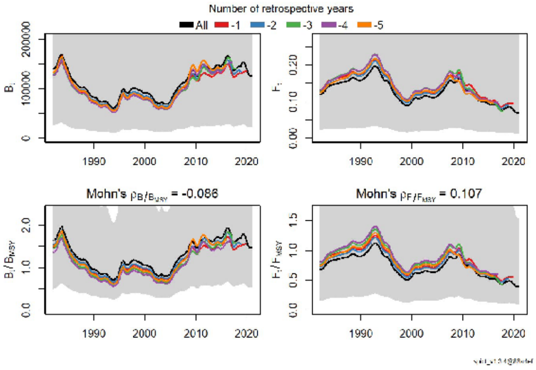
```
## [1] TRUE
```

```
r5 <- calc.osa.resid(res5)
plotspict.diagnostic(r5)
```



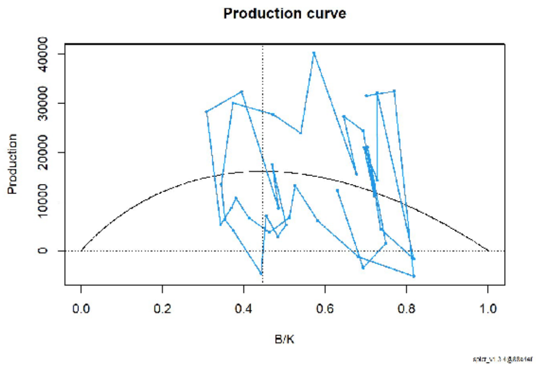



```
r5<- fit.spict(inp5)
rep5=retro(r5, nretroyear=5)
plotspict.retro(rep5)
```




```
##       FFmsy       BBmsy
##  0.10717694 -0.08557766
```

```
plotspict.production(res5)
```




```
set.seed(1234)
a=check.ini(inp5, ntrials=30,verbose = FALSE)
```

```
## Warning in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control): NA/
## NaN function evaluation
```

```
## Error in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.control) :
##   gradient function must return a numeric vector of length 12
## obj$par:
##        logm        logK        logq        logq       logqf        logn
##   8.7951340   9.3175293 -11.9449332 -10.9074999   0.1503767   2.3732691
##      logsdb      logsdf      logsdi      logsdi      logsde      logsdc
##  -2.4931942  -1.5700749  -3.6741815  -1.3120828   0.1996405  -3.3525861
## obj$fn:
## [1] NaN
## obj$gr:
## [1] NaN
## Error in fit.spict(inpsens) :
##   Could not fit model. Error msg:Error in nlminb(obj$par, obj$fn, obj$gr, control = inp$optimiser.
control) :
##   gradient function must return a numeric vector of length 12
```

```
a$check.ini$resmat
```

```
##            Distance         m        K  q  q   qf    n  sdb  sdf  sdi  sdi  sde
## Basevec        0.00  16151.26 201801.8  0  0 0.14 1.51 0.17 0.14 0.23 0.34 0.08
## Trial 1        0.06  16151.25 201801.8  0  0 0.14 1.51 0.17 0.14 0.23 0.34 0.08
## Trial 2        0.00  16151.26 201801.8  0  0 0.14 1.51 0.17 0.14 0.23 0.34 0.08
## Trial 3        0.00  16151.26 201801.8  0  0 0.14 1.51 0.17 0.14 0.23 0.34 0.08
## Trial 4   216822.01 118096.63  10441.1  0  0 0.91 1.10 0.24 0.12 0.20 0.34 0.09
## Trial 5        0.01  16151.26 201801.8  0  0 0.14 1.51 0.17 0.14 0.23 0.34 0.08
## Trial 6        0.00        NA       NA NA NA   NA   NA   NA   NA   NA   NA   NA
## Trial 7        0.00  16151.26 201801.8  0  0 0.14 1.51 0.17 0.14 0.23 0.34 0.08
```

```
## Trial 8        0.09  16151.26 201801.9  0  0 0.14 1.51 0.17 0.14 0.23 0.34 0.08
## Trial 9        0.01  16151.26 201801.8  0  0 0.14 1.51 0.17 0.14 0.23 0.34 0.08
## Trial 10       0.04  16151.26 201801.9  0  0 0.14 1.51 0.17 0.14 0.23 0.34 0.08
## Trial 11       0.01  16151.26 201801.8  0  0 0.14 1.51 0.17 0.14 0.23 0.34 0.08
## Trial 12       0.00  16151.26 201801.8  0  0 0.14 1.51 0.17 0.14 0.23 0.34 0.08
## Trial 13       0.09  16151.26 201801.9  0  0 0.14 1.51 0.17 0.14 0.23 0.34 0.08
## Trial 14       0.15  16151.26 201801.7  0  0 0.14 1.51 0.17 0.14 0.23 0.34 0.08
## Trial 15       0.01  16151.26 201801.8  0  0 0.14 1.51 0.17 0.14 0.23 0.34 0.08
## Trial 16       0.00  16151.26 201801.8  0  0 0.14 1.51 0.17 0.14 0.23 0.34 0.08
## Trial 17       0.02  16151.26 201801.8  0  0 0.14 1.51 0.17 0.14 0.23 0.34 0.08
## Trial 18       0.04  16151.26 201801.9  0  0 0.14 1.51 0.17 0.14 0.23 0.34 0.08
## Trial 19       0.05  16151.26 201801.9  0  0 0.14 1.51 0.17 0.14 0.23 0.34 0.08
## Trial 20       0.00  16151.26 201801.8  0  0 0.14 1.51 0.17 0.14 0.23 0.34 0.08
## Trial 21       0.16  16151.26 201801.7  0  0 0.14 1.51 0.17 0.14 0.23 0.34 0.08
## Trial 22       0.05  16151.26 201801.8  0  0 0.14 1.51 0.17 0.14 0.23 0.34 0.08
## Trial 23       0.00  16151.26 201801.8  0  0 0.14 1.51 0.17 0.14 0.23 0.34 0.08
## Trial 24       0.38  16151.27 201802.2  0  0 0.14 1.51 0.17 0.14 0.23 0.34 0.08
## Trial 25       0.01  16151.27 201801.8  0  0 0.14 1.51 0.17 0.14 0.23 0.34 0.08
## Trial 26       0.00  16151.26 201801.8  0  0 0.14 1.51 0.17 0.14 0.23 0.34 0.08
## Trial 27       0.07  16151.26 201801.8  0  0 0.14 1.51 0.17 0.14 0.23 0.34 0.08
## Trial 28       0.10  16151.26 201801.7  0  0 0.14 1.51 0.17 0.14 0.23 0.34 0.08
## Trial 29 216822.45 118097.76  10441.2  0  0 0.91 1.10 0.24 0.12 0.20 0.34 0.09
## Trial 30       0.01  16151.26 201801.8  0  0 0.14 1.51 0.17 0.14 0.23 0.34 0.08
##             sdc
## Basevec  0.03
## Trial 1  0.03
## Trial 2  0.03
## Trial 3  0.03
## Trial 4  0.04
## Trial 5  0.03
## Trial 6    NA
## Trial 7  0.03
## Trial 8  0.03
## Trial 9  0.03
## Trial 10 0.03
## Trial 11 0.03
## Trial 12 0.03
## Trial 13 0.03
## Trial 14 0.03
## Trial 15 0.03
## Trial 16 0.03
## Trial 17 0.03
## Trial 18 0.03
## Trial 19 0.03
## Trial 20 0.03
## Trial 21 0.03
## Trial 22 0.03
## Trial 23 0.03
## Trial 24 0.03
## Trial 25 0.03
## Trial 26 0.03
## Trial 27 0.03
## Trial 28 0.03
## Trial 29 0.04
## Trial 30 0.03
```

```
fit=res5
get.par("logBmBmsy", fit, exp=TRUE, CI = 0.9)
```

```
##                  ll     est       ul        sd        cv
## logBmBmsy 0.6330481 1.47546 3.438887 0.5144399 0.5504296
```

```
get.par("logFmFmsy", fit, exp=TRUE, CI = 0.9)
```

```
##                  ll       est       ul        sd        cv
## logFmFmsy 0.1226827 0.3890968 1.234048 0.7017201 0.7976569
```

I also compute AIC value:

```
get.AIC(res5)
```

```
## [1] 23.21347
```

5.1 Sensitivity Analysis for prior values of Run 5

```
BKPrior <- list ("Baseline" = c(log(0.6),0.5, 1), "HighMean" = c(log(0.8),0.5,1), "LowMean" = c(log(0
.4),0.5,1),"HighSD" = c(log(0.6),1,1))

warn<-options(warn=-1)
options(warn)

out2 <- data.frame()
for (i in 1:length (BKPrior))
  {
      hakeSens <- inp5
      hakeSens$priors$logbkfrac <- BKPrior[[i]]
      res <- tryCatch(fit.spict(hakeSens),
             error = function()  next)
      out <- cbind(names(BKPrior[i]), as.numeric(as.character(res$opt$convergence)), res$opt$message,
as.numeric(as.character(round(res$opt$objective,3))),as.numeric(as.character(round(res$report$MSY,0))
),as.numeric(as.character(round(res$value["Fmsy"],2))),as.numeric(as.character(round(res$value["Bmsy"
],0))),calc.bmsyk(res), as.numeric(as.character(res$value["K"])), round(sumspict.parest(res)["n",1],2
), get.par("logBmBmsy", res, exp=TRUE, CI = 0.90)[2],get.par("logBmBmsy", res, exp=TRUE, CI = 0.90)[1
],get.par("logBmBmsy", res, exp=TRUE, CI = 0.90)[3],get.par("logFmFmsy", res, exp=TRUE, CI = 0.90)[2]
,get.par("logFmFmsy", res, exp=TRUE, CI = 0.90)[1],get.par("logFmFmsy", res, exp=TRUE, CI = 0.90)[3])

    out2 <- rbind(out2, out)

  }

names(out2) <- c("BKPrior", "Convergence", "TypeConve", "ObjectiveFunction", "MSY", "Fmsy", "Bmsy", "
BKfrac", "K", "n", "BBmsy", "BBmsycilow","BBmsyciupp","FBmsy", "FBmsycilow","FBmsyciupp")

rownames(out2) <- NULL
out2
```

Working document

ICES Working Group for the Celtic Seas Ecoregion
5–14 May 2021
By Correspondence

ICES Working Group for the Assessment of the Bay of Biscay and the Iberian waters Ecoregion
5–12 May 2021
By Correspondence

At-Sea Sampling in Ireland for 2020

Sara-Jane Moore and Hans Gerritsen
Marine Institute
Galway
Ireland

Introduction

In 2020, normal at-sea sampling ceased after quarter 1 and the MI moved towards an at-sea **self** sampling scheme to collect catch data at-sea. This document is a guide to the sampling levels that occurred in 2020.

Material and Methods

The Marine Institute's at-sea data collection programme is based on statistically sound sampling using guidelines from WKPICS, 2013. There are 3 main demersal draw lists for ICES areas 6ab, 7a, 7b-k. A list of randomly selected vessels is contacted in sequence over the period of a quarter and the selection probability of each vessel is proportional to its catches in the preceding year. The theory is that the random selection should result in a representative sample of the catches by the Irish demersal fleet.
Usually, the owner of the vessel is contacted by the industry liaison team leader for a trip to be arranged and an observer is then sent out on that vessel. In Quarter 1 of 2020, the normal programme of at-sea collection was in place.

In Quarter 2, following the COVID-19 outbreak, those normal operations ceased and a new self-sampling programme was introduced whereby the fisher collected a sample of unwanted catch rather than the observer.

The fishers were asked to sample only one haul per day. This included the recording of positional data, bulk catch information, a landings tally and the collection of a random box of unwanted catch. These protocols were the same as the normal observer scheme with the exception of the number of hauls sampled (normally at least 75% of the hauls in a trip would be sampled by observers). As a result, the number of hauls sampled are greatly reduced for Quarters 2-4. The decision to only sample one haul per day was a balance of data collection and resource management. As the protocols were the same as the normal sampling strategy and the data was validated and quality checked, the hauls were treated the same as per the usual raising procedure for stock assessments.

Results

Seven at-sea sampling trips were carried out in Quarter 1 and 35 at-sea self-sampling trips were carried out in Quarters 2-4. A total of 351 hauls were sampled and although sampling was reduced (780 hauls were sampled in 2019) coverage was similar to previous years (Figure 1).

Figure 2 shows the targets and achieved sampling per sampling frame between in 2016 and 2020. This figure is displayed as number of trips so does not reflect the low sampling levels per haul. The biggest impact of reduced sampling is in 7a although sampling numbers have been reduced in this sampling frame in recent years. A total of 3 trips across two metiers was sampled and as a result no discard estimates were submitted for any of the 7a stocks. Sampling levels in 6ab and 7bk are similar but for some stocks there were not enough samples to submit raised discard estimates. Figure 3 displays the number of sampled trips by métier for each sampling frame. Typically the best sampled métiers are the OTB_CRU and OTB_DEF métiers.

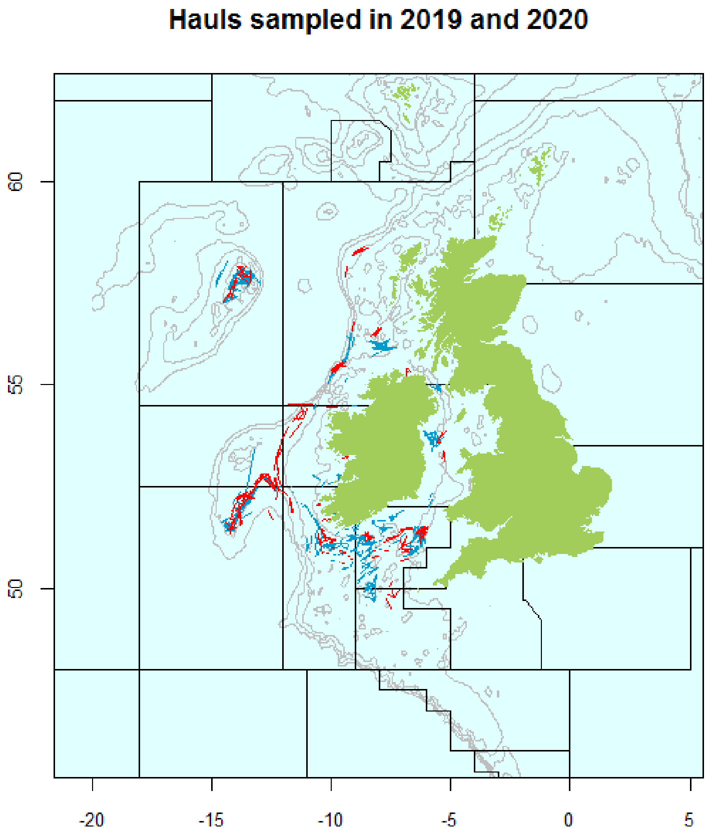


Figure 1. Haul positions sampled in 2020 (red) and for comparison 2019 (blue).

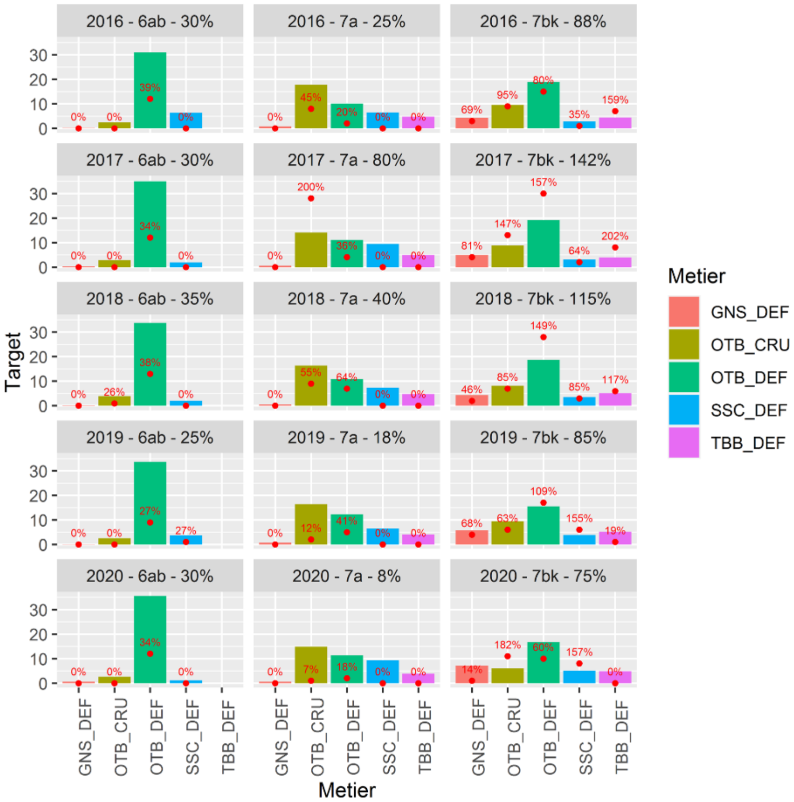


Figure 2. Achieved and target trips per sampling frame for 2016-2020.

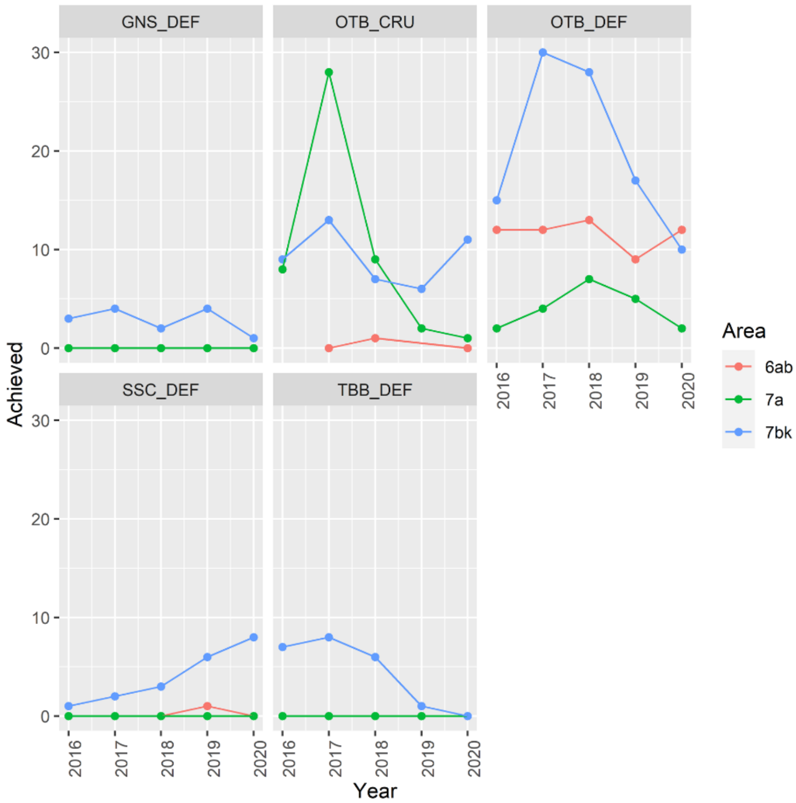


Figure 3. Number of sampled trips by métier for each sampling frame

References

ICES 2013, Report of the third Workshop on Practical Implementation of Statistical Sound Catch Sampling Programmes (WKPICS3). 19-22 November 2013, Copenhagen, Denmark. ICES CM2013 /ACOM:54

Working Document for the ICES Working Group for the Bay of Biscay and the Iberian Waters Ecoregion (*WGBIE*), 05-12 May, 2021

Discards of WGBIE species by the Portuguese bottom otter trawl operating in ICES Division 27.9.a

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Abstract

The information on discards produced by Portuguese vessels operating with bottom otter trawl fleet in Portuguese ICES Division 27.9.a is compiled. The sampling effort, species frequencies of occurrence and discard estimates are presented, for the period 2016-2019. The species included in the WGBIE are the European hake (*Merluccius merluccius*), Norway lobster (*Nephrops norvegicus*), megrim (*Lepidorhombus whiffiagonis*), four-spot megrim (*Lepidorhombus boscii*), common sole (*Solea solea*), plaice (*Pleuronectes platessa*), pollack (*Pollachius pollachius*), whiting (*Merlangius merlangus*) and European seabass (*Dicentrarchus labrax*). The samples were collected by the Portuguese onboard sampling programme (PNAB/EU DCF). The low frequency of occurrence registered by most of these species in OTB fisheries for the whole sampling period 2004-2019 indicates that discards can be considered negligible for assessment purposes, with exception of the European hake that is frequently discarded by this fleet. In 2020, the Portuguese onboard sampling programme was compromised by the pandemic situation due to Covid-19 and the sampling only occurred in the first quarter of the year. For this reason, the sampling effort was not representative of the fishing effort of the bottom otter trawl fleet (OTB) and the algorithm usually used for discards estimation could not be applied. The less frequent species were then considered to have also null or negligible discards in 2020. In the case of European hake, discarded volumes by fleet were calculated from the 2017-2019 discard estimates.

1. Introduction

This working document compiles the information available, from the period 2016-2019, on the discards of European hake (*Merluccius merluccius*), Norway lobster (*Nephrops norvegicus*), megrim (*Lepidorhombus whiffiagonis*), four-spot megrim (*Lepidorhombus boscii*), common sole (*Solea solea*), plaice (*Pleuronectes platessa*), pollack (*Pollachius pollachius*), whiting (*Merlangius merlangus*) and European seabass (*Dicentrarchus labrax*), produced by the Portuguese bottom otter trawl fleet (OTB) (Table 1). The data was collected by the Portuguese onboard sampling programme and a summary of the onboard sampling and discards estimation are presented in Sections 2 and 3. The discard series obtained for the period 2016-2019 is presented in Section 3. Due to the pandemic situation in 2020, very few trips were sampled in the first quarter of the year for the bottom otter trawl targeting demersal species (OTB_DEF), and no trips were sampled in the bottom otter trawl targeting crustaceans (OTB_CRU). Since the sampling effort was not representative of the fishing effort of the fleet, the discard raising procedure previously used (Jardim and Fernandes, 2013) cannot be used to estimate discards at fleet level for 2020, and a different approach for discard estimation was performed.

Table 1 – Species composition and common names of the WGBIE species

Species	3-alpha code	English name	Portuguese name
Dicentrarchus labrax	BSS	European seabass	Robalo-legítimo
Lepidorhombus boscii	LDB	Four-spot megrim	Areeiro-quatro-manchas
Lepidorhombus whiffiagonis	MEG	Megrim	Areeiro
Merlangius merlangus	WHG	Whiting	Badejo
Merluccius merluccius	HKE	European hake	Pescada-branca
Nephrops norvegicus	NEP	Norway lobster	Lagostim
Pleuronectes platessa	PLE	Plaice	Solha
Pollachius pollachius	POL	Pollack	Juliana
Solea solea	SOL	Common sole	Linguado-legítimo

2. Onboard sampling

The Portuguese onboard sampling program, included in the EU DCF/PNAB, uses a stratified random sampling design and the vessel selection is based on an opportunistic sampling of cooperative commercial vessels between 12 and 40 meters' over-all length (LOA). For sampling purposes, the bottom otter trawl fleet is split into two components: a crustacean fishery (OTB_CRU) that operates cod-end mesh sizes 55-59mm and ≥70mm targeting deep-water rose shrimp, Norway lobster and blue whiting and a demersal species fishery (OTB_DEF) that operates cod-end mesh size 65-69mm and ≥70mm and targets horse-mackerel, cephalopods and other finfish. Annual sampling targets are fixed for each fishery, namely 12 trips in the OTB_CRU fishery, 27 trips in the OTB_DEF fishery. Table 2 presents the sampling levels of the period 2016-2020.

Table 2 – Sampling levels of the Portuguese onboard sampling programme in the OTB_DEF and OTB_CRU fisheries for the period 2016-2020.

Year	Trips sampled		Hauls sampled		Hours fished	
	OTB_CRU	OTB_DEF	OTB_CRU	OTB_DEF	OTB_CRU	OTB_DEF
2016	12	29	42	61	172	143
2017	10	32	28	69	128	155
2018	11	22	40	47	174	86
2019	8	23	27	45	119	98
2020	0	4	0	6	0	11

The sampling protocol used in Portuguese sampling of the OTB fisheries is detailed in Jardim, *et al* (2012). A brief account follows. Two observers are deployed per fishing trip. Several hauls are made on each fishing trip and observers take a sample from the haul's catch, sort the specimens into retained and discarded fraction and register the weight and length composition of each species fraction. Observers collect concurrent fishing effort information (e.g. hours fished) and register environmental information (GPS coordinates, depth, bottom type, etc.). The onboard sampling protocols of the OTB_CRU, OTB_DEF fisheries have suffered only minor changes and adaptations between 2004 and 2010. In 2011 the size of catch samples taken from the OTB fishery was doubled (from 1 to 2 boxes of catch) and the within-trip selection of hauls and sets was standardized to "at least, every other haul".

3. Data analysis

The procedures used to raise discard data from samples to haul and fleet level, considering each fishery have been previously described in Jardim and Fernandes (2013) and Fernandes *et al.* (2017). A brief account follows.

3.1 Estimates of discards at haul level

In the OTB fisheries, the total volume discarded (in kg) in each haul is estimated by multiplying the ratio of discarded and retained sample weights (all species combined) by the total retained weight in the haul (all species combined). The volume of discards of individual species in each haul is calculated *a posteriori* by multiplying the proportion (in weight) of species discards in the catch sample by the total catch volume estimated for each haul (total volume discarded + total volume landed) (Fernandes *et al.*, 2017).

3.2 Estimates of discards at fleet level (2004-2019)

The procedure generally used to raise discards from haul to fleet level in the Portuguese trawl fisheries is described in Jardim and Fernandes (2013). This procedure relies on haul level discard data (discards per hour) and effort data (fishing hours and fishing trips) derived from logbooks, sales slips and, for 2012-2019 periods, VMS (Vessel Monitoring System) data was also used. Using this procedure species with low frequency of occurrence or abundance in discards (i.e., a large number of zeros in the data set) cannot be reliably estimated at fleet level, because the discard estimation algorithm is sensitive to large numbers of zeros in the dataset (Fernandes *et al.*, 2021; Jardim *et al.*, 2011).
Summary discard information for the period 2016-2019 is presented in Tables 3-7. Frequencies of occurrence of the WGBIE species in the sampled hauls are presented in Table 3 and Table 4. Discards information (mean number of individuals in the sampled hauls, standard deviation and range) are summarized in Table 5 and Table 6. European hake (HKE) discard volumes are presented in Table 7.

Table 3 – Frequency of occurrence (%) of species in discards of hauls sampled from the OTB_DEF fishery. See Table 1 for species codes; "--" = no occurrence.

3-alpha code	2016	2017	2018	2019
BSS	--	--	--	--
HKE	44	49	45	62
LDB	7	9	15	2
MEG	--	1	--	--
NEP	--	--	--	--
PLE	--	--	--	--
POL	--	--	--	--
SOL	2	--	--	--
WHG	--	--	--	--

Table 4 – Frequency of occurrence (%) of species in discards of hauls sampled from the OTB_CRU fishery. See Table 1 for species codes; "--" = no occurrence.

3-alpha code	2016	2017	2018	2019
BSS	--	--	--	--
HKE	48	43	55	70
LDB	43	18	28	15
MEG	2	4	5	4
NEP	21	18	5	11
PLE	--	--	--	--
POL	--	--	--	--
SOL	--	--	--	--
WHG	--	--	--	--

Table 5 – Discards (in number of specimens per haul) of species in the OTB_DEF fishery (2004-2019); See Table 1 for species codes; "--" indicates no occurrence; SD – standard deviation.

	HKE			LDB			MEG			SOL		
Year	Mean	SD	Range	Mean	SD	Range	Mean	SD	Range	Mean	SD	Range
2016	185	628	0-4335	3	12.8	0-65	--	--	--	0.6	4.4	0-34
2017	245	747	0-5586	12	51	0-351	0.5	4.1	0-34	--	--	--
2018	191	591	0-3743	24	134	0-931	--	--	--	--	--	--
2019	209	389	0-1508	0.6	4.1	0-28	--	--	--	--	--	--

Table 6 – Discards (in number of specimens per haul) of species in the OTB_CRU fishery (2016-2019); See Table 1 for species codes; "--" indicates no occurrence; SD – standard deviation.

	HKE			LDB			MEG			NEP		
Year	Mean	SD	Range	Mean	SD	Range	Mean	SD	Range	Mean	SD	Range
2016	328	992	0-5787	76	185	0-981	0.3	1.7	0-11	29	85	0-470
2017	85	210	0-835	7	18	0-72	2.8	14	0-78	15	42	0-195
2018	93	134	0-515	17	38	0-187	6.2	33	0-205	8.3	40	0-240
2019	348	586	0-2123	6.2	18	0-81	1.2	6.1	0-32	4.4	14	0-53

Table 7 – European hake discarded by the Portuguese OTB_CRU and OTB_DEF fisheries (2016-2019); volume (in metric tons) and CVs (% in brackets).

Year	OTB_CRU	OTB_DEF
2016	80 (50%)	85 (65%)
2017	13 (57%)	181 (46%)
2018	65 (34%)	112 (40%)
2019	156 (38%)	151 (33%)

4. Discard estimates - 2020

In what concerns to 2020, discards could not be estimated with the usual raising procedure because there was no representative sampling effort in OTB fisheries. A preliminary analysis performed to investigate the OTB fleet fishing pattern (e.g. fishing days, fishing duration in hours, number of hauls per trip, landed weights) showed no significant differences between 2020 and the all previous sampling period (2004-2019). Thus, it is assumed that discarding practices were also not significantly different. For this reason, the WGBIE species that presented frequencies of occurrence below 30% in all the previous sampling period were also considered to have no or negligible discards in 2020. In the case of four-spot megrim (LDB), the frequencies of occurrence in the OTB_CRU fleet for period 2004-2015 were low (average 14% with range 2-30) and in the more recent period (2016-2019) it presented 43% of occurrence only in 2016 (26 discarded tons, 49% CV) for the OTB_CRU. Taking into account the low frequency pattern for the 2004-2019 period, no discard estimate is presented for this species in 2020.

The low occurrence of Norway lobster in the discards of the OTB_CRU fleet is usually related to occasional damages of specimens during the fishing process, and thus its discards are also considered negligible.

For the European hake (only species frequently discarded in this group), discard estimates were obtained considering the discard values from the last 3-year period (2017-2019). Average values of discards per unit effort (DPUE, in tones per hour) by fleet (OTB_CRU and OTB_DEF) are calculated. Those values were then multiplied by the fishing hours performed in 2020, to obtain the annual discard estimates for each fleet (77 tons in OTB_CRU and 151 tons in OTB_DEF). Regarding the length composition of discards in 2020, the same approach was used: calculation of an average length composition from 2017-2019 period, and the SOP was performed using the estimated annual discard values. The annual mean lengths obtained for 2020 were 16.2 cm and 14.9 cm for OTB_DEF and OTB_CRU, respectively.

5. Conclusions

Discards of most WGBIE species carried out by Portuguese vessels operating bottom otter trawl within ICES Division 27.9a are not quantified at fleet level due to limitations of the current estimation algorithm to more frequently discarded species (Fernandes *et al.*, 2021; Jardim *et al.*, 2011). Even so, the low frequency of occurrence and the low number of specimens usually registered in most species indicate that discards are null or negligible for assessment purposes. In 2020, although the onboard sampling effort was not representative of the fishing effort of the fleet, a preliminary analysis of the fishing pattern of the OTB fleets in 2020 showed no significant differences from the previous sampling period (2004-2019). For this reason, the discard information provided for 2020 was based on the last 3-year sampling period (2017-2019). Therefore, discards for all species, except hake, were also considered null or negligible for assessment purposes. The hake discards in 2020 obtained for OTB_CRU and OTB_DEF were 77 tons and 151 tons respectively, and are mainly composed of fish under the minimum landing size (16.2cm in OTB_DEF and 14.9cm in OTB_CRU) that is dumped dead overboard due to regulatory reasons.

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Ifremer
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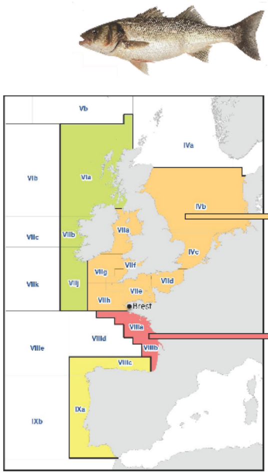
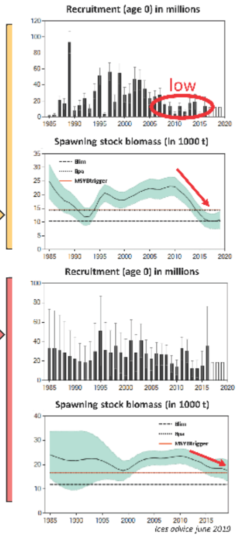
INRAE
Inferring fish population structure and connectivity by the combination of individual markers: application to the European seabass
Mathieu Woillez, Chloé Dambrine, Martin Huret, Pierre-Alexandre Gagnaire, Françoise Daverat, Emilie Le Luherne, Hélène de Pontual
BARFRAY
UNION EUROPÉENNE
L'Europe s'engage en France
FRANCE FILIÈRE PÊCHE

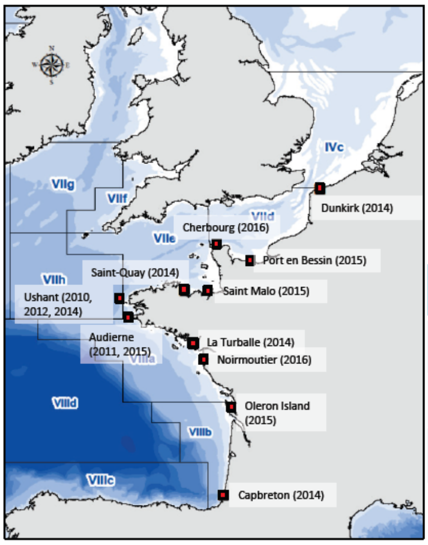
The European seabass





- A strong socio-economic weight in France : professional and recreative fishing
- Decreasing trends for two seabass stocks
- Northern stock is in a worrying state
  - High fishing pressure
  - Series of low recruitments
- Management measures since 2015
- **Knowledge gaps in the population structure and connectivity** → consequences on its actual states and its management

Individual markers

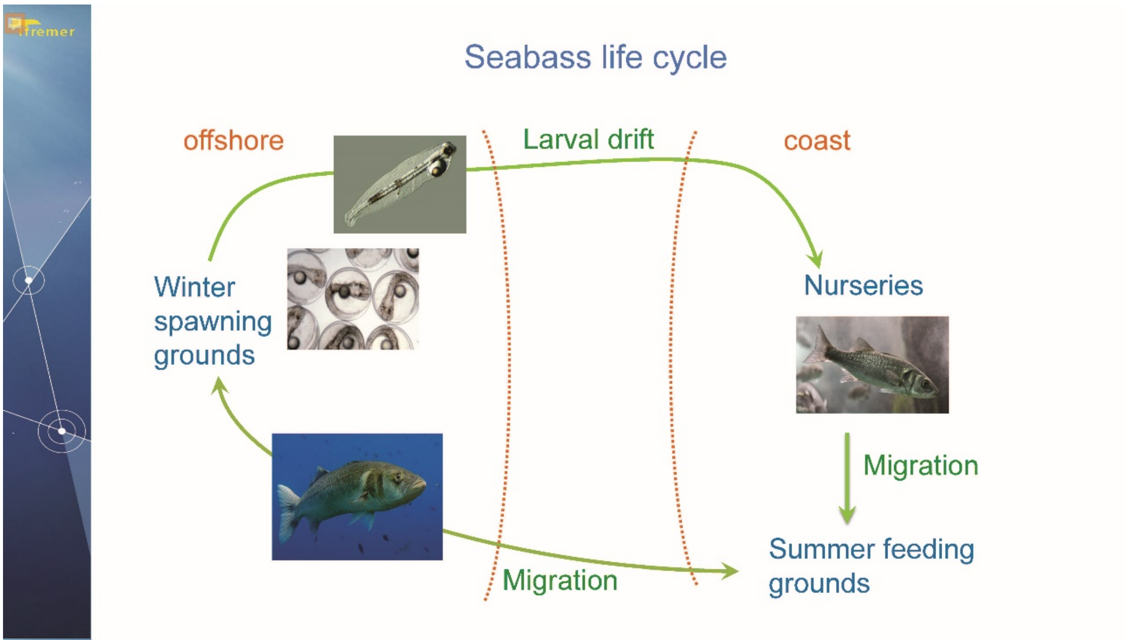


- Electronic tag: CTL G5 long life (Temperature/pressure)
- Fish scales
- Fish tissue (caudal fin sample)

Project	Year	Nb tagged	Nb returned	%
Iroise	2010-2012	246	40	16
BARGIP	2014-2016	1220	460	37
All	2010-2016	1466	500	34

- Otoliths and scales at recapture when available

08/05/2021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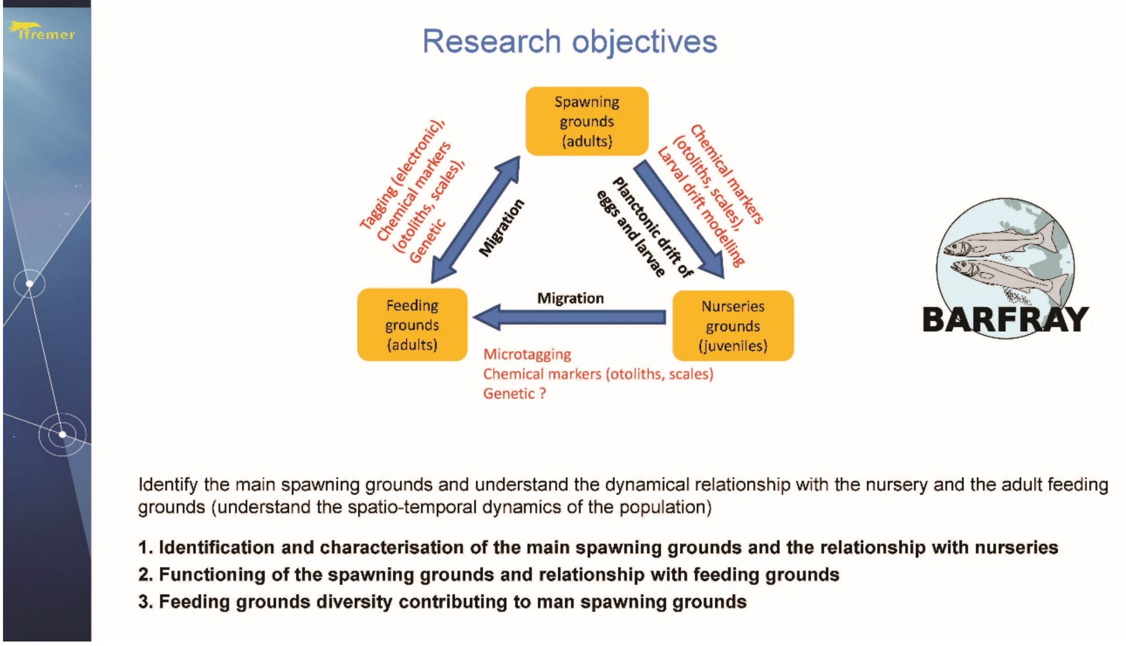
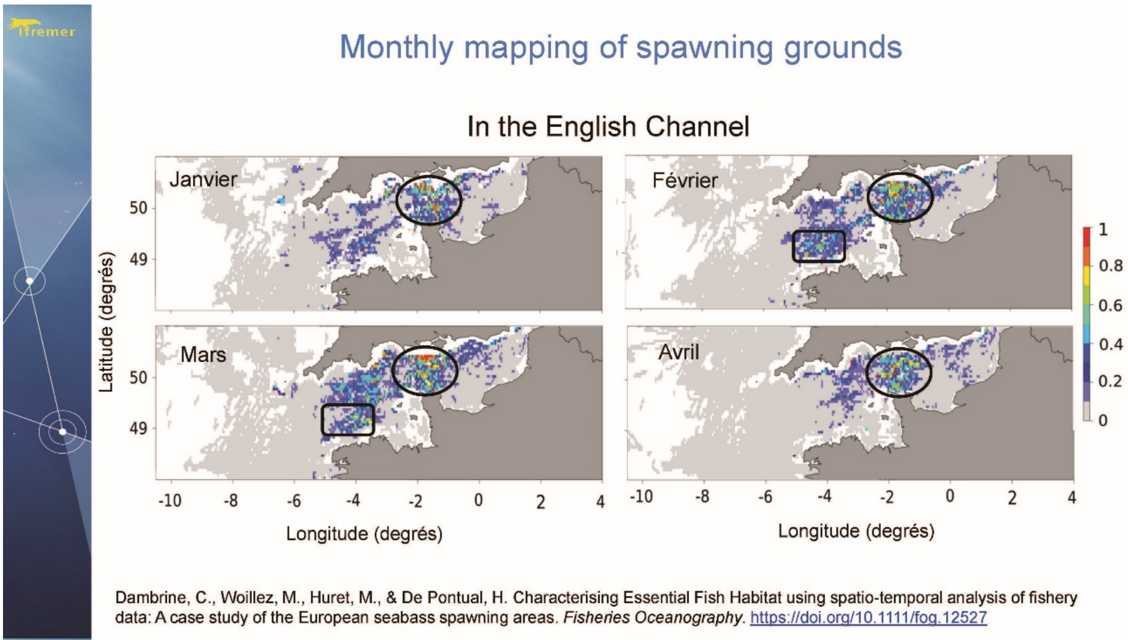
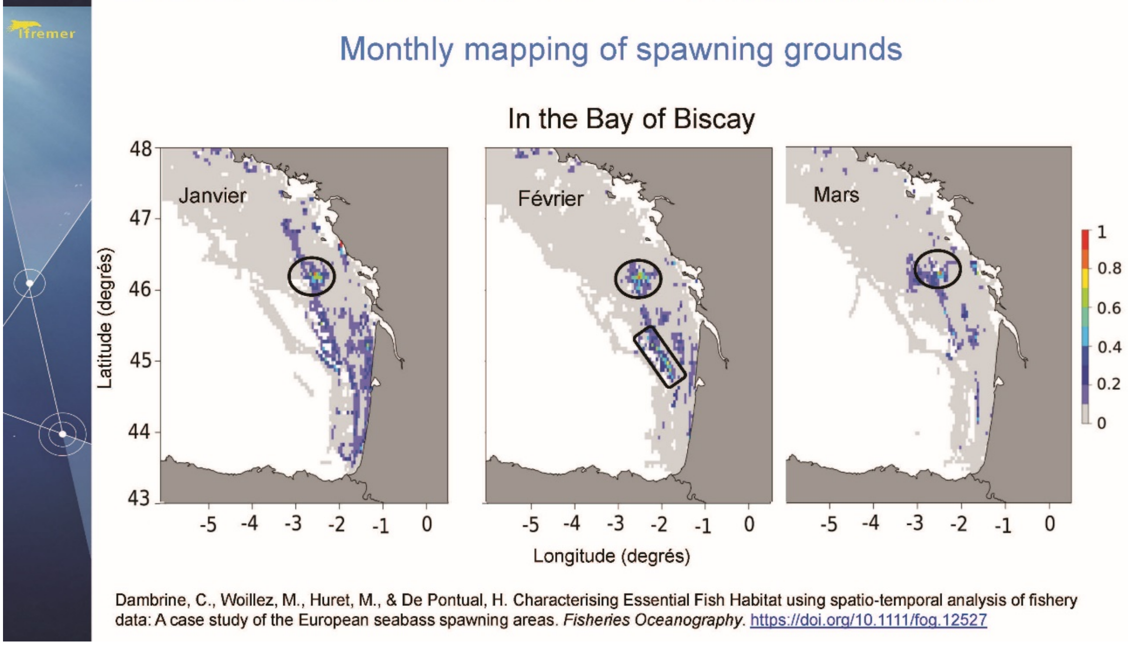
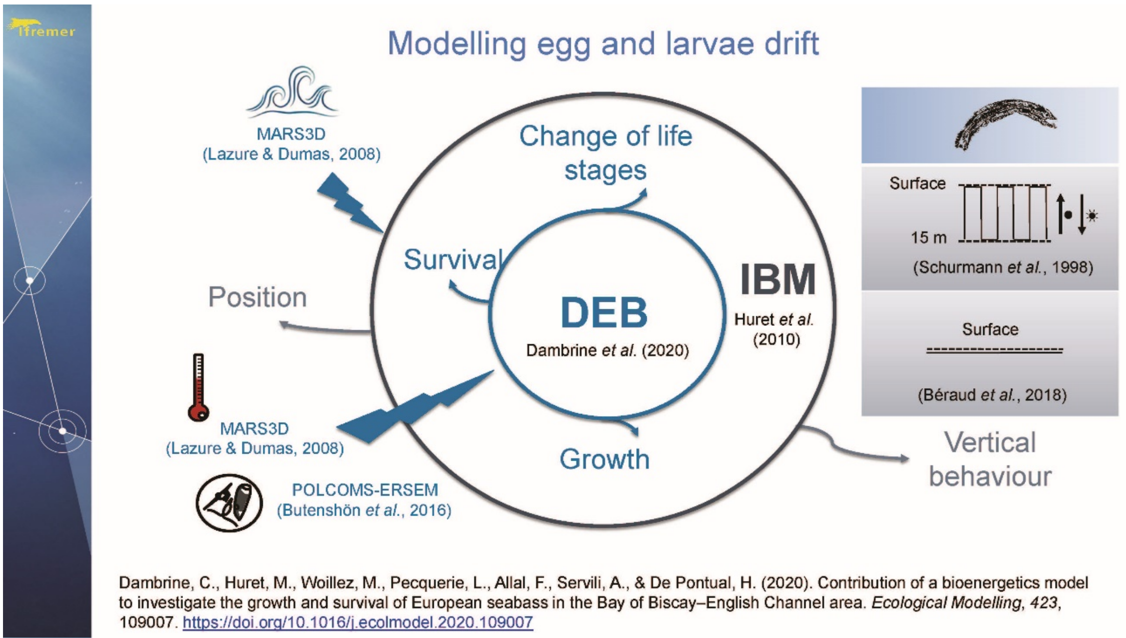
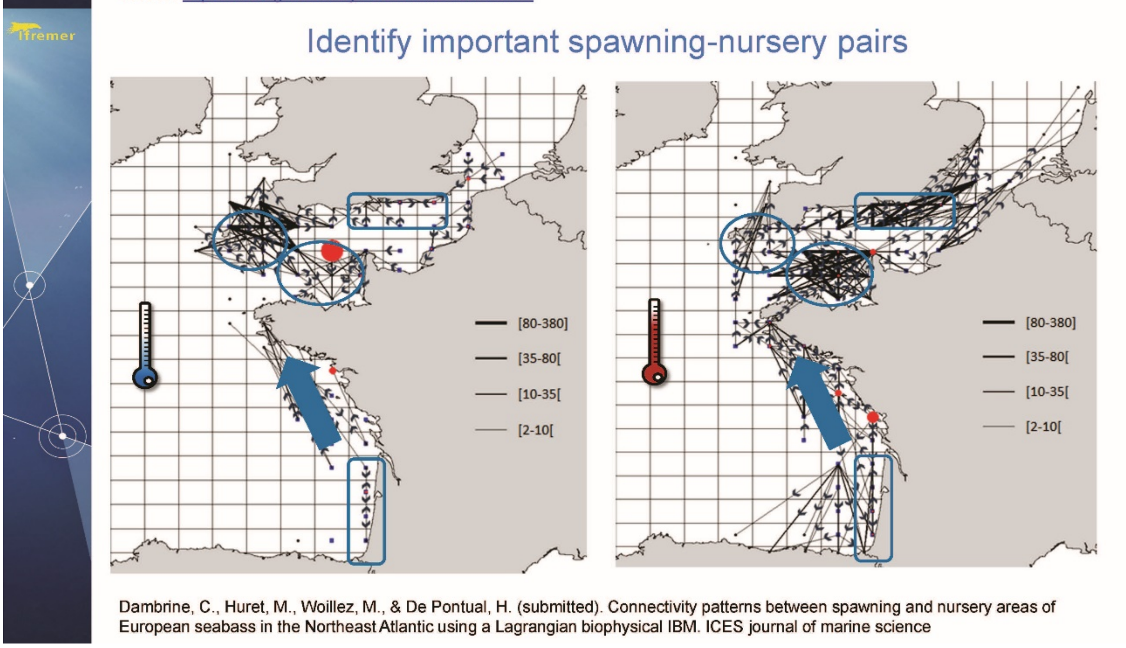
Seabass life cycle
offshore
Larval drift
coast
Winter spawning grounds
Nurseries
Migration
Summer feeding grounds
Migration


ifremer
Research objectives
Spawning grounds (adults)
Tagging (electronic), Chemical markers (otoliths, scales), Genetic
Migration
Planctonic drift of eggs and larvae
Chemical markers (otoliths, scales), Larval drift modelling
Feeding grounds (adults)
Migration
Nurseries grounds (juveniles)
Microtagging
Chemical markers (otoliths, scales)
Genetic ?
BARFRAY
Identify the main spawning grounds and understand the dynamical relationship with the nursery and the adult feeding grounds (understand the spatio-temporal dynamics of the population)
1. Identification and characterisation of the main spawning grounds and the relationship with nurseries
2. Functioning of the spawning grounds and relationship with feeding grounds
3. Feeding grounds diversity contributing to man spawning grounds


ifremer
Monthly mapping of spawning grounds
In the English Channel
Janvier
Février
Mars
Avril
Latitude (degrés)
Longitude (degrés)
50
49
-10 -8 -6 -4 -2 0 2 4
1
0.8
0.6
0.4
0.2
0
Dambrine, C., Woillez, M., Huret, M., & De Pontual, H. Characterising Essential Fish Habitat using spatio-temporal analysis of fishery data: A case study of the European seabass spawning areas. Fisheries Oceanography. https://doi.org/10.1111/fog.12527


ifremer
Monthly mapping of spawning grounds
In the Bay of Biscay
Janvier
Février
Mars
Latitude (degrés)
Longitude (degrés)
48
47
46
45
44
43
-5 -4 -3 -2 -1 0
1
0.8
0.6
0.4
0.2
0
Dambrine, C., Woillez, M., Huret, M., & De Pontual, H. Characterising Essential Fish Habitat using spatio-temporal analysis of fishery data: A case study of the European seabass spawning areas. Fisheries Oceanography. https://doi.org/10.1111/fog.12527


ifremer
Modelling egg and larvae drift
MARS3D
(Lazure & Dumas, 2008)
Change of life stages
Survival
Position
DEB
Dambrine et al. (2020)
IBM
Huret et al. (2010)
Surface
15 m
(Schurmann et al., 1998)
Surface
(Béraud et al., 2018)
MARS3D
(Lazure & Dumas, 2008)
Growth
Vertical behaviour
POLCOMS-ERSEM
(Butenshön et al., 2016)
Dambrine, C., Huret, M., Woillez, M., Pecquerie, L., Allal, F., Servili, A., & De Pontual, H. (2020). Contribution of a bioenergetics model to investigate the growth and survival of European seabass in the Bay of Biscay–English Channel area. Ecological Modelling, 423, 109007. https://doi.org/10.1016/j.ecolmodel.2020.109007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Identify important spawning-nursery pairs
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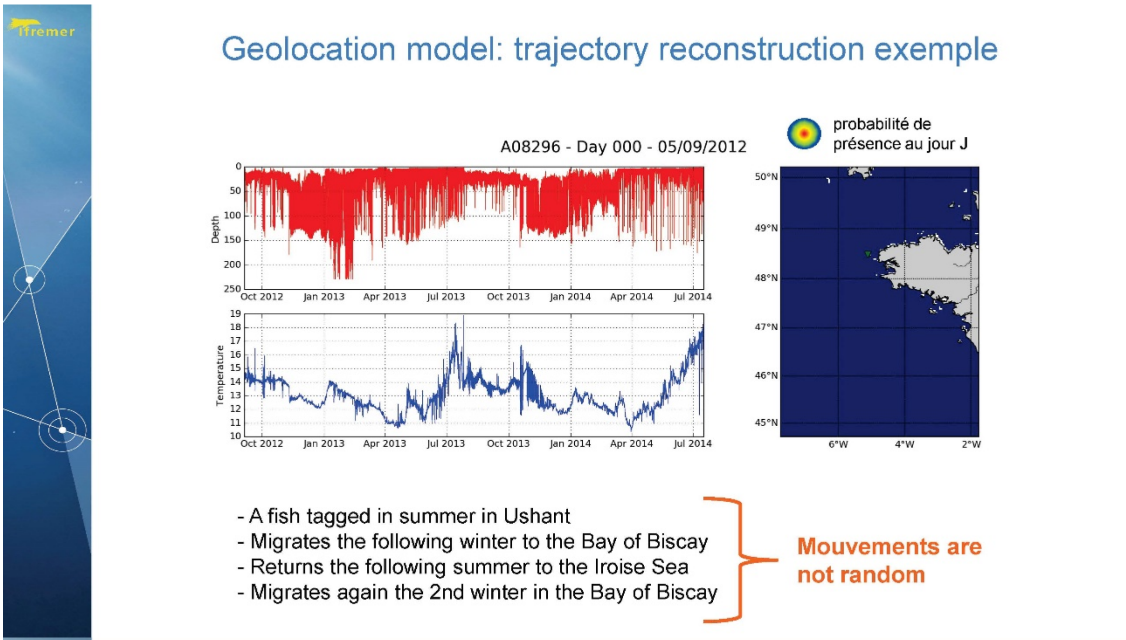
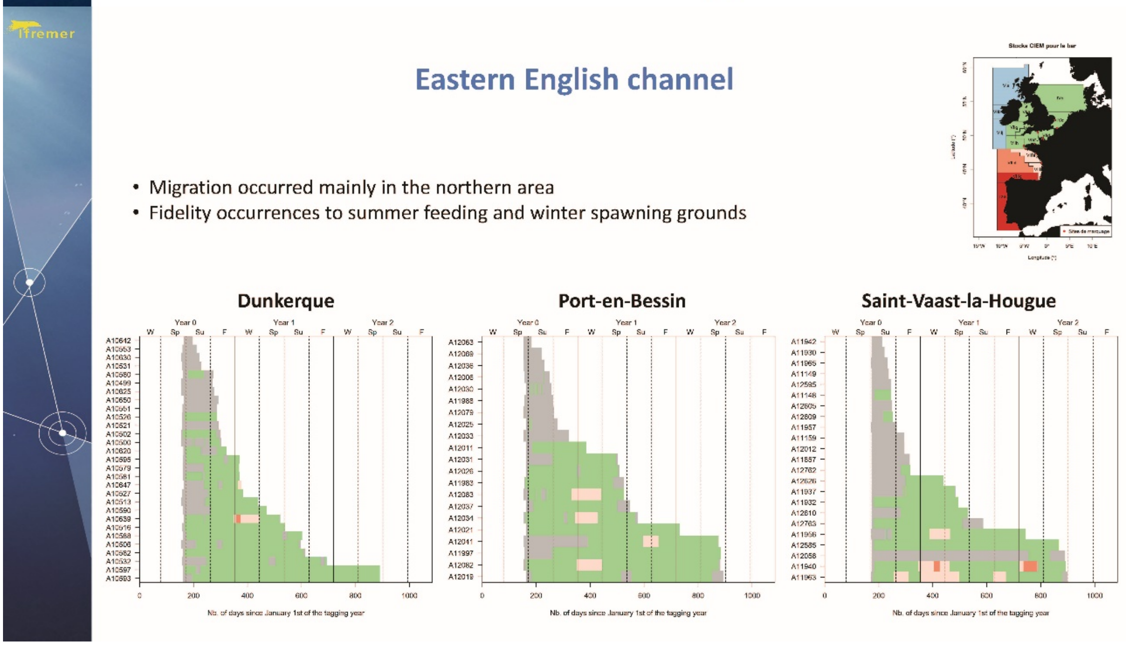
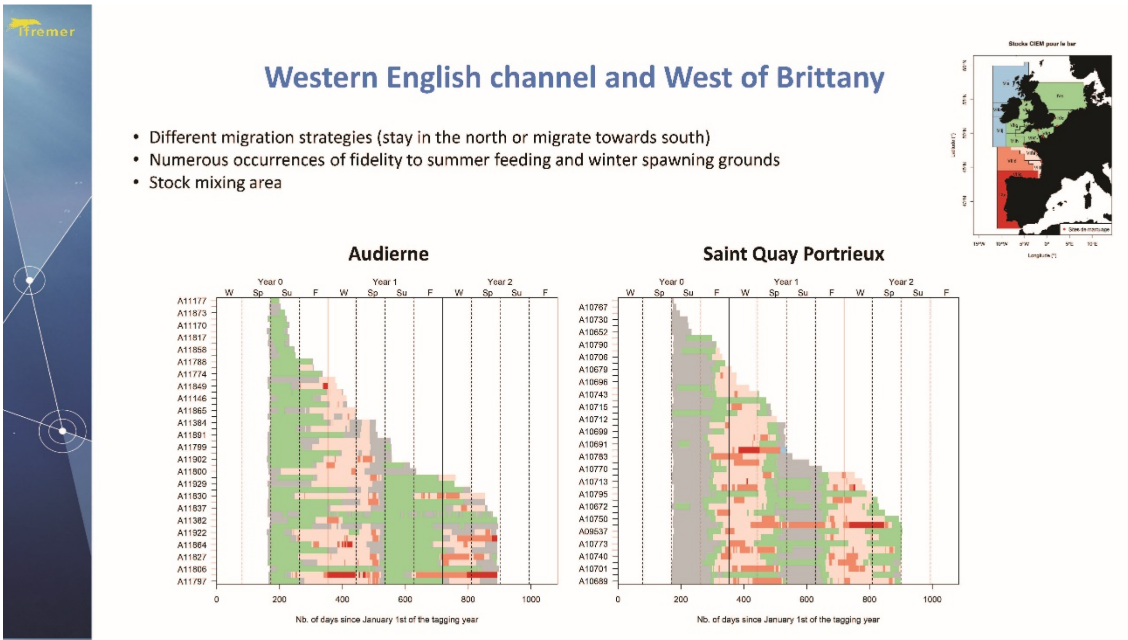
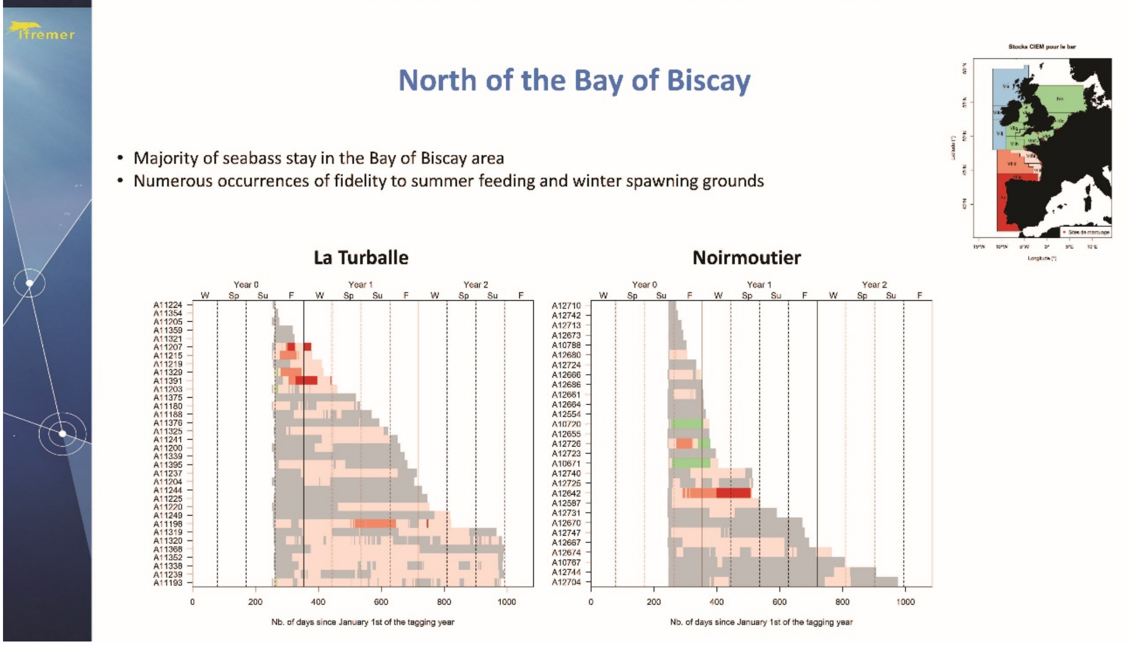
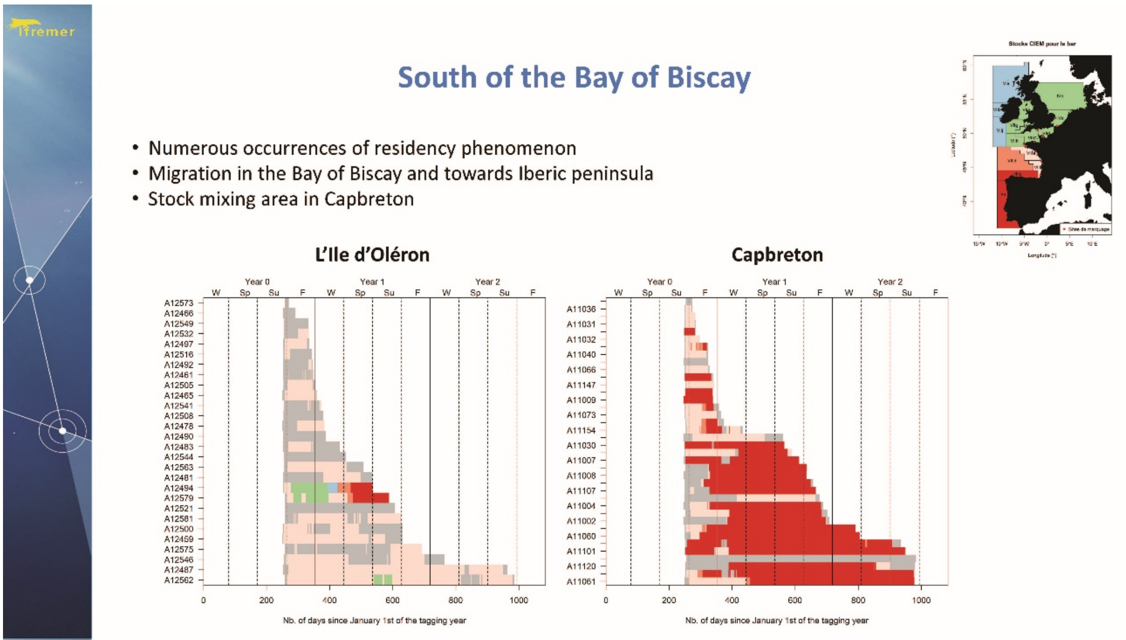
[2-10[
Dambrine, C., Huret, M., Woillez, M., & De Pontual, H. (submitted). Connectivity patterns between spawning and nursery areas of European seabass in the Northeast Atlantic using a Lagrangian biophysical IBM. ICES journal of marine science

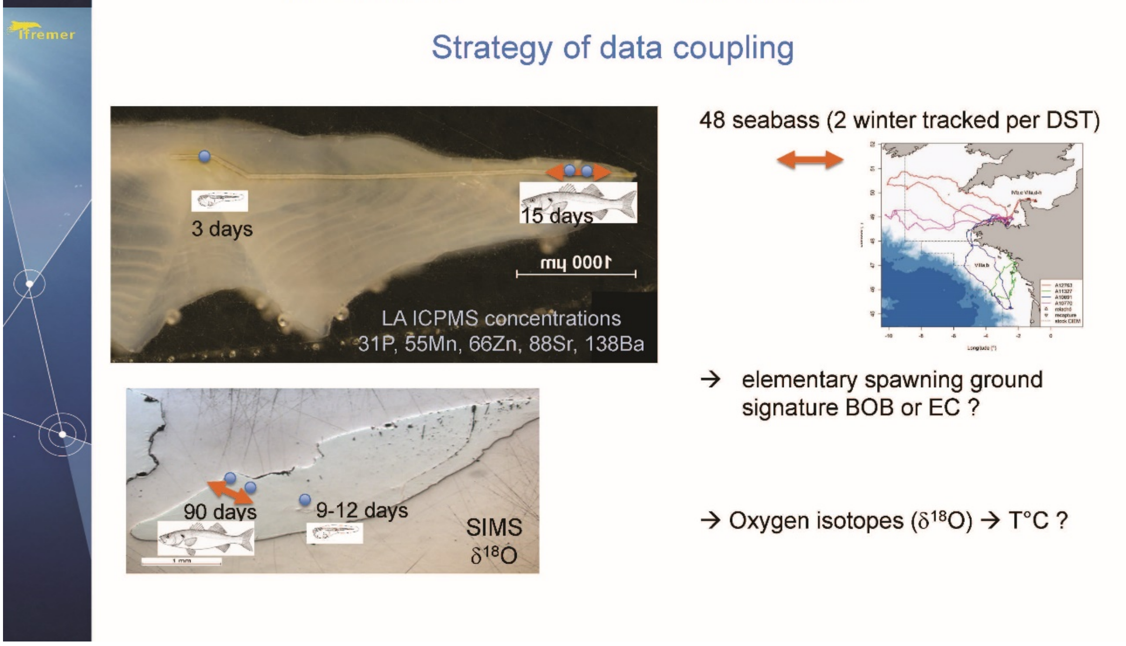

ifremer
Geolocation model: trajectory reconstruction exemple
A08296 - Day 000 - 05/09/2012
probabilité de présence au jour J
Depth
Temperature
Oct 2012
Jan 2013
Apr 2013
Jul 2013
Oct 2013
Jan 2014
Apr 2014
Jul 2014
50°N
49°N
48°N
47°N
46°N
45°N
6°W
4°W
2°W
- A fish tagged in summer in Ushant
- Migrates the following winter to the Bay of Biscay
- Returns the following summer to the Iroise Sea
- Migrates again the 2nd winter in the Bay of Biscay
Mouvements are not random


ifremer
Eastern English channel
• Migration occurred mainly in the northern area
• Fidelity occurrences to summer feeding and winter spawning grounds
Dunkerque
Port-en-Bessin
Saint-Vaast-la-Hougue
Year 0
Year 1
Year 2
Nb. of days since January 1st of the tagging year

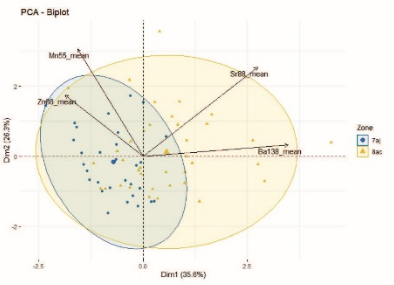

ifremer
Western English channel and West of Brittany
• Different migration strategies (stay in the north or migrate towards south)
• Numerous occurrences of fidelity to summer feeding and winter spawning grounds
• Stock mixing area
Audierne
Saint Quay Portrieux
Year 0
Year 1
Year 2
Nb. of days since January 1st of the tagging year

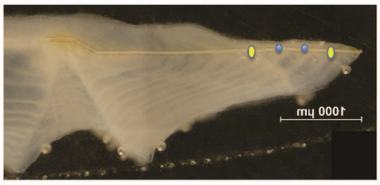

ifremer
North of the Bay of Biscay
• Majority of seabass stay in the Bay of Biscay area
• Numerous occurrences of fidelity to summer feeding and winter spawning grounds
La Turballe
Noirmoutier
Year 0
Year 1
Year 2
Nb. of days since January 1st of the tagging year


ifremer
South of the Bay of Biscay
• Numerous occurrences of residency phenomenon
• Migration in the Bay of Biscay and towards Iberic peninsula
• Stock mixing area in Capbreton
L'Ile d'Oléron
Capbreton
Year 0
Year 1
Year 2
No. of days since January 1st of the tagging year
No. of days since January 1st of the tagging year


ifremer
Strategy of data coupling
3 days
15 days
1000 µm
LA ICPMS concentrations
31P, 55Mn, 66Zn, 88Sr, 138Ba
90 days
9-12 days
SIMS
δ18O
48 seabass (2 winter tracked per DST)
→ elementary spawning ground signature BOB or EC ?
→ Oxygen isotopes (δ18O) → T°C ?

Results of adult fidelity to spawning grounds





Random Forest classification model ^{55}Mn, ^{66}Zn, ^{138}Ba
Out of Bag estimate of error rate: 19.12%

Confusion matrix

	EC	BOB	class.error
EC	24	6	0,20
BOB	7	31	0,18

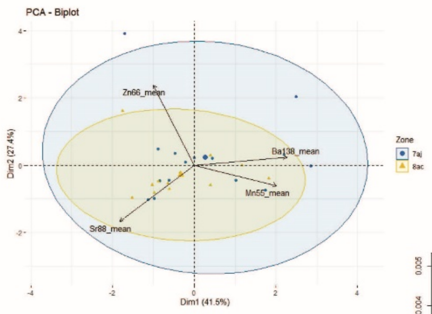
Reallocation of winter spawning grounds not tracked by DSTs with this classification model :

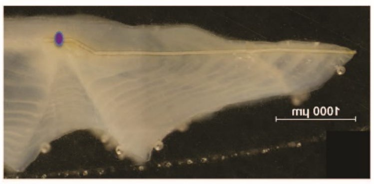
Fidelity 27 seabass/35 = 77,14 % of fidelity to spawning ground
Of which 12 seabass attributed to BOB, and 15 seabass attributed to EC.

Faithful to EC tagged at AD(1) CH(2) DK(3) PB(4) SB(4) SM(1)

Faithful to BOB tagged at AD(1) CB(4) LT(2) NO(2) OL(2) SB(1)

Larval phase analysis (homing?): elementary signature

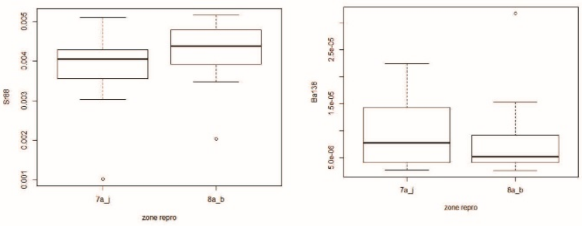


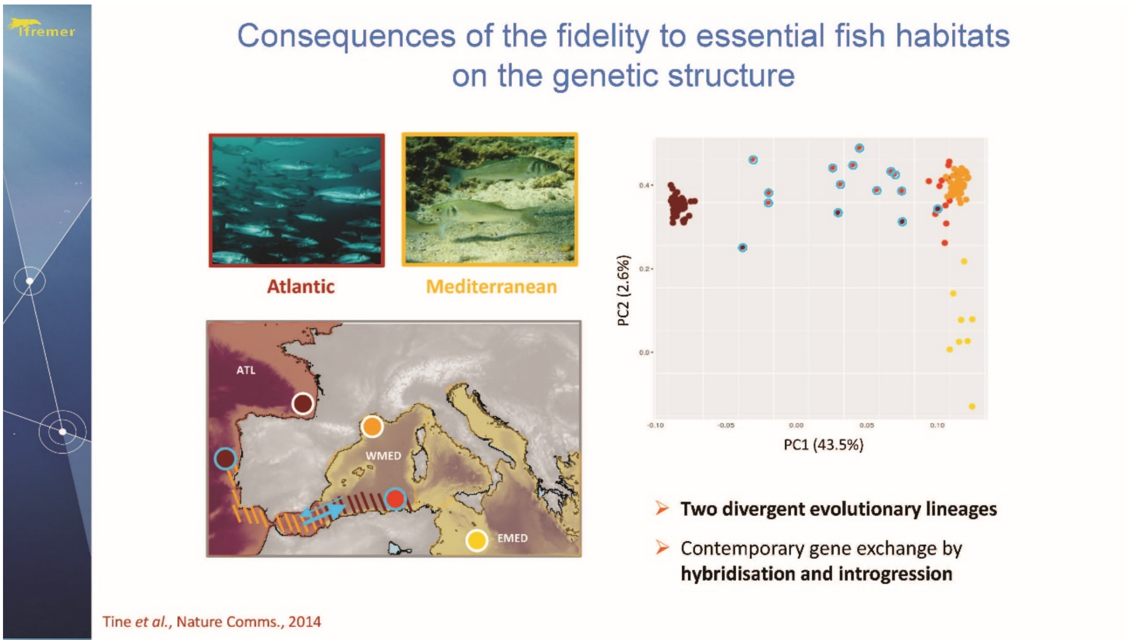


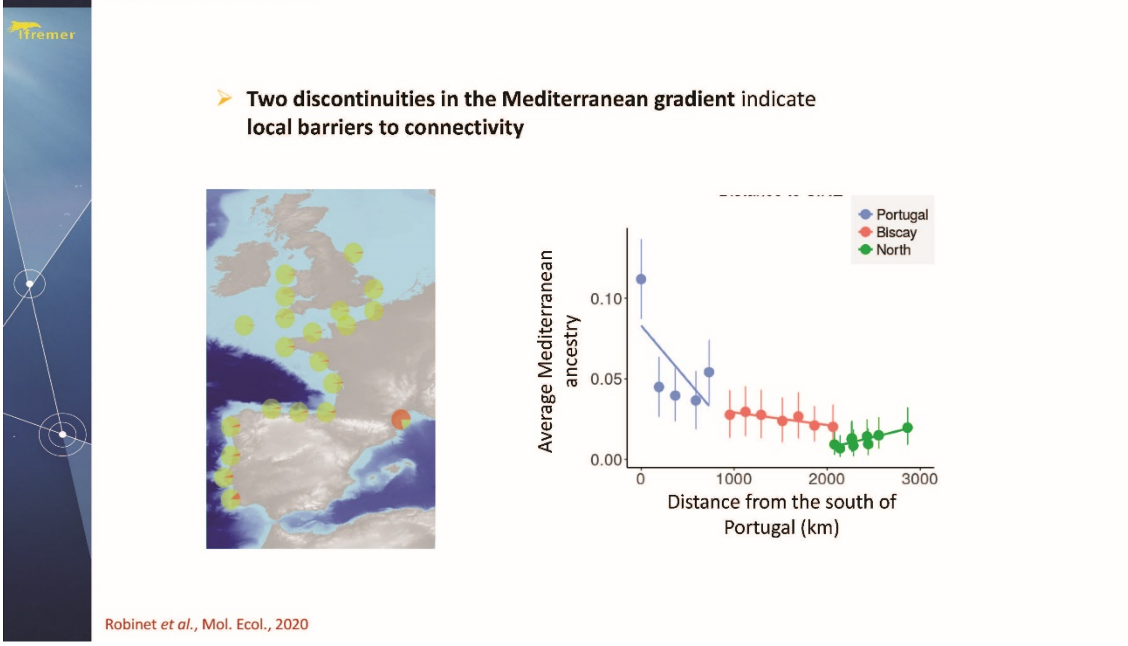
Do fish loyal to a spawning ground have a larval signature characteristic of their ground ?

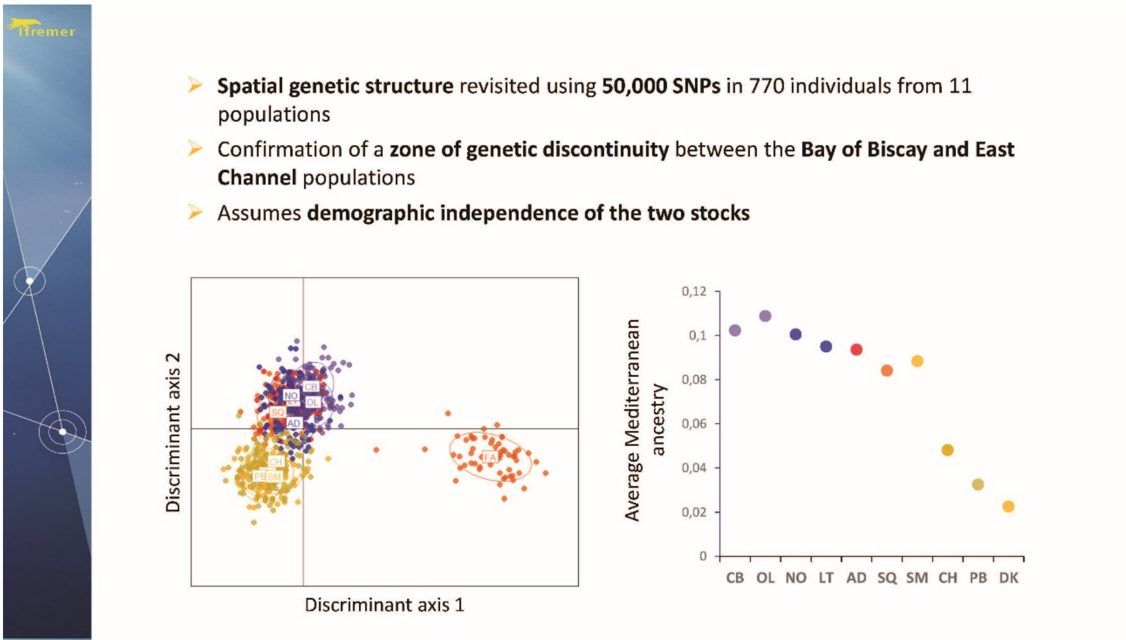
Results not conclusive (Random forest model fails to reallocate larval elemental signatures because chemical composition varies between stages (ontogenic effect).

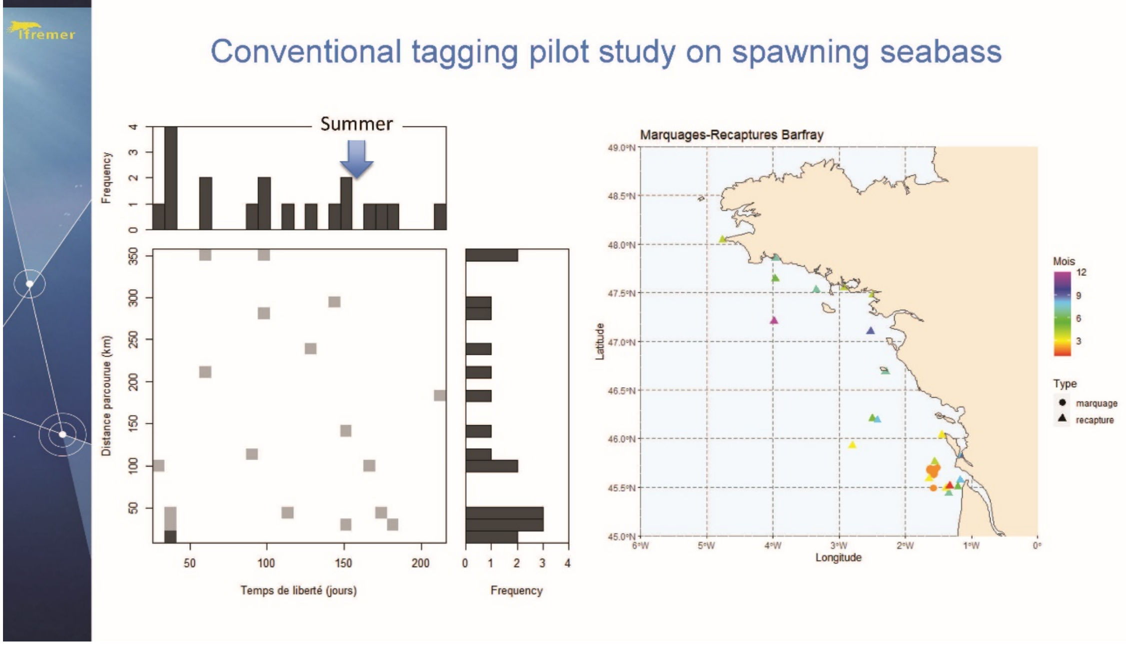
There are differences but not significant

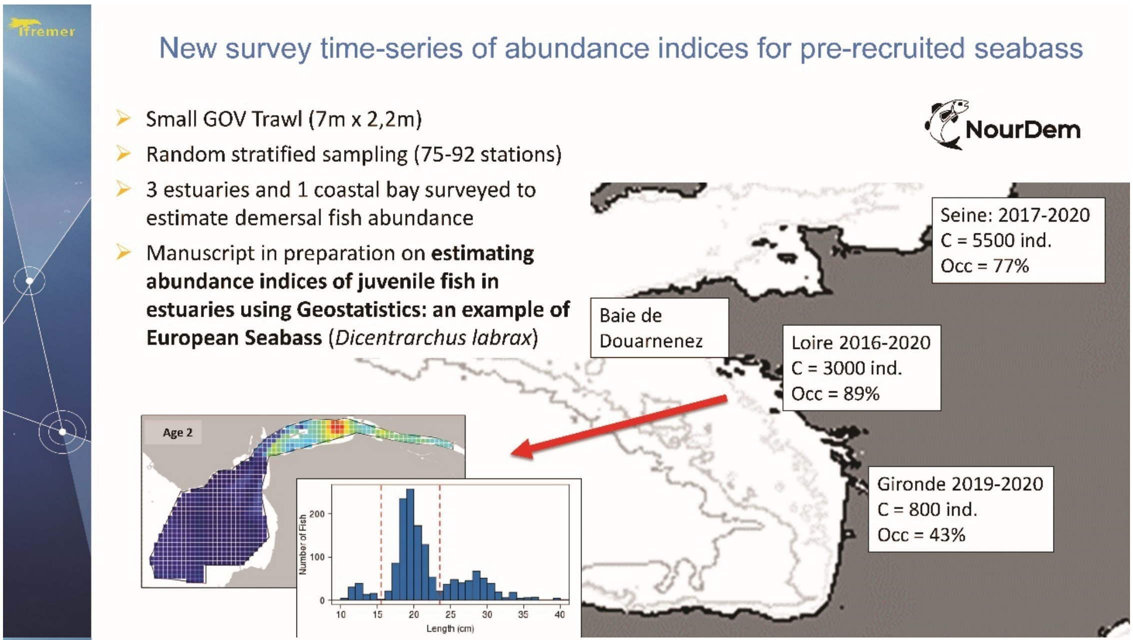


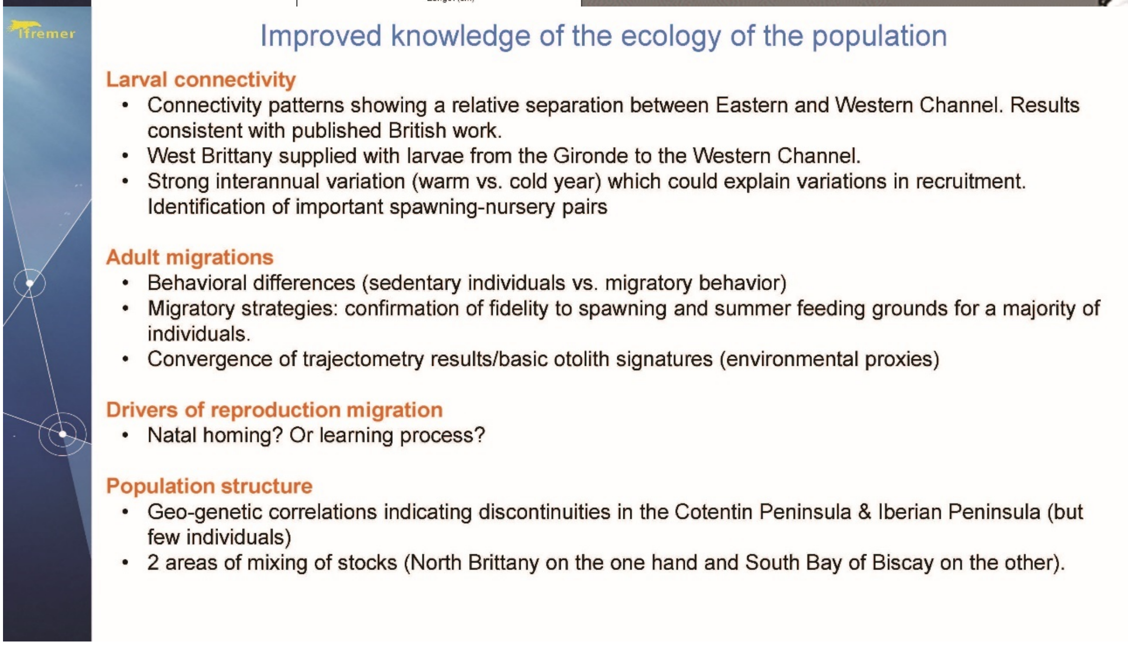

ifremer
Consequences of the fidelity to essential fish habitats on the genetic structure
Atlantic
Mediterranean
ATL
WMED
EMED
PC2 (2.6%)
PC1 (43.5%)
0.4
0.2
0.0
-0.10
-0.05
0.00
0.05
0.10
Two divergent evolutionary lineages
Contemporary gene exchange by hybridisation and introgression
Tine et al., Nature Comms., 2014

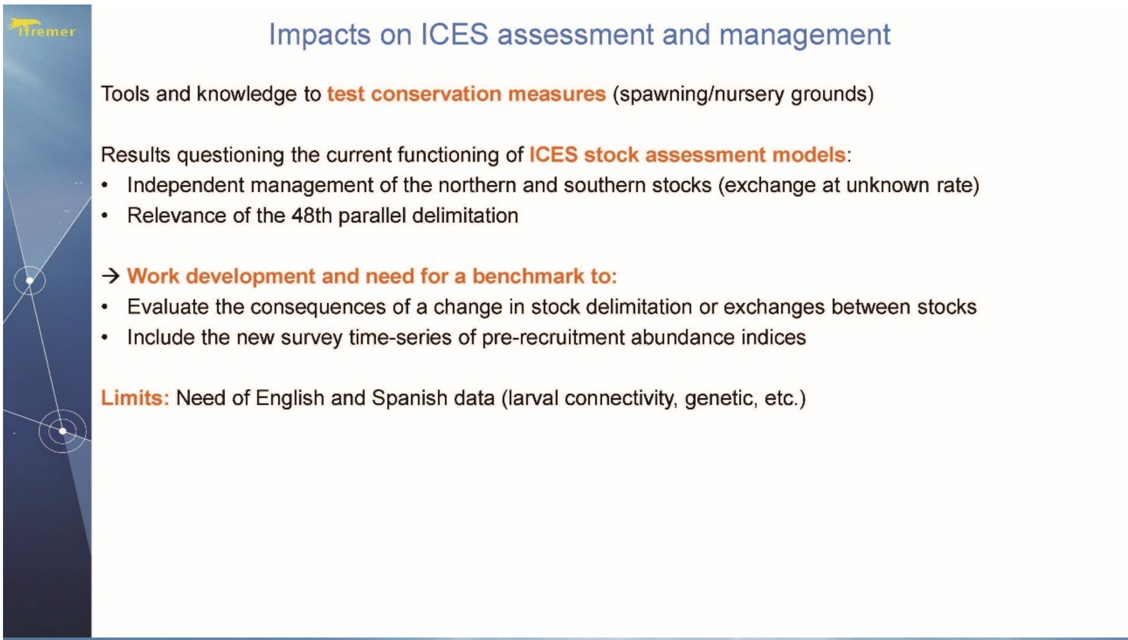

ifremer
Two discontinuities in the Mediterranean gradient indicate local barriers to connectivity
Portugal
Biscay
North
Average Mediterranean ancestry
0.10
0.05
0.00
0
1000
2000
3000
Distance from the south of Portugal (km)
Robinet et al., Mol. Ecol., 2020


ifremer
Spatial genetic structure revisited using 50,000 SNPs in 770 individuals from 11 populations
Confirmation of a zone of genetic discontinuity between the Bay of Biscay and East Channel populations
Assumes demographic independence of the two stocks
Discriminant axis 2
Discriminant axis 1
CB
OL
NO
SQ
AD
CH
PB
SM
IFA
Average Mediterranean ancestry
0,12
0,1
0,08
0,06
0,04
0,02
0
CB OL NO LT AD SQ SM CH PB DK


ifremer
Conventional tagging pilot study on spawning seabass
Summer
Frequency
Distance parcourue (km)
Temps de liberté (jours)
Frequency
Marquages-Recaptures Barfray
Latitude
Longitude
Mois
Type
marquage
recapture


ifremer
New survey time-series of abundance indices for pre-recruited seabass
NourDem
Small GOV Trawl (7m x 2,2m)
Random stratified sampling (75-92 stations)
3 estuaries and 1 coastal bay surveyed to estimate demersal fish abundance
Manuscript in preparation on estimating abundance indices of juvenile fish in estuaries using Geostatistics: an example of European Seabass (Dicentrarchus labrax)
Seine: 2017-2020
C = 5500 ind.
Occ = 77%
Baie de Douarnenez
Loire 2016-2020
C = 3000 ind.
Occ = 89%
Gironde 2019-2020
C = 800 ind.
Occ = 43%
Age 2
Number of Fish
Length (cm)


ifremer
Improved knowledge of the ecology of the population
Larval connectivity
Connectivity patterns showing a relative separation between Eastern and Western Channel. Results consistent with published British work.
West Brittany supplied with larvae from the Gironde to the Western Channel.
Strong interannual variation (warm vs. cold year) which could explain variations in recruitment. Identification of important spawning-nursery pairs
Adult migrations
Behavioral differences (sedentary individuals vs. migratory behavior)
Migratory strategies: confirmation of fidelity to spawning and summer feeding grounds for a majority of individuals.
Convergence of trajectometry results/basic otolith signatures (environmental proxies)
Drivers of reproduction migration
Natal homing? Or learning process?
Population structure
Geo-genetic correlations indicating discontinuities in the Cotentin Peninsula & Iberian Peninsula (but few individuals)
2 areas of mixing of stocks (North Brittany on the one hand and South Bay of Biscay on the other).


Impacts on ICES assessment and management
Tools and knowledge to test conservation measures (spawning/nursery grounds)
Results questioning the current functioning of ICES stock assessment models:
• Independent management of the northern and southern stocks (exchange at unknown rate)
• Relevance of the 48th parallel delimitation
→ Work development and need for a benchmark to:
• Evaluate the consequences of a change in stock delimitation or exchanges between stocks
• Include the new survey time-series of pre-recruitment abundance indices
Limits: Need of English and Spanish data (larval connectivity, genetic, etc.)


BARFRAY
NourDem
Thanks for your attention
UNION EUROPÉENNE
L'Europe s'engage en France
Ifremer

WKMSYSPiCT
ICES, 15 – 19 February 2021

Data compilation and application of SPiCT model for the assessment of *Nephrops* in Functional Units 28-29

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Instituto Português do Mar e da Atmosfera, I.P. (IPMA),
Departamento do Mar e dos Recursos Marinhos

Abstract

This Working Document summarizes the information and data available from *Nephrops* stock in FU 28-29 to be used at the WKMSYSPiCT benchmark. A short description of the fishery is also provided. The standardization of the crustacean fleet CPUE is described based on logbook data linked with VMS and depth information. The modelled standardized CPUE, the corresponding fishing effort, a survey-based biomass index and the commercial catches are used as input series for Surplus Production in Continuous Time (SPiCT, Pedersen and Berg, 2017) exploratory runs.

Introduction

The Norway lobster (*Nephrops norvegicus*) is distributed along the continental slope off the southwest (FU 28) and south (FU 29) Portuguese coast, at depths ranging from 200 to 800 m. Its distribution is limited to muddy sediments with 10–100% silt and clay content, required to excavate burrows (Bell *et al.*, 2013).

The area of distribution of Norway lobster in these FUs, includes ICES rectangles 03E, 04E0 and 05E0 in FU 28 and rectangles 02E0, 02E1, 02E2 and 01E2 in FU 29 (Figure 1). Although FUs 28 and 29 are different stocklets, landing records are not differentiated by FU and are assessed together.

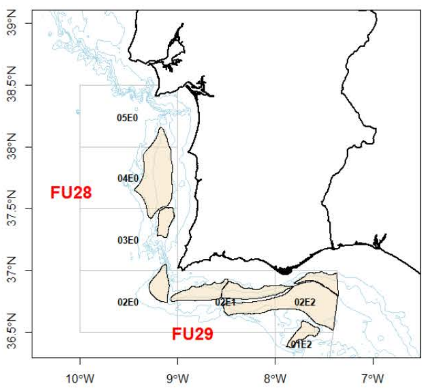

Figure 1. ***Nephrops*** **in FUs 28-29 (SW and S Portugal). Fishing grounds overlaying ICES statistical rectangles.**

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ICES, 15 – 19 February 2021

Background information

The fishery

Norway lobster is a very valuable and important resource for the demersal trawl fisheries operating in the region. Together with the deepwater rose shrimp (*Parapenaeus longirostris*), Norway lobster constitutes the main target species of the majority of the crustacean trawl fleet and is not generally caught as bycatch in other fleets. These two species have a different but overlapping depth distribution: the deepwater rose shrimp occurs at the depth range of 100–350 meters whereas Norway lobster is distributed from 200 to 800 meters. The number of fishing trips directed to one species or to the other depends on the abundance of these species each year.

The Portuguese trawl fleet comprises two components, namely the trawl fleet targeting demersal fish and the trawl fleet targeting crustaceans. The trawl fleet targeting demersal fish operates off the entire Portuguese coast while the trawl fleet directed to crustaceans operates mainly in Southwest and South Portugal and at deeper waters (≥ 200 m), where the crustacean species are more abundant. The fish trawlers are licensed to use a mesh size ≥ 65 mm and the crustacean trawlers are licensed for two different mesh sizes, 55 mm for catching shrimp and ≥ 70 mm for Norway lobster.

The number of trawlers targeting crustaceans has been fixed at 35 since the early 1990s. However, in late 1990s, some vessels have been replaced by new ones, better equipped and more powerful, and the number of crustacean trawlers was then reduced to 30. In the last decade (2010s), the fishery in FUs 28 and 29 was mostly conducted by the Portuguese crustacean fleet composed by an average of 23 vessels (18 – 29 m of overall length and 220 – 450 kW) and up to 5 Spanish trawlers licensed for this fishery under a bilateral agreement.

The fishery takes place throughout the year, with the highest landings usually being made in spring and summer. The main bycatch species are blue whiting, hake and anglerfish (Abad *et al.*, 2007).

Management applied to this fishery

A recovery plan for southern hake and Iberian *Nephrops* stocks was enforced since the end of January 2006 (Council Regulation (EC) No 2166/2005 – EU, 2006). This recovery plan included a reduction of 10% in the hake F relative to the previous year and TAC set accordingly, within the limits of ±15% of the previous year TAC. Although no clear targets were defined for Norway lobster stocks in the plan, the same 10% reduction was applied to these stocks TAC. The recovery plan target and rules were not changed since its implementation. Although not revoked, the enforcement of the plan was relaxed in 2017-2018 and, in March 2019, a new multiannual plan for stocks fished in the Western Waters (including the *Nephrops* stocks in these FUs) and adjacent waters was established (European Parliament and Council Regulation (EU) No 2019/472 – EU, 2019a), repealing the previous recovery plan. In the current Management Plan for Western Waters, applied to 2020 onwards, no effort limitations were established.

Besides the recovery plan, the C.R. (EC) No 2166/2005 also amended the C.R. (EC) No 850/98 (EU, 1998) introducing two boxes in Division 9.a, one of them located in FU 28. In the period of higher catches (May-August), this box is closed for *Nephrops* fishing. By derogation, fishing with bottom trawls in this area and period is authorised if the bycatch of Norway lobster does not exceed 2 % of the total weight of the catch. The same applies to creels that do not catch *Nephrops*.

With the aim of reducing effort on crustacean stocks, a Portuguese national regulation (Portaria no. 1142, 13th September 2004) closed the crustacean fishery in January-February 2005 and enforced a ban in *Nephrops* fishing for 30 days in September–October 2005, in FUs 28-29. This regulation was revoked in January 2006, after the entry in force of the recovery plan and the amendment to the Council Regulation (EC) No 850/98, keeping only one month of closure of the crustacean fishery in January (Portaria no. 43/2006, of 12th January 2006). This period was extended to February in 2016 (Portaria no. 8-A/2016, of 28th January 2016), for this year only. The national regulations are only applicable to the Portuguese fleet.

Portugal and Spain have bilateral agreements for fishing in each other waters. Under this agreement a number of Spanish trawlers are licensed to fish crustaceans in Portuguese waters. No information from landings of these vessels is available for the years prior to 2011.

Unwanted catches from *Nephrops* are regulated by the discard plan for demersal fisheries in South-Western waters for the period 2019-2021 (Council Regulations (EC) No 2018/2033 and 2019/2237 – EU, 2018, 2019b), under which they are exempted from the landing obligation based on the species high survival rates. This exemption applies to all catches of Norway lobster from ICES subareas 8 and 9 with bottom trawls, and all discards shall be released, immediately and in the area where they were caught.

The minimum landing size (MLS) for *Nephrops norvegicus* is 20 mm of carapace length (CL) or 70 mm of total length (TL).

Data

Landings and Discards

The available *Nephrops* landings information for the operation in FUs 28-29 by the Portuguese and Spanish fleets during the period 1975-2019, are summarized in Table A.1. The landings reported between 1975 and 1982 are of higher magnitude and have some associated uncertainty (i.e. during that period Spain reported around 1600 ton, and after that, no landings were reported until 2011).

Discards are considered negligible, based on the results obtained from the DCF discard sampling program onboard the Portuguese crustacean trawlers, since 2004. When occurring, discards of *Nephrops* are not related to size but mainly related to quality (i.e. broken or soft shells).

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Standardized commercial CPUE and effort

Initial CPUE Model

The standardized commercial CPUE series used in the most recent advices was presented to Inter-Benchmark Protocol for *Nephrops* in 2012 (ICES, 2012). The commercial CPUE series was standardized using generalized linear models (GLMs) and built with positive records of Norway lobster, based on the assumption that this is a target fishery. The data used for this standardization were the crustacean trawlers logbooks and the VMS records for the period 1998–2019.

As explained before, crustacean trawlers target two main species, deepwater rose shrimp and Norway lobster, which have different market values. Depending on their abundance/availability, the effort is mostly directed at one species or the other (Figure 2). Considering the behaviour of the fleet in periods of high abundance of deepwater rose shrimp, variables related to the catches of this species and the proportion of *Nephrops* in the total catch of crustaceans (proxy of *Nephrops* as the target species) were incorporated in the model. As the spatial distribution of deepwater rose shrimp and *Nephrops* are fishing ground and depth dependent, these variables were derived from VMS data and included in the model.

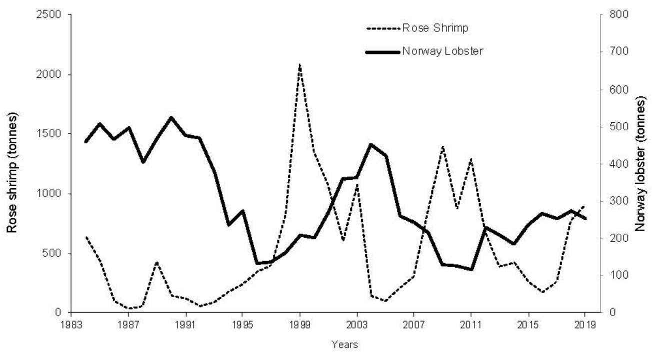

Figure 2. *Nephrops* in FU 28-29. Landings (in tonnes) of the two main target species of the Crustacean Fishery in the period 1984–2019.

The overall analysis of the geo-referenced catches confirmed the general preference of deepwater rose shrimp and *Nephrops* for grounds shallower and deeper than 400 m, respectively. These data also confirmed that, in years of higher abundance of deepwater rose shrimp, a greater effort is allocated to depths shallower than 400 m.

In what concerns the distribution of the fishing effort between the two Functional Units, FU29 represents in average 83% of the total effort. However, the CPUE in the two FUs were found not to be significantly different and therefore the variable FU was removed from the model.

The explanatory variables and levels retained in the final model were the following:

- year: 1998–2019;
- month: 1–12;
- depth interval: [100, 400[, [400, 800[, [800, 1500] m;
- log catch classes of deepwater rose shrimp: [0, 2[, [2, 5] (corresponding to low and high catch rates);
- proportion of *Nephrops* in the total catch of crustaceans: [0, 0.25[, [0.25, 1]; and
- vessel category: A (standard), B and C. These two categories correspond to vessels less or more productive than the standard type.

The choice of the final model was based on the highest value of explained variance and the smallest AIC. The model obtained for the period 1998-2019 explained 51.3% of the total variability (Table 1). The proportion of *Nephrops* in the crustacean catches ("cat_pnep") was the most important factor.

Table 1. *Nephrops* in FU 28-29. Analysis of deviance for the Gamma-based GLM model fitted to the positive *Nephrops* CPUE in the catches.

Source of variation	Df	Deviance	Resid. Df	Resid. Dev	Pr(>F)	% explained
NULL			118651	153886		
year	21	27087	118630	126799	< 2.2e-16	17.6%
month	11	3786	118619	123014	< 2.2e-16	2.5%
depth.class2	2	3071	118617	119942	< 2.2e-16	2.0%
catdps	1	2054	118616	117888	< 2.2e-16	1.3%
cat_pnep	1	41264	118615	76624	< 2.2e-16	26.8%
catPRT2	2	1745	118613	74879	< 2.2e-16	1.1%
Total	**38**	**79007**				**51.3%**

The depth interval class [400, 800[, the log catch of deepwater rose shrimp class [0, 2[, the category of proportion of *Nephrops* [0.25, 1] and the vessel category A were used as the reference factors to obtain the mean estimates of the standardized CPUE of *Nephrops* in FUs 28-29. Figure 3 shows the comparison between the standardized and the nominal CPUE (also using only positive catches).

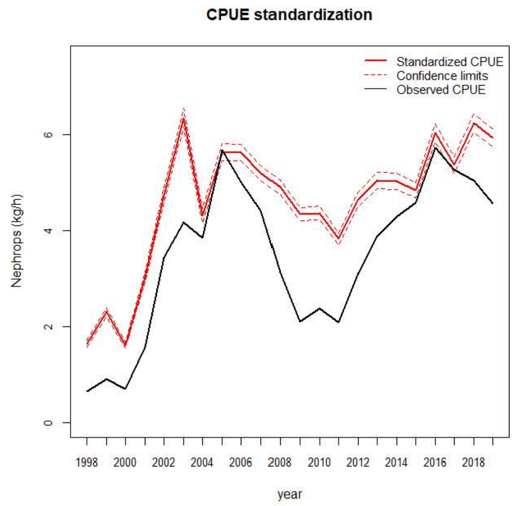

Figure 3. ***Nephrops* in FU 28-29. Comparison of standardized and nominal (observed) CPUE. Standardized series modelled including only positive catches of *Nephrops*.**

New CPUE standardization approaches

Under the WKMSYSPiCT data evaluation workshop held in November 2020 a new standardization model approach was investigated to incorporate both positive and null records of *Nephrops* in the model. Several essays were tested that will be explained ahead.

The data source used in the models was the same as in the previous model, i.e. crustacean trawlers logbooks and VMS records, but including records with zero catches of *Nephrops*.

Concerning the explanatory variables tested, some different considerations were made, with the aim of finding a better model to explain the variance in the *Nephrops* CPUE, in particular:

- **Year** was tested with two different time periods:

  Option 1: 1998-2019 (n= 193319 records);

  Option 2: 2001-2019 (n= 192425 records), i.e. removing the years in the beginning of the series, with lower number of records.

- **Month** was kept as a factor with 12 levels.
- A new variable was included in the model, the **fishing ground**, to take into account the spatial dimension of the *Nephrops* distribution. Eight levels were considered in this factor, defined by the spatial polygons represented in Figure 1, which includes two fishing grounds in FU28 and 6 in FU29.
- **Depth** was included in the models with two different approaches:

  Option 1: using depth as a continuous variable but transformed with multiple fractional polynomials (MFP) using the '*mfp*' package (Benner, 2015), as linear models assume explanatory variables to be linearly associated with the response variable, and depth has a non-linear behaviour. The MFP which best predicted the depth variable was: I((depth/1000)^2)+I((depth/1000)^3).

Option 2: using depth intervals, but with narrower ranges than those used in the initial model, i.e. [100, 200[, [200, 400[, [400, 600[, 600, 800], [800, 1600] m;

- Log catch classes of deepwater rose shrimp and proportion of *Nephrops* in the total catch of crustaceans were replaced by a new variable that aimed to serve as proxy of the target fishing, as the proportion of *Nephrops* was identified as being not truly independent from the response variable. To identify **clusters of target fishing**, a non-hierarchical clustering technique, CLARA (Kaufman and Rousseeuw, 1990; Struyf et al., 1996), was applied to the catch composition matrix, using the '*cluster*' package (Maechler et al., 2019). The matrix contained the proportion in weight per hour of the five main crustacean species caught by the fishery in each record in relation to the total weight per hour of crustaceans. The species considered were: *Nephrops*, deepwater rose shrimp, blue and red shrimp (*Aristeus antennatus*), giant red shrimp (*Aristaeomorpha foliacea*) and scarlet shrimp (*Plesiopenaeus edwardsianus*). The CLARA analysis was based on 100 data samples, each comprising 1000 records. The optimal number of '*k*' clusters was selected by iterative maximization of the 'Average Silhouette Width' (ASW) (Figure 4). Although the highest ASW was obtained for k=2 clusters (ASW=0.62), it was discussed that this could be limitative to describe the target fishing, so that the scenario using k=4, the second largest value obtained (ASW=0.57), was also considered. For the scenario k=2 the characterization by cluster with the species proportion by year (Figure 5) led to identify one cluster (cluster 2) with a high proportion of deepwater rose shrimp (95%) and the other (cluster 1) with a higher diversity of species, being *Nephrops* the dominant one (67%). For the scenario k=4, apart from a deepwater rose shrimp cluster (100%, cluster 3), one can be considered a *Nephrops* cluster (86%, cluster 4), other with a mixture of those two main species but with higher proportion of deepwater rose shrimp (66%, cluster 2) and a fourth one (cluster 1) containing more deep-water species like blue and red shrimp (56%) and scarlet shrimp (11%). The different depth ranges explored in each cluster seem to be better explained in the k=4 scenario and result on a better segregation of the target species (Figure A.1).
- **Vessel** (*cfr*) was included in the models with three different approaches:

  Option 1: grouped in three categories: A (standard), B and C. These two categories correspond to vessels less or more productive than the standard type (as in the initial model);

  Option 2: considering the all 44 different vessel as factor levels;

  Option 3: included as a random variable.

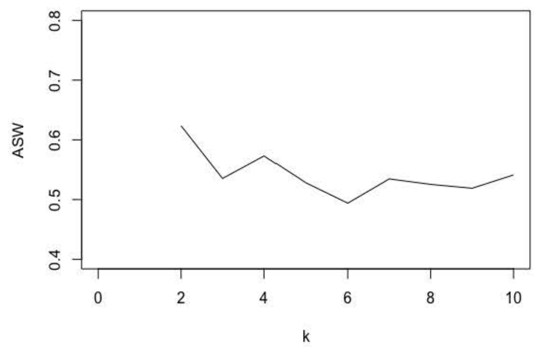

Figure 4. *Nephrops* in FU 28-29. Average Silhouette Width (ASW) obtained for different number of clusters of the target fishing in the crustacean trawl fishery catching *Nephrops*.

In order to find the best model to describe the annual trend of *Nephrops* commercial CPUE in FU 28-29, different types of models were applied: GLMs, Generalize Linear Mixed Models (GLMM) and Generalized Additive Models (GAM), with different input variables that are described in detail in Table 2. In the case of GLMM, different functions were tested: glmmPQL (Penalised Quasi-Likelihood) from package *'MASS'* (Venables and Ripley, 2002) and glmmTMB (Template Model Builder) from package *'glmmTMB'* (Brooks et al., 2017). For all the tested models, given that the response variable is a continuous variable with a discrete mass at 0, a Tweedie distribution with a log link function was assumed. The package *'tweedie'* (Dunn, 2009) was used to estimate the Tweedie power-parameter (*p*) in GLMs and in GLMM using *'glmmPQL'*. The best model was selected based on the explained variance, the Akaike information criterion (AIC) and residual diagnostics. The GLMM model using the 'glmmPQL' function did not provide the AIC as it uses the framework of quasi-likelihood (Shono, 2008). A total of 19 different models were tested (Table 2). The mean estimates of the standardized CPUE series of *Nephrops* from each model were obtained with the least-squares means (Lenth, 2016).

In overall, all the variables tested were significant to explain the variance of the response variable; models without some of them had a lower total explained variance and higher AIC. Also, removing the years with more uncertainty due to the lower number of records (i.e. removing 1998-2000) did not improve the models. In relation to the tests with different depth specifications (by classes or transformed with MFP), the model performance, in the GLMs, was better when using the transformed variable and therefore selected to be used in the GLMMs; yet when testing the GAM models, better results were achieved when applying a smooth function instead of using the MFP, as GAM can accommodate variables with nonlinear behaviour. Finally, when testing the use of 2 or 4 clusters to define the target fishing, the results were significantly improved when using the latter. In summary, the model 'Mod8.k4', a GAM with year, month, fishing ground, depth with a smooth function and target fishing defined by 4 clusters (clstr_k4) as fixed terms and vessel as a random effect, was selected as the best model (59.6% explained deviance and AIC= 690316.2). The residual diagnostics and the comparison between the standardized and the nominal CPUE are presented in Figures 6 and 7, respectively.

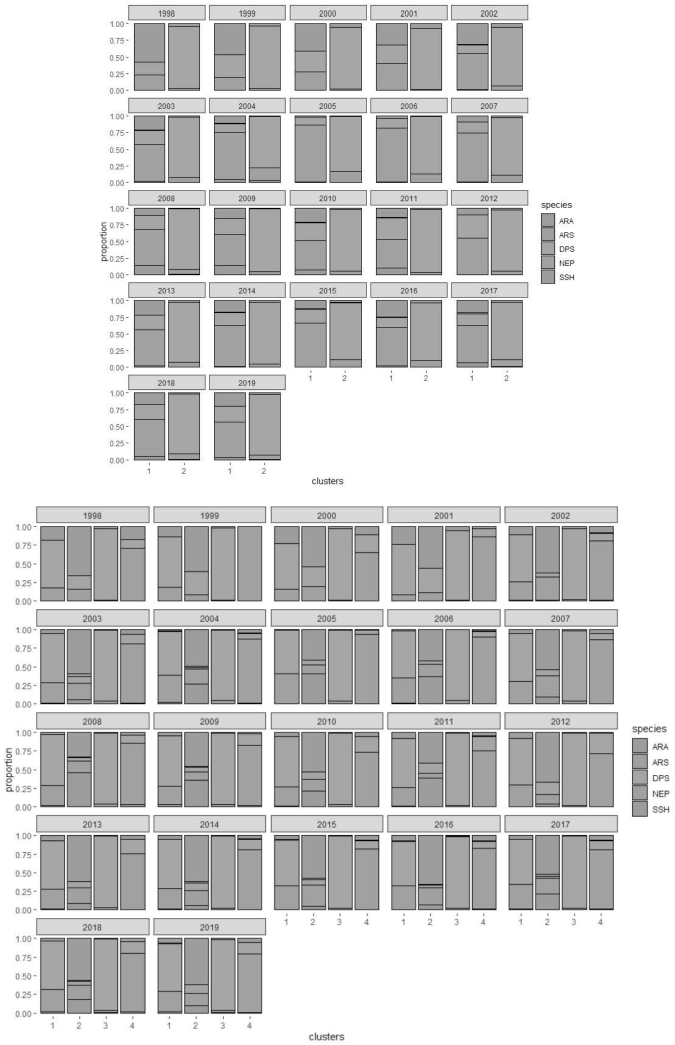

Figure 5. ***Nephrops*** **in FU 28-29. Proportion in weight of the five crustacean species by cluster, considering two clusters (upper panel), and four clusters (lower panel). ARA: blue and red shrimp (*Aristeus antennatus*), ARS: giant red shrimp (*Aristaeomorpha foliacea*), DPS: deepwater rose shrimp (*Parapenaeus longirostris*), NEP: Norway lobster (*Nephrops norvegicus*), SSH: scarlet shrimp (*Plesiopenaeus edwardsianus*).**

Table 2. ***Nephrops*** **in FU 28-29. Name and characteristics of each tested model, including time period (in years), type of model (and function used in the case of GLMM), explanatory variables included and corresponding explained variance (only for GLM), total explained variance and AIC. The selected best model is highlighted in bold.**

			Explanatory Variables											
Model name	year	model	year	month	fish ground	depth (pol)	depth class	clstr_k2	clstr_k4	cfr (44 lvl)	cfr (3lvl)	cfr (re)	Expl dev %	AIC
Mod0.k2	1998-2019	GLM	8.2%	5.6%	5.9%	1.6%		18.2%					39.5%	768,031.7
Mod01.k2	2001-2019	GLM	7.8%	5.6%	5.9%	1.6%		18.3%					39.2%	766,953.2
Mod0.k4	1998-2019	GLM	8.2%	5.6%	5.9%	0.5%			32.7%				52.9%	719,185.4
Mod01.k4	2001-2019	GLM	8.2%	5.6%	5.9%	0.5%			32.6%				52.8%	718,447.4
Mod1.k2	1998-2019	GLM	8.2%	5.6%	5.9%			18.2%					37.9%	773,278.4
Mod1.k4	1998-2019	GLM	8.2%	5.6%	5.9%				32.7%				52.4%	721,113.8
Mod2.k2	1998-2019	GLM	8.2%	5.6%	5.9%		2.4%	16.8%					38.9%	769,940.1
Mod2.k4	1998-2019	GLM	8.2%	5.6%	5.9%		2.4%		30.6%				52.7%	719,966.4
Mod3.k2	1998-2019	GLM	8.2%	5.6%	5.9%	3.3%		16.5%		1.7%			41.1%	762,452.6
Mod3.k2.cat	1998-2019	GLM	8.2%	5.6%	5.9%	3.3%		16.5%			1.2%		40.6%	764,081.3
Mod3.k4	1998-2019	GLM	8.2%	5.6%	5.9%	3.3%			29.9%	1.2%			54.1%	714,462.9
Mod3.k4.cat	1998-2019	GLM	8.2%	5.6%	5.9%	3.3%			29.9%		0.6%		53.5%	716,749.3
Mod3.1.k4	2001-2019	GLM	7.8%	5.6%	5.9%	3.3%			30.0%	1.2%			53.9%	713,730.2
Mod3.1.k4.cat	2001-2019	GLM	7.8%	5.6%	5.9%	3.3%			30.0%		0.6%		53.3%	716,020.5
Mod4.k4	1998-2019	GLMM (glmmPQL)	x	x	x	x			x			x	NA	NA
Mod5.k4	1998-2019	GLMM (glmmTMB)	x	x	x	x			x			x	NA	691,038.4
Mod6.k4	1998-2019	GLMM (glmmTMB)	x	x	x	x			x	x			NA	690,903.7
Mod7.k4	1998-2019	GAM	x	x	x	x			x			x	59.4%	691,036.1
Mod8.k4	**1998-2019**	**GAM**	**x**	**x**	**x**	**s()**			**x**			**x**	**59.6%**	**690,316.2**

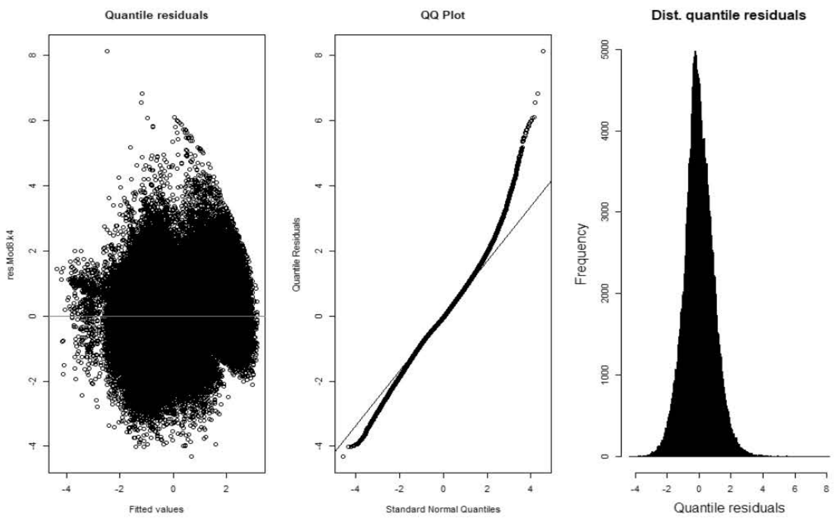

Figure 6. ***Nephrops*** **in FUs 28-29. CPUE standardization model, residuals plots, from the model Mod8.k4**

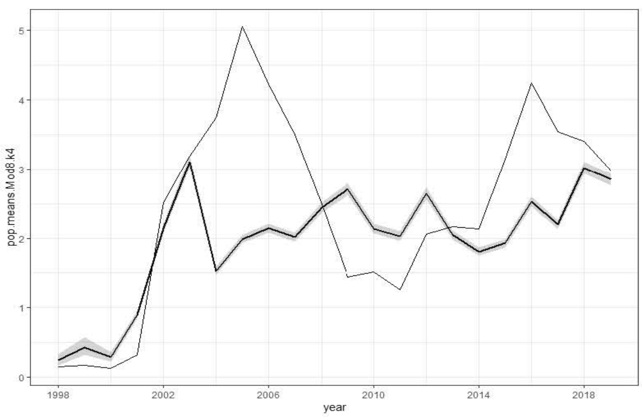

Figure 7. ***Nephrops*** **in FU 28-29. Comparison of standardized CPUE from model Mod8.k4 (thicker line with confidence intervals shaded in grey) and nominal CPUE (thinner line), considering both zero and positive catches of** ***Nephrops*****.**

A comparison of the standardized CPUE series obtained with some of the new tested models (including the selected model Mod8.k4) with the nominal CPUE series (considering both zeros and positive catches of *Nephrops*) and the initial CPUE model not considering the zeros (mod7_catPRT2) was plotted (Figure 8). The trends followed by the new models including zero catches are very similar and, as expected, with mean values lower than the series from the initial model containing only positive catches.

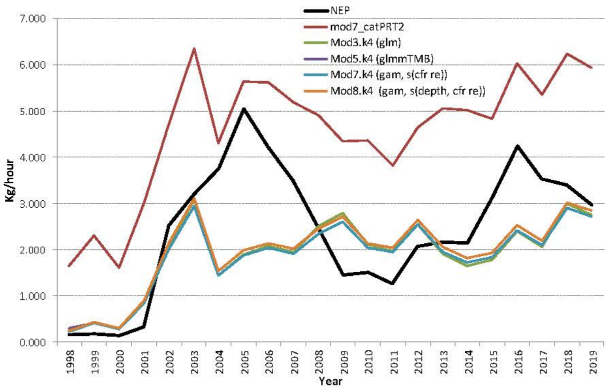

Figure 8. Comparison between candidate models with the nominal *Nephrops* CPUE series (NEP). All series considered zeros and positive catches of *Nephrops*, except mod7_catPRT2 (only with positive catches).

Surveys

The Portuguese 3-week crustaceans trawl survey is conducted every year in May – July (NepS (FU 28-29)), in the period when males and females are at their maximum activity, out of the burrows and both sexes available to the trawl gear. The design of the survey is described in ICES (2018) and Silva *et al.* (2018). The survey, covering the whole area, started in 1997. There are some missing values in some of the years, due to different problems. The series was disrupted in 2019 and will be re-started with a different vessel.

Figure 9 shows the time series of the estimated biomass indices for deepwater rose shrimp and Norway lobster (Silva *et al.*, 2019). The biomass index values for Norway lobster are presented in the summary Table A.2.

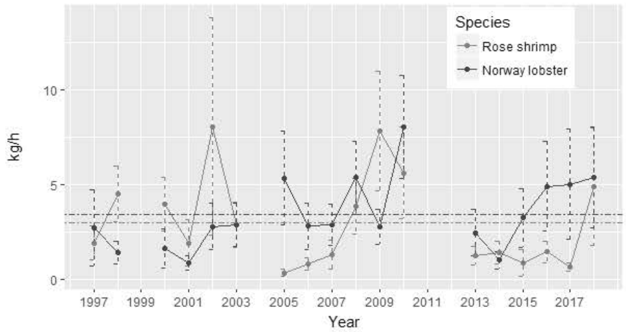

Figure 9. Stratified mean biomass index time series with 95% confidence interval for Norway lobster and deepwater rose shrimp in FU 28-29.

SPiCT model exploratory runs

The analyses were made with R version 3.6.3 (R Core Team, 2020) and the package SPiCT (Pedersen and Berg, 2017), following the Handbook and Guidelines developed for this package (Pedersen *et al.*, 2020; Midenberger *et al.*, 2020).

The following data series (summarized in Table A.2) were available for the SPiCT runs:

- Total catches for the period 1975 – 2019 (most runs used the period 1984 – 2019, due to the high uncertainty in the reported catches prior to 1984),
- the standardized commercial CPUE, as estimated in the previous section, for the period 1998 -2019 (Mod8_k4),
- the survey biomass index for the period 1997 – 2018, obtained from the Crustaceans Trawl Survey, covering the whole area of FU 28-29, and
- the total effort estimated using the catches and the standardized commercial CPUE.

After some trials exploring the use of one single biomass index (the survey index or the standardized CPUE index) or the effort series, some runs were carried out using i) both biomass indices or ii) the survey index and the estimated standardized effort. All the individual runs were compiled in the document "ANNEX I – nep.fu.2829 extra runs.pdf", including those using the full catch series (1975 – 2019), despite the catches prior to 1984 being very uncertain.

The prior for n was set as 2, corresponding to the Schaeffer model. Uncertainty was added to the catches prior to 1993 in all runs and in some of the runs also to the survey index in years 2010 and 2014, which were extreme values. The same was done for the years 1998 – 2001 of the CPUE series, which were based in less data records. All the parameters were estimated by the model. Table 3 summarizes the input data and results, as well as some indicators for the acceptance of the models. Tables 4 to 8 and Figures 10 to 17 include the main outputs from the model including only the survey index and from the best models using the survey and the CPUE or effort.

Table 3. Summary of SPiCT runs: Input series, diagnostics and results.

	Survey Index	Std CPUE + Survey Index				Std Effort + Survey Index			
		v1	v2	v3	v4	v1	v2	v3	v4
Input series									
C	1984-2019	1984-2019	1984-2019	1984-2019	1984-2019	1984-2019	1984-2019	1984-2019	1984-2019
E (C/I1)						1998-2019	1998-2019	1998-2019	1998-2019
I1 (std CPUE)		1998-2019	1998-2019	1998-2019	1998-2019				
I2 (survey)	1997-2019	1997-2019	1997-2019	1997-2019	1997-2019	1997-2019	1997-2019	1997-2019	1997-2019
Increased uncertainty									
C	1984-1992	1984-1992	1984-1992	1984-1992	1984-1992	1984-1992	1984-1992	1984-1992	1984-1992
E (C/I1)							1998-2001		1998-2001
I1 (std CPUE)			1998-2001		1998-2001				
I2 (survey)	2010, 2014		2010, 2014	2010, 2014			2010, 2014	2010, 2014	
Checklist for acceptance									
1. Convergence	✓	✓	✓	✓	✓	✓	✓	✓	✓
2. Finite parameters	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
3. Violation of model assumptions									
shapiro	✓	✓	C*I1.	✓	✓	✓	✓	I2.	✓
bias	✓	✓	✓	✓	C*	✓	✓	✓	✓
acf	✓	C*	C*I1*I2.	C*	✓	✓	✓	✓	✓
LBox	✓	C.	C*I1.	C.	C.	✓	✓	✓	✓
4. Retrospective pattern	✓(-4)	✓(-1)	✓	✓	×	✓	✓(-3)	✓	✓
Mohn's Rho									
F/Fmsy	0.0468	-0.0182	-0.0601	-0.0302	×	-0.0183	0.0190	-0.0182	-0.0040
B/Bmsy	-0.0469	0.0068	0.0344	0.0110	×	0.0084	-0.0210	0.0069	-0.0019
5. Realistic production curve	✓	✓	✓	✓	✓	✓	✓	✓	✓
6. Assessment uncertainty	×	✓	✓	✓	×	✓	✓	✓	✓
7. Initial values sensitivity	✓	✓	✓	✓	✓	✓	✓	✓	✓
Model Results									
K	3673	246	2747	239	326	204	267	217	257
r	0.56	8.62	0.73	9.06	7.22	9.68	8.67	9.37	8.61
q1		0.01092	0.00100	0.01111	0.00823				
q2	0.00129	0.02101	0.00166	0.02220	0.01495	0.02610	0.01925	0.02522	0.01963
qf						0.00001	0.00001	0.00001	0.00001
B_{2019}	2892	203	2466	199	275	169	227	181	218
B_{2019}/B_{MSY}	1.78	1.56	1.89	1.54	3.23	1.62	1.66	1.60	1.65
B_{MSY}	1629	1352	1307	129	85	105	137	113	132
F_{2019}	0.10	1.39	0.11	1.42	1.02	1.62	1.20	1.52	1.25
F_{2019}/F_{MSY}	0.39	0.39	0.36	0.39	0.25	0.36	0.34	0.36	0.34
F_{MSY}	0.25	0.28	0.31	3.61	4.05	4.55	3.52	4.22	3.67
MSY	398	375	398	465	516	476	490	476	490

Note: In red are indicated the series with problems in the model quality checks and the number of runs with no convergence in the retrospective pattern.

Table 4. SPiCT model with Survey Index series 1997-2018 with missing values in 1999, 2004, 2011 and 2012

Convergence: 0 MSG: relative convergence (4)
Objective function at optimum: 21.2043977
Euler time step (years): 1/16 or 0.0625
Nobs C: 36, Nobs I1: 18

Residual diagnostics (p-values)

	shapiro	bias	acf	LBox	shapiro	bias	acf	LBox
C	0.3607	0.4964	0.1703	0.1974	-	-	-	-
I1	0.885	0.3629	0.157	0.4513	-	-	-	-

Priors
logn ~ dnorm[log(2), 0.3^2]
logalpha ~ dnorm[log(1), 0.3^2]
logbeta ~ dnorm[log(1), 0.3^2]

Model parameter estimates w 95% CI

	estimate	cilow	ciupp	log.est
alpha	1.318924	0.886241	1.962851	0.276816
beta	0.875744	0.484524	1.582847	-0.13268
r	0.560289	0.144017	2.179772	-0.5793
rc	0.546532	0.152402	1.959933	-0.60416
rold	0.533435	0.125986	2.258609	-0.62842
m	506.7226	37.04536	6931.171	6.227964
K	3673.374	111.1066	121448.1	8.208866
q	0.001295	1.47E-05	0.114263	-6.64946
n	2.050341	1.131793	3.71437	0.718006
sdb	0.313666	0.218514	0.450254	-1.15943
sdf	0.060694	0.01637	0.225037	-2.80191
sdi	0.413702	0.294805	0.580551	-0.88261
sdc	0.053153	0.01663	0.169887	-2.93459

Deterministic reference points (Drp)

	estimate	cilow	ciupp	log.est
Bmsyd	1854.318	54.50827	63082.12	7.525272
Fmsyd	0.273266	0.076201	0.979967	-1.29731
MSYd	506.7226	37.04536	6931.171	6.227964

Stochastic reference points (Srp)

	estimate	cilow	ciupp	log.est	rel.diff.Drp
Bmsys	1628.863	52.95327	50104.46	7.395638	-0.13841
Fmsys	0.248078	0.060557	1.016287	-1.39401	-0.10153
MSYs	398.407	36.31431	4370.953	5.987474	-0.27187

States w 95% CI (inp$msytype: s)

	estimate	cilow	ciupp	log.est
B_2019.94	2891.898	35.24213	237303.3	7.969668
F_2019.94	0.096014	0.00115	8.018922	-2.34326
B_2019.94/Bmsy	1.775409	0.567981	5.549614	0.574031
F_2019.94/Fmsy	0.387031	0.012059	12.42181	-0.94925

Predictions w 95% CI (inp$msytype: s)

	predictior	cilow	ciupp	log.est
B_2021.00	2826.167	36.23799	220410.2	7.946677
F_2021.00	0.096014	0.001148	8.03251	-2.34326
B_2021.00/Bmsy	1.735055	0.562206	5.354647	0.551039
F_2021.00/Fmsy	0.387032	0.012033	12.44869	-0.94925
Catch_2020.00	274.2373	176.2893	426.6061	5.613994
E(B_inf)	2240.246	NA	NA	7.714341

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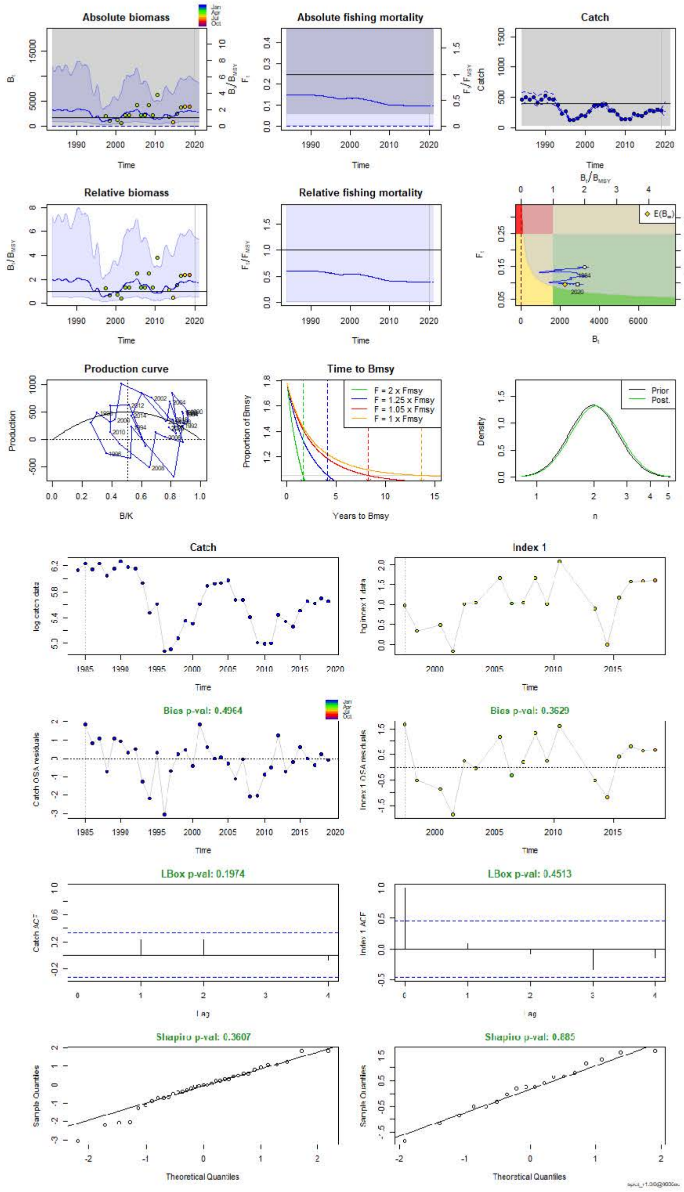
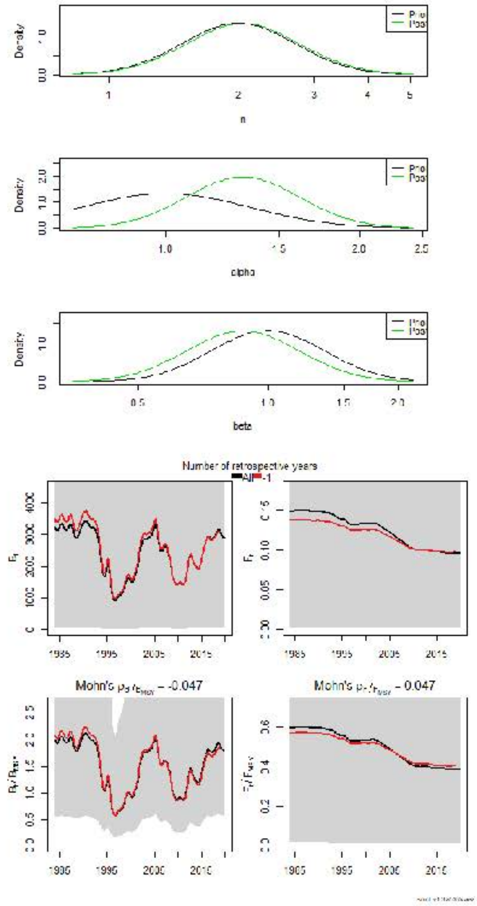


Figure 10. SPiCT model with Survey Index series: Model estimates for biomass, fishing mortality and reference points and residuals diagnostics plots.



Excluded 4 retrospective runs that were not converged: 2, 3, 4, 5

Mohn's Rho

BBmsy	FFmsy
-0.0469	0.0468

Figure 11. SPiCT models with Survey Index series. Priors and posterior distributions of model parameters (upper panel) and retrospective plots (lower panel) with four peels missing in retrospective plot due to lack of convergence.

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Table 5. SPiCT model with Std CPUE and Survey Index series – v1

Convergence: 0 MSG: relative convergence (4)
Objective function at optimum: 32.6423196
Euler time step (years): 1/16 or 0.0625
Nobs C: 36, Nobs I1: 22, Nobs I2: 18

Residual diagnostics (p-values)

	shapiro	bias	acf	LBox	shapiro	bias	acf	LBox
C	0.287	0.6036	0.0153	0.0714	-	-	*	.
I1	0.9464	0.5734	0.2262	0.5277	-	-	-	-
I2	0.167	0.8173	0.4272	0.8641	-	-	-	-

Priors
logn ~ dnorm[log(2), 0.3^2]
logalpha ~ dnorm[log(1), 0.3^2]
logbeta ~ dnorm[log(1), 0.3^2]

Model parameter estimates w 95% CI

	estimate	cilow	ciupp	log.est
alpha1	0.716027	0.444053	1.154581	-0.33404
alpha2	1.725984	1.099322	2.709871	0.545798
beta	0.530961	0.328508	0.858181	-0.63307
r	8.620483	3.004266	24.73573	2.154141
rc	6.798911	2.575743	17.94635	1.916762
rold	5.61287	2.072914	15.19808	1.725062
m	455.4035	404.9984	512.0818	6.121184
K	245.5356	88.60512	680.4089	5.503442
q1	0.010921	0.0039	0.030583	-4.5171
q2	0.02101	0.007292	0.060539	-3.86275
n	2.535842	1.723798	3.730424	0.930526
sdb	0.321172	0.210717	0.489524	-1.13578
sdf	0.181409	0.133021	0.247399	-1.707
sdi1	0.229968	0.15566	0.339748	-1.46982
sdi2	0.554337	0.417612	0.735827	-0.58998
sdc	0.096321	0.062871	0.147569	-2.34007

Deterministic reference points (Drp)

	estimate	cilow	ciupp	log.est
Bmsyd	133.9637	48.70856	368.4416	4.897569
Fmsyd	3.399456	1.287871	8.973177	1.223615
MSYd	455.4035	404.9984	512.0818	6.121184

Stochastic reference points (Srp)

	estimate	cilow	ciupp	log.est	rel.diff.Drp
Bmsys	129.9977	54.94007	307.5971	4.867517	-0.03051
Fmsys	3.593551	1.690985	7.636737	1.279141	0.054012
MSYs	467.9232	396.4965	552.2169	6.148304	0.026756

States w 95% CI (inp$msytype: s)

	estimate	cilow	ciupp	log.est
B_2019.94	202.7506	70.96901	579.2358	5.311977
F_2019.94	1.385604	0.469919	4.085591	0.326136
B_2019.94/Bmsy	1.559647	1.186005	2.051002	0.44446
F_2019.94/Fmsy	0.385581	0.250221	0.594166	-0.95301

Predictions w 95% CI (inp$msytype: s)

	predictior	cilow	ciupp	log.est
B_2021.00	202.5234	71.0961	576.9056	5.310856
F_2021.00	1.385604	0.442366	4.340066	0.326136
B_2021.00/Bmsy	1.5579	1.179768	2.057229	0.443339
F_2021.00/Fmsy	0.385581	0.218747	0.679655	-0.953
Catch_2020.00	280.6465	205.5894	383.1058	5.637096
E(B_inf)	202.628	NA	NA	5.311372

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Table 6. SPiCT model with Std CPUE and Survey Index series – v3

Convergence: 0 MSG: relative convergence (4)
Objective function at optimum: 30.6951931
Euler time step (years): 1/16 or 0.0625
Nobs C: 36, Nobs I1: 22, Nobs I2: 18

Residual diagnostics (p-values)

	shapiro	bias	acf	LBox	shapiro	bias	acf	LBox
C	0.4174	0.6721	0.0176	0.0746	-	-	*	.
I1	0.9431	0.5815	0.1893	0.4805	-	-	-	-
I2	0.1049	0.9087	0.3507	0.7072	-	-	-	-

Priors
logn ~ dnorm[log(2), 0.3^2]
logalpha ~ dnorm[log(1), 0.3^2]
logbeta ~ dnorm[log(1), 0.3^2]

Model parameter estimates w 95% CI

	estimate	cilow	ciupp	log.est
alpha1	0.764737	0.472927	1.236602	-0.26822
alpha2	1.592627	1.007097	2.518587	0.465385
beta	0.537739	0.33156	0.872131	-0.62038
r	9.062218	3.082742	26.63985	2.204114
rc	6.861767	2.524324	18.65206	1.925965
rold	5.521145	1.980783	15.38939	1.708585
m	454.2728	403.2949	511.6946	6.118698
K	239.2816	83.8081	683.1761	5.477641
q1	0.011114	0.00385	0.032087	-4.49956
q2	0.022196	0.007483	0.065842	-3.80782
n	2.641366	1.786358	3.905606	0.971296
sdb	0.30306	0.198317	0.463124	-1.19383
sdf	0.179889	0.131976	0.245196	-1.71542
sdi1	0.231761	0.157944	0.340077	-1.46205
sdi2	0.482661	0.358834	0.649219	-0.72844
sdc	0.096733	0.063241	0.147964	-2.3358

Deterministic reference points (Drp)

	estimate	cilow	ciupp	log.est
Bmsyd	132.407	46.63632	375.9217	4.88588
Fmsyd	3.430884	1.262162	9.326031	1.232818
MSYd	454.2728	403.2949	511.6946	6.118698

Stochastic reference points (Srp)

	estimate	cilow	ciupp	log.est	rel.diff.Drp
Bmsys	128.771	52.24542	317.3861	4.858036	-0.02824
Fmsys	3.609869	1.628676	8.001072	1.283671	0.049582
MSYs	465.4972	395.3284	548.1206	6.143106	0.024113

States w 95% CI (inp$msytype: s)

	estimate	cilow	ciupp	log.est
B_2019.94	198.5239	67.65181	582.5672	5.290909
F_2019.94	1.41702	0.467875	4.291633	0.348556
B_2019.94	1.541681	1.191976	1.993984	0.432874
F_2019.94	0.392541	0.257382	0.598675	-0.93512

Predictions w 95% CI (inp$msytype: s)

	predictior	cilow	ciupp	log.est
B_2021.00	198.3607	67.72789	580.9564	5.290087
F_2021.00	1.417021	0.441476	4.548258	0.348557
B_2021.00	1.540414	1.184698	2.002936	0.432051
F_2021.00	0.392541	0.2249	0.685143	-0.93511
Catch_202	281.1014	206.7587	382.1749	5.638715
E(B_inf)	198.4059	NA	NA	5.290315

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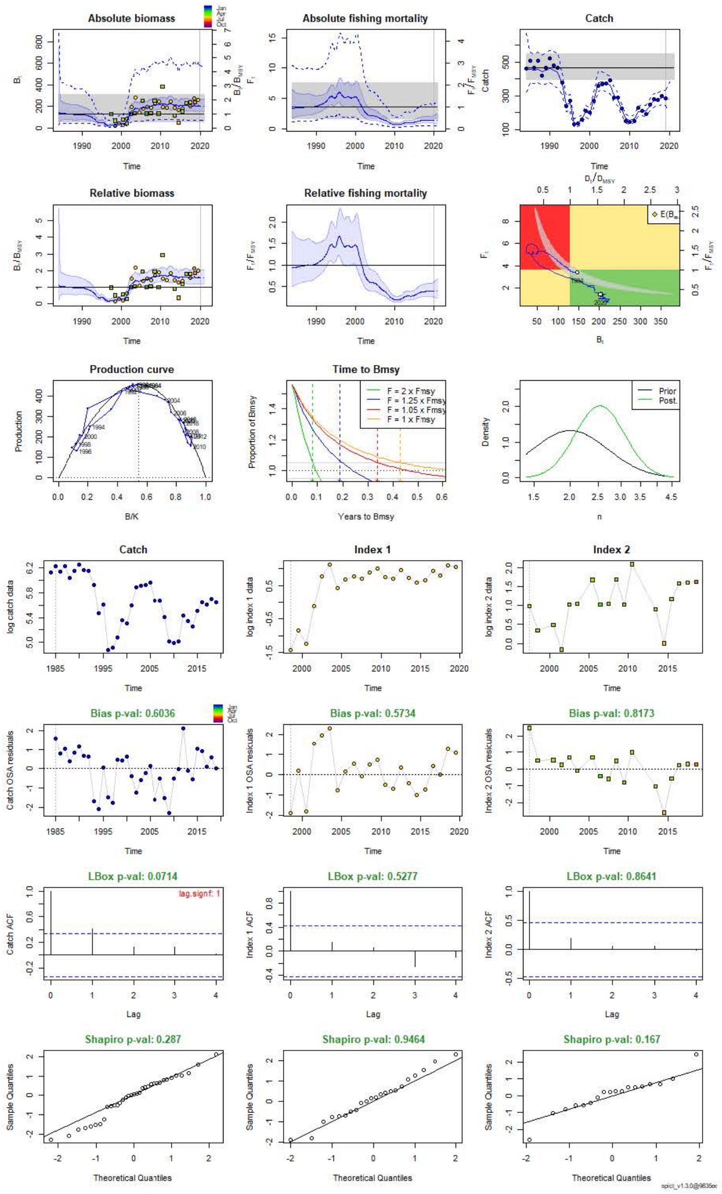

Figure 12. SPiCT model with Std CPUE and Survey Index series – v1: Model estimates for biomass, fishing mortality and reference points and residuals diagnostics plots.

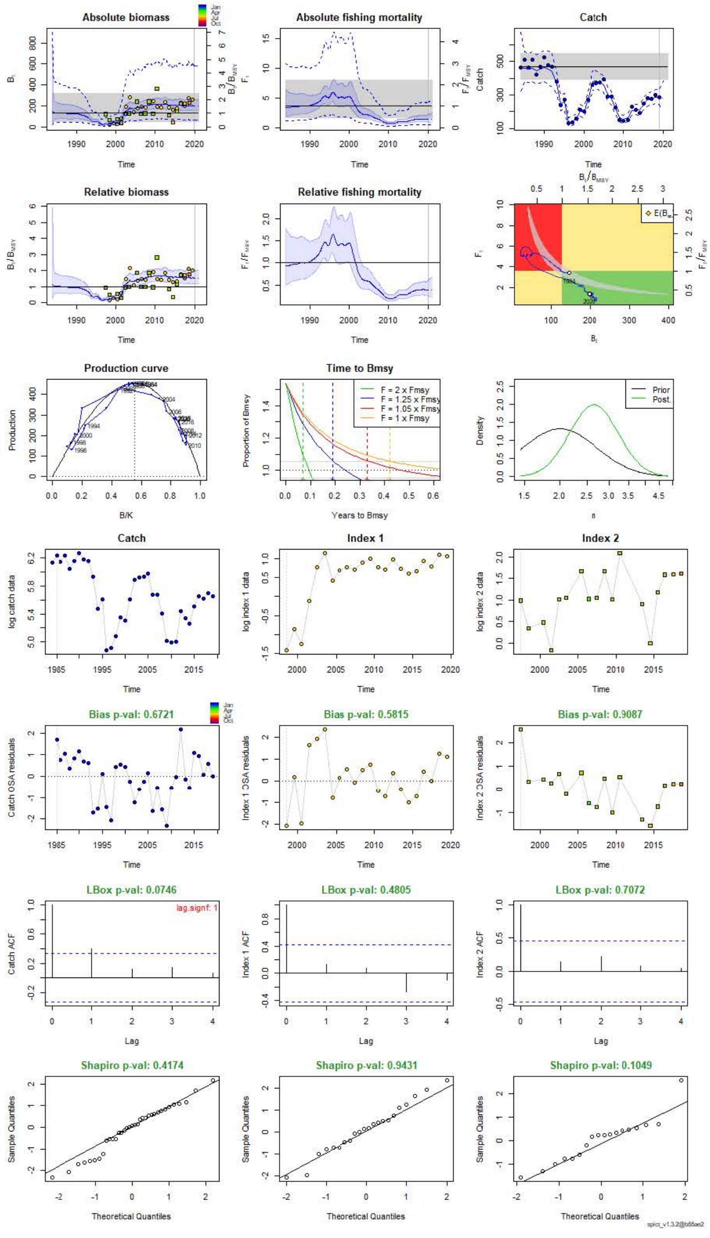

Figure 13. SPiCT model with Std CPUE and Survey Index series – v3: Model estimates for biomass, fishing mortality and reference points and residuals diagnostics plots.

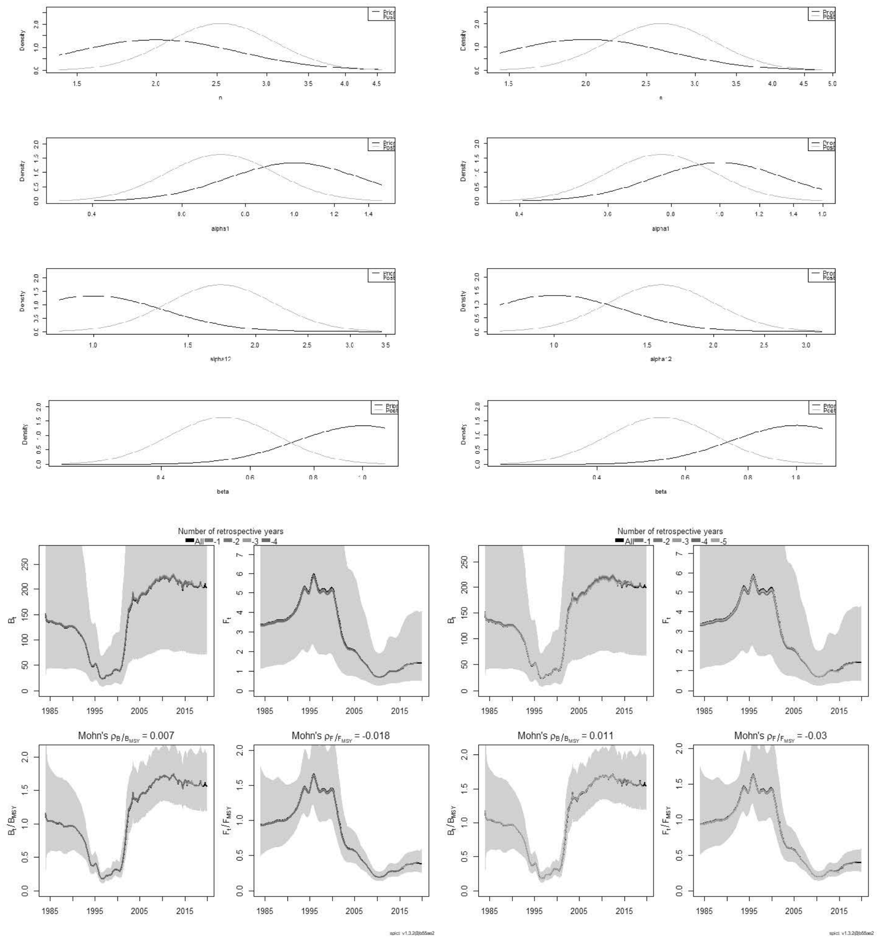

Figure 14. SPiCT models with Std CPUE and Survey Index series – v1 and v3 (left and right, respectively). Priors and posterior distributions of model parameters (upper panel) and retrospective plots (lower panel) with one peel missing in v1 retrospective plot (-5 line) due to lack of convergence.

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Table 7. SPiCT model with Std Effort and Survey Index series – v1

Convergence: 0 MSG: relative convergence (4)
Objective function at optimum: 27.2506973
Euler time step (years): 1/16 or 0.0625
Nobs C: 36, Nobs I1: 18, Nobs E: 22

Residual diagnostics (p-values)

	shapiro	bias	acf	LBox	shapiro	bias	acf	LBox
C	0.1419	0.2996	0.1443	0.2824	-	-	-	-
E	0.4661	0.531	0.2755	0.4714	-	-	-	-
I1	0.156	0.9419	0.413	0.8373	-	-	-	-

Priors
logn ~ dnorm[log(2), 0.3^2]
logalpha ~ dnorm[log(1), 0.3^2]
logbeta ~ dnorm[log(0.5), 0.3^2]
logsdf ~ dnorm[log(0.2), 0.3^2]

Model parameter estimates w 95% CI

	estimate	cilow	ciupp	log.est
alpha	1.324893	0.750999	2.33734	0.281331
beta	0.326495	0.205221	0.519434	-1.11934
r	9.680456	3.628704	25.82499	2.270109
rc	8.802446	3.441244	22.516	2.17503
rold	8.070461	3.003889	21.68268	2.088211
m	465.8543	426.4967	508.8439	6.143873
K	204.2049	78.94161	528.2341	5.319124
q	0.026098	0.009587	0.071045	-3.64589
qf	1.34E-05	5.1E-06	3.52E-05	-11.2169
n	2.199492	1.588421	3.045646	0.788227
sdb	0.461719	0.249229	0.855376	-0.7728
sdf	0.216213	0.162632	0.287446	-1.53149
sdi	0.611728	0.444156	0.842521	-0.49147
sde	0.189652	0.123126	0.292123	-1.66256
sdc	0.070592	0.044351	0.11236	-2.65083

Deterministic reference points (Drp)

	estimate	cilow	ciupp	log.est
Bmsyd	105.8466	40.87403	274.0981	4.661991
Fmsyd	4.401223	1.720622	11.258	1.481882
MSYd	465.8543	426.4967	508.8439	6.143873

Stochastic reference points (Srp)

	estimate	cilow	ciupp	log.est	rel.diff.Drp
Bmsys	104.567	42.10007	259.7207	4.649828	-0.01224
Fmsys	4.552065	1.928282	10.74599	1.515581	0.033137
MSYs	476.1889	427.9413	529.8761	6.165815	0.021703

States w 95% CI (inp$msytype: s)

	estimate	cilow	ciupp	log.est
B_2019.94	169.2958	62.44014	459.0168	5.131648
F_2019.94	1.616151	0.592217	4.410456	0.480048
B_2019.94	1.619017	1.213749	2.159603	0.481819
F_2019.94	0.355037	0.253268	0.4977	-1.03553

Predictions w 95% CI (inp$msytype: s)

	predictior	cilow	ciupp	log.est
B_2021.00	167.1587	61.91157	451.3214	5.118943
F_2021.00	1.616152	0.54075	4.830228	0.480048
B_2021.00	1.598579	1.189041	2.149174	0.469115
F_2021.00	0.355037	0.204392	0.616712	-1.03553
Catch_202	270.3882	193.0381	378.7324	5.599859
E(B_inf)	165.7112	NA	NA	5.110247

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Table 8. SPiCT model with Std Effort and Survey Index series – v4

Convergence: 0 MSG: relative convergence (4)
Objective function at optimum: 26.8460166
Euler time step (years): 1/16 or 0.0625
Nobs C: 36, Nobs I1: 18, Nobs E: 22

Residual diagnostics (p-values)

	shapiro	bias	acf	LBox	shapiro	bias	acf	LBox
C	0.197	0.4056	0.1059	0.2561	-	-	-	-
E	0.2678	0.7643	0.2453	0.441	-	-	-	-
I1	0.2056	0.8047	0.5854	0.9485	-	-	-	-

Priors
logn ~ dnorm[log(2), 0.3^2]
logalpha ~ dnorm[log(1), 0.3^2]
logbeta ~ dnorm[log(0.5), 0.3^2]
logsdf ~ dnorm[log(0.2), 0.3^2]

Model parameter estimates w 95% CI

	estimate	cilow	ciupp	log.est
alpha	1.347575	0.784151	2.315827	0.298306
beta	0.343175	0.214526	0.548974	-1.06952
r	8.610485	2.954309	25.0957	2.152981
rc	6.48935	2.393838	17.59169	1.870162
rold	5.206711	1.843023	14.70945	1.649948
m	462.9434	420.2542	509.969	6.137605
K	257.4307	94.41505	701.9067	5.55075
q	0.019628	0.006854	0.056205	-3.93081
qf	1.06E-05	3.9E-06	2.89E-05	-11.4559
n	2.653728	1.73636	4.055768	0.975966
sdb	0.421283	0.236979	0.748925	-0.86445
sdf	0.202963	0.151835	0.271307	-1.59473
sdi	0.567711	0.411865	0.782527	-0.56614
sde	0.177068	0.117642	0.266511	-1.73122
sdc	0.069652	0.043516	0.111484	-2.66425

Deterministic reference points (Drp)

	estimate	cilow	ciupp	log.est
Bmsyd	142.6779	52.44335	388.1709	4.96059
Fmsyd	3.244675	1.196919	8.795844	1.177015
MSYd	462.9434	420.2542	509.969	6.137605

Stochastic reference points (Srp)

	estimate	cilow	ciupp	log.est	rel.diff.Drp
Bmsys	132.2976	71.88964	243.4657	4.885054	-0.07846
Fmsys	3.669935	2.154542	6.251175	1.300174	0.115877
MSYs	489.9379	400.9883	598.6188	6.194279	0.055098

States w 95% CI (inp$msytype: s)

	estimate	cilow	ciupp	log.est
B_2019.94	218.1271	76.76391	619.815	5.385078
F_2019.94	1.252482	0.437801	3.583165	0.225127
B_2019.94	1.64876	1.010845	2.689247	0.500024
F_2019.94	0.341282	0.189886	0.613385	-1.07505

Predictions w 95% CI (inp$msytype: s)

	predictior	cilow	ciupp	log.est
B_2021.00	215.0001	76.34754	605.4556	5.370639
F_2021.00	1.252482	0.405294	3.870551	0.225128
B_2021.00	1.625124	1.002462	2.634543	0.485584
F_2021.00	0.341282	0.166877	0.697958	-1.07505
Catch_202	269.6448	193.777	375.2163	5.597106
E(B_inf)	215.9322	NA	NA	5.374964

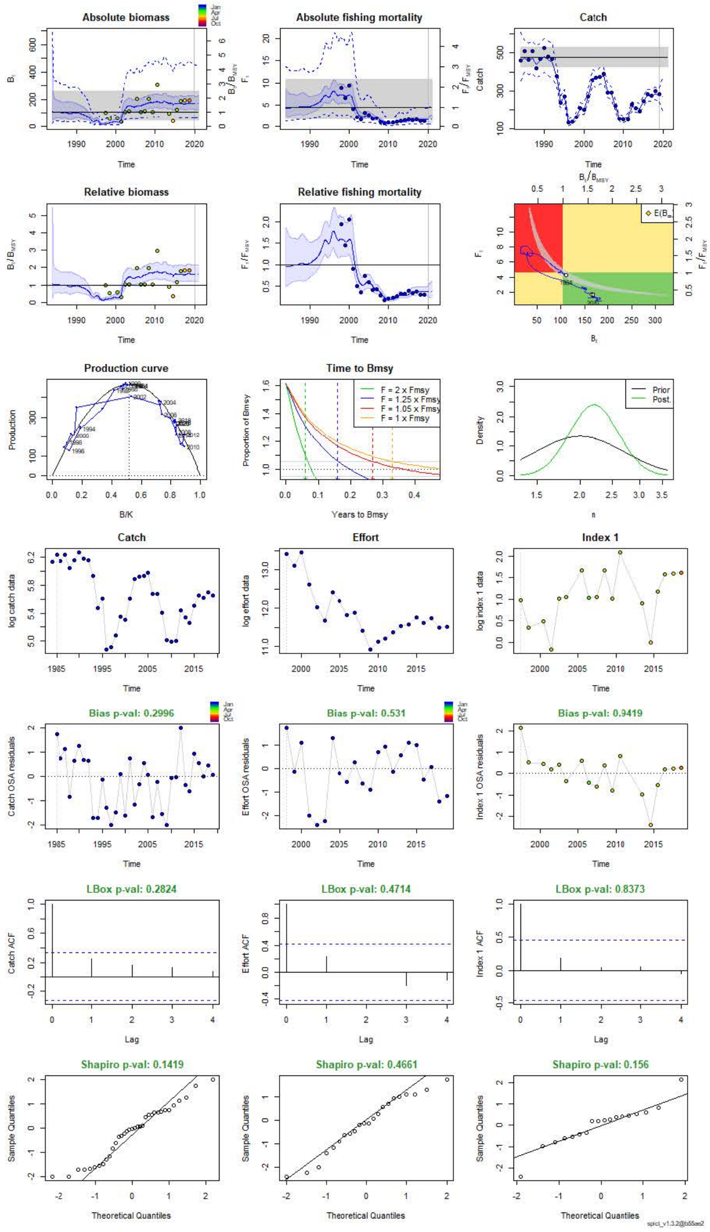

Figure 15. SPiCT model with Std Effort and Survey Index series – v1: Model estimates for biomass, fishing mortality and reference points and residuals diagnostics plots.

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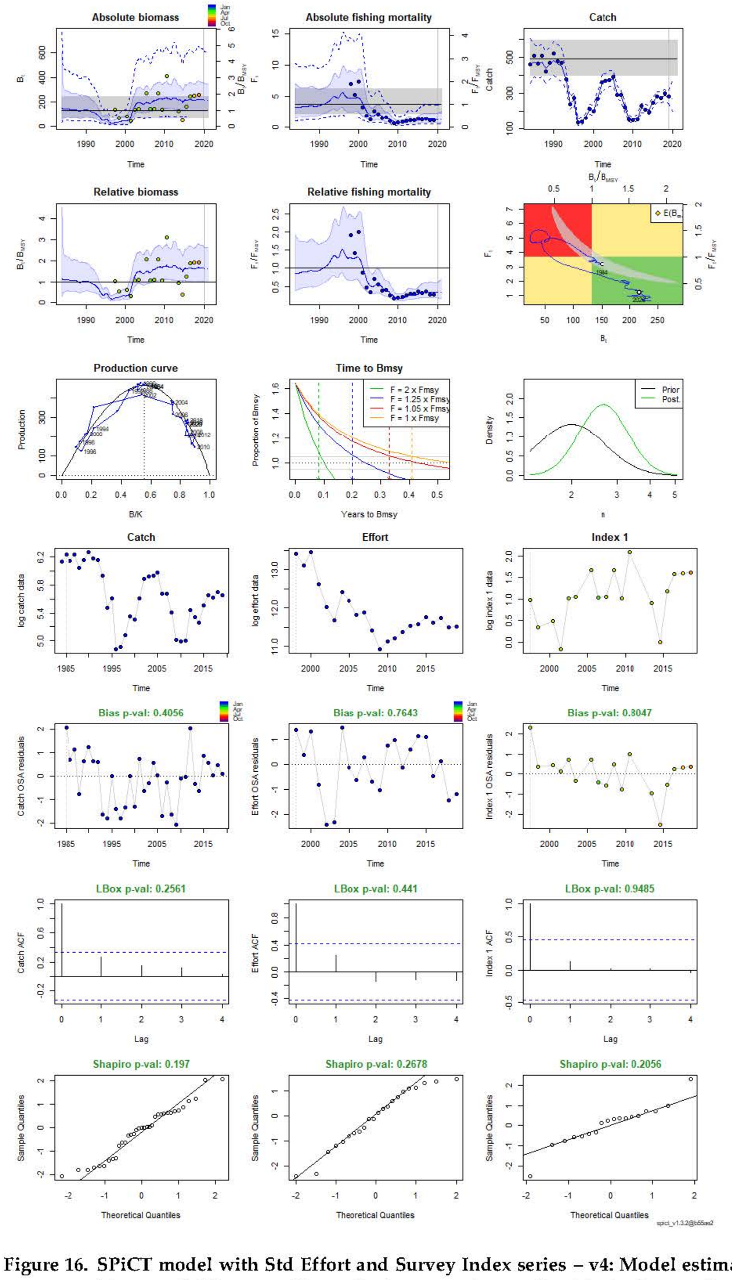

Figure 16. SPiCT model with Std Effort and Survey Index series – v4: Model estimates for biomass, fishing mortality and reference points and residuals diagnostics plots.

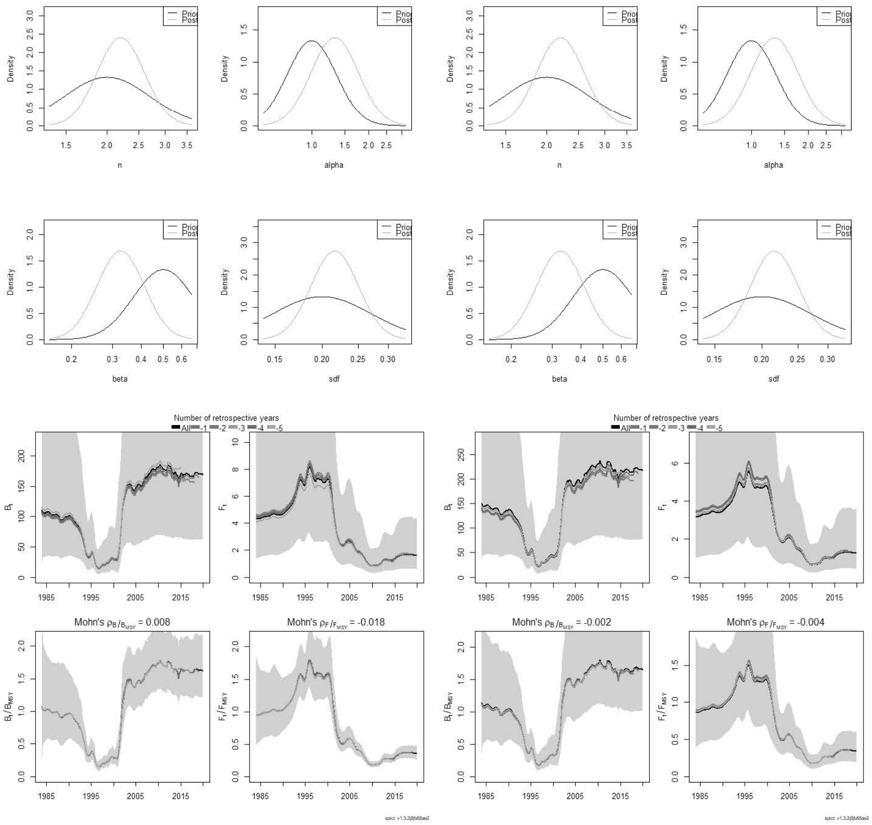

Figure 17. SPiCT models with Std Effort and Survey Index series – v1 and v4 (left and right, respectively). Priors and posterior distributions of model parameters (upper panel) and retrospective plots (lower panel).

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ANNEX

Table A.1. ***Nephrops*** **landings time series from FUs 28-29, by Portuguese and Spanish fleets.**

FU 28+29 SW+S Portugal

	Spain		Portugal			Total
	28***	29	28 + 29			
Year	Trawl	Trawl	Artisanal	Trawl	Total	
1975	137	1510		34	34	1681
1976	132	1752		30	30	1914
1977	95	1764		15	15	1874
1978	120	1979		45	45	2144
1979	96	1532		102	102	1730
1980	193	1300		147	147	1640
1981	270	1033		128	128	1431
1982	130	1177		86	86	1393
1983				244	244	244
1984				461	461	461
1985				509	509	509
1986				465	465	465
1987			11	498	509	509
1988			15	405	420	420
1989			6	463	469	469
1990			4	520	524	524
1991			5	473	478	478
1992			1	469	470	470
1993			1	376	377	377
1994				237	237	237
1995			1	272	273	273
1996			4	128	132	132
1997			2	134	136	136
1998			2	159	161	161
1999			5	206	211	211
2000			4	197	201	201
2001			2	269	271	271
2002			1	358	359	359
2003			35	335	370	370
2004			31	345	375	375
2005			31	360	391	391
2006			17	274	291	291
2007			18	274	291	291
2008			35	188	223	223
2009			17	133	151	151
2010			16	131	147	147
2011		17	16	117	133	150
2012		14	3	211	214	229
2013		10	1	198	199	209
2014		8	3	183	186	193
2015		12	4	231	235	247
2016		21	8	254	262	283
2017		26	9	241	249	275
2018		25	10	263	273	299
2019**		31	8	245	253	284

** **Preliminary values**
*** **Spanish landings from FU28 included in FU29**

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Table A.2. *Nephrops* FU 28-29. Landings, effort and biomass indices.

Year	Total Landings (t)	Standardized Trawl Effort (hours)	Std CPUE (kg/h) (new model)	Crustacean Survey CPUE (kg/h)
1975*	1681			
1976*	1914			
1977*	1874			
1978*	2144			
1979*	1730			
1980*	1640			
1981*	1431			
1982*	1393			
1983*	244			
1984	461			
1985	509			
1986	465			
1987	509			
1988	420			
1989	469			
1990	524			
1991	478			
1992	470			
1993	377			
1994	237			
1995	273			
1996	132			
1997	136			2.683
1998	161	663,870	0.243	1.404
1999	211	493,740	0.427	
2000	201	695,442	0.289	1.617
2001	271	303,189	0.894	0.847
2002	359	167,420	2.144	2.763
2003	370	119,055	3.108	2.854
2004	375	245,106	1.530	
2005	391	196,586	1.989	5.336
2006	291	135,792	2.143	2.789
2007	291	144,343	2.016	2.859
2008	223	91,137	2.447	5.350
2009	151	55,716	2.710	2.769
2010	147	68,833	2.136	8.059
2011	150	73,804	2.032	
2012	229	86,711	2.641	
2013	209	101,879	2.051	2.459
2014	193	106,824	1.807	1.003
2015	247	128,154	1.927	3.236
2016	283	111,824	2.531	4.895
2017	275	125,228	2.196	4.961
2018	299	99,140	3.016	5.042
2019	284	99,619	2.851	

* Uncertain Landings
ns No survey
(a) Survey with a different vessel
(b) Survey did not cover the whole area

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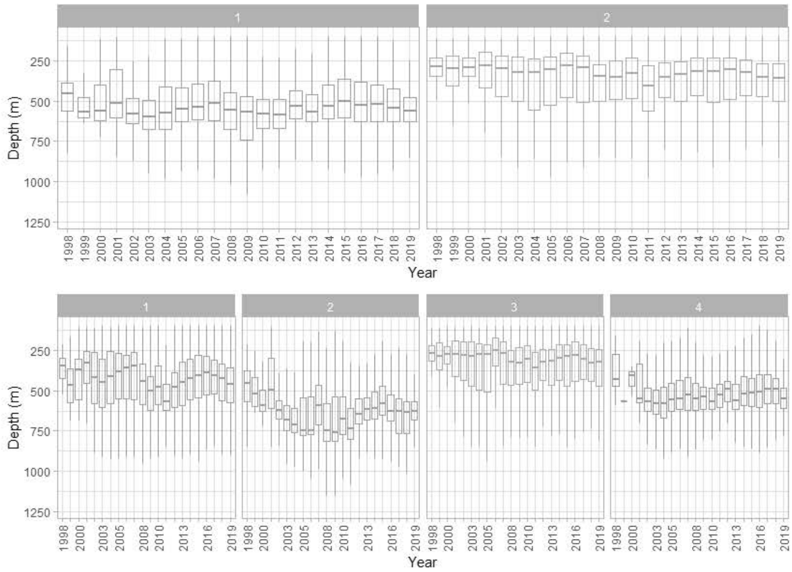


Figure A.1. Depth range by cluster, given the two scenarios: k=2 clusters (upper panel), k=4 clusters (lower panel).

Annex 6: Deviations from Stock Annex

1. Stock: *Lophius piscatorius* in 27.78abd

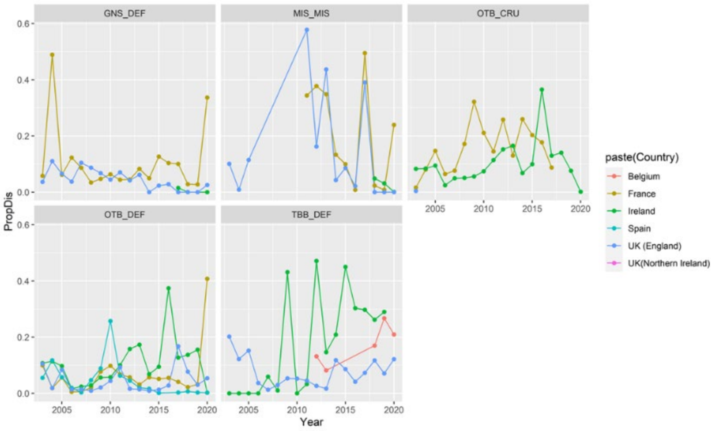
2. Missing or deteriorated survey data: (Also indicate also the reliance of the assessment on this data i.e. which other survey data were available)

No issues

3. Missing or deteriorated catch data: (Indicate proportion of total catch reported/sampled, by métier if appropriate)

Discards data from the Spanish trawlers fishing in division 7 were missing.

French gillnets and trawlers and Irish trawlers discard data were very weird, see figure below proportion of discards per gear, country and year.



4. Missing or deteriorated commercial LPUE/cpue data: (where commercial LPUE/cpue are used in the assessment indicate the impact of the disruption on these data)

Not used in the assessment

5. Missing or deteriorated biological data: (e.g. maturity data)

No issues

6. Brief description of methods explored to remedy the challenge:

Unsampled discards are normally filled in using discard ratios of the same country, fleet and year, remaining missing data are filled in using discard ratios of the same fleet and year and finally any remaining missing data are filled in using the overall discard ratio of the year.

Discards data from the Spanish trawlers fishing in division 7 were filled with data of the other trawlers fishing in division 8. The estimate was very similar to the previous year.

French and Irish discard ratios were replaced with the average of the last 3 years.

7. Suggested solution to the challenge, including reason for this selecting this solution: (clearly document changes from the normal procedures in the stock annex)

The Spanish discard ratio in area 7 is historically very similar to area 8

Discard ratios of French and Irish trawlers were reasonably constant in recent years.

8. Was there an evaluation of the loss of certainty caused by the solution that was carried out? (Please describe)

No, there was not evaluation because we thought it had not big impact in the assessment. The amount of discard data that resulted from fill-ins was higher than in recent years but discarding in this stock is relatively low.

1. Stock: *Lophius budegassa* in 27.78abd

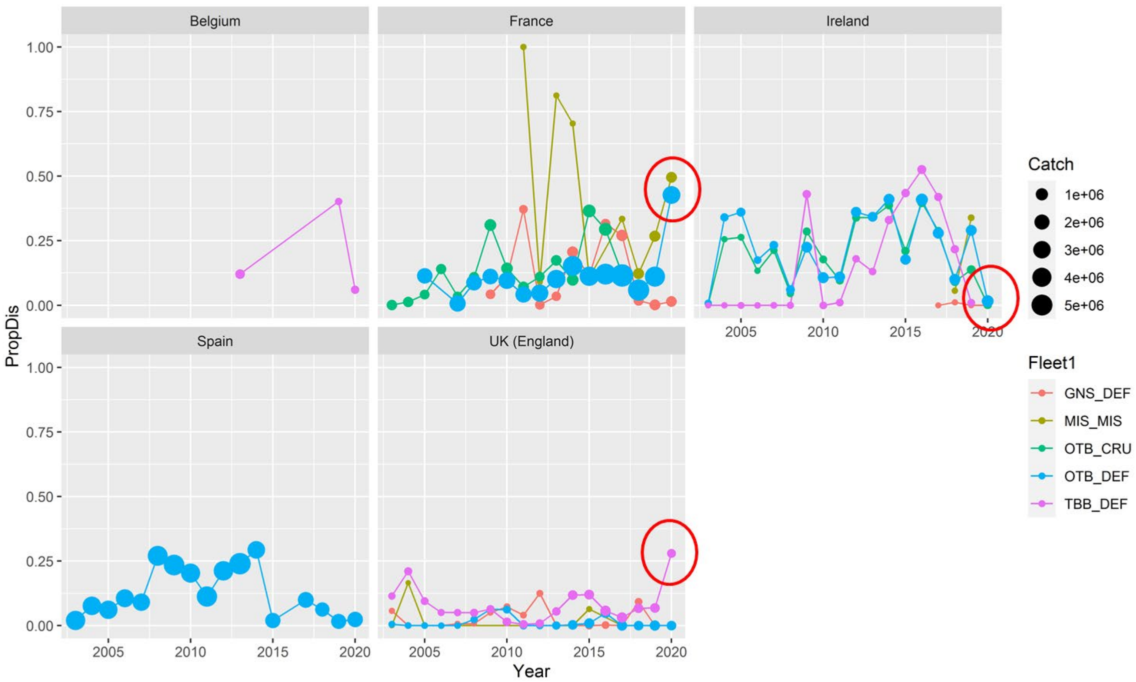
2. Missing or deteriorated survey data: (Also indicate also the reliance of the assessment on this data i.e. which other survey data were available)

No issues

3. Missing or deteriorated catch data: (Indicate proportion of total catch reported/sampled, by métier if appropriate)

Discards data from the Spanish trawlers fishing in division 7 were missing.

The discard ratios of French bottom-trawlers and UK beam trawlers were unusually high, and those of Irish bottom-trawlers were unusually low (see figure below proportion of discards per gear, country and year).



4. Missing or deteriorated commercial LPUE/cpue data: (where commercial LPUE/cpue are used in the assessment indicate the impact of the disruption on these data)

Not used

5. Missing or deteriorated biological data: (e.g. maturity data)

No issues

6. Brief description of methods explored to remedy the challenge:

Unsampled discards are normally filled in using discard ratios of the same country, fleet and year, remaining missing data are filled in using discard ratios of the same fleet and year and finally any remaining missing data are filled in using the overall discard ratio of the year.

This year the discard ratios used for filling in unsampled discards were replaced for French and Irish bottom-trawlers and UK beam trawlers by their average values of the last 5 years.

7. Suggested solution to the challenge, including reason for this selecting this solution: (clearly document changes from the normal procedures in the stock annex)

Discard ratios were reasonably constant in recent years.

8. Was there an evaluation of the loss of certainty caused by the solution that was carried out? (Please describe)

There was no way of evaluating the loss of certainty; catch data are only used in the advice though the mean-length Z method and there is no way to provide this method with uncertainty of the input data.

Annex 7: Benchmark progress southern hake

Southern European Hake (*Merluccius merluccius*) progress to benchmark

Summary of the main advances and issues regarding the adaptation of the southern European hake annual stock assessment to a Stock Synthesis (SS; Methot and Wendel, 2013) model. Further details is available in Working Document n°3 of the WGBIE 2021 report (ICES, 2021b).

Achieved objectives, as suggested, during the WKTaDSA (ICES, 2021a):

- ✓ Input historical data (1953-1982) combined with the new dataset (1994-2020) and categorized by fleets.
- ✓ Established workflow for SS using *r4ss* (Taylor et al., 2019) and *ss3diags* (Carvalho et al., 2021) packages in RStudio (R Core Team, 2020).
- ✓ Performed recruitment settlements analysis. Configured for months 1, 4 and 7.
- ✓ Annual LFDs weighted by fleets from sample size data collected from ICES reports (ICES, xxxx; xxxx, xxxx).
- ✓ Implemented advanced recruitment deviation options.
- ✓ Grouped fleets analyses applying double normal and time-varying selectivities.
- ✓ Implemented sex specific models (note: only based on Spanish survey data).
- ✓ Tested single M and M-at-age Lorenzen options (current model).
- ✓ Tested Spawner-Recruit relationships, Beverton-Holt and Ricker methods to estimate the steepness and sigma R responses and performances.

Future aims:

- Review and update the catch time-series.
- Improve fitting of fleet's selectivity, especially for period 1953-1994.
- In-depth analysis of the implementation of biological parameter values from literature to collect alternative information on southern hake stock based on life-history invariants (LHI) theory (ICES, 2014), as for both combined sex and sex separated models. Currently work in progress as the model is sensitive to alternative biological parameters.
- Include additional information (review in progress)
    - Standardized Spanish cpue.
    - New standardized Portuguese cpue.
    - Sex-separated data from Portuguese survey.
- Continue exploring SR relationship alternatives.
- Further diagnostic analyses: The general strategy is to establish several of SS plausible scenario models and to select the best model through diagnosis explorations using *ss3diags* package).

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Annex 8: Advice revision northern hake

In 2020, WGBIE did an update of the Stock Synthesis-based assessment of the northern hake stock (Merluccius merluccius) in subareas 4, 6, and 7, and in divisions 3.a, 8.a–b, and 8.d, Northern stock (Greater North Sea, Celtic Seas, and the northern Bay of Biscay).

While updating the 2021 assessment model, the northern hake stock coordinator detected a minor error in the control file specifically on the “year from which the deviation from the recruitments are no longer considered” (see section 9.6 comments in this report). During this year’s assessment, the specified year should have been 2019, instead of 2020 and this error was inherited from the 2020 assessment. The resulting trends from the previous and corrected assessment files were very similar. However, SSB was slightly lower and F higher which produced a significantly lower advice last year.

The revised abbreviated advice for 2021 now states that based on the MSY approach, catches in 2021 should be no more than 102 888 tonnes, which shows a 4% difference from the initial advice catch released last year.

The 2020 abbreviated ICES advice released last June 2020, and the revised version released this year for 2021 are both included in this report as annexes (see following pages).

9 Hake in Division 3.a, Subareas 4, 6 and 7 and Divisions 8.a,b,d (northern stock)

Type of assessment: Update. Stock was benchmarked in 2014 (ICES, 2014a) inter-benchmarked in 2019 (ICES, 2019a). Stock on observation list.

Data revisions: French discard volume in 2018 revised.

Review Group issues: Not issues identified

9.1 General

9.1.1 Stock definition and ecosystem aspects

This section is described in the Stock Annex.

9.1.2 Fishery description

The general description of the fishery is now presented in the Stock Annex.

9.1.3 Summary of ICES advice for 2020 and historical management

ICES advice for 2020. The stock was considered to be above any potential MSY $B_{trigger}$. Following the ICES MSY framework implies that fishing mortality (F) needs to be maintained at 0.26, resulting in landings of 97 949 t and total catches of 104 763 t in 2020.

Like the main stocks of the EU, Northern hake is managed by a TAC and quotas. The TACs (in tonnes) for the recent years are presented in the Table below. No agreement was set for the 2021 TAC.

TAC(t)	2013	2014	2015	2016	2017	2018	2019	2020
3a, 3b,c,d (EC Zone)	2093	2466	2738	2997	3371	3136	4286	3403
2a (EC Zone), 4	2438	2874	3190	3492	3928	3653	4994	3940
Vb (EC Zone), 6, 7	38938	45896	50944	61902	67658	62536	79762	63325
8a,b,d,e	25970	30610	33977	40393	44808	42460	52118	42235
Total northern Stock	69440	81846	90849	108784	119765	111785	141160	112903

Historical management: The minimum landing sizes (MLSs) for fish caught in Sub areas 4-6-7 and 8 is set at 27 cm total length (30 cm in Division 3a) since 1998 (EU, 1998).

The 14th of June 2001, an Emergency Plan was implemented by the Commission for the recovery of the Northern hake stock (EU, 2001a; 2001b; 2002). In addition to a TAC reduction, two technical measures were implemented. First, a 100 mm minimum mesh size was implemented for otter-trawlers when hake comprises more than 20% of the total amount of marine organisms retained onboard. This measure did not apply to vessels less than 12 m in length and which return to port within 24 hours of their most recent departure. Furthermore, two areas were defined, one in Sub area 7 and the other in Sub area 8, where a 100 mm minimum mesh size is required for all otter-trawlers, whatever the amount of hake caught.

In 2004, explicit management objectives for the recovery of this stock were implemented (EU, 2004). It was aiming at increasing the quantities of mature fish to values equal to or greater than 140 000 t (the B_{PA} value at that time). This could be achieved by limiting F to 0.25 and by allowing a maximum change of 15% in the TAC between years. According to the ICES advice for 2012, due to the new perspective of historical stock trends resulting from the new assessment, the previously defined precautionary reference points are no longer appropriate. In particular, the absolute levels of spawning stock biomass (SSB), F and recruitment have shifted to different scales. As a consequence, the TAC corresponding to the recovery plan (EU, 2004) should no longer be considered because the plan uses target values based on precautionary reference points that are no longer appropriate.

The TACs from 2016 to 2019 were slightly below the ICES advised TAC. The difference was due to the way the Scientific, Technical and Economic Committee for Fisheries (STECF) calculated the TAC adjustments for stocks subject to the landing obligation. In 2019, according to the MSY framework, ICES proposed a decrease in the 2020 TAC advice of a 26% from 142 240 t to 104 763 t. The agreed TAC limited the interannual variability to 20% (TAC = 112 903 t).

9.2 Data

9.2.1 Commercial catches and discards

Total landings from the northern stock of hake by area for the period 1961-2019 as used by the WG are given in Table 9.1. They include landings from Division 3a, Sub-areas 4, 6 and 7, and Divisions 8a,b,d, as reported to ICES. Unallocated landings are also included in Table 9.1. The values observed were elevated over the first decade (1961-1970) when the uncertainties in the fisheries statistics were also high. In the years 2011, 2012 and 2013, additional increases were observed again due to the differences between official statistics and scientific estimations. In 2014 and 2015, the differences between scientific and official landings decreased significantly which produced a big decrease in unallocated landings. The 2016 unallocated landings were reported by area and in 2017 there were no more unallocated landings which explains their disappearance in Table 9.2. Table 9.1 of the Stock Annex provides a historical perspective of the aggregation level at which landings have been available to the WG.

Except for 1995, landings decreased steadily from 66 500 t in 1989 to 35 000 t in 1998. Up to 2003, landings fluctuated around 40 000 t. Since then, with the exception of 2006, landings have been increasing up to 107 500 t in 2016, the highest in the whole time series. From 2009 to 2015, the landings and the catches in 2016 were above the TAC advice. Since 2016, the catches have decreased every year and they have been below both the TAC and the catch advice.

The discard data sampling and data availability are presented in the Stock Annex. Table 9.2 presents discards, landings and the number of samples collected for each of the fleets considered in the assessment model since 2013. The discards had an increasing trend until 2011 and decreased steadily afterwards. The increase was general to all the fleets. The case of gillnetters is remarkable in that discarding was absent until 2011 but registered high levels of discards since 2012. In 2016, discards increased for all fleets expect for Spanish trawlers in area 7. In 2017, total discards decreased for all fleets, except for the Spanish trawlers, with an overall decrease of 36%. The increase in the Spanish trawlers in division 8.a,b,d was equal to 38%. In 2018, the discards increased for Spanish trawlers in area 7 and in the other trawl fleets but decreased in all the rest of the fleets. The number of samples and number of measured fishes is relatively stable every year, except in TRAWLOTH fleet that has a high variability.

9.2.2 Biological sampling

Countries that contribute to the total catch of each Fishery Unit (FU) and which contribute with length-frequency distribution (LFD) is given in Table 9.3.

Length compositions of the 2019 landings by FU and quarter were provided mainly by Ireland, France, Scotland, Spain, UK (Eastern & Western) and Denmark. However, some other countries also provide some data.

Length composition samples are not available for all FUs of each country in which landings are observed (see Stock Annex). Only the main FUs are sampled (Table 9.3).

9.2.3 Abundance indices from surveys

Four surveys provide relative indices of hake abundance over time: (1) the French RESSGASC (G2537) survey conducted in the Bay of Biscay from 1978 to 2002, (2) the EVHOE-WIBTS-Q4 (G9527) survey covering the Bay of Biscay and the Celtic Sea with a new design since 1997, (3) the SpPGFS-WIBTS-Q3 (G5768) survey conducted in the Porcupine Bank since 2001 and (4) the Irish Groundfish Survey (IGFS-WIBTS-Q4, G7212) carried out in the west of Ireland and the Celtic Sea since 2003. A brief description of each survey is given in the Stock Annex and in section 2 of this report. Figure 9.1 presents the abundance indices obtained from these surveys.

From 1985 until the end of the survey in 2002, the index from RESSGASC (G2537) showed a slightly decreasing trend. The 2002 index is considered not reliable and is not presented in Figure 9.1.

Throughout the available time series, the abundance index provided by EVHOE-WIBTS-Q4 (G9527) showed five peaks in 2002, 2004, 2008, 2012 and 2016. The index obtained in 2012 was the highest value of the series, 193% higher than previous year. In 2013 and 2014, the index accumulated a decrease of 78%. In 2015 and 2016, it increased and the 2016 index value was three times higher compared to that in 2015. In 2017, the index was not available since the survey was not conducted. In 2018, the index value decreased relative to the 2016 value and was around the same value as in 2015. In 2019, the index increased again.

The abundance index provided by the IGFS-WIBTS-Q4 (G7212) is consistent with the EVHOE WIBTS-Q4 (G9527) survey over recent years. The index showed four peaks coincident with those observed in the EVHOE-WIBTS-Q4 (G9527) index but to a lesser extent. In 2012, the index achieved the highest value of the series, 268% higher than the previous year. The accumulated decrease in 2013 and 2014 was equal to 86%. The index increased moderately from 2015 to 2017. However, the increase in 2016 was not as sharp as that observed with the EVHOE-WIBTS-Q4 (G9527) index. The index decreased in 2018 and in the last two years the variation has been low. The index is currently around its historical minimum level.

The abundance index from SpPGFS-WIBTS-Q4 (G5768) survey follows an increasing trend since 2003, reaching its highest value in 2009 and slightly decreasing in 2010 and 2011. After two years of an increasing trend, with an accumulated increase of 218%, the index decreased sharply in 2015 and again but moderately in 2016. The peaks detected by EVHOE-WIBTS-Q4 (G9527) and IGFS-WIBTS-Q4 (G7212) were also detected in this sur-vey but occurring a year later, confirming the sharp increase observed in 2017. This is consistent with the fact that this survey catches bigger individuals. In the last three years, the index has decreased to a value comparable to that observed in 2007.

The spatial distributions of the EVHOE-WIBTS-Q4 (G9527), IGFS-WIBTS-Q4 (G7212) and SpPGFS-WIBTS-Q4 (G5768) biomass indices (Kg/hr) since 2005 are provided in Figure 9.2. The SpPGFS-WIBTS-Q4 (G5768) biomass index shows a homogenous spatial distribution in the sampled area throughout the time series. Among the three surveys, the SpPGFS-WIBTS-Q4 (G5768) shows the highest biomass values in the maps, confirming that this survey catches bigger individuals. A contraction of the spatial distribution was visible for some years, with the year 2018 showing the greatest spatial contraction (Figure 9.2). In 2017, EVHOE-WIBTS-Q4 (G9527) was only carried out partially. For the IGFS-WIBTS-Q4 (G7212) the spatial distribution of the biomass index was stable throughout the time series, with only a slight decrease observed in 2018. The southern region of the sampled area showed a higher biomass index in recent years. For the IGFS-WIBTS-Q4 (G7212), high biomass concentration seems to occur in areas closer to the French continental shelf. Overall, a contraction of the spatial distribution is visible since 2015 for all surveys.

EVHOE-WIBTS-Q4 (G9527) and IGFS-WIBTS-Q4 (G7212) surveys catch mainly young individuals below 25 cm while SpPGFS-WIBTS-Q4 (G5768) captures larger sized individuals (35 – 75 cm) (Figure 9.3). In the case of EVHOE-WIBTS-Q4 (G9527), the distribution is quite homogeneous year after year, with the mode around 12 cm. In the case of the Irish survey, in 2018, most of the individuals were around 25 cm, and there were almost no individuals around 12 cm, which is the mode of the distribution for most of the years. The length distribution from SpPGFS-WIBTS-Q4 (G5768) is quite flat between 40 and 65 cm, with a peak around 20 cm which is associated to the previous year's recruitment in previous years. This peak was very high in 2017. The variability in the shape of the LFDs of these two indices may be due to the limited area covered in the SpPGFS-WIBTS-Q4 (G5768) in comparison to the EVHOE-WIBTS-Q4 (G9527) index that covers a wider area.

9.3 Assessment

This is an update assessment in relation to the assessment carried out during the inter-benchmark working group at the beginning of 2019 (ICES, 2019a).

The assessment was revised after the assessment working group in 2021 because a problem was detected in the settings of the assessment model. The last year of recruitment deviations parameter was set to 2018 instead of 2019 for the 2020 assessment run where the correct value for this parameter is always the last data year (2019 in this case) before the assessment. This error was observed during the 2021 assessment which was also consequently corrected. The 2020 assessment for 2021 was then rerun using the correct value. Also, the latest Stock Synthesis (SS; Methot Jr. and Wetzel, 2013) assessment model (v 3.30) that includes all the advances made in the WKTaDSa (ICES, 2021) was used for the 2020 rerun assessment.

9.3.1 Input data

See Stock Annex (under "Input data for SS3"). The catch contribution of the fleets used in the configuration of the model has changed over time (Figure 9.4). At the beginning of the time series, more than 75% of the catch was caught by the trawler fleets. However, their contribution is around 25% to the total catch during the last years. On the contrary, the catches of longliners and gillnetters were residual in the past but, currently, the contribution of each of these fleets is similar to that of the trawlers. The increase in the biomass of the stock in the last decade led to a high increase in the catch of the OTHER fleets. Nowadays, catches outside the Bay of Biscay and Celtic Sea (area covered by the OTHER fleets) are similar to the catches in the Bay of Biscay area.

The quarterly LFDs for the landings and discards are given in Figure 9.5. For most of the fleets, the LFD of the landings is quite stable over time. Fleets in area 8 catch only smaller individuals. For trawlers, discards occur in the lower part of the distribution while for the gillnetters and OTHER fleets, discarding takes place in the whole range indiscriminately.

9.3.1.1 Data Revisions

France revised the discards volume in 2018. The main differences were in the discards from gillnetters that were doubled while those from OTHER fleets were divided by four. The seasonal distribution also changed significantly. However, the impact of these changes in the stock estimates was not significant. The discards are seasonally estimated by the model using the selection and retention curves that are fixed over time for most of the fleets. Hence, the model is not very sensitive to changes in discards volume.

9.3.2 Model

The Stock Synthesis (SS) assessment model (Methot Jr. and Wetzel, 2013) was selected for use in this assessment. Model description and settings are presented in the Stock Annex (under "Current assessment" for model description and "SS3 settings (input data and control files)" for model settings).

9.3.3 Model results

Residuals of the fit to the surveys log(abundance indices) are presented in Figure 9.6. The upward trend of the relative abundance observed until 2017 in all three contemporary trawl surveys (EVHOE-WIBTS-Q4 (G9527), SpPGFS-WIBTS-Q4 (G5768) and IGFS-WIBTS-Q4 (G7212)) has been captured by the model. In the last three years, the model estimates are higher than the observed values in the IGFS-WIBTS-Q4 (G7212) and EVHOE-WIBTS-Q4 (G7212) surveys, and only for the last two years in the SpPGFS-WIBTS-Q4 (G5768) survey.

The Pearson residuals of the LFDs of the EVHOE-WIBTS-Q4 (G7212) survey have a "fairly random" pattern with no general trend or lack of fit (Figure 9.7, where blue and red circles denote positive and negative residuals, respectively). However, in the other two surveys the model has problems of explaining the peak in small individuals observed with the SpPGFS-WIBTS-Q4 (G5768) index as well as the lack of small individuals in the 2018 IGFS-WIBTS-Q4 (G7212) index for example.

Residuals of the LFDs of the commercial fleets landings and discards (not presented in this report but available on the Github repository https://github.com/ices-taf/2021_hke.27.3a46-8abd_assessment) show some patterns, as mentioned in the 2014 benchmark report (ICES, 2014a).

The assessment model includes estimation of size-based selectivity functions (selection pattern-at-length) for commercial fleets and for population abundance indices (surveys). For commercial fleets, total catch is subsequently partitioned into discarded and retained portions. Figure 9.8 presents the selectivity for the total catch and Figure 9.9 the retention functions by fleet estimated by the model. The selection curve is assumed constant over the whole period for all the fleets except for those operating outside areas 7 and 8 (i.e., the OTHERS fleet). For the Spanish trawl fleet in area 7, three retention functions are estimated: 1) for the period 1978-1997, 2) for the period 1998-2009 and 3) for the period 2010-present. For the Spanish trawl fleet in area 8, two retention functions are estimated: 1) for the period 1978-1997 and 2) for the period 1998-present. The change in retention functions in 1998 for both trawl fleets was clearly observed when examining the LFDs of the landings and might be due to a more rigorous enforcement of the MLS. The most recent change in the retention of Spanish trawl fleet in area 7 was motivated by the observed change in the mean size of discards from 23.6 cm until 2009 to 28.8 cm since 2010. For the French trawlers targeting *Nephrops* in area 8, the same retention function is assumed throughout the entire assessment period (1978-present). For the other fleets, both selection and retention curves are considered constant until 2002 then varying from year to year since 2003. The variation is modelled using an annual random walk deviations as described in the Stock Annex. The selection pattern has changed significantly over the years.

The retrospective analysis (Figure 9.10) shows that for the three summary indicators (F, SSB and Recruitment), the model results are sensitive to the exclusion of the recent data, especially the recruitment. The inclusion of new data significantly impacted the recruitment estimates in the most recent years which are generally revised downwards. The change in the recruitment estimates impacted, in turn, the retrospective pattern in the SSB and F. Although the update implementation of the model to the 3.30 version had a negligible impact on the stock status estimates for the last year, the resulting retrospective pattern was observed to be worst overall. Before, the pattern did not show any clear trend so the cancellation effects reduced the value of the Mohn's rho (Mohn, 1999). However, the almost systematic overestimation of recruitment removed the cancellation effects and the obtained Mohn's rho values were higher (Figure 9.11). Despite only some of the values in the whole time series were within the confidence intervals estimated by the model (Figure 9.10), according to the guidelines provided in the WKFORBIAS (ICES, 2020), the observed retrospective pattern is acceptable to provide advice (see Figure12). The Mohn's rho value for SSB is inside the bounds (<0.2) while the value for F is outside the bounds (>0.2) with the 2 recent peels outside the envelope. However, as the pattern is close to the limit and the SSB is well below the reference points, it is considered possible to give advice with the assessment model presented in this report as the possibility of a future inter-benchmark to investigate the pattern cannot be held due to the short time constraints.

Summary results from the SS model are given in Table 9.4 and Figure 9.13.

Recruitment values (age 0) estimated by the model are provided in Table 9.4. For the recruitment, fluctuations appear to be without substantial trend over the whole series. The recruitment in 2008 was the highest in the whole series with 753 millions of individuals followed by that observed in 2019 (613 millions of individuals).

From high levels at the start of the series (100 000 t in 1980), the SSB decreased steadily to a low level at the end of the 1990s (23 000 t in 1998). Since then, SSB has increased to the highest value of the series in 2016 (291 000 t) then decreased until 2019.

F is calculated as the average annual F for sizes 15–80 cm. This measure of F is nearly identical to the average F for ages 1–5. F increased from values around 0.5-0.6 in the late 70s and early 80s to values around 1.0 during the 90s. Between 2006 and 2011, F declined sharply. Since 2012, F fluctuates around F_{MSY} (0.26). The F estimate for 2019 (0.23) is below F_{MSY}.

The 90% confidence intervals are quite narrow (Figure 9.4). These intervals correspond with the uncertainty estimated by the SS model and does not include all the existing uncertainty. For example, it does not include the uncertainty in the input data. For the next benchmark, the data weighting in SS should be revisited in order to get more realistic confidence intervals.

9.4 Catch options and prognosis

9.4.1 Replacement of recruitment in 2018 and 2019 by the geometric mean recruitment

In the 2019 assessment, recruitment estimates for the last two years (2017 and 2018), were replaced by the geometric mean (GM). The recruitment in 2017 was the second highest value in the time series but this high estimate was not supported by the available data at that time, LFDs and abundance indices (ICES, 2019b). The 2017 year class had a large contribution to the TAC advice, thus, a reliable and precautionary recruitment was required for the short-term projections. With the inclusion of the 2019 data, the assessment model has revised the 2017 recruitment downwards and the estimated value is closer to the GM (Figure 9.13).

This year, the recruitment estimates for the last two years (2018 and 2019), were also replaced by the GM. The 2018 recruitment was close to the GM. However, the 2019 estimate was well above that level. The assessment model overestimated the three abundance indices available in the last two years. Furthermore, the model has revised the most recent recruitments downwards. Hence, replacing the recruitment estimates for the last two years was considered more reliable and precautionary for projections.

9.4.2 Short - Term projection

SS has a forecast module which provides the capability to do a projection for a user-specified number of years that is directly linked to the model ending conditions, associated uncertainty and to a specified level of fishing intensity. The forecast requires information on life-history traits, fishing selectivity, relative harvest rate between fleets, overall fishing intensity and recruitment. However, due to some inconsistencies with the ICES short-term forecast observed in 2010 SS short-term projection, forecast has never been done internally in the model but transferred to and estimated by another module, a specific R (R Core Team, 2020) script written for this specific task.

For the current projection, unscaled F is used, corresponding to $F_{(15\text{-}80cm)} = 0.28$. The recruitment used for projections in this WG is the GM calculated from 1990 to the final assessment year minus 2 (2017). Recruitment short-term projection assumption values are given in Table 9.5.

Landings in 2021 and SSB in 2022 predicted for various levels of F in 2021 are given in Table 9.5 and Figure 9.14.

Maintaining *status quo* F in 2021 is expected to result in an increase in the catches of 4% and a decrease of around 8% in SSB with respect to 2020.

9.4.3 Yield and biomass per recruit analysis

Options for long-term projection are indicated in the Stock Annex. Results of equilibrium yield and SSB per recruit are presented in Table 9.6 and Figure 9.15 . The F-multiplier in Table 9.6 is with respect to the F *status quo* (F_{sq} = average F in the final 3 assessment years, 2017-2019). Considering the yield and SSB per recruit curves, F_{max}, $F_{0.1}$, $F_{35\%}$ and $F_{30\%}$ are respectively estimated to be 128%, 83%, 88%, and 104% of the F_{sq}. The maximum equilibrium yield-per-recruit is similar to the equilibrium yield at F_{sq}.

9.5 Biological reference points

Biological reference points for the northern hake stock were calculated in 2019 after the inter-benchmark carried out in February (Garcia, 2019 – WD 06, in ICES, 2019b).

	Type	Value	Technical basis
MSY Approach	MSY $B_{trigger}$	56 000	B_{pa} (WD 06, ICES, 2019b)
	F_{MSY}	0.26	F_{MSY} in the segmented regression stock recruitment relationship (WD 06, ICES, 2019b)
Precautionary Approach	B_{lim}	40 000	The median of the breakpoints in the segmented stock recruitment relationship estimated with a Bayesian Model.
	B_{pa}	56 000	1.4Blim (WD 06, ICES, 2019b)
	F_{lim}	0.84	Fishing mortality resulting in a 5% probability of SSB falling below B_{lim} (WD 06, ICES, 2019b)
	F_{pa}	0.6	F_{lim}/1.4 (WD 06, ICES, 2019b)
MAP	F_{low}	0.18	The lowest F that produces catch in the long term 5% below of the catch at F_{MSY}. (WD 06, ICES, 2019b)
	F_{upp}	0.4	The lowest F that produces catch in the long term 5% below of the catch at F_{MSY}. (WD 06, ICES, 2019b)

9.6 Comments on the assessment

The retrospective pattern in 2008 recruitment was partially corrected during the last benchmark (ICES, 2014a) but remained significant. It could be related with the changes in the estimates of the selection patterns for some fleets and surveys. These selection patterns are considered constant by the model and new data on LFDs are introduced every year in the model. If a non-constant selection pattern is applied, this could result in significant changes in selection curve estimates which in turn could result in a retrospective pattern in recruitment, F and SSB. Moreover, the recruitment in the most recent years is difficult to estimate, because little information is available in the data. Thus, the uncertainty in the recent estimates of recruitment is high and the estimated value needs several years to be established.

During the 2021 WG, a mistake was detected in the control file of the assessment model specifically on the 'year from which deviations from recruitment are no longer considered' parameter. For the 2020 assessment, this year was equal to 2018 instead of 2019. The 2020 revised assessment using the year 2019 showed similar resulting trends when compared with the uncorrected (with year 2018) assessment. However, there were some differences in the absolute level of F and biomass that led to an increase of 2% in the 2020 revised catch advice for 2021.

9.7 Management considerations

The significant increase in SSB and the decrease in F are the consequences of the strong recruitment observed in 2008 and 2012. However, these increase rates should be taken with caution as limited information is currently available to explain the variation in abundance of large fish not to mention that the current model is very sensitive to additional data integration and applied settings used. It must be noted that the fast growth rate combined with the assumed high natural mortality rate (M=0.4 since the 2010 benchmark, ICES, 2010) generates a rapid turnover of the hake stock dynamic. This means that short-term predictions in SSB and landings are strongly related to variations in recruitment. Now that the SSB has decreased, caution is needed to avoid a rapid consequential decrease in biomass. Since 2017, the observed catches have been significantly below the TAC and the catch advice, which would be a signal of an overestimation of stock productivity.

The ICES catch advice is for the whole stock but the sum of the TACs for 2019 in this report are only for the EU member states.

9.8 References

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9.10 Tables

Table 9.1: Hake in Division 3a, Subareas 4, 6 and 7 and Divisions 8a,b,d (northern stock. Estimates of landings ('000 t) by area for 1961-2019.

[1]	Landings (t)[1]										Discards (t)[2]							Catches(t)[3]
Year	1	2	3	4	5	6	7	8	Unn.	Total	3	4	5	6	7	8	Total	Total
1961									95.6	95.6								95.6
1962									86.3	86.3								86.3
1963									86.2	86.2								86.2
1964									76.8	76.8								76.8
1965									64.7	64.7								64.7
1966									60.9	60.9								60.9
1967									62.1	62.1								62.1
1968									62.0	62.0								62.0
1969									54.9	54.9								54.9
1970									64.9	64.9								64.9
1971				8.5			19.4	23.4	0.0	42.8								42.8
1972				9.4			14.9	41.2	0.0	56.1								56.1
1973				9.5			31.2	37.6	0.0	68.8								68.8
1974				9.7			28.9	34.5	0.0	63.4								63.4
1975				11.0			29.2	32.5	0.0	61.7								61.7
1976				12.9			26.7	28.5	0.0	55.2								55.2
1977				8.5			21.0	24.7	0.0	45.7								45.7
1978				8.0			20.3	24.5	-2.2	42.6								42.6
1979				8.7			17.6	27.2	-2.4	42.4								42.4
1980				9.7			22.0	28.4	-2.8	47.6								47.6
1981				8.8			25.6	22.3	-2.8	45.1								45.1
1982				5.9			25.2	26.2	-2.3	49.1								49.1
1983				6.2			26.3	27.1	-2.1	51.3								51.3
1984				9.5			33.0	22.9	-2.1	53.8								53.8
1985				9.2			27.5	21.0	-1.6	46.9								46.9
1986				7.3			27.4	23.9	-1.5	49.8								49.8
1987				7.8			32.9	24.7	-2.0	55.6								55.6
1988				8.8			30.9	26.6	-1.5	56.0								56.0
1989				7.4			26.9	32.0	0.2	59.1								59.1
1990				6.7			23.0	34.4	-4.2	53.3								53.3
1991				8.3			21.5	31.6	-3.4	49.8								49.8
1992				8.6			22.5	23.5	2.1	48.1								48.1
1993				8.5			20.5	19.8	3.3	43.7								43.7
1994				5.4			21.1	24.7	0.0	45.8								45.8
1995				5.3			24.1	28.1	0.1	52.3								52.3
1996				4.4			24.7	18.0	0.0	42.8								42.8
1997				3.3			18.9	20.3	-0.1	39.2								39.2
1998				3.2			18.7	13.1	0.0	31.9								31.9
1999				4.3			24.0	11.6	0.0	35.6								35.6
2000				4.0			26.0	12.0	0.0	38.0								38.0
2001				4.4			23.1	9.2	0.0	32.3								32.3
2002				2.9			21.2	15.9	0.0	37.2								37.2
2003				3.3			25.4	14.4	0.0	39.9							1.4	41.3
2004				4.4			27.5	14.5	0.0	42.0							2.6	44.6
2005				5.5			26.6	14.5	0.0	41.1							4.6	45.7
2006				6.1			24.7	10.6	0.0	35.3							1.2	36.6
2007				7.0			27.5	10.6	0.0	38.1							2.2	40.2
2008				10.7			22.8	14.3	0.0	37.2							3.4	40.5
2009				13.1			25.3	20.4	0.0	45.7							11.0	56.8

1	Landings (t)[1]										Discards (t)[2]							Catches(t)[3]
Year	1	2	3	4	5	6	7	8	Unn.	Total	3	4	5	6	7	8	Total	Total
2010				14.2			33.5	25.1	0.0	58.6							12.1	70.7
2011				18.8			18.6	16.6	32.0	87.5							13.9	101.4
2012				22.4			22.2	16.7	19.3	85.6							14.9	100.5
2013			0.3	10.7		5.2	50.1	19.9	0.0	86.1	0.3	2.9		1.5	6.6	4.1	15.4	101.6
2014			0.4	12.1		11.4	40.5	25.6	0.0	89.9	0.3	3.1		1.0	4.0	1.5	9.8	99.8
2015			0.4	14.6	0	7.1	44.4	28.5	0.0	95.0	0.1	3.4		0.1	4.2	3.1	10.9	106.0
2016			0.7	19.6	0	11.4	49.4	26.5	0.0	107.5	0.1	4.2	0	0.3	2.3	4.2	11.1	118.7
2017			0.8	19.7	0	9.6	45.7	28.9	0.0	104.7	0.1	1.8	0	0.3	1.2	3.7	7.1	111.8
2018			0.7	18.9	0	7.3	36.9	25.9	0.0	89.7	0.3	1.3		0.3	2.1	3.1	7.0	96.7
2019	0	0.8	0.7	15.6	0	6.8	36.9	21.5	0.0	82.3	0.2	0.9		0.3	1.4	2.1	4.9	87.2

[1]Divisions 3a and 4b,c are included in column '3a, 4 and 6' only after 1976. There were some unallocated landings especially for the period 1961-1970.

[2]Discard estimates from observer programmes. In 2003-2020, partial discard estimates are available and used in the assessment. For the remaining years for which no values are presented as some estimates were available but were not considered valid and, thus, not used in the assessment.

[3]From 1978, total catches used in the Working Group.

Table 9.2: Hake in Division 3a, Subareas 4, 6 and 7 and Divisions 8a,b,d (northern stock). Discards and landings (in tonnes), number of length samples per catch category (NLgSp_D and NLgSp_L) and number of fishes measured per catch category (NLgMs_D and NLgMs_L) since 2013 for the fleets used in the assessment model.

Year	ss3_fleet	Discards	Landings	NLgSp_D	NLgSp_L	NLgMs_D	NLgMs_L
2013	FRNEP8	1475	1219	0	0	0	0
2014	FRNEP8	391	1566	0	0	0	0
2015	FRNEP8	1134	1197	0	0	0	0
2016	FRNEP8	2310	973	39	51	1414	1627
2017	FRNEP8	1819	1124	31	53	1073	1360
2018	FRNEP8	889	1029	26	92	832	3495
2019	FRNEP8	816	1131	26	75	811	2365
2013	GILLNET	1257	15671	0	31	0	12133
2014	GILLNET	65	22549	27	412	164	27691
2015	GILLNET	857	16876	29	501	218	28777
2016	GILLNET	1175	25017	475	855	4964	49702
2017	GILLNET	653	25299	228	574	2406	32823
2018	GILLNET	1014	25848	459	526	3339	38290
2019	GILLNET	333	24800	219	536	1803	34874
2014	LONGLINE	1	26289	0	77	0	37386
2015	LONGLINE	559	36881	0	59	0	26655
2016	LONGLINE	2	31390	0	126	0	42003
2017	LONGLINE	1	29728	0	113	0	28754
2018	LONGLINE	4	20710	0	101	0	33141
2019	LONGLINE	0	19112	0	99	0	30853
2013	LONGLINE		14516		51		24319
2013	OTHER	6287	45004	145	328	7282	20454
2014	OTHER	5007	26165	288	863	9944	20898
2015	OTHER	4154	23515	257	895	11164	13048
2016	OTHER	4687	33099	530	834	11138	34417
2017	OTHER	2326	31371	413	577	9338	17731
2018	OTHER	1943	28396	521	802	17024	27263
2019	OTHER	1817	26437	426	596	16457	22876
2013	SPTRAWL7	3495	1948	300	61	2518	13864
2014	SPTRAWL7	1467	1991	310	77	1433	17568
2015	SPTRAWL7	2064	1975	268	52	2125	13773
2016	SPTRAWL7	616	2099	357	48	1208	10898
2017	SPTRAWL7	651	1711	340	56	3014	18703
2018	SPTRAWL7	903	1850	324	57	3063	19211
2019	SPTRAWL7	318	1891	193	51	1340	14001
2014	SPTRAWL8	183	2720	287	44	1610	7360
2015	SPTRAWL8	589	4405	0	43	0	9181
2016	SPTRAWL8	656	3647	95	43	3008	9482
2017	SPTRAWL8	906	4622	296	45	9240	9859
2018	SPTRAWL8	347	3467	280	53	3748	10526
2019	SPTRAWL8	586	2956	299	58	5390	5829
2013	SPTRAWL8		1988		38		5138
2013	TRAWLOTH	2936	5801	0	0	0	0
2014	TRAWLOTH	2718	8659	478	817	24072	7841
2015	TRAWLOTH	1564	10192	381	404	11649	6766
2016	TRAWLOTH	1669	11321	1367	1423	37190	36008
2017	TRAWLOTH	744	10815	169	595	13117	11732
2018	TRAWLOTH	1937	8394	1536	832	71517	21048
2019	TRAWLOTH	1070	5970	408	526	13734	11199

Table 9.3: Hake in Division 3a, Subareas 4, 6 and 7 and Divisions 8a,b,d (northern stock). Catches (C) and length-frequency distribution (LFD) provided in 2020.

FU	Quarter	Denmark	France	Ireland	Others	Spain	UK (England)	UK(Scotland)
FU2 &	1	0	C	0	0	C+LFD	C	0
FU2 &	2	0	C	0	0	C	0	0
FU2 &	3	0	C	0	0	C	C	0
FU2 &	4	0	C	0	0	C	C	0
FU03	1	0	C	C+LFD	0	C+LFD	C+LFD	0
FU03	2	0	C	C+LFD	0	C	C+LFD	0
FU03	3	0	C	C+LFD	0	C	C+LFD	0
FU03	4	0	C	C+LFD	0	C	C+LFD	0
FU6 +	1	0	C+LFD	C+LFD	C	C+LFD	C	0
FU6 +	2	0	C	C+LFD	C	C	C	0
FU6 +	3	0	C	C+LFD	C	C+LFD	C	0
FU6 +	4	0	C+LFD	C+LFD	C	C+LFD	C+LFD	0
FU8	1	0	C+LFD	C+LFD	C	0	0	0
FU8	2	0	C	C+LFD	C	0	0	0
FU8	3	0	C	C+LFD	C	0	C	0
FU8	4	0	C	C+LFD	C	0	0	0
FU9	1	0	C	0	0	0	0	0
FU9	2	0	C	0	0	0	0	0
FU9	3	0	C	0	0	0	0	0
FU9	4	0	C	0	0	0	0	0
FU10&FU	1	0	C+LFD	0	0	C+LFD	0	0
FU10&FU	2	0	C+LFD	0	0	C+LFD	0	0
FU10&FU	3	0	C+LFD	0	0	C+LFD	0	0
FU10&FU	4	0	C+LFD	0	0	C+LFD	C	0
FU12	1	0	C+LFD	0	0	C+LFD	0	0
FU12	2	0	C+LFD	0	0	C+LFD	0	0
FU12	3	0	C+LFD	0	0	C	0	0
FU12	4	0	C	0	0	C	0	0
FU13	1	0	C+LFD	0	0	C+LFD	0	0
FU13	2	0	C+LFD	0	0	C	0	0
FU13	3	0	C+LFD	0	0	C	C	0
FU13	4	0	C+LFD	0	0	C	0	0
FU15	1	0	C	C+LFD	C	0	C	0
FU15	2	0	C	C+LFD	C	0	0	0
FU15	3	0	C	C+LFD	0	0	C+LFD	0
FU15	4	0	C	C+LFD	C	0	C+LFD	0
FU16	1	C+LFD	C+LFD	C+LFD	C+LFD	C+LFD	C	C+LFD
FU16	2	C+LFD	C	C+LFD	C+LFD	C+LFD	C	C
FU16	3	C+LFD	C+LFD	C+LFD	C+LFD	C+LFD	C	C+LFD
FU16	4	C+LFD	C+LFD	C+LFD	C+LFD	C+LFD	C	C+LFD

Table 9.4: Hake in Division 3a, Subareas 4, 6 and 7 and Divisions 8a,b,d (northern stock). Summary of landings and assessment results.

Year	Recruit Age 0	Total Biomass	Total SSB	Landings	Discards	Catch	Yield/SSB	F(15-80 cm)
1978	315996	460250	73090	50551		50551	0.69	0.54
1979	310857	479160	93587	51096		51096	0.55	0.58
1980	305081	450065	95892	57265		57265	0.60	0.68
1981	617154	389070	82151	53918		53918	0.66	0.69
1982	427138	381687	66162	54994		54994	0.83	0.72
1983	139974	415706	64254	57507		57507	0.89	0.66
1984	302111	409510	77359	63286		63286	0.82	0.70
1985	648048	342260	74200	56099		56099	0.76	0.85
1986	383385	295537	55031	57092		57092	1.04	0.95
1987	447444	290033	40350	63369		63369	1.57	1.04
1988	518750	295969	43899	64823	2	64825	1.48	1.05
1989	499813	290369	43064	66473	73	66546	1.55	1.13
1990	499783	279193	40374	59954		59954	1.48	1.07
1991	283311	262659	39593	58129		58129	1.47	1.02
1992	301963	245190	38086	56617		56617	1.49	1.05
1993	541699	213631	37336	52144		52144	1.40	1.10
1994	300480	214482	29358	51259	356	51615	1.76	1.11
1995	155659	239551	28628	57621		57621	2.0	1.17
1996	376780	197514	33657	47210		47210	1.40	1.03
1997	261910	178678	28857	42465		42465	1.47	1.11
1998	435630	176858	23203	35060		35060	1.51	1.03
1999	221903	201777	26578	39814	349	40163	1.51	1.01
2000	193479	208628	29353	42026	83	42109	1.43	0.95
2001	353789	209701	34893	36675		36675	1.05	0.79
2002	283151	231643	35956	40107		40107	1.12	0.83
2003	164980	245203	36558	43162	2110	45272	1.24	0.84
2004	354644	242813	41636	46417	2552	48969	1.18	0.85
2005	228008	221239	39748	46550	4676	51226	1.29	0.99
2006	307150	227513	32233	41467	1816	43283	1.34	0.87
2007	472319	271196	39132	45028	2191	47219	1.21	0.75
2008	775084	376604	46746	47739	3248	50987	1.09	0.60
2009	252712	621622	71095	58818	10590	69408	0.98	0.49
2010	273747	919353	130446	72799	9978	82777	0.63	0.37
2011	282614	1088531	213190	87540	14156	101696	0.48	0.30
2012	534220	1132102	240596	85677	12680	98357	0.41	0.27
2013	389935	1201132	242607	77753	15886	93639	0.39	0.27
2014	218976	1335338	254288	89940	9913	99853	0.39	0.24
2015	231543	1439183	293299	93670	9820	103490	0.35	0.23
2016	346319	1435094	322440	109106	12741	121847	0.38	0.25
2017	413588	1308432	300478	104671	7386	112057	0.37	0.33
2018	399335	1221920	261398	89671	7034	96705	0.37	0.26
2019	613305	1289597	254003	82298	4940	87238	0.34	0.23
Arithmetic mean	366280	522286	96543	60425	6026	63582	1.02	0.74
Units	Thousands of individuals	Thousands	Tonnes	Tonnes	Tonnes	Tonnes	Percentage	

Table 9.5: Hake in Division 3a, Subareas 4, 6 and 7 and Divisions 8a,b,d (northern stock). Catch option table.

SSB(2020)	Rec proj	F(15-80cm)	Catch(2020)	Land(2020)	SSB(2021)
272,677	314,897	0.28	103,967	93,533	274,559

Fmult	Fcatch (15-80cm)	Fland (15-80cm)	Fdisc (15-80cm)	Catch(2021)	Land(2021)	Disc(2021)	SSB(2022)
0.0	0.0000	0.0000	0.0000	0	0	0	404772
0.1	0.0275	0.0209	0.0067	12464	11228	1236	392655
0.2	0.0551	0.0417	0.0134	24527	22081	2445	380929
0.4	0.1102	0.0834	0.0268	47500	42714	4786	358597
0.5	0.1377	0.1043	0.0335	58436	52518	5918	347965
0.7	0.1928	0.1460	0.0468	79268	71158	8110	327710
0.8	0.2204	0.1669	0.0535	89187	80016	9171	318064
0.9	0.2479	0.1877	0.0602	98789	88580	10209	308725
1.0	0.2755	0.2086	0.0669	108085	96860	11225	299683
1.1	0.3030	0.2294	0.0736	117085	104866	12219	290927
1.3	0.3581	0.2712	0.0870	134236	120092	14144	274236
1.4	0.3857	0.2920	0.0937	142405	127330	15076	266282
1.5	0.4132	0.3129	0.1004	150316	134328	15988	258579
1.6	0.4408	0.3337	0.1070	157977	141096	16880	251117
1.7	0.4683	0.3546	0.1137	165395	147641	17754	243889
1.8	0.4959	0.3754	0.1204	172579	153970	18610	236886
1.9	0.5234	0.3963	0.1271	179538	160091	19447	230102
2.0	0.5510	0.4172	0.1338	186277	166010	20266	223528

Table 9.6: Hake in Division 3a, Subareas 4, 6 and 7 and Divisions 8a,b,d (northern stock). Yield-per-recruit table.

SPR-level	Fmult	F(15-80cm)	YPR-catch.	YPR-landings	SSB-PR
1.00	0.00	0.00	0.00	0.00	3.2
0.87	0.100	0.020	0.077	0.074	2.8
0.76	0.20	0.040	0.136	0.132	2.4
0.66	0.30	0.070	0.183	0.176	2.1
0.59	0.40	0.090	0.22	0.21	1.88
0.52	0.50	0.110	0.25	0.24	1.67
0.47	0.60	0.130	0.27	0.26	1.49
0.42	0.70	0.160	0.28	0.27	1.34
0.38	0.80	0.180	0.30	0.28	1.21
0.34	0.90	0.20	0.30	0.29	1.09
0.31	1.00	0.22	0.31	0.30	1.00
0.28	1.10	0.25	0.32	0.30	0.91
0.26	1.20	0.27	0.32	0.30	0.83
0.24	1.30	0.29	0.32	0.30	0.77
0.22	1.40	0.31	0.32	0.30	0.71
0.20	1.50	0.33	0.32	0.30	0.66
0.191	1.60	0.36	0.32	0.30	0.61
0.178	1.70	0.38	0.32	0.29	0.57
0.166	1.80	0.40	0.31	0.29	0.53
0.155	1.90	0.42	0.31	0.29	0.50
0.146	2.0	0.45	0.31	0.28	0.47

SPR-level	Fmult	F (15-80cm)	YPR-catch	YPR-landings	SSB-PR
0.24	1.28	0.29	0.32	0.30	0.78
0.37	0.83	0.18	0.30	0.28	1.18
0.35	0.88	0.20	0.30	0.29	1.12
0.30	1.04	0.23	0.31	0.30	0.96

9.11 Figures

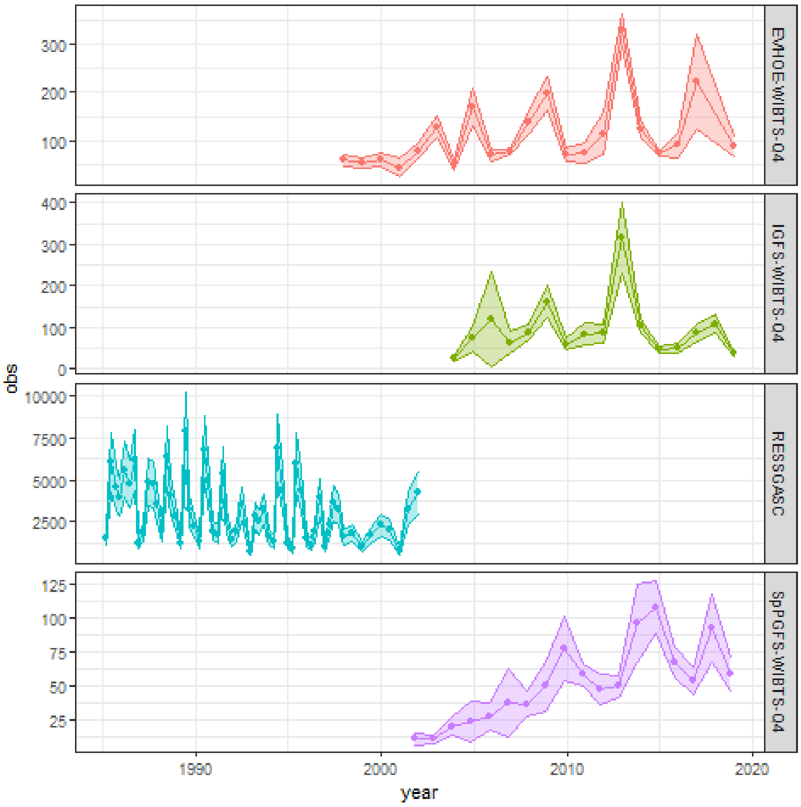

Figure 9.1: Hake in Division 3a, Subareas 4, 6 and 7 and Divisions 8a,b,d (northern stock). Abundance indices from surveys.

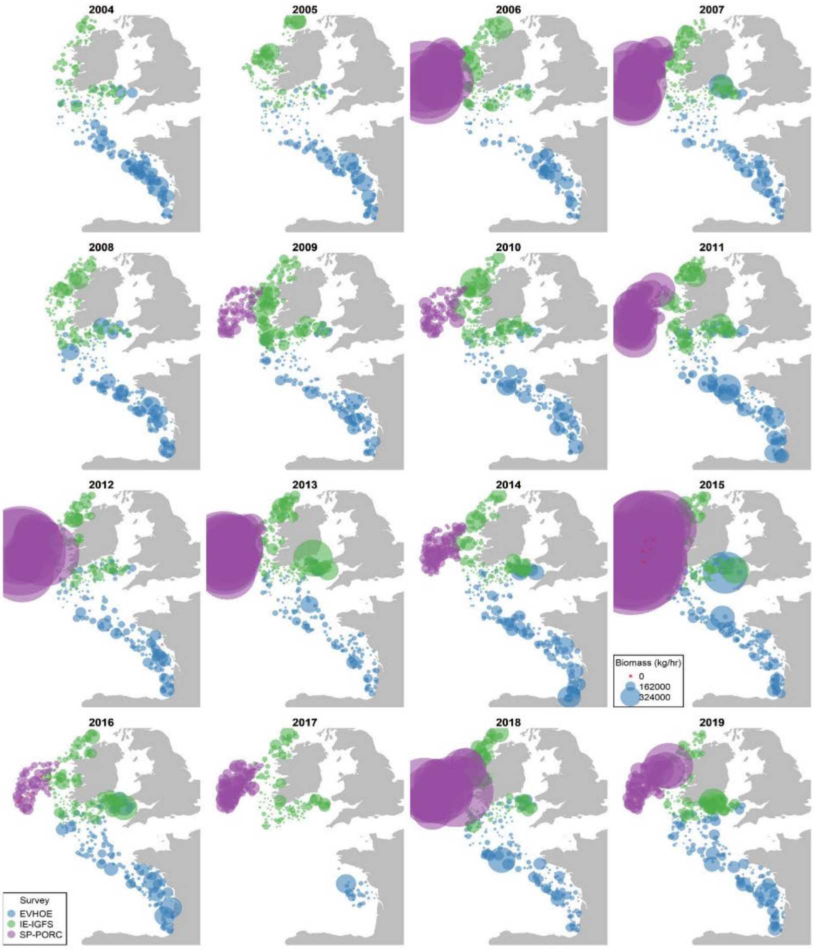

Figure 9.2: Hake in Division 3a, Subareas 4, 6 and 7 and Divisions 8a,b,d (northern stock). Spatial distribution of the EVHOE-WIBTS-Q4 (G9527), IGFS-WIBTS-Q4 (G7212) and SpPGFS-WIBTS-Q4 (G5768) index of biomass (Kg/hr) from 2003 to 2018.

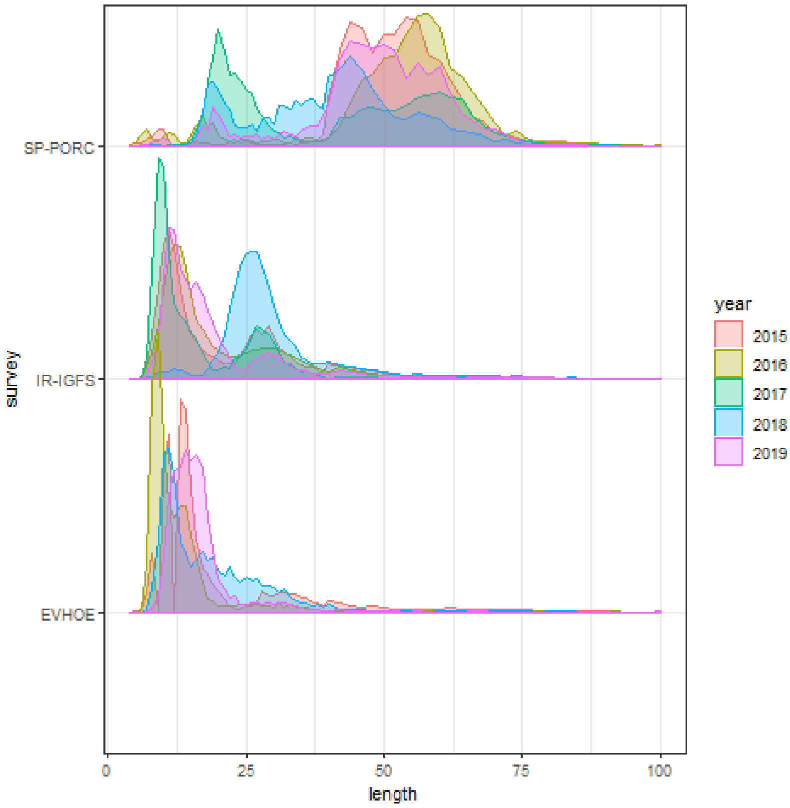

Figure 9.3: Hake in Division 3a, Subareas 4, 6 and 7 and Divisions 8a,b,d (northern stock). Length-frequency distribution of surveys in the most recent years, from 2018 to 2020.

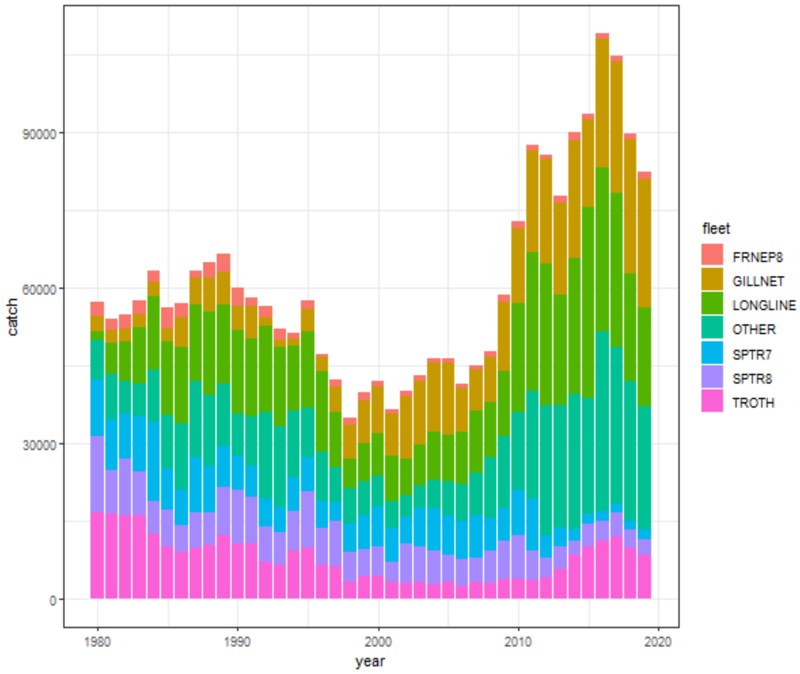

Figure 9.4: Hake in Division 3a, Subareas 4, 6 and 7 and Divisions 8a,b,d (northern stock). Total catch over time, the colors correspond with the fleets used in the assessment model configuration.

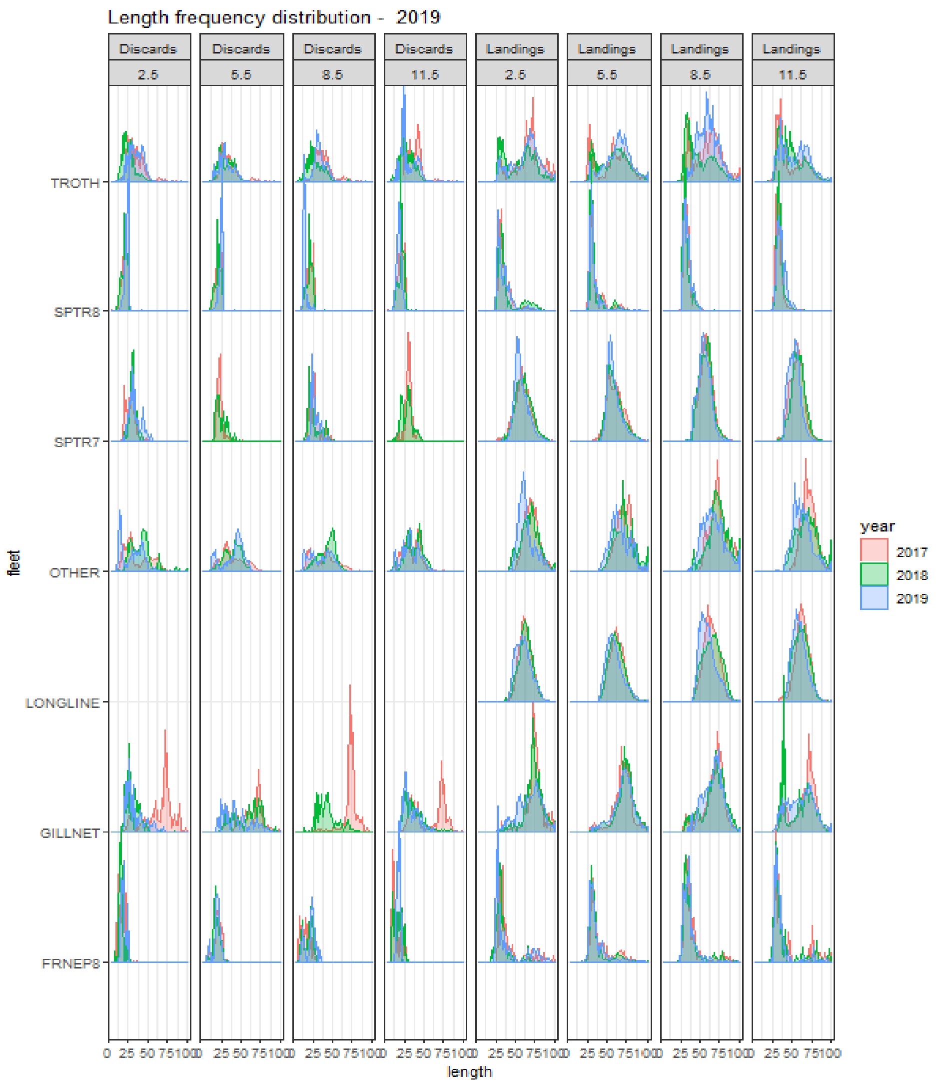

Figure 9.5: Hake in Division 3a, Subareas 4, 6 and 7 and Divisions 8a,b,d (northern stock). Length-frequency distribution for landings and discards by fleet in the most recent years, from 2018 to 2020, by season and the fleet as used in the assessment model configuration.

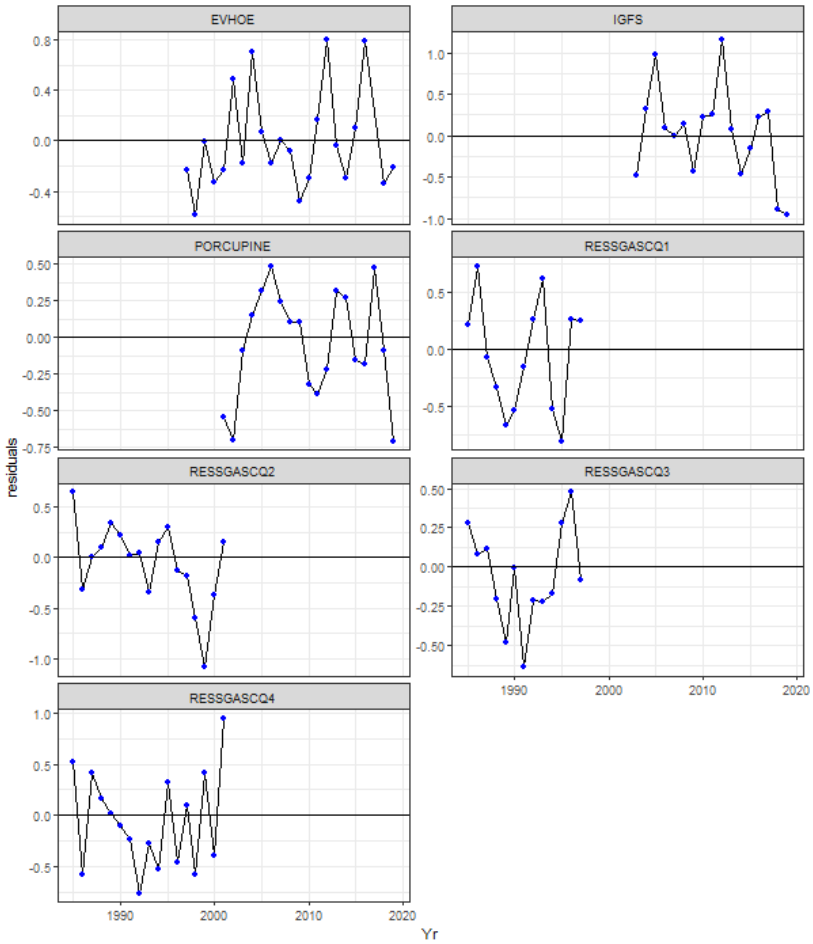

Figure 9.6: Hake in Division 3a, Subareas 4, 6 and 7 and Divisions 8a,b,d (northern stock). Residuals of the fits to the surveys log(abundance indices). For RESSGASC (G2537), EVHOE (EVHOE-WIBTS-Q4, G9527), PORCUPINE (SpPGFS-WIBTS-Q3, G5768) and IGFS (IGFS-WIBTS-Q4, G7212), fits are by quarter.

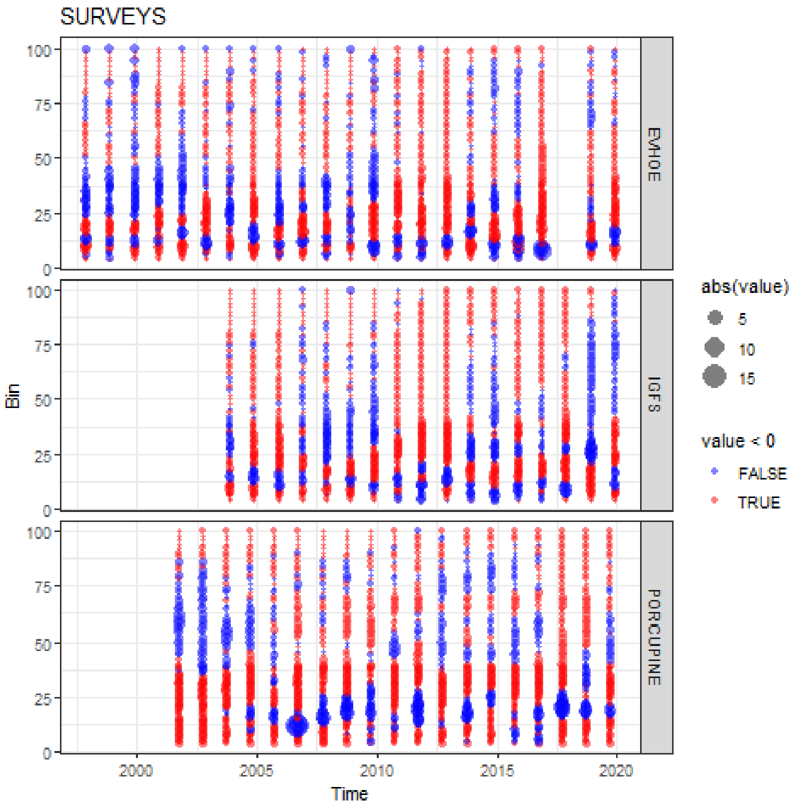

Figure 9.7: Hake in Division 3a, Subareas 4, 6 and 7 and Divisions 8a,b,d (northern stock). Pearson residuals of the fit to the length distributions of the surveys abundance indices. For EVHOE (EVHOE-WIBTS-Q4, G9527), PORCUPINE (SpPGFS-WIBTS-Q3, G5768) and IGFS (IGFS-WIBTS-Q4, G7212), fits are by quarter.

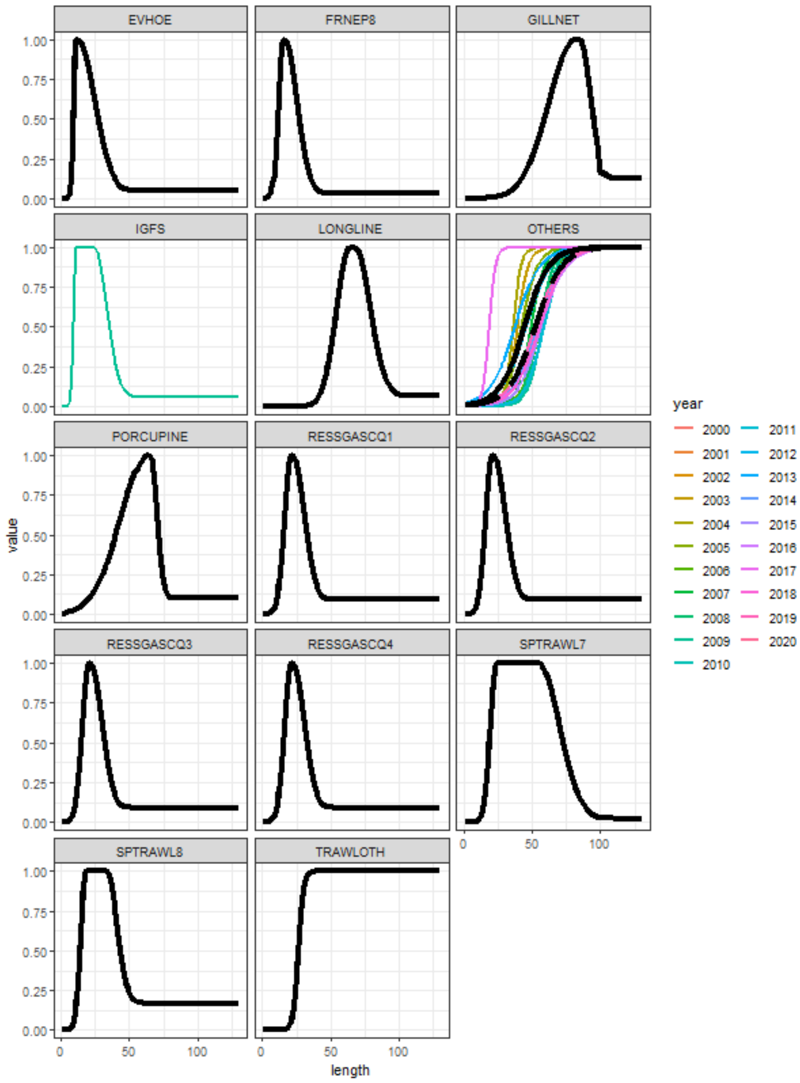

Figure 9.8: Hake in Division 3a, Subareas 4, 6 and 7 and Divisions 8a,b,d (northern stock). Selection curves by commercial fleet estimated by SS. The solid black line corresponds with the selectivity in 2020 and the black dashed line with the selection in 2019.

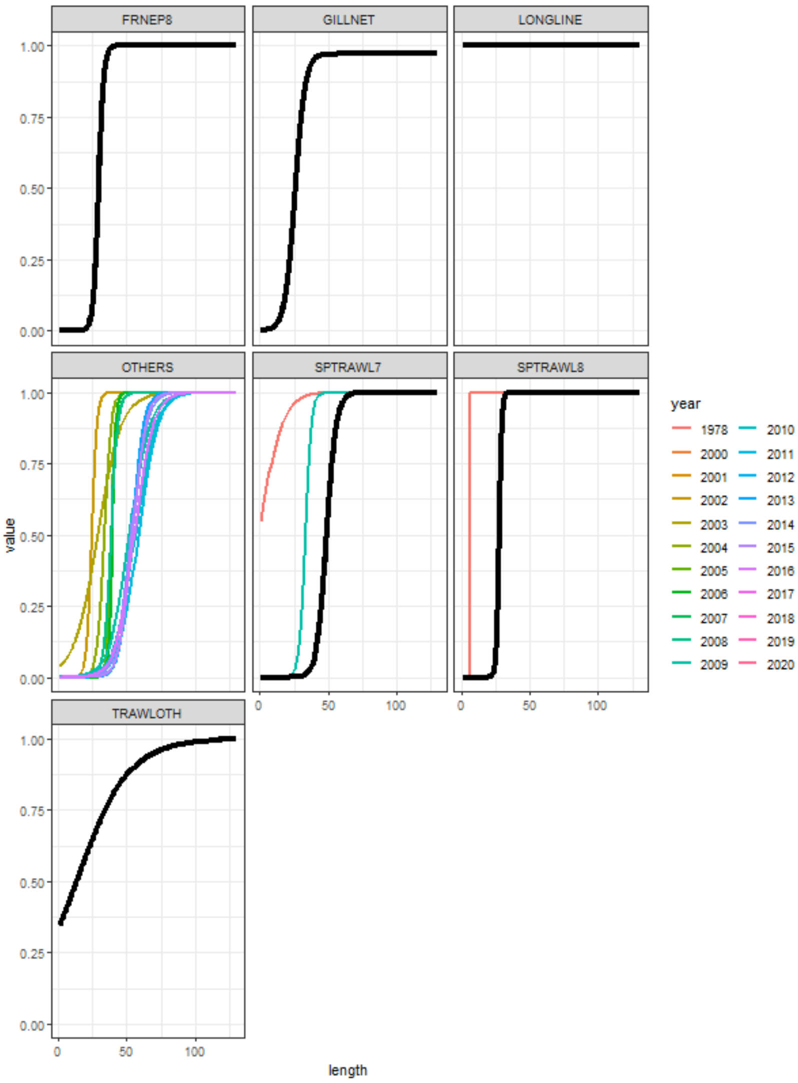

Figure 9.9: Hake in Division 3a, Subareas 4, 6 and 7 and Divisions 8a,b,d (northern stock). Retention curves by commercial fleet estimated by SS. The solid black line corresponds with the selectivity in 2020 and the black dashed line with the selection in 2019.

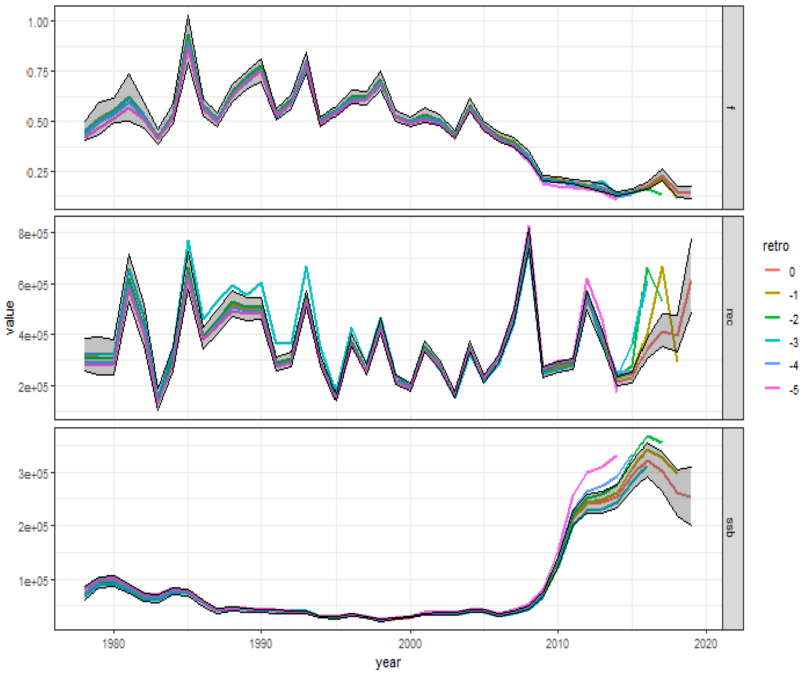

Figure 9.10: Hake in Division 3a, Subareas 4, 6 and 7 and Divisions 8a,b,d (northern stock). Retrospective plot from the SS model including confidence intervals.

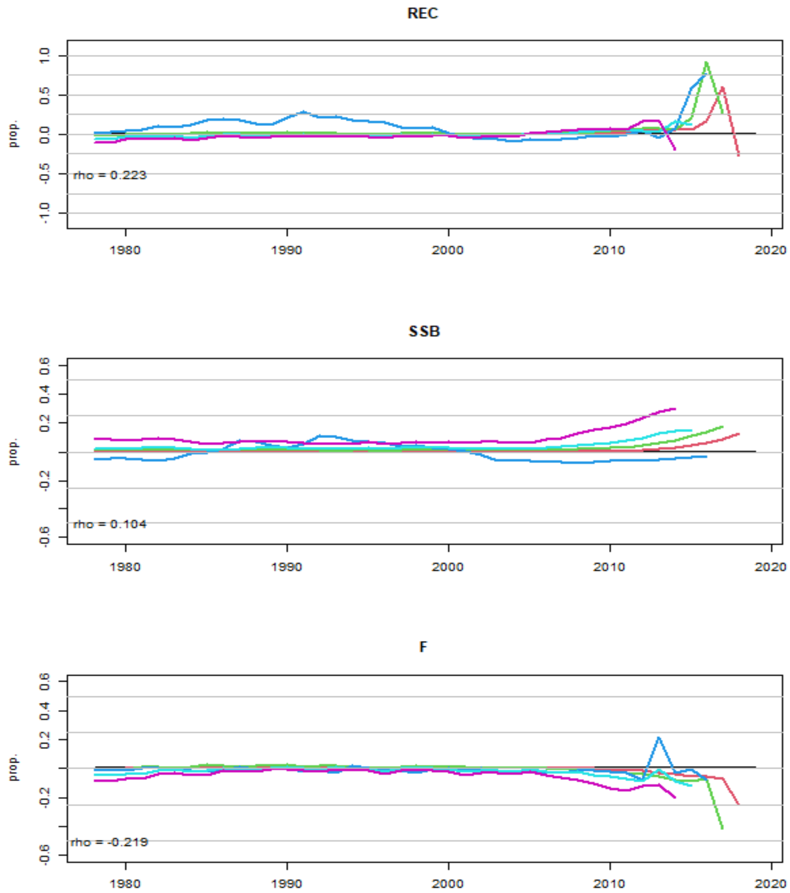

Figure 9.11: Hake in Division 3a, Subareas 4, 6 and 7 and Divisions 8a,b,d (northern stock). Differences between time series in the retrospective analysis plot from SS3 for 2015-2020. The number in the bottom-left of the plot corresponds with the Mohn's rho.

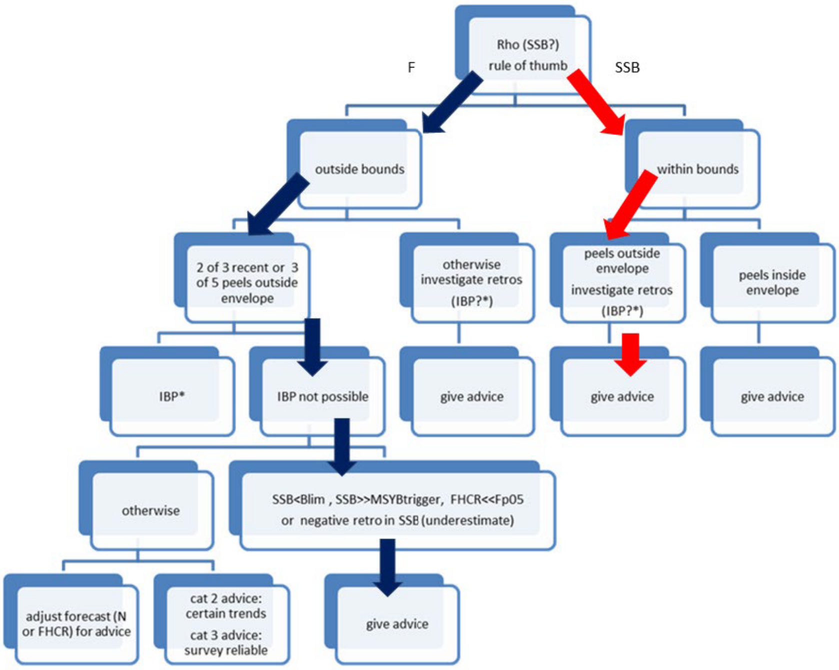

Figure 9.12: Hake in Division 3a, Subareas 4, 6 and 7 and Divisions 8a,b,d (northern stock). Scheme from WKFORBIAS (ICES, 2020) to assess determine if it is possible to produce advice based on an assessment model with a given retrospective pattern

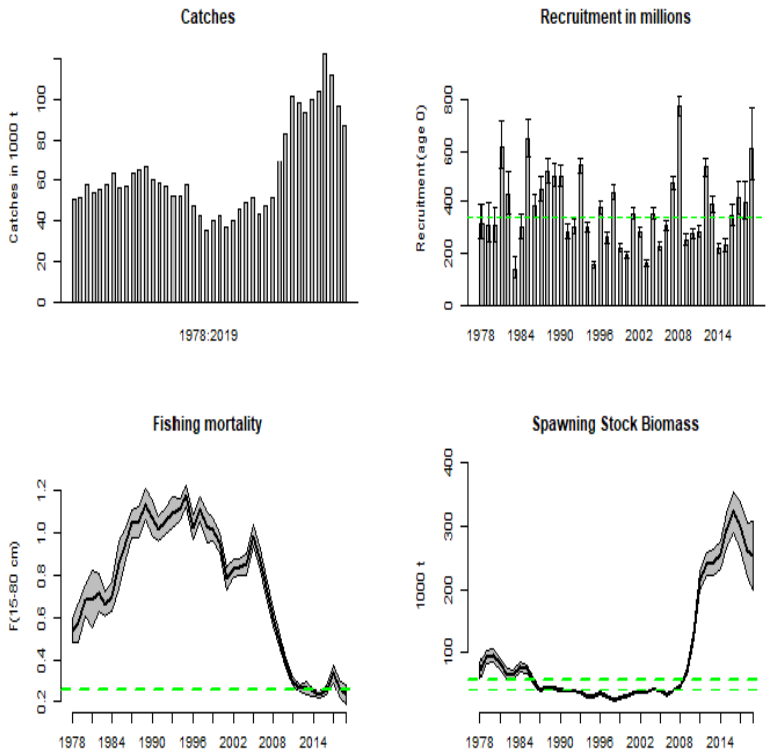

Figure 9.13: Hake in Division 3a, Subareas 4, 6 and 7 and Divisions 8a,b,d (northern stock). Summary plot of stock trends. Green dashed lines correspond with geometric mean recruitment, F_{MSY} and, B_{lim} and B_{pa}.

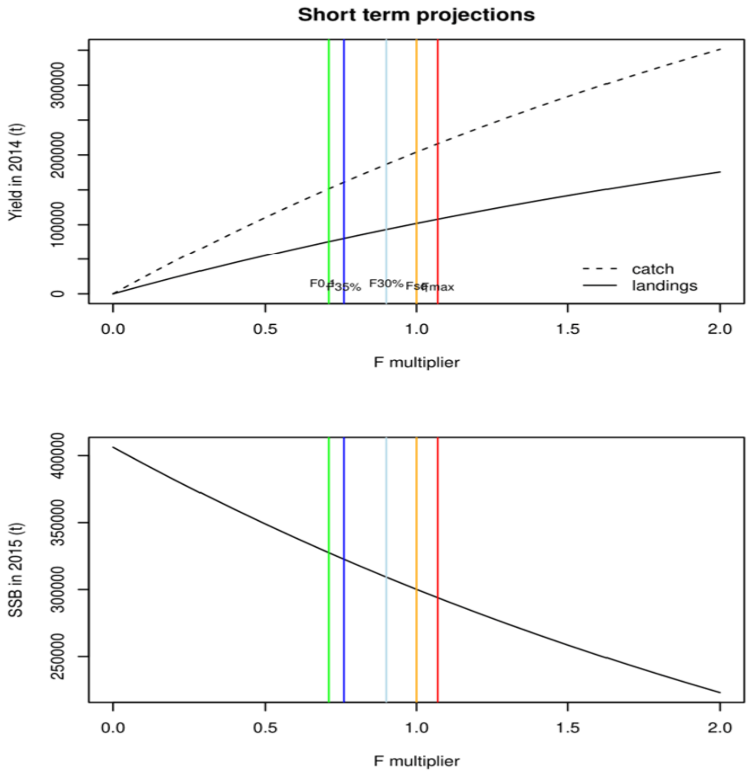

Figure 9.14: Hake in Division 3a, Subareas 4, 6 and 7 and Divisions 8a,b,d (northern stock). Summary plot of stock trends. Green dashed lines correspond with geometric mean recruitment, F_{MSY} and, B_{lim} and B_{pa}.

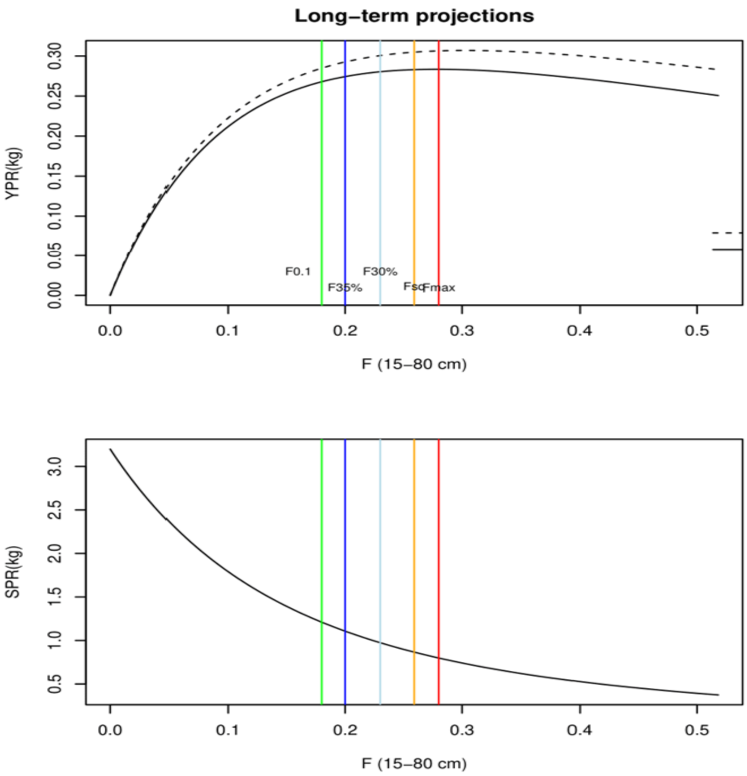

Figure 9.15: Hake in Division 3a, Subareas 4, 6 and 7 and Divisions 8a,b,d (northern stock). Summary plot of stock trends. Green dashed lines correspond with geometric mean recruitment, F_{MSY} and, B_{lim} and B_{pa}.