BENCHMARK WORKSHOP 3 ON SELECTED ELASMOBRANCH STOCKS (WKBELASMO3)

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Contents

i Executive summary

A Benchmark Workshop for selected elasmobranch stocks (WKBELASMO3) was convened to evaluate the appropriateness of data and methods to assess and provide short-term forecast for three rays stocks in Atlantic Iberian waters: thornback ray (rjc.27.9a), blonde ray (rjh.27.9a) and cuckoo ray (rjn.27.9a).

For **thornback ray in Iberian waters**, a SPiCT assessment using landings since 2000 and four series of biomass indices (PT-IBTS-Q4, PT-LPUE, SpGFS-GC-WIBTS -Q1 and SpGFS-GC-WIBTS -Q4) combined, since 1990 was accepted. The workshop also agreed on the settings for the short-term forecast, allowing the stock to be assessed as **category 2**. This stock is estimated to be harvested well below Fmsy with a biomass above Bmsy. The 15th percentile of the landings at Fmsy is very closed to MSY and corresponds to landings slightly lower (-10.5%) than the previous landings advice.

For **blonde ray in Iberian waters**, SPiCT assessments using landings since 2000 and one series of biomass indices (PT-LPUE from polyvalent fleet) since 2008 were tested but not accepted. The workshop agreed that the stock should remain in **category 3 and the advice given according to the *rfb* rule.**

For **cuckoo ray in Iberian waters**, a SPiCT assessment using landings since 2001 and two series of biomass indices (SpGFS-GC-WIBTS-Q1 and SpGFS-GC-WIBTS -Q4) since 2001 was accepted. The workshop also agreed on the settings for the short-term forecast, allowing the stock to be assessed as category 2. This stock is estimated to be harvested well below Fmsy with a biomass above Bmsy. The 15th percentile of the landings at Fmsy is slightly above MSY and corresponds to landings higher (~2 times) than the previous advice.

ii Expert group information

Expert group name	Benchmark Workshop 3 on selected Elasmobranch Stocks (WKBELASMO3)
Expert group cycle	Annual
Year cycle started	2024
Reporting year in cycle	1/1
Chair(s)	Alain Biseau, France
Meeting venue(s) and dates	20-24 November 2023, Online, 16 participants
	26 February – 1 March 2024, Copenhagen Denmark and Online, 16 participants

1 Introduction

1.1 Terms of reference

2023/WK/FRSG32 **Benchmark workshop 3 on selected elasmobranch stocks** (WKBELASMO3) chaired by Alain Biseau, France, and attended by invited external experts Alfonso Pérez Rodríguez, Spain; Margarita Rincón Hidalgo, Spain; and Arni Magnusson; will be established and meet online 20–24 November 2023 for the data workshop, and 26 February–1 March 2024 at ICES HQ, Copenhagen, Denmark, for the assessment methods workshop. WKBELASMO3 will:

a) As part of the data workshop:
   1. Consider the quality of data proposed for use in the assessment;
   2. Consider stock identity and migration issues;
   3. Make a proposal to the benchmark on the use and treatment of data for each assessment, including landings, discards, surveys, life history, etc.
      i. Note: stakeholders are also invited to contribute data in advance of the data workshop (including data from non-traditional sources) and to contribute to data preparation and the evaluation of data quality.

b) In preparation for the assessment methods workshop:
   1. Produce working documents to be reviewed during the assessment methods workshop at least 14 days before the meeting.

c) As part of the assessment methods workshop, agree to and thoroughly document the most appropriate, data, methods, and assumptions for:
   1. Obtaining population abundance and exploitation level estimates (conducting the stock assessment);
   2. Estimating fisheries and biomass reference points that are in line with ICES guidelines (see latest relevant Technical Guidelines);
      i. Note: if additional time is needed to conduct the work and agree to e.g. reference points, harvest control rules etc., additional meetings may need to be scheduled.
   3. Conducting the short-term forecast.

d) As part of the assessment methods workshop, a full suite of diagnostics (regarding e.g. data, retrospective behaviour, model fit, predictive power etc.) should be examined to evaluate the appropriateness of any model developed and proposed for use in generating advice.

e) If no analytical assessment method can be agreed upon, then an alternative method (the former method or following the ICES data-limited stock approach as outlined in WKLIFE XI) should be put forward by the benchmark;

f) Update the Stock Annex; and

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

WKBELASMO3 will report by 8 April 2024 for the attention of ACOM.

Recurrent single-stock fishing opportunity advice benchmark: stock list	
rjc.27.9a	Thornback ray (*Raja clavata*) in Division 9.a (Atlantic Iberian waters)
rjh.27.9a	Blonde ray (*Raja brachyura*) in Division 9.a (Atlantic Iberian waters)

Recurrent single-stock fishing opportunity advice benchmark: stock list	
rjn.27.9a	Cuckoo ray (*Leucoraja naevus*) in Division 9.a (Atlantic Iberian waters)

1.2 Conduct of the Benchmark

The list of participants and the agenda for the benchmark workshop meetings are presented in Annex 1 and Annex 2, respectively.

The ICES benchmark for selected elasmobranch stocks (in Iberian waters) included the following steps:

1) A data compilation workshop was held online 20-24 November 2023. The main focus of this meeting was to review the relevant data and consider information and issues for each stock.
2) An intersessional meeting was held online on the 9th of January, and the benchmark meeting 26 February – 1 March with 12 participants, 9 in person and 3 online.
3) The following working documents were provided to meeting participants in advance of the final meeting:

Title	Description	Contributors
1. WD_PT_Historical Landings Reconstruction 2000_2007	Reconstruction of Portuguese landings for rjc.27.9a, rjh.27.9a and rjn.27.9a	Catarina Maia, Teresa Moura, Barbara Serra-Pereira, Ivone Figueiredo
2. WD_WKBELASMO_Data compilation for RJN.9a stock	Description of data available for the assessment of Cuckoo ray (rjn.27.9a)	Cristina Rodriguez-Cabello, Teresa Moura, Catarina Maia, Barbara Serra-Periera, Guzman Diez, Ivone Figueiredo
WD_rjh.27.9a_Data_Compilation_WKELASMO3	Description of data available for the assessment of Blonde ray (rjh.27.9a)	Catarina Maia, Barbara Serra-Periera, Teresa Moura, Cristina Rodriguez-Cabello, Ivone Figueiredo
rjh.27.9a_LPUE standardization_2008_2022	Standardization of LPUE for Blonde ray (rjh.27.9a) from the polyvalent fleet from Peniche in Portuguese waters.	Catarina Maia, Teresa Moura, Barbara Serra-Pereira, Ivone Figueiredo
WD_rjc.27.9a_Data_Compilation_WKELASMO3	Description of data available for the assessment of Thornback ray (rjc.27.9a)	Barbara Serra-Periera, Teresa Moura, Cristina Rodriguez-Cabello, Ivone Figueiredo
WD_WBELASMO3_rjn.27.9a_SPiCT_assessments	Exploratory assessment of Cuckoo ray (rjn.27.9a) using SPiCT	Teresa Moura, Cristina Rodriguez-Cabello, Catarina Maia, Barbara Serra-Pereira, Ivone Figueiredo
WD_rjc.27.9a_Stock Summary_WKBELASMO3	Exploratory assessment of Thornback ray (rjc.27.9a) using SPiCT	Barbara Serra-Periera, Teresa Moura, Catarina Maia, Cristina Rodriguez-Cabello, Ivone Figueiredo
RJH9a_assessment_SPiCT	Exploratory assessment of Blonde ray (rjch.27.9a) using SPiCT	Catarina Maia, Teresa Moura, Barbara Serra-Periera, Cristina Rodriguez-Cabello, Ivone Figueiredo

1.3 Conduct of the meetings

The working documents were received prior to the meeting and presentations were made by the participants, which subsequently formed the basis of the workshop's investigations during the two meetings.

To ensure credibility, salience, legitimacy, transparency and accountability in ICES' work, to avoid CoI and to safeguard the reputation of ICES as an impartial knowledge provider, all contributors to ICES' work are required to abide by the ICES' Code of Conduct. The ICES' Code of Conduct document dated October 2018 was brought to the attention of participants at the workshop and no CoI was reported.

1.4 Recommendations

TO WGEF :

- work on LPUE series…
- coastal survey

the PT-LPUE from the polyvalent fleet should be improved

Blonde:

Since the assessment, in the absence of any relevant survey, is highly dependent on the LPUE series, any improvement of the data used and/or statistical treatment should be encouraged to better provide an index more representative of the abundance of the stock.

The panel recommends revisiting the model as new data become available in coming years to evaluate if longer time series of more informative data can solve model issues. The main criteria to monitor are standard SPiCT diagnostics and the overall uncertainty in the relative B/B_{msy}. A future fishery-independent survey for this stock could help reduce the overall uncertainty.References **(if needed)**

1.5 Reviewers´ report

The reviewers' report was jointly prepared by the invited external experts Margarita Rincón Hidalgo), (Spain), Alfonso Pérez Rodríguez (Spain) and Arni Magnusson (SPC).

This report presents the reviewers' assessment of the Benchmark Workshop for the three selected elasmobranch stocks in Atlantic Iberian waters (Division 9.a) (WKELASMO3): Thornback ray (*Raja clavata*), Blonde ray (*Raja brachyura*), Cuckoo ray (*Leucoraja naevus*).

Details on the stock specific assessments is include in the section of each stock, but the main conclusions are presented below:

Thornback ray *Raja clavata* in Division 9a (Atlantic Iberian waters) (rjc.27.9a)

Based on the different models presented, the tests and sensitivity analysis conducted during the meeting, the SPiCT assessment model was accepted as the basis for providing advice for thornback ray in the Atlantic Iberian waters.

Blonde ray *Raja brachyura* in Division 9.a (Atlantic Iberian waters) (rjh.27.9a)

The SPiCT assessment of blonde ray in division 9a was not considered suitable for providing management advice. The panel recommends revisiting the model as new data become available in coming years to evaluate if longer time series of more informative data can solve model issues. The main criteria to monitor are standard SPiCT diagnostics and the overall uncertainty in the relative B/B_{msy}. A future fishery-independent survey for this stock could help reduce the overall uncertainty.

Cuckoo ray *Leucoraja naevus* in Division 9.a (Atlantic Iberian waters) (rjn.27.9a)

Based on the different models presented, the tests and sensitivity analysis conducted during the meeting, the SPiCT assessment model was accepted as the basis for providing advice for cuckoo ray in the Atlantic Iberian waters.

2 Reconstruction of Historical landings

Production models (such as SPiCT), require a time series of catches as input data, preferably long enough to cover one generation time, and that includes contrasting periods in terms of stock biomass and fishery mortality. Landing data currently available for each of the different *Rajidae* species here addressed only comprised the period from 2008 to 2022. Given the short time period available it was crucial to reconstruct landings previous to 2008.

2.1 Portugal

Since 2000, Portuguese *Rajidae* official landings ranged between 1011 and 1358 tons, with the polyvalent fleet accounting for 71-83% (Figure 2.1).

For the polyvalent fleet both the number of trips and the number of vessels landing *Rajidae* have been decreasing since 2011, while the average landed weight per trip has been increasing since 2017 (attaining values similar to the period previous to 2011) (Figures 2.2-2.4.). For the trawl fleet, the number of vessels and trips landing *Rajidae* species decreased from 2000 to 2010 being stable since then, while the average landed weight per trip shows a peak between 2009 and 2011 and a slight increase in the last years (Figures 2.2-2.4.).

To better understand landings information, it should be noted that, since 2009, several management measures have been implemented at both EU and regional (Portugal) level:

- The first management measure implemented for the Atlantic Iberian waters (ICES 9a) was the establishment of a TAC in 2009 that consists of a common TAC for all *Rajidae* species, excluding *Raja undulata* and *Rostroraja alba* that "*may not be retained on board"* (Council Regulation (EC) No 43/2009). In 2010, *R. undulata* was listed as a prohibited species on quota regulations (Section 6 of CEC, 2010). The Portuguese annual quota ranged between 1051-1974 tons for the period 2009-2022 (Figure 2.1).

- The Portuguese Administration adopted, on 29 December 2011, a national legislation that *prohibits the catch, the maintenance on board and the landing of any skate species belonging to the Rajidae family, during the month of May along the whole continental Portuguese EEZ*. This applies *to all fishing trips, except bycatch of less than 5% in weight* Portaria no 315/2011). The legislation was updated on 21 March 2016 (Portaria no 47/2016) by extending the fishing prohibition period to June.

- By 22 August 2014, the Portuguese Administration adopted a national legislation (Portaria no 170/2014) that *establishes a minimum landing size of 52 cm total length (LT) for all Raja spp. and Leucoraja spp*. In 2022, the minimum landing size was updated to 60 cm total length for all *Raja* spp. and *Leucoraja* spp. (Portaria nº 255/2022).

- On 19 May 2016, Portugal adopted a legislative framework (Portaria no. 96/2016) regarding the 2016 quota (~15 tons) of *Raja undulata* in ICES Division 9.a assigned to Portugal. This framework includes a set of conditions to provide licenses for specific vessels, maximum landed weight per trip, maximum and minimum conservation reference sizes and closed fishing period.

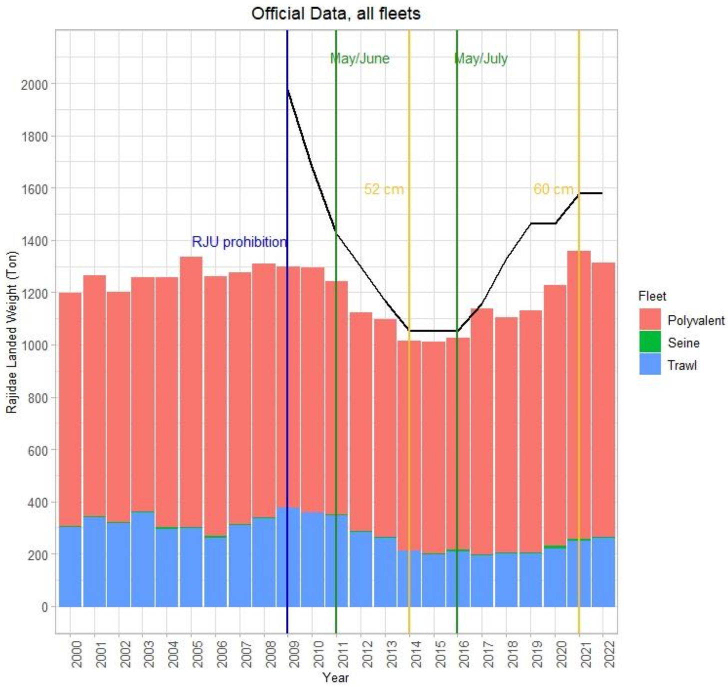

Figure 2.1 Rajidae Portuguese official landings (tonnes) in 9a for the period 2000-2022 per fleet (polyvalent, trawl and seine). Black line – TAC assigned to Portugal since 2009; Blue line – Raja undulata landing prohibition; Green lines – closed

fishing period establish in 2011 and updated in 2016 and; Yellow lines – minimum landing size established in 2004 and updated in 2021.

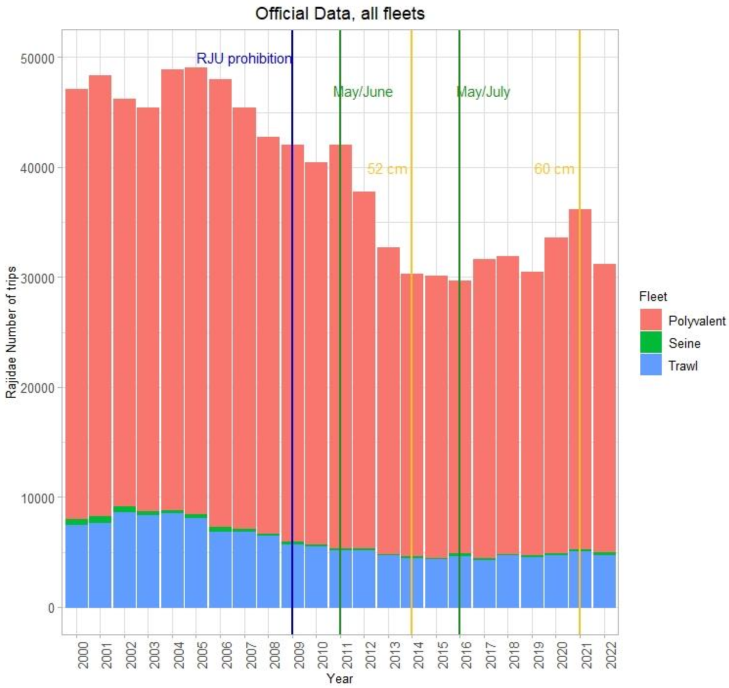

Figure 2.2 Rajidae Portuguese official landings (number of trips) in 9a for the period 2000-2022 per fleet (polyvalent, trawl and seine). Black line – TAC assigned to Portugal since 2009; Blue line – Raja undulata landing prohibition; Green lines – closed fishing period establish in 2011 and updated in 2016 and; Yellow lines – minimun conservation reference size stablished in 2004 and updated in 2021.

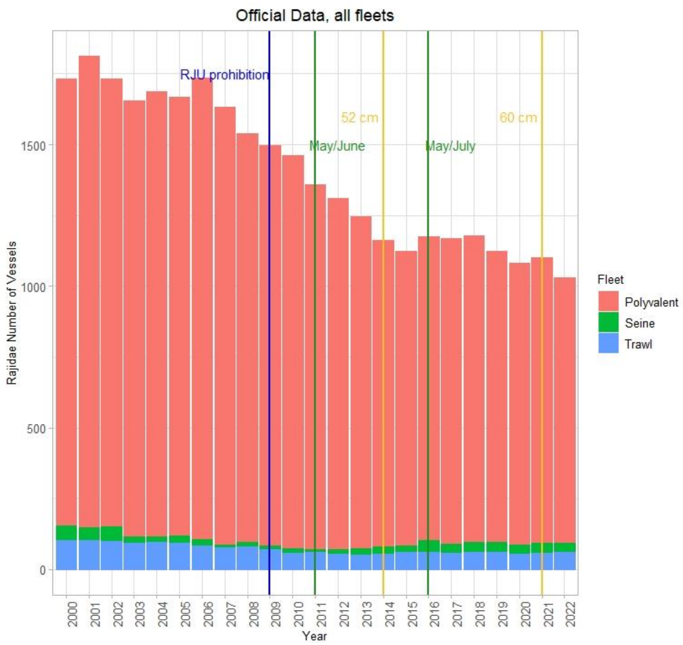

Figure 2.3 Rajidae Portuguese official landings (number of vessels) in 9a for the period 2000-2022 per fleet (polyvalent, trawl and seine). Black line – TAC assigned to Portugal since 2009; Blue line – Raja undulata landing prohibition; Green

lines – closed fishing period establish in 2011 and updated in 2016 and; Yellow lines – minimum conservation reference size stablished in 2004 and updated in 2021.

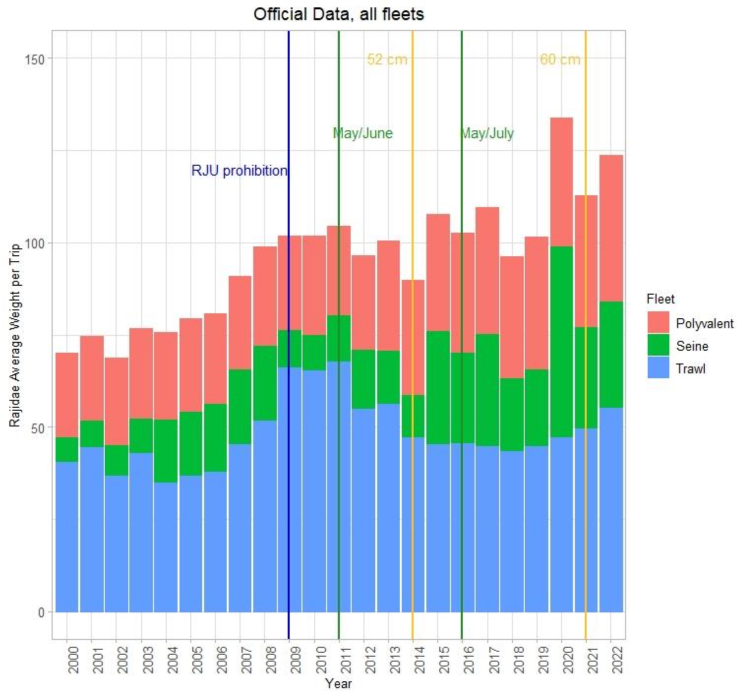

Figure 2.4 Rajidae Portuguese official landings (average landed weight per fishing trip) in 9a for the period 2000-2022 per fleet (polyvalent, trawl and seine). Black line – TAC assigned to Portugal since 2009; Blue line – Raja undulata landing prohibition; Green lines – closed fishing period establish in 2011 and updated in 2016 and; Yellow lines – minimun landing size stablished in 2004 and updated in 2021.

Historically, in Portugal mainland, *Rajidae* species were landed under a generic category (skates and rays *nei*) since the middle of the last century (Figueiredo et al., 2007; ICES, 2005). _Since the 90's, *Rajidae* have been mostly landed under different commercial species denominations but with high level of misidentification (Figueiredo et al 2020). In order to estimate landings by species, landings of all *Rajidae* are annually pooled together and then separated by species following a statistical stepwise procedure that uses sampling information collected under the Data Collection Framework (DCF). Details on the methodology used are described in Figueiredo et al. (2020). During WGEF 2014 (ICES, 2014), Portuguese official landings by species for the period 2008-2013 were revised based on the developed procedure and, since then, the same methodology has been applied to provide species specific landings to ICES.

2.1.1.1 *Estimates for the period 2000-2007*

Before 2008, DCF sampling data on *Rajidae* species is less abundant and mainly covers the polyvalent fleet in the Peniche landing port in the period 2003-2007. Therefore, the lack of sufficient DCF data before 2008 precludes the application of the method developed for the subsequent period. Table 2.1, summarizes the data collected during 2003-2007 at the Peniche landing port. Sampling procedures followed the same approach as 2008-2022. At each visit to landing ports, fishing trips with landings of *Rajidae* were randomly selected. For each selected trip, fishermen were interviewed and the information on the type of fishing(s) gear(s) used was registered. The sampling of the landings comprised the record by trip of: i) landed weight and commercial designation assigned to each auction box used to land *Rajidae* species and ii) species, total length (cm), weight (kg) and sex by specimen in each auction box.

Table 2.1 Number of polyvalent sampled trips with Rajidae species collected under the scope of DCF in the Peniche landing port for the period 2003-2007.

Year	Number of trips
2003	52
2004	76
2005	105
2006	107
2007	105

To expand the Portuguese time series of landings for the period 2000-2007, three options were explored, all based in the methodologies also followed in recent elasmobranch benchmarks (e.g., ICES 2023; Maia et al. 2023 WD):

1. Average of each *Rajidae* species proportion in the period 2008-2010 applied over 2000-2007 separately for each fleet;
2. Average of each *Rajidae* species proportion in the period 2008-2010 applied over 2000-2007 separately for each port and fleet;
3. Average of each *Rajidae* species proportion in the period 2008-2010 applied over 2000-2007 separately for each port and fleet, except for the polyvalent fleet in Peniche. In this port, DCF samples for the period 2003-2007 are used for estimating yearly proportions for the period and the average of each *Rajidae* species proportion in the period 2003-2005 was applied over 2000-2002.

Since the Peniche landing port accounted, in that period, for 31-58% of the total *Rajidae* landings of the polyvalent fleet, the group decided that the final procedure to be adopted for the benchmark, and subsequently for future assessment, was method 3, as it is based on more sampling information.

Method 3 involved two steps:

Step 1 - Average of each *Rajidae* species in the period 2008-2010 applied over 2000-2007 separately for each port and fleet (except for the polyvalent fleet in Peniche landing port).

An average proportion of each species in each landing port and fleet for the period 2008-2010 was estimated and applied to the respective landing ports and fleets with *Rajidae* landings in the period 2000-2007. Average regional proportions for the period 2003-2005 were also estimated to apply to ports landing *Rajidae* during 2000-2007 for which no landings were recorded in 2008-2010.

Step 2 – Polyvalent fleet in Peniche: DCF samples from the period 2003-2007 were used to estimate yearly species proportions for that period and the respective landings for this fleet; the average of each *Rajidae* species in the period 2003-2005 was then applied in each of the years from 2000 to 2002.

Species weight proportion to the total weight of *Rajiade* in each year (2003-2007) in Peniche was estimated as:

$$P\hat{a}_{(s,y)} = \sum_{i=1} w_{(s,y)i} / wt_{(y)}$$

where $w_{(s,y)i}$ is the landed weight of s^{th} *Rajidae* species in the i^{th} fishing trip and $wt_{(y)}$ is the total landed weight of *Rajidae* in the sampled trips at the y^{th} year. The resulting proportions were then applied to the total landed weight of *Rajidae* in that landing port and year.

Finally, the average proportion of each *Rajidae* species in the period 2003-2005 was then applied over 2000-2002 (years without sampling).

Results obtained for each fleet, polyvalent and trawl, are presented in tables 2.2 and 2.3 and Figure 2.5 (more details can be found in Maia et al., 2023 WD).

Table 2.2 Total landings (tonnes) of Rajidae species estimated for the Portuguese polyvalent fleet in the period 2000-2007. Only species for which category 3 advice is provided are presented.

Year	RJC	RJH	RJM	RJN	Other species
2000	322	230	111	29	200
2001	339	229	122	29	203
2002	334	196	128	26	195
2003	334	211	132	30	190
2004	366	204	149	28	210
2005	401	230	161	28	213
2006	404	176	157	27	227
2007	399	153	165	24	221

Table 2.3 Total landings (tonnes) of Rajidae species estimated for the Portuguese trawl fleet for the period 2000-2007. Only species for which category 3 advice is provided are presented.

Year	RJC	RJH	RJM	RJN	Other species
2000	170	31	37	20	41
2001	195	34	40	22	47
2002	179	33	43	25	38
2003	204	37	46	26	43
2004	169	31	39	23	34
2005	169	30	39	21	38
2006	143	28	37	22	30
2007	172	32	42	26	36

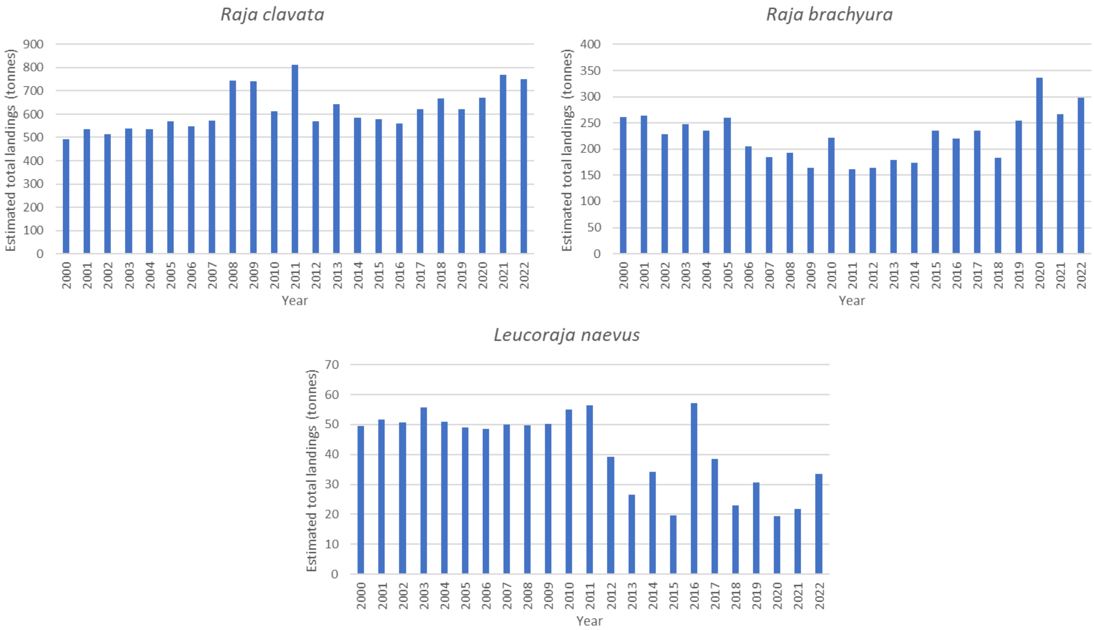

Figure 2.5 Portuguese estimated total landings (tonnes) of thornback ray (Raja clavata), blonde ray (Raja brachyura) and cuckoo ray (Leucoraja naevus) for the period 2000-2022.

2.2 Spain

In the case of the Spanish landings, landings by species are available since 2010. To reconstruct the landings for 2000-2009, an average proportion of each species over 2010-2013 was applied to the total Spanish *Rajidae* landings for the period 2000-2009 (Tables 2.4, Figure 2.6).

Table 2.4 Spanish estimated total landings (tonnes) of some Rajidae species for the period 2000-2009. Only species for which category 3 advice is provided are presented.

Year	RJC	RJH	RJM	RJN	Other species
2000	98.9	1.0	3.2	5.1	181.8
2001	141.8	1.4	4.6	7.4	260.8
2002	115.8	1.2	3.8	6.0	212.8
2003	117.6	1.2	3.8	6.1	216.2
2004	111.8	1.1	3.6	5.8	205.6
2005	107.2	1.1	3.5	5.6	197.1
2006	116.4	1.2	3.8	6.0	213.9
2007	111.8	1.1	3.6	5.8	205.5

2008	119.0	1.2	3.9	6.2	218.8
2009	94.2	1.0	3.1	4.9	173.2

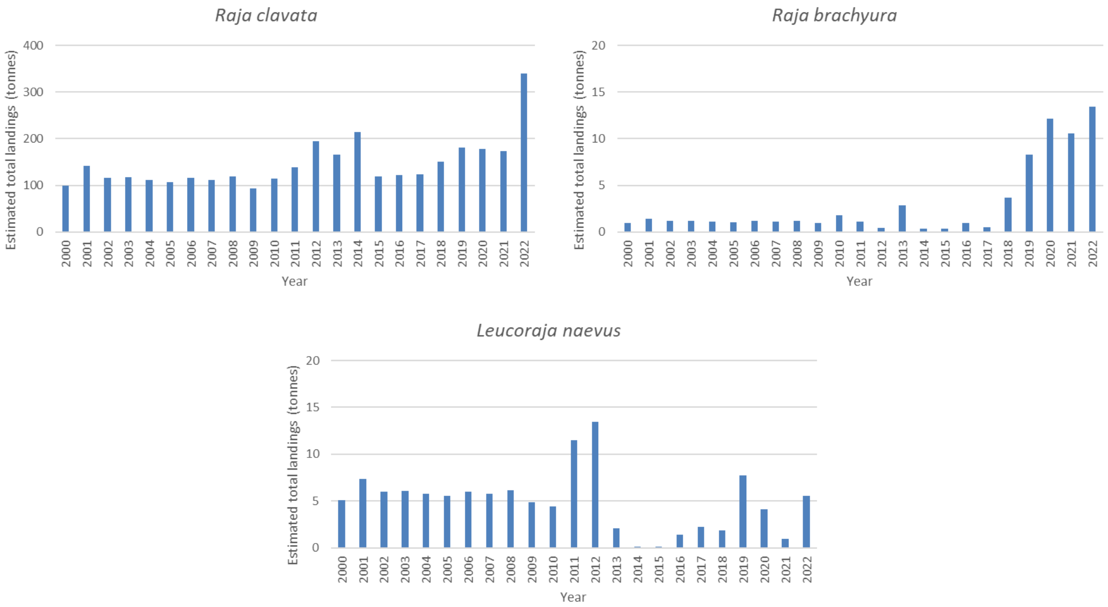

Figure 2.6 Spanish estimated total landings (tonnes) of thornback ray (Raja clavata), blonde ray (Raja brachyura) and cuckoo ray (Leucoraja naevus) for the period 2000-2022.

2.3 References

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3 Thornback ray (*Raja clavata*) in Division 9.a (Atlantic Iberian waters) (**rjc.27.9a**)

3.1 Introduction

Thornback ray, *Raja clavata*, is the most ubiquitous and common skate species across the Northeast Atlantic. The species is distributed along the Atlantic Iberian waters ICES division 9a.

In the West of Galicia thornback ray is more abundant in the northern waters and in the Cantabrian Sea mainly in mud and sandy bottoms. It has a wide depth distribution, from 20 m to 400 m, but it is more abundant between 50-200 m depth, particularly close to 75 m. There is no information regarding size or sex segregation, neither on spawning or egg laying site (Sánchez et al., 2002). The species can be found throughout the Portuguese continental coast, from 18 to 700 m, being more abundant in the southwest and southern regions (i.e. south off Cabo Carvoeiro), at depths shallower than 200 m. In the centre of mainland Portugal, the species occupies a broad range of habitat types, from mud and fine sand to rocky bottoms, showing different spatial dynamics according to the life stage (Serra-Pereira et al., 2014). In the Gulf of Cadiz, the thornback ray is present along the whole area at depths ranging from 20 to 800 meters, being especially abundant in trawlable grounds placed in the south area of the Gulf, in the range between 100 and 350 m depth. A more detailed description of the species distribution in ICES Division 9a can be found in the working document presented to WKBELASMO 3 with the stock summary information on rjc.27.9a (Serra-Pereira et al., 2024a).

Thornback ray is the most important commercial *Rajidae* species and landings in ICES Division 9a have been ranged from 591 to 1090 tonnes, during the period 2000-2022, which represents more than 50% of all skate species landed in that geographical area. Portugal contributes for 69-89% and Spain for 11-31%.

Since 2009, several management measures for *Rajidae* species have been implemented at both EU and regional (Portugal) level, such as a TAC implementation, a fishery closed period and the establishment of a minimum landing size (see section 2.1 for more details).

Under ICES, the stock of thornback ray in Atlantic Iberian waters (rjc.27.9a) has been assessed under category 3 since 2014, and the latest advice in 2022, involved the application of the ICES framework for category 3 stocks applying the rfb rule (method 2.1; ICES, 2022a-b).

For the present benchmark, the proposal was focussed on evaluating the application of a surplus production model SPiCT (Stochastic Production model in Continuous Time, Pedersen and Berg 2017) on the stock for providing future assessments.

3.2 Stock Identity

The stock structure of the species along the ICES areas is unknown. Migrations between different areas are admitted (ICES, 2013). ICES currently considers seven distinct assessment units, including one in the Greater North Sea, three in the Celtic Sea, two in the Bay of Biscay and a distinct stock unit for Division 9.a, west of Galicia, Portugal, and Gulf of Cadiz (rjc.27.9a), which is the focus of this working document.

Strong regional genetic differentiation is described for thornback ray between the Mediterranean basin, the Azores and the European continental shelf (Chevolot et al., 2006). The distribution and movement of this species is apparently highly influenced by ocean depth, which acts as physical barrier to dispersal for thornback rays, as also described to occur in other demersal fish between continental shelf and Icelandic populations (Hoarau et al., 2002). The low nuclear allelic diversity and the high genetic differentiation found in the Azores are consistent with a strong bottleneck and physical isolation of the Azores (Chevolot et al., 2006). The highest haplotype diversity was found in the Iberian Peninsula and in more northern English Channel/North Sea populations, while the lowest was found in the Black Sea (Figure 3.1). This suggests restricted gene flow between northern and southern European populations which is in accordance with the current stock structure.

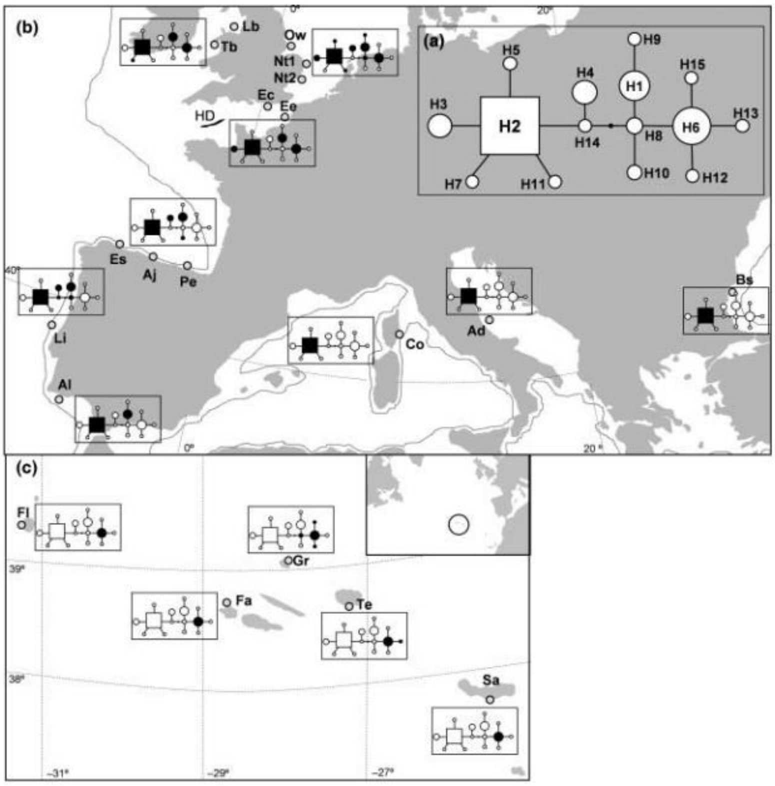


Figure 3.1 Population genetic structure of thornback ray: Sampling locations and distribution of mtDNA haplotypes (H). (source: Chevolot et al., 2006).

More recent European projects on the population genetic structure of thornback ray indicate that on a large spatial scale, samples are clearly clustered by Ecoregions (Figure 3.2) (Poos et al., 2023). The Celtic Sea samples cluster slightly separately from the Greater North Sea samples, whereas the Biscay and Iberia samples clearly cluster separately from those gathered in the northern ecoregions. Also, small scale genetic population structure appears to occur for this species in this ecoregion, between offshore and nearshore areas (Figure 3.3). Those results were in line with a demographic connectivity study (Trenkel et al., 2022) that provided the basis for distinct local populations and the consequent split of thornback ray in Subarea 8 (Bay of Biscay), into a Bay of Biscay (rjc.27.8abd) and a Cantabrian Sea (rjc.27.8c) component, during the 2022 WKBELASMO benchmark (ICES, 2022c).

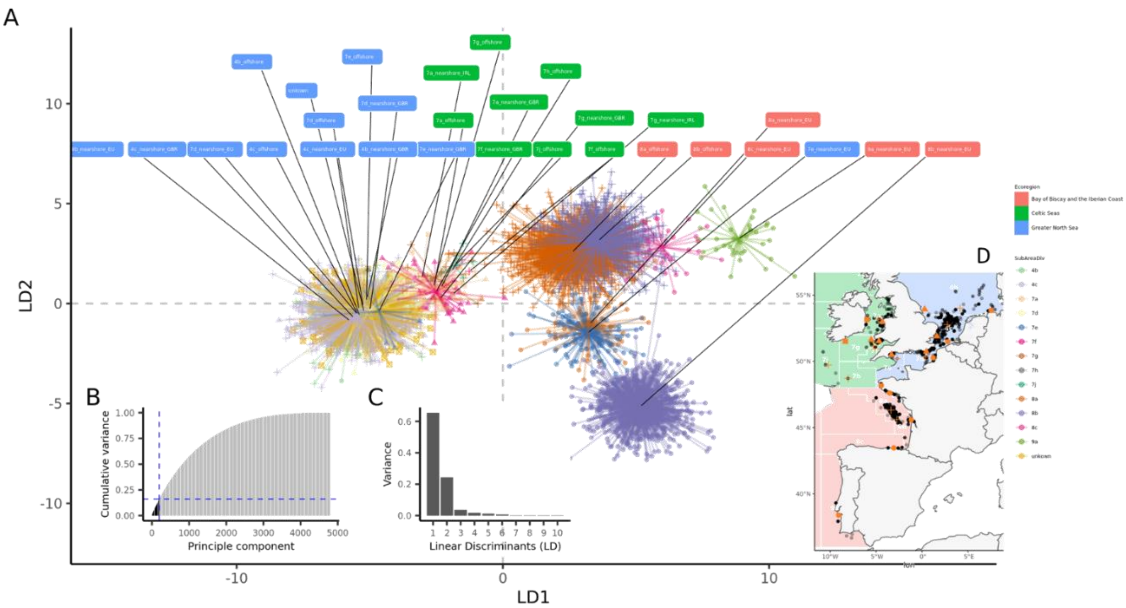


Figure 3.2 Population genetic structure of thornback ray: (A) discriminant analysis of principal components (DAPC) with grouping Prior based on ICES divisions. (B) cumulative variance of optimal number for DAPC. (C) Variance of linear discriminants retained in DAPC. (D) location of Spatial locations of samples collected and genotyped in several projects across European waters. (source: Poos et al., 2023)

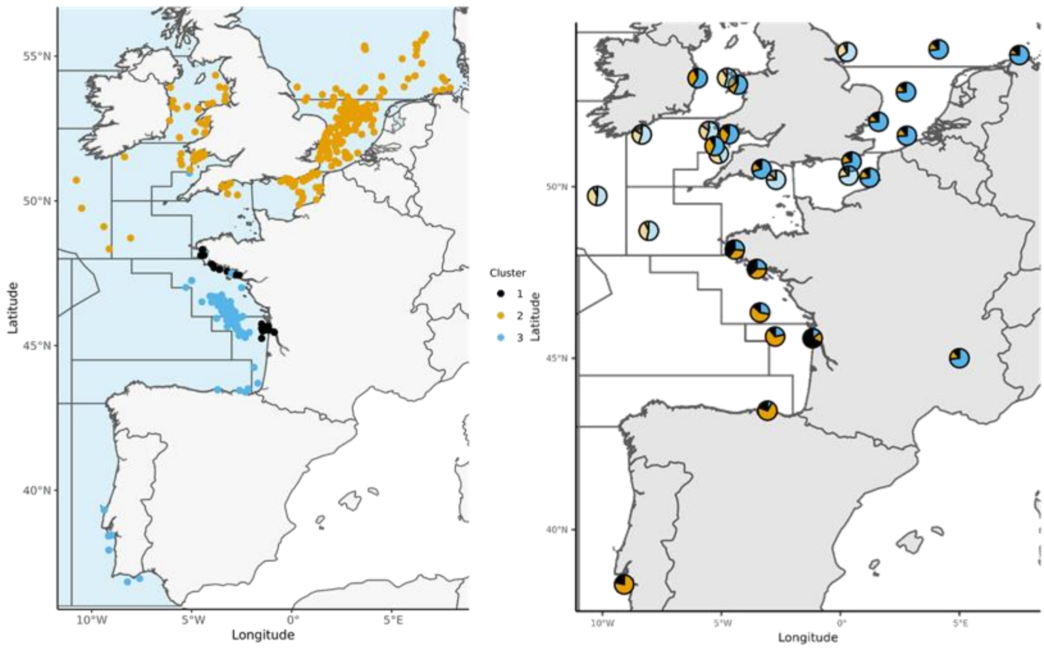


Figure 3.3 Population genetic structure of thornback ray: (left) cluster results of DAPC without prior; (right) average ancestry cluster proportions (admixture) grouped by sample areas, for k= 3 (adapted from Poos et al., 2023)

Bird et al. (2020) compiled and reviewed 50 years of tagging data for eight commercially important skate species around the British Isles. Thornback ray was the most frequently tagged species. Overall, more than 99% of returned tags were from within the defined stock unit of release. Some individuals showed more extensive movements between stock units and management areas, yet it remains unclear whether these are regular or occasional movements. According to those results, along with genetic evidences, the stock boundaries for the North Sea thornback ray stock unit were not updated during WKBELASMO2 (ICES, 2023a).

A recent acoustic telemetry study conducted in a Marine Protected Area (MPA) in the southwest coast of Portugal, has also confirmed the resident behaviour of thornback ray in a coastal area in the ICES Division 9a (Kraft et al., *submitted*). Most of the individuals were observed inside the MPA for a period of three years, while the remaining showed more expansive movements, particularly after 200 days after tagging, coinciding with the period between September and December. One mature female was observed to move into the Sado estuary also during the same period, which coincides with the second half of the spawning period described for this stock (Serra-Pereira et al., 2011). The same behaviour of strong connection to inshore waters, was also observed in the north of Spain (Division 9a), with movements detected in and out the *Ría de Vigo* (Papadopoulo et al., 2023). Other tagging studies have demonstrated the importance of estuaries in the life-cycle of the species in other ecoregions (Walker et al. 1997; Hunter et al. 2006; Ellis et al., 2018; Simpson et al., 2020). The Outer Thames was identified as an important area for the North Sea-eastern Channel stock, with individuals being not restricted to that estuary, as they move throughout the southern North Sea (Ellis et al., 2018). Annual migration patterns were also observed, with individuals moving in autumn from the spawning grounds in the Thames estuary to the central North Sea for winter, followed by a return to the estuary in the spawning season (Hunter et al, 2006).

As such, based on available genetic and tagging data there is no evidence to update the current stock unit in Iberian waters (ICES division 9a) for thornback ray.

3.3 Input data for stock assessment

A detailed description on data available for thornback ray in ICES division 9a can be found in Serra-Pereira. (2024).

3.3.1 Catch data

Catch data of thornback ray in ICES Division 9a (Atlantic Iberian waters) was available from Intercatch since 2008 and 2009 for Portugal and Spain respectively.

3.3.1.1 Landings

Species-specific landings were only available since 2008 and 2009 for Portugal and Spain respectively. In order to obtain a longer time series, landings for the period 2000-2007 for Portugal and 2000-2009 for Spain have been estimated for the different fleets (polyvalent and trawl) independently and using different approaches. For details on historical landings estimation methods see section 2 of the present report and the working documents from Maia et al. (2023) and Rodriguez-Cabello et al. (2024).

Landings of thornback ray in ICES Division 9a have been ranged from 591 to 1090 tonnes, with Portugal contributing for 69-89% and Spain for 11-31% (Table 3.1). Along the time series, landings from the polyvalent fleet represented 50-69% of the species landed weight, followed by trawl that have been representing between 22-49% (Figure 3.4). A more detailed description of landings in ICES Division 9a can be found in Serra-Pereira et al. (2024).

Table 3.1 Thornback ray *Raja clavata* in ICES Division 9a. Annual landings (in tonnes) and representativeness by country.

Year	Portugal		Spain		Total
	Ton	%	Ton	%	
2000	492	83	99	17	591
2001	534	79	142	21	676
2002	513	82	116	18	629
2003	538	82	118	18	655
2004	534	83	112	17	646
2005	571	84	107	16	678
2006	547	82	116	18	663
2007	571	84	112	16	683
2008	745	86	119	14	864
2009	739	89	94	11	833
2010	611	84	115	16	725
2011	811	85	139	15	950
2012	570	75	194	25	764
2013	643	80	166	20	809
2014	585	73	215	27	800
2015	578	83	120	17	697
2016	559	82	123	18	682
2017	620	83	124	17	744
2018	654	81	152	19	806
2019	621	77	181	23	802
2020	670	79	178	21	848
2021	768	82	174	18	942
2022	751	69	339	31	1090

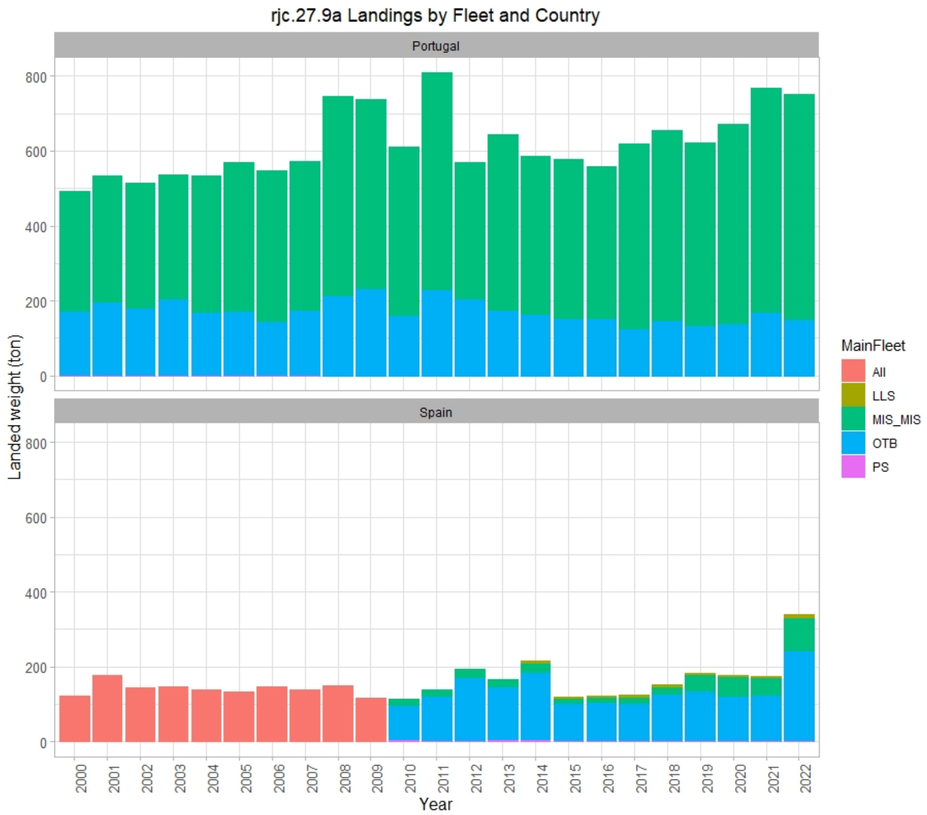


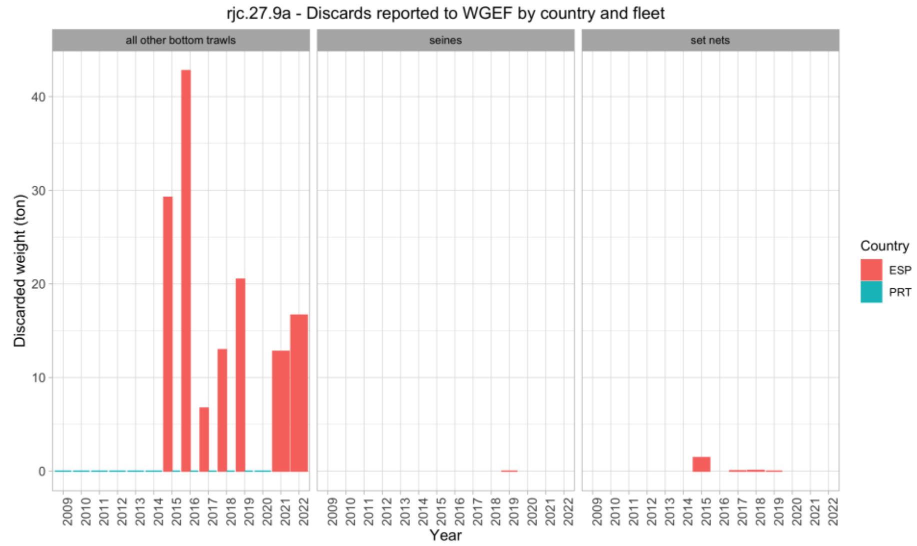
Figure 3.4 Thornback ray *Raja clavata* in ICES Division 9a. Annual landings (in tonnes) by country and fleet. "All" – all fleets combined; "LLS" – longlines; "MIS_MIS" – polyvalent fleet; "OTB" – trawl fleet and; "PS" – seine fleet.

3.3.1.2 Discards

Discards for thornback ray in ICES Division 9a were mainly reported for the Spanish bottom otter trawl fleet and in low quantities (below 45 tons) compared to the total landings for the stock (average proportion of 0.01±0.018) (Figure 3.5). The low frequency of occurrence registered for the species in the discards of the Portuguese trawl fleet indicates that discards can be considered negligible for that particular fleet (Fernandes, 2021). For the Portuguese polyvalent fleet, discards are known to take place and assumed to be low, but are not fully quantified as the information available is insufficient to estimate total discards (Fernandes, 2021).

In summary, discarding is known to take place for thornback ray in ICES Division 9a, but ICES cannot estimate the quantity or the corresponding dead catch. Yet, based on information available, discarding for this stock is assumed to be low and therefore has not been included in the previous advices and will not be considered for the SPiCT assessment explored in the WKBELASMO3 benchmark.

A



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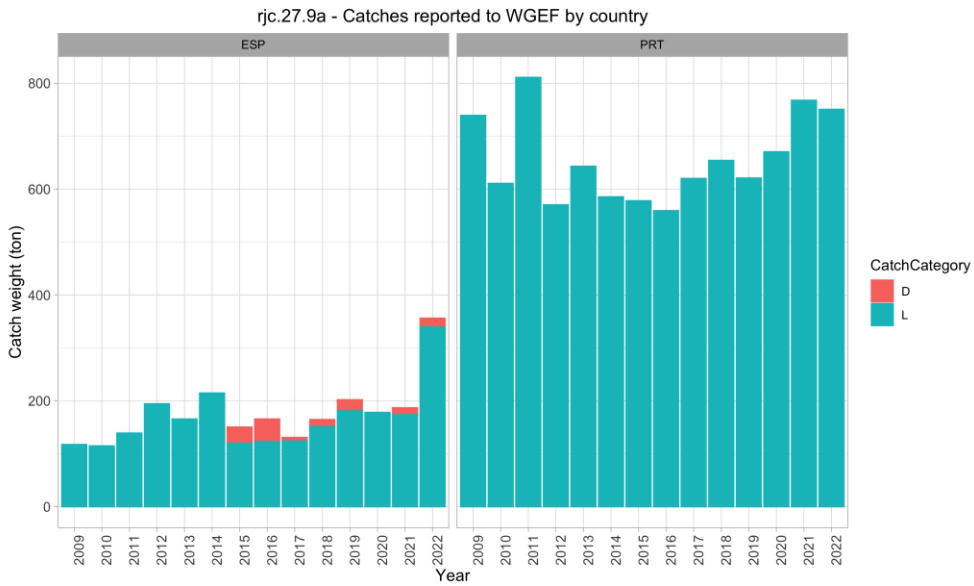


Figure 3.5 Thornback ray *Raja clavata* in ICES Division 9a. (A) Discards reported by country and fleet. (B) Catches reported by country, separated by landings (L) and discards (D).

3.3.1.3 Survival

Discard survival studies on thornback ray have been conducted in ICES Division 9a both in Portugal (Serra-Pereira and Figueiredo, 2019) and Spain (Valeiras and Álvarez-Blazquez, 2018), covering the main fishing gears catching the species.

In summary, based on results for the Portuguese polyvalent fleet, collected under the DCF Skates Pilot Study, a high Categorical Vitality Assessment (CVA) was found for thornback ray, with more than 75% of the individuals found in Excellent or Good vitality status (Table 3.2). Both mesh size and soaking time seem to affect this indicator. The catch vitality after capture was not related to the size of the retain fraction of the caught skates, while for the discarded, differences between size classes were observed, as the large skates discarded were generally not in good conditions for selling due to parasite infection for example (Table 3.3). According to a study conducted onboard the polyvalent fleet in the north of Spain (DESCARSEL project), all skates were alive after capture, with 89% of them in Excellent or Good conditions, and after 30 days in captivity the short-term survival was estimated at 73, considering all skate species combined, including the thornback ray (Valeiras and Álvarez-Blazquez, 2018).

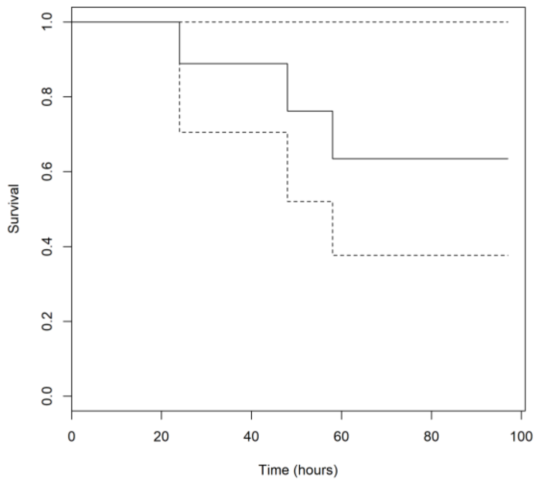
Table 3.2 Thornback ray *Raja clavata* in ICES Division 9a. Categorical Vitality Assessment (CVA) after capture by mesh size (mm) and soaking time (h), recorded onboard commercial vessels operating with trammel nets (n=171). (source: Serra-Pereira and Figueiredo, 2019).

		Vitality status				
Mesh size (mm)	Soak time (h)	1	2	3	n	TL range (cm)
< 180	< 24	100%	0%	0%	17	23-72
	> 24	72%	12%	16%	25	39-80
> 180	< 24	92%	4%	4%	26	48-88
	> 24	52%	23%	24%	103	40-96

Table 3.3 Thornback ray *Raja clavata* in ICES Division 9a. Categorical Vitality Assessment (CVA) after capture by length class (cm), recorded onboard commercial vessels operating with trammel nets (source: Serra-Pereira and Figueiredo, 2019).

	Retained Vitality status				**Discarded** Vitality status			
Length class	1	2	3	n	1	2	3	n
<52 cm	68%	18%	14%	22	83%	0%	17%	12
>52 cm	70%	19%	10%	125	0%	0%	100%	12

Regarding the trawl fleet, experiences conducted onboard the Portuguese Autumn Groundfish Survey, suggested that thornback ray has a relatively high survival rate after capture with trawl, although lower than with trammel nets (Serra-Pereira and Figueiredo, 2019). Kaplan-Meier model fitted to survival data, showed no significant differences between vitality status (p=0.84), and estimated a preliminary survival rate of 64% (Figure 3.6). To note that this study although it may be indicative of the species survival it involved a small sample which was translated in a high uncertainty.



time	n.risk	n.event	survival	s.e.	lower 95% CI	upper 95% CI
24	9	1	0.89	0.11	0.71	1.00
48	7	1	0.76	0.15	0.52	1.00
58	6	1	0.64	0.17	0.38	1.00

Figure 3.6 Thornback ray *Raja clavata* in ICES Division 9a. Kaplan-Meier estimate of survival after capture with trawl nets, at 100 hours (4.2 days) in captivity (solid lines) and 95% pointwise confidence intervals (dashed lines). Survival probability estimates within the observation period with standard error and upper and lower 95% CIs estimates are presented below the plot (source: Serra-Pereira and Figueiredo, 2019).

Results obtained by fishing operation, onboard the Spanish trawl fleet, suggest differences between hauls in vitality proportions (e.g. associated to a large catch weight of the target species, horse mackerel, resulting in a higher proportion of skates in "Poor" condition) (Valeiras and Álvarez-Blazquez, 2018). A proportion of 93.5% of skates survived to fishing operations and handling onboard (Table 3.4). Based on captivity trials, the overall survival rate was 58% after 36h and 17% after 30 days. Differences were observed on the survival rate of skates categorised as "Good" (46%), compared with those as "Poor" (2%). As several factors may have influenced the survivability of the individuals during the experiment, it can be assumed that the survival rate obtained may be greatly underestimated. Factors affecting the estimates were: large catch weight of the target species (horse mackerel) in some hauls, transport, onboard captivity conditions, as well as the fact that most of the thornback rays did not eat till 3 weeks at captivity which may have compromise the health status at captivity of the species (Valeiras and Álvarez-Blazquez, 2018). Studies conducted in trawl fleets from other areas obtained higher estimates of survival, like for example 75% after 21 days, obtained for the fleets operating in the North Sea and English Channel (Van Bogaert et al., 2020).

Table 3.4 Thornback ray *Raja clavata* in ICES Division 9a. Categorical Vitality Assessment (CVA) after capture recorded onboard commercial trawlers in the north of Spain (n=153).

Vitality	Captured	Number fish in tanks	Proportion Vitality in total catch
Excellent	2	1	1.3%
Good	45	24	29.4%
Poor	96	53	62.8%
Dead	10	0	6.5%
Total	**153**	**78**	

Overall, the results from the different studies suggest that the thornback ray caught by different fishing gears in ICES Division 9a have a high survival after capture, more precisely those caught by polyvalent vessels operating with trammel nets and otter trawlers. All the studies followed the procedures described in previous studies on the survival of this group of species and the recommendations made by the STECF and the ICES Working Group on Methods to Estimate Discard Survival.

3.3.2 Biomass index

Relevant fisheries independent data for the stock rjc.27.9a is collected onboard three Iberian research surveys, covering most of the stock area (Figure 3.7): (i) Portuguese Autumn Groundfish Survey (PtGFS-WIBTS-Q4), (ii) Spring southern Spanish bottom trawl survey (SpGFS-GC-WIBTS-Q1; ARSA Q1) and (iii) Autumn southern Spanish bottom trawl survey (SpGFS-GC-WIBTS-Q4; ARSA Q4). The input from these three surveys have been used to provide the assessment under the Data-limited approach for category 3 stocks (trend-based). A more detailed description on these surveys can be found in Serra-Pereira et al. (2024a).

Although not included in the assessment, additional information is provided from the Spanish Autumn Groundfish Survey (SpGFS-WIBTS-Q4), although the yields of thornback ray from this survey present an irregular time-series, with biomass estimates close to zero in some of the years. Detailed information on this survey can be found in Serra-Pereira et al. (2024a).

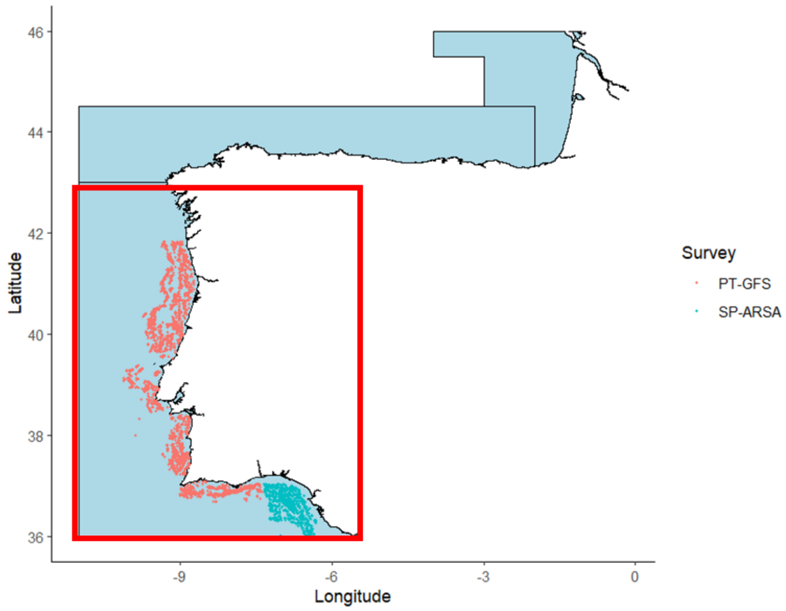


Figure 3.7 Thornback ray *Raja clavata* in ICES Divison 9a. Surveys conducted in Division 9a with relevant captures of the species: Portuguese Autumn Groundfish Survey (PtGFS-WIBTS-Q4; PT-GFS) and Spanish bottom trawl survey SpGFS-GC-WIBTS-Q1 and Q4 (SP-ARSA).

3.3.2.1 *Portuguese Autumn Groundfish Survey (PtGFS-WIBTS-Q4) [G8899]*

The Portuguese Autumn Groundfish Survey (PtGFS-WIBTS-Q4) has been conducted by the Portuguese Institute for the Sea and Atmosphere (IPMA, ex-IPIMAR) and has the main objective to monitor the abundance and distribution of hake (*Merluccius merluccius*) and horse mackerel (*Trachurus trachurus*) recruitment (Cardador et al., 1997). The survey is performed along the Portuguese continental coast, extending from latitude 41°20'N to 36°30'N (ICES Division 9.a) from 20 to 500 m deep. The surveyed area is stratified into 12 sectors, each further divided into four depth strata: 1) 20-100 m, 2) 101-200 m, 3) 201-500 m, and 4) 501-750 m. For more details on vessels characteristics (RV *'Noruega'*) and technical characteristics of fishing operations see ICES (2017a).

In 2012 no survey was conducted, as well as in 2019 and in 2020, due to issues external to IPMA and to the covid-19 outbreak. In 1996, 1999, 2003 and 2004 the survey was conducted with a different gear. In 2018, the survey had technical problems, and part of the stations were sampled using a commercial trawler and a different fishing net (using FGAV019 instead of NCT). Since 2021, the survey has been conducted with a new vessel (RV *'Mário Ruivo'*) and some modifications in the fishing gear.

In PtGFS-WIBTS-Q4, thornback ray is the most frequent skate species caught (88% of the total weight of skates), being caught all along the entire Portuguese continental shelf and upper slope, at depths ranging from 18 m to 700 m, being more abundant in southwest and south regions at depths shallower than 200 m (Figure 3.8). Length composition of thornback ray in Portuguese Autumn Groundfish Survey for the all period combined is present in Figure 3.9.

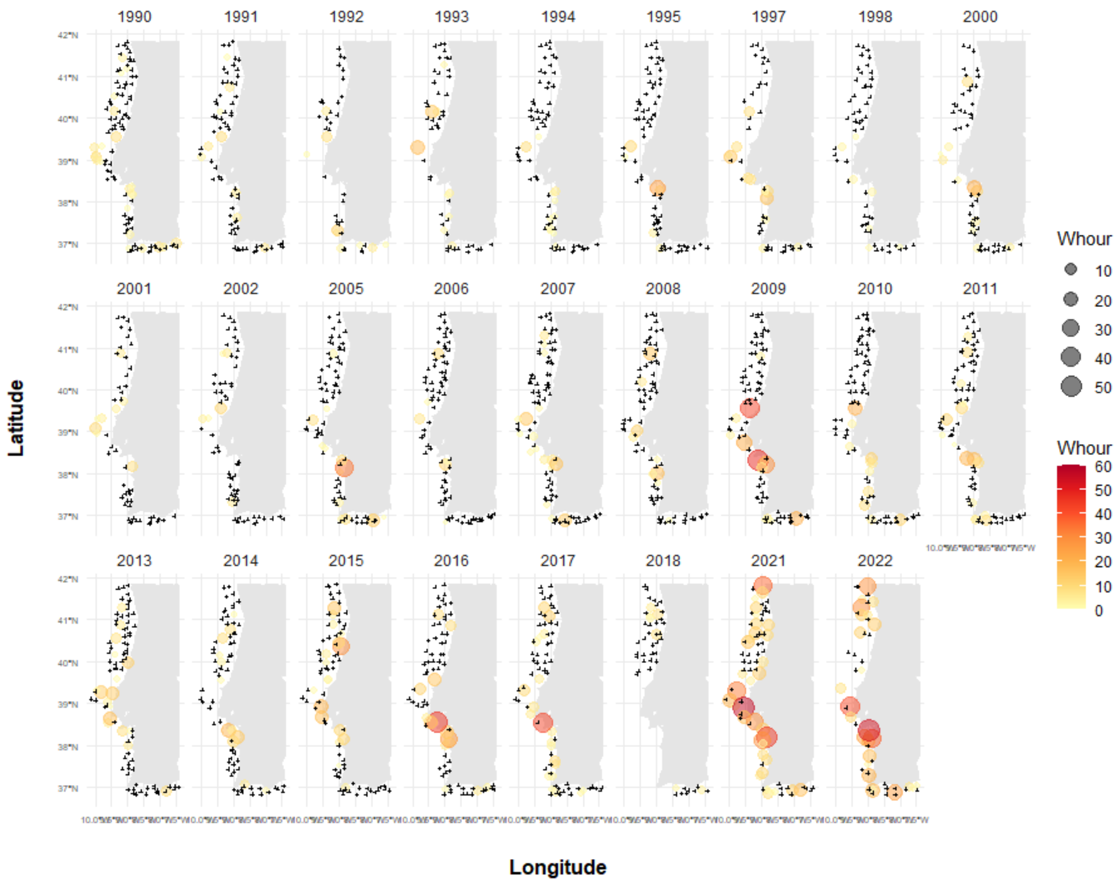


Figure 3.8 Thornback ray *Raja clavata* in ICES Divison 9a. Catches and distribution in Portuguese Autumn Groundfish Survey (PtGFS-WIBTS-Q4) during the period 1990-2022.

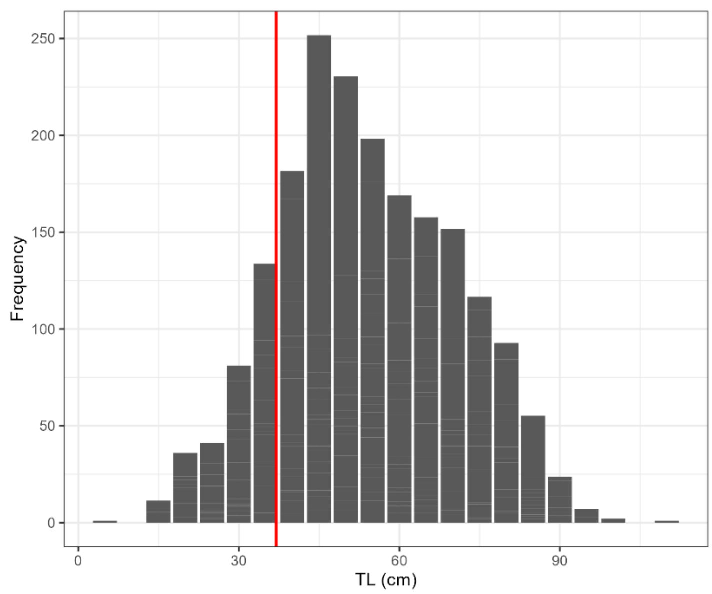


Figure 3.9 Thornback ray *Raja clavata* in ICES Divison 9a. Length distribution (5 cm classes) in the Portuguese Autumn Groundfish Survey (PtGFS-WIBTS-Q4) during the period 1990-2022. Red line identifies the 35 cm threshold applied to select the exploitable biomass component of the survey catch.

As PtGFS-WIBTS-Q4 was not designed to capture skates, a model-based approach was adopted to produce a biomass index. Given the occurrence of the species at 20-350 m deep, the dataset was restricted to this depth range. Generalized linear mixed models (GLMM; Bolker et al., 2009) were used in the standardization process, which include the year and depth as explanatory variables and the sector as random effect:

$$glmm\ (log(catch\ rate + 1) \sim year + log(depth) + (1|sector)$$

Due to the high percentage of zeroes in the data series (Figure 3.10), the model followed a Tweedie distribution for the observations. A detailed description of adopted methodologies can be found in Figueiredo and Serra-Pereira (2013) and in the stock annex.WKBELASMO3 considered this index as relevant to be used for the assessment of the stock.

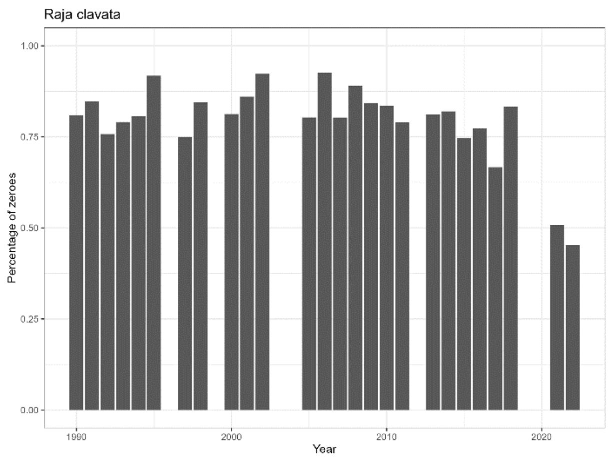


Figure 3.10 Thornback ray Raja clavata in ICES Divison 9a. Percentage of stations with no capture of thornback ray in the Portuguese Autumn Groundfish Survey (PtGFS-WIBTS-Q4), by year.

For the WKBELASMO3, the exploitable biomass index for thornback ray was computed, considering individuals with total length (TL) larger than 35 cm, threshold defined based on the analysis of length frequency data from commercial landings (see section 3.2 of the working document Serra-Pereira et al., 2024a). Individual weight of specimens with TL>35cm was estimated based on length-weight relationships defined for the stock (Serra-Pereira et al., 2010). The standardized CPUE index shows a gradual increasing trend since 2006 (Figure 3.11 and Table 3.5).

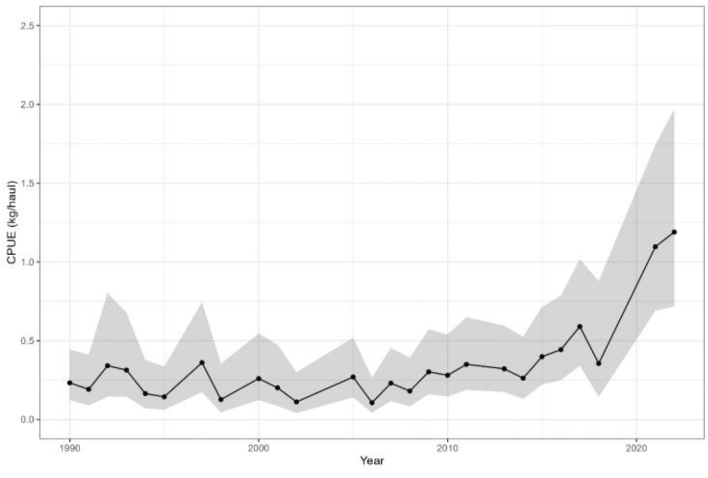


Figure 3.11 Thornback ray *Raja clavata* in ICES Divison 9a. Standardized survey biomass index from the Portuguese Autumn Groundfish Survey (PtGFS-WIBTS-Q4). Shaded grey area represents the upper and lower confidence intervals.

Table 3.5 Thornback ray Raja clavata in ICES Divison 9a. Standardized exploitable biomass index (kg.h^{-1}) for the Portuguese Autumn Groundfish Survey (PtGFS-WIBTS-Q4) and the corresponding confidence intervals.

Year	Mean	SE.inf	SE.sup
1990	0.232	0.122	0.441
1991	0.191	0.089	0.411
1992	0.341	0.145	0.803
1993	0.313	0.145	0.677
1994	0.164	0.072	0.377
1995	0.143	0.061	0.334
1996			
1997	0.361	0.175	0.744
1998	0.126	0.045	0.353
1999			
2000	0.259	0.123	0.545
2001	0.201	0.085	0.474
2002	0.111	0.041	0.299
2003			
2004			
2005	0.269	0.140	0.519
2006	0.106	0.043	0.265
2007	0.230	0.117	0.455
2008	0.180	0.083	0.391
2009	0.302	0.160	0.571
2010	0.280	0.146	0.538
2011	0.350	0.189	0.649
2012			
2013	0.321	0.174	0.595
2014	0.262	0.131	0.525
2015	0.398	0.222	0.715
2016	0.443	0.250	0.785
2017	0.590	0.342	1.018
2018	0.355	0.144	0.878
2019			
2020			
2021	1.096	0.690	1.742
2022	1.190	0.718	1.970

3.3.2.2 The southern Spanish bottom trawl survey (SpGFS-GC-WIBTS-Q1 and Q4; ARSA) [G4309]

The southern Spanish bottom trawl surveys (commonly named 'ARSA') that take place in the Gulf of Cadiz (Division 9.a) have been carried out in spring since 1993 (SpGFS-GC-WIBTS-Q1) and in autumn (SpGFS-GC-WIBTS-Q4) since 1997. No survey was conducted in 2021 due to the covid-19 outbreak. The surveyed area corresponds to the continental shelf and upper-middle slope (depths of 15–800 m) and from longitude 6º20'W to 7º20'W, covering an area of 7224 km^2. In the ARSA time series, thornback ray is one the most abundant skate species. More details about these surveys can be found in ICES (2021a).

Length composition of thornback ray in the Spanish bottom trawl surveys for the all period combined is presented in Figure 3.12. The exploitable biomass index for these surveys, considering skates larger than 35 cm, was obtained by averaging both surveys, since 1997. The species shows an increasing trend in biomass since the beginning of the combined series, with the highest values reached in 2022 (Figure 3.13 and Table 3.6).

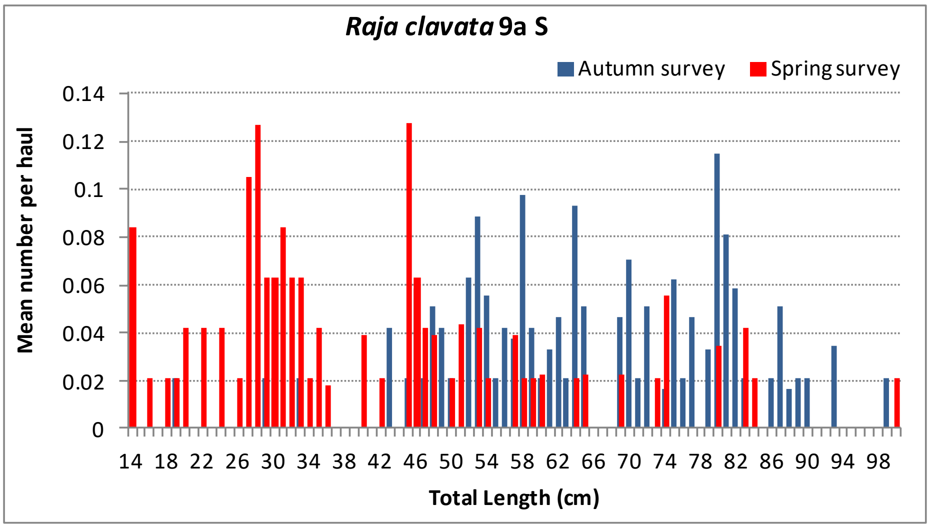
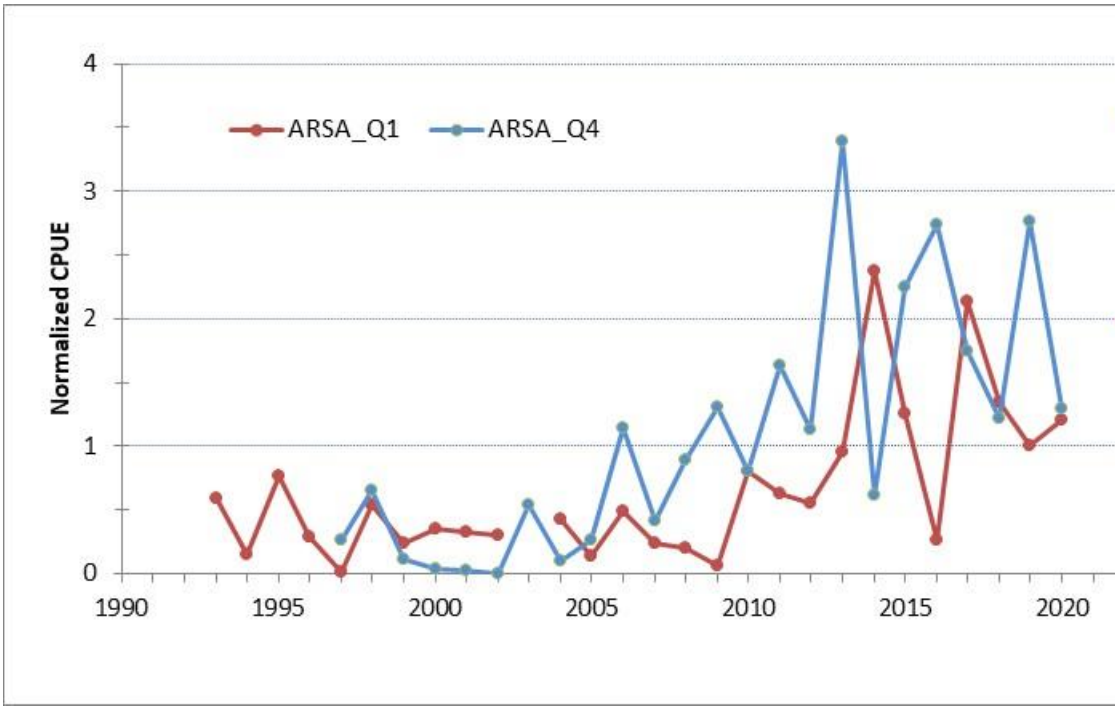


Figure 3.12 Thornback ray Raja clavata in ICES Divison 9a. Mean number per haul by length class in the southern Spanish bottom trawl surveys (ARSA; SpGFS-GC-WIBTS-Q1 and Q4) combined for the period 1997-2022.

A



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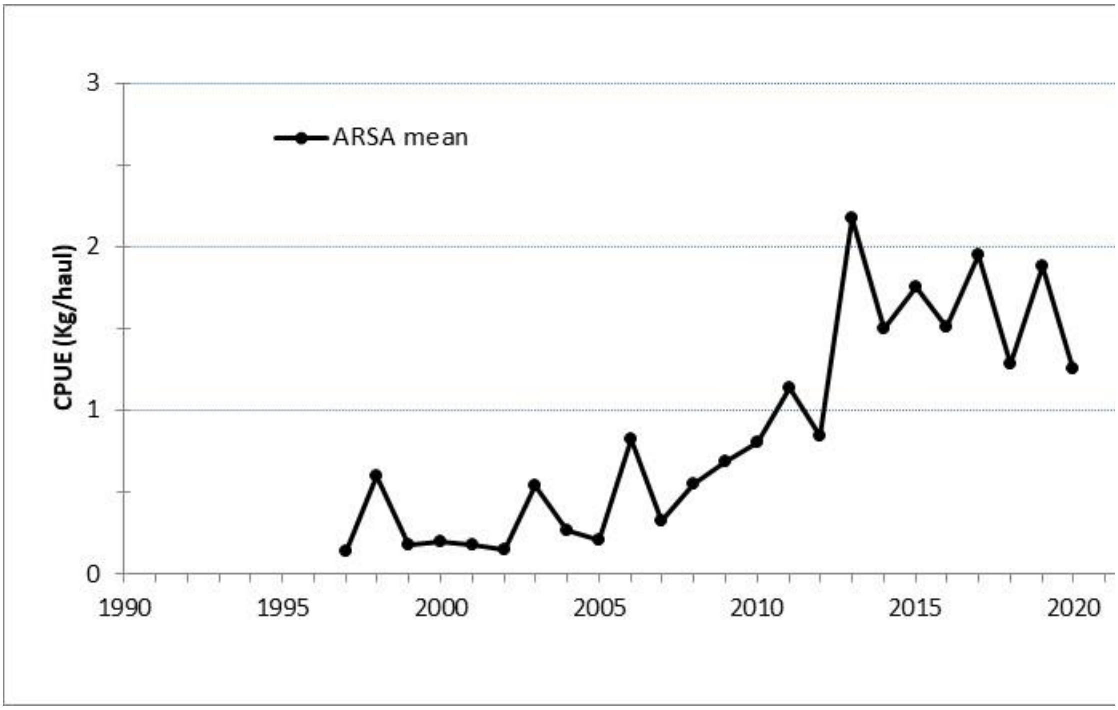


Figure 3.13 Thornback ray Raja clavata in ICES Divison 9a. (A) Biomass index from southern Spanish bottom trawl surveys (ARSA; SpGFS-GC-WIBTS-Q1 and Q4) for the period from 1993 to 2022. (B) Mean biomass index from Spanish bottom trawl surveys (1997-2022).

Table 3.6 Thornback ray Raja clavata in ICES Divison 9a. Biomass index from each southern Spanish bottom trawl survey, SpGFS-GC-WIBTS-Q1 (ARSA_Q1) and SpGFS-GC-WIBTS-Q4 (ARSA_Q4), and the mean biomass index between the two surveys.

Year	ARSA_Q1	ARSA_Q4	ARSA_mean
1993	0.594904		
1994	0.154147		
1995	0.768161		
1996	0.283925		
1997	0.011103	0.265749	0.138426
1998	0.540825	0.650836	0.595831
1999	0.24197	0.115292	0.178631
2000	0.352613	0.036949	0.194781
2001	0.326566	0.019488	0.173027
2002	0.295973	0	0.147986
2003		0.543966	0.543966
2004	0.428069	0.096493	0.262281
2005	0.137284	0.269178	0.203231
2006	0.488661	1.148186	0.818423
2007	0.234602	0.416155	0.325379
2008	0.205096	0.892021	0.548559
2009	0.06518	1.309013	0.687096
2010	0.804443	0.800233	0.802338
2011	0.632795	1.63911	1.135953
2012	0.55634	1.132101	0.84422
2013	0.954735	3.387842	2.171288
2014	2.378839	0.609369	1.494104
2015	1.25689	2.247977	1.752434
2016	0.267242	2.739409	1.503326
2017	2.137017	1.751278	1.944148
2018	1.347219	1.221674	1.284446
2019	1.004517	2.759843	1.88218
2020	1.2083	1.296156	1.252228
2021			
2022	1.977745	3.62442	2.801082

3.3.2.3 Spanish Autumn Groundfish Survey (SpGFS-WIBTS-Q4) [G2784]

In the North Spanish survey (SpGFS-WIBTS-Q4; DEMERSALES), the geographical distribution of thornback ray in ICES Division 9.a (10–97 cm TL) remained similar throughout the time-series, with a greater relative abundance in the North of Galicia and eastern Cantabrian Sea (ICES Division 8.c; Figure 3.14), which corresponds to the area of the rjc.27.8c stock (Fernandéz-Zapico, et al. 2022). In relation to the area of rjc.27.9a the yields of thornback ray from this survey present an irregular time-series, with biomass estimates close to zero from 1993 to 2009 (Figure 3.15). For this reason, it has not been included in the assessment, although it may be used to provide supporting information (ICES, 2021).

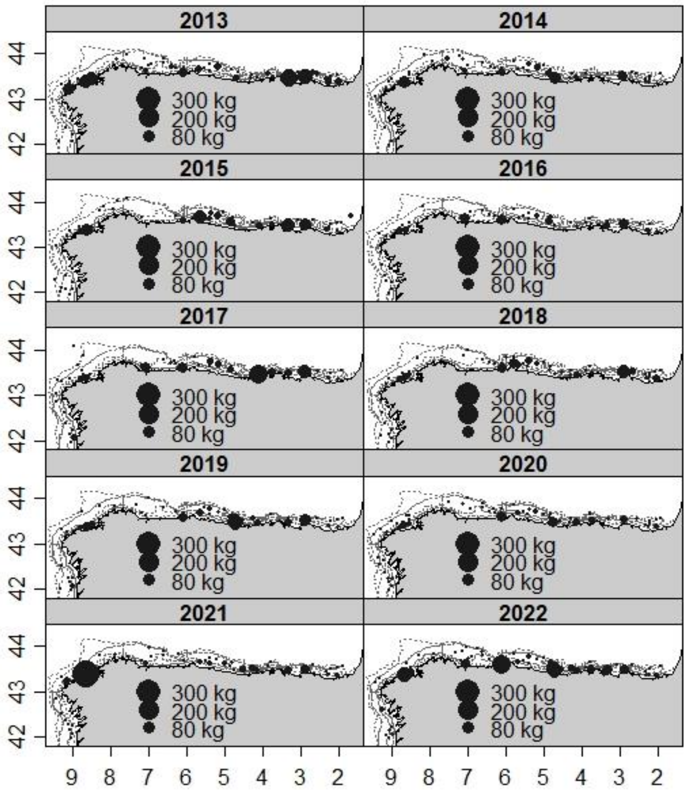


Figure 3.14 Thornback ray Raja clavata in ICES Divison 9a. Geographic distribution of Raja clavata catches (kg/30 min haul) in the North Spanish Shelf bottom trawl surveys (SpGFS-WIBTS-Q4) between 2013 and 2022. (source: Fernández-Zapico et al., 2023)

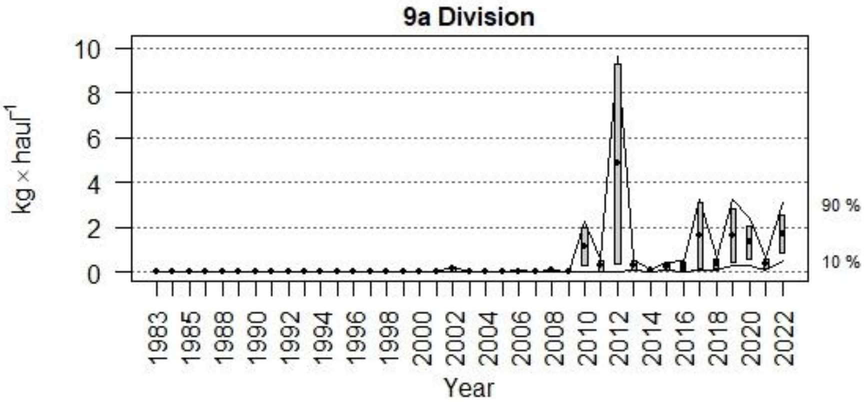


Figure 3.15 Thornback ray Raja clavata in ICES Divison 9a. Biomass index from the North Spanish shelf bottom trawl survey (SpGFS-WIBTS-Q4) for the period from 1983 to 2022. Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α= 0.80, bootstrap iterations = 1000). (source: Fernández-Zapico et al., 2023)

3.3.2.4 Portuguese Commercial LPUE

Up to 2018, the rjc.27.9a stock was assessed using data derived from the Spanish ARSA survey (SpGFS-GC-WIBTS-Q1 and SpGFS-GC-WIBTS-Q4) and the Portuguese Autumn Groundfish Surveys (PtGFS-WIBTS-Q4). However, because of the issues with the PtGFS-WIBTS-Q4 survey data availability for the period 2018–2020 (see details in Section 3.3.2), and changes in the RV and gear used, a new time-series was considered and an alternative assessment approach using a standardized commercial LPUE series was reviewed and accepted at WKSKATE (ICES, 2021).

It should be noted that the computation of this LPUE index does not include the zeroes in the analysis, as it is not possible to distinguish between real and false zeroes. This is mainly due to the facts that: 1) *R. clavata* is a by-catch species of the polyvalent fishery, so absence of the species in the catch is more related to the fishing strategy; 2) the species has a patchy distribution and information available is not georeferenced; 3) different selectivity of the set of gears used in a trip and 4) the weight landed per trip results from the application of estimates, which can lead to false zeros.

Details on the LPUE estimation methodology can be found in Serra-Pereira *et al.* (2020) and ICES (2021). The best model selected with the updated dataset, used in the last advice (ICES, 2023b) included the variables: years, quarter, landing port, vessel size, fishing seasonality on skates and rays and fishing gear (trammel nets or gillnets) (explained variance = 0.81, AIC = 762514). The standardized mean LPUE was then predicted by year and considering the following criteria: quarter = 4, landing port = Peniche, SIZEs = L (large), SAZ = c (constant) and fishing gear = nets.

LPUE varied from 21.08 $kg.trip^{-1}$ (in 2009) to 53.20 $kg.trip^{-1}$ (in 2022), with an average of 35.91 $kg.trip^{-1}$ for the entire time series (Table 3.7, Figure 3.16).

For comparison purposes, the LPUE data series was normalized to the long-term mean and compared with the normalized biomass Index obtained from the PtGFS-WIBTS-Q4 survey and Spanish bottom trawl surveys (Figure 3.17).

Table 3.7 Thornback ray Raja clavata in ICES Division 9a. LPUE (kg.trip^{-1}) from the polyvalent in mainland Portugal for the period 2008-2022.

Year	LPUE	SE	Standardized LPUE
2008	25.99	0.66	0.72
2009	21.08	0.53	0.59
2010	30.16	0.77	0.84
2011	31.91	0.82	0.89
2012	27.80	0.71	0.77
2013	34.67	0.92	0.97
2014	36.51	0.95	1.02
2015	32.04	0.85	0.89
2016	35.32	0.97	0.98
2017	39.27	1.04	1.09
2018	42.55	1.07	1.18
2019	42.38	1.16	1.18
2020	40.27	0.99	1.12
2021	45.49	1.16	1.27
2022	53.20	1.46	1.48

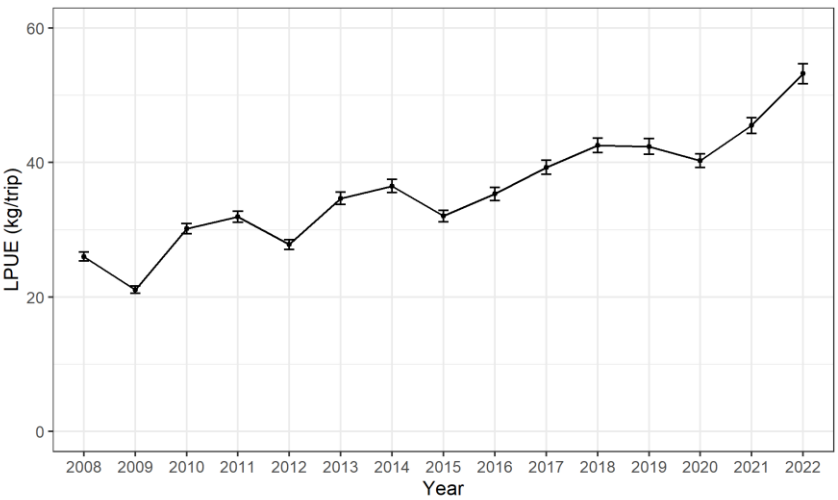


Figure 3.16 Thornback ray *Raja clavata* in ICES Division 9a. LPUE (kg.trip^{-1}) from the polyvalent in mainland Portugal for the period 2008-2022.

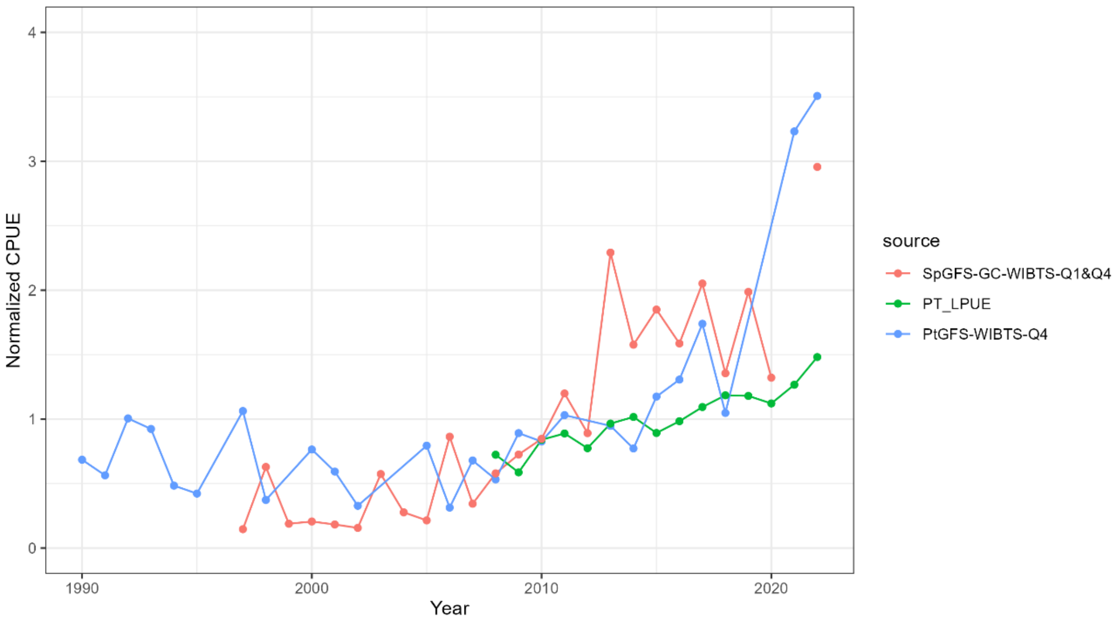


Figure 3.17 Thornback ray *Raja clavata* in ICES Division 9a. Comparison between the standardized LPUE from the polyvalent fleet in mainland Portugal, the standardized Portuguese Autumn Groundfish Survey Biomass Index (PtGFS-WIBTS-Q4) and the Spanish bottom trawl surveys in Gulf of Cádiz (SpGFS-GC-WIBTS-Q1 and Q4; ARSA). All series are normalized to their long-term mean.

3.3.2.5 Combined Index

For thornback ray, rjc.27.9a stock, two methods of combining the available biomass indices were considered. Both methods followed a three-step procedure:

i) produce a Portuguese index (PT_INDEX) by averaging the normalized PTGFS-WIBTS-Q4 and LPUE series (1990-2022);

ii) produce the Spanish/ARSA index (ES_ARSA) by averaging the two ARSA surveys (SpGFS-GC-WIBTS-Q1 and Q4) and normalized (1997-2022);

iii) **A. Combined stock indicator:** calculating the average between the PT-INDEX and ARSA indices, (1990-2022);

or

B. Weighted combined stock indicator: calculating the weighted average between the PT-INDEX and ARSA indices, applying the overall proportion of landings of thornback ray from each country, i.e. 80% for the PT_index and 20% for the ES_ARSA (1990-2022).

The outputs from the two combined indices are presented in Figure 3.18 and Table 3.8. According to the recommendations from WKBELASMO 3, the **weighted combined stock indicator** was considered the most appropriate as it better reflects the contribution of the two areas to the total stock.

Figure 3.18 Thornback ray *Raja clavata* in ICES Division 9a. Averaged combined index and weighted averaged combined index.

Table 3.8 Thornback ray *Raja clavata* in ICES Division 9a. Averaged combined index and weighted averaged combined index.

Year	Combined Index	Combined Weighted Index
1990	0.685	0.685
1991	0.564	0.564
1992	1.006	1.006
1993	0.924	0.924
1994	0.484	0.484
1995	0.422	0.422
1996	-	-
1997	0.604	0.877
1998	0.501	0.425
1999	0.189	0.189
2000	0.485	0.651
2001	0.388	0.510
2002	0.242	0.293
2003	0.574	0.574
2004	0.277	0.277
2005	0.504	0.677
2006	0.589	0.425
2007	0.511	0.611

2008	0.645	0.685
2009	0.747	0.760
2010	0.880	0.899
2011	1.082	1.013
2012	0.821	0.779
2013	1.612	1.207
2014	1.234	1.030
2015	1.400	1.133
2016	1.363	1.230
2017	1.766	1.596
2018	1.248	1.184
2019	1.659	1.464
2020	1.104	0.974
2021	2.191	2.191
2022	2.696	2.541

3.3.3 Life-history parameters

Key life-history parameters, namely the length-weight relationship, length-at-maturity, growth rates and annual fecundity of thornback ray can be found in Serra-Pereira et al., (2024a).

The selected parameters used to obtain a mean prior for the intrinsic rate of biomass increase (r) are summarized below and in Table 3.9):

- Length-weight relationship considered was $W=0.00052*TL^{3.05}$ according with Serra-Pereira et al. (2010).
- Estimates of the length at which 50% of the population is mature ($L_{50\%}$) for thornback ray in the stock area are available from Serra-Pereira et al. (2011). A $L_{50\%}$ of 78.4 cm (value estimated for females) was considered. Length at which 95% of the population is mature ($L_{95\%}$) was estimated as 86.24 following Prince et al., 2015 where $L_{95\%}=1.1L_{50\%}$.
- Fecundity was assumed to be 136 eggs/female/year (Serra-Pereira et al., 2011).
- Growth parameters considered are available from Serra-Pereira et al. (2008): L_{inf} = 128 cm, K = 0.117 y^{-1} and t_0 = –0.617.
- Following the methodology defined for other elasmobranch stocks previously benchmarked (ICES, 2023a), natural mortality (M) was estimated at 0.17 and is derived from Then et al., (2015): $M=4.118*K^{0.73}*L_{inf}^{-0.33}$.
- A value for the maximum age (A_{max}) of 29.6 was estimated based on Fabens (1965): $A_{max}=5(\ln2/k)$.

Table 3.9. Thornback ray *Raja clavata* in ICES Division 9a. Biological parameters estimates available for rjc.27.9a stock.

Source		Serra-Pereira et al., 2008	Serra-Pereira et al., 2011	Serra-Pereira et al., 2010
TL range (cm)		14.5-91.3	32.0-93.4	31.5-93.4
L_{50} (cm) F		-	78.4	-
L_{50} (cm) M		-	67.6	-
A_{50} (cm) F		-	7.5	-
A_{50} (cm) M		-	5.8	-
L_{95} (cm) F		-	86.2***	
Reproductive period		-	May-Jan	-
Potential fecundity (eggs/female/year)			136	-
Growth model		VBGM	-	-
Growth parameters estimates	L_{∞} (cm)	128	-	-
	k (y^{-1})	0.117	-	-
	t_0 (years)	-0.617	-	-
	L_{max} (cm)	91.3 (124*)	-	-
	t_{max} (years)	10 (30**)	-	-
W~L	a	-	-	0.00052
	b	-	-	3.05
Period		2003-2007	2003-2008	2001-2008
Region		Portugal	Portugal	Portugal

*PNAB/DCF sample onboard a scientific survey. ** Theoretical maximum age for an L_{max}=124 cm. *** L_{95}=1.1L_{50} (Prince et al., 2015)

For the estimation of the intrinsic rate of biomass increase (*r*) different methods were tested:

i) according to the Jennings et al (2001); this estimate was used in the SPiCT trials during WGEF2022 and WKBELASMO3 follow-up WK;
ii) applying the function *jbleslie* implemented in R package JABBA (Winker et al., 2018), was used to estimate r, adopting the parameters described in section 3.3.4, and summarized in Table 3.10. This methodology was also adopted in WKBELASMO2 (ICES, 2023a);
iii) applying the methods proposed by Eberhardt et al. (1982), Skalski et al. (2008), Smith at el.'s (1998) and the Demographic Invariant Method following Cortés (2016);
iv) adopting the *r* value in Fishbase (Froese and Pauly, 2023).

The estimates of *r* from the different methods are presented in Table 3.11; estimates for other stocks are also presented for comparison. The *jbleslie* output was considered the most relevant, being based in biological information available for the stock and being also the methodology adopted for all the skate stocks benchmarked in WKBELASMO2 (ICES, 2023a).

Table 3.10 Biological variables used in the call to JABBA::jbleslie() to obtain a mean prior for the intrinsic rate of biomass increase (r) using a Leslie matrix calculation of female net reproductive rate.

A_0	A_{max}	L_∞	K	t_0	L_{50}	L_{95}	Fec.	aW	bW	M
0	30	128	0.117	-0.617	78.4	86.2	136	0.00052	3.05	0.17
Serra-Pereira et al., 2008					Serra-Pereira et al., 2011			Serra-Pereira et al., 2010		

Table 3.11 Estimates of intrinsic rate of biomass increase (*r*) for thornback ray from the present study and from other references. The primary value adopted for the SPiCT trials is highlighted in bold.

Stock	Method	r [CI]	Reference
rjc.27.9a	Jennings et al. (2001)	0.284	Present study
	***jbleslie* function (R package JABBA) (Winker et al., 2023)**	**0.27**	**Present study**
	Eberhardt et al. (1982), based on Cortés (2016)	0.47	Present study
	Skalski et al. (2008), based on Cortés (2016)	0.47	Present study
	Smith at el.'s (1998), based on Cortés (2016)	0.08	Present study
	Demographic Invariant Method (Cortes, 2016)	0.08	Present study
	FishBase (Froese and Pauly, 2023)	0.18	Present study
rjc.27.8ab	McAllister et al. (2001) – used as prior	0.105	ICES, 2022c
	Bayesian state-space biomass production model (Marandel et al., 2016)	0.18 [0.07,0.33]	ICES, 2022c
	Genetic close-kin mark-recapture approach (Trenkel et al., 2022)	0.19 [0.07, 033]	ICES, 2022c
rjc.27.8c	FishBase (Froese and Pauly, 2023) – used as prior	0.18	ICES, *in press*
	SPiCT	0.25 [0.13, 0.46]	ICES, *in press*
rjc.27.3a47d	*jbleslie* function (R package JABBA) Winker et al., 2023)	0.29*	ICES, 2023a
	"vague prior" due to high estimate with *jbleslie* -– used as prior	0.15	ICES, 2023a
	SPiCT	0.23	ICES, 2023a
	Following Jennings et al. (1999)	0.30**	Frisk et al., 2001

* considered high when compared to the estimate for *rjc.27.8ab* (ICES, 2023a). ** potential population increase (r´)

3.4 Stock assessment

The stock rjc.27.9a has been assessed since 2014 under category 3 (trend-based assessment) every two years. Last assessment was conducted in 2022.

Up to 2018, this stock was assessed using data derived from the southern Spanish surveys (ARSA quarter 1 and 4) and the Portuguese Autumn Groundfish Surveys. These surveys were normalized to their long-term mean, the two Spanish surveys averaged, and then this index averaged with the Portuguese survey to provide the stock size indicator. The advice was based on a comparison of the two latest index values with the five preceding values, multiplied by the recent advised landings.

In 2020, because of the issues with the Portuguese Autumn Groundfish survey data availability for the period 2018–2020 and uncertain future, an alternative assessment approach using a standardized commercial LPUE series was reviewed and accepted at WKSKATE (ICES, 2021). For detail on LPUE series see section 3.3.2.4.

In 2022, last assessment year, the stock assessment was done following ICES guidelines for category 3 which involves the application of the rfb rule (ICES, 2022a, 2022b). A biomass index combining the Spanish groundfish surveys data and the normalized LPUE index from the Portuguese polyvalent fleet was used as an indicator of stock development. The advice was based on the ratio of the mean of the last two index values (index A) and the mean of the three preceding values (index B), multiplied by the previous advised catches, a ratio of observed mean length in the catch relative to the target mean length (length-based indicators, length distributions from the Portuguese commercial polyvalent and trawl fleets combined as input data), a biomass safeguard, and a precautionary multiplier.

For the present benchmark, the proposal is focussed on evaluating the application of a surplus production model SPiCT (Stochastic Production model in Continuous Time, Pedersen and Berg 2017) on the stock for providing advice, following the guidelines and procedures described in the SPiCT handbook (Mildenberger et al., 2020)

3.4.1 Exploratory assessments

3.4.1.1 Scenarios

As a starting point, a total of 12 SPiCT scenarios for rjc.27.9a using several combinations of input data series (including runs with increased uncertainty in some years of the PTGFS-WIBTS-Q4) were tested prior to the WKBELASMO 3 benchmark meeting and summarized in a working document (Serra-Pereira et al., 2024b). The input data and periods of uncertainty in thePTGFS-WIBTS-Q4 survey considered in each of the 12 scenarios are summarized in Table 3.12.

The results from Scenarios 8, 9 and 12 were presented in the WKBELASMO 3 benchmark meeting, as the most promising to go further with the optimization of the SPiCT assessment for rjc.27.9a. Although the retrospective results were better for Scenario 8 (using the simple combined index as input biomass index), the reviewers and the chair recommended to proceed with Scenario 9, as it uses the weighted average combined index (1990-2022), giving more weight to the data available from the area with more landings for the stock (i.e., Portugal). A summary of the exploratory runs under Scenario 9 are presented in section 3.4.1.3.

Table 3.12 Thornback ray *Raja clavata* in ICES Division 9a. Summary of the SPiCT input data and uncertainty periods considered for the 12 scenarios tested under WKBELASMO 3.

	Input data						
Scenario	PTGFS-WIBTS-Q4	PT_LPUE	ES_ARSA	PT Index	Combined Index	W combined Index	Notes
1							Following the accepted run from WGEF 2022 (Scenario 5b); same as WKBELASMO 3 data compilation WK run. PT LPUE + ARSA (Moura et al., 2022)
2							
3							Higher uncertainty in survey PTGFS-WIBTS-Q4 during 2018-2022
4							
5	(<2008)						
6	(<2018)	(≥2018)					
7							
8					(>1998)		
9							**REFERENCE RUN**
10						(>1998)	
11							
12							Higher uncertainty in survey PTGFS-WIBTS-Q4 during 2018-2022

3.4.1.2 Definition of priors

The 12 reference scenarios used the same priors' configuration:

i) Intrinsic rate of biomass increase

A prior probability distribution was defined for intrinsic rate of biomass increase (r). The informative prior value used for r was the one estimated applying the function **jbleslie** implemented in R package JABBA (Winker et al., 2023), and using the input parameters available from Portuguese studies, and summarized in Table 3.10 ($r = 0.27\ y^{-1}$):

```
inp$priors$logr     <- c(log(0.27),0.5,1)
```

ii) Production curve

A prior for the parameter *logn* determining the shape of the production curve was considered for all 12 runs, resembling a tighter Schaefer production curve shape, as used in the best model presented to WGEF 2022 (ICES, 2022d):

```
inp$priors$logn <- c(log(2), 0.5, 1)
```

iii) Noise ratios

Priors *logalpha* and *logbeta* were disabled as recommended in the SPiCT handbook and guidelines.

```
inp$priors$logalpha <- c(1, 1, 0)
inp$priors$logbeta  <- c(1, 1, 0)
```

3.4.1.3 Sensitivity analysis

Runs on selected scenarios (8 and 9) involved other priors' configurations, more specifically:

i) Intrinsic rate of biomass increase (r)

Sensitivity runs were performed around *r* using the estimates obtained from Fishbase (Froese and Pauly, 2023), $r = 0.18\ y^{-1}$, and from Eberhardt et al. (1982) and Skalski et al. (2008) approaches, based on Cortes (2016), $r = 0.47\ y^{-1}$. All runs considered a CV=0.5.

ii) Production curve

Tests were also performed by fixing *n* to resemble the Schaefer production model:

```
inp$priors$logn <- inp$phases$logn <- -1
```

iii) ***standard deviation on the biomass process (sdb)***

Since the catch time-series for this stock lacks contrast, further constraining the process error within plausible ranges (i.e., model estimated value for *logsdb* was close to zero in most runs) a formulation of an informative prior for *logsdb* was considered in some runs. The prior value was set at 0.15 as suggested by a meta-study performed by Casper Berg (unpublished):

```
inp$priors$logsdb    <- c(log(0.15), 0.5, 1)
```

The same value was adopted for the thornback ray stock in the Cantabrian Sea (rjc.27.8c) benchmarked in the WKBMSYSPiCT 2 (ICES, 2023c). A sensitivity analysis around *logsdb* was performed, varying the prior +/- 25% (between 0.11 and 0.19). The expected range of process error is biologically linked to the inertia of the population biomass (natural fluctuation), with intermediate values (0.07–0.15) for many demersal commercial species (e.g. cods, hakes, flatfish, herring) and lower values (0.03–0.1) for very slow growing, long lived with late maturation and long generation times (as viviparous elasmobranchs, like for example the porbeagle shark; Winker, 2018[1]). Given its biological traits, the thornback ray is expected to be more resilient than the later, and therefore to have an *sdb* value close to the maximum range for that group.

iv) ***initial depletion rate (bkfrac)***

The input data series starts in 1990, when the stock was probability at lower levels of biomass due to more intense fishing. Therefore, a prior for B/k was tested in some runs, assuming levels ranging from 0.1 to 0.5.

Trials for a free model (i.e. without any prior) and with free configuration for each one of the priors (*n*, *sdb* and *bkfrac*) were also tested.

3.4.1.4 Scenario 9 tests and results

The input data considered for Scenario 9 (Figure 3.19) was:

- Catch: total landings (2000-2022);
- Index 1: Weighted combined stock indicator (average between: mean of the normalized PTGFS-WIBTS-Q4 and LPUE + normalized ARSA surveys) weighted to the proportion of landings from each country, 80% PT and 20% ES) (1990-2022).

[1] https://bit.ly/3v965SY

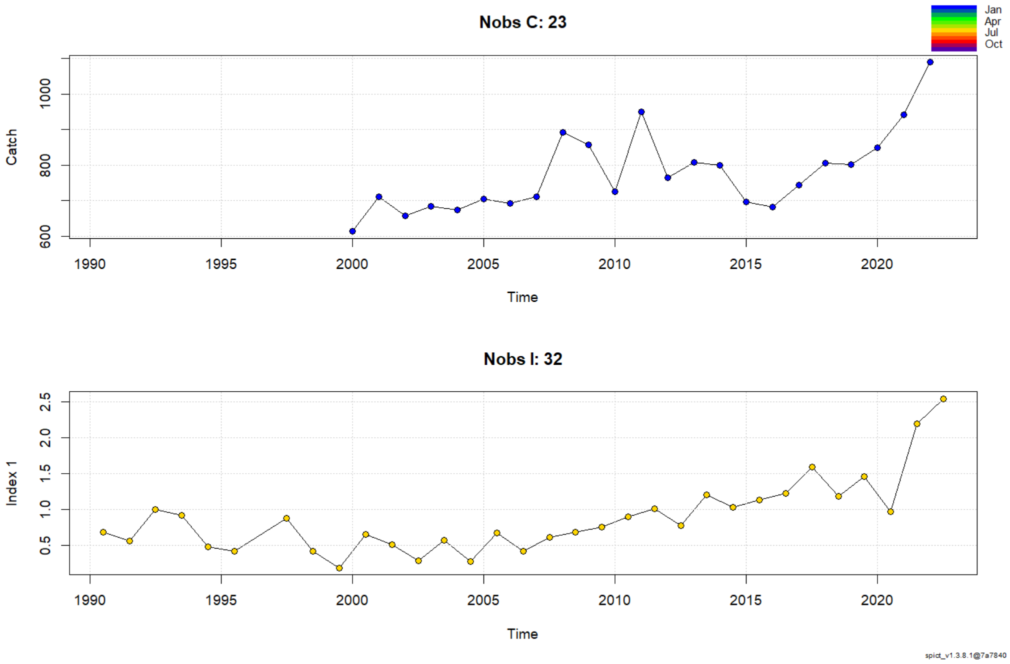


Figure 3.19 Thornback ray *Raja clavata* in ICES Division 9a. Input data considered for Scenario 9. C: catch, I: biomass index.

A total of 38 model configurations were tested around Scenario 9, differing in terms of uncertainty added to certain periods of the catch and biomass index series, and on the informative priors used on parameters *r*, *n*, *bkfrac* and *sdb* (results for all the runs are available in the SharePoint data folder). In this report we have selected as the most relevant models: 0 (free model), 6, 18, 19 and 22. Table 3.13 summarizes the model configuration of those SPiCT models, the diagnostics and main results.

In summary, tests were performed around the uncertainty added to the historical catch data (*stdevfacC*):

- Option 1: For most runs (i.e., model 0 to 18), uncertainty was added to the historical catches (2000-2009) by a factor of *stdevfacC* = 2.

- Option 2: For the final runs (e.g. model 19 and 22), a sequential uncertainty was added to the historical catches, considering a factor of *stdevfacC* = 3 on the period to which a global average was applied for each country (2000-2007) and a factor of *stdevfacC* = 2 on the years when the estimated catch from Portugal was based on sampling data (see section 3.3.1.1 and Maia et al. (2023) and Rodriguez-Cabello et al. (2024) for more details).

Different options were also tested around the uncertainty added to the biomass index series (*stdevfacI*), but the group decided that the most appropriate approach was to add uncertainty, by a factor of *stdevfacI* = 2, to the years when only one of the three indexes were available to calculate the combined index (i.e., 1990-1995 (only PTGFS-WIBTS-Q4 available) and 1999, 2003-2004 (only ARSA available)).

Regarding the priors, apart from the free model (model 0), all relevant models considered the following prior configuration:

- r = 0.27 y^{-1}, adopting the value obtained from the function **jbleslie** implemented in R package JABBA (Winker et al., 2023), and using the input parameters available from Portuguese studies, and summarized in Table 3.10;
- fixing n to resemble the Schaefer production model, as it was considered more adequate taking into account the life history of the species and the available data for this stock (i.e., data poor stocks with short catch data series with no contrast and biomass index with straight line increase); The same approach was also followed for the North Sea skate stocks benchmarked in WKBELASMO 2 (ICES, 2023a);
- disabling the noise ratio priors *logalpha* and *logbeta*.

```
inp$phases$logn <- -1   # Fixing n to resemble the Schaefer production model


inp$priors$logr <- c(log(0.27),0.5,1)   # intrinsic biomass growth (obtained from jbleslie function (R pack
age JABBA))


inp$priors$logalpha <- c(1, 1, 0)      #disabled
inp$priors$logbeta  <- c(1, 1, 0)      #disabled
```

Tests around the use of an informative prior for the initial depletion level (*bkfrac*) and for the standard deviation on the biomass process (*sdb*) were also performed in models 18, 19 and 22:

```
inp$priors$logbkfrac  <- c(log(0.23), 0.5, 1)  # B/K (amplitude=0.5 - following the handbook); high exploit
ation level in the start of the series, using the value estimated by the accepted model(bkfrac=0.23)- only
applied to model 22




inp$priors$logsdb    <- c(log(0.15), 0.5, 1)
```

All the selected models tested, except the free model, passed the diagnostics for acceptance, with minor issues, but with high Mon's rho values (above 0.2) due to the high increase in the biomass index in the last two years of the series (Table 3.13). The issues observed in the free model, led to the conclusion that for this stock, informative priors needed to be considered. However, the model does not seem to be sensitive to the prior values. For models 6, 18, 19 and 22 similar results were obtained in terms of trajectories of absolute and relative biomass and fishing mortality, perception of the stock status against the relative reference points and initial depletion rate (*bkfrac*), which was estimated between 0.223 and 0.230. The estimated intrinsic rate of biomass increase (r) was also similar between models (0.31-0.34).

Since for this stock, we do not have informative basis to justify the level of initial depletion, the WKBELASMO 3 and the SPiCT expert (Casper Berg), recommended not using a prior for B/k. Yet, an additional trial was conducted and discussed, following the accepted methodology for the North Sea thornback ray stock (rjc.27.3a47d), benchmarked in WKBELASMO 2 (ICES, 2023a), i.e. by using the estimated value for *bkfrac* from the best model as a vaguely informative prior. This approach aimed to solve the instability of the retrospective analysis from the model with no prior. In fact, when applying a *bkfrac* prior, in model 22, an improvement on the Mon's rho for B/B_{MSY} was obtained (0.272 vs. 0.383 from model 19). However, as explained earlier, this approach was not considered adequate, and the group agreed that it would be more reasonable not to set a *bkfrac* prior.

Table 3.13 Thornback ray *Raja clavata* in ICES Division 9a. Summary of the SPiCT input data, model configuration, diagnostics and main results for selected models under Scenario 9. Model 19 (9u) was considered the best/final model and is highlighted in bold.

Input series	MODEL 0 (free model) (9a)	MODEL 6 (9g)	MODEL 18 (9t)	**MODEL 19 (9u)**	MODEL 22 (9x)
C					
I1 (survey PTGFS-WIBTS-Q4)	2000-2022	2000-2022	2000-2022	**2000-2022**	2000-2022
	1990-2022	1990-2022	1990-2022	**1990-2022**	1990-2022
Increased uncertainty (stdev)					
C					
I1 (survey PTGFS-WIBTS-Q4)	2 (2000-2009)	2 (2000-2009)	2 (2000-2009)	**3 (2000-2007); 2 (2008-2009)**	3 (2000-2007); 2 (2008-2009)
I1 (stock indicator weighted average)	2 (1990-1995; 1999; 2003-2004)	2 (1990-1995; 1999; 2003-2004)	2 (1990-1995; 1999; 2003-2004)	**2 (1990-1995; 1999; 2003-2004)**	2 (1990-1995; 1999; 2003-2004)
Priors					
logn	-	Fixed Schaefer	Fixed Schaefer	**Fixed Schaefer**	Fixed Schaefer
logr	-	log(0.27),0.5,1	log(0.27),0.5,1	**log(0.27),0.5,1**	log(0.27),0.5,1
logalpha	c(1, 1, 0)	c(1, 1, 0)	c(1, 1, 0)	**c(1, 1, 0)**	c(1, 1, 0)
logbeta	c(1, 1, 0)	c(1, 1, 0)	c(1, 1, 0)	**c(1, 1, 0)**	c(1, 1, 0)
logbkfrac	-	-	-	**-**	High:log(0.23), 0.5, 1
logsdb	-	-	log(0.15), 0.5, 1	**log(0.15), 0.5, 1**	log(0.15), 0.5, 1
Diagnostics					
1. Convergence	✓	✓	✓	✓	✓
2. Finite parameters	TRUE	TRUE	TRUE	**TRUE**	TRUE
3. Violation of model assumptions					
shapiro	✓	*I	✓	✓	✓
bias	✓	✓	✓	✓	✓
acf	✓	✓	✓	**C***	*C
LBox	✓	✓	✓	✓	✓
4.Retrospective pattern					
Mohn's Rho					
BBmsy	Only peels 1, 3 ,4	0.346	0.407	**0.383**	0.272
FFmsy	Only peels 1, 3 ,4	-0.034	-0.081	**-0.078**	-0.050
5.Realistic production curve	✓	✓	✓	✓	✓
6. Assessment uncertainty	✓	✓	✓	✓	✓
7. Initial values sensitivity	☒	✓	✓	✓	✓
objective function at optimum	11.21	15.75	16.93	**17.13**	14.30
Model parameter estimates					
alpha1	0.95	16.55	2.44	**2.03**	2.02
beta	0.07	0.43	0.30	**0.04**	0.04
r	0.47	0.31	0.33	**0.34**	0.33
rc	2.39	0.31	0.33	**0.34**	0.33
rold	0.78	0.31	0.33	**0.34**	0.33
m	904	1410	1405	**1398**	1403
K	3502	18139	16979	**16621**	16823
q1	0.00	0.00	0.00	**0.00**	0.00
n	0.40				
sdb	0.25	0.02	0.10	**0.12**	0.12
sdf	0.12	0.11	0.11	**0.13**	0.13
sdi1	0.24	0.27	0.25	**0.25**	0.24
sdc	0.01	0.05	0.03	**0.01**	0.01
bkfrac	0.07	0.22	0.22	**0.23**	0.23
Stochastic reference points (Srp)					
Bmsys	753	9065	8330	**8095**	8191
Fmsys	1.19	0.16	0.16	**0.16**	0.16
MSYs	892	1408	1356	**1332**	1336
States w 95% CI (inp$msytype: s)					
B_2022.94	704	10176	10333	**10565**	10668
F_2022.94	1.50	0.11	0.11	**0.11**	0.11
B_2022.94/Bmsy	0.93	1.12	1.24	**1.31**	1.30
F_2022.94/Fmsy	1.26	0.70	0.67	**0.65**	0.65

A sensitivity analysis around the final model (model 19) was conducted, by testing different values for *r* and *sdb* (see section 3.4.1.2 for more details on the values chosen). Similar results were obtained for those runs, with similar trajectories of biomass and fishing mortality and stock status (Table 3.14, Figures 3.20-3.23). The model seems to be more sensitive to changes in the *r* prior, but the informative value adopted ($r = 0.27$) was decided to be acceptable, as it is based on biological information provided by studies conducted in the stock area. Both informative priors were then considered by the group as adequate for the rjc.27.9a stock, being among the values adopted for other previously benchmarked thornback ray stocks (e.g., ICES, 2023a and 2023c).

Table 3.14 Thornback ray *Raja clavata* in ICES Division 9a. Summary of the SPiCT model configuration, diagnostics and main results for sensitivity runs for *r and sdb* around the final model (Model 19).

	MODEL 19 (9u)	MODEL 25 (9za)	MODEL 26 (9zb)	MODEL 35 (9zk)	MODEL 36 (9zl)
Priors					
logn	**Fixed Schaefer**	Fixed Schaefer	Fixed Schaefer	Fixed Schaefer	Fixed Schaefer
logr	**log(0.27),0.5,1**	**log(0.18),0.5,1**	**log(0.47),0.5,1**	log(0.27),0.5,1	log(0.27),0.5,1
logalpha	**c(1, 1, 0)**	c(1, 1, 0)	c(1, 1, 0)	c(1, 1, 0)	c(1, 1, 0)
logbeta	**c(1, 1, 0)**	c(1, 1, 0)	c(1, 1, 0)	c(1, 1, 0)	c(1, 1, 0)
logbkfrac	-			-	-
logsdb	**log(0.15), 0.5, 1**	log(0.15), 0.5, 1	log(0.15), 0.5, 1	**log(0.11), 0.5, 1**	**log(0.13), 0.5, 1**
Diagnostics					
1. Convergence	✓	✓	✓	✓	✓
2. Finite parameters	**TRUE**	TRUE	TRUE	TRUE	TRUE
3. Violation of model assumptions					
shapiro	✓	✓	✓	✓	✓
bias	✓	✓	✓	✓	✓
acf	**C***	C*	✓	*C	*C
LBox	✓	✓	✓	✓	✓
4.Retrospective pattern					
Mohn's Rho					
BBmsy	**0.383**	0.753	0.215	0.369	0.391
FFmsy	**-0.078**	-0.114	-0.114	-0.067	-0.086
5.Realistic production curve	✓	✓	✓	✓	✓
6. Assessment uncertainty	✓	✓	✓	✓	✓
7. Initial values sensitivity	✓	✓	✓	✓	✓
objective function at optimum	**17.13**	17.48	16.68	16.97	17.39
Model parameter estimates					
alpha1	**2.03**	2.07	1.92	2.39	1.87
beta	**0.04**	0.04	0.04	0.05	0.04
r	**0.34**	0.22	0.56	0.33	0.34
rc	**0.34**	0.22	0.56	0.33	0.34
rold	**0.34**	0.22	0.56	0.33	0.34
m	**1398**	1950.64	1149.72	1421.63	1380.84
K	**16621**	35167.45	8232.14	17261.05	16170.75
q1	**0.00**	0.00	0.00	0.00	0.00
sdb	**0.12**	0.12	0.13	0.10	0.13
sdf	**0.13**	0.13	0.12	0.13	0.12
sdi1	**0.25**	0.25	0.25	0.25	0.24
sdc	**0.01**	0.01	0.00	0.01	0.00
bkfrac	**0.23**	0.15	0.30	0.23	0.23
Stochastic reference points (Srp)					
Bmsys	**8095**	17000.00	4034.77	8461.75	7843.89
Fmsys	**0.16**	0.11	0.28	0.16	0.17
MSYs	**1332**	1820.00	1110.64	1370.61	1305.40
States w 95% CI (inp$msytype: s)					
B_2022.94	**10565**	16100.00	6104.46	10619.74	10510.94
F_2022.94	**0.11**	0.07	0.18	0.11	0.11
B_2022.94/Bmsy	**1.31**	0.95	1.51	1.26	1.34
F_2022.94/Fmsy	**0.65**	0.66	0.66	0.66	0.64

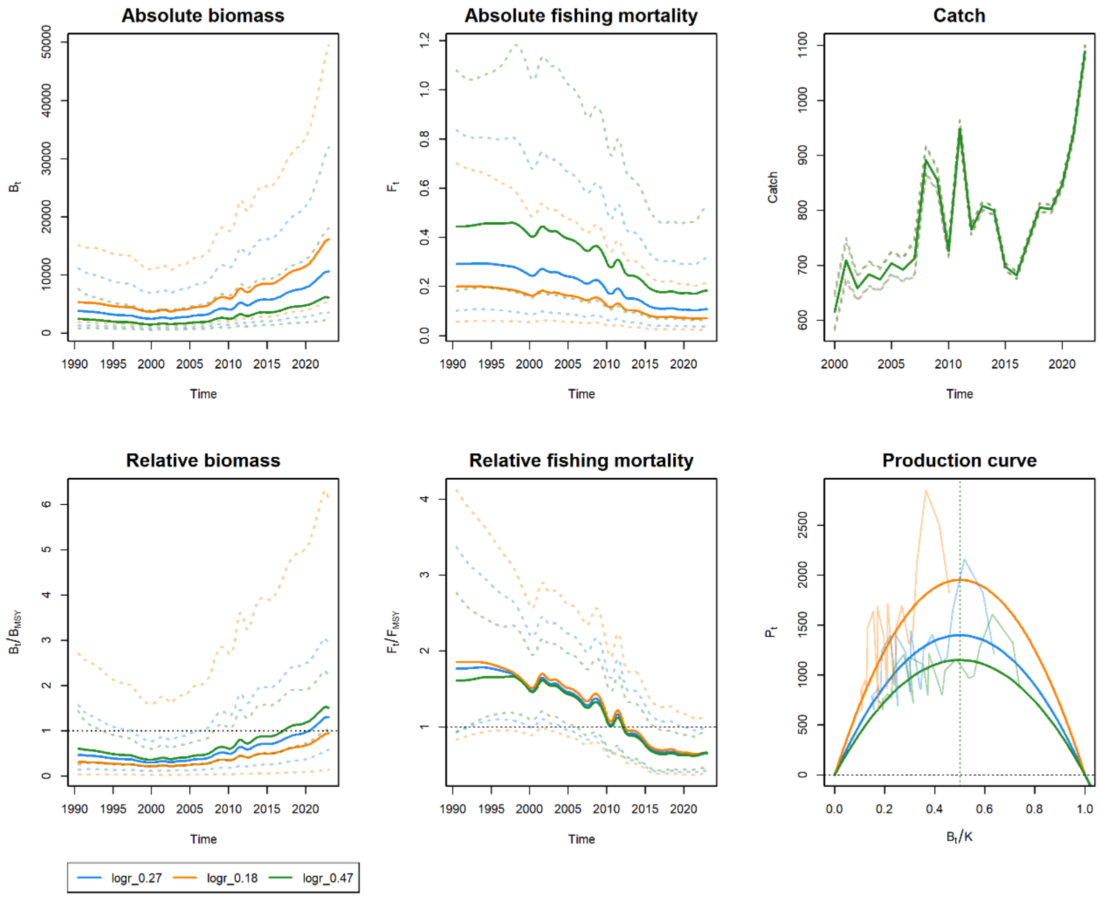


Figure 3.20 Thornback ray *Raja clavata* in ICES Division 9a. Comparison of models run with different *r* priors (see table 3.14 for more information about the models).

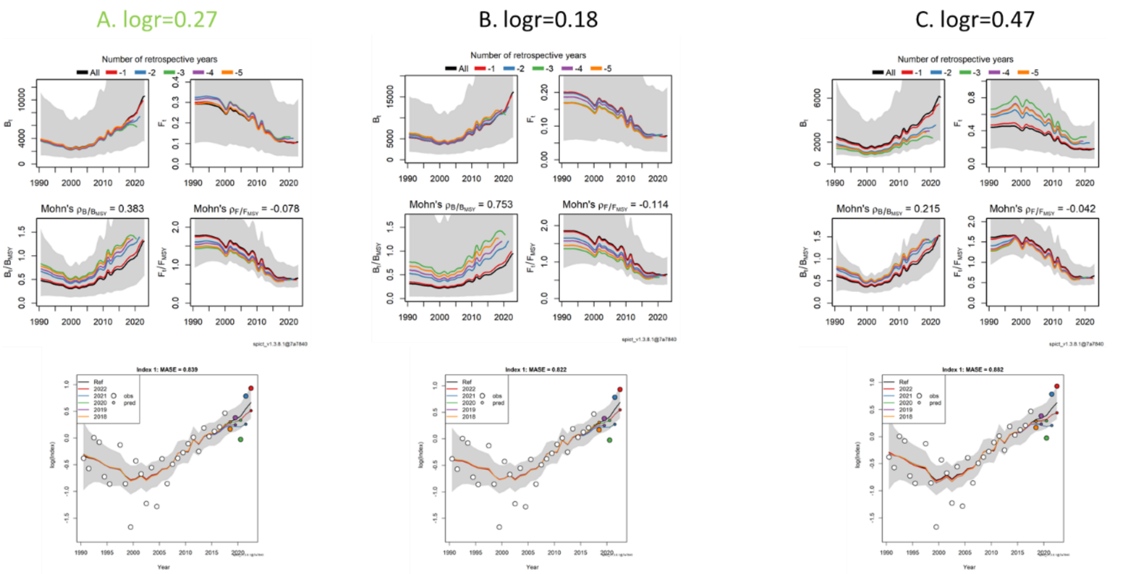


Figure 3.21 Thornback ray *Raja clavata* in ICES Division 9a. Comparison of the retrospective patterns and hindcast for the models runs with different *r* priors: A. *r* = 0.27, B. *r* = 0.18 and C. *r* = 0.47 (see table 3.14 for more information about the models).

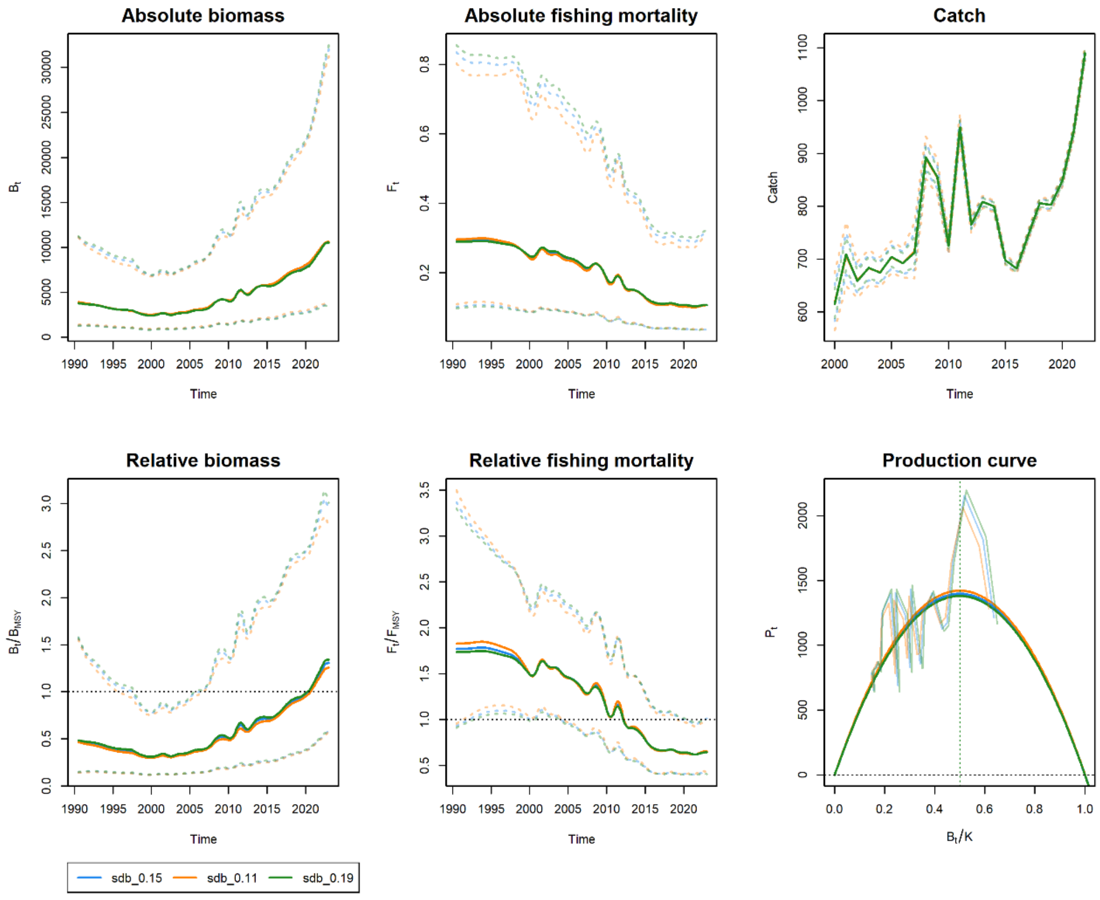


Figure 3.22 Thornback ray *Raja clavata* in ICES Division 9a. Comparison of models run with different *sdb* priors (see table 3.14 for more information about the models).

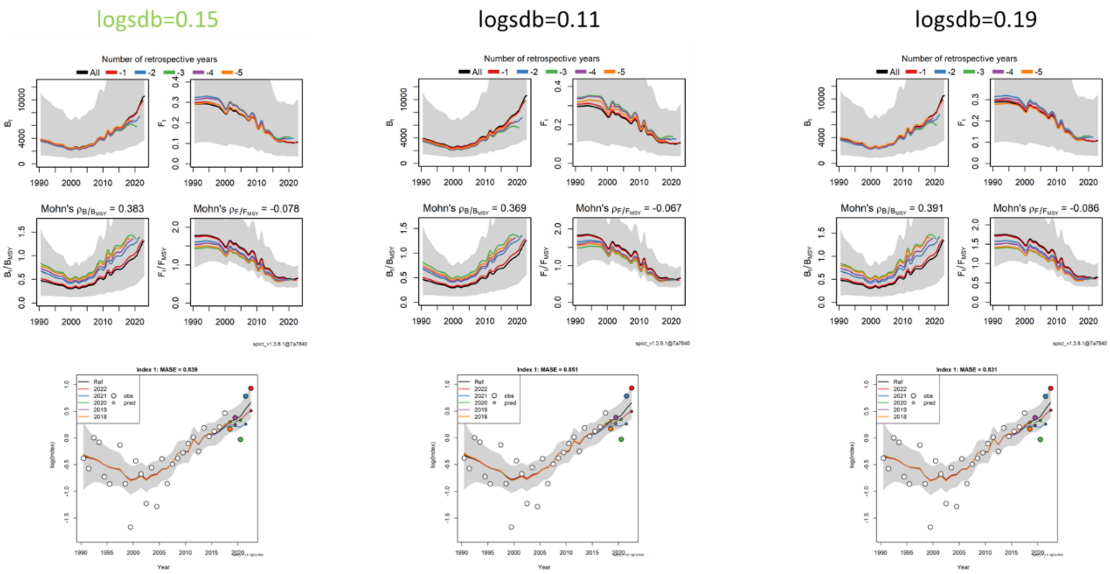


Figure 3.23 Thornback ray *Raja clavata* in ICES Division 9a. Comparison of the retrospective patterns and hindcast for the models runs with different *sdb* priors: A. *sdb* = 0.15, B. *sdb* = 0.11 and C. *sdb* = 0.19 (see table 3.14 for more information about the models).

Finally, three new scenarios were simulated to test the robustness of the final model (Model 19) to different variations of the biomass index in the next year of assessment (2023), considering a possible increase or reduction of 50% in biomass or keeping the same index value from 2022 (i=2.541). The catches were kept stable, i.e., considering the same catches as in 2022 (1090 ton). In what respects the checklist for the acceptance of a SPiCT assessment, all criteria were met except some minor issue with the auto-correlation of catch data and high Mon's Rho for $B/B_{MSY,}$ especially for the scenario with +50% increase of the biomass index, as expected (Table 3.15 and Figure 3.24). These results, confirms the robustness of the model,.

Table 3.15. Thornback ray *Raja clavata* in ICES Division 9a. Model configurations and results when testing for a hypothetical new year under three different scenarios of biomass index values at the end of the time series.

	MODEL 19 (9u) FINAL MODEL	MODEL 32 (9zh) FINAL MODEL -50%	MODEL 33 (9zi) FINAL MODEL +50%	MODEL 34 (9zj) FINAL MODEL statusquo
Input series				
C	**2000-2022**	2000-2023	2000-2023	2000-2023
I1 (stock indicator weighted average)	**1990-2022**	1990-2023	1990-2023	1990-2023
Increased uncertainty (stdev)				
C		**3 (2000-2007); 2 (2008-2009)**		
I1 (stock indicator weighted average)		**2 (1990-1995; 1999; 2003-2004)**		
Priors				
logn	**Fixed Schaefer**	Fixed Schaefer	Fixed Schaefer	Fixed Schaefer
logr	**log(0.27),0.5,1**	log(0.27),0.5,1	log(0.27),0.5,1	log(0.27),0.5,1
logalpha	**c(1, 1, 0)**	c(1, 1, 0)	c(1, 1, 0)	c(1, 1, 0)
logbeta	**c(1, 1, 0)**	c(1, 1, 0)	c(1, 1, 0)	c(1, 1, 0)
logbkfrac	**-**	-	-	-
logsdb	**log(0.15), 0.5, 1**	log(0.15), 0.5, 1	log(0.15), 0.5, 1	log(0.15), 0.5, 1
Diagnostics				
1. Convergence	✓	✓	✓	✓
2. Finite parameters	**TRUE**	TRUE	TRUE	TRUE
3. Violation of model assumptions				
shapiro	✓	✓	✓	✓
bias	✓	✓	✓	✓
acf	**C***	*C	*C	*C
LBox	✓	✓	✓	✓
4.Retrospective pattern				
Mohn's Rho				
BBmsy	**0.383**	0.097	0.558	0.310
FFmsy	**-0.078**	-0.039	-0.044	-0.042
5.Realistic production curve	✓	✓	✓	✓
6. Assessment uncertainty	✓	✓	✓	✓
7. Initial values sensitivity	✓	✓	✓	✓
objective function at optimum	**17.13**	16.55	18.12	16.10
Model parameter estimates				
alpha1	**2.03**	2.17	2.17	2.02
beta	**0.04**	0.05	0.04	0.04
r	**0.34**	0.40	0.30	0.33
rc	**0.34**	0.40	0.30	0.33
rold	**0.34**	0.40	0.30	0.33
m	**1398**	1182	1842	1483
K	**16621**	11942	24455	17836
q1	**0.00**	0.00	0.00	0.00
sdb	**0.12**	0.12	0.12	0.12
sdf	**0.13**	0.12	0.13	0.12
sdi1	**0.25**	0.25	0.26	0.24
sdc	**0.01**	0.01	0.01	0.01
bkfrac	**0.230**	0.29	0.16	0.21
Stochastic reference points (Srp)				
Bmsys	**8095**	5844	11898	8688
Fmsys	**0.16**	0.19	0.15	0.16
MSYs	**1332**	1137	1751	1413
States w 95% CI (inp$msytype: s)				
B_2022.94	**10565**	7939	13762	11291
F_2022.94	**0.11**	0.14	0.08	0.10
B_2022.94/Bmsy	**1.31**	1.36	1.16	1.30
F_2022.94/Fmsy	**0.65**	0.70	0.54	0.59

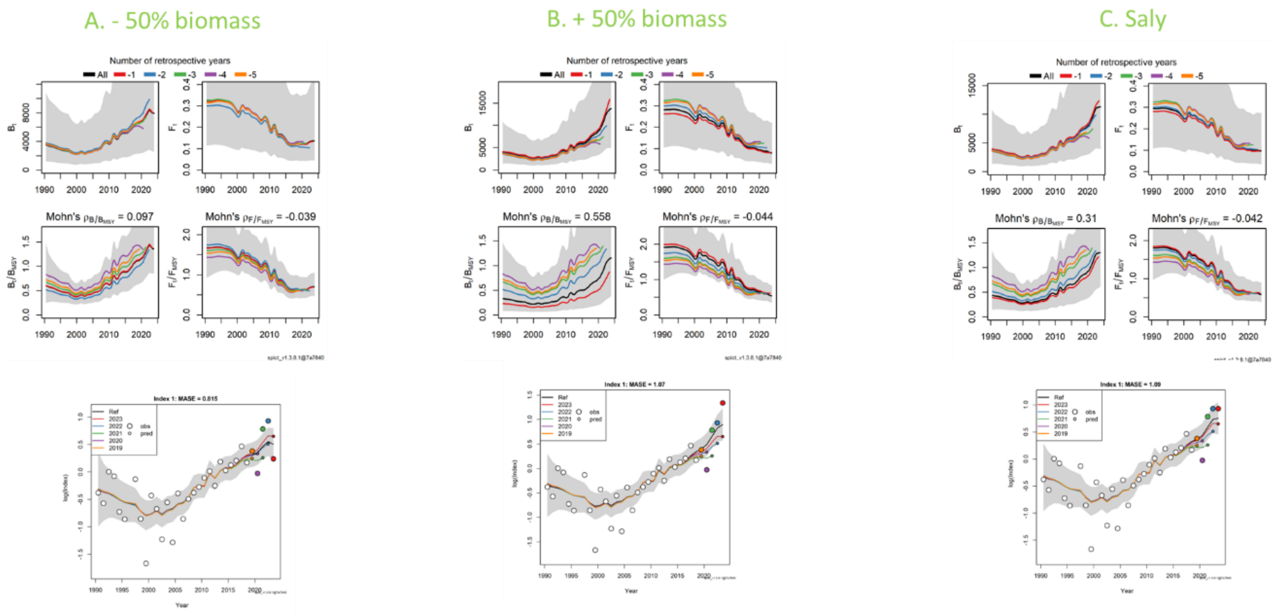


Figure 3.24. Thornback ray *Raja clavata* in ICES Division 9a. Retrospective pattern and hindcast when testing for a hypothetical new year under three different scenarios of biomass index values at the end of the time series. A. -50% biomass in 2023, B. +50% biomass in 2023 and C. Same biomass in 2023 as in 2022.

3.4.2 Final assessment

Settings and parameter values agreed for the accepted model (Model 19) are presented in Table 3.16. The plots and results from the final assessment are presented in Figures 3.25-3.29 and Tables 3.17-3.18.

Mohn's rho is with a value of 0.383 for B/B_{MSY} above the value of the general guidelines (0.2), but all peels are within the confidence bounds. An expected range for Mohn's rho was calculated using the R function *mrci* developed by Casper Berg (unpublished) that simulates 400 new datasets conditional on the estimated model, refitting the model and calculating Mohn's rho for each replicate. This gave an expected range (95% of the replicates) of [-0.23, 0.50] for B/B_{MSY} (Figure 3.28). The observed value of Mohn’s rho is thus within the range of the expected values and can be ascribed to the general model uncertainty rather than potential model misspecification. The same approach was used for another stock (cod 27.2) in the benchmark meeting WKBM-SYSPiCT 3 (ICES, *in press*).

The R scripts to produce the data preparation and assessment with SPiCT for this stock were prepared and added to the ICES Transparent Assessment Framework (TAF) repository for WKBELASMO on GitHub (Transparent Assessment Framework (TAF) (github.com)).

Table 3.16. Thornback ray *Raja clavata* in ICES Division 9a. Settings and parameter values agreed for the accepted model (Model 19).

Input data	
Landings	2001-2022, using reconstructed landings from 2001 to 2007 (Portugal) and 2001-2009 (Spain) 3x higher uncertainty in 2000-2007 and 2x higher uncertainty in 2008-2009
Biomass indices	Index 1: Weighted combined stock indicator (average between: mean of the normalized PTGFS-WIBTS-Q4 and LPUE + normalized ARSA surveys) weighted to the proportion of landings from each country, 80% PT and 20% ES) (1990-2022).
Parameter	
r	r = 0.27 y^{-1}, CV = 0.5
Shape of the production curve	Schaefer (n=2)
Process error (*sdb*)	*sdb* = 0.15, CV = 0.5
Noise ratios *logalpha*, *logbeta*	Disabled

Table 3.17. Thornback ray Raja clavata in ICES Division 9a. SPiCT summary results for the accepted model (Model 19).

Model parameter estimates w 95% CI				
	estimate	**cilow**	**ciupp**	**log.est**
alpha	2.03	0.99	4.14	0.71
beta	0.04	0.00	46.74	-3.20
r	0.34	0.13	0.89	-1.09
rc	0.34	0.13	0.89	-1.09
rold	0.34	0.13	0.89	-1.09
m	1398	656	2979	7.24
K	16621	3374	81872	9.72
q	0.00	0.00	0.00	-8.59
sdb	0.12	0.07	0.22	-2.11
sdf	0.13	0.07	0.22	-2.08
sdi	0.25	0.18	0.33	-1.40
sdc	0.01	0.00	5.48	-5.28
Deterministic reference points (Drp)				
	estimate	**cilow**	**ciupp**	**log.est**
B_{MSYD}	8311	1687	40936	9.03
F_{MSYD}	0.17	0.06	0.45	-1.78
MSYd	1398	656	2979	7.24

Stochastic reference points (Srp)					
	estimate	**cilow**	**ciupp**	**log.est**	**rel.diff.Drp**
B_{MSYS}	8095	1669	39259	9.00	-0.03
F_{MSYS}	0.16	0.06	0.44	-1.80	-0.02
MSYs	1332	638	2780	7.19	-0.05

States w 95% CI				
	estimate	**cilow**	**ciupp**	**log.est**

B_2022.94	10565	3508	31818	9.27
F_2022.94	0.11	0.04	0.32	-2.24
B_2022.94/B_{MSY}	1.31	0.58	2.95	0.27
F_2022.94/F_{MSY}	0.65	0.42	1.01	-0.43

Predictions w 95% CI				
	prediction	**cilow**	**ciupp**	**log.est**
B_2024.00	10652	3218	35255	9.27
F_2024.00	0.11	0.04	0.32	-2.24
B_2024.00/B_{MSY}	1.32	0.65	2.67	0.27
F_2024.00/F_{MSY}	0.65	0.39	1.08	-0.43
Catch_2023.00	1132	860	1490	7.03
E(B_inf)	10495	NA	NA	9.26

Table 3.18. Thornback ray Raja clavata in ICES Division 9a. SPiCT estimates for B/B_{MSY} and F/F_{MSY}. CI, 95% confidence intervals, obtained for the accepted model (Model 19).

Year	B/B_{MSY}			F/F_{MSY}		
	Estimate	CI high	CI Low	Estimate	CI high	CI Low
2001	0.465	1.473	0.147	1.770	3.293	0.951
2002	0.452	1.348	0.151	1.772	3.156	0.995
2003	0.437	1.264	0.151	1.780	3.057	1.036
2004	0.414	1.171	0.146	1.782	2.971	1.069
2005	0.392	1.092	0.140	1.770	2.874	1.090
2006	0.378	1.046	0.137	1.747	2.780	1.097
2007	0.371	1.018	0.135	1.722	2.708	1.095
2008	0.346	0.926	0.129	1.688	2.634	1.082
2009	0.313	0.818	0.120	1.606	2.454	1.052
2010	0.301	0.776	0.117	1.493	2.222	1.004
2011	0.323	0.840	0.124	1.561	2.315	1.052
2012	0.320	0.836	0.122	1.622	2.424	1.086
2013	0.319	0.835	0.122	1.568	2.362	1.041
2014	0.335	0.881	0.127	1.525	2.318	1.004
2015	0.354	0.935	0.134	1.459	2.228	0.956
2016	0.375	0.996	0.141	1.415	2.175	0.920
2017	0.389	1.038	0.146	1.312	2.033	0.846
2018	0.455	1.234	0.168	1.327	2.065	0.853
2019	0.518	1.428	0.188	1.346	2.138	0.848
2020	0.497	1.350	0.183	1.107	1.763	0.695
2021	0.582	1.606	0.211	1.099	1.762	0.685
2022	0.616	1.710	0.222	1.054	1.711	0.650
2023	0.624	1.720	0.227	0.911	1.480	0.561

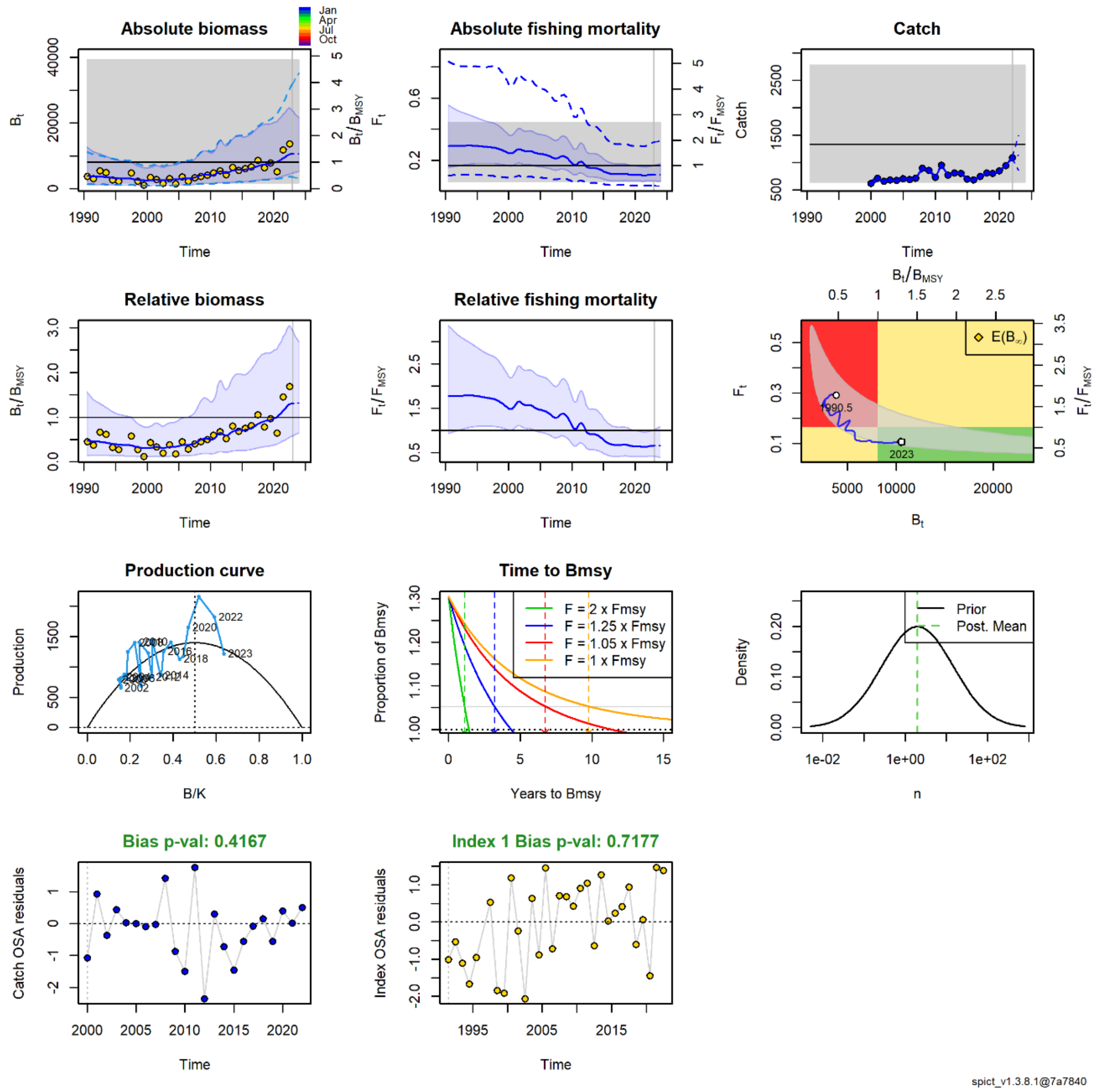


Figure 3.25 Thornback ray *Raja clavata* in ICES Division 9a. Results for the final SPiCT assessment (Model 19).

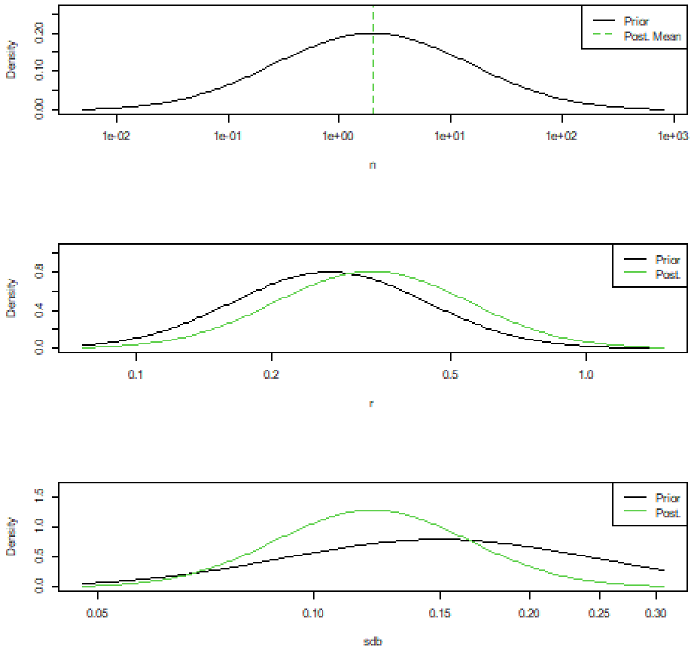


Figure 3.26. Thornback ray *Raja clavata* in ICES Division 9a. Estimated priors and posteriors for the final SPiCT assessment (Model 19).

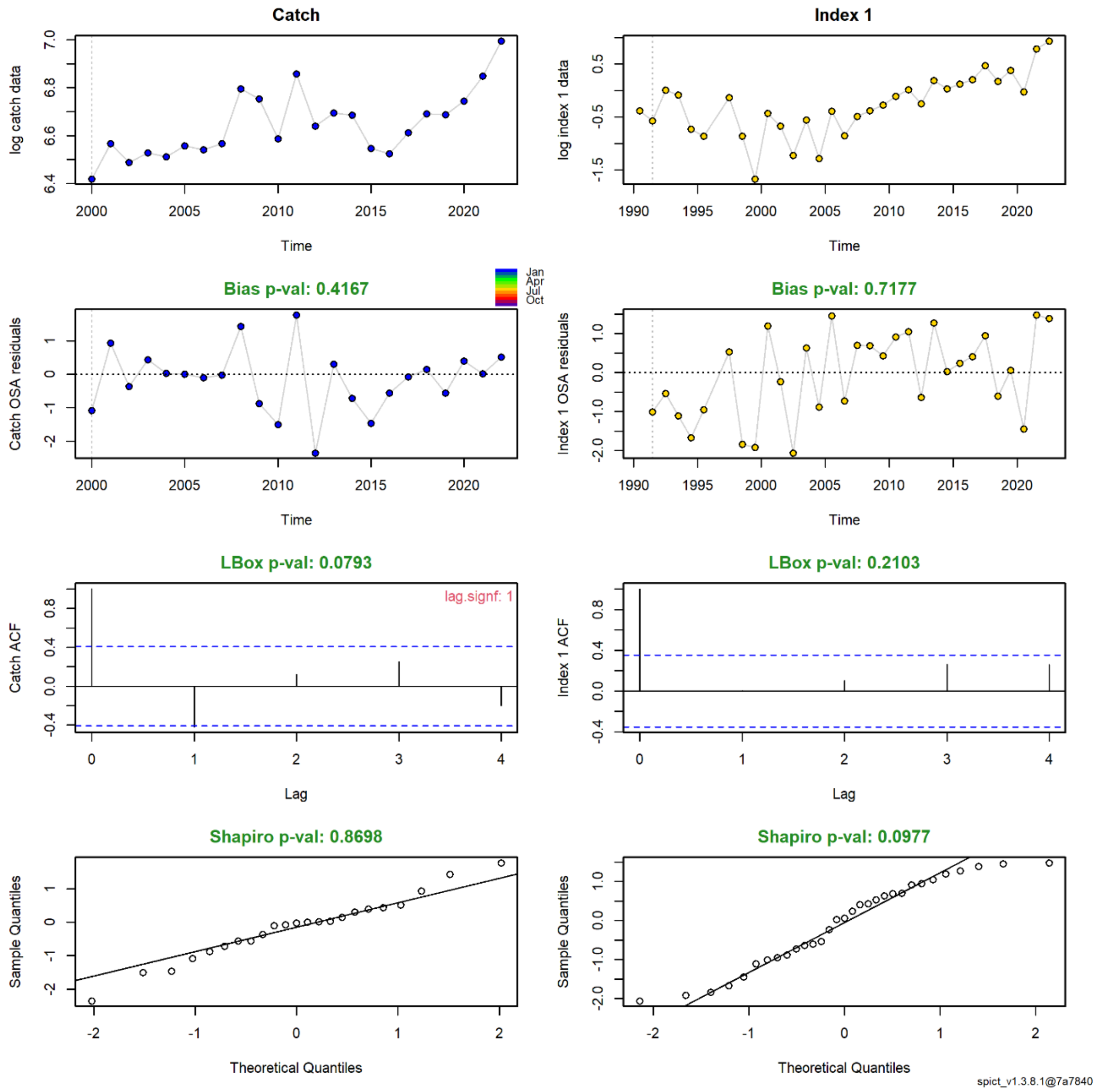
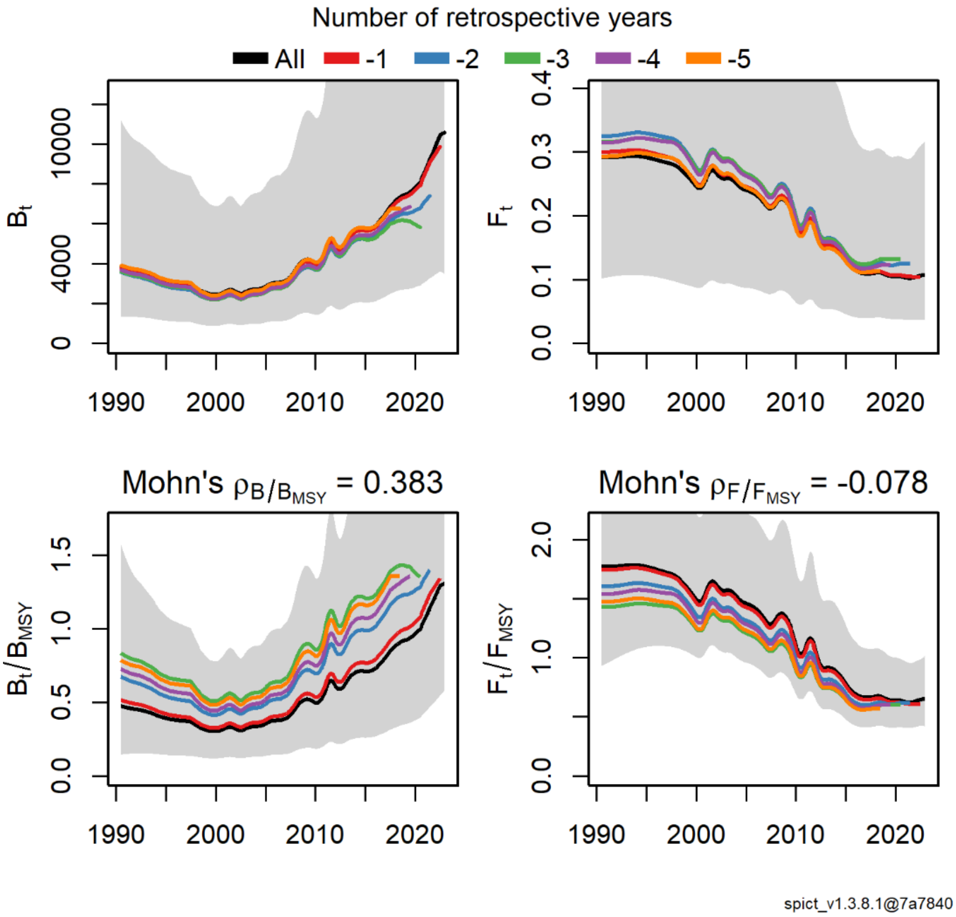


Figure 3.27 Thornback ray *Raja clavata* in ICES Division 9a. Diagnostics of the final SPiCT assessment (Model 19).



	B/B_{MSY}	F/F_{MSY}
2.5%	-0.230	-0.454
50%	0.004	-0.007
97.5%	0.495	0.587

Figure 3.28. Thornback ray *Raja clavata* in ICES Division 9a. Retrospective pattern of the final SPiCT assessment (Model 19) and expected range for Mohn's rho calculated using the *mrci* function (Casper Berg, unpublished).

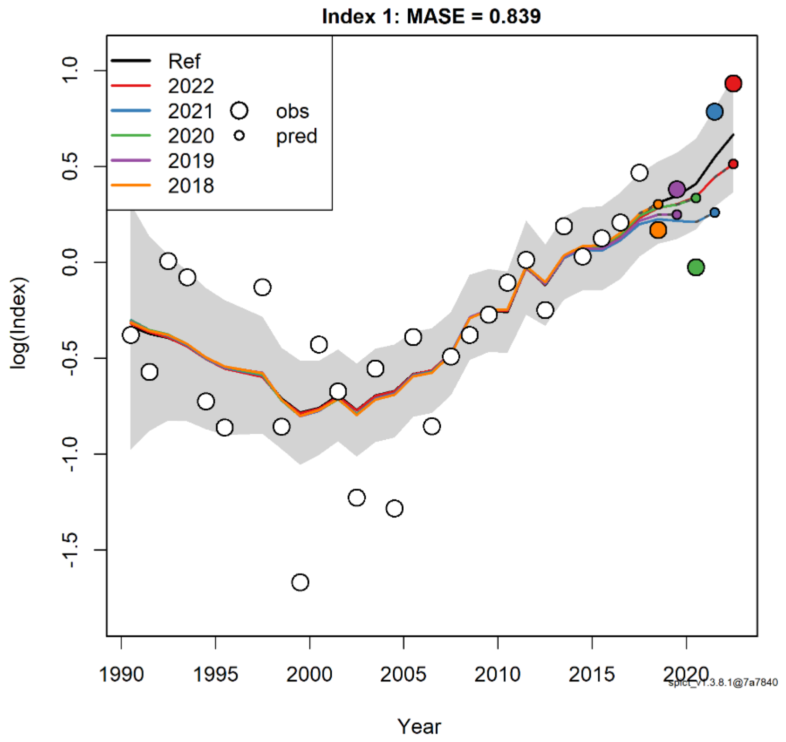


Figure 3.29. Thornback ray *Raja clavata* in ICES Division 9a. Hindcast cross-validation for the final SPiCT assessment (Model 19).

3.4.3 Forecast

A two-year projection (2024 and 2025) was carried out assuming a *status quo* harvest rate in the interim year, and an F corresponding to the advice for the following year. Table 3.19 presents the results for each year under different F scenarios. The predicted trajectories for the management period 2024-2025 can be observed in Figure 3.30.

The advised landings for the thornback ray stock in division 9a, issued in 2022 using the rfb rule, were 1452 t for each of the years 2023 and 2024. The forecast scenario used to provide advice for other *Rajidae* stocks assessed with SPiCT under WGEF (ICES, 2023b) was the one corresponding to the 15th percentile of the catch. This scenario leads to a decrease in landings of 10.5% in 2024 in relation to the previous advice. Forecast for 2025 shows a decrease of 0.7% in relation to 2024.

Table 3.19. Thornback ray *Raja clavata* in ICES Division 9a. Estimates of catch. B/B$_{MSY}$ and F/F$_{MSY}$ in each of the years 2024 and 2025 for the scenarios proposed *under the* final SPiCT assessment (Model 19).

2024			
Scenario	**Catch (t)**	**B/B$_{MSY}$**	**F/F$_{MSY}$**
F = 0	0	1.46	0
F = Fsq	1139.7	1.32	0.65
F = F_{msy}	1714.3	1.26	1
F = $F_{msy\_c\_fractile\_35}$	1545.4	1.28	0.89
F = $F_{msy\_c\_fractile\_15}$	1300.1	1.31	0.74
2025			
Scenario	**Catch (t)**	**B/B$_{MSY}$**	**F/F$_{MSY}$**
F = 0	0	1.58	0
F = Fsq	1146.1	1.33	0.65
F = F_{msy}	1643.7	1.21	1
F = $F_{msy\_c\_fractile\_35}$	1503.4	1.24	0.89
F = $F_{msy\_c\_fractile\_15}$	1290.5	1.30	0.74

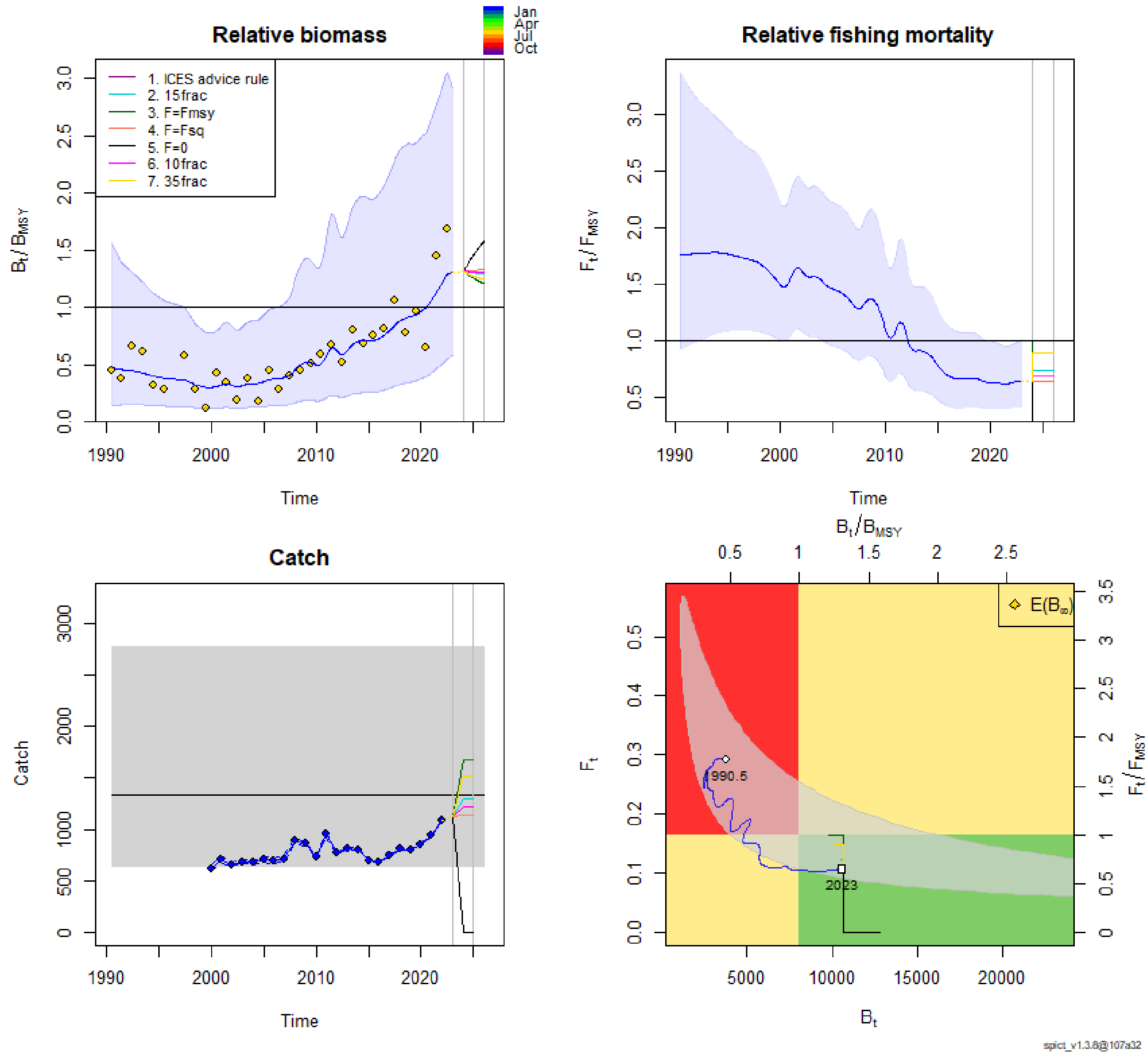


Figure 3.30. Thornback ray *Raja clavata* in ICES Division 9a. Predicted trajectories for the management period 2024-2025.

3.5 Future considerations/recommendations

For future SPiCT assessment used to produce advice for this stock it would advisable to check the recommendations reported by future ICES WKLIFE workshops or future benchmarks using SPiCT to make any adjustments on the scripts, based on the most recent SPiCT developments and recommendations.

Another consideration due to differences in spatial coverage of both indices used to calculate the weighted combined index is to explore or find out the best approach to weight indices.

Any improvement of the data used and/or statistical treatment to produce the LPUE should be encouraged to better provide an index more representative of the abundance of the stock.

Finally, it is also recommended to try different values of intrinsic rate and initial depletion level to run sensitivity analysis, if possible, based on the best informative priors possible, given the available information for the stock.

3.6 Reviewers report

As agreed during the data compilation workshop, the Portuguese commercial landings in area 9a for this species was reconstructed for the years 2000-2007 following the methodology (method 3) described in Maia et al. 2023, a working document presented at the ICES WKELASMO3 data compilation online meeting, 20-24 November 2023. The relative indices of exploitable biomass were obtained from two scientific surveys, the Portuguese survey PTGFS-WIBTS-Q4 and the two surveys covering the Spanish area in the Gulf of Cádiz ARSA in quarters 1 and 4 over the period 1990-2022. These scientific surveys provide information on the exploitable biomass above 35 cm fish length. In addition, from 2008 a Portuguese LPUE index was estimated. An important aspect to consider is that since 2014 the minimum landing size was set at 58 cm, and this may have involved a change in the portion of the population covered by both the LPUE index and total commercial landings. However, the low catches obtained for this stock during the scientific survey did not allow to increase the size limit in the survey index to 58 cm.

The commercial catches showed a marked increase since 2014. The survey indices (PTGFS-WIBTS-Q4 and ARSA) and the LPUE also showed a steady increase almost all along the time period. But that increase was specially marked in the ARSA and PTGFS-WIBTS-Q4 surveys, showing a steep increase since 2018. This increase coincided with a change in the research vessel used in the Portuguese survey.

SPiCT (Surplus Production in Continuous Time) was proposed as the modelling framework to be applied to this stock. In a set of initial runs with SPICT, different scenarios about the use of the input data were tested: fitting to separate biomass indices or a combined index, starting the model in 1990 or 1997, and including or excluding the reconstructed landings from 2000-2007. The analysis of model diagnostics led to the selection of the model that uses the entire commercial catch time series 2000-2022 and is fitted to a single combined biomass index 1990-2022. The combined biomass index was produced from the three survey indices and the LPUE index following a two-step approach. In the first step, a Portuguese index was constructed by averaging the normalized PTGFS-WIBTS-Q4 survey and LPUE, and a Spanish index was constructed by averaging the normalized ARSA surveys Q1 and Q4. In the final step, a combined index was calculated as the weighted average of the Portuguese and Spanish indices, based on the relative magnitude of landings by country where Portuguese catches were assigned a weight of 80% and Spanish catches 20%.

SPiCT has a number of parameters for which it is possible to provide a fixed value, to specify a prior distribution, or estimate the parameter without priors. During the benchmark meeting a wide range of different SPiCT model parameter settings were tested and presented as candidate models to assess the status and serve as a basis of scientific advice for this stock.

One of the most important parameters is the intrinsic population growth rate *r*. The model did not converge and pass diagnostics checks when *r* was estimated as a free parameter, so different priors of *r* were presented and evaluated during the benchmark meeting. The method selected was the one adopted in WKBELASMO2 (ICES 2023) using the function *jbleslie* of the R package JABBA (Winker et al. 2018). This function requires a list of life history trait parameter values, such as the length at 50% maturity L50, growth parameters Linf, K and t0, potential fecundity and others, which were obtained from the existing literature and a previous WKELASMO meeting. The value of *r* estimated following this approach for thornback ray was 0.27, which was used as a prior with a CV of 0.5.

A second highly influential parameter for modeling stock dynamics using SPiCT is *n*, which determines the shape of the production curve. After some model runs and tests it was decided that, for this type of stock, with limited amount of data and relatively short time series, there is insufficient information to estimate the shape of the production curve and a pragmatic approach is to fix it as *n*=2, corresponding to a Schaefer production curve.

A third essential parameter is *bkfrac*, defining the level of biomass in the first year of the model as a proportion of the carrying capacity *K*. Initial model explorations presented at the benchmark meeting involved various priors of *bkfrac* around the values 0.2, 0.3, and 0.5. The resulting models showed that these priors were highly influential for the final *bkfrac* estimate, as well as the current stock status. The review panel looked into the strong mathematical connection in a Schaefer-based model between *r* and *Fmsy*, *K* and *Bmsy*, and also between *bkfrac* and *B*/*Bmsy*, where the difference between the initial *bkfrac* and final *B*/*Bmsy* is determined by the relative values of early vs. recent biomass index values. After consulting with a domain expert (Casper Berg, DTU Aqua) on the matter, the panel concluded that while biological information can be used to provide a basis for *r* and a pragmatic approach can be used for *n*, the recommended approach for modeling *bkfrac* should be to estimate this parameter without a prior. Using a prior on *r* and *bkfrac* in a Schaefer-based model effectively pins down both *Fmsy* and *B*/*Bmsy*, which is too restrictive and can lead to a predetermined outcome that defeats the purpose of a stock assessment to estimate the population dynamics and current stock status. A rare exception might arise when the dataset starts with an unfished stock, where the initial *bkfrac* can be expected to be near 1. The final model proposed for thornback ray estimated *bkfrac* without a prior.

Another important parameter is *sdb*, determining the variability of the estimated annual surplus production in relation to the model's production curve. The initial model runs presented at the benchmark tended to estimate *sdb* around zero, where the model will not generate production peaks that differ from what the stock biomass would determine based on the production curve. To allow the model to estimate annual surplus that varies from the deterministic curve, a prior of *sdb* around 0.15 was used, with a CV of 0.5, which was also used during WKLIFEII (ICES 2023).

Regarding the uncertainty in the observed data, due to the change over the historic period in the sampling programme implemented to obtain data on the reconstructed commercial catch, it was decided to group the commercial catches in terms of uncertainty as 2000-2007, 2008-2010, and 2011-2022) for which the estimated standard deviation would be scaled by 3, 2 and 1 respectively. The biomass index was also subject to a change in the data sampling in 2018, when a new research vessel was adopted for the Portuguese survey. To model the increased uncertainty due to the research vessel change, the uncertainty in the observations from 2018 were scaled up in relation to the earlier period. This configuration of observation error improved some of the model diagnostics, including the retrospective pattern.

The main purpose of Mohn's rho is to identify whether a given model shows signs of being a consistently biased estimator of the current status of the stock. In cases when the most recent years include extremely high or low outliers in the biomass index, the model estimates will change considerably when those outliers are included or excluded by retrospective peels. In this case, Mohn's rho will increase even though the model may be a generally unbiased estimator and fit for purpose. In other words, recent data outliers can cause Mohn's rho to increase as a result of extremely low or high observed data values rather than problems in the model. The review panel concluded that this was the case for thornback ray, that the Mohn’s rho values were indicative of unusually high biomass index data points in recent years and not indicative of a consistent model bias.

A final sensitivity analysis was applied for model stability testing. This analysis consisted of simulating one new year of data *y+1* with commercial catch being equal to year *y*, and three different scenarios for the index of biomass: -50%, no change, and +50% in relation to the index in the previous year y. The results indicated that the model is stable under these circumstances, resulting in relatively small and sensible changes in the parameter estimates and current stock size, responding to the latest trends in the biomass index.

TAF repository

The stock assessor and the review panel worked together to produce a TAF workflow (https://github.com/ices-taf/2024_rjc.27.9a_benchmark) that fully documents the construction of the combined biomass index as well as the final SPiCT model run in an open and reproducible format, creating a CSV summary table of landings, index, and model results for Stock Assessment Graphs. At the time of writing, the TAF repository is private and requires login.

The design and functionality of the TAF workflow was well received by the ICES secretariat, as an unambiguous documentation of the combined biomass index calculation is of importance and SPiCT assessments at ICES continue to grow in number. The ICES TAF team may develop a general TAF template for SPiCT assessments based on the 2024 thornback ray 9a benchmark repository.

Conclusion

Based on the different models presented, the tests and sensitivity analysis conducted during the meeting, the SPiCT assessment model was accepted as the basis for providing advice for thornback ray in the Atlantic Iberian waters.

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4 Blonde ray (*Raja brachyura*) in Division 9.a (Atlantic Iberian waters) (**rjh.27.9a**)

4.1 Introduction

Blond ray *Raja brachyura* is a common skate species in Atlantic Iberian waters, being distributed throughout the entire ICES division 9a, including the north Spanish area (Galician waters), Portuguese mainland waters and south Spanish waters (Gulf of Cadiz). In the west of Galicia, the species is found on sand and sand-rock bottoms along the coast at depths ranging from 20 to 120 m. In Portuguese continental waters *R. brachyura* occurs along the entire coast at depths ranging from 10 to 700 m being more abundant at depths shallower than 200 m. In the center off Portugal, the species lives preferentially in areas shallower than 100 m deep, showing different spatial dynamics according to its life stages (Serra-Pereira *et al.*, 2014). A more detailed description of the species distribution in ICES Division 9a can be found in Maia et al. (2023a).

Raja brachyura is an important commercial species and landings in ICES Division 9a have been ranged from 162 to 347 tons, with Portugal contributing for 96-100% and Spain for up to 4%.

Since 2009, several management measures for *Rajidae* species have been implemented at both EU and regional (Portugal) level, such as a TAC implementation, a fishery closed period and the establishment of a minimum landing size (for details see section 2).

The stock rjh.27.9a has been assessed under category 3 since 2014, and the latest advice in 2022, involved the application of the ICES framework for category 3 stocks applying *rfb* rule (method 2.1; ICES, 2021; ICES, 2022).

For the present benchmark, the proposal was focussed on evaluating the application of a surplus production model SPiCT (Stochastic Production model in Continuous Time, Pedersen and Berg 2017) on the stock for providing advice.

4.2 Stock Identity

The stock structure of the species throughout the ICES area is poorly known. Migrations between different areas are admitted (ICES, 2013). For advice purposes, ICES considers a distinct stock unit for Division 9.a (west of Galicia, Portugal, and Gulf of Cadiz).

There are no studies on movements or population structure of the species in ICES Division 9a. As a consequence, there is no evidence to update the current stock unit in Iberian waters for *R. brachyura*. Studies available in other ICES ecoregions also do not suggest the need to change stock boundaries.

Preliminary results from a recent European project on the population genetic structure of *R. brachyura* in the North Sea and the Celtic Sea (Poos et al., 2023), suggest the existence of some population structure between the Celtic Sea and the North Sea. However further investigation on the spatial structure of *R. brachyura* in the Greater North Sea and adjacent areas is needed to clarify the stock boundaries defined in this ecoregion.

Bird et al. (2020) compiled and reviewed 50 years of tagging data for eight commercially important skate species around the British Isles. Overall, a return rate of 16% was obtained across the study area. The majority of the returned individuals showed short distance movements, as 47% travelled less than 50 km from the tagging site, 27% between 51-100 km and 26% travelled more than 100 km. The furthest straight-line distance travelled was 910 km by one female. The current ICES stock units in that region broadly encompassed the observed movements of this species; 91.8% of the individuals returned were tagged within the same stock unit area. Some individuals showed more extensive movements between stock units and management areas, yet it remains unclear whether these are regular or occasional movements.

In the absence of any genetic and ragging data in ICES Division 9a, there is no evidence to update the current stock unit in Iberian waters for *R. brachyura*.

4.3 Input data for stock assessment

A detailed description on data available for *R. brachyura* in ICES division 9a can be found in Maia et al. (2023a).

4.3.1 Fisheries

In Iberian waters, *R. brachyura* is mainly caught as a bycatch by the polyvalent fleet, followed by trawl. The polyvalent fleet is characterized by multi-species and mixed fisheries and includes vessels with length overall (LOA) ranging from 5 to 27m, which generally operate between 10 to 150m deep (occasionally down to 600m) (Figueiredo et al., 2020). The analysis of DCF sampling data indicates that *R. brachyura* is mainly caught by trammel nets, which is considered to be the most appropriated gear to catch this species. The main country involved in this species fisheries is Portugal, as detailed below.

4.3.2 Fishing effort

Estimates of fishing effort are only available for some Portuguese fishing fleets. Fishing effort time series in number of trips is annually reported to WGEF and suggests a downward trend for both polyvalent and trawl fleets (ICES, 2023b).

4.3.3 Catch data

Catch data of *R. brachyura* in ICES Division 9a was available from Intercatch since 2008 and 2009 for Portugal and Spain respectively.

4.3.3.1 Landings

Species-specific landings were only available since 2008 and 2009 for Portugal and Spain respectively. In order to obtain a longer time series, landings for the period 2000-2007 for Portugal and

2000-2009 for Spain have been estimated for the different fleets (polyvalent and trawl) independently and using different approaches. For details on historical landings estimation methods see section 2 of the present report and the working document Maia et al. (2023b).

Raja brachyura landings in ICES Division 9a have ranged from 162 to 347 tons, with Portugal contributing for 96-100% and Spain for up to 4% (Table 4.1). Belgium only reported 0.04 tons in 2017. Along the time series, landings from the polyvalent fleet represented 71-94% of the species total landed weight, followed by trawl that have contributing between 6-29% (Figure 4.1). A more detailed description of landings for the species in ICES Division 9a can be found in Maia et al. (2023a).

Table 4.1 *Raja brachyura* in ICES Division 27.9a. Annual landings (in tonnes) and representativeness by country for the period 2000-2022.

Year	Belgium		Portugal		Spain		Total
	Ton	%	Ton	%	Ton	%	
2000	0	0	262	100	1	0	263
2001	0	0	263	99	1	1	265
2002	0	0	229	99	1	1	230
2003	0	0	248	100	1	0	249
2004	0	0	235	100	1	0	236
2005	0	0	259	100	1	0	261
2006	0	0	205	99	1	1	206
2007	0	0	185	99	1	1	186
2008	0	0	193	99	1	1	194
2009	0	0	163	99	1	1	164
2010	0	0	221	99	2	1	223
2011	0	0	161	99	1	1	162
2012	0	0	165	100	0	0	165
2013	0	0	179	98	3	2	182
2014	0	0	174	100	0	0	174
2015	0	0	236	100	0	0	236
2016	0	0	221	100	1	0	222
2017	0	0	235	100	0	0	236
2018	0	0	191	98	4	2	195
2019	0	0	255	97	8	3	263
2020	0	0	335	97	12	3	347
2021	0	0	267	96	11	4	278
2022	0	0	297	96	13	4	311

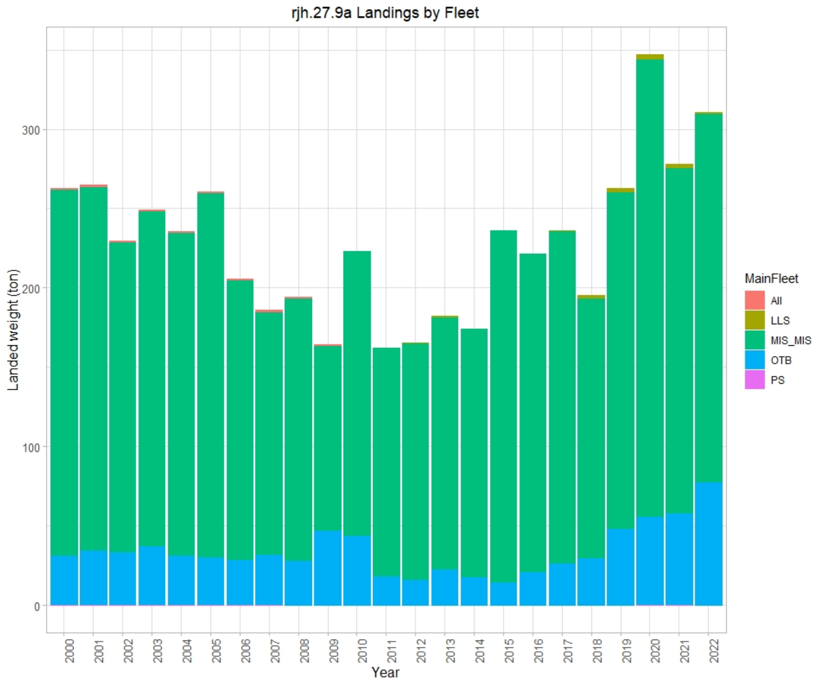

Figure 4.1 *Raja brachyura* in ICES Division 27.9a. Annual landings (in tonnes) by fleet for the period 2000-2022. "All" – all fleets combined; "LLS" – longlines; "MIS_MIS" – polyvalent fleet; "OTB" – trawl fleet and; "PS" – seine fleet.

4.3.3.2 Discards

Discards for *R. brachyura* in ICES Division 9a were mainly reported for the Spanish bottom otter trawl fleet and in low quantities (below 3 tons) compared to the total landings for the stock (average proportion of 0.002±0.004) (Figure 4.2). The low frequency of occurrence registered for the species in discards of the Portuguese trawl fleet indicates that discards can be considered negligible for that particular fleet (Fernandes, 2021). In the Portuguese polyvalent fleet, discards are known to take place and assumed to be low, but are not fully quantified as the information available is insufficient to estimate total discards (Fernandes, 2021). Further details on the discards for all skate species was presented to WKSHARKS3 (ICES, 2017; Serra-Pereira et al., 2017)

In summary, discarding is known to take place for *R. brachyura* in ICES Division 9a, but ICES cannot estimate the quantity or the corresponding dead catches. However, based on information available, discarding for this stock is assumed to be low and therefore has not been included in the previous advices and is not considered for the SPiCT assessment explored in the present benchmark.

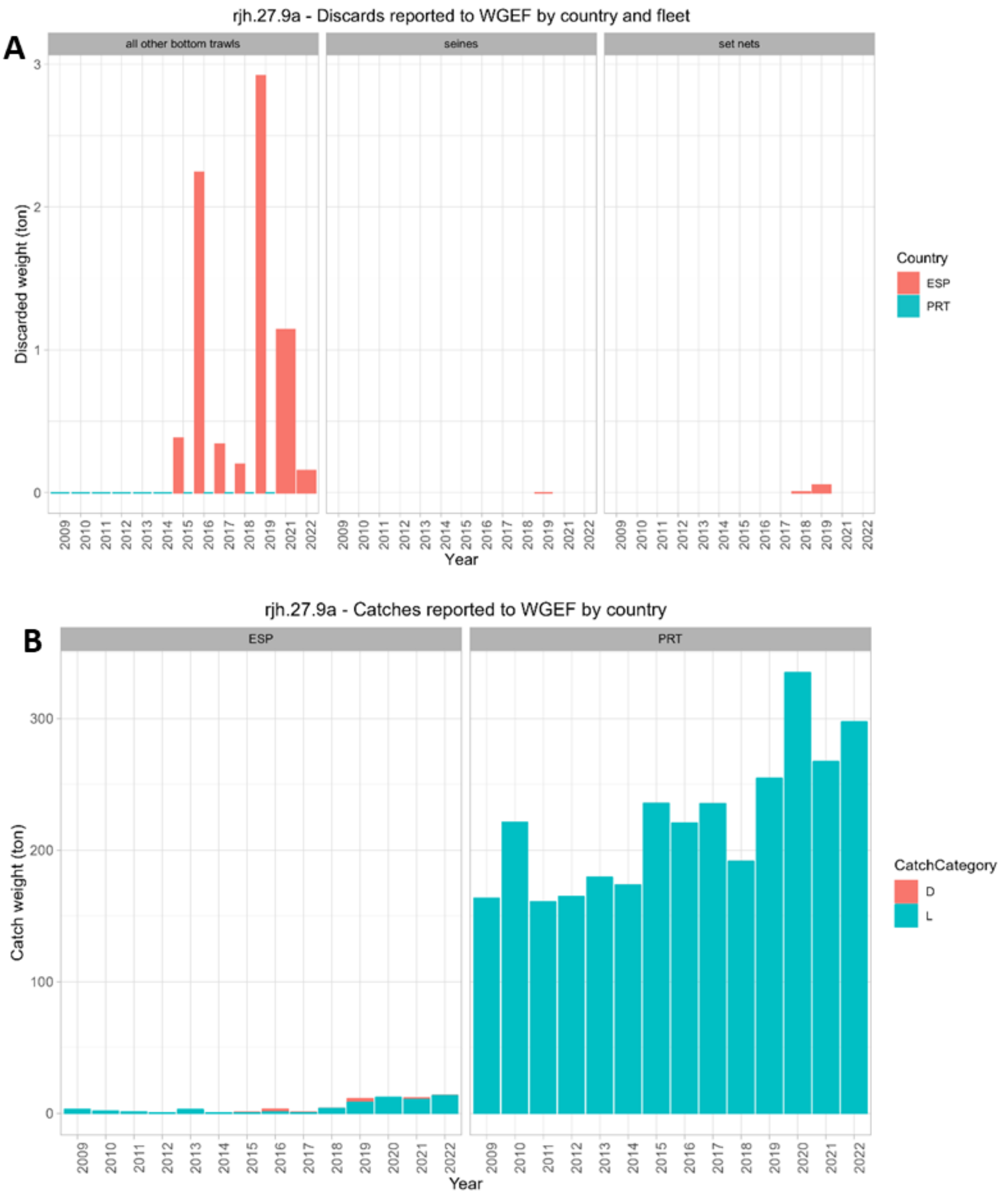

Figure 4.2 ***Raja brachyura*** **in ICES Division 27.9a. (A) Discards reported by country and fleet; (B) catches reported by country, separated by landings (L) and discards (D) for the period 2000-2022.**

4.3.3.3 Survival

Discard survival studies on *R. brachyura* have been conducted in ICES Division 9a both in Portugal (Serra-Pereira and Figueiredo, 2019) and Spain (Valeiras et al., 2018), covering the main fishing gears catching the species.

Based on results for the Portuguese polyvalent fleet, collected under the DCF Skates Pilot Study, a high Categorical Vitality Assessment (CVA) was found for *R. brachyura*, with more than 76% of the individuals found in Excellent or Good vitality status (Table 4.2). Both mesh size and soaking time seem to have some effect on this indicator. The catch vitality after capture was not related to the size of the caught skates in the case of the retained fraction whereas for the discarded fraction, differences between size classes were observed. For example, large skates (> 52 cm) discarded were generally in bad conditions for selling due to parasite infection (Table 4.3).

Table 4.2 Raja brachyura in ICES Division 27.9a. Categorical Vitality Assessment (CVA) after capture by mesh size (mm) and soaking time (h), recorded onboard commercial vessels operating with trammel nets (n=197). (source: Serra-Pereira and Figueiredo, 2019).

		Vitality status				
Mesh size (mm)	Soak time (h)	1	2	3	n	TL range (cm)
< 180	< 24	**67%**	**22%**	**11%**	**9**	**39-66**
	> 24	**92%**	4%	4%	24	27-75
> 180	< 24	**57%**	19%	24%	21	49-95
	> 24	**70%**	20%	10%	143	18-106

Table 4.3 Raja brachyura in ICES Division 27.9a. Categorical Vitality Assessment (CVA) after capture by length class (cm), recorded onboard commercial vessels operating with trammel nets (source: Serra-Pereira and Figueiredo, 2019).

	Retained				**Discarded**			
	Vitality status				Vitality status			
Length class	1	2	3	n	1	2	3	n
<52 cm	**69%**	**15%**	**15%**	**26**	**83%**	**8%**	**8%**	**12**
>52 cm	**75%**	20%	5%	150	0%	0%	100%	9

Additional experiments were carried out as part of the PPCENTRO project conducted by IPMA, focusing on *R. brachyura* caught by trammel nets, which involved captivity observations for periods of at least three weeks. Preliminary results from those experiments indicate a survival rate of 76% (Castelo, J. 2021; Figure 4.3).

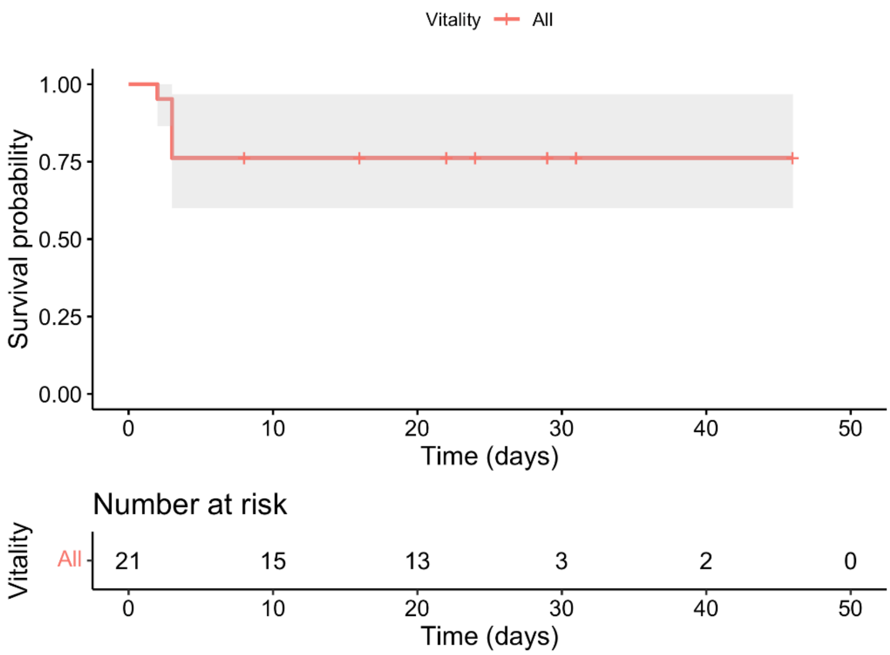

Figure 4.3 Discard survival of *Raja brachyura* caught by trammel net. Kaplan-Meier estimate of survival along 50 days of captivity (solid lines) and 95% pointwise confidence intervals (dashed lines). Survival probability within the observation period with standard error and upper and lower 95% CIs estimates (source: Castelo, J. 2021).

Results from the different studies suggest that the *R. brachyura* caught by trammel nets, the main fishing gear to catch this species in ICES Division 9a, have a high survival after capture. All the studies followed the procedures described in previous experiments on the survival of this group of species and the recommendations made by the STECF and the ICES Working Group on Methods to Estimate Discard Survival. The high survivability rate strengthens the decision of ignoring discards in the assessment of this species/stock.

4.3.4 Biomass index

Portuguese bottom trawl research surveys are considered inadequate for monitoring *R. brachyura* populations in ICES Division 9a due to the reduced number of hauls held at deeps smaller than 50m. Given this, a commercial standardized LPUE time-series index based on data derived from the Portuguese polyvalent fleet has been used to provide advice on stock status. The model and procedures were revised during the present benchmark. All the details on the LPUE standardisation methodology are described in Maia *et al.* (2023c).

Annual biomass index varied from 13.23 kg.trip-1 (in 2009) to 34.86 kg.trip-1 (in 2017), with an average of 23.61 kg.trip-1 for the entire time series (Table 4.4, Figure 4.4). Since 2016, values have been above the long-term mean.

Table 4.4 *Raja brachyura* in ICES Division 27.9a. LPUE index (kg.trip^{-1}), standard error and normalized LPUE from 2008 to 2022.

Year	LPUE (kg.trip^{-1})	sd	mean-sd	mean+sd	Standirdized LPUE
2008	15.40	6.55	8.86	21.95	0.65
2009	13.23	6.54	6.69	19.76	0.56
2010	19.42	10.95	8.47	30.37	0.82
2011	19.82	11.08	8.74	30.90	0.84
2012	20.96	11.94	9.01	32.90	0.89
2013	13.78	7.84	5.95	21.62	0.58
2014	15.42	9.19	6.23	24.60	0.65
2015	21.23	10.51	10.72	31.74	0.90
2016	27.65	15.62	12.03	43.27	1.17
2017	34.86	17.96	16.90	52.83	1.48
2018	26.32	12.73	13.59	39.05	1.11
2019	33.31	21.26	12.04	54.57	1.41
2020	29.07	15.72	13.35	44.79	1.23
2021	31.35	15.13	16.21	46.48	1.33
2022	32.32	13.70	18.62	46.03	1.37

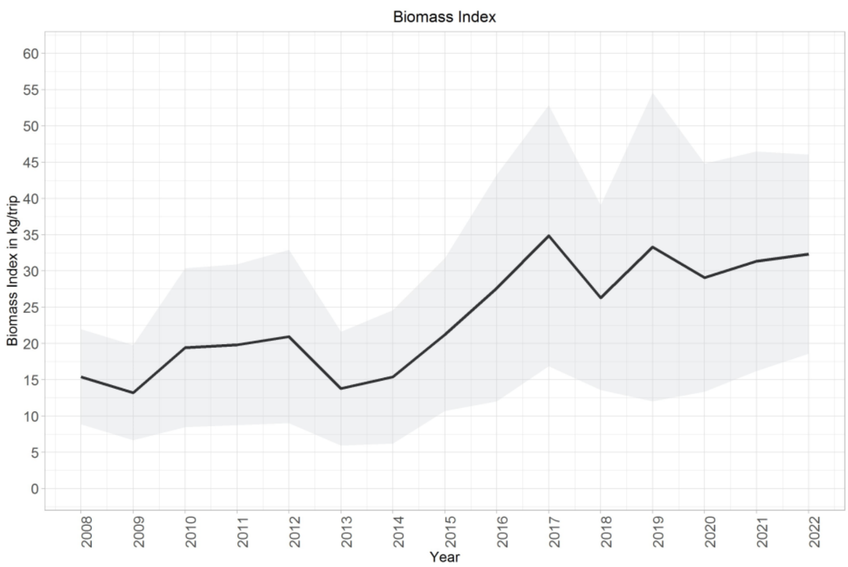

Figure 4.4 *Raja brachyura* in ICES Division 27.9a. Exploitable biomass index (kg.trip^{-1}) and respective standard error for the period 2008-2022.

4.3.5 Life-history parameters

Key life-history parameters, namely the length-weight relationship, length-at-maturity, growth rates and annual fecundity of *R. brachyura* can be found in Maia et al. (2023a).

The selected parameters used to obtain a mean prior for the intrinsic rate of biomass increase (r) are summarized below.

Length-weight relationship parameters considered were: a= 0.00198 and b= 3.2, according Serra-Pereira et al. (2010).

Estimates of the length at which 50% of the population is mature (L50%) and length at which 95% of the population is mature (L95%) for this stock are available from Maia et al. (2022). A L50% of 95.2 cm and a L95% of 101.3 cm (both values estimated for females) were considered. Fecundity was assumed to be 115 eggs/female/year (Maia et al., 2022).

There are two studies regarding the growth of *R. brachyura* in this area, in particular from Farias (2005) and Pina-Rodrigues (2012) (see details in Maia et al., 2023a), but, for both, age readings and consequent von Bertalanffy Growth Parameters (VBGP) estimates are uncertain. Thus, and following the methodology defined for other *R. brachyura* stocks (rjh.27.4bc7d) previously benchmarked (ICES, 2023a), the VBGP considered for this stock were obtained from the average values estimated for *R. brachyura* females in three studies: Holden, 1972; Fahy, 1989 (mean value from four different study areas) and Gallagher et al., 2005. The parameters considered were: Linf = 134.31 cm, K = 0.182 y–1 and t0 = –0.56.

Following the methodology defined for other elasmobranch stocks previously benchmarked (ICES, 2023a), natural mortality (M) was estimated as 0.23 and is derived from Then et al., (2015) (M=4.118∗ K0.73∗Linf–0.33).

A value for the maximum age (tmax) was extracted from the database of life history correlations available in the FishLife R package (Thorson et al., 2023). The maximum value, from those available for *R. brachyura*, was chosen (tmax = 17 y).

4.4 Stock assessment

The stock rjh.27.9a has been assessed under category 3 (trend-based assessment) since 2014.

In 2022, last assessment year, the advice followed ICES guidelines for category 3 stocks which involves the application of the rfb rule (ICES, 2021; ICES, 2022). The standardized commercial LPUE time-series was used as an indicator of stock development. The advice was based on the recent advised catches, multiplied by the ratio of the mean of the last two index values (index A) and the mean of the three preceding values (index B), a ratio of observed mean length in the catch relative to the target mean length (length-based indicators, length distributions from the Portuguese commercial polyvalent and trawl fleets combined as input data), a biomass safeguard, and a precautionary multiplier.

For the present benchmark, the proposal was focused on evaluating the application of a surplus production model SPiCT (Stochastic Production model in Continuous Time, Pedersen and Berg 2017) on the stock for providing advice.

4.4.1 Priors

Intrinsic rate of biomass increase (r)

A prior probability distribution was considered for the intrinsic rate of biomass increase (*r*). A Leslie matrix was built using the biological variables available for *R. brachyura* (see section 4.3.5 and Table 4.5) to obtain a mean prior value for the intrinsic rate of increase (*r*). The *jbleslie* function in the R package JABBA (Winker et al., 2018) was used to return a value of $r = 0.22$. This value was considered for model's runs.

For this prior, runs considering CVs of 0.2 and 0.5 were both tested.

Table 4.5 Raja brachyura in ICES Division 27.9a. Biological variables used in the call to JABBA::jbleslie() to obtain a mean prior for the intrinsic rate of biomass increase (r) using a Leslie matrix calculation of female net reproductive rate.

Min age	Max age	Linf	k	t0	LWR a	LWR b	M	fec	L50%	L95%
0	17	134.31	0.182	-0.56	0.00198	3.2	0.23	115	95.2	101.3

An extra run considering a higher *r* (0.33 with a CV of 0.5), similar to the one considered for the stock rjh.27.4bc7d previously benchmarked (ICES, 2023a), was also tested.

Production curve (n)

All models tested considered a prior for the production curve: Schaefer, tighter Schaefer or no prior.

Initial depletion rate (bkfrac)

A prior for *bkfrac* was tested in some runs. But since for this stock, there is no informative basis to justify the level of any initial depletion, a range of values from 0.1 to 0.5 were tested.

Noise ratios

Priors *logalpha* and *logbeta* were disabled as recommended in the SPiCT handbook and guidelines.

4.4.2 Model's input data

- Catch: Stock landings (2000-2022) (Figure 4.5)
- Index 1: PT LPUE (2008-2022, set at the middle of the year) (Figure 4.5)

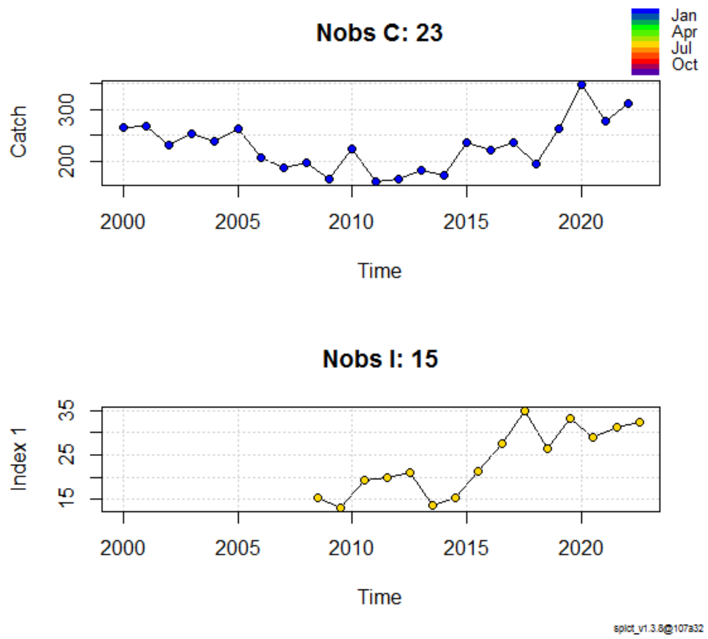

Figure 4.5: Raja brachyura in ICES Division 27.9a. Input data.

4.4.3 Exploratory assessments

Various simulation scenarios were tested, differing in terms of the time series considered for catches and the introduction of informative priors on parameters *r*, *n*, and *bkfrac*. Altogether, 53 scenarios were explored (results for all the runs are available in the SharePoint data folder). Here we present the most relevant models considered to achieve a final assessment.

Model 2 was considered the reference model. It considered a Schaefer production curve, which is more adequate taking into account the life history of the species and when dealing with data poor stocks with short time series. Priors adopted were:

- Schaefer production curve: rjh_data$phases$logn <- -1
- Initial depletion level (rjh_data$priors$logbkfrac <- c(log(0.20),0.2,1)
- Intrinsic rate of population increase (r): rjh_data$priors$logr <- c(log(0.22),0.2, 1)
- Alpha: rjh_data$priors$logalpha <- c(1, 1, 0)
- Beta: rjh_data$priors$logbeta <- c(1, 1, 0)

Given the CV considered for both *r* and *bkfrac* in model 2, a new run adjusting CV to 0.5 was performed (model 27). Results from model 27 showed that autocorrelation is present in the index results (LBox *p*=0.05) (Table 4.6, Figures 4.6-4.8).

A sensitivity analysis around the prior for *bkfrac* (no prior, 0.1, 0.3 and 0.5) showed that the model was highly sensitive to this *bkfrac* prior, resulting in highly variable initial depletion rates estimates, between 0.1 and 0.38 (Table 4.6 and Figure 4.9: models 26, 15, 17 and 38). Resulting estimates of F/F_{msy} and B/B_{msy} were also highly variable depending on the prior considered for *bkfrac*, varying between 0.99-1.32 and 0.36-1.14, respectively. Furthermore, model 26 (no prior for *bkfrac*) showed large confidence intervals outside the acceptable range (more than 1 degree of magnitude) for B/B_{msy}. For model 15 (*bkfrac* prior = 0.3), the diagnostics showed that autocorrelation is present in the index results (LBox *p*=0.014) and retrospective bias for B/B_{msy} failed to fall within the acceptable range for long-lived species (Mohn's Rho ϱ = − 0.15–0.2).

Table 4.6 Raja brachyura in ICES Division 9a. SPiCT model priors and results summary for models 2, 27, 26, 15, 17, 38.

	Model 2	Model 27	Model 26	Model 15	Model 17	Model 38
Input series						
C	2000-2022	2000-2022	2000-2022	2000-2022	2000-2022	2000-2022
I1 (PT LPUE)	2008-2022	2008-2022	2008-2022	2008-2022	2008-2022	2008-2022
Priors						
logn (production curve)	$phases$logn <- -1	$phases$logn <- -1	$phases$logn <- -1	$phases$logn <- -1	$phases$logn <- -1	$phases$logn <- -1
logr (intrinsic biomass growth)	c(log(0.22),0.2, 1)	c(log(0.22),0.5, 1)	c(log(0.22),0.5, 1)	c(log(0.22),0.5, 1)	c(log(0.22),0.5, 1)	c(log(0.22),0.5, 1)
logalpha	c(1, 1, 0)	c(1, 1, 0)	c(1, 1, 0)	c(1, 1, 0)	c(1, 1, 0)	c(1, 1, 0)
logbeta	c(1, 1, 0)	c(1, 1, 0)	c(1, 1, 0)	c(1, 1, 0)	c(1, 1, 0)	c(1, 1, 0)
logbkfrac	c(log(0.20),0.2,1)	c(log(0.2),0.5,1)	-	c(log(0.3),0.5,1)	c(log(0.5),0.5,1)	c(log(0.1),0.5,1)
Diagnostics						
1. Convergence	0	0	0	0	0	0
2. Finite parameters	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
3. Violation of model assumptions (> 0.05)						
shapiro	OK	OK	OK	OK	OK	OK
bias	OK	OK	OK	OK	OK	OK
LBox	OK	I1(0.05)	OK	I1(0.014)	OK	OK
4.Retrospective pattern						
Mohn's Rho (-0.2 < mohns_rho < 0.2)						
BBmsy	-0.05	0.05	1.02	0.20	0.08	0.01
FFmsy	0.07	-0.03	-0.17	-0.04	-0.04	-0.04
5.Realistic production curve	0.50	0.50	0.50	0.50	0.50	0.50
6. Assessment uncertainty	1,1	1,1	2,1	1,1	1,1	1,1
7. Initial values sensitivity	OK	OK	OK	OK	OK	OK
Model parameter estimates						
r	0.24	0.33	0.30	0.36	0.27	0.29
n	2	2	2	2	2	2
Bkfrac	0.19	0.17	0.11	0.20	0.38	0.10
B/Bmsy	0.72	0.60	0.40	0.71	1.14	0.36
F/Fmsy	1.09	1.22	1.30	1.18	0.99	1.32
Obj. function	2.29	3.55	6.39	3.99	4.61	3.38

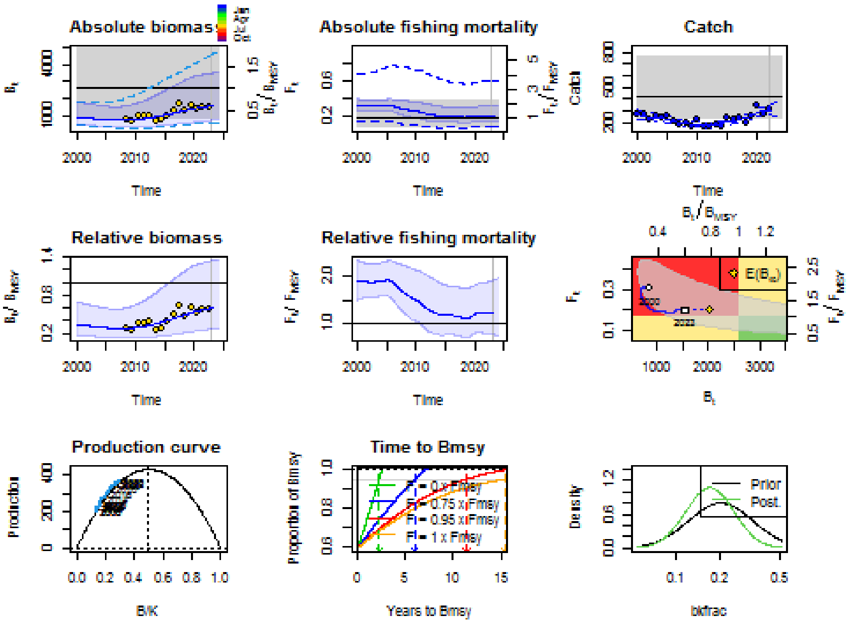

Figure 4.6 Raja brachyura in ICES Division 27.9a. Run 27: results from SPiCT model.

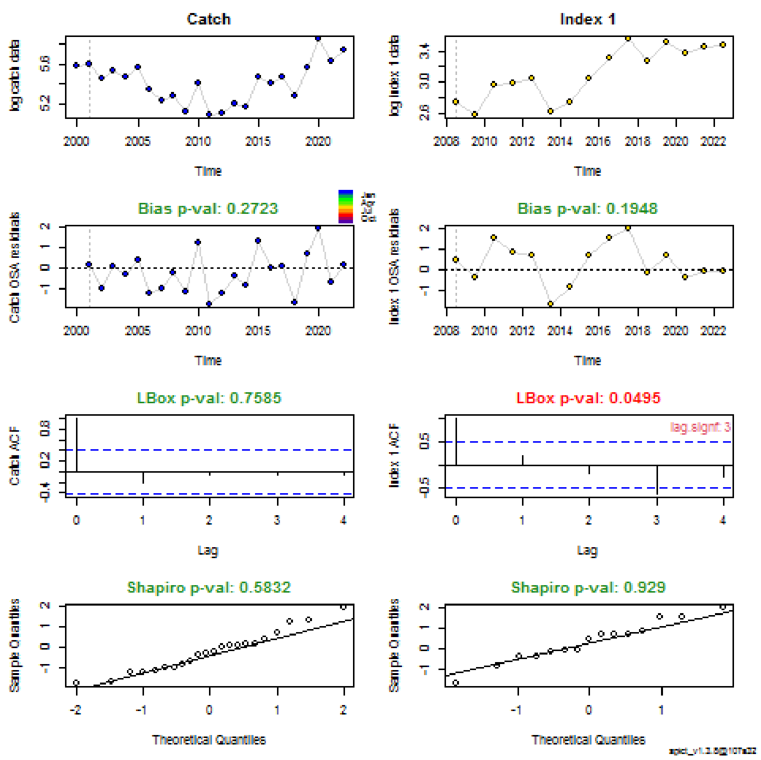

Figure 4.7 Raja brachyura in ICES Division 27.9a. Run 27: results from SPiCT model. Row1, Log of the input data series. Row 2, OSA residuals with the p-value of a test for bias. Row 3, empirical autocorrelation of the residuals with tests for significant autocorrelation. Row 4, tests for normality of the residuals, QQ-plot and Shapiro test.

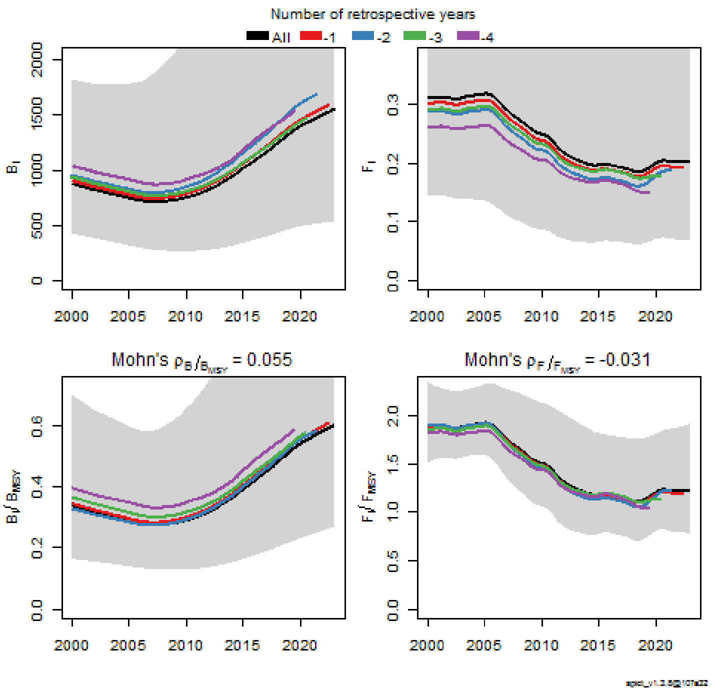

Figure 4.8 Raja brachyura in ICES Division 27.9a. Run 27: results from SPiCT model; retrospective analysis. Upper panel, absolute biomass and fishing mortality. Lower panel, relative biomass and fishing mortality. Grey regions represent 95% CIs.

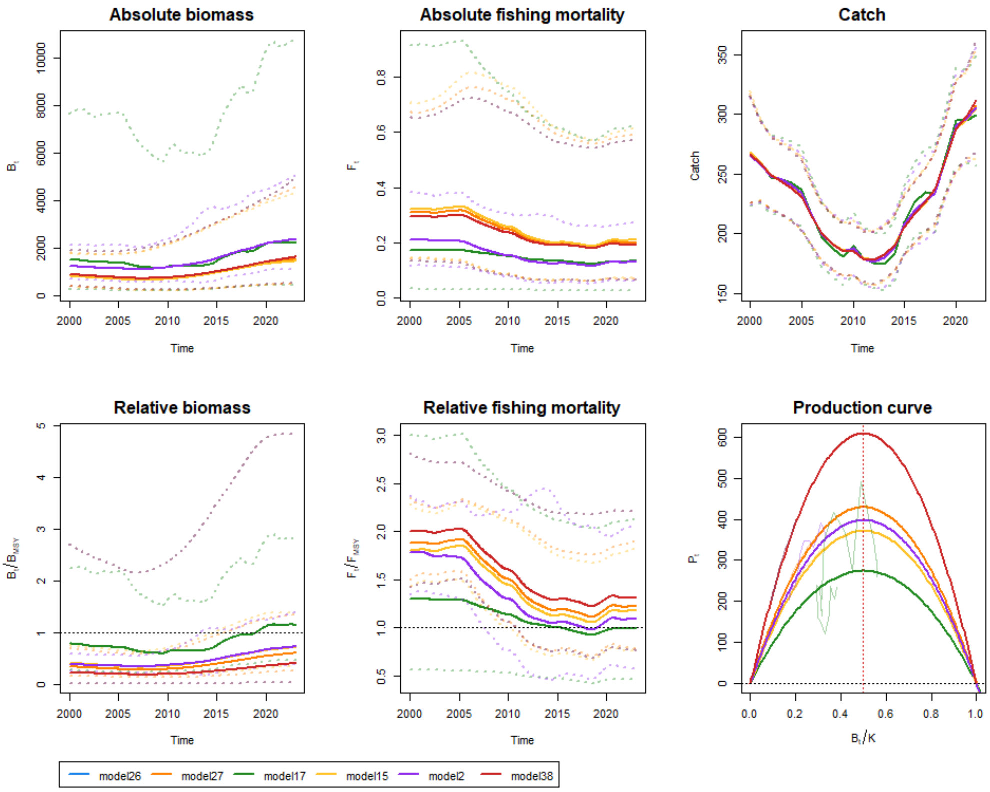

Figure 4.9 Raja brachyura in ICES Division 27.9a. Comparison among SPiCT models 2, 27, 26, 15, 17 and 38.

To potentially solve the model's high sensitivity to *bkfrac*, it was suggested to match the time periods considered for both catch series and biomass index, i.e., consider only the period 2008-2022. Runs considering different priors for *bkfrac* (no prior, 0.2, 0.3 and 0.5) were performed, resulting in highly variable initial depletion rates estimates, between 0.08-0.38 (models 40 to 43 in the Data folder). Resulting estimates of F/F_{msy} and B/B_{msy} were also highly variable depending on the prior considered for *bkfrac*, between 0.38-1.20 and 0.38-1.59, respectively.

Given the persistent model sensitivity to *bkfrac*, it was decided to proceed with models without setting a prior for *bkfrac*: models 26; 40 and 45 (details in the Data folder). These models only differed in the time series period considered and in uncertainty associated to landings. Three options were considered: 1) all-time series (model 26), 2) shorter time series from 2008-2022 (model 40) and; 3) all-time series with uncertainty associated to the reconstructed period for catches, from 2000-2007 (model 45). Results for the three models showed large confidence intervals outside the acceptable range (more than 1 degree of magnitude) for B/B_{msy}. Furthermore, the retrospective bias for B/B_{msy} failed to fall within the acceptable range.

These former models, showed a very low estimate for *sdb* (close to zero). To potentially correct the overfitting of the production curve, a process error (*sdb*) prior of 0.15 with a CV of 0.5 was considered: models 48, 49 and 50 (Table 4.7, Figure 4.10). Models 48 and 49 showed large confidence intervals outside the acceptable range, in particular for B/B_{msy}. Models 48 and 50 had retrospective bias for B/B_{msy} failing to fall within the acceptable range (Mohn's Rho ϱ of 0.32 and 0.3, respectively).

Table 4.7 Raja brachyura in ICES Division 9a. SPiCT model priors and results summary for models 48, 49 and 50.

	Model 48	Model 49	Model 50
Input series			
C	2000-2022	2008-2022	2000-2022
I1 (PT LPUE)	2008-2022	2008-2022	2008-2022
Increased uncertainty (stdev)			
C	-	-	2000-2007
Priors			
logn (production curve)	$phases$logn <- -1	$phases$logn <- -1	$phases$logn <- -1
logr (intrinsic biomass growth)	c(log(0.22),0.5, 1)	c(log(0.22),0.5, 1)	c(log(0.22),0.5, 1)
logalpha	c(1, 1, 0)	c(1, 1, 0)	c(1, 1, 0)
logbeta	c(1, 1, 0)	c(1, 1, 0)	c(1, 1, 0)
logsdb	c(log(0.15), 0.5, 1)	c(log(0.15), 0.5, 1)	c(log(0.15), 0.5, 1)
logbkfrac	-	-	-
Diagnostics			
1. Convergence	0	0	0
2. Finite parameters	TRUE	TRUE	TRUE
3. Violation of model assumptions (> 0.05)			
shapiro	OK	OK	OK
bias	OK	OK	OK
LBox	OK	OK	OK
4.Retrospective pattern			
Mohn's Rho (-0.2 < mohns_rho < 0.2)			
BBmsy	0.32	0.13	0.35
FFmsy	-0.11	-0.11	-0.16
5.Realistic production curve	0.50	0.50	0.50
6. Assessment uncertainty	2,1	3,1	1,1
7. Initial values sensitivity	OK	OK	OK
Model parameter estimates			
r	0.28	0.24	0.28
n	2.00	2.00	2.00
sdb	0.10	0.10	0.11
Bkfrac	0.23	0.22	0.27
B/Bmsy	0.75	0.98	0.91
F/Fmsy	1.20	0.86	1.10
Obj. function	7.76	12.02	10.28

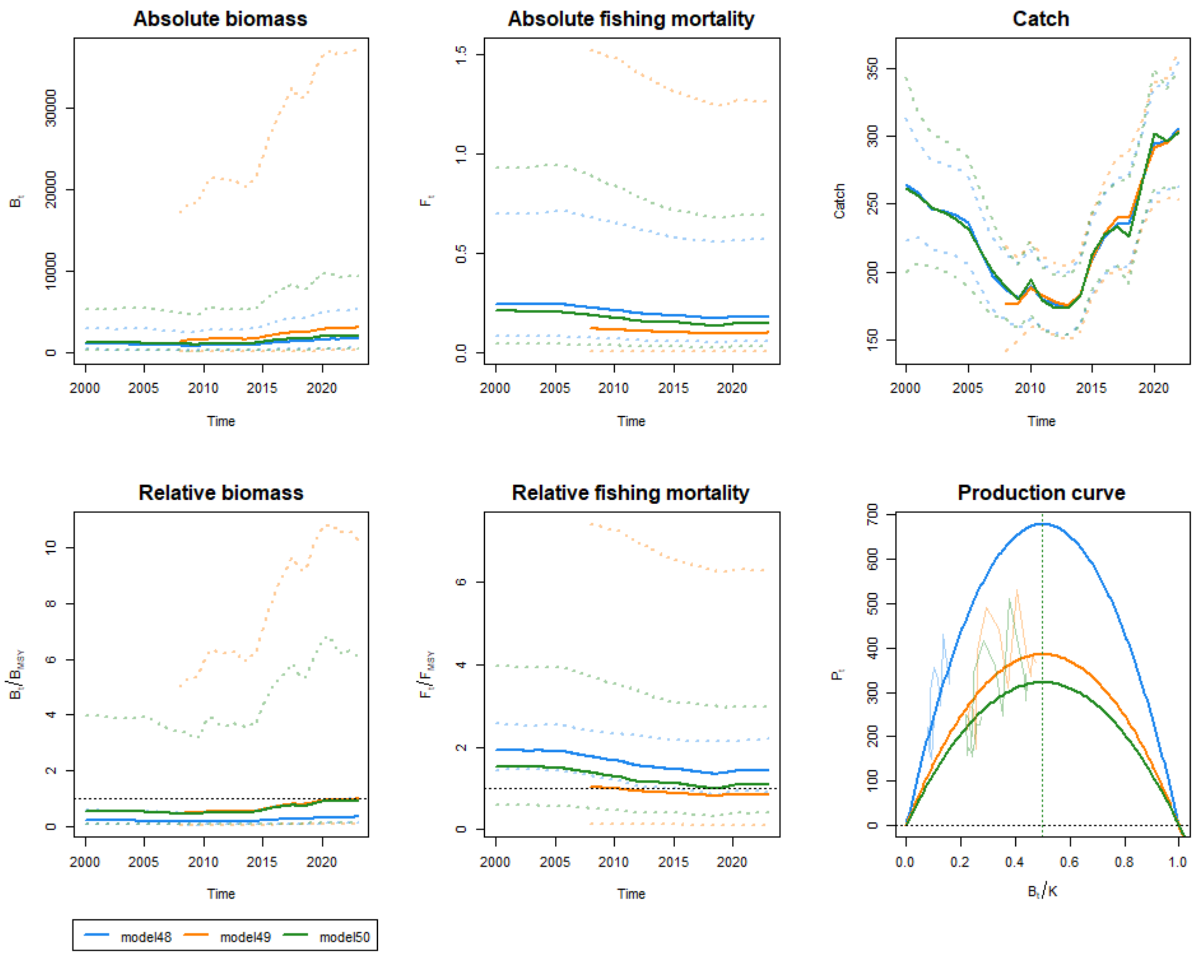

Figure 4.10 Raja brachyura in ICES Division 27.9a. Comparison among SPiCT models 48, 49 and 50.

4.4.4 Final assessment

The model that best fits the data available was model 50. The parameter settings used for this assessment are found in (Table 4.7), and the results, diagnostics and retrospective analysis in Figures 4.11-4.13. High uncertainties around the estimates of F and B, and strong retrospective patterns were found.

Furthermore, a hindcast cross-validation was performed for this assessment (3 years) (Figure 4.14). A Mean Absolute Scaled Error (MASE) of 1.32, larger than 1, indicates that the model has no prediction skill for the index.

Finally, a sensitivity analysis test was carried out from model 50 to assess the sensitivity of the model to a possible increase or reduction of the biomass index by 50% in the near future. Results showed highly variable initial depletion rates estimates, between 0.16 and 0.50, and estimates of F/F_{msy} and B/B_{msy} also highly variable, between 0.93-1.12 and 0.63-1.28, respectively. Furthermore, results showed large confidence intervals outside the acceptable range (more than 1 degree of magnitude) for B/B_{msy} and F/F_{msy}. The retrospective bias for B/B_{msy} failed to fall within the acceptable range.

All these results indicate that with the current input data, no specification of the SPiCT model could lead to an acceptable assessment of the stock rjh.27.9a (Table 4.8, Figures 4.15-4.17).

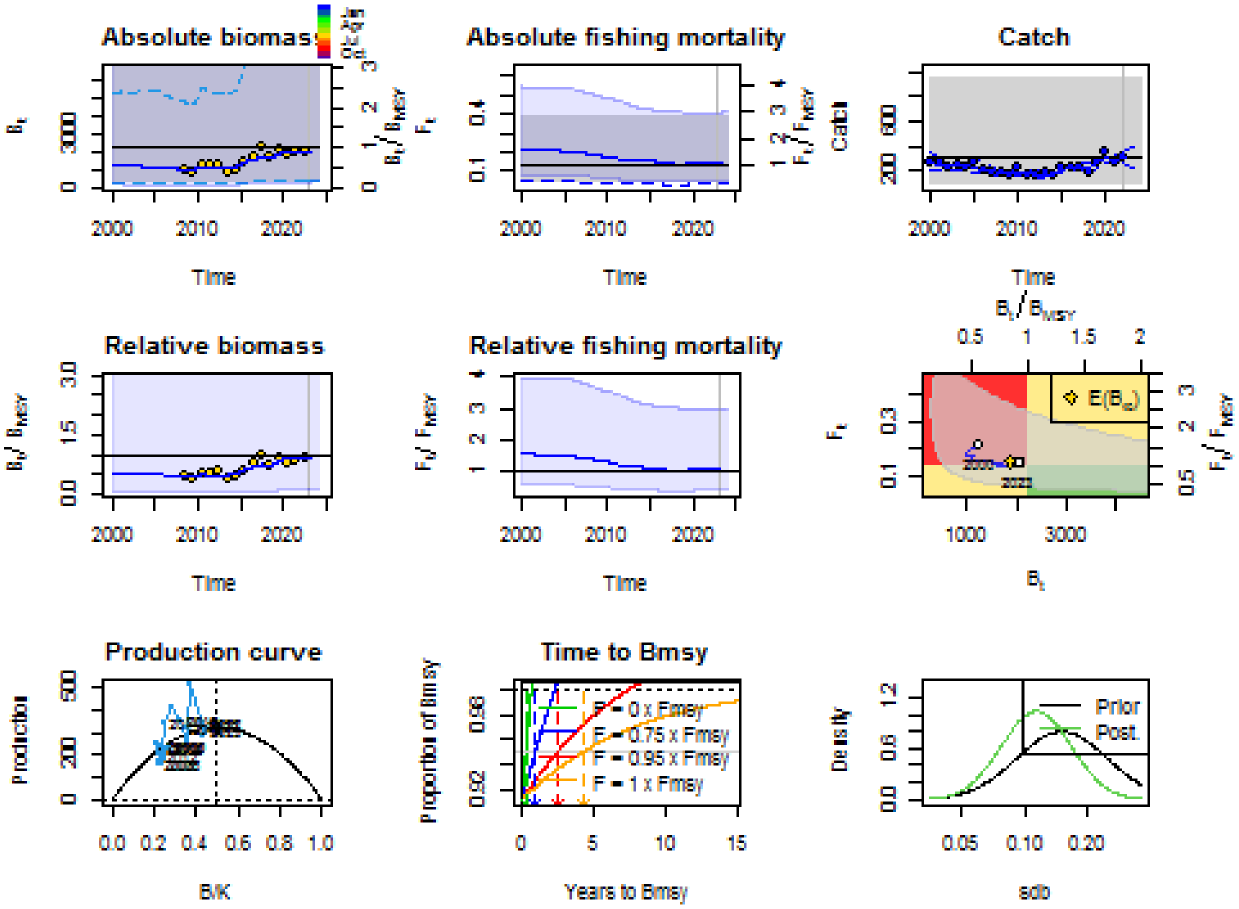

Figure 4.11 Raja brachyura in ICES Division 27.9a. Model 50: results from SPiCT model.

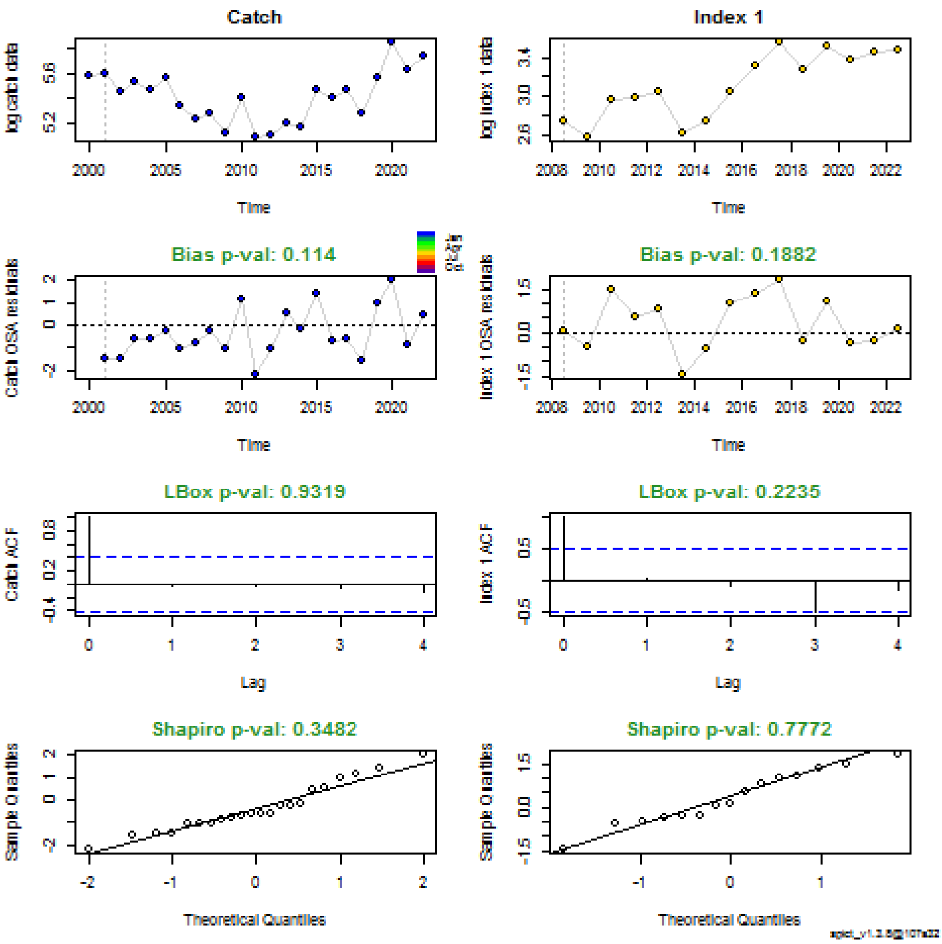

Figure 4.12 Raja brachyura in ICES Division 27.9a. Model 50: results from SPiCT model. Row1, Log of the input data series. Row 2, OSA residuals with the p-value of a test for bias. Row 3, Empirical autocorrelation of the residuals with tests for significant autocorrelation. Row 4, Tests for normality of the residuals, QQ-plot and Shapiro test.

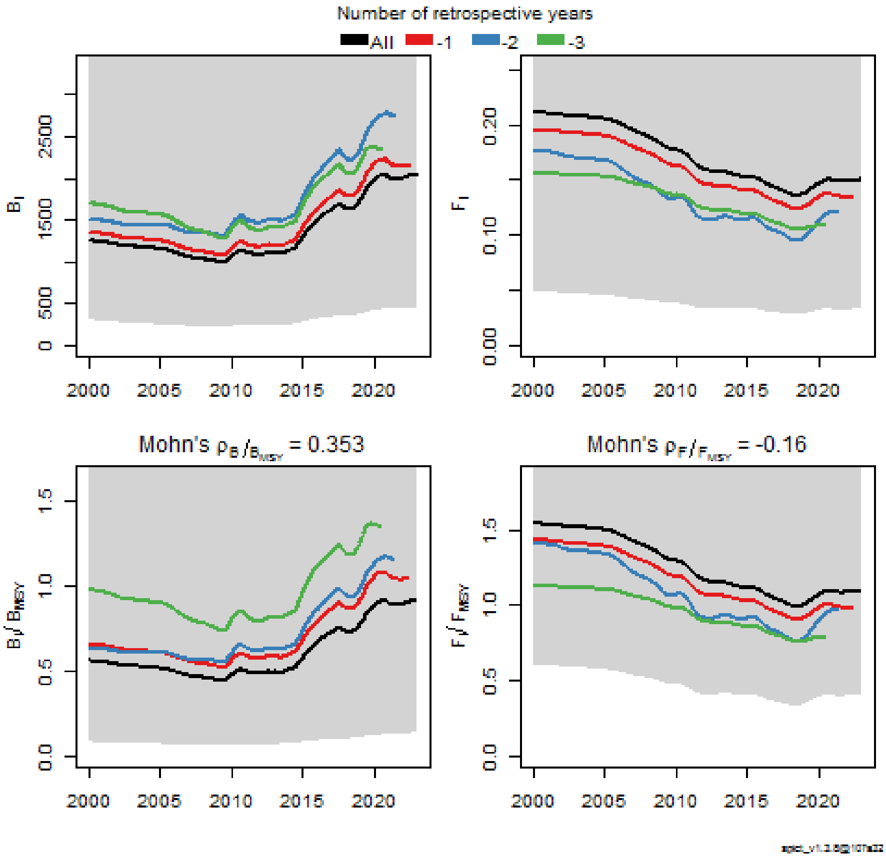
Number of retrospective years
All
-1
-2
-3
Mohn's ρB/BMSY = 0.353
Mohn's ρF/FMSY = -0.16

Figure 4.13 Raja brachyura in ICES Division 27.9a. Model 50: results from SPiCT model; retrospective analysis. Upper panel, absolute biomass and fishing mortality. Lower panel, relative biomass and fishing mortality. Grey regions represent 95% CIs.

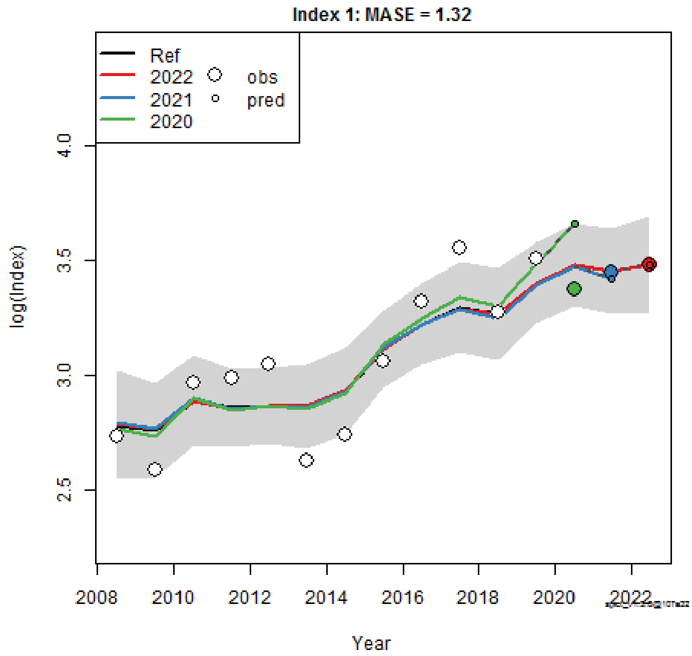

Figure 4.14 Raja brachyura in ICES Division 27.9a. Hindcast cross-validation for model 50.

Table 4.8 Raja brachyura in ICES Division 9a. SPiCT model 50 sensitivity analysis.

	Model 50	Model 50 (+50%)	Model 50 (-50%)	Model 50 (saly)
Input series				
C	2000-2022	2000-2023	2000-2023	2000-2023
I1 (PT LPUE)	2008-2022	2008-2023	2008-2023	2008-2023
Increased uncertainty (stdev)				
C	2000-2007	2000-2007	2000-2007	2000-2007
Priors				
logn (production curve)	$phases$logn <- -1	$phases$logn <- -1	$phases$logn <- -1	$phases$logn <- -1
logr (intrinsic biomass growth)	c(log(0.22),0.5, 1)	c(log(0.22),0.5, 1)	c(log(0.22),0.5, 1)	c(log(0.22),0.5, 1)
logalpha	c(1, 1, 0)	c(1, 1, 0)	c(1, 1, 0)	c(1, 1, 0)
logbeta	c(1, 1, 0)	c(1, 1, 0)	c(1, 1, 0)	c(1, 1, 0)
logsdb	c(log(0.15), 0.5, 1)	c(log(0.15), 0.5, 1)	c(log(0.15), 0.5, 1)	c(log(0.15), 0.5, 1)
logbkfrac	-	-	-	-
Diagnostics				
1. Convergence	0	0	0	0
2. Finite parameters	TRUE	TRUE	TRUE	TRUE
3. Violation of model assumptions (> 0.05)				
shapiro	OK	OK	OK	OK
bias	OK	OK	OK	OK
LBox	OK	OK	OK	OK
4.Retrospective pattern				
Mohn's Rho (-0.2 < mohns_rho < 0.2)				
BBmsy	0.35	0.62	0.07	0.20
FFmsy	-0.16	-0.12	-0.18	-0.10
5.Realistic production curve	0.50	0.50	0.50	0.50
6. Assessment uncertainty	1,1	2,1	1,1	1,1
7. Initial values sensitivity	OK	OK	OK	OK
Model parameter estimates				
r	0.28	0.28	0.28	0.29
n	2.00	2.00	2.00	
sdb	0.11	0.10	0.12	0.11
logbkfrac	0.27	0.16	0.50	0.26
rold	0.28	0.28	0.28	0.29
B/Bmsy	0.91	0.63	1.28	0.89
F/Fmsy	1.10	1.15	0.93	1.12
Obj. function	10.28	10.25	12.89	8.66

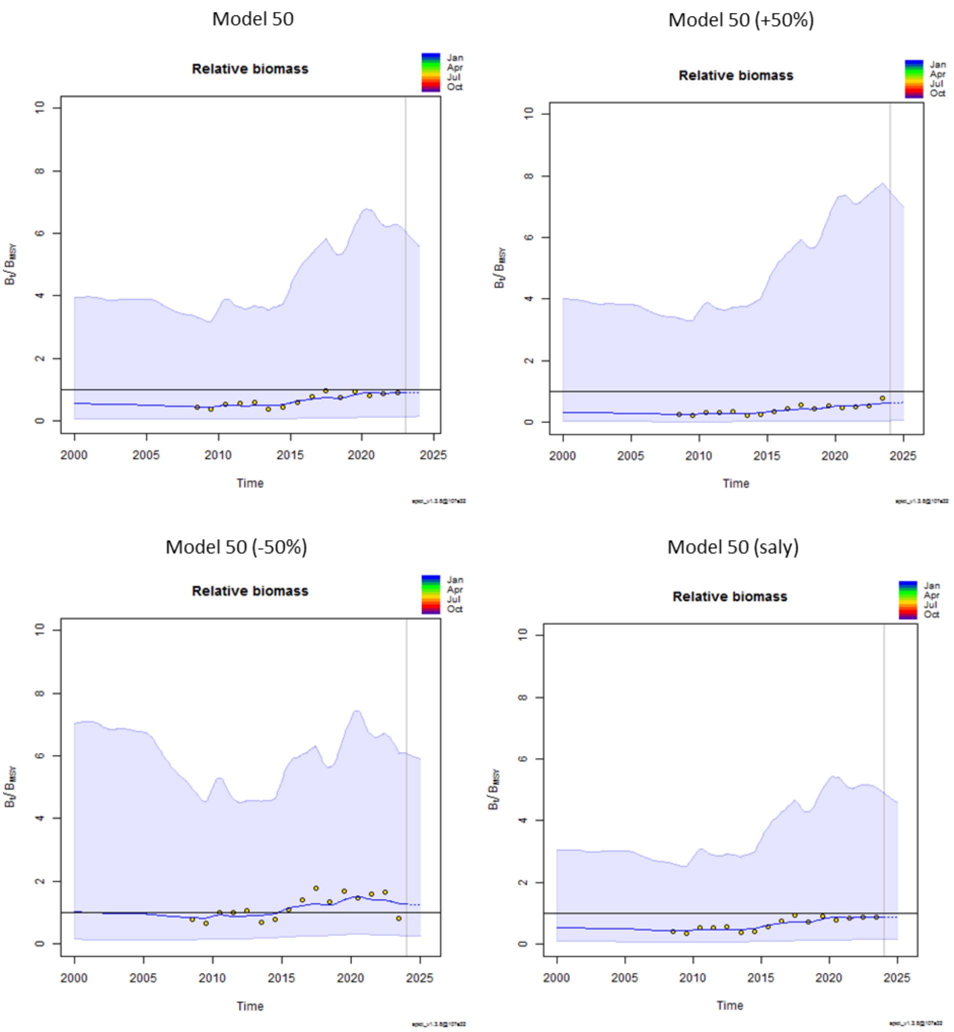

Figure 4.15 Raja brachyura in ICES Division 27.9a. Model 50 sensitivity analysis: Plots for the relative biomass.

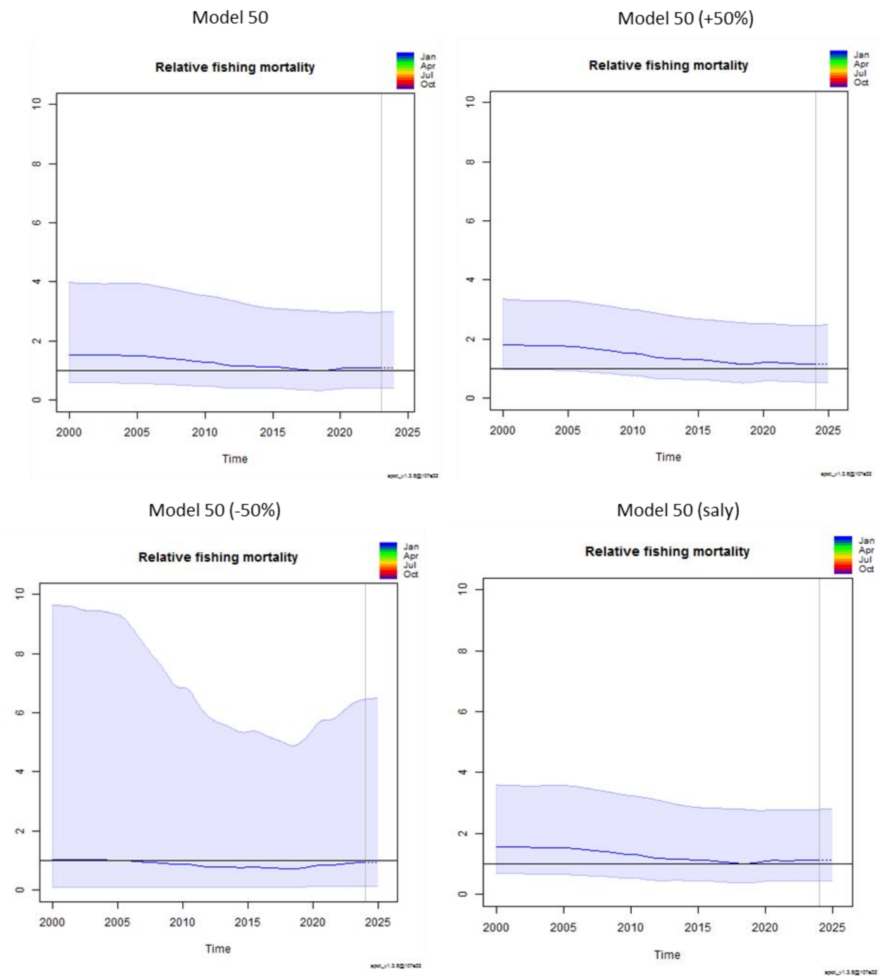

Figure 4.16 Raja brachyura in ICES Division 27.9a. Model 50 sensitivity analysis: Plots for the relative fishing mortality.

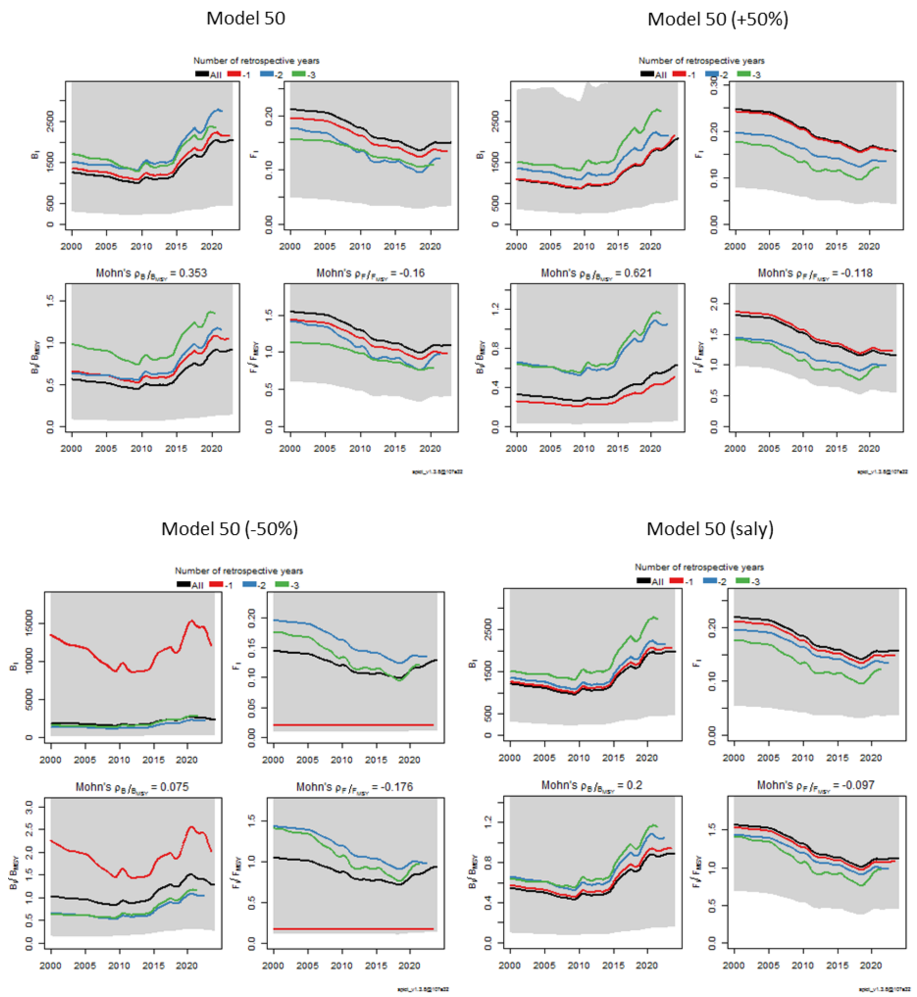

Figure 4.17 Raja brachyura in ICES Division 27.9a. Model 50 sensitivity analysis: Plots of the retrospective analysis.

4.4.5 Conclusion

For *R. brachyura* in ICES Division 9a, SPiCT assessments using landings since 2000 and one series of biomass indices (PT-LPUE from polyvalent fleet) since 2008 were tested but not accepted. The model was highly sensitive to *bkfrac*, resulting in high confidence intervals for the relative biomass and fishing mortality. The group agreed that the stock should remain in category 3 and the advice given according to the *rfb* rule.

4.5 Future considerations/recommendations

The group recommended that a SPiCT model without a *bkfrac* prior should be tested in the forthcoming years as the inclusion of more years and data would improve the model fit.

Since the assessment, in the absence of any relevant survey, is highly dependent on the LPUE series, any improvement of the data used and/or statistical treatment should be encouraged to better provide an index more representative of the abundance of the stock.

4.6 Reviewers report

Landings data were available from 2008-2022 from the Portuguese fishery and 2009-2022 for the Spanish fishery, but were estimated back in time until 2000, see the working document by Maia et al. (2023a) from the data evaluation workshop and Rodriguez-Cabello et al. (2024) for the methods used. A commercial standardized LPUE time-series index based on data derived from the Portuguese polyvalent fleet was considered to provide information on trends in stock size. The LPUE standardization methodology is described in Maia *et al.* (2023b). No fishery-independent survey time series is available for this stock.

Various parameter settings were presented for consideration within the SPiCT model to evaluate the stock status. SPiCT offers flexibility in defining parameters by either setting fixed values, specifying priors, or allowing parameters to be estimated without priors.

Among these parameters is the intrinsic population growth rate *r*. Diverse estimates of *r* were reviewed, and ultimately, the methodology outlined in WKBELASMO2 (ICES 2023) was selected. This methodology employs the *jbleslie* function from the R package JABBA (Winker et al. 2018). Following this methodology the estimated *r* was 0.22 and that value was selected as the prior median for this parameter. Another influential parameter in modeling stock dynamics using the SPiCT method is *n*, which shapes the production curve. After model explorations and consulting with a domain expert (Casper Berg, DTU Aqua), it was concluded that for stocks characterized by limited data availability and relatively short time series, assuming a symmetric Schaefer production curve *n*=2 was a reasonable and practical approach.

A third essential parameter is *bkfrac*, the parameter that defines the level of biomass in the first year of the model in comparison to *K*. It became evident through multiple iterations that model outcomes were significantly influenced by this parameter. Moreover, there was insufficient empirical basis to establish a specific prior value. Consequently, it was determined that *bkfrac* should be estimated in the model without a prior distribution. This decision was further supported by the strong relationship between the initial *bkfrac* and final B/B_{msy} in a Schaefer-based model. See further commentary on *bkfrac* in the thornback ray review section.

Considering that landings were reconstructed from 2007 backwards a higher degree of uncertainty was assumed for this subset of the landings (2000-2007) by multiplying the standard deviation of those observations by 2.

To allow annual variation in surplus production from the deterministic Schaefer curve, a prior on the standard deviation on the biomass process *sdb* was defined with a median value of 0.15 and a CV of 0.5. Those values were provided by a meta-study and were used during WKLIFEII (ICES 2023).

Stock assessment model

The model including the data input and parameter settings described above was considered the best modeling approach, similar to the models recommended for thornback ray and cuckoo ray in this benchmark. The model results for blonde ray, however, showed extremely high levels of uncertainty about the historical and current stock status, rendering it useless as a basis for providing scientific advice for the management of the stock. The model can still be seen as a useful tool to faithfully present the high degree of uncertainty about the population dynamics and status of this stock.

A sensitivity test of model stability was performed by simulating one new year of data with the same landings as the previous year and one new LPUE index that is -50%, same, or +50% compared to the previous year. The results of this test showed that the model estimates were greatly affected by one extra year of data, and in some cases the model estimates of stock status responded in the opposite direction from what could be expected. This further indicated that the model was unstable and not suitable to provide advice.

Conclusion

The SPiCT assessment of blonde ray in division 9a was not considered suitable for providing management advice. The panel recommends revisiting the model as new data become available in coming years to evaluate if longer time series of more informative data can solve model issues. The main criteria to monitor are standard SPiCT diagnostics and the overall uncertainty in the relative B/B_{msy}. A future fishery-independent survey for this stock could help reduce the overall uncertainty.

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5 Cuckoo ray (*Leucoraja naevus*) in Division 9.a (Atlantic Iberian waters) (**rjn.27.9a**)

5.1 Introduction

The cuckoo ray (*Leucoraja naevus)* has a wide geographic distribution in the North-east Atlantic and Mediterranean (Stehmann and Bürkel, 1984). In Atlantic Iberian waters, the species presents a patchy distribution along the shelf and upper slope, occurring at depths ranging from 30 m to 700 m, being particularly abundant between 260 and 520 m depth (ICES, 2021a).

This stock (rjn.27.9a), which comprises the ICES Division 9a, includes the north Spanish area (Galician waters), Portuguese mainland waters and south Spanish waters (Gulf of Cadiz). Scientific advice on this stock is provided by ICES every two years. Since 2014 it is assessed under the ICES category 3 for Data limited stocks (DLS), based on biomass trend from the research surveys (average of normalized series) conducted in the Gulf of Cadiz in Q1 and Q4 (ICES, 2022a). In 2020, methodologies to estimate LPUE indices from the Portuguese commercial polyvalent fleet (mostly operating with gillnets and trammel nets) for different skate species were discussed and approved at WKSKATE (ICES, 2021a). A combined index, based on the average of normalized series from both the Spanish bottom trawl survey in the Gulf of Cadiz (average of both normalized indices Q1 and Q4) and the Portuguese LPUE was proposed as stock size indicator for assessment in 2022. However, the ADGEF considered this new combined index unsuitable for assessing this stock given the contrasting trends of both LPUE and survey index (more information below). As a consequence, the last assessment, in 2022, followed the *rfb* rule (applied for the first time to this stock) using only the research surveys conducted in the Gulf of Cadiz (ARSA surveys).

Among some of the other methods suggested to obtain reference points (RP) for data limited stocks (DLS) are production models (ICES, 2021b) and particularly the stochastic surplus production model in continuous time (SPiCT; Pedersen and Berg, 2017). A compilation and revision of the data available to implement such assessment were conducted at WKBELASMO 3 (see Rodriguez-Cabello et al., 2023 WD; Moura et al., 2024 WD). A summary of these data is presented below followed by several runs of the model, sensitivity analysis and the final accepted assessment.

5.2 Stock Identity

A genetic analysis of cuckoo ray samples from several locations in the North-East Atlantic (around Ireland waters) revealed high diversity and no evidence of stock structure (Nykänen et al., 2020). However, no samples from this stock were included in the analysis. No other population structure studies are known.

Tagging has been carried out in Galician waters but very few recaptures are available to infer about movement patterns. According to a tagging study conducted in the northern waters (ICES subareas 4, 6 and 7 and Divisions 3a and 8abd), cuckoo rays recaptured (n=43 among 521 tagged) were usually caught in the same region of release or adjacent ICES Division (Bird et al., 2020). However, 37.2% of recaptures were from distances >100 km and the maximum distance travelled was 425 km (Bird et al., 2020).

In the absence of any relevant data there is no evidence to revise the current stock limit in the Iberian waters.

5.3 Input data for stock assessment

5.3.1 Fisheries

In Iberian waters, skates are mainly caught as a bycatch in mixed demersal fisheries, which target several species, primarily hake, Norway lobster, anglerfish and megrims. The main fishing gears used are otter trawl, bottom-set gillnets and trammel nets. Countries involved in these fisheries are Spain and Portugal, as detailed below.

5.3.2 Fishing effort

Estimates of fishing effort are only available for some Portuguese fishing fleets. Fishing effort in number of trips is annually reported to WGEF and the series suggests a downward trend for both polyvalent and trawl fleets (ICES, 2022c). Fishing effort for bottom otter trawls targeting demersal fish (in kW*days) is available since 2010 and presents an increase in 2022 after a 5-year period of relatively lower values.

5.3.3 Catch data

5.3.3.1 Landings

Landings of cuckoo ray are available for both Portuguese and Spanish fleets operating in this division. Reconstructed and estimated landings are presented in Figure 5.1 and Table 5.1. Portuguese landings represent, on average, 89% of the total landings reported for this stock. Landings have been relatively stable, around 55 t, from 2000 to 2012 and fluctuated around 38 t since 2013 (Figure 5.1). Management regulations started in 2012 with one-month closure (May) for skates' landings; in August 2014, a minimum landing size was established for all skate species; and in March 2016 the seasonal closure was extended to two months (May and June). In terms of landings by fishing gear, most are provided by the Portuguese polyvalent fleet (between 67 and 81% in the last three years for the overall stock landings, using mainly nets). Bottom trawlers also account for a large proportion of the catches, particularly until 2018 (Figure 5.2). More details are presented in section 2 (Landings reconstruction section), Figueiredo et al., (2020) and Maia et al. (2023 WD).

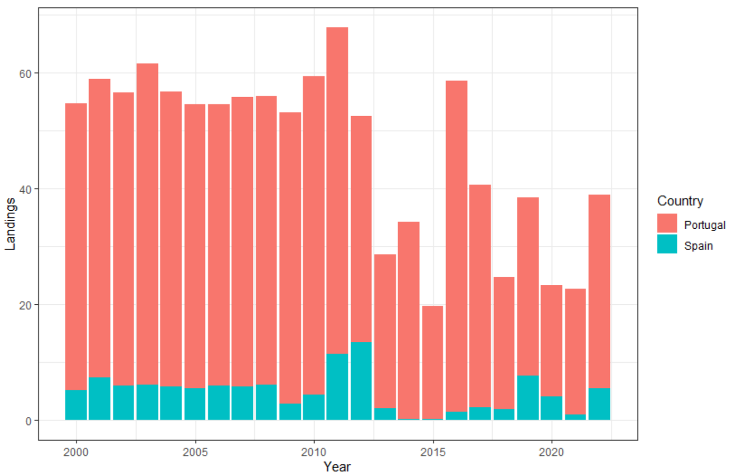


Figure 5.1. *Leucoraja naevus* in ICES Division 27.9a. Total landings for the period 2000 to 2022.

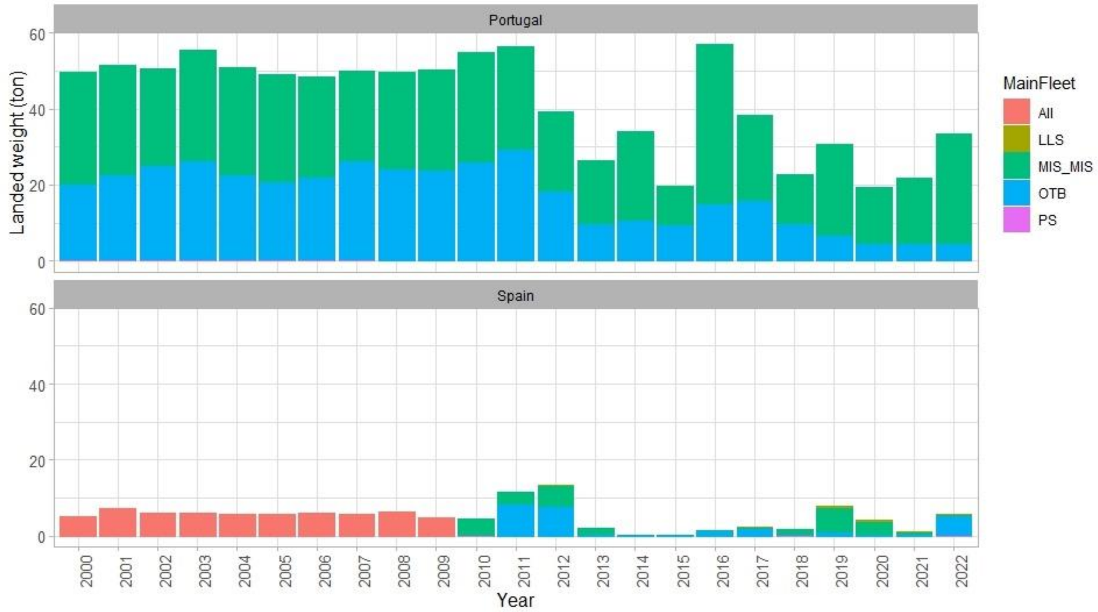


Figure 5.2. ***Leucoraja naevus*** **in ICES Division 27.9a. Landings by country and fishing gear. On the top Portuguese landings on the bottom Spanish landings.**

Table 5.1. ***Leucoraja naevus*** **in ICES Division 27.9a. Total estimated landings by country. Portuguese and Spanish landings were reconstructed for the period 2000-2007 and 2000-2009, respectively. (*) Discards were only available from Spanish fleet and since 2015.**

Year	Spain	Portugal	Total Landings	Discards*	Total Catch
2000	5.1	49.6	54.7		109.4
2001	7.4	51.6	59.0		117.9
2002	6.0	50.7	56.7		113.4
2003	6.1	55.6	61.7		123.4
2004	5.8	50.9	56.7		113.4
2005	5.6	49.1	54.6		109.2
2006	6.0	48.6	54.6		109.2
2007	5.8	50.0	55.8		111.7
2008	6.2	49.8	55.9		111.9
2009	4.9	50.2	55.1		110.2
2010	4.4	55.0	59.3		118.7
2011	4.6	56.4	61.0		122.0
2012	5.0	39.2	44.2		88.3
2013	5.1	26.5	31.7		63.4
2014	4.9	34.2	39.0		78.1
2015	2.7	19.6	22.3	4.0	48.6
2016	3.2	57.2	60.5	41.0	161.9
2017	3.7	38.5	42.2	22.0	106.5
2018	4.1	22.9	26.9	15.9	69.7
2019	4.7	30.6	35.3	7.3	77.9
2020	4.6	19.2	23.8		47.6
2021	3.8	21.7	25.4	0	50.9
2022	5.1	33.4	38.5	2.6	79.5

5.3.3.2 Discards

Discards for cuckoo ray in ICES Division 9a are only reported for the Spanish bottom otter trawl fleet since 2015, being relatively low and highly variable (Table 5.1; Figure 5.3). The low frequency of occurrence registered for the species in discards of the Portuguese trawl fleet indicates that discards can be considered negligible for that particular fleet (Fernandes et al., 2017). In the case of the Portuguese polyvalent fleet, discards are known to take place and assumed to be low, but are not fully quantified as the information available is insufficient to estimate total discards. In summary, based on information available, discards (dead catches) are not fully quantified for this stock and are assumed to be relatively low, and, for these reasons will not be considered for the SPiCT assessment explored in the present benchmark.

Further details on the discards for all skate species was presented to WKSHARKS3 (ICES, 2017a; Serra-Pereira et al., 2017).

A

B

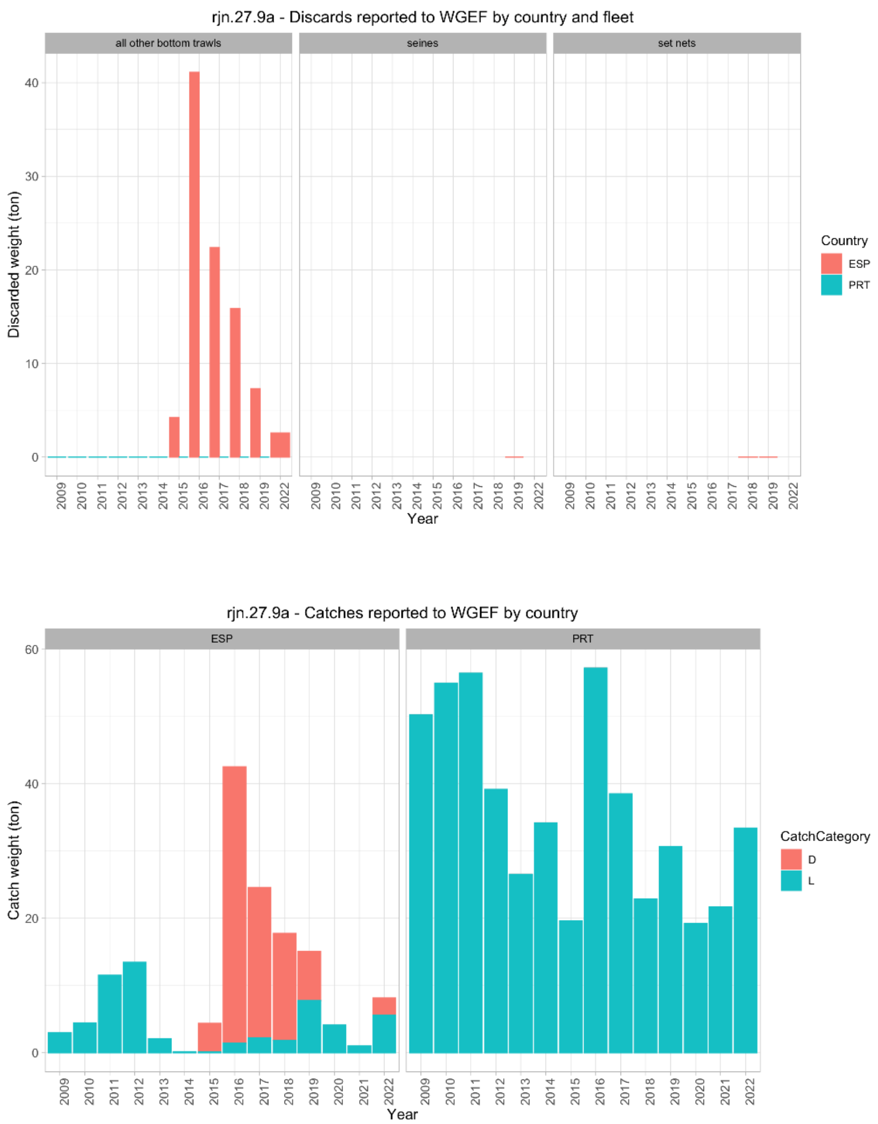


Figure 5.3. Leucoraja naevus in ICES Division 27.9a. (A) Discards reported by country and fleet. (B) Catches reported by country, separated by landings (L) and discards (D).

5.3.3.3 Survival

Discard survival studies on *L. naevus* have been conducted in ICES Division 9a both in Portugal (Serra-Pereira and Figueiredo, 2019) and Spain (Valeiras et al., 2019), covering the main fishing gears catching the species. In summary, based on results for the Portuguese polyvalent fleet, collected under the DCF Skates Pilot Study, a high Categorical Vitality Assessment (CVA) was found for *L. naevus*, with 79% of the individuals caught by vessels operating with mesh size > 180 mm and soaking time > 24h (n=24) were found in Excellent or Good vitality status (Serra-Pereira and Figueiredo, 2019). Yet, according to studies conducted onboard the trawl fleet, under the project DESCARSEL, survival of this species is low compared to other *Rajidae* species (Valeiras *et al*., 2019). The results indicated that ~ 67% of the *L. naevus* caught (n= 503) survive to fishing operations and onboard handling. However, the estimated survival after 36h of captivity was low (21-36%).

5.3.4 Biomass indices

5.3.4.1 Biomass index from *SPGC-GFS-WIBTS-Q1-4* (ARSA surveys)

Two biomass survey indices are available from the annual bottom trawl surveys carried out in spring and autumn in the south of Spain, Gulf of Cadiz (SpGC-GFS-WIBTS-Q1-4), herein ARSA surveys, which represents a small fraction of the total 9a ICES area. Both indices follow the same sampling design since early 2000´s and methodologies. A combined index has been used since 2015 to assess this stock, corresponding to the mean of both series.

The bottom trawl gear catches all sizes, from 11 cm to 70 cm. WKBELASMO agreed to use the exploitable biomass index (TL≥ 35 cm) instead of the total biomass (Figure 5.4 and Table 5.2).

The biomass index of *L. naevus* (1998-2022) fluctuated with an increasing trend until 2018 (maximum of the time series). In 2020, the biomass dropped to low levels and recovered in 2022. Due to problems with the research vessel, the survey was not conducted in 2021.

The initial values of the series are very low (close to zero). Although it can reflect the low abundance of the species in the surveyed area, it is also known that the number of hauls conducted in 1998 and 2000 is lower than in the following years (Table 5.2) and that the survey as extended, in some areas, to deeper water where the species is known to occur.

Due to this, the survey index was restricted to the period 2001-2022.

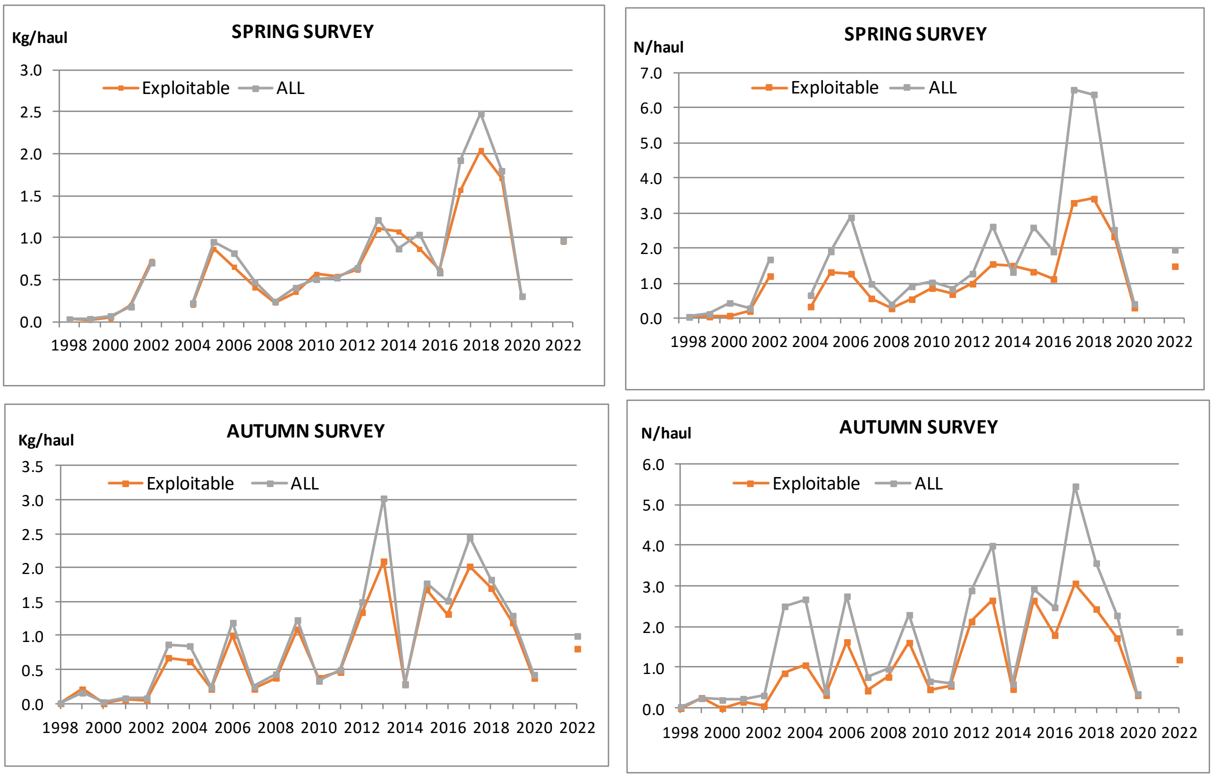


Figure 5.4. *Leucoraja naevus* in ICES Division 27.9a. Time series of biomass (kilograms per haul) on the left and abundance (number/haul) on the right for each of the ARSA surveys conducted in spring or autumn in the Gulf of Cadiz. ALL refers to all cuckoo ray specimens caught whereas exploitable refers to cuckoo rays caught equal or above 35 cm total length.

Table 5.2. *Leucoraja naevus* in ICES Division 27.9a. Exploitable biomass index obtained from the ARSA surveys conducted in the Gulf of Cadiz during spring and autumn since 1998.

		SPRING SURVEY				AUTUMN	
Year	No. hauls	No./haul	Kg/haul	Year	No. hauls	No./haul	Kg/haul
1998	31	0.04	0.03	1998	34	0.00	0.00
1999	38	0.05	0.02	1999	38	0.26	0.21
2000	41	0.08	0.04	2000	30	0.00	0.00
2001	40	0.21	0.20	2001	39	0.16	0.05
2002	41	1.21	0.72	2002	39	0.05	0.04
2003				2003	41	0.86	0.67
2004	40	0.34	0.20	2004	40	1.06	0.62
2005	40	1.32	0.87	2005	42	0.32	0.21
2006	41	1.27	0.65	2006	41	1.63	1.00
2007	41	0.57	0.41	2007	37	0.43	0.21
2008	41	0.28	0.23	2008	41	0.77	0.38
2009	40	0.55	0.36	2009	43	1.61	1.09
2010	36	0.86	0.57	2010	44	0.46	0.38
2011	42	0.69	0.55	2011	40	0.55	0.46
2012	33	0.99	0.62	2012	37	2.13	1.34
2013	40	1.55	1.10	2013	43	2.65	2.09
2014	40	1.51	1.08	2014	45	0.47	0.29
2015	43	1.33	0.87	2015	43	2.64	1.68
2016	44	1.12	0.61	2016	45	30.19	20.79
2017	45	3.30	1.57	2017	44	3.06	2.02
2018	41	3.42	2.05	2018	45	2.43	1.70
2019	46	2.34	1.71	2019	43	1.72	1.19
2020	45	0.31	0.29	2020	44	0.32	0.37
2021				2021			
2022	45	1.49	0.95	2022	45	1.19	0.81

3.3.3.2. Portuguese LPUE index (PT LPUE)

During the WKSKATE meeting, in 2021, it was acknowledged the adequacy of the commercial LPUE series from the Portuguese polyvalent fleet (PT LPUE; ICES, 2021a). The polyvalent fleet includes vessels licensed to operate with several fishing gears, mainly gillnets, trammel nets, longlines and traps. The main concern from the reviewers about the methodology proposed was the non-inclusion of the zeroes in the analysis. The justification for this approach relies on the fact that it is not possible to distinguish real zeroes mainly due to: 1) is a by-catch species from the polyvalent fleet fisheries, so absence of the species in the catch is more related to the fishing strategy and selectivity of the gear; 2) the species has a patchy distribution and the information available is not georeferenced; 3) the weight landed per trip results from the application of estimates, which can lead to false zeros.

In the case of *L. naevus*, the LPUE index estimated was restricted to the Peniche landing port, for which higher sampling effort is recorded. Peniche is among the most important ports for the polyvalent fleet landings of *L. naevus* (i.e., together with Matosinhos and Póvoa do Varzim, Sesimbra and Setúbal), which all contributed, on average, with 49% of the total landed weight of this fleet (Figure 5.5). Within the polyvalent fleet, Peniche represented, on average, 44%, of the landed weight during the period 2008-2022. Vessels landing in Peniche operate, in a great extent, in areas around this port, but also conduct fishing operations along other areas in the north, centre and southwest coasts.

Therefore, landings and effort from Peniche are considered representative of the whole fishery.

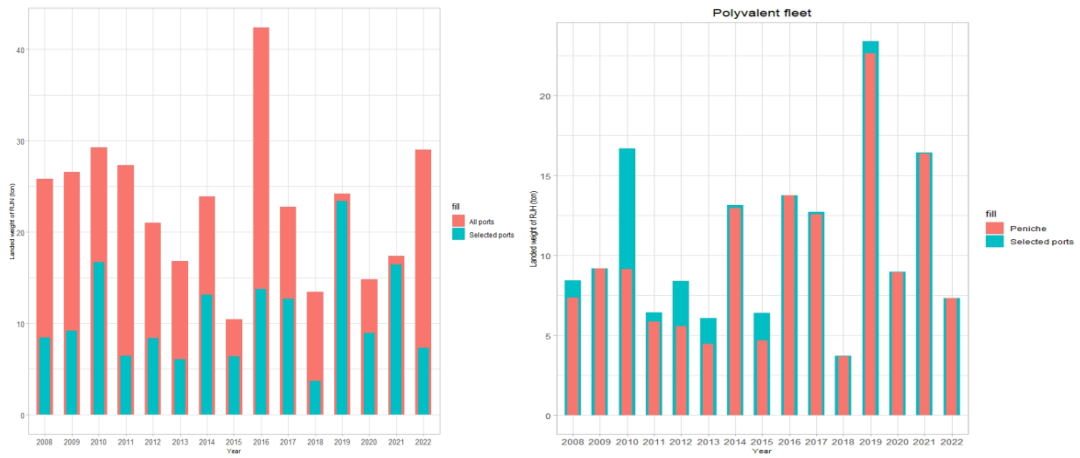


Figure 5.5. Leucoraja naevus in ICES Division 27.9a. Portuguese landings of the polyvalent fleet. Left: Ports of Póvoa de Varzim, Matosinhos, Peniche, Sesimbra and Setúbal representativeness in terms of the species polyvalent landed weight. Right: Peniche representativeness in terms of the species polyvalent landed weight within the most important ports.

Details on the PT LPUE estimation methodology can be found in Serra-Pereira *et al*. (2020) and ICES (2021a). The best model selected included the variables year, quarter, vessel size, fishing seasonality on skates and rays and fishing gear (trammel nets or gillnets). The annual biomass index (kg/trip) is shown in Figure 5.6 and Table 5.3.

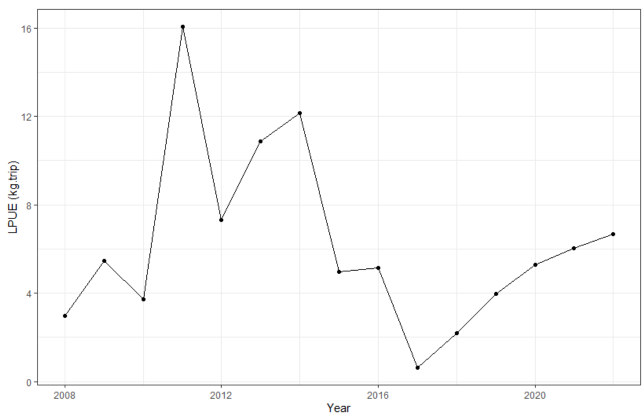


Figure 5.6. *Leucoraja naevus* in ICES Division 27.9a. Evolution of biomass index LPUE obtained from the Portuguese polyvalent fleet.

Table 5.3. ***Leucoraja naevus*** **in ICES Division 27.9a. LPUE index and correspondent standard error estimated for the Portuguese polyvalent fleet for the period 2008-2022**.

Year	LPUE (kg/trip)	se
2008	2.99	0.22
2009	5.46	0.40
2010	3.71	0.24
2011	16.08	1.26
2012	7.30	0.52
2013	10.85	0.80
2014	12.15	0.82
2015	4.98	0.45
2016	5.13	0.46
2017	0.62	0.06
2018	2.21	0.16
2019	3.97	0.34
2020	5.28	0.39
2021	6.05	0.45
2022	6.66	0.52

3.3.3.3. Combined index

A combined index, weighted by landings of each country, was estimated, as proposed at WKBELASMO3 data compilation workshop. To this purpose, an overall proportion value of Portuguese and Spanish landings was estimated (0.89 and 0.11, respectively) and applied to the PT LPUE and ARSA biomass indices (after normalization) (Figure 5.7 and Table 5.4).

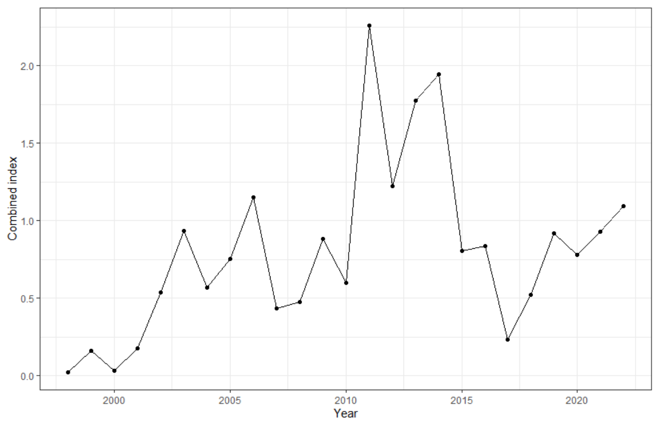


Figure 5.7. ***Leucoraja naevus*** **in ICES Division 27.9a. Combined index, weighted by landings of Portugal and Spain, after normalization of the Spanish ARSA surveys (average) and the Portuguese LPUE.**

Table 5.4. ***Leucoraja naevus*** **in ICES Division 27.9a. Combined index, weighted by landings of Portugal and Spain, after normalization of the Spanish ARSA surveys (average) and the PT LPUE.**

Year	Combined Index
1998	0.02
1999	0.16
2000	0.03
2001	0.17
2002	0.53
2003	0.94
2004	0.57
2005	0.75
2006	1.15
2007	0.43
2008	0.47
2009	0.89
2010	0.60
2011	2.38
2012	1.19
2013	1.79
2014	1.84
2015	0.90
2016	0.88
2017	0.35
2018	0.59
2019	0.78
2020	0.81
2021	0.97
2022	1.09

Both the LPUE and survey indices have different trends in the last years (ARSA increases and LPUE shows the lowest values) (Figure 5.8). Based on this, the last advice excluded the PT LPUE: *"a standardized LPUE from the Portuguese polyvalent fleet presented in WKSKATE (ICES, 2021b) may provide information from areas further north. This index shows opposite trends to the survey index in recent years and has not been included in the current assessment. Further work is required to reconcile these two series"* (ICES, 2022a). In fact, the years that are contradictory are those after the start of management regulations in Portuguese waters regarding the minimum size (>2014). Also, since 2014 a decrease in the sampling effort in Peniche has been observed which can have affected the estimation of species abundance, given its patchy distribution. Precaution is also needed in the future use of the PT LPUE due to the increase of the minimum landing size from 52 to 60 cm in 2022, which will decrease the landings for this species in the forthcoming years.

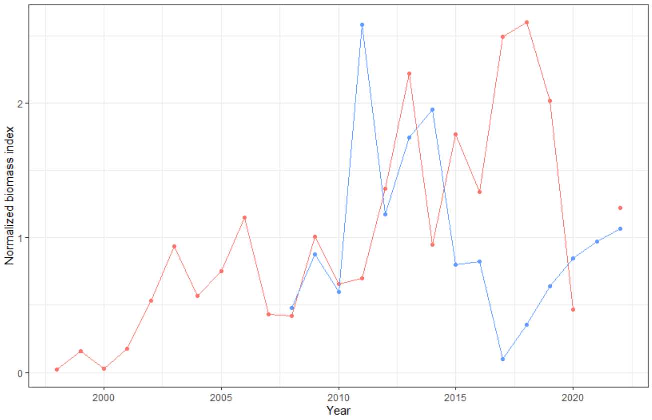


Figure 5.8. *Leucoraja naevus* in ICES Division 27.9a. Comparison between ARSA index and PT LPUE (normalized indices).

5.3.5 Life-history parameters

Life history parameters are available for this species in different ICES areas (Tables 5.5 and 5.6).

Table 5.5. *Leucoraja naevus* in ICES Division 27.9a. Summary of growth parameters recorded for studies conducted on different ICES areas on cuckoo ray, adapted from Ellis et al. (2023). Vert.: analyses of vertebrae; MRD: mark-recapture data.

Area	Sex	N	Length range (cm)	Age range (y)	L_{inf} (cm)	K (y^{-1})	t_0 (y)	Method	Source
Celtic Sea	C	50	13-69	0-12	91.64	0.109	-0.05	Vert.	Du Buit (1977)
Irish Sea	C	818	37-73	1-9	---	---	---	Vert.	Fahy (1989a)
Celtic Sea	F	759	---	1-8	73.1	0.23	-2.47	Vert.	Fahy (1989b), Fahy (1991)
	M	670	---	1-7	69.9	0.33	-1.12	Vert.	
Irish Sea	F	209	?-70	0-8*	83.92	0.197	-0.151	Vert.	Gallagher et al. (2005)
	M	351	?-71	0-8*	74.57	0.294	-0.997	Vert.	
North Sea	F	48	ca.36-65	3-11	75.2	0.16	-0.95	Vert.	Walker (1999)
	M	47	ca.30-35	3-10	67.5	0.31	-0.9	Vert.	
Celtic Sea	F		---	---	70	0.127	---	MRD	Dureuil et al. (2022)
	M		---	---	70.1	0.127	---	MRD	
---	C	---	---	---	78.4	0.24	-0.54	---	Froese and Pauly, 2022

*Age range for sexes combined

Table 5.6. ***Leucoraja naevus*** **in ICES Division 27.9a. Summary of reproduction data recorded for studies conducted on different ICES areas on cuckoo ray. Lengths in cm; ages in years.**

Area	Sex	Length range (cm)	Fec. (no. follicles)	$L_{50\%}$ (cm)	$A_{50\%}$ (y)	Source
Portugal	F	---		55.6		Farias (2005)
Portugal	M	---		56.5		
Portugal	F	14.9-71.8	63	56.5		Maia et al. (2012)
Portugal	M	13.3-68.2		56.0		
Irish Sea	F	ca.13-70		56.9	4.17	Gallagher *et al.* (2005)
Irish Sea	M	ca.13-71		56.2	4.25	
	F	ca.10-69		59.8		
Celtic Seas	M	ca.11-72		57.3		McCully et al. (2012)
North Sea	F	ca.15-62		53.6		McCully et al. (2012)
	M	ca.17-63		50.8		

Values for the intrinsic rate of biomass increase (*r*) were extracted from literature or estimated using the function *jbleslie* implemented in R package JABBA (Winker et al., 2023). Frisk et al. (2001), adopted the methodology from Jennings et al. (1999) and estimated *r* in 0.41 year^{-1}.

Given the inexistence of reliable growth parameters for this stock, estimates obtained from *jbleslie* function were based in two different studies available from the Celtic and Irish Seas (Fahy, 1989b; Gallagher et al., 2005). The used parameters and respective *r* estimates are presented in Table 5.7. In the results here presented only r values of 0.21 y^{-1} and 0.41 y^{-1} were considered, as well as a value of 0.3 y^{-1} in the sensitivity analysis.

Table 5.7. ***Leucoraja naevus*** **in ICES Division 27.9a. Estimates of** ***r*****, based on** ***jbleslie*** **function (Winker et al., 2023), using different growth parameters (females).**

A_0	A_{max}	Linf	k	to	L50	L95	Fec.	aW	bW	M	r
0	17.6	83.92	0.197	-0.151	56.5	66.4	63	0.0006	3.58	0.29	0.13
Gallagher et al. (2005)					Maia et al. (2012)			Serra-Pereira et al. (2010)			
A_0	A_{max}	Linf	k	to	L50	L95	Fec.	aW	bW	M	r
0	15.1	73.1	0.23	-2.47	56.5	66.4	63	0.0006	3.58	0.30	0.21
Fahy (1989)					Maia et al. (2012)			Serra-Pereira et al. (2010)			

Natural mortality (M) derived from Then et al., (2015), following the methodology defined for other elasmobranch stocks previously benchmarked (ICES, 2023):

$$M=4.118*K^{0.73}*L_{inf}^{-0.33}$$

In addition, maximum age was estimated based on Fabens (1965).

$$A_{max}=5x(\ln 2/k)$$

5.4 Stock assessment

5.4.1 Exploratory assessments

Different model configurations under three scenarios (with different biomass indices) were tested and discussed at WKELASMO 3:

- Scenario 1: combined index (2001-2022) (Moura et al., 2024 WD);
- Scenario 2: combined index (2008-2022) (Moura et al., 2024 WD);
- Scenario 3: ARSA surveys only (2001-2022).

Runs conducted in each scenario considered priors for intrinsic rate of biomass increase (*r*), shape of the production curve, process error (*sdb*) and initial depletion rate (*bkfrac*). A prior on *r* was considered in several runs, adopting the various values presented in section 5.3.5. Runs considering a Fixed Schaefer production curve (n=2), a tighter Schaefer or no prior for n were also tested.

It was decided to match the beginning of both survey indices and landings. Thus, the data series adopted started in 2001, when the stock was likely at lower levels of biomass due to fishing as shown by the lowest values of the stock size indicator in the earlier part of the time series. Landings time series Models under scenarios 1 and 2 required a *bkfrac* prior to be set to fulfil all the requirements to be accepted for assessment, which was tested for some runs assuming levels ranging from 0.2 to 0.5. For these scenarios, the checklist for the acceptance of a SPiCT assessment failed for several items, particularly the order of magnitude of fishing mortality confidence intervals, robustness to the initial parameters and diagnostics.

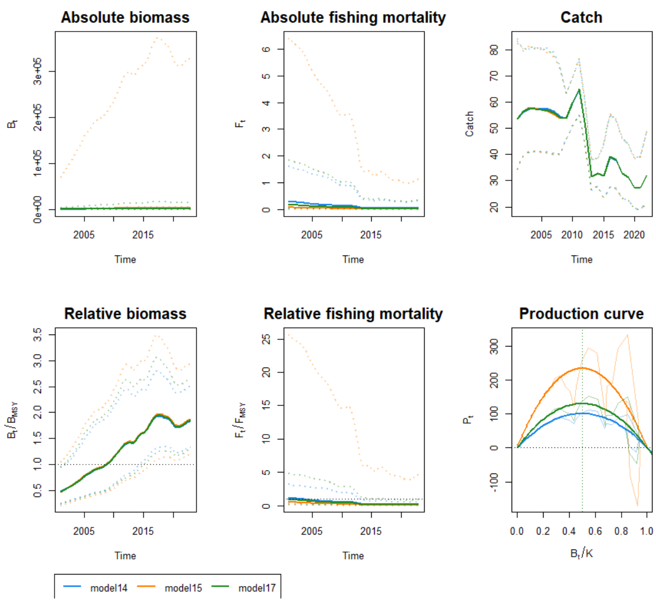
In addition, WKBELASMO 3 concluded that the level of uncertainty of the PT LPUE was high from 2014 onwards, for the reasons explained in section 5.3.3.2, which can affect the assessment and perception of the stock status. It was also remarked that the minimum landing size is now 60 cm for all skates landed in Portugal which can bias this stock indicator in the forthcoming years, as the maximum length recorded for the species is around 70 cm.

Given the above, WKBELASMO 3 agreed to use ARSA surveys only, considering each survey, spring (Q1) and autumn (Q4), as an independent biomass index.

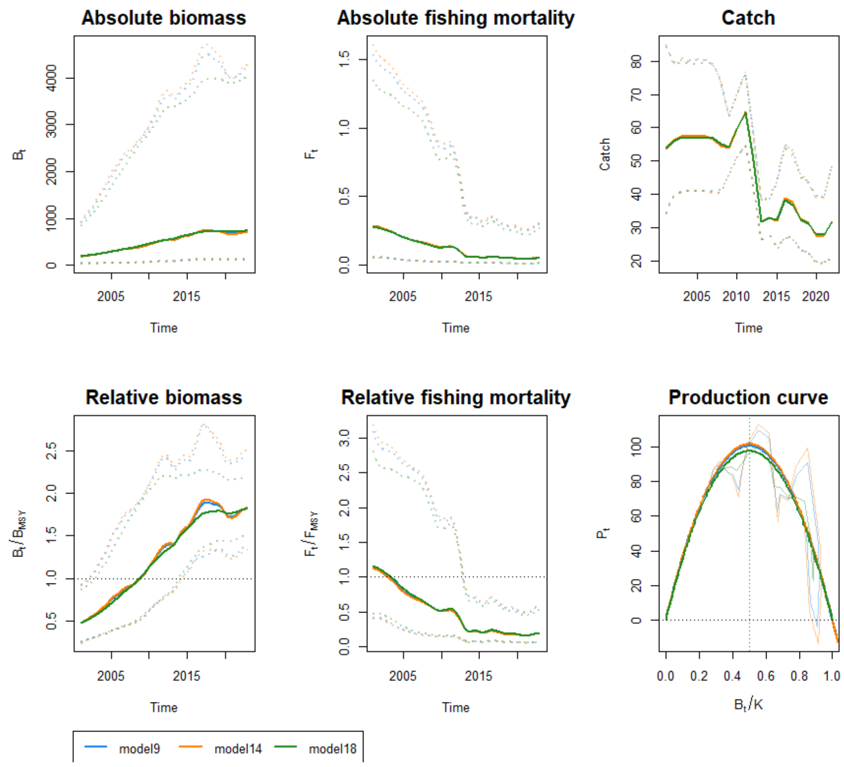
The models tested also considered uncertainty in catches in the reconstructed period (2001-2008) and in the period after the implementation of the Portuguese regulations concerning the minimum landing size (*stdevfacC* =3). Given the short time series, the fixed Schaefer production curve was adopted. Other settings agreed were to disable both *logalpha* and *logbeta* noise ratios and consider a prior on *sdb* to avoid overfitting of the model. A sensitivity analysis around the proposed model was conducted, by testing different values for the *r* and *sdb* (Table 5.8). No prior was defined for *bkfrac*. All the models tested produced similar results in terms of both trajectories of biomass and fishing mortality, perception of the stock status against the relative reference points and initial depletion rate, which was estimated between 0.221 and 0.238 in all runs (Table 5.8; Figures 5.9-5.10). F/F_{msy} was more sensitive to changes in the settings of the models, particularly to changes in the *r* value. The *r* value of 0.41 was considered adequate as prior for this species, being among the values adopted for elasmobranch species (e.g., Frisk et al., 2001; Cortés, 2016). This value was also supported by the *r* estimate obtained for rjn.27.678abd stock (r=0.52 y^{-1}), benchmarked in WKELASMO with SPiCT (ICES, 2022b).

Table 5.8. *Leucoraja naevus* in ICES Division 27.9a. Summary of the models tested and results.

		ARSA_7	ARSA_9	ARSA_14	ARSA_15	ARSA_16	ARSA_17	ARSA_18	ARSA_19
Settings	Uncertainty		Catches	Catches	Catches	Catches	Catches	Catches	Catches
	Prod. curve	Schaefer	Schaefer	Schaefer	Schaefer	Schaefer	Schaefer	Schaefer	Schaefer
	r	---	c(log(0.41),0.5,1)	c(log(0.41),0.5,1)	c(log(0.21),0.5,1)	c(log(0.3),0.5,1)	c(log(0.3),0.5,1)	c(log(0.41),0.5,1)	c(log(0.3),0.5,1)
	sdb	---	---	c(log(0.15),0.5,1)	c(log(0.15),0.5,1)	---	c(log(0.15),0.5,1)	c(log(0.07),0.5,1)	c(log(0.07),0.5,1)
	Bkfrac	---	---	---	---	---	---	---	---
Results	Converg.	x	ok	ok	ok	ok	ok	ok	ok
	Conf. Interv.		0,1	0,1	0,3	0,1	0,1	0,1	0,1
	Initial par.		ok	ok	x	ok	ok	ok	ok
	Diagnostics		ok	ok	ok	ok	ok	ok	ok
	Retrosp. (3 y)		ok	ok	ok	ok	ok	ok	ok
	r		0.462	0.502	0.260	0.343	0.371	0.471	0.351
	n		2	2	2	2	2	2	2
	Bkfrac		0.238	0.234	0.221	0.227	0.226	0.237	0.227
	F/Fmsy		0.19	0.189	0.085	0.151	0.149	0.190	0.151
	B/Bmsy		1.810	1.820	1.855	1.824	1.836	1.81	1.826
	Obj. function		73.67	74.34	74.91	73.83	74.60	73.95	74.14



Figures 5.9. *Leucoraja naevus* in ICES Division 27.9a. Comparison of models run with different *r* priors (see table 5.8 for input data)



Figures 5.10. *Leucoraja naevus* in ICES Division 27.9a. Comparison of models run with different priors on *sdb* or no prior (see table 5.8 for input data).

Finally, three new scenarios were run to test the robustness of the model, by including an extra year with three different biomass values: higher than in 2023 (the highest value of each time series was adopted), lower than in 2023 (the lowest value of each time series was adopted), and the same as last year (Figure 5.11). Regarding the checklist for the acceptance of a SPiCT assessment, all criteria were met except the order of magnitude of the confidence intervals of F/F_{msy} in the scenario assuming the update of both biomass indices at low levels of biomass (Table 5.9). In addition, in all tests the trends of both relative biomass and fishing mortality are maintained and *bkfrac* estimates and r posterior estimates do not significantly change. These results confirm the adequacy of model specifications.

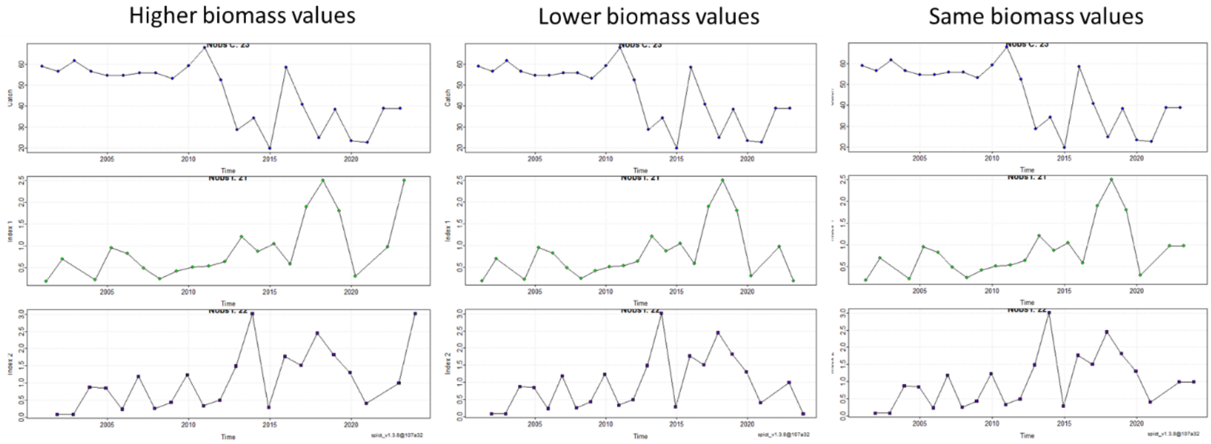


Figure 5.11. ***Leucoraja naevus*** **in ICES Division 27.9a. Input data considered when testing for a hypothetical new year under three different scenarios of biomass index values at the end of the time series.**

Table 5.9. ***Leucoraja naevus*** **in ICES Division 27.9a. Model configurations and results when testing for a hypothetical new year under three different scenarios of biomass index values at the end of the time series.**

		Final model	FinalM_high	FinalM_low	FinalM_statusquo
Settings	Uncertainty	Catches	Catches	Catches	Catches
	Prod. curve	Schaefer	Schaefer	Schaefer	Schaefer
	r	c(log(0.41),0.5,1)	c(log(0.41),0.5,1)	c(log(0.41),0.5,1)	c(log(0.41),0.5,1)
	sdb	c(log(0.15),0.5,1)	c(log(0.15),0.5,1)	c(log(0.15),0.5,1)	c(log(0.15),0.5,1)
	Bkfrac	---	---	---	---
Results	Converg.	ok	ok	ok	ok
	Conf. Interv.	0,1	0,1	0,2	0,1
	Initial par.	ok	ok	ok	ok
	Diagnostics	ok	ok	ok	ok
	Retrosp. (3 y)	ok	ok	ok	ok
	r	0.502	0.468	0.518	0.505
	n	2	2	2	2
	Bkfrac	0.234	0.209	0.299	0.233
	F/Fmsy	0.189	0.201	0.206	0.211
	B/Bmsy	1.820	1.886	1.708	1.817
	Obj. function	74.34	77.28	82.17	75.57

5.4.2 Final assessment

Settings and parameter values agreed for the accepted model are presented in Table 5.10. Plots and results from the final assessment are presented in Figures 5.12-5.16 and Tables 5.11-5.12. No significant bias or autocorrelation were found and both QQ-plot and the Shapiro test show normality in the residuals. Some retrospective pattern is observed when testing 5 years although all peels are within the confidence intervals and Mohn's rho is within the accepted values. However, no retrospective pattern is observed when running only 3 years (0.006 for B/B_{MSY} and of -0.019 for F/F_{MSY}), which is considered appropriate when only a short time series is available. The hindcast cross-validation shows a Mean Absolute Scaled Error (MASE) less than 1 for both survey index.

Considering the adopted reference points proposed for production models by ICES (ICES, 2016), F/F_{MSY} in 2022 is below F_{MSY} and B/B_{MSY} in 2023 is above B_{MSY}.

The R scripts to produce the data preparation and assessment with SPiCT for this stock were prepared and added to the ICES Transparent Assessment Framework (TAF) repository for WKBELASMO on GitHub (Transparent Assessment Framework (TAF) (github.com)).

Table 5.10. *Leucoraja naevus* in ICES Division 27.9a. Settings and parameter values agreed for the accepted model.

Input data	
Landings	2001-2022, using reconstructed landings from 2001 to 2008 (Portugal) and 2001-2009 (Spain) 3x higher uncertainty in 2001-2008 and >2014
Biomass indices	Index 1: SpGC-GFS-WIBTS-Q1, 2001-2022 Index 2: SpGC-GFS-WIBTS-Q4, 2001-2022
Parameter	
r	0.41 y^{-1}, cv=0.5
Shape of the production curve	Schaefer (n=2)
Process error (*sdb*)	*sdb* = 0.15, CV = 0.5
Noise ratios *logalpha*, *logbeta*	Disabled

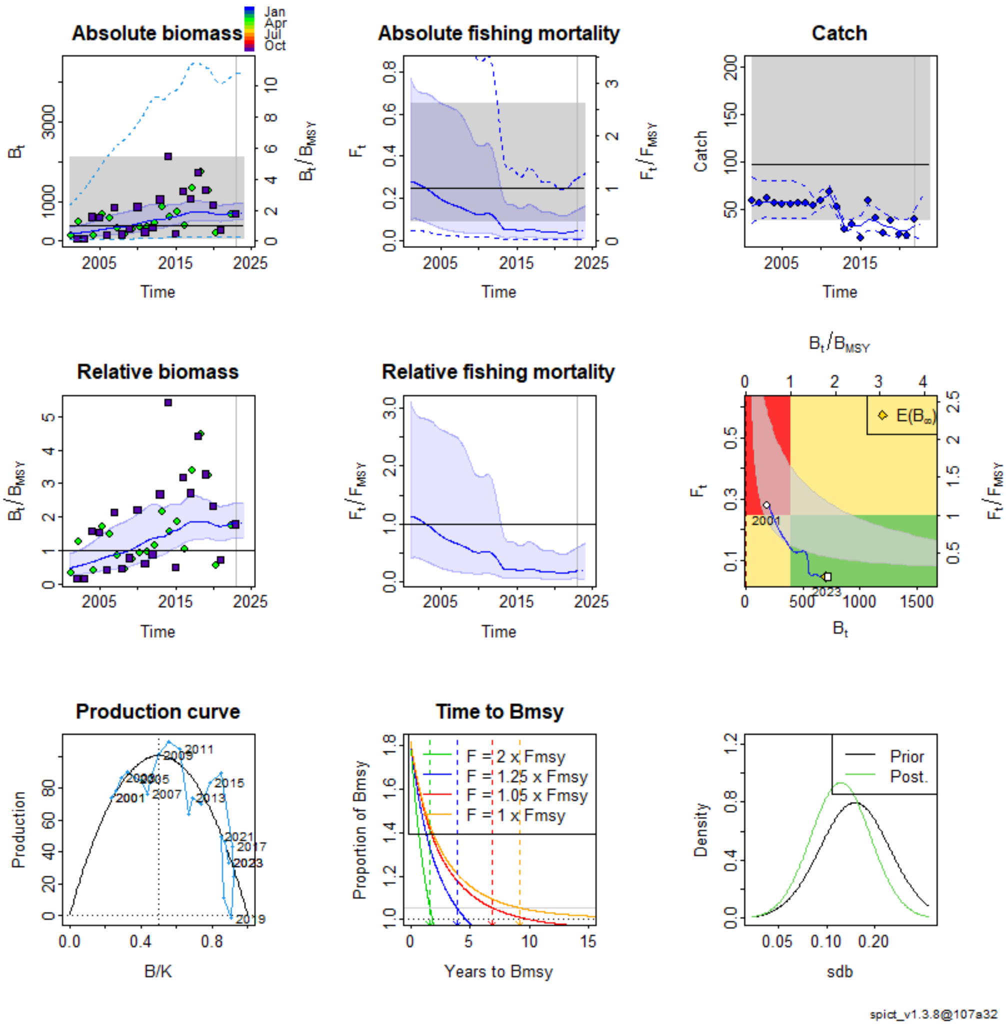


Figure 5.12. ***Leucoraja naevus*** **in ICES Division 27.9a. Results of final assessment.**

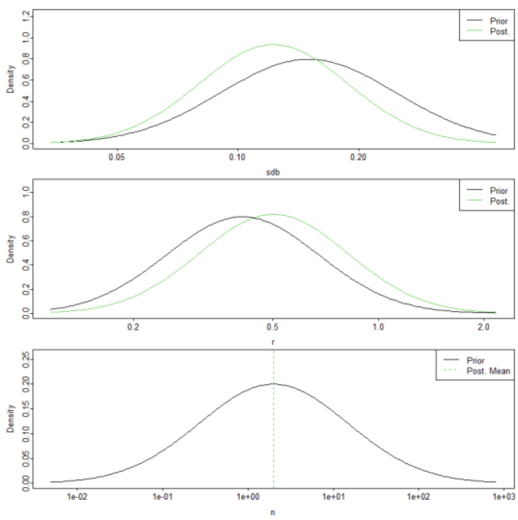


Figure 5.13. ***Leucoraja naevus*** **in ICES Division 27.9a. Estimated priors and posteriors for the final assessment.**

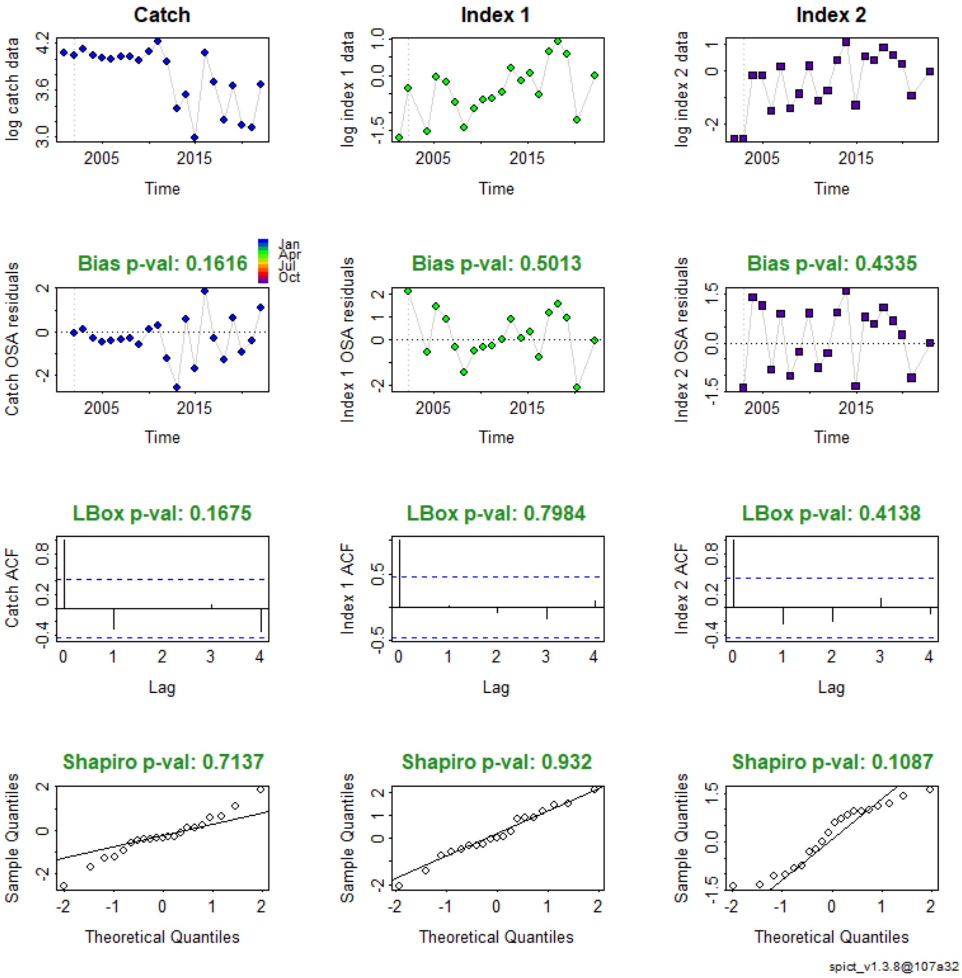


Figure 5.14. ***Leucoraja naevus*** **in ICES Division 27.9a. Diagnostics of the final assessment.**

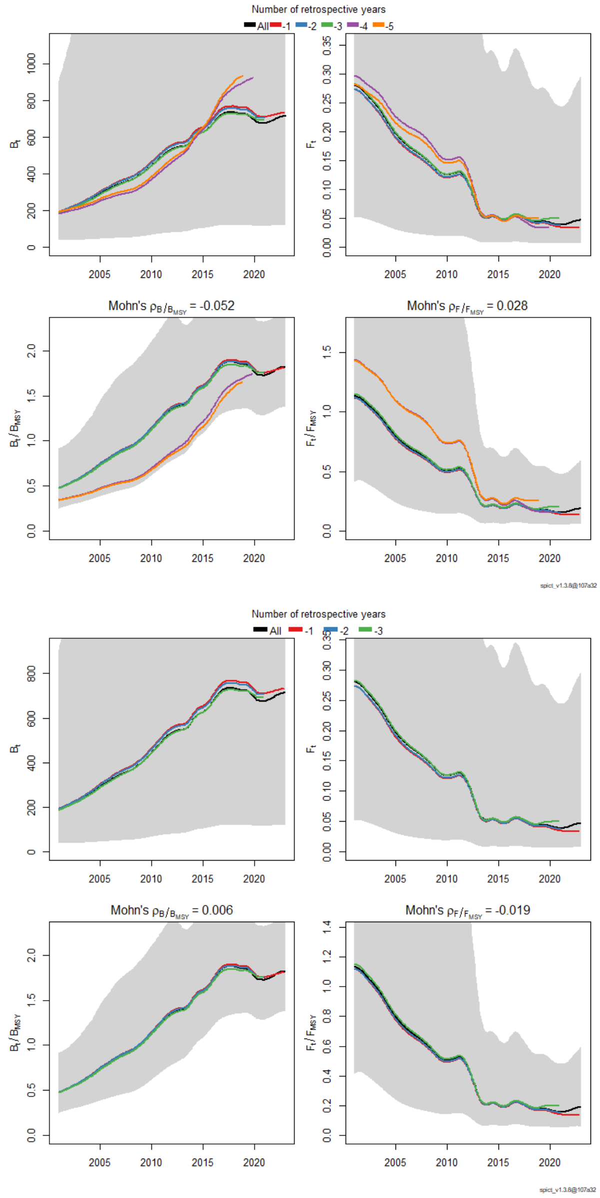


Figure 5.15. ***Leucoraja naevus*** **in ICES Division 27.9a. Retrospective pattern of the final assessment. Left: using 5 retro-years; Right: using 3 retro-years.**

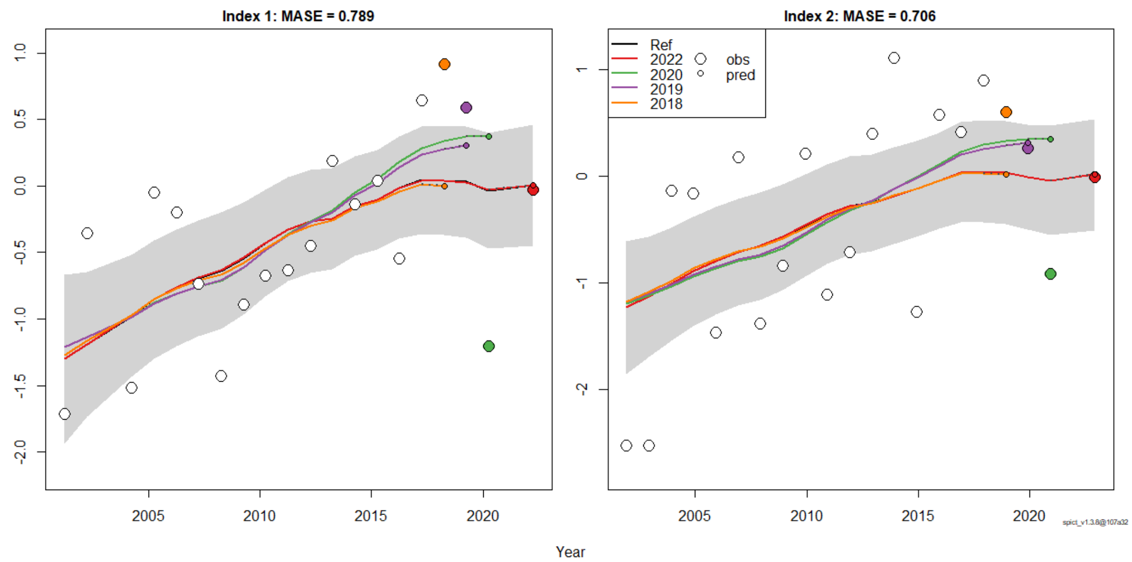


Figure 5.16. *Leucoraja naevus* in ICES Division 27.9a. Hindcast cross-validation for the final assessment (Index 1: ARSA Q1; Index 2: ARSA Q4).

Table 5.11. Leucoraja naevus in ICES Division 27.9a. SPiCT summary results.

Model parameter estimates w 95% CI					
	estimate	**cilow**	**ciupp**	**log.est**	
alpha1	4.7720	1.9087	11.9310	1.5628	
alpha2	6.7763	2.7544	16.6703	1.9134	
beta	0.3384	0.1454	0.7880	-1.0834	
r	0.5024	0.1932	1.3065	-0.6884	
rc	0.5024	0.1932	1.3065	-0.6884	
rold	0.5024	0.1932	1.3065	-0.6884	
m	100.3311	39.8443	252.6415	4.6085	
K	798.8467	145.2612	4393.1625	6.6832	
q1	0.0014	0.0002	0.0086	-6.5539	
q2	0.0014	0.0002	0.0088	-6.5572	
sdb	0.1227	0.0533	0.2829	-2.0978	
sdf	0.2649	0.1491	0.4709	-1.3283	
sdi1	0.5856697	0.4221569	0.8125157	-0.5349992	
sdi2	0.8316462	0.6052917	1.1426482	-0.1843482	
sdc	0.0896589	0.0547301	0.1468793	-2.4117424	
Deterministic reference points (Drp)					
	estimate	**cilow**	**ciupp**	**log.est**	
B_{MSYD}	399.4233553	72.630601	2196.581244	5.990022	
F_{MSYD}	0.2511899	0.096589	0.653246	-1.381546	
MSYd	100.3311124	39.844335	252.641487	4.608476	
Stochastic reference points (Srp)					
	estimate	**cilow**	**ciupp**	**log.est**	**rel.diff.Drp**
B_{MSYS}	391.591873	72.0135916	2129.3785224	5.970220	-0.01999909
F_{MSYS}	0.247502	0.0940091	0.6516096	-1.396337	-0.01490048
MSYs	96.890872	39.3137681	238.7927068	4.573585	-0.03550634
States w 95% CI					
	estimate	**cilow**	**ciupp**	**log.est**	

B_2022.94	712.7558	120.6209	4211.7150	6.5691
F_2022.94	0.0469	0.0075	0.2944	-3.0607
B_2022.94/B_{MSY}	1.8201	1.3729	2.4130	0.5989
F_2022.94/F_{MSY}	0.1893	0.0605	0.5924	-1.6644
Predictions w 95% CI				
	prediction	**cilow**	**ciupp**	**log.est**
B_2024.00	712.6073	119.3893	4253.3883	6.5689
F_2024.00	0.0469	0.0069	0.3177	-3.0607
B_2024.00/B_{MSY}	1.8198	1.3708	2.4158	0.5987
F_2024.00/F_{MSY}	0.1893	0.0537	0.6674	-1.6644
Catch_2023.00	33.3913	17.7445	62.8352	3.5083
E(B_inf)	698.9253			6.5495

Table 5.12. Leucoraja naevus in ICES Division 27.9a. SPiCT estimates for B/BMSY and F/FMSY. CI, 95% confidence intervals.

Year	B/B_{MSY}			F/F_{MSY}		
	Estimate	CI high	CI Low	Estimate	CI high	CI Low
2001	0.4767	0.9198	0.2471	1.0897	2.8560	0.4158
2002	0.5276	0.9805	0.2839	1.0104	2.8121	0.3630
2003	0.5841	1.0920	0.3125	0.9115	2.7496	0.3022
2004	0.6576	1.2473	0.3467	0.8029	2.6309	0.2450
2005	0.7422	1.4354	0.3838	0.7254	2.5682	0.2049
2006	0.8155	1.5948	0.4170	0.6711	2.5036	0.1799
2007	0.8850	1.7385	0.4505	0.6179	2.3439	0.1629
2008	0.9342	1.8277	0.4775	0.5485	2.0257	0.1485
2009	1.0165	1.9475	0.5305	0.5096	1.8227	0.1425
2010	1.1360	2.0989	0.6149	0.5246	1.8481	0.1489
2011	1.2621	2.2601	0.7048	0.4697	1.6578	0.1331
2012	1.3629	2.3825	0.7796	0.2840	0.9824	0.0821
2013	1.3974	2.3126	0.8444	0.2129	0.6950	0.0652
2014	1.5051	2.3439	0.9665	0.2085	0.6560	0.0663
2015	1.5991	2.3635	1.0819	0.2071	0.6429	0.0667
2016	1.7298	2.4662	1.2132	0.2243	0.6868	0.0732
2017	1.8588	2.6433	1.3071	0.1911	0.5883	0.0621
2018	1.8731	2.6118	1.3433	0.1774	0.5444	0.0578
2019	1.8524	2.5263	1.3582	0.1713	0.5217	0.0562
2020	1.7678	2.3741	1.3164	0.1581	0.4816	0.0519
2021	1.7264	2.3218	1.2836	0.1713	0.5121	0.0573
2022	1.7831	2.3712	1.3408	0.1893	0.5924	0.0605
2023	1.8201	2.4133	1.3727			

5.4.3 Forecast

A two-year projection (2024 and 2025) was carried out assuming a *status quo* harvest rate in the interim year, and an F corresponding to the advice for the following year. Table 5.13 presents the results for each year under different F scenarios. The predicted trajectories for the management period 2024-2025 can be observed in Figure 5.17.

The advised landings of this species in division 9a were 59 t for each of the years 2023 and 2024. The option used to provide advice for other *Rajidae* assessed with SPiCT - the one that corresponds to the 15th percentile of the catch at F_{msy} represents an increase of 76% in 2024 in relation to the previous advice. Forecast for 2025 shows a decrease of ~7% in relation to 2024.

Table 5.13. Leucoraja naevus in ICES Division 27.9a. Estimates of catch, B/B_{msy} and F/F_{msy} in each of the years 2024 and 2025 for the scenarios proposed.

2024			
Scenario	**Catch (t)**	**B/BMSY**	**F/FMSY**
F = 0	0	1.89	0
F = Fsq	33	1.82	0.189
F = F_{msy}	162	1.54	1
F = $F_{msy\_c\_fractile\_35}$	138	1.60	0.83
F = $F_{msy\_c\_fractile\_15}$	104	1.67	0.62
2025			
Scenario	**Catch (t)**	**B/BMSY**	**F/FMSY**
F = 0	0	1.94	0
F = Fsq	33	1.82	0.189
F = F_{msy}	141	1.38	1
F = $F_{msy\_c\_fractile\_35}$	123	1.46	0.83
F = $F_{msy\_c\_fractile\_15}$	97	1.57	0.62

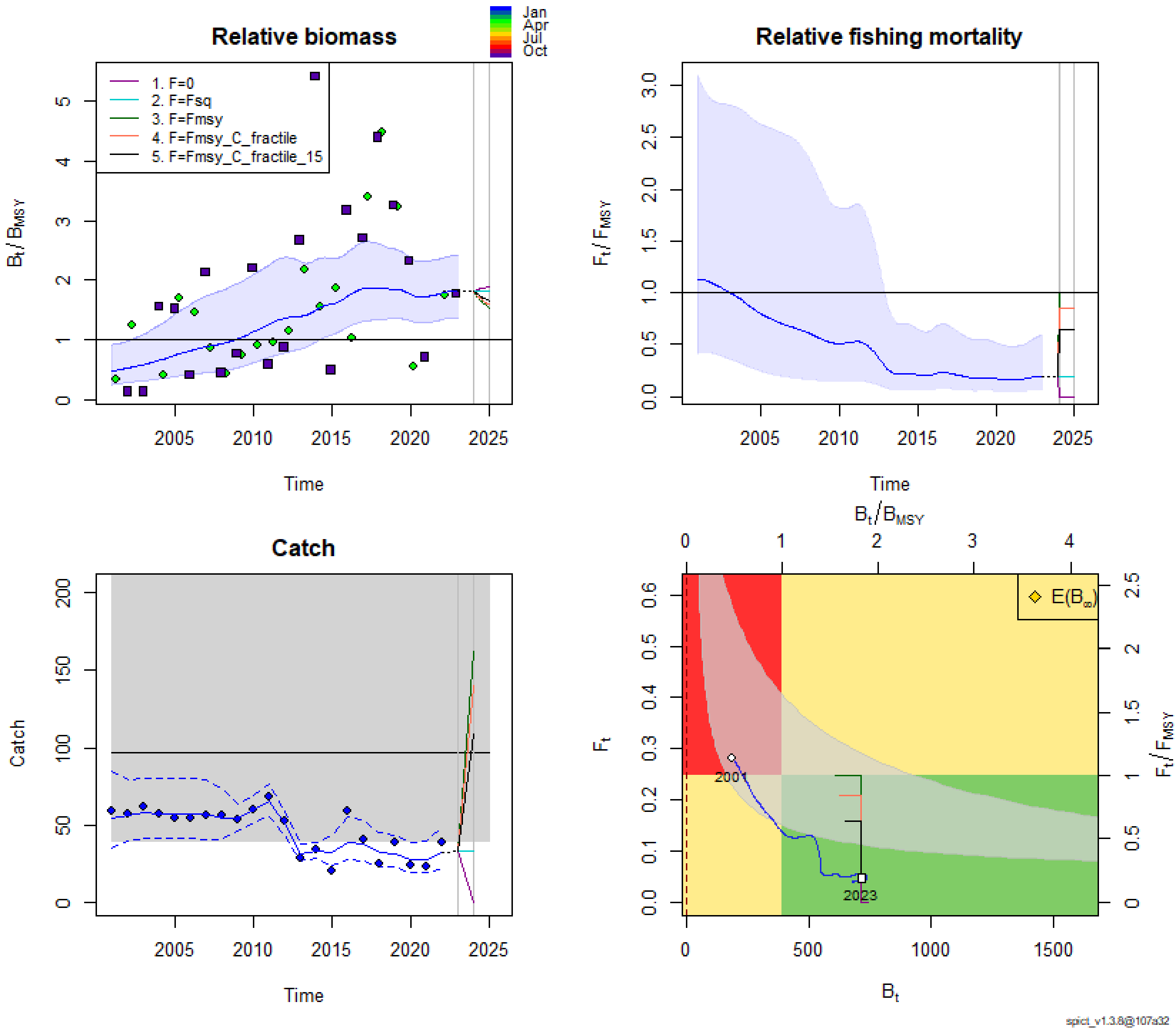


Figure 5.17. ***Leucoraja naevus*** **in ICES Division 27.9a. Predicted trajectories for the management period 2024-2025.**

5.5 Future considerations/recommendations

The group highlighted the concern over the small area of the distribution of the stock being covered by the Spanish ARSA surveys. However, this stock has been assessed using these surveys since 2015 and this will continue to be the only source of reliable data for the stock. Information from Portuguese waters is limited given the uncertainty of the LPUE values. This biomass index shows an increase in the last period of the time series, as the ARSA surveys, although, in the case of the PT LPUE, it comes after a period of very low LPUE values. As remarked in section 1.4 the PT-LPUE from the polyvalent fleet should be improved.

It should be remarked, however, that results from models tested under scenario 1 which have as input data the combined weighted index, show similar trends for the relative biomass and relative fishing mortality as the final model (Figure 5.18). It should be noted that this model was not considered due to the reasons mentioned in section 5.4.1.

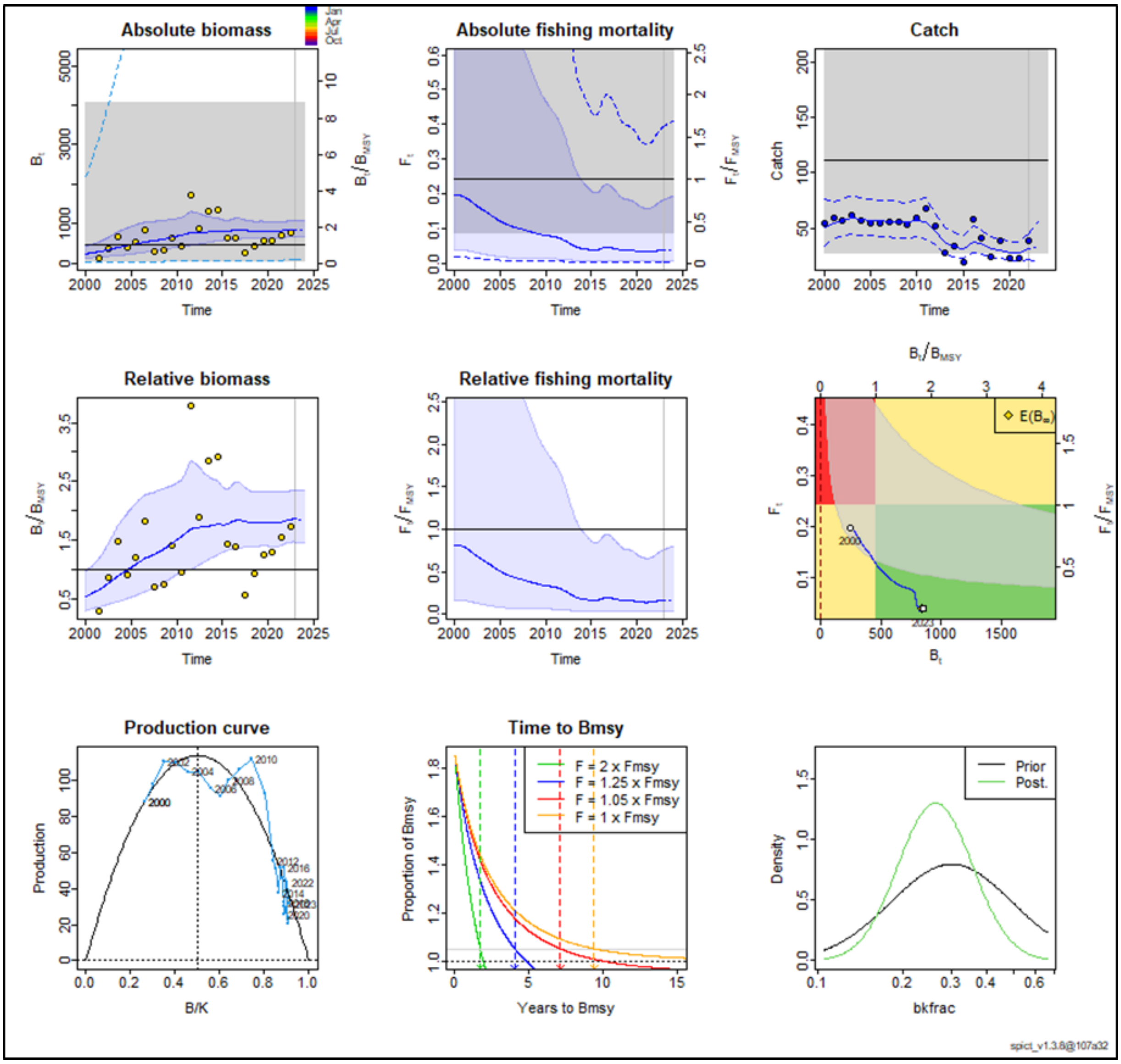


Figure 5.18. ***Leucoraja naevus*** **in ICES Division 27.9a. Results from a model tested under scenario i) and presented to WKELASMO 3 with the following configurations: catches from 2000 to 2022, no uncertainty included; weighted biomass index from 2001 to 2022, combining both PT-LPUE (representing ~89%) and ARSA surveys (representing ~11%), with uncertainty from 2015 onwards (cv=3); r prior= 0.41 y^{-1}; bkfrac prior= 0.3 (cv=0.5).**

5.6 Reviewers report

Initial models presented at the benchmark meeting were fitted to a combined biomass index where the LPUE index for the period 2008-2022 was merged with the biomass survey indices obtained in the two Spanish ARSA surveys conducted on Q2 and Q4 since 1998 in the Gulf of Cádiz. For the period from 1998 to 2007, before the LPUE index became available, the biomass index was entirely based on the Spanish ARSA survey. From 2008 onward, the biomass index was calculated as the weighted annual average of the ARSA biomass index and the LPUE index, weighted according to the proportion of catches taken by Spain and Portugal. The resulting biomass index showed a steady increasing trend, except for the last year. In the years 1998-2000 the value of the biomass index was near zero. In these early years the biomass index was based only on the Spanish ARSA survey. The number of survey stations was lower in those three initial years than after 2001, with partial geographic coverage that did not cover the deeper areas. For these reasons, it was decided that the years 1998-2000 be removed from the biomass index time series, starting the model in 2001.

With additional analyses presented at the benchmark meeting, it became increasingly clear that there was an important discrepancy between Portuguese LPUE index and the Spanish ARSA survey trends. One possible factor behind this discrepancy could be the increase in the legal landing size introduced in 2014, affecting the LPUE series. The two ARSA Q1 and Q4 surveys show trends that are in general agreement with each other, and current advice is relying on these surveys rather than on LPUE to represent stock trends. In light of the above, the review panel recommended that SPiCT model runs should use the two ARSA surveys as two biomass indices and exclude the LPUE data. Since the Spanish ARSA survey only covers the Gulf of Cádiz, it was questioned if this biomass index would be enough to inform about the dynamic of the entire stock, with the majority of catches being from Portuguese waters. Finally, it was decided to continue this line of work based on the facts that 1) the LPUE index is likely not consistent across the period 2008-2022, 2) the ARSA surveys have been in the past the only source of biomass index time series used in the assessment of this stock, and 3) that the ARSA Q1 and Q4 surveys would still be the only biomass indices that could be used for biomass trend analysis on a category 3 *rfb* rule. Accordingly, it was decided to continue with SPiCT modelling using the two ARSA survey indices separated.

The model parameter settings for the final model followed a similar approach as the models recommended for thornback ray and blonde ray in this benchmark. The prior for the intrinsic population growth rate *r* was based on an estimate using the *jbleslie* function of the R package JABBA. However, a variety of possible life history input values exist for this species, with different combinations resulting in different *r* estimates. When different model settings were tested in SPiCT model runs, the assessment results were somewhat sensitive to which *r* prior was used. After a careful evaluation of all options, the review panel recommended using a prior around 0.41 with a CV of 0.5, which is in line with the *r* prior adopted for cuckoo ray in the Celtic Sea during WKBELASMO2.

Alternative options for the *n* parameter defining the shape of the production curve were explored in initial model runs during the benchmark, but eventually fixed at the Schaefer value of n=2. This was done for the same reasons as the other two ray stocks in this benchmark, given the short time series and relatively information-poor data available.

A variety of priors were explored for the *bkfrac* parameter in the early SPiCT model runs, but as with the other two ray stocks, the priors turned to be highly influential on model estimates of stock status. The review panel recommended that *bkfrac* be estimated without a prior to allow the model to estimate the population dynamics and stock status with minimal constraints. See further commentary on *bkfrac* in the thornback ray review section.

For the parameter *sdb* defining the degree of error process in the biomass estimation, two different priors were tested, 0.07 and 0.15. Both options resulted in similar biomass estimation. It was decided to apply a prior with *sdb* around 0.15 with a CV of 0.5, which was used during WKLIFEII (ICES 2023).

A sensitivity test of model stability was performed by simulating one extra year of data with the same landings as the previous year and one new LPUE index that equals the lowest observed index, same as the previous year, or equals the highest observed index. This approach is slightly different from the -50%, same, +50% sensitivity test conducted for thornback ray and blonde ray but does the same job. The results indicated that the model is stable under these circumstances, resulting in relatively small and sensible changes in the parameter estimates and current stock size, responding to the latest trends in the biomass index.

Conclusion

Based on the different models presented, the tests and sensitivity analysis conducted during the meeting, the SPiCT assessment model was accepted as the basis for providing advice for cuckoo ray in the Atlantic Iberian waters.

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Annex 1: List of participants

DEWK: Data Evaluation workshop: 20-24 November 2023
WP: Meeting on Work progress: 9 January 2024
ABWK: Benchmark workshop: 26 February – 1 March 2024

Name	Institute	Country	Email	DEWK	WP	WK
Alain Biseau *ICES Chair*	Ifremer	France	abiseau@ifremer.fr	X	X	X
Alfonzo Perez Rodrigez *External reviewer*	IEO	Spain	alfonso.perez@ieo.csic.es	X	X	X
Arni Magnusson *External reviewer*	SPC		arnim@spc.int	X	X	X
Bárbara Serra-Pereira	IPMA	Portugal	bpereira@ipma.pt	X	X	X
Catararina Maia	IPMA	Portugal	cmaia@ipma.pt	X	X	X
Christopher Griffiths	SLU	Sweden	christopher.griffiths@slu.se	X	X	X
Cristina Rodríguez-Cabello	IEO	Spain	cristina.cabello@ieo.csic.es	X	X	X
Graham Johnston	Marine Institute	Ireland	graham.johnston@marine.ie	X	X	X
Guzmán Diez	AZTI	Spain	gdiez@azti.es	X	X	
Inigo Martinez	ICES		inigo@ices.dk	X	X	X
Loïc Baulier	Ifremer	France	Loic.Baulier@ifremer.fr	X	X	X
Margarita Rincón Hidalgo *External reviewer*	IEO	Spain	margarita.rincon@ieo.csic.es	X	X	X
Teresa Moura	IPMA	Portugal	tmoura@ipma.pt	X	X	X
Thomas Barreau	Museum national d'Histoire naturelle	France	thomas.barreau@mnhn.fr	X	X	
Casper Berg *Invited expert*	DTU	Denmark	cbe@aqua.dtu.dk			X

Annex 2: Workshop agendas

WKBELASMO 2024, 20-24 November 2023

(Online meeting)

Data Evaluation

Agenda

20 Nov (Monday)

10:00-10:15 (CPH TIME))

- Opening of the meeting, code of conduct, introduction participants & meeting ToRs.

10:15-11:30

All stocks (issues common to all stocks)

1. Presentation of the workplan (Bárbara Pereira)
2. Reconstruction of historical landings (Catarina Maia)
3. Discards (Bárbara Pereira)

11:30-13:30

Blonde ray (*Raja brachyura*) in divisions 9a (Atlantic Iberian waters) (**rjh.27.9a**) – Category 3 stock (Catarina Maia)

Presentations and plenary discussions:

- Catch data, discard survival, surveys, life-history parameters and potential models for stock assessment
- Genetic population structure
- Data handling and estimation procedures for discards and length distributions
- Commercial LPUE indices

21 Nov (Tuesday)

10:00-13:30

Thornback ray (*Raja clavata*) in Division 9.a (Atlantic Iberian waters) (**rjc.27.9a**) – Category 3 stock (Bárbara Pereira)

Presentations and plenary discussions:

- Catch data, discard survival, surveys, life-history parameters and potential models for stock assessment

- Genetic population structure
- Data handling and estimation procedures for discards and length distributions
- Survey and commercial LPUE indices
- Modelling abundance and biomass from the surveys

22 Nov (Wednesday)

10:00-13:30

Cuckoo ray (*Leucoraja naevus*) in divisions 9a (Atlantic Iberian waters) (**rjn.27.9a**) – Category 3 stock (Teresa Moura/Cristina Rodriguez-Cabello)

Presentations and plenary discussions:

- Catch data, discard survival, surveys, life-history parameters and potential models for stock assessment
- Genetic population structure
- Data handling and estimation procedures for discards and length distributions
- Survey and commercial LPUE indices
- Modelling abundance and biomass from the surveys

23 Nov (Thursday)

10:00-12:00

- Adopted **workplan** for Thornback ray, Cuckoo ray & Blonde ray.

24 Nov (Friday)

Continued (if needed)

WKBELASMO 2024, 26 February – 1 March 2024

Benchmark meeting

Venue: ICES headquarters (Baltic room)

Agenda

Daily schedule: 09:00-18:00

Health breaks: 11:30-11:45; 15:30-15:45

Lunch break: 13:00-14:00

26 February (Monday)

09:00-09:15

- Opening of the meeting, code of conduct, introduction participants & meeting ToRs.

09:15-13:00

Thornback ray (*Raja clavata*) in Division 9.a (Atlantic Iberian waters) (**rjc.27.9a**) – Category 3 stock (Bárbara Pereira):

- Recap on input data for stock assessment
- Exploratory assessment runs with SPICT
- Plenary discussions and agreement on input data, SPICT base-case run and set of sensitivity analysis to be carried out for Thornback ray

14:00-18:00

Blonde ray (*Raja brachyura*) in divisions 9a (Atlantic Iberian waters) (**rjh.27.9a**) – Category 3 stock (Catarina Maia):

- Recap on input data for stock assessment
- Exploratory assessment runs with SPICT
- Plenary discussions and agreement on input data, SPICT base-case run and set of sensitivity analysis to be carried out for Blonde ray

27 February (Tuesday)

09:00-13:00

Cuckoo ray (*Leucoraja naevus*) in divisions 9a (Atlantic Iberian waters) (**rjn.27.9a**) – Category 3 stock (Teresa Moura/Cristina Rodriguez-Cabello):

- Recap on input data for stock assessment
- Exploratory assessment runs with SPICT
- Plenary discussions and agreement on input data, SPICT base-case run and set of sensitivity analysis to be carried out for Cuckoo ray

14:00-18:00

- Sub-groups work: extra runs / sensitivity analyses

28 February (Wednesday)

09:00-13:00

- Sub-groups work: extra runs / sensitivity analyses (cont')

14:00-18:00

- Presentation of extra runs / sensitivity analyses
- Plenary discussion and final decision

29 February (Thursday)

9:00-13:00

- Sub-groups work: final assessment and forecast

14:00-16:00

- Plenary: adoption of final assessment runs short-term forecasts

16:00-18:00

- TAF and report

1 March (Friday)

09:00-13:00

- Summary of WKBELASMO main conclusions and recommendations.

14:00-17:00

- Report (cont').

Annex 3: Working Documents

Working Document presented at ICES WKELASMO3
Data compilation online meeting, 20th to 24rd November 2023

LPUE standardization of Blonde ray *Raja brachyura* caught in the polyvalent fleet in Portuguese waters (Division 9a) for the period 2008-2022

Catarina Maia, Teresa Moura, Bárbara Serra-Pereira and Ivone Figueiredo

Divisão de Modelação e Gestão de Recursos da Pesca, Instituto Português do Mar e da Atmosfera (IPMA)

Rua Alfredo Magalhães Ramalho 6, 1495-006 Lisboa, PORTUGAL

1. Introduction

Blonde ray *Raja brachyura* is rarely caught in the existing Portuguese bottom trawl research surveys. These surveys are considered inadequate for monitoring the species populations, which have a coastal distribution and fishing hauls held at deeps smaller than 50m are reduced. To overcome this fishery independent data deficiency, the present work presents the results from an analysis on the estimation of commercial standardized LPUE time-series index for the Portuguese polyvalent fleet.

2. Data and methods

2.1 Input data

LPUE starndardization method relies on fishery dependent data derived from the Portuguese polyvalent fleet and are based on the estimated *R. brachyura* landed weight per fishing trip. The analysis was restricted to the most important landing ports for Rajidae species: Matosinhos and Póvoa do Varzim (north), Peniche (centre) and Sesimbra and Setúbal (southwest). 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.

Estimated landed weight by species per trip was obtained applying the stepwise statistical methodology described in Figueiredo et al. (2020), in which the vessels are stratified by size (L=large, M=medium, S=small) and fishing seasonality (c=constant, s=seasonal, o=occasional).

The time period considered for the analysis extends from 2008 to 2022.

2.2 Methods

The dataset was subset to trips with positive landings of the species and with fishing gear assigned. LPUE standardization procedure was done via the adjustment of a stepwise generalized linear model (GLM) to the matrix data, where the response variable is the *R. brachyura* landed weight per trip (unit effort).

Several variables were evaluated as candidate to be included in the model: year, quarter, month, gear, vessel size, and fishing seasonality. 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).

Diagnostic plots, distribution of residuals and the quantile-quantile (Q-Q) plots, are used to assess the 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 r^2.

Up to 2022, annual estimates of LPUE and the corresponding standard error were determined for a reference condition of the variables included in the model apart from the year level. During the WGEF 2022, it was decided by the group to use the model´s mean predicted values to estimate LPUE (see details in result section).

All the statistical analysis was performed using R programming language, version 3.6.2 (R Development Core Team, 2019).

3. Results

3.1 Data overview

Most *R. brachyura* landings were derived from the polyvalent fleet during the period 2008-2022 (between 71 and 94%) (Table 1).

The most important ports (i.e. Matosinhos and Póvoa do Varzim, Peniche, Sesimbra and Setúbal) contributed with 61% for *R. brachyura* polyvalent landed weight (Figure 1). Within these, Peniche represented on average 45% of the landed weight during the period 2008-2022 (Figure 2); for this reason the analysis was restricted to the Peniche landing port. Furthermore, vessels landing in Peniche operate along the north, center and southwest coasts, not being restricted to Peniche's vicinity.

Working Document presented at ICES WKELASMO3
Data compilation online meeting, 20th to 24rd November 2023

Table 1: *Raja brachyura* in Portuguese waters (Division 9a). Estimated landed weight per fleet, polyvalent and trawl, for the period 2008-2022. Percentages of the total national landed weight are present in brackets.

Year	Polyvalent (in Ton)	Trawl (in Ton)
2008	165 (86%)	28 (14%)
2009	117 (71%)	47 (29%)
2010	178 (80%)	44 (20%)
2011	143 (89%)	18 (11%)
2012	149 (90%)	16 (10%)
2013	159 (89%)	21 (11%)
2014	156 (90%)	17 (10%)
2015	222 (94%)	14 (6%)
2016	200 (91%)	20 (9%)
2017	209 (89%)	26 (11%)
2018	154 (84%)	29 (16%)
2019	207 (81%)	48 (19%)
2020	280 (83%)	56 (17%)
2021	210 (79%)	57 (21%)
2022	220 (74%)	77 (26%)

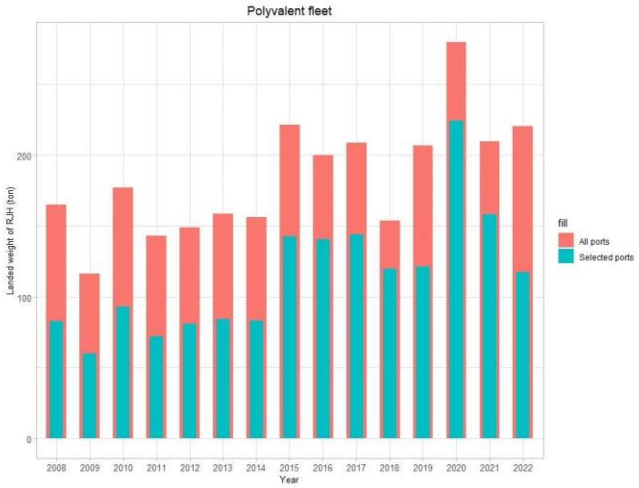

Figure 1. *Raja brachyura* in Portuguese waters (Division 9a). Ports of Póvoa de Varzim, Matosinhos, Peniche, Sesimbra and Setúbal) representativeness in terms of the species polyvalent landed weight.

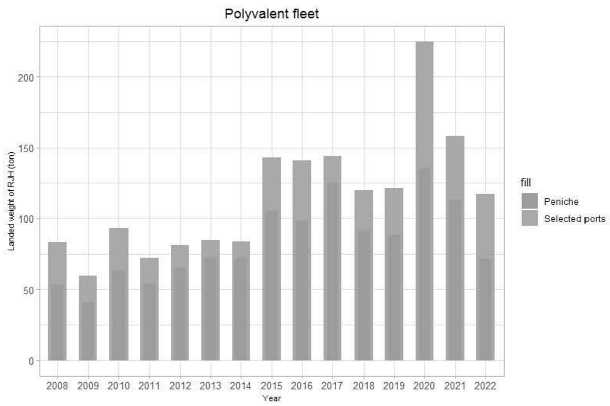

Figure 2. *Raja brachyura* in Portuguese waters (Division 9a). Peniche representativeness in terms of the species polyvalent landed weight within the most important ports.

Trips performed with nets and nets/traps were selected once that contributed for the majority of the species landings; representing between 71-92%.

Trips performed by occasional vessels were removed due to its reduced contribution for the species polyvalent landings. These vessels only contributed up to 2.6% of the polyvalent annual landed weight during the period 2008-2022.

Due to a high density of fishing trips with landed weight close to zero, as well as, the presence of some fishing trips with very high values, trips with very low or very high values of landed weight were excluded, i.e., fishing trips with landed weight below the 1% quantile (corresponding to 0.26 kg.trip^{-1}) and above 99% quantile (corresponding to 226.16 kg.trip^{-1}). These trips represented around 2%.

Rajidae species fisheries have a close season in May and June and for this reason these months were removed from the analysis.

The density distribution and the boxplot of the nominal LPUE (kg.trip^{-1}) of *R. brachyura* per year are presented in Figure 3. For the period 2008-2022, the mean nominal CPUE by year varied between 13.6-33.4 kg.trip^{-1}, with these values registered in 2009 and 2017 respectively (32.1 kg.trip^{-1} in 2022) (Figure 4).

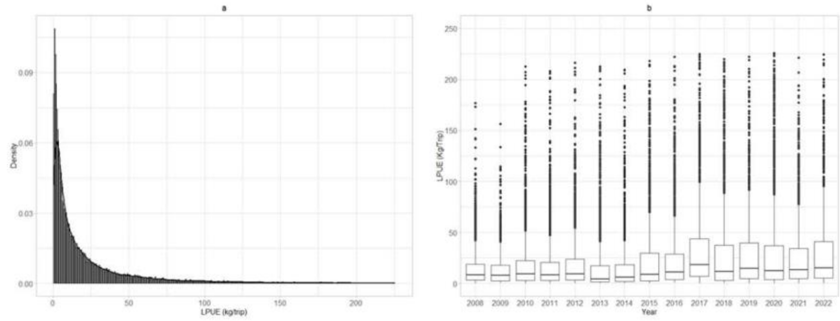

Figure 3. *Raja brachyura* in Portuguese waters (Division 9a). Nominal LPUE in the Peniche landing port during the period 2008-2022: a) density distribution and b) distribution by year.

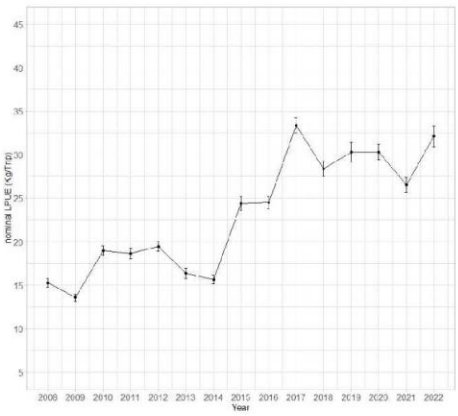

Figure 4: *Raja brachyura* in Portuguese waters (Division 9a). Mean nominal LPUE and associated standard error by year in the Peniche landing port for the period 2008-2022.

3.2 CPUE standardization model

The GLM model adjusted considered a gamma distribution with a log link function and included the explanatory variables year, quarter, gear, vessel size and seasonality (AIC = 232296) and can be expressed as:

glm(LPUE ~ Year + Quarter + Gear + Vessel size + Fishing seasonality, family=Gamma (link=log))

Residual graphical analysis for the best model selected is presented in Figure 5. Explained variance was 75%.

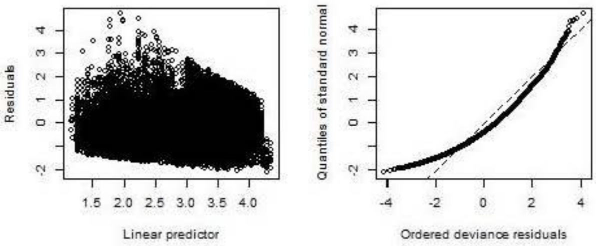

Figure 5. ***Raja brachyura*** **in Portuguese waters (Division 9a). Residuals of the best GLM model fitted to the LPUE data: (left) fitted vs. residuals (right) quantile-quantile (Q-Q) plot.**

Up to 2022, the standardized LPUE was estimated considering a reference situation: quarter = 1, SIZEs = M (medium), SAZ = c (constant) and fishing gear = nets. During WGEF 2022, the high value obtained for 2019 was considered unreliable by the working group, so a deeper look at the input data was done (ICES, 2022).

Nominal LPUE variation for the period by year (Figure 2b), by year for different quarters (Figure 6), for different vessel size (Figure 7), for different fishing seasonality (Figure 8) and for different gears (Figure 9) show that values for 2019 were within the time-series range.

Once the resultant biomass index estimates for the reference situation and for the model mean predicted values followed the same trend along the entire time-series, it was accepted by the WGEF group to construct the LPUE time-series based on the model´s mean predicted values to assess the status of this stock.

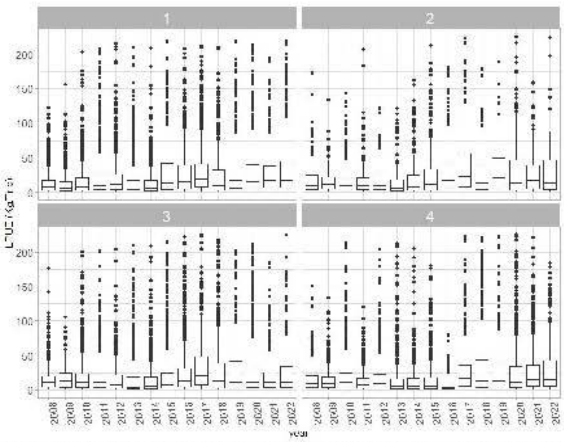

Figure 6: ***Raja brachyura*** **in Portuguese waters (Division 9a). Nominal LPUE distribution by year (2008-2022) for different quarters.**

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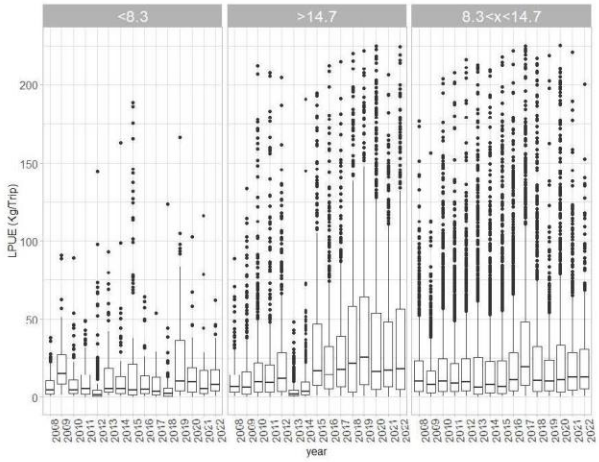

Figure 7: *Raja brachyura* in Portuguese waters (Division 9a). Nominal LPUE distribution by year (2008-2022) for different vessel size groups.

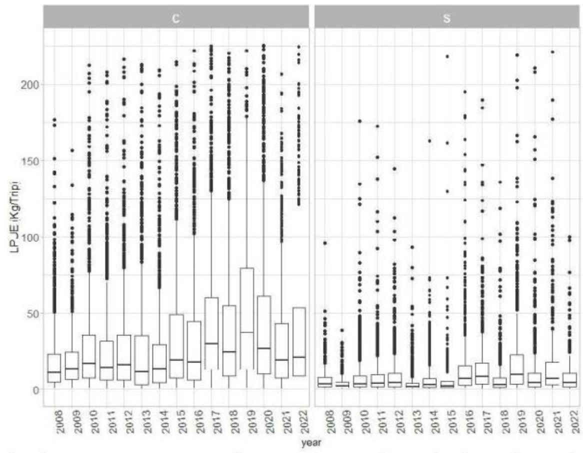

Figure 8: *Raja brachyura* in Portuguese waters (Division 9a). Nominal LPUE distribution by year (2008-2022) for different fishing seasonality groups: c – constant and; s – seasonal.

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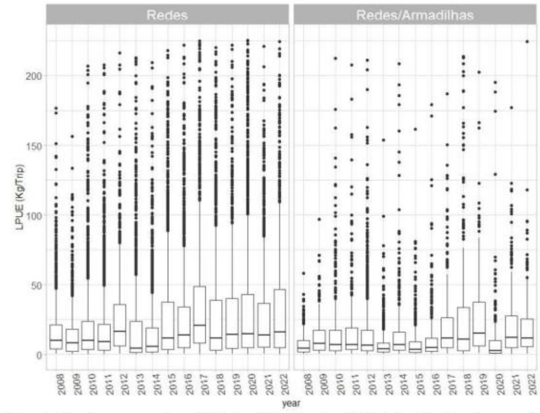

Figure 9: *Raja brachyura* in Portuguese waters (Division 9a). Nominal LPUE distribution by year (2008-2022) for different fishing gears, Redes – nets and; Redes/armadilhas – nets/traps.

Annual biomass index varied from 13.23 kg.trip^{-1} (in 2009) to 34.86 kg.trip^{-1} (in 2017), with and average of 23.61 kg.trip^{-1} for the entire time series (Table 3, Figure 10). Since 2016, values have been above the long-term mean. For comparison proposes, estimates obtained considering the previous reference situation are present in figure 11.

Table 2. *Raja brachyura* in Portuguese waters (Division 9a). LPUE index (kg.trip-1), standard error and normalized LPUE from 2008 to 2022.

Year	LPUE (kg.trip^{-1})	sd	mean-sd	mean+sd	Standirdized LPUE
2008	15.40	6.55	8.86	21.95	0.65
2009	13.23	6.54	6.69	19.76	0.56
2010	19.42	10.95	8.47	30.37	0.82
2011	19.82	11.08	8.74	30.90	0.84
2012	20.96	11.94	9.01	32.90	0.89
2013	13.78	7.84	5.95	21.62	0.58
2014	15.42	9.19	6.23	24.60	0.65
2015	21.23	10.51	10.72	31.74	0.90
2016	27.65	15.62	12.03	43.27	1.17
2017	34.86	17.96	16.90	52.83	1.48
2018	26.32	12.73	13.59	39.05	1.11
2019	33.31	21.26	12.04	54.57	1.41
2020	29.07	15.72	13.35	44.79	1.23
2021	31.35	15.13	16.21	46.48	1.33
2022	32.32	13.70	18.62	46.03	1.37

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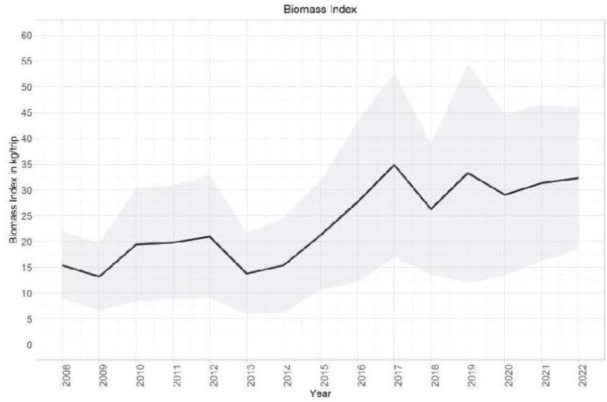

Figure 10. *Raja brachyura* in Portuguese waters (Division 9a). Biomass index (kg.trip-1) and respective standard error for the period 2008-2022.

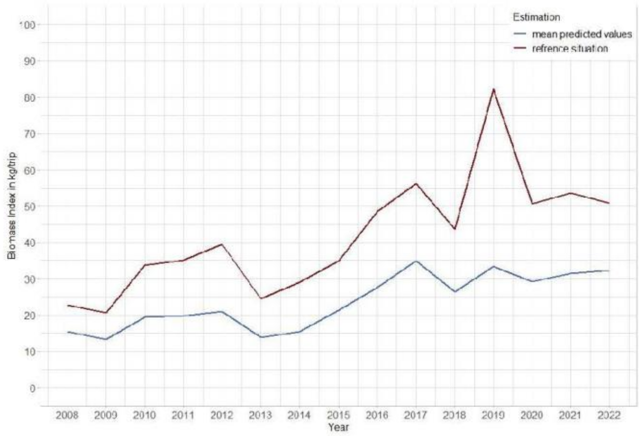

Figure 11. *Raja brachyura* in Portuguese waters (Division 9a). Biomass index (kg.trip-1) for the period 2008-2022 considering the previous reference situation (blue line) and model mean predicted values (black line) for the period 2008-2022.

4. References

Figueiredo, I., Maia, C., Lagarto, N. and Serra-Pereira, B. 2020. Bycatch estimation of Rajiformes in multispecies and multigear fisheries. Fisheries Research: 232. https://doi.org/10.1016/j.fishres.2020.105727.

ICES. 2022. Working Group on Elasmobranch Fishes (WGEF). ICES Scientific Reports. 4:74. 848 pp. http://doi.org/10.17895/ices.pub.21089833

Morgan, J.A., and Tatar J.F. 1972. Calculation of the Residual Sum of Squares for all Possible Regressions. Technometrics, 14, 317-325.

McLeod, A.I., and Xu, C. 2010. bestglm: Best Subset GLM. URL http://CRAN.Rproject.org/package=bestglm.

Working Document presented at ICES WKELASMO3
Data compilation online meeting, 26th February to 3rd March 2024

Blonde ray (*Raja brachyura*) in Division 9.a (Atlantic Iberian waters) (rjh.27.9a) - SPiCT assessment

Catarina Maia[1], Teresa Moura[1], Bárbara Serra-Pereira[1], Cristina Rodriguez-Cabello[2] and Ivone Figueiredo[1]

[1] Instituto Português do Mar e da Atmosfera (IPMA)
[2] Instituto Español de Oceanografía (IEO-CSIC)

Conteúdo

Abstract

The present working document presents the information considered for Raja brachyura in Iberian waters (ICES division 27.9a) for the application of a surplus production model SPiCT (Stochastic Production model in Continuous Time). A compilation and revision of the data available to implement future assessments of this stock with a SPiCT model are presented as well as several SPiCT runs considering different priors.

Working Document presented at ICES WKELASMO3
Data compilation online meeting, 26th February to 3rd March 2024

1. Introduction

Blonde ray *Raja brachyura* has a wide geographic distribution in the north-east Atlantic and Mediterranean (Stehmann and Bürkel, 1984). In the Atlantic Iberian waters, it is distributed along the shelf and upper slope.

This stock (rjh.27.9a), which comprises the ICES Division 9a, includes the north Spanish area (Galician waters), Portuguese mainland waters and south Spanish waters (Gulf of Cadiz). Since 2014 that it is assessed under the ICES category 3 for Data limited stocks (DLS), currently using biomass indicator trends estimated from LPUE from Portuguese polyvalent fleet (method 2.1; ICES, 2021; ICES, 2022). Scientific advice on this stock is provided by ICES WGEF every two years.

At the ACOM meeting, in March 2021, it was agreed to implement the WKLIFE X Annex 3 methods for all category 3 stocks. Based on these guidelines, the last assessment, conducted in 2022, followed the rfb rule which was applied for the first time for this stock.

Among some of the other methods suggested to obtain reference points (RP) for data limited stocks (DLS) are production models (ICES, 2021) and particularly the stochastic surplus production model in continuous time (SPiCT; Pedersen and Berg, 2017). A compilation and revision of the data available to implement future assessments of this stock with a SPiCT model are presented. Several SPiCT runs were conducted and results from those trials are also shown below.

2. Input data for SPiCT assessment

2.1. Landings

Species-specific landings were only available since 2008 and 2009 for Portugal and Spain respectively. In order to obtain a longer time series, landings since 2000 have been estimated both for the Spanish and Portuguese fleets independently and using different approaches (see Maia *et al.*, (2023a) and Rodriguez-Cabello *et al.*, 2024 for the methods used).

Raja brachyura landings in ICES Division 9a have been ranged from 162 to 347 tonnes, with Portugal contributing for 96-100% and Spain for up to 4% (Table 2.1.1). Belgium only reported 0.04 tonnes in 2017. Along the time series, landings from the polyvalent fleet represented 71-94% of the species landed weight, followed by trawl that have been representing between 6-29% (Figure 2.1.1).

Working Document presented at ICES WKELASMO3
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Table 2.1.1: *Raja brachyura* in ICES Division 27.9a. Annual landings (in tonnes) and representativeness by country

Year	Belgium		Portugal		Spain		Total
	Ton	%	Ton	%	Ton	%	
2000	0	0	262	100	1	0	263
2001	0	0	263	99	1	1	265
2002	0	0	229	99	1	1	230
2003	0	0	248	100	1	0	249
2004	0	0	235	100	1	0	236
2005	0	0	259	100	1	0	261
2006	0	0	205	99	1	1	206
2007	0	0	185	99	1	1	186
2008	0	0	193	99	1	1	194
2009	0	0	163	99	1	1	164
2010	0	0	221	99	2	1	223
2011	0	0	161	99	1	1	162
2012	0	0	165	100	0	0	165
2013	0	0	179	98	3	2	182
2014	0	0	174	100	0	0	174
2015	0	0	236	100	0	0	236
2016	0	0	221	100	1	0	222
2017	0	0	235	100	0	0	236
2018	0	0	191	98	4	2	195
2019	0	0	255	97	8	3	263
2020	0	0	335	97	12	3	347
2021	0	0	267	96	11	4	278
2022	0	0	297	96	13	4	311

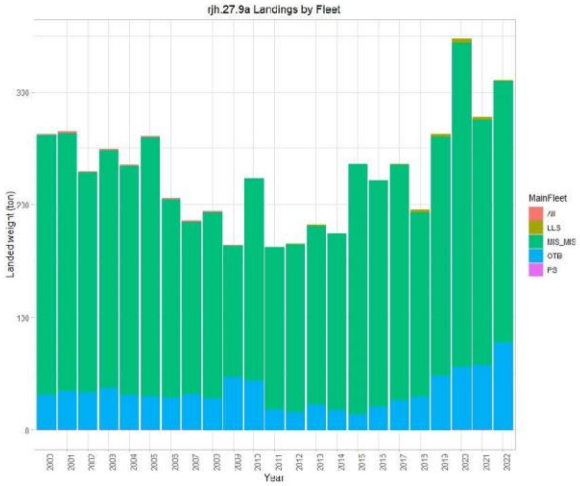

Figure 2.1.1: *Raja brachyura* in ICES Division 27.9a. Annual landings (in tonnes) by fleet. "All" – all fleets combined; "LLS" – longlines; "MIS_MIS" – polyvalent fleet; "OTB" – trawl fleet and; "PS" – seine fleet.

2.2. Biomass indices

Commercial LPUE

Once that Portuguese bottom trawl research surveys are inadequate for monitoring *R. brachyura* populations in ICES Division 9a, a commercial standardized LPUE time-series index based on data derived from the Portuguese polyvalent fleet is considered to provide assessment on stock status.

All the details on the LPUE standardization methodology are described in Maia *et al.* (2023b, WD).

Annual biomass index varied from 13.23 $kg.trip^{-1}$ (in 2009) to 34.86 $kg.trip^{-1}$ (in 2017), with an average of 23.61 $kg.trip^{-1}$ for the entire time series (Table 2.2.1, Figure 2.2.1). Since 2016, values have been above the long-term mean.

Table 2.2.1: *Raja brachyura* in ICES Division 27.9a. LPUE index (kg.trip^{-1}), standard error and normalized LPUE from 2008 to 2022.

Year	LPUE (kg.trip^{-1})	sd	mean-sd	mean+sd	Standirdized LPUE
2008	15.40	6.55	8.86	21.95	0.65
2009	13.23	6.54	6.69	19.76	0.56
2010	19.42	10.95	8.47	30.37	0.82
2011	19.82	11.08	8.74	30.90	0.84
2012	20.96	11.94	9.01	32.90	0.89
2013	13.78	7.84	5.95	21.62	0.58
2014	15.42	9.19	6.23	24.60	0.65
2015	21.23	10.51	10.72	31.74	0.90
2016	27.65	15.62	12.03	43.27	1.17
2017	34.86	17.96	16.90	52.83	1.48
2018	26.32	12.73	13.59	39.05	1.11
2019	33.31	21.26	12.04	54.57	1.41
2020	29.07	15.72	13.35	44.79	1.23
2021	31.35	15.13	16.21	46.48	1.33
2022	32.32	13.70	18.62	46.03	1.37

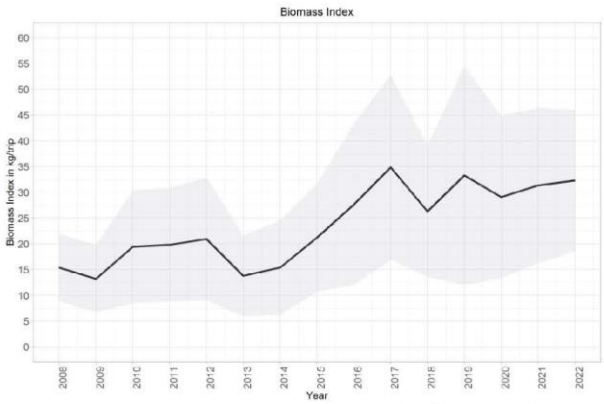

Figure 2.2.1: *Raja brachyura* in ICES Division 27.9a. Biomass index (kg.trip^{-1}) and respective standard error for the period 2008-2022.

2.3. Life-history parameters

Growth and reproduction life history parameters are available for this species in the study area as well in other ICES areas. A summary of the most relevant studies available can be found in Maia et al. (2023c). For the purposes of the present benchmark, the selected parameters are described below.

Length-weight relationship considered is $W=0.00198*TL^{3.2}$ according with Serra-Pereira *et al.* (2010).

Estimates of the length at which 50% of the population is mature (L50%) and length at which 95% of the population is mature (L95%) for *R. brachyura* in the stock area are available from Maia *et al.* (2022). A L50% of 95.2 cm and a L95% of 101.3 cm (both values estimated for females) are considered. Fecundity is assumed to be 115 eggs/female/year (Maia *et al.*, 2022).

There are few studies regarding growth of *R. brachyura* in the stock area, in particular from Farias (2005) and Pina-Rodrigues (2012) (see details in Maia et al., 2023c). However, given the uncertainty associated with it, the averaged VBGP provided for female *R. brachyura* from three studies (Holden, 1972; Fahy, 1989 (mean value from four different study areas) and Gallagher et al., 2005) are considered following the methodology defined for other *R. brachyura* stocks (rjh.27.4bc7d) previously benchmarked (ICES, 2023). The parameters considered are: Linf = 134.31 cm, K = 0.182 y−1 and t0 = −0.56.

Natural mortality (M) is estimated as 0.23 and is derived from Then et al., (2015), following the methodology defined for other elasmobranch stocks previously benchmarked (ICES, 2023).

$$M=4.118* K^{0.73}*L_{inf}^{-0.33}$$

A value for the maximum age (tmax) is extracted from the database of life history correlations available in the FishLife R package (Thorson et al., 2023). The maximum value from those available for *R. brachyura* is chosen, with tmax = 17.

3. SPiCT exploratory assessments

Various simulation runs are tested, differing in terms of informative priors on parameter intrinsic rate of biomass increase (*r*) and initial depletion rate (*bkfrac*). A Schaefer production curve is considered for all models here presented.

3.1. Definition of priors

Intrinsic rate of biomass increase (r)

A prior probability distribution is considered for the intrinsic rate of biomass increase (r). A Leslie matrix is built using the biological variables available for *R. brachyura* (Table 3.1.1) to obtain a mean prior value for the intrinsic rate of increase (*r*). The jbleslie function in the R package JABBA (Winker et al., 2018) is used to return a value of *r* = 0.22. This value is considered for model's runs.

For this prior, runs considering CVs of 0.2 and 0.5 are both tested.

An extra run considering a higher *r* (0.33 with a CV of 0.5), similar to the one considered for the stock rjh.27.4bc7d previously benchmarked (ICES, 2023), is also tested.

Table 3.1.1: *Raja brachyura* in ICES Division 27.9a. Biological variables used in the call to JABBA::jbleslie() to obtain a mean prior for the intrinsic rate of biomass increase (r) using a Leslie matrix calculation of female net reproductive rate.

Min age	Max age	Linf	k	t0	LWR a	LWR b	M	fec	L50%	L95%
0	17	134.31	0.182	-0.56	0.00198	3.2	0.23	115	95.2	101.3

Initial depletion rate

A run without setting a prior for the initial depletion (*bkfrac*) is tested resulting in a bad performance of the model. Given this, several runs considering *bkfrac* of 0.2 and 0.5 are tested. For this prior, runs considering CVs of 0.2 and 0.5 are both tested.

logalpha and logbeta

Priors on *logalpha* and *logbeta* (noise ratios) are disabled.

3.2. Model's input data

- Catch: Stock landings (2000-2022) (Figure 3.2.1)
- Index 1: PT LPUE (2008-2022, set at the middle of the year) (Figure 3.2.1)

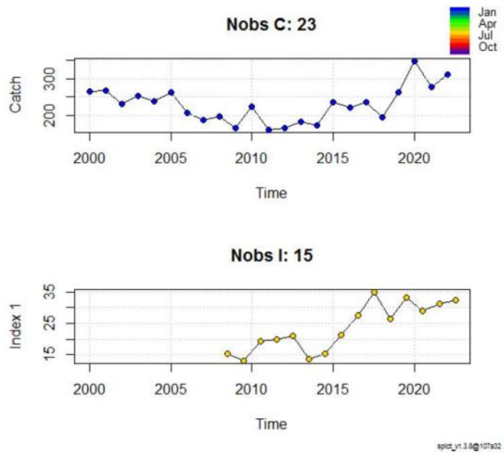

Figure 3.2.1: *Raja brachyura* in ICES Division 27.9a. Input data.

3.3. Runs

Several runs are tested to check model performance using different priors and CVs. A Schaefer production curve is considered for all models here presented.

The checklist for the acceptance of a SPiCT assessment is followed (Mildenberger et al., 2020).

Below we present results for the models that provided the best fit and could be potentially accepted to assess this stock. A summary of the results for the runs can be found in Table 3.3.1. A file with extra details on model's outputs (as model parameter estimates, deterministic reference points, stochastic reference points, states with 95% C, predictions with

95% CI and Catch Advice) as well as extra runs considering different combination of priors and tighter Schaefer production curve is also available in the SharePoint (Data\rjh.27.9a_SPiCT\ rjh.27.9a_SPiCT_runs.xls).

3.3.1 Run 2 (results in Table 3.3.1, figures 3.3.1.1-3.3.1.3)

Priors:

- Schaefer production curve: rjh_data$phases$logn <- -1
- Initial depletion level (rjh_data$priors$logbkfrac <- c(log(0.20),0.2,1)
- Intrinsic rate of population increase (r): rjh_data$priors$logr <- c(log(0.22),0.2, 1)
- Alpha: rjh_data$priors$logalpha <- c(1, 1, 0)
- Beta: rjh_data$priors$logbeta <- c(1, 1, 0)

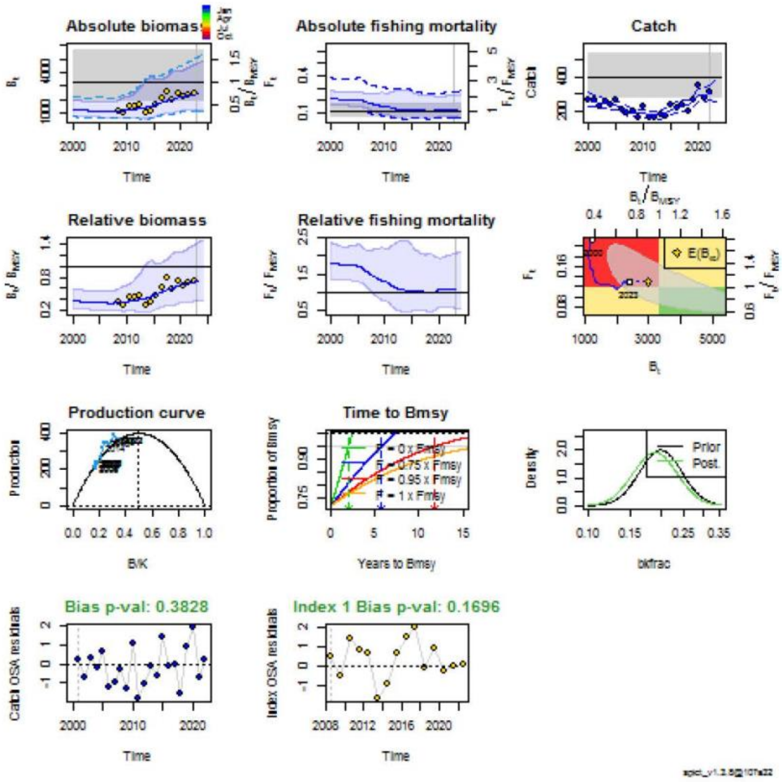

Figure 3.3.1.1: *Raja brachyura* in ICES Division 27.9a. Run 2: results from SPiCT model.

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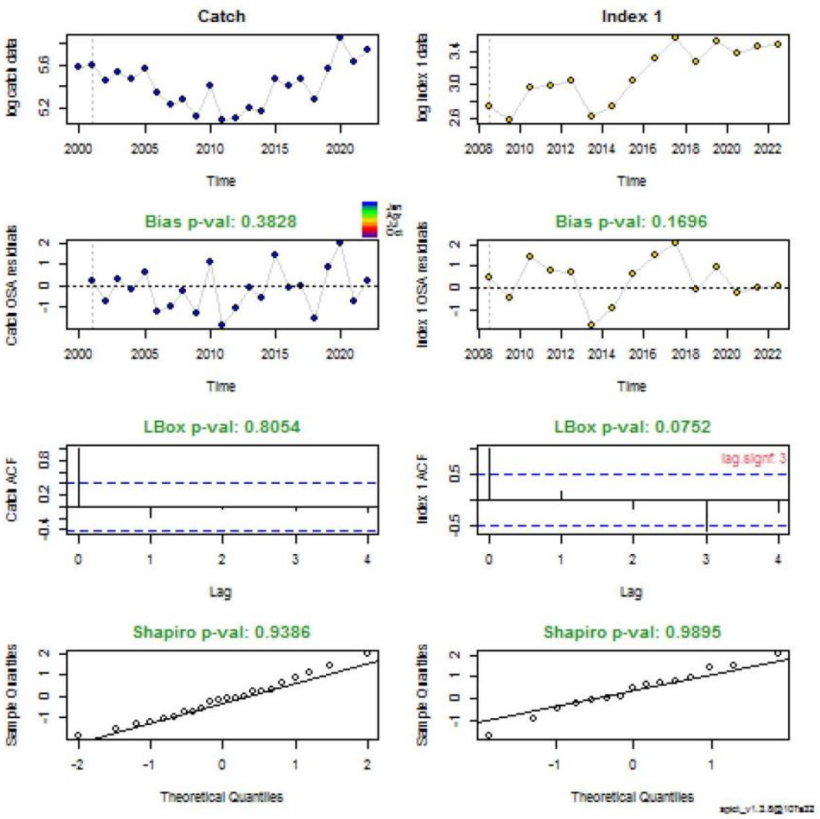

Figure 3.3.1.2: *Raja brachyura* in ICES Division 27.9a. Run 2: results from SPiCT model. Row1, Log of the input data series. Row 2, OSA residuals with the p-value of a test for bias. Row 3, Empirical autocorrelation of the residuals with tests for significant autocorrelation. Row 4, Tests for normality of the residuals, QQ-plot and Shapiro test.

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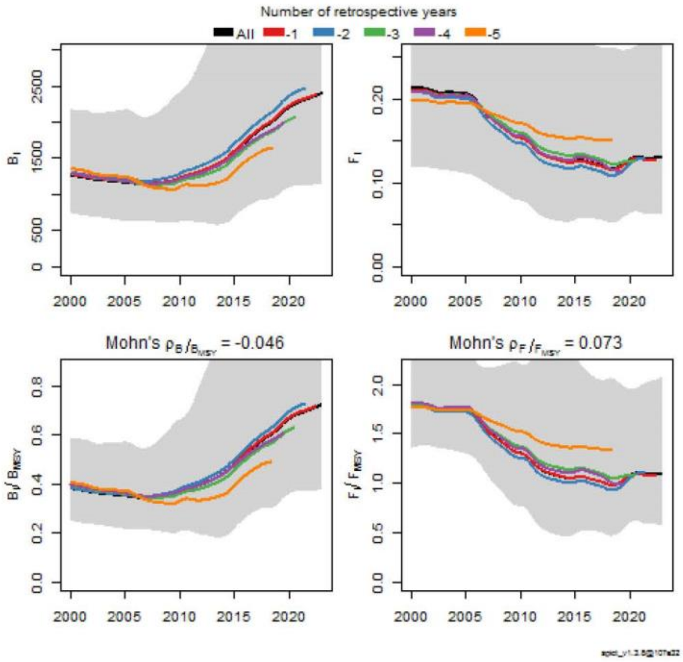

Figure 3.3.1.3: *Raja brachyura* in ICES Division 27.9a. Run 2: results from SPiCT model; retrospective analysis. Upper panel, absolute biomass and fishing mortality. Lower panel, relative biomass and fishing mortality. Grey regions represent 95% CIs.

3.3.2 Run 13 (results in Table 3.3.1, figures 3.3.2.1-3.3.2.3)

Priors:

- Schaefer production curve: rjh_data$phases$logn <- -1
- Initial depletion level (rjh_data$priors$logbkfrac <- c(log(0.20),0.5,1)
- Intrinsic rate of population increase (r): rjh_data$priors$logr <- c(log(0.22),0.2, 1)
- Alpha: rjh_data$priors$logalpha <- c(1, 1, 0)
- Beta: rjh_data$priors$logbeta <- c(1, 1, 0)

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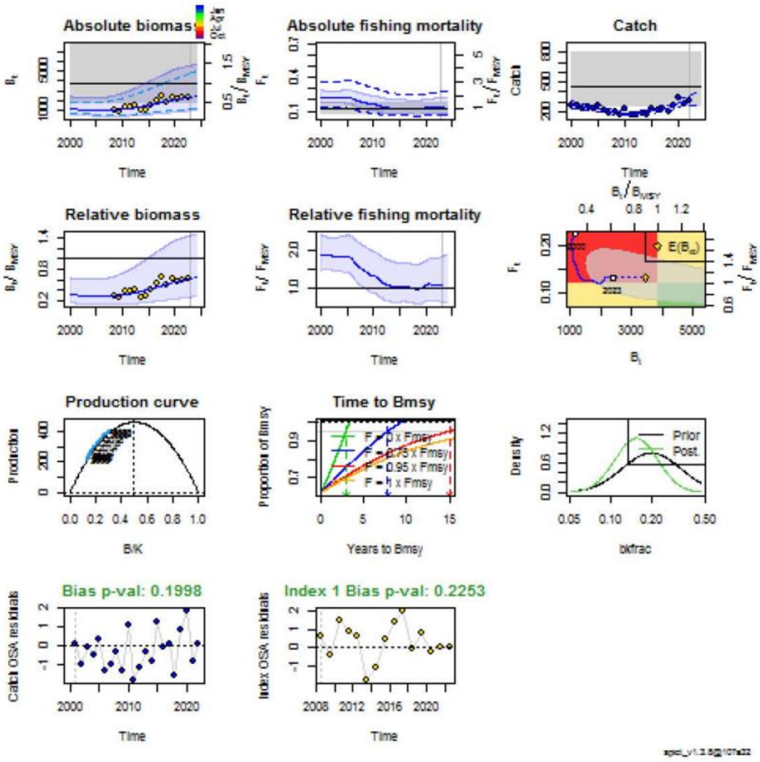

Figure 3.3.2.1: *Raja brachyura* in ICES Division 27.9a. Run 13: results from SPiCT model.

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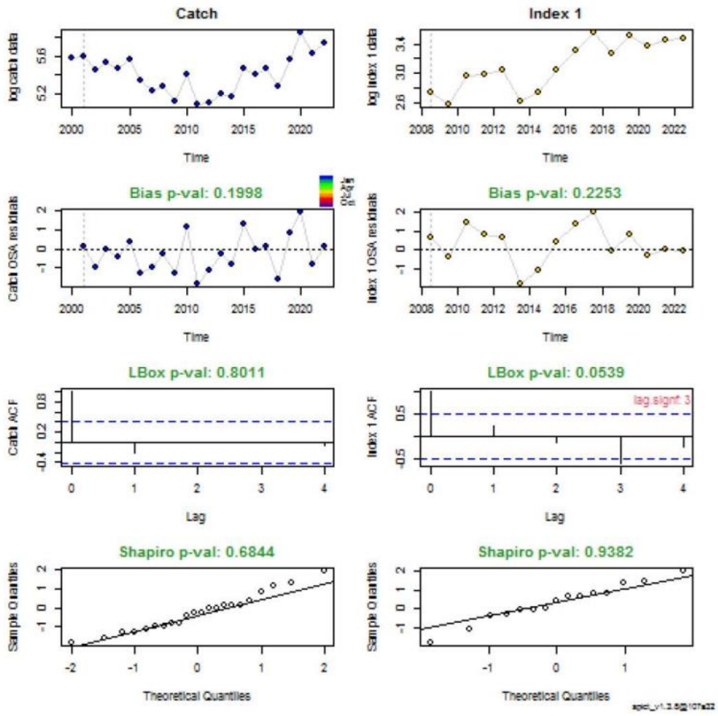

Figure 3.3.2.2: *Raja brachyura* in ICES Division 27.9a. Run 13: results from SPiCT model. Row1, Log of the input data series. Row 2, OSA residuals with the p-value of a test for bias. Row 3, Empirical autocorrelation of the residuals with tests for significant autocorrelation. Row 4, Tests for normality of the residuals, QQ-plot and Shapiro test.

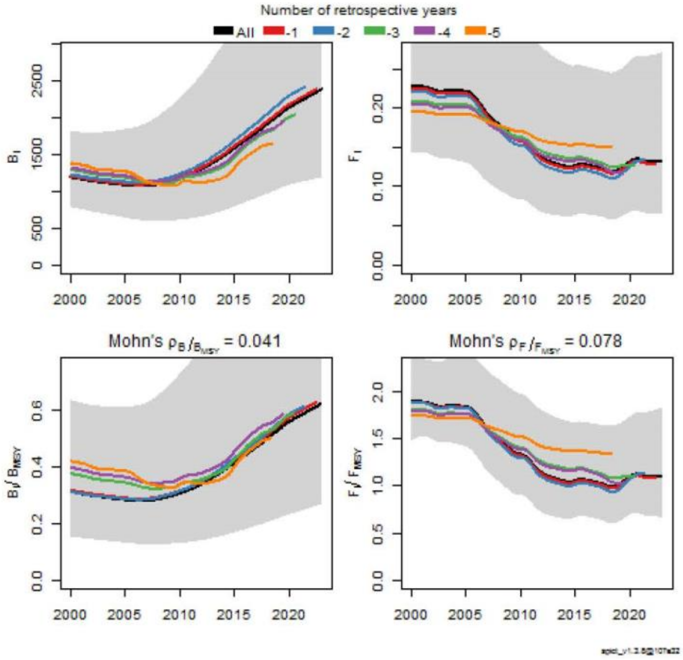

Figure 3.3.2.3: *Raja brachyura* in ICES Division 27.9a. Run 13: results from SPiCT model; retrospective analysis. Upper panel, absolute biomass and fishing mortality. Lower panel, relative biomass and fishing mortality. Grey regions represent 95% CIs.

3.3.3 Run 9 (results in Table 3.3.1, figures 3.3.3.1-3.3.3.3)

Priors:

- Schaefer production curve: rjh_data$phases$logn <- -1
- Initial depletion level (rjh_data$priors$logbkfrac <- c(log(0.50),0.5,1)
- Intrinsic rate of population increase (r): rjh_data$priors$logr <- c(log(0.22),0.2, 1)
- Alpha: rjh_data$priors$logalpha <- c(1, 1, 0)
- Beta: rjh_data$priors$logbeta <- c(1, 1, 0)

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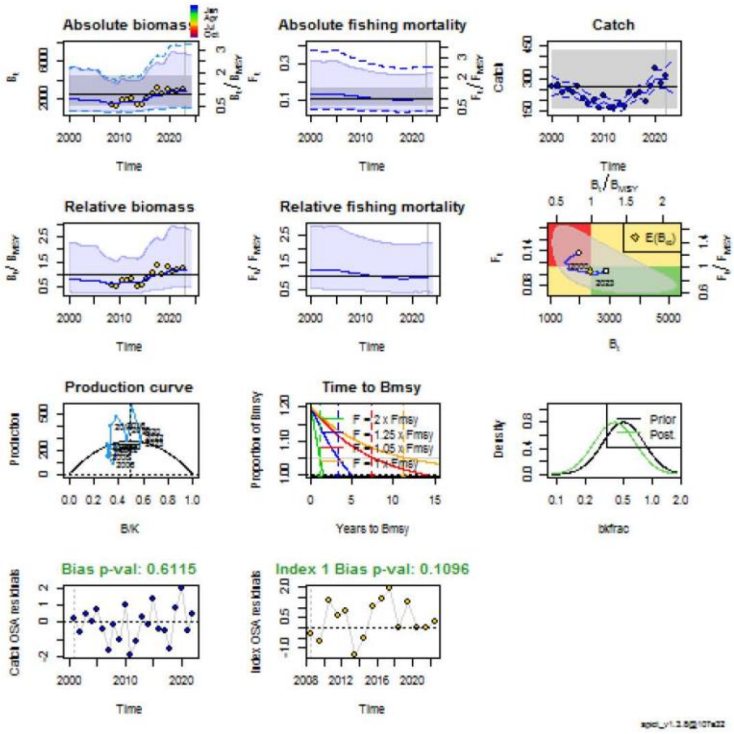

Figure 3.3.3.1: *Raja brachyura* in ICES Division 27.9a. Run 9: results from SPiCT model.

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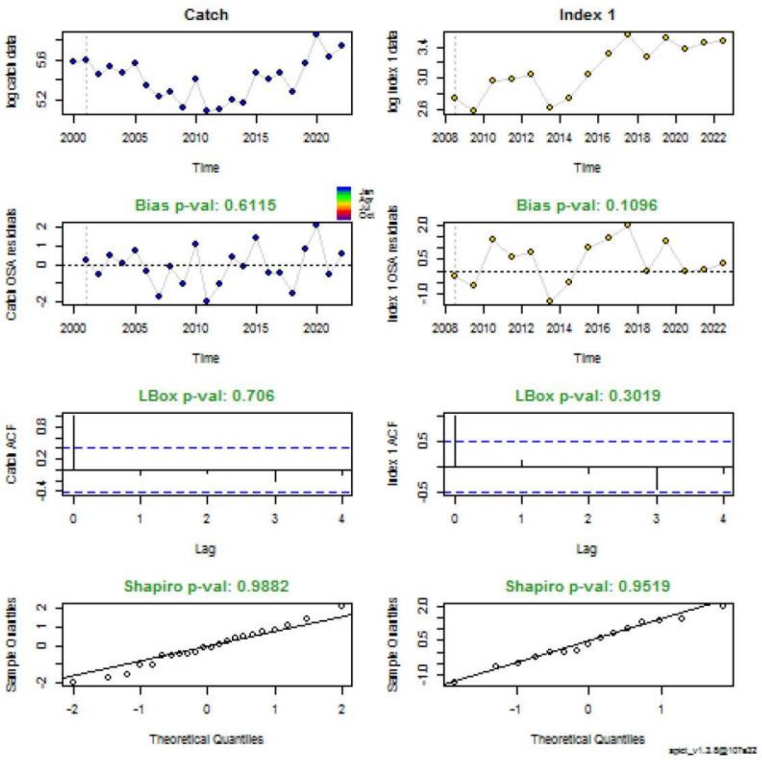

Figure 3.3.3.2: *Raja brachyura* in ICES Division 27.9a. Run 9: results from SPiCT model. Row1, Log of the input data series. Row 2, OSA residuals with the p-value of a test for bias. Row 3, Empirical autocorrelation of the residuals with tests for significant autocorrelation. Row 4, Tests for normality of the residuals, QQ-plot and Shapiro test.

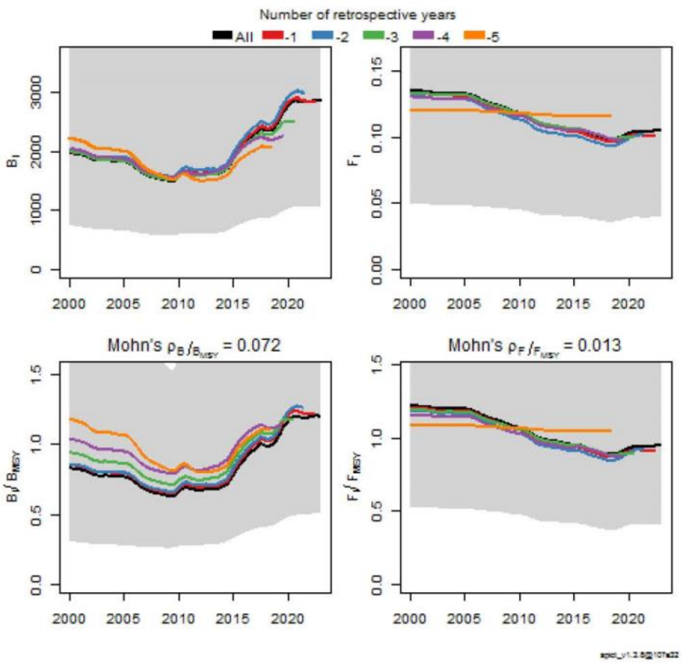

Figure 3.3.3.3: *Raja brachyura* in ICES Division 27.9a. Run 9: results from SPiCT model; retrospective analysis. Upper panel, absolute biomass and fishing mortality. Lower panel, relative biomass and fishing mortality. Grey regions represent 95% CIs.

3.3.4 Run 16 (results in Table 3.3.1, figures 3.3.4.1-3.3.4.3)

Priors:

- Schaefer production curve: rjh_data$phases$logn <- -1
- Initial depletion level: rjh_data$priors$logbkfrac <- c(log(0.50),0.5,1)
- Intrinsic rate of population increase (r): rjh_data$priors$logr <- c(log(0.33),0.5, 1)
- Alpha: rjh_data$priors$logalpha <- c(1, 1, 0)
- Beta: rjh_data$priors$logbeta <- c(1, 1, 0)

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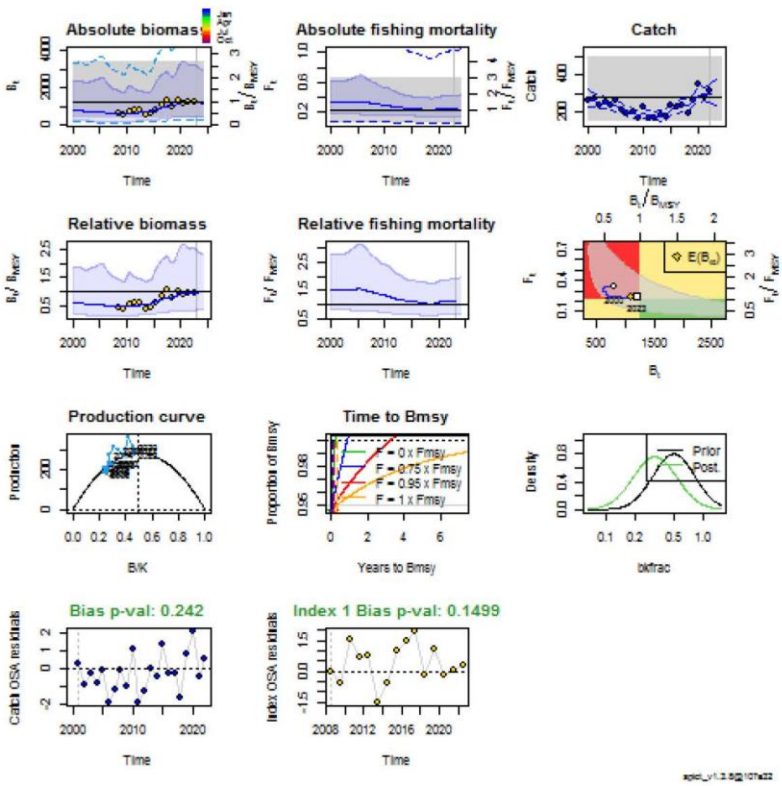

Figure 3.3.4.1: *Raja brachyura* in ICES Division 27.9a. Run 16: results from SPiCT model.

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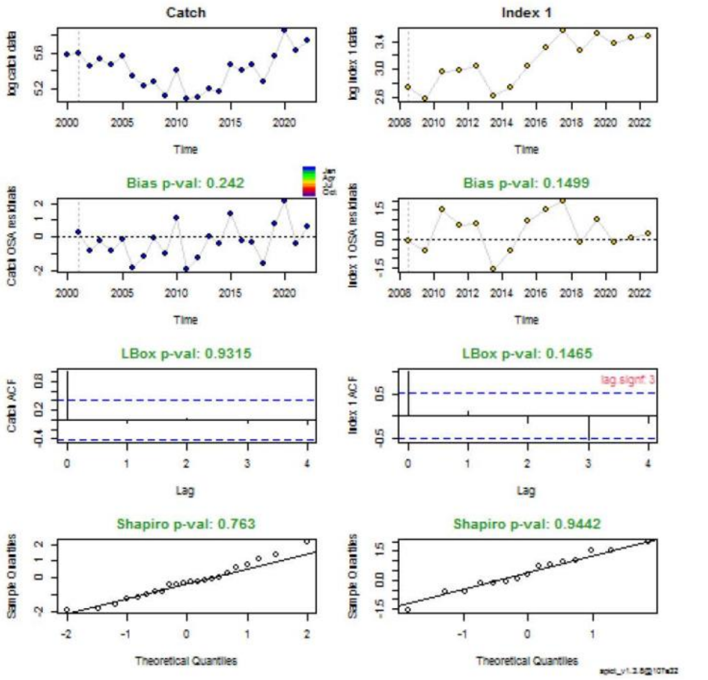

Figure 3.3.4.2: *Raja brachyura* in ICES Division 27.9a. Run 16: results from SPiCT model. Row1, Log of the input data series. Row 2, OSA residuals with the p-value of a test for bias. Row 3, Empirical autocorrelation of the residuals with tests for significant autocorrelation. Row 4, Tests for normality of the residuals, QQ-plot and Shapiro test.

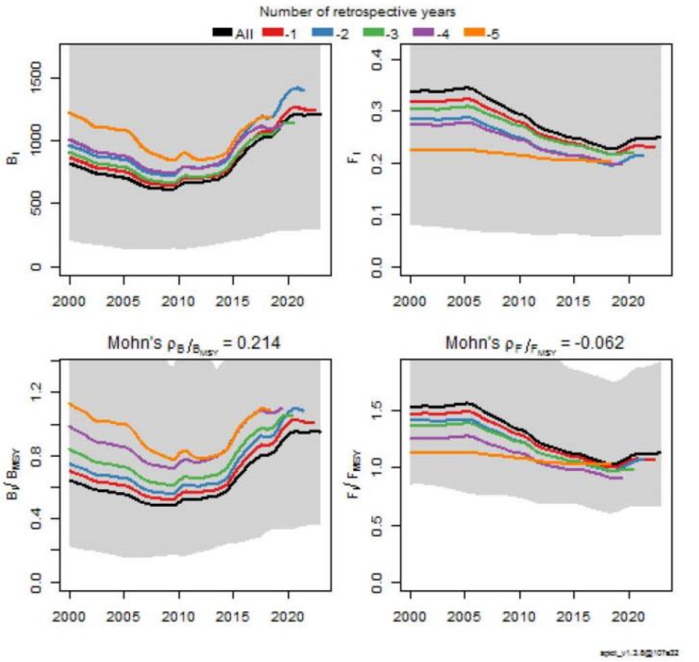

Figure 3.3.4.3: *Raja brachyura* in ICES Division 27.9a. Run 16: results from SPiCT model; retrospective analysis. Upper panel, absolute biomass and fishing mortality. Lower panel, relative biomass and fishing mortality. Grey regions represent 95% CIs.

3.3.5 Run 17 (results in Table 3.3.1, figures 3.3.5.1-3.3.5.3)

Priors:

- Schaefer production curve: rjh_data$phases$logn <- -1
- Initial depletion level (rjh_data$priors$logbkfrac <- c(log(0.50),0.5,1)
- Intrinsic rate of population increase (r): rjh_data$priors$logr <- c(log(0.22),0.5, 1)
- Alpha: rjh_data$priors$logalpha <- c(1, 1, 0)
- Beta: rjh_data$priors$logbeta <- c(1, 1, 0)

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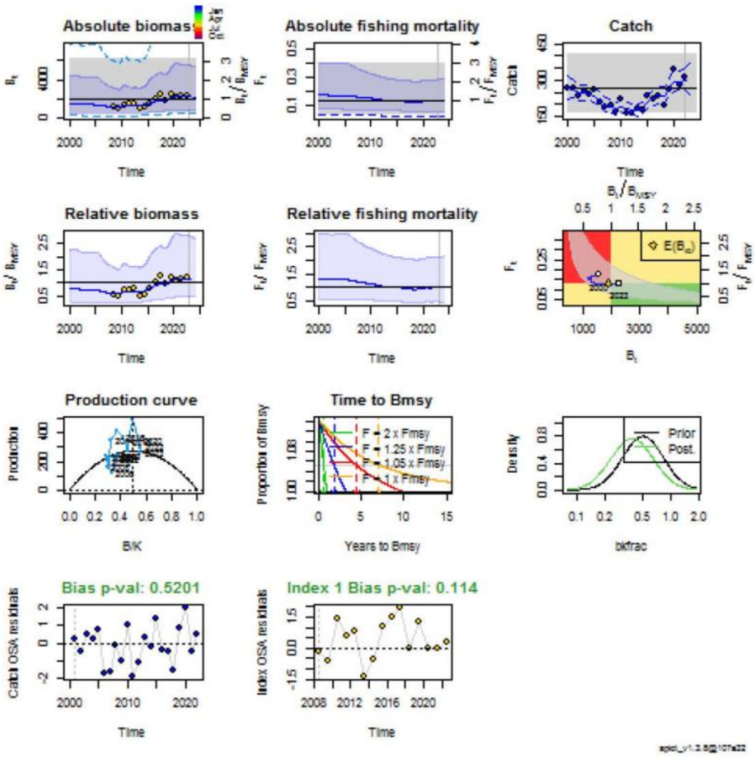

Figure 3.3.5.1: *Raja brachyura* in ICES Division 27.9a. Run 17: results from SPiCT model.

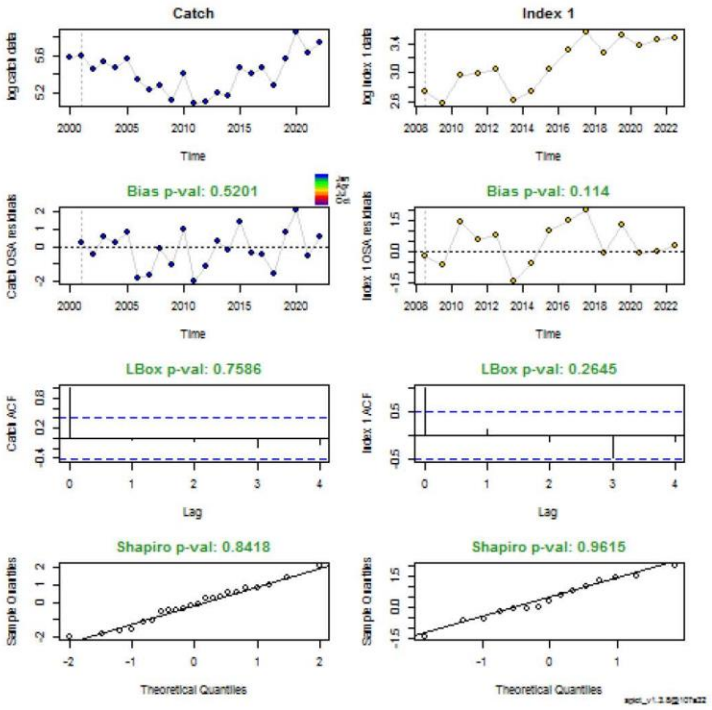

Figure 3.3.5.2: *Raja brachyura* in ICES Division 27.9a. Run 17: results from SPiCT model. Row1, Log of the input data series. Row 2, OSA residuals with the p-value of a test for bias. Row 3, Empirical autocorrelation of the residuals with tests for significant autocorrelation. Row 4, Tests for normality of the residuals, QQ-plot and Shapiro test.

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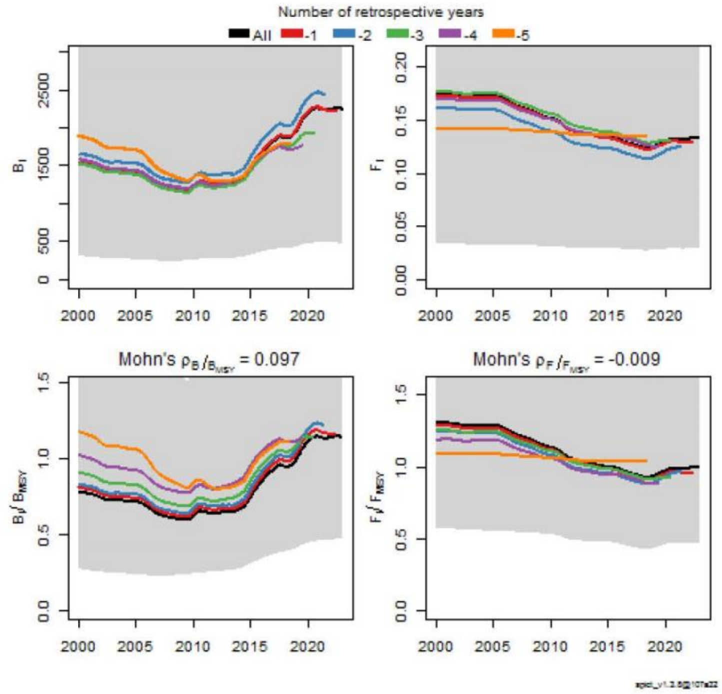

Figure 3.3.5.3: *Raja brachyura* in ICES Division 27.9a. Run 17: results from SPiCT model; retrospective analysis. Upper panel, absolute biomass and fishing mortality. Lower panel, relative biomass and fishing mortality. Grey regions represent 95% CIs.

3.3.6 Run 18 (results in Table 3.3.1, figures 3.3.6.1-3.3.6.3)

Priors:

- Schaefer production curve: rjh_data$phases$logn <- -1
- Initial depletion level: No prior
- Intrinsic rate of population increase (r): rjh_data$priors$logr <- c(log(0.22),0.2, 1)
- Alpha: rjh_data$priors$logalpha <- c(1, 1, 0)
- Beta: rjh_data$priors$logbeta <- c(1, 1, 0)

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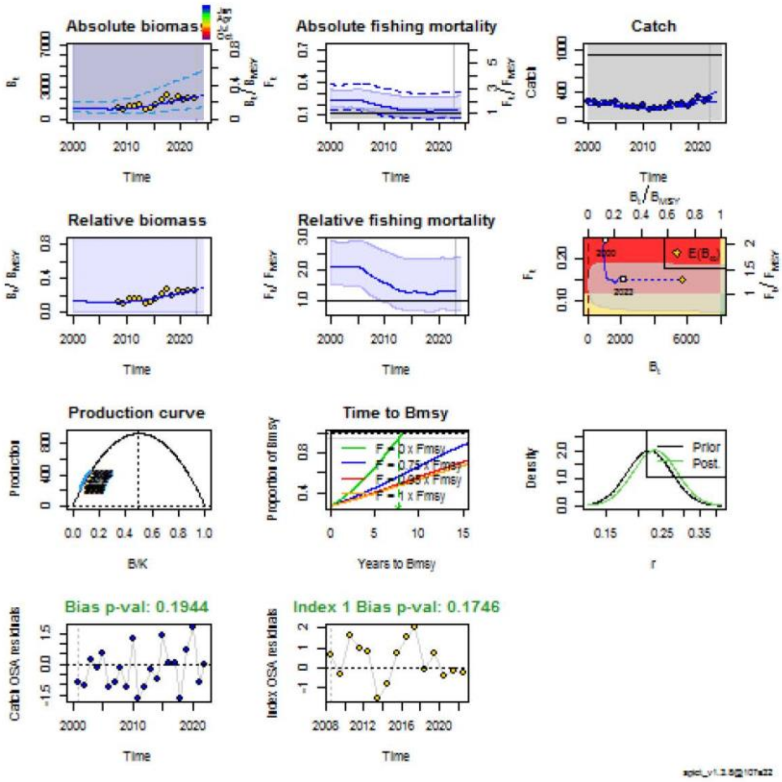

Figure 3.3.6.1: *Raja brachyura* in ICES Division 27.9a. Run 18: results from SPiCT model.

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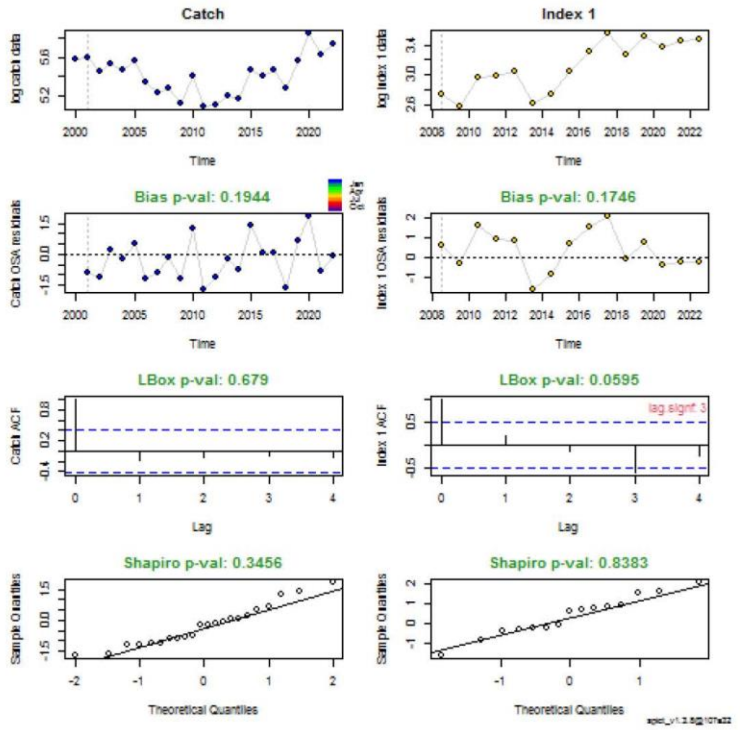

Figure 3.3.6.2: *Raja brachyura* in ICES Division 27.9a. Run 18: results from SPiCT model. Row1, Log of the input data series. Row 2, OSA residuals with the p-value of a test for bias. Row 3, Empirical autocorrelation of the residuals with tests for significant autocorrelation. Row 4, Tests for normality of the residuals, QQ-plot and Shapiro test.

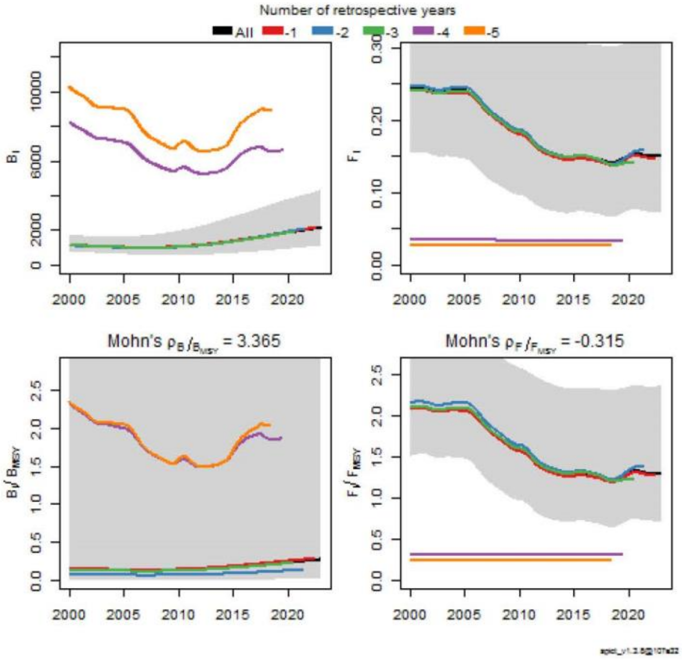

Figure 3.3.6.3: *Raja brachyura* in ICES Division 27.9a. Run 18: results from SPiCT model; retrospective analysis. Upper panel, absolute biomass and fishing mortality. Lower panel, relative biomass and fishing mortality. Grey regions represent 95% CIs.

3.3.7 Run 21 (results in Table 3.3.1, figures 3.3.7.1-3.3.7.3)

Input data:

- Add uncertainty to catch time series for the period 2000-2007

Priors:

- Schaefer production curve: rjh_data$phases$logn <- -1
- Initial depletion level (rjh_data$priors$logbkfrac <- c(log(0.50),0.5,1)
- Intrinsic rate of population increase (r): rjh_data$priors$logr <- c(log(0.22),0.2, 1)
- Alpha: rjh_data$priors$logalpha <- c(1, 1, 0)
- Beta: rjh_data$priors$logbeta <- c(1, 1, 0)

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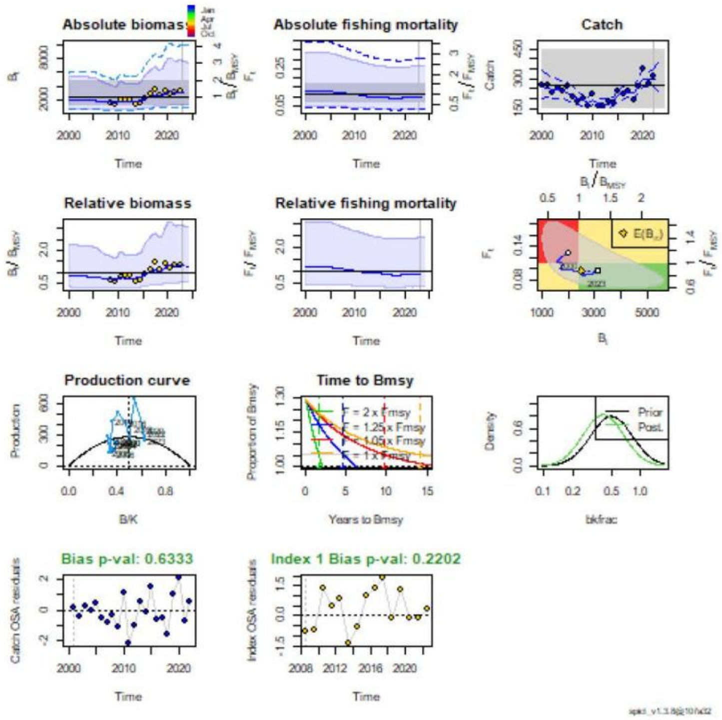

Figure 3.3.7.1: *Raja brachyura* in ICES Division 27.9a. Run 21: results from SPiCT model.

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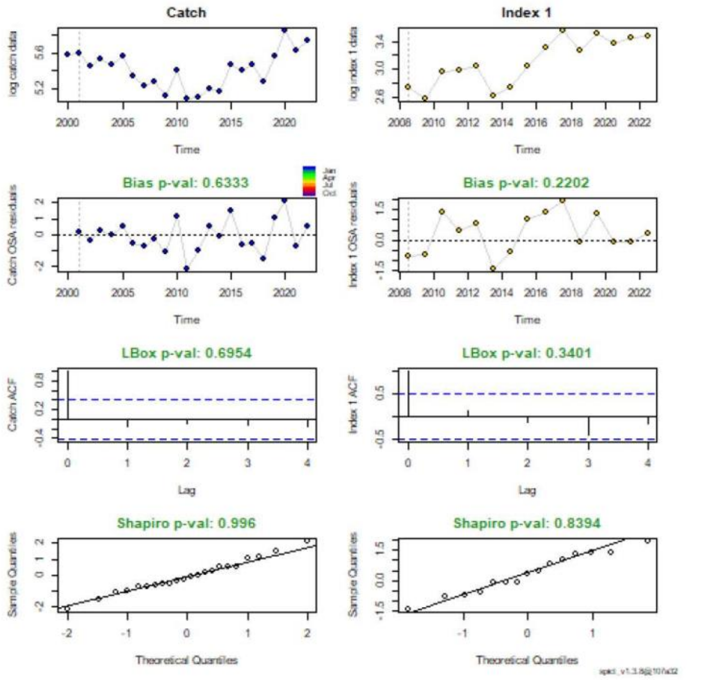

Figure 3.3.7.2: *Raja brachyura* in ICES Division 27.9a. Run 21: results from SPiCT model. Row1, Log of the input data series. Row 2, OSA residuals with the p-value of a test for bias. Row 3, Empirical autocorrelation of the residuals with tests for significant autocorrelation. Row 4, Tests for normality of the residuals, QQ-plot and Shapiro test.

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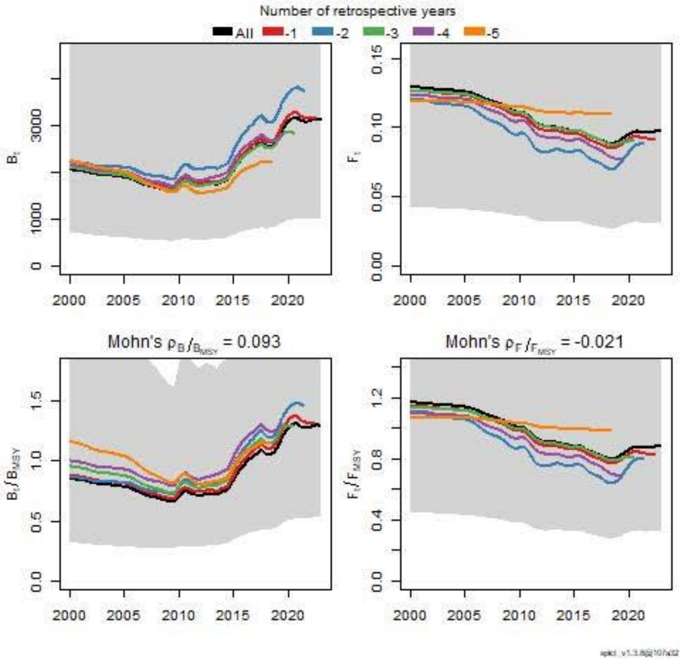

Figure 3.3.7.3: ***Raja brachyura*** **in ICES Division 27.9a, Run 21: results from SPICT model; retrospective analysis. Upper panel, absolute biomass and fishing mortality. Lower panel, relative biomass and fishing mortality. Grey regions represent 95% CIs.**

Table 3.3.1: *Raja brachyura* in ICES Division 9a. SPiCT results summary.

	SPiCT runs						
Input series	**2**	**13**	**9**	**16**	**17**	**18**	**21**
C	2000-2022	2000-2022	2000-2022	2000-2022	2000-2022	2000-2022	2000-2022
I1 (PT LPUE)	2008-2022	2008-2022	2008-2022	2008-2022	2008-2022	2008-2022	2008-2022
Increased uncertainty (stdev)							
C	-	-	-	-	-	-	2000-2007
I1 (PT LPUE)	-	-	-	-	-	-	-
Priors							
logn (production curve)	$phases$logn <- -1	$phases$logn <- -1	$phases$logn <- -1	$phases$logn <- -1	$phases$logn <- -1	$phases$logn <- -1	$phases$logn <- -1
logr (intrinsic biomass growth)	c(log(0.22),0.2, 1)	c(log(0.22),0.2, 1)	c(log(0.22),0.2, 1)	c(log(0.33),0.5, 1)	c(log(0.22),0.5, 1)	c(log(0.22),0.2, 1)	c(log(0.22),0.2, 1)
logalpha	c(1, 1, 0)	c(1, 1, 0)	c(1, 1, 0)	c(1, 1, 0)	c(1, 1, 0)	c(1, 1, 0)	c(1, 1, 0)
logbeta	c(1, 1, 0)	c(1, 1, 0)	c(1, 1, 0)	c(1, 1, 0)	c(1, 1, 0)	c(1, 1, 0)	c(1, 1, 0)
logsdc							
logsdb							
logsdf							
logbkfrac	c(log(0.20),0.2,1)	c(log(0.2),0.5,1)	c(log(0.5),0.5,1)	c(log(0.5),0.5,1)	c(log(0.5),0.5,1)	-	c(log(0.5),0.5,1)
Diagnostics							
1. Convergence	0	0	0	0	0	0	0
2. Finite parameters	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
3. Violation of model assumptions (> 0.05)							
shapiro	OK	OK	OK	OK	OK	OK	OK
bias	OK	OK	OK	OK	OK	OK	OK
acf	I1(0.02186125)	I1(0.01792826)	OK	I1(0.03630221)	OK	I1(0.01903898)	OK
LBox	OK	OK	OK	OK	OK	OK	OK
4.Retrospective pattern							
Mohn's Rho (-0.2 < mohns_rho < 0.2)							
BBmsy	-0.04636477	0.0414966	0.07168856	0.21438658	0.09696134	3.3653962	0.09338411
FFmsy	0.07346172	0.07800116	0.01258602	-0.06152787	-0.009337733	-0.3146362	-0.02137806
5.Realistic production curve	0.5	0.5	0.5	0.5	0.5	0.5	0.5
6. Assessment uncertainty	1,1	1,1	1,1	1,1	1,1	4,1	1,1
7. Initial values sensitivity	OK	OK	OK	OK	OK	X	OK

3.4. Model's comparisons

From models here presented and with exception of model 18, all the remain models provided good fits and could be potentially accepted to assess this stock. The checklist for the acceptance of a SPiCT model (Mildenberger et al., 2020) was followed and no major issues were found. Models 2, 13, 9, 17 and 16 present a similar trajectory for the stock development over time (only with slightly differences in the final perception of the stock status) (Figure 3.4.1), with model 9 being the more optimistic one.

Model 18 (with no prior for *bkfrac*) show large confidence intervals outside the acceptable range (span more than 1 order of magnitude) for B/B_{MSY} (Table 3.3.1). Furthermore, this model also present problems regarding the retrospective pattern for both B/B_{MSY} and F/F_{MSY} (Figure 3.3.6.3).

Varying the prior *bkfrac* between 0.2 and 0.5 and considering different CV of 0.2 and 0.5 (models 2, 13 and 9) seems to have no major impact on the models results (Figure 3.4.2).

Increasing *r* (models 9 and 17 vs model 16) seems to have no major impact on the models results (Figure 3.4.3). However, model 16 (with higher *r*, 0.33) show some problems in the retrospective for the B/B_{MSY}. Increasing the CV of this prior had minor effect on the results (model 9 vs model 17) (Figure 3.4.3).

Given the different methodology applied for landings estimation for the period 2000-2007, a run adding uncertainty to these years was considered. No major differences were found between this model and model 9 (Figure 3.4.4).

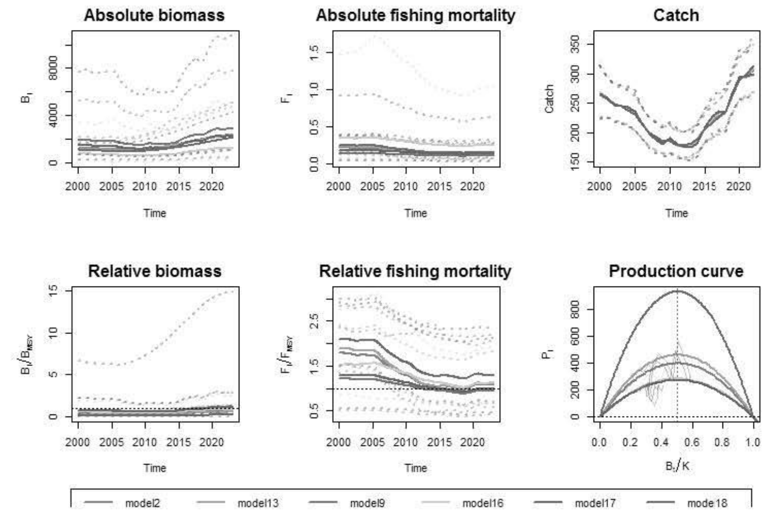

Figure 3.4.1: Raja *brachyura* in ICES Division 27.9a. Comparison among SPiCT all models.

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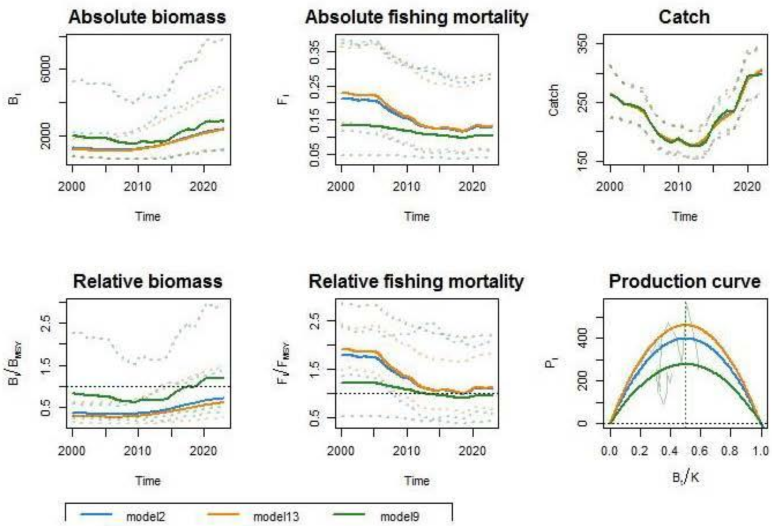

Figure 3.4.2: Raja *brachyura* in ICES Division 27.9a. Comparison among SPICT models 2, 13 and 9.

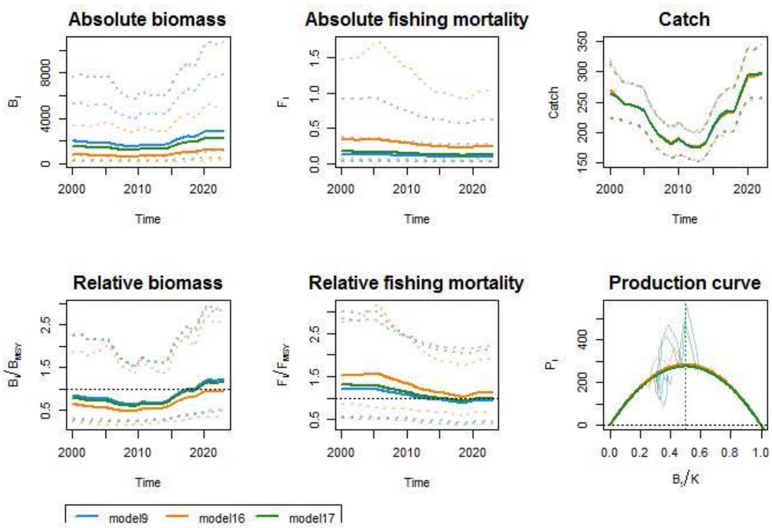

Figure 3.4.3: Raja *brachyura* in ICES Division 27.9a. Comparison among SPICT models 9, 17 and 16.

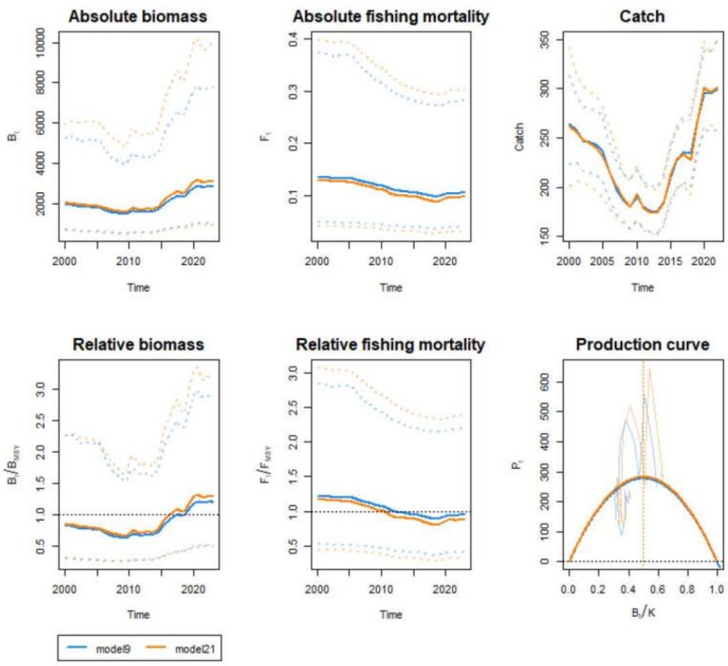

Figure 3.4.4: Raja *brachyura* in ICES Division 27.9a. Comparison among SPiCT models 9 and 21.

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Reconstruction of Portuguese Historical landings for the period 2000-2007

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Abstract

The present working document presents several methodologies followed to reconstruct Rajidae species-specific landing data for the period 2000-2007 in Portuguese landing ports of ICES division 9a. This work aims to extend the time series of landings for rjc.27.9a, rjh.27.9a and rjn.27.9a stocks of interest for the present benchmark, to be used in future assessment models, and in particular SPiCT.

1. Introduction

In Portugal mainland, several Rajidae species are frequently caught as bycatch of commercial fisheries operating with gillnets and trammel nets vessels (polyvalent fleet) and with bottom trawls (Figueiredo et al., 2020). Historically, Rajidae species in Portugal mainland (ICES division 9a), were landed under a generic category (skates and rays nei) since the middle of the last century (Figueiredo et al., 2007). More recently, Rajidae have been mostly landed under different commercial species denominations but with high level of misidentification. In order to provide species specific data to ICES, landings of all Rajidae are annually pooled together and then separated by species following a statistical stepwise procedure that uses sampling information collected under the DCF program. At the moment, data available for the different Rajidae species landed in Portuguese continental waters only comprises de period from 2008 to 2022.

Production models (such as SPiCT), require a time series of catches as input data, preferably long enough to cover one generation time, and that includes contrasting periods in terms of stock biomass and fishery mortality (REF). Given the short time period available it is crucial to reconstruct landings previous to 2008.

This working document presents several methodologies followed in the attempt to reconstruct Rajidae species-specific landing data for the period 2000-2007.

2. Official Data

Since 2000, Portuguese Rajidae official landings ranged between 1011 and 1358 tonnes, with the polyvalent fleet accounting for 71-83% (Table 2.1. and Figure 2.1.).

For the polyvalent fleet both the number of trips and the number of vessels landing Rajidae has been decreasing since 2011, while the average landed weight per trip has been increasing since 2017 (attaining values similar to the period previous to 2011) (Figures 2.2. to 2.4.). For the trawl fleet, the number of vessels and trips landing Rajidae species decreased from 2000 to 2010 being stable since then, while the average landed weight per trip shows a peak between 2009-2011 and a slight increase in the last years (Figures 2.2. to 2.4.).

To better understand landings information, it should be remarked that, since 2009, several management measures have been implemented at both EU and regional (Portugal) level:

- The first management measure implemented for the Atlantic Iberian waters (ICES 9a) was the establishment of a TAC in 2009 that consists of a common TAC for all Rajidae species, excluding *Raja undulata* and *Rostroraja alba* that *"may not be retained on board"* (Council Regulation (EC) No 43/2009). In 2010, *R. undulata* was listed as a prohibited species on quota regulations (Section 6 of CEC, 2010). The Portuguese annual quota ranged between 1051-1974 tonnes for the period 2009-2022 (Figure 1).

- The Portuguese Administration adopted, on 29 December 2011, national legislation that *prohibits the catch, the maintenance on board and the landing of any skate species belonging to the Rajidae family, during the month of May along the whole continental Portuguese EEZ*. This applies *to all fishing trips, except bycatch of less than 5% in weight* Portaria no 315/2011). The legislation was updated on 21 March 2016 (Portaria no 47/2016) by extending the fishing prohibition period to June.

- By 22 August 2014, the Portuguese Administration adopted a national legislation (Portaria no 170/2014) that *establishes a minimum landing size of 52 cm total length (LT) for all Raja spp. and Leucoraja spp.* In 2022, the minimum landing size was updated to 60 cm total length for all *Raja* spp. and *Leucoraja* spp. (Portaria nº 255/2022).

- On 19 May 2016, Portugal adopted a legislative framework (Portaria no. 96/2016) regarding the 2016 quota (~15 tonnes) of *Raja undulata* in ICES Division 9.a assigned to Portugal. This framework includes a set of conditions to provide licenses for specific vessels, maximum landed weight per trip, maximum and minimum conservation reference sizes and closed fishing period.

Table 2.1.: Rajidae official landings (tonnes) in Portuguese mainland waters for the period 2000-2022. Source: DGRM.

ANO	Polyvalent	Seine	Trawl	Total
2000	892	4	301	1197
2001	922	4	339	1266
2002	878	4	317	1200
2003	897	3	356	1256
2004	957	4	296	1257
2005	1033	5	297	1335
2006	992	7	260	1259
2007	963	7	308	1277
2008	1105	4	331	1440
2009	1064	2	382	1448
2010	1118	2	336	1456
2011	1075	2	348	1425
2012	836	2	284	1122
2013	838	2	262	1103
2014	802	1	212	1014
2015	813	4	196	1012
2016	811	6	209	1026
2017	941	5	190	1136
2018	899	3	200	1103
2019	928	3	202	1132
2020	997	10	219	1227
2021	1103	7	250	1359
2022	1040	7	260	1307

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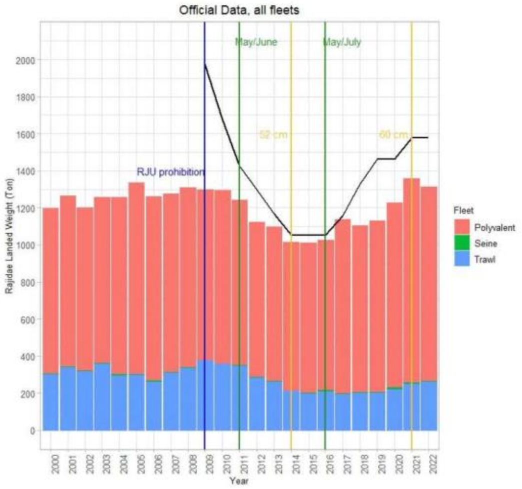

Figure 2.1.: Rajidae official landings (tonnes) in Portuguese mainland waters for the period 2000-2022 per fleet (polyvalent, trawl and seine). Black line – TAC assigned to Portugal since 2009; Blue line – *Raja undulata* landing prohibition; Green lines – closed fishing period stablish in 2011 and updated in 2016 and; Yellow lines – minimun landing size stablished in 2004 and updated in 2021.

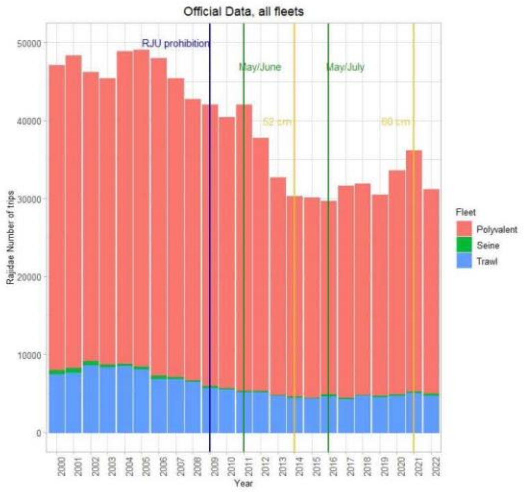

Figure 2.2.: Total number of trips landing Rajidae species in Portuguese mainland waters for the period 2000-2022 by fleet (polyvalent, trawl and seine). Black line – TAC assigned to Portugal since 2009; Blue line – *Raja undulata* landing prohibition; Green lines – closed fishing period stablish in 2011 and updated in 2016 and; Yellow lines – minimun *conservation reference* size stablished in 2004 and updated in 2021.

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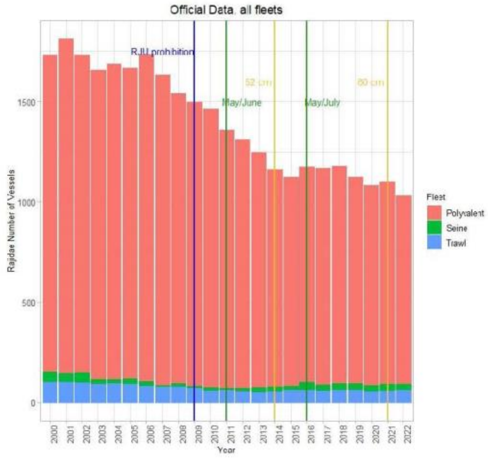

Figure 1.3.: Total number of vessels landing Rajidae species in Portuguese mainland waters for the period 2000-2022 by fleet (polyvalent, trawl and seine). Black line – TAC assigned to Portugal since 2009; Blue line – *Raja undulata* landing prohibition; Green lines – closed fishing period stablish in 2011 and updated in 2016 and; Yellow lines – minimum *conservation reference* size stablished in 2004 and updated in 2021.

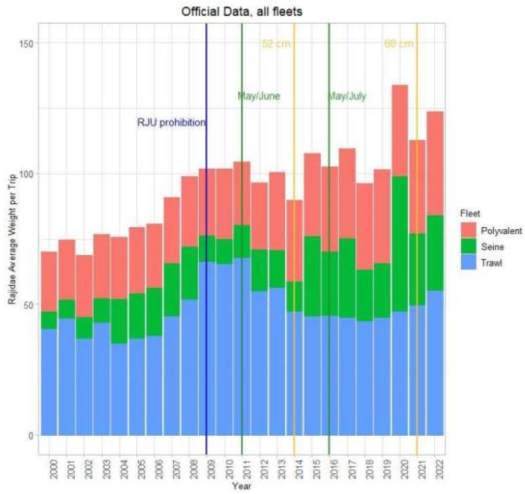

Figure 2.4.: Average landed weight of Rajidae species per fishing trip in Portuguese mainland waters for the period 2000-2022 by fleet (polyvalent, trawl and seine). Black line – TAC assigned to Portugal since 2009; Blue line – *Raja undulata* landing prohibition; Green lines – closed fishing period stablish in 2011 and updated in 2016 and; Yellow lines – minimun landing size stablished in 2004 and updated in 2021.

3. Data provided to ICES for the period 2008-2022

To improve the knowledge and data on the Portuguese fisheries of Rajidae IPMA started, in 2011, a three-year Pilot Study (under the scope of DCF/PNAB) in the most important Rajidae landing ports along the Portuguese coast. The target of this Pilot Study was the fisheries belonging to the polyvalent fleet with landings of Rajiformes in mainland Portugal. The main objective of this pilot project was to estimate the species-specific landed weight. For that, a statistical stepwise procedure involving factor analysis for mixed data and flexible discriminant analysis, was developed to estimate the total number of trips and the correspondent total landed weight by species based on official data, scientific sampling information and fishermen knowledge. Details on the methodology used are described in Figueiredo et al. (2020). During WGEF 2014 (ICES, 2014), Portuguese landings for the period 2008-2013 were revised based on the developed procedure and, since then, the same methodology has been applied to provide species specific landings to ICES (Table 3.1.).

Table 3.1.: Rajidae species estimated landed weight (tonnes) in Portuguese mainland waters for the period 2005-2022. Only species for which category 3 advice is provided are presented. *Data needs to be revised.

Year	RJN	RJH	RJC	RJM	Other species
2005	43*	495*	480*	76*	209
2006	51*	586*	569*	90*	249
2007	79*	459*	472*	119*	315
2008	50	193	745	144	306
2009	50	163	739	184	307
2010	55	221	611	275	293
2011	56	161	811	121	276
2012	39	165	570	108	240
2013	27	179	643	111	144
2014	34	174	585	101	131
2015	20	236	578	67	113
2016	57	221	559	68	122
2017	39	235	620	94	150
2018	23	191	654	57	179
2019	31	255	621	82	145
2020	19	335	670	58	145
2021	22	267	768	104	192
2022	33	297	751	78	146

4. Estimates for the period 2000-2007

Before 2008, DCF sampling data on Rajidae species is less abundant and mainly covers the polyvalent fleet in the Peniche landing port in the period 2003-2007. Therefore, the lack of sufficient DCF data before 2008 precludes the application of the method developed for the subsequent period.

Table 4.1., summarises the data collected during 2003-2007 at the Peniche landing port. Sampling procedures followed the same approach as 2008-2022. At each visit to landing ports, fishing trips with landings of rajiform were randomly selected. For each selected trip, fishermen were interviewed and the information on the type of fishing(s) gear(s) used was registered. The sampling of the landings comprised the record by trip of: i) landed weight and commercial designation assigned to each auction box used to land rajiform species and ii) species, total length (cm), weight (kg) and sex by specimen in each auction box.

Table 4.1.: Number of polyvalent sampled trips with Rajidae species collected under the scope of DCF in the Peniche landing port for the period 2003-2007.

Year	Number of trips
2003	52
2004	76
2005	105
2006	107
2007	105

To expand the time series of landings for the period 2000-2007, three options were explored, all based in the methodologies also followed in recent elasmobranch benchmarks (WKBELASMO2023):

1. Average of each Rajidae species in the period 2008-2010 applied over 2000-2007 separately for each fleet;
2. Average of each Rajidae species in the period 2008-2010 applied over 2000-2007 separately for each port and fleet;
3. Average of each Rajidae species in the period 2008-2010 applied over 2000-2007 separately for each port and fleet, except for the polyvalent fleet in Peniche. In this port, DCF samples for the period 2003-2007 are used for estimating yearly proportions for the period and the average of each Rajidae species in the period 2003-2005 will finally be applied over 2000-2002.

4.1. Method 1: Average of each Rajidae species in the period 2008-2010 applied over 2000-2007 separately for each fleet

Proportion of each Rajidae species in the landings of the polyvalent fleet in each of the years in the period 2008-2022 (data reported to ICES) are present in Annex A. *Raja clavata* is the species most contributing for Rajidae landings corresponding, on average, to 46% in 2008-2010 (40-58%

for the entire time-series), followed by *Raja brachyura* accounting, on average, for 14% in the period 2008-2010 (11-28% for the entire time-series), and *Raja montagui* (4-19% for the entire time series). Landings of *Leucoraja naevus* correspond to 2% on average (1-5% for the entire time series).

Proportion of each Rajidae species in the landings of the trawl fleet in each of the years in the period 2008-2022 (data reported to ICES) are present in Annex A. Species proportions follow a similar pattern as for the polyvalent fleet. *Raja clavata* is the species most contributing for Rajidae landings corresponding to, in average, with 57% during the period 2008-2010 (47-77% for the entire time-series), followed by *R. montagui* which accounts for 13% on the period 2008-2010 (4-17% for the entire time-series) and *Raja brachyura* (4-19% for the entire time series). Landings of *Leucoraja naevus* correspond to 5% on average (2-8% for the entire time series).

Results of applying the average of the estimated proportions for the period 2008-2010 over 2000-2007 landings for the polyvalent and trawl fleets are presented in tables 4.1.1. and 4.1.2., respectively. Figure 4.1.1. shows the estimated landings of *Raja clavata*, *Raja brachyura* and *Leucoraja naevus* for the whole time-series and fleets combined.

Table 4.1.1.: Estimated polyvalent total landings (tonnes) of Rajidae species for the period 2000-2007 following method 1. Only species for which category 3 advice is provided are presented.

Year	RJC	RJH	RJM	RJN	Other species
2000	407	124	127	22	211
2001	420	128	132	23	218
2002	400	122	125	22	208
2003	409	125	128	22	212
2004	436	133	137	24	226
2005	471	144	148	26	244
2006	452	138	142	25	234
2007	439	134	138	24	227

Table 4.1.2.: Estimated trawl total landings (tonnes) of Rajidae species for the period 2000-2007 following method 1. Only species for which category 3 advice is provided are presented.

Year	RJC	RJH	RJM	RJN	Other species
2000	172	34	38	21	35
2001	194	38	43	24	42
2002	181	36	40	22	39
2003	204	40	45	25	44
2004	169	33	38	21	35
2005	170	33	38	21	35
2006	149	29	33	18	32
2007	176	35	39	22	36

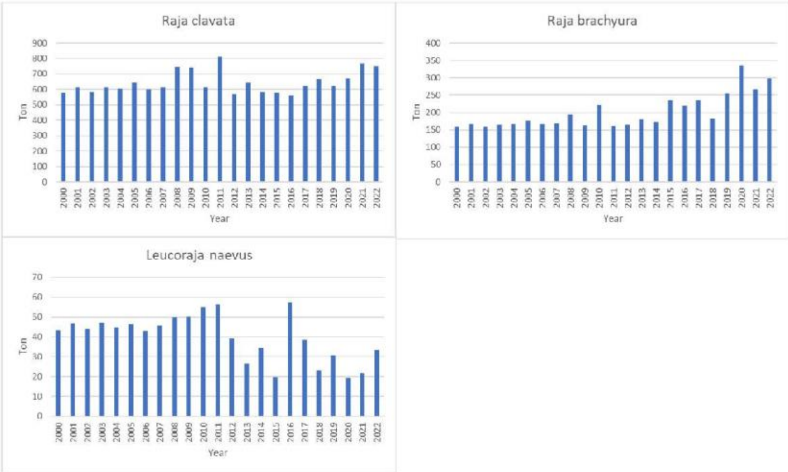

Figure 4.1.1.: Estimated total landings (tonnes) of *Raja clavata*, *Raja brachyura* and *Leucoraja naevus* for the period 2000-2022 following method 1.

4.2. Method 2: Average of each Rajidae species in the period 2008-2010 applied over 2000-2007 separately for each port and fleet

Estimated species specific landed weight for each landing port along the Portuguese coast is also an output of the method currently applied to estimate landings per species. Given this, an average proportion of each species in each landing port and fleet for the period 2008-2010 can be estimated and applied to the respective landing ports with Rajidae landings in the period 2000-2007. Average regional proportions for the period 2003-2005 were also estimated to apply to ports landing Rajidae during 2000-2007 without correspondence in 2008-2010.

Resulting average proportions for the period 2008-2010 by port for the polyvalent fleet are presented in Annex B. *Raja clavata* is the species most contributing for Rajidae landings accounting between 32-63%, followed by *Raja brachyura* accounting between 2-27%, and *Raja montagui* (ranging between 3-14%). *Leucoraja naevus* corresponds to 0-14%.

Resulting average proportions for the period 2008-2010 by port for the trawl fleet are presented in Annex B. *Raja clavata* is the species most contributing for Rajidae landings accounting between 27-78%, followed by *Raja brachyura* accounting between 1-27%, and *Raja montagui* (rangingbetween 3-23%). *Leucoraja naevus* corresponds to 0-27%.

Results of applying the average of the estimated proportions for the period 2008-2010 by port over 2000-2007 for the polyvalent and trawl fleets are presented in tables 4.2.1. and 4.2.2., respectively. Results were quite similar to the ones obtained with method 1. Figure 4.2.1 shows the estimated landings of *Raja clavata*, *Raja brachyura* and *Leucoraja naevus* for the whole time-series and all fleets combined.

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Table 4.2.1.: Estimated polyvalent total landings (tonnes) of Rajidae species for the period 2000-2007 following method 2. Only species for which category 3 advice is provided are presented.

Year	RJC	RJH	RJM	RJN	Other species
2000	407	153	115	29	189
2001	424	152	125	29	194
2002	401	135	131	25	185
2003	409	139	136	26	185
2004	432	149	152	29	197
2005	473	162	163	31	205
2006	455	145	158	27	208
2007	440	132	150	23	218

Table 4.2.2.: Estimated trawl total landings (tonnes) of Rajidae species for the period 2000-2007 following method 2. Only species for which category 3 advice is provided are presented.

ANO	RJC	RJH	RJM	RJN	Other species
2000	170	31	37	20	41
2001	195	34	40	22	47
2002	179	33	43	25	38
2003	204	37	46	26	43
2004	169	31	39	23	34
2005	169	30	39	21	38
2006	143	28	37	22	30
2007	172	32	42	26	36

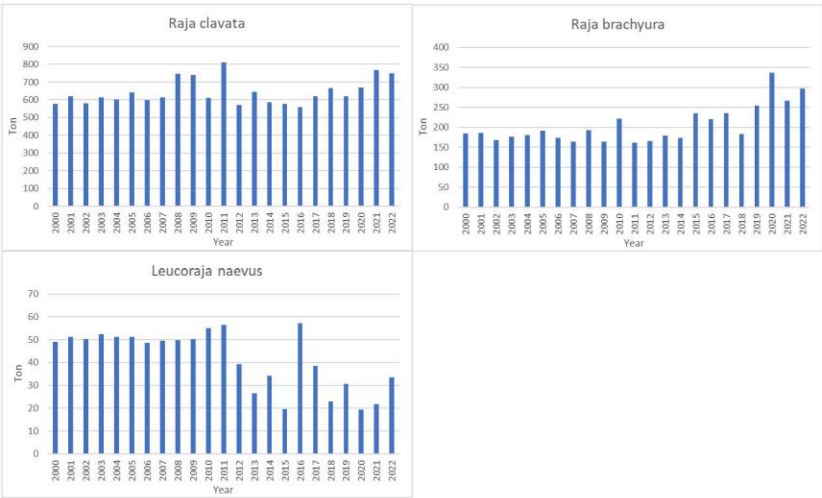

Figure 4.2.1.: Estimated total landings (tonnes) of *Raja clavata*, *Raja brachyura* and *Leucoraja naevus* for the period 2000-2022 following method 2.

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4.3. Method 3: Average of each Rajidae species in the period 2008-2010 applied over 2000-2007 separately for each port and fleet, except for the polyvalent fleet in Peniche

The third method is similar to method 2 except for the polyvalent fleet in Peniche for which samples collected under the DCF are available for 2003-2007. The decision of using the samples available seems appropriate, as it makes use of the observations from the period for which we want to estimate species specific landings. In this port, samples for the period 2003-2007 were used to estimate yearly proportions for that period.

Species weight proportion to the total weight of Rajiade in each year (2003-2007) in Peniche was estimated as:

$$P\hat{a}_{(s,y)} = \sum_{i=1} w_{(s,y)i} / wt_{(y)}$$

where $w_{(s,y)i}$ is the landed weight of s^{th} Rajidae species in the i^{th} fishing trip and $wt_{(y)}$ is the total landed weight of Rajidae in the sampled trips at the y^{th} year. The resulting proportions are then applied to the total landed weight of Rajidae in that landing port and in the year.

The average proportion of each Rajidae species in the period 2003-2005 were then applied over 2000-2002 (years without sampling).

Estimated proportions by species obtained for the polyvalent fleet in Peniche, as well as, the estimated average proportion obtained with the period 2003-2005 are present in Annex C.

Results show a slight increase of *Raja brachyura* landed weight in relation to estimates obtained with the other two methods and a sightly decrease of *Raja clavata* caught by the polyvalent fleet in the period 2000-2007 (table 4.3.1.). Figure 4.3.1. shows the estimated total landings of *Raja clavata*, *Raja brachyura* and *Leucoraja naevus* for the whole time-series and all fleets combined.

Table 4.3.1.: Estimated polyvalent total landings (tonnes) of Rajidae species for the period 2000-2007 for the polyvalent fleet following method 3. Only species for which category 3 advice is provided are presented.

ANO	RJC	RJH	RJM	RJN	Other species
2000	322	230	111	29	200
2001	339	229	122	29	203
2002	334	196	128	26	195
2003	334	211	132	30	190
2004	366	204	149	28	210
2005	401	230	161	28	213
2006	404	176	157	27	227
2007	399	153	165	24	221

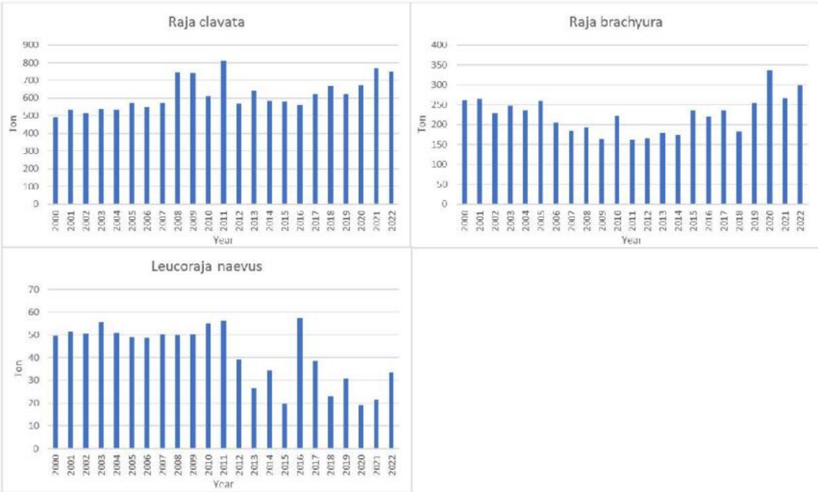

Figure 4.3.1.: Estimated total landings (tonnes) of *Raja clavata*, *Raja brachyura* and *Leucoraja naevus* for the period 2000-2022 following method 3.

5. Discussion and conclusions

Method 3 seems to be the most appropriate to reconstruct the landings time series until 2000, making use of all the available data collected in DCF. It should be remarked that the Peniche landing port accounted, in that period, for 31-58% the total Rajidae landings of the polyvalent fleet.

In addition, the results obtained for *Raja brachyura* which shows a decrease in landings, are consistent with the perception of the Peniche's fishermen association (*pers. comm.*), whose associated vessels reported a decreasing in *Raja brachyura* landings in years before 2009 (Figure 5.1). Such perception led to propose and consequent implementation of technical management measures at national level to guarantee the conservation of Rajidae, particularly the implementation of a close season and a Minimum Conservation Reference Sizes (MCRS).

Such technical management measures likely affected the total landings of Rajidae, from 2009 onwards, as follows:

- The decrease of ~120 tonnes in Rajidae landings in 2012 is believed to be a result of both the close season applied to Rajidae in the month of May and later in 2016 also during June, as well the inclusion of *Raja undulata* in the prohibited species list (Council Regulation (EC) No 43/2009 of 16 January 2009). This decrease is also reflected in the total number of trips and vessels landing Rajidae in Portugal mainland. A relatively stable period follows up to 2016, after which it is possible to observe an increasing trend in the total landed weight of Rajidae, as well on the average landed weight per trip. This increasing pattern is particularly observed for the polyvalent fleet that represents between 71-83% of the total landed weight of Rajidae between 2000-2022.

- The implementation of a MCRS have impact particularly for smaller commercial size categories in which smaller species as *Raja montagui*, *Leucoraja naevus* and *Raja miraletus* are landed. A decrease in the former species landings can be observed after 2014 and seems to be related with the MCRS implementation.

- Restrictive quota in the period 2014-2017 (Figure 2.1).

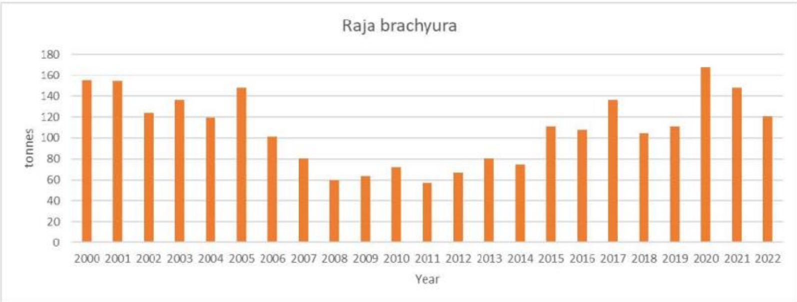

Figure 5.1.: Estimated total landings (tonnes) of *Raja brachyura* in the Peniche landing port for the period 2000-2022 following method 3.

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Annex A

Method 1: Average of each Rajidae in the period 2008-2010 applied over 2000-2007 separately for each fleet

Table: Rajidae species proportions in the polyvalent fleet for the period 2008-2022. Average proportions for the period 2008-2010 and respective standard deviation, as well as, average proportions for the periods 2008-2012, 2008-2014 and 2008-2022 are present.

ANO	RJC	RJH	RJM	RJN	Other species
2008	0.48	0.15	0.10	0.02	0.24
2009	0.48	0.11	0.13	0.02	0.25
2010	0.40	0.16	0.19	0.03	0.21
2011	0.54	0.13	0.08	0.03	0.22
2012	0.44	0.18	0.09	0.03	0.27
2013	0.56	0.19	0.10	0.02	0.13
2014	0.53	0.20	0.10	0.03	0.14
2015	0.53	0.27	0.07	0.01	0.12
2016	0.51	0.25	0.06	0.05	0.13
2017	0.53	0.22	0.08	0.02	0.14
2018	0.58	0.17	0.05	0.01	0.19
2019	0.53	0.22	0.07	0.03	0.16
2020	0.54	0.28	0.04	0.01	0.12
2021	0.54	0.19	0.08	0.02	0.17
2022	0.58	0.21	0.05	0.03	0.12
Average 2008-2010	**0.46**	**0.14**	**0.14**	**0.02**	**0.23**
sd	**0.04**	**0.03**	**0.05**	**0.00**	**0.02**
Average 2008-2012	47	15	12	3	0.24
Average 2008-2014	49	16	11	2	0.21
Average 2008-2022	52	20	9	2	0.17

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Table: Rajidae species proportions in the trawl fleet for the period 2008-2022. Average proportions for the period 2008-2010 and respective standard deviation, as well as, average proportions for the periods 2008-2012, 2008-2014 and 2008-2022 are present.

ANO	**RJC**	**RJH**	**RJM**	**RJN**	**Other species**
2008	0.64	0.08	0.10	0.07	0.1
2009	0.60	0.12	0.11	0.06	0.09
2010	0.47	0.13	0.17	0.08	0.14
2011	0.66	0.05	0.08	0.08	0.11
2012	0.71	0.06	0.11	0.06	0.06
2013	0.66	0.08	0.12	0.04	0.1
2014	0.76	0.08	0.04	0.05	0.06
2015	0.77	0.07	0.04	0.05	0.06
2016	0.71	0.10	0.08	0.07	0.03
2017	0.64	0.14	0.12	0.08	0.02
2018	0.73	0.15	0.07	0.05	0.01
2019	0.66	0.24	0.07	0.03	0
2020	0.62	0.26	0.09	0.02	0.02
2021	0.67	0.23	0.08	0.02	0.01
2022	0.57	0.30	0.08	0.02	0.04
Average 2008-2010	**0.57**	**0.11**	**0.13**	**0.07**	**0.11**
sd	**0.09**	**0.02**	**0.04**	**0.01**	**0.02**
Average 2008-2012	62	9	11	7	0.10
Average 2008-2014	64	9	10	6	0.09
Average 2008-2022	66	14	9	5	0.06

Annex B

Method 2: Average of each Rajidae species in the period 2008-2010 applied over 2000-2007 separately for each port and fleet

Table: Average Rajidae species proportions by port in the polyvalent fleet for the period 2008-2010.

Landing port	RJC	RJH	RJM	RJN	Other species
Anjeiras	0.44	0.06	0.01	0.00	0.48
Armacao De Pera	0.32	0.02	0.60	0.00	0.06
Aveiro	0.43	0.06	0.02	0.00	0.48
Azenha Do Mar	0.35	0.25	0.16	0.14	0.11
Caminha	0.44	0.06	0.01	0.00	0.48
Carrasqueira	0.47	0.27	0.06	0.04	0.16
Cascais	0.47	0.27	0.06	0.04	0.16
Castelo Do Neiva	0.44	0.06	0.01	0.00	0.48
Costa Da Caparica	0.47	0.27	0.06	0.04	0.16
Ericeira	0.47	0.27	0.06	0.04	0.16
Esposende	0.44	0.06	0.01	0.00	0.48
Fao	0.44	0.06	0.01	0.00	0.48
Figueira Da Foz	0.50	0.03	0.08	0.00	0.4
Fonte Da Telha	0.47	0.27	0.06	0.04	0.16
Lagos	0.32	0.02	0.60	0.00	0.06
MatosinhosPovoaVarzim	0.44	0.06	0.01	0.00	0.48
Mira	0.43	0.06	0.02	0.00	0.48
Nazare	0.47	0.27	0.06	0.04	0.16
Olhao	0.32	0.02	0.60	0.00	0.06
Peniche	0.47	0.27	0.06	0.04	0.16
Portimao	0.32	0.02	0.60	0.00	0.06
Quarteira	0.32	0.02	0.60	0.00	0.06
Sagres	0.32	0.02	0.60	0.00	0.06
SesimbraSetubal	0.63	0.09	0.14	0.02	0.12
Sines	0.35	0.25	0.16	0.14	0.11
Tavira	0.32	0.02	0.60	0.00	0.06
Torreira	0.43	0.06	0.02	0.00	0.48
Trafaria	0.47	0.27	0.06	0.04	0.16
V. Nova De Milfontes	0.35	0.25	0.16	0.14	0.11
V. Praia Da Ancora	0.44	0.06	0.01	0.00	0.48
Vagueira	0.43	0.06	0.02	0.00	0.48
Viana Do Castelo	0.44	0.06	0.01	0.00	0.48
Vila Do Conde	0.44	0.06	0.01	0.00	0.48
Vila Real St.Antonio	0.32	0.02	0.60	0.00	0.06
Zambujeira	0.35	0.25	0.16	0.14	0.11

Table: Average Rajidae species proportions by region in the polyvalent fleet for the period 2008-2010.

Region	RJC	RJH	RJM	RJN	Other species
Alentejo	0.35	0.25	0.16	0.14	0.11
Algarve	0.32	0.02	0.60	0.00	0.06
Centro	0.45	0.12	0.04	0.01	0.37
Lisboa e Vale do Tejo	0.49	0.24	0.07	0.04	0.15
Norte	0.44	0.06	0.01	0.00	0.48

Table: Average Rajidae species proportions by port in the Trawl fleet for the period 2008-2010.

Landing Port	RJC	RJH	RJM	RJN	Other species
Aveiro	0.71	0.05	0.03	0.01	0.19
Figueira Da Foz	0.78	0.01	0.13	0.00	0.07
Lagos	0.46	0.06	0.12	0.27	0.09
Matosinhos	0.66	0.13	0.06	0.01	0.13
Nazare	0.51	0.17	0.23	0.06	0.03
Olhao	0.46	0.06	0.12	0.27	0.09
Peniche	0.51	0.17	0.23	0.06	0.03
Portimao	0.46	0.06	0.12	0.27	0.09
Sesimbra	0.49	0.04	0.05	0.00	0.42
Setubal	0.40	0.27	0.23	0.09	0
Sines	0.46	0.06	0.12	0.27	0.09
Vila Real St.Antonio	0.27	0.09	0.03	0.14	0.47

Table: Average Rajidae species proportions by region in the Trawl fleet for the period 2008-2010.

Region	RJC	RJH	RJM	RJN	Other species
Alentejo	0.46	0.06	0.12	0.27	0.09
Algarve	0.41	0.07	0.10	0.24	0.19
Centro	0.63	0.10	0.15	0.03	0.09
Lisboa e Vale do Tejo	0.45	0.16	0.14	0.05	0.21
Norte	0.66	0.13	0.06	0.01	0.13

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Annex C

Method 3: Average of each Rajidae species in the period 2008-2010 applied over 2000-2007 separately for each port and fleet, except for the polyvalent fleet in Peniche.

Table: Rajidae species proportions for the polyvalent fleet in Peniche for the period 2000-2007. Note that proportions for the period 2000-2002 is obtained avereging years 2003-2005.

Ano	RJC	RJH	RJM	RJN	Other species
2000	0.16	0.55	0.05	0.05	0.21
2001	0.16	0.55	0.05	0.05	0.21
2002	0.16	0.55	0.05	0.05	0.21
2003	0.12	0.60	0.04	0.06	0.18
2004	0.15	0.53	0.04	0.04	0.24
2005	0.19	0.53	0.05	0.04	0.19
2006	0.23	0.41	0.06	0.04	0.26
2007	0.24	0.39	0.14	0.05	0.18

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Thornback ray (*Raja clavata*) in Division 9a (Atlantic Iberian waters) (rjc.27.9a)

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1. Introduction

Thornback ray *Raja clavata* is the most common skate species in Atlantic Iberian waters, being distributed along the entire ICES division 9a and landings ranging from 591 to 1090 tonnes during the period 2000-2022. The stock rjh.27.9a has been assessed under category 3 which involves the application of the rfb rule (ICES, 2021; ICES, 2022). For the present benchmark, the proposal is focussed on evaluating the application of a surplus production model SPiCT (Stochastic Production model in Continuous Time, Pedersen and Berg 2017) on the stock for providing advice.

The present working document presents the information available on the stock.

2. Stock identity

The stock structure of the species along the ICES areas is unknown. Migrations between different areas are admitted (ICES, 2013). For advice purposes, ICES considered a distinct stock unit for Division 9.a (west of Galicia, Portugal, and Gulf of Cadiz).

2.1. Species Distribution

Raja clavata is a coastal species with a wide geographic distribution from shallow waters (including estuaries) to 700 m depth. Occurs in the Eastern Atlantic from Iceland to South Africa, and in the North Sea, Mediterranean, Baltic and Black Seas (Stehmann and Bürkel, 1984). The species is mainly found on hard seabed (e.g. gravel and pebbles), in areas of intermediate to strong tidal currents (Ellis et al., 2005).

In ICES division 9a, the species is distributed along the entire area.

In the West of Galicia *R. clavata* is more abundant in the northern waters and in the Cantabrian Sea mainly in mud and sandy bottoms. It has a wide depth distribution, from 20 m to 400 m, but it is more abundant between 50-200 m depth, particularly close to 75 m (Figure 2.1.a). There is no information regarding size or sex segregation, neither on spawning or egg laying site.

The species can be found throughout the Portuguese continual coast, from 18 m to 700 m, being more abundant in the southwest and southern regions (i.e. south off Cabo Carvoeiro), at depths shallower than 200 m (Figure 2.1.b). In the centre of mainland Portugal, the species occupies a broad range of habitat types, from mud and fine sand to rocky bottoms, showing different spatial dynamics according to the life stage (Serra-Pereira et al., 2014). Spatial segregation by sex was observed; females are more abundant in shallower grounds, while males frequently occur offshore, deeper than 100 m. Distinct areas were identified as egg laying grounds, that differ in depth (all shallower than 100 m), bottom topography and seabed composition (from fine sand to gravel). A seasonal variation in juvenile's abundance was registered in these areas - higher abundances are recorded during the 1st and 3rd quarters of the year, showing a temporal spatial overlap between egg-laying and nursery grounds. Nursery and egg laying grounds are located at depths shallower than the adults, suggesting the existence of migrations associated to reproduction. Worth to note that in the North Sea and eastern English Channel adults from this species migrate from deeper to shallower waters for mating and for egg deposition. Juveniles tend to stay in shallow waters during the first years of growth and migrate to deeper areas afterwards (Steven, 1936; Walker et al., 1997; Hunter et al., 2005, 2006).

In the Gulf of Cadiz is present along the whole area at depths ranging from 20 to 800 meters, being especially abundant in trawlable grounds placed in the south area of the Gulf, in the range between 100 and 350 m depth (Figure 2.1.c).

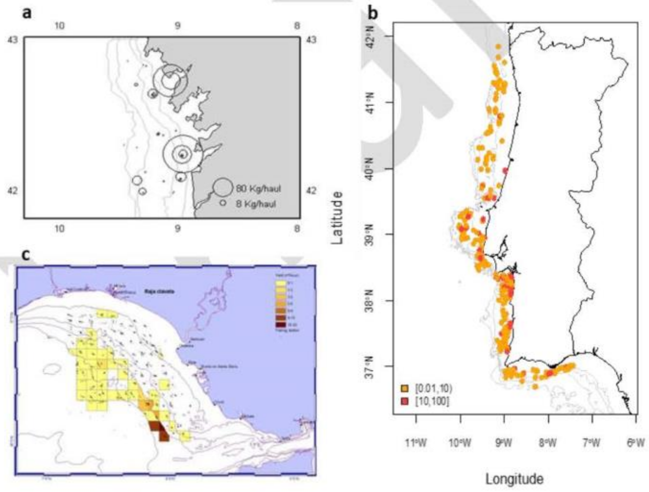

Figure 2.1: *Raja clavata* in ICES Division 9a. Species distribution: a) distribution and catch rate (kg/30 min) in Spanish autumn Ground Fish Survey (SP-GFS) from 1983 to 2013 in West of Galicia; b) distribution and catch rate (kg.hour-1) in Portuguese Autumn Groundfish Surveys (PT-GFS) from 1990 to 2013 along the Portuguese coast and c) distribution and abundance index (no/hour) in the Gulf of Cádiz (from ARSA surveys 1993-2009, Q1 SP – GCGFS and Q4 SP - GCGFS) in the Gulf of Cadiz.

2.2. Genetics and Tagging – to be completed

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3. Catch data

3.1. Landings

Landings data were obtained from the WGEF landings table (ICES, 2023), and have been reported by Portugal and Spain.

Given that production models (such as SPiCT) require a time series of catches as input data, preferably long enough to cover one generation time and that includes contrasting periods in terms of stock biomass and fishery mortality, data from 2000 was reconstructed.

Portuguese data available in WGEF landings table comprised the period 2005-2022. Due to misreporting errors in Rajidae species official data, IPMA developed a statistical stepwise procedure involving factor analysis for mixed data and flexible discriminant analysis to estimate the total landed weight by species and have been applying this procedure since 2008 (details can be found in Figueiredo et al., 2020). For the present benchmark and aiming the extension of the landings time-series, historical data for the period 2000-2007 was reconstructed by fleet and detailed information on the methods adopted can be found in Maia et al., (2023). Given the uncertainty associated with landings previously reported for the period 2005-2007, these years were also included in the reconstruction.

Spanish data available comprised the period 2009-2022. Given the uncertainty associated with landings reported for 2009, historical data reconstruction covered the period 2000-2009. For that the average proportion of *R. clavata* of 2010-2013 was applied over the period 2000-2009 considering all fleets together.

Raja clavata landings in ICES Division 9a have been ranged from 591 to 1090 tonnes, with Portugal contributing for 69-89% and Spain for 11-31% (Table 3.1.1). Along the time series, landings from the polyvalent fleet represented 50-69% of the species landed weight, followed by trawl that have been representing between 22-49% (Figure 3.1.1). A detailed description of the Portuguese polyvalent fleet can be found in Figueiredo et al. (2020).

Landings from the polyvalent fleet were mainly reported by Portugal and represented on average 97% of the landed weight while Spain contributed on average for 3% (Figure 3.1.2). Whitin the Trawl fleet, landings from Portugal represented on average 75% while Spain contributed with an average of 25%.

Table 3.1.1.: *Raja clavata* in ICES Division 9a. Annual landings (in tonnes) and representativeness by country.

Year	Portugal		Spain		Total
	Ton	%	Ton	%	
2000	492	83	99	17	591
2001	534	79	142	21	676
2002	513	82	116	18	629
2003	538	82	118	18	655
2004	534	83	112	17	646

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2005	571	84	107	16	678
2006	547	82	116	18	663
2007	571	84	112	16	683
2008	745	86	119	14	864
2009	739	89	94	11	833
2010	611	84	115	16	725
2011	811	85	139	15	950
2012	570	75	194	25	764
2013	643	80	166	20	809
2014	585	73	215	27	800
2015	578	83	120	17	697
2016	559	82	123	18	682
2017	620	83	124	17	744
2018	654	81	152	19	806
2019	621	77	181	23	802
2020	670	79	178	21	848
2021	768	82	174	18	942
2022	751	69	339	31	1090

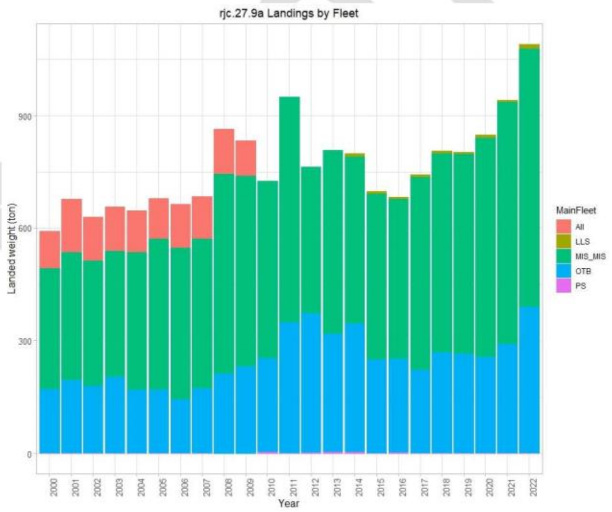

Figure 3.1.1: *Raja clavata* in ICES Division 9a. Annual landings (in tonnes) by fleet. "All" – all fleets combined; "LLS" – longlines; "MIS_MIS" – polyvalent fleet; "OTB" – trawl fleet and; "PS" – seine fleet.

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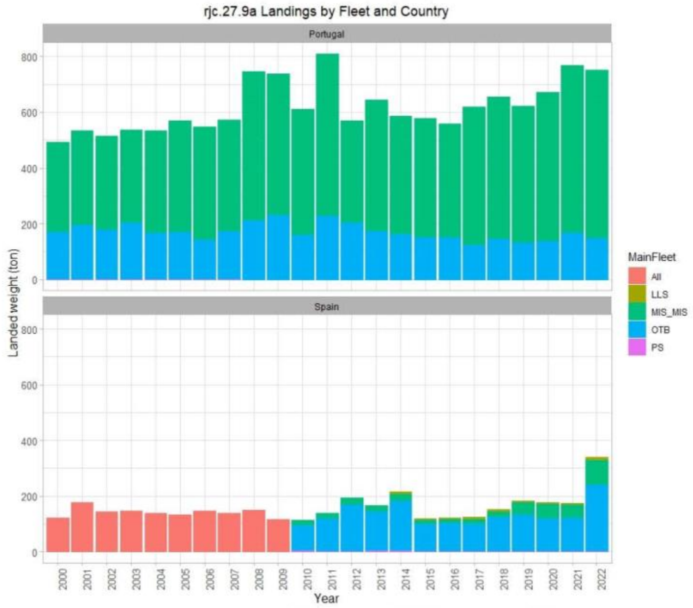

Figure 3.1.2: *Raja clavata* in ICES Division 9a. Annual landings (in tonnes) by country and fleet. "All" – all fleets combined; "LLS" – longlines; "MIS_MIS" – polyvalent fleet; "OTB" – trawl fleet and; "PS" – seine fleet.

3.2. Length Distribution from landings

Length distributions of *R. clavata* from the Portuguese commercial polyvalent and trawl fleets for the period 2008–2022 are presented in Figures 3.2.1 and 3.2.2. Figure 3.2.3 presents the overall distribution with the two fleets combined. Length distributions were raised to the total estimated landed weight of each species.

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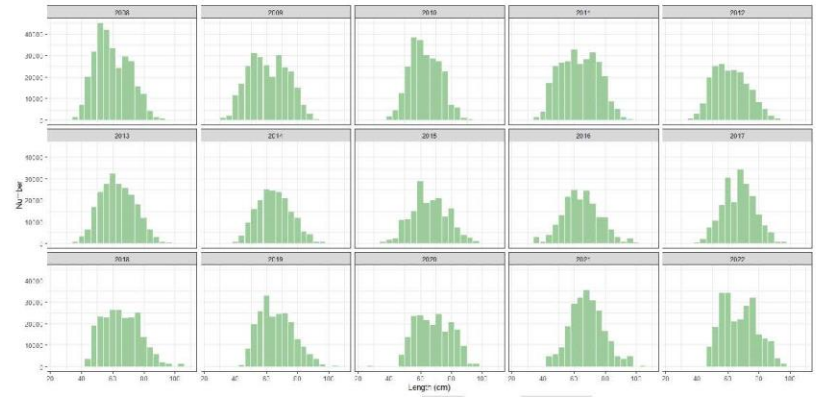

Figure 3.2.1: *Raja clavata* in ICES Division 9a. Length distribution (4 cm classes, 3033 sampled trips) for the period 2008-2022 in mainland Portugal from the polyvalent fleet.

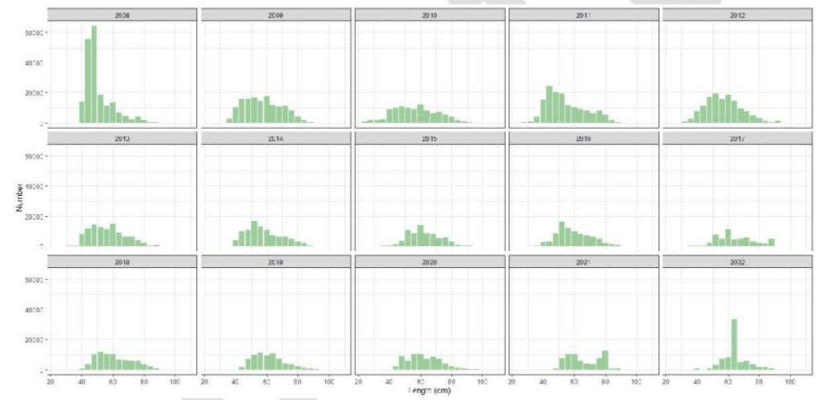

Figure 3.2.2: *Raja clavata* in ICES Division 9a. Length distribution (4 cm classes, 895 sampled trips) for the period 2008-2022 in mainland Portugal from the trawl fleet.

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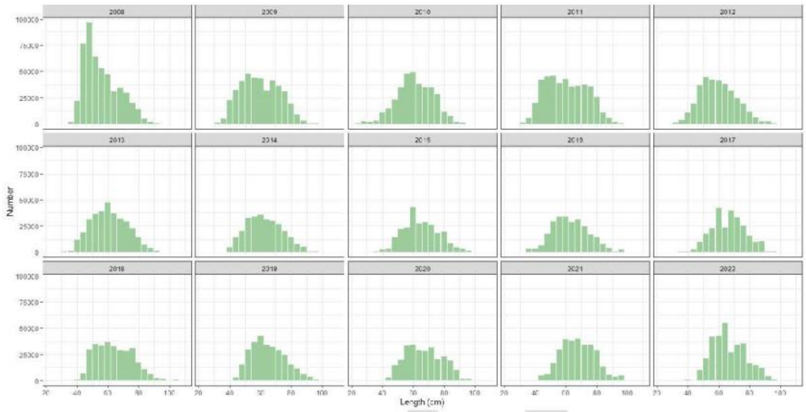

Figure 3.2.3: *Raja clavata* in ICES Division 9a. Length distribution (4 cm classes, 3928 sampled trips) for the period 2008-2022 in mainland Portugal from polyvalent and trawl fleets combined.

3.3. Discards – to be completed

3.4. Survival – to be completed

4. Surveys biomass index – to be completed

4.1. Portuguese Autumn Groundfish Survey (PtGFS-WIBTS-Q4) [G8899]

This survey has been conducted by the Portuguese Institute for the Sea and Atmosphere (IPMA, ex-IPIMAR) and has the main objective to monitor the abundance and distribution of hake (*Merluccius merluccius*) and horse mackerel (*Trachurus trachurus*) recruitment (Cardador et al., 1997). The survey is performed along the Portuguese continental coast, extending from latitude 41°20'N to 36°30'N (ICES Division 9.a) from 20 to 500 m deep. For details on vessels characteristics, survey stratification and technical characteristics of fishing operations see ICES (2017). The survey was not conducted in 2012, 2019 and 2020 and in 1996, 1999, 2003 and 2004 the survey was conducted with a different gear. In 2018, the survey had technical problems, and part of the stations were sampled using a commercial trawler and a different fishing net (using FGAV019 instead of NCT). Since 2021, the survey has been conducted with a new vessel and some modifications in the fishing gear.

Raja clavata has been caught along the entire Portuguese coast at depths ranging from 18 m to 700 m, being more abundant in southwest and south regions at depths shallower than 200 m (Figure 4.1.1). Length composition of *Raja clavata* in Portuguese Autumn Groundfish Survey for the all period combined is present in (Figure 4.1.2).

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Up to 2020, the biomass abundance index has been estimated trough the adjustment of a Generalized linear mixed model (GLMM; Bolker *et al.*, 2009) assuming a Tweedie distribution for the observations. In the model the response variable is catch rate of *R. clavata* at each haul, in kilogram per hour and the considered linear predictors have been: year, depth and strata (Figure 4.1.3). A detailed description of adopted methodologies can be found in Serra-Pereira and Figueiredo (2013, WGEF WD).

4.2. The Spanish bottom trawl survey IBTS-GC-Q1-Q4 (ARSA) [G4309]

This survey take place in the Gulf of Cadiz (Division 9.a) has been carried out in spring since 1993 and in autumn since 1997 up to 2022 (no survey was conducted in 2021). The surveyed area corresponds to the continental shelf and upper-middle slope (depths of 15–800 m) and from longitude 6º20'W to 7º20'W, covering an area of 7224 km2. In the ARSA time series survey, *R. clavata* is one the most abundant skate species.

Length composition of *Raja clavata* in the Spanish bottom trawl surveys for the all period combined is present in (Figure 4.2.1). The biomass index for these surveys is obtained by averaging both surveys normalized to their long-term mean. The species shows an increasing trend in biomass since 1997, with the highest values reached in 2022 (Figure 4.2.2).

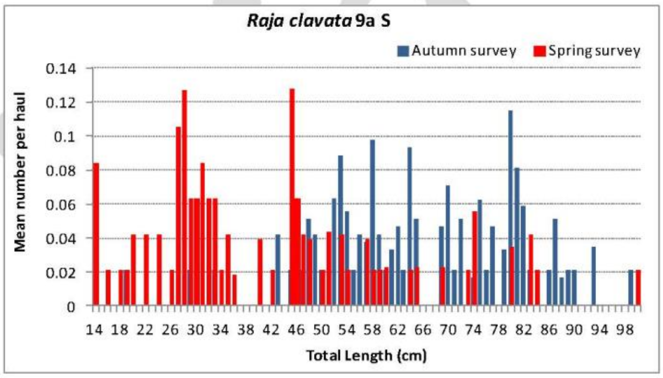

Figure 4.2.1: *Raja clavata* in ICES Divison 9a. Mean number per haul by length class in the Spanish bottom trawl surveys combined for the period xxxx-xxxx.

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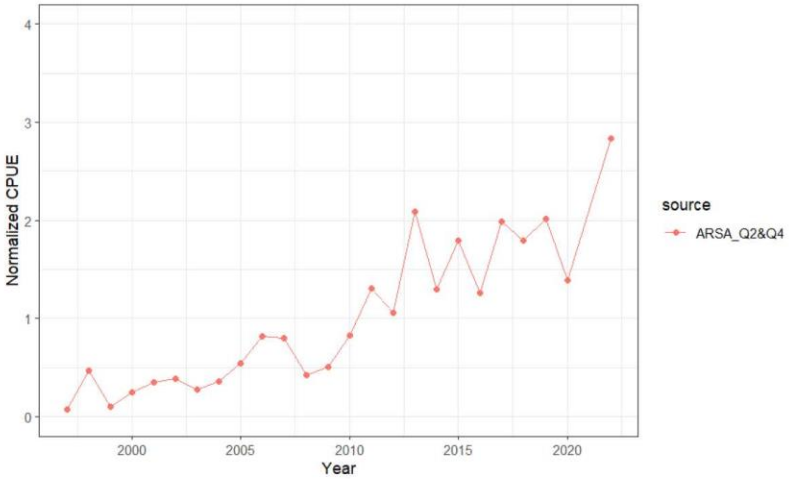

Figure 4.2.2: *Raja clavata* in ICES Divison 9a. Average of mean normalized biomass index from Spanish bottom trawl surveys (quarter 2 and 4) for the period from 1997 to 2022.

5. Commercial LPUE

Up to 2018, this stock was assessed using data derived from the Spanish ARSA survey in Gulf of Cadiz (SpGFS-GC-WIBTS-Q1 and SpGFS-GC-WIBTS-Q4) and the Portuguese Autumn Groundfish Surveys (PtGFS-WIBTS-Q4). However, because of the problems with the PtGFS-WIBTS-Q4 survey data availability for the period 2018–2020 (see details in Section 4.) and uncertain future, an alternative assessment approach using a standardized commercial LPUE series was reviewed and accepted at WKSKATE (ICES, 2021). The reviewers also recognized the choice made by the group to look at the use of LPUEs as an alternative to surveys. The main concern from the reviewers about the methodology proposed was the non-inclusion of the zeroes in the analysis.

The justification for this approach relies on the fact it is not possible to distinguish real zeroes mainly due to: i) is a by-catch species for the polyvalent fishery so absence of the species in the catch is more related to the fishing strategy; 2) the species has a patchy distribution and information available is not georeferenced; 2) different selectivity of the set of gears used in a trip and 4) the weight landed per trip results from the application of estimates, which can lead to false zeros.

Details on the LPUE estimation methodology can be found in Serra-Pereira *et al.* (2020) and ICES (2021). During the last WGEF (ICES, 2023), the model was updated (explained variance = 0.81, AIC = 762514). The best model selected with the updated dataset included the variables years, quarter, landing port, vessel size, fishing seasonality on skates and rays and fishing gear (trammel nets or gillnets). The effects of each explanatory variable are presented in Figure 5.1. The standardized mean CPUE was then predicted by year and considering the following criteria: quarter = 4, landing port = Peniche, SIZEs = L (large), SAZ = c (constant) and fishing gear = nets.

LPUE varied from 21.08 kg.trip^{-1} (in 2009) to 53.20 kg.trip^{-1} (in 2022), with an average of 35.91 kg.trip^{-1} for the entire time series (Table 5.1, Figure 5.2).

For comparison purposes, the LPUE data series was normalized to the long-term mean and compared with the normalized biomass Index obtained from the PtGFS-WIBTS-Q4 survey (Figure 5.3). In general, both time-series followed similar increasing trends since 2008, and LPUE estimates are within the range of the CI.

Table 5.1: *Raja clavata* in ICES Division 9a. LPUE (kg.trip-1) from the polyvalent in mainland Portugal for the period 2008-2022.

Year	LPUE	SE	Standardized LPUE
2008	25.99	0.66	0.72
2009	21.08	0.53	0.59
2010	30.16	0.77	0.84
2011	31.91	0.82	0.89
2012	27.80	0.71	0.77
2013	34.67	0.92	0.97
2014	36.51	0.95	1.02
2015	32.04	0.85	0.89
2016	35.32	0.97	0.98
2017	39.27	1.04	1.09
2018	42.55	1.07	1.18
2019	42.38	1.16	1.18
2020	40.27	0.99	1.12
2021	45.49	1.16	1.27
2022	53.20	1.46	1.48

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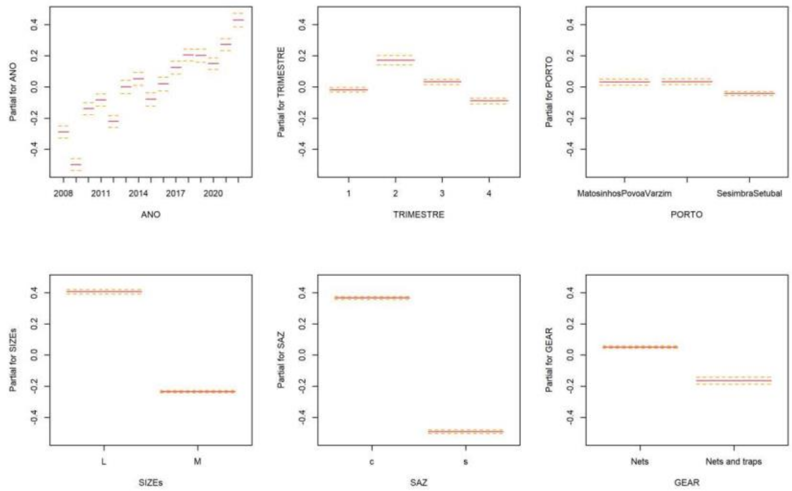

Figure 5.1: *Raja clavata* in ICES Division 9a. Effect of each explanatory variable included in the standardization of the LPUE for the polyvalent fleet in mainland Portugal: year ("ANO"), quarter ("TRIMESTRE"), landing port ("PORTO"), vessel size ("SIZEs"), fishing seasonality ("SAZ") and fishing gear (trammel nets or gillnets).

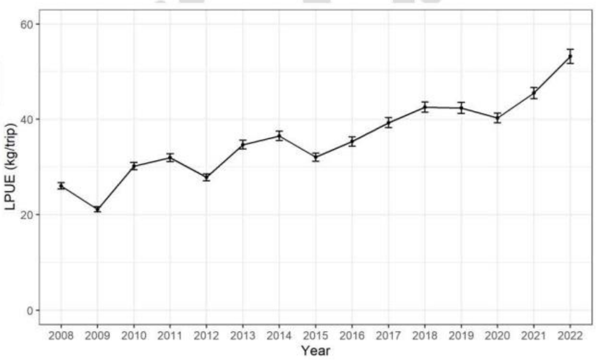

Figure 5.2: *Raja clavata* in ICES Division 9a. LPUE (kg.trip-1) from the polyvalent in mainland Portugal for the period 2008-2022.

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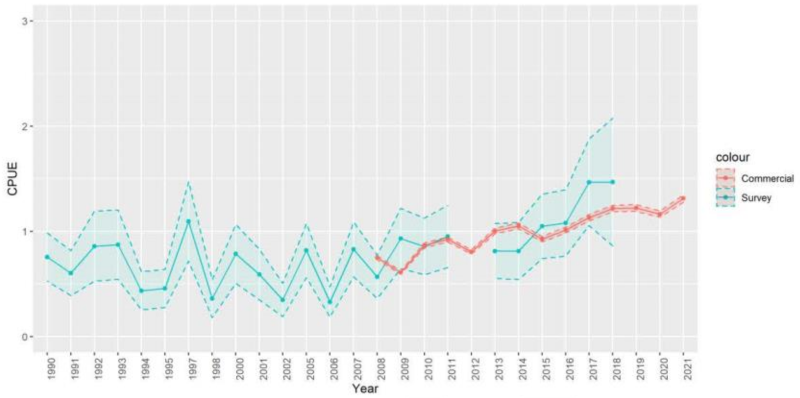

Figure 5.3: *Raja clavata* in ICES Division 9a. Standardized LPUE from the polyvalent fleet in mainland Portugal vs standardized Portuguese Autumn Groundfish Survey biomass Index. Both series are normalized to the long-term mean and present the standard errors in shade.

Figure 5.4 present the comparison between the normalized biomass indices from the Portuguese Autumn Groundfish Survey (considering the new proposed model), the Spanish bottom trawl surveys and LPUE from the polyvalent fleet in mainland Portugal. ESCOLHER IMAGEM DO SLIDE 28 DA APRESENTAÇÃO.

6. Life-history parameters

Table 6.1 summarizes the information available on biological parameters estimates for *R. clavata* in ICES Division 9a. Table 6.2 summarizes estimates of intrinsic growth rates (r´) following different methodologies. Biological parameters estimates for other geographic regions within ICES area can be found in Ellis et al., (2023, ICES WD).

Table 6.1. *Raja clavata* in ICES Division 9a. Biological parameters estimates available.

Source		Serra-Pereira et al., 2008	Serra-Pereira et al., 2011
TL range (cm)		14.5-91.3	32.0-93.4
L50 (cm) F		-	78.4
L50 (cm) M		-	67.6
Reproductive period		-	May-Jan
Potential fecundity (eggs/female/year)			136
Growth model		VBGM	-
Growth parameters estimates	L∞ (cm)	128	-
	k (y−1)	0.12	-
	t0 (years)	-0.62	-
	Lmax (cm)	91.3 (124*)	-
Period		2003-2007	2003-2008
Region		Portugal	Portugal

*PNAB/DCF sample onboard a scientific survey.

Table 6.2. *Raja clavata* in ICES Division 9ª. Methods used to estimate the intrinsic rate of population growth.

Method	Equation	r´estimate	Reference

7. Current Stock Assessment

The stock rjc.27.9a has been assessed under category 3 (trend-based assessment).

Up to 2018, this stock was assessed using data derived from the Spanish ARSA surveys (quarter 1 and 4) in Gulf of Cadiz and the Portuguese Autumn Groundfish Surveys. These surveys were normalized to their long-term mean, the two Spanish surveys averaged, and then this index averaged with the Portuguese survey to provide the stock size indicator. The advice was based on a comparison of the two latest index values with the five preceding values, multiplied by the recent advised landings.

In 2020, because of the problems with the Portuguese Autumn Groundfish survey data availability for the period 2018–2020 and uncertain future, an alternative assessment approach using a standardized commercial LPUE series was reviewed and accepted at WKSKATE (ICES, 2021). For detail on LPUE series see section 5 of the present working document.

In 2022, last assessment year, the stock assessment was done following ICES guidelines for category 3 which involves the application of the rfb rule (ICES, 2021; ICES, 2022). A biomass index combining the Spanish groundfish surveys data and the normalized LPUE index from the Portuguese polyvalent fleet was used as an indicator of stock development. The advice was based on the ratio of the mean of the last two index values (index A) and the mean of the three preceding values (index B), multiplied by the previous advised catches, a ratio of observed mean length in the catch relative to the target mean length (length-based indicators, length distributions from the Portuguese commercial polyvalent and trawl fleets combined as input data), a biomass safeguard, and a precautionary multiplier.

8. Stock assessment proposed methods

For the present benchmark, the proposal is focussed on evaluating the application of a surplus production model SPiCT (Stochastic Production model in Continuous Time, Pedersen and Berg 2017) on the stock for providing advice.

8.1. SPiCT initial runs during WGEF2022

During WGEF 2022, several SPiCT runs were tested to check model performance and effects of using different datasets and priors. All the runs' results can be found in Moura et al., 2022. The checklist for the acceptance of a SPiCT assessment was followed (Mildenberger et al., 2020).

At that time, given the different methods applied for estimating Portuguese landings, uncertainty in landings estimates in the first 5 years of the series was always considered (except when running the model with the default settings – model 1, 2 and 3).

Schaefer production curve shape was considered in all runs where priors were defined.

Most runs, with different datasets and settings, showed issues with at least one item in the checklist for the acceptance of SPiCT assessments. Given that at the time only SP ARSA and PT LPUE series are providing biomass data for the assessment of rjc.27.9a, the inclusion of both series in the assessment model seemed appropriate. However, despite both series being proposed to assess this stock at WKSKATE, other input data was also considered in the trials conducted.

Assessments which included the two SP-ARSA surveys in separate (models 2 and 3) were considered not acceptable. It worth mentioning that the area covered by the surveys is too small in relation to the total stock area so it seems adequate to use a single index that represents the Gulf of Cadiz. For this reason, Q1 and Q4 surveys were combined, following the same methodology used to estimate the stock-size indicator, i.e., by averaging both series, previously normalized.

Assessment trials using all sources of data (i.e., PT survey, SP ARSA surveys and PT LPUE) showed issues both in the checklist for acceptance of the assessment and reliability of the model. For example, models 2 and 4, resulted in a *r* estimate >17 year^{-1}, considered too high for the species.

Given the above, and following the defined guidelines for SPiCT assessments, the model 1a, using as input data the PT LPUE and the combined SP ARSA survey and priors on the production curve and r, was the only model acceptable. This is considered the base model.

Several runs were conducted around the base model, to check for influence of different prior values. Results are presented in Table A2 in Moura et al. (2022). Different priors for the production curve shape, intrinsic rate of population increase (*r*) and initial depletion were evaluated.

Production curve – setting the prior on the production curve shape (Schaefer) has influence on the model results, improving the confidence intervals for B/Bmsy (order of magnitude of 0 instead of 1) and results of the influence of initial values in the parameter estimates (base model *vs* model *a*). However, no major changes in the model estimates were observed when the coefficient of variation of the prior (CV) was changed (model *e*).

Intrinsic rate of population increase (r) - the model was not acceptable if the prior on *r* was set to 0.18 year^{-1}, has suggested in Fishbase (estimate based in Froese et al., 2017). However, when no prior is defined, the model estimates a value close to 0.284 year^{-1} (model *j*). In fact, results from both base model and model *j* are similar but, in the first, no issues were found when testing the parameters estimates with different initial values.

Initial depletion (B/k) – it is expected that at the beginning of the time-series this stock was already exploited. However, the inclusion of a prior on the initial depletion level does not improve the model. In addition to having issues with its acceptance (several items of the checklist for the acceptance of a SPiCT assessment were not fulfilled), results are also not realistic (models *f* and *g*).

The model proposed for assessment of rjc.27.9a during WGEF2022 used the following input data and priors (R code and results available in the WGEF Data folder: "06. Data/SPiCT assessments"; all model runs can be made available upon request).

Input data:

- Stock landings (2003-2021) (Figure 8.1.1)
- PT LPUE (2008-2021, set at the middle of the year) (Figure 8.1.1)
- ARSA Surveys (normalized; 1997-2020; no survey in 2021, set at the middle of the year) (Figure 8.1.1)
- Uncertainty in landings in the first 5 years (rjc_data$stdevfacC <- c(rep(4,5). rep(1,14))

Priors:

- Schaefer production curve with a cv of 0.5 (rjc_data$priors$logn<- c(log(2),0.5,1))
- Intrinsic rate of population increase (r) (rjc_data$priors$logr <- c(log(0.284),0.5,1))

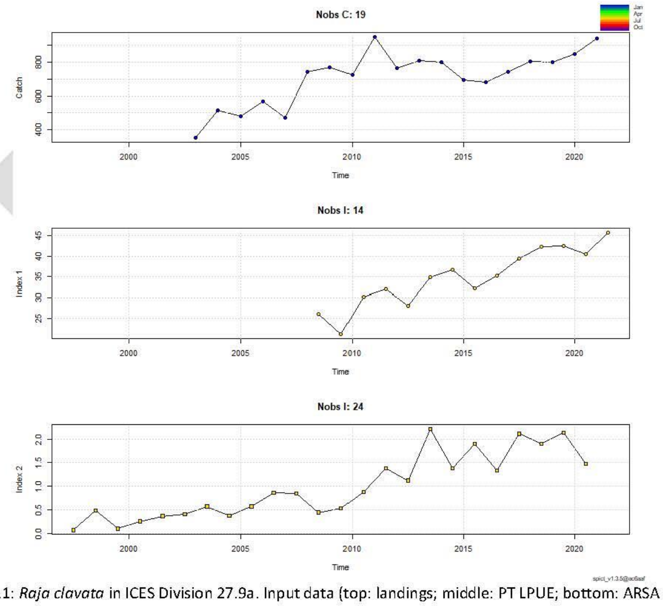

Figure 8.1.1: *Raja clavata* in ICES Division 27.9a. Input data (top: landings; middle: PT LPUE; bottom: ARSA survey).

The prior for the intrinsic population increase (r) was calculated based on the empirical estimator from Jennings et al. (2001), taking as input *R. clavata* fecundity and age at first maturity estimated for the stock (Serra-Pereira et al., 2011). As mentioned previously, the method used to estimate species-specific landings of skates in Portuguese waters, (which represents the major fraction of the stock total landings), from 2003 to 2007 differed from the method currently adopted, applied since 2008 (described in Figueiredo et al., 2020). For this reason, for modeling purposes uncertainty in landings for the years 2003-2007 was adopted.

Results are presented in Figures 8.1.2-8.1.5 and as additional information. No significant bias or autocorrelation were found and both QQ-plot and the Shapiro test show normality in the residuals. Regarding the retrospective pattern. Mohn's rho is <0.2 for both B/B_{MSY} and F/F_{MSY} (0.045 for B/B_{MSY} and of -0.085 for F/F_{MSY}). The checklist for the acceptance of a SPiCT model (Mildenberger et al., 2020) was followed and no issues were found. Despite the large confidence intervals for F/F_{MSY} those do not span more than 1 order of magnitude (Figure 6).

Considering the adopted reference points proposed for production models by ICES (ICES, 2017; ICES, 2021e). F/F_{MSY} in 2021 is below F_{MSY} and B/B_{MSY} in 2022 is above B_{MSY}.

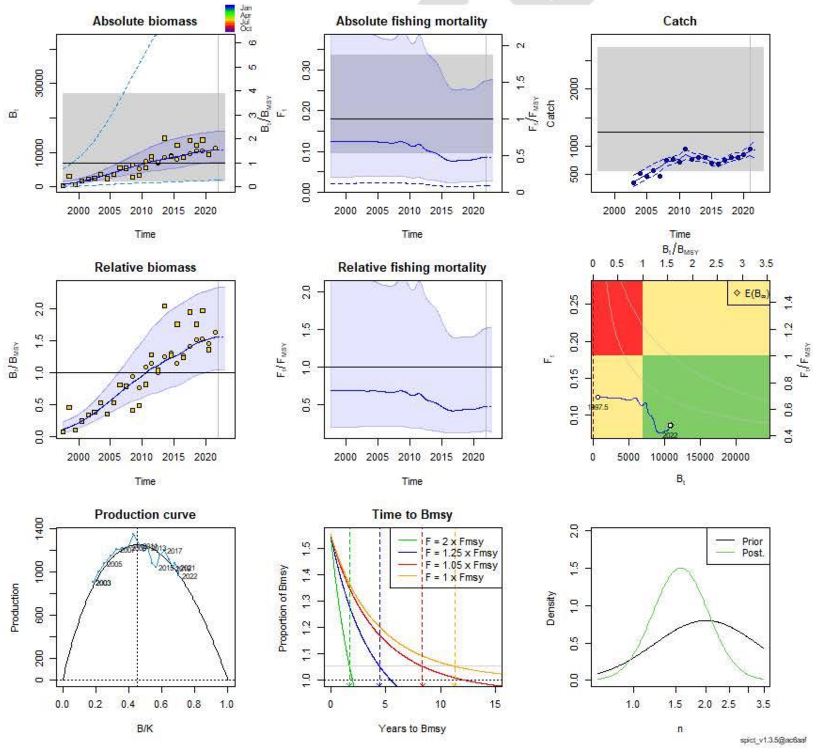

Figure 8.1.2: *Raja clavata* in ICES Division 27.9a. Results from SPiCT model.

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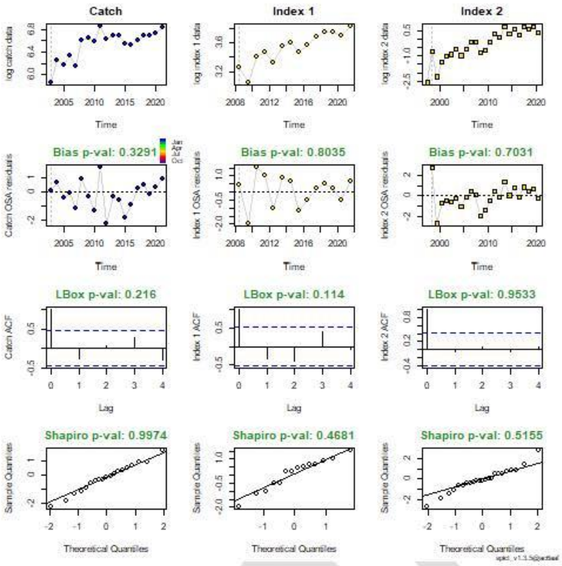

Figure 8.1.3: *Raja clavata* in ICES Division 27.9a. Results from SPICT model. Row1. Log of the input data series. Row 2. OSA residuals with the p-value of a test for bias. Row 3. Empirical autocorrelation of the residuals with tests for significant autocorrelation. Row 4. Tests for normality of the residuals. QQ-plot and Shapiro test.

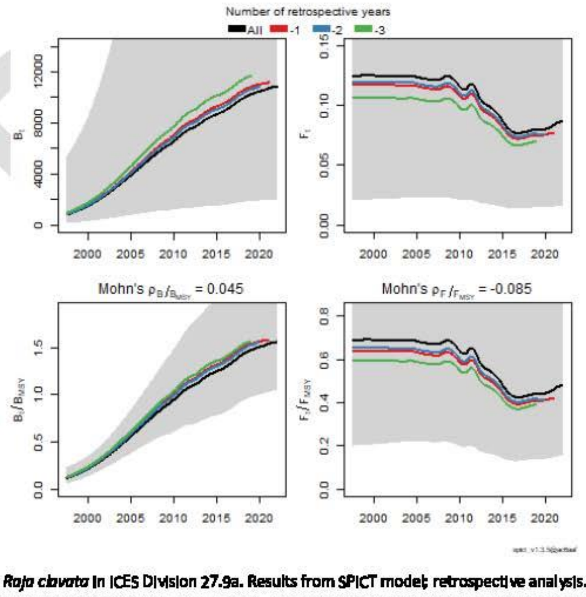

Figure 8.1.4: *Raja clavata* in ICES Division 27.9a. Results from SPICT model; retrospective analysis. Upper panel. absolute biomass and fishing mortality. Lower panel. relative biomass and fishing mortality. Grey regions represent 95% CIs.

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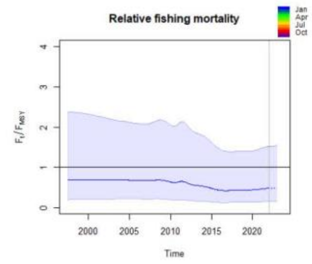

Figure 8.1.5. *Raja clavata* in ICES Division 27.9a. Results from SPiCT model: Relative fishing mortality.

8.2. SPiCT runs during WKBELASMO3, data compilation meeting - to be completed

9. References

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Working document presented to the Benchmark Workshop on Selected Elasmobranchs Species 3 (WKBELASMO3)

Benchmark workshop – 26th February to 1st March 2024

Thornback ray (*Raja clavata*) in Division 9a (Atlantic Iberian waters) (rjc.27.9a)

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Content

Abstract

The present working document aims to summarize the available information for Raja clavata in in Atlantic Iberian waters (ICES division 27.9a) to be used in the assessment of the stock rjc.27.9a, particularly on: stock identity, catch data, surveys biomass indexes, commercial LPUE, life-history parameters, the latest assessment and advice. Furthermore, a summary of the initial runs explored with surplus production model SPiCT (Stochastic Production model in Continuous Time), presented at the ICES WGEF meeting in 2022 are also presented.

1. Introduction

Thornback ray *Raja clavata* is the most ubiquitous and common skate species across the Northeast Atlantic. The species is distributed along the Atlantic Iberian waters ICES division 9a, with landings ranging from 591 to 1090 tonnes, during the period 2000-2022, which represents more than 50% of all skate species landed in that geographical area. Under ICES, the stock of thornback ray in Atlantic Iberian waters (rjc.27.9a) has been assessed under category 3 since 2014, and the latest advice in 2022, involved the application of the ICES framework for category 3 stocks applying the rfb rule (method 2.1; ICES, 2022a-b).

For the present benchmark, the proposal to improve the assessment for this stock is focussed on evaluating the application of a surplus production model SPiCT (Stochastic Production model in Continuous Time, Pedersen and Berg 2017) for providing advice.

The present working document summarizes the information available on the rjc.27.9a stock.

2. Stock identity

The stock structure of the species along the ICES areas is unknown. Migrations between different areas are admitted (ICES, 2013). For advice purposes, ICES currently considers seven distinct assessment units, including one in the Greater North Sea, three in the Celtic Sea, two in the Bay of Biscay and a distinct stock unit for Division 9.a, west of Galicia, Portugal, and Gulf of Cadiz (rjc.27.9a), which is the focus of this working document.

2.1. Species Distribution

Thornback ray is a coastal species with a wide geographic distribution from shallow waters (including estuaries) to 700 m depth. Occurs in the Eastern Atlantic from Iceland to South Africa, and in the North Sea, Mediterranean, Baltic and Black Seas (Stehmann and Bürkel, 1984). The species is mainly found on hard seabed (e.g. gravel and pebbles), in areas of intermediate to strong tidal currents (Ellis et al., 2005).

In ICES division 9a, the species is distributed along the entire area.

In the West of Galicia thornback ray is more abundant in the northern waters and in the Cantabrian Sea mainly in mud and sandy bottoms. It has a wide depth distribution, from 20 m to 400 m, but it is more abundant between 50-200 m depth, particularly close to 75 m (Figure 2.1.1.a). There is no information regarding size or sex segregation, neither on spawning or egg laying site (Sánchez et al., 2002).

The species can be found throughout the Portuguese continual coast, from 18 to 700 m, being more abundant in the southwest and southern regions (i.e. south off Cabo Carvoeiro), at depths shallower than 200 m (Figure 2.1.1.b). In the centre of mainland Portugal, the species occupies a broad range of habitat types, from mud and fine sand to rocky bottoms, showing different spatial dynamics according to the life stage (Serra-Pereira et al., 2014). Spatial segregation by sex was observed; females are more abundant in shallower grounds, while males frequently occur offshore, deeper than 100 m. Distinct areas were identified as egg laying grounds, that differ in depth (all shallower than 100 m), bottom topography and seabed composition (from fine sand to gravel). A seasonal variation in juvenile's abundance was registered in these areas: higher abundances are recorded during the 1st and 3rd quarters of the year, showing a temporal spatial overlap between egg-laying and nursery grounds. Nursery and egg laying grounds are located at depths shallower than the adults, suggesting the existence of migrations associated to reproduction. Worth to note that in the North Sea and eastern English Channel adults from this species migrate from deeper to shallower waters for mating and for egg deposition. Juveniles tend to stay in shallow waters during the first years of growth and migrate to deeper areas afterwards (Steven, 1936; Walker et al., 1997; Hunter et al., 2005, 2006).

In the Gulf of Cadiz, the thornback ray is present along the whole area at depths ranging from 20 to 800 meters, being especially abundant in trawlable grounds placed in the south area of the Gulf, in the range between 100 and 350 m depth (Figure 2.1.1.c).

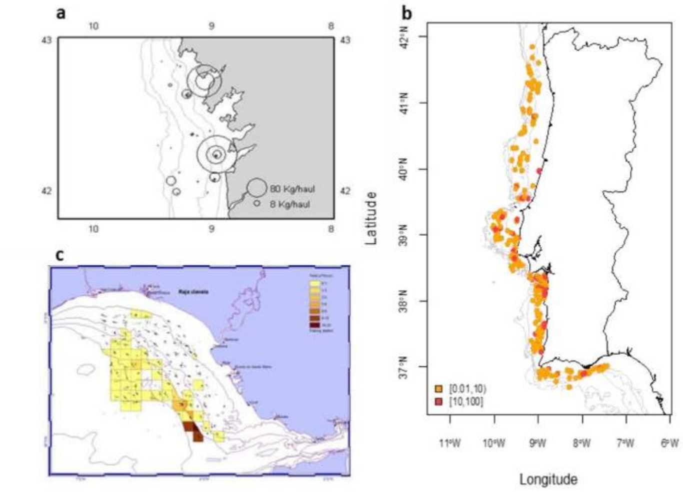


Figure 2.1.1: *Raja clavata* in ICES Division 9a. Species distribution: a) distribution and catch rate (kg/30 min) in Spanish autumn Ground Fish Survey (SpGFS-WIBTS-Q4) from 1983 to 2013 in West of Galicia; b) distribution and catch rate (kg.hour^{-1}) in Portuguese Autumn Groundfish Surveys (PtGFS-WIBTS-Q4) from 1990 to 2013 along the Portuguese coast and c) distribution and abundance index (no/hour) in the Spring Spanish bottom trawl survey in the Gulf of Cádiz (from ARSA surveys 1993-2009, SpGFS-GC-WIBTS-Q1 and Q4).

2.2. Genetics and tagging

Strong regional genetic differentiation is described for thornback ray between the Mediterranean basin, the Azores and the European continental shelf (Chevolot et al., 2006). The distribution and movement of this species is apparently highly influenced by ocean depth, which acts as physical barrier to dispersal for thornback rays, as also described to occur in other demersal fish between continental shelf and Icelandic populations (Hoarau et al., 2002). The low nuclear allelic diversity and the high genetic differentiation found in the Azores are consistent with a strong bottleneck and physical isolation of the Azores (Chevolot et al., 2006). The highest haplotype diversity was found in the Iberian Peninsula and in more northern English Channel/North Sea populations, while the lowest was found in the Black Sea (Figure 2.2.1). This suggests restricted gene flow between northern and southern European populations which is in accordance with the current stock structure.

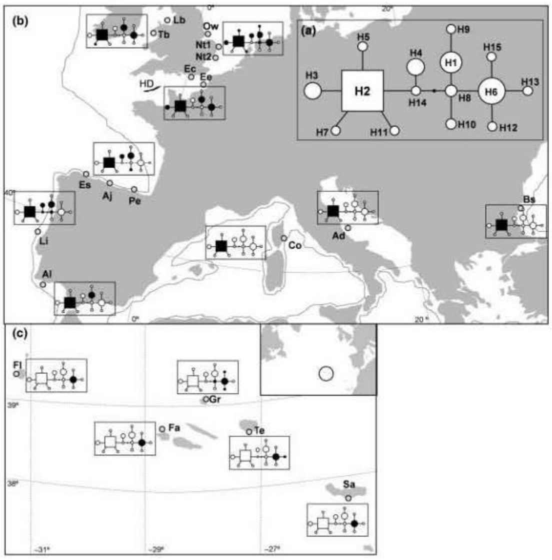


Figure 2.1.1: population genetic structure of thornback ray: Sampling locations and distribution of mtDNA haplotypes (H). (source: Chevolot et al., 2006).

More recent European projects on the population genetic structure of thornback ray indicate that on a large spatial scale, samples are clearly clustered by Ecoregions (Figure 2.1.2) as has been reported by Poos et al. (2023). The Celtic Sea samples cluster slightly separately from the Greater North Sea samples, whereas the Biscay and Iberia samples clearly cluster separately from those gathered in the northern ecoregions. Also, small scale genetic population structure appears to occur for this species in this ecoregion, between offshore and nearshore areas (Figure 2.1.3). Those results were in line with a demographic connectivity study (Trenkel et al., 2022) that provided the basis for distinct local populations and the consequent split of thornback ray in Subarea 8 (Bay of Biscay), into a Bay of Biscay (rjc.27.8abd) and a Cantabrian Sea (rjc.27.8c) component, during the 2022 WKBELASMO benchmark (ICES, 2022c).

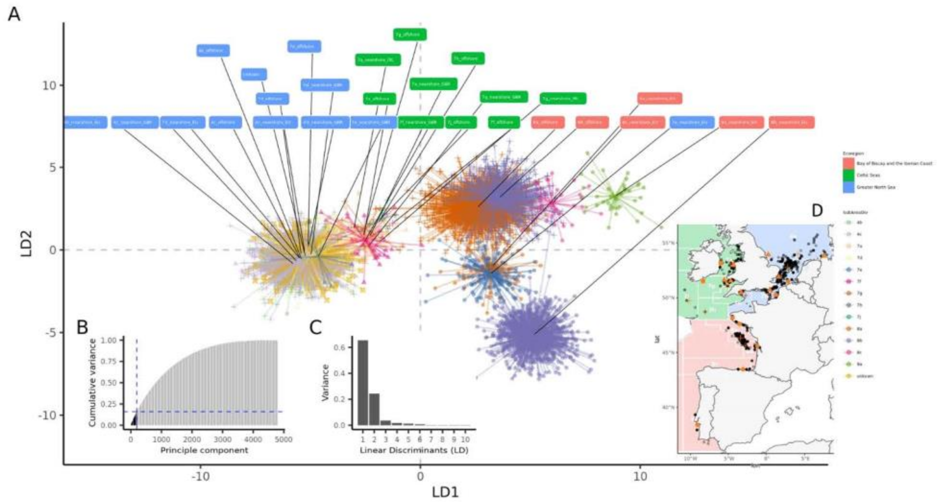


Figure 2.1.2: population genetic structure of thornback ray: (A) discriminant analysis of principal components (DAPC) with grouping Prior based on ICES divisions. (B) cumulative variance of optimal number for DAPC. (C) Variance of linear discriminants retained in DAPC. (D) location of Spatial locations of samples collected and genotyped in several projects across European waters. (source: Poos et al., 2023)

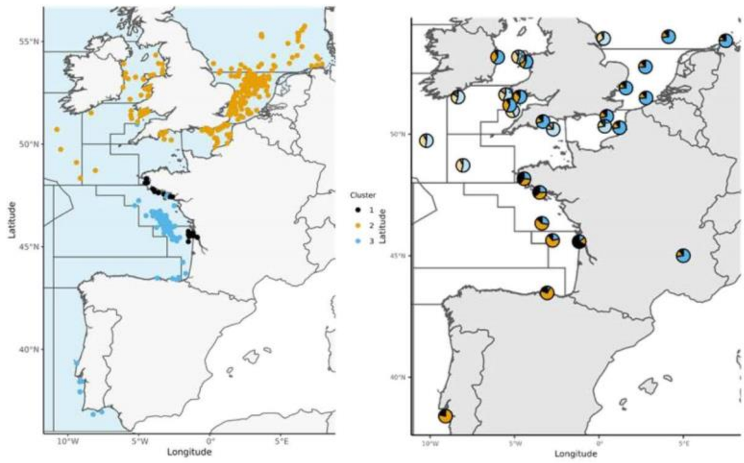


Figure 2.1.3: population genetic structure of thornback ray: (left) cluster results of DAPC without prior; (right) average ancestry cluster proportions (admixture) grouped by sample areas, for k= 3 (adapted from Poos et al., 2023)

Bird et al. (2020) compiled and reviewed 50 years of tagging data for eight commercially important skate species around the British Isles. Thornback ray was the most frequently tagged species. Overall, more than 99% of returned tags were from within the defined stock unit of release (Figure 2.1.4). Some individuals showed more extensive movements between stock units and management areas, yet it remains unclear whether these are regular or occasional movements. According to those results, along with genetic evidences, the stock boundaries for the North Sea thornback ray stock unit were not updated during WKBELASMO2 (ICES, 2023a).

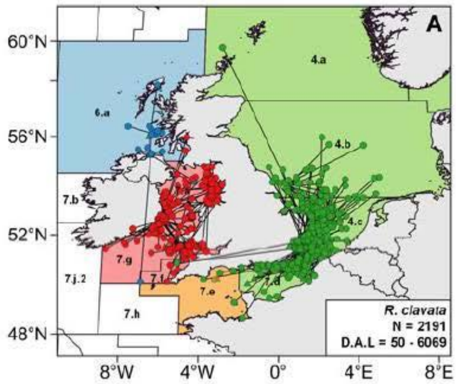


Figure 2.1.4: Tag releases (triangles), returns (circles) and straight-line distances (lines) for thornback ray (*Raja clavata*) at liberty for ≥50 days (n = 2191). Different colours indicate ICES stock units. (source: Bird et al., 2020)

A recent acoustic telemetry study conducted in a Marine Protected Area (MPA) in the southwest coast of Portugal, has also confirmed the resident behavior of thornback ray in a coastal area in the ICES Division 9a (Kraft et al., *submitted*). Most of the individuals were observed inside the MPA for a period of three years, while the remaining showed more expansive movements, particularly after 200 days after tagging, coinciding with the period between September and December. One mature female was observed to move into the Sado estuary also during the same period, which coincides with the second half of the spawning period described for this stock (Serra-Pereira et al., 2011). The same behavior of strong connection to inshore waters, was also observed in the north of Spain (Division 9a), with movements detected in and out the *Ria de Vigo* (Papadopoulo et al., 2023). Other tagging studies have demonstrated the importance of estuaries in the life-cycle of the species in other ecoregions (Walker et al. 1997; Hunter et al. 2006; Ellis et al., 2018; Simpson et al., 2020; McAllister et al., 2023). The Outer Thames was identified as an important area for the North Sea-eastern Channel stock, with individuals being not restricted to that estuary, as they move throughout the southern North Sea (Ellis et al., 2018). Annual migration patterns were also observed, with individuals moving in autumn from the spawning grounds in the Thames estuary to the central North Sea for winter, followed by a return to the estuary in the spawning season (Hunter et al, 2006).

As such, based on available genetic and tagging data there is no evidence to update the current stock unit in Iberian waters for thornback ray. Further genetic and tagging studies in the area could improve the knowledge of the importance of inshore areas, migration patterns or existence of metapopulations.

3. Catch data

3.1. Landings

Landings data were obtained from the WGEF landings table (ICES, 2023b), and have been reported by Portugal and Spain (the two main countries with fishing fleets in the area).

Given that production models (such as SPiCT) require a time series of catches as input data, preferably long enough to cover one generation time (~10 years) and that includes contrasting periods in terms of stock biomass and fishery mortality, data from 2000 was reconstructed.

Portuguese data available in WGEF landings table comprised the period 2005-2022. Due to misreporting errors in Rajidae species official data, IPMA developed a statistical stepwise procedure involving factor analysis for mixed data and flexible discriminant analysis to estimate the total landed weight by species and have been applying this procedure since 2008 (details can be found in Figueiredo et al., 2020). For the present benchmark historical data for the period 2000-2007 was reconstructed by fleet and detailed information on the methods adopted can be found in Maia et al. (2023). Given the uncertainty associated with landings previously reported for the period 2005-2007, these years were also included in the reconstruction.

Spanish data available comprised the period 2009-2022. Given the uncertainty associated with landings reported for 2009, historical data reconstruction covered the period 2000-2009. For that the average proportion of thornback ray of 2010-2013 was applied over the period 2000-2009 considering all fleets together.

Landings of thornback ray in ICES Division 9a have been ranged from 591 to 1090 tonnes, with Portugal contributing for 69-89% and Spain for 11-31% (Table 3.1.1). Along the time series, landings from the polyvalent fleet represented 50-69% of the species landed weight, followed by trawl that have been representing between 22-49% (Figure 3.1.1). A detailed description of the Portuguese polyvalent fleet can be found in Figueiredo et al. (2020).

Portuguese landings represent around the 82 % of total landings considering all fishing gears. Landings from the polyvalent fleet were mainly reported by Portugal and represented on average 97% of the landed weight while Spain contributed on average for 3% (Figure 3.1.2). Whitin the Trawl fleet, landings from Portugal represented on average 75% while Spain contributed with an average of 25%.

Table 3.1.1.: Thornback ray *Raja clavata* in ICES Division 9a. Annual landings (in tonnes) and representativeness by country.

Year	Portugal		Spain		Total
	Ton	%	Ton	%	
2000	492	83	99	17	591
2001	534	79	142	21	676
2002	513	82	116	18	629
2003	538	82	118	18	655
2004	534	83	112	17	646
2005	571	84	107	16	678
2006	547	82	116	18	663
2007	571	84	112	16	683
2008	745	86	119	14	864
2009	739	89	94	11	833
2010	611	84	115	16	725
2011	811	85	139	15	950
2012	570	75	194	25	764
2013	643	80	166	20	809
2014	585	73	215	27	800
2015	578	83	120	17	697
2016	559	82	123	18	682
2017	620	83	124	17	744
2018	654	81	152	19	806
2019	621	77	181	23	802
2020	670	79	178	21	848
2021	768	82	174	18	942
2022	751	69	339	31	1090

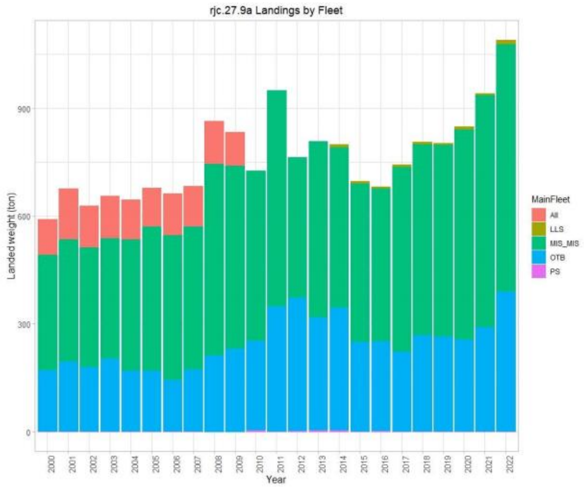


Figure 3.1.1: Thornback ray *Raja clavata* in ICES Division 9a. Annual landings (in tonnes) by fleet. "All" – all fleets combined; "LLS" – longlines; "MIS_MIS" – polyvalent fleet; "OTB" – trawl fleet and; "PS" – seine fleet.

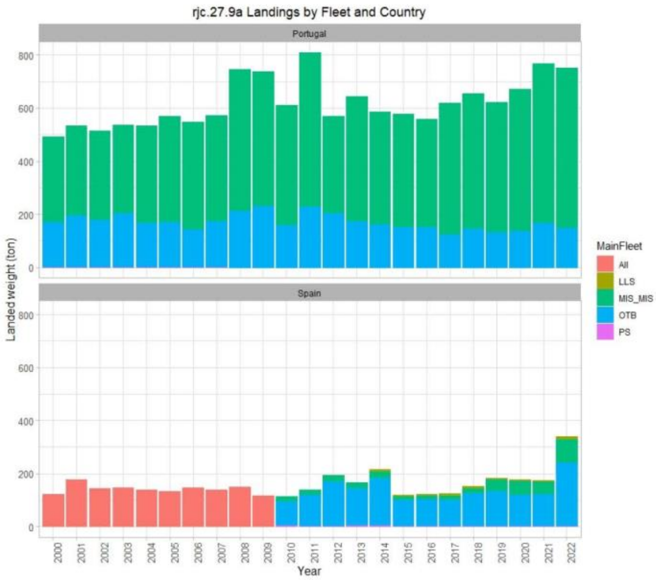


Figure 3.1.2: Thornback ray *Raja clavata* in ICES Division 9a. Annual landings (in tonnes) by country and fleet. "All" – all fleets combined; "LLS" – longlines; "MIS_MIS" – polyvalent fleet; "OTB" – trawl fleet and; "PS" – seine fleet.

3.2. Length Distribution from landings

Length distributions of thornback ray from the Portuguese commercial polyvalent and trawl fleets for the period 2008–2022 are presented in Figures 3.2.1 and 3.2.2. Figure 3.2.3 presents the overall distribution with the two fleets combined. Length distributions were raised to the total estimated landed weight of each species.

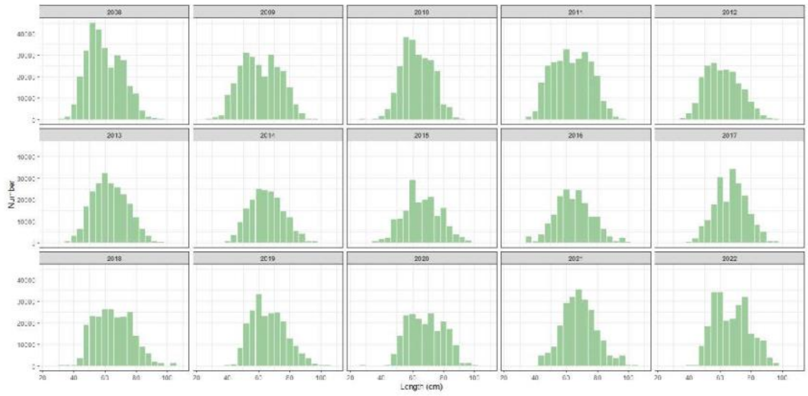


Figure 3.2.1: Thornback ray *Raja clavata* in ICES Division 9a. Length distribution (4 cm classes, 3033 sampled trips) for the period 2008-2022 in mainland Portugal from the polyvalent fleet.

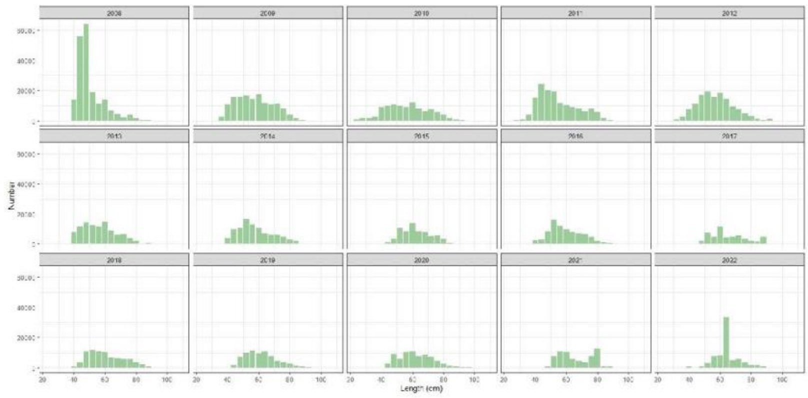


Figure 3.2.2: Thornback ray *Raja clavata* in ICES Division 9a. Length distribution (4 cm classes, 895 sampled trips) for the period 2008-2022 in mainland Portugal from the trawl fleet.

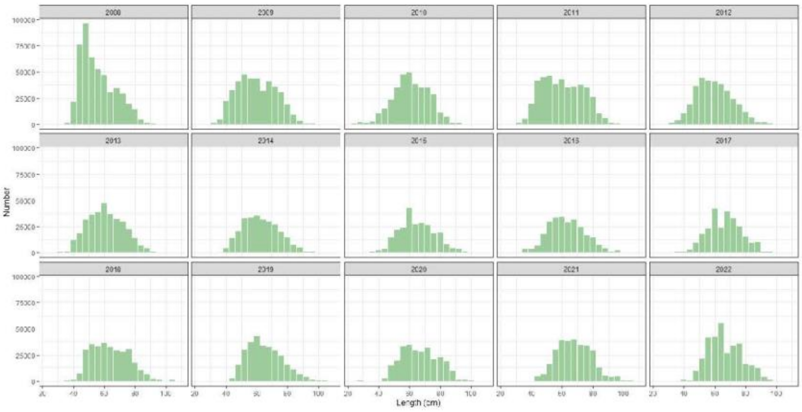


Figure 3.2.3: Thornback ray *Raja clavata* in ICES Division 9a. Length distribution (4 cm classes, 3928 sampled trips) for the period 2008-2022 in mainland Portugal from polyvalent and trawl fleets combined.

3.3. Discards

Discards for thornback ray in ICES Division 9a were mainly reported for the Spanish bottom otter trawl fleet and in low quantities (below 45 ton) compared to the total landings for the stock (average proportion of 0.01±0.018) (Figure 3.3.1). The low frequency of occurrence registered for the species in the discards of the Portuguese trawl fleet indicates that discards can be considered negligible for that particular fleet (Fernandes, 2021). In relation to the Portuguese polyvalent fleet, discards are known to take place and assumed to be low, but are not fully quantified as the information available is insufficient to estimate total discards (Fernandes, 2021). Further details on the discards for all skate species was presented to WKSHARKS3 (ICES, 2017a; Serra-Pereira et al., 2017)

In summary, discarding is known to take place for thornback ray in ICES Division 9a, but ICES cannot estimate the quantity or the corresponding dead catch. Yet, based on information available, discarding for this stock is assumed to be low and therefore has not been included in the previous advices and will not be considered for the SPiCT assessment explored in the present benchmark.

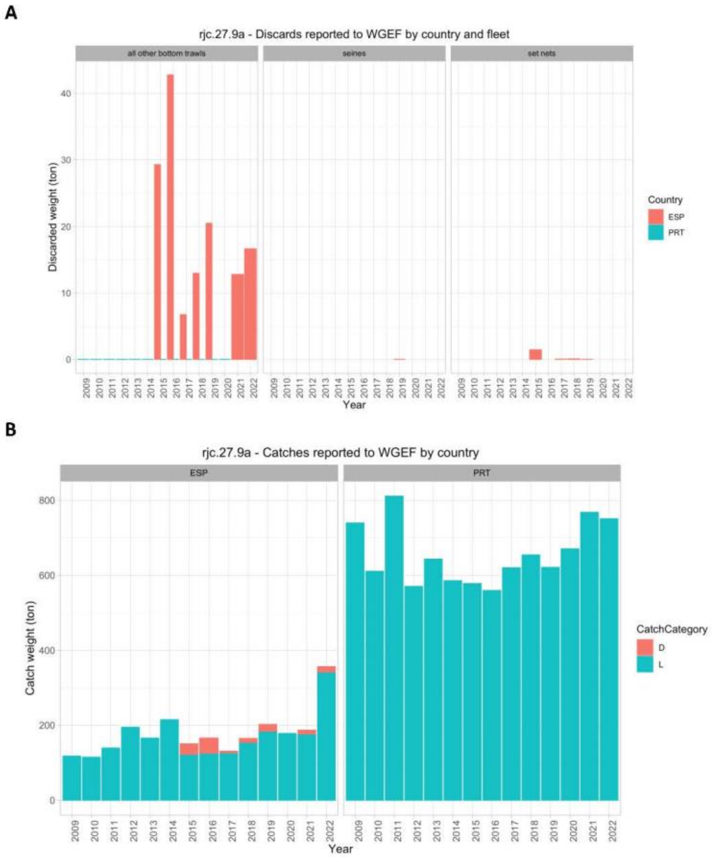


Figure 3.3.1: Thornback ray *Raja clavata* in ICES Division 9a. (A) Discards reported by country and fleet. (B) Catches reported by country, separated by landings (L) and discards (D).

3.4. Survival

Discard survival studies on thornback ray have been conducted in ICES Division 9a both in Portugal (Serra-Pereira and Figueiredo, 2018) and Spain (Valeiras and Álvarez-Blazquez, 2018), covering the main fishing gears catching the species.

In summary, based on results for the Portuguese polyvalent fleet, collected under the DCF Skates Pilot Study, a high Categorical Vitality Assessment (CVA) was found for thornback ray, with more than 75% of the individuals found in Excellent or Good vitality status (Table 3.4.1). Both mesh size and soaking time seem to affect survival. In terms of the relation with the size of the caught skates, in the retain fraction of the catch vitality after capture was not related to size, while for the discarded, differences between size classes were observed, as the large skates discarded were generally not in good conditions for selling due to parasite infection for example (Table 3.4.2). According to a study conducted onboard the polyvalent fleet in the north of Spain (DESCARSEL project), all skates were alive after capture, with 89% of them in Excellent or Good conditions, and after 30 days in captivity the short-term survival was estimated in 72.7%, considering all skate species combined, including the thornback ray (Valeiras and Álvarez-Blazquez, 2018).

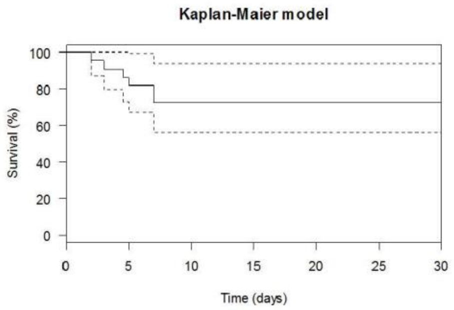
Table 3.4.1: Thornback ray *Raja clavata* in ICES Division 9a. Categorical Vitality Assessment (CVA) after capture by mesh size (mm) and soaking time (h), recorded onboard commercial vessels operating with trammel nets (n=171). (source: Serra-Pereira and Figueiredo, 2018).

		Vitality status				
Mesh size (mm)	Soak time (h)	1	2	3	n	TL range (cm)
< 180	< 24	100%	0%	0%	17	23-72
	> 24	72%	12%	16%	25	39-80
> 180	< 24	92%	4%	4%	26	48-88
	> 24	52%	23%	24%	103	40-96

Table 3.4.2: Thornback ray *Raja clavata* in ICES Division 9a. Categorical Vitality Assessment (CVA) after capture by length class (cm), recorded onboard commercial vessels operating with trammel nets (source: Serra-Pereira and Figueiredo, 2018).

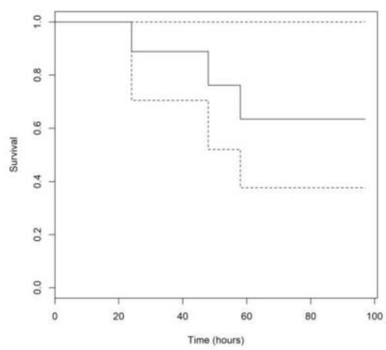
	Retained				**Discarded**			
	Vitality status				Vitality status			
Length class	1	2	3	n	1	2	3	n
<52 cm	68%	18%	14%	22	83%	0%	17%	12
>52 cm	70%	19%	10%	125	0%	0%	100%	12

Regarding the trawl fleet, experiences conducted onboard the Portuguese Autumn Groundfish Survey, suggested that thornback ray has a relatively high survival rate after capture to trawl, although lower than to trammel nets (Serra-Pereira and Figueiredo, 2018). Kaplan-Meier model fitted to survival data, showed no significant differences between vitality status (p=0.84), and estimated a preliminary survival rate of 64% (Figure 3.4.2). To note that this study although it may be indicative of the species survival it involved a small sample which was translated in a high uncertainty.



time	n.risk	n.event	survival	std.err	lower 95% C	upper 95% CI
48	22	1	0.955	0.0444	0.871	1
72	21	1	0.909	0.0613	0.797	1
108	20	1	0.864	0.0732	0.732	1
120	19	1	0.818	0.0822	0.672	0.996
168	18	2	0.727	0.095	0.563	0.939

Figure 3.4.1. Discard survival of Rajidae combined, including thornback ray. Kaplan-Meier estimate of survival along 30 days of captivity (solid lines) and 95% pointwise confidence intervals (dashed lines). Survival probability within the observation period with standard error and upper and lower 95% CIs estimates (source: Valeiras and Álvarez-Blazquez, 2018).



time	n.risk	n.event	survival	s.e.	lower 95% CI	upper 95% CI
24	9	1	0.89	0.11	0.71	1.00
48	7	1	0.76	0.15	0.52	1.00
58	6	1	0.64	0.17	0.38	1.00

Figure 3.4.2: Thornback ray *Raja clavata* in ICES Division 9a. Kaplan-Meier estimate of survival along 100 hours (4.2 days) of captivity (solid lines) and 95% pointwise confidence intervals (dashed lines). Survival probability within the observation period with standard error and upper and lower 95% CIs estimates (source: Serra-Pereira and Figueiredo, 2018).

Results obtained by fishing operation, onboard the Spanish trawl fleet, suggest differences between hauls in vitality proportions (e.g. associated to a large catch weight of the target species, horse mackerel, resulting in a higher proportion of skates in "Poor" condition) (Valeiras and Álvarez-Blazquez, 2018). A proportion of 93.5% of skates survived to fishing operations and handling onboard (Table 3.4.3). Based on captivity trials, the overall survival rate was 58% after 36h. Differences were observed on the survival rate of skates categorised as "Good" (46%), compared with those as "Poor" (2%). As several factors may have influenced the survivability of the individuals during the experiment, it can be assumed that the survival rate obtained is underestimated. Factors affecting the estimates were: large catch weight of the target species (horse mackerel) in some hauls, transport, onboard captivity conditions, as well as the fact that most of the thornback rays did not eat till 3 weeks at captivity which may have compromise the health status at captivity of the species (Valeiras and Álvarez-Blazquez, 2018).

Table 3.4.3: Thornback ray *Raja clavata* in ICES Division 9a. Categorical Vitality Assessment (CVA) after capture recorded onboard commercial trawlers in the north of Spain (n=153).

Vitality	Captured	Number fish in tanks	Proportion Vitality in total catch
Excellent	2	1	1.3%
Good	45	24	29.41%
Poor	96	53	62.8%
Dead	10	0	6.5%
Total	**153**	**78**	

Overall, the results from the different studies suggest that the thornback ray caught by different fishing gears in ICES Division 9a have a high survival after capture, more precisely those caught by polyvalent vessels operating with trammel nets and otter trawlers. All the studies followed the procedures described in previous studies on the survival of this group of species and the recommendations made by the STECF and the ICES Working Group on Methods to Estimate Discard Survival.

4. Surveys biomass index

Relevant fisheries independent data for the stock rjc.27.9a is collected onboard three Iberian research surveys, covering most of the stock area (Figure 4.1): (i) Portuguese Autumn Groundfish Survey (PtGFS-WIBTS-Q4), (ii) Spring southern Spanish bottom trawl survey (SpGFS-GC-WIBTS-Q1; ARSA Q1) and (iii) Autumn southern Spanish bottom trawl survey (SpGFS-GC-WIBTS-Q4; ARSA Q4). The input from these three surveys have been used to provide the assessment under the Data-limited approach for category 3 stocks (trend-based). Although not included in the assessment, additional information is provided from the Spanish Autumn Groundfish Survey (SpGFS-WIBTS-Q4), although the yields of thornback ray from this survey present an irregular time-series, with biomass estimates close to zero in some of the years. Detailed information about the four surveys is presented in the following sections.

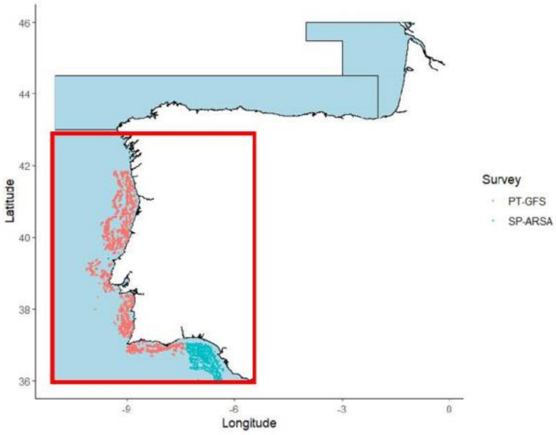


Figure 4.1: Thornback ray *Raja clavata* in ICES Divison 9a. Surveys conducted in Division 9a with relevant captures of the species: Portuguese Autumn Groundfish Survey (PtGFS-WIBTS-Q4; PT-GFS) and Spanish bottom trawl survey SpGFS-GC-WIBTS-Q1 and Q4 (SP-ARSA).

4.1. Portuguese Autumn Groundfish Survey (PtGFS-WIBTS-Q4) [G8899]

The Portuguese Autumn Groundfish Survey (PtGFS-WIBTS-Q4) has been conducted by the Portuguese Institute for the Sea and Atmosphere (IPMA, ex-IPIMAR) and has the main objective to monitor the abundance and distribution of hake (*Merluccius merluccius*) and horse mackerel (*Trachurus trachurus*) recruitment (Cardador et al., 1997).

The survey is performed along the Portuguese continental coast, extending from latitude 41°20'N to 36°30'N (ICES Division 9.a) from 20 to 500 m deep. The surveyed area is stratified into 12 sectors, each further divided into four depth strata: 1) 20-100 m, 2) 101-200 m, 3) 201-500 m, and 4) 501-750 m. For more details on vessels characteristics (RV *'Noruega'*) and technical characteristics of fishing operations see ICES (2017b).

In 2012 no survey was conducted, as well as in 2019 and in 2020, due to issues external to IPMA and to the covid-19 outbreak. In 1996, 1999, 2003 and 2004 the survey was conducted with a different gear. In 2018, the survey had technical problems, and part of the stations were sampled using a commercial trawler and a different fishing net (using FGAV019 instead of NCT). Since 2021, the survey has been conducted with a new vessel (RV *'Mário Ruivo'*) and some modifications in the fishing gear. To overcome possible issues with the use of PtGFS-WIBTS-Q4 data in the assessment of rjc.27.9a an LPUE index from the Portuguese polyvalent fishing fleet was proposed at WKSKATE and accepted by the group and reviewers (ICES, 2021a).

In PtGFS-WIBTS-Q4, thornback ray is the most frequent skate species caught (88% of the total weight of skates), being caught all along the entire Portuguese continental shelf and upper slope, at depths ranging from 18 m to 700 m, being more abundant in southwest and south regions at depths shallower than 200 m (Figure 4.1.1). Length composition of thornback ray in Portuguese Autumn Groundfish Survey for the all period combined is present in Figure 4.1.2.

Working document presented to the Benchmark Workshop on Selected Elasmobranchs Species 3 (WKBELASMO3)

Benchmark workshop – 26th February to 1st March 2024

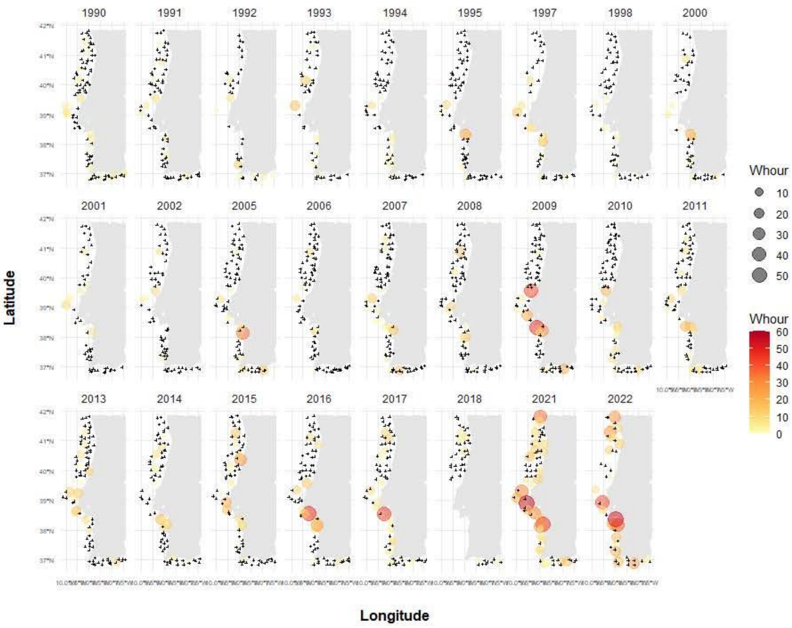


Figure 4.1.1: Thornback ray *Raja clavata* in ICES Divison 9a. Catches and distribution in Portuguese Autumn Groundfish Survey (PtGFS-WIBTS-Q4) during the period 1990-2022.

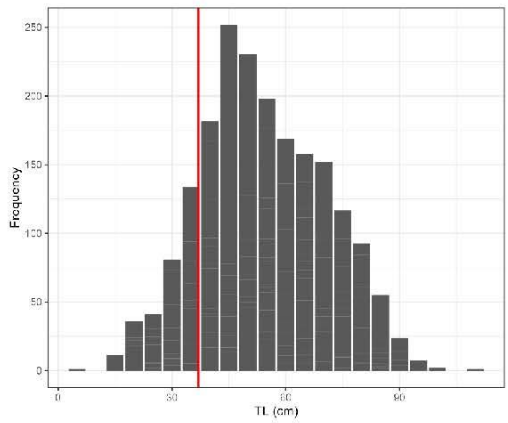


Figure 4.1.2: Thornback ray Raja clavata in ICES Divison 9a. Length distribution (5 cm classes) in the Portuguese Autumn Groundfish Survey (PtGFS-WIBTS-Q4) during the period 1990-2022. Red line identifies the 35 cm threshold applied to select the exploitable biomass component of the survey catch.

Up to 2020, the PtGFS-WIBTS-Q4 biomass index used to assess this stock was standardized using the catch rates (in kilogram per hour) by fishing haul from 1990 to 2018. Given the occurrence of the species at 20-350 m deep, the dataset was also restricted to this depth range. Generalized linear mixed models (GLMM; Bolker et al., 2009) were used in the standardization process, which include the year and depth as explanatory variables and the sector as random effect:

glmm (log(catch rate + 1) ~ year + log(depth) + (1|sector)

Due to the high percentage of zeroes in the data series (Figure 4.1.3), the model followed a Tweedie distribution for the observations. A detailed description of adopted methodologies can be found in Figueiredo and Serra-Pereira (2013) and in the stock annex.

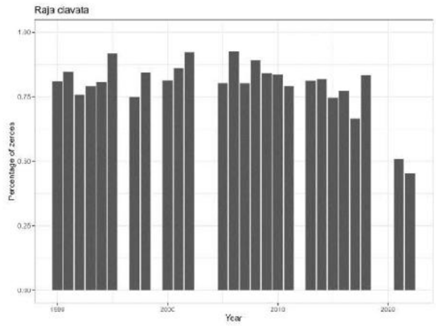


Figure 4.1.3: Thornback ray *Raja clavata* in ICES Divison 9a. Percentage of stations with no capture of thornback ray in the Portuguese Autumn Groundfish Survey (PtGFS-WIBTS-Q4), by year.

For the WKBELASMO3, the exploitable biomass index for thornback ray was computed, considering individuals with total length (TL) larger than 35 cm, threshold defined based on the analysis of length frequency data from commercial landings (see section 3.2 of this working document). Individual weight of specimens with TL >35 cm was estimated based on length-weight relationships defined for the stock (Serra-Pereira et al., 2010). The standardized CPUE index shows a gradual increasing trend since 2006 (Figure 4.1.4 and Table 4.1.1).

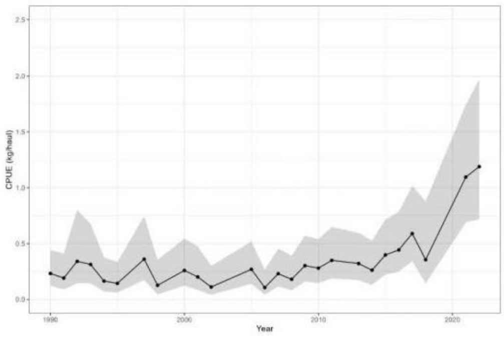


Figure 4.1.4: Thornback ray Raja clavata in ICES Divison 9a. Standardized survey biomass index from the Portuguese Autumn Groundfish Survey (PtGFS-WIBTS-Q4). Shaded grey area represents the upper and lower confidence intervals.

Table 4.1.1: Thornback ray *Raja clavata* in ICES Divison 9a. Standardized exploitable biomass index (kg.h^{-1}) for the Portuguese Autumn Groundfish Survey (PtGFS-WIBTS-Q4) and the corresponding confidence intervals.

Year	Mean	SE.inf	SE.sup
1990	0.232	0.122	0.441
1991	0.191	0.089	0.411
1992	0.341	0.145	0.803
1993	0.313	0.145	0.677
1994	0.164	0.072	0.377
1995	0.143	0.061	0.334
1996			
1997	0.361	0.175	0.744
1998	0.126	0.045	0.353
1999			
2000	0.259	0.123	0.545
2001	0.201	0.085	0.474
2002	0.111	0.041	0.299
2003			
2004			
2005	0.269	0.140	0.519
2006	0.106	0.043	0.265
2007	0.230	0.117	0.455
2008	0.180	0.083	0.391
2009	0.302	0.160	0.571
2010	0.280	0.146	0.538
2011	0.350	0.189	0.649
2012			
2013	0.321	0.174	0.595
2014	0.262	0.131	0.525
2015	0.398	0.222	0.715
2016	0.443	0.250	0.785
2017	0.590	0.342	1.018
2018	0.355	0.144	0.878
2019			
2020			
2021	1.096	0.690	1.742
2022	1.190	0.718	1.970

4.2. The southern Spanish bottom trawl survey (SpGFS-GC-WIBTS-Q1 and Q4; ARSA) [G4309]

The southern Spanish bottom trawl survey (commonly named 'ARSA') that take place in the Gulf of Cadiz (Division 9.a) has been carried out in spring since 1993 (SpGFS-GC-WIBTS-Q1) and in autumn (SpGFS-GC-WIBTS-Q4) since 1997. No survey was conducted in 2021 due to the covid-19 outbreak. The surveyed area corresponds to the continental shelf and upper-middle slope (depths of 15–800 m) and from longitude 6º20'W to 7º20'W, covering an area of 7224 km². In the ARSA time series, thornback ray is one the most abundant skate species. More details about these surveys can be found in ICES (2021).

Length composition of thornback ray in the Spanish bottom trawl surveys for the all period combined is present in Figure 4.2.1. The biomass index for these surveys is obtained by averaging both surveys. The species shows an increasing trend in biomass since 1997, with the highest values reached in 2022 (Figure 4.2.2).

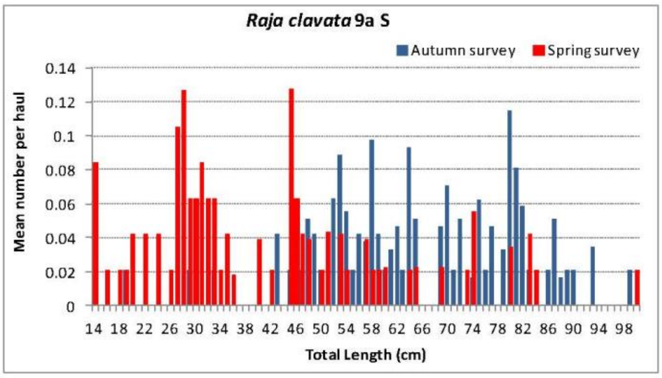


Figure 4.2.1: Thornback ray *Raja clavata* in ICES Divison 9a. Mean number per haul by length class in the southern Spanish bottom trawl surveys (ARSA; SpGFS-GC-WIBTS-Q1 and Q4) combined for the period 1997-2022.

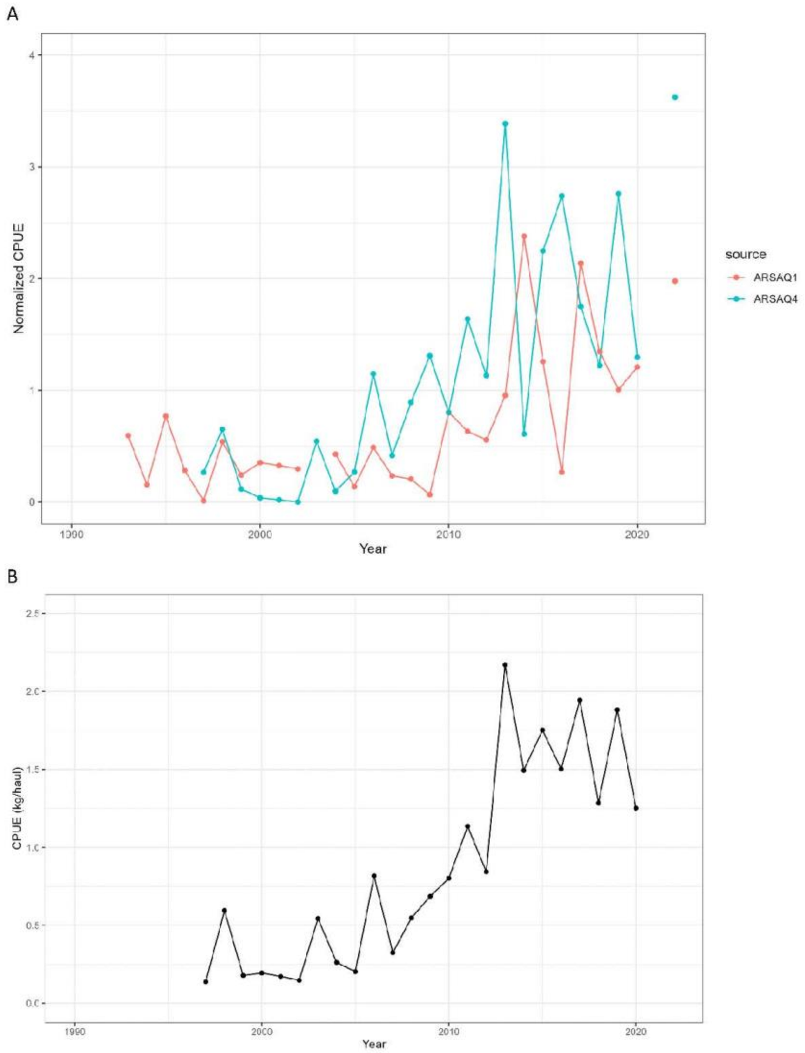


Figure 4.2.2: Thornback ray *Raja clavata* in ICES Divison 9a. (A) Biomass index from southern Spanish bottom trawl surveys (ARSA; SpGFS-GC-WIBTS-Q1 and Q4) for the period from 1993 to 2022. (B) Mean biomass index from Spanish bottom trawl surveys (1997-2022).

Table 4.2.1: Thornback ray *Raja clavata* in ICES Divison 9a. Biomass index from each southern Spanish bottom trawl survey, SpGFS-GC-WIBTS-Q1 (ARSA_Q1) and SpGFS-GC-WIBTS-Q4 (ARSA_Q4), and the mean biomass index between the two surveys.

Year	ARSA_Q1	ARSA_Q4	ARSA_mean
1993	0.594904		
1994	0.154147		
1995	0.768161		
1996	0.283925		
1997	0.011103	0.265749	0.138426
1998	0.540825	0.650836	0.595831
1999	0.24197	0.115292	0.178631
2000	0.352613	0.036949	0.194781
2001	0.326566	0.019488	0.173027
2002	0.295973	0	0.147986
2003		0.543966	0.543966
2004	0.428069	0.096493	0.262281
2005	0.137284	0.269178	0.203231
2006	0.488661	1.148186	0.818423
2007	0.234602	0.416155	0.325379
2008	0.205096	0.892021	0.548559
2009	0.06518	1.309013	0.687096
2010	0.804443	0.800233	0.802338
2011	0.632795	1.63911	1.135953
2012	0.55634	1.132101	0.84422
2013	0.954735	3.387842	2.171288
2014	2.378839	0.609369	1.494104
2015	1.25689	2.247977	1.752434
2016	0.267242	2.739409	1.503326
2017	2.137017	1.751278	1.944148
2018	1.347219	1.221674	1.284446
2019	1.004517	2.759843	1.88218
2020	1.2083	1.296156	1.252228
2021			
2022	1.977745	3.62442	2.801082

4.3. Spanish Autumn Groundfish Survey (SpGFS-WIBTS-Q4) [G2784]

In the North Spanish survey (SpGFS-WIBTS-Q4; DEMERSALES), the geographical distribution of thornback ray in ICES Division 9.a (10–97 cm TL) remained similar throughout the time-series, with a greater relative abundance in the North of Galicia and eastern Cantabrian Sea (ICES Division 8.c; Figure 4.3.1), which corresponds to the area of the rjc.27.8c stock. In relation to the area of rjc.17.9a the yields of thornback ray from this survey present an irregular time-series, with biomass estimates close to zero from 1993 to 2009 (Figure 4.3.2). For this reason, it has not been included in the assessment, although it may be used to provide supporting information (ICES, 2021a).

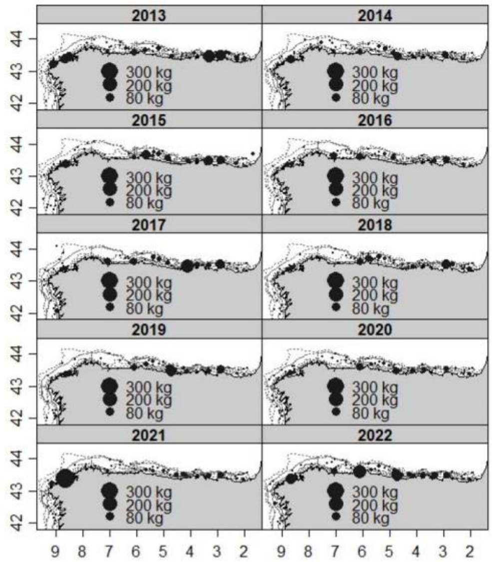


Figure 4.3.1.: Thornback ray *Raja clavata* in ICES Divison 9a. Geographic distribution *of Raja clavata* catches (kg/30 min haul) in the North Spanish Shelf bottom trawl surveys (SpGFS-WIBTS-Q4) between 2013 and 2022. (source: Fernández-Zapico et al., 2023)

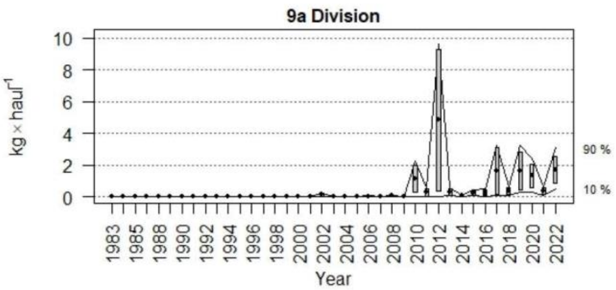


Figure 4.3.1.: Thornback ray *Raja clavata* in ICES Divison 9a. Biomass index from the North Spanish shelf bottom trawl survey (SpGFS-WIBTS-Q4) for the period from 1983 to 2022. Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α= 0.80, bootstrap iterations = 1000). (source: Fernández-Zapico et al., 2023)

5. Commercial LPUE

Up to 2018, the rjc.27.9a stock was assessed using data derived from the Spanish ARSA survey (SpGFS-GC-WIBTS-Q1 and SpGFS-GC-WIBTS-Q4) and the Portuguese Autumn Groundfish Surveys (PtGFS-WIBTS-Q4). However, because of the issues with the PtGFS-WIBTS-Q4 survey data availability for the period 2018–2020 (see details in Section 4.1), and changes in the RV and gear used, a new time-series is still to be considered and an alternative assessment approach using a standardized commercial LPUE series was reviewed and accepted at WKSKATE (ICES, 2021a). The reviewers also recognized the choice made by the group to look at the use of LPUEs as an alternative to surveys. The main concern from the reviewers about the methodology proposed was the non-inclusion of the zeroes in the analysis.

The justification for this approach relies on the fact it is not possible to distinguish real zeroes mainly due to: i) is a by-catch species for the polyvalent fishery so absence of the species in the catch is more related to the fishing strategy; 2) the species has a patchy distribution and information available is not georeferenced; 2) different selectivity of the set of gears used in a trip and 4) the weight landed per trip results from the application of estimates, which can lead to false zeros.

Details on the LPUE estimation methodology can be found in Serra-Pereira *et al.* (2020) and ICES (2021). During the last WGEF (ICES, 2023b), the model was updated (explained variance = 0.81, AIC = 762514). The best model selected with the updated dataset included the variables years, quarter, landing port, vessel size, fishing seasonality on skates and rays and fishing gear (trammel nets or gillnets). The effects of each explanatory variable are presented in Figure 5.1. The standardized mean CPUE was then predicted by year and considering the following criteria: quarter = 4, landing port = Peniche, SIZEs = L (large), SAZ = c (constant) and fishing gear = nets.

LPUE varied from 21.08 kg.trip^{-1} (in 2009) to 53.20 kg.trip^{-1} (in 2022), with an average of 35.91 kg.trip^{-1} for the entire time series (Table 5.1, Figure 5.2).

For comparison purposes, the LPUE data series was normalized to the long-term mean and compared with the normalized biomass Index obtained from the PtGFS-WIBTS-Q4 survey (Figure 5.3). In general, both time-series followed similar increasing trends since 2008, and LPUE estimates are within the range of the CI.

Figure 5.4 present the comparison between the normalized biomass indices from the Portuguese Autumn Groundfish Survey, the Spanish bottom trawl surveys and LPUE from the polyvalent fleet in mainland Portugal.

Table 5.1: Thornback ray *Raja clavata* in ICES Division 9a. LPUE (kg.trip^{-1}) from the polyvalent in mainland Portugal for the period 2008-2022.

Year	LPUE	SE	Standardized LPUE
2008	25.99	0.66	0.72
2009	21.08	0.53	0.59
2010	30.16	0.77	0.84
2011	31.91	0.82	0.89
2012	27.80	0.71	0.77
2013	34.67	0.92	0.97
2014	36.51	0.95	1.02
2015	32.04	0.85	0.89
2016	35.32	0.97	0.98
2017	39.27	1.04	1.09
2018	42.55	1.07	1.18
2019	42.38	1.16	1.18
2020	40.27	0.99	1.12
2021	45.49	1.16	1.27
2022	53.20	1.46	1.48

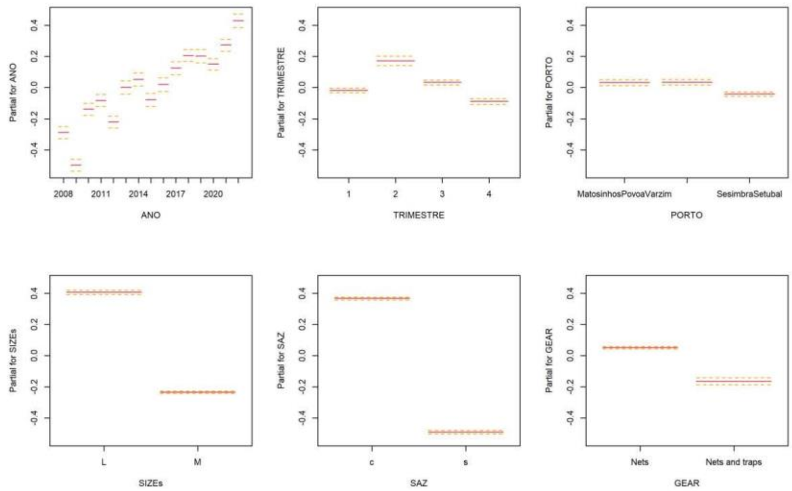


Figure 5.1: Thornback ray *Raja clavata* in ICES Division 9a. Effect of each explanatory variable included in the standardization of the LPUE for the polyvalent fleet in mainland Portugal: year ("ANO"), quarter ("TRIMESTRE"), landing port ("PORTO"), vessel size ("SIZEs"), fishing seasonality ("SAZ") and fishing gear (trammel nets or gillnets).

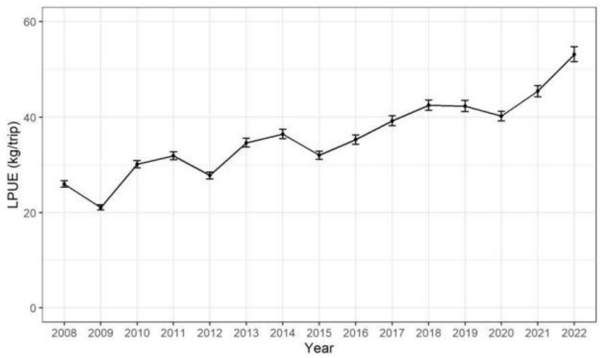


Figure 5.2: *Thornback ray Raja clavata* in ICES Division 9a. LPUE (kg.trip^{-1}) from the polyvalent in mainland Portugal for the period 2008-2022.

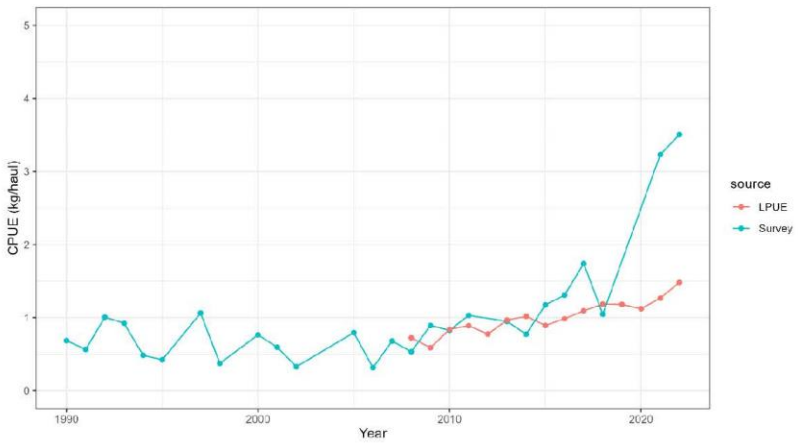


Figure 5.3: *Thornback ray Raja clavata* in ICES Division 9a. Standardized LPUE from the polyvalent fleet in mainland Portugal vs standardized Portuguese Autumn Groundfish Survey Biomass Index (PtGFS-WIBTS-Q4). Both series are normalized to the long-term mean.

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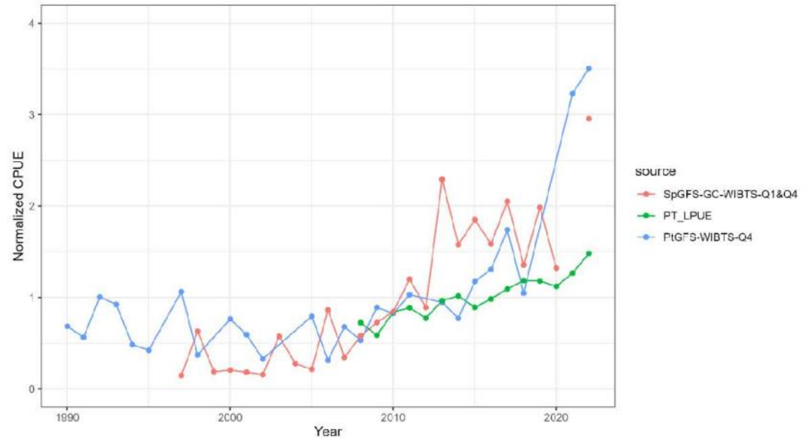

Figure 5.4: *Thornback ray Raja clavata* in ICES Division 9a. Comparison between the standardized LPUE from the polyvalent fleet in mainland Portugal, the standardized Portuguese Autumn Groundfish Survey Biomass Index (PtGFS-WIBTS-Q4) and the Spanish bottom trawl surveys in Gulf of Cádiz (SpGFS-GC-WIBTS-Q1 and Q4; ARSA). All series are normalized to their long-term mean.

6. Life-history parameters

The information available on biological parameters estimates for thornback ray in ICES Division 9a is summarized in Table 6.1. Estimates of biological parameters for other geographic regions within the ICES area can be found in Ellis et al. (2023, ICES WD) and are summarized in Annexe I, but for the assessment of this stock only those conducted in the area are considered. Table 6.2 summarizes estimates of intrinsic growth rates (r´) following different methodologies.

For the application of SPiCT assessment models a prior probability distribution needs to be defined for intrinsic rate of population increase (*r*). For the estimation of the *r* different methods were tested:

i) according to the Jennings et al (2001); this estimate was used in the SPiCT trials during WGEF2022 and WKBELASMO3 follow-up WK;
ii) applying the function *jbleslie* implemented in R package JABBA (Winker et al., 2018), was used to estimate r. The growth parameters available for this stock from Serra-Pereira et al. (2008) were adopted (Table 6.1). This methodology was the adopted in WKBELASMO2 (ICES, 2023);
iii) applying the methods proposed by Eberhardt et al. (1982), Skalski et al. (2008), Smith at el.'s (1998) and the Demographic Invariant Method following Cortés (2016);
iv) using the package FishLife (Thorsen et al., 2017);
v) adopting the *r* value in Fishbase (Froese and Pauly, 2023).

The estimates of *r* from the different methods are presented in Table 6.2; estimates for other stocks are also presented.

Table 6.1. *Thornback ray Raja clavata* in ICES Division 9a. Biological parameters estimates available for rjc.27.9a stock.

Source		Serra-Pereira et al., 2008	Serra-Pereira et al., 2011
TL range (cm)		14.5-91.3	32.0-93.4
L_{50} (cm) F		-	78.4
L_{50} (cm) M		-	67.6
A_{50} (cm) F			7.5
A_{50} (cm) M			5.8
Reproductive period		-	May-Jan
Potential fecundity (eggs/female/year)			136
Growth model		VBGM	-
Growth parameters estimates	L_{∞} (cm)	128	-
	k (y^{-1})	0.117	-
	t_0 (years)	-0.617	-
	L_{max} (cm)	91.3 (124*)	-
	t_{max} (years)	10 (30**)	
Period		2003-2007	2003-2008
Region		Portugal	Portugal

*PNAB/DCF sample onboard a scientific survey. ** Theoretical maximum age for an L_{max}=124 cm.

Table 6.2. Estimates of intrinsic rate of population increase (*r*) for thornback ray from the present study and from other references. The primary value adopted for the SPiCT trials is highlighted in bold.

Stock	Method	r [CI]	Reference
rjc.27.9a	Jennings et al. (2001)	0.284	Present study
	***jbleslie* function (R package JABBA) (Winker et al., 2023)**	**0.27**	**Present study**
	FishLife (Thorsen et al., 2017)	0.07*	Present study
	Eberhardt et al. (1982), based on Cortés (2016)	0.47	Present study
	Skalski et al. (2008), based on Cortés (2016)	0.47	Present study
	Smith at el.'s (1998), based on Cortés (2016)	0.08	Present study
	Demographic Invariant Method (Cortes, 2016)	0.08	Present study
	FishBase (Froese and Pauly, 2023)	0.18	Present study
rjc.27.8ab	McAllister et al. (2001) – used as prior	0.105	ICES, 2022c
	Bayesian state-space biomass production model (Marandel et al., 2016)	0.18 [0.07,0.33]	ICES, 2022c
	Genetic close-kin mark-recapture approach (Trenkel et al., 2022)	0.19 [0.07, 033]	ICES, 2022c
rjc.27.8c	FishBase (Froese and Pauly, 2023) – used as prior	0.18	ICES, *in press*
	SPiCT	0.25 [0.13, 0.46]	ICES, *in press*
rjc.27.3a47d	*jbleslie* function (R package JABBA) Winker et al., 2023)	0.29**	ICES, 2023a
	"vague prior" due to high estimate with *jbleslie* - – used as prior	0.15	ICES, 2023a
	SPiCT	0.23	ICES, 2023a
	Following Jennings et al. (1999)	0.30***	Frisk et al., 2001

* to be discussed in the WKBELASMO 3 benchmark meeting, what is the output value to be considered from FishLife package. ** considered high when compared to the estimate for *rjc.27.8ab* (ICES, 2023a). *** potential population increase (r´)

To apply the method from Winker et al. (2023) to estimate *r* it requires a value for natural mortality (M). In the last WKBELASMO2 the adopted method to estimate M was derived from Then et al., (2015):

$$M=4.118*K^{0.73}*L_{inf}^{-0.33}$$

The estimate of M according to this method is presented in Table 6.3 (in bold), along with estimates derived from other methods and for other stocks.

A value for maximum age (A_{max}) of 29.6 years was estimated based on Fabens (1965), and used in the *r* estimation for the present stock:

$$A_{max}=5x(\ln 2/k).$$

For comparison, the adopted value for A_{max} for *rjc.27.3a47d*, in WKBELASMO2, was 17 years, and was extracted from the database of life history correlations available in the FishLife R package (Thorson, 2019).

Table 6.2. Estimates of natural mortality (M) for thornback ray from the present study and from other references.

Stock	Method	M	Reference
rjc.27.9a	**Then et al. (2015)**	**0.17**	**Present study**
	Pauly (1980)	0.30	Present study
	Jensen (1996)	0.19	Present study
	Hoenig (1983)	0.12	Present study
rjc.27.3a47d	Then et al. (2015)	0.19	ICES, 2023a

7. Current Stock Assessment

The stock rjc.27.9a has been assessed under category 3 (trend-based assessment) every two years. Last assessment was conducted in 2022.

Up to 2018, this stock was assessed using data derived from the southern Spanish surveys (ARSA quarter 1 and 4) and the Portuguese Autumn Groundfish Surveys. These surveys were normalized to their long-term mean, the two Spanish surveys averaged, and then this index averaged with the Portuguese survey to provide the stock size indicator. The advice was based on a comparison of the two latest index values with the five preceding values, multiplied by the recent advised landings.

In 2020, because of the issues with the Portuguese Autumn Groundfish survey data availability for the period 2018–2020 and uncertain future, an alternative assessment approach using a standardized commercial LPUE series was reviewed and accepted at WKSKATE (ICES, 2021a). For detail on LPUE series see section 5 of the present working document.

In 2022, last assessment year, the stock assessment was done following ICES guidelines for category 3 which involves the application of the rfb rule (ICES, 2022a, 2022b). A biomass index combining the Spanish groundfish surveys data and the normalized LPUE index from the Portuguese polyvalent fleet was used as an indicator of stock development. The advice was based on the ratio of the mean of the last two index values (index A) and the mean of the three preceding values (index B), multiplied by the previous advised catches, a ratio of observed mean length in the catch relative to the target mean length (length-based indicators, length distributions from the Portuguese commercial polyvalent and trawl fleets combined as input data), a biomass safeguard, and a precautionary multiplier.

8. Stock assessment proposed methods

For the present benchmark, the proposal is focussed on evaluating the application of a surplus production model SPiCT (Stochastic Production model in Continuous Time, Pedersen and Berg 2017) on the stock for providing advice. In the present working document are included only the SPiCT initial runs presented and discussed during WGEF2022 (ICES, 2022d). New trials to be discussed during the WKBELASMO 3 benchmark meeting will be presented in a separate Working Document (Serra-Pereira et al., 2024).

8.1. SPiCT initial runs during WGEF2022

During WGEF 2022, several SPiCT runs were tested to check model performance and effects of using different datasets and priors. All the runs' results can be found in Moura et al. (2022). The checklist for the acceptance of a SPiCT assessment was followed (Mildenberger et al., 2020). To note that during those trials the available data series of landings started in 2003.

Given that in 2022 only ARSA surveys and the Portuguese LPUE series were providing biomass data for the assessment of rjc.27.9a, the inclusion of both series in the assessment model as input data series seemed appropriate. However, despite both series being proposed to assess this stock at WKSKATE, other input data was also considered in the trials conducted.

Assessments which included the two ARSA surveys in separate (models 2 and 3) were considered not acceptable. It worth mentioning that the area covered by the surveys is too small in relation to the total stock area, so it seems adequate to use a single index to represent the Gulf of Cadiz. For this reason, Q1 and Q4 surveys were combined, following the same methodology used to estimate the stock-size indicator, i.e., by averaging both normalized series. At that time, given the different methods applied for estimating Portuguese landings, uncertainty in landings estimates in the first 5 years of the series was always considered (except when running the model with the default settings – model 1, 2 and 3).

Schaefer production curve shape was considered in all runs where priors were defined.

Some of the assessment trials using all sources of data (i.e., PtGFS-WIBTS-Q4, mean of the ARSA surveys and PT LPUE) showed issues both in the checklist for acceptance of the assessment and reliability of the model. For example, models 2 and 4, resulted in a *r* estimate >17 $year^{-1}$, considered too high for the species.

Given the above, and following the defined guidelines for SPiCT assessments, the model 1a, using as input data the PT LPUE and the combined SP ARSA survey and priors on the production curve and r, was selected as the base model. Several runs were conducted around the base model, to check for influence of different prior values. Results are presented in Table A2 in

Moura et al. (2022). Different priors for the production curve shape, intrinsic rate of population increase (*r*) and initial depletion level were evaluated.

Production curve – setting the prior on the production curve shape (Schaefer) has influence on the model results, improving the confidence intervals for B/Bmsy (order of magnitude of 0 instead of 1) and results of the influence of initial values in the parameter estimates (base model *vs* model *a*). However, no major changes in the model estimates were observed when the coefficient of variation of the prior (CV) was changed (model *e*).

Intrinsic rate of population increase (r) - the model was not acceptable if the prior on *r* was set to 0.18 year^{-1}, has suggested in Fishbase (estimate based in Froese et al., 2017). However, when no prior is defined, the model estimates a value close to 0.284 year^{-1} (model *j*). In fact, results from both base model and model *j* are similar but, in the first, no issues were found when testing the parameters estimates with different initial values.

Initial depletion (B/k) – it is expected that at the beginning of the time-series this stock was already exploited. However, the inclusion of a prior on the initial depletion level does not improve the model. In addition to having issues with its acceptance (several items of the checklist for the acceptance of a SPiCT assessment were not fulfilled in some of the trials), results are also not realistic (models *f* and *g*).

The model proposed for assessment of rjc.27.9a during WGEF2022 used the following input data and priors (R code and results available in the WGEF sharepoint Data folder: "06. Data/SPiCT assessments" – password required; all model runs can be made available upon request).

Input data:

- Stock landings (2003-2021) (Figure 8.1.1)
- PT LPUE (2008-2021, set at the middle of the year) (Figure 8.1.1)
- ARSA Surveys (normalized; 1997-2020; no survey in 2021, set at the middle of the year) (Figure 8.1.1)
- Uncertainty in landings in the first 5 years (*rjc_data$stdevfacC <- c(rep(4,5). rep(1,14))*

Priors:

- Schaefer production curve with a cv of 0.5 (*rjc_data$priors$logn<-c(log(2),0.5,1)*)
- Intrinsic rate of population increase (*r*) (*rjc_data$priors$logr <- c(log(0.284),0.5,1)*)

The prior for *r* was calculated based on the empirical estimator from Jennings et al. (2001), taking as input the fecundity and age-at-first-maturity estimated for the stock (Serra-Pereira et al., 2011).
As mentioned previously, the method used to estimate species-specific landings of skates in Portuguese waters, (which represents the major fraction of the stock total landings), from 2003 to 2007 differed from the method currently adopted, applied since 2008 (described in Figueiredo et al., 2020). For this reason, for modelling purposes, uncertainty in landings for the years 2003-2007 was adopted.

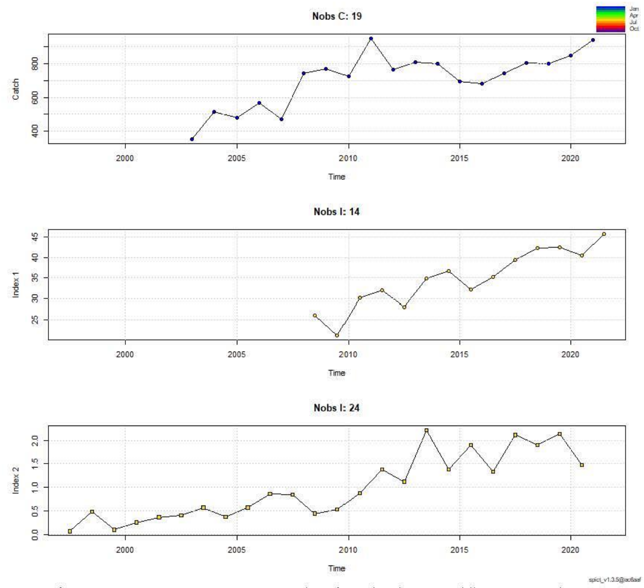

Figure 8.1.1: *Raja clavata* in ICES Division 27.9a. Input data (top: landings; middle: PT LPUE; bottom: ARSA survey).

Results are presented in Figures 8.1.2-8.1.5. No significant bias or autocorrelation were found and both QQ-plot and the Shapiro test show normality in the residuals. Regarding the retrospective pattern Mohn's rho was <0.2 for both B/B_{MSY} and F/F_{MSY} (0.045 for B/B_{MSY} and of -0.085 for F/F_{MSY}). The checklist for the acceptance of a SPiCT model (Mildenberger et al., 2020) was followed and no issues were found. Despite the large confidence intervals for F/F_{MSY} those do not span more than 1 order of magnitude (Figure 8.1.5). Considering the adopted reference points proposed for production models by ICES (ICES, 2017c; ICES, 2021b), F/F_{MSY} in 2021 is below F_{MSY} and B/B_{MSY} in 2022 is above B_{MSY}.

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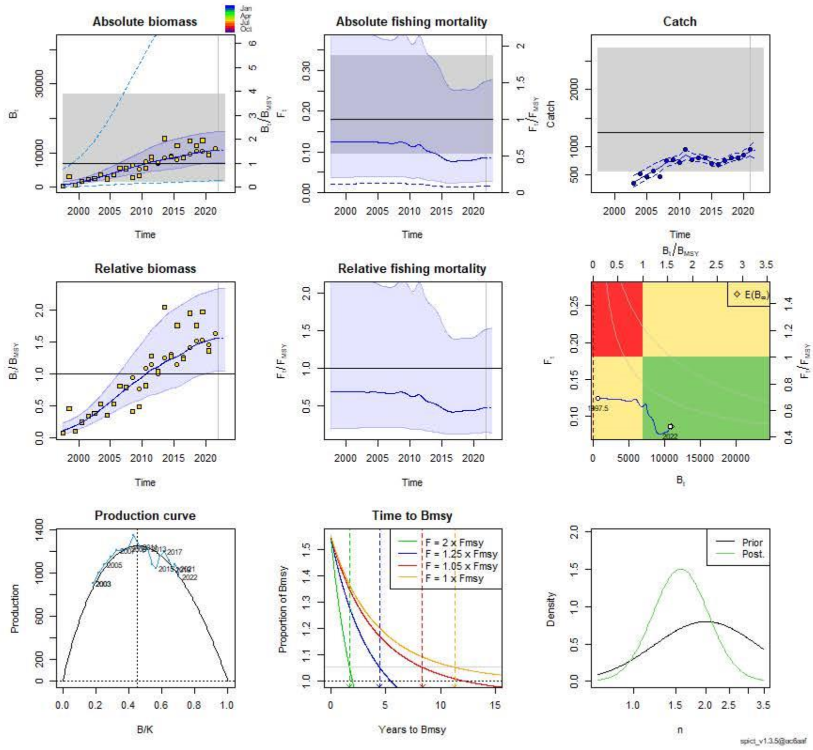

Figure 8.1.2: *Raja clavata* in ICES Division 27.9a. Results from SPiCT model.

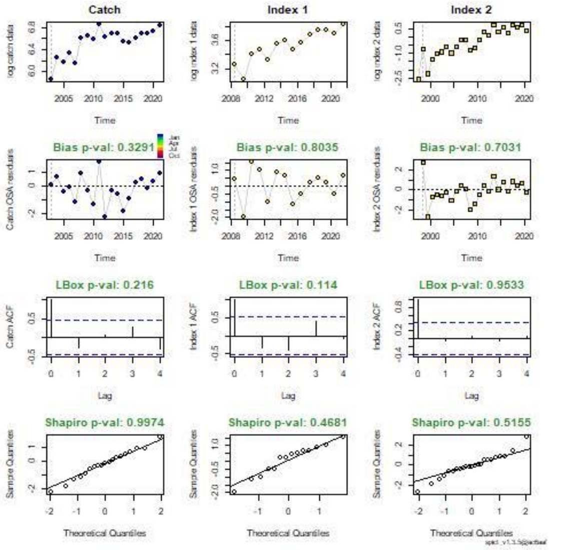

Figure 8.1.3: ***Raja clavata*** **in ICES Division 27.9a. Results from SPICT model. Row1. Log of the input data series. Row 2. OSA residuals with the p-value of a test for bias. Row 3. Empirical autocorrelation of the residuals with tests for significant autocorrelation. Row 4. Tests for normality of the residuals. QQ-plot and Shapiro test.**

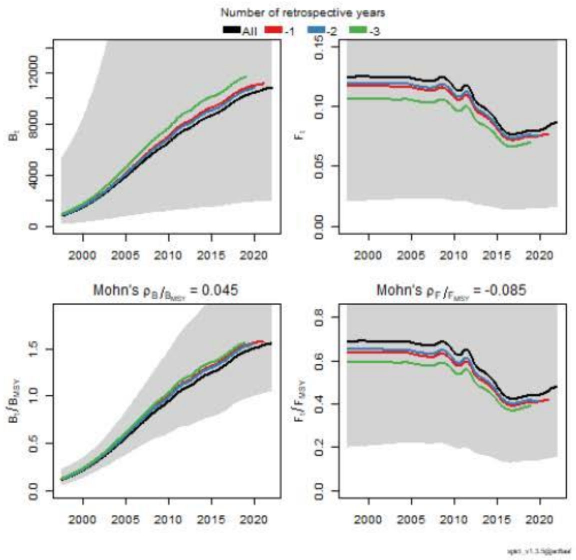

Figure 8.1.4: ***Raja clavata*** **in ICES Division 27.9a. Results from SPICT model; retrospective analysis. Upper panel. absolute biomass and fishing mortality. Lower panel. relative biomass and fishing mortality. Grey regions represent 95% CIs.**

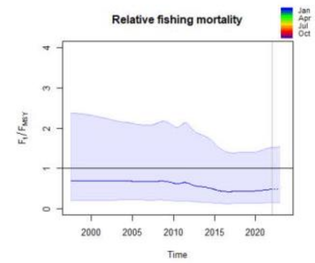

Figure 8.1.5. *Raja clavata* in ICES Division 27.9a. Results from SPiCT model: Relative fishing mortality.

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ANNEXE 1

Table 1: Published length-weight relationships for thornback ray in the stock area and adjacent waters. Data presented by sex, include sample size (N), size range (total length, with information based on disc width in square brackets) and the conversion parameters a and b ($W = aL^b$). (adapted from: Ellis et al., 2023)

Area	Sex	N	Size range (cm)	*a*	*b*	r^2	Source
Portugal	**All**	**327**	**36-93**	**0.0052**	**3.05**	**NA**	**Serra-Pereira et al. (2010)**
Div. 4.c /7.d	All	756	13–94	0.0058	3.0166	0.9905	Silva *et al.* (2013)
North Sea	All	95	16–93	0.0045	3.0686	0.9907	Silva *et al.* (2013)
British Isles	All	2417	10–94	0.0045	3.0961	0.9921	Silva *et al.* (2013)
English Channel	All	960 (82)	10–101	0.00319	3.1938	0.999	Dorel (1986)
Scottish waters	All	12	[22–31]	0.0187	3.0062	NA	Coull *et al.* (1989)
North Sea	All	57	13.5–83.5	0.0029	3.2006	0.9903	Wilhelms (2013)
Div. 7.a,d-g	M	257		0.0039	3.142	0.99	Lemey *et al.* (2022)
Div. 7.a,f-g	F	120		0.0034	3.177	0.99	Lemey *et al.* (2022)
Div. 7.d	F	128		0.003	3.215	0.99	Lemey *et al.* (2022)

Table 2: Published maturity information for thornback ray in the stock area and adjacent waters, including the length at 50% maturity (L_{50}) and the estimated age at 50% maturity (A_{50}). (adapted from: Ellis et al., 2023)

Area	Sex	N	Length (cm) of/at Smallest mature	Largest immature	L_{50}	A_{50}	Source
Portugal	**F**		**69.9**		**78.40**	**7.5**	**Serra-Pereira *et al.*, 2011**
Portugal	**M**		**59**		**67.60**	**5.8**	
North Sea	F	52			77.1	8.78	Walker (1999)
North Sea	M	41			67.9	7.08	
British Isles (North Sea)	F	3229 (861)	47 (57)	90 (82)	76.6 (73.7)	NA	McCully *et al.* (2012)
British Isles	M	3490	47	88	66.6	NA	
Irish Sea	F				71.81	6.1	Gallagher *et al.* (2005)
Irish Sea	M				65.70	6.1	
Irish Sea	F	135			70.50	5.3	Whittamore and McCarthy (2005)
Irish Sea	M	54			58.80	3.9	
Div. 7.a, e-g	F	254			79.5	7.00	Lemey *et al.* (2022)
Div. 7.a, e-g	M	257			66.8	5.92	

Table 3: Published fecundity estimates for thornback ray in the stock area and adjacent waters. (adapted from: Ellis et al., 2023)

Area	Method	Fecundity	Source	Notes
Portugal	**Ovarian fecundity (batch fecundity)**	**35 (12–81)**	**Serra-Pereira *et al.* (2011)**	**Median = 35**
Portugal	**Ovarian fecundity (4 batches)**	**136**	**Serra-Pereira *et al.* (2011)**	
British Isles	Ovarian fecundity	ca. 50–110	Holden (1975)	$F_O = 1.19.L_T - 30.2$
British Isles	Annual egg production	142	Holden (1975)	$F_A = 1.19.L_T + 25.1$
British Isles	Extrapolation of egg-laying rates	150	Holden *et al.* (1971)	
Bristol Channel	Egg-laying of captive specimens	48	Ellis & Shackley (1995)	
North Sea	Egg-laying of captive specimens	38–74	Cefas, unpublished	
North Sea	Ovarian fecundity	32–69	Walker (1999)	N = 3 (one value of 4 excluded here)
Bristol Channel	Ovarian fecundity	62–74	Ryland & Ajayi (1984)	
Mediterranean	Proportion of spawning fish, egg laying rates and ovarian counts	108–262	Capapé *et al.* (2007)	
Turkish waters	Ovarian fecundity	27–60	Saglam and Ak (2012)	
Mediterranean	Ovarian fecundity, proportion of spawning fish and assumed egg laying rate	141–167	Capapé (1976)	

Table 4. Published age and growth information for thornback ray in the stock area and adjacent waters. Methods used are Vert.: analyses of vertebral sections; Thorns: analyses of caudal thorns; MRD: mark-recapture data (MRD); LFA: length-frequency analysis. (adapted from: Ellis et al., 2023)

Area	Division	Sex	N	Length range	Age range	L_{inf}	K	t_0	Method	Source	Comments
Portugal	**Div. 9.a**	**C**	**251**	**19.5–91.3**		**128**	**0.117**	**−0.617**	**Thorns**	**Serra-Pereira *et al.* (2008)**	
Portugal	**Div. 9.a**	**F**	**129**	**19.9–91.3**		**140.7**	**0.097**	**−0.88**	**Thorns**	**Serra-Pereira *et al.* (2008)**	
Portugal	**Div. 9.a**	**M**	**122**	**19.5–87.0**		**117.1**	**0.142**	**−0.358**	**Thorns**	**Serra-Pereira *et al.* (2008)**	
British Isles	NA	F	85	(51.4–93.0)	3–11	127.3	0.1	−2.5	Vert.	Taylor & Holden (1964)	
British Isles	NA	M	61	(48.3–81.5)	3–10	88.3	0.22	−1.3	Vert.	Taylor & Holden (1964)	
British Isles	4,6,7	F				107	0.13	−0.6	MRD	Holden (1972)	
British Isles	4,6,7	M				85.6	0.21	−0.6	MRD	Holden (1972)	
Bristol Channel	Div. 7.f	C				139.2	0.09	−2.656	Vert.	Ryland & Ajayi (1984)	See Brander & Palmer (1985)
Irish Sea	Div. 7.a	C				105	0.215	0.45	LFA	Brander & Palmer (1985)	
Irish Sea	Div. 7.a	F	697	NA	3–10	118.8	0.15	−0.83	Vert.	Fahy (1989)	
Irish Sea	Div. 7.a	M	128	NA	3–8	100.1	0.23	−0.35	Vert.	Fahy (1989)	
West of Ireland	Div. 7.b	F	297	NA	3–8	114.4	0.17	−1.01	Vert.	Fahy (1989)	
West of Ireland	Div. 7.b	M	233	NA	3–8	96.8	0.24	−0.32	Vert.	Fahy (1989)	
Celtic Sea	Div. 7.g,j	F	247	NA	3–8	107.8	0.26	−0.05	Vert.	Fahy (1989)	
Celtic Sea	Div. 7.g,j	M	216	NA	3–7	101.9	0.24	−0.34	Vert.	Fahy (1989)	
Hebridean Sea	Div. 6.a	F	263	NA	3–9	120	0.16	−0.8	Vert.	Fahy (1989)	
Hebridean Sea	Div. 6.a	M	206	NA	3–8	104.3	0.19	−1.36	Vert.	Fahy (1989)	
North Sea	Subarea 4	F	51	ca. 30–95	2–14	118	0.14	−0.88	Vert.	Walker (1999)	
North Sea	Subarea 4	M	41	ca. 25–85	2–11	98	0.17	−0.43	Vert.	Walker (1999)	
Irish Sea	Div. 7.a	F	93	?–104	(0–8)	139.5	0.093	−1.841	Vert.	Gallagher *et al.* (2005)	
Irish Sea	Div. 7.a	M	165	?–90	(0–8)	106.5	0.135	−1.74	Vert.	Gallagher *et al.* (2005)	Age range for sexes combined
Irish Sea	Div. 7.a	F	135	18.4–91.6	1–9	117.6	0.16	−0.71	Vert.	Whittamore & McCarthy (2005)	
Irish Sea	Div. 7.a	M	54	26.9–77.8	1–7	100.9	0.18	−0.95	Vert.	Whittamore & McCarthy (2005)	
North Sea/Channel	4.c/7.d	C	81			113.4	0.07486	−3.546	Vert.	Thys *et al.* (2022)	Preliminary data
British Isles	7.a,f-g	C				102.5	0.158	−1.39	Vert	Lemey *et al.* (2022)	
British Isles	7.d	F				90.7	0.182	−1.12	Vert	Lemey *et al.* (2022)	
British Isles	7.d	M				87.6	0.182	−1.12	Vert	Lemey *et al.* (2022)	

Working Document presented at ICES WKELASMO3
Data compilation online meeting, 20th to 24rd November 2023

Blonde ray (*Raja brachyura*) in Division 9a (Atlantic Iberian waters) (rjh.27.9a)

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Content

Abstract

The present working document aims to summarize the available information for Raja brachyura in Atlantic Iberian waters (ICES division 27.9a) to be used in the assessment of the stock rjh.27.9a., in particular on: stock identity, catch data, commercial LPUE, life-history parameters, the latest assessment and advice. Furthermore, a summary of the initial run explored with surplus production model SPiCT (Stochastic Production model in Continuous Time), presented at the ICES WGEF meeting in 2022 is also presented.

Working Document presented at ICES WKELASMO3
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1. Introduction

Blond ray *Raja brachyura* is one of the common skate species in Atlantic Iberian waters, being distributed along the entire ICES division 9a and landings ranging from 162 to 347 tonnes during the period 2000-2022. The stock rjh.27.9a has been assessed under category 3 since 2014, and the latest advice in 2022, involved the application of the ICES framework for category 3 stocks applying rfb rule (method 2.1; ICES, 2021; ICES, 2022).

For the present benchmark, the proposal is focussed on evaluating the application of a surplus production model SPiCT (Stochastic Production model in Continuous Time, Pedersen and Berg 2017) on the stock for providing advice.

The present working document summarizes the information available on the rjh.27.9a stock.

2. Stock identity

The stock structure of the species along the ICES areas is unknown. Migrations between different areas are admitted (ICES, 2013). For advice purposes, ICES considered a distinct stock unit for Division 9.a (west of Galicia, Portugal, and Gulf of Cadiz).

2.1. Species Distribution

Raja brachyura is a coastal benthic species with a wide geographic distribution in the northeast Atlantic, from Norway to Marroco, to the Mediterranean Sea (Stehmann and Bürkel, 1984) (Figure 2.1.1a). The species is often found in sandbanks and sand-rock bottoms (Ellis *et al.*, 2005).

In ICES division 9a, the species is distributed along the entire area.

In the west of Galicia, the species is found on sand and sand-rock bottoms along the coast at depths ranging from 20 to 120 m. In this area there is no information on nursery or spawning areas; length of specimens caught by the artisanal fleet varied from 26 to 116 cm suggesting that both juveniles and adults are present in this area.

In Portuguese continental waters *R. brachyura* occurs along the entire coast at depths ranging from 10 to 700 m (Figure 2.1.1a), being more abundant at depths shallower than 200 m. In center off Portugal, the species lives preferentially in areas shallower than 100 m deep, showing different spatial dynamics according to its life stages (Serra-Pereira *et al.,* 2014). Most of the times the two sexes occur in equal proportions but spatial segregation by sex may exist. Nursery and egg deposition grounds are situated inshore, at different types of seabeds, which can vary from sandy to rocky bottoms. A seasonal variation in abundance of juveniles was found - higher abundances are recorded during the 4rd quarter of the year, showing a temporal spatial overlap between egg-laying and nursery grounds. A higher abundance of adults is found during the 2nd quarter of the year, in more offshore grounds characterized by sand surrounding rocks. This different spatial pattern is likely to be related with migrations associated to reproduction; adults migrate to more inshore and shallow waters to reproduce.

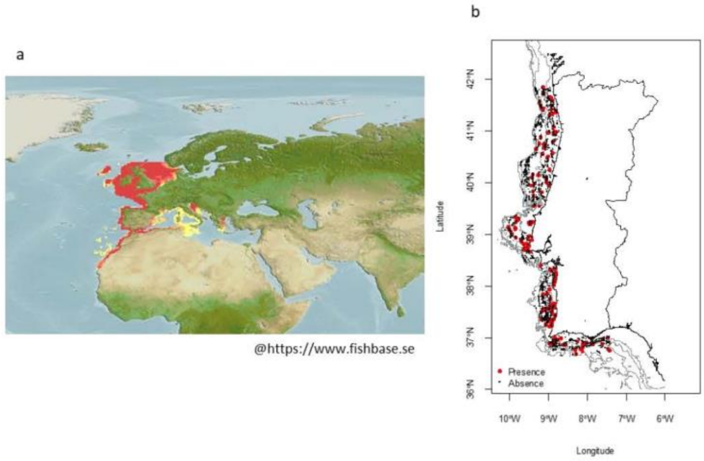

Figure 2.1: *Raja brachyura* in ICES Division 27.9a. Species distribution: a) distribution in the northeast Atlantic and b) distribution in Portuguese Autumn Groundfish Surveys (PT-GFS) and Winter Groundfish Surveys (PtGFS-WIBTS-Q1) from 1990 to 2013.

2.2. Genetics and Tagging

There are no studies on movements or population structure of the species in ICES Division 9a, yet there are studies available in other ICES ecoregions.

Preliminary results from a recent European project on the population genetic structure of *R. brachyura* in the North Sea and the Celtic Sea (Poos et al., 2023), indicate that 7g and 7f samples were more separated from the Greater North Sea samples, while 7a were clustered more closely to the Greater North Sea samples, and samples from 4b and 4c appear to cluster together, indicating a genetically similar stock (Figure 2.2.1). A discriminant analysis of principle components (DAPC) with prior spatial information did not identify a clear difference in clustering by spatial sampling locations across Ecoregion (Celtic Sea or Greater North Sea Samples) or ICES division (Figure 2.2.2). An admixture model, using the three clusters, indicates some population structure between the Celtic Sea and the North Sea, with one of the clusters contributing a greater proportion to the samples taken from the Celtic Sea. Further investigation on the spatial structure of *R. brachyura* in the Greater North Sea and adjacent areas is needed to clarify the stock boundaries defined in this ecoregion.

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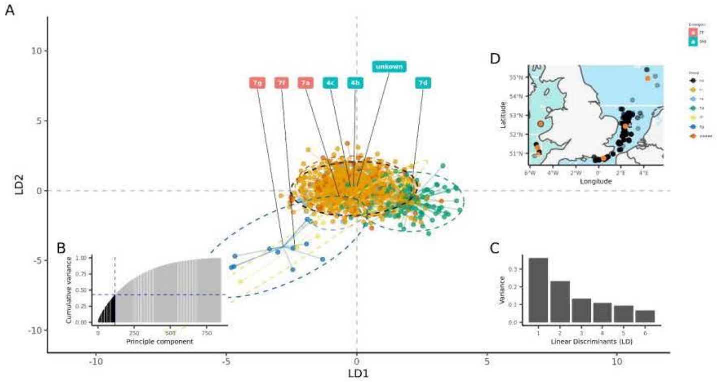

Figure 2.2.1: Population genetic structure of *Raja brachyura*. (A) discriminant analysis of principal components (DAPC) with grouping Prior based on ICES divisions. (B) Cumulative variance of optimal number for DAPC. (C) Variance of linear discriminants retained in DAPC. (D) location of Spatial locations of samples collected and genotyped in several projects across European waters. (source: Poos et al., 2023)

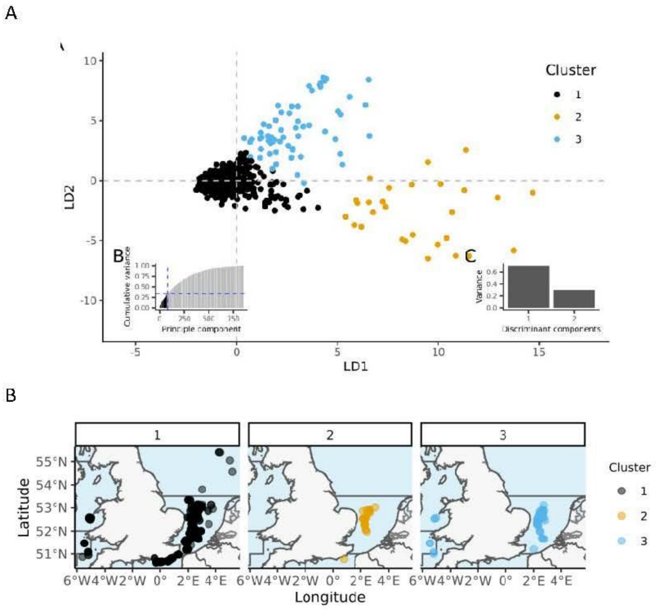

Figure 2.2.2: Population genetic structure of *Raja brachyura*. (A) DAPC without prior for *Raja brachyura* with 3 clusters, (B) cumulative variance of optimal 83 PCs, (C) Variance of Linear Discriminants in the DAPC and (D) Sample locations colour coded by cluster results of DAPC without prior (source: Poos et al., 2023).

Bird et al. (2020) compiled and reviewed 50 years of tagging data for eight commercially important skate species around the British Isles. Overall, a return rate of 15.57% was obtained across the study area. From the returned individuals, the majority of the individuals showed short distance movements, as 46.9% travelled less than 50 km from the tagging site, 27% between 51-100 km and 26% travelled more than 100 km. The furthest straight-line distance travelled was 910 km by one female. The current ICES stock units broadly encompassed the observed movements of this species; 91.8% of the individuals returned were tagged within the same stock unit area (Figure 2.2.3). Some individuals showed more extensive movements between stock units and management areas, yet it remains unclear whether these are regular or occasional movements.

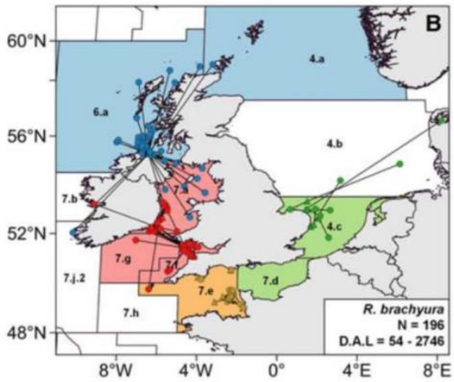

Figure 2.2.3: Tag releases (triangles), returns (circles) and straight-line distances (lines) for *R. brachyura* at liberty for ≥50 days. Different colours indicate ICES stock units. Source: Bird et al. 2020.

According to those results, along with genetic evidences, the stock boundaries for the North Sea *R. brachyura* stock unit were not updated during WKBELASMO2 (ICES, 2023a). As such, based on available genetic and tagging data available there is also no evidence to update the current stock unit in Iberian waters for *R. brachyura*.

3. Catch data

3.1. Landings

Landings data were obtained from the WGEF landings table (ICES, 2023b), and have been reported by Portugal and Spain.

Given that production models (such as SPiCT) require a time series of catches as input data, preferably long enough to cover one generation time and that includes contrasting periods in terms of stock biomass and fishery mortality, data from 2000 was reconstructed.

Portuguese data available in WGEF landings table comprised the period 2005-2022. Due to misreporting errors in Rajidae species official data, IPMA developed a statistical stepwise procedure involving factor analysis for mixed data and flexible discriminant analysis to estimate the total landed weight by species and have been applying this procedure since 2008 (details can be found in Figueiredo et al., 2020). For the present benchmark and aiming the extension of the landings time-series, historical data for the period 2000-2007 was reconstructed by fleet and detailed information on the methods adopted can be found in Maia et al., (2023a). Given the uncertainty associated with landings previously reported for the period 2005-2007, these years were also included in the reconstruction.

Spanish data available comprised the period 2009-2022. Given the uncertainty associated with landings reported for 2009, historical data reconstruction covered the period 2000-2009. For that the average proportion of *R. brachyura* of 2010-2013 was applied over the period 2000-2009 considering all fleets together.

Raja brachyura landings in ICES Division 9a have been ranged from 162 to 347 tonnes, with Portugal contributing for 96-100% and Spain for up to 4% (Table 3.1.1). Belgium only reported 0.04 tonnes in 2017. Along the time series, landings from the polyvalent fleet represented 71-94% of the species landed weight, followed by trawl that have been representing between 6-29% (Figure 3.1.1). A detailed description of the Portuguese polyvalent fleet can be found in Figueiredo et al. (2020).

Landings from the polyvalent fleet were mainly reported by Portugal and represented between 95-100% of the landed weight while Spain contributed up to 5% (Figure 3.1.2). Whitin the Trawl fleet, landings from Portugal represented between 93-100% while Spain contributed up to 7%.

Table 3.1.1.: *Raja brachyura* in ICES Division 27.9a. Annual landings (in tonnes) and representativeness by country.

Year	Belgium		Portugal		Spain		Total
	Ton	%	Ton	%	Ton	%	
2000	0	0	262	100	1	0	263
2001	0	0	263	99	1	1	265
2002	0	0	229	99	1	1	230
2003	0	0	248	100	1	0	249
2004	0	0	235	100	1	0	236
2005	0	0	259	100	1	0	261
2006	0	0	205	99	1	1	206
2007	0	0	185	99	1	1	186
2008	0	0	193	99	1	1	194
2009	0	0	163	99	1	1	164
2010	0	0	221	99	2	1	223
2011	0	0	161	99	1	1	162
2012	0	0	165	100	0	0	165
2013	0	0	179	98	3	2	182
2014	0	0	174	100	0	0	174
2015	0	0	236	100	0	0	236
2016	0	0	221	100	1	0	222
2017	0	0	235	100	0	0	236
2018	0	0	191	98	4	2	195
2019	0	0	255	97	8	3	263
2020	0	0	335	97	12	3	347
2021	0	0	267	96	11	4	278
2022	0	0	297	96	13	4	311

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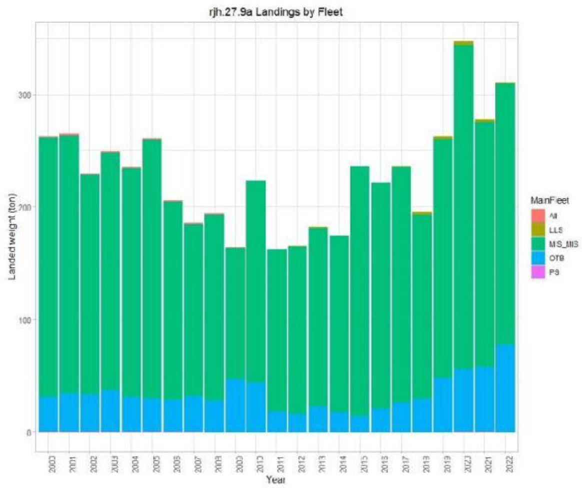

Figure 3.1.1: *Raja brachyura* in ICES Division 27.9a. Annual landings (in tonnes) by fleet. “All” – all fleets combined; “LLS” – longlines; “MIS_MIS” – polyvalent fleet; “OTB” – trawl fleet and; “PS” – seine fleet.

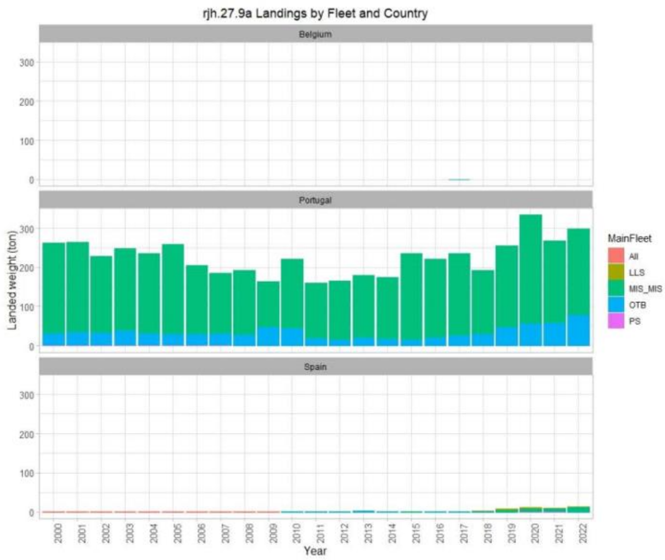

Figure 3.1.2: *Raja brachyura* in ICES Division 27.9a. Annual landings (in tonnes) by country and fleet. “All” – all fleets combined; “LLS” – longlines; “MIS_MIS” – polyvalent fleet; “OTB” – trawl fleet and; “PS” – seine fleet.

3.2. Length Distribution from landings

Length distributions of *R. brachyura* from the Portuguese commercial polyvalent and trawl fleets for the period 2008–2022 are presented in Figures 3.2.1 and 3.2.2. Figure 3.2.3 presents the overall distribution with the two fleets combined. Length distributions were raised to the total estimated landed weight of each species.

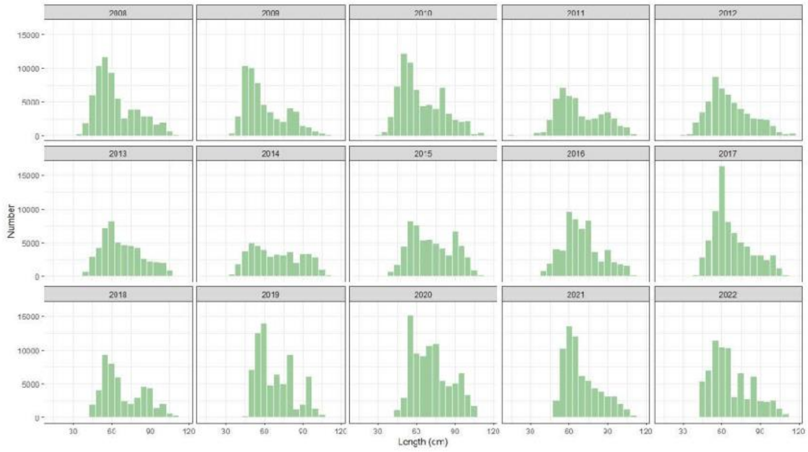

Figure 3.2.1: *Raja brachyura* in ICES Division 27.9a. Length distribution (5 cm classes, 1838 sampled trips) for the period 2008-2022 in mainland Portugal from the polyvalent fleet.

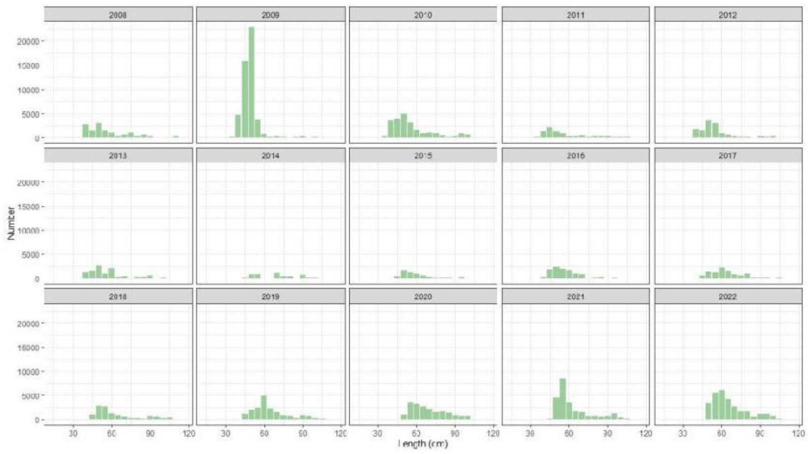

Figure 3.2.2: *Raja brachyura* in ICES Division 27.9a. Length distribution (5 cm classes, 314 sampled trips) for the period 2008-2022 in mainland Portugal from the trawl fleet.

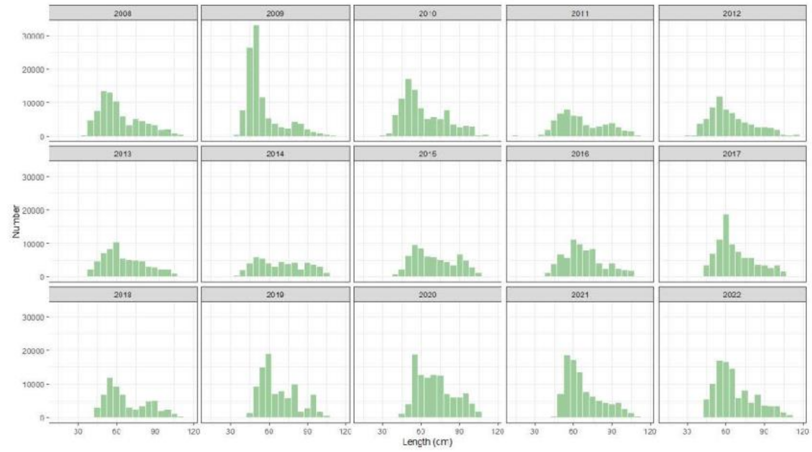

Figure 3.2.3: *Raja brachyura* in ICES Division 27.9a. Length distribution (5 cm classes, 2152 sampled trips) for the period 2008-2022 in mainland Portugal from polyvalent and trawl fleets combined.

3.3. Discards

Discards for *R. brachyura* in ICES Division 9a were mainly reported for the Spanish bottom otter trawl fleet and in low quantities (below 3 ton) compared to the total landings for the stock (average proportion of 0.002±0.004) (Figure 3.3.1). The low frequency of occurrence registered for the species in discards of the Portuguese trawl fleet indicates that discards can be considered negligible for that particular fleet (Fernandes, 2021). In relation to the Portuguese polyvalent fleet, discards are known to take place and assumed to be low, but are not fully quantified as the information available is insufficient to estimate total discards (Fernandes, 2021). Further details on the discards for all skate species was presented to WKSHARKS3 (ICES, 2017a; Serra-Pereira et al., 2017)

In summary, discarding is known to take place for *R. brachyura* in ICES Division 9a, but ICES cannot estimate the quantity or the corresponding dead catches. Yet, based on information available, discarding for this stock is assumed to be low and therefore has not been included in the previous advices and will not be considered for the SPiCT assessment explored in the present benchmark.

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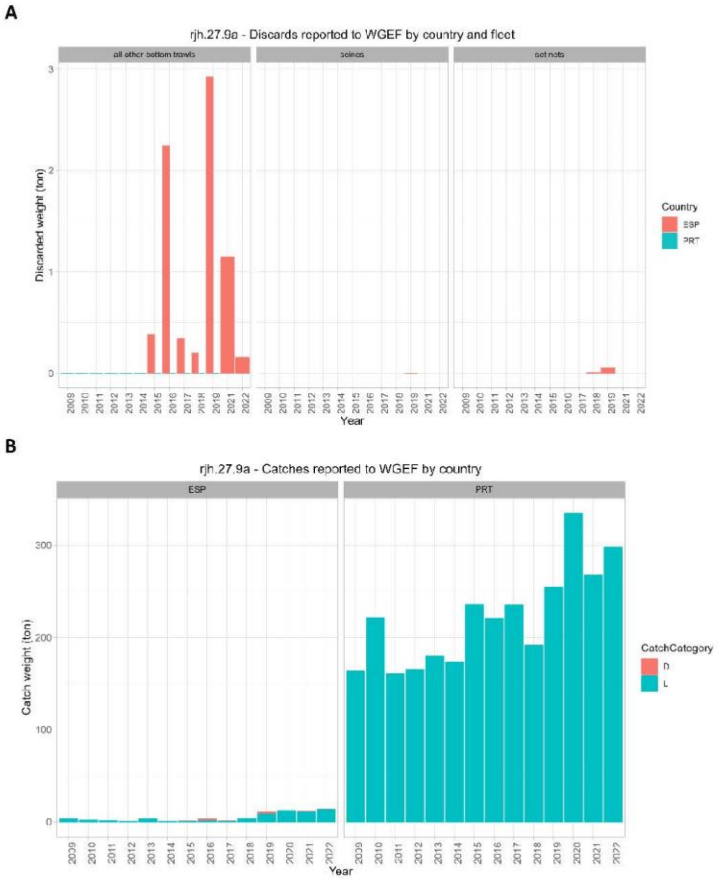

Figure 3.3.1: *Raja brachyura* in ICES Division 27.9a. (A) Discards reported by country and fleet. (B) Catches reported by country, separated by landings (L) and discards (D).

3.4. Survival

Discard survival studies on *R. brachyura* have been conducted in ICES Division 9a both in Portugal (Serra-Pereira and Figueiredo, 2019) and Spain (Valeiras et al., 2018), covering the main fishing gears catching the species.

In summary, based on results for the Portuguese polyvalent fleet, collected under the DCF Skates Pilot Study, a high Categorical Vitality Assessment (CVA) was found for *R. brachyura*, with more than 76% of the individuals found in Excellent or Good vitality status (Table 3.4.1). Both mesh size and soaking time seem to have some effect on survival. In terms of the relation with the size of the caught skates, in the retain fraction of the catch vitality after capture was not related to size, while for the discarded, differences between size classes were observed, as the large skates discarded were generally not in good conditions for selling due to parasite infection for example (Table 3.4.2).

Table 3.4.1: *Raja brachyura* in ICES Division 27.9a. Categorical Vitality Assessment (CVA) after capture by mesh size (mm) and soaking time (h), recorded onboard commercial vessels operating with trammel nets (n=197). (source: Serra-Pereira and Figueiredo, 2019).

		Vitality status				
Mesh size (mm)	Soak time (h)	1	2	3	n	TL range (cm)
< 180	< 24	**67%**	**22%**	**11%**	**9**	**39-66**
	> 24	**92%**	4%	4%	24	27-75
> 180	< 24	**57%**	19%	24%	21	49-95
	> 24	**70%**	20%	10%	143	18-106

Table 3.4.2: *Raja brachyura* in ICES Division 27.9a. Categorical Vitality Assessment (CVA) after capture by length class (cm), recorded onboard commercial vessels operating with trammel nets (source: Serra-Pereira and Figueiredo, 2019).

	Retained				**Discarded**			
	Vitality status				Vitality status			
Length class	1	2	3	n	1	2	3	n
<52 cm	**69%**	**15%**	**15%**	**26**	**83%**	**8%**	**8%**	**12**
>52 cm	**75%**	20%	5%	150	0%	0%	100%	9

Additional experiments were carried out as part of the PPCENTRO project conducted by IPMA, focusing on *R. brachyura* caught by trammel net, which involved captivity observations for periods of at least three weeks. Preliminary results from those experiments indicate a survival rate of 76% (Castelo, J. 2021; Figure 3.4.1).

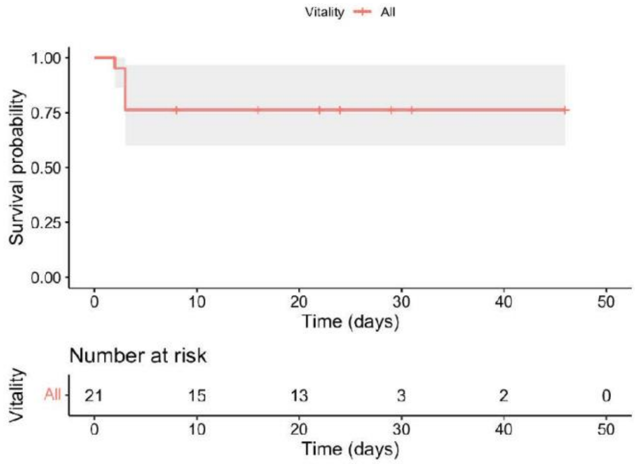

Figure 3.4.1. Discard survival of *Raja brachyura* caught by trammel net. Kaplan-Meier estimate of survival along 50 days of captivity (solid lines) and 95% pointwise confidence intervals (dashed lines). Survival probability within the observation period with standard error and upper and lower 95% CIs estimates (source: Castelo, J. 2021).

Overall, the results from the different studies suggest that the *R. brachyura* caught by trammel net, the main fishing gear to catch this species in ICES Division 9a, have a high survival after capture. All the studies followed the procedures described in previous studies on the survival of this group of species and the recommendations made by the STECF and the ICES Working Group on Methods to Estimate Discard Survival.

4. Survey biomass index

4.1. Portuguese Autumn Groundfish Survey (PtGFS-WIBTS-Q4) [G8899]

This survey has been conducted by the Portuguese Institute for the Sea and Atmosphere (IPMA, ex-IPIMAR) and has the main objective to monitor the abundance and distribution of hake (*Merluccius merluccius*) and horse mackerel (*Trachurus trachurus*) recruitment (Cardador et al., 1997). The survey is performed along the Portuguese continental coast, extending from latitude 41°20'N to 36°30'N (ICES Division 9.a) from 20 to 500 m deep. For details on vessels characteristics, survey stratification and technical characteristics of fishing operations see ICES (2017c). The survey was not conducted in 2012, 2019 and 2020 and in 1996, 1999, 2003 and 2004 the survey was conducted with a different gear. In 2018, the survey had technical problems, and part of the stations were sampled using a commercial trawler and a different fishing net (using FGAV019 instead of NCT). Since 2021, the survey has been conducted with a new vessel and some modifications in the fishing gear.

Raja brachyura is a coastal species with a patchy distribution that is caught infrequently by the Portuguese Autumn Groundfish Survey (usually lower than 0.1 kg haul-1 in any year of the series). Consequently, abundance indices derived from this survey is not considered indicative of stock status.

5. Commercial LPUE

Once that Portuguese bottom trawl research surveys are inadequate for monitoring *R. brachyura* populations in ICES Division 9a, a commercial standardized LPUE time-series index based on data derived from the Portuguese polyvalent fleet is considered to provide assessment on stock status.

All the details on the LPUE standardization methodology are described in Maia *et al.* (2023b, WD).

LPUE standardization procedure is done via the adjustment of a stepwise generalized linear model (GLM) to fishery dependent data derived from the Portuguese polyvalent fleet where the response variable is the *R. brachyura* landed weight per fishing trip (unit effort).

Most *R. brachyura* landings were derived from the polyvalent fleet during the period 2008-2022 (between 71 and 94%). In Portuguese continental waters, the most important ports (i.e. Matosinhos and Póvoa do Varzim, Peniche, Sesimbra and Setúbal) contributed with 61% for *R. brachyura* polyvalent landed weight. Within these, Peniche represented on average 45% of the landed weight during the period 2008-2022; for this reason, the analysis was restricted to the Peniche landing port. Furthermore, vessels landing in Peniche operate along the north, center and southwest coasts, not being restricted to Peniche's vicinity. Trips performed with nets and nets/traps were selected once that contributed for the majority of the species landings; representing between 71-92%.

Up to 2022, the standardized LPUE was estimated considering a reference situation: quarter = 1, SIZEs = M (medium), SAZ = c (constant) and fishing gear = nets. During WGEF 2022, the high value obtained for 2019 was considered unreliable by the working group, so a deeper look at the input data was done. Nominal LPUE variation for the period by year, by year for different quarters, for different vessel size, for different fishing seasonality and for different gears show that values for 2019 were within the time-series range. Once the resultant biomass index estimates for the reference situation and for the model mean predicted values followed the same trend along the entire time-series, it was accepted by the WGEF group to construct the LPUE time-series based on the model´s mean predicted values to assess the status of this stock.

The GLM model adjusted considered a gamma distribution with a log link function and included the explanatory variables year, quarter, gear, vessel size and seasonality and can be expressed as:

glm(LPUE ~ Year + Quarter + Gear + Vessel size + Fishing seasonality, family=Gamma (link=log)).

Annual biomass index varied from 13.23 $kg.trip^{-1}$ (in 2009) to 34.86 $kg.trip^{-1}$ (in 2017), with an average of 23.61 $kg.trip^{-1}$ for the entire time series (Table 5.1, Figure 5.1). Since 2016, values have been above the long-term mean. For comparison proposes, estimates obtained considering the previous reference situation are present in figure 5.2.

Table 5.1: *Raja brachyura* in ICES Division 27.9a. LPUE index (kg.trip^{-1}), standard error and normalized LPUE from 2008 to 2022.

Year	LPUE (kg.trip^{-1})	sd	mean-sd	mean+sd	Standirdized LPUE
2008	15.40	6.55	8.86	21.95	0.65
2009	13.23	6.54	6.69	19.76	0.56
2010	19.42	10.95	8.47	30.37	0.82
2011	19.82	11.08	8.74	30.90	0.84
2012	20.96	11.94	9.01	32.90	0.89
2013	13.78	7.84	5.95	21.62	0.58
2014	15.42	9.19	6.23	24.60	0.65
2015	21.23	10.51	10.72	31.74	0.90
2016	27.65	15.62	12.03	43.27	1.17
2017	34.86	17.96	16.90	52.83	1.48
2018	26.32	12.73	13.59	39.05	1.11
2019	33.31	21.26	12.04	54.57	1.41
2020	29.07	15.72	13.35	44.79	1.23
2021	31.35	15.13	16.21	46.48	1.33
2022	32.32	13.70	18.62	46.03	1.37

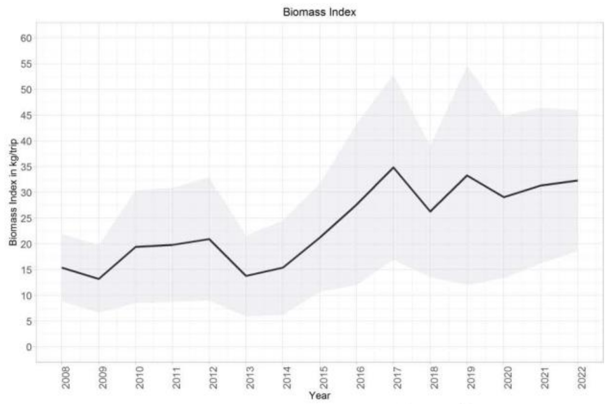

Figure 5.1: *Raja brachyura* in ICES Division 27.9a. Biomass index (kg.trip^{-1}) and respective standard error for the period 2008-2022.

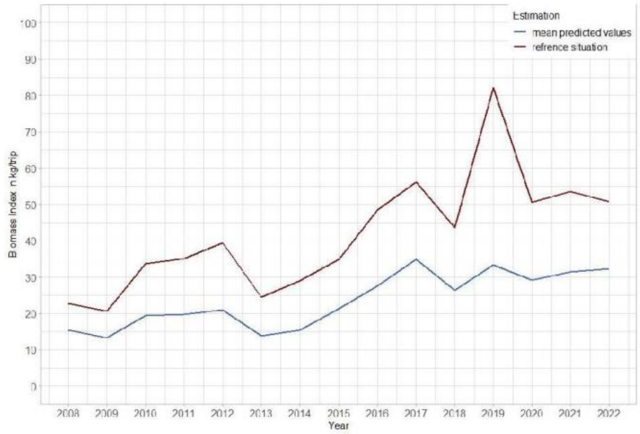

Figure 5.2: *Raja brachyura* in ICES Division 27.9a. Biomass index (kg.trip^{-1}) for the period 2008-2022 considering the previous reference situation (red line) and model mean predicted values (blue line) for the period 2008-2022.

6. Life-history parameters

Table 6.1 summarizes the information available on biological parameters estimates for *R. brachyura* in different ICES areas (adapted from Ellis et al. (2023, ICES WD)).

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Table 6.1: Summary of life-history parameters recorded for some studies conducted on different ICES areas on *Raja brachyura* (adapted from Ellis et al., 2023).

Study area	Ices area	TL range (cm)	L50 (cm)		L95 (cm)		A50 (years)		Fecundity	Reproductive period	Growth parameters estimates				Age range	L-W relationship		Source
			F	M	F	M	F	M			Sex	Linf (cm)	$k(y^{-1})$	t0				
Iberian waters	9a	37-106	97.9	88.8	-	-	-	-	-	Mar-Jul	All	110.5	0.12	0.26	3-10	-	-	Farias, 2005
Iberian waters	9a	37-108	96.6	88.6	-	-	-	-	-	Mar-Jul	F	121	0.13	0.19	-	-	-	Pina Rodrigues, 2012
							-	-			M	103.7	0.16	0.22	-	-	-	
Iberian waters	9a	37-111	95.2	90	101.3	100.9			115	Apr-Sep	-	-	-	-	-	-	-	Maia et al., 2022 WD
British Isles		?–109	83.4	78	-	-	-	-	-	-	-	-	-	-	-	-	-	McCully *et al.* (2012)
											-	-	-	-	-	-	-	
Irish Sea	7a	-	83.6	81.9	-	-	5.5	4.6	-	-	F	154.7	0.129	-0.84	0-8	-	-	Gallagher *et al.* (2005)
											M	145.8	0.145	-0.93	0-8	-	-	
Mediterranean	-	-	87.2	80.8	-	-	14	10	37-44	-	-	-	-	-	-	-	-	Porcu *et al.* (2015)
											-	-	-	-	-	-	-	
British Isles	4,6,7	-	-	-	-	-	-	-	90	-	F	118.4	0.19	-0.8	-	-	-	Holden (1972)
											M	115	0.19	-0.18		-	-	
Irish Sea	7a	-	-	-	-	-	-	-	-	-	F	120.6	0.29	0.49	2-10	-	-	Fahy (1989b)
											M	119.4	0.26	0.15	2-9	-	-	
Celtic Sea	7gj	-	-	-	-	-	-	-	-	-	F	120	0.24	-0.27	2-8	-	-	Fahy (1989b)
											M	116.7	0.24	-0.31	2-8	-	-	
West of Ireland	7b	-	-	-	-	-	-	-	-	-	F	134.4	0.19	-0.45	2-8	-	-	Fahy (1989b)
											M	-	-	-	2-7	-	-	
Hebridean Sea	6a	-	-	-	-	-	-	-	-	-	F	144.3	0.19	0.07	2-8	-	-	Fahy (1989b)
											M	-	-	-	2-6	-	-	
Iberian waters	9a	-	-	-	-	-	-	-	-	-	-	-	-	-	-	a	0.00198	Serra-Pereira et al. 2010
																b	3.2	

For the application of SPiCT assessment model a prior probability distribution needs to be defined for intrinsic rate of population increase (*r*). For the estimation of the *r*, different methods were tested:

i) applying the function jbleslie implemented in R package JABBA (Winker et al., 2018);
ii) Applying the methods proposed by Eberhardt et al. (1982), Skalski et al. (2008), Smith at el.'s (1998) and the Demographic Invariant Method following Cortés (2016);
iii) Using the package FishLife (Thorson et al., 2023);
iv) Fishbase (Froese et al. 2017);
v) Following Jennings et al. (1999) (Frisk et al., 2001).

Applying the method from Winker et al. (2023) to estimate *r* requires setting several life-history parameters:

- given the uncertainty associated with growth studies available for ICES 9a, the averaged VBGP parameters provided for female *R. brachyura* from three studies (Holden, 1972; Fahy, 1989 (mean value from four different study areas) and Gallagher et al., 2005) were Linf = 134.31 cm, K = 0.182 y–1 and t0 = –0.56, following the methodology defined for other *R. brachyura* stocks (rjh.27.4bc7d) previously benchmarked (ICES, 2023a);

- natural mortality (M) was estimated as 0.23 and was derived from Then et al., (2015), following the methodology defined for other elasmobranch stocks previously benchmarked (ICES, 2023a):

$$M=4.118* K^{0.73}*L_{inf}^{-0.33};$$

- maximum age (tmax) was extracted from the database of life history correlations available in the FishLife R package (Thorson, 2019) and used in the *r* estimation for the present stock. The maximum value from those available for blonde ray was chosen, with tmax = 17.
- Length-weight relationship considered was $W=0.00198*TL^{3.2}$ according with Serra-Pereira *et al.* (2010).
- Estimates of the length at which 50% of the population is mature (L50%) and length at which 95% of the population is mature (L95%) for *R. brachyura* in the stock area are available from Maia *et al.* (2022). A L50% of 95.2 cm and a L95% of 101.3 cm (both values estimated for females) are considered. Fecundity was assumed to be 115 eggs/female/year (Maia *et al.*, 2022).

Table 6.2 summarizes estimates of intrinsic growth rates (r´) following the different methodologies.

Table 6.2. Estimates of intrinsic rate of population increase (*r*) for *Raja brachyura* from the present study and from other references. The primary value adopted for the SPiCT trials is highlighted in bold.

Stock	Method	r [CI]	Reference
rjh.27.9a	***jbleslie* function (R package JABBA)**	**0.22**	**Present study**
	FishLife (Thorsen et al., 2019)	1.063 or 0.059	Present study
	Eberhardt et al. (1982), based on Cortés (2016)	0.38	Present study
	Skalski et al. (2008), based on Cortés (2016)	0.38	Present study
	Smith at el.'s (1998), based on Cortés (2016)	0.09	Present study
	Demographic Invariant Method (Cortes, 2016)	0.06	Present study
	FishBase (Froese et al. 2017)	0.20	
	Following Jennings et al. (1999)	0.33**	Frisk et al., 2001
rjh.27.4bc7d	*jbleslie* function (R package JABBA)	r = 0.337, CV = 0.3	ICES, 2023a

** potential population increase (r´)

7. Current Stock Assessment

The stock rjh.27.9a has been assessed under category 3 (trend-based assessment).

In 2022, last assessment year, the stock assessment was done following ICES guidelines for category 3 which involves the application of the rfb rule (ICES, 2021; ICES, 2022). A standardized commercial LPUE time-series is used as an indicator of stock development. The advice is based on the recent advised catches, multiplied by the ratio of the mean of the last two index values (index A) and the mean of the three preceding values (index B), a ratio of observed mean length in the catch relative to the target mean length (length-based indicators, length distributions from the Portuguese commercial polyvalent and trawl fleets combined as input data), a biomass safeguard, and a precautionary multiplier.

8. Stock assessment proposed methods

For the present benchmark, the proposal is focussed on evaluating the application of a surplus production model SPiCT (Stochastic Production model in Continuous Time, Pedersen and Berg 2017) on the stock for providing advice.

8.1. SPiCT initial runs during WGEF2022

During WGEF 2022, several runs were tested to check model performance using different settings and priors. All the runs' results can be found in Moura et al., 2022. The checklist for the acceptance of a SPiCT assessment was followed (Mildenberger et al., 2020).

The most adequate model (model 5) included as priors:

- Schaefer production curve
- an intrinsic rate of population increase (r) extracted from FishBase which follows Froese et al. (2017)
- initial depletion (B/k) of 0.2. This low value was considered, admitting low levels of species abundance in early 2000´s. This situation was likely reversed after the adoption of the Portuguese technical management, set to all the Rajidae species.

For all the priors a CV of 0.2 was considered. The sensitivity analyses considering higher CVs for the priors did not show major differences on the posterior (models 8 to 11).

Considering model 5 as the base model, the following runs tested the use of different priors (models 7, 12 to 14; Table A1). In the case of the production curve, assumed as Schaefer, fixed and larger CV were tested (models 7 and 8). However, these changes had no major impact in the model estimates. Sensitivity analyses on the r parameter (models 12 and 13) showed that the model is highly dependent of the value assigned to its prior. However, given the biology of the species the r value initially adopted seems adequate.

The increase of the prior for B/k to 0.5 had great impact on model estimates (model 14). Under this scenario, the status of the stock shows a better perspective than the based model but credible intervals for F/Fmsy are quite wide and larger than the values acceptable.

Model proposed

The model presented to WGEF and proposed for the assessment of rjh.27.9a was model 5. This model uses the following input data and priors (Figure 2; R code and results available in the WGEF Data folder: "06. Data/SPiCT assessments"; all model runs can be made available upon request).

Input data:

- Stock landings (2008-2021) (Figure 8.1.1)
- PT LPUE (2008-2021, set at the middle of the year) (Figure 8.1.1)

Priors:

- Schaefer production curve: rjh_data$priors$logn<-c(log(2),0.2,1)
- Initial depletion level (rjh_data$priors$logbkfrac = c(log(0.2),0.2,1))
- Intrinsic rate of population increase (r): rjh_data$priors$logr <- c(log(0.2),0.2, 1)

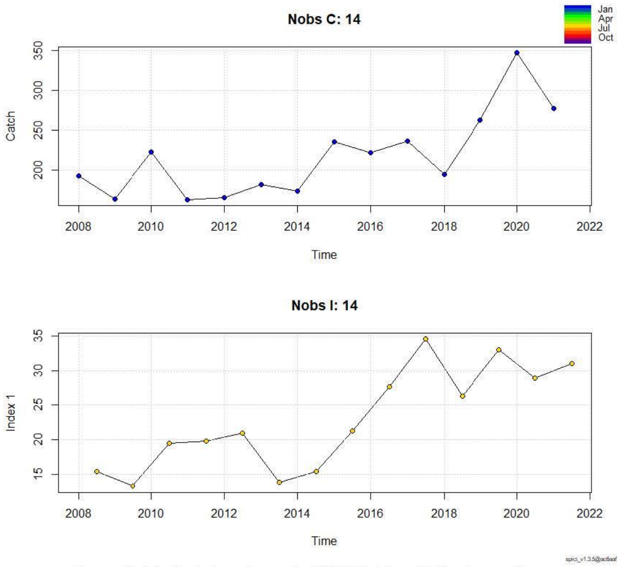

Figure 8.1.1: *Raja brachyura* in ICES Division 27.9a. Input data.

The intrinsic rate of population increase was extracted from FishBase which follows Froese et al. (2017). Results are presented in Figures 8.1.2-8.1.4 and additional information. No significant bias or autocorrelation were found and both QQ-plot and the Shapiro test show normality in the residuals. Regarding the retrospective pattern, Mohn's rho is <0.2 for both B/B_{MSY} and F/F_{MSY} (of 0.029 for B/B_{MSY} and of -0.025 for F/F_{MSY}). However, only three peels were included in the analysis due to the small time series. The checklist for the acceptance of a SPiCT model (Mildenberger et al., 2020) was followed and no issues were found. Despite the large confidence intervals for B/B_{MSY} and F/F_{MSY} those do not span more than 1 order of magnitude.

Considering the adopted reference points proposed for production models by ICES (ICES, 2017b; ICES, 2021c), F/F_{MSY} in 2021 is below F_{MSY} and B/B_{MSY} in 2022 is above B_{MSY}.

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Data compilation online meeting, 20th to 24rd November 2023

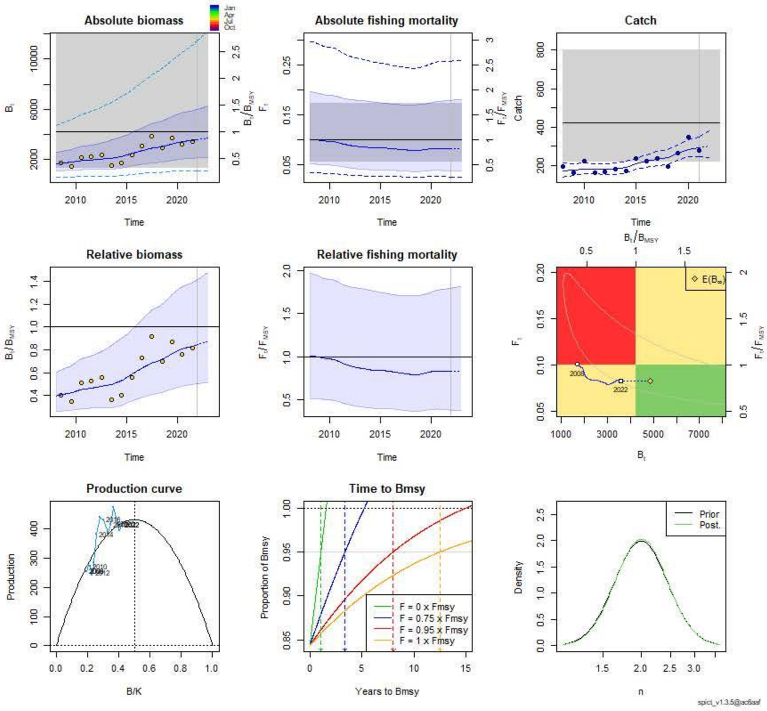

Figure 8.1.2: *Raja brachyura* in ICES Division 27.9a. Results from SPiCT model.

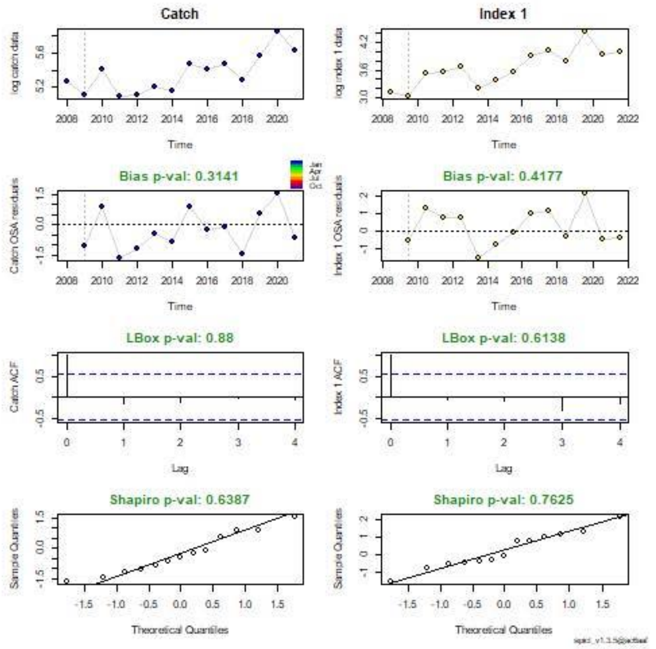

Figure 8.1.3: *Raja brachyura* in ICES Division 27.9a. Results from SPiCT model. Row1, Log of the input data series. Row 2, OSA residuals with the p-value of a test for bias. Row 3, Empirical autocorrelation of the residuals with tests for significant autocorrelation. Row 4, Tests for normality of the residuals, QQ-plot and Shapiro test.

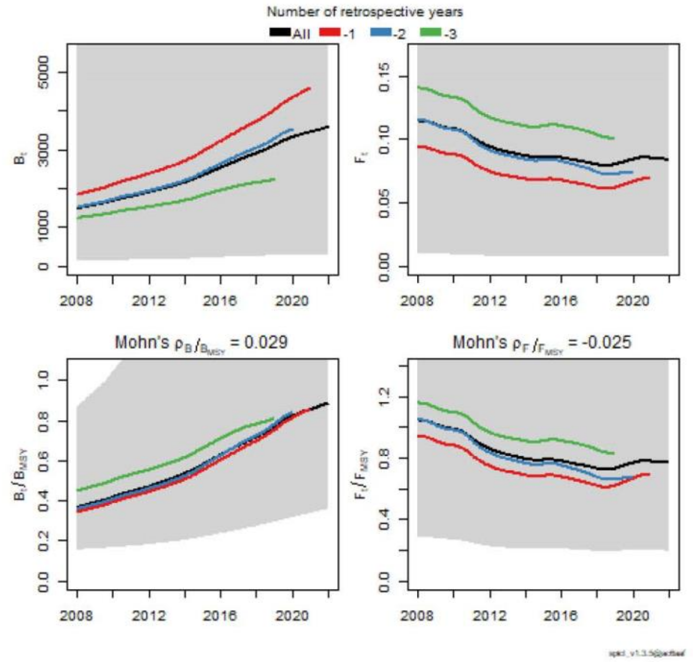

Figure 8.1.4: *Raja brachyura* in ICES Division 27.9a. Results from SPiCT model; retrospective analysis. Upper panel, absolute biomass and fishing mortality. Lower panel, relative biomass and fishing mortality. Grey regions represent 95% CIs.

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Cuckoo ray (*Leucorajanaevus*) in Division 9.a (Atlantic Iberian waters): exploratory assessment using SPiCT

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1. Introduction

The cuckoo ray (*Leucoraja naevus)* has a wide geographic distribution in the north-east Atlantic and Mediterranean (Stehmann and Bürkel, 1984). In the Atlantic Iberian waters, it is distributed along the shelf and upper slope.

This stock (rjn.27.9a), which comprises the ICES Division 9a, includes the north Spanish area (Galician waters), Portuguese mainland waters and south Spanish waters (Gulf of Cadiz). Scientific advice on this stock is provided by ICES WGEF every two years. Since 2014 it is assessed under the ICES category 3 for Data limited stocks (DLS), based on biomass trend from the research surveys conducted in the Gulf of Cadiz (ICES, 2022a). In 2020, methodologies to estimate LPUE indices from the Portuguese commercial polyvalent fleet (mostly operating with gillnets and trammel nets) for different skate species were discussed and approved at WKSKATE (ICES, 2020). However, in the case of this stock, the ADGEF considered the new index unsuitable for assessment given the contrasting trends of both LPUE and survey index (more information below). As a consequence, the last assessment, in 2022, followed the rfb rule (applied for the first time to this stock) using only the research surveys conducted in the Gulf of Cadiz (ARSA surveys).

Among some of the other methods suggested to obtain reference points (RP) for data limited stocks (DLS) are production models (ICES, 2021a) and particularly the stochastic surplus production model in continuous time (SPiCT; Pedersen and Berg, 2017). A compilation and revision of the data available to implement future assessments of this stock with a SPiCT model are presented. Several SPiCT runs were conducted and results from those trials are also shown and discussed below.

2. Input data for SPiCT assessment

2.1. Landings

In Iberian waters (Spain and Portugal), skates are mainly caught as a bycatch in mixed demersal fisheries. The main fishing gears used are otter trawl, bottom-set gillnets and trammel nets.

Species-specific landings were only available since 2008 and 2009 for Portugal and Spain respectively. In order to obtain a longer time series, landings since 2000 have been estimated both for the Spanish and Portuguese fleets independently and using different approaches (Figure 1; see Maia et al., 2023 WD and Rodriguez-Cabello et al., 2023 WD for the methods used). Portuguese landings represent, in average, 89% of the total landings of the stock. Discards are only available for the Spanish fleet since 2015 and are highly variable (Table 1). Therefore, discards were not considered for the assessment.

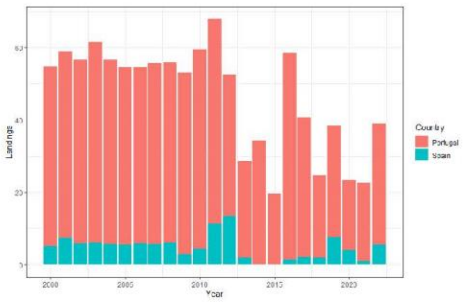

Figure 1. Landings of *Leucoraja naevus* in ICES subdivision 9a (2000-2022).

Table 1. Total landings by country of cuckoo ray in ICES 9a. Portuguese landings were estimated for the period 2000- 2007 and Spanish landings were estimated for 2000-2009. (*) Discards were only available from Spanish fleet and since 2015.

Year	Spain	Portugal	Total Landings	Discards*
2000	5.1	49.6	54.7	
2001	7.4	51.6	59.0	
2002	6.0	50.7	56.7	
2003	6.1	55.6	61.7	
2004	5.8	50.9	56.7	
2005	5.6	49.1	54.6	
2006	6.0	48.6	54.6	
2007	5.8	50.0	55.8	
2008	6.2	49.8	56.0	
2009	2.8	50.2	53.1	
2010	4.4	55.0	59.4	
2011	11.5	56.4	68.0	
2012	13.4	39.2	52.6	
2013	2.1	26.5	28.6	
2014	0.2	34.2	34.4	
2015	0.1	19.6	19.7	4.0
2016	1.4	57.2	58.6	41.0
2017	2.2	38.5	40.7	22.0
2018	1.9	22.9	24.8	15.9
2019	7.8	30.6	38.4	7.3
2020	4.1	19.2	23.4	
2021	1.0	21.7	22.7	
2022	5.6	33.4	39.0	2.6

2.2. Biomass indices

Biomass index from SpGC-GFS-WIBTS-Q1-4

The biomass survey index from the bottom trawl surveys carried out in spring and autumn in the south of Spain, Gulf of Cadiz (SpGC-GFS-WIBTS-Q1-4) have been used to assess this stock. WKBELASMO 3 agreed to use the exploitable biomass index (TL≥ 35 cm) instead ofthe total biomass (Figure 2, Table 2).

The biomass index of *L. naevus* (1998-2022) fluctuated with an increasing trend until 2018 (maximum of the time series). In 2020, the biomass dropped to low levels and recovered in 2022. Due to problems with the research vessel, the survey was not conducted in 2021.

The initial values of the series are very low (close to zero). Although it can reflect the low abundance of the species in the surveyed area, it is also known that the number of hauls conducted in 1998 and 2000 is lower than in the remaining years. The effect of this decrease in this species that is not randomly distributed is unknown.

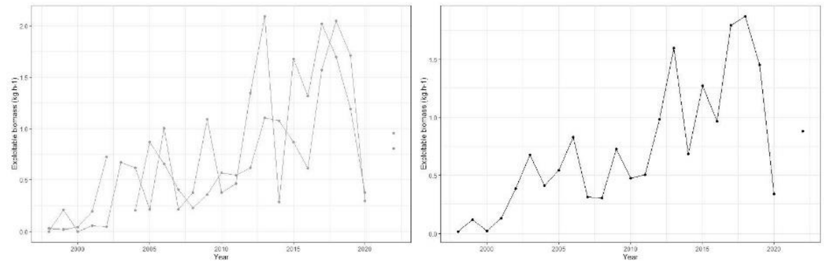

Figure 2. Exploitable biomass index from SpGC-GFS-WIBTS-Q1-4 (ARSA surveys, Gulf of Cadiz; >35 cm total length). Left: biomass values for Q2 (red) and Q4 (blue). Right: average of both Q2 and Q4 surveys.

Table 2. Exploitable biomass index obtained from the bottom trawl surveys (SpGC-GFS-WIBTS-Q1-4) conducted in the Gulf of Cadiz during spring and autumn since 1998.

Explotable Biomass >= 35 cm					
	SPRING SURVEY			AUTUMN	
Year	Nº/haul	Kg/haul	Year	Nº/haul	Kg/haul
1998	0.04	0.03	1998	0.00	0.00
1999	0.05	0.02	1999	0.26	0.21
2000	0.08	0.04	2000	0.00	0.00
2001	0.21	0.20	2001	0.16	0.05
2002	1.21	0.72	2002	0.05	0.04
2003			2003	0.86	0.67
2004	0.34	0.20	2004	1.06	0.62
2005	1.32	0.87	2005	0.32	0.21
2006	1.27	0.65	2006	1.63	1.00
2007	0.57	0.41	2007	0.43	0.21
2008	0.28	0.23	2008	0.77	0.38
2009	0.55	0.36	2009	1.61	1.09
2010	0.86	0.57	2010	0.46	0.38
2011	0.69	0.55	2011	0.55	0.46
2012	0.99	0.62	2012	2.13	1.34
2013	1.55	1.10	2013	2.65	2.09
2014	1.51	1.08	2014	0.47	0.29
2015	1.33	0.87	2015	2.64	1.68
2016	1.12	0.61	2016	30.19	20.79
2017	3.30	1.57	2017	3.06	2.02
2018	3.42	2.05	2018	2.43	1.70
2019	2.34	1.71	2019	1.72	1.19
2020	0.31	0.29	2020	0.32	0.37
2021			2021		
2022	1.49	0.95	2022	1.19	0.81

LPUE index

The LPUE index from the Portuguese commercial polyvalent fleet (kg/trip) is shown in Figure 3 and Table 3. Details on the LPUE estimation methodology can be found in Serra-Pereira *et al.* (2020), ICES (2021b) and Rodriguez-Cabello et al. (2023 WD).

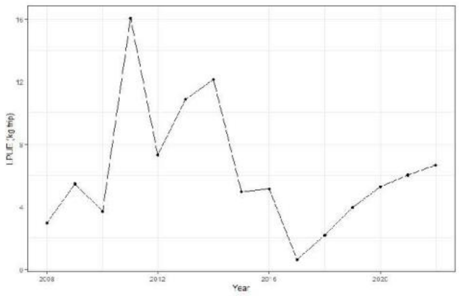

Figure 3. LPUE index for the Portuguese polyvalent fleet (2008-2022).

Table 3. LPUE index estimated forthe Portuguese polyvalent fleet for the period 2008-2022.

Year	LPUE (kg/trip)	Standard error
2008	2.99	0.22
2009	5.46	0.40
2010	3.71	0.24
2011	16.08	1.26
2012	7.30	0.52
2013	10.85	0.80
2014	12.15	0.82
2015	4.98	0.45
2016	5.13	0.46
2017	0.62	0.06
2018	2.21	0.16
2019	3.97	0.34
2020	5.28	0.39
2021	6.05	0.45
2022	6.66	0.52

Combined index

As proposed at WKBELASMO3 data compilation workshop, a combined index, weighted by landings of each country, was estimated. To this purpose, an overall proportion value of Portuguese and Spanish landings was estimated and applied to the PT-LPUE and ARSA biomass indices (after normalization) (Figure 4 and Table 4).

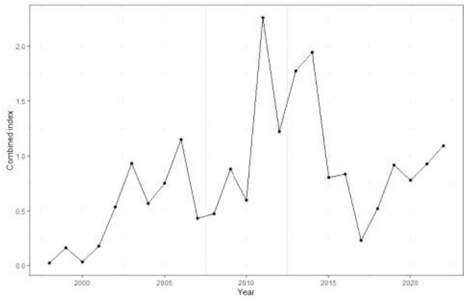

Figure 4. Combined index for *L. naevus* in ICES subdivision 9a.

Table 4. Combined index for rjn.27.9a, weighted by landings of Portugal and Spain, after normalization of the Spanish ARSA biomass surveys (average) and the Portuguese LPUE.

Year	Combined Index
1998	0.02
1999	0.16
2000	0.03
2001	0.17
2002	0.53
2003	0.94
2004	0.57
2005	0.75
2006	1.15
2007	0.43
2008	0.47
2009	0.89
2010	0.60
2011	2.38
2012	1.19
2013	1.79
2014	1.84
2015	0.90
2016	0.88
2017	0.35
2018	0.59
2019	0.78
2020	0.81
2021	0.97
2022	1.09

Both the LPUE and survey indices have different trends in the last years (ARSA increases and LPUE is in the lowest values) (Figure 5). Based on this, the last advice excluded the PT-LPUE: *"a standardized LPUE from the Portuguese polyvalent fleet presented in WKSKATE (ICES, 2021b) may provide information from areas further north. This index shows opposite trends to the survey index in recent years and has not been included in the current assessment. Further work is required to reconcile these two series"* (ICES, 2022a). In fact, the years that are contradictory are those after the start of management regulations in Portuguese waters regarding the minimum size (>2014).

Also, since 2014 a decrease in the sampling effort has been observed which can have effect in the estimation of species abundance, given its patchy distribution. Precaution is also needed in the future use of the PT-LPUE due to the increase of the minimum landing size from 52 to 60 cm in 2022, which will decrease the landings for this species in the forthcoming years.

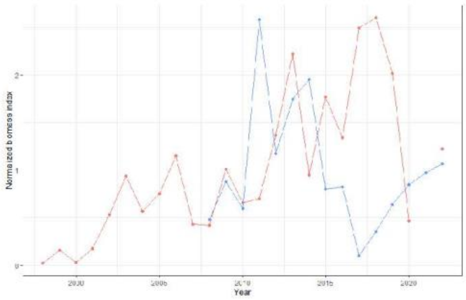

Figure 5. Comparison between ARSA index and LPUE (normalized indices).

2.3. Life-history parameters

Life history parameters are available for this species in ICES areas (Tables 5 and 6). For this stock in particular, reliable growth parameters are missing but those estimated from Gallagher et al. (2005) were adopted. The maximum size registered from Iberian Waters studies (Portuguese waters) is 79 cm (unpublished data, from PNAB/DCF). Based on this value, following Pauly (1984), L_{inf} was estimated as 83.2 cm (L_{inf}= TL_{max}/0.95).

Table 5. Summary of growth parameters recorded for studies conducted on different ICES areas on cuckoo ray, adapted from Ellis et al. (2023). Vert.: analyses of vertebrae; MRD: mark-recapture data.

Area	Sex	N	Length range (cm)	Age range (y)	L_{inf} (cm)	K (y^{-1})	t_0 (y)	Method	Source
Celtic Sea	C	50	13-69	0-12	91.64	0.109	-0.05	Vert.	Du Buit (1977)
Irish Sea	C	818	37-73	1-9	---	---	---	Vert.	Fahy (1989a)
Celtic Sea	F	759	---	1-8	73.1	0.23	-2.47	Vert.	Fahy (1989b), Fahy (1991)
	M	670	---	1-7	69.9	0.33	-1.12	Vert.	
Irish Sea	F	209	?-70	0-8*	83.92	0.197	-0.151	Vert.	Gallagher et al. (2005)
	M	351	?-71	0-8*	74.57	0.294	-0.997	Vert.	
North Sea	F	48	ca.36-65	3-11	75.2	0.16	-0.95	Vert.	Walker (1999)
	M	47	ca.30-35	3-10	67.5	0.31	-0.9	Vert.	
Celtic Sea	F		---	---	70	0.127	---	MRD	Dureuil et al. (2022)
	M		---	---	70.1	0.127	---	MRD	
---	C	---	---	---	78.4	0.24	-0.54	---	Froese and Pauly, 2022

*Age range for sexes combined

Table 6. Summary of reproduction data recorded for studies conducted on different ICES areas on cuckoo ray. Lengths in cm; ages in years

Area	Sex	Length range (cm)	Fec. (no. follicles)	$L_{50\%}$ (cm)	$A_{50\%}$ (y)	Source
Portugal	F	---		55.6		Farias (2005)
Portugal	M	---		56.5		
Portugal	F	14.9-71.8	63	56.5		Maia et al. (2012)
Portugal	M	13.3-68.2		56.0		
Irish Sea	F	ca.13-70		56.9	4.17	Gallagher *et al.* (2005)
Irish Sea	M	ca.13-71		56.2	4.25	
	F	ca.10-69		59.8		
Celtic Seas	M	ca.11-72		57.3		McCully et al. (2012)
North Sea	F	ca.15-62		53.6		McCully et al. (2012)
	M	ca.17-63		50.8		

2.4. Intrinsic rate of biomass increase

Values for the intrinsic rate of biomass increase (*r*) were extracted from literature or estimated based on different methods (Table 7).

These estimates assumed the natural mortality (M) derived from Then et al., (2015), following the methodology defined for other elasmobranch stocks previously benchmarked (ICES, 2023):

$$M=4.118*K^{0.73}*L_{inf}^{-0.33}$$

In addition, maximum age was estimated based on Fabens (1965).

$$A_{max}=5x(\ln 2/k)$$

Table 7. Intrinsic rate of biomass increase estimates following different methods.

Method	r estimate	Reference
Leslie matrix (females)*	0.13	Following *jbleslie* function (Winker et al., 2023)
Leslie matrix (females)*	0.21	Following *jbleslie* function (Winker et al., 2023)
Eberhardt et al. (1982)	0.60	Estimate following R script from Cortés (2016)
Skalski et al. (2008)	0.60	Estimate following R script from Cortés (2016)
Smith at el. (1998)	0.17	Estimate following R script from Cortés (2016)
Demographic Invariant Method	0.11	Estimate following R script from Cortés (2016)
FishLife	0.08 (or 1.08?)	Estimate following Thorson (2023)
rnj.27.678abd*(FishLife)*	0.08	*FishLife* (Thorson, 2023; ICES, 2022b)
Jennings et al. (1999)	0.41	Frisk et al. 2001

* In the case of the function *jbleslie* implemented in R package JABBA (Winker et al., 2023), one of the methods used to estimate r, given the inexistence of reliable growth parameters for this stock, estimates were based on two different studies available from the Celtic and Irish Seas (Table 8).

Table 8. Estimates of *r*, based on *jbleslie* function (Winker et al., 2023), using different growth parameters (females).

A_0	A_{max}	Linf	k	to	L50	L95	Fec.	aW	bW	M	r
0	17.6	83.92	0.197	-0.151	56.5	66.4	63	0.0006	3.58	0.29	0.13
Gallagher et al. (2005)					Maia et al. (2012)			Serra-Pereira et al. (2010)			
A_0	A_{max}	Linf	k	to	L50	L95	Fec.	aW	bW	M	r
0	15.1	73.1	0.23	-2.47	56.5	66.4	63	0.0006	3.58	0.30	0.21
Fahy (1989)					Maia et al. (2012)			Serra-Pereira et al. (2010)			

3. Exploratory assessments

3.1. Scenarios

Two different model configurations under three scenarios will be tested:

1) Use the combined index (1998-2022) and consider uncertainty in the biomass data from 2015 onwards.
2) Use the combined index (2008-2022) and consider uncertainty in the biomass data from 2015 onwards.

3.2. Definition of the priors

Initial depletion rate

The data series starts around 2000´s, when the stock was probability at lower levels of biomass due to fishing. In fact, in this time period, the stock size indicator is at the lowest values of the time series. Therefore, a prior for B/k was tested, assuming levels ranging from 0.2 to 0.5.

Intrinsic rate of biomass increase

A prior value was considered in several runs, adopting values values presented in table 7.

Production curve

All models considered the Schaefer production curve (logn ~dnorm[log(2), 2^2]) or no prior. Some trials (not presented) with tighter Schaefer were run for some model configurations but no improvements were observed (but can/should be considered in future runs).

3.3. Scenario 1 tests and results (combined index, 1998-2022)

Input data and models configurations:

- Landings (2000-2022)
- Combined index (1998-2022 or 2001-2022) – set at the middle of the year
- Schaeffer production curve
- B/k prior considered
- *r* prior considered
- uncertainty in the biomass index considered (≥2015)

Results are presented in table 9.From the tested models, models 7-9 were those that provided the best fit and could be potentially accepted to assess this stock (results for model 7 are presented in Figures 6 and 7). In the three models, the first 3 years of the biomass series were excluded and there was some uncertainty associated to the last years, related to the uncertainty of the Portuguese LPUE series. The three models differ in the B/k prior but overall results in terms of stock development over time are similar (Figure 8). In addition, all the models considered the highest *r* prior (estimate of 0.41 y^{-1}; Frisk et al. 2001). Models 7, 10 and 11 differ in the *r* prior and results show that lower values lead to larger confident intervals on fishing mortality. However, trajectory on relative biomass and fishing mortality show similar trends (Figure 9). Model 1, despite the good fit, return unrealistic estimates for r (*r*=32.71). Models were also tested disabling priors on *logalpha* and *logbeta* (noise ratios) but had minor effect on the results. The r scripts for the three models are available in the WKBELASMO3 sharepoint (link).

3.4. Scenario 2 tests and results (combined index, 2008-2022)

Input data and models configurations:

- Landings (2000-2022)
- Combined index (2008-2022) – set at the middle of the year
- Schaeffer production curve
- B/k prior considered
- *r* prior considered
- uncertainty in the biomass index considered (≥2015)

Results are presented in table 10. Only model 7 fulfilled the requirements to be accepted for assessment. Model 7 assumes a fixed Schaeffer production curve, a moderate initial exploitation depletion and an *r* prior of 0.41. Difference from other tested models is the lower CV on the r prior (0.2 instead of 0.5). Models were also tested disabling priors on *logalpha* and *logbeta* (noise ratios) but had minor effect on the results. Results for the best model (model 7) are presented in Figures10 and 11, and the r script is available in the WKBELASMO3 sharepoint (link).

Table 9. SPiCT results for scenario 1 (combined index: 1998-2022)

	Priors			Model specific.		Results/Assessment checklist				
Model	Prod. curve	b/k (value/CV)	r (value/CV)	Uncertainty	Others	Converg.	CI (B/Bmsy, F/Fmsy)	Init. Parameters	Retro.	Diagnostics
0	---	---	---	---	---	No				
1*	Schaefer	---	---		---	✓	0,0	✓	✓	Lbox sign (I)
2	Schaefer	---	0.13 (0.5)	---	---	✓	0,7	✓	✓	Shapiro (C)
3	Schaefer	---	0.21 (0.5)	---	---	✓	0,8	✓	✓	Shapiro (C)
4	Schaefer	0.3 (0.5)	0.21 (0.5)	---		✓	0,7	✓	✓	Shapiro (C)
5	Schaefer	0.3 (0.5)	0.21 (0.5)	---	I: Exclude 1998-2000	✓	0,6	✓	✓	✓
6	Schaefer	0.3 (0.5)	0.41 (0.5)	---	I: Exclude 1998-2000	✓	0,3	✓	✓	✓
7	Schaefer	0.3 (0.5)	0.41 (0.5)	I: >2014; cv=3	I: Exclude 1998-2000	✓	0,1	✓	✓	✓
8	Schaefer	0.2 (0.5)	0.41 (0.5)	I: >2014; cv=3	I: Exclude 1998-2000	✓	0,1	✓	✓	✓
9	Schaefer	0.5 (0.5)	0.41 (0.5)	I: >2014; cv=3	I: Exclude 1998-2000	✓	0,1	✓	✓	✓
10	Schaefer	0.3 (0.5)	FishLifelnr and se	I: >2014; cv=3	I: Exclude 1998-2000	✓	0,7	x	✓	Shapiro (C)
11	Schaefer	0.3 (0.5)	0.3 (0.5)	I: >2014; cv=3	I: Exclude 1998-2000	✓	0,3	✓	✓	Shapiro(C)

* *r* value estimated by the model=32.71

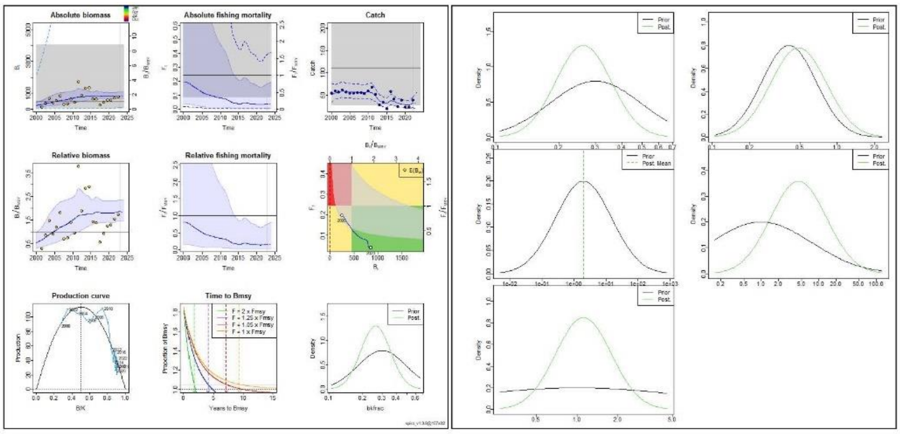

Figure 6 – Scenario 1. Results from model 7.

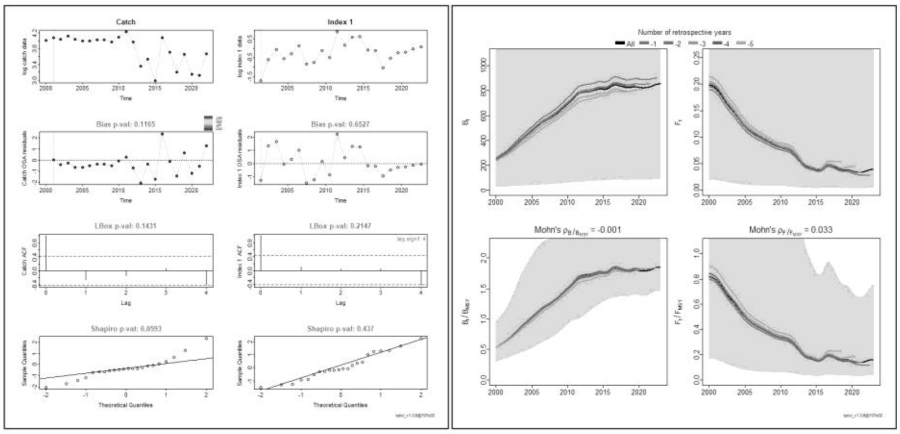

Figure 6 (cont.)– Scenario 1. Results from model 7.

```
Convergence: 0  MSG: relative convergence (4)
Objective function at optimum: 41.8014205
Euler time step (years):  1/16 or 0.0625
Nobs C: 23,  Nobs I1: 22

Priors
 logbkfrac  ~  dnorm[log(0.3), 0.5^2]
      logr  ~  dnorm[log(0.41), 0.5^2]
      logn  ~  dnorm[log(2), 2^2]
  logalpha  ~  dnorm[log(1), 2^2]
   logbeta  ~  dnorm[log(1), 2^2]

Fixed parameters
   fixed.value
 n           2

Model parameter estimates w 95% CI
           estimate       cilow        ciupp    log.est
 alpha    4.4700707   0.5038380   39.6586418  1.4974042
 beta     1.1155965   0.4432880    2.8075557  0.1093893
 r        0.4889615   0.1789836    1.3357831 -0.7154716
 rc       0.4889615   0.1789836    1.3357831 -0.7154716
 rold     0.4889615   0.1789836    1.3357831 -0.7154716
 m      113.6473761  28.1694452  458.5012594  4.7331005
 K      929.7041763 104.2132242 8294.0515676  6.8348664
 q        0.0013726   0.0001188    0.0158627 -6.5910715
 sdb      0.0932475   0.0116582    0.7458333 -2.3724986
 sdf      0.2120260   0.1050996    0.4277374 -1.5510465
 sdi      0.4168227   0.2985827    0.5818863 -0.8750943
 sdc      0.2365354   0.1542789    0.3626486 -1.4416572

Deterministic reference points (Drp)
         estimate      cilow        ciupp   log.est
 Bmsyd 464.8520881 52.1066121 4147.0257838  6.141719
 Fmsyd   0.2444807  0.0894918    0.6678915 -1.408619
 MSYd  113.6473761 28.1694452  458.5012594  4.733100
Stochastic reference points (Srp)
         estimate      cilow        ciupp   log.est rel.diff.Drp
 Bmsys 459.4875432 51.8241703 4073.9446736  6.130112 -0.011675061
 Fmsys   0.2423491  0.0883851    0.6645136 -1.417376 -0.008795685
 MSYs  111.3449637 28.0915706  441.3317118  4.712633 -0.020678191

States w 95% CI (inp$msytype: s)
                   estimate      cilow       ciupp    log.est
 B_2022.94      852.2798638 85.7450982 8471.399313  6.7479150
 F_2022.94        0.0385540  0.0037688    0.394395 -3.2556965
 B_2022.94/Bmsy   1.8548487  1.4634069    2.350996  0.6178031
 F_2022.94/Fmsy   0.1590844  0.0334564    0.756442 -1.8383205

Predictions w 95% CI (inp$msytype: s)
                 prediction      cilow        ciupp    log.est
 B_2024.00      850.6919584 85.0462225 8509.2175365  6.7460501
 F_2024.00        0.0385541  0.0036243    0.4101295 -3.2556921
 B_2024.00/Bmsy   1.8513929  1.4598306    2.3479817  0.6159383
 F_2024.00/Fmsy   0.1590851  0.0315788    0.8014248 -1.8383162
 Catch_2023.00   32.8256141 19.3649883   55.6427365  3.4912091
 E(B_inf)       839.0750198         NA           NA  6.7323001
```

Figure 7. Scenario 1. Results from model 7.

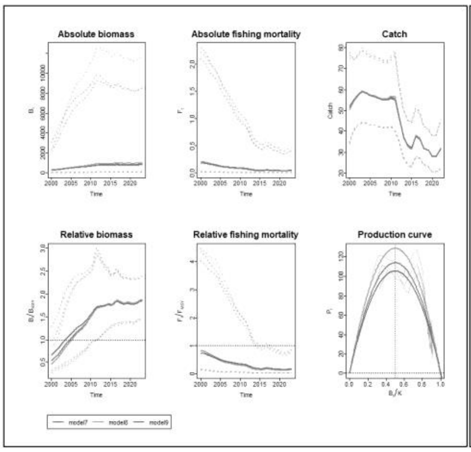

Figure 8. Comparison among SPiCT models 7, 8 and 9 (Scenario1).

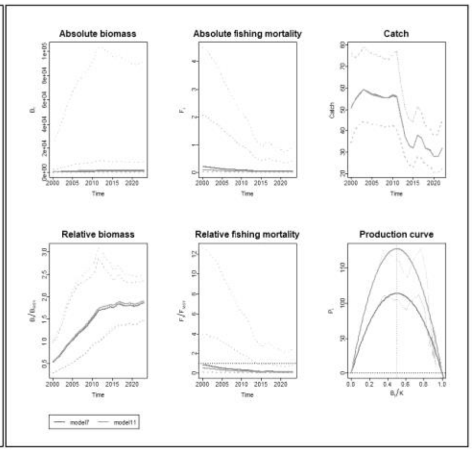

Figure 9. Comparison among SPiCT models 7 and 11 (Scenario1).

Table 10.SPiCT results for scenario 2 (combined index: 2008-2022)

	Priors			Model specific.		Results/Assessment checklist				
Model	Prod. curve	b/k (value/CV)	r (value/CV)	Uncertainty	Others	Converg.	CI (B/Bmsy, F/Fmsy)	Init. Parameters	Retro.	Diagnostics
0	---	---	---	---	---	No				
1	Schaefer	---	---	---	---	No				
2	Schaefer	---	0.21 (0.5)	---	---	✓	1,7	✓	×	×
3	Schaefer	0.3 (0.5)	0.21 (0.5)	---	---	✓	2,1	×	✓	Shapiro (C)
4	Schaefer	0.3 (0.5)	0.21 (0.5)	I: >2014; cv=3	---	✓	0,3	×	×	✓
5	Schaefer	0.5 (0.5)	0.21 (0.5)	I: >2014; cv=3	---	✓	0,3	✓	✓	✓
6	Schaefer	0.5 (0.5)	0.41 (0.5)	I: >2014; cv=3	---	No				
7	Schaefer	0.5 (0.5)	0.41 (0.2)	I: >2014; cv=3	---	✓	0,1	✓	✓	✓
8	Schaefer	0.5 (0.5)	0.41 (0.2)	---	---	✓	0,3	x	✓	✓
9	Schaefer	0.3 (0.5)	0.41 (0.2)	I: >2014; cv=3	---	✓	0,1	x	✓	✓
10	Schaefer	0.5 (0.5)	0.21 (0.2)	I: >2014; cv=3	---	✓	0,3	✓	✓	✓

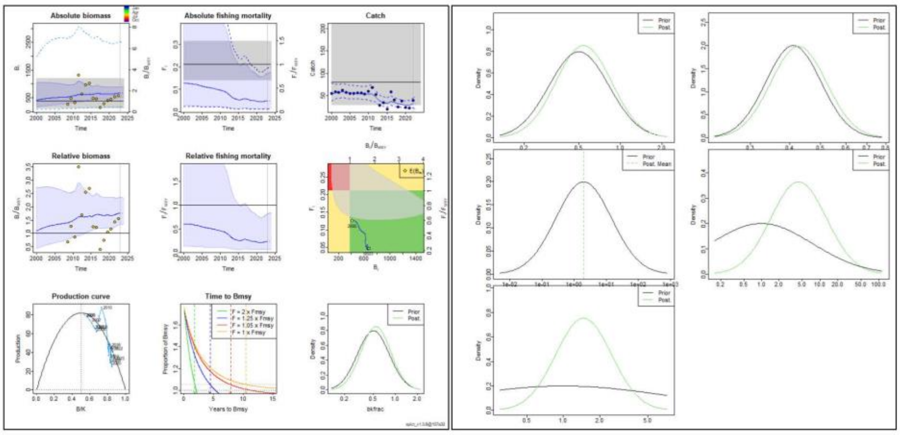

Figure 10 – Scenario 2. Results from model 7.

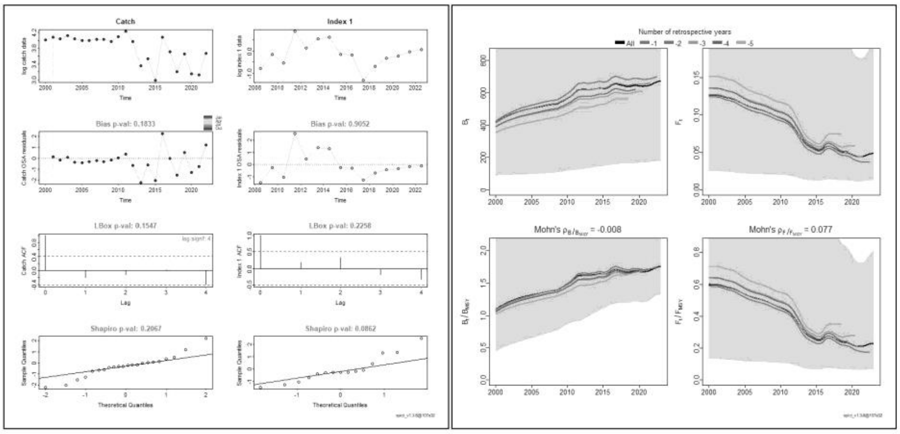

Figure 10 (cont.) – Scenario 2. Results from model 7.

```
Convergence: 0  MSG: relative convergence (4)
Objective function at optimum: 34.282431
Euler time step (years):  1/16 or 0.0625
Nobs C: 23,  Nobs I1: 15

Priors
 logbkfrac  ~  dnorm[log(0.5), 0.5^2]
      logr  ~  dnorm[log(0.41), 0.2^2]
      logn  ~  dnorm[log(2), 2^2]
  logalpha  ~  dnorm[log(1), 2^2]
   logbeta  ~  dnorm[log(1), 2^2]

Fixed parameters
   fixed.value
 n           2
```

```
Fixed parameters
   fixed.value
 n           2

Model parameter estimates w 95% CI
          estimate       cilow        ciupp    log.est
 alpha   4.3019483   0.5016631   36.8908134  1.4590680
 beta    1.4718341   0.5211866    4.1564682  0.3865093
 r       0.4257481   0.2864758    0.6327288 -0.8539074
 rc      0.4257481   0.2864758    0.6327288 -0.8539074
 rold    0.4257481   0.2864758    0.6327288 -0.8539074
 m      81.9901589  29.8556362  225.1630518  4.4065992
 K     770.3160990 242.8848824 2443.0787398  6.6468009
 q       0.0017918   0.0003791    0.0084702 -6.3245173
 sdb     0.0909138   0.0119869    0.6895300 -2.3978434
 sdf     0.1655930   0.0700821    0.3912704 -1.7982224
 sdi     0.3911065   0.2649732    0.5772821 -0.9387753
 sdc     0.2437254   0.1642604    0.3616336 -1.4117131

Deterministic reference points (Drp)
         estimate       cilow        ciupp   log.est
 Bmsyd 385.1580495 121.4424412 1221.5393699  5.953654
 Fmsyd   0.2128741   0.1432379    0.3163644 -1.547054
 MSYd   81.9901589  29.8556362  225.1630518  4.406599
Stochastic reference points (Srp)
         estimate       cilow        ciupp   log.est rel.diff.Drp
 Bmsys 380.4756806 120.9748099 1196.6271628  5.941422 -0.012306618
 Fmsys   0.2108371   0.1414532    0.3142541 -1.556670 -0.009661312
 MSYs   80.2088324  29.6713538  216.8238377  4.384634 -0.022208608

States w 95% CI (inp$msytype: s)
                   estimate       cilow        ciupp    log.est
 B_2022.94      669.6320320 178.0898281 2517.8701277  6.5067284
 F_2022.94        0.0481299   0.0119989    0.1930578 -3.0338521
 B_2022.94/Bmsy   1.7599864   1.3240657    2.3394249  0.5653061
 F_2022.94/Fmsy   0.2282800   0.0646022    0.8066565 -1.4771824

Predictions w 95% CI (inp$msytype: s)
                 prediction       cilow        ciupp    log.est
 B_2024.00      671.6448403 179.6250277 2511.3804980  6.5097297
 F_2024.00        0.0481300   0.0115318    0.2008797 -3.0338486
 B_2024.00/Bmsy   1.7652767   1.3362681    2.3320183  0.5683074
 F_2024.00/Fmsy   0.2282808   0.0618478    0.8425861 -1.4771789
 Catch_2023.00   32.2811714  20.4305901   51.0055767  3.4744841
 E(B_inf)       667.2927936          NA           NA  6.5032289
```

Figure 11 – Scenario 2. Results from model 7.

Discussion

- From the two scenarios compared, scenario 2 lead to poor fits, which can reflect the lack of contrast and short biomass time series.
- In scenario 1, better fits were obtained when excluding the first three years of the biomass (1998-2000), given the uncertainty in the estimates (lower number of hauls in 1998 and 2000).
- In scenario 1, the different prior values on the depletion rate (B/k) (0.2-0.5) lead to similar trajectories in the relative biomass and fishing mortality.
- In both scenarios, increasing the uncertainty in the last years of the biomass index (from 2015 onwards) contribute to get better fits.
- In both scenarios, the value of the *r* prior was found to affect the fit of the model and particularly the CI for fishing mortality: higher values lead to tighter CI and acceptable assessments.
- *r* values estimated varied between 0.08 and 0.60. All are acceptable for elasmobranch species (Cortés, 2016), and are lower than results for other skate species (e.g., Barnett et al., 2013; Cortés et al., 2023).
- In elasmobranchs, low *r* values are often related to larger species (Frisk et al., 2001).
- Within ICES WKELASMO, *r* values adopted ranged from 0.105 for the thornback ray (rjc.27.8abd) to 0.337 for the blonde ray (rjh.27.4bc7d).
- *r* estimates are sensitive to the input parameters.
- Despite the low prior admitted, rjn.27.678abd assessment with SPiCT result in a *r* estimate of 0.52 (ICES, 2022b).
- There is a degree of uncertainty and/or variation in the input parameters to any model. A range of scenarios that consider different sets of life history parameters that reflect uncertainty or variation must be considered (Simpferdorfer, 2005).

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Data compilation for the assessment of cuckoo ray (*Leucoraja naevus*) in Division 9.a (Atlantic Iberian waters)

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Abstract

The present working document presents the information available for the assessment of *Leucoraja naevus* in Iberian waters (ICES division 27.9a), including landings, discards, length distribution from landings, survey data and commercial indices. Results of previous assessments using rfb rule and length based indicators (LBI) are also presented.

Content

1. Introduction

The cuckoo ray (*Leucoraja naevus*) is a species with a wide geographic distribution in the north-east Atlantic and Mediterranean (Stehmann and Bürkel, 1984; Ellis et al. 2005). In the Atlantic Iberian Waters, it is distributed along the entire coast at depths ranging from 30 m to 700 m. In Portuguese waters, it is more abundant in the south-west and southern regions at depths shallower than 500 m. In Galicia waters, the species is found along the continental shelf mainly between 70 to 200 m depth and in the Gulf of Cadiz it occurs along the whole area being particularly abundant in the range between 260 and 520 m depth ICES, 2020; 2021a).

This stock (rjn.27.9a), which comprises the ICES Division 9a, includes the north Spanish area (Galician waters), Portuguese waters and south Spanish waters (Gulf of Cadiz). It is assessed since 2014 under category 3 of ICES Data limited stocks (DLS) using biomass indicator trends estimated from survey data. The surveys used in the assessment are the two Spanish bottom trawl surveys, *ARSA* (SpGC-GFS-WIBTS-Q1&Q4) carried out in spring and autumn, in the Gulf of Cadiz (9a South). Biomass and abundance indices based from the Portuguese Crustacean Survey (NepS (FU28-29)) have been used as auxiliary information but not in the advice due to the irregularity of the series. The north Spanish bottom trawl survey (SpNGFS-WIBTS-Q4), does not provide a biomass index for this species in 9a Division (Fernández-Zapico et *al.*, 2021).

Scientific advice on this stock is provided by ICES WGEF every two years. Last assessment was conducted in 2022 and the rfb rule was applied for the first time during the WGEF 2022 to assess the status of cuckoo ray (*Leucoraja naevus*) in Iberian waters ICES Division 9.a (stock rjn.27.9a).

Previous catch advice (Ay) given in 2020 was 120 t which corresponded to landings of 84 t. Following the *rfb* method the catch advice for 2023 and 2024 should not exceed 84 tns which implies landings no more than 71 t. This corresponds to a decrease of 30 % compared to previous advice since the stability clause was considered and applied to limit the reduction in landings advice to 30%.

At the ACOM meeting, in March 2021, it was agreed to implement the WKLIFE X Annex 3 methods for all category 3 stocks. Among some of the methods suggested to obtain reference points (RP) for data limited stocks (DLS) are production models (ICES, 2021b) and particularly the stochastic surplus production model in continuous time (SPiCT; Pedersen and Berg, 2017). In this working document we provide the data available to evaluate future assessments of the stock rjn.27.9a with a SPiCT model. The analysis will be done during a benchmark meeting that will be held in Copenhagen in March 2024.

2. Biomass indices

Two biomass indices are available to assess *L. naevus* in ICES area 9a. One is obtained from Spanish research surveys and the other from Portuguese commercial polyvalent fleet. Additionally the Portuguese research survey targeting *Nephrops norvergicus* (FU 28–29) data is provided as complementary information that could be likely used although is not updated

2.1. Survey index

The biomass survey index used in this analysis corresponds to the normalized biomass index obtained from the two annual bottom trawl surveys carried out in spring and autumn in the south of Spain (SpGC-GFS-WIBTS-Q1-4). This area (9aS) represents a fraction of the total 9a ICES area.

The biomass index of *L naevus* (1998-2022) fluctuatedg with an increasing trend until 2018 (maximum of the time series). In 2020 the biomass dropped to lower levels and recovered in 2022 (Figure 1). Due to problems with the research vessel, the survey was not conducted in 2021.

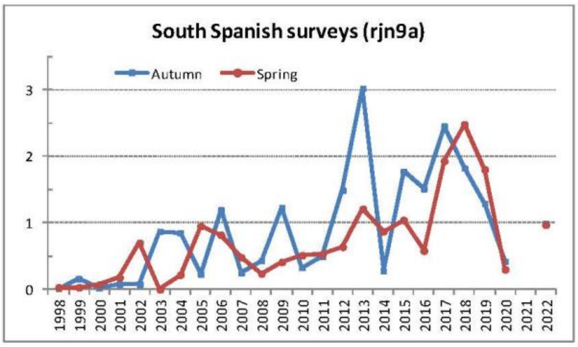

Figure 1. *Leucoraja naevus* in ICES Division 27.9a. Evolution of biomass index obtained from the two South Spanish bottom trawl surveys (ARSA) in ICES Division 9aS conducted in spring and autumn.

2.2. LPUE Data

During the WKSKATE meeting (ICES, 2023) it was acknowledged the adequacy of the commercial LPUE series from the Portuguese polyvalent fleet. The polyvalent fleet includes vessels licensed to operate with several fishing gears mainly gillnets, trammel nets, longlines and traps. The main concern from the reviewers about the methodology proposed was the non-inclusion of the zeroes in the analysis. The justification for this approach relies on the fact that it is not possible to distinguish real zeroes mainly due to: 1) is a by-catch species from the polyvalent fleet fisheries, so absence of the species in the catch is more related to the fishing strategy and selectivity of the gear; 2) the species has a patchy distribution and the information available is not georeferenced; 3) the weight landed per trip results from the application of estimates, which can lead to false zeros.

Details on the LPUE estimation methodology can be found in Serra-Pereira *et al.* (2020) and ICES 2021 (Report). In 2022, the model was updated (explained variance = 54%, AIC= 30777). The best model selected with the updated dataset included the variables years, quarter, vessel size, fishing seasonality on skates and rays and fishing gear (trammel nets or gillnets). The annual biomass index (kg/trip) is shown in Figure 2.

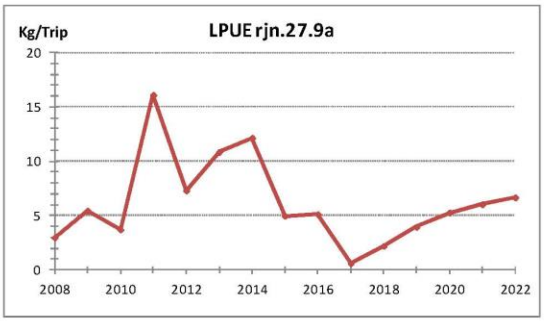

Figure 2. *Leucoraja naevus* in ICES Division 27.9a. Evolution of biomass index LPUE obtained from the Portuguese polyvalent fleet.

2.3. Portuguese survey data

The Portuguese crustacean survey also catch *L. naevus* specimens but catch rates are very low (Figure 3). The biomass index is presented in Figure 4 for the years 1997-2018 (details on the methodology used can be found in the stock annex). The survey was not conducted in 2019 and 2020 and a new vessel started to operate in 2021, with no calibration studies. New methodologies to obtain the biomass index are being tested and, if successful can be applied to this species.

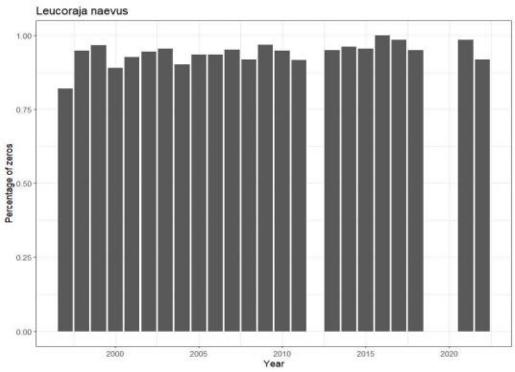

Figure 3. *Leucoraja naevus* in ICES Division 27.9a. Percentage of hauls with zero catch of *L. naevus* in the Crustacean survey, by year.

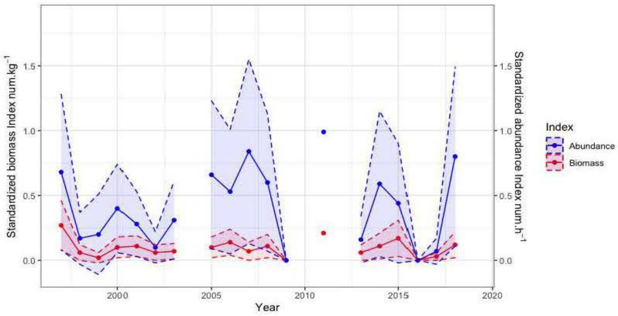

Figure 4. Abundance and biomass index of *Leucoraja naevus* caught in ICES 9a NepS (FU 28–29) surveys (9aC) from 1997 to 2018. Shaded areas represent the standard error.

Table 1. *Leucoraja naevus* in ICES Division 27.9a. Yearly values of the biomass indices (survey data and LPUE). The stock indicator is the average of the normalized biomass index from Spanish groundfish surveys in Gulf of Cadiz (SpGC-GFS-WIBTS-Q1-Q3) and the Portuguese LPUE series.

	Survey data			Commercial PT fleet		
Year	Spring (Kg/haul)	Autum (Kg/haul)	Mean Normaliz.	LPUE (kg/trip)	LPUE Normaliz	Stock Indicator
1998	0.03	0.01	0.03			0.03
1999	0.03	0.16	0.12			0.12
2000	0.07	0.02	0.06			0.06
2001	0.18	0.08	0.18			0.18
2002	0.70	0.08	0.56			0.56
2003	0.00	0.87	0.51			0.51
2004	0.22	0.85	0.66			0.66
2005	0.95	0.23	0.84			0.84
2006	0.82	1.19	1.30			1.30
2007	0.48	0.25	0.49			0.49
2008	0.24	0.43	0.43	2.99	0.48	0.46
2009	0.41	1.23	1.02	5.46	0.88	0.95
2010	0.51	0.33	0.57	3.71	0.60	0.58
2011	0.53	0.49	0.68	16.08	2.58	1.63
2012	0.64	1.49	1.35	7.30	1.17	1.26
2013	1.21	3.02	2.67	10.85	1.74	2.21
2014	0.87	0.28	0.80	12.15	1.95	1.38
2015	1.04	1.77	1.80	4.98	0.80	1.30
2016	0.58	1.51	1.32	5.13	0.82	1.07
2017	1.93	2.45	2.85	0.62	0.10	1.48
2018	2.48	1.82	2.90	2.21	0.35	1.63
2019	1.80	1.29	2.08	3.97	0.64	1.36
2020	0.30	0.42	0.47	5.28	0.85	0.66
2021	0.00	0.00	*	6.05	0.97	0.97
2022	0.97	0.99	1.30	6.66	1.07	1.18

*In 2021 there was not survey biomass index available, only LPUE data.

Based on the two biomass index, the one from the average of Spanish groundfish surveys in Gulf of Cadiz (SpGC-GFS-WIBTS-Q1-Q3) and the LPUE index from Portuguese fleet we obtained the stock indicator showed on Figure 5 and Table 1.

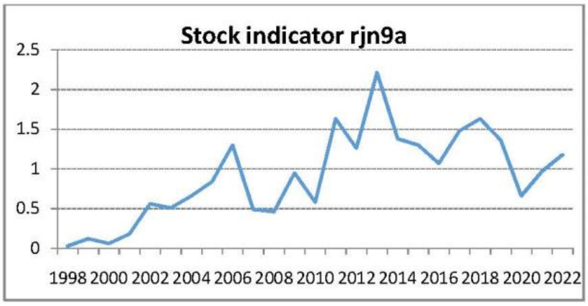

Figure 5. *Leucoraja naevus* in ICES Division 27.9a. Biomass indicator for the period 1998-2022. It corresponds to the standardized average of biomass index from Spanish groundfish surveys in Gulf of Cadiz (SpGC-GFS-WIBTS-Q1-Q3) and the LPUE index from the Portuguese polyvalent fleet.

3. Catch data (Landings and discards)

Catch data used correspond to landings (t) of *Leucoraja naevus* by the Portuguese and Spanish fleets operating in this area ICES Div.9a. Species-specific landings were only available since 2008 and 2009 for Portugal and Spain respectively. However in order to obtain a longer time series, landings since 2000 have been estimated both for the Spanish and Portuguese fleets independently. In the case of the Spanish landings, the estimates are based on the average of the proportion of landings obtained for each stock in the years where there is specific information (2010-2022). Details on Portuguese landings estimates for the period 2000-2007 are presented in Maia et al. (2023 WD).

Portuguese landings represent on average 91% of the total landings reported in this area (Figure 5). Landings have been relatively stable, around 55 t, from 2000 to 2012. Since 2013 that landings fluctuated around 38 t.

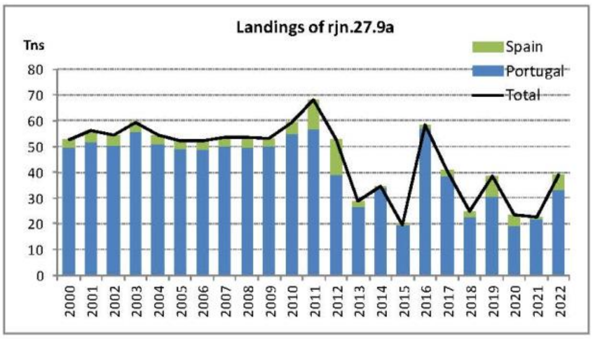

Figure 5. Landings of *L. naevus* by the Portuguese and Spanish fleet in Div.9a.

Discard data for the Portuguese fleet is considered negligible while the discard data available for the Spanish fleet, since 2015, is relative low but highly variable (Table 2). In terms of landings by fishing gear, most are provided by the Portuguese polyvalent fleet (between 67 and 81% in the last three years for the overall stock landings, using mainly nets). Bottom trawlers also account for a large proportion of the catches (Figure 6).

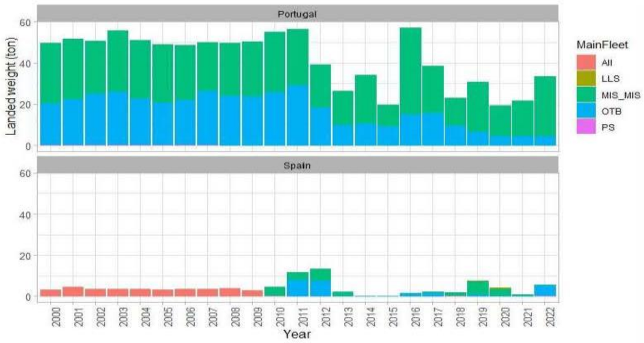

Figure 6. *Leucoraja naevus in* 9a. Landings by country and fishing gear. On the top Portuguese landings on the bottom Spanish landings.

Table 2. *Leucoraja naevus* in ICES Division 27.9a. Total landings (tns) and discards. Data from 2000.2009 has been estimated.

Year	Spain	Portugal	Discards*	Total Catch
2000	3.0	49.6		52.6
2001	4.4	51.6		56.0
2002	3.6	50.7		54.3
2003	3.7	55.6		59.3
2004	3.5	50.9		54.4
2005	3.4	49.1		52.4
2006	3.7	48.6		52.2
2007	3.5	50.0		53.5
2008	3.7	49.8		53.5
2009	3.0	50.2		53.2
2010	4.4	55.0		59.4
2011	11.5	56.4		68.0
2012	13.4	39.2		52.6
2013	2.1	26.5		28.6
2014	0.2	34.2		34.3
2015	0.1	19.6	4.0	23.7
2016	1.4	57.2	41.0	99.6
2017	2.2	38.5	22.0	62.7
2018	1.9	22.9	15.9	40.6
2019	7.8	30.6	7.3	45.7
2020	4.1	19.2		23.4
2021	1.0	21.7		22.7
2022	5.6	33.4	2.6	41.6

4. Lengths and Life history parameters

In the 2022 assessment, length frequency distributions from landings for the combined trawl and polyvalent Portuguese fleet were used to determine *f* proxy (Figure 7).

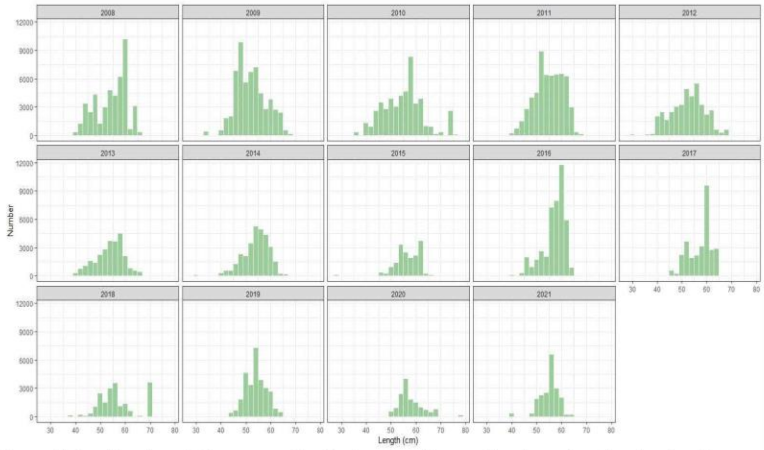

Figure 7. Landings length frequency distributions for the combined trawl and polyvalent Portuguese fleet (bin 2 cm).

Length distribution range from 35 cm to 70 cm. Although yearly variations mean length is between 50.3 cm -57.7 cm and maximum observed length is 70 cm. To estimate asymptotic length for LBI analysis we used Froese (2004) equation (Table 3). Studies conducted in other ICES area provide different values according to ICES areas but very close to 70-75 cm (Ellis et al., 2023).

Table 3. Biological parameters used for calculating the LBI parameters on this stock rjn.27.9a.

Parameter	Value	Definition	Source
L∞ (cm)	75	Asymptotic average maximum length	Linf=Lobs / 0.95 (Froese, 2004)
Lmat	56.2	Length at 50% maturity	Maia et al., 2012
a	0.0027	Condition factor parameter of length-weight relationship	IEO Data base (DELASS)
b	3.204	Slope parameter of length-weight relationship	IEO Data base (DELASS)

5. Survival studies

According to some survival studies reported in the area, survival of this species is low compared to other Rajidae species. The results from an experimental study on board of a commercial trawl vessel operatingin the ICES 9a area indicate that ~ 66.8% of the *L. naevus* specimens caught (n=

503) survive to fishing operations and handling onboard. However the estimated survival after 36 h of captivity was 27% (21-36%). More information can be found in Valeiras et al. (2019).

Several factors may influence the survival estimate: characteristics of the haul, rough weather at sea during half of the fishing days, transport and onboard captivity conditions.

Leucoraja naevus caught by OTB in division 27.9a was excluded from the high survivability exemption in 2020 (Commission Delegated Regulation (EU) 2019/2237).

6. Previous assesments

6.1. Rfb rule

The rfb rule (ICES, 2021a) was applied for the first time during the WGEF 2022 to assess the status of *Leucoraja naevus* in Iberian waters ICES Division 9.a. Previous assesments were done following the 2 over 3 rule. Stock indicator used corresponded to the standardized average of biomass index from Spanish groundfish surveys in Gulf of Cadiz (SpGC-GFS-WIBTS-Q1-Q3) and the LPUE index from the Portuguese polyvalent fleet for the period 1998-2021. More information on the sharepoint WGEF 2022 and WD (Rodriguez-Cabello et al., 2022).

Following the ICES guidance on the parameter determination for the rfb rule (ICES, 2021a; ICES, 2022), the input values for applying rfb rule on rjn.27.9a are presented in Table 4.

Previous catch advice (A_y) was 120 t catches corresponding to 84 tns landings. According to the rfb guidelines the catch advice for 2023 and 2024 should not exceed 84 t which implies landings no more than 71 t. This corresponds to a decrease of 30 % compared to previous advice since the stability clause was considered and applied to limit the reduction in landings advice to 30%.

Table 4. *Leucoraja naevus* in ICES Division 9a (rjn.27.9a). Estimates used in the rfb rule, with comments.

Variable	Estimate	Input data	Comment
r: Stock biomass trend	0.41	Stock-size indicator: Biomass survey index and standardized commercial LPUE from Portuguese polyvalent fleet.	Index A (2020, 2021) = 0.582 Index B (2017, 2018, 2019) = 1.433
b: Biomass safeguard $= \min(1. I_{y-1}/I_{\text{trigger}})$ $I_{\text{trigger}} = I_{\text{loss}}\ \omega$ Considering $\omega = 1.4$	1	Stock indicator; I_{loss}, minimum estimate (1998) = $I_{trigger}$ = 0.035 $(\frac{I_{y-1}}{I_{\text{trigger}}} = 13.57)$	The series shows an increasing trend since its beginning but in the last 2 years index values decreased.
m linked to von Bertalanffy k	0.95	k estimated from the Von Bertalanffy model adopted for the species	
f: Fishing proxy	1.14	Length data collected under the sampling program raised to the overall landings. Length data were from 2019 to 2021. L_{mean}=56.4 cm $L_{F=M}$= 49.5 cm	To overcome deficiencies in sampling in 2020 due to covid disruption, data from 2019-2021 was combined. See more information below.
Ay × r × f × b × m	84 t		The stability clause was applied to limit the reduction in landings advice to 30%. in relation to the previous catch advice (A_y of 120 t).

6.2. Estimation of length-based indicators (F proxy)

In the last assessment conducted in 2022, to determine *f* proxy, landing length frequency distributions used were those from the combined trawl and polyvalent Portuguese fleet in the last period as agreed during the WGEF (Figure 7). Due to Covid related data collection constrains, data for the period 2019-2021 was combined, according to WGEF decision. Only Portuguese length data was available. Discard data are only available from the Spanish trawl fleet for the period 2015-2019 but length information is deficient. Input parameters used to estimate length based indicators were L_{mat} = 56.2 and L_{Inf} = 75 cm.

To determine F proxy based on length-based indicators estimates of L_{inf}, L_{50} and *a* and *b* parameters from the weight-length relationship were used. These parameters are defined for this stock (Table 3). Length classes of 2 cm were adopted. LBI analysis resulted in L_c= 41.0 cm, L_{mean}=56.36 cm and $L_{F=M}$= 49.50 cm for the period 2019-2021.

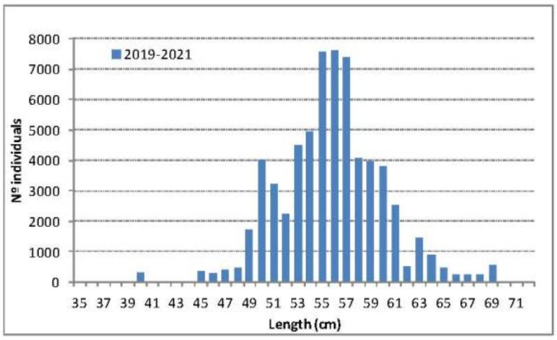

Figure 7. *Leucoraja naevus* in ICES Division 27.9a. Length–frequency distribution for the Portuguese fleet, polyvalent and trawl fleets combined, and for the period for 2019-2021 (combined).

6.3. SPiCT Trials

In 2022 some trials with SPICT were presented to the WGEF. At that moment the model was run with the following data:

Input data:

- Stock landings (2008-2021)
- PT LPUE (2008-2021)
- ARSA Surveys (normalized; 2008-202=; no survey in 2021*)

Priors:

- Schaeffer production curve (inp$phases$logn <- -1)
- Initial depletion (inp$logbkfrac = c(log(0.25),0.2,1)

Preliminary results were presented in a WD during the WGEF 2022 (Rodriguez-Cabello et al., 2022).

Management measures

Rajidae are managed under a total allowed catch (TAC) management system in EU waters. Since 2009 EU Member States have been required to provide species-specific landings data for the major of species of rays and skates (EU Regulation 43/2009).

On 22 August 2014 the Portuguese government adopted national legislation (Portaria no. 170/2014) that established a minimum landing size of 520 mm (total length) for specimens of the genus *Leucoraja* or *Raja*, covering all of the continental Portuguese EEZ. In 2022, the minimum landing size was updated to 60 cm total length for all *Raja* spp. and *Leucoraja* spp. (Portaria nº 255/2022). Portuguese regulations (Portaria no. 315/2011, updated by Portaria no. 47/2016) also prohibits the catch, retention onboard, and landing of any skate species belonging to Rajiformes during the months of May and June, which covers the spawning period of the species. During these two months, vessels are permitted to retain on board and to land a maximum of 5% bycatch, in weight, of the Rajiformes species per trip.

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