Institut Català de Recerca per a la Governança del Mar

State of fisheries in Catalonia 2025, Part 2:

Stock assessment

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Glossary

B_{curr}: Biomass current, in the period of time analyzed.

BKfrac: Ratio between biomass in the initial year relative to K. Stock depletion level at the beginning of the time series.

B_{lim}: Biomass limit, defined as the lowest biomass from which a recovery has been confirmed. 30% of B_{msy}.

B_{th}: Biomass threshold. 50% of B_{msy}.

B_{msy}: Biomass at maximum sustainable yield.

B_{tgt}: Biomass target

CPUE: Catch per unit of effort

DCF: Data Collection Framework

F: Fishing mortality

F_{msy}: Fishing mortality at a maximum sustainable yield.

F/M: relative fishing mortality.

F_{tgt}: Fishing mortality target.

F_{curr}: Fishing mortality current, in the period of time analysed.

GNS: Set gillnet

GSA: Geographic Sub-Area

k: Growth rate (Von Bertalanffy Growth Function)

LBSPR: Length-Based Spawning Potential Ratio.

LFD: Length Frequency Distribution

L_{inf}: Length infinity or asymptotic length at which growth is zero (Von Bertalanffy Growth Function)

LLS: Set longline

LLD: Drifted long liner

L_{mat50}: Length where 50% of individuals are mature

L_{mat95}: Length where 95% of individuals are mature

M: Natural mortality

OTB: Bottom otter trawl

PS: Purse seiner

SL_{50}: Length where 50% of individuals are caught

SPR: Spawning Potential Ratio of a stock is defined as the proportion of the unfished reproductive potential left at any given level of fishing pressure.

SPR_{lim}: limit spawning potential ratio. Defined as 10% of SPR, below this value the population will not recover.

SPR_{tgt}: target spawning potential ratio. Defined as 40% of SPR remaining in the sea to achieve maximum sustainable yield.

SPiCT: Stochastic Production model in Continuous Time.

t_0: age at which the organisms would have had zero size (Von Bertalanffy Growth Function)

Executive summary

This report presents the stock assessment results obtained by ICATMAR for reference year 2025. Five demersal stocks (red mullet, European hake, deep-water rose shrimp, Norway lobster and blue and red shrimp) and two small pelagic fish stocks (European sardine and anchovy) were evaluated with length-based (LBSPR) and production (SPiCT) models under different scenarios. For LBSPR, data correspond to the continuous monitoring from ICATMAR in Catalonia (N GSA 6) for years 2019 to 2025. For SPiCT, the report uses official data from the Data Collection Framework (DCF), the EU fleet register and the Spanish Government from the entire GSA 6, for different time spans specified in each corresponding section.

Each model provides different indicators which may lead to different perceptions of the stock status. LBSPR estimates the Spawning Potential Ratio (SPR) whereas SPiCT estimates Biomass and Fishing mortality. Length-based models (LBSPR) make use of the available thorough length-structure data but can handle a high level of uncertainty, mainly due to their sensitivity to input data and biological assumptions. Key limitations include the exclusion of historical catch data and biomass indices. The surplus production model (SPiCT) can incorporate these data, but its results are influenced by the lack of information on the stock's length structure.

For LBSPR, the results indicate that the 2025 SPR for red mullet, European hake and Norway lobster is below SPR_{lim}. For blue and red shrimp, SPR is above SPR_{lim}. In contrast, SPR is above SPR_{tgt} for deep-water rose shrimp (Figure 1). Trends for red mullet and Norway lobster have remained relatively stable over the years, with a slight increase in the terminal year. For European hake, although SPR has remained relatively stable overall, some fluctuations are observed, with a decreasing trend over the last two years. Deep-water rose shrimp shows a fluctuating trend, with a slight increase in SPR in 2025. Blue and red shrimp also shows some fluctuations, with a decrease in the SPR estimate in 2025. Finally, the estimated SPR is above SPR_{lim} for European sardine and above SPR_{tgt} for anchovy (Figure 2). SPR trends are more stable for European sardine and increasing for anchovy.

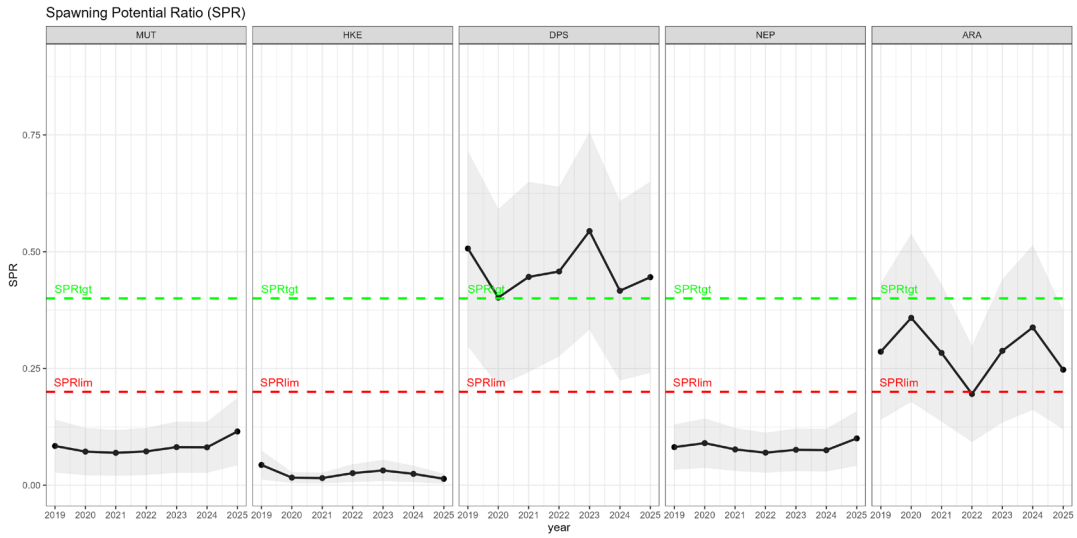


Figure 1. Spawning potential ratio (SPR) per year (2019 to 2025) for the five demersal stocks evaluated with LBSPR model. MUT: red mullet, HKE: European hake, DPS: deep-water rose shrimp, NEP: Norway lobster, ARA: blue and red shrimp, LBSPR: Length-Based Spawning Potential Ratio, SPR_{lim}: limit spawning potential ratio, SPR_{tgt}: target spawning potential ratio. The scenario selected for each species is explained in the corresponding section. The grey shade shows the standard deviation.

According to the SPiCT results, biomass estimates for 2025 are above B_{msy} for red mullet and deep-water rose shrimp, although a slight decrease is observed in the terminal year. European hake shows an increasing biomass trend in recent years, with the 2025 estimate reaching approximately B_{thr}. For Norway lobster and blue and red shrimp, biomass is estimated between B_{thr} and B_{tgt}, with a slight increasing trend in the terminal years (Figure 3a). In terms of fishing mortality, red mullet is clearly below F_{msy}, while Norway lobster and blue and red shrimp are estimated below, but relatively close to, F_{msy}. For European hake, fishing mortality remains above, but close to, F_{msy}. In contrast, fishing mortality for deep-water rose shrimp has shown an increasing trend over time and is estimated to be around F_{msy} in 2025 (Figure 3b). These results should be interpreted with caution for deep-water rose shrimp and Norway lobster, for which the uncertainty around the biomass and fishing mortality estimates is particularly large, encompassing substantially different stock status scenarios.

Overall, the progression of the stocks over the assessment period can be broadly grouped into three categories. Red mullet shows a relatively stable biomass trend and a fishing mortality clearly below F_{msy}, indicating a favorable stock status (Figure 4a). Deep-water rose shrimp has experienced an increase in biomass over time, reaching levels above B_{msy}, although the recent increase in fishing mortality and the slight decline in biomass in the terminal year (Figure 4c). Norway lobster has shown some improvement mainly through a reduction in fishing mortality (Figure 4d), while blue and red shrimp shows a slight increasing trend in biomass (Figure 4e); however, both stocks remain between B_{thr} and B_{tgt} and their fishing mortality is still relatively close to F_{msy}. European hake remains the stock with the least favorable status, with biomass around B_{thr} and fishing mortality above F_{msy}, although the recent increase in biomass and reduction in fishing mortality suggest some progress towards improved stock status (Figure 4b).

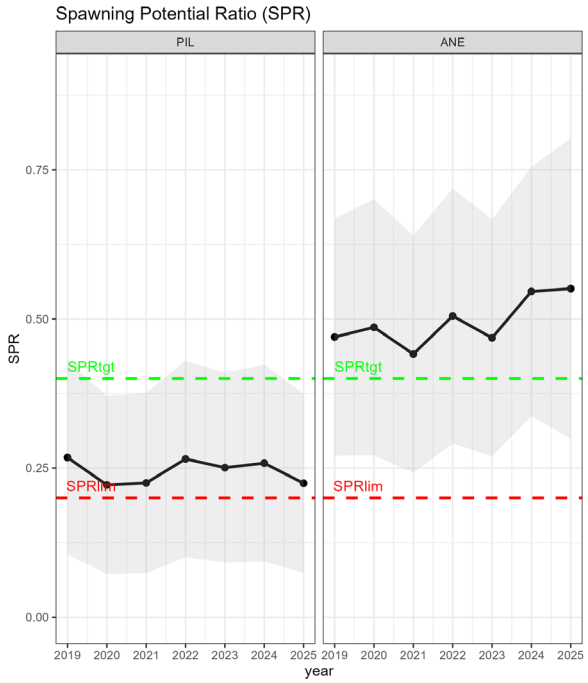
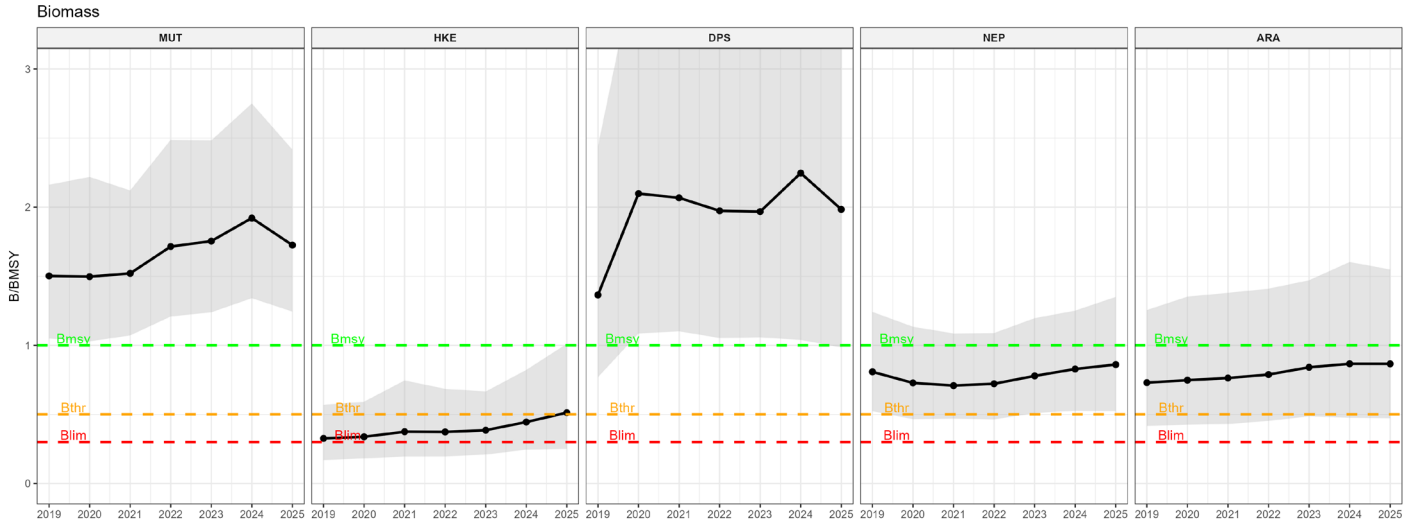


Figure 2. Spawning potential ratio (SPR) per year (2019 to 2025) for the two small pelagic stocks evaluated with LBSPR model. PIL: European sardine, ANE: anchovy, LBSPR: Length-Based Spawning Potential Ratio, SPR_{lim}: limit spawning potential ratio, SPR_{tgt}: target spawning potential ratio. The scenario selected for each species is explained in the corresponding section. The grey shade shows the standard deviation.

a)



b)

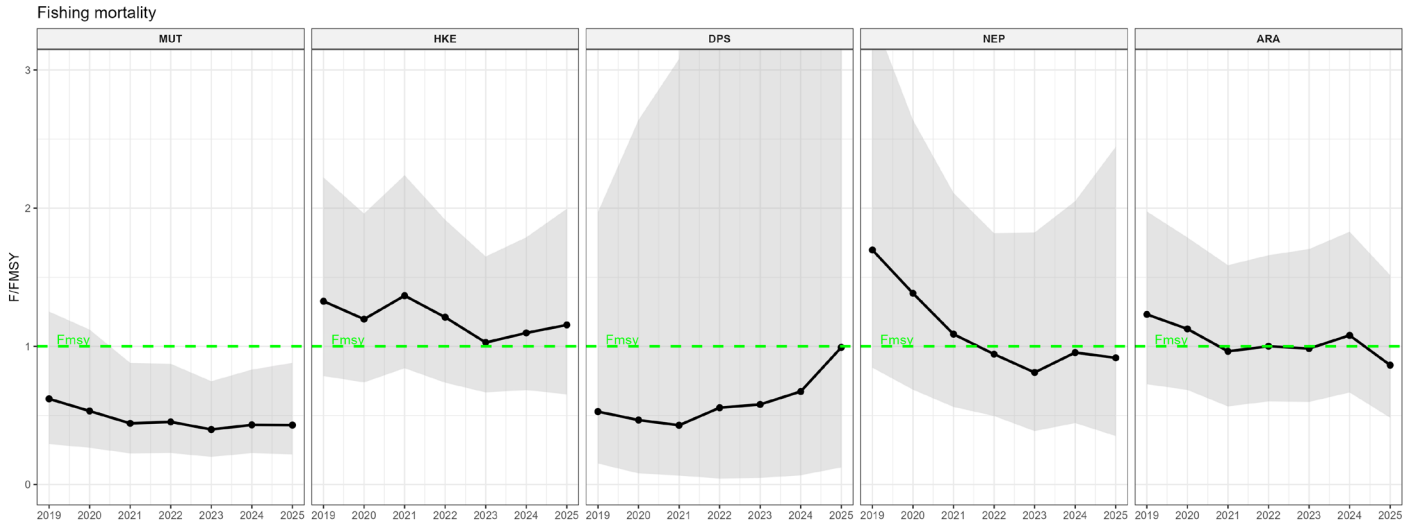


Figure 3. (a) Relative biomass (B_{curr}/B_{msy}) and (b) relative fishing mortality (F_{curr}/F_{msy}) per year (2019 to 2025) for the five demersal stocks evaluated with SPiCT model. MUT: red mullet, HKE: European hake, DPS: deep-water rose shrimp, NEP: Norway lobster, ARA: blue and red shrimp. SPiCT: Stochastic Production model in Continuous Time. F_{msy}: Fishing mortality at a maximum sustainable yield, B_{lim}: Biomass limit, B_{thr}: Biomass threshold, B_{msy}: Biomass target.

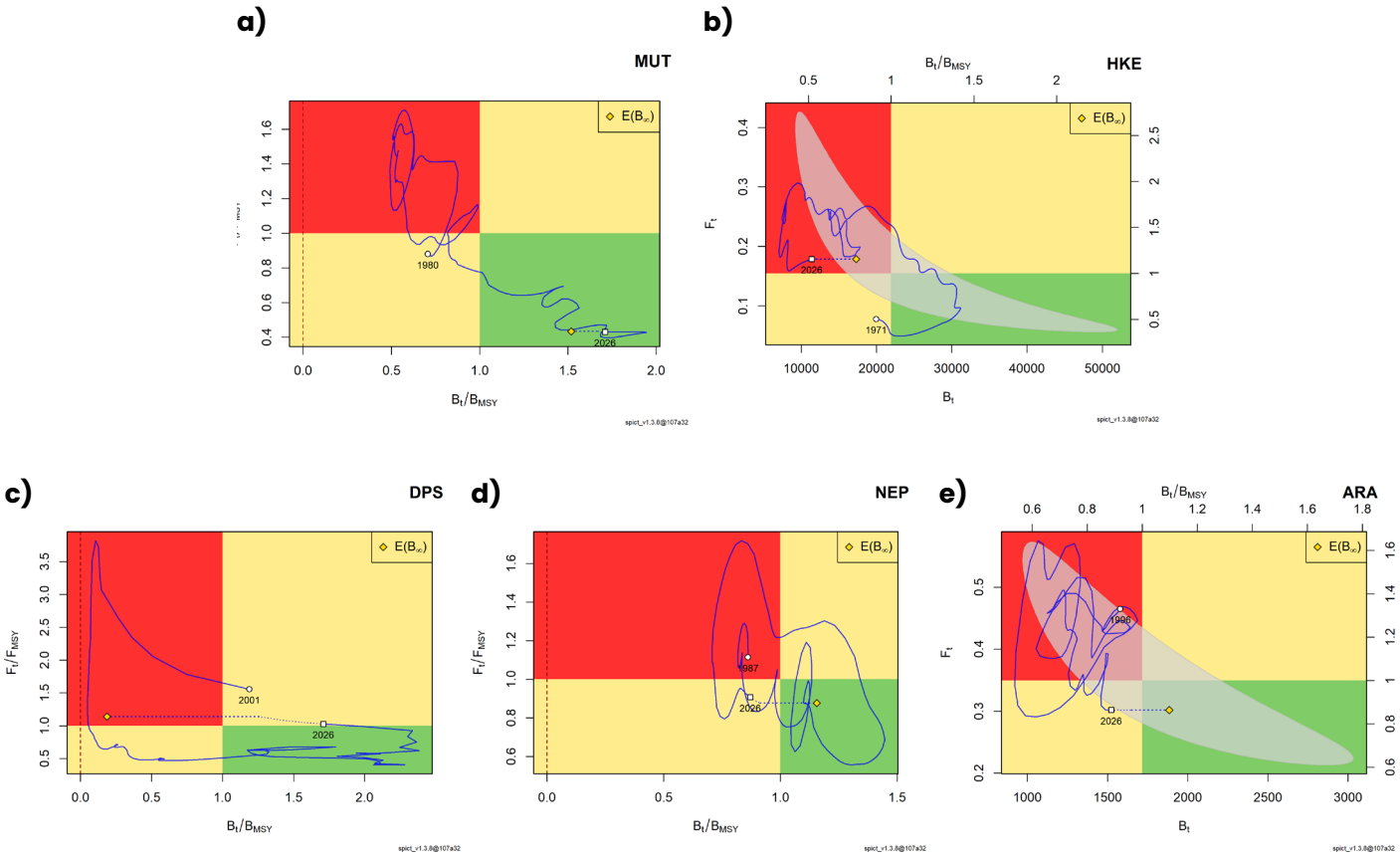


Figure 4. Kobe plots for the five demersal stocks evaluated with SPiCT showing the results for the final scenarios. MUT: red mullet, HKE: European hake, DPS: deep-water rose shrimp, NEP: Norway lobster, ARA: blue and red shrimp. SPiCT: Stochastic Production model in Continuous Time. F_{msy}: Fishing mortality at a maximum sustainable yield, B_{lim}: Biomass limit, B_{thr}: Biomass threshold and B_{msy}: Biomass target. The grey shade shows the uncertainty.

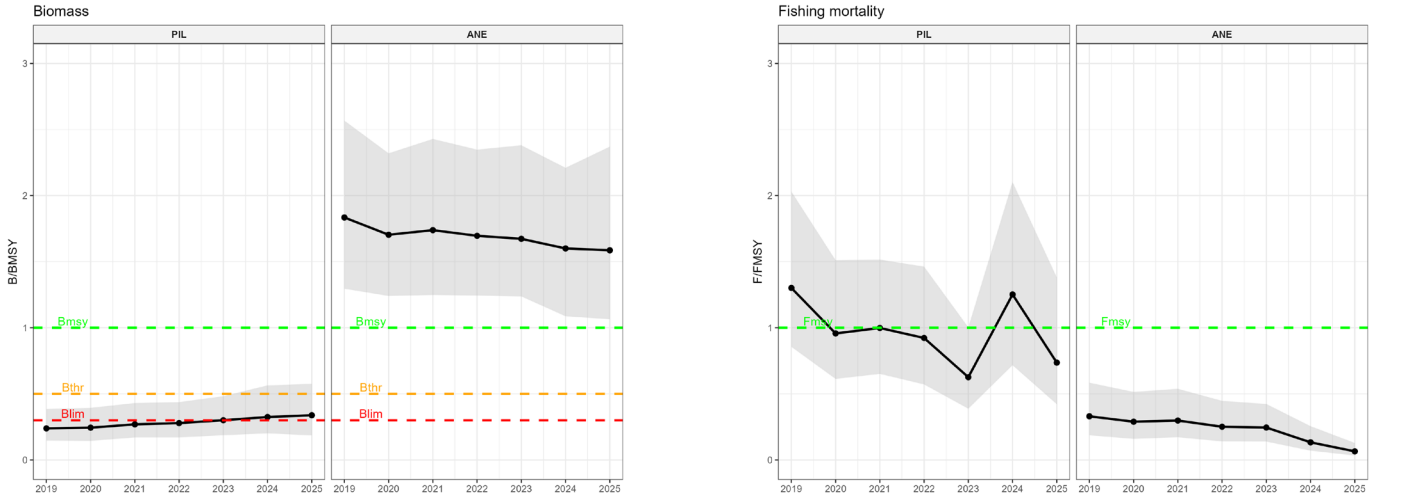


Figure 5. (a) Relative biomass (B_{curr}/B_{msy}) and (b) relative fishing mortality (F_{curr}/F_{msy}) per year (2019 to 2025) for the two small pelagic stocks evaluated with SPiCT model. PIL: European sardine, ANE: anchovy. SPiCT: Stochastic Production model in Continuous Time. F_{msy}: Fishing mortality at a maximum sustainable yield, B_{lim}: Biomass limit, B_{thr}: Biomass threshold, B_{msy}: Biomass target.

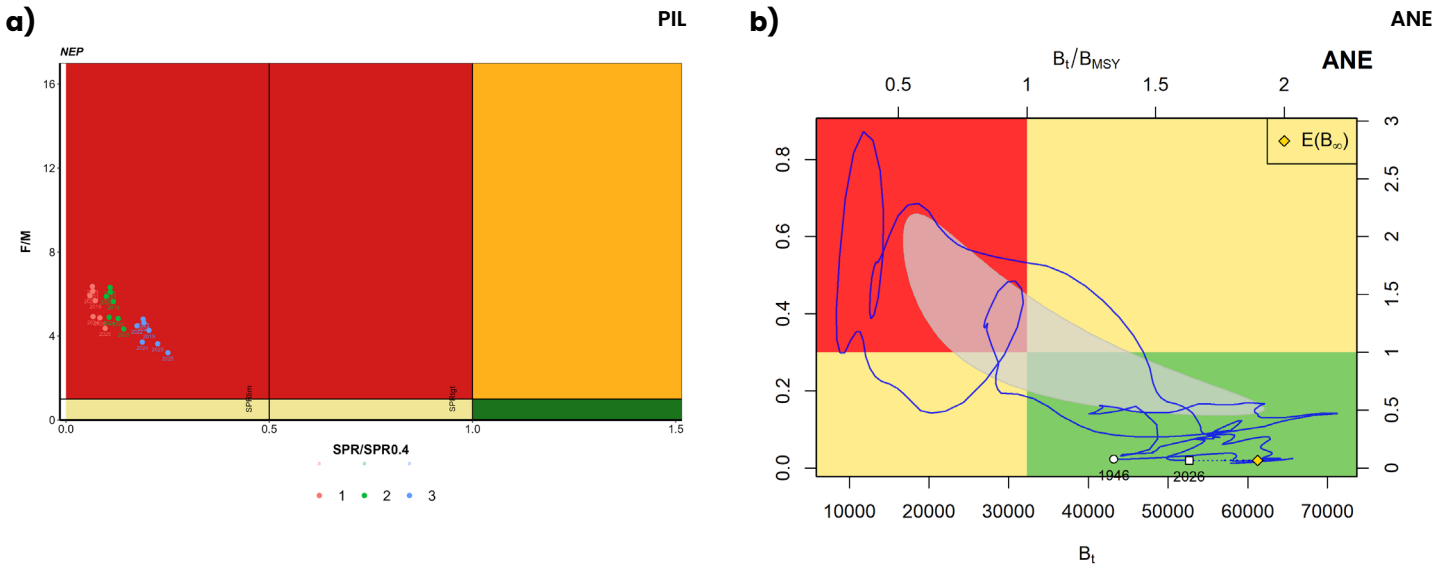


Figure 6. Kobe plots for the two small pelagic stocks evaluated with the SPiCT model. a) PIL: European sardine and b) ANE: anchovy. SPiCT: Stochastic Production model in Continuous Time. F_{msy}: Fishing mortality at a maximum sustainable yield, B_{lim}: biomass limit, B_{thr}: biomass threshold, and B_{msy}: biomass target. The grey shade shows the uncertainty.

For small pelagics, biomass is estimated to be just above B_{lim} for European sardine and above B_{msy} for anchovy. Fishing mortality in 2025 is estimated to be below F_{msy} for both species with a decreasing trend in the case of anchovy (Figure 5, Figure 6)

The advice derived from these models should be considered qualitative in all cases, and the results should be interpreted with caution given the differences in the information and assumptions underlying each modelling approach. Some discrepancies between LBSPR and SPiCT are evident for several stocks. For red mullet, LBSPR estimates a 2025 SPR below SPR_{lim}, whereas SPiCT estimates biomass above B_{msy} and fishing mortality clearly below F_{msy}, indicating a more favorable stock status. A similar discrepancy is observed for European hake, where LBSPR estimates SPR below SPR_{lim}, whereas SPiCT estimates an increasing biomass trend, although biomass remains around B_{thr} and fishing mortality is still above F_{msy}. For Norway lobster, LBSPR also estimates SPR below SPR_{lim}, whereas SPiCT places biomass between B_{thr} and B_{tgt} and fishing mortality below, but close to, F_{msy}. Blue and red shrimp shows a somewhat different pattern, with LBSPR estimating SPR above SPR_{lim}, while SPiCT estimates biomass between B_{thr} and B_{tgt} and fishing mortality below, but close to, F_{msy}. For deep-water rose shrimp, both approaches indicate a relatively favorable status, with LBSPR estimating SPR above SPR_{tgt} and SPiCT estimating biomass above B_{msy}, although fishing mortality has increased over time and is currently around F_{msy}. These discrepancies highlight the importance of considering the different sources of information each model uses when interpreting stock status. LBSPR relies primarily on available length-structure data and is sensitive to biological assumptions and to the quality and representativeness of the length data, whereas SPiCT integrates historical catch and biomass-index information but is subject to uncertainty due to the absence of length-structure data. In particular, the large uncertainty associated with the SPiCT estimates for deep-water rose shrimp and Norway lobster should be taken into account when interpreting their current status. Overall, the differences between model outputs reinforce the need to consider multiple sources of information, including monitoring data, landings and survey indices, rather than relying on a single model to characterize the status of all stocks.

A summary table by stock (Table 1) is provided to allow at-a-glance understanding of the results from the stock assessment models.

The technical grounds for a new systemic biomass indicator are presented. The components that are currently being considered are: a) biomass of a representative group of species; b) size-frequency distribution through biomass spectra; and c) extracted vs. fishable biomass ratio. Based on empirical data, it can complement the current stock assessments while providing a straight-forward, general picture of the state of the exploited system.

Table 1. Stock assessment outputs from LBSPR (Length-Based Spawning Potential Ratio), and SPiCT (Stochastic Production model in Continuous Time). Official STECF assessments for the studied stocks have been included for comparison. A general commentary column is provided, bearing in mind that LBSPR results are from the N GSA 6 in 2025 and SPiCT results are from the entire GSA 6 in 2025 (for demersal stocks) and for N GSA 6 in 2025 (for small pelagic stocks). Up arrows indicate increasing trend; Down arrows indicate decreasing trend; Right arrows indicate stable trend; Up-and-down arrows indicate fluctuating trend. MUT: red mullet, HKE: European hake, DPS: deep-water rose shrimp, NEP: Norway lobster, ARA: blue and red shrimp, PIL: European sardine, ANE: anchovy, SPR: Spawning Potential Ratio, SPR0.4: SPR at 40%, B_{curr}: Biomass for the current year, B_{msy}: Biomass at maximum sustainable yield, F_{curr}: Fishing mortality for the current year, F_{msy}: Fishing mortality at maximum sustainable yield. *For LBSPR, indicator is SPR_{curr}/SPR_{tgt}

Stock	Source	Assessment method	B Ref. Point	F Ref. Point	Ref. Year	Area	Trend B	Trend F	Bcurr /Btgt*	Fcurr /Ftgt	Comments
MUT	This report	LBSPR	SPR	F/M	2025	NGSA6	⇧	⇩	below	above	The MEDITS index indicates an increasing trend. The SPiCT model, which integrates historical data, provides a biomass estimate that aligns closely to this positive trend. In contrast, length-based models (LBSPR) do not reflect this increase. These models suggest stable biomass levels and may not fully capture recent changes in stock dynamics, possibly due to limitations in their reliance on length-frequency data. The a4a model shows similar trends to SPiCT, indicating an increase in biomass.
	This report	SPiCT	B/Bmsy	F/Fmsy	2025	GSA6	⇩	⇳	above	below	
	STECF EWG 25-09	a4a	B/Bmsy	F/Fmsy	2024	GSA6	⇧	⇩	above	below	
HKE	This report	LBSPR	SPR	F/M	2025	NGSA6	⇩	⇧	below	above	Truncated size structure, with minor contribution of adults. Biomass indices show a decreasing trend over time. The MEDITS index suggests recent stability but only reflects smaller fish, while the CPUE indices for longliners and gillnets, which were a biomass indicator for larger individuals, show a drastic decreasing trend over the last few years, although the reasons remain unclear. Length-based models capture current size structure for the fishery but lack historical data and survey information. SPiCT includes historical context for the fishery but misses size and age structure, and results vary depending on the indices used (there is no way to inform the model about which index represents each part of the population). The a4a model, although data-rich, currently does not account for sexual dimorphism or the fishery's historical context, which limits its reliability. Overall, biomass is possibly near the thresholt reference point, and possibly in overexplotation, but with a reduced fishing mortality in recent years. However, the stock remains historically low and will likely take time to recover. Improved selectivity, realistic biological parameters, and fleet-specific historical data are key to rebuilding the stock.
	This report	SPiCT	B/Bmsy	F/Fmsy	2025	GSA6	⇧	⇧	below	above	
	STECF EWG 25-09	a4a	B/Bmsy	F/Fmsy	2024	GSA1-5-6-7	⇧	⇩	below	above	
DPS	This report	LBSPR	SPR	F/M	2025	NGSA6	⇧	⇳	above	below	The MEDITS index is reflected in the model estimates as an increase of biomass. The SPiCT model, which includes a parameter to inform the model about time-varying recruitment and is used in contexts where, for example, environmental factors can affect the dynamics of the stock, provides a biomass estimate that aligns closely with this positive trend. Given the rapid increase in catches and the ability to sustain them, the status of the stock seems positive, but precaution is needed until MSY is identified. Sizes have decreased compared with previous years. In EWG25-09, no advice was given for this stock because the dynamics of the stock are not fully explained by the stock assessment.
	This report	SPiCT	B/Bmsy	F/Fmsy	2025	GSA6	⇩	⇧	above	below	
	STECF EWG 24-10	a4a	B/Bmsy	F/Fmsy	2024	GSA5-6-7	⇧	No advice			
NEP	This report	LBSPR	SPR	F/M	2025	NGSA6	⇧	⇩	below	above	Although biomass has been relatively stable over the last 5 years, the stock is at low biomass levels, even with the historic decrease in F, with no clear trend in the MEDITS index and a decrease in landings in the last decade. SPiCT captures these trends and provides no clear contrast for evaluating biomass, so the stock status may be overexploited. For length-based models, the lack of large individuals conditions the analysis and prevents a positive assessment. Environmental factors (e.g. increase of sea temperature) might be negatively conditioning the species development. Results from a4a are in line with length-based models if we acknowledge the size issue, bearing in mind differences in spatial extension.
	This report	SPiCT	B/Bmsy	F/Fmsy	2025	GSA6	⇳	⇩	below	below	
	STECF EWG 25-09	a4a	B/Bmsy	F/Fmsy	2024	GSA6	⇩	⇳	below	above	
ARA	This report	LBSPR	SPR	F/M	2025	NGSA6	⇩	⇧	below	above	MEDITS index is stable and at high levels in the historical series, while catches and CPUE remain stable. SPiCT estimates increasing biomass and evaluates the stock as possibly sustainably exploited, with trends in line with indices and fisheries data. The status of the stock seems to be more sensitive to length frequency distribution than to the decrease in F. Models that use length frequency data (LBSPR) estimate low biomass levels, probably related to outdated biological parameters that drive the models to interpret a low spawning stock biomass, and so give a more pessimistic assessment. Environmental factors such as dense shelf water cascading are known to influence the stock dynamics.
	This report	SPiCT	B/Bmsy	F/Fmsy	2025	GSA6	⇳	⇩	below	below	
	STECF EWG 25-09	a4a	B/Bmsy	F/Fmsy	2024	GSA6-7	⇧	⇩	below	above	
PIL	This report	LBSPR	SPR	F/M	2025	NGSA6	⇩	⇳	below	above	Assessment based on historical data from N GSA 6, assuming comparable MEDIAS biomass index trends. All models estimate that biomass is at the lowest levels in the time series for recent years, and F has decreased over time. The results are comparable to those from GSA 6.
	This report	SPiCT	B/Bmsy	F/Fmsy	2025	NGSA6	⇳	⇩	below	below	
	GFCM WGSASP, 2025	a4a	-	F/F0.4	2024	GSA6	⇧	⇩	below	above	
ANE	This report	LBSPR	SPR	F/M	2025	NGSA6	⇳	⇩	above	below	Assessment based on historical data from N GSA 6, assuming comparable MEDIAS biomass index trends. All models estimate an increasing biomass since 2018, and a decrease in F. The results are comparable to those from GSA 6.
	This report	SPiCT	B/Bmsy	F/Fmsy	2025	NGSA6	⇳	⇩	above	below	
	GFCM WGSASP, 2025	SPiCT	B/Bmsy	F/Fmsy	2024	GSA6	⇳	⇳	above	below	

*For LBSPR, indicator is SPRcurr/SPRtgt

SECTION 1
Introduction



Introduction

The European Union Data Collection Framework (DCF) establishes that the member states must collect, manage and annually report biological, environmental and socioeconomic data from fisheries to use as a base for scientific advice in management strategies (EU 2017/1004). In the Mediterranean and Black Seas, Geographical Sub-Areas (GSAs), as defined by the General Fisheries Commission for the Mediterranean (GFCM, Resolution GFCM/33/2009/2), are used to structure the data collection. The GSA 6 (Northern Spain) comprises the Spanish Mediterranean coast from Cartagena to the Spanish-French border.

The European Common Fisheries Policy (CFP) aims to ensure long-term sustainability for fisheries and regulates Mediterranean fisheries controlling fishing effort (fishing days) which, combined with specific technical measures such as gear regulation (Resolution GFCM/33/2009/2), the establishment of a minimum conservation reference size (EU Reg. 2019/1241) and the implementation of closure areas and closed seasons (EU Reg. 2022/1614), are the main management strategies adopted in the western Mediterranean Sea. Then, the CFP manages all fishing modalities including bottom trawling and purse seine. The bottom trawling fleet is currently regulated under the Western Mediterranean Multiannual Plan (WMMAP, EU reg. 2019/1022), which establishes a series of management measures. The bottom trawlers from the Spanish Mediterranean are allowed to fish between 50 and 1000 m depth or 3 miles far from shore when the seabed is shallow and five days per week with a maximum of 12 labor hours per day. The maximum power of the vessel may not exceed 500 hp and the vessel length is limited to a range between 12 and 24 meters (*Real Decreto 1440/1999*). In addition, the Ministry of Agriculture and Fisheries, Food and Environment may limit, by regulation, the number of days per year that a vessel may fish to regulate the total effort exerted in each of the fishing areas (EU Reg, 2019/1022). The purse seine fleet is regulated by the order (APA/1127/2023) approved by the Spanish Ministry of Agriculture, Fisheries and Food to comply with the CFP. This order aims to regulate the stocks for sardine and anchovy through spatial, temporal and catch fishing restrictions, including the increase of the minimum reference conservation size for both species.

Since 2000, the EU Member States have been collecting fisheries data to support CFP through fisheries-dependent and -independent methods. The fisheries-dependent samplings come from on-board samplings and occur monthly in some specific ports by on-board observers, whereas the fisheries-independent data is gathered once a year from the Mediterranean Trawl Survey (MEDITS). With the goal to obtain a more exhaustive data set to better manage marine resources, the monitoring program established by the DCF is complemented with a dataset obtained by the *Institut Català de Recerca per a la Governança del Mar* (ICATMAR). ICATMAR, promoted by the Directorate-General for Fisheries and Maritime Affairs of the Government of Catalonia and the *Institut de Ciències del Mar* (ICM-CSIC), is an autonomous organization whose main goal is to generate scientific advice for management purposes in the blue economy field. Since 2019, ICATMAR has developed and implemented a fisheries monitoring program in Catalonia, which constitutes the northern part of the GSA 6 (from the French border to the south of the Ebre delta). This program uses fisheries-dependent methods that also allow the collection of biological and stock parameters. The goal is to monitor the main target species of the Catalan commercial fleet of different fishing modalities, including bottom trawling and purse seining. In detail, bottom trawling is, economically, the most important fishing modality with a revenue of 54.95 M€ in 2025 (ICATMAR, 26-02). Moreover, bottom trawlers target demersal species, such as those defined by the WMMAP including red mullet, hake, deep-water rose shrimp, Norway lobster, and blue and red shrimp (EU reg. 2019/1022). Purse seine is the fishing modality that accounts for the highest biomass in catches, with a total value of 6 942 t in 2025 (ICATMAR, 26-02) and targets sardine and anchovy, species of special interest to manage for the CFP.

To provide scientific advice for management purposes in the northern GSA 6, two models were used for stock assessment evaluations for the five demersal species regulated by WMMAP and the two small pelagic fishes targeted by purse seine (Figure 7). First, the length-based model LBSPR with data gathered by ICATMAR during the period 2019 to 2025 was used for stock assessment evaluations in the northern GSA6. Second, a surplus production model (SPiCT), was applied to test the influence of a long-term data series, such as landings and biomass index, for the selected species in the whole GSA 6. Each model is based on different assumptions and uses different input data, giving different perspectives of stock status and types of advice (Reference points for LBSPR: SPR, for SPiCT: B_{msy} and F_{msy}). SPiCT reference points are comparable with the ones used for age-structured models (i.e., a4a) or other integrated models (i.e., SS3). The long-term data collection from ICATMAR continuous and exhaustive monitoring program will allow, in the following years, the use of more complex integrated models, e.g. Stock Synthesis (SS3), which integrates species life-history and catch at length information with the time series of catch and fisheries-independent data.

In Section 5, we present the technical grounds for a multispecific indicator based on biological observational data, which is being developed in collaboration with the Spanish Institute of Oceanography at the Balearic Islands (COB-IEO-CSIC). This indicator aims to inform about a representative part of the exploited system, while avoiding the uncertainty inherent to models of growing complexity, and ensuring understandability among all stakeholders involved in fisheries management decision-making processes.

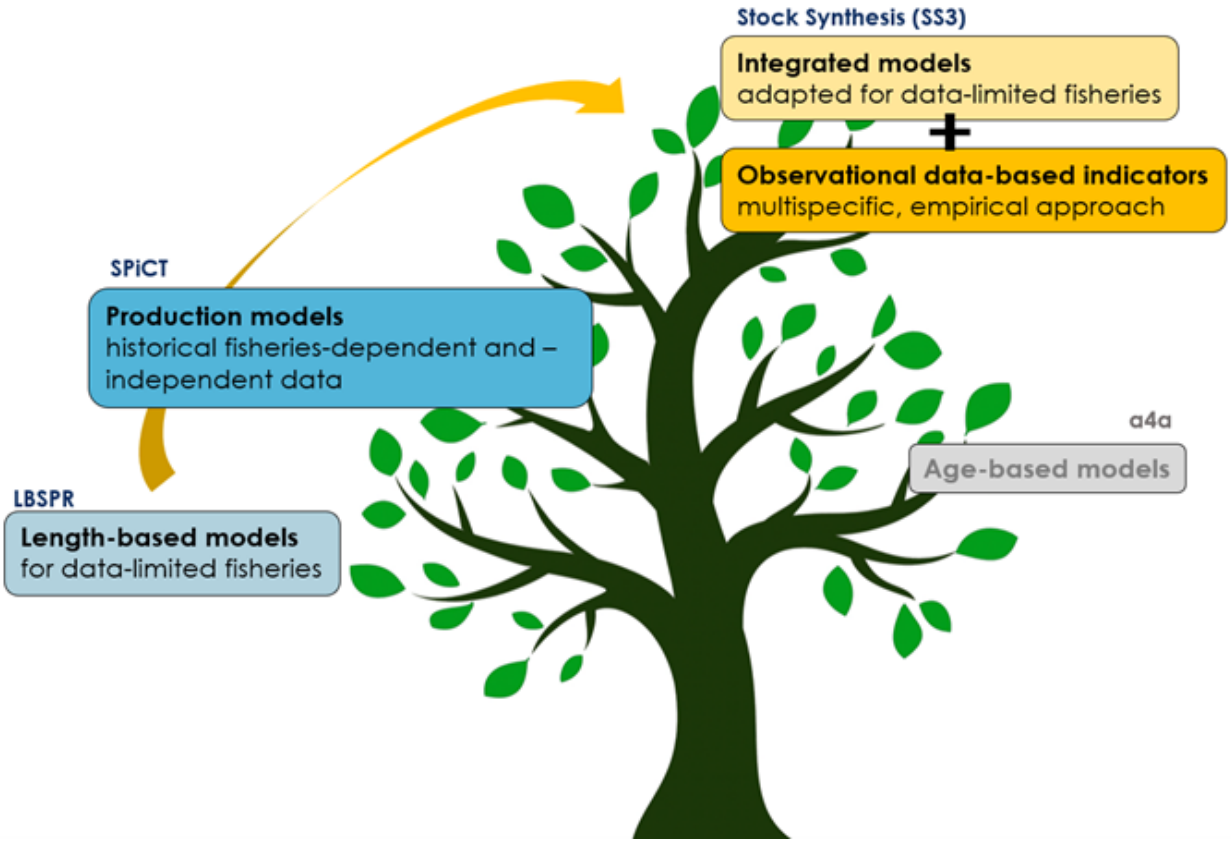


Figure 7. Different models used for fisheries stock assessment: LBSPR is a length-based data-limited model, SPiCT is a Surplus production model and Stock Synthesis (SS3) is an integrated stock assessment model.

SECTION 2
Material and Methods



- **Machine learning for métiers assignation**

As explained in a previous report (ICATMAR, 22-04), the fishing fleet activity is defined by métiers. In short, a métier is defined as a "group of fishing operations targeting a similar assemblage of species, using similar gear, during the same period of the year and/or within the same area and which are characterized by a similar exploitation pattern" (Reg. (EC) N° 949/2008 and Commission Decision 2010/93/UE). In this study area, the daily fishing landings of a vessel correspond to one effective fishing day, as vessels land their catch daily. Therefore, as each sampling haul is allocated to a specific métier, the sampled length frequencies can be weighed and extrapolated to the fishing landings by métier.

Seven métiers are defined performing dendrograms and cluster analysis for the Catalan bottom trawling fleet (OTB). These métiers are related to different depths, areas and catch composition. All daily landings from 2002 to 2021 were classified according to these métiers.

For 2022 onwards, machine learning algorithms have been used to assign the corresponding métier to each daily trip (vessel + day). Machine learning is a branch of artificial intelligence that focuses on the training of algorithms and models to predict results based on data. In this case, random forests were the machine learning algorithms used because they are more suitable to classify the fishing trips in each different métier.

The applied process is described below:

- **Data preparation:**

Landings data from 2021 were selected, but only trips from 2021 had métiers assigned. The species considered for the analyses are those which biomasses contribute to the 95% of the daily trip. This filter allows to eliminate the species that rarely appear and have barely any influence on the métier assignation. The data were transformed to have one row per daily trip, area, métier and a column for each species that was caught with its percentage of biomass contribution to the daily trip.

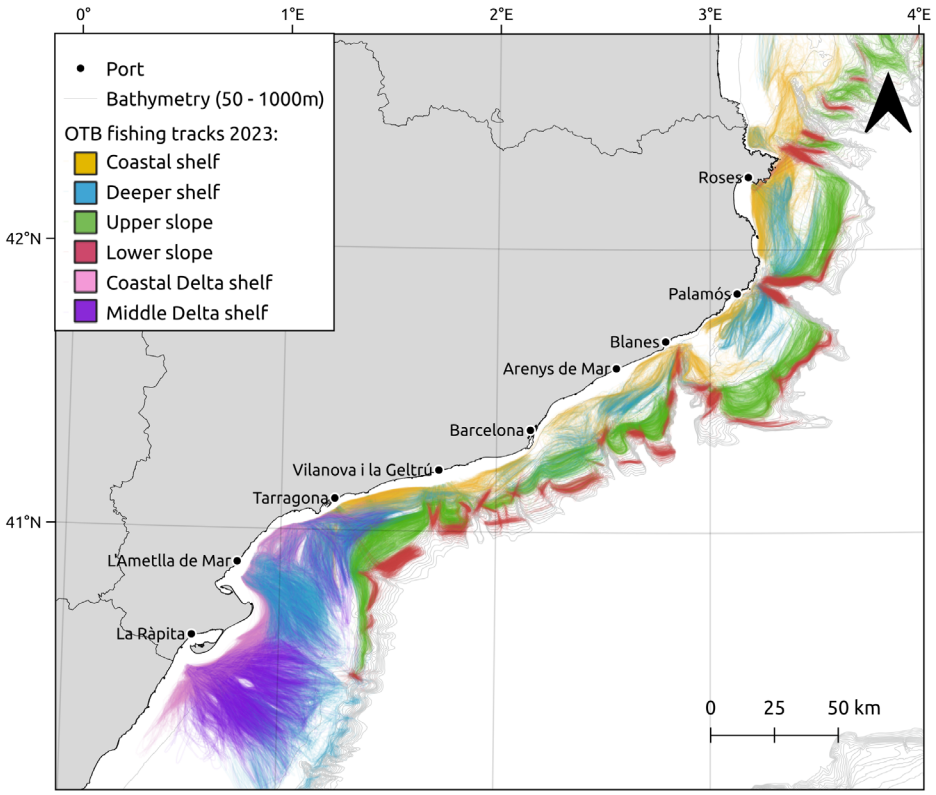


Figure 8. Spatial distribution of the bottom trawl fishery (OTB) tracks. Colors represent the different OTB métiers identified for the Catalan fishery in 2024.

- **Model execution:**

A process of model tuning was applied to test different combinations of the parameters and ways to split the data to find the most suitable model. To do this, 80% of the classified data from 2021 were used for model training and 20% for model validation. The model has a 95% of accuracy, which is obtained executing the model with the validation data. The trained model is used to predict the métier assignation for non-classified data for 2022 onwards. Besides the model execution with the validation data, the predicted métiers are combined with their corresponding VMS track to generate a map and perform a visual validation (Figure 8). Finally, the predicted métiers for 2022 onwards are imported to the database for the extrapolation of the data.

- **Data extrapolation**

To estimate the annual length-frequency distributions (LFD) of the target species in Catalonia (N GSA6), data from the ICATMAR monitoring program (trawling and purse seine) and from EU-DCF (GSA6, artisanal fisheries) were used. A three-step process was followed: 1) Raising of monitoring data, 2) inclusion of artisanal fisheries catch, and 3) validation of the estimated LFD using the sum of products (SOP) approach.

Raising of the monitoring data

Bottom trawling

The basic unit for the data raising were the fishing hauls, which were previously assigned to a métier according to its catch composition. The calculations for each area (North, Center, and Ebre delta) were made separately to keep the spatial resolution of the sampling and, within each area, fishing hauls were separated by port. Starting from this spatial aggregation, the data raising also considered seasonal variations in catch, calculated according to the following steps:

Monthly LFD (sampled ports, by area, métier and month)

Seasonal LFD (sampled ports, by area, métier and season)

Seasonal LFD (all fleet, by area, métier and season)

Annual LFD (total for Catalonia)

This process is described below for each fraction of the catch (landed and discarded) and calculated independently for each target species. Note that the LFD were grouped by intervals of 1 cm for fish species and 1 mm for crustaceans. The extrapolation used two ICATMAR databases: monitoring data and commercial fishing landings.

Raising process for the landed catch

Monthly LFD (sampled ports, by area, métier and month)

For every fishing haul, the LFD and its total weight were extracted from the monitoring database. A ratio was calculated dividing the monthly landings by the total weight of each haul. The resulting monthly LFD was determined by multiplying the LFD of each fishing haul by the corresponding ratio.

Seasonal LFD (sampled ports, by area, métier and season)

In this step, the previous procedure is replicated, but now starting with the monthly LFD. The ratio was calculated dividing the seasonal landings of each port and métier by the corresponding monthly landings. The seasonal LFD was obtained by multiplying this ratio with the monthly size distribution.

Seasonal LFD (all fleet, by area, métier and season)

The previously calculated LFD of the sampled ports corresponding to the same season and métier were summed. The ratio was calculated dividing the total landings (considering all ports of each area) by the weight from the sum of the LFD of the sampled ports. The total LFD by area, season, and métier were obtained by the product of the LFD of the sampled ports by its ratio.

Annual LFD by area and totals for Catalonia

The annual LFD by area was obtained by the sum of the LFD of the different seasons and métiers. This process must be repeated for each year and area to obtain the estimated annual LFD of the landed individuals from the target species corresponding to all the trawling fishing fleet in Catalonia.

Raising process for the discarded catch

The raising of discards LFD follows the same structure as the raising of landings. The proportion of discards within the total catch was estimated from the monitoring database. This proportion was calculated for each year, area, season and métier. For those months when no sampling was available, the annual discard ratio was used. Then, the steps explained for landed size distributions can be replicated, considering that the commercial landings must be multiplied by the discard ratio beforehand.

Purse seine

The raising process of the purse seine sampling requires a simplified version of the method for trawling. In this case the spatial structure (area – port) is maintained but in the raising process only month and season were considered, as no métiers were available for purse seine.

Inclusion of the artisanal fisheries catch data for modelling

Our sampling includes both bottom trawling and purse seine. However, it does not include artisanal fisheries despite their catch may be important to be considered, especially for hake and red mullet. Then, for these two species, we employed data from the EU-DCF (GSA6) in order to obtain the LFD for our target species in Catalonia and add these data to our bottom trawling monitoring data. The ratio from the artisanal fisheries was calculated by dividing the catches from Catalonia by the total catches in the GSA6. The product of this ratio with the LFD of the GSA6 provides an estimate of the LFD corresponding to Catalonia. These LFD can be summed to the trawling (landing + discards) extrapolation to get the annual LFD for Catalonia considering all fishing gears.

SOP validation

The sum of products (SOP) is computed by summing the number of individuals at each length class of the LFD multiplied by their corresponding weight, estimated with the species' growth parameters:

The results of the SOP validation for the landed catch must be similar to the reported landings.

Model settings

1. Stochastic Production model in Continuous Time (SPiCT)

Model assumptions and input data

SPiCT is classified as a data-moderate stock assessment model. To perform surplus production models for a certain stock, it is needed to have information on the time series of landings, effort, CPUE (ideally standardized), and/or fishery-independent biomass index. The catch data should be representative of both landings and bycatch. It is also possible to use a time series of landings, but the interpretation of the results varies in this case. When available, seasonal catches should be also used as input.

Stock size indices should be provided in terms of biomass and should be representative of the exploitable stock biomass. Given that the surplus production models require the comparison between the same fraction of the stock, to build the biomass index there should only be considered the range of lengths that are observed in the catches.

Biomass indices are assumed to be snapshots on given time points. Therefore, the timing of survey indices has to be given as decimal year, corresponding to the timing of the survey in the vector. Commercial CPUE indices should be associated to the midpoint of the interval of the corresponding catches, i.e. when CPUE indices are based on yearly aggregated

catches and effort, the value in the mid-year should be considered.

The SPiCT model estimates reference points with associated uncertainties and accounts for both observation and process error.

2. Length-Based Spawning Potential Ratio (LBSPR)

Table 2. Settings used for model LBSPR computation uncertainty.

Number of random draws: nits=1000	
CVL_{inf}lower <- 0.075 CVL_{inf}upper <- 0.3 CVL_{inf}mid <- 0.15 CVL_{inf}vec <- rtriangle(nits, CVLinflower, CVLinfupper, CVLinfmid)	MKlower <- (M/K) *0.75 MKupper <- (M/K) *1.25 MKmid <- M/K MKvec <- rtriangle(nits, MKlower, MKupper, MKmid)

L_{inf}lower <- L_{inf}*0.75
L_{inf}upper <- L_{inf} *1.25
L_{inf}mid <- L_{inf}
L_{inf}vec <- rtriangle(nits, L_{inf}lower, L_{inf}upper, L_{inf}mid)
	L_{mat50}vec <- L_{inf}vec * (Lmat50/L_{inf}) # Assume constant Lmat50/L_{inf} ratio
	LHpars <- MyPars
	L_{mat95}vec <- L_{mat50}vec + (LHpars@L_{mat95} - LHpars@L_{mat50}) # assume constant L_{mat95}-L_{mat50}

LBSPR is classified as a data-limited stock assessment model which relies on a number of assumptions. In particular, the LBSPR models are equilibrium-based and assume that the length composition data is representative of the exploited population at a steady state. Also, selectivity is assumed to follow a logistic function.

To better fit the model, some facts should be considered such as:

- The length structure of the harvested population raised by considering the main factors (time: monthly and annual catches; sample size; ports, fleets/gears and/or depth).
- Local estimates of life-history parameters, including von Bertalanffy growth parameters, length of maturity (L_{mat50} and L_{mat95}) and M.
- Information on the input data and methods used to estimate life history.

Natural mortality (M) estimation

Natural mortality (M) is one of the most critical yet difficult parameters to estimate in fisheries stock assessment, as it cannot be directly observed and is known to significantly influence model outputs (Kenchington, 2014). Following the framework proposed by Maunder et al. (2023), M was estimated for each species and case scenario using multiple empirical approaches to account for uncertainty in this parameter.

A total of eleven empirical estimators were applied, encompassing three broad categories: life history approaches, maximum age-based methods, and M correlation methods (Table 3). Life history approaches relate M to key biological parameters such as age at maturity (t_m), the von Bertalanffy growth coefficient (K), and asymptotic length (L_{inf}), under the assumption that organisms with faster growth rates tend to experience higher natural mortality (Jensen, 1996; Roff, 1984; Beverton, 1992). Maximum age-based methods estimate M from the maximum observed age (t_{max}), relying on the biological principle that longevity is inversely related to mortality (Cope & Hamel, 2022). Finally, M correlation methods incor-

porate multiple life history and environmental variables — including growth parameters, body size (weight, W; asymptotic length, L_{inf}), temperature (T), and gonadosomatic index (GSI) — to derive empirically derived estimates across a broader range of taxa (Pauly, 1980; Then et al., 2015; Cope & Hamel, 2022; Hamel, 2014; Lorenzen, 1996).

Table 3. Equations used for estimating natural mortality (M) for each species in each case scenario.

Approach	Equation	Reference
Life history approaches	M = 1.65/tm	Jensen (1996)
Life history approaches	M = 1.5 K	Jensen (1996)
Life history approaches	M = 3K/(exp(tmK) 1)	Roff (1984)
Life history approaches	M = K ((3Linf/Lm) - 3)	Beverton (1992)
Maximum age	M = 3/tmax	Rule of thumb
Maximum age	M = 5.4/tmax	Hamel & Cope (2022)
M correlations	M= 0.9849K0.6543 Linf-0.279T0.4634	Pauly (1980)
M correlations	M = 4.1181K-0.73Linf0.33	Then et al. (2015)
M correlations	M = 1.55 K	Hamel & Cope (2022)
M correlations	M = 1.817GSI	Hamel (2015)
M correlations	M = 3 W-0.288	Lorenzen (1996)

To ensure the robustness of the final M estimate, extreme values — likely resulting from data limitations or violations of the assumptions underlying individual estimators — were identified and excluded prior to averaging. The remaining estimates were then averaged to produce a single representative M value for each species and case scenario. This approach of combining multiple estimators reduces the influence of any single method and provides a more stable central estimate that reflects the inherent uncertainty in natural mortality estimation (Maunder et al., 2023).

Detailed information on the input parameters used for each estimator, as well as the individual M estimates obtained for each species and scenario, will be available at https://github.com/ICATMAR .

Sensitivity analysis

Different scenarios were carried out by stock to test the sensitivity of the model. In general, scenarios were chosen based on STECF or GFCM data inputs, available bibliography and ICATMAR data.

Uncertainty in life history parameters

To include uncertainty in the model computation, the following settings were applied for each stock and scenario (Table 2):

The main output of the model is the Spawning Potential Ratio (SPR) which is defined as a proportion of the unfished reproductive potential left in the population at any given level of fishing pressure.

The reference points were proposed for the length-based methods approach as: SPR_{tgt}=0.4, SPR_{pa}=0.2 and SPR_{lim}=0.1. Due to the model's instability regarding the stock's life history, the FM estimator is not considered a reference point.

SECTION 3
Results by stock
Demersal species
Stock assessment results for species in the GSA6



Red mullet (*Mullus barbatus*) MUT

The spawning area for red mullet is the continental shelf but the nursery zone is located on coastal areas. The recruitment season is between October and December (Lombarte et al. 2000).

Input data

The spatial distribution of total landings for red mullet in the Catalan fishing grounds (Figure 9) is located, mainly, in coastal areas considering bathymetry. However, in terms of total landings, red mullet is more abundant in the central and southern areas.

Historical red mullet landings in Catalonia since 2002 are shown in Figure 10. Landings showed an overall increasing trend until 2016, when one of the highest values in the time series was observed. Subsequently, landings remained relatively stable. In 2024, the time series reached its peak, whereas in 2025 red mullet landings returned to values similar to those recorded in previous years.

Figure 11 shows red mullet landing distribution by métier from 2019 to 2025. Bottom trawlers have the highest landings for coastal delta, coastal and deeper shelf métiers. Lower landings are observed in the middle delta shelf and upper slope métiers. Artisanal fisheries have a small proportion of landings in all years, especially in 2025.

Annual LFD

After raising the length frequencies obtained with the monitoring program, and considering discards and small-scale fisheries length frequency, the annual length frequency of red mullet in Catalonia is plotted in Figure 12. The SOP validation results are presented in Table 4, while the number of individuals sampled by the ICATMAR monitoring program is shown in Table 5. The shape of the plots varies among them, indicating different length-frequency distributions in time. An increase in smaller length classes was observed in 2021 and 2022. In 2024 there was a notable rise in the number of individuals measuring 130–150 mm, whereas in 2025 the length-frequency distribution exhibited a smoother and broader pattern, with a more even representation of intermediate length classes and a less pronounced modal peak. It is also worth noting that the largest individuals are mainly caught with small-scale fisheries.

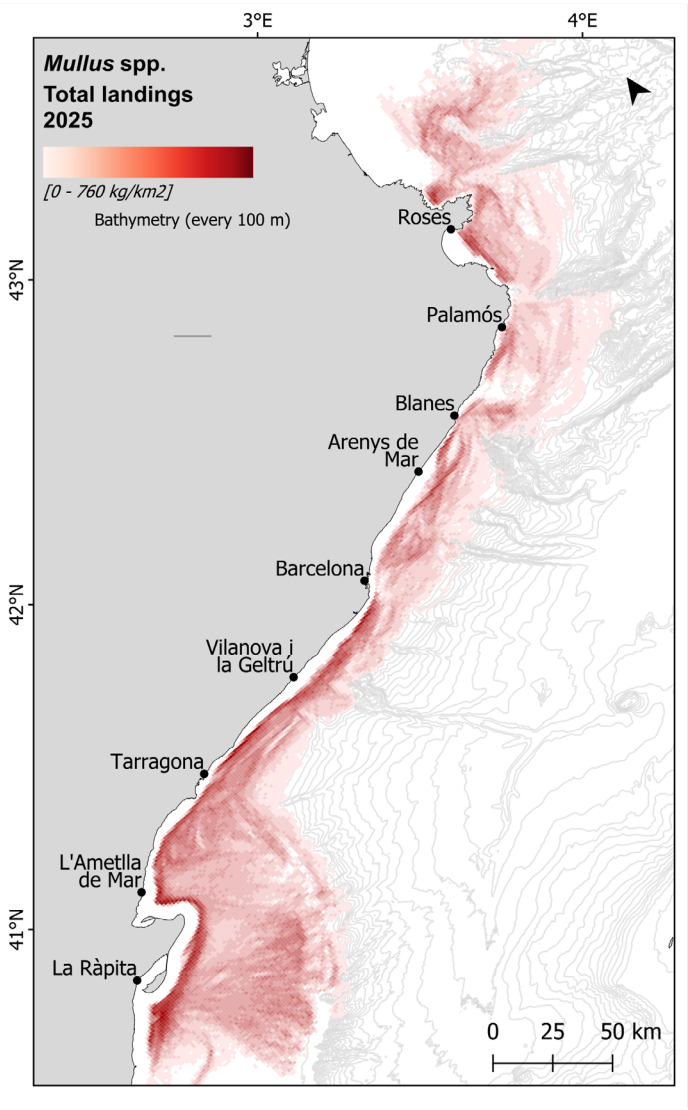


Figure 9. Spatial distribution of landings (kg/km²) for red mullet (*Mullus spp.)* in the Catalan fishing grounds (North GSA6) in the year analyzed.

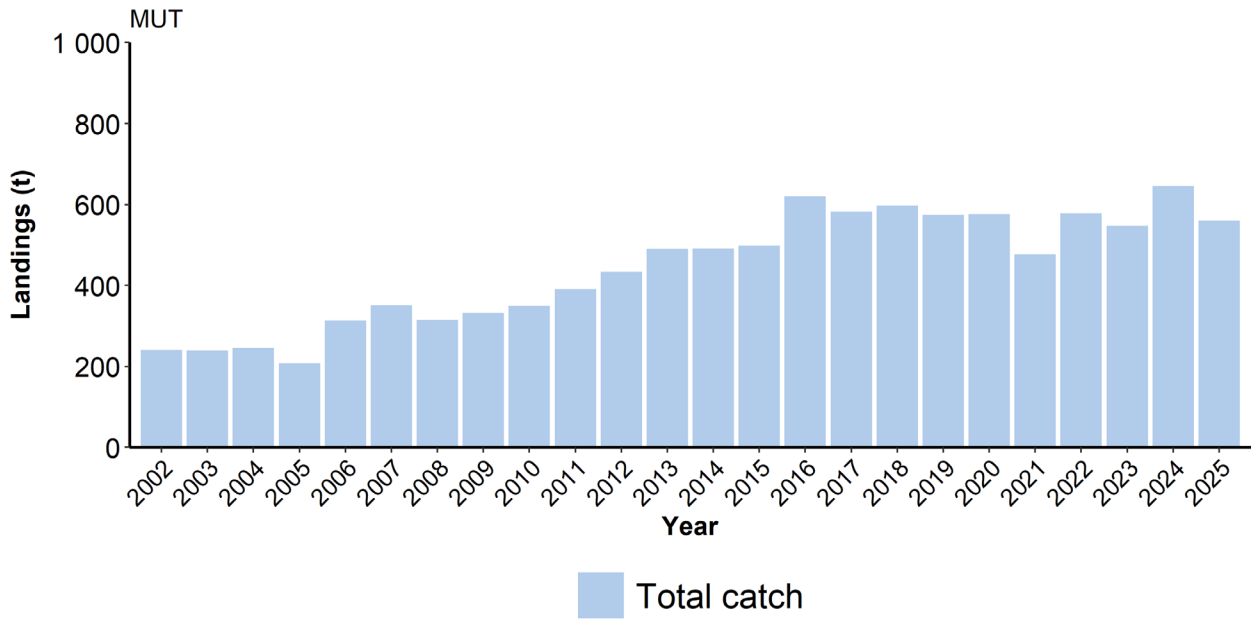


Figure 10. Historical landings (t) for red mullet in Catalonia.

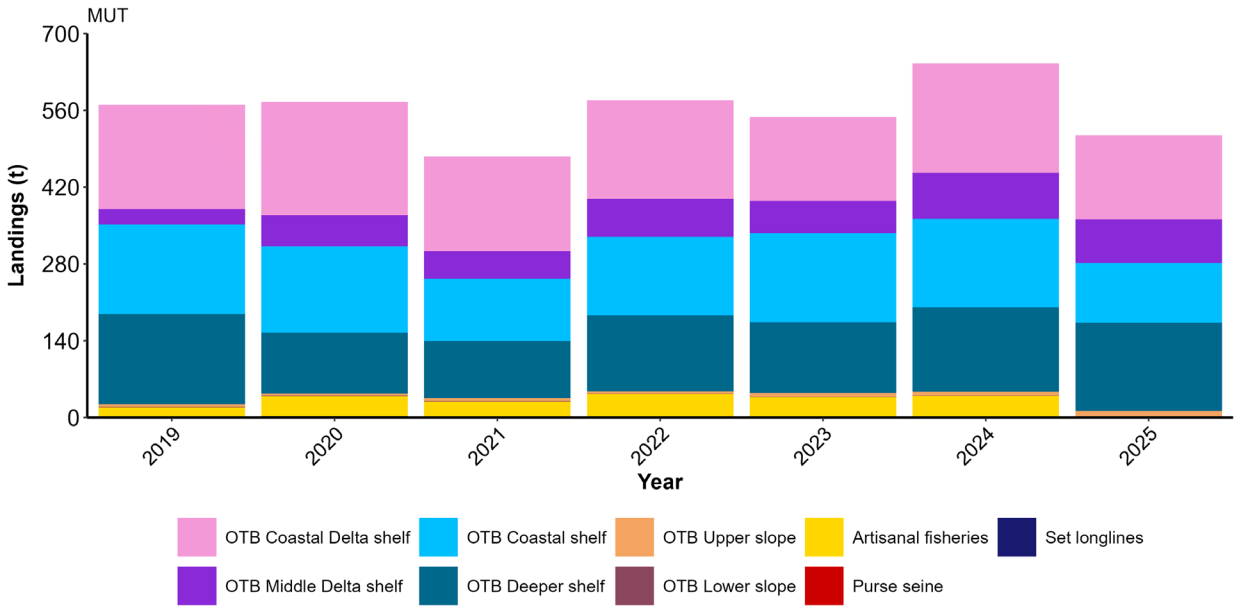


Figure 11. Landings (t) for red mullet by métier and fishing gear. OTB: bottom trawling.

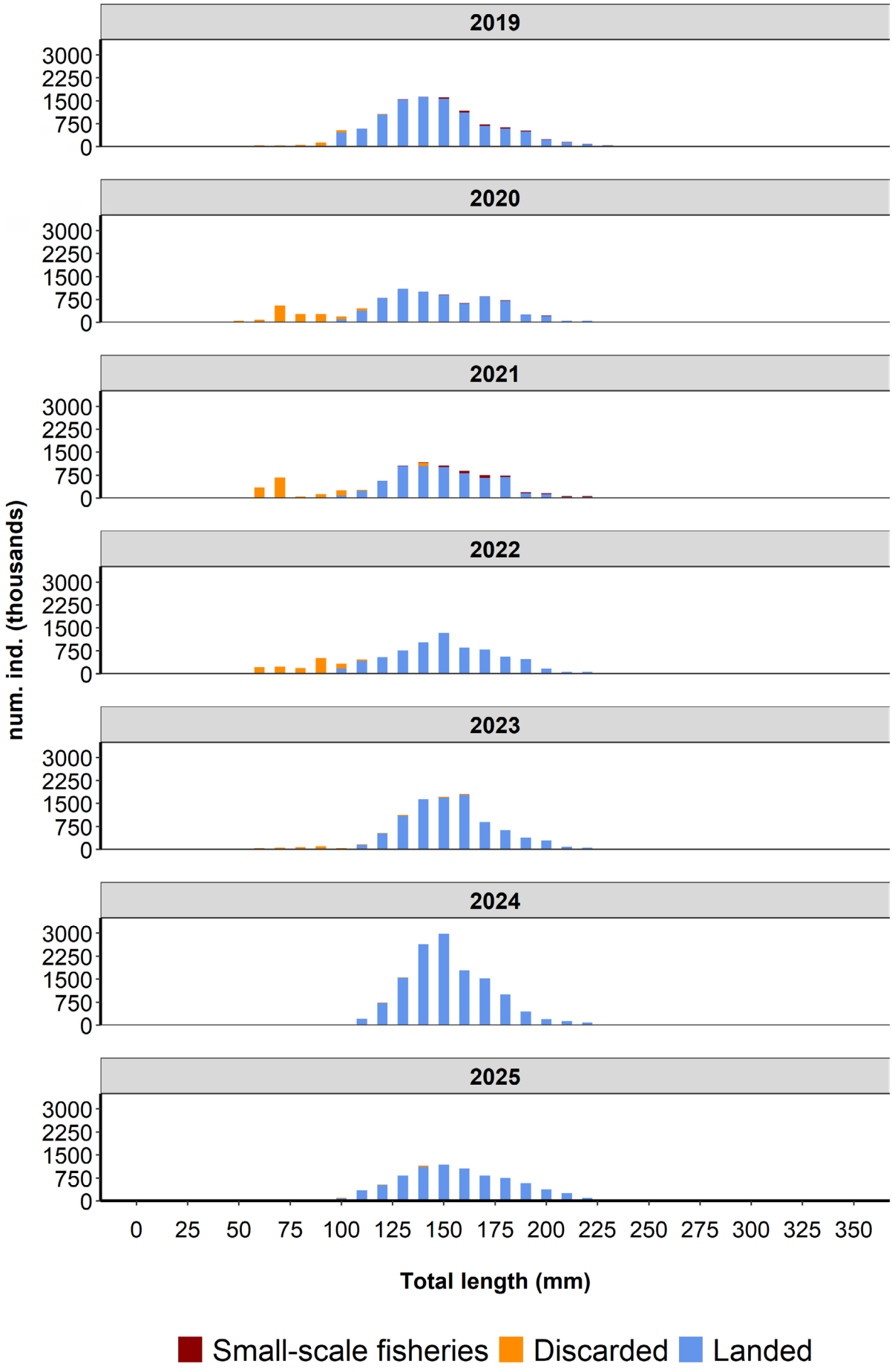


Figure 12. Annual length frequency distributions of red mullet from bottom trawling and small-scale fisheries. The data from bottom trawling is raised from ICATMAR data and details landed and discarded Red mullet. The data from small-scale fisheries is obtained from DCF (Data Collection Framework) dataset.

Table 4. Sum of Products (SOP) validation for red mullet (MUT): The column Calculated Weight in GSA6N (SOP) represents the biomass estimated through the raising process, while landings refer to the reported landings in NGSA6. The ratio between SOP and landings is known as the Sum of Products (SOP). Values close to 1 indicate that the raising process provides biomass estimates that closely match the reported landings, thereby validating the accuracy of the estimation method.

Species	Year	Catch classification	Gear	Calculated weight GSA6N (kg) (SOP)	Landings in GSA6N (kg)	SOP/Landings
MUT	2019	ASSF	Artisanal fisheries	16766	17934	0.93
MUT	2020	ASSF	Artisanal fisheries	2941	39157	0.08
MUT	2021	ASSF	Artisanal fisheries	27149	29071	0.93
MUT	2022	ASSF	Artisanal fisheries	27149	42559	0.64
MUT	2023	ASSF	Artisanal fisheries	27149	37052	0.73
MUT	2024	ASSF	Artisanal fisheries	27149	39857	0.68
MUT	2025	ASSF	Artisanal fisheries	27149	44881	0.60
MUT	2019	Discarded	Bottom trawl	2526	-	-
MUT	2020	Discarded	Bottom trawl	7928	-	-
MUT	2021	Discarded	Bottom trawl	9556	-	-
MUT	2022	Discarded	Bottom trawl	8460	-	-
MUT	2023	Discarded	Bottom trawl	5008	-	-
MUT	2024	Discarded	Bottom trawl	997	-	-
MUT	2025	Discarded	Bottom trawl	1489	-	-
MUT	2019	Landed	Bottom trawl	401805	555142	0.72
MUT	2020	Landed	Bottom trawl	290476	536623	0.54
MUT	2021	Landed	Bottom trawl	262414	447110	0.59
MUT	2022	Landed	Bottom trawl	306099	535696	0.57
MUT	2023	Landed	Bottom trawl	402499	510819	0.79
MUT	2024	Landed	Bottom trawl	557383	605741	0.92
MUT	2025	Landed	Bottom trawl	385737	514365	0.75

Table 5. Number of red mullet individuals sampled by zone and season from ICATMAR monitoring data used to raise the length frequencies.

Fishery	Year	Zone	Winter	Spring	Summer	Autumn	N hauls
			Number individuals sampled				
Bottom trawl	2021	North	261	88	121	60	18
Bottom trawl	2021	Center	123	135	91	49	11
Bottom trawl	2021	South	33	46	221	211	20
Bottom trawl	2022	North	111	97	99	162	16
Bottom trawl	2022	Center	122	64	141	134	11
Bottom trawl	2022	South	88	188	272	359	21
Bottom trawl	2023	North	303	240	272	339	24
Bottom trawl	2023	Center	297	207	252	188	12
Bottom trawl	2023	South	297	141	285	122	20
Bottom trawl	2024	North	418	141	285	122	40
Bottom trawl	2024	Center	219	337	208	285	14
Bottom trawl	2024	South	245	319	270	477	24
Bottom trawl	2025	North	253	195	183	570	23
Bottom trawl	2025	Center	109	195	102	69	7
Bottom trawl	2025	South	269	377	407	411	23

Stochastic Production model in Continuous Time (SPiCT)

For red mullet, fleet data were obtained from the EU Fleet Register provided by the European Commission (Reg. EU 2017/218); daily commercial fishing landings in GSA6 were provided by the Spanish Ministry of Agriculture, Fisheries and Food; MEDITS data were obtained from the most recent available GFCM Stock Assessment Form (SAF) for MUT in GSA6 (RY2024), the Joint Research Center (JRC, 2025; STECF-PLEN-25-01 background), and data from the Spanish Institute of Oceanography – CSIC (IEO-CSIC) were also used. Annual biomass index for N GSA6 and the MEDITS autumn survey were obtained from ICATMAR data. (Figure 13).

- Landings from 1971 to 2025 (Tons)
- Standardized CPUE (OTB): 2005 - 2024 (based on Henning Winker (GFCM) & Hoyle et al., 2024) -> Here, CPUE = LPUE
- Index: MEDITS survey data from 1994 to 2025 (Biomass, kg/km^2)
- Index: MEDITS-AUT survey data from November 2025 (Biomass, kg/km^2)
- Annual biomass index: ICATMAR data: 2019 – 2025 (Biomass, kg/km^2

For the MEDITS and ICATMAR biomass indices, the uncertainty associated with each annual estimate was derived from the survey data following the approach used in GFCM stock assessments. Annual coefficients of variation (CVs) were calculated for each index, and the corresponding uncertainty was incorporated into the assessment. A mean CV (CVmean) was calculated across the available time series and used as a reference for the overall uncertainty of each index. The annual variability in precision was then accounted for using a standard deviation factor (StDevF), calculated as the ratio of the annual CV to the CVmean. This approach allows the observation error assigned to the survey indices in SPiCT to reflect the uncertainty associated with the underlying survey data and its year-to-year variation, consistent with the treatment of survey indices in GFCM stock assessments.

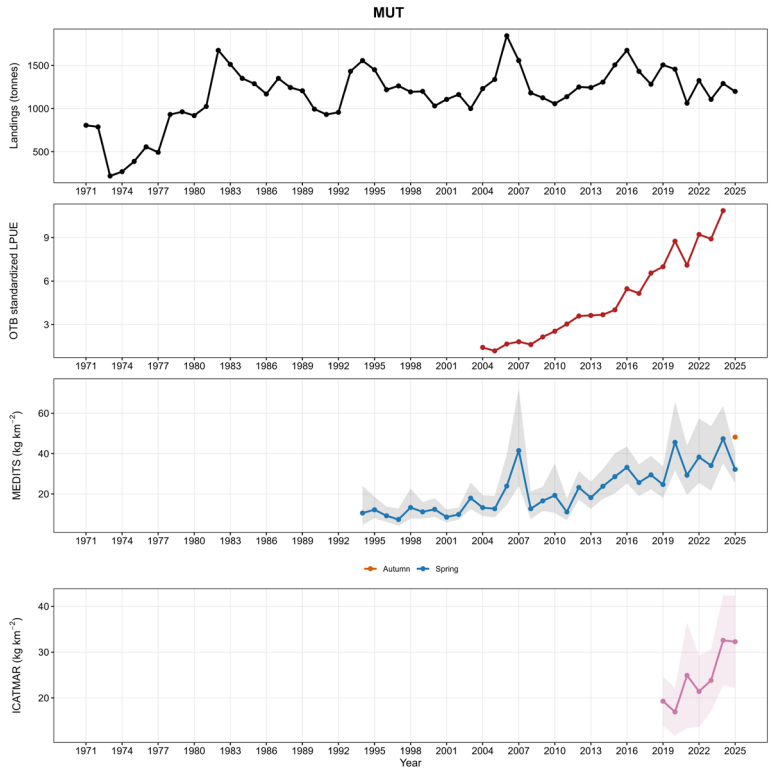


Figure 13. Data available for the assessment of red mullet in GSA6 using the SPiCT model. From top to bottom: catch data from 1971 to 2025; standardized OTB LPUE data from 2004 to 2024; MEDITS survey biomass indices from 1994 to 2025, including Spring and Autumn surveys; and ICATMAR biomass indices from 2019 to 2025.

Time-varying recruitment (TVR) was included in some of the SPiCT scenarios to allow recruitment to vary over time rather than assuming a constant stock–recruitment relationship. This provides greater flexibility to capture interannual variability in recruitment that may arise from environmental conditions or other processes not explicitly included in the model. The TVR estimates deviations from the expected stock–recruitment relationship and thus allows the model to account for recruitment changes not directly explained by changes in spawning biomass.

Although only the final scenario was presented, different scenarios were tested:

- Scenario 1: Landings 1980-2025 + MEDITS biomass index (1994–2024 and AUT 2025) + CI.
- Scenario 2: Landings 1980-2025 + MEDITS biomass index (1994–2024 and AUT 2025) + ICATMAR biomass indices + CI.
- Scenario 3: Same as Scenario 2, including annual r prior time-varying (TVR)
- Scenario 4: Catch 1980-2025, MEDITS spring + ICATMAR + TVR + CI

A final comparison of all scenarios is shown in Figure 14. The final assessment was based on Scenario 4, which was considered the most consistent configuration. This scenario integrates the available MEDITS Spring and ICATMAR biomass information, uses indices representative of the same period of the year, and accounts for their annual uncertainty through year-specific confidence intervals. The inclusion of time-varying recruitment (TVR) also allows for temporal variability in recruitment not explained by the stock–recruitment relationship.

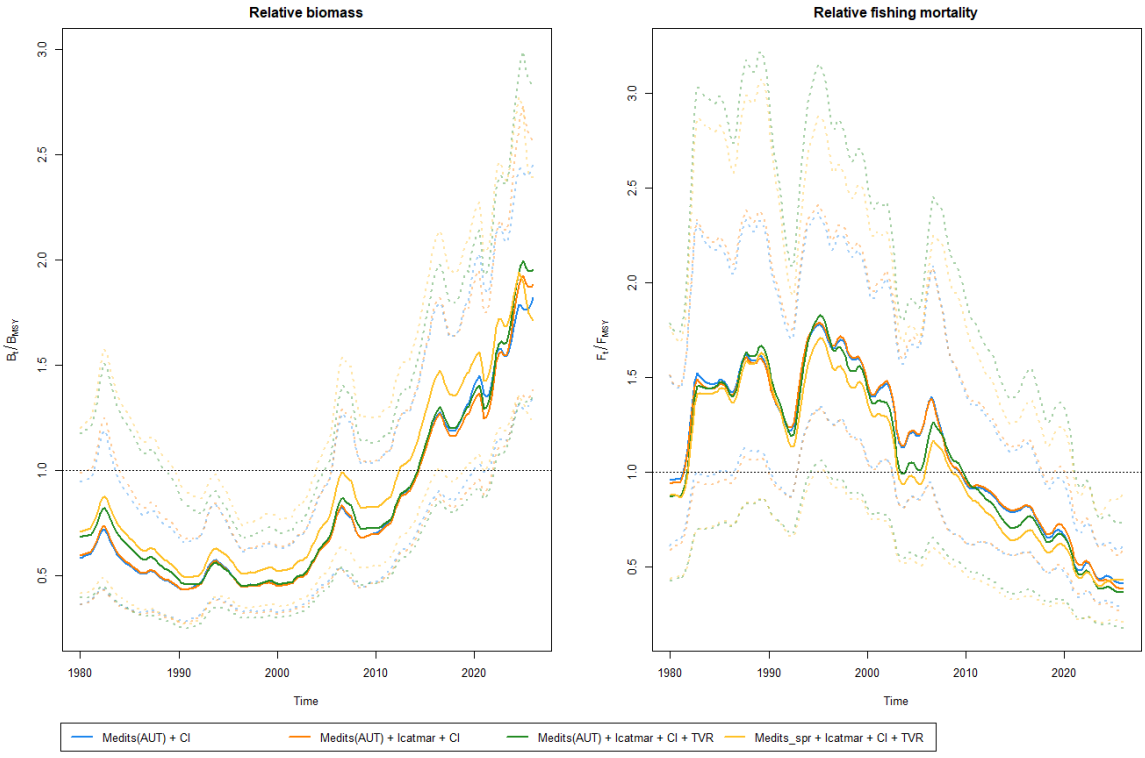


Figure 14. Scenarios comparison for red mullet in GSA6.

Final scenario

Settings used for the final scenario are shown in Table 6. Among other settings, BKfrac prior was 0.5, which is a moderate value.

The final scenario input data are shown in Figure 15, and the final summary assessment results are presented in Figure 16. The results show an increasing trend in biomass since 2000, with values above the reference point B_{msy} since 2012. For fishing mortality, the estimated values have been consistently below 1 since 2008, although they have remained relatively stable since 2020.

All diagnostics can be checked in Figure 17, Figure 18, Figure 19, Figure 20 and Figure 21. Retrospective diagnostics showed low retrospective bias, with Mohn's ρ of 0.048 for B and −0.019 for F, supporting the robustness of the selected model configuration. Although the ICATMAR SAP index showed a higher MASE than the MEDITS index (0.692 and 1.64, respectively), its inclusion provided complementary information on recent biomass trends and did not lead to substantial changes in the overall stock status. Overall, Scenario 4 provided the most coherent combination of available biomass information, temporal consistency among indices, and model diagnostics, and was therefore selected as the final assessment. A sensitivity analysis for the final scenario was performed, testing r prior, BKfrac, process error, and observation error to assess the model's robustness within these priors. All these plots and results for the other scenarios will be available at https://github.com/ICATMAR.

Type	Prior	Description	Assignment	Mean	Standard deviation	Comment
Fishery dynamic	logbkfrac	B/K fraction (depletion)	-	Log(0.5)	0.3	A prior for BKfrac is Included because we already know that fisheries occurred before the beginning of the time series. A moderate depletion of 0.5 is used.
Relative standard deviation time series (input data)	stdevfacC	Standard deviation factor for catches	-	-	-	
	stdevfacI	Standard deviation factor for indices	-	-	-	StDevF and CV from the data
Stock dynamic	Logr	Population growth	-	Log(0.54)	0.7	Fishlife
	Logn	Shape of production curve	-	Log(2)	-	Shaefer
Error	Logsdc	Catch error	-	Log(0.05)	0.2	
	Logsdf	Fishing mortality error	-	Log(4)	0.5	
	Logsdb	Process error	-	Log(0.3)	0.5	
	logsdi	Observation error	-	Log(0.2)	0.5	MEDITS
				Log(0.2)	0.5	ICATMAR
TVR	logsdm	Time Varying Growth	-	Log(0.3)	0.3	Allow recruitment to vary over time
	logpsi	Time Varying Growth	-	Log(0.5)	0.3	

Table 6. Prior settings for red mullet in GSA 6 for final scenario.

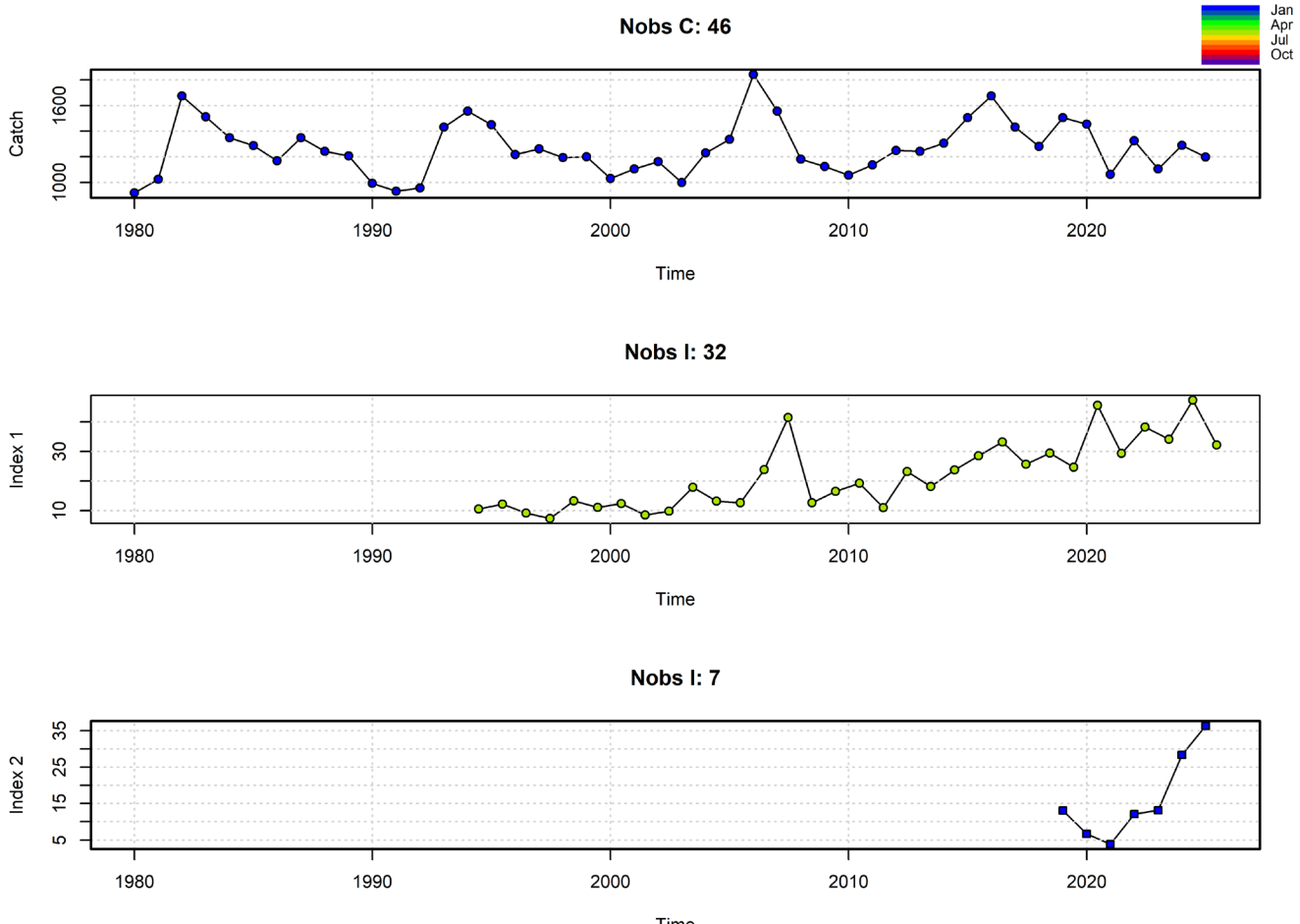


Figure 15. Input data used in the SPiCT assessment of red mullet in GSA6 under scenario 4. From top to bottom: annual catch data (tonnes) from 1971 to 2025; MEDITS biomass index from 1994 onwards; and ICATMAR biomass index from 2019 onwards.

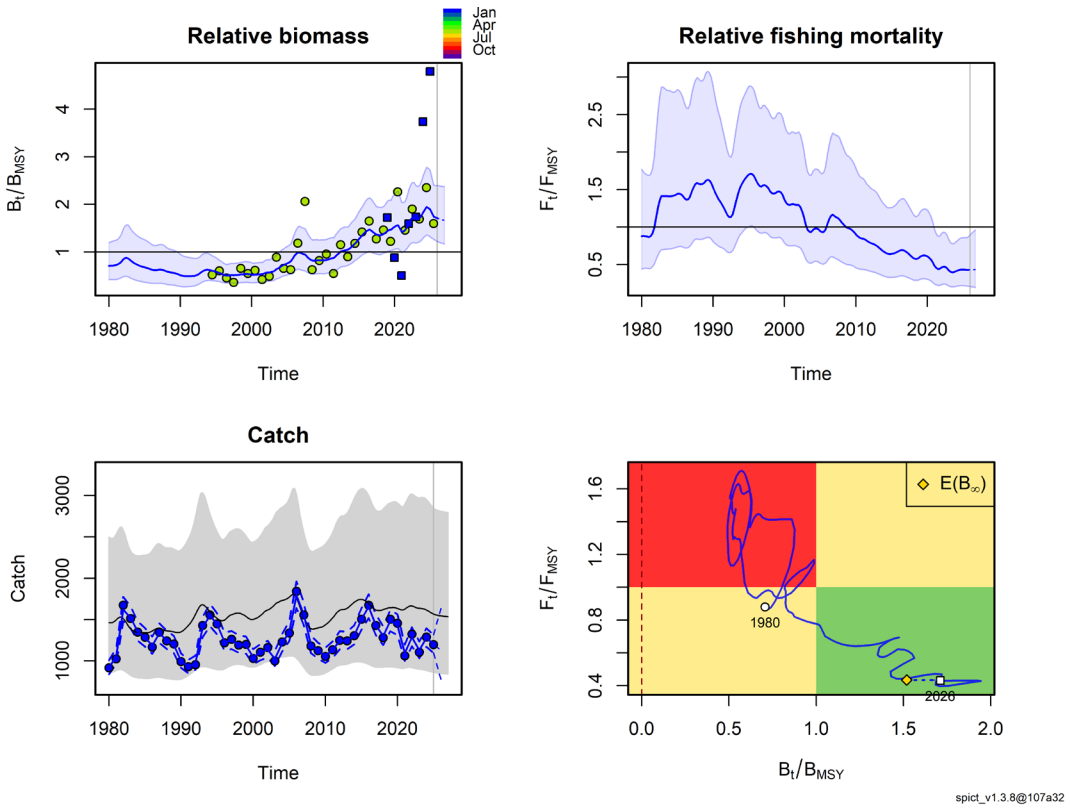


Figure 16. Stock assessment summary for SPiCT model for red mullet in GSA6 for final scenario.

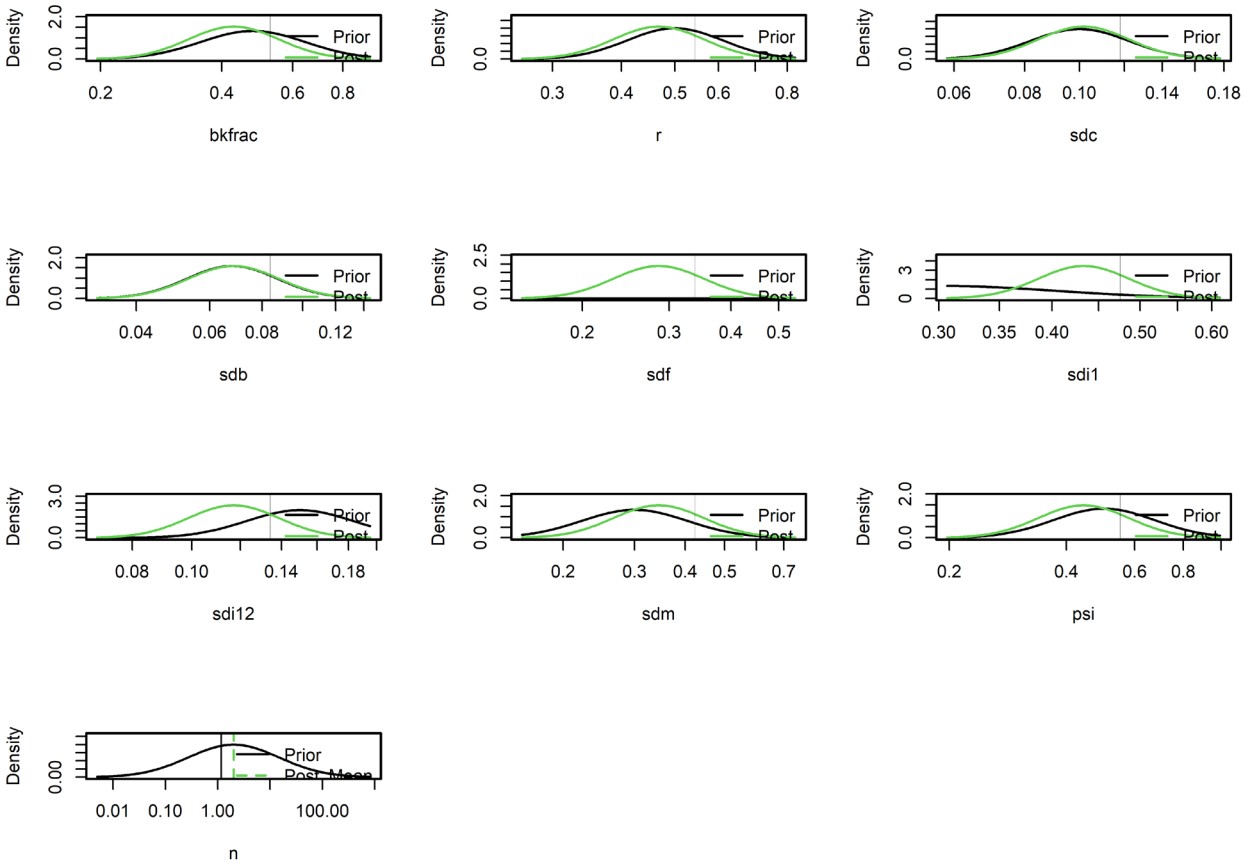


Figure 17. Estimated priors and posteriors for the updated assessment for red mullet in GSA6 for final scenario

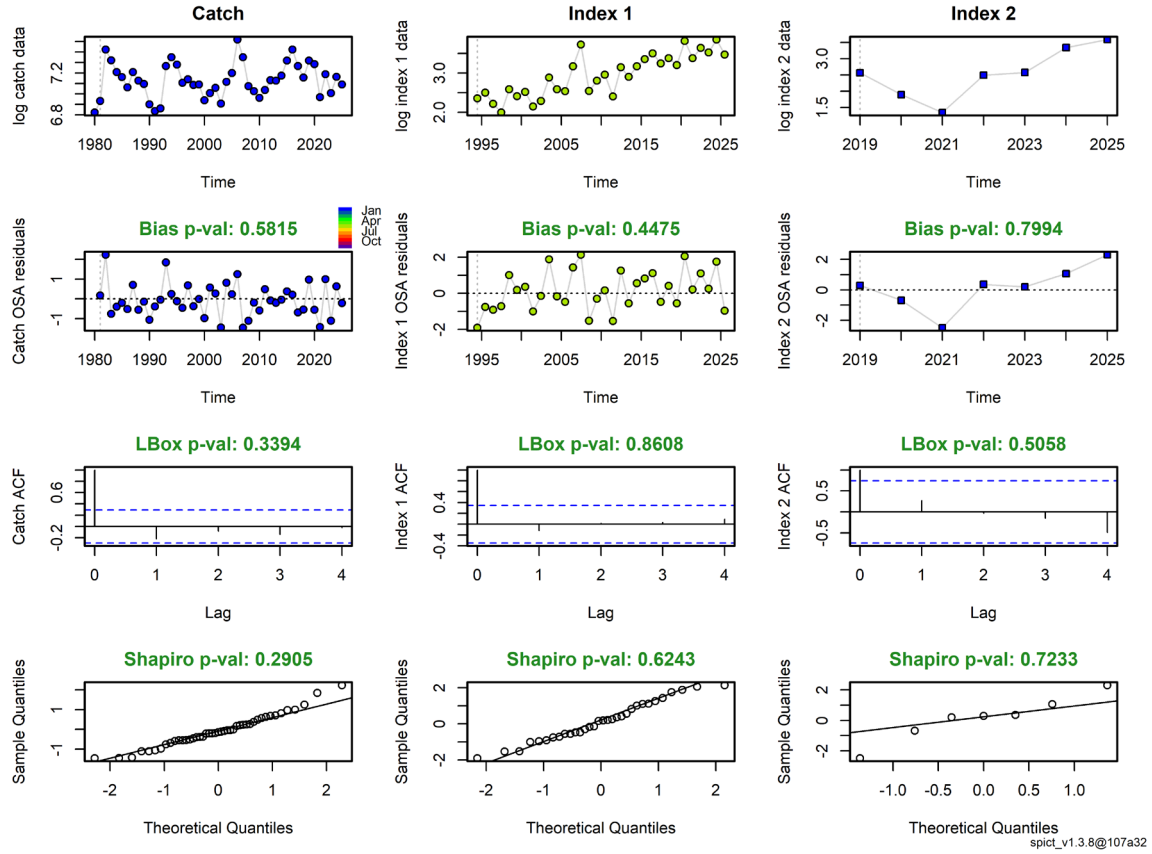


Figure 18. One-step-ahead residuals for the model for red mullet in GSA6 for final scenario.

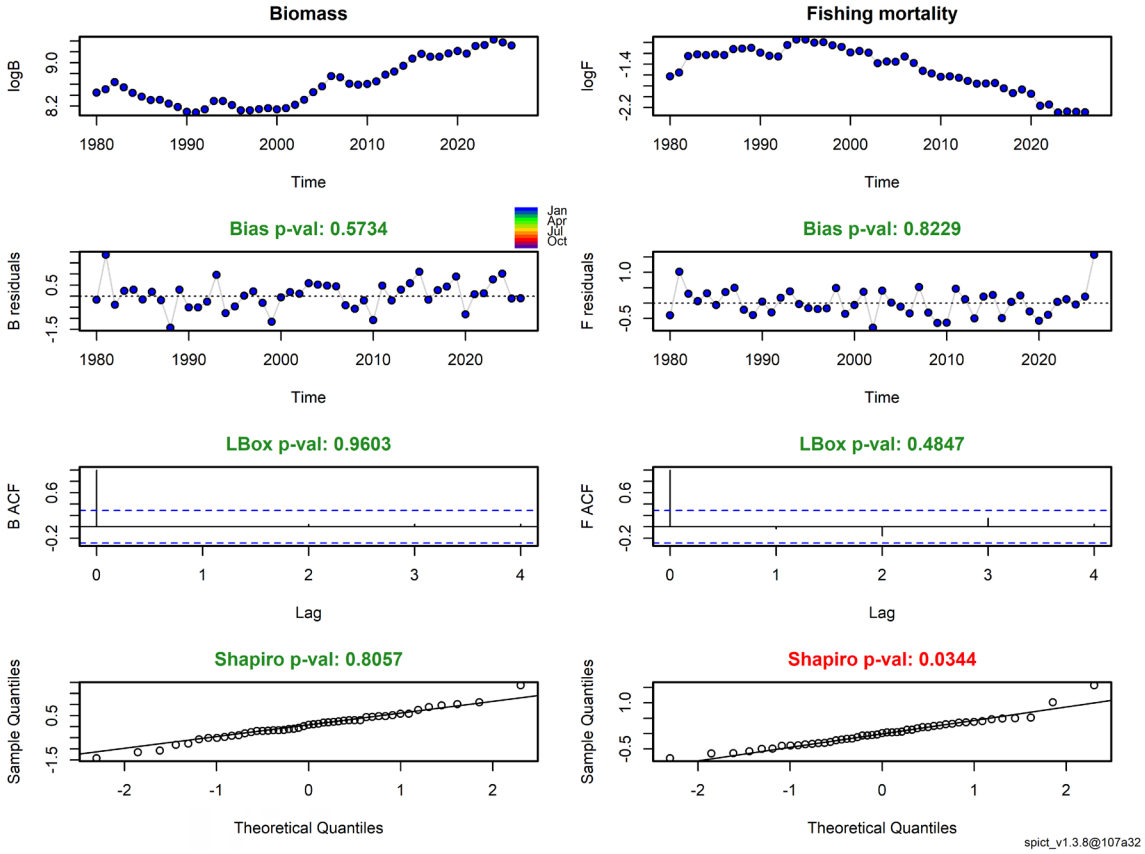


Figure 19. Process error deviations for the model for red mullet in GSA6 for final scenario.

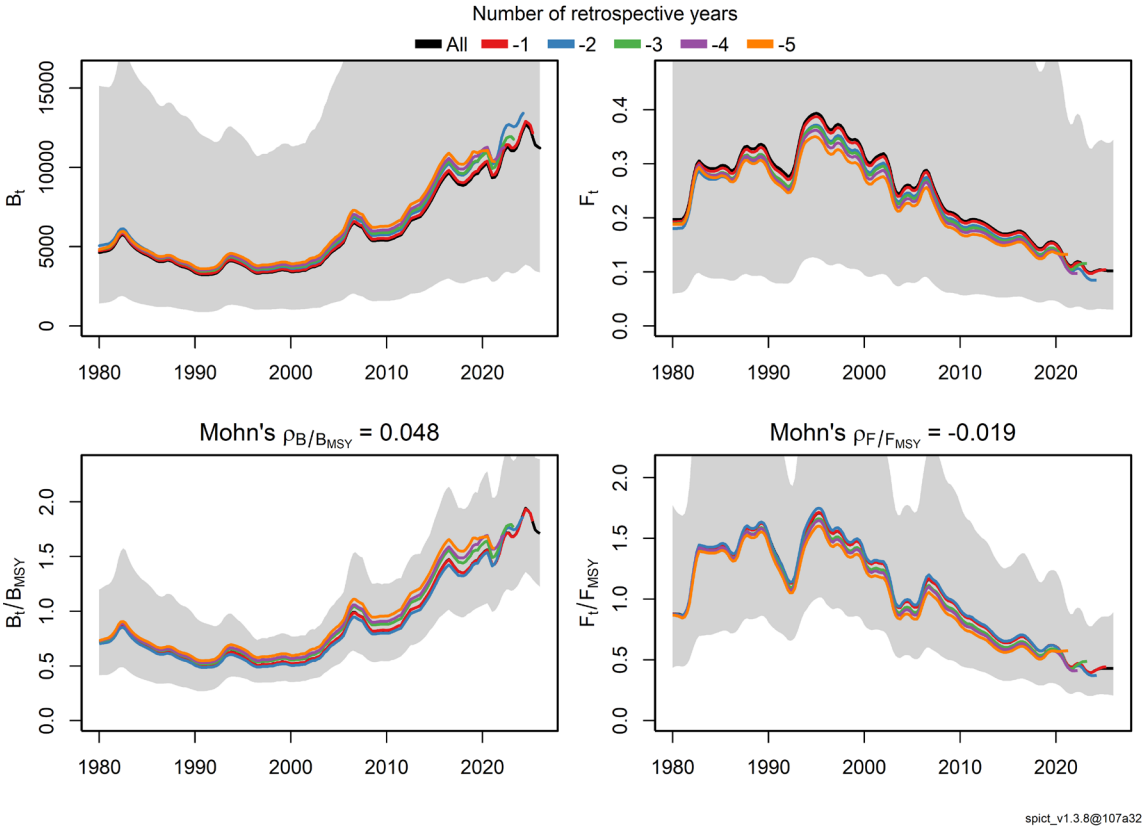


Figure 20. Retrospective analysis for red mullet in GSA6 for final scenario.

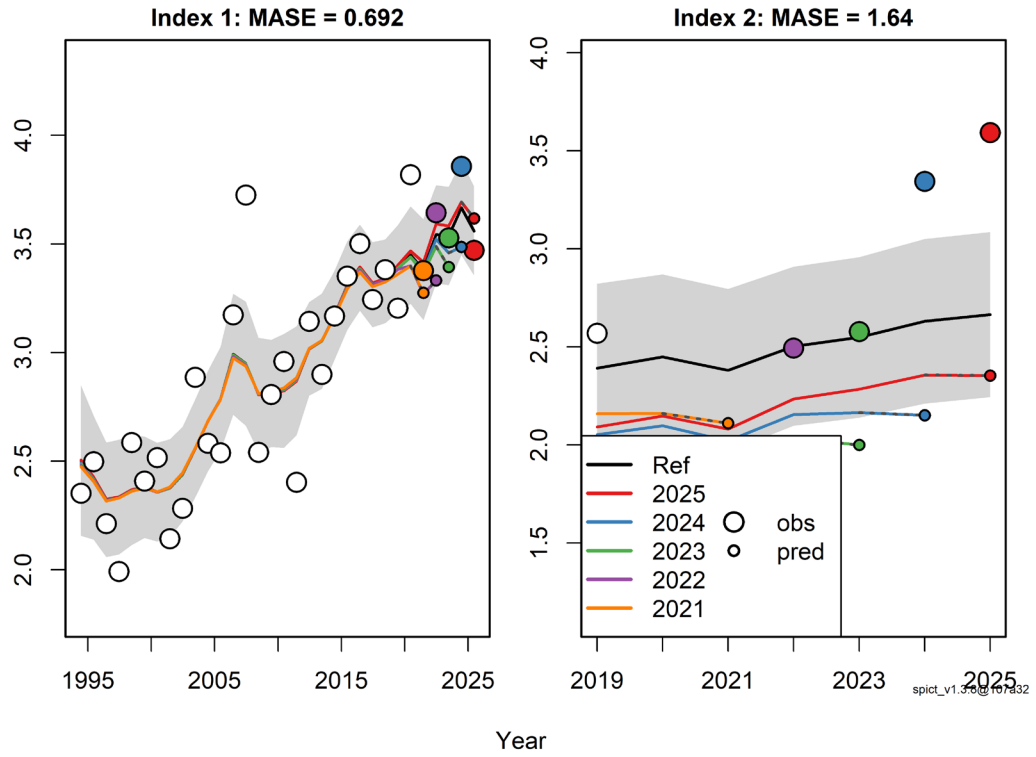


Figure 21. Hindcasting for the model for red mullet in GSA6 for final scenario.

Final scenario advice

Final scenario advice is presented in Figure 22 and in Table 7, which outlines the indicators for red mullet in GSA 6 in 2025, based on the GFCM advice framework. The assessment results should be considered qualitative, although the model results in good diagnostics. The sensitivity analysis and different scenarios result in similar stock status, indicating that the model is relatively stable and robust.

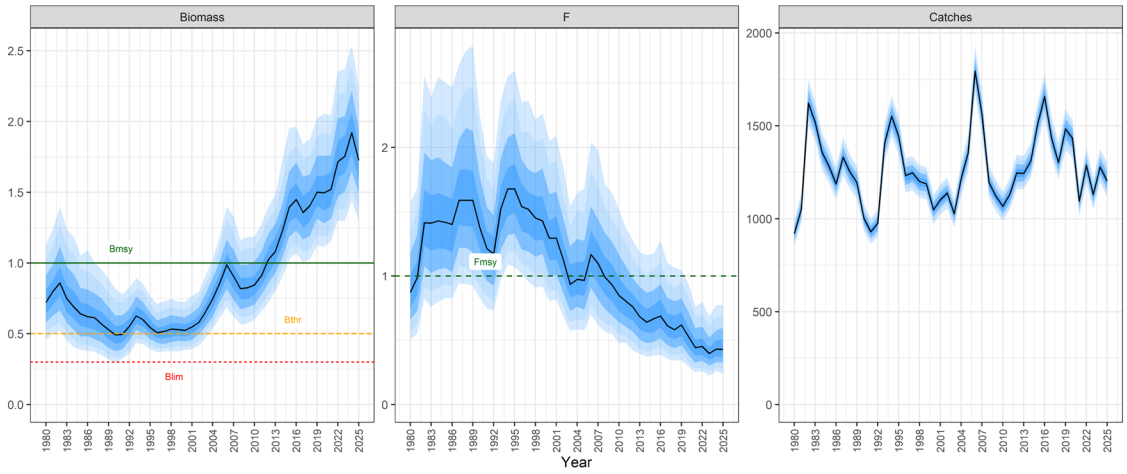


Figure 22. Advice for final scenario for red mullet in GSA6: Historical and current stock status regarding F_{msy}, B_{msy} and $B_{lim.}$

Table 7. Indicators in 2025 from SPiCT for red mullet in GSA6 final scenario.

Species	Year	Catch (t)	F/F_{msy}	B/B_{msy}	B/B_{pa}	B/B_{lim}
MUT	2025	1199.2	0.43	1.72	3.45	5.75

Length-Based Spawning Potential Ratio (LBSPR)

Table 8. Biological parameters used in the different LBSPR scenarios for red mullet (MUT). L_{inf}: asymptotic length at which growth is zero, k: growth rate, M: natural mortality, L_{mat50}: length where 50% of individuals are mature, L_{mat95}: length where 95% of individuals are mature.

Species	Scenario	L_{inf} (mm)	L_{mat50} (mm)	L_{mat95} (mm)	M/k
MUT	1	345	137	150.7	1.68
MUT	2	330	137	150.7	1.61

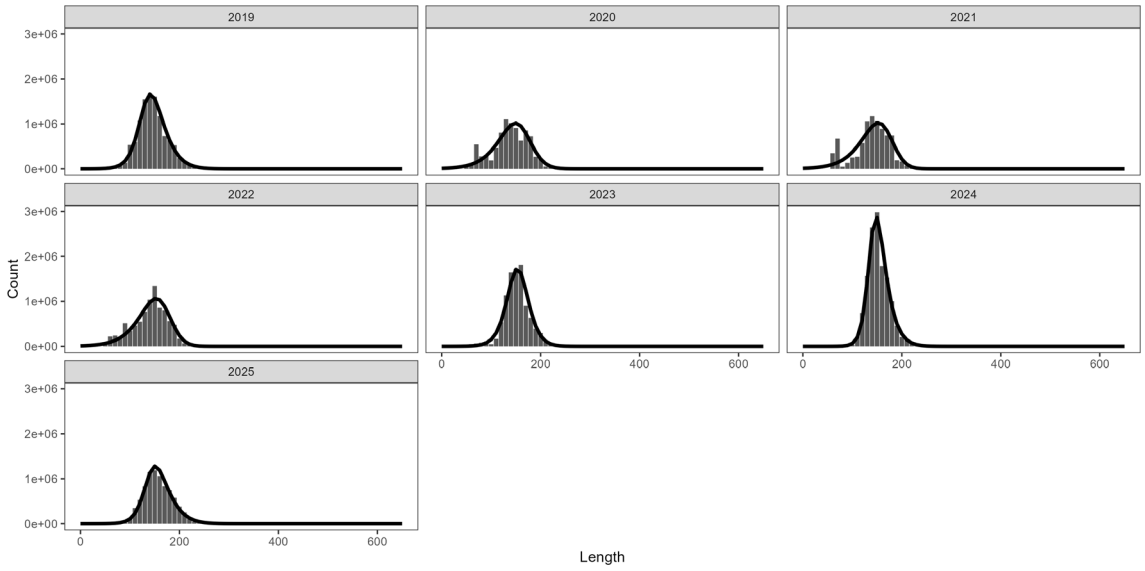


Figure 23. Fit of the data using the LBSPR model for red mullet for each studied year. Grey columns indicate length frequencies. Black lines indicate the fit of the model.

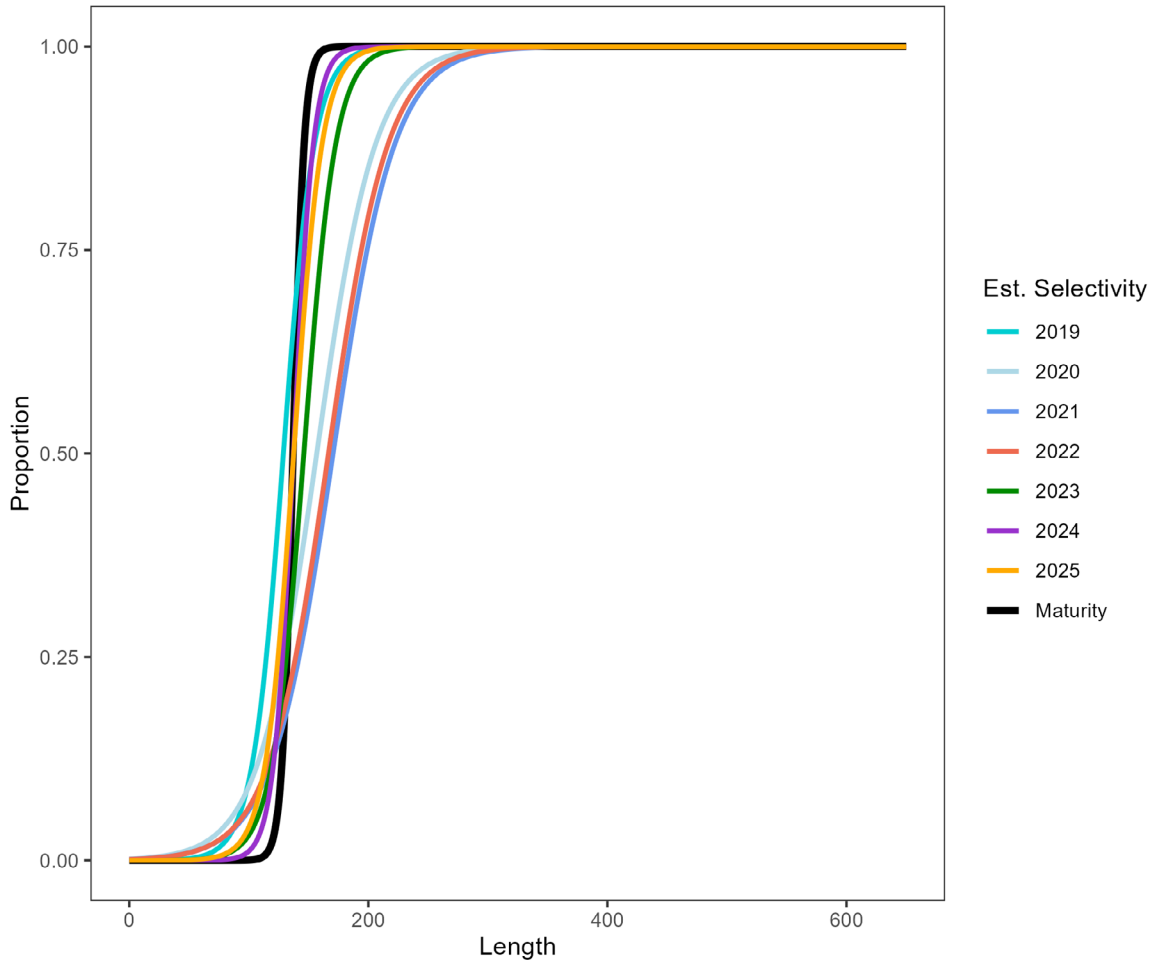


Figure 24. Length curves for red mullet. Black line shows the length curve at maturity. Color lines show the estimated selectivity at length curve predicted by the LBSPR model for each year in scenario 2 (the scenario selected).

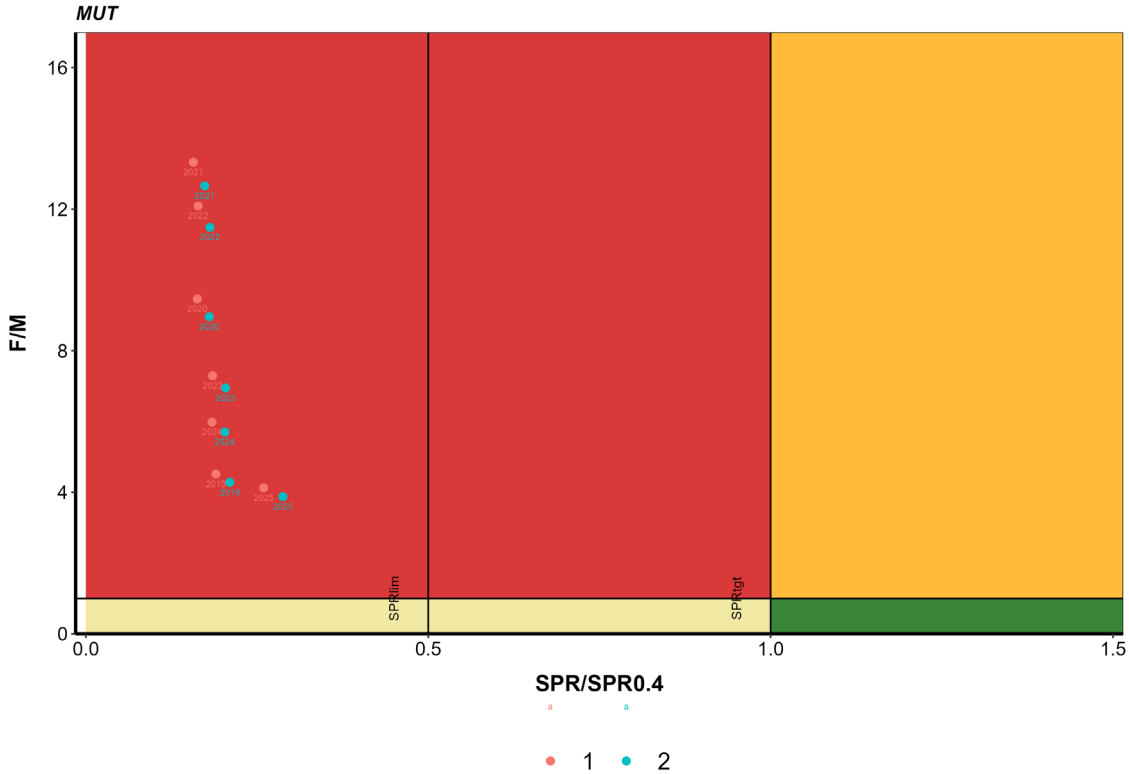


Figure 25. Kobe plot for red mullet by scenario (1-2) and year. SPR_{lim}: limit spawning potential ratio, SPR_{tgt}: target spawning potential ratio, F: fishing mortality, M: natural mortality, and F/M: relative fishing mortality.

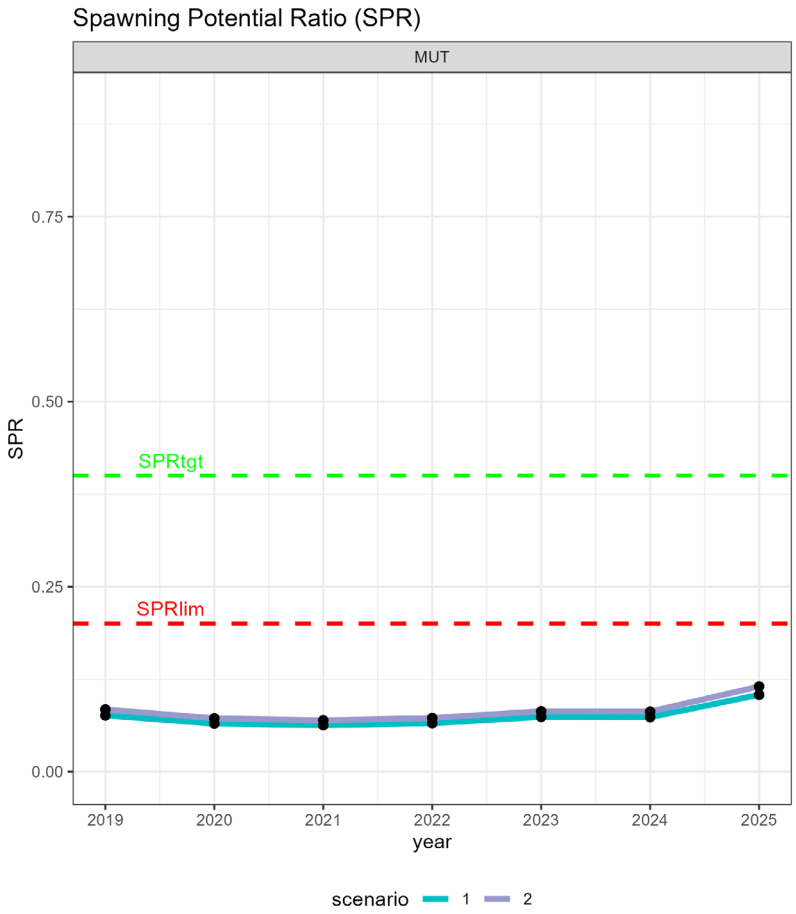


Figure 26. Spawning potential ratio (SPR) per year analyzed for red mullet evaluated with LBSPR model. LBSPR: Length-Based Spawning Potential Ratio. SPR_{lim}: limit spawning potential ratio, SPR_{tgt}: target spawning potential ratio. Colored lines show the results for each scenario.

Table 9. LBSPR model results for red mullet with the different scenarios tested for each year analyzed. SL_{50}: Length where 50% of individuals are caught, SPR: spawning potential ratio and FM: fishing mortality. SD is the standard deviation calculated for each indicator. The selected scenario is highlighted in blue.

Species	Scenario	Year	SL_{50}	SD	SPR	SD	FM	SD
MUT	1	2019	131.9	1.86	0.08	0.05	4.52	1.25
MUT	1	2020	165.14	4.8	0.07	0.05	9.46	2.96
MUT	1	2021	177.47	3.92	0.06	0.04	13.33	4.05
MUT	1	2022	174.45	4.39	0.07	0.05	12.09	3.74
MUT	1	2023	148.64	1.5	0.07	0.05	7.29	1.91
MUT	1	2024	139.08	1.05	0.07	0.05	5.98	1.53
MUT	1	2025	141.09	2.29	0.1	0.07	4.12	1.23
MUT	2	2019	131.63	1.95	0.08	0.06	4.28	1.2
MUT	2	2020	164.77	5.05	0.07	0.05	8.96	2.84
MUT	2	2021	177.29	4.07	0.07	0.05	12.66	3.9
MUT	2	2022	174.27	4.59	0.07	0.05	11.49	3.6
MUT	2	2023	148.56	1.55	0.08	0.05	6.95	1.84
MUT	2	2024	138.98	1.09	0.08	0.05	5.7	1.47
MUT	2	2025	140.72	2.4	0.12	0.07	3.88	1.18

Model setting and results

Scenarios

For the present report, natural mortality (M) values for all scenarios were estimated using a combination of ICATMAR data and published literature. When stock-specific estimates were unavailable, values from nearby and biologically similar stocks were used.

Two different scenarios were applied for the sensitivity analysis for red mullet (Table 8), based on growth parameters reported by Demestre et al. (1997), and maturity data from STECF and GFCM stock assessments.

Fitted data

The length frequency distribution fit per year is shown in Figure 23. The model generally follows the mode for all years, slightly underestimating the number of individuals for some length classes.

Selectivity

The outputs of the model for the selectivity of the fishery are shown for each scenario in Table 9. The output of the selected scenario (2) is also plotted with L_{mat50} and SL_{50} in Figure 24. The estimated selectivity occurs at lengths generally larger than L_{mat50}, indicating that most individuals are likely to reach maturity before becoming fully vulnerable to the fishery.

Reference points

Even though the model is very sensitive to changes in growth parameters and maturity, the stock is below SPR_{lim} (=0.2) in all the scenarios (Table 9 and Figure 26). However, a slight positive increase in the trend is observed for 2025. The Kobe plot for red mullet (Figure 25) shows the stock status throughout the different years. The stock is, in all cases, located in the red zone meaning that it is overfished.

Final scenario

Scenario 2 was selected for the final LBSPR assessment and management advice because its growth parameters were estimated for GSA 6 North, making it the most representative scenario for the study area.

European hake (*Merluccius marluccius*) HKE

The spawning area for European hake is the continental shelf and upper slope but the nursery area is only on the continental shelf. Recruitment occurs all year round but peaks in winter and spring (Recasens et al. 2008, ICATMAR, 26-04).

Input data

The spatial distribution of total landings for European hake in the Catalan fishing ground is shown in Figure 27. The distribution is relatively homogeneous with respect to bathymetry; however, in terms of total landings per km², the northern and southern areas exhibit higher values.

Historical European hake landings in Catalonia, from 2002 to 2025, are shown in Figure 28. Landings decreased throughout the entire time series until 2020, when the lowest value was recorded. Subsequently, in 2021 and 2022, an increasing trend was observed. However, European hake landings declined again in 2023, reaching a new minimum in 2024. In 2025, landings recovered to levels similar to those recorded in 2021.

Figure 29 shows the distribution of European hake landings by métier from 2019 to 2025. Bottom trawlers account for the highest landings, especially for deeper shelf and upper slope métier. Artisanal fisheries and set longliners contribute less to total landings, and their European hake catches have declined in recent years.

Annual LFD

After raising the length frequencies obtained with the monitoring program, and incorporating discards and small-scale fisheries Figure 30 presents the annual length frequency of European hake in Catalonia from 2019 to 2025. The ICATMAR dataset also provides sex ratio information, allowing for sex-specific assessments, as certain biological parameters differ between females and males (Recasens et al., 1998). Nevertheless, sex differentiation was not included in this year's analysis, as it did not provide additional information relevant to the objectives of this report. The SOP validation results are shown in Table 10, while Table 11 summarizes the number of individuals sampled through the ICATMAR monitoring program. A marked increase in the abundance of small length classes was observed in 2020 and 2022, with a greater number of individuals occurring in the discards fraction than in the commercial landings fraction (Table 10). This pattern may reflect stronger recruitment during those years. In contrast, the distributions observed in 2024 and 2025 were characterized by a higher abundance of intermediate length classes (approximately 180-220 mm), with 2025 showing a particularly pronounced mode around 190-200 mm. It is also noteworthy that the largest individuals were predominantly caught by small-scale fisheries.

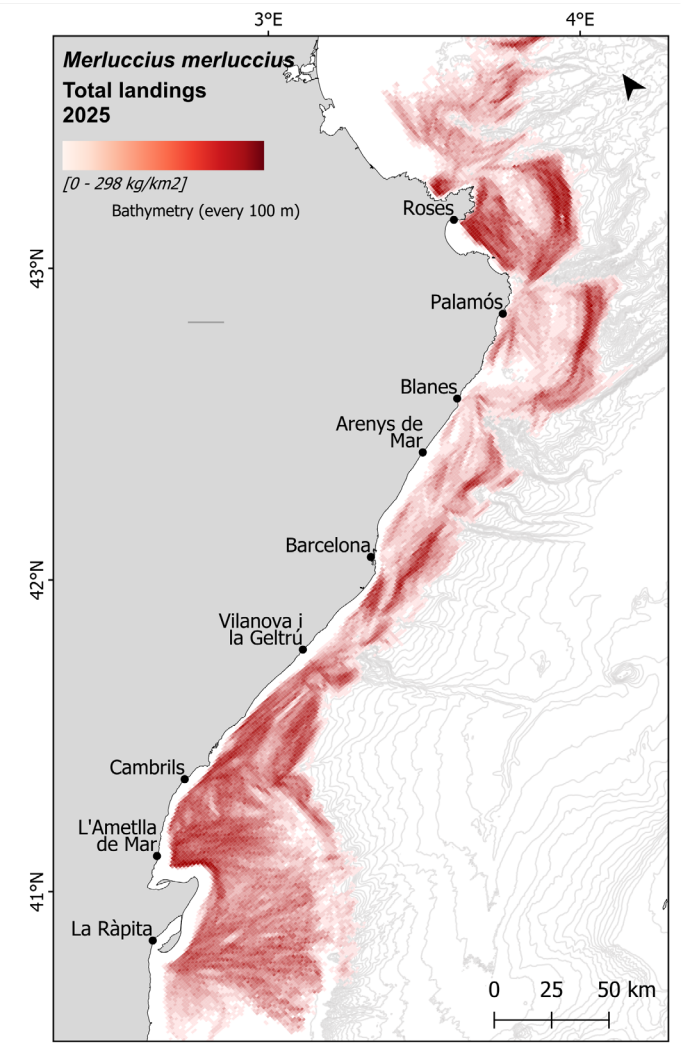


Figure 27. Spatial distribution of landings (kg/km²) for European hake in the Catalan fishing grounds (North GSA6) in the year analyzed.

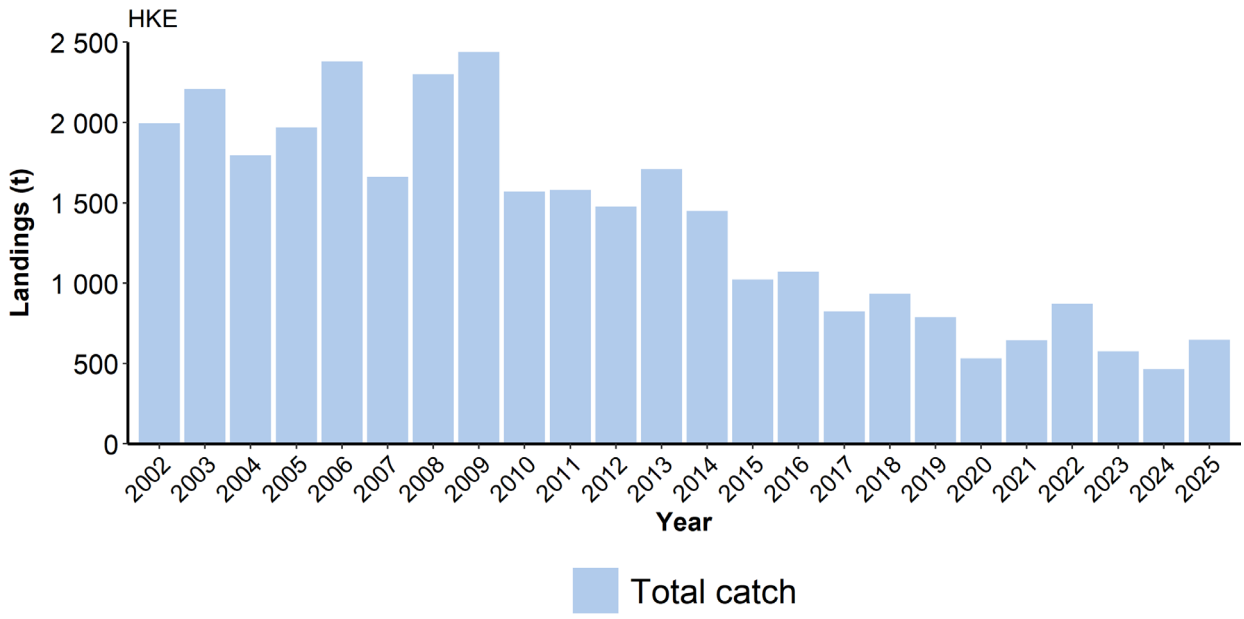


Figure 28. Historical landings (t) for European hake in Catalonia.

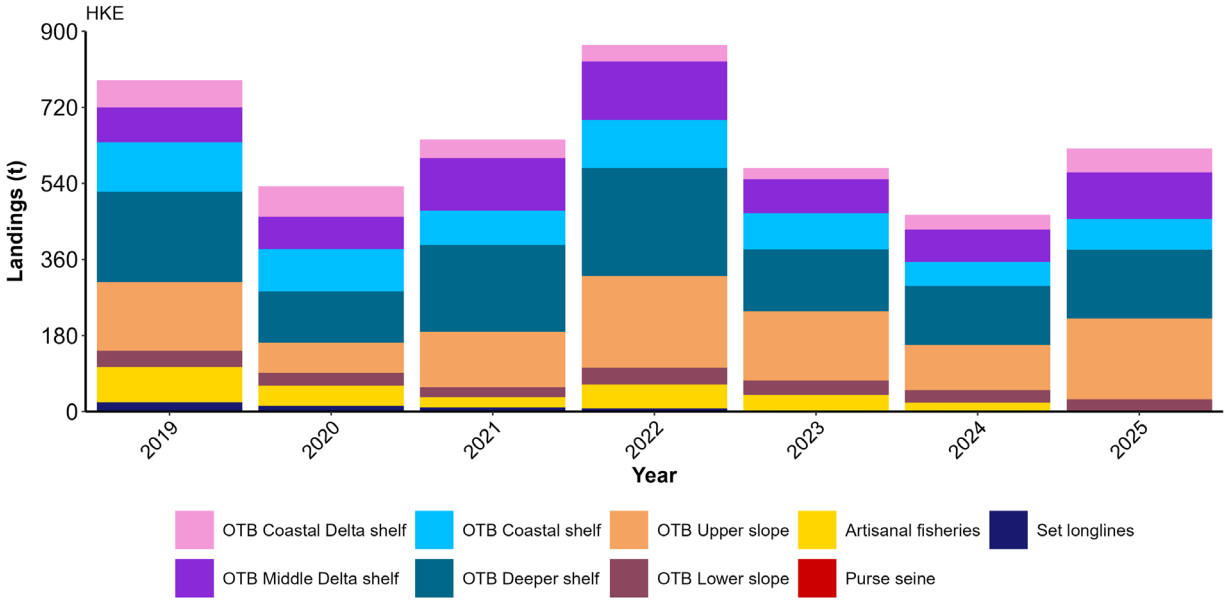


Figure 29. Landings (t) for European hake by métier and fishing gear. OTB: bottom trawling.

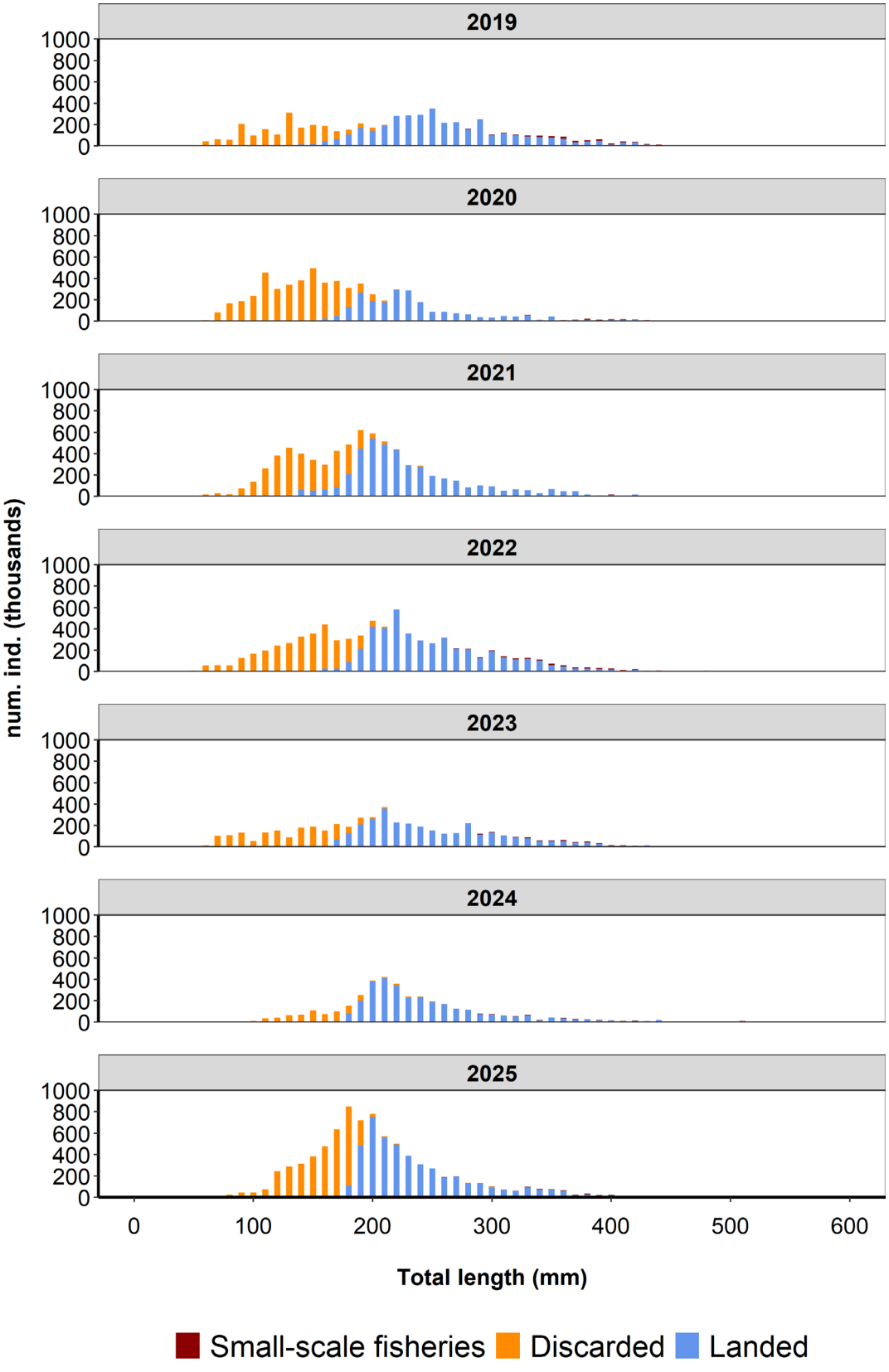


Figure 30. Annual length frequency distributions of European hake from bottom trawling and small-scale fisheries. The data from bottom trawling is raised from ICATMAR data and details landed and discarded European hake. The data from small-scale fisheries is obtained from DCF (Data Collection Framework) dataset.

Table 10. Sum of Products (SOP) validation for European hake (HKE): The column Calculated Weight in N GSA6 (SOP) represents the biomass estimated through the raising process, while landings refer to the reported landings in N GSA6. The ratio between SOP and landings is known as the Sum of Products (SOP). Values close to 1 indicate that the raising process provides biomass estimates that closely match the reported landings, thereby validating the accuracy of the estimation method.

Species	Year	Catch classification	Gear	Calculated weight GSA6N (kg) (SOP)	Landings in GSA6N (kg)	SOP/Landings
HKE	2019	ASSF	Artisanal fisheries	95582	105440	0.91
HKE	2020	ASSF	Artisanal fisheries	14352	61159	0.23
HKE	2021	ASSF	Artisanal fisheries	15806	33931	0.47
HKE	2022	ASSF	Artisanal fisheries	56378	63895	0.88
HKE	2023	ASSF	Artisanal fisheries	34922	39579	0.88
HKE	2024	ASSF	Artisanal fisheries	18535	21007	0.88
HKE	2025	ASSF	Artisanal fisheries	23423	26547	0.88
HKE	2019	Discarded	Bottom trawl	29090	-	-
HKE	2020	Discarded	Bottom trawl	72446	-	-
HKE	2021	Discarded	Bottom trawl	71609	-	-
HKE	2022	Discarded	Bottom trawl	64944	-	-
HKE	2023	Discarded	Bottom trawl	29873	-	-
HKE	2024	Discarded	Bottom trawl	21216	-	-
HKE	2025	Discarded	Bottom trawl	102628	-	-
HKE	2019	Landed	Bottom trawl	559176	680919	0.82
HKE	2020	Landed	Bottom trawl	271156	471789	0.57
HKE	2021	Landed	Bottom trawl	446184	609698	0.73
HKE	2022	Landed	Bottom trawl	587027	803304	0.73
HKE	2023	Landed	Bottom trawl	435460	537217	0.81
HKE	2024	Landed	Bottom trawl	386375	444366	0.87
HKE	2025	Landed	Bottom trawl	521062	622287	0.84

Table 11. Number of European hake individuals sampled by zone and season from ICATMAR monitoring data used to raise the length frequencies.

Fishery	Year	Zone	Winter	Spring	Summer	Autumn	N hauls
			Number individuals sampled				
Bottom trawl	2021	North	320	390	487	293	43
Bottom trawl	2021	Center	190	528	751	325	27
Bottom trawl	2021	South	141	56	641	441	20
Bottom trawl	2022	North	181	449	755	643	41
Bottom trawl	2022	Center	464	216	507	394	31
Bottom trawl	2022	South	92	165	353	306	18
Bottom trawl	2023	North	632	536	330	427	45
Bottom trawl	2023	Center	427	169	279	254	34
Bottom trawl	2023	South	189	152	289	164	20
Bottom trawl	2024	North	383	283	263	553	40
Bottom trawl	2024	Center	164	217	494	177	32
Bottom trawl	2024	South	165	136	246	245	21
Bottom trawl	2025	North	177	387	474	491	42
Bottom trawl	2025	Center	129	164	294	260	17
Bottom trawl	2025	South	157	324	487	897	22

Stochastic Production model in Continuous Time (SPiCT)

For European hake, fleet data were obtained from the EU Fleet Register provided by the European Commission (Reg. EU 2017/218); daily commercial fishing landings in GSA6 were provided by the Spanish Ministry of Agriculture, Fisheries and Food; MEDITS data were obtained from the most recent available GFCM Stock Assessment Form (SAF) for HKE in GSA6 (RY2024), the Joint Research Center (JRC, 2025; STECF-PLEN-25-01 background), and data from the Spanish Institute of Oceanography – CSIC (IEO-CSIC) were also used. Annual biomass index for N GSA6 and the MEDITS autumn survey were obtained from ICATMAR data. (Figure 31). Additional details regarding the data source and treatment are explained in ICATMAR 25-06.

- Catch from 1971 to 2025
- Standardized CPUE (LLS and GNS): 2004- 2025 (based on Henning Winker (GFCM) & Hoyle et al., 2024) -> Here, it is assumed that CPUE = LPUE.
- Index: MEDITS survey data from 1994 to 2025 (Biomass, kg/km²)
- Index: MEDITS-AUT survey data from November 2025 (Biomass, kg/km²)
- Annual biomass index: ICATMAR data: 2019 – 2025 (Biomass, kg/km²

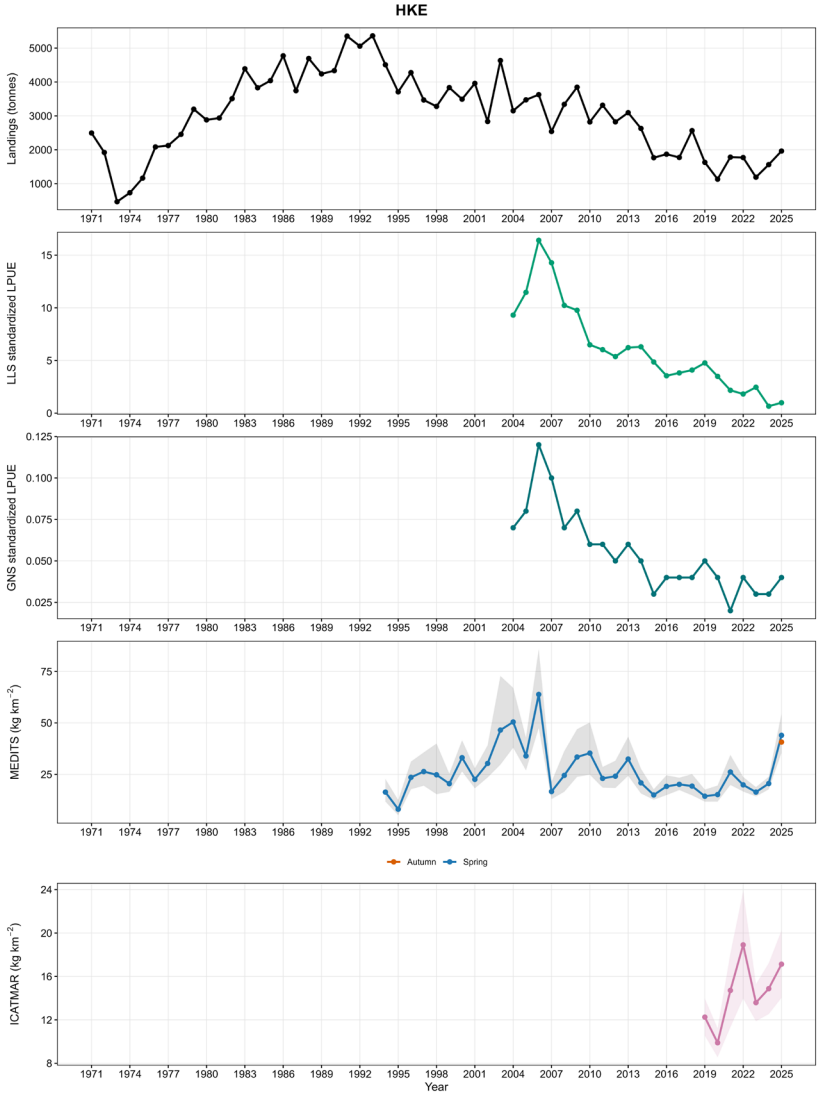


Figure 31. Data available for the assessment of European hake in GSA6 using the SPiCT model. From top to bottom: catch data from 1971 to 2025; standardized OTB LPUE data from 2004 to 2024; MEDITS survey biomass indices from 1994 to 2025, including Spring and Autumn surveys; and ICATMAR biomass indices from 2019 to 2025.

For the MEDITS and ICATMAR biomass indices, the uncertainty associated with each annual estimate was derived from the survey data following the approach used in GFCM stock assessments. Annual coefficients of variation (CVs) were calculated for each index, and the corresponding uncertainty was incorporated into the assessment. A mean CV (CVmean) was calculated across the available time series and used as a reference for the overall uncertainty of each index. The annual variability in precision was then accounted for using a standard deviation factor (StDevF), calculated as the ratio of the annual CV to the CVmean. This approach allows the observation error assigned to the survey indices in SPiCT to reflect the uncertainty associated with the underlying survey data and its year-to-year variation, consistent with the treatment of survey indices in GFCM stock assessments.

Following the sensitivity analysis conducted in the previous assessment (ICATMAR 25-06), which combined the MEDITS biomass index with CPUE indices from LLS and GNS, additional scenarios were explored to evaluate the assessment's robustness to the inclusion of new information. In the current assessment, the ICATMAR biomass index was incorporated as an additional independent abundance index. The MEDITS and ICATMAR series showed consistent trends, providing complementary information and increasing confidence in the robustness of the model results. In contrast, the recent LLS observations showed a marked decrease that may be related to changes in fleet activity and the index's representativeness, rather than necessarily reflecting a comparable decrease in hake abundance. Therefore, a sensitivity scenario excluding the most recent five years of the LLS series (2021–2025) was tested. Finally, confidence intervals were incorporated for the MEDITS and ICATMAR indices to explicitly account for observation uncertainty. The final scenario was selected based on the spring–summer MEDITS index, ICATMAR, GNS CPUE and LLS CPUE excluding 2021–2025, with confidence intervals included for the MEDITS and ICATMAR series. Overall, the model remained robust after incorporating multiple independent abundance indices and their associated observation uncertainty.

A final comparison of all scenarios is shown in Figure 32.

- Scenario 1: Landings 1971-2025 + MEDITS biomass index (1994–2024 and AUT 2025) + LLS + GNS.
- Scenario 2: Landings 1971-2025 + MEDITS biomass index (1994–2024 and AUT 2025) + LLS + GNS + ICATMAR.
- Scenario 3: Same as Scenario 2, but LLS until 2020.
- Scenario 4: Catch 1971-2025, MEDITS spring + LLS (until 2020) + GNS + ICATMAR.

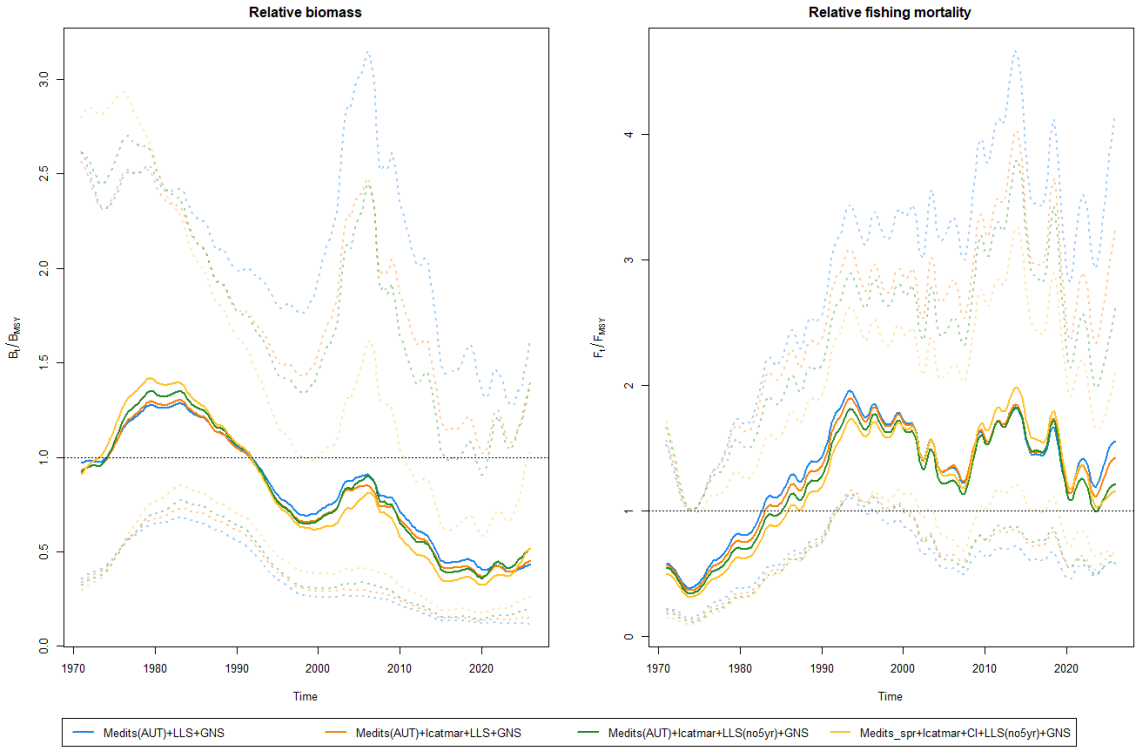


Figure 32. Scenarios comparison for European hake in GSA6.

Final scenario

The settings used for the final scenario are shown in Table 12, along with explanations of the assumptions made. Among other settings, the BKfrac prior was 0.6, selected because biomass was higher at that time, following sensitivity analyses of this prior. Also, to reduce the possible effect of the high value in 2006 and that the last years of the time series index for LLS and GNS could be less representative of the adult biomass, a different standard deviation factor was applied to the different indices.

The final scenario input data are shown in Figure 33, and the final summary assessment results are presented in Figure 34. The results show a decreasing trend in biomass since 2005, with slight stability since 2015, compared with the historical time series. Since then, values have remained between the reference points, B_{lim} and B_{thr}. For fishing mortality, the estimated values have been consistently above 1 since 1980. Since 2020, F/F_{msy} has remained below 1.5 and close to 1, although these estimates should be considered qualitative indicators.

All diagnostics can be checked in Figure 35, Figure 36, Figure 37, Figure 38 and Figure 39. The chosen scenario met all of the model diagnostics, such as Mohnr values for the retrospective analysis and a MASE less than 1. A sensitivity analysis for the final scenario was performed, testing r prior, BKfrac, process error, and observation error to assess the model's robustness within these priors. All these plots and results for the other scenarios will be available at https://github.com/ICATMAR.

Type	Prior	Description	Assignment	Mean	Standard deviation	Comment
Fishery dynamic	logbkfrac	B/K fraction (depletion)	-	Log(0.6)	0.3	A value of 0.6 was selected as the biomass was higher at that time, and after conducting different sensitivity analyses on this prior.
Relative standard deviation time series (input data)	stdevfacC	Standard deviation factor for catches	1971-1973	3	-	Landings between 1971 and 1973 were the lowest and may have been less credible.
	stdevfacI	Standard deviation factor for indices	MEDTIS + ICATMAR	-	-	StDevF and CV from the data
			LLS 2006 & 2021-2024	1.5		Reduce the possible effect of the high value in 2006.
			GNS 2006 & 2021-2024	1.5 & 2		Reduce the possible effect of the high value in 2006. The last years of the time series index for GNS may be less representative of the medium to adult biomass.
Stock dynamic	Logr	Population growth	-	Log(0.17)	0.82	Fishlife
	Logn	Shape of production curve	-	Log(2)	-	Shaefer
Error	Logsdc	Catch error	-	Log(0.1)	0.2	
	Logsdf	Fishing mortality error	-	Log(4)	0.5	
	Logsdb	Process error	-	Log(0.1)	0.5	
	logsdi	Observation error	MEDITS	Log(0.2)	CV MEDITS	MEDITS index was assumed to be more credible than CPUE indices
			ICATMAR	Log(0.2)	CV ICATMAR	
			LLS	Log(0.3)	0.3	
			GNS	Log(0.3)	0.3	

Table 12. Prior settings for European hake in GSA 6 for final scenario.

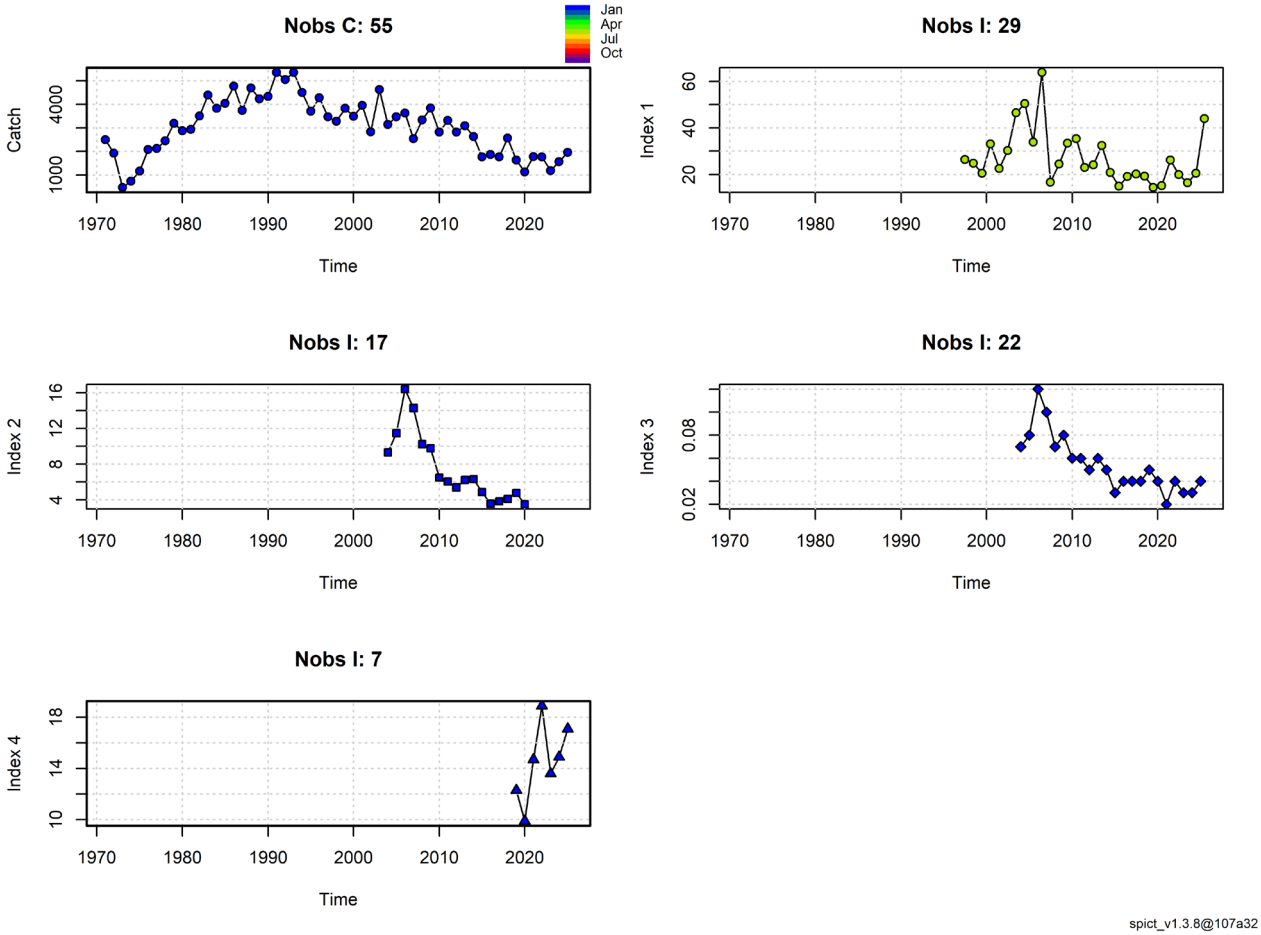


Figure 33. Input data series used in the SPiCT assessment of European hake in GSA 6. From top to bottom and left to right: catch in tons per year from 1971 to 2024, MEDITS biomass index from 1997 to 2025, Standardize CPUE for LLS from 2004 to 2020, Standardize CPUE for GNS from 2004 to 2025, and ICATMAR biomass index from 2019 to 2025. CPUE: catch per unit of effort. LLS: longliners. GNS: gillnets.

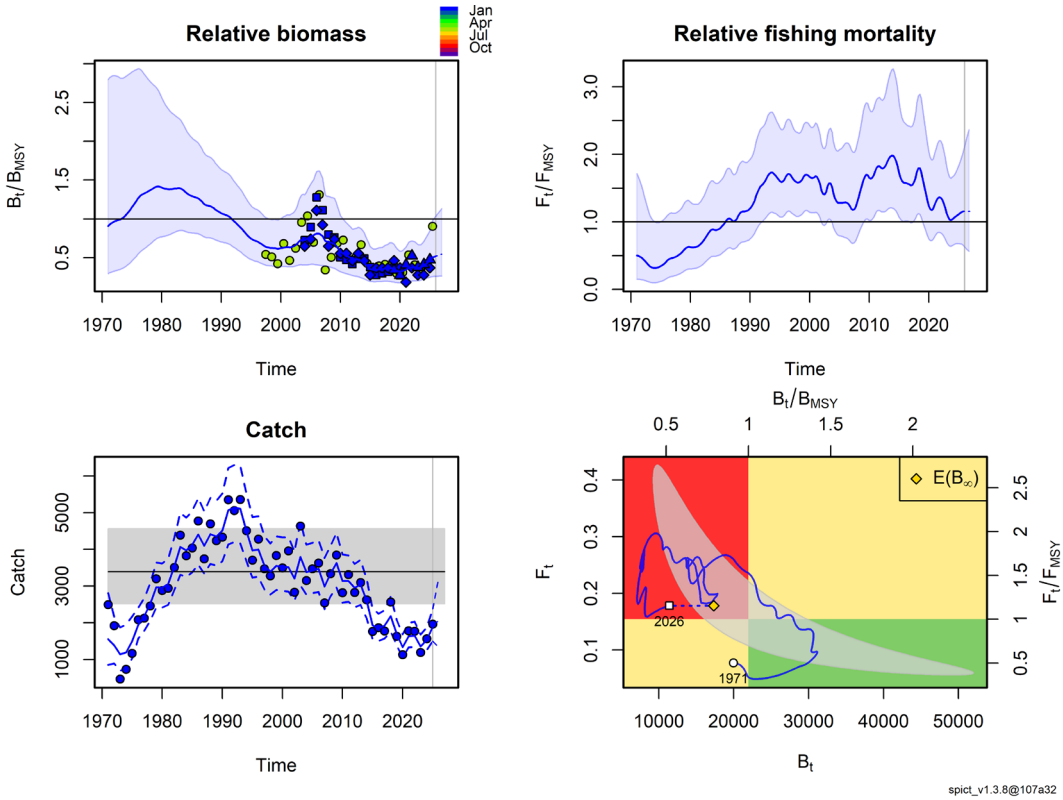


Figure 34. Stock assessment summary for SPiCT model for European hake in GSA6 for final scenario.

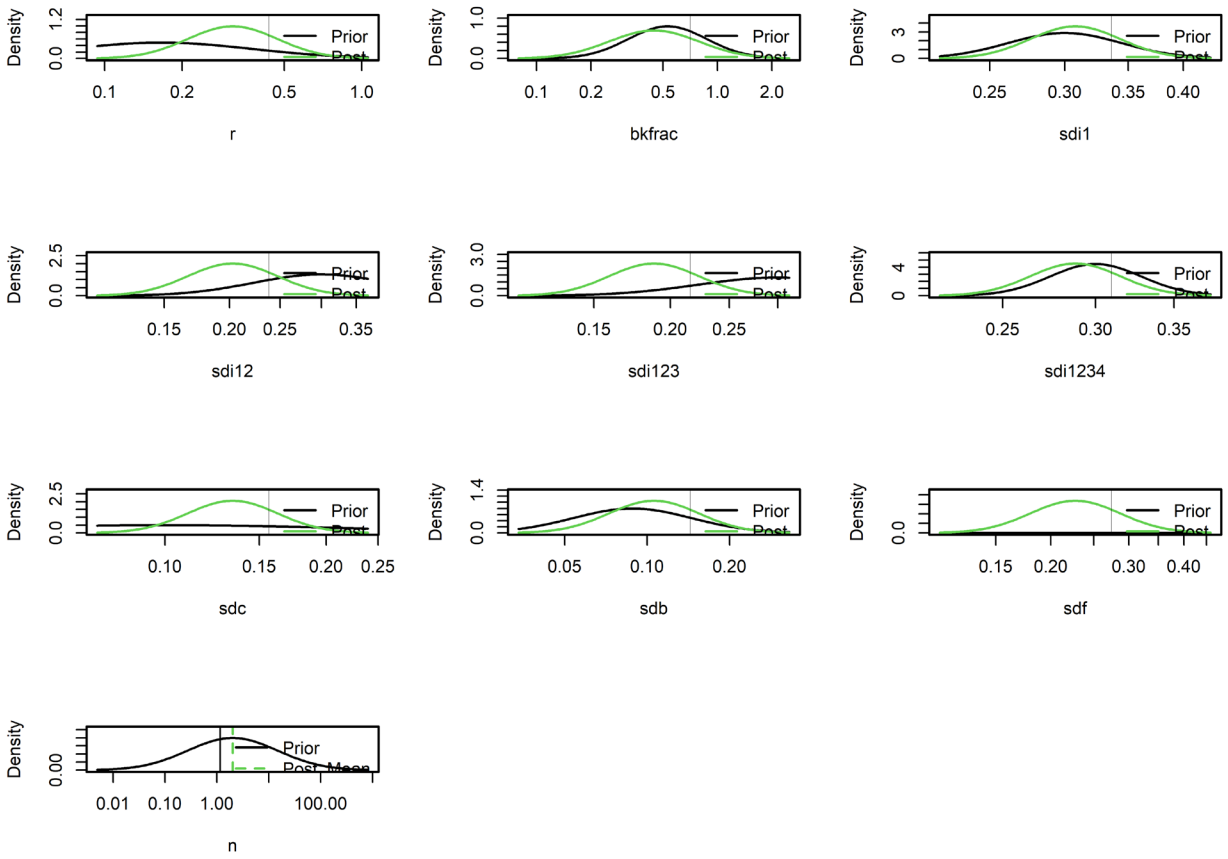


Figure 35. Estimated priors and posteriors for the updated assessment for European hake in GSA6 for final scenario

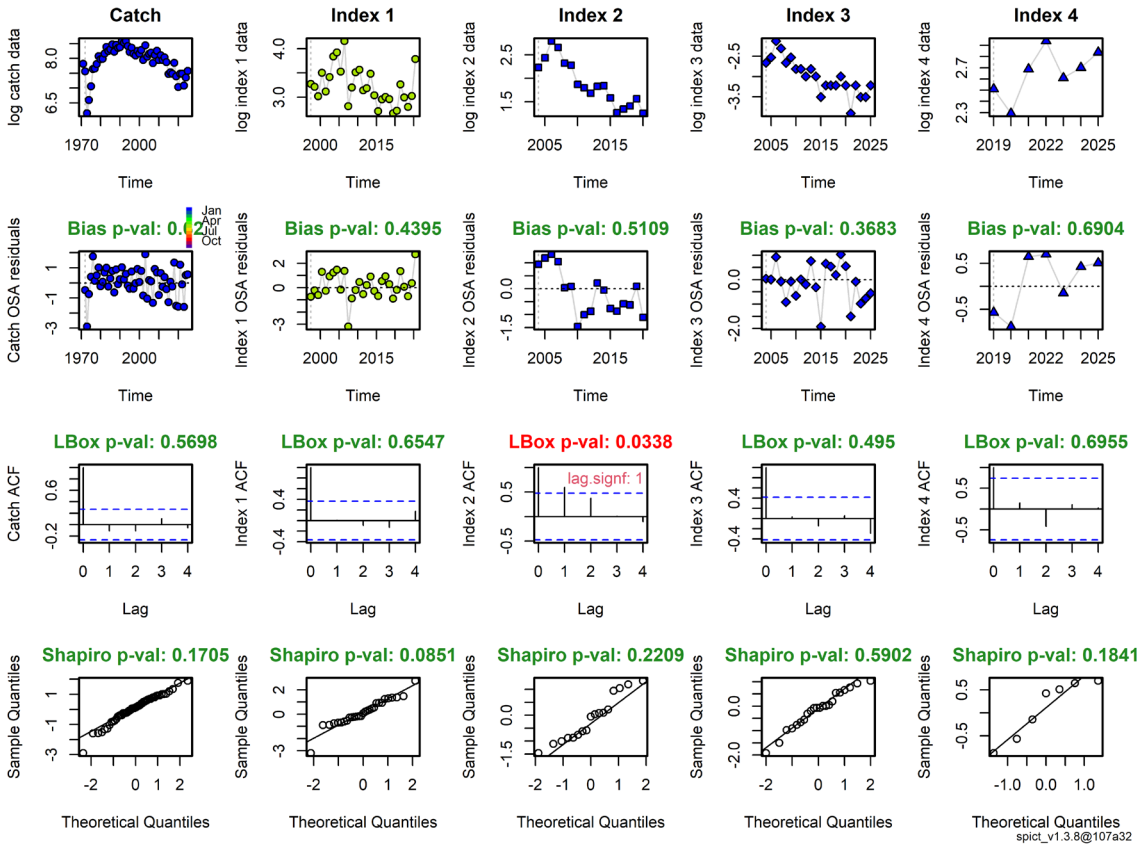


Figure 36. One-step-ahead residuals for the model for European hake in GSA6 for final scenario.

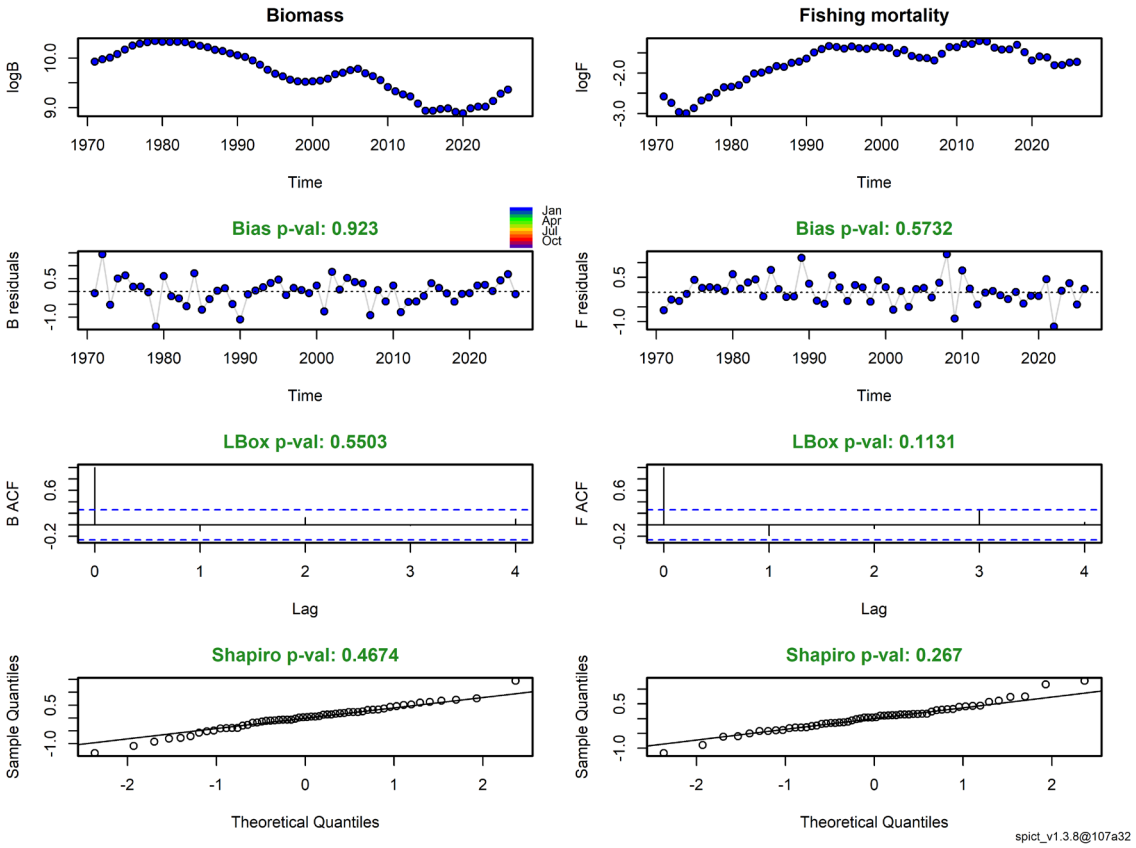


Figure 37. Process error deviations for the model for European hake in GSA6 for final scenario.

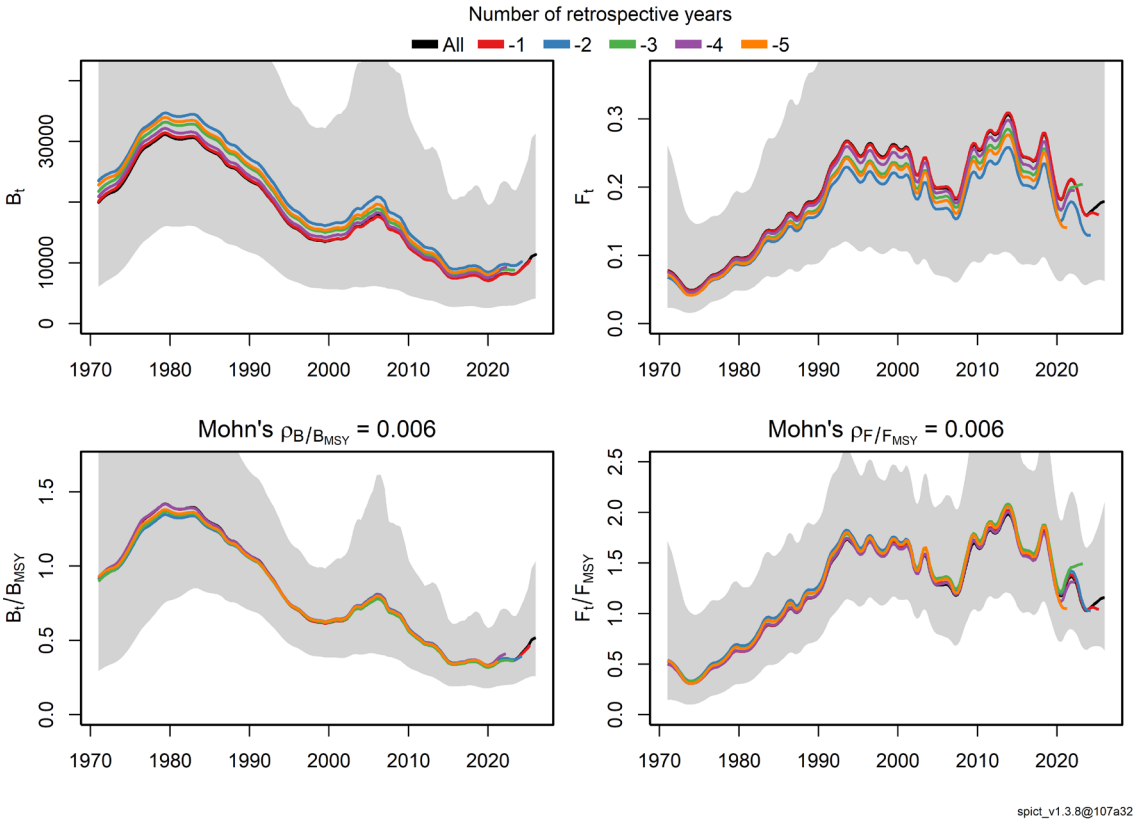


Figure 38. Retrospective analysis for European hake in GSA6 for final scenario.

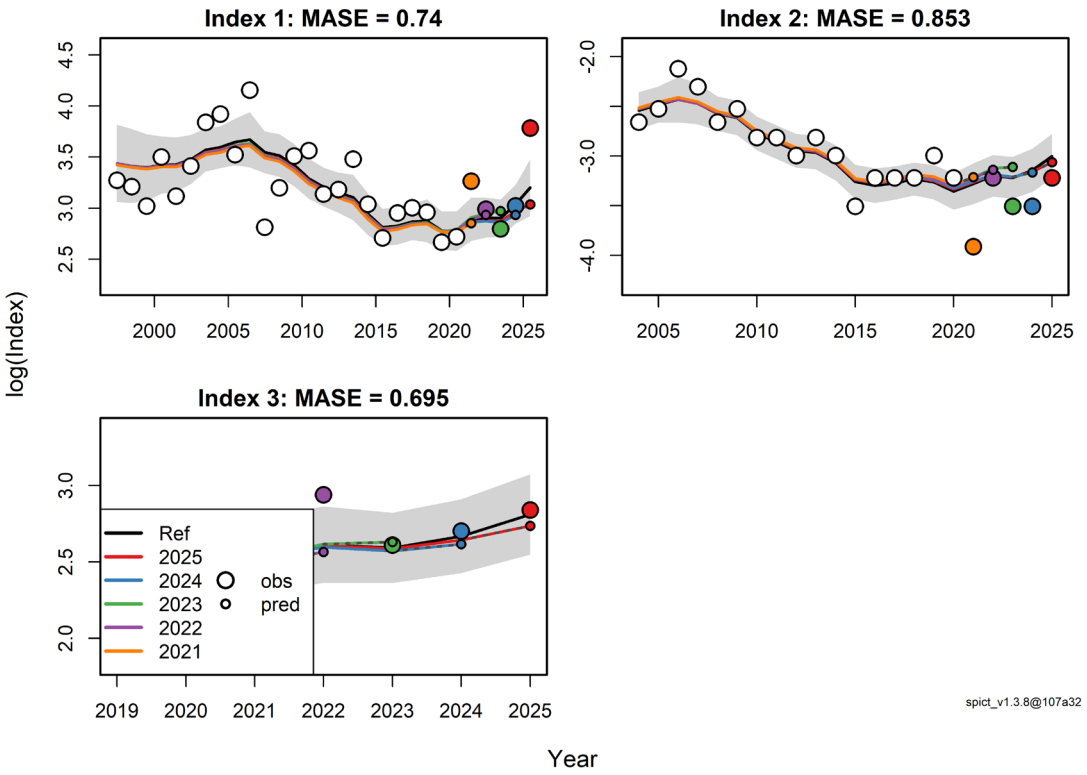


Figure 39. Hindcasting for the model for European hake in GSA6 for final scenario.

Final scenario advice

Final scenario advice is presented in Figure 40 and in Table 13, which outlines the indicators for European hake in GSA 6 in 2025, based on the GFCM advice framework. The assessment results should be considered qualitative, although the model results in good diagnostics. B/B_{msy} is close to B_{thr} and has been increasing since 2020; more time is needed to see a recovery in the biomass indicator. F/F_{msy} is close to 1, but this reference point is more variable depending on the biomass input (ad hoc WGHKE, GFCM 2025). The sensitivity analysis and different scenarios result in similar stock status, indicating that the model is relatively stable and robust.

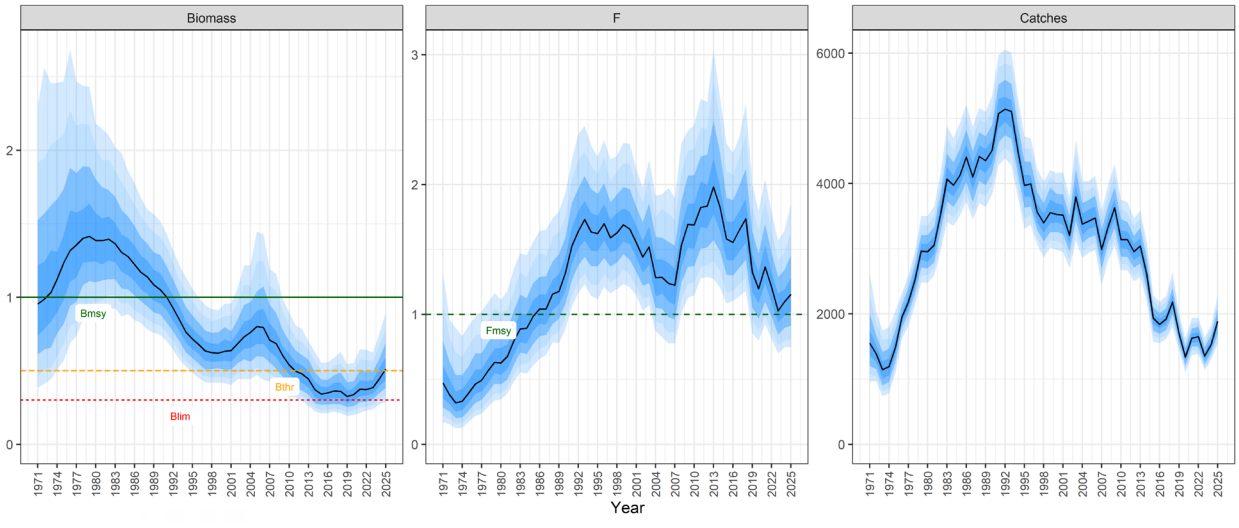


Figure 40. Advice for final scenario for European hake in GSA6: Historical and current stock status regarding F_{msy}, B_{msy} and $B_{lim.}$

Table 13. Indicators in 2025 from SPiCT for European hake in GSA6 final scenario.

Species	Year	Catch (t)	F/Fmsy	B/Bmsy	B/Bpa	B/Blim
HKE	2025	1963	1.16	0.51	1.02	1.71

Length-Based Spawning Potential Ratio (LBSPR)

Table 14. Biological parameters used in the different LBSPR scenarios for European hake (HKE). L_{inf}: asymptotic length at which growth is zero, k: growth rate, M: natural mortality, L_{mat50}: length where 50% of individuals are mature, L_{mat95}: length where 95% of individuals are mature.

Species	Scenario	Linf (mm)	Lmat50 (mm)	Lmat95 (mm)	M/k
HKE	1	1100	260	309.4	1.53
HKE	2	1100	282	335.6	1.53
HKE	3	802	285	403	1.97

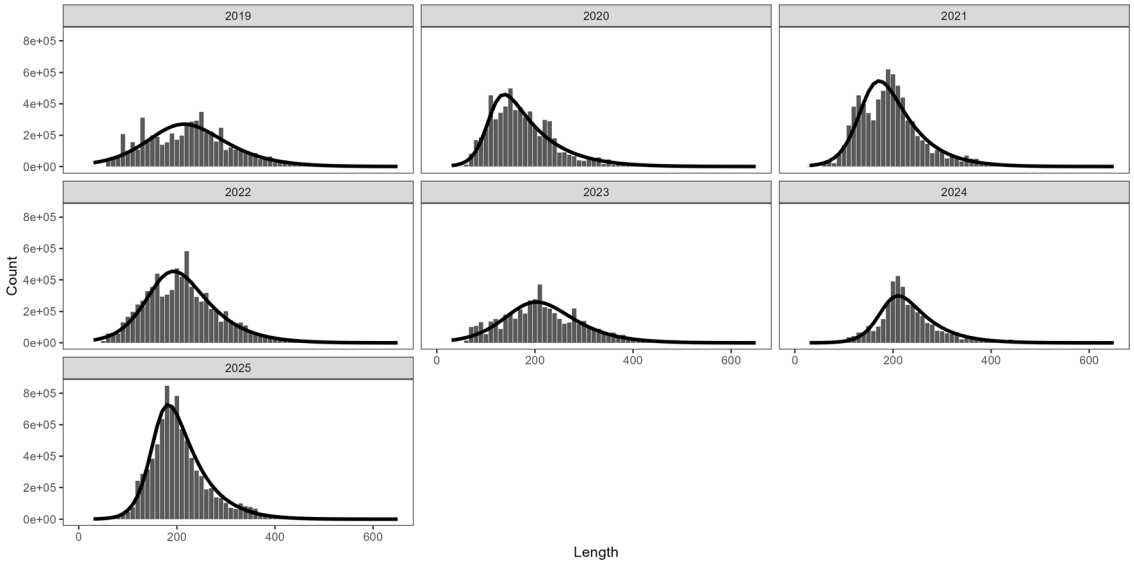


Figure 41. Fit of the data using the LBSPR model for European hake for each studied year. Grey columns indicate length frequencies. Black lines indicate the fit of the model.the model..

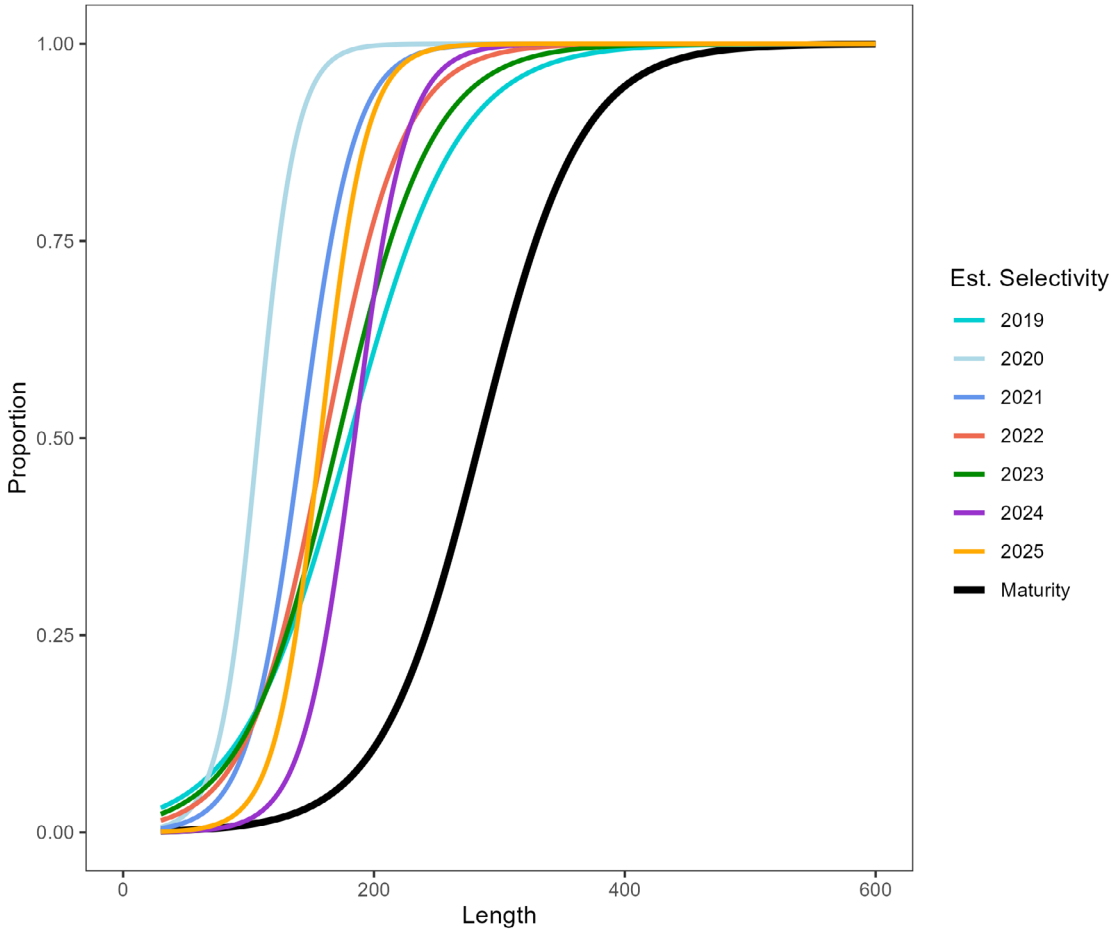


Figure 42. Length curves for European hake. Black line shows the length curve at maturity. Color lines show the estimated selectivity at length curve predicted by the LBSPR model for each year in scenario 3 (the scenario selected).

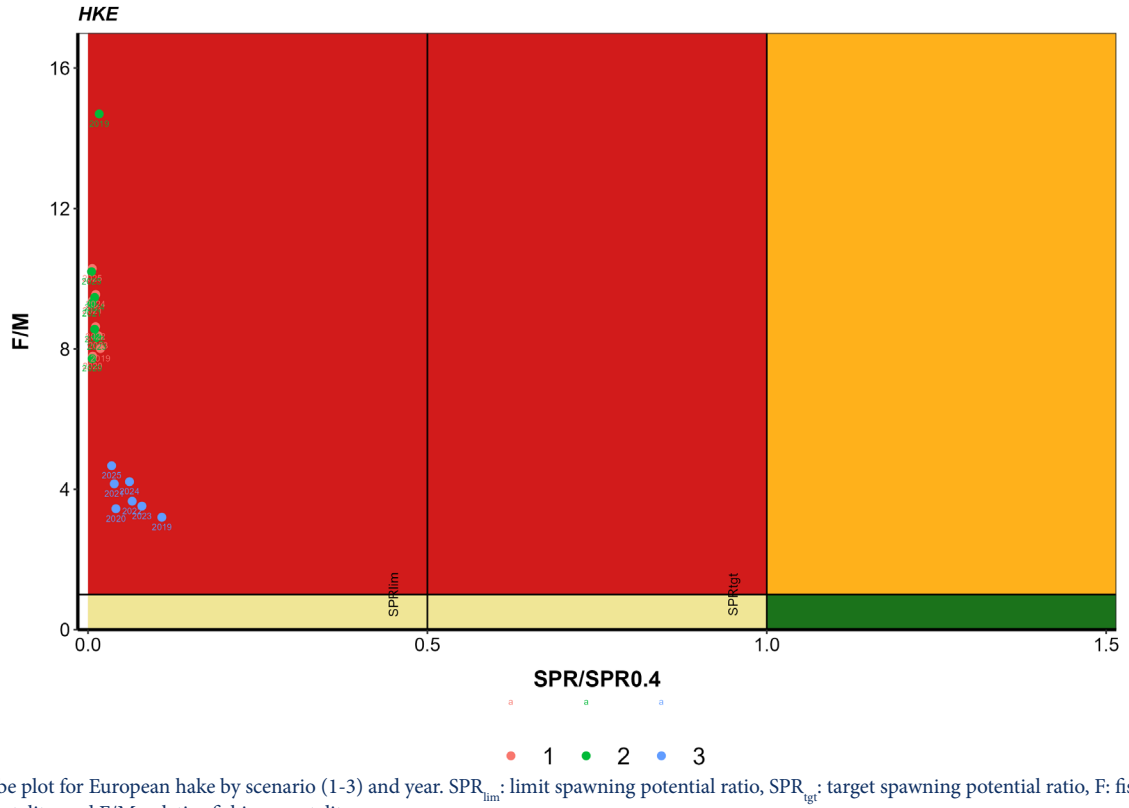


Figure 43. Kobe plot for European hake by scenario (1-3) and year. SPR_{lim}: limit spawning potential ratio, SPR_{tgt}: target spawning potential ratio, F: fishing mortality, M: natural mortality, and F/M: relative fishing mortality.

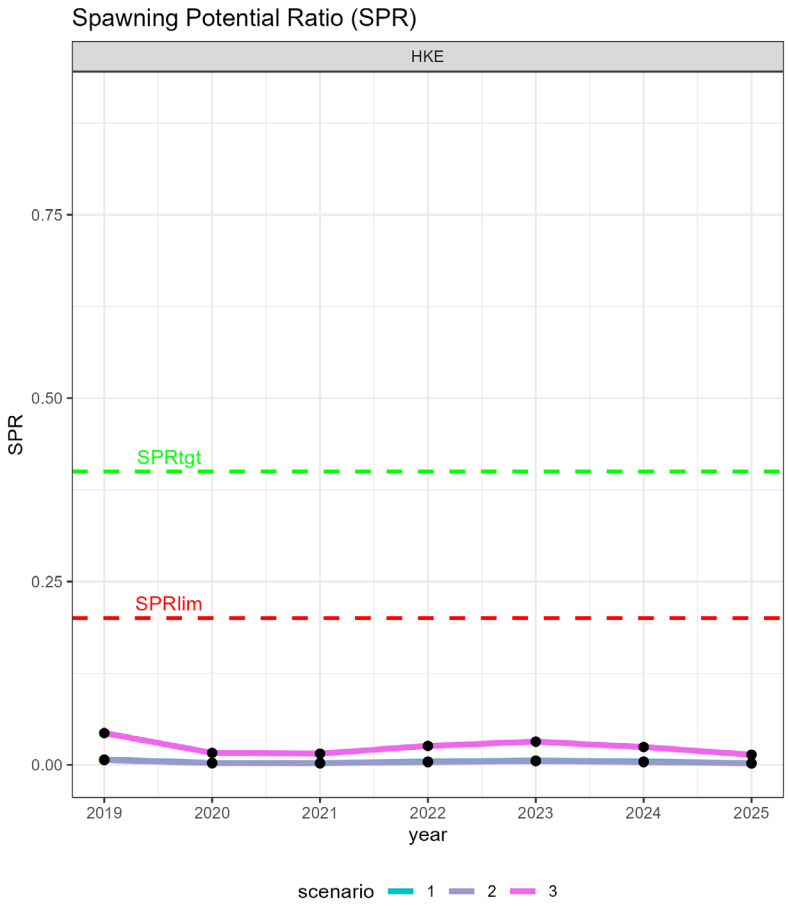


Figure 44. Spawning potential ratio (SPR) per year analyzed for European hake evaluated with LBSPR model. LBSPR: Length-Based Spawning Potential Ratio. SPR_{lim}: limit spawning potential ratio, SPR_{tgt}: target spawning potential ratio. Colored lines show the results for each scenario.

Table 15. LBSPR model results for European hake with the different scenarios tested for each year analyzed. SL_{50}: Length where 50% of individuals are caught, SPR: spawning potential ratio and FM: fishing mortality. SD is the standard deviation calculated for each indicator. The selected scenario is highlighted in blue.

Species	Scenario	Year	SL_{50}	SD	SPR	SD	FM	SD
HKE	1	2019	197.98	7.52	<0.01	<0.01	8.01	1.69
HKE	1	2020	111.76	1.71	<0.01	<0.01	7.79	1.44
HKE	1	2021	148.39	2.42	<0.01	<0.01	9.37	1.75
HKE	1	2022	170.67	3.82	<0.01	<0.01	8.63	1.69
HKE	1	2023	180.7	18.06	<0.01	<0.01	8.37	1.89
HKE	1	2024	187.83	1.52	<0.01	<0.01	9.55	1.78
HKE	1	2025	160.55	1.41	<0.01	<0.01	10.29	1.87
HKE	2	2019	199.09	25.59	<0.01	<0.01	14.69	213.39
HKE	2	2020	111.76	2.17	<0.01	<0.01	7.72	1.48
HKE	2	2021	148.44	2.44	<0.01	<0.01	9.29	1.8
HKE	2	2022	170.72	3.75	<0.01	<0.01	8.56	1.74
HKE	2	2023	181.64	15.09	<0.01	<0.01	8.34	1.88
HKE	2	2024	187.87	1.54	<0.01	<0.01	9.47	1.84
HKE	2	2025	160.59	1.43	<0.01	<0.01	10.2	1.93
HKE	3	2019	190.53	8.8	0.04	0.03	3.2	0.91
HKE	3	2020	109.5	2.06	0.02	0.01	3.45	0.79
HKE	3	2021	145.95	3.05	0.02	0.01	4.16	0.96
HKE	3	2022	166.33	4.72	0.03	0.02	3.66	0.92
HKE	3	2023	177.93	5.74	0.03	0.02	3.52	0.92
HKE	3	2024	186.87	1.86	0.02	0.02	4.22	0.98
HKE	3	2025	159.56	1.69	0.01	0.01	4.67	1.03

Model setting and results

Scenarios

For the present report, natural mortality (M) values for all scenarios were estimated using a combination of ICATMAR data and published literature. When stock-specific estimates were unavailable, values from nearby and biologically similar stocks were used.

Three different scenarios were applied for the sensitivity analysis for European hake (Table 14):

- Scenario 1: used growth parameters and maturity data from the STECF and GFCM stock assessments.
- Scenario 2: used the same parameters as in Scenario 1 but incorporated maturity parameters from the ICATMAR dataset.
- Scenario 3: used growth parameters reported by Aldebert et al. (1993), maturity parameters from the ICATMAR dataset.

Fitted data

The length frequency distribution fit per year is shown in Figure 41. The model generally follows the mode for all years, but tends to overestimate or underestimate the number of individuals in the middle-length classes.

Selectivity

The outputs of the model for the selectivity of the fishery are shown for each scenario in Table 15. The outputs of the selected scenario (3) are also plotted with L_{mat50} and SL_{50} in Figure 42. The model output reveal that the fishery is fishing below the SL_{50}.

Reference points

Although the model is highly sensitive to changes in growth and maturity parameters, the stock is below SPR_{lim} (= 0.2) in all the scenarios (Table 15 and Figure 44). The Kobe plot for European hake (Figure 43) displays the stock status over time, with no clear trend. However, in all cases, the stock falls within the red zone, indicating that it is both overfished and subject to ongoing overfishing.

Final scenario

Although Scenarios 1 and 2 used the growth parameters currently adopted in the GSA 6 stock assessments (GFCM/STECF), Scenario 3 was selected for the final LBSPR assessment because it combined maturity parameters derived from the ICATMAR dataset with growth parameters estimated specifically for GSA 6 North, making it the most representative scenario for the study area.

Deep-water rose shrimp (*Parapenaeus longirostris*) DPS

The spawning season for deep-water rose shrimp occurs between January and November, with a peak between April and September (ICATMAR, 26-04); recruitment occurs afterwards.

Input data

The spatial distribution of total landings for deep-water rose shrimp in the Catalan fishing ground is shown in Figure 45. Considering bathymetry, the species has a main distribution in slope areas. However, in terms of total landings per km², it is more abundant in the central and southern areas.

Historical deep-water rose shrimp landings in Catalonia from 2002 to 2025 are shown in Figure 46. The species shows a clear increase in landings since 2016, with the highest value in 2025.

Figure 47 shows deep-water rose shrimp landing distribution by métier from 2019 to 2025. The highest landings are obtained with bottom trawlers, specifically for deeper shelf and upper slope métiers.

Annual LFD

After raising the length frequencies obtained with the monitoring program (Table 17), and considering discards, the annual length frequency of deep-water rose shrimp in Catalonia is plotted in Figure 48. The SOP validation results are shown in Table 16, while Table 17 summarizes the number of individuals sampled through the ICATMAR monitoring program. Small and medium length classes were more abundant in 2020 and 2021, associated with higher discard rates. The abundance of small individuals decreased in 2022 and 2023 but showed an increased in 2024 and 2025.

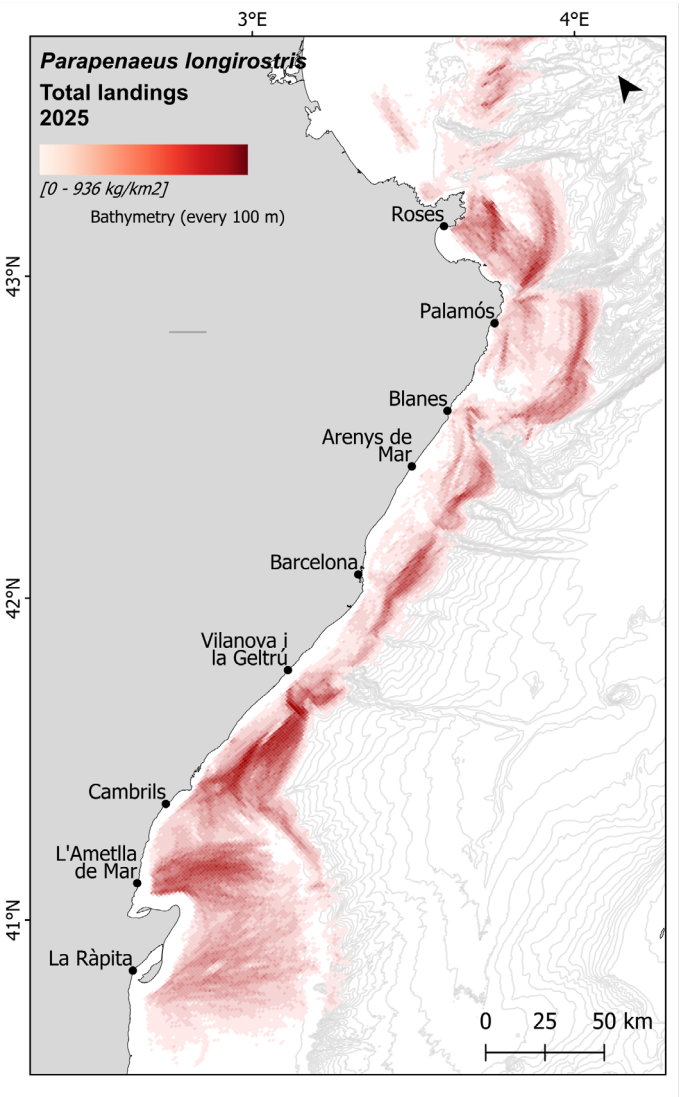


Figure 45. Spatial distribution of landings (kg/km²) for deep-water rose shrimp in the Catalan fishing grounds (North GSA6) in the year analyzed.

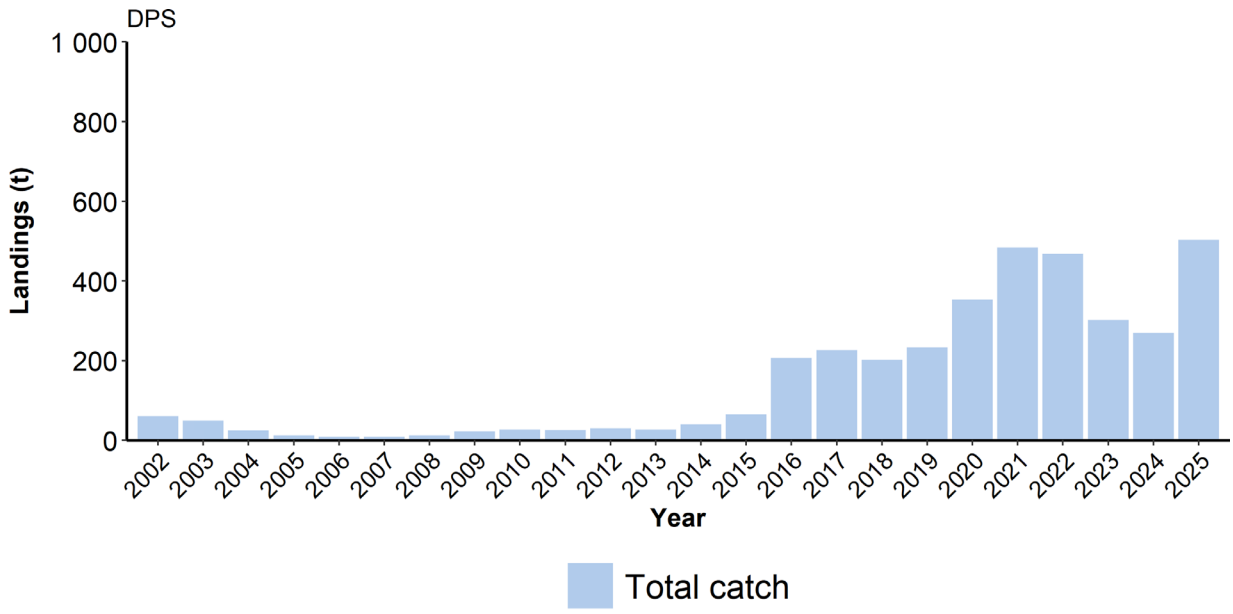


Figure 46. Historical landings (t) for deep-water rose shrimp in Catalonia.

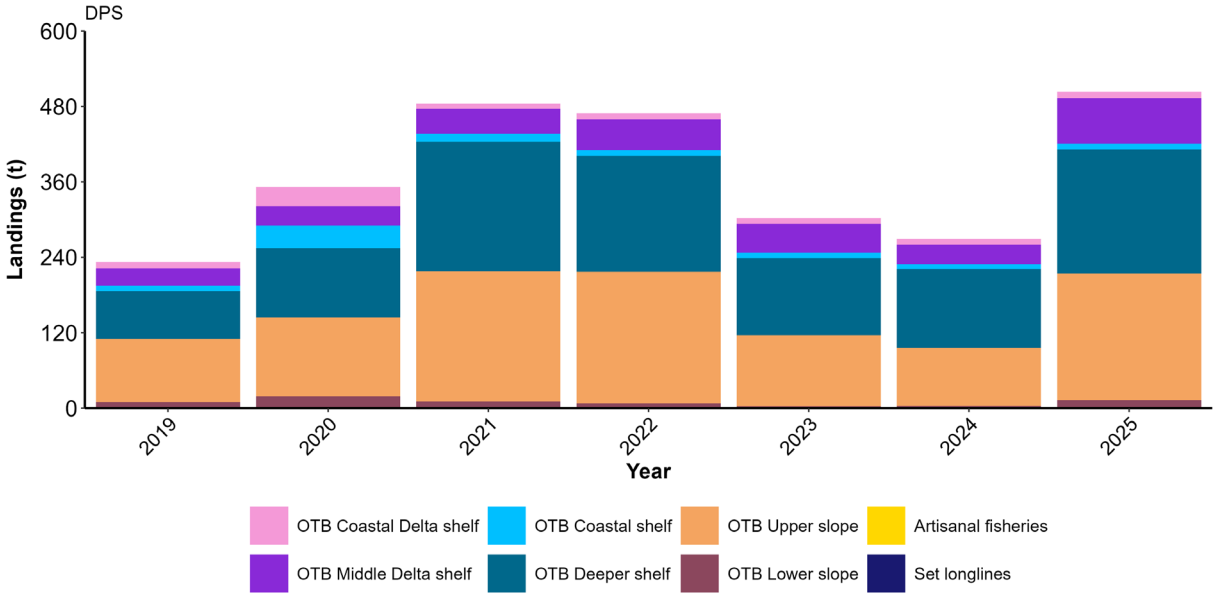


Figure 47. Landings (t) for deep-water rose shrimp by métier and fishing gear. OTB: bottom trawling.

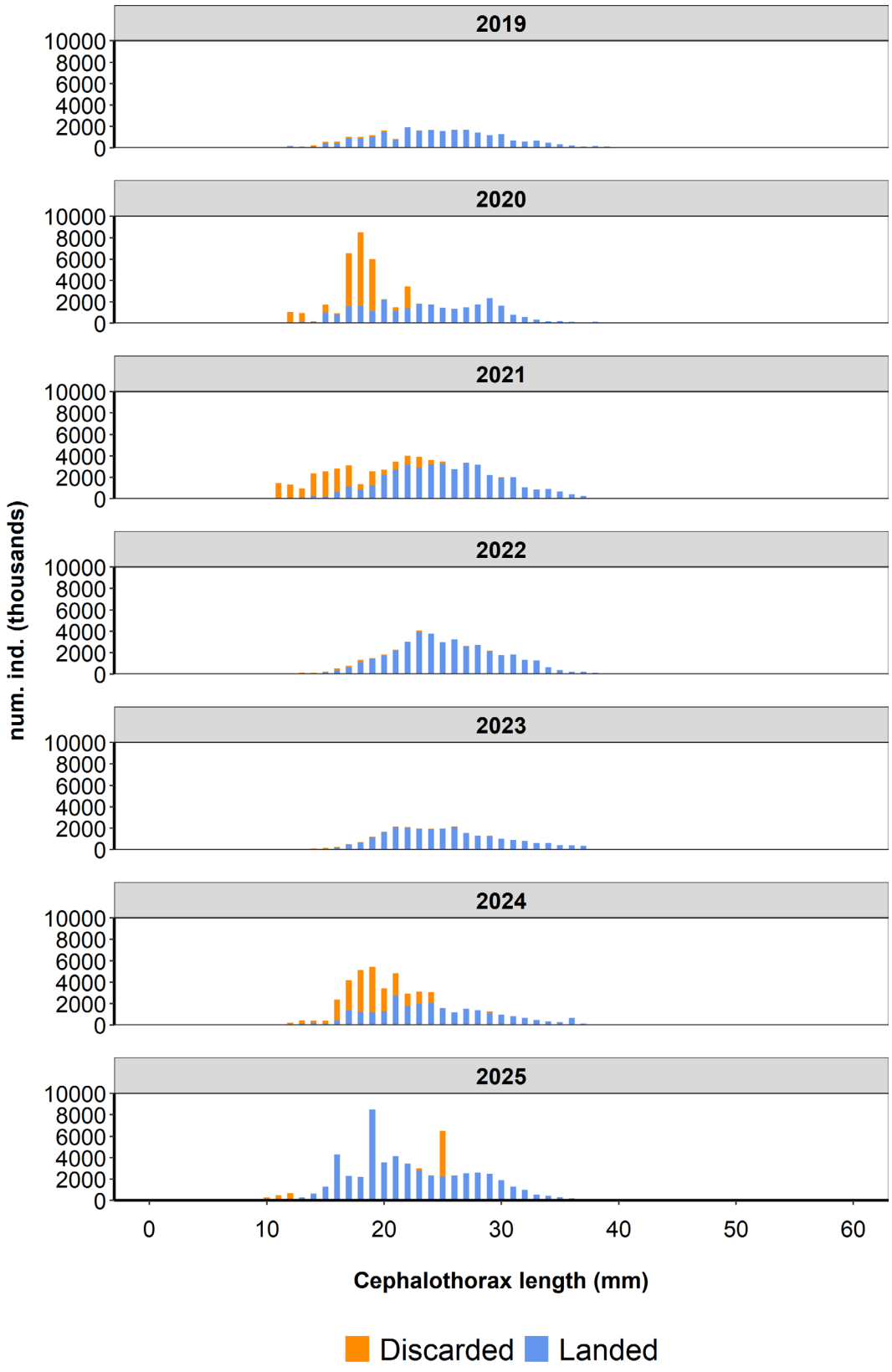


Figure 48. Annual length frequency distributions of deep-water rose shrimp from bottom trawling and small-scale fisheries. The data from bottom trawling is raised from ICATMAR data and details landed and discarded deep-water rose shrimp.

Table 16. Sum of Products (SOP) validation for deep-water rose shrimp (DPS): The column Calculated Weight in N GSA6 (SOP) represents the biomass estimated through the raising process, while landings refer to the reported landings in N GSA6. The ratio between SOP and landings is known as the Sum of Products (SOP). Values close to 1 indicate that the raising process provides biomass estimates that closely match the reported landings, thereby validating the accuracy of the estimation method.

Species	Year	Catch classification	Gear	Calculated weight GSA6N (kg) (SOP)	Landings in GSA6N (kg)	SOP/Landings
DPS	2019	Discarded	Bottom trawl	4782	-	-
DPS	2020	Discarded	Bottom trawl	92614	-	-
DPS	2021	Discarded	Bottom trawl	109940	-	-
DPS	2022	Discarded	Bottom trawl	11786	-	-
DPS	2023	Discarded	Bottom trawl	23249	-	-
DPS	2024	Discarded	Bottom trawl	117334	-	-
DPS	2025	Discarded	Bottom trawl	1208400	-	-
DPS	2019	Landed	Bottom trawl	237244	233472	1.09
DPS	2020	Landed	Bottom trawl	256648	353327	0.72
DPS	2021	Landed	Bottom trawl	427638	484386	0.91
DPS	2022	Landed	Bottom trawl	407641	468905	0.91
DPS	2023	Landed	Bottom trawl	263299	302555	0.90
DPS	2024	Landed	Bottom trawl	241653	269391	0.93
DPS	2025	Landed	Bottom trawl	423859	503414	0.93

Table 17. Number of deep-water rose shrimp individuals sampled by zone and season from ICATMAR monitoring data used to raise the length frequencies.

Fishery	Year	Zone	Winter	Spring	Summer	Autumn	N hauls
			Number individuals sampled				
Bottom trawl	2021	North	518	676	818	591	34
Bottom trawl	2021	Center	402	404	387	214	19
Bottom trawl	2021	South	297	41	204	224	16
Bottom trawl	2022	North	397	419	931	983	32
Bottom trawl	2022	Center	311	239	1197	659	19
Bottom trawl	2022	South	186	242	380	753	13
Bottom trawl	2023	North	1245	880	1012	565	25
Bottom trawl	2023	Center	585	369	591	207	18
Bottom trawl	2023	South	895	517	449	311	14
Bottom trawl	2024	North	830	742	627	936	26
Bottom trawl	2024	Center	355	657	1001	889	20
Bottom trawl	2024	South	576	282	611	1227	17
Bottom trawl	2025	North	627	1103	1457	1040	31
Bottom trawl	2025	Center	196	478	608	324	13
Bottom trawl	2025	South	850	766	965	1555	19

Stochastic Production model in Continuous Time (SPiCT)

For Deep-water rose shrimp, daily commercial fishing landings in GSA6 were provided by the Spanish Ministry of Agriculture, Fisheries and Food; MEDITS data were obtained from the most recent available GFCM Stock Assessment Form (SAF) for DPS in GSA6 (RY2024), the Joint Research Center (JRC, 2025; STECF-PLEN-25-01 background), and data from the Spanish Institute of Oceanography – CSIC (IEO-CSIC) were also used. Annual biomass index for N GSA6 and the MEDITS autumn survey were obtained from ICATMAR data. (Figure 49).

- Landings from 2000 to 2025 (Tons)
- Index: MEDITS survey data from 1994 to 2025 (Biomass, kg/km^2)
- Index: MEDITS-AUT survey data from November 2025 (Biomass, kg/km^2)
- Annual biomass index: ICATMAR data: 2019 – 2025 (Biomass, kg/km^2)

For the MEDITS and ICATMAR biomass indices, the uncertainty associated with each annual estimate was derived from the survey data following the approach used in GFCM stock assessments. Annual coefficients of variation (CVs) were calculated for each index, and the corresponding uncertainty was incorporated into the assessment. A mean CV (CVmean) was calculated across the available time series and used as a reference for the overall uncertainty of each index. The annual variability in precision was then accounted for using a standard deviation factor (StDevF), calculated as the ratio of the annual CV to the CVmean. This approach allows the observation error assigned to the survey indices in SPiCT to reflect the uncertainty associated with the underlying survey data and its year-to-year variation, consistent with the treatment of survey indices in GFCM stock assessments.

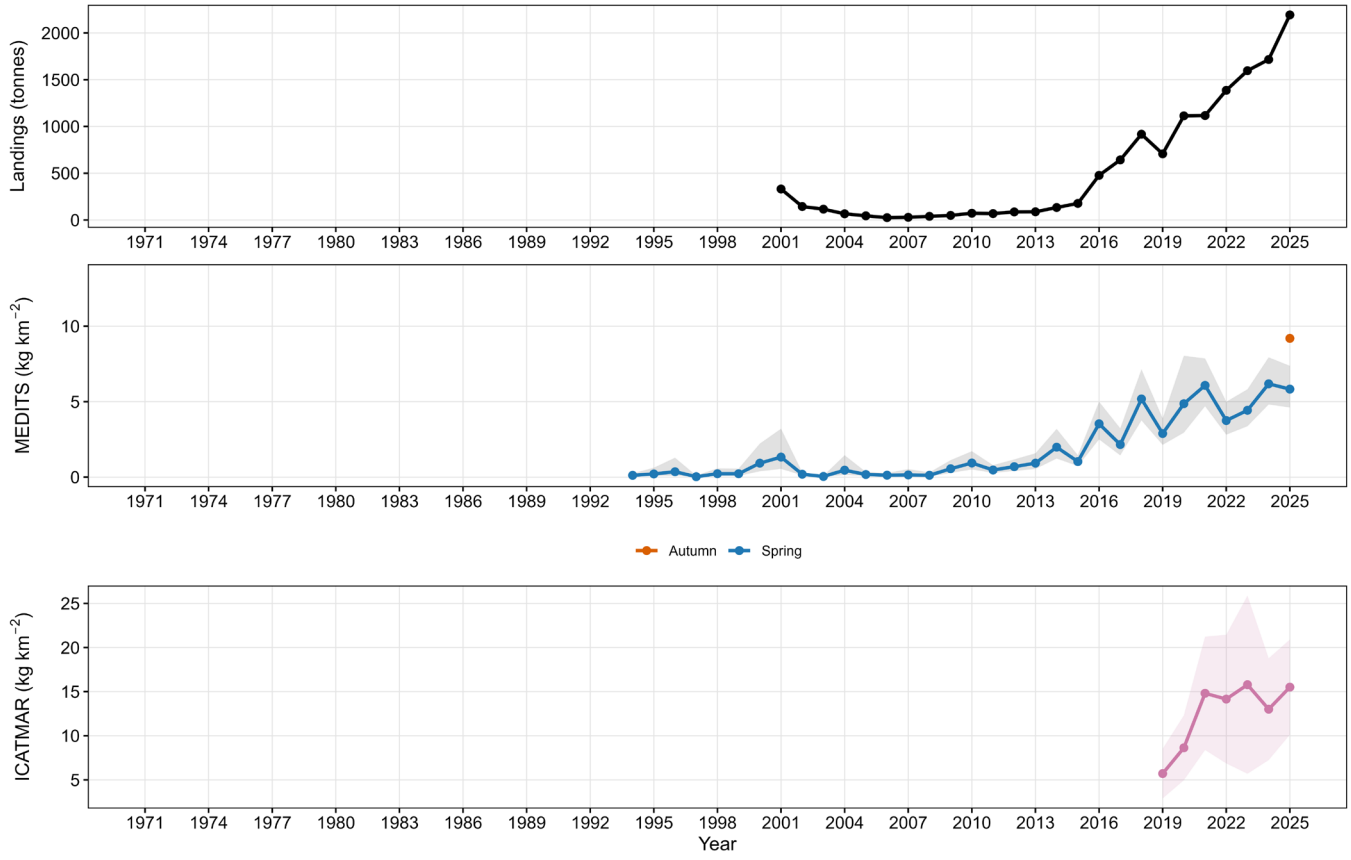


Figure 49. Data available for the assessment of deep-water rose shrimp in GSA6 using the SPiCT model. From top to bottom: catch data from 1971 to 2025; standardized OTB LPUE data from 2004 to 2024; MEDITS survey biomass indices from 1994 to 2025, including Spring and Autumn surveys; and ICATMAR biomass indices from 2019 to 2025.

Time-varying recruitment (TVR) was included in some of the SPiCT scenarios to allow recruitment to vary over time rather than assuming a constant stock–recruitment relationship. This provides greater flexibility to capture interannual variability in recruitment that may arise from environmental conditions or other processes not explicitly included in the model. The TVR estimates deviations from the expected stock–recruitment relationship and thus allows the model to account for recruitment changes not directly explained by changes in spawning biomass.

Although only the final scenario was presented, different scenarios were tested:

- Scenario 1: Landings 2001-2025 + MEDITS biomass index (2001–2024 and AUT 2025) + CI.
- Scenario 2: Landings 2001-2025 + MEDITS biomass index (2001–2024 and AUT 2025) + ICATMAR biomass indices + CI.
- Scenario 3: Same as Scenario 2, including annual r prior time-varying (TVR)
- Scenario 4: Landings 2001-2025 + MEDITS spring + ICATMAR + TVR + CI

Several sensitivity analyses were conducted to evaluate the robustness of the SPiCT assessment of DPS in GSA 6. The analyses considered alternative model configurations, including different combinations of the available abundance indices, prior settings, and assumptions regarding population dynamics. Commercial landings and the MEDITS biomass index were used as the main data sources, while the ICATMAR SAP biomass index was incorporated as an additional independent abundance index. The inclusion of both MEDITS and ICATMAR SAP provided complementary information on stock biomass, and the consistency between the two indices increased confidence in the estimated stock dynamics.

Following the initial sensitivity analysis, a reference scenario was selected based on the consistency of the model estimates across alternative configurations. The model was also formulated to account for a time-varying intrinsic population growth rate (r), which was considered biologically plausible for deep-water rose shrimp, given the recent increase in biomass and the apparent expansion of the population. Further sensitivity analyses focused on the temporal definition of the MEDITS index and the treatment of observation uncertainty. In particular, the MEDITS series was aligned with the main survey sampling period, with the final assessment using the spring–summer MEDITS index. Confidence intervals were incorporated for the MEDITS and ICATMAR biomass indices to explicitly account for observation uncertainty. A final comparison of all scenarios is shown in Figure 50.

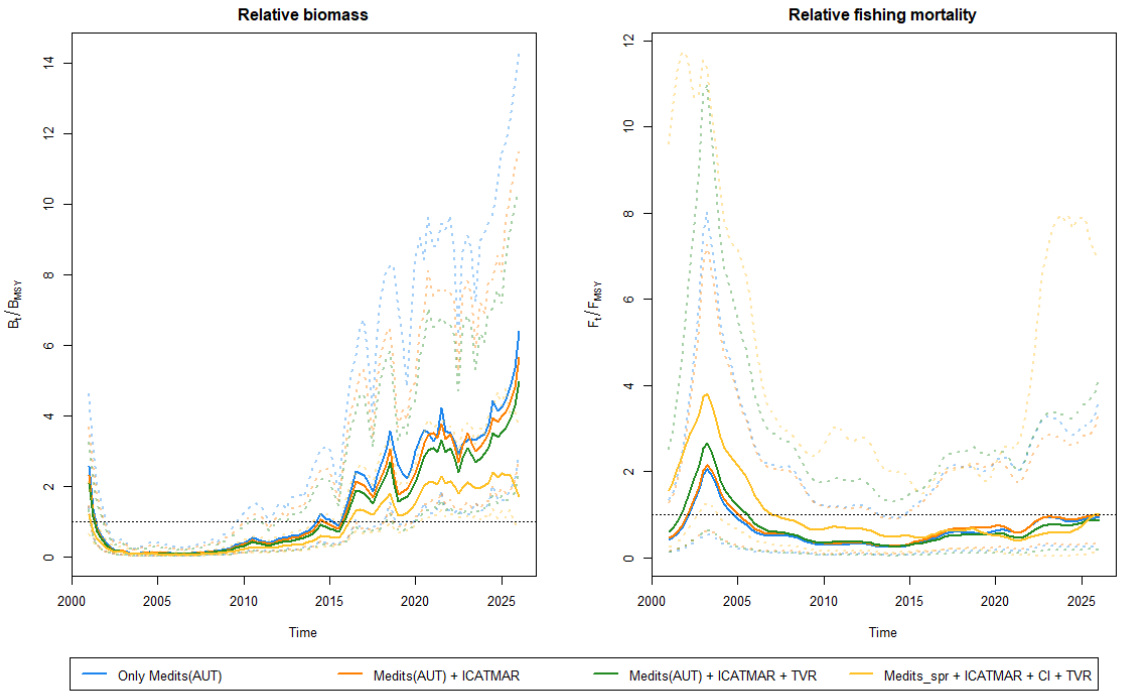


Figure 50. Scenarios comparison for deep-water rose shrimp in GSA6.

Final scenario

The settings used for the final scenario are presented in Among other settings, BKfrac prior was 0.7 and a Time Varying Growth (TVR) was applied to run the model.

The final scenario input data is shown in Figure 51, and the final summary assessment results are shown in Figure 52. The results were therefore based on commercial landings from 2001 to 2025, the spring–summer MEDITS biomass index, and the ICATMAR SAP biomass index from 2019 to 2025. The model converged successfully and provided consistent estimates of stock dynamics. Although retrospective diagnostics indicated some retrospective pattern and MASE values above the desirable threshold, the consistency of the results across the sensitivity analyses supported the robustness of the assessment and the selection of Scenario 4 as the final model (Figure 53, Figure 54, Figure 55, Figure 56 and Figure 57).

A sensitivity analysis for the final scenario was performed, testing r prior, BKfrac, process error, and observation error to assess the model's robustness within these priors. All these plots and results for the other scenarios will be available at https://github.com/ICATMAR.

Type	Prior	Description	Assignment	Mean	Standard deviation	Comment
Fishery dynamic	logbkfrac	B/K fraction (depletion)	-	Log(0.7)	0.2	A value of 0.7 was selected as the biomass was higher at that time, and after conducting different sensitivity analyses on this prior.
Relative standard deviation time series (input data)	stdevfacC	Standard deviation factor for catches	-	-	-	
	stdevfacI	Standard deviation factor for indices	MEDTIS + ICATMAR	-	-	StDevF and CV from the data
Stock dynamic	Logr	Population growth	-	Log(1.4)	0.2	-
	Logn	Shape of production curve	-	Log(2)	-	Shaefer
Error	Logsdc	Catch error	-	Log(0.05)	0.2	
	Logsdf	Fishing mortality error	-	Log(4)	0.5	
	Logsdb	Process error	-	Log(0.2)	0.5	
	logsdi	Observation error	MEDITS	Log(0.3)	CV MEDITS	MEDITS index was assumed to be more credible than CPUE indices
			ICATMAR	Log(0.3)	CV ICATMAR	
TVR	logsdm	Time Varying Growth	-	Log(0.3)	0.3	Allow recruitment to vary over time
	logpsi	Time Varying Growth	-	Log(0.5)	0.3	

Table 18. Priors settings for deep-water rose shrimp (DPS) in all scenarios..

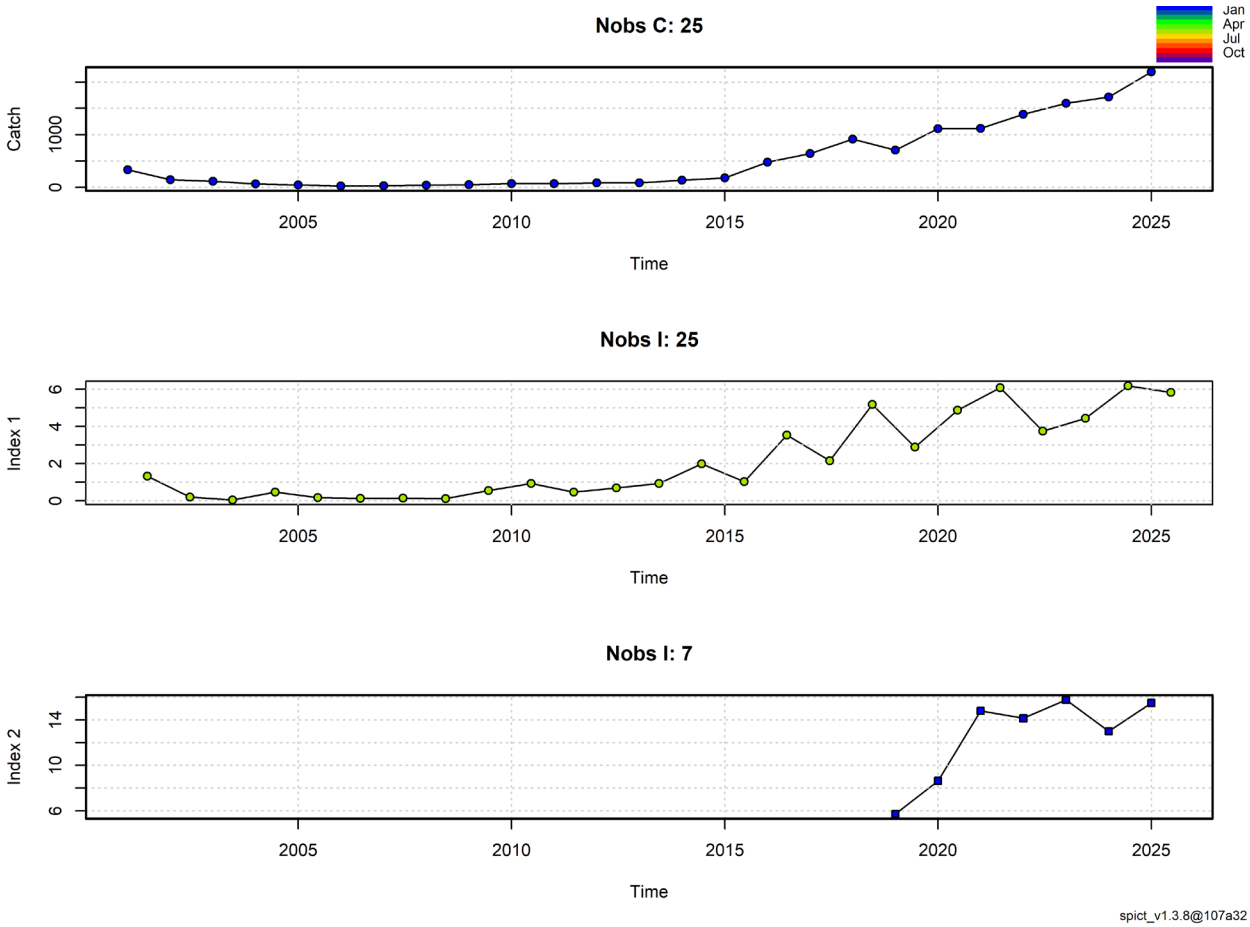


Figure 51. Input data used in the SPiCT assessment for deep-water rose shrimp in GSA6 under Scenario 4. From top to bottom: annual catch data (tonnes) from 2001 to 2025; MEDITS biomass index from 2001 onwards; and ICATMAR biomass index from 2019 onwards.

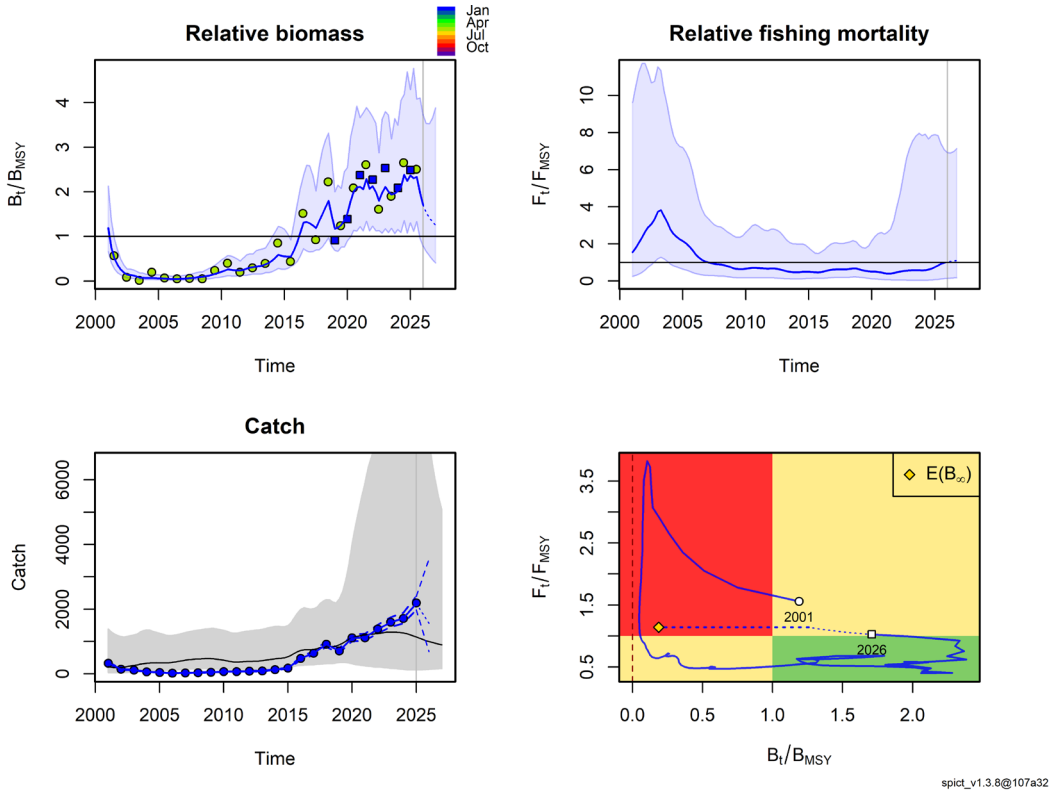


Figure 52. Stock assessment summary for the SPiCT model for deep-water rose shrimp in GSA6 for the final scenario.

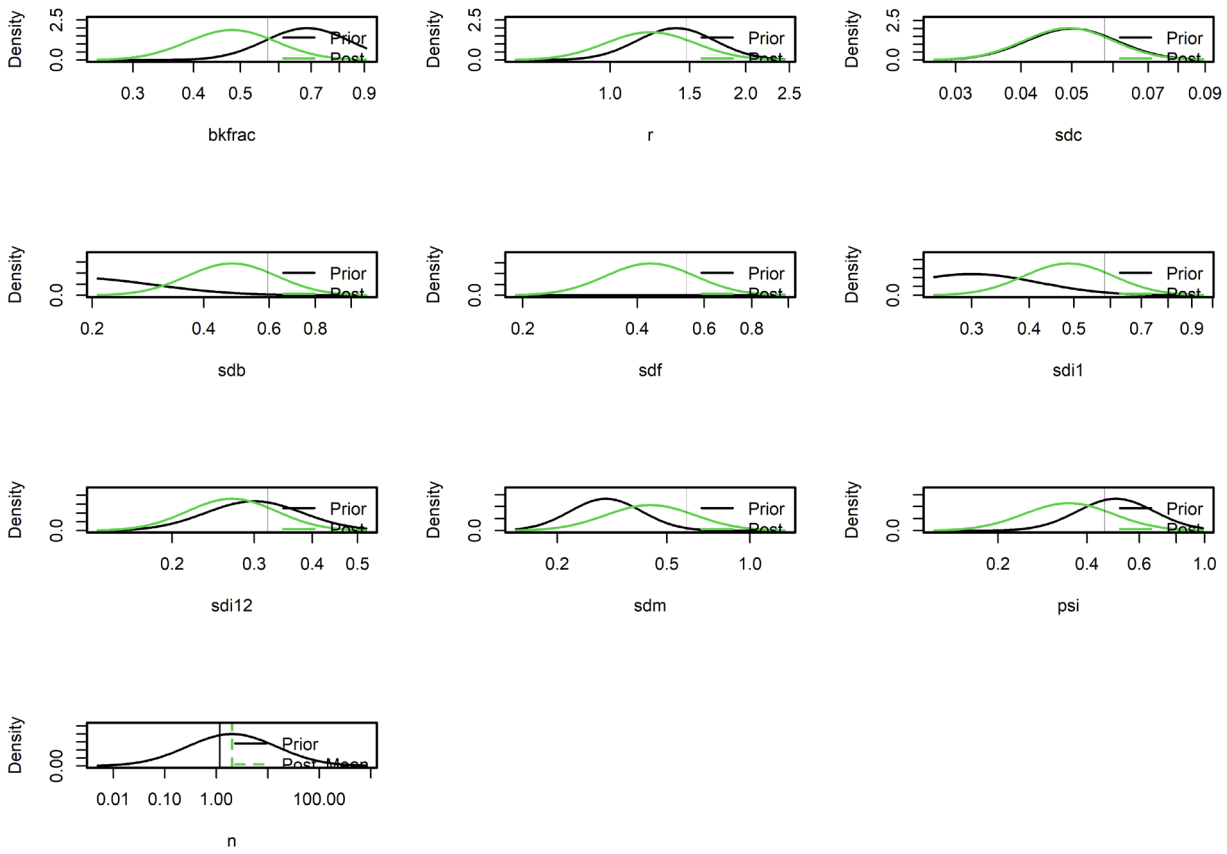


Figure 53. Estimated priors and posteriors for the updated assessment for deep-water rose shrimp in GSA6 for final scenario

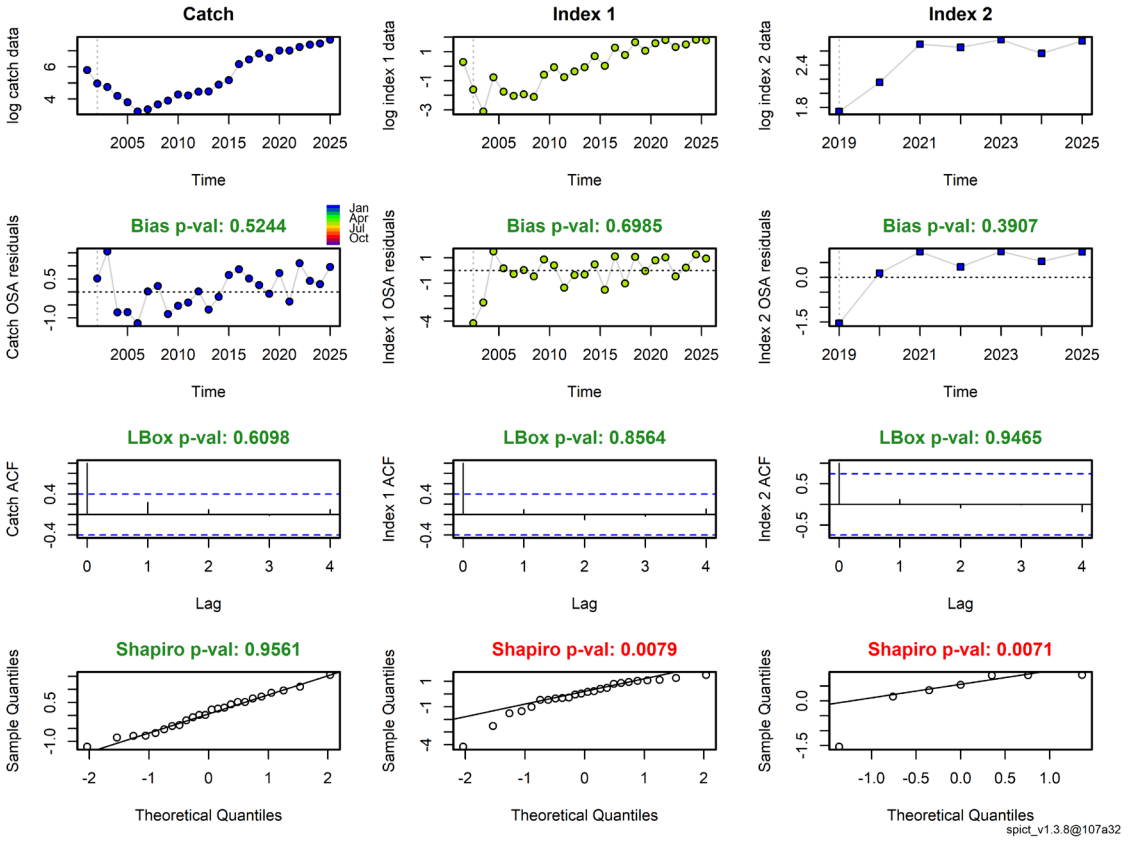


Figure 54. One-step-ahead residuals for the model for deep-water rose shrimp in GSA6 for final scenario.

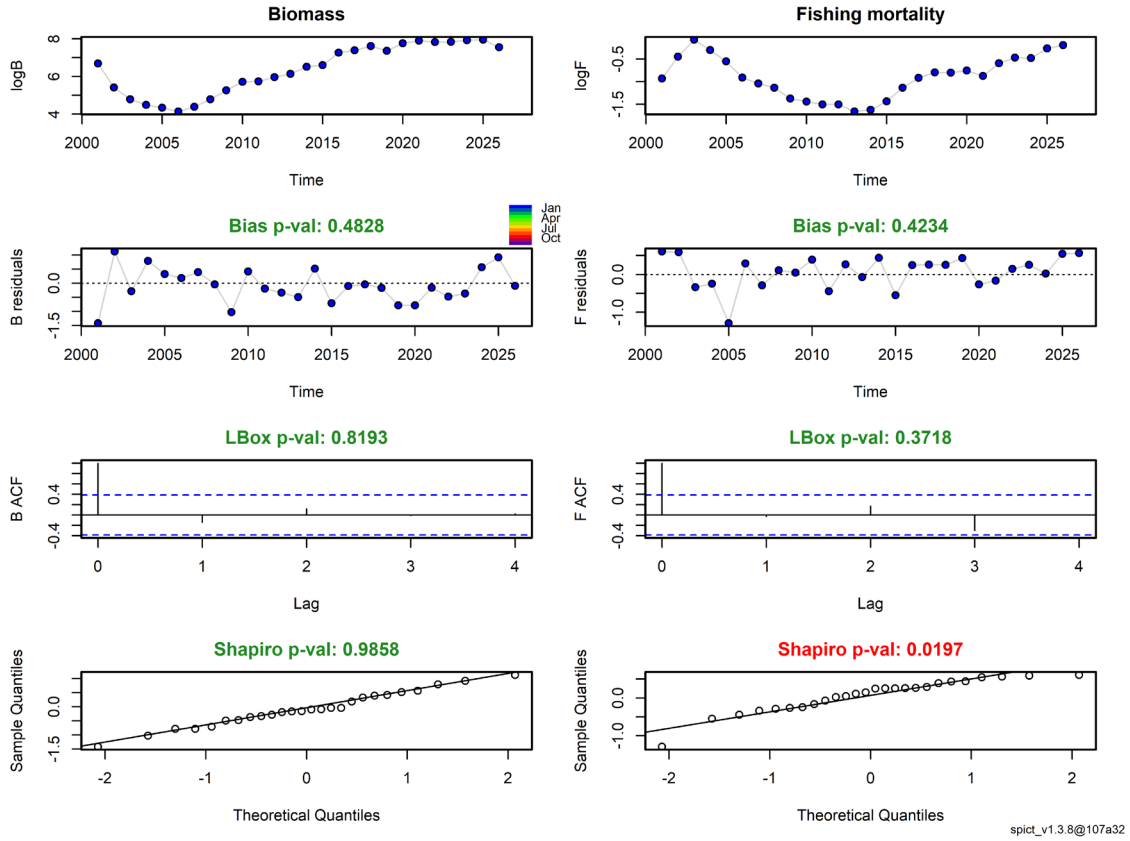


Figure 55. Process error deviations for the model for deep-water rose shrimp in GSA6 for final scenario.

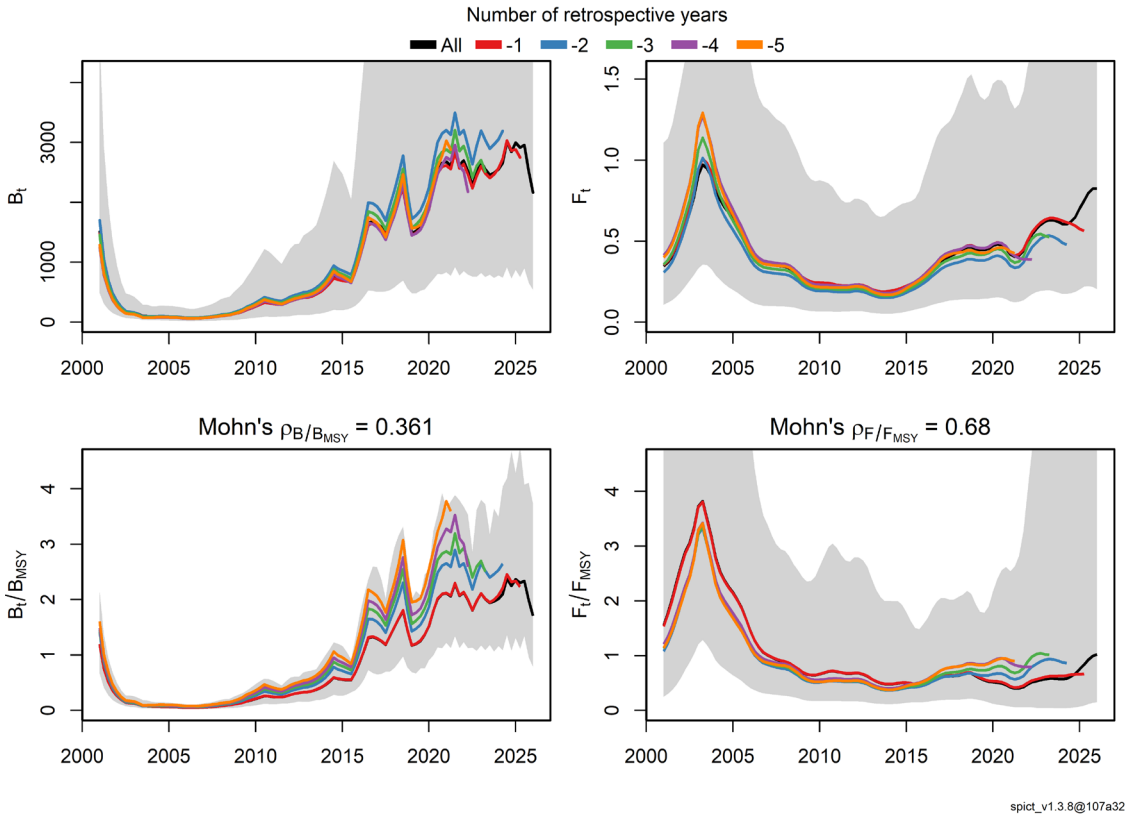


Figure 56. Retrospective analysis for deep-water rose shrimp in GSA6 for final scenario.

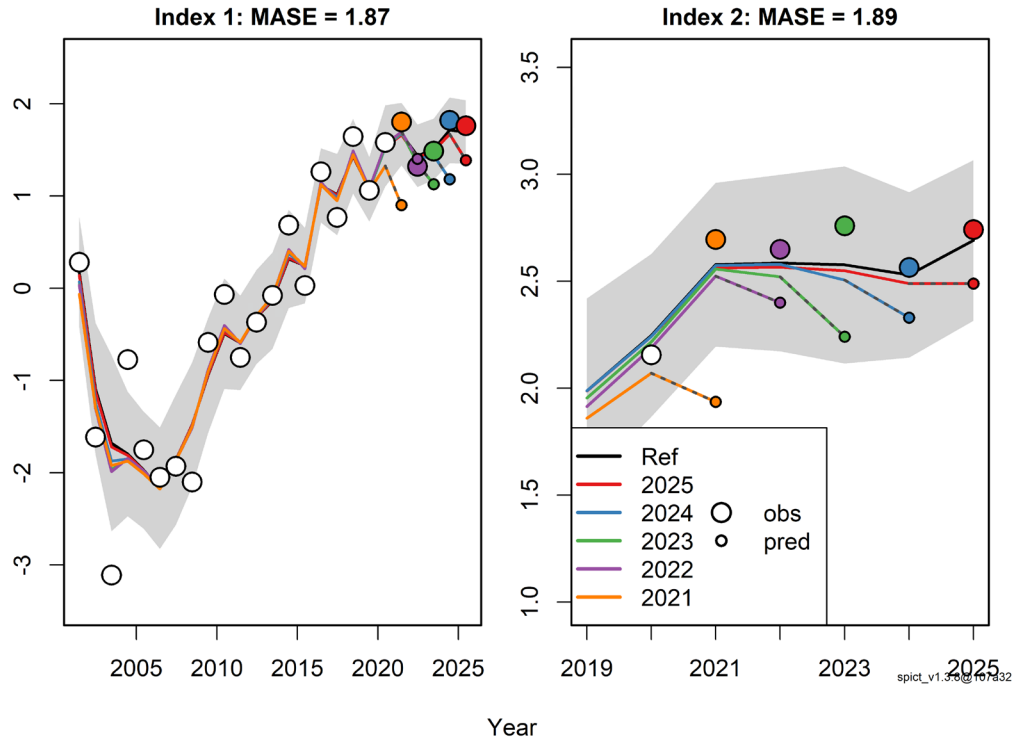


Figure 57. Hindcasting for the model for deep-water rose shrimp in GSA6 for final scenario.

Final scenario advice

Final scenario advice is presented in and Figure 58 and in Table 19, which outlines the indicators for deep-water rose shrimp in the GSA6 for the year 2025. The assessment results should be considered qualitative. The model estimates indicate a marked increase in stock biomass in recent years, although the rate of increase appears to have slowed towards the end of the time series. In 2025, biomass was estimated to be above the MSY reference level, while fishing mortality was estimated to be approximately at the MSY reference level. However, the relatively wide confidence intervals around these estimates indicate substantial uncertainty in the assessment results.

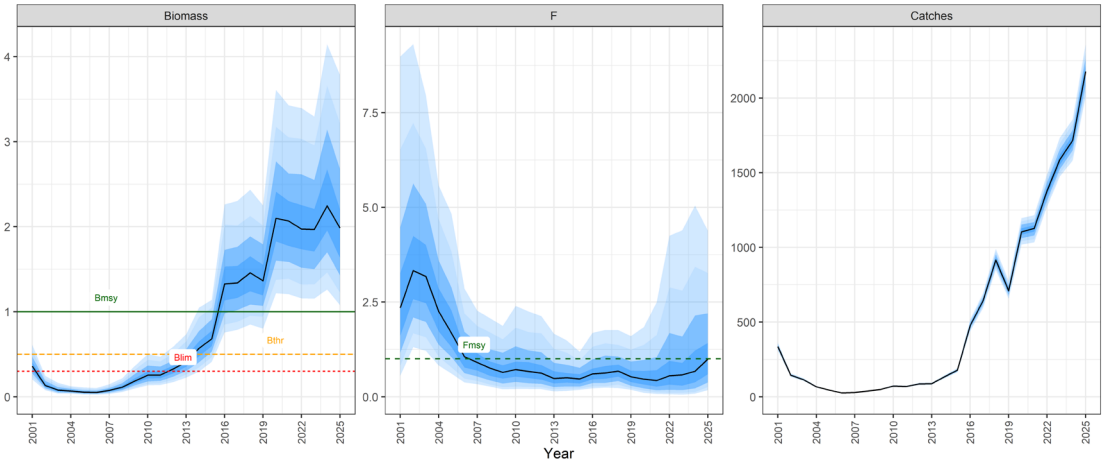


Figure 58. Advice for final scenario for Deep-water rose shrimp in GSA6: Historical and current stock status regarding F_{msy}, B_{msy} and $B_{lim.}$

Table 19. Indicators in 2025 from SPiCT for deep-water rose shrimp in GSA6 final scenario.

Species	Year	Catch (t)	F/Fmsy	B/Bmsy	B/Bpa	B/Blim
DPS	2025	2193	0.99	1.98	3.97	6.61

Length-Based Spawning Potential Ratio (LBSPR)

Table 20. Biological parameters used in the different LBSPR scenarios for deep-water rose shrimp (DPS). L_{inf}: asymptotic length at which growth is zero, k: growth rate, M: natural mortality, L_{mat50}: length where 50% of individuals are mature, L_{mat95}: length where 95% of individuals are mature.

Species	Scenario	Linf (mm)	Lmat50 (mm)	Lmat95 (mm)	M/k
DPS	1	45	25.60	28.16	1.71
DPS	2	44	25.60	28.16	1.71
DPS	3	47	17.48	26.00	2.92

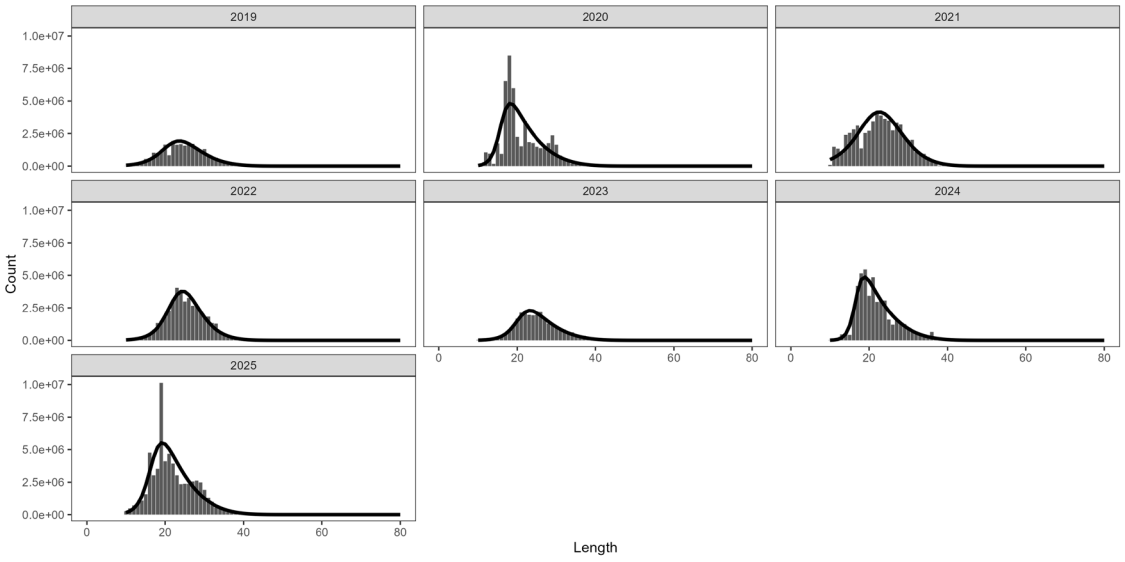


Figure 59. Fit of the data using the LBSPR model for deep-water rose shrimp for each studied year. Grey columns indicate length frequencies. Black lines indicate the fit of the model.

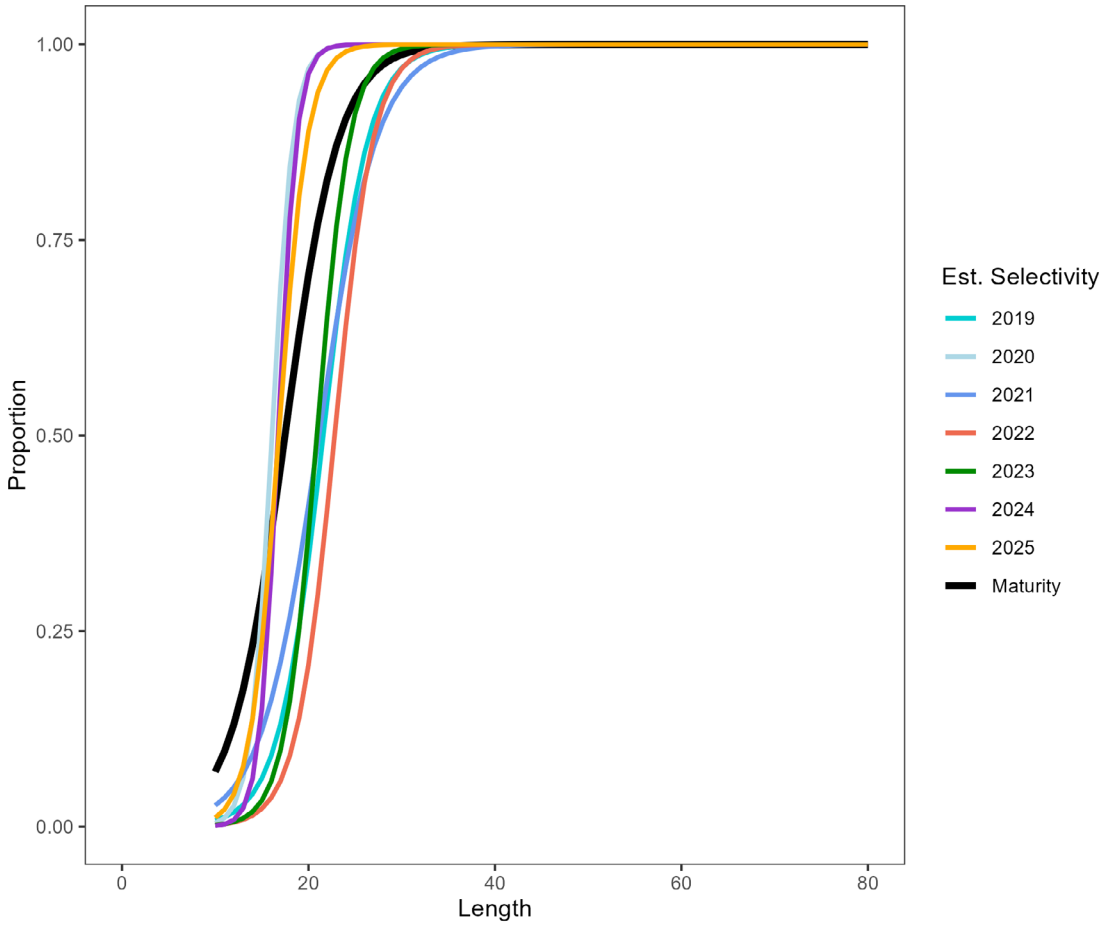


Figure 60. Length curves for deep-water rose shrimp. Black line shows the length curve at maturity. Color lines show the estimated selectivity at length curve predicted by the LBSPR model selected (3)..

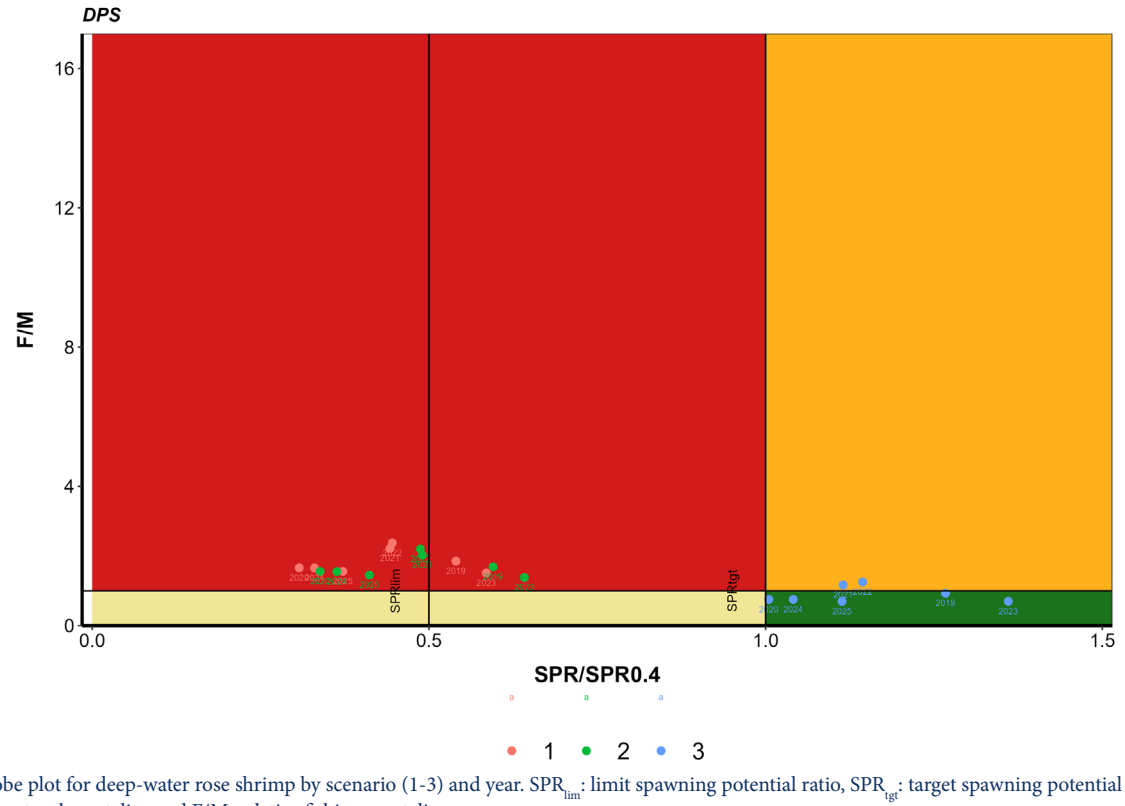


Figure 61. Kobe plot for deep-water rose shrimp by scenario (1-3) and year. SPR_{lim}: limit spawning potential ratio, SPR_{tgt}: target spawning potential ratio, F: fishing mortality, M: natural mortality, and F/M: relative fishing mortality..

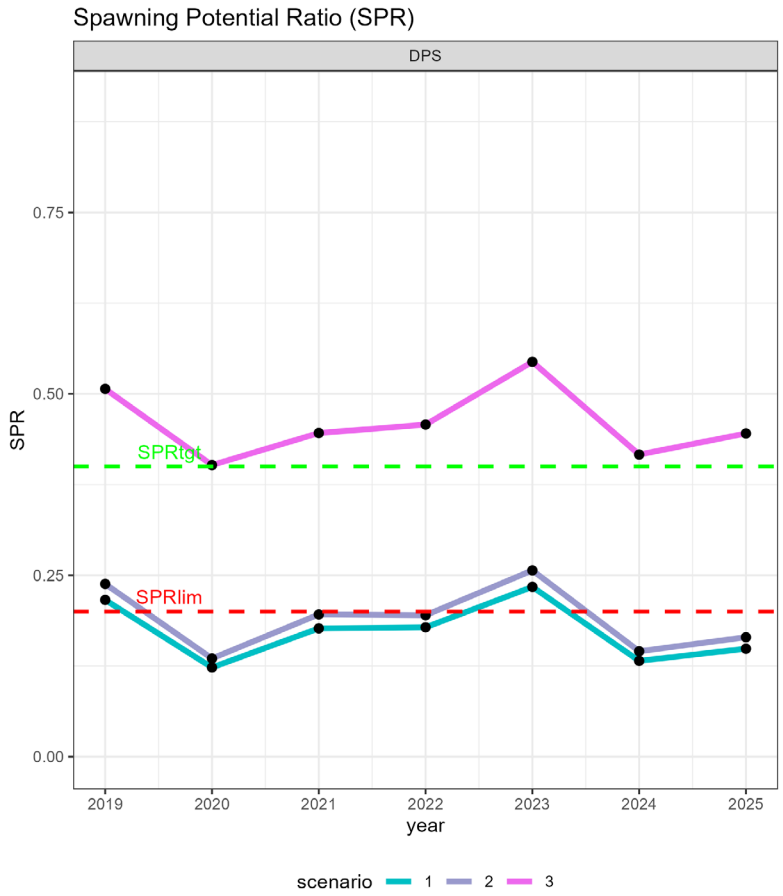


Figure 62. Spawning potential ratio (SPR) per year analyzed for deep-water rose shrimp evaluated with LBSPR model. LBSPR: Length-Based Spawning Potential Ratio. SPR_{lim}: limit spawning potential ratio, SPR_{tgt}: target spawning potential ratio. Colored lines show the results for each scenario.

Table 21. LBSPR model results for deep-water rose shrimp with the different scenarios tested for each year analyzed. SL_{50}: Length where 50% of individuals are caught, SPR: spawning potential ratio and FM: fishing mortality. SD is the standard deviation calculated for each indicator. The selected scenario is highlighted in blue.

Species	Scenario	Year	SL_{50}	SD	SPR	SD	FM	SD
DPS	1	2019	22.12	1.09	0.22	0.18	1.85	0.94
DPS	1	2020	16.1	0.14	0.12	0.1	1.66	0.6
DPS	1	2021	21.75	1.73	0.18	0.17	2.21	1.14
DPS	1	2022	23.22	0.62	0.18	0.14	2.37	1.03
DPS	1	2023	21.14	0.52	0.23	0.17	1.51	0.72
DPS	1	2024	16.8	0.16	0.13	0.1	1.66	0.61
DPS	1	2025	16.86	0.29	0.15	0.12	1.56	0.61
DPS	2	2019	21.99	1.12	0.24	0.19	1.69	0.89
DPS	2	2020	16.08	0.15	0.14	0.11	1.56	0.58
DPS	2	2021	21.56	1.79	0.2	0.18	2.02	1.07
DPS	2	2022	23.15	0.64	0.19	0.15	2.2	0.97
DPS	2	2023	21.08	0.53	0.26	0.19	1.38	0.68
DPS	2	2024	16.78	0.16	0.15	0.12	1.55	0.59
DPS	2	2025	16.82	0.3	0.16	0.13	1.45	0.59
DPS	3	2019	22.59	0.76	0.51	0.21	0.93	0.55
DPS	3	2020	16.21	0.11	0.4	0.19	0.75	0.37
DPS	3	2021	22.49	1.1	0.45	0.2	1.17	0.66
DPS	3	2022	23.39	0.44	0.46	0.18	1.25	0.62
DPS	3	2023	21.41	0.39	0.54	0.21	0.7	0.43
DPS	3	2024	16.89	0.13	0.42	0.19	0.75	0.37
DPS	3	2025	17.06	0.23	0.45	0.2	0.7	0.37

Model setting and results

Scenarios

For the present report, natural mortality (M) values for all scenarios were estimated using a combination of ICATMAR data and published literature. When stock-specific estimates were unavailable, values from nearby and biologically similar stocks were used.

Three different scenarios were applied for the sensitivity analysis for deep-water rose shrimp (Table 20):

- Scenario 1 used growth parameters and from the STECF stock assessment, and maturity data from the GFCM.
- Scenarios 2: applied growth and maturity parameters from the GFCM stock assessment.
- Scenario 3: applied growth parameters reported by Garcia-Rodriguez et al. (2009), incorporated maturity data from the ICATMAR dataset.

Fitted data

The length frequency distribution fit per year is shown in Figure 59. The model generally follows the mode for all years, except for 2020, when the model does not fit the data properly due to the presence of different peaks with no normal distribution of the observed data.

Selectivity

The outputs of the model for the selectivity of the fishery are shown for each scenario in Table 21. The output for scenario selected (3) is also plotted with L_{mat50} and SL_{50} in Figure 60. The model outputs reveal that the fishery is fishing similar to, or slightly greater than, L_{mat50} in scenario 3.

Reference points

Although the model shows sensitivity to changes in growth and maturity parameters, the stock remains around SPR_{lim} (= 0.2) under Scenarios 1 and 2. However, the model is highly sensitive to changes in mortality parameters (M/k). When M/k is increased to 2.92, as in Scenario 3, the estimated SPR values approaching or exceeding SPR_{tgt} (= 0.4), indicating a favorable stock status under this assumption (Figure 62). The Kobe plot for deep-water rose shrimp under Scenarios 1 and 2 (Figure 61) shows the stock status across years, with no clear temporal trend. In Scenarios 1 and 2, all years are located in the red quadrant. In contrast, most years in Scenario 3 fall within the green quadrant, while two years are located in the yellow quadrant, suggesting a more favorable stock status and a lower risk of overexploitation under this scenario.

Final scenario

Although Scenarios 1 and 2 used the growth parameters currently adopted in the GSA 6 stock assessments (GFCM/STECF), Scenario 3 was selected for the final LBSPR assessment because it combined maturity parameters derived from the ICATMAR dataset with growth parameters estimated for GSA 6, making it the most representative scenario for the study area.

Norway lobster (*Nephrops norvegicus*) NEP

The Norway lobster is known to have a dimorphic growth pattern, with males growing slower and reaching larger sizes than females. Reproduction occurs between April and September, and recruitment is observed afterwards, in fall and winter (ICATMAR, 26-04).

Input data

The spatial distribution of total landings for Norway lobster in the Catalan fishing ground is shown in Figure 63. The species is mainly distributed in upper slope areas (300-600 m) along the Catalan coast, with less occurrence in the Delta area (i.e. L'Ametlla de Mar and La Ràpita). Discards of Norway lobster are negligible.

Historical Norway lobster landings in Catalonia from 2002 to 2025 are shown in Figure 64. The species shows a decreasing trend in landings, especially since 2015, with the lowest value recorded in 2021. Since then, landings have shown a slight increase.

Figure 65 shows the Norway lobster landing distribution by métier from 2019 to 2024. The highest landings are obtained with bottom trawlers, specifically for the upper slope métier.

Annual LFD

After raising the length frequencies obtained with the monitoring program (Table 23), and considering discards, the annual length frequency of Norway lobster in Catalonia is plotted in Figure 66. The SOP validation results are shown in Table 22, while Table 23 summarizes the number of individuals sampled through the ICATMAR monitoring program.

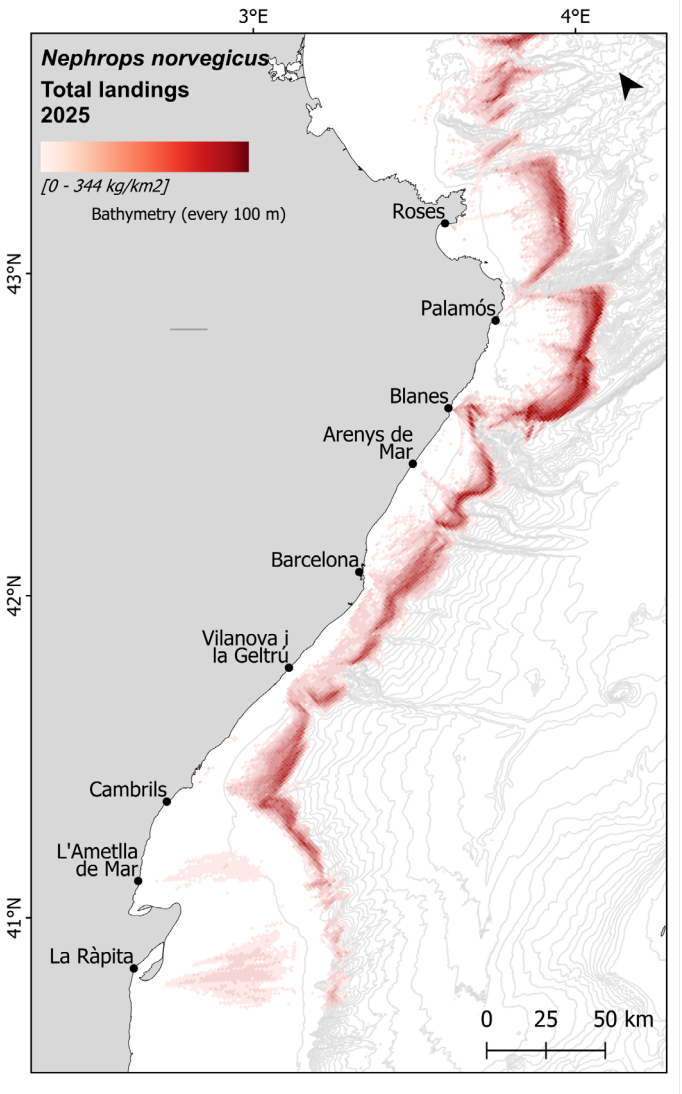


Figure 63. Spatial distribution of landings (kg/km²) for Norway lobster in the Catalan fishing grounds (North GSA6) in the year analyzed.

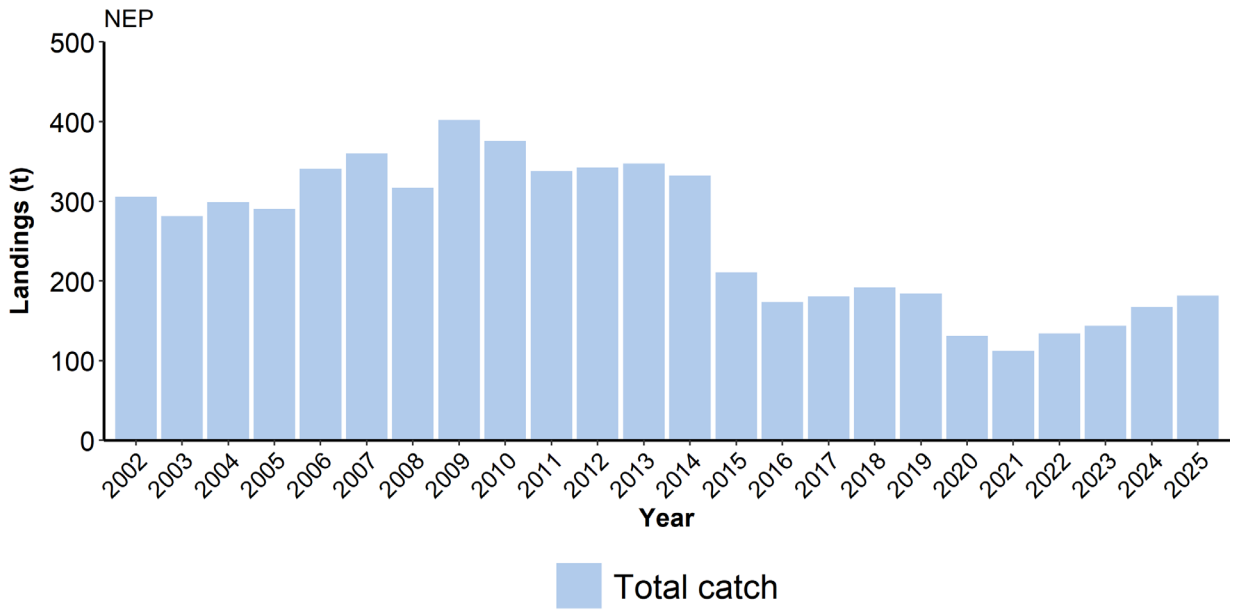


Figure 64. Historical landings (t) for Norway lobster in Catalonia.

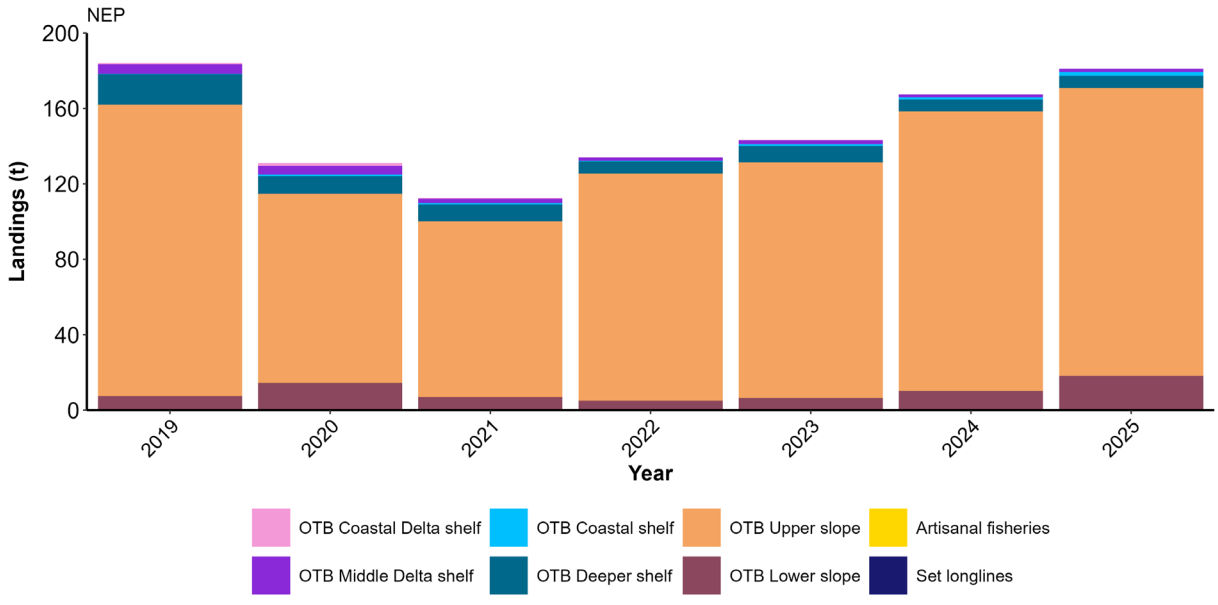


Figure 65. Landings (t) for Norway lobster by métier and fishing gear. OTB: bottom trawling.

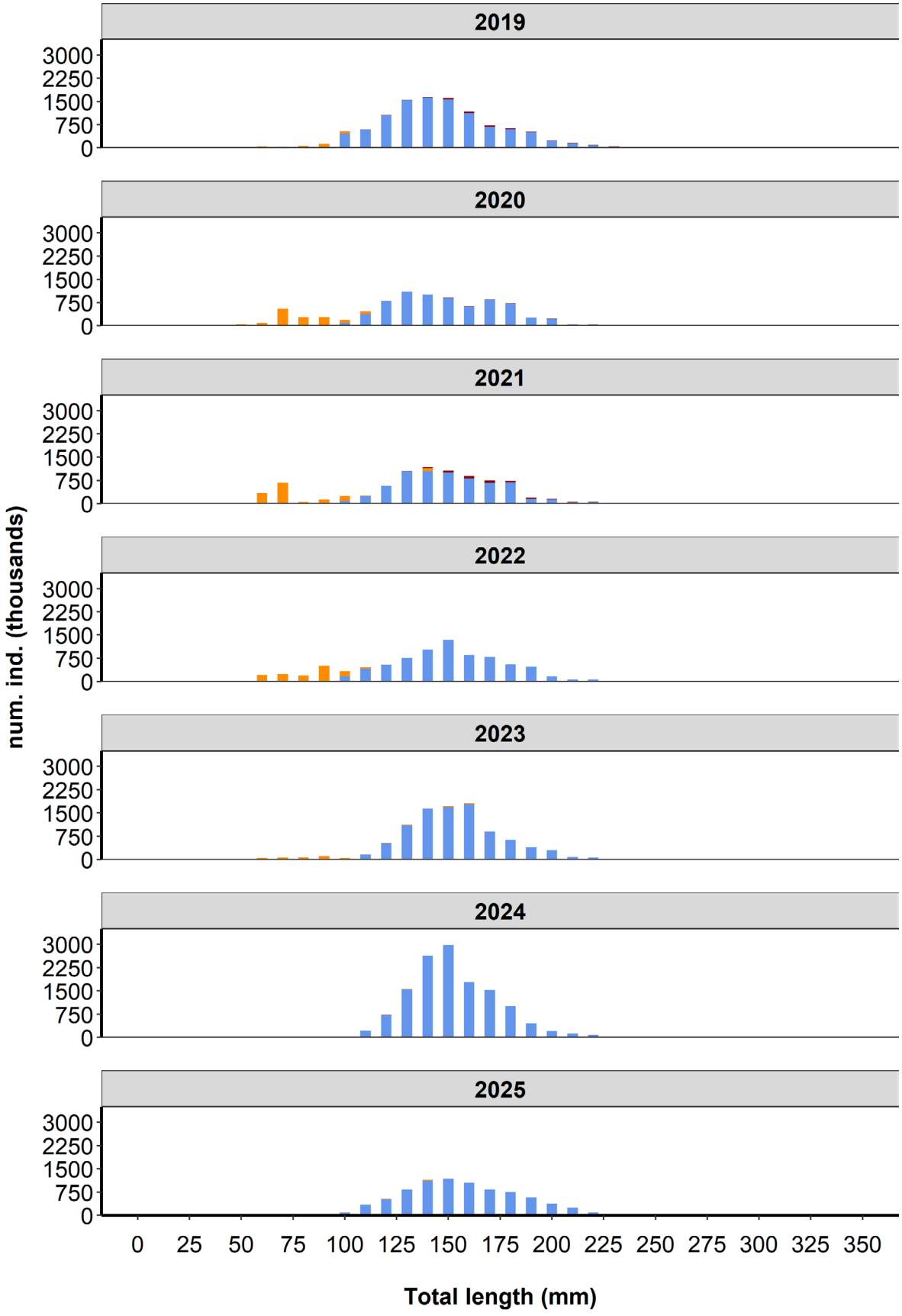


Figure 66. Annual length frequency distributions of Norway lobster from bottom trawling. The data from bottom trawling is raised from ICATMAR data and details landed and discarded Norway lobster.

Table 22. Sum of Products (SOP) validation for Norway lobster (NEP): The column Calculated Weight in N GSA6 (SOP) represents the biomass estimated through the raising process, while landings refer to the reported landings in N GSA6. The ratio between SOP and landings is known as the Sum of Products (SOP). Values close to 1 indicate that the raising process provides biomass estimates that closely match the reported landings, thereby validating the accuracy of the estimation method.

Species	Year	Catch classification	Gear	Calculated weight GSA6N (kg) (SOP)	Landings in GSA6N (kg)	SOP/Landings
NEP	2019	Discarded	Bottom trawl	720	-	-
NEP	2020	Discarded	Bottom trawl	85	-	-
NEP	2021	Discarded	Bottom trawl	782	-	-
NEP	2022	Discarded	Bottom trawl	139	-	-
NEP	2023	Discarded	Bottom trawl	199	-	-
NEP	2024	Discarded	Bottom trawl	572	-	-
NEP	2025	Discarded	Bottom trawl	229	-	-
NEP	2019	Landed	Bottom trawl	246540	184329	1.34
NEP	2020	Landed	Bottom trawl	131638	131172	1.01
NEP	2021	Landed	Bottom trawl	113303	112438	1.01
NEP	2022	Landed	Bottom trawl	136936	133978	1.02
NEP	2023	Landed	Bottom trawl	147931	143155	1.03
NEP	2024	Landed	Bottom trawl	179472	167310	1.07
NEP	2025	Landed	Bottom trawl	193919	181020	1.07

Table 23. Number of Norway lobster individuals sampled by zone and season from ICATMAR monitoring data used to raise the length frequencies.

Fishery	Year	Zone	Winter	Spring	Summer	Autumn	N hauls
			Number individuals sampled				
Bottom trawl	2021	North	348	666	892	676	30
Bottom trawl	2021	Center	732	484	807	417	16
Bottom trawl	2021	South	15	1	6	2	8
Bottom trawl	2022	North	273	642	724	713	27
Bottom trawl	2022	Center	446	313	573	844	22
Bottom trawl	2022	South	1	1	2	0	4
Bottom trawl	2023	North	738	1017	1023	1044	27
Bottom trawl	2023	Center	414	803	662	450	24
Bottom trawl	2023	South	2	1	0	0	3
Bottom trawl	2024	North	636	1266	818	874	27
Bottom trawl	2024	Center	334	478	497	523	23
Bottom trawl	2024	South	3	9	1	3	8
Bottom trawl	2025	North	406	503	643	1010	27
Bottom trawl	2025	Center	88	503	302	42	11
Bottom trawl	2025	South	0	9	5	106	6

Stochastic Production model in Continuous Time (SPiCT)

For Norway lobster, fleet data were obtained from the EU Fleet Register provided by the European Commission (Reg. EU 2017/218); daily commercial fishing landings in GSA6 were provided by the Spanish Ministry of Agriculture, Fisheries and Food; MEDITS data were obtained from the most recent available GFCM Stock Assessment Form (SAF) for DPS in GSA6 (RY2024), the Joint Research Center (JRC, 2025; STECF-PLEN-25-01 background), and data from the Spanish Institute of Oceanography – CSIC (IEO-CSIC) were also used. Annual biomass index for N GSA6 and the MEDITS autumn survey were obtained from ICATMAR data (Figure 67).

- Landings from 1970 to 2025 (Tons)
- LPUE standardize from 2008 to 2025 (kg*h/km^2)
- Index: MEDITS survey data from 1994 to 2025 (Biomass, kg/km^2)
- Index: MEDITS-AUT survey data from November 2025 (Biomass, kg/km^2)
- Annual biomass index: ICATMAR data: 2019 – 2025 (Biomass, kg/km^2)

For the MEDITS and ICATMAR biomass indices, the uncertainty associated with each annual estimate was derived from the survey data following the approach used in GFCM stock assessments. Annual coefficients of variation (CVs) were calculated for each index, and the corresponding uncertainty was incorporated into the assessment. A mean CV (CVmean) was calculated across the available time series and used as a reference for the overall uncertainty of each index. The annual variability in precision was then accounted for using a standard deviation factor (StDevF), calculated as the ratio of the annual CV to the CVmean. This approach allows the observation error assigned to the survey indices in SPiCT to reflect the uncertainty associated with the underlying survey data and its year-to-year variation, consistent with the treatment of survey indices in GFCM stock assessments.

Time-varying recruitment (TVR) was included in some of the SPiCT scenarios to allow recruitment to vary over time rather than assuming a constant stock–recruitment relationship. This provides greater flexibility to capture interannual variability in recruitment that may arise from environmental conditions or other processes not explicitly included in the model. The TVR estimates deviations from the expected stock–recruitment relationship and thus allows the model to account for recruitment changes not directly explained by changes in spawning biomass.

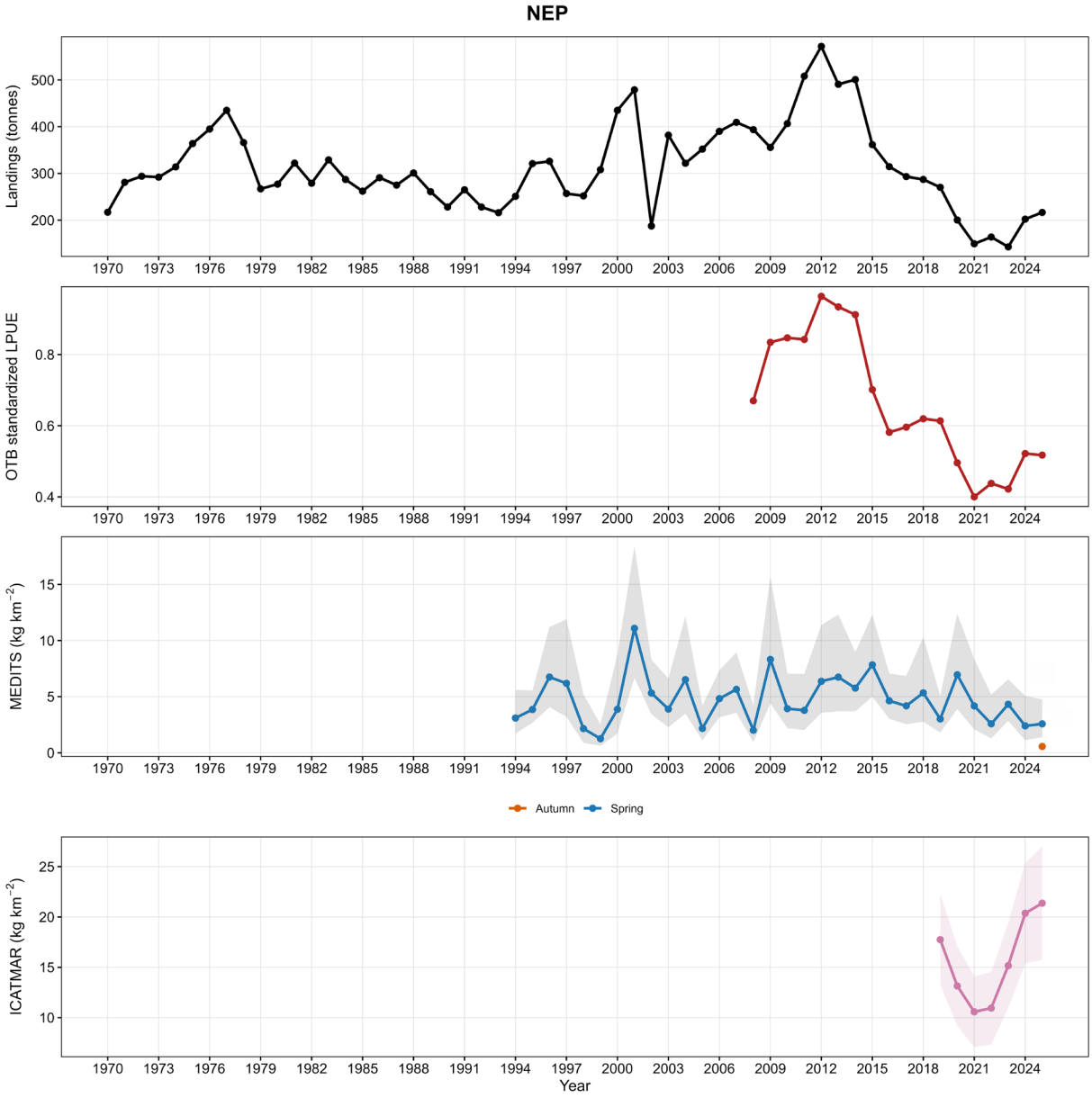


Figure 67. Data available for the assessment for Norway lobster in GSA6 to run SPiCT model. From top to bottom: catch data from 1971 to 2025; standardized OTB LPUE data from 2008 to 2025; MEDITS survey biomass indices from 1994 to 2025, including Spring and Autumn surveys; and ICATMAR biomass indices from 2019 to 2025.

Although only the two final scenarios are presented below, several sensitivity analyses were conducted to assess the influence of the catch time series, abundance indices and model assumptions on the SPiCT assessment of Norway lobster (Nephrops norvegicus) in GSA 6 (Figure 68):

- Scenario 1: Landings started in 1994, using both the MEDITS (2025 AUT) and ICATMAR survey + CI and LPUE as abundance indices + TVR.
- Scenario 2: Historical landings starting in 1970, using the MEDITS spring survey + CI and LPUE as abundance indices + TVR.

The initial analyses explored alternative starting years for the catch series and different combinations of abundance indices. Configurations based on landings from 1994 onwards were tested using the MEDITS survey, including the 2025 autumn component, along with the ICATMAR SAP biomass index and LPUE. The earliest MEDITS observations were downweighted in some configurations to reduce their influence on the model fit. Time-varying intrinsic population growth (r, TVR) was subsequently incorporated to allow for temporal variability in population productivity. Further sensitivity analyses considered the inclusion of year-specific confidence intervals to account for observational uncertainty and alternative definitions of the MEDITS series based on the survey sampling season.

After these analyses, two final configurations were selected for comparison. Scenario 1 used landings starting in 1994, the MEDITS index including the 2025 autumn survey (MEDITS-AUT), the ICATMAR SAP biomass index, LPUE, confidence intervals and TVR. Scenario 2 used the complete historical catch series starting in 1970, the spring MEDITS biomass index, LPUE, confidence intervals and TVR.

The final assessment was based on Scenario 2, which was considered the most consistent configuration. This scenario combines the longest available catch series with the spring MEDITS biomass index and LPUE, with both abundance indices representing the same period of the year. LPUE provides complementary information that helps to better capture and understand recent stock dynamics, while year-specific confidence intervals account for annual observation uncertainty. The inclusion of time-varying r (TVR) allows for temporal variability in recruitment not fully explained by the stock–recruitment relationship. Overall, Scenario 2 provided the most coherent combination of historical catch information, complementary abundance indices, temporal consistency and model assumptions, and was therefore selected as the final assessment.

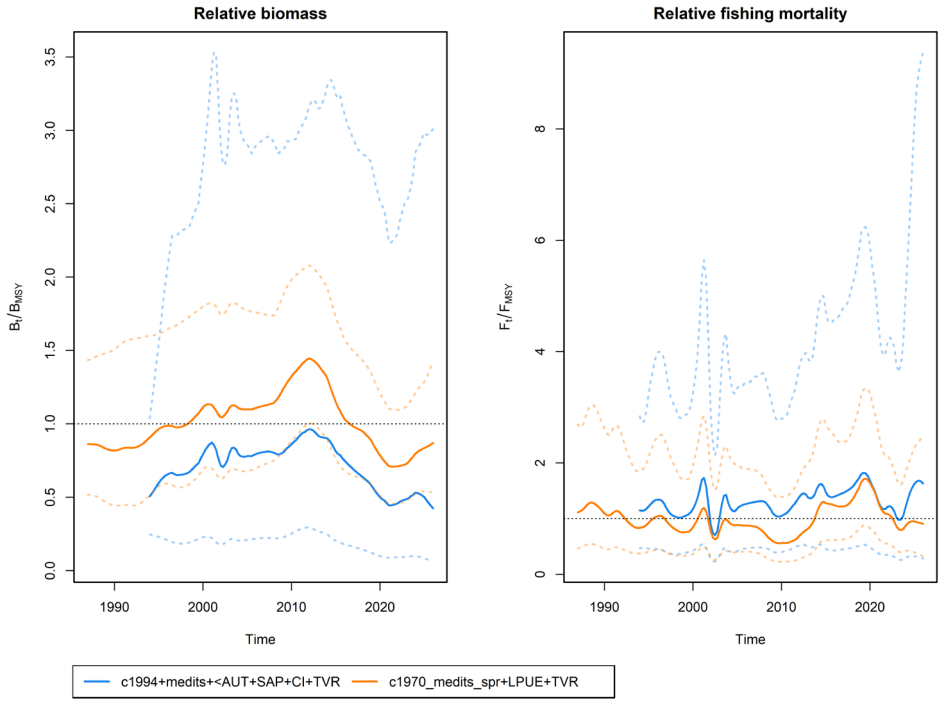


Figure 68. Scenarios comparison for Norway lobster in GSA6.

Final scenario

The final scenario input data are shown in Figure 69 and the final summary assessment results are presented in Figure 70. The abundance index showed some stability, not accompanied by an increase or decrease in catches; for example, despite the sustained decrease in catches since 2010, no increase in the abundance index is observed in the following years.

The results show a decreasing trend in biomass since 2012, with values below the reference point B_{msy} since 2015. For fishing mortality, the estimated values have been oscillating between 1 and below 1 since 2020.

Settings used for the final scenario are shown in Table 24. Among other settings, the BKfrac prior was 0.5, a moderate value, and Time Varying Growth (TVR) was applied to run the model.

Type	Prior	Description	Assignment	Mean	Standard deviation	Comment
Fishery dynamic	logbkfrac	B/K fraction (depletion)	-	Log(0.5)	0.3	A value of 0.5 was selected as an intermediate value, and after conducting different sensitivity analyses on this prior.
Relative standard deviation time series (input data)	stdevfacC	Standard deviation factor for catches	-	-	-	
	stdevfacI	Standard deviation factor for indices	MEDTIS	-	-	StDevF and CV from the data
Stock dynamic	Logr	Population growth	-	Log(0.5)	0.2	Fishlife
	Logn	Shape of production curve	-	Log(2)	-	Shaefer
Error	Logsdc	Catch error	-	Log(0.1)	0.2	
	Logsdf	Fishing mortality error	-	Log(4)	0.5	
	Logsdb	Process error	-	Log(0.07)	0.25	
	logsdi	Observation error	MEDITS	Log(0.3)	CV MEDITS	
			LPUE	Log(0.15)	0.2	
TVR	logsdm	Time Varying Growth	-	Log(0.3)	0.3	Allow recruitment to vary over time
	logpsi	Time Varying Growth	-	Log(0.5)	0.3	

Table 24. Prior settings for Norway lobster in GSA 6 for final scenario.

All diagnostics can be checked in Figure 71, Figure 72, Figure 73, Figure 74 and Figure 75. Retrospective diagnostics showed low retrospective bias, with Mohn's ρ of 0.033 for B and −0.085 for F, supporting the robustness of the selected model configuration. Although the LPUE index showed a higher MASE than the MEDITS index (0.689 and 1.39, respectively), its inclusion provided complementary information on recent biomass trends. A sensitivity analysis for the final scenario was performed, testing r prior, BKfrac, process error, and observation error to assess the model's robustness within these priors. All these plots and results for the other scenarios will be available at https://github.com/ICATMAR.

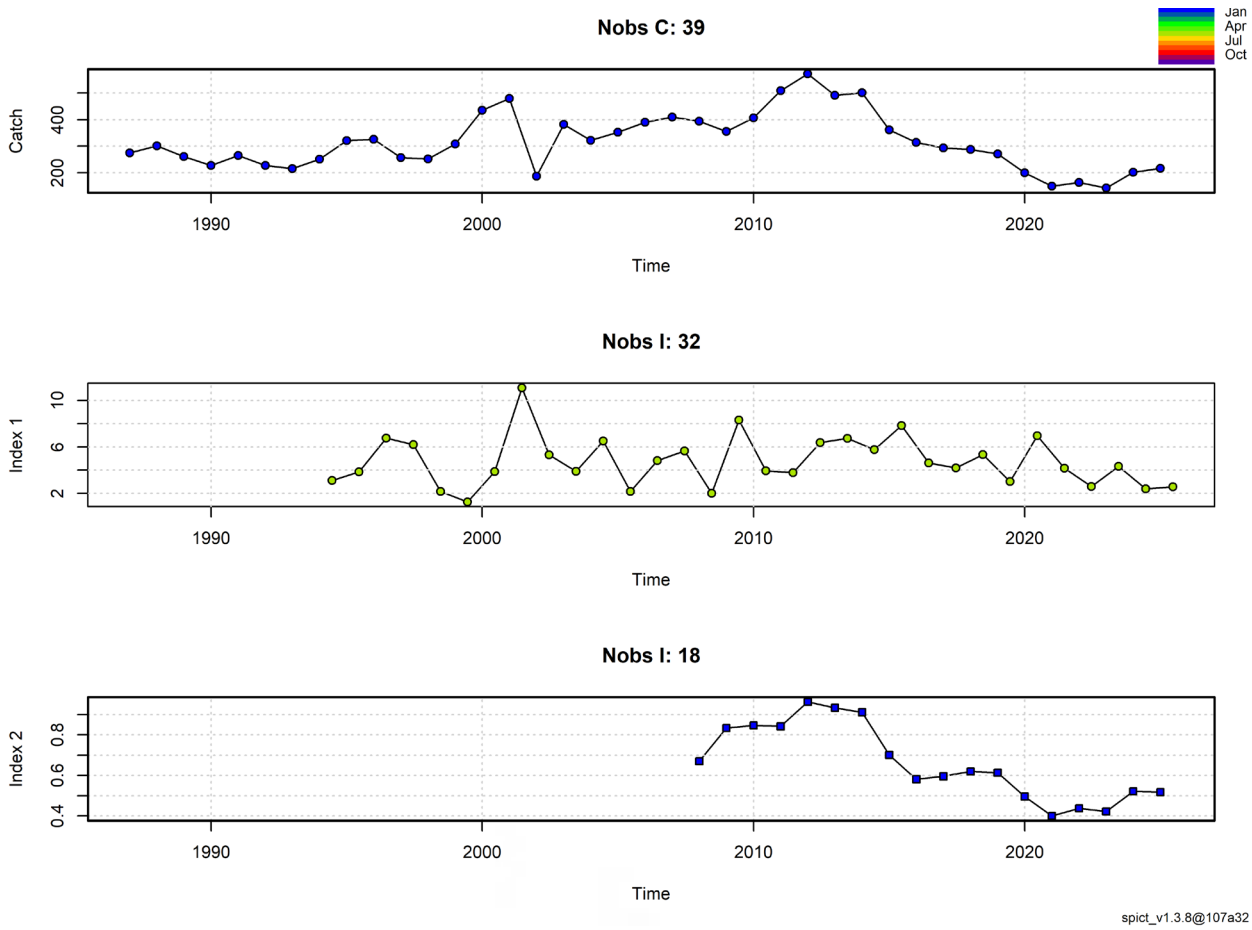


Figure 69. Input data for SPiCT model for Norway lobster in GSA6 for scenario 1. Top: catch in tons per year since 1970, center: index data of biomass derived from MEDITS since 1994, and bottom: LPUE index since 2008.

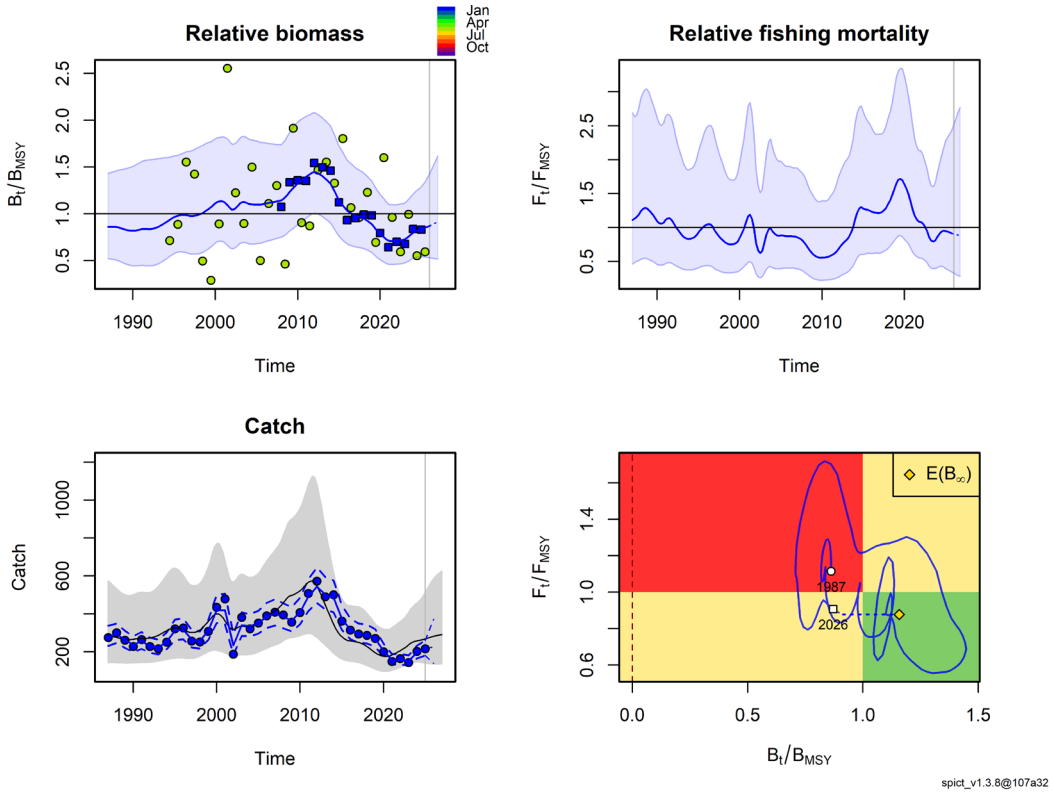


Figure 70. Stock assessment summary for SPiCT model for Norway lobster in GSA6 for final scenario.

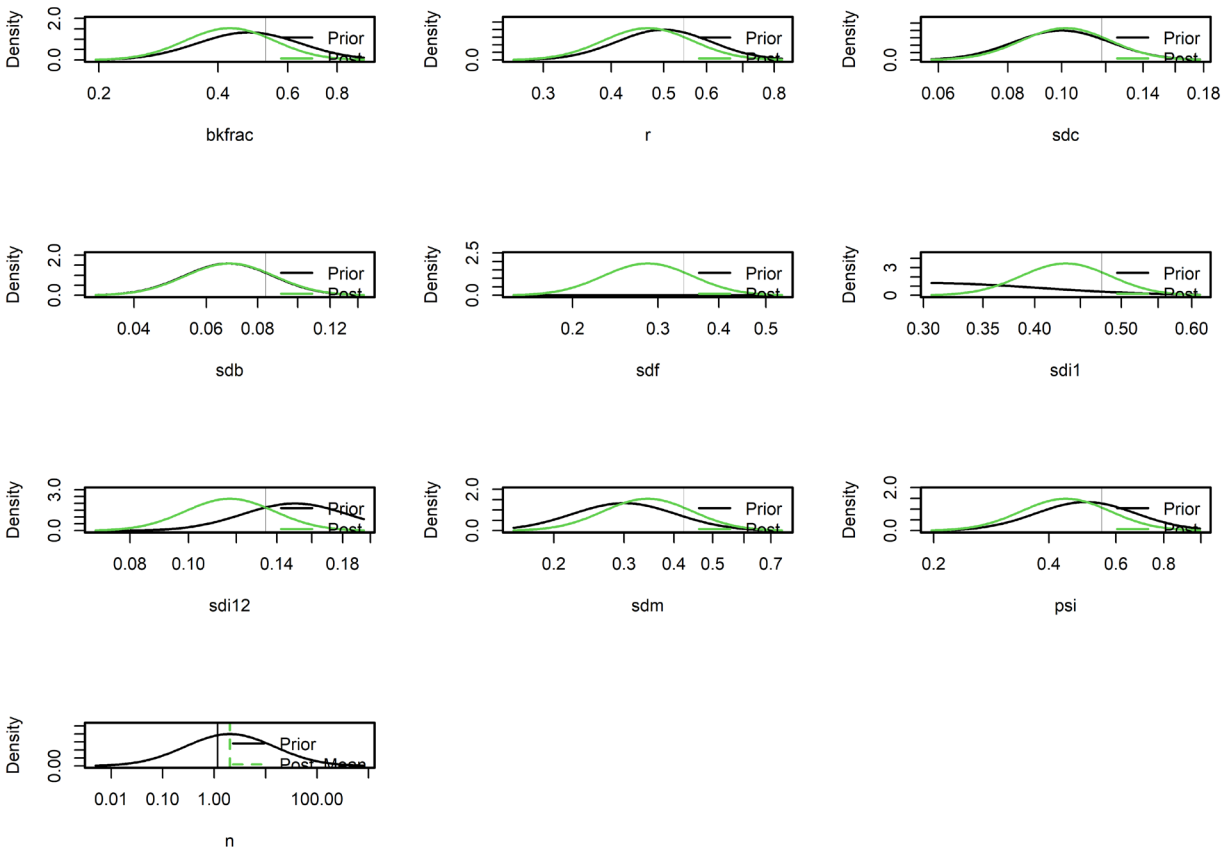


Figure 71. Estimated priors and posteriors for the updated assessment for Norway lobster in GSA6 for final scenario

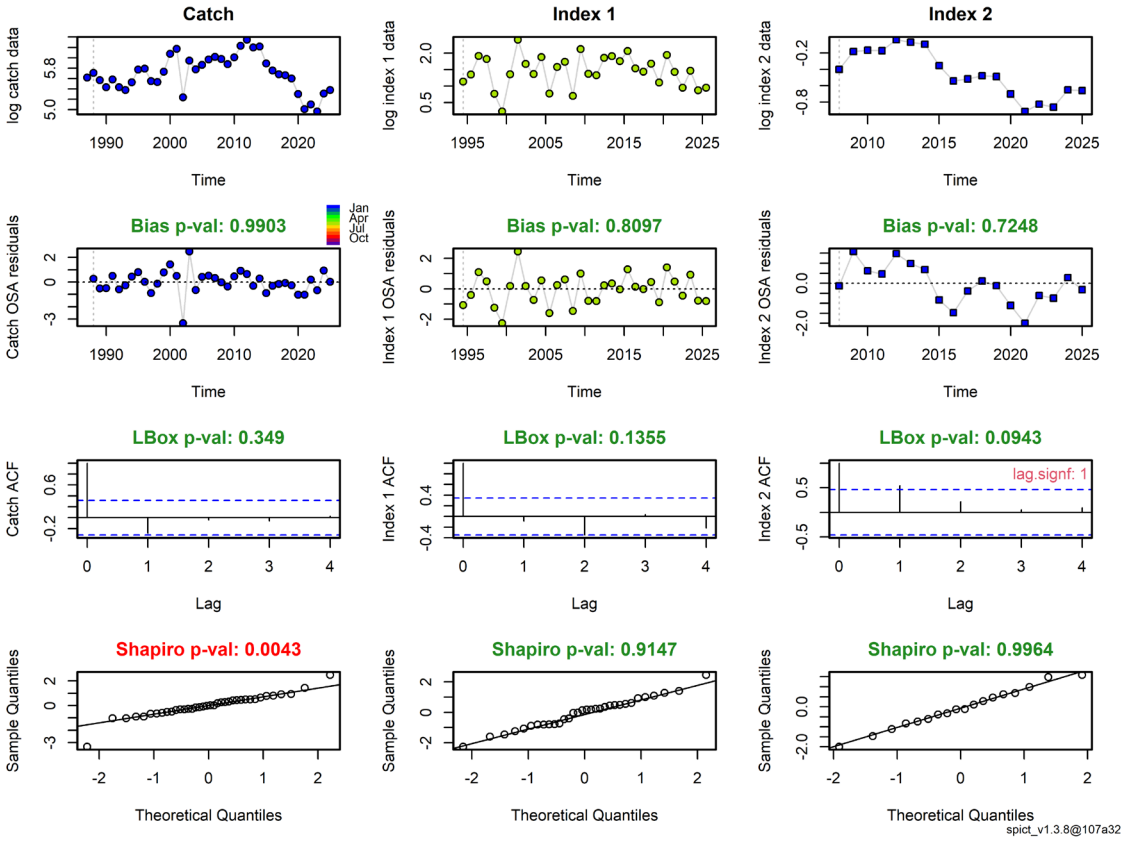


Figure 72. One-step-ahead residuals for the model for Norway lobster in GSA6 for final scenario.

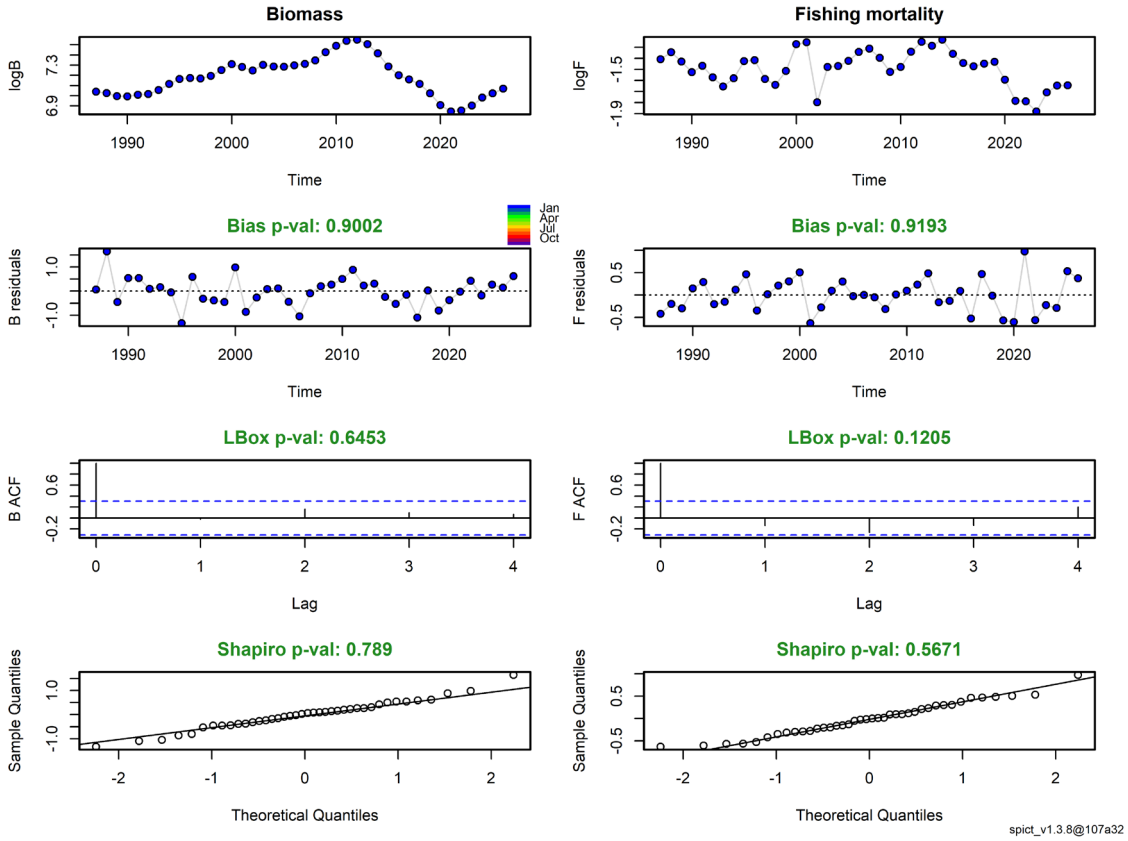


Figure 73. Process error deviations for the model for Norway lobster in GSA6 for final scenario.

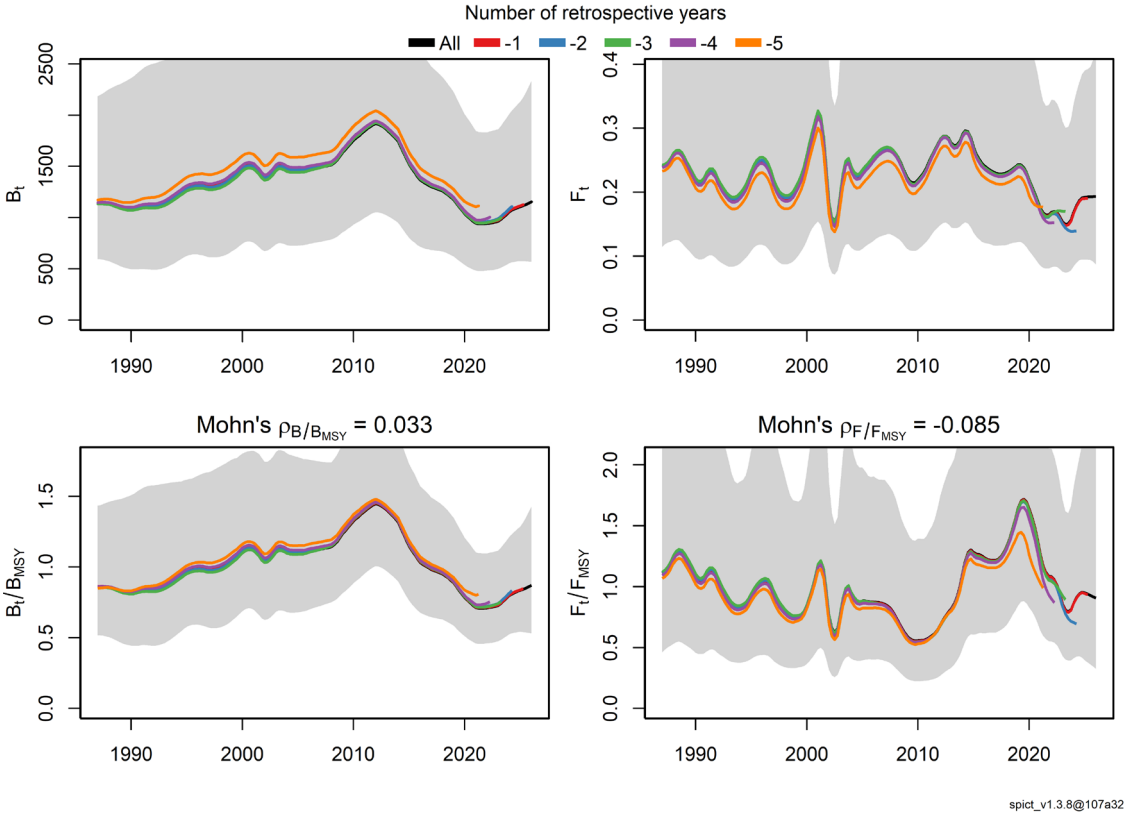


Figure 74. Retrospective analysis for Norway lobster in GSA6 for final scenario.

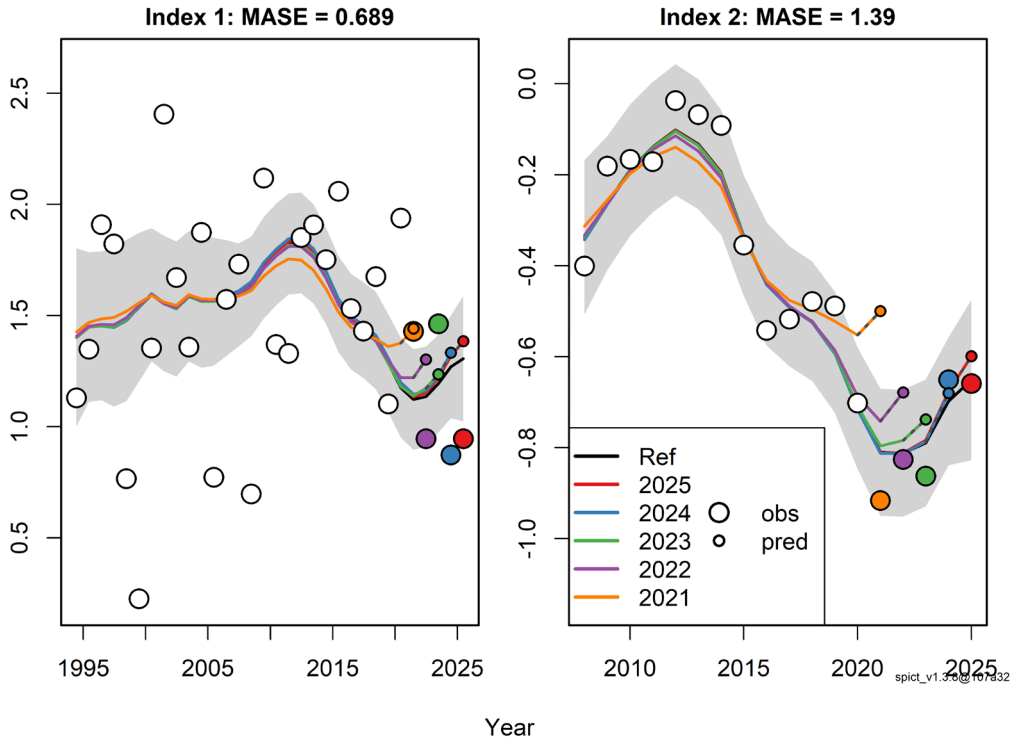


Figure 75. Hindcasting for the model for Norway lobster in GSA6 for final scenario.

Final scenario advice

Final scenario advice is presented in Figure 76 and Table 25, which outline the indicators for Norway lobster in GSA6 for 2025. The assessment results should be treated with caution and interpreted qualitatively, since, from the beginning of the time series, changes in catches are not consistently reflected in the MEDITS abundance index. In 2025, the estimated stock biomass was below the MSY reference level (B/BMSY < 1), and fishing mortality was also below the MSY reference level (F/FMSY < 1).

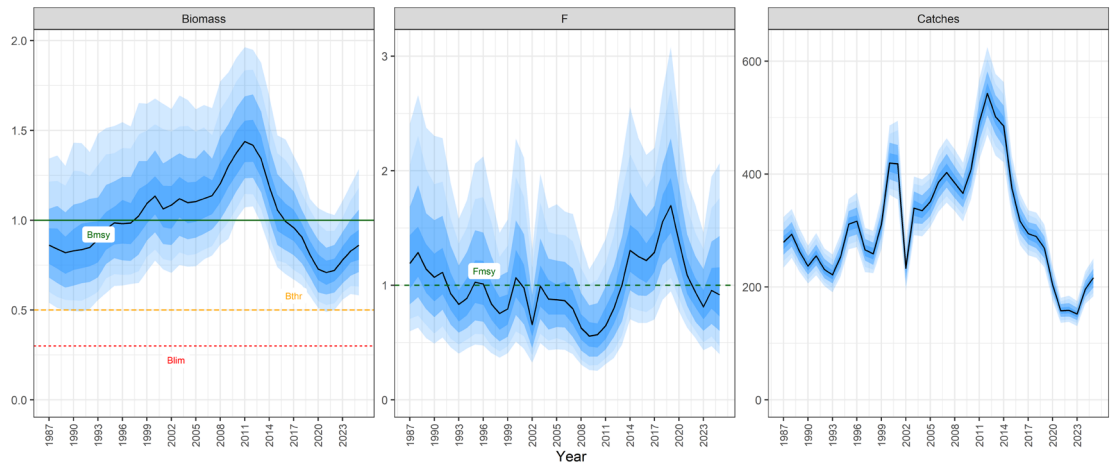


Figure 76. Advice for final scenario for Norway lobster in GSA6: Historical and current stock status regarding F_{msy}, B_{msy} and $B_{lim.}$

Table 25. Indicators in 2025 from SPiCT for Norway lobster (NEP) in GSA6.

Species	Year	Catch (t)	F/Fmsy	B/Bmsy	B/Bpa	B/Blim
NEP	2025	216.56	0.92	0.86	1.72	2.87

Length-Based Spawning Potential Ratio (LBSPR)

Table 26. Biological parameters used in the different LBSPR scenarios for Norway lobster (NEP). L_{inf}: asymptotic length at which growth is zero, k: growth rate, M: natural mortality, L_{mat50}: length where 50% of individuals are mature, L_{mat95}: length where 95% of individuals are mature.

Species	Scenario	Linf (mm)	Lmat50 (mm)	Lmat95 (mm)	M/k
NEP	1	86.1	32.50	36.00	1.66
NEP	2	86.1	25.60	28.40	1.66
NEP	3	72.9	24.90	28.40	1.58

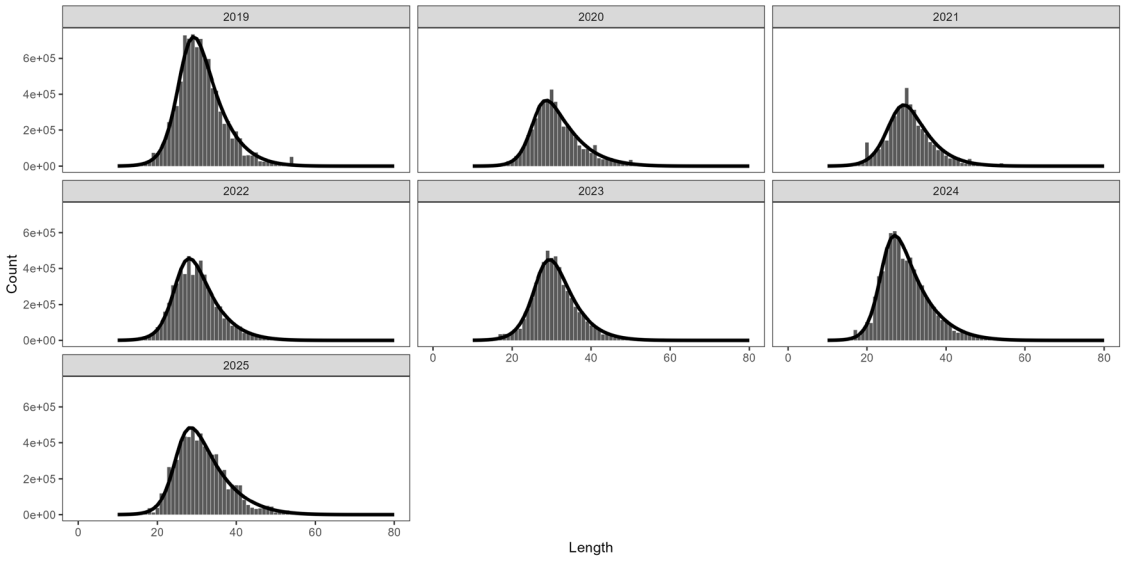


Figure 77. Fit of the data using the LBSPR model for Norway lobster for each studied year. Grey columns indicate length frequencies. Black lines indicate the fit of the model.

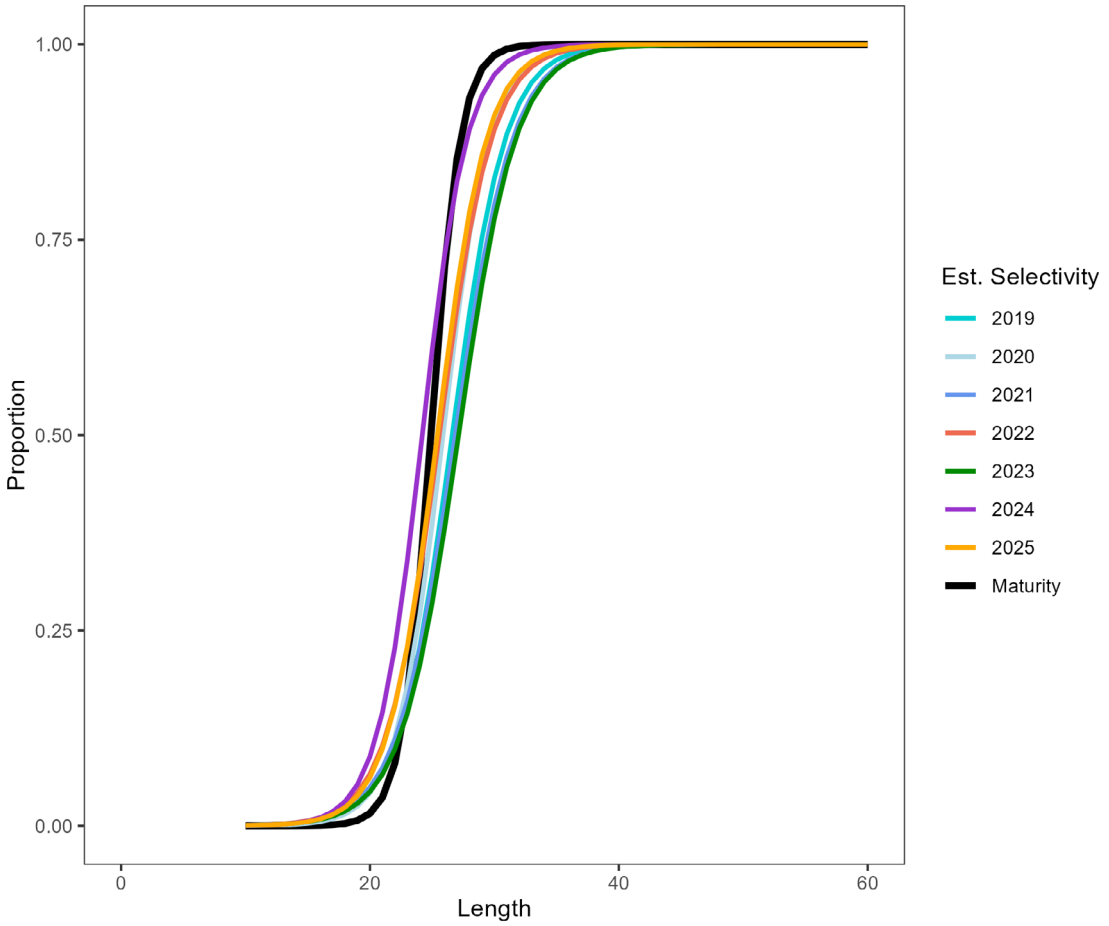


Figure 78. Length curves for Norway lobster. Black line shows the length curve at maturity. Color lines show the estimated selectivity at length curve predicted by the LBSPR model for each year in scenario 3 (the scenario selected).

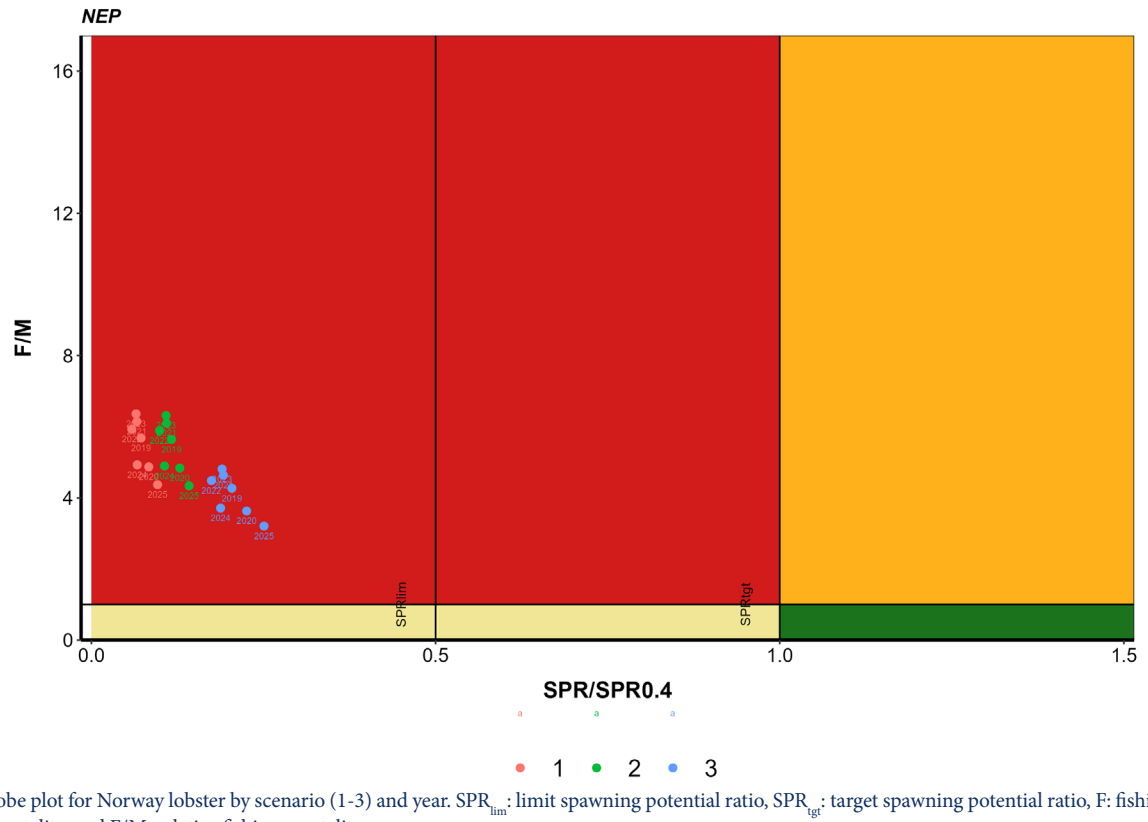


Figure 79. Kobe plot for Norway lobster by scenario (1-3) and year. SPR_{lim}: limit spawning potential ratio, SPR_{tgt}: target spawning potential ratio, F: fishing mortality, M: natural mortality, and F/M: relative fishing mortality.

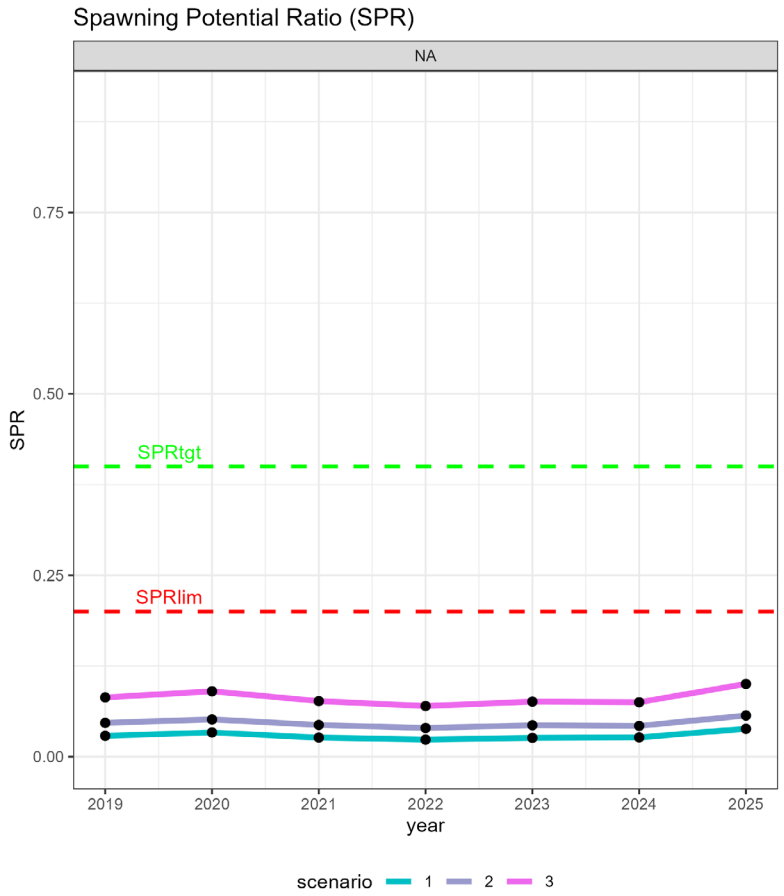


Figure 80. Spawning potential ratio (SPR) per year analyzed for Norway lobster evaluated with LBSPR model. LBSPR: Length-Based Spawning Potential Ratio. SPR_{lim}: limit spawning potential ratio, SPR_{tgt}: target spawning potential ratio. Colored lines show the results for each scenario.

Table 27. LBSPR model results for Norway lobster with the different scenarios tested for each year analyzed. SL_{50}: Length where 50% of individuals are caught, SPR: spawning potential ratio and FM: fishing mortality. SD is the standard deviation calculated for each indicator. The selected scenario is highlighted in blue.

Species	Scenario	Year	SL_{50}	SD	SPR	SD	FM	SD
NEP	1	2019	27.18	0.25	0.03	0.02	5.68	1.34
NEP	1	2020	26.37	0.22	0.03	0.03	4.87	1.17
NEP	1	2021	27.43	0.26	0.03	0.02	6.14	1.44
NEP	1	2022	26.17	0.27	0.02	0.02	5.93	1.39
NEP	1	2023	27.68	0.25	0.03	0.02	6.36	1.48
NEP	1	2024	24.67	0.22	0.03	0.02	4.93	1.16
NEP	1	2025	26.07	0.29	0.04	0.03	4.37	1.09
NEP	2	2019	27.16	0.26	0.05	0.03	5.64	1.37
NEP	2	2020	26.35	0.23	0.05	0.03	4.83	1.19
NEP	2	2021	27.42	0.27	0.04	0.03	6.1	1.46
NEP	2	2022	26.15	0.28	0.04	0.03	5.89	1.41
NEP	2	2023	27.66	0.26	0.04	0.03	6.32	1.51
NEP	2	2024	24.66	0.23	0.04	0.03	4.89	1.18
NEP	2	2025	26.06	0.31	0.06	0.03	4.34	1.11
NEP	3	2019	27.02	0.32	0.08	0.05	4.27	1.16
NEP	3	2020	26.21	0.28	0.09	0.05	3.63	1.01
NEP	3	2021	27.28	0.33	0.08	0.05	4.63	1.24
NEP	3	2022	25.99	0.34	0.07	0.04	4.48	1.2
NEP	3	2023	27.53	0.31	0.08	0.05	4.81	1.28
NEP	3	2024	24.51	0.27	0.08	0.05	3.71	1
NEP	3	2025	25.83	0.38	0.1	0.06	3.21	0.94

Model setting and results

Scenarios

For the present report, natural mortality (M) values for all scenarios were estimated using a combination of ICATMAR data and published literature. When stock-specific estimates were unavailable, values from nearby and biologically similar stocks were used.

Three different scenarios were applied for the sensitivity analysis for Norway lobster (Table 26):

- Scenario 1: includes growth parameters and maturity information from the STECF and GFCM stock assessments.
- Scenario 2: used same growth parameters as in Scenario 1 and maturity data from the literature (Vigo et al., 2023).
- Scenario 3: applied growth parameters from the literature (Ulmestrand & Eggert, 2001) and maturity data from the ICATMAR dataset (ICATMAR, 26-04).

Fitted data

The length frequency distribution fit per year is shown in Figure 77. The model generally follows the modal length for all years; however, in some years, overestimated abundance at certain intermediate length classes where peaks are observed.

Selectivity

The model outputs for fishery selectivity under the scenarios tested are presented in Table 27. The output of the selected scenario (3) is also plotted with L_{mat50} and SL_{50} in Figure 78. The model outputs indicate that, under Scenario 3, the fishery is operating at lengths above L_{mat50}.

Reference points

Even though the model is very sensitive to changes in growth parameters and maturity, the stock is below SPR_{lim} (= 0.2) in all assessed scenarios (Table 27 and Figure 80). Although a slight increase in SPR is evident in 2025, the stock remains below the limit reference point. Consistent with this result, the Kobe plot for Norway lobster (Figure 79 shows that the stock remains in the red quadrant throughout the time series, indicating that it is overfished and experiencing ongoing overfishing.

Final scenario

As LFD and L_{mat} were derived from the ICATMAR dataset, Scenario 3 was selected as the basis for the final LBSPR assessment and management advice.

Blue and red shrimp (*Aristeus antennatus*) ARA

The blue and red shrimp presents sexual dimorphism, with females reaching larger sizes than males. However, for the analysis, a combined set of growth parameters was used; thus, the length data available was a dataset with both male and female parameters. Reproduction of blue and red shrimp occurs between April and September (ICATMAR, 26-04), and recruitment is observed afterwards, in autumn and winter. The blue and red shrimp is a deep-water species caught exclusively by bottom trawling. The species has a wide bathymetric distribution, between 80 and 3300 m depth (Sardà et al., 2004), although commercial fishing grounds are located between 450 and 800 m depth.

Input data

The spatial distribution of total landings for blue and red shrimp in the Catalan fishing ground is shown in Figure 81. The species is mainly distributed in the lower slope along the Catalan coast, with less occurrence in the Delta area (i.e. L'Ametlla de Mar).

Historical blue and red shrimp landings in Catalonia from 2002 to 2025 are shown in Figure 82. The lowest value was observed in 2005. Following a peak in 2008, landings declined and have remained stable over recent years. However, in 2025, landings reached their lowest level since 2006.

Landings distribution for the blue and red shrimp by métier from 2019 to 2025 are presented in Figure 83, with the highest landings obtained with bottom trawlers, especially for the lower slope métier.

Annual LFD

After raising the length frequencies obtained with the monitoring program (Table 29), the annual length frequency of blue and red shrimp in Catalonia is shown in Figure 84. In general, females reach larger sizes and migrate to shallower depths (< 600 m) during summer (Company and Sardà, 2000; Sardà et al., 2004), coinciding with the reproductive period, when landings of blue and red shrimp were higher (ICATMAR, 26-02). In contrast, males are smaller and remain in deeper waters, making females more susceptible to capture by the bottom trawling fishery. Nevertheless, sex differentiation was not included in this year's analysis, as it did not provide additional information relevant to the objectives of this report. The SOP validation results are shown in Table 28, while Table 29 summarizes the number of individuals sampled through the ICATMAR monitoring program.

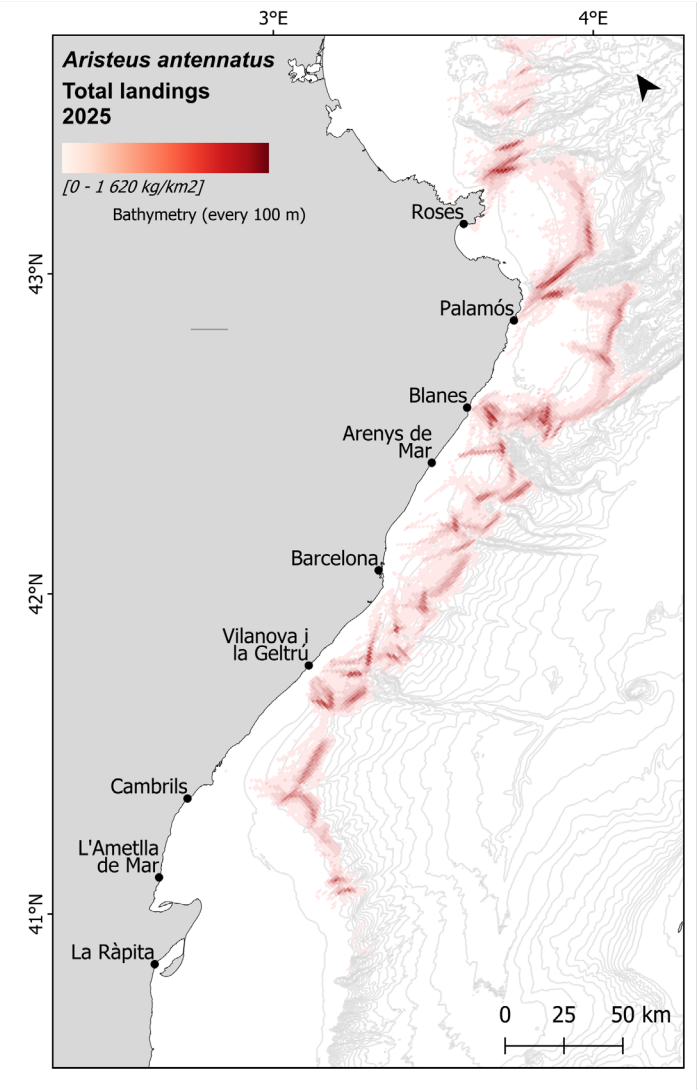


Figure 81. Spatial distribution of landings (kg/km²) for blue and red shrimp in the Catalan fishing grounds (North GSA6) in the year analyzed.

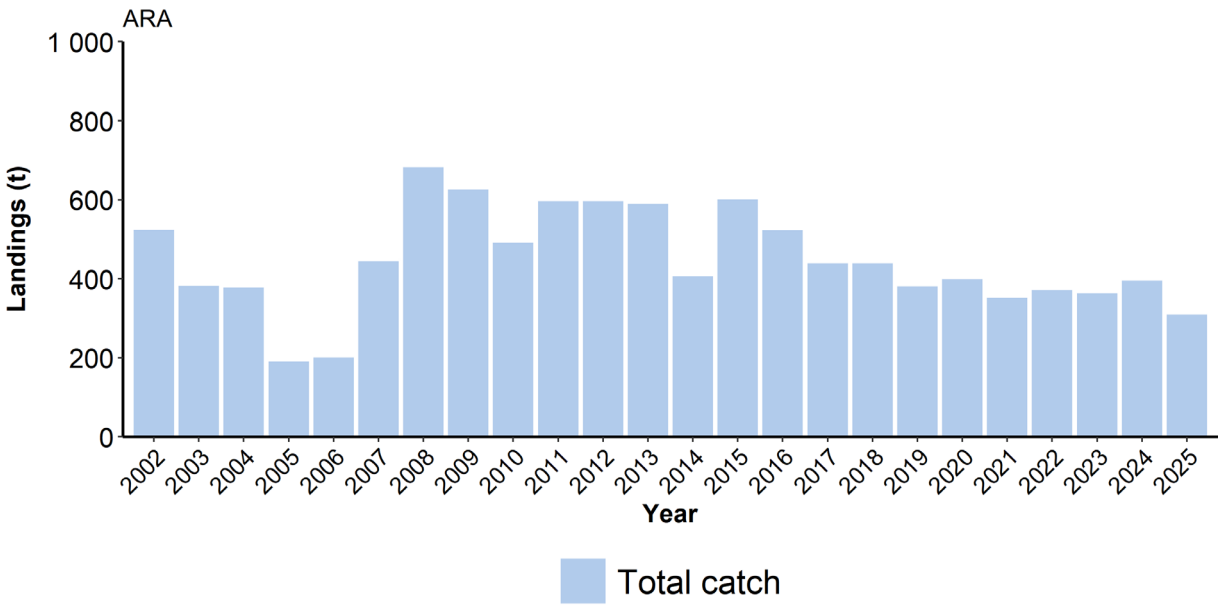


Figure 82. Historical landings (t) for blue and red shrimp in Catalonia.

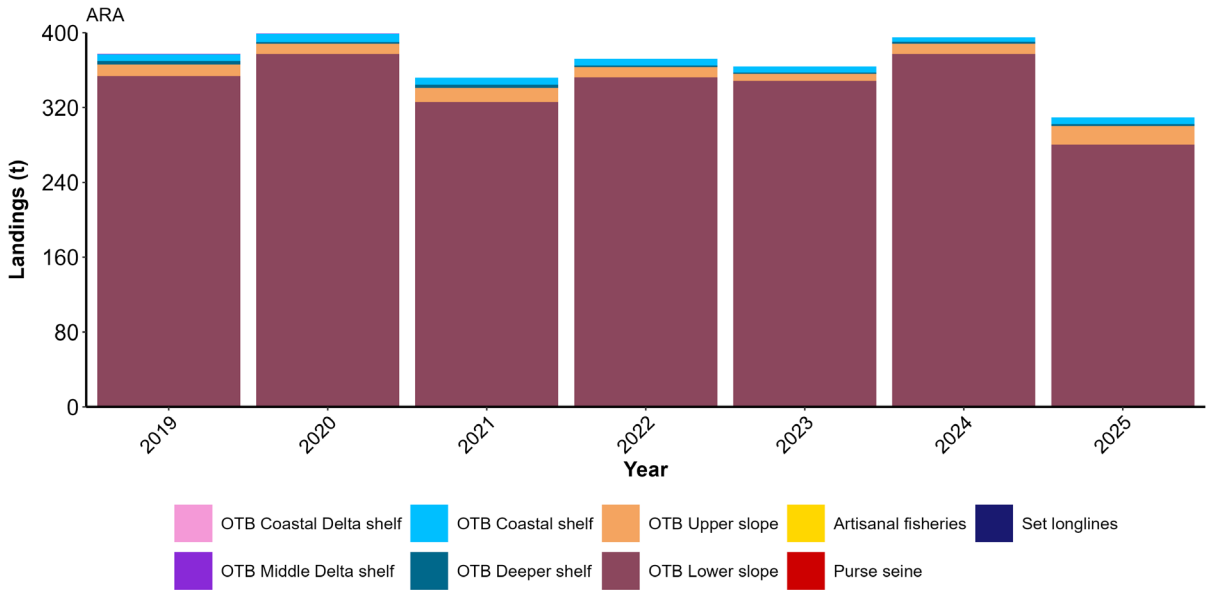


Figure 83. Landings (t) for blue and red shrimp by métier and fishing gear. OTB: bottom trawling.

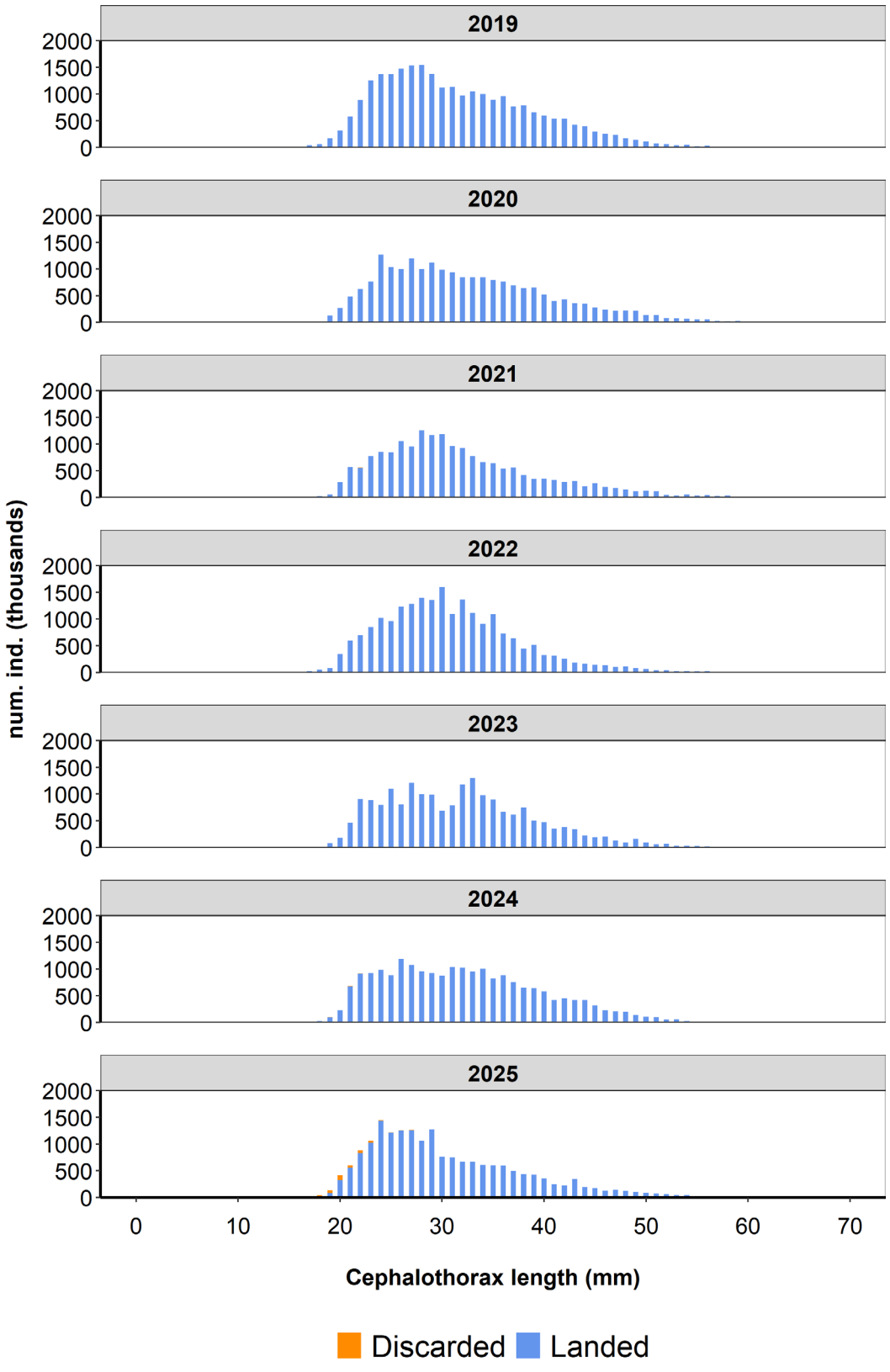


Figure 84. Annual length frequency distributions of blue and red shrimp from bottom trawling and small-scale fisheries. The data from bottom trawling is raised from ICATMAR data and details landed and discarded blue and red shrimp.

Table 28. . Sum of Products (SOP) validation for blue and red shrimp (ARA): The column Calculated Weight in N GSA6 (SOP) represents the biomass estimated through the raising process, while landings refer to the reported landings in N GSA6. The ratio between SOP and landings is known as the Sum of Products (SOP). Values close to 1 indicate that the raising process provides biomass estimates that closely match the reported landings, thereby validating the accuracy of the estimation method.

Species	Year	Catch classification	Gear	Calculated weight GSA6N (kg) (SOP)	Landings in GSA6N (kg)	SOP/Landings
ARA	2019	Discarded	Bottom trawl	0	-	-
ARA	2020	Discarded	Bottom trawl	0	-	-
ARA	2021	Discarded	Bottom trawl	45	-	-
ARA	2022	Discarded	Bottom trawl	9	-	-
ARA	2023	Discarded	Bottom trawl	0	-	-
ARA	2024	Discarded	Bottom trawl	31	-	-
ARA	2025	Discarded	Bottom trawl	1821	-	-
ARA	2019	Landed	Bottom trawl	398551	380515	1.05
ARA	2020	Landed	Bottom trawl	357598	399302	0.90
ARA	2021	Landed	Bottom trawl	294870	352167	0.84
ARA	2022	Landed	Bottom trawl	315949	372080	0.85
ARA	2023	Landed	Bottom trawl	315294	363835	0.87
ARA	2024	Landed	Bottom trawl	350666	395314	0.89
ARA	2025	Landed	Bottom trawl	274773	309347	0.89

Table 29. Number of blue and red shrimp individuals sampled by zone and season from ICATMAR monitoring data used to raise the length frequencies.

Fishery	Year	Zone	Winter	Spring	Summer	Autumn	N hauls
			Number individuals sampled				
Bottom trawl	2021	North	1 053	979	1 146	1 100	16
Bottom trawl	2021	Center	1 067	974	552	465	11
Bottom trawl	2022	North	889	921	934	746	15
Bottom trawl	2022	Center	835	532	663	431	11
Bottom trawl	2023	North	650	629	921	721	12
Bottom trawl	2023	Center	587	750	816	772	12
Bottom trawl	2024	North	924	964	859	881	14
Bottom trawl	2024	Center	556	895	931	1 062	12
Bottom trawl	2025	North	572	1 059	920	700	17
Bottom trawl	2025	Center	274	841	524	223	7

Stochastic Production model in Continuous Time (SPiCT)

For blue and red shrimp, fleet data were obtained from the EU Fleet Register provided by the European Commission (Reg. EU 2017/218), while daily commercial fishing landings in GSA6 were provided by the Spanish Ministry of Agriculture, Fisheries and Food. MEDITS data were obtained from the most recent available GFCM Stock Assessment Form (SAF) for ARA in GSA6 (RY2024), complemented with data from the Joint Research Center (JRC, 2025; STECF-PLEN-25-01 background) and the Spanish Institute of Oceanography – CSIC (IEO-CSIC). Annual biomass indices for N GSA6 and the MEDITS autumn survey were obtained from ICATMAR data. Historical catch and CPUE data were additionally obtained from Martin (2001) and Gorelli et al. (2016) and were incorporated to extend the available time series and provide information on long-term stock dynamics (Figure 85).

- Landings from 1965 to 2025 (Tons)
- CPUE (kg/fishing effort) historical series from 1965 to 2013 (Gorelli et al. 2016).
- Index: MEDITS survey data from 1996 to 2025 (Biomass, kg/km^2)
- Index: MEDITS-AUT survey data from November 2025 (Biomass, kg/km^2)
- Annual biomass index: ICATMAR data: 2019 – 2025 (Biomass, kg/km^2

For the MEDITS and ICATMAR biomass indices, the uncertainty associated with each annual estimate was derived from the survey data following the approach used in GFCM stock assessments. Annual coefficients of variation (CVs) were calculated for each index, and the corresponding uncertainty was incorporated into the assessment. A mean CV (CVmean) was calculated across the available time series and used as a reference for the overall uncertainty of each index. The annual variability in precision was then accounted for using a standard deviation factor (StDevF), calculated as the ratio of the

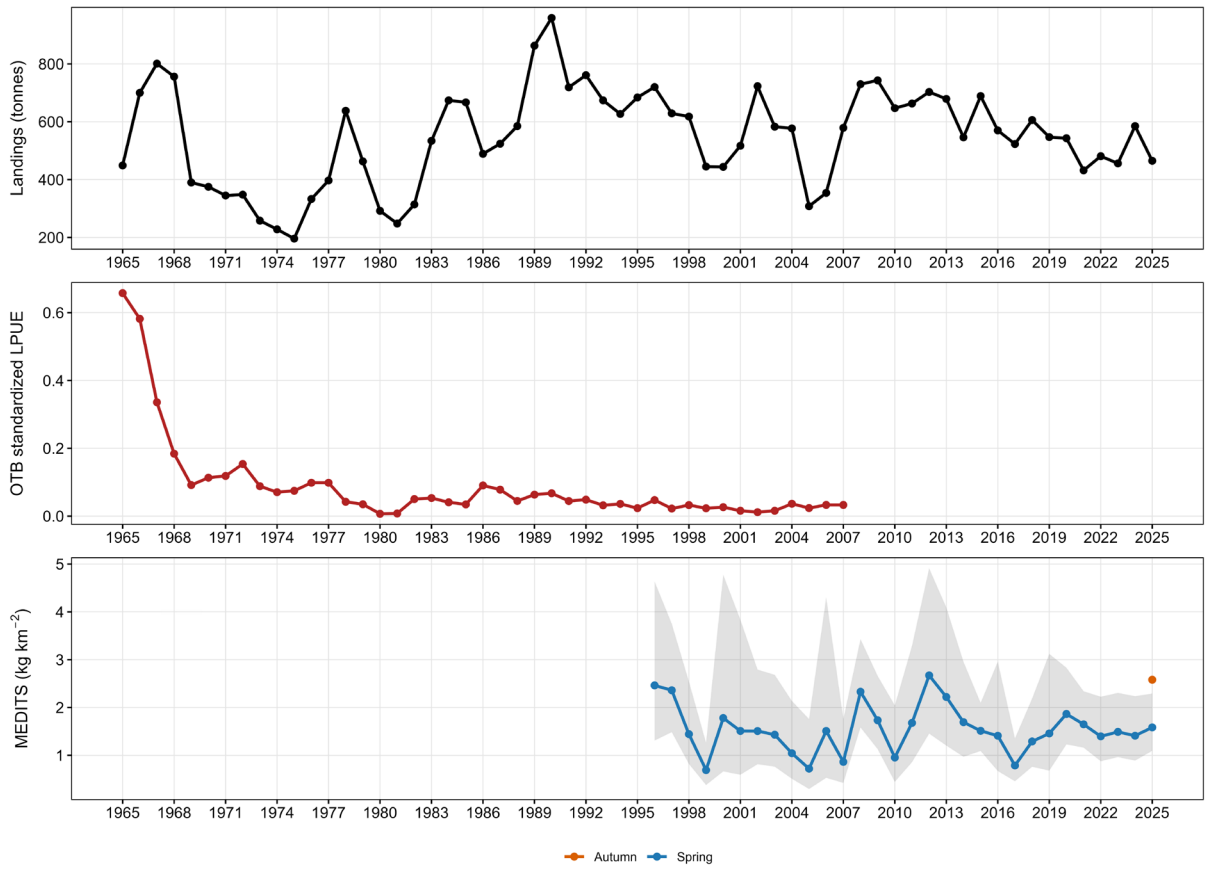


Figure 85. Data available for the assessment for blue and red shrimp in GSA6 to run SPiCT model. From top to bottom: catch data from 1965 to 2025; historical OTB CPUE data from 2004 to 2024; MEDITS survey biomass indices from 1996 to 2025, including Spring and Autumn surveys; and ICATMAR biomass indices from 2019 to 2025.

annual CV to the CVmean. This approach allows the observation error assigned to the survey indices in SPiCT to reflect the uncertainty associated with the underlying survey data and its year-to-year variation, consistent with the treatment of survey indices in GFCM stock assessments.

Several sensitivity analyses were conducted to evaluate the influence of the different abundance indices, historical information and the treatment of the terminal MEDITS observation on the SPiCT assessment of red shrimp (Aristeus antennatus) in GSA 6.

Although only the final scenario is presented below, different scenarios were tested:

- Scenario 1: Landings 1996-2025 + MEDITS biomass index (1996–2024 and AUT 2025) + CI.
- Scenario 2: Landings 1996-2025 + MEDITS biomass index (1996–2024 and AUT 2025) + ICATMAR biomass indices + CI.
- Scenario 3: Landings 1965-2025 + CPUE historical 1965-2013 + MEDITS biomass index (1996–2024 and AUT 2025) + ICATMAR biomass indices + CI.
- Scenario 4: Catch 1996-2025, MEDITS spring + ICATMAR + CI.

The analyses progressively incorporated additional information into the model, starting with the MEDITS biomass index alone, then including the independent ICATMAR biomass index (Scenario 1). Scenario 2 further extended the assessment by incorporating historical catches and an additional historical abundance index (CPUE), allowing the model to use information spanning a longer period of stock dynamics. Scenario 3 evaluated the influence of the most recent MEDITS observation by removing the terminal survey point. Scenario 4 used the MEDITS spring index for all the time series, ICATMAR data, and the CI for both indices. In this final scenario, no historical information was used due to the need to better standardise its inclusion in the same landing time series.

The scenarios were compared based on model convergence, residual diagnostics, biological reference points and estimated terminal stock status. Overall, the inclusion of additional abundance data yielded broadly consistent trends in the estimated stock dynamics, while the use of the extended historical series provided further insight into long-term changes in biomass and fishing mortality.

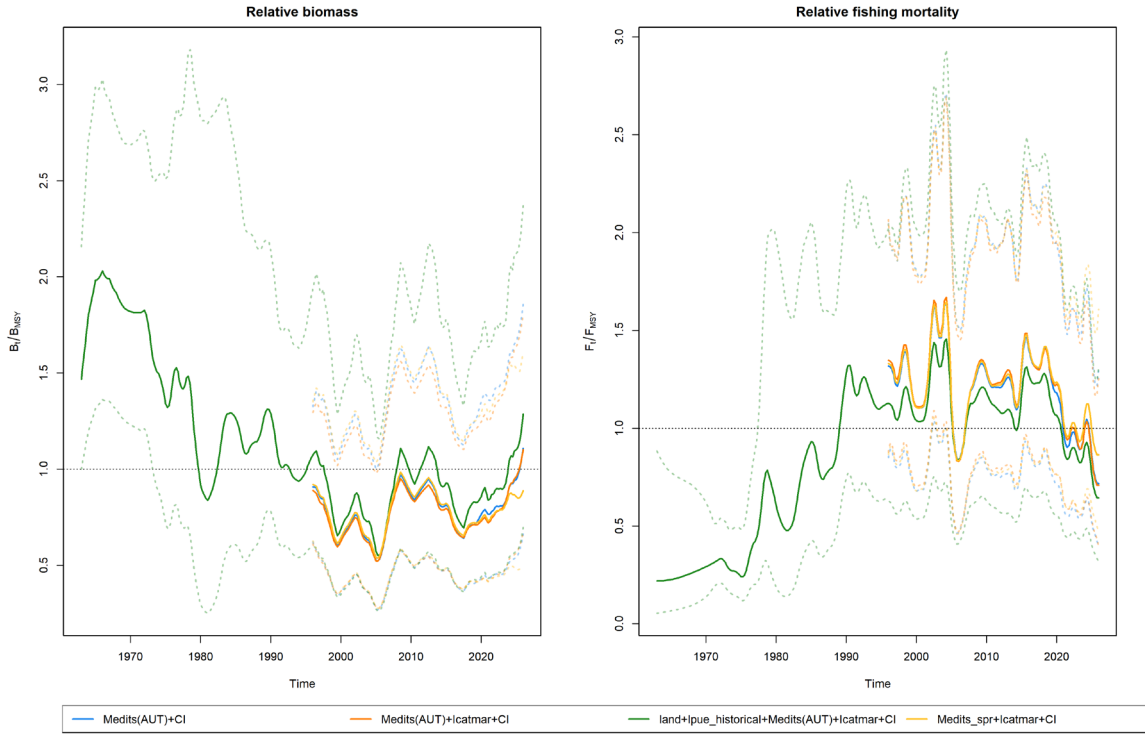


Figure 86. Scenarios comparison for blue and red shrimp in GSA6.

Final scenario

The final assessment was based on Scenario 4, which uses the complete MEDITS spring series, including the 2025 observation, together with the ICATMAR biomass index and CI. This configuration was considered the most appropriate representation of the available information and was therefore selected as the final assessment scenario.

The settings used for the final scenario are presented in Table 30.

Type	Prior	Description	Assignment	Mean	Standard deviation	Comment
Fishery dynamic	logbkfrac	B/K fraction (depletion)	-	Log(0.4)	0.2	Based on historic information and the high catches at the beginning of the catch series
Relative standard deviation time series (input data)	stdevfacC	Standard deviation factor for catches	-	-	-	
	stdevfacI	Standard deviation factor for indices	MEDTIS & ICATMAR	-	-	StDevF from the data
Stock dynamic	Logr	Population growth	-	Log(0.66)	0.2	Fishlife
	Logn	Shape of production curve	-	Log(2)	-	Shaefer
Error	Logsdc	Catch error	-	Log(0.05)	0.2	
	Logsdf	Fishing mortality error	-	Log(4)	0.5	
	Logsdb	Process error	-	Log(0.3)	0.5	
	logsdi	Observation error	MEDITS	Log(0.3)	CV MEDITS	
			ICATMAR	Log(0.3)	CV ICATMAR	

Table 30. Priors settings for blue and red shrimp (ARA) in all scenarios..

The final scenario input data is shown in Figure 87, and the final summary assessment results are shown in Figure 88. The results show an increasing trend in biomass since 2016, with values above the reference point B_{thr} across all-time series. For fishing mortality, the estimated values have been close to 1 since 2019.

The chosen scenario met most of the model diagnostics and provided good retrospective analysis and hindcasting diagnostics (Figure 89, Figure 90, Figure 91, Figure 92 and Figure 93). Retrospective diagnostics showed low retrospective bias, with Mohn's ρ of 0.016 for B and −0.027 for F, supporting the robustness of the selected model configuration. Although the ICATMAR SAP index showed a higher MASE than the MEDITS index (1.02 and 1.23, respectively), its inclusion provided complementary information on recent biomass trends and did not lead to substantial changes in the overall stock status. A sensitivity analysis for the final scenario was performed, testing r prior, BKfrac, process error, and observation error to assess the model's robustness within these priors. All these plots and results for the other scenarios will be available at https://github.com/ICATMAR.

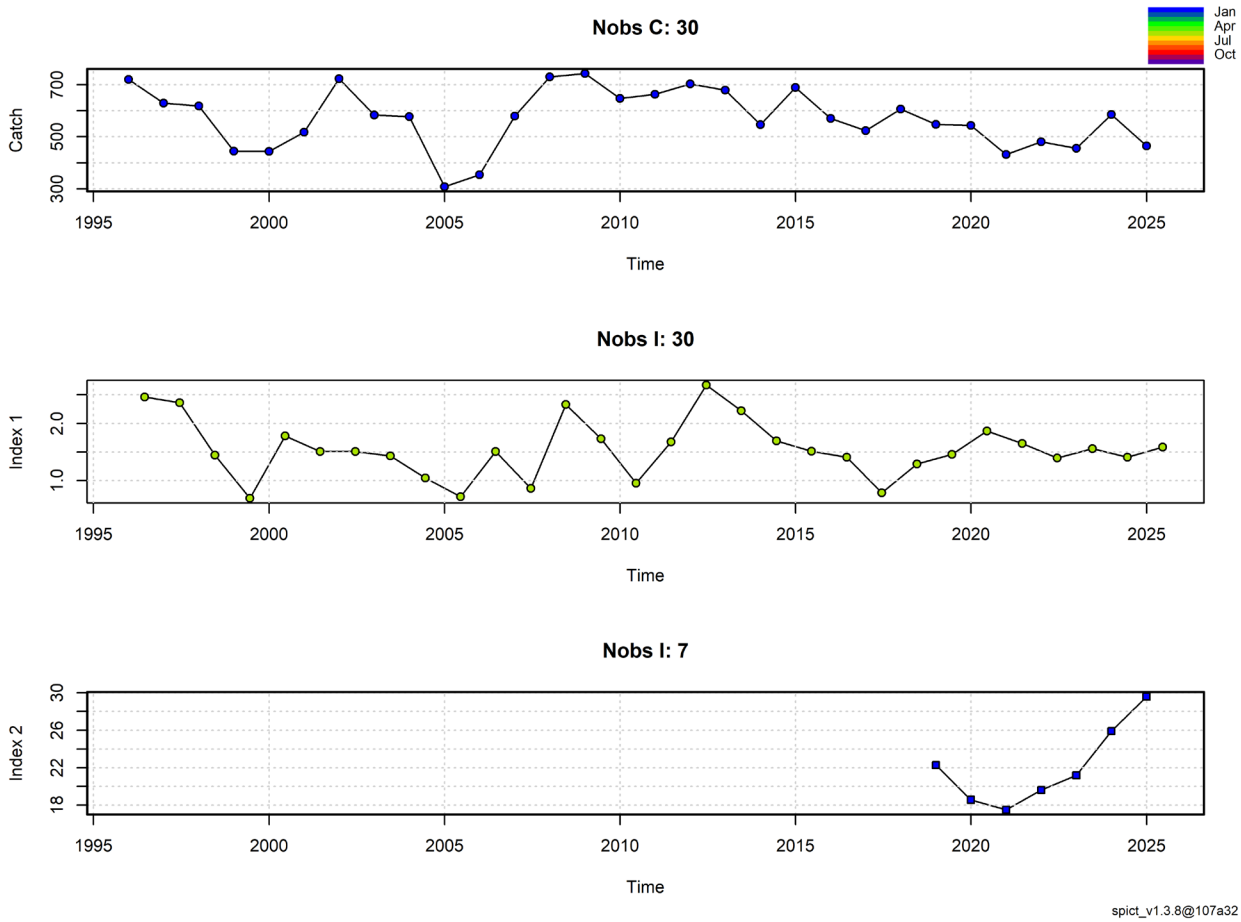


Figure 87.Input data for SPiCT model for blue and red shrimp in GSA6 for scenario 1. From top to bottom: annual catch data (tonnes) from 1996 to 2025; MEDITS biomass index from 1996 onwards; and ICATMAR biomass index from 2019 onwards.

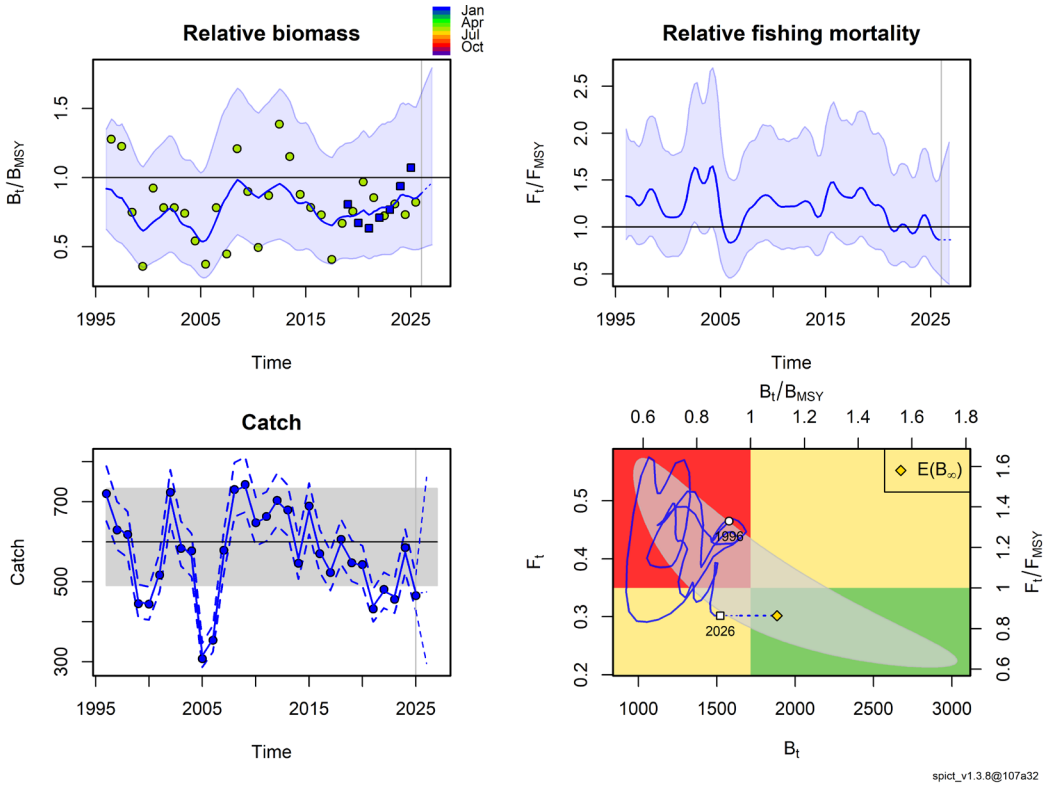


Figure 88. Stock assessment summary for the SPiCT model for blue and red shrimp in GSA6 for the final scenario.

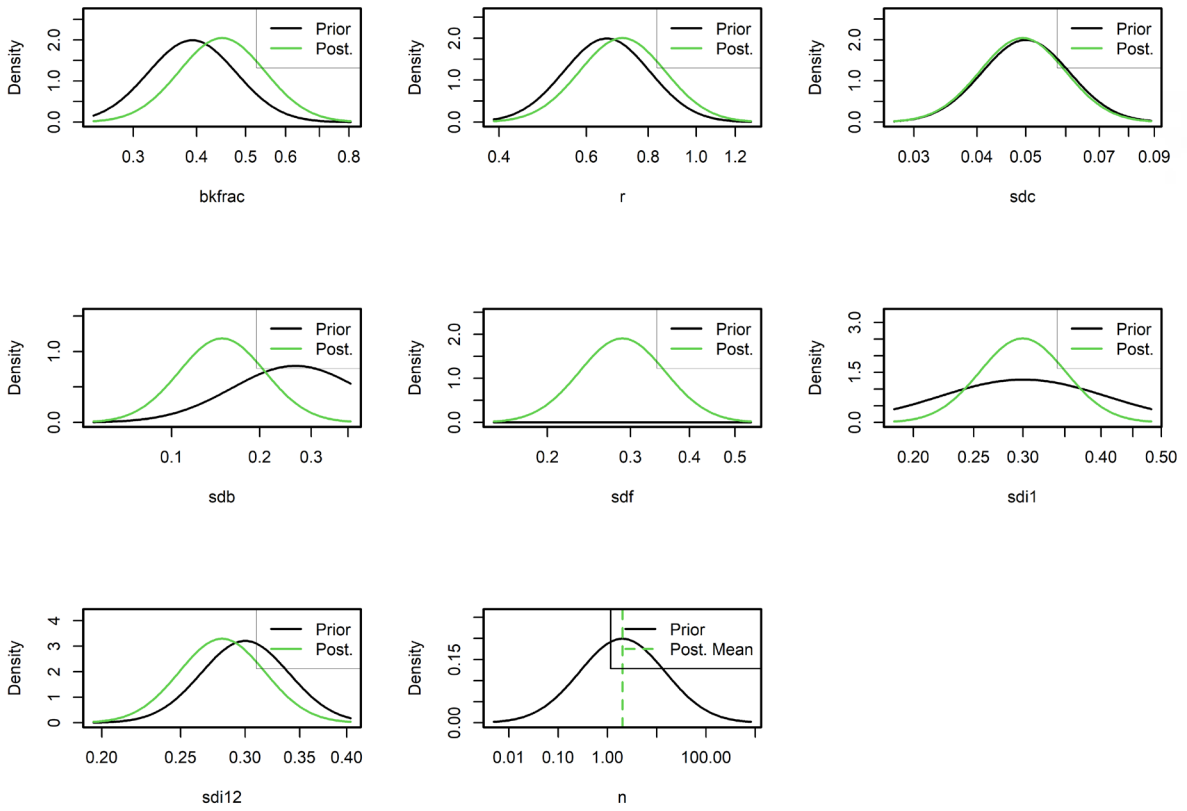


Figure 89. Estimated priors and posteriors for the updated assessment for blue and red shrimp in GSA6 for final scenario

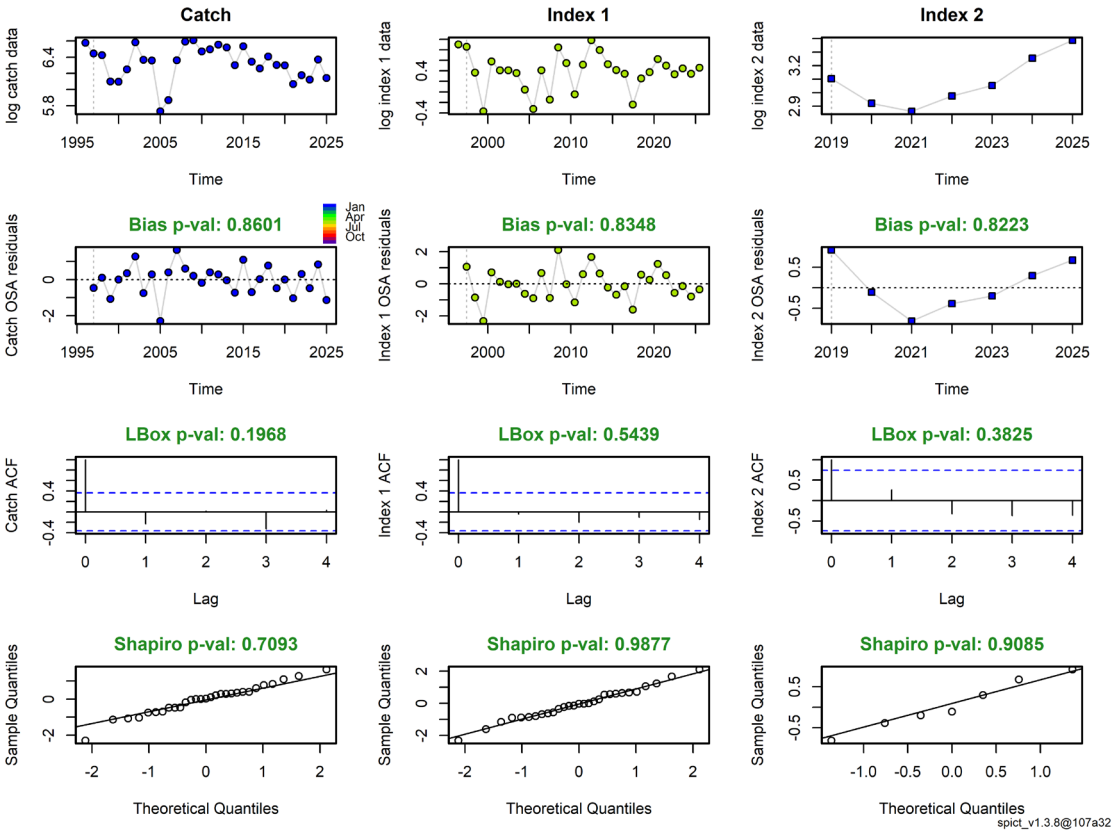


Figure 90. One-step-ahead residuals for the model for blue and red shrimp in GSA6 for the final scenario.

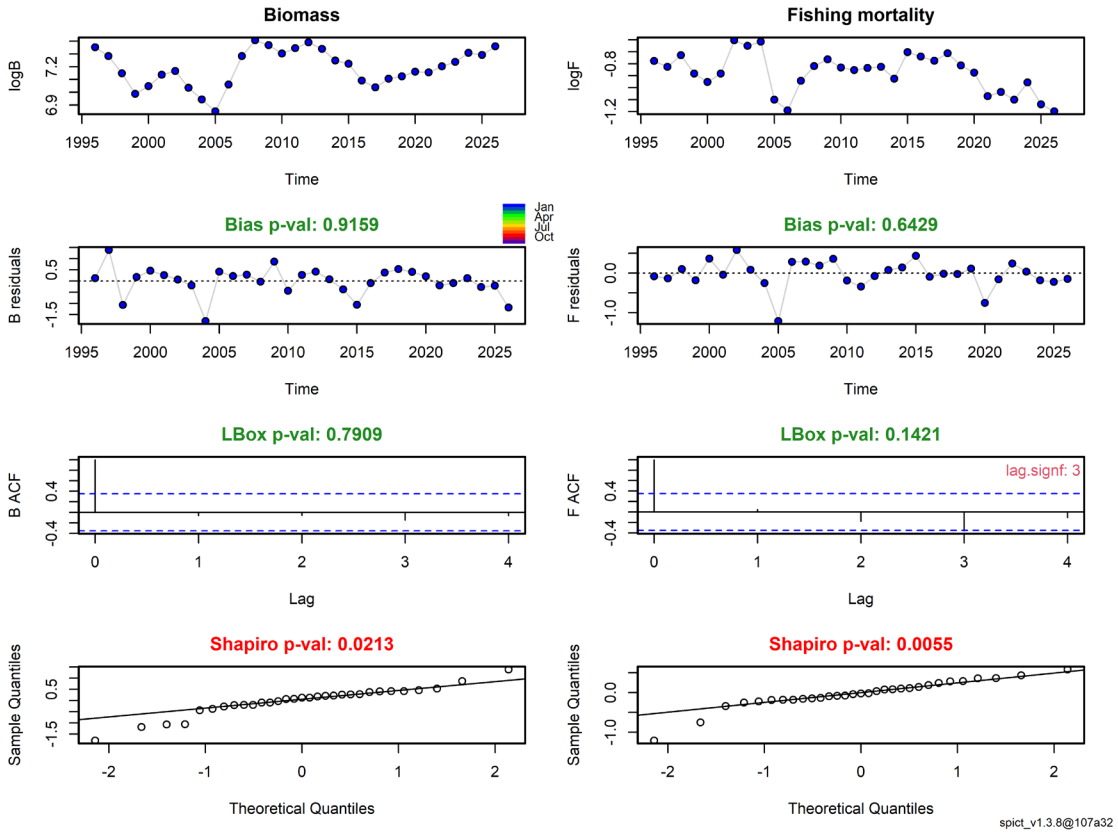


Figure 91. Process error deviations for the model for blue and red shrimp in GSA6 for final scenario.

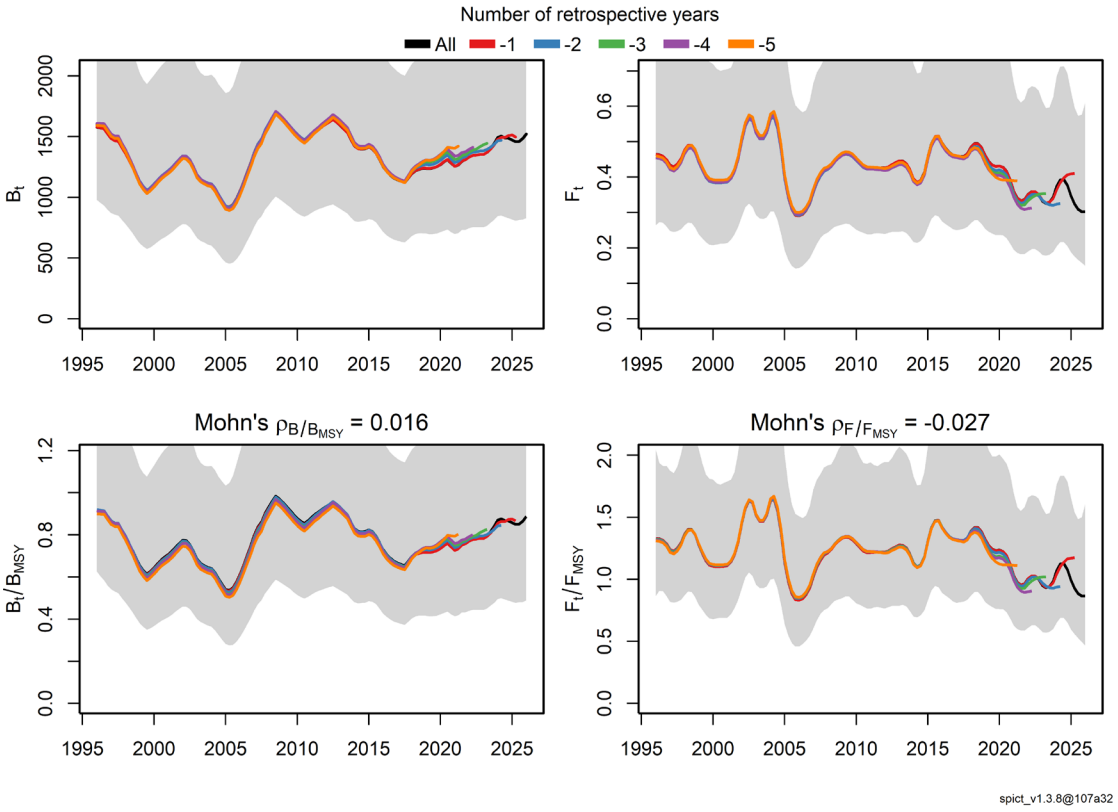


Figure 92. Retrospective analysis for blue and red shrimp in GSA6 for final scenario.

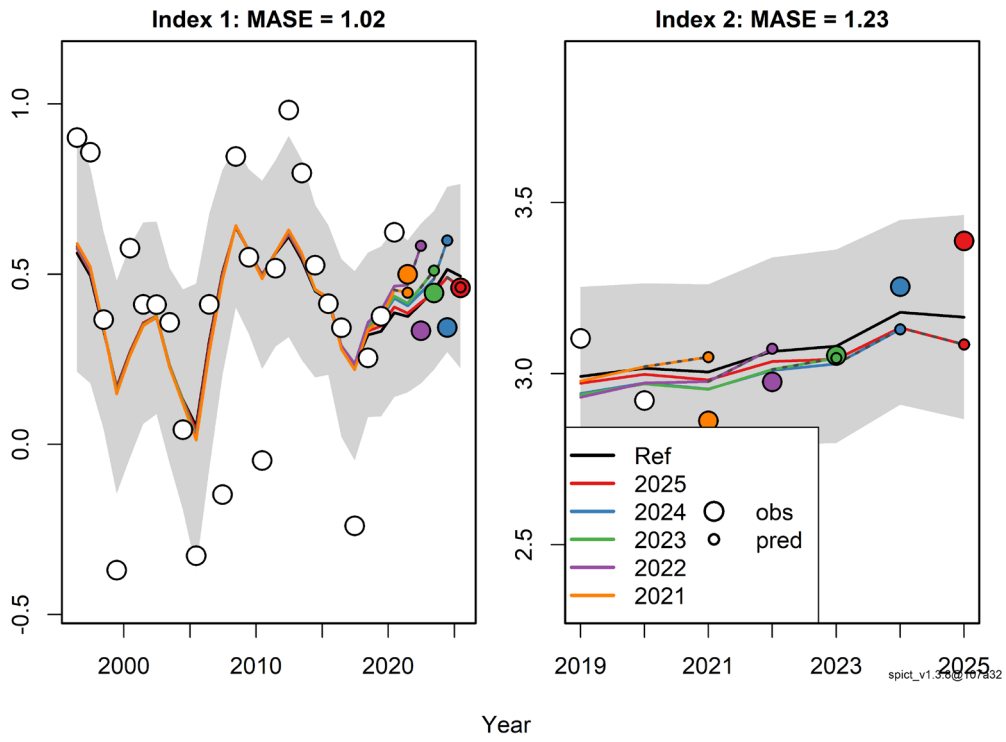


Figure 93. Hindcasting for the model for blue and red shrimp in GSA6 for final scenario.

Final scenario advice

Final scenario advice is presented in Figure 94 and Table 31, which outlines the indicators for blue and red shrimp in the GSA6 for the year 2025 based on the GFCM advice framework. The assessment results should be treated with caution and interpreted qualitatively. In 2025, the estimated stock biomass was below the MSY reference level (B/BMSY < 1), and fishing mortality was also below the MSY reference level (F/FMSY < 1).

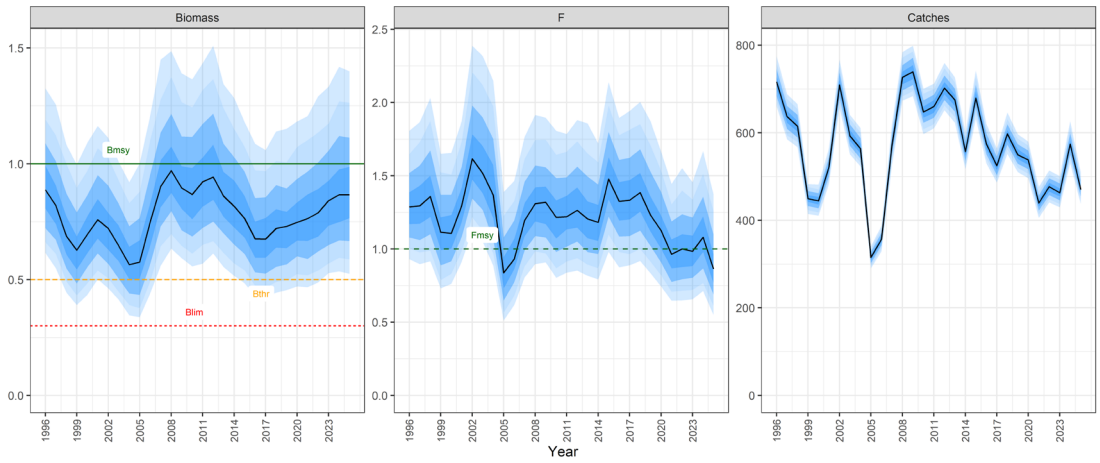


Figure 94. Advice for the final scenario for blue and red shrimp in GSA6: Historical and current stock status regarding F_{msy}, B_{msy} and $B_{lim.}$

Table 31. Indicators in 2025 from SPiCT for blue and red shrimp (ARA) in GSA6

Species	Year	Catch (t)	F/F_{msy}	B/B_{msy}	B/B_{pa}	B/B_{lim}
ARA	2025	465	0.86	0.87	1.73	2.89

Length-Based Spawning Potential Ratio (LBSPR)

Table 32. Biological parameters used in the different LBSPR scenarios for blue and red shrimp (ARA). L_{inf}: asymptotic length at which growth is zero, k: growth rate, M: natural mortality, L_{mat50}: length where 50% of individuals are mature, L_{mat95}: length where 95% of individuals are mature.

Species	Scenario	Linf (mm)	Lmat50 (mm)	Lmat95 (mm)	M/k
ARA	1	77	20.00	23.10	1.56
ARA	2	77	25.50	29.40	1.56
ARA	3	70	24.20	27.90	2.17

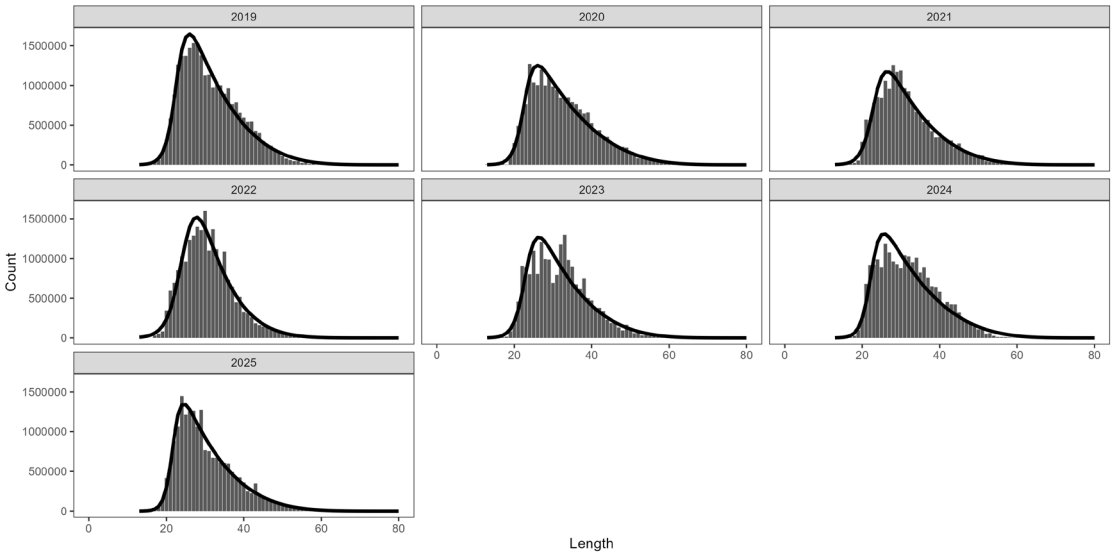


Figure 95. Fit of the data using the LBSPR model for blue and red shrimp for each studied year. Grey columns indicate length frequencies. Black lines indicate the fit of the model.

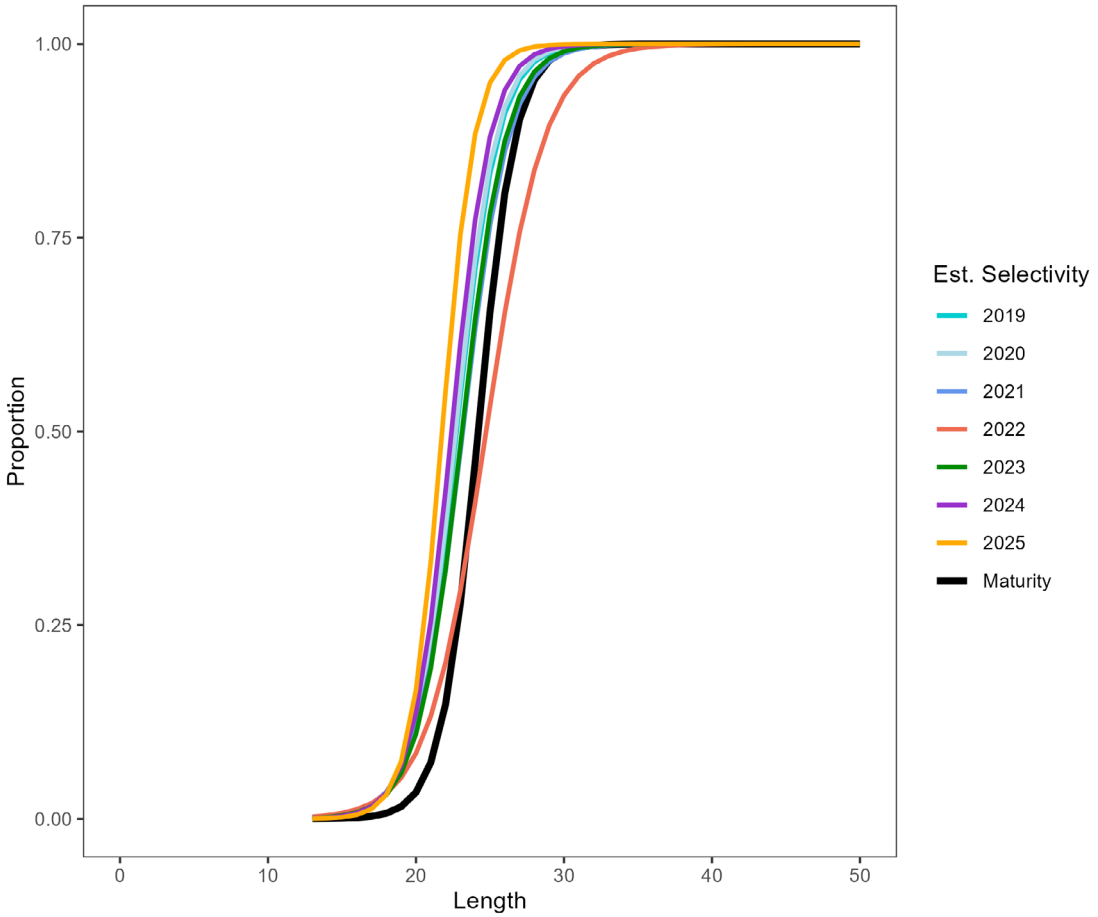


Figure 96. Length curves for blue and red shrimp. Black line shows the length curve at maturity. Color lines show the estimated selectivity at length curve predicted by the LBSPR model selected (3)..

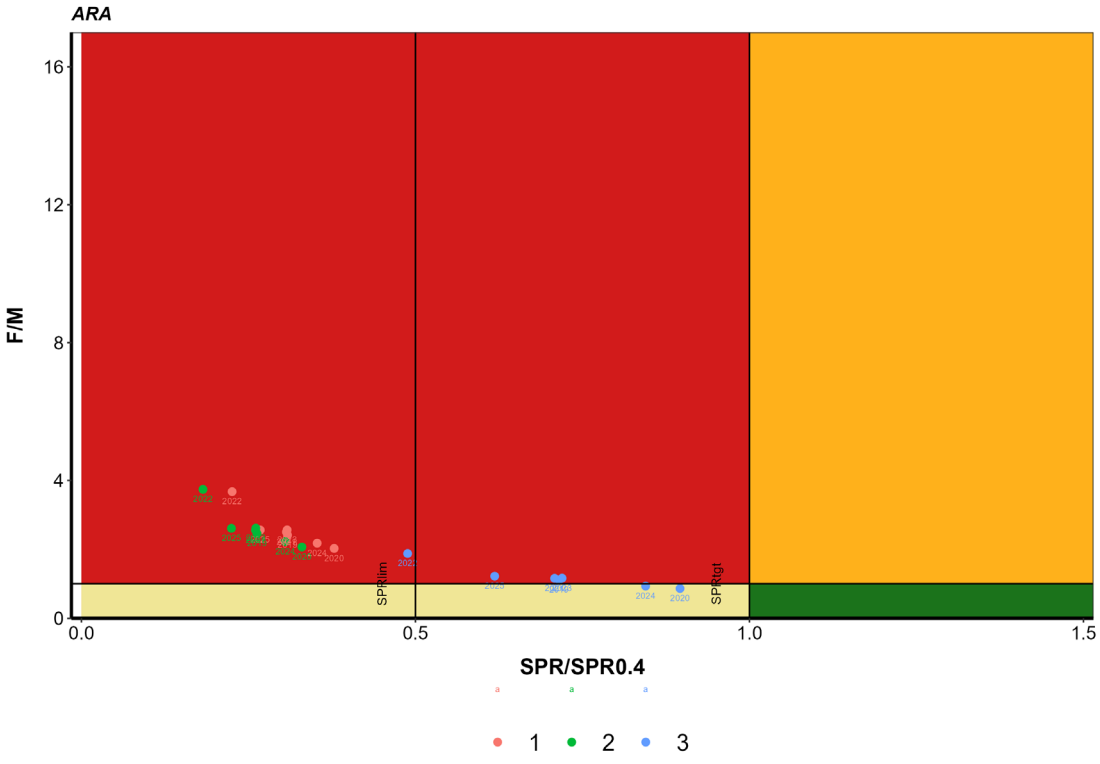


Figure 97. Kobe plot for blue and red shrimp by scenario (1-3) and year. SPR_{lim}: limit spawning potential ratio, SPR_{tgt}: target spawning potential ratio, F: fishing mortality, M: natural mortality, and F/M: relative fishing mortality..

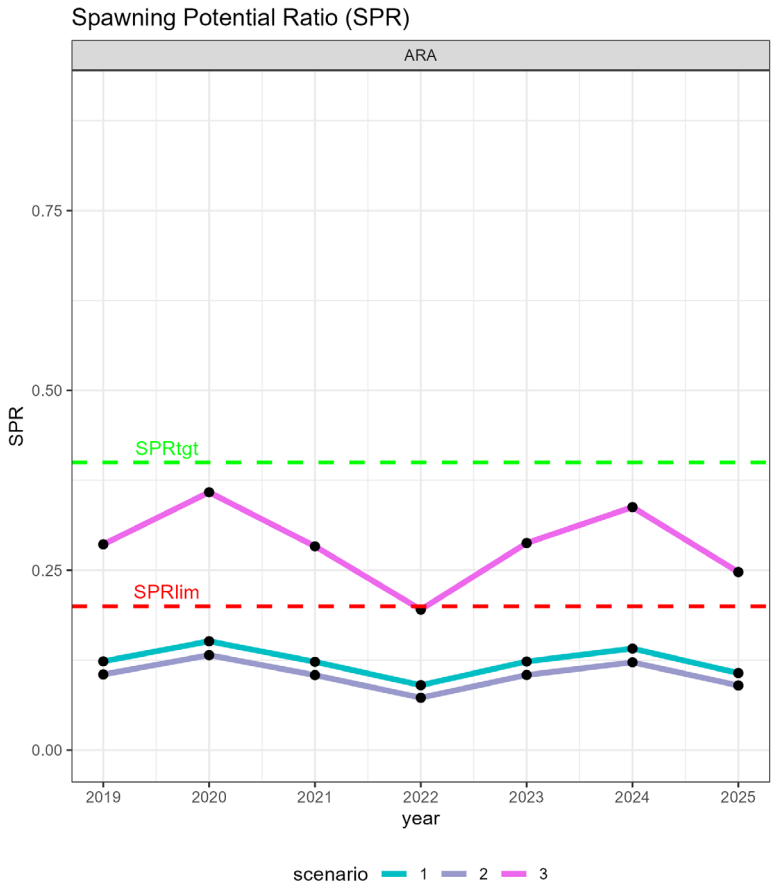


Figure 98. Spawning potential ratio (SPR) per year analyzed for blue and red shrimp evaluated with LBSPR model. LBSPR: Length-Based Spawning Potential Ratio. SPR_{lim}: limit spawning potential ratio, SPR_{tgt}: target spawning potential ratio. Colored lines show the results for each scenario.

Table 33. LBSPR model results for blue and red shrimp with the different scenarios tested for each year analyzed. SL_{50}: Length where 50% of individuals are caught, SPR: spawning potential ratio and FM: fishing mortality. SD is the standard deviation calculated for each indicator. The selected scenario is highlighted in blue.

Species	Scenario	Year	SL_{50}	SD	SPR	SD	FM	SD
ARA	1	2019	23.1	0.28	0.12	0.06	2.41	0.74
ARA	1	2020	23.08	0.31	0.15	0.08	2.03	0.66
ARA	1	2021	23.65	0.36	0.12	0.06	2.5	0.77
ARA	1	2022	25.32	0.41	0.09	0.05	3.67	1.05
ARA	1	2023	23.96	0.63	0.12	0.06	2.57	0.84
ARA	1	2024	23.1	0.57	0.14	0.07	2.18	0.74
ARA	1	2025	22.01	0.18	0.11	0.05	2.56	0.74
ARA	2	2019	23.12	0.26	0.11	0.06	2.46	0.71
ARA	2	2020	23.09	0.29	0.13	0.07	2.07	0.64
ARA	2	2021	23.67	0.33	0.1	0.06	2.55	0.74
ARA	2	2022	25.34	0.39	0.07	0.04	3.74	1
ARA	2	2023	23.99	0.59	0.1	0.06	2.62	0.81
ARA	2	2024	23.13	0.53	0.12	0.07	2.22	0.71
ARA	2	2025	22.01	0.17	0.09	0.05	2.61	0.71
ARA	3	2019	22.99	0.28	0.29	0.15	1.11	0.47
ARA	3	2020	22.93	0.31	0.36	0.18	0.86	0.42
ARA	3	2021	23.51	0.37	0.28	0.15	1.16	0.49
ARA	3	2022	25.21	0.42	0.2	0.1	1.88	0.67
ARA	3	2023	23.62	0.61	0.29	0.15	1.16	0.53
ARA	3	2024	22.78	0.53	0.34	0.18	0.94	0.46
ARA	3	2025	21.94	0.18	0.25	0.13	1.22	0.47

Model setting and results

Scenarios

For the present report, natural mortality (M) values for all scenarios were estimated using a combination of ICATMAR data and published literature. When stock-specific estimates were unavailable, values from nearby and biologically similar stocks were used.

Three different scenarios were applied in the sensitivity analysis for blue and red shrimp (Table 32):

- Scenario 1: used growth and maturity parameters from the STECF and GFCM stock assessment data.
- Scenario 2: used same growth parameters as in Scenario 1 and incorporated maturity data from the literature (Sardà et al., 2004).
- Scenario 3: used growth parameters reported by Demestre & Lleonart (1993) and maturity data from the ICATMAR dataset (ICATMAR, 26-04).

Fitted data

The length frequency distribution fit per year is shown in Figure 95. The model generally follows the mode for all years but overestimates or underestimates some length classes in the middle mode part for all years.

Selectivity

The outputs of the model for the selectivity of the fishery are shown for each scenario in Table 33. The output of the selected scenario (3) is also plotted with L_{mat50} and SL_{50} in Figure 96. Each scenario provides different results. In detail, for scenario 1, the model reveals that the fishery is fishing above L_{mat50}, for scenario 2 the fishing is below L_{mat50} and for scenario 3, also below L_{mat50} except for 2022.

Reference points

Although the model is highly sensitive to changes in growth and maturity parameters, the estimated SPR remains below SPR_{lim} (= 0.2) in most years for scenarios 1 and 2 (Table 33 and Figure 98). In contrast, Scenario 3 yields substantially higher SPR values, generally at or above SPR_{lim}, although still below SPR_{tgt} (= 0.4). The Kobe plot for blue and red shrimp (Figure 97) shows the stock status over time, with all years under Scenarios 1 and 2 located in the red quadrant, indicating that the stock is overfished and subject to ongoing overfishing. In Scenario 3, the estimates for 2020 and 2024 fall within the yellow quadrant, while the remaining years remain in the red quadrant but are shifted towards higher SPR values. These results suggest a substantially more favorable stock status under Scenario 3, although the stock would still be considered subject to overfishing.

Final scenario

Although Scenarios 1 and 2 used the growth parameters currently adopted in the GSA 6 stock assessments (GFCM/STECF), Scenario 3 was selected for the final LBSPR assessment because it combined maturity parameters derived from the ICATMAR dataset with growth parameters estimated for GSA 6, making it the most representative scenario for the study area.

SECTION 4
Results by stock
Small pelagic fishes
Stock assessment results for species in the GSA6



European sardine (*Sardina pilchardus*) PIL

The reproduction of the European sardine occurs between November and February (ICATMAR, 26-04), and recruitment is observed afterwards, in spring and summer.

Input data

The spatial distribution of total landings for European sardine in the Catalan fishing grounds (Figure 99) is located, mainly, in lower coastal areas along the Catalan coast, with no occurrence in the Delta area (the southernmost area of the coast).

Historical European sardine landings in Catalonia from 2002 to 2025 are shown in Figure 100. Landings peaked in 2007 with a great decrease from 2008 to 2010. The lowest recorded landings occurred in 2023, while in 2024, landings recovered to levels comparable to those of 2016—the highest within the last decade. However, landings in 2025 decreased to similar levels to those observed in 2020 and 2021.

Annual LFD

After raising the length frequencies obtained with the monitoring program from commercial landings (Table 35), the annual length frequency of European sardine in Catalonia is plotted in Figure 101. The size classes with greater frequencies are about 120 - 130 mm in total length. Although for some bottom trawling métiers in the delta shelf discards of small pelagic fishes were important (Blanco et al. 2023) its biomasses were residual compared to purse seine landings. The SOP validation results are shown in Table 34, while Table 35 summarizes the number of individuals sampled through the ICATMAR monitoring program.

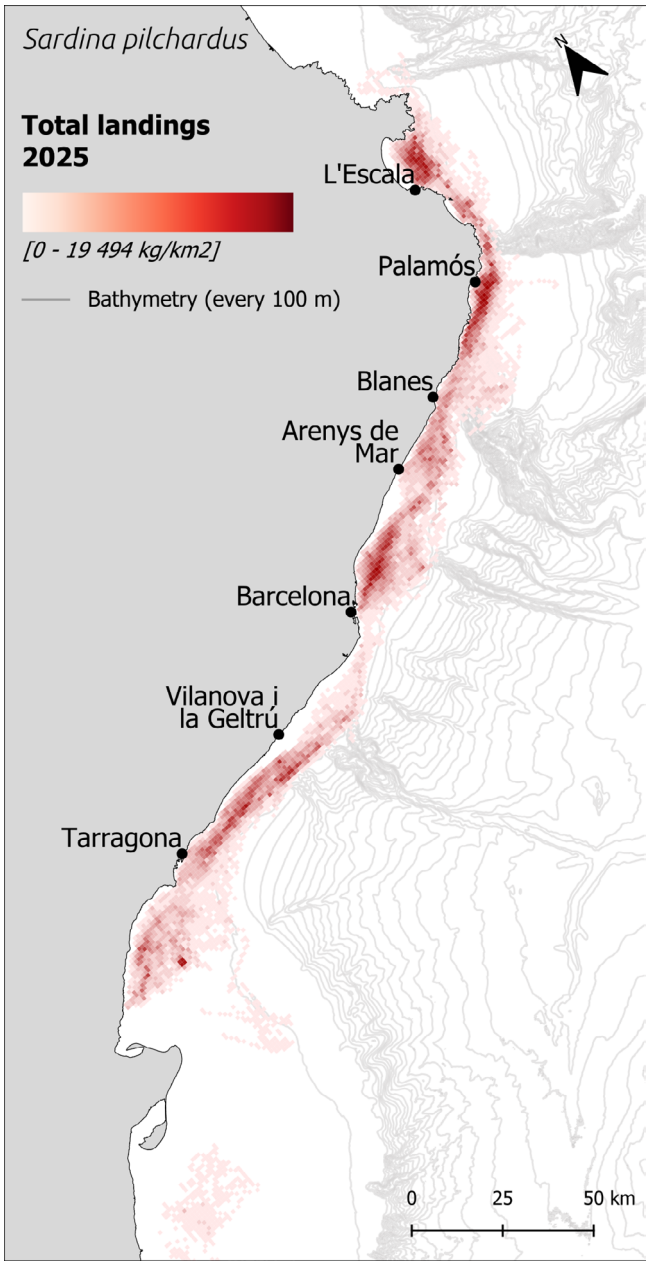


Figure 99. Spatial distribution of landings (kg/km²) for European sardine in the Catalan fishing grounds (North GSA6) in the year analyzed.

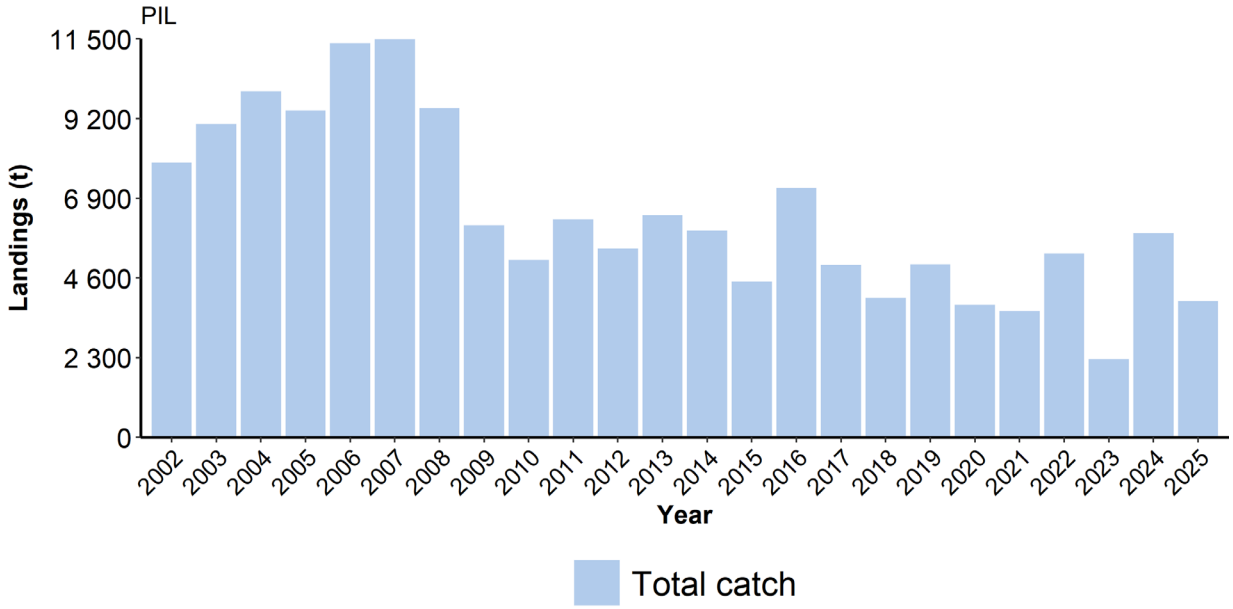


Figure 100. Historical landings (t) for European sardine in Catalonia.

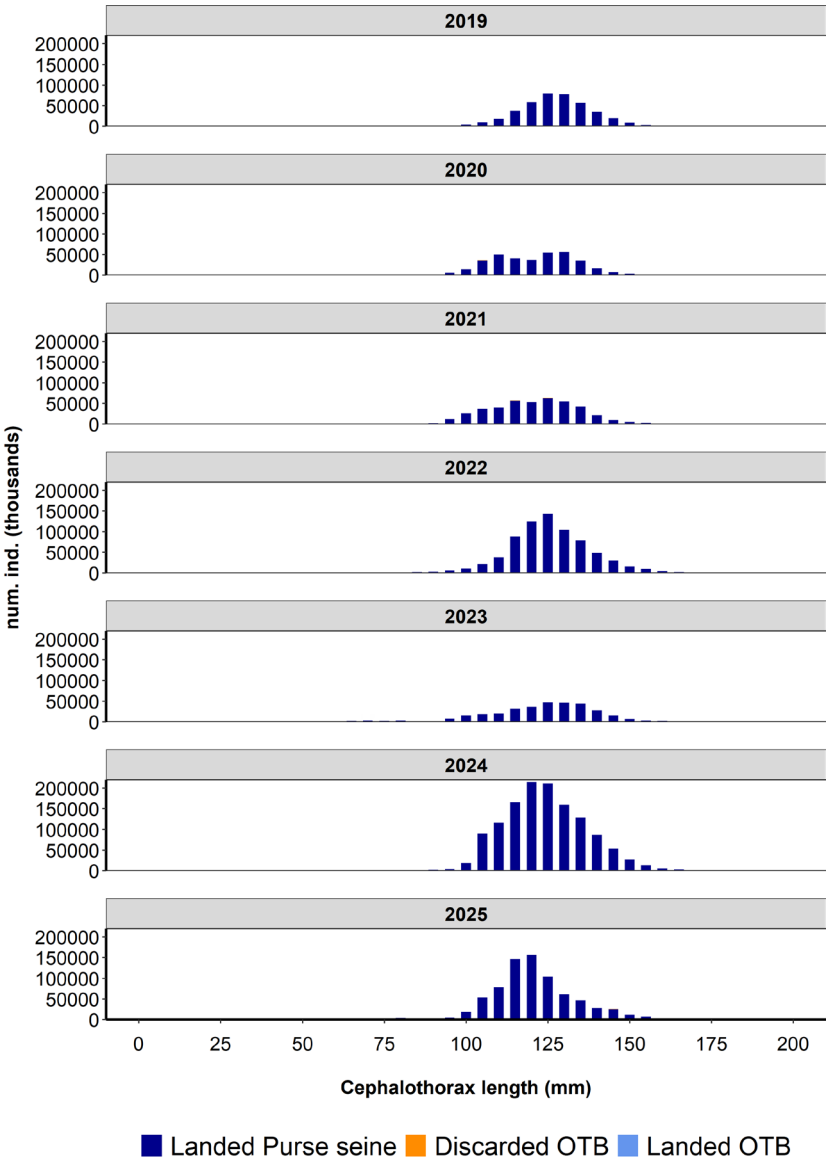


Figure 101. Annual length frequency distributions of European sardine from bottom trawling and small-scale fisheries. The data from purse seine and discards of bottom trawling is raised from ICATMAR dataset.

Table 34. Sum of Products (SOP) validation for European sardine (PIL): The column Calculated Weight in N GSA6 (SOP) represents the biomass estimated through the raising process, while Landings refer to the reported landings in N GSA6. The ratio between SOP and landings is known as the Sum of Products (SOP). Values close to 1 indicate that the raising process provides biomass estimates that closely match the reported landings, thereby validating the accuracy of the estimation method.

Species	Year	Catch classification	Gear	Calculated weight GSA6N (kg) (SOP)	Landings in GSA6N (kg)	SOP/Landings
PIL	2019	Discarded OTB	Bottom trawl	4202	-	-
PIL	2020	Discarded OTB	Bottom trawl	4007	-	-
PIL	2021	Discarded OTB	Bottom trawl	6307	-	-
PIL	2022	Discarded OTB	Bottom trawl	747	-	-
PIL	2023	Discarded OTB	Bottom trawl	1582	-	-
PIL	2024	Discarded OTB	Bottom trawl	1795	-	-
PIL	2025	Discarded OTB	Bottom trawl	2160	-	-
PIL	2019	Landed OTB	Bottom trawl	0	0	-
PIL	2020	Landed OTB	Bottom trawl	0	0	-
PIL	2021	Landed OTB	Bottom trawl	1577	7513	0.21
PIL	2022	Landed OTB	Bottom trawl	1439	6158	0.23
PIL	2023	Landed OTB	Bottom trawl	1174	6390	0.18
PIL	2024	Landed OTB	Bottom trawl	1000	8134	0.12
PIL	2025	Landed OTB	Bottom trawl	297	9001	0.03
PIL	2019	Landed Purse seine	Purse seine	5908535	4974958	1.19
PIL	2020	Landed Purse seine	Purse seine	4429885	3818591	1.16
PIL	2021	Landed Purse seine	Purse seine	5247100	3646690	1.44
PIL	2022	Landed Purse seine	Purse seine	10118285	5302242	1.91
PIL	2023	Landed Purse seine	Purse seine	4421857	2258797	1.96
PIL	2024	Landed Purse seine	Purse seine	17164659	5888806	2.91
PIL	2025	Landed Purse seine	Purse seine	9142300	3917928	2.33

Table 35. Number of European sardine individuals sampled by zone and season from ICATMAR monitoring data used to raise the length frequencies.

Fishery	Year	Zone	Winter	Spring	Summer	Autumn	N hauls
			Number individuals sampled				
Artisanal fisheries	2021	North	1	0	0	0	1
Artisanal fisheries	2024	North	2	0	0	0	1
Artisanal fisheries	2025	North	23	0	0	0	2
Bottom trawl	2021	North	4	0	4	0	4
Bottom trawl	2021	Center	9	1	15	11	6
Bottom trawl	2021	South	16	85	352	191	17
Bottom trawl	2022	North	0	5	2	1	4
Bottom trawl	2022	Center	4	0	0	38	2
Bottom trawl	2022	South	0	31	182	166	12
Bottom trawl	2023	North	0	8	2	3	3
Bottom trawl	2023	Center	0	70	31	0	2
Bottom trawl	2023	South	7	247	294	29	18
Bottom trawl	2024	North	0	5	1	0	3
Bottom trawl	2024	Center	2	16	89	0	3
Bottom trawl	2024	South	64	135	111	41	21
Bottom trawl	2025	North	0	0	6	0	4
Bottom trawl	2025	Center	1	8	1	10	4
Bottom trawl	2025	South	12	139	213	117	20
Purse seine (fish market)	2021	North	867	878	925	557	21
Purse seine (fish market)	2021	Center	623	370	921	526	17
Purse seine (fish market)	2022	North	979	785	500	407	17
Purse seine (fish market)	2022	Center	699	905	663	561	19
Purse seine (fish market)	2023	North	470	394	485	130	10
Purse seine (fish market)	2023	Center	570	463	598	431	15
Purse seine (fish market)	2024	North	314	425	416	164	9
Purse seine (fish market)	2024	Center	761	542	532	266	15
Purse seine (fish market)	2025	North	350	456	466	241	9
Purse seine (fish market)	2025	Center	307	447	790	542	13
Purse seine (on-board sampling)	2020	North	1800	0	0	0	5
Purse seine (on-board sampling)	2020	Center	21	0	0	0	1
Purse seine (on-board sampling)	2021	North	0	0	0	974	4
Purse seine (on-board sampling)	2021	Center	0	0	219	149	2
Purse seine (on-board sampling)	2022	North	736	497	750	11	17
Purse seine (on-board sampling)	2022	Center	0	267	193	0	4
Purse seine (on-board sampling)	2023	North	1058	942	970	144	23
Purse seine (on-board sampling)	2023	Center	78	332	0	0	4
Purse seine (on-board sampling)	2023	South	0	0	1	0	1
Purse seine (on-board sampling)	2024	North	795	1274	951	683	28
Purse seine (on-board sampling)	2024	Center	296	879	111	0	10
Purse seine (on-board sampling)	2025	North	1264	420	2118	698	33
Purse seine (on-board sampling)	2025	Center	0	178	96	208	3
Purse seine (on-board sampling)	2025	South	206	299	238	0	3

Stochastic Production model in Continuous Time (SPiCT)

The GFCM Working Group on Small Pelagics completed the sardine stock assessment for GSA6 in 2025. In the present report, the assessment was conducted for Northern GSA6. Historical and recent data on sardine in Catalonia were compiled, including historical information and more recent fisheries and fleet data, as described in detail in the ICATMAR 25-06 report. After that, a SPiCT model was run to estimate the stock status in the area.

For European sardine, catch data were available from 1946 to 2025. Landings with missing values for 1951–1961 and 1988–1992 were filled using the mean landing value calculated from the available data at the beginning and end of each gap (i.e. between 1951 and 1961, and between 1988 and 1992, respectively). Here, we assume that the total biomass trends in the time series are equivalent to those in GSA6, so we used two indices: ECOMED, an autumn acoustic survey from 1996 to 2009, and MEDIAS, a summer acoustic survey from 2009 to 2023 (Figure 102). Additionally, a landings per unit effort (LPUE) index was used (from 2000 to 2025), with units expressed in kg per day and per vessel. This assessment reference year is 2025, although no data for the biomass index in 2024 and 2025 are available.

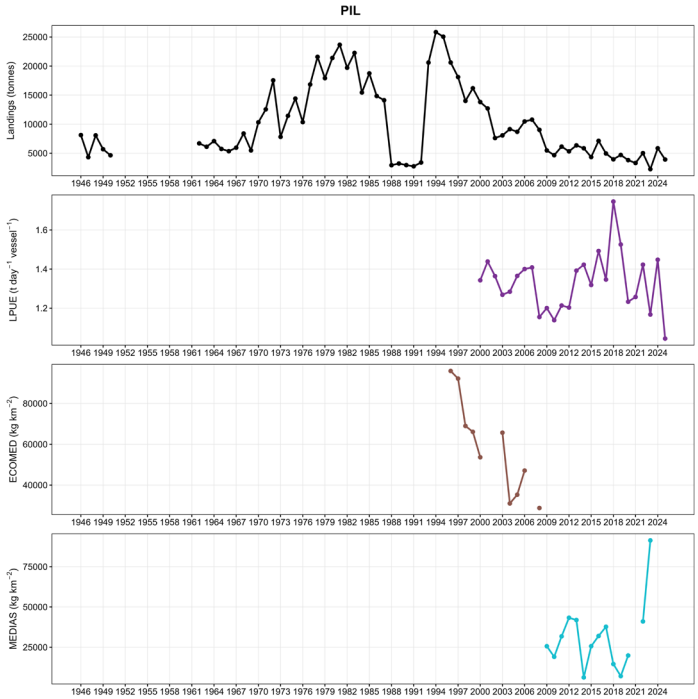


Figure 102. Figure Data available for the assessment of European sardine in Catalonia using the SPiCT model. From top to bottom: catch data from 1946 to 2025; LPUE index from 2000 to 2025; ECOMED acoustic survey data from 1996 to 2008; and MEDIAS acoustic survey data from 2009 to 2023.

Although only the final scenario was presented, different scenarios were tested:

- Scenario 1: Landings started in 1946, using Ecomed, MEDIAS and LPUE as indices, and a BK prior of 0.5.
- Scenario 2: Landings started in 1946, using Ecomed and MEDIAS as indices, and a BK prior of 0.5.
- Scenario 3: Landings ending in 2023, using Ecomed, MEDIAS and LPUE as indices, and a BK prior of 0.5.
- Scenario 4: Landings started in 1996, using Ecomed, MEDIAS and LPUE as indices, and a BK prior of 0.3.

A final plot comparison of scenarios 1-4 is shown in Figure 103. Different model configurations were explored to assess the influence of including the LPUE index (Scenarios 1 and 2), the starting year of the assessment, and the alignment of the LPUE and MEDIAS time series (Scenarios 3 and 4). In particular, the sensitivity of the model to starting the assessment in 1996, corresponding to the start of the available MEDIAS index, and to including the historical catch series was evaluated.

When no index information is available for 2024 and 2025, the model uses the 2023 high-biomass estimate, driven by the MEDIAS index, as an important reference for the recent stock trajectory. As a result, the estimated biomass for the most recent years is substantially higher. However, the overall assessment results are relatively similar between Scenarios 1 and 4, indicating that the inclusion or exclusion of the historical catch data has a limited effect on the estimated stock status. Note that the Bk frac prior was adjusted based on the starting year of each scenario.

Overall, the model appears to be influenced by the trend in the LPUE index. Given the lack of MEDIAS data available for 2024 and 2025 for the present report, Scenario 1 was selected as the final scenario, as it provides a more informative estimate of stock status for the most recent assessment years.

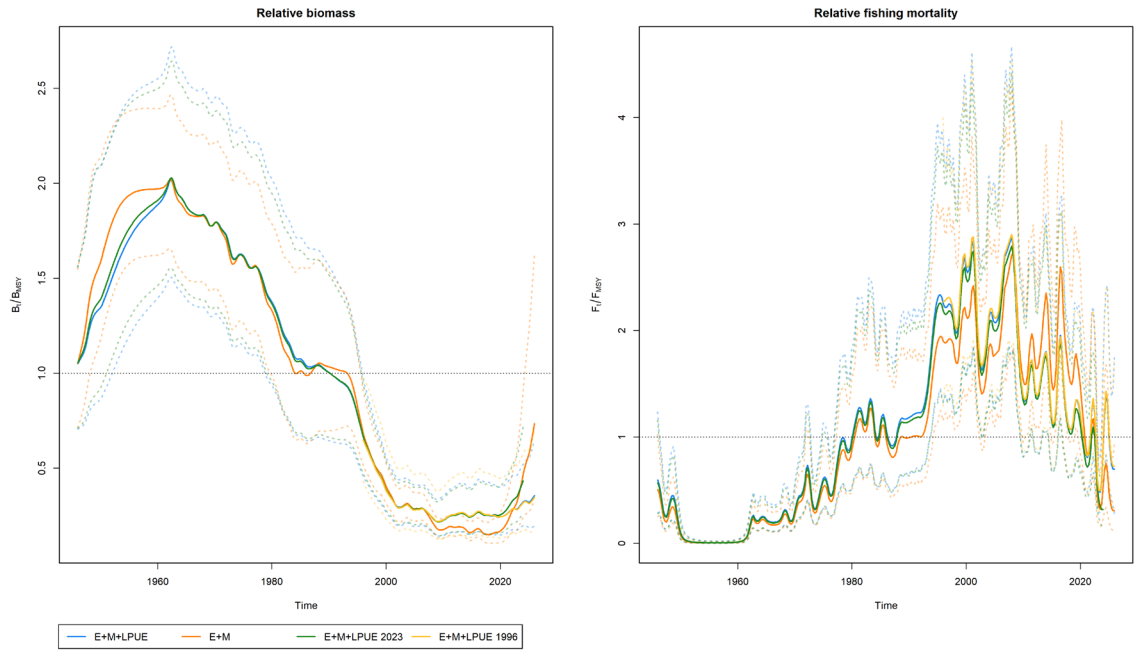


Figure 103. Scenarios comparison for European sardine in GSA6.

Final scenario

Table 36 shows the settings used for the final scenario. Among other settings, the BKfrac prior was 0.5 because, at the beginning of the time series, the European sardine was a target species for the fishery. Additionally, before 2000, a standard deviation factor of 2 was used because the data were less reliable.

Table 36. Prior settings for European sardine in GSA 6 for final scenario.

Type	Prior	Description	Assignment	Mean	Standard deviation	Comment
Fishery dynamic	logbkfrac	B/K fraction (depletion)	-	Log(0.5)	0.2	Target species at the beginning of the time series. Same BK value as used for GSA6 (SAF, GFCM2024). A sensitivity analysis was done for this prior, resulting in a similar stock status in the current year.
Relative standard deviation time series (input data)	stdevfacC	Standard deviation factor for catches	<2000	2	1	Landing data for years before 2000 were less reliable.
	stdevfacI	Standard deviation factor for indices		1	1	
Stock dynamic	Logr	Population growth	-	Log(0.46)	0.26	Fishlife
	Logn	Shape of production curve	-	Log(2)	-	Shaefer
Error	Logsdc	Catch error	-	Log(0.05)	0.3	
	Logsdf	Fishing mortality error	-	Log(4)	0.5	
	Logsdb	Process error	-	Log(0.15)	0.5	
	logsdi	Observation error	-	Log(0.5)	0.5	Ecomed + Medias
				Log(0.2)	0.5	Higher observation uncertainty was assumed for LPUE

The final scenario input data are shown in Figure 104 , and the final summary assessment results are presented in Figure 105. The results show a decreasing trend in biomass below the reference point since 1990; there has been a slight improvement since 2020, but it remains below the baseline level (B_{lim}) until 2025, only slightly above it. For fishing mortality, the estimated values have been below 1 since 2022, though they are close to F_{msy}.

All diagnostics can be checked in Figure 106, Figure 107, Figure 108, Figure 109 and Figure 110. The chosen scenario didn't meet all the model diagnostics, including some residual patterns. Mohnr values for the retrospective analysis are within acceptable ranges (0.13 and -0.12 for B and F, respectively), with a MASE of 0.417 for Medias (until 2023) and 1.92 for LPUE; the latter is higher than 1. The trends are similar to those in GSA6. Further analysis and scenarios will be needed to improve the final diagnostics of the SPiCT assessment for this stock. A sensitivity analysis for the final scenario was performed, testing r prior, BKfrac, process error, and observation error to assess the model's robustness within these priors. All these plots and results for the other scenarios will be available at https://github.com/ICATMAR.

Final scenario advice

Final scenario advice is presented in Figure 111 and Table 37, which outline the indicators for European sardine in Catalonia in 2025, based on the GFCM advice framework. The assessment results should be considered qualitative, although they were in line with the GSA6 assessment, where European sardine Biomass < B_{msy} and Fishing mortality < F_{msy}.

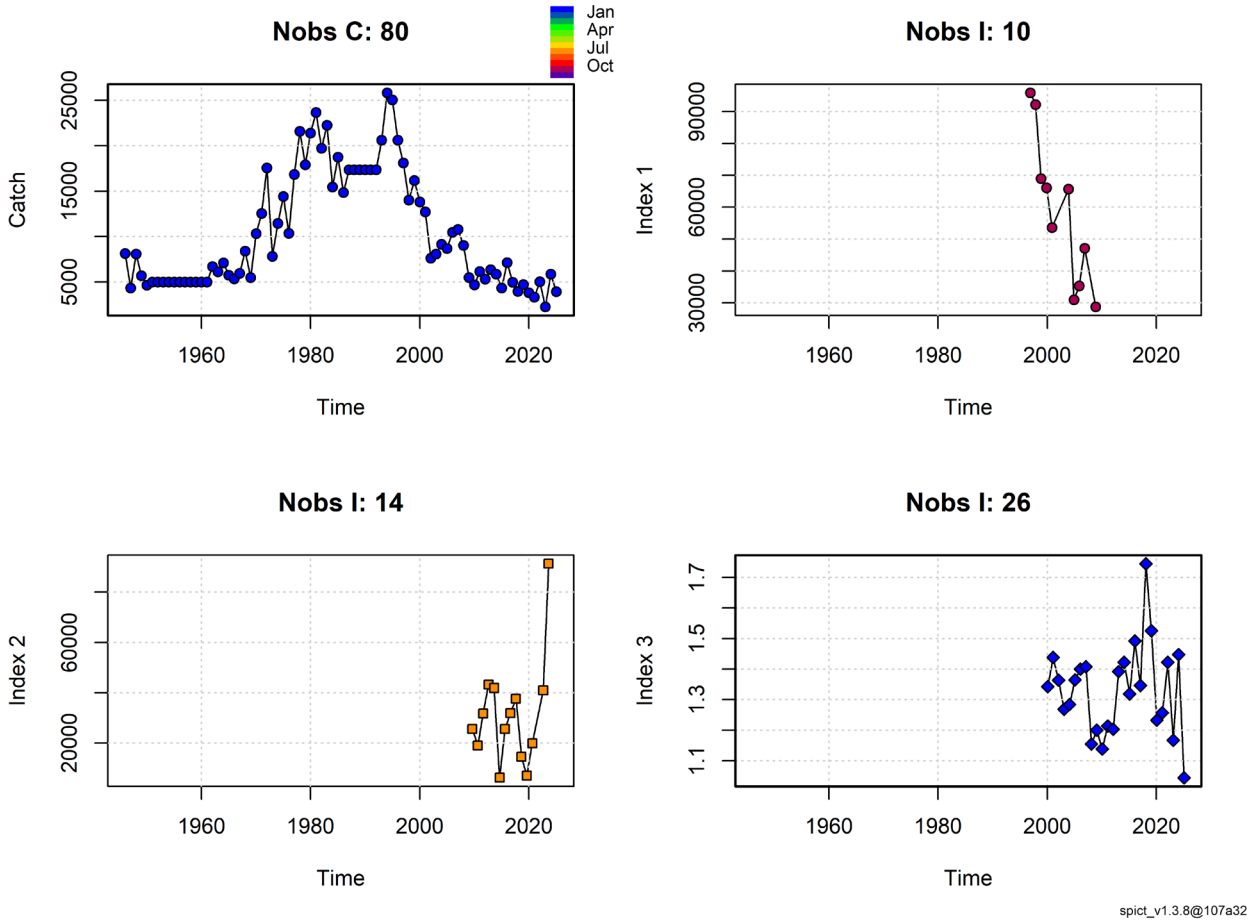


Figure 104. Input data for SPiCT model for European sardine in Catalonia. Top left: catch in tons per year since 1946, top right: biomass index derived from the Ecomed survey from 1994 to 2008, bottom left: MEDIAS survey from 2009 to 2022, and bottom right: LPUE index from 2000 to 2025.

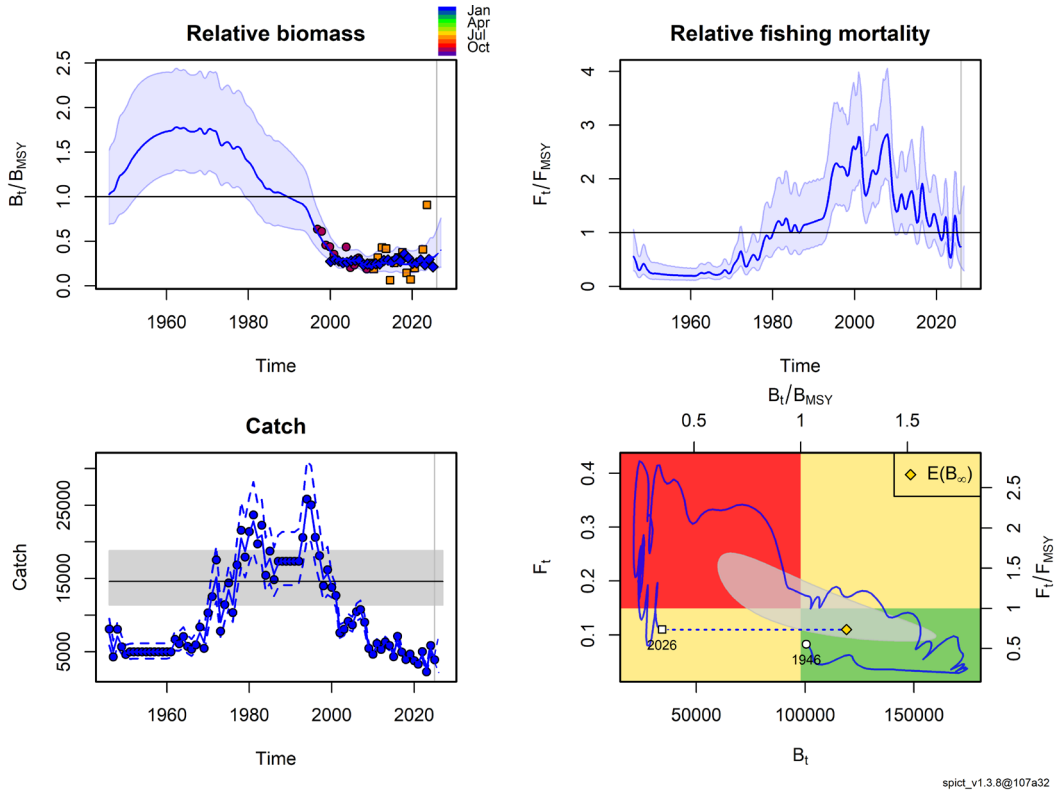


Figure 105. Stock assessment summary for SPiCT model for European sardine in GSA6 for final scenario.

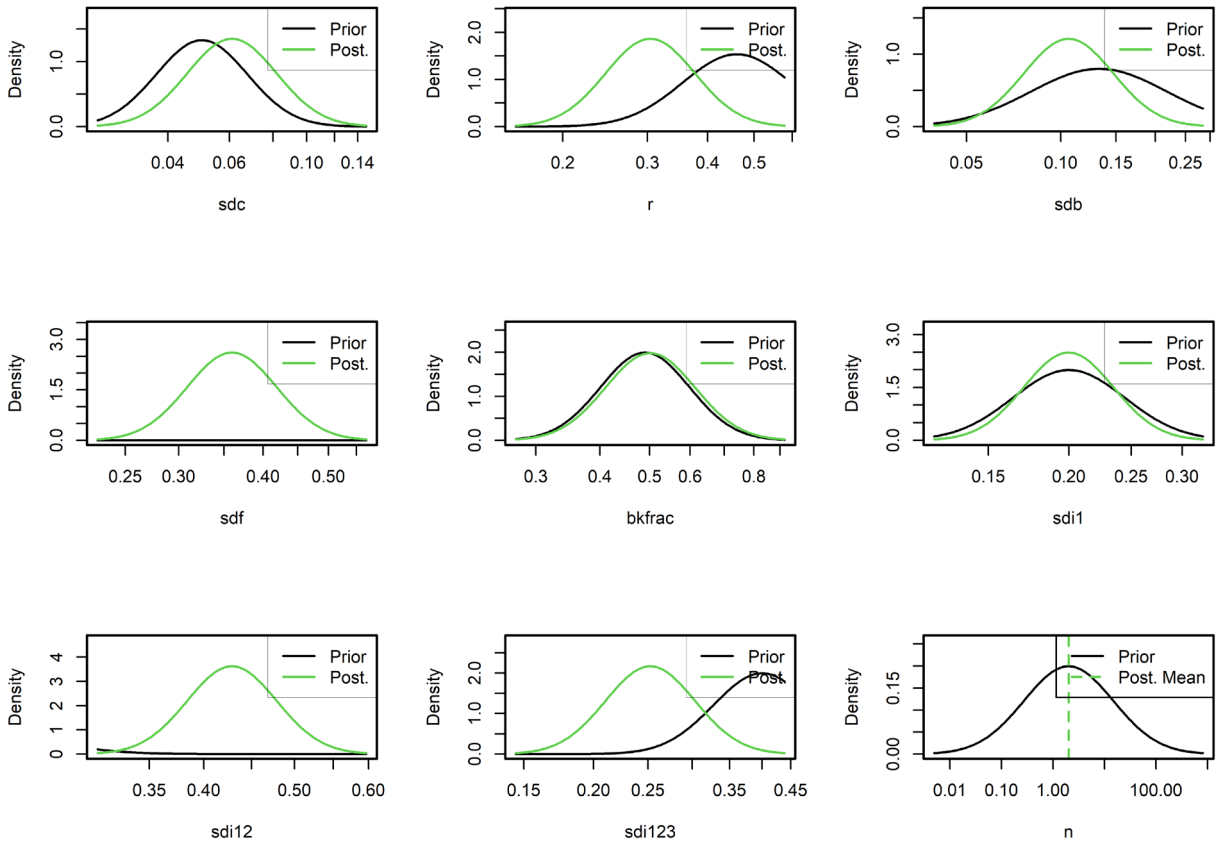


Figure 106. Estimated priors and posteriors for the updated assessment for European sardine in GSA6 for final scenario

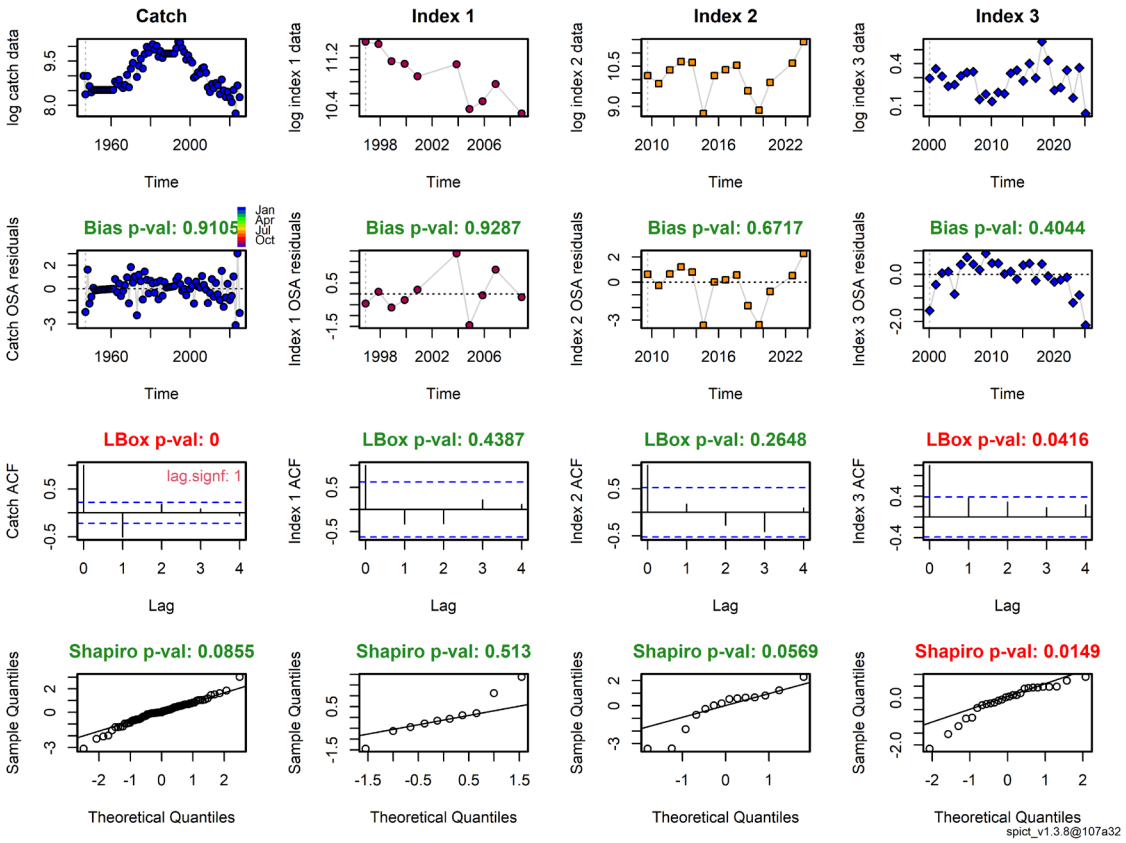


Figure 107. One-step-ahead residuals for the model for European sardine in GSA6 for final scenario.

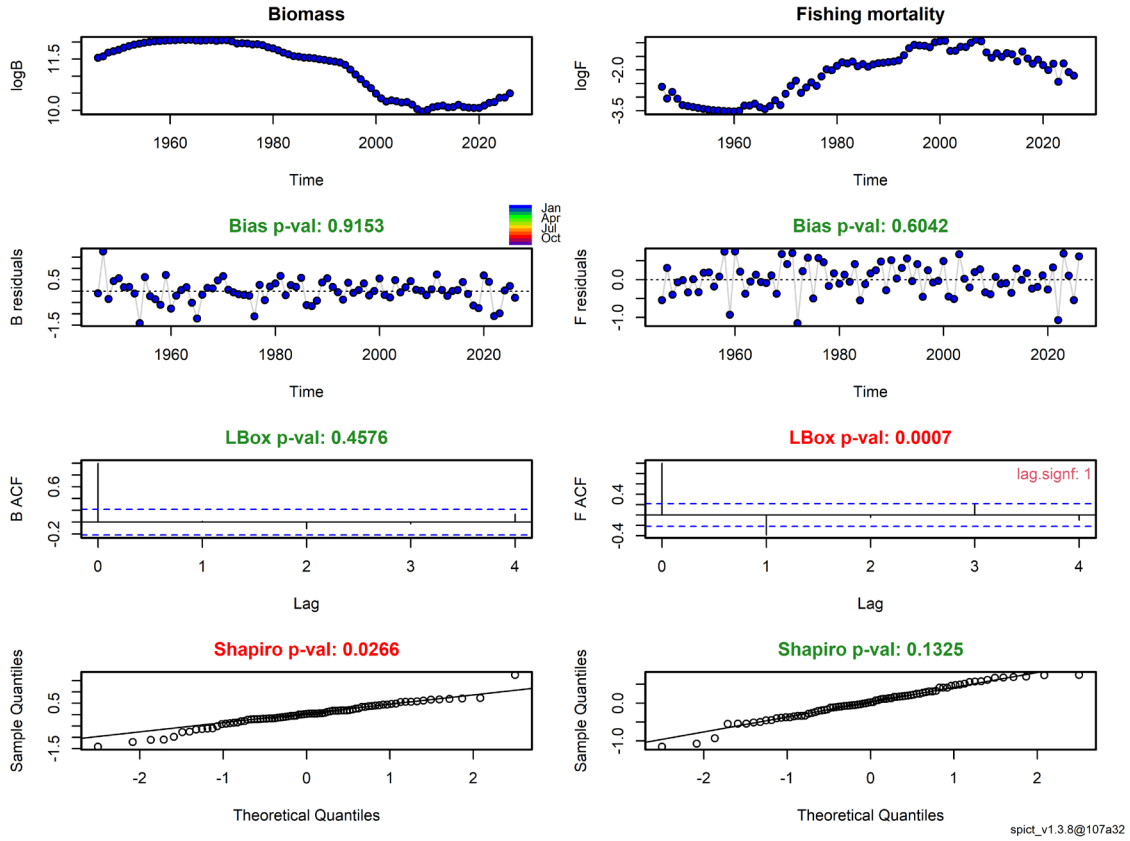


Figure 108. Process error deviations for the model for European sardine in GSA6 for final scenario.

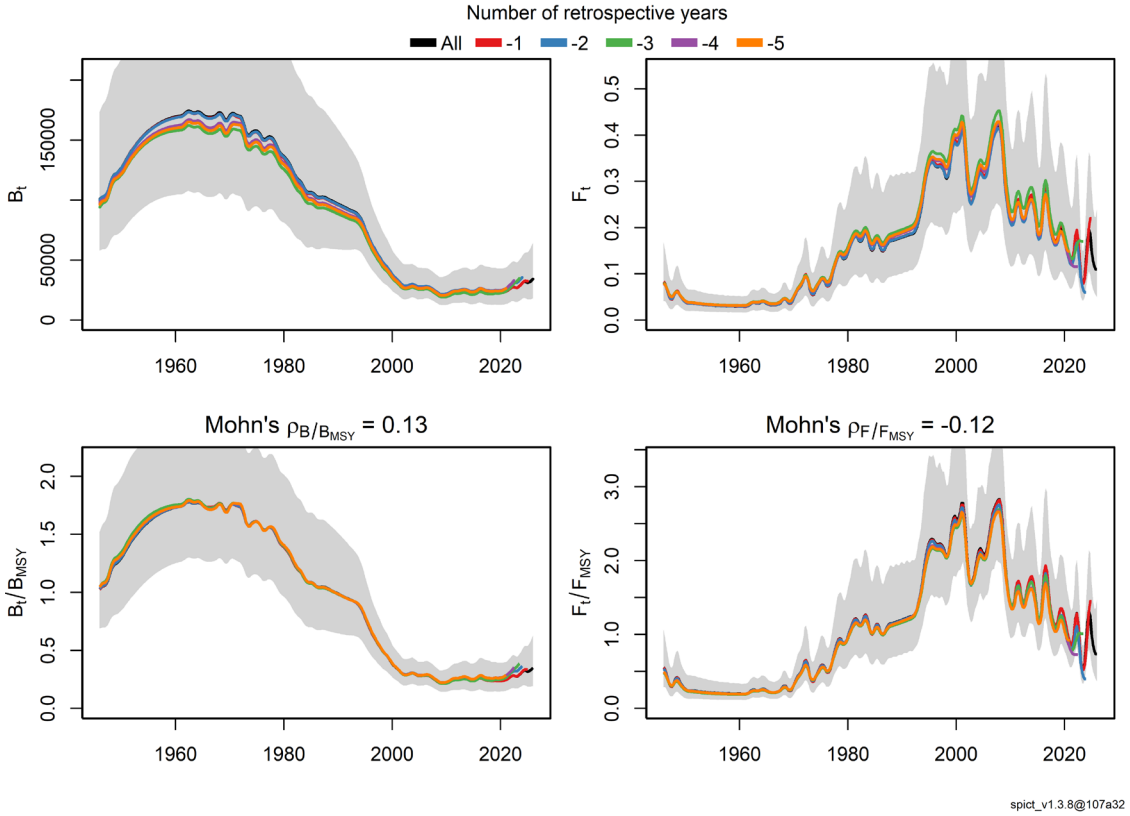


Figure 109. Retrospective analysis for European sardine in GSA6 for final scenario.

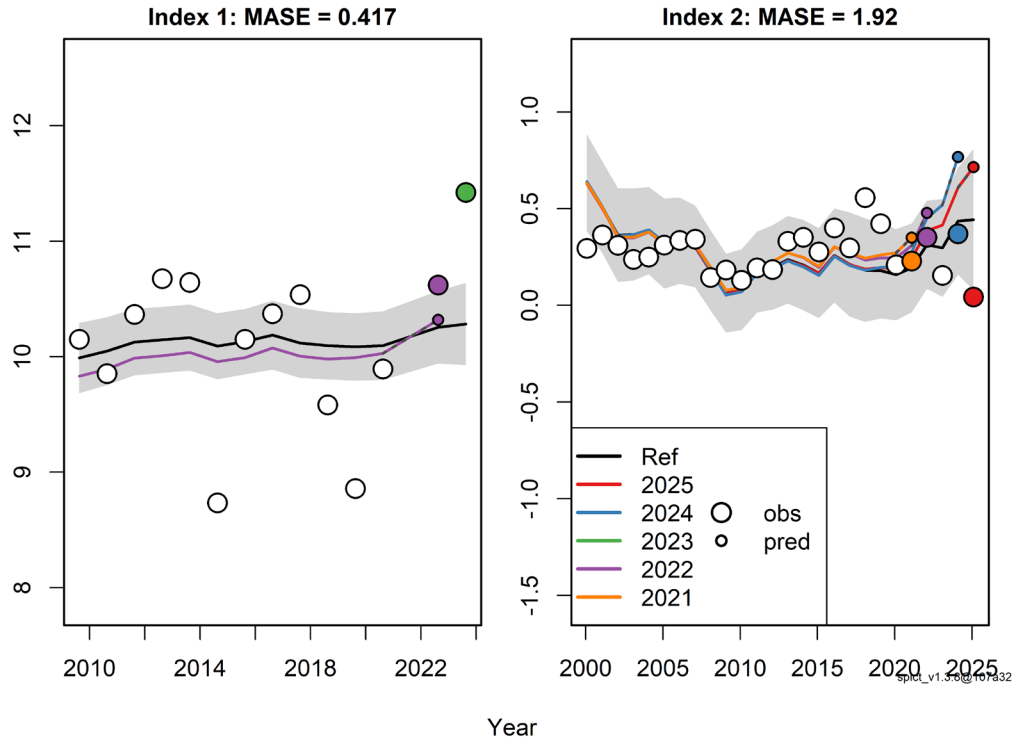


Figure 110. Hindcasting for the model for European sardine in GSA6 for final scenario.

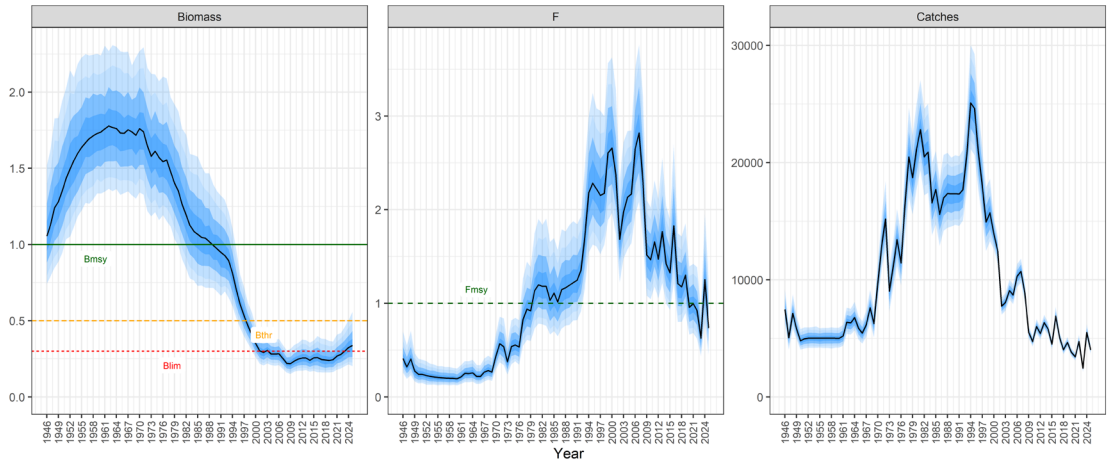


Figure 111. Advice for final scenario for European sardine in GSA6: Historical and current stock status regarding F_{msy}, B_{msy} and B_{lim}.

Table 37. Indicators in 2025 from SPiCT for European sardine in GSA6 final scenario.

Species	Year	Catch (t)	F/F_{msy}	B/B_{msy}	B/B_{pa}	B/B_{lim}
PIL	2025	3917.9	0.74	0.34	0.68	1.13

Length-Based Spawning Potential Ratio (LBSPR)

Table 38. Biological parameters used in the different LBSPR scenarios for European sardine (PIL). L_{inf}: asymptotic length at which growth is zero, k: growth rate, M: natural mortality, L_{mat50}: length where 50% of individuals are mature, L_{mat95}: length where 95% of individuals are mature.

Species	Scenario	L_{inf} (mm)	L_{mat50} (mm)	L_{mat95} (mm)	M/k
PIL	1	184	113.00	135.00	1.71
PIL	2	209	113.00	135.00	1.83
PIL	3	184	103.00	123.10	1.85
PIL	4	178	111.20	123.10	2.69

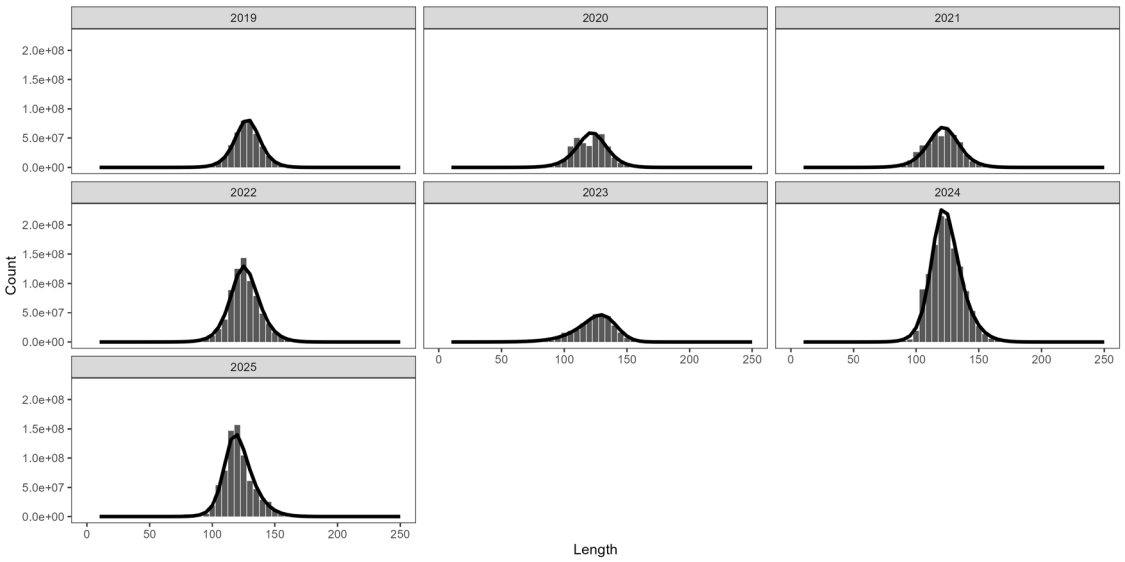


Figure 112. Fit of the data using the LBSPR model for European sardine for each studied year. Grey columns indicate length frequencies. Black lines indicate the fit of the model.

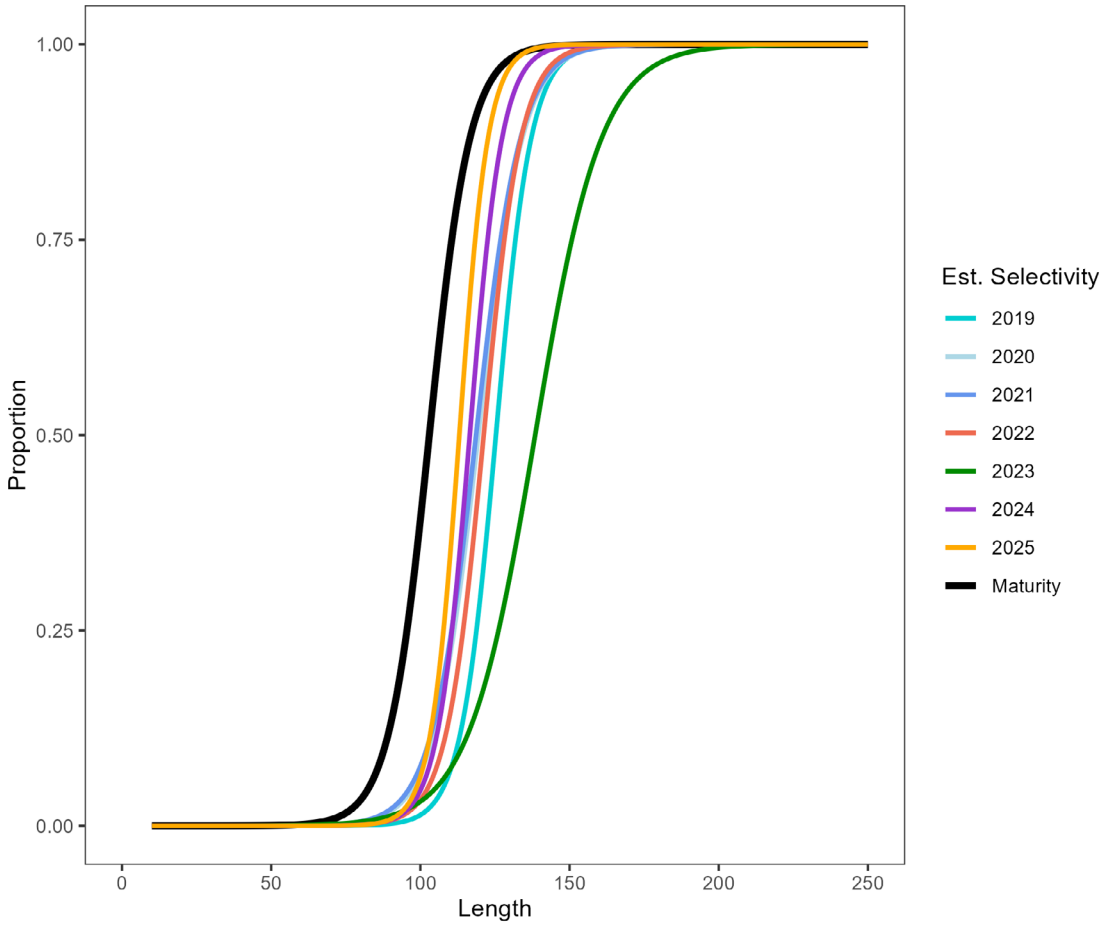


Figure 113. Length curves for European sardine. Black line shows the length curve at maturity. Color lines show the estimated selectivity at length curve predicted by the LBSPR model for selected scenario (1)..

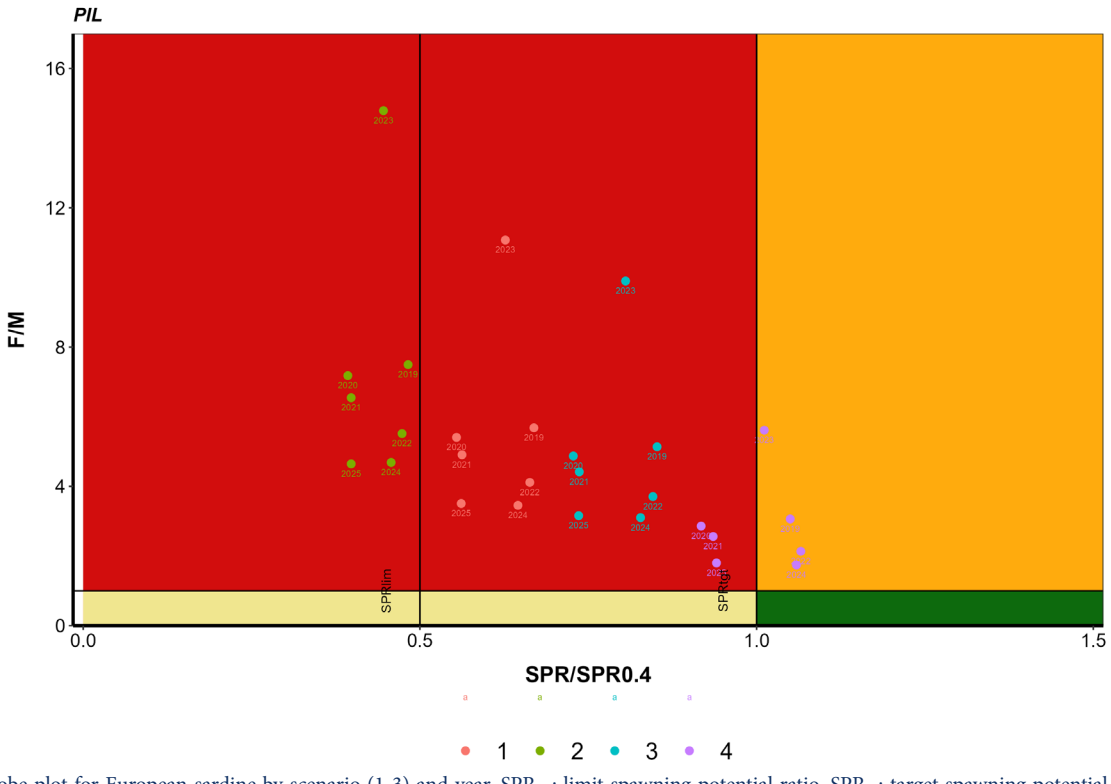


Figure 114. Kobe plot for European sardine by scenario (1-3) and year. SPR_{lim}: limit spawning potential ratio, SPR_{tgt}: target spawning potential ratio, F: fishing mortality, M: natural mortality, and F/M: relative fishing mortality.

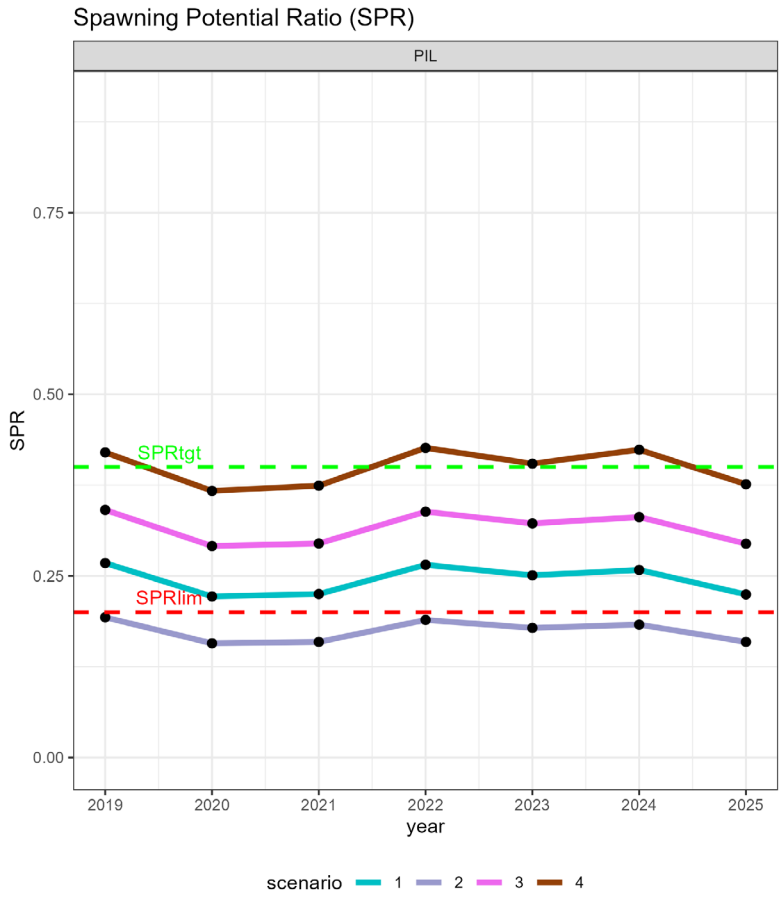


Figure 115. Spawning potential ratio (SPR) per year analyzed for European sardine evaluated with LBSPR model. LBSPR: Length-Based Spawning Potential Ratio. SPR_{lim}: limit spawning potential ratio, SPR_{tgt}: target spawning potential ratio. Colored lines show the results for each scenario.

Table 39. LBSPR model results for European sardine with the different scenarios tested for each year analyzed. SL_{50}: Length where 50% of individuals are caught, SPR: spawning potential ratio and FM: fishing mortality. SD is the standard deviation calculated for each indicator. The selected scenario is highlighted in blue.

Species	Scenario	Year	SL_{50}	SD	SPR	SD	FM	SD
PIL	1	2019	126.93	0.83	0.27	0.16	5.68	2.18
PIL	1	2020	122.51	1.76	0.22	0.15	5.41	2.2
PIL	1	2021	121.62	1.69	0.23	0.15	4.91	2.01
PIL	1	2022	122.8	0.87	0.27	0.16	4.11	1.64
PIL	1	2023	141.57	1.84	0.25	0.16	11.07	4.8
PIL	1	2024	118.5	1.2	0.26	0.16	3.45	1.44
PIL	1	2025	114.2	0.68	0.22	0.15	3.51	1.33
PIL	2	2019	127.01	0.76	0.19	0.12	7.5	2.49
PIL	2	2020	122.9	1.45	0.16	0.11	7.18	2.51
PIL	2	2021	122	1.41	0.16	0.11	6.55	2.29
PIL	2	2022	122.96	0.77	0.19	0.12	5.52	1.87
PIL	2	2023	142.05	1.53	0.18	0.12	14.79	5.48
PIL	2	2024	118.85	1	0.18	0.12	4.69	1.64
PIL	2	2025	114.34	0.6	0.16	0.11	4.65	1.51
PIL	3	2019	126.86	0.8	0.34	0.17	5.14	2.02
PIL	3	2020	122.42	1.75	0.29	0.17	4.87	2.04
PIL	3	2021	121.53	1.64	0.29	0.17	4.42	1.86
PIL	3	2022	122.76	0.83	0.34	0.18	3.71	1.52
PIL	3	2023	141.15	1.83	0.32	0.17	9.9	4.36
PIL	3	2024	118.45	1.16	0.33	0.18	3.1	1.34
PIL	3	2025	114.19	0.65	0.29	0.17	3.16	1.24
PIL	4	2019	126.67	0.65	0.42	0.22	3.06	1.43
PIL	4	2020	122.21	1.51	0.37	0.22	2.86	1.42
PIL	4	2021	121.34	1.39	0.37	0.22	2.56	1.29
PIL	4	2022	122.71	0.67	0.43	0.23	2.13	1.07
PIL	4	2023	139.26	1.68	0.4	0.22	5.61	2.82
PIL	4	2024	118.41	0.99	0.42	0.23	1.74	0.94
PIL	4	2025	114.27	0.54	0.38	0.22	1.8	0.87

Model setting and results

Scenarios

For the present report, natural mortality (M) values for all scenarios were estimated using a combination of ICATMAR data and published literature. When stock-specific estimates were unavailable, values from nearby and biologically similar stocks were used.

Four scenarios were applied considering different growth parameters from GFCM working groups (Table 38). In scenarios 3 and 4, maturity data correspond to ICATMAR dataset (ICATMAR, 26-04), while growth parameters in scenario 4 were reported by Mir-Argibau et al. (2025).

Fitted data

The length frequency distribution fit per year is shown in Figure 112. The model generally follows the mode for all years but it overestimates or underestimates some length classes in the middle mode part and underestimates small individuals in 2020 and 2021.

Selectivity

The outputs of the model for the selectivity of the fishery are shown for each scenario in Table 39. The output for the selected scenario is also plotted with L_{mat50} and SL_{50} in Figure 113. In all scenarios, the fishery is fishing above or similar to L_{mat50}.

Reference points

Although the model is highly sensitive to changes in growth and maturity parameters, the estimated SPR varies considerably among scenarios (Table 39 and Figure 115). Scenario 2 consistently yields SPR values below SPR_{lim} (= 0.2), whereas Scenario 1 remains close to the limit reference point. Scenario 3 produces higher SPR estimates, all above SPR_{lim}, while Scenario 4 generally approaches or exceeds SPR_{tgt} (= 0.4). The Kobe plot for European sardine (Figure 114) shows the stock status over time, with no clear temporal trend. All years under Scenarios 1, 2 and 3 are located in the red quadrant, indicating that the stock is overfished and subject to ongoing overfishing. In contrast, all years under Scenario 4 fall within the orange quadrant, indicating that the stock is above the target biomass reference point but remains subject to overfishing.

Final scenario

After evaluating the available options, Scenario 1 was chosen as the basis for the final advice, as it provided the most appropriate input parameters for the LBSPR model.

Anchovy (*Engraulis encrasicolus*) ANE

The reproduction of the anchovy occurs between May and September (ICATMAR, 26-04), and recruitment is observed afterwards, in fall and winter.

Input data

The spatial distribution of total landings for anchovy in the Catalan fishing grounds (Figure 116) is located, mainly, in lower coastal areas along the Catalan coast, with no occurrence in the Delta area (the southernmost area of the coast).

Historical anchovy landings in Catalonia from 2002 to 2025 are shown in Figure 117. From 2002 to 2008, there was a decrease in landings. Afterwards, the landings increased until 2018, when they inverted the trend and decreased again, reaching the lowest value of the whole time series in 2025.

Annual LFD

After raising the length frequencies obtained with the monitoring program from commercial landings, the annual length frequency of anchovy in Catalonia is plotted in Figure 118. There is no clear consistency in the length frequency of small and big individuals. Although for some bottom trawling métiers in the delta shelf discards of small pelagic fishes were important (Blanco et al. 2023) its biomasses were residual compared to purse seine landings. The SOP validation results are shown in Table 40, while Table 41 summarizes the number of individuals sampled through the ICATMAR monitoring program.



Figure 116. Spatial distribution of landings (kg/km²) for anchovy in the Catalan fishing grounds (North GSA6) in the year analyzed.

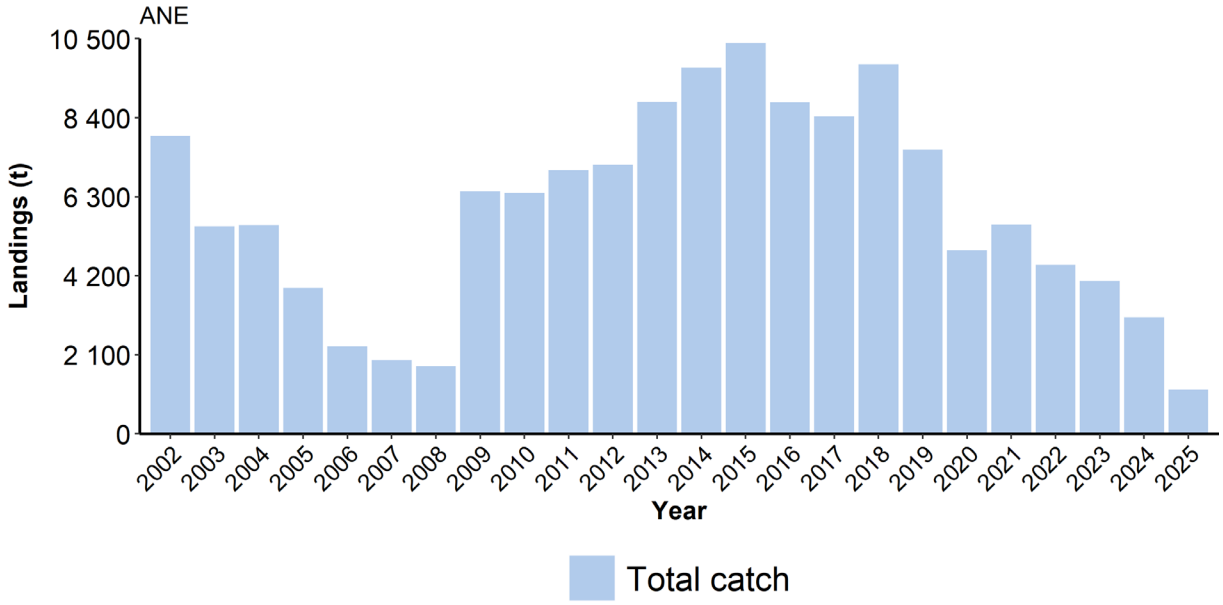


Figure 117. Historical landings (t) for anchovy in Catalonia.

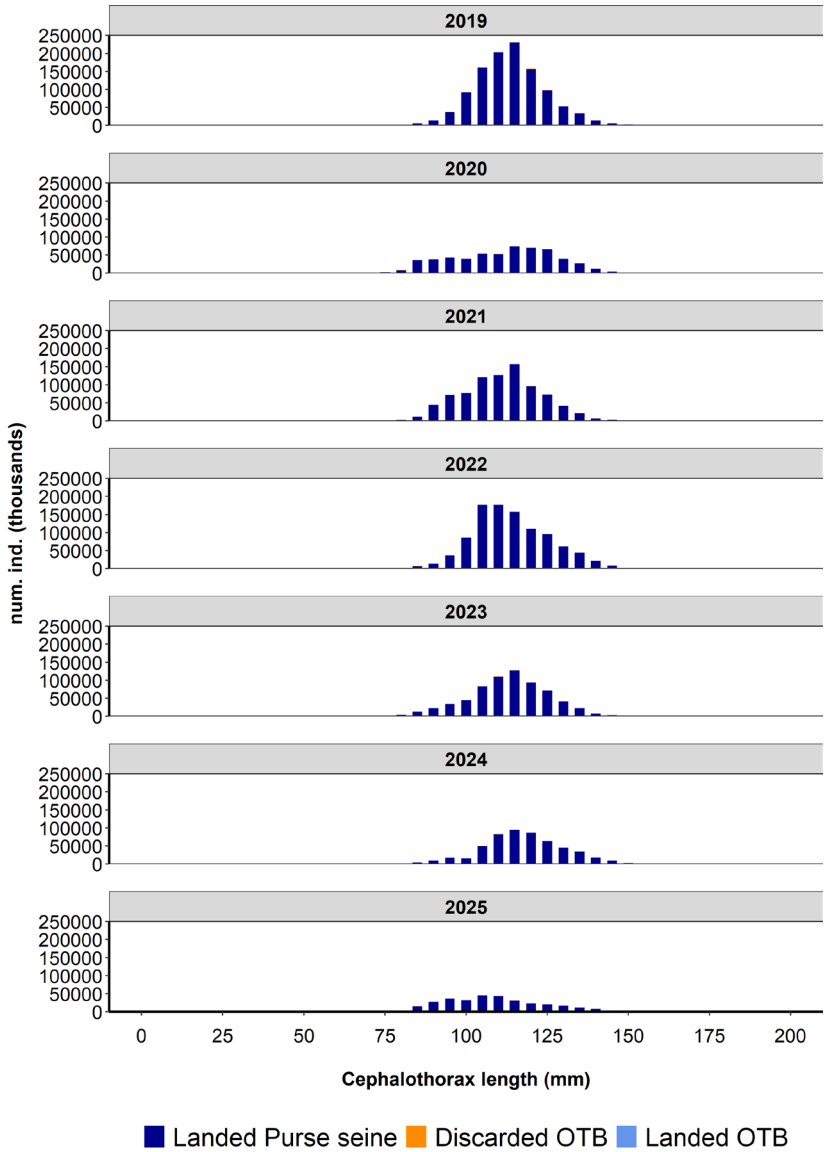


Figure 118. Annual length frequency distributions of anchovy from bottom trawling and small-scale fisheries. The data from purse seine and discards of bottom trawling is raised from ICATMAR dataset.

Table 40. Sum of Products (SOP) validation for anchovy (ANE): The column Calculated Weight in N GSA6 (SOP) represents the biomass estimated through the raising process, while landings refer to the reported landings in N GSA6. The ratio between SOP and landings is known as the Sum of Products (SOP). Values close to 1 indicate that the raising process provides biomass estimates that closely match the reported landings, thereby validating the accuracy of the estimation method.

Species	Year	Catch classification	Gear	Calculated weight GSA6N (kg) (SOP)	Landings in GSA6N (kg)	SOP/Landings
ANE	2019	Discarded OTB	Bottom trawl	58697	-	-
ANE	2020	Discarded OTB	Bottom trawl	19568	-	-
ANE	2021	Discarded OTB	Bottom trawl	22480	-	-
ANE	2022	Discarded OTB	Bottom trawl	17485	-	-
ANE	2023	Discarded OTB	Bottom trawl	7384	-	-
ANE	2024	Discarded OTB	Bottom trawl	31671	-	-
ANE	2025	Discarded OTB	Bottom trawl	12062	-	-
ANE	2019	Landed OTB	Bottom trawl	11571	25895	0.45
ANE	2020	Landed OTB	Bottom trawl	2521	18558	0.14
ANE	2021	Landed OTB	Bottom trawl	5941	14199	0.42
ANE	2022	Landed OTB	Bottom trawl	3873	8987	0.43
ANE	2023	Landed OTB	Bottom trawl	2994	6258	0.48
ANE	2024	Landed OTB	Bottom trawl	1962	11407	0.17
ANE	2025	Landed OTB	Bottom trawl	5479	17850	0.31
ANE	2019	Landed Purse seine	Purse seine	10372239	7517351	1.38
ANE	2020	Landed Purse seine	Purse seine	5212628	4856577	1.07
ANE	2021	Landed Purse seine	Purse seine	7478644	5541606	1.35
ANE	2022	Landed Purse seine	Purse seine	9499653	4484937	2.12
ANE	2023	Landed Purse seine	Purse seine	6403144	4057504	1.58
ANE	2024	Landed Purse seine	Purse seine	5660520	3089884	1.83
ANE	2025	Landed Purse seine	Purse seine	2671451	1161940	2.30

Table 41. Number of anchovy individuals sampled by zone and season from ICATMAR monitoring data used to raise the length frequencies.

Fishery	Year	Zone	Winter	Spring	Summer	Autumn	N hauls
			Number individuals sampled				
Artisanal fisheries	2021	North	0	3	0	1	2
Artisanal fisheries	2021	Center	105	0	0	0	3
Artisanal fisheries	2022	Center	0	13	0	0	1
Artisanal fisheries	2023	North	0	0	0	30	1
Artisanal fisheries	2023	Center	39	0	0	0	1
Artisanal fisheries	2025	North	140	0	0	0	2
Bottom trawl	2021	North	3	52	5	0	8
Bottom trawl	2021	Center	56	6	30	47	4
Bottom trawl	2021	South	72	143	192	297	19
Bottom trawl	2022	North	3	40	91	0	4
Bottom trawl	2022	Center	0	13	0	0	1
Bottom trawl	2022	South	8	259	155	180	17
Bottom trawl	2023	North	0	2	1	0	2
Bottom trawl	2023	Center	0	31	0	0	1
Bottom trawl	2023	South	60	277	109	1	17
Bottom trawl	2024	North	0	5	3	0	3
Bottom trawl	2024	Center	0	20	40	0	3
Bottom trawl	2024	South	174	130	140	19	20
Bottom trawl	2025	North	0	0	4	0	2
Bottom trawl	2025	Center	0	35	0	0	1
Bottom trawl	2025	South	75	302	43	101	21
Purse seine (fish market)	2021	North	1307	1100	1416	565	19
Purse seine (fish market)	2021	Center	778	1037	1083	968	18
Purse seine (fish market)	2022	North	576	1637	867	752	16
Purse seine (fish market)	2022	Center	710	1337	1135	399	16
Purse seine (fish market)	2023	North	986	551	697	387	12
Purse seine (fish market)	2023	Center	907	1327	384	269	13
Purse seine (fish market)	2024	North	396	579	343	240	8
Purse seine (fish market)	2024	Center	707	801	649	325	13
Purse seine (fish market)	2025	North	254	593	585	456	9
Purse seine (fish market)	2025	Center	0	343	624	467	7
Purse seine (on-board sampling)	2022	North	1600	153	939	573	15
Purse seine (on-board sampling)	2022	Center	430	383	471	834	9
Purse seine (on-board sampling)	2023	North	967	185	887	525	13
Purse seine (on-board sampling)	2023	Center	254	193	0	0	2
Purse seine (on-board sampling)	2023	South	0	0	221	398	3
Purse seine (on-board sampling)	2024	North	515	208	510	1033	19
Purse seine (on-board sampling)	2024	Center	145	778	342	0	11
Purse seine (on-board sampling)	2025	North	1405	484	726	0	21
Purse seine (on-board sampling)	2025	Center	0	50	49	0	2
Purse seine (on-board sampling)	2025	South	305	31	4	0	3

Stochastic Production model in Continuous Time (SPiCT)

The GFCM Working Group on Small Pelagics completed the anchovy stock assessment for GSA6 in 2025. In the present report, the assessment was conducted for Northern GSA6. Historical and recent data on anchovy in Catalonia were compiled, including historical information and more recent fisheries and fleet data, as described in detail in the ICATMAR 25-06 report. After that, a SPiCT model was run to estimate the stock status in the area.

For anchovy, catch data were available from 1946 to 2025. Landings with missing values for 1951–1961 and 1988–1992 were filled using the mean landing value calculated from the available data at the beginning and end of each gap (i.e. between 1951 and 1961, and between 1988 and 1992, respectively). Here, we assume that the total biomass trends in the time series are equivalent to those in GSA6, so we used two indices: ECOMED, an autumn acoustic survey from 1996 to 2009, and MEDIAS, a summer acoustic survey from 2009 to 2024 (Figure 119). Additionally, a landings per unit effort (LPUE) index was used (from 2000 to 2025), with units expressed in kg per day and per vessel. This assessment reference year is 2025, although no data for the biomass index in 2025 are available.

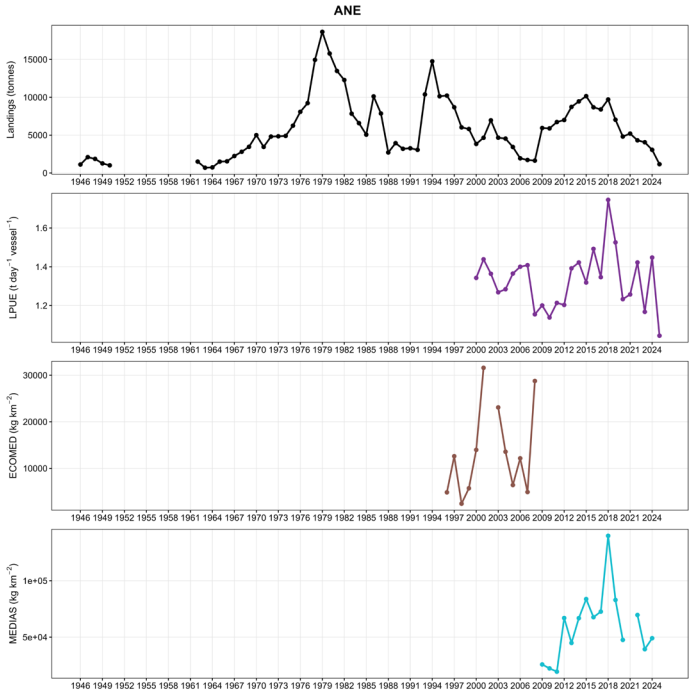


Figure 119. Data available for the assessment of anchovy in Catalonia to run the SPiCT model. From top to bottom: catch data from 1946 to 2025; LPUE index from 2000 to 2025; ECOMED acoustic survey data from 1996 to 2008; and MEDIAS acoustic survey data from 2009 to 2024.

Although only the final scenario was presented, different scenarios were tested:

- Scenario 1: Landings started in 1946, using Ecomed, MEDIAS and LPUE as indices, and a BK prior of 0.8.
- Scenario 2: Landings started in 1946, using Ecomed and MEDIAS as indices, and a BK prior of 0.8.
- Scenario 3: Landings ending in 2023, using Ecomed, MEDIAS and LPUE as indices, and a BK prior of 0.8.
- Scenario 4: Landings started in 1996, using Ecomed, MEDIAS and LPUE as indices, and a BK prior of 0.8.

A final plot comparison of scenarios 1-3 (scenario 4 did not converge) is shown in Figure 120. Different model configurations were explored to assess the influence of including the LPUE index (Scenarios 1 and 2), the starting year of the assessment, and the alignment of the LPUE and MEDIAS time series (Scenarios 3 and 4). In particular, the sensitivity of the model to starting the assessment in 1996, corresponding to the start of the available MEDIAS index, and to including the historical catch series was evaluated.

When no index information is available for 2025, the model is driven by the two biomass indices. The overall assessment results are relatively similar between Scenarios 1 and 3. The model appears to be influenced by the trend in the LPUE index. Given the lack of MEDIAS data for 2025 in the present report, Scenario 1 was selected as the final scenario (with the LPUE index downweighed) as it provides a more informative estimate of stock status for the most recent assessment years.

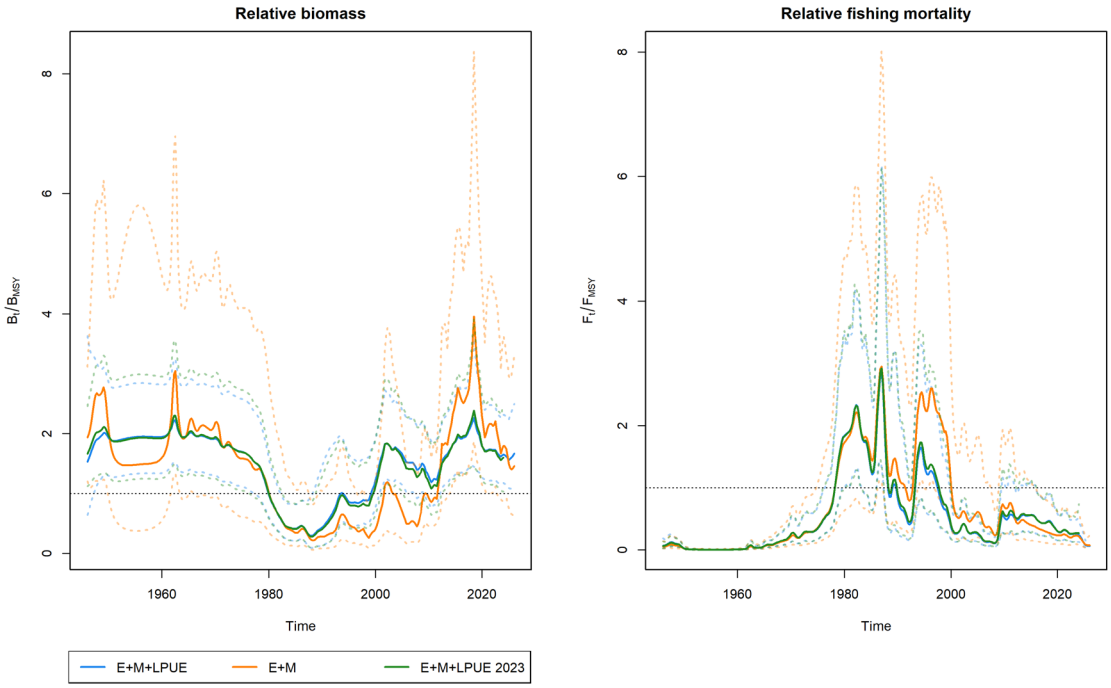


Figure 120. Scenarios comparison for anchovy in Catalonia.

Final scenario

The settings used for the final scenario are presented in Table 42. Among other settings, the BKfrac prior was 0.8 because, at the beginning of the time series, anchovy was not a target species for the fishery. Additionally, before 2000, a standard deviation factor of 2 was used because the data were less reliable than after that time, and the LPUE index was down-weighted.

Table 42. Priors settings for anchovy in Catalonia for final scenario.

Type	Prior	Description	Assignment	Mean	Standard deviation	Comment
Fishery dynamic	logbkfrac	B/K fraction (depletion)	-	Log(0.5)	0.2	Target species at the beginning of the time series. Same BK value as used for GSA6 (SAF, GFCM2024). A sensitivity analysis was done for this prior, resulting in a similar stock status in the current year.
Relative standard deviation time series (input data)	stdevfacC	Standard deviation factor for catches	<2000	2	1	Landing data for years before 2000 were less reliable.
	stdevfacI	Standard deviation factor for indices		1	1	
Stock dynamic	Logr	Population growth	-	Log(0.46)	0.26	Fishlife
	Logn	Shape of production curve	-	Log(2)	-	Shaefer
Error	Logsdc	Catch error	-	Log(0.05)	0.3	
	Logsdf	Fishing mortality error	-	Log(4)	0.5	
	Logsdb	Process error	-	Log(0.15)	0.5	
	logsdi	Observation error	-	Log(0.5)	0.5	Ecomed + Medias
				Log(0.2)	0.5	Higher observation uncertainty was assumed for LPUE

The final scenario input data is shown in Figure 121, and the final summary assessment results are shown in Figure 122. The results show a decreasing trend of biomass above the reference point since 2020. For fishing mortality, the estimated values have remained below 1 since 2000.

All diagnostics can be checked in Figure 123, Figure 124, Figure 125, Figure 126 and Figure 127. The chosen scenario met most of the model diagnostics, with some residual patterns, and provided good retrospective analysis and hind-casting diagnostics. A sensitivity analysis for the final scenario was performed, testing r prior, BKfrac, process error, and observation error to assess the model's robustness within these priors. All these plots and results for the other scenarios will be available at https://github.com/ICATMAR.

Final scenario advice

Final scenario advice is presented in Figure 128 in Table 43, which outlines the indicators for anchovy in Catalonia in 2025, based on the GFCM advice framework. The assessment results should be considered qualitative, although they were in line with the GSA6 assessment, where anchovy Biomass > B_{msy} and Fishing mortality < F_{msy}.

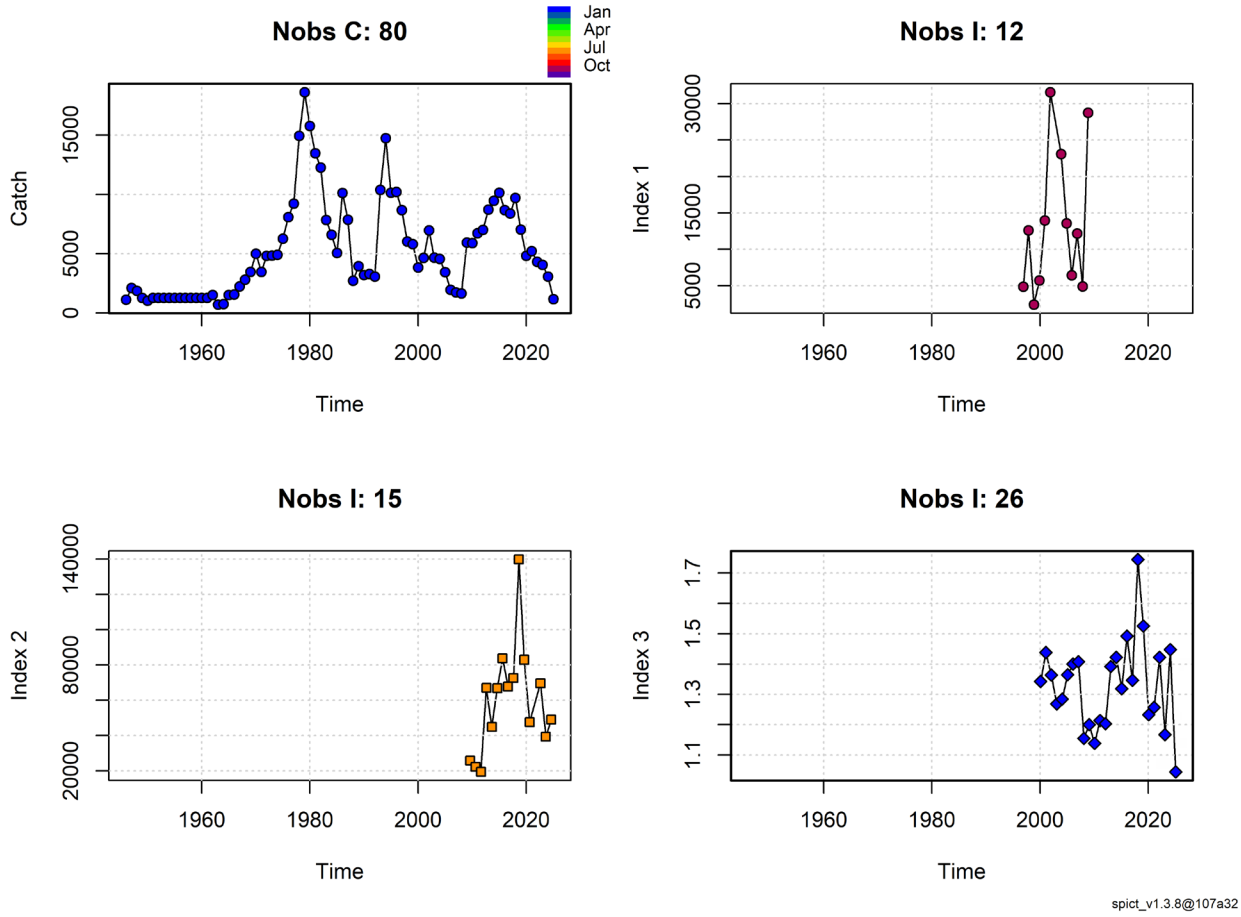


Figure 121. Input data for SPiCT model for anchovy in Catalonia. Top left: catch in tons per year since 1946, top right: biomass index derived from the Ecomed survey from 1994 to 2008, bottom left: MEDIAS survey from 2009 to 2024, and bottom right: LPUE index from 2000 to 2025..

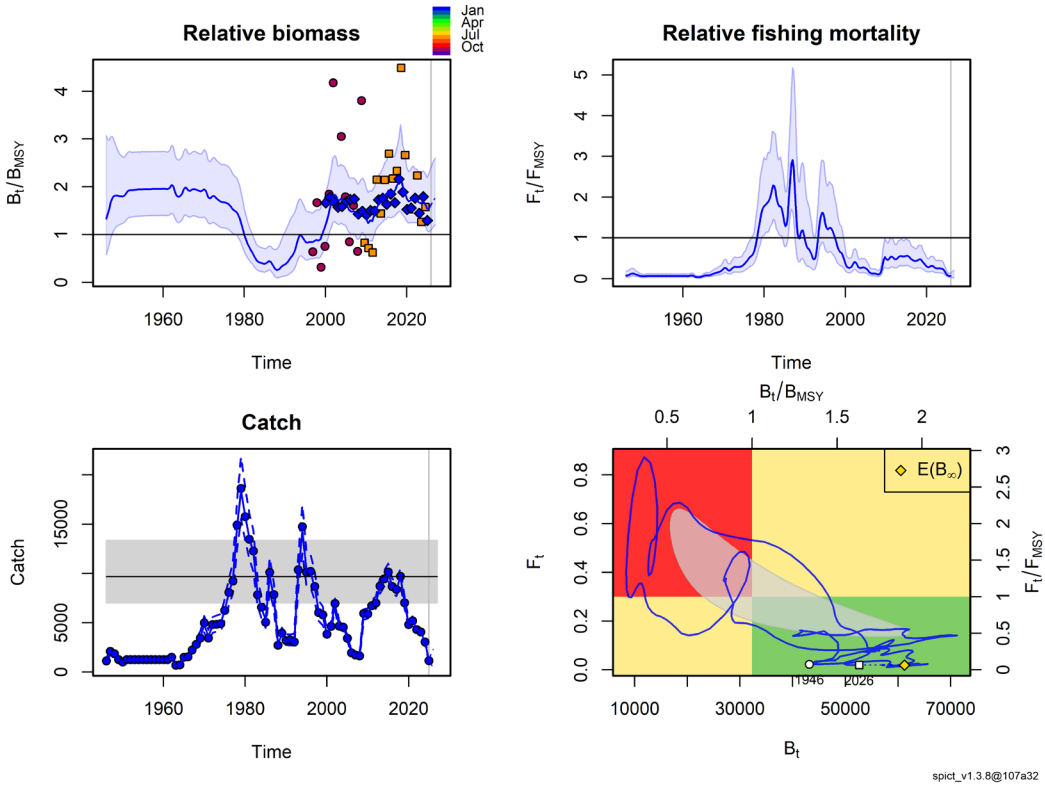


Figure 122. Stock assessment summary for SPiCT model for anchovy in Catalonia for the final scenario.

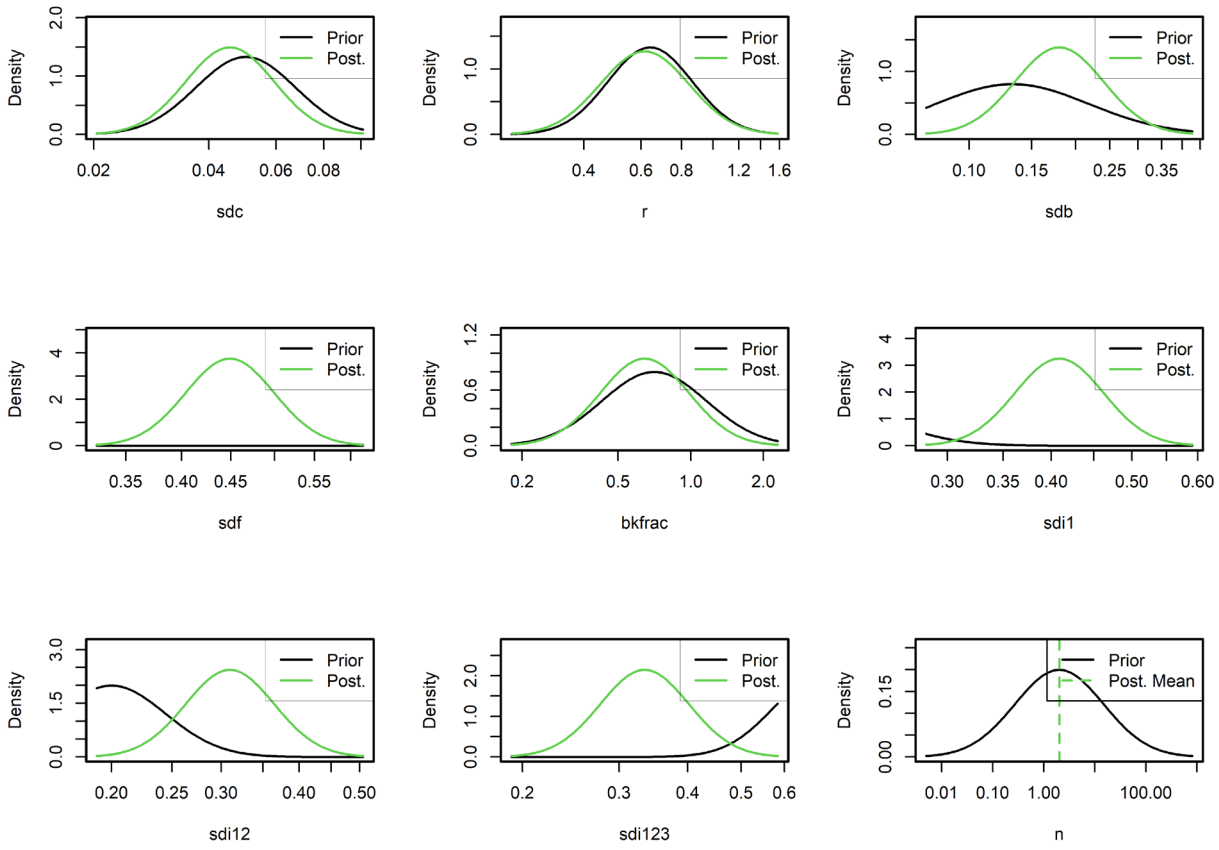


Figure 123. Estimated priors and posteriors for the updated assessment for anchovy in Catalonia for the final scenario.

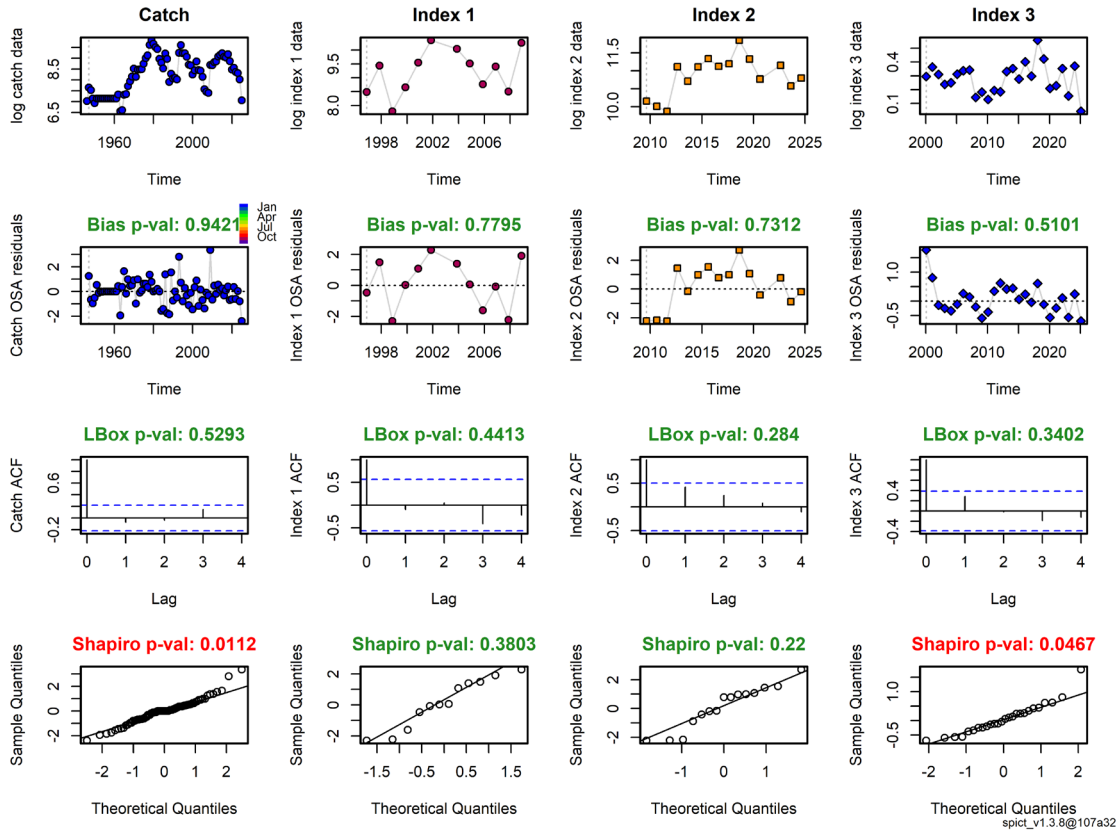


Figure 124. One-step-ahead residuals for the model for anchovy in Catalonia for the final scenario.

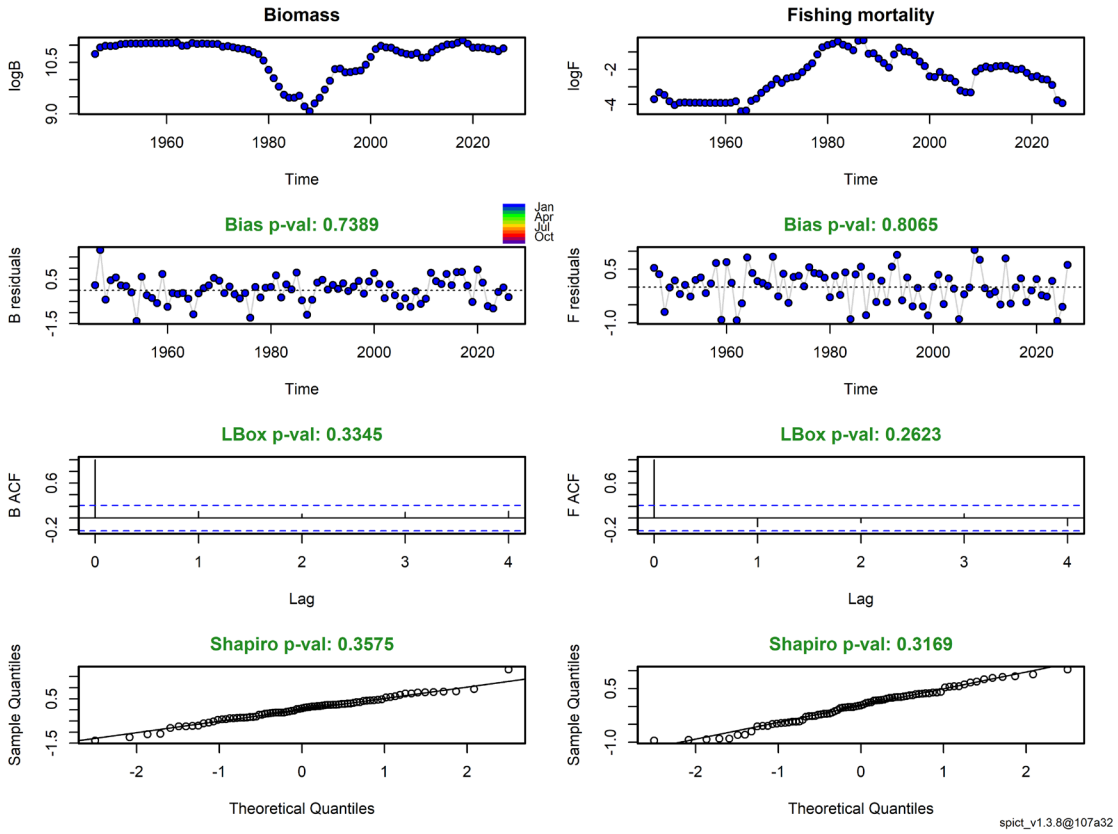


Figure 125. Process error deviations for the model for anchovy in Catalonia for the final scenario.

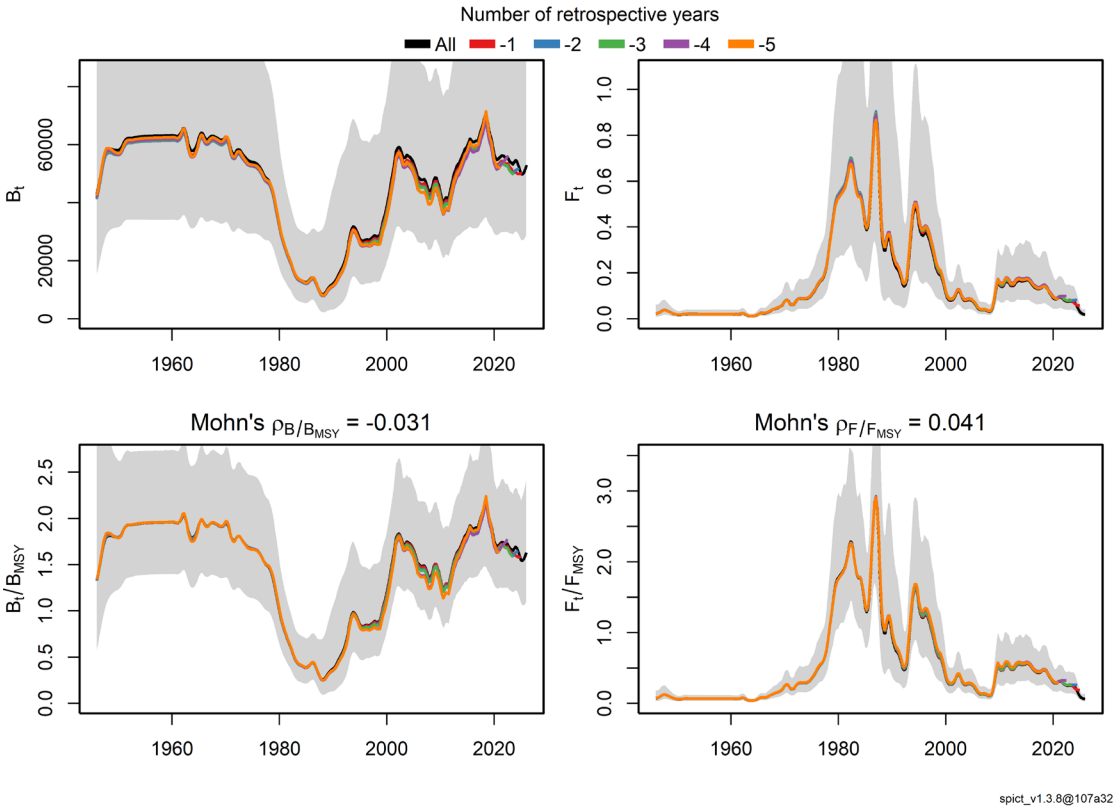


Figure 126. Retrospective analysis for anchovy in Catalonia for the final scenario.

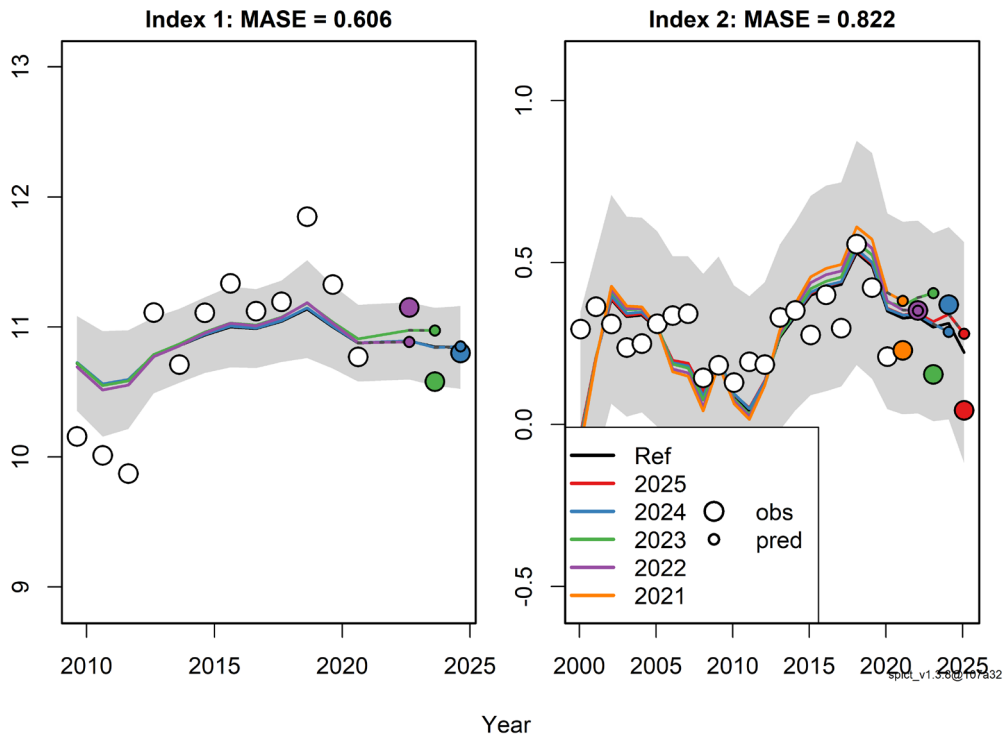


Figure 127. Hindcasting for the model for anchovy in Catalonia for the final scenario.

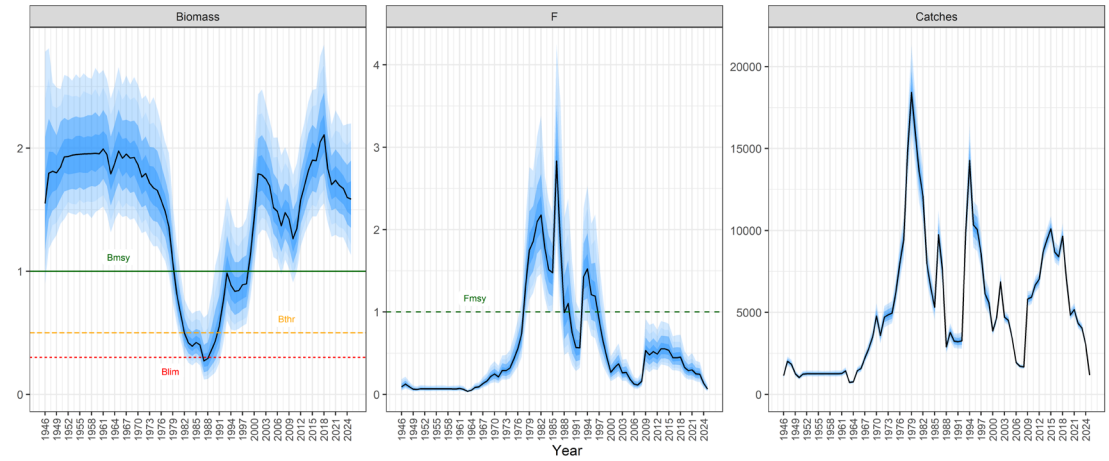


Figure 128. Advice for final scenario for anchovy in Catalonia: Historical and current stock status regarding F_{msy}, B_{msy} and $B_{lim.}$

Table 43. Indicators in 2025 from SPiCT for anchovy in Catalonia for the final scenario.

Species	Year	Catch (t)	F/F_{msy}	B/B_{msy}	B/B_{pa}	B/B_{lim}
ANE	2025	1161.9	0.06	1.59	3.17	5.29

Length-Based Spawning Potential Ratio (LBSPR)

Table 44. Biological parameters used in the different LBSPR scenarios for anchovy (ANE). L_{inf}: asymptotic length at which growth is zero, k: growth rate, M: natural mortality, L_{mat50}: length where 50% of individuals are mature, L_{mat95}: length where 95% of individuals are mature.

Species	Scenario	Linf (mm)	Lmat50 (mm)	Lmat95 (mm)	M/k
ANE	1	155	99.00	117.00	1.99
ANE	2	155	96.00	114.00	2.04
ANE	3	155	82.00	97.40	2.23
ANE	4	150	87.50	96.25	1.70

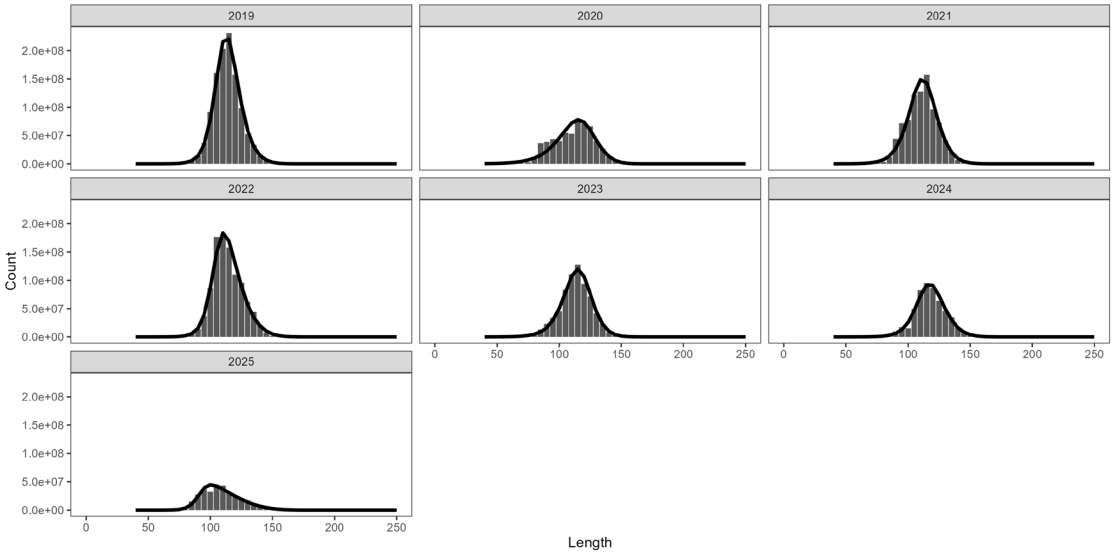


Figure129. Fit of the data using the LBSPR model for anchovy for each studied year. Grey columns indicate length frequencies. Black lines indicate the fit of the model.

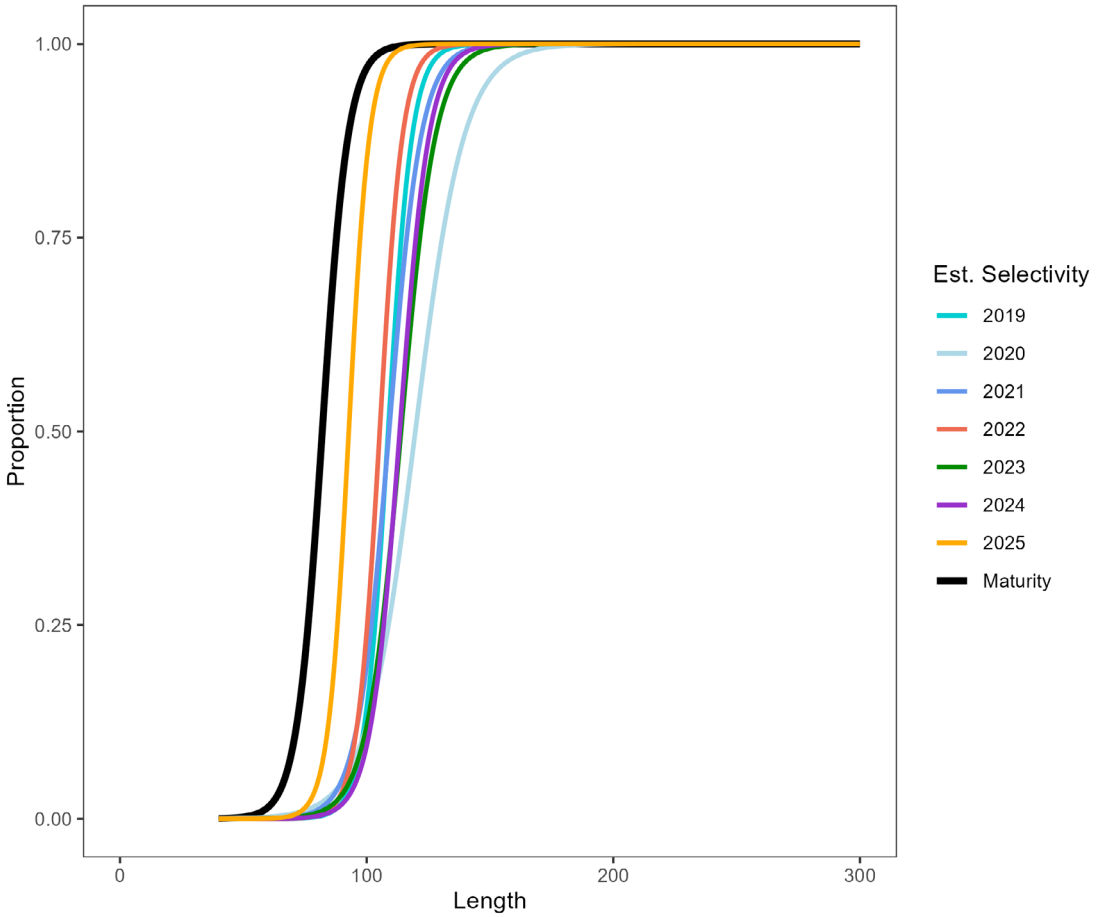


Figure 130. Length curves for anchovy. Black line shows the length curve at maturity. Color lines show the estimated selectivity at length curve predicted by the LBSPR model for selected scenario (4)..

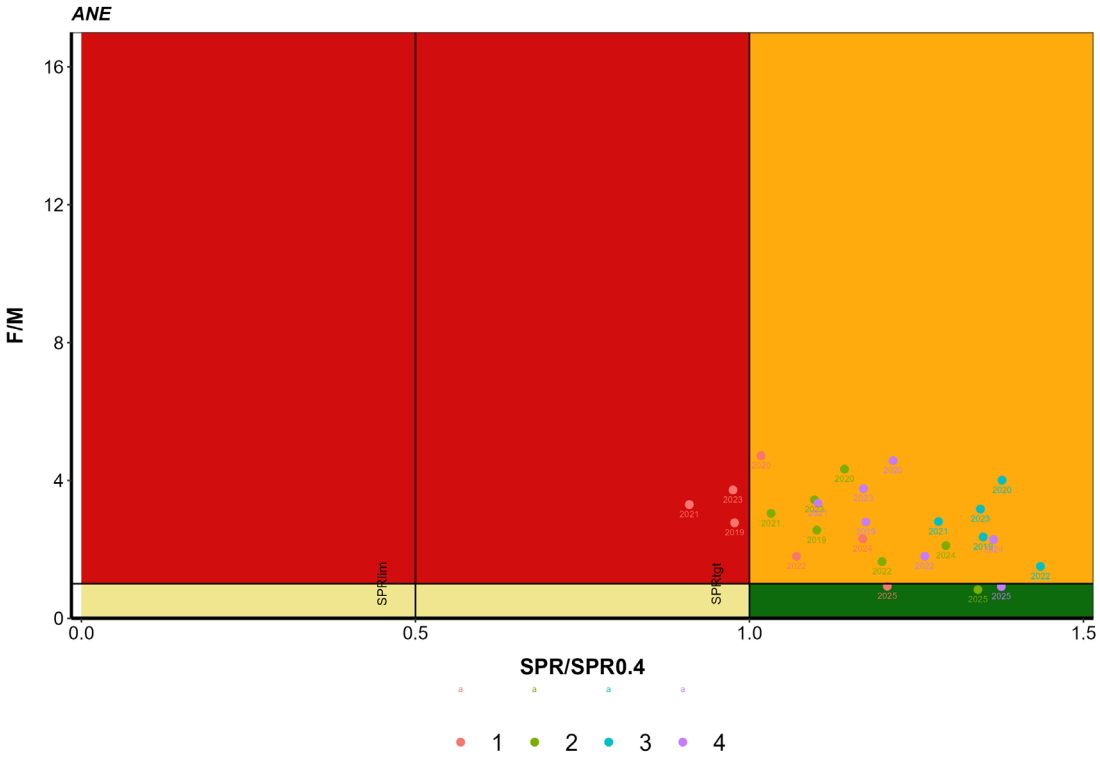


Figure 131. Kobe plot for anchovy by scenario (1-3) and year. SPR_{lim}: limit spawning potential ratio, SPR_{tgt}: target spawning potential ratio, F: fishing mortality, M: natural mortality, and F/M: relative fishing mortality.

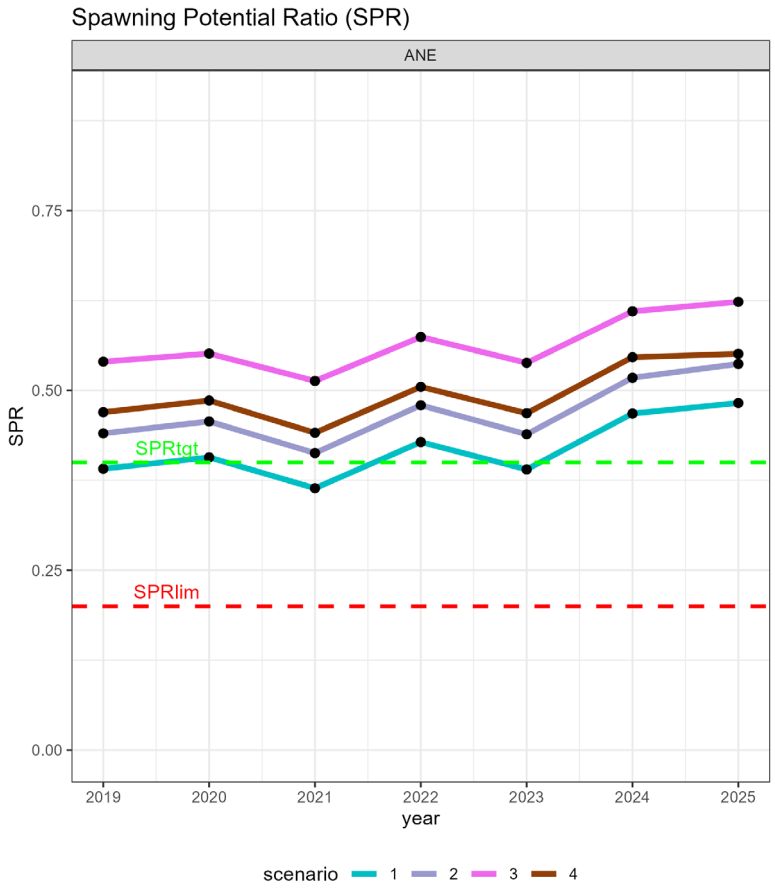


Figure 132. Spawning potential ratio (SPR) per year analyzed for anchovy evaluated with LBSPR model. LBSPR: Length-Based Spawning Potential Ratio. SPR_{lim}: limit spawning potential ratio, SPR_{tgt}: target spawning potential ratio. Colored lines show the results for each scenario.

Table 45. LBSPR model results for anchovy with the different scenarios tested for each year analyzed. SL_{50}: Length where 50% of individuals are caught, SPR: spawning potential ratio and FM: fishing mortality. SD is the standard deviation calculated for each indicator. The selected scenario is highlighted in blue.

Species	Scenario	Year	SL_{50}	SD	SPR	SD	FM	SD
ANE	1	2019	110.18	0.83	0.39	0.21	2.77	1.29
ANE	1	2020	124.09	3.68	0.41	0.22	4.72	2.81
ANE	1	2021	111.52	1.37	0.36	0.2	3.3	1.57
ANE	1	2022	106.93	1.07	0.43	0.22	1.8	0.96
ANE	1	2023	116.04	1.12	0.39	0.21	3.72	1.76
ANE	1	2024	115.54	1.34	0.47	0.22	2.3	1.24
ANE	1	2025	96.11	2.18	0.48	0.26	0.93	0.65
ANE	2	2019	110.09	0.78	0.44	0.22	2.56	1.28
ANE	2	2020	123.75	3.75	0.46	0.23	4.33	2.73
ANE	2	2021	111.38	1.34	0.41	0.22	3.04	1.56
ANE	2	2022	106.83	0.98	0.48	0.24	1.65	0.95
ANE	2	2023	115.93	1.09	0.44	0.22	3.44	1.74
ANE	2	2024	115.42	1.29	0.52	0.23	2.11	1.23
ANE	2	2025	96.05	2.14	0.54	0.27	0.83	0.64
ANE	3	2019	110.13	0.83	0.54	0.2	2.36	1.18
ANE	3	2020	124.03	3.51	0.55	0.2	4.01	2.47
ANE	3	2021	111.4	1.3	0.51	0.2	2.81	1.43
ANE	3	2022	106.93	1.1	0.57	0.21	1.5	0.87
ANE	3	2023	115.89	1.09	0.54	0.2	3.17	1.6
ANE	3	2024	115.53	1.86	0.61	0.2	1.94	1.13
ANE	3	2025	96.3	2.56	0.62	0.24	0.74	0.58
ANE	4	2019	110.07	0.92	0.47	0.2	2.8	1.38
ANE	4	2020	123.13	4.56	0.49	0.21	4.58	3.03
ANE	4	2021	111.34	1.59	0.44	0.2	3.33	1.69
ANE	4	2022	106.69	1.06	0.5	0.21	1.8	1.02
ANE	4	2023	115.98	1.29	0.47	0.2	3.76	1.89
ANE	4	2024	115.34	1.36	0.55	0.21	2.28	1.33
ANE	4	2025	95.43	2.21	0.55	0.25	0.92	0.69

Model setting and results:

Scenarios

For the present report, natural mortality (M) values for all scenarios were estimated using a combination of ICATMAR data and published literature. When stock-specific estimates were unavailable, values from nearby and biologically similar stocks were used.

Four scenarios were applied considering different growth parameters from GFCM working groups (Table 44). Growth parameters in scenario 4 and maturity data in scenarios 3 and 4 are derived from the ICATMAR dataset.

Fitted data

The length frequency distribution fit per year is shown in Figure 129. The model generally follows the modal lengths across all years; however, in some length classes, the observed data fall outside the range of the simulated estimates.

Selectivity

The outputs of the model for the selectivity of the fishery are shown for each scenario in Table 45. The output of the selected scenario (4) is also plotted with L_{mat50} and SL_{50} in Figure 130. In Scenarios 1 and 2, the fishery primarily exploits individuals below L_{mat50} in 2025, whereas in Scenarios 3 and 4 it operates at lengths above L_{mat50}

Reference points

The estimated SPR remained above SPR_{lim} (= 0.2) under all assessed scenarios (Table 45 and Figure 132). Scenario 1 yielded SPR values close to SPR_{tgt} (= 0.4), falling slightly below the target in some years, whereas Scenarios 2, 3 and 4 consistently produced SPR estimates above SPR_{tgt}. The Kobe plot for anchovy (Figure 131) shows the stock status over time, with no clear temporal trend. Most estimates fall within the orange quadrant, indicating that the stock is above the target reference point but remains subject to overfishing. However, some years, particularly 2022 and 2025, fall within the green quadrant, indicating stock conditions consistent with sustainable exploitation. Overall, the results suggest a stock status close to or above the target reference point, despite signs of ongoing overfishing in most years.

Final scenario

As LFD, growth and maturity parameters derived from ICATMAR data, scenario 4 was selected to provide final advice for the LBSPR model.

SECTION 5
A biomass-based index for fisheries management



Context

The complexity of Mediterranean fisheries has driven the stock assessment process to growing levels of intricacy and is highlighting the challenges associated with uncertainty. At the moment, decisions are based on complex management tools derived from model outputs that are difficult to translate for all stakeholders to evaluate, from the fishing sector to administrations, not to mention a large section of the scientific community which is not specialized in programming assessment models of growing complexity.

In order to adapt stock assessment tools to Mediterranean fisheries, there are two roads ahead: either increasing complexity to aim for a full, comprehensive representation of the bioeconomic system, at risk of broadening the gap between the few model experts and the rest of the scientific community and other stakeholders, or simplifying the tools in favor of a more accessible, straight-forward process. In this sense, Management Strategy Evaluation (MSE) is presented as a promising tool to incorporate and generate knowledge in complex systems, with various levels of intricacy depending on data and expertise availability. However, a system built on an increasingly elaborate loop of simulations is not likely to be either operable or understandable by the wide array of stakeholders who are expected to participate in the various phases of the decision-making process, from data collection to proposal of management measures. Also, there is growing concern as to whether such a complex tool is adequate for the Mediterranean context, where data series can often be short, incomplete, or missing. For these reasons, efforts should focus on simplification of the tools that lead to decision-making in Mediterranean fisheries.

Observational biomass data are currently used as an input among many others in stock assessment models, but are in fact one of the most robust data series in the Mediterranean Sea, with at least one annual cruise with the same research vessel and mesh size since the decade of the 1990s. Rules based on biomass indexes are currently used by ICES either on their own or in combination with other sources of data when quantitative assessments cannot be performed (ICES 2025). However, these rules (e.g. rfb, chr, rb) are, on one hand, always referred to one monospecific stock, and so need some component of species-specific biological parameter, and on the other hand, still use biomass reference points estimated from models to establish biomass safeguards or limits for harvest control rules (ICES 2025). There is a need to build such a tool adapted to the multispecificity of Mediterranean fisheries while remaining easily understandable by all stakeholders.

We here present the technical grounds for a new systemic biomass indicator, based on empirical data, that can complement the current stock assessments while providing a straight-forward, general picture of the state of the exploited system. The components that are being considered are a) biomass of a representative group of species, b) size-frequency distribution through biomass spectrum, and c) extracted vs. fishable biomass ratio. This technical proposal is being developed in collaboration with the Spanish Institute of Oceanography in the Balearic Islands (IEO-CSIC Baleares). It may be modified along the discussion process with collaborators and stakeholders.

System biomass monitoring

Time period definition

The objective is to monitor the exploited system biomass in the northern GSA 6 over time, defining time periods according to relevant changes in management measures, effort, or similar variables. For this first trial run, we have considered the following periods:

- 1994-2011: from the beginning of the MEDITS trawl survey series to the implementation of the 40-mm square mesh codend for the bottom trawl fleet
- 2012-2018: from the change in mesh size to the year prior to the WestMed MAP implementation
- 2019-2024: from the WestMed MAP implementation to the most recent year available in the series

Species group selection

Data from MEDITS cruises for the northern GSA 6 from 1994 to 2024 were used to calculate species biomass and total biomass by stratum (stratum A: 0-50 m; stratum B: 50-100 m; stratum C: 100-200 m; stratum D: 200-500 m; stratum E: 500-800 m). Selection of which species groups to monitor can be done according to representativity of the species within the total biomass of each stratum. We defined a reference period of the last 4 years of the data series (2021-2024) in order to avoid any anomalies that the year 2020 may show due to the COVID-19 pandemic. Species that amount to 80% of the total biomass of each stratum every year of the reference period were selected, with a total of 54 species for the whole period (between 27 and 39 species by year), regardless of whether they were commercial or not. Figure 133 shows the representativity of the selected species within the total biomass, considered together of by commercial category (commercial / non-commercial).

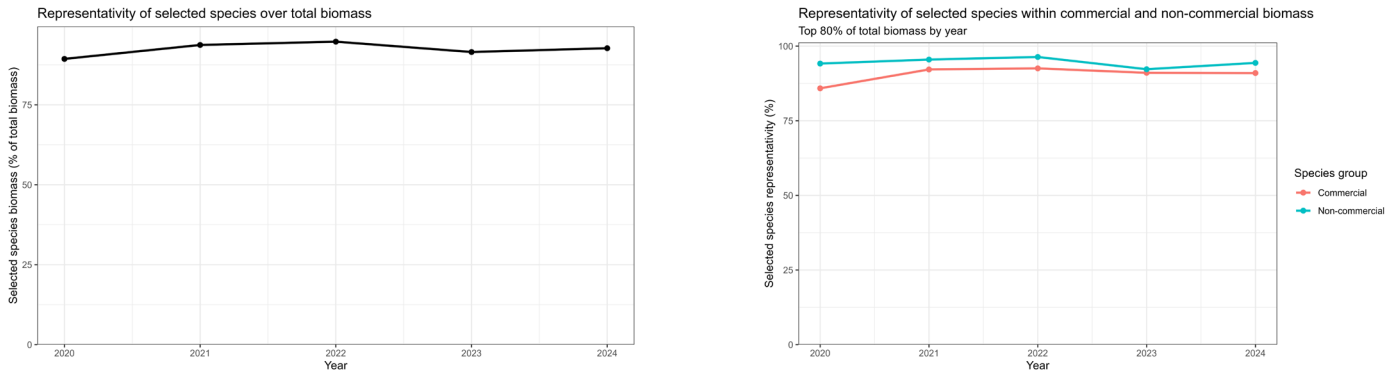


Figure 133. Representativity of selected species group in relation to (top) total biomass and (bottom) biomass of commercial and non-commercial species, during years 2020-2024.

Calculation of biomass trends

Overall, the objective was to compute a weighted geometric mean that gives more weight to biomass trends that are sustained over time, in contrast with fluctuating values that change direction every year and may not be as informative.

First, considering the selected groups of species by stratum, the annual biomass values (kg/km²) were calculated. Species biomass values were only considered in strata which correspond to their spatial distribution (e.g., *Aristeus antennatus* biomass values were only computed over stratum E, but *Merluccius merluccius* was considered throughout all strata). Then, the annual proportional change (r) between each pair of consecutive biomass values was computed, noting the direction of the trend in each case (increase, decrease or maintain). In order to account for the duration of each trend, a run weight value (w) was assigned to each annual proportional change. For instance, if the trend is decreasing for 3 consecutive years, the run weight value associated to these 3 annual proportional changes is 3. Then, a weighted geometric mean was calculated for each species group, stratum and time period, using the annual proportional changes weighted by the length of the runs.

In summary, the calculation of this run-length weighted geometric mean was done following this formula:

$$G = \exp\left(\frac{\sum_t w_t \log(r_t)}{\sum_t w_t}\right)$$

where:

- G is the biomass trend value of each species group in a given stratum and time period,
- w is the length of the biomass trend run
- r is the annual proportional change between consecutive biomass values

The result is a biomass trend value G by species group, stratum and time period, where values lower than 1 indicate system biomass decrease, a value of 1 indicate biomass maintained, and values higher than 1 indicate biomass increase.

Results

Preliminary results are shown in Figure 134. In general, excepting stratum A which is characterized by species with particularly patchy distributions, biomass decreased from the first to the second time period, probably responding to a sharp increase in fishing effort and a lack of management measures. Then, an improvement in system biomass is observed from the second to the third time period, in consonance with the start of management measures for the bottom trawl fleet.

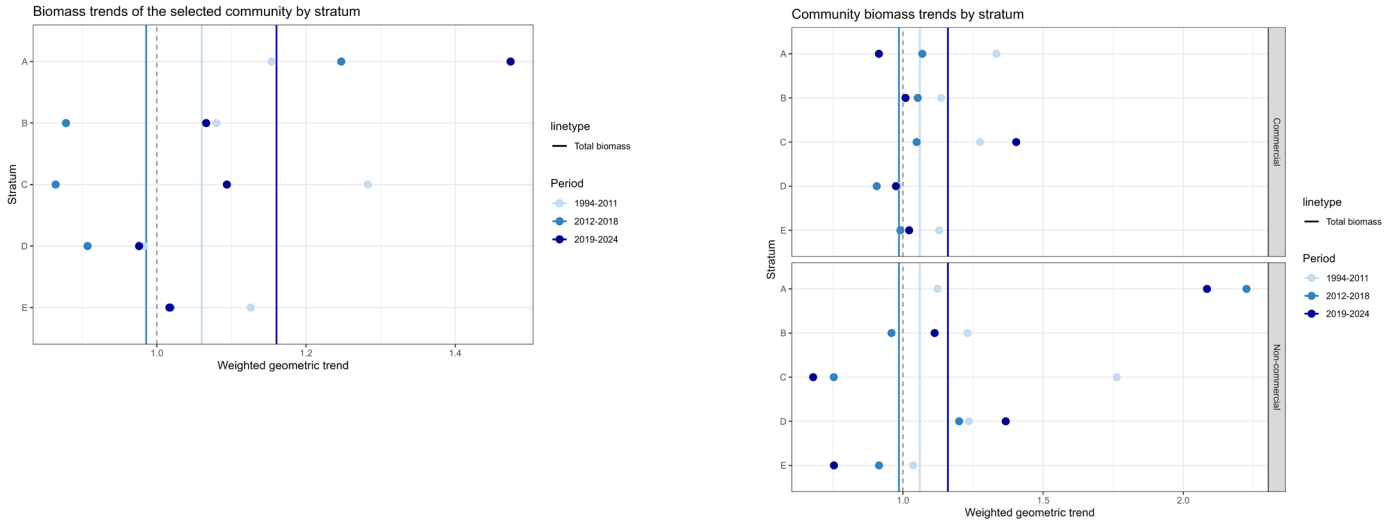


Figure 134. Biomass trends for selected species groups by stratum and time period. Top: all species combined; bottom: Commercial and non-commercial species represented separately. Dots represent biomass trends for species groups. Colors represent time periods (light blue: 1994-2011; medium blue: 2012-2018; dark blue: 2019-2024). Trends for total biomass are shown in vertical lines for each period for comparison.

Size structure monitoring

Length data can be extracted from MEDITS data series to build biomass size spectra by stratum for each selected species group. Biomass size spectra are size-frequency distributions that consider the biomass of an entire species group or community as a whole, and represent it with relation to a standardized size unit. Although originally built for planktonic communities, their use has progressed onto other organisms, including exploited fish and crustacean communities (Figure 135, Jung and Houde 2005, Sprules and Barth 2016 and references therein). The objective of this component is to give an overview of the size frequency distribution of the representative species through the defined time periods. Combined with biomass monitoring, it can help detect changes in population size structure that can be due to environmental factors or fishing pressure.

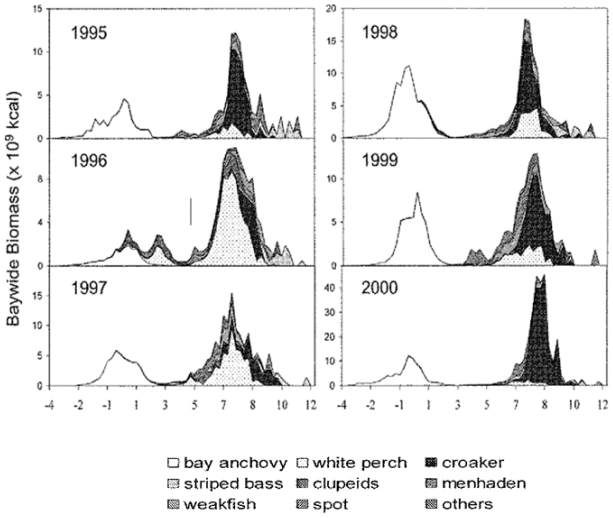


Figure 135. Example of mean biomass size spectrum for a fish community in Chesapeake Bay over time. The biomass of the community is represented with reference to a standardized size unit. Source: Jung and Houde 2005.

Extracted vs. fishable biomass ratio

Bottom trawling cannot, with current technology, select catch by species before each haul, and so the total biomass extracted from the system must be taken into account, regardless of the commercial status of each species. Data on total extracted biomass can be extrapolated from ICATMAR on-board sampling data (2019-2025, Carreton et al. 2025), which include high resolution weight data of all species in the discard fraction. A catch rate in total kg per hour was calculated from the sampling data, and extrapolated to the total biomass extracted by the Catalan fleet through VMS data (total fishing hours), available from the Spanish *Ministerio de Agricultura, Pesca y Alimentación*. This extracted biomass was then compared to the total biomass available in the fishable area of Catalonia (from MEDITS data, excluding stratum A where bottom trawling is not allowed). Finally, a ratio was calculated to relate total extracted biomass and total fishable biomass. Monitoring of this ratio can give an idea on whether the fleet is extracting more, less or about the same proportion of the system biomass over time, which can help guide decisions on effort or gear selectivity control.

Preliminary results are shown by year in Figure 136 for the northern GSA 6 (Catalonia). The ratio of extracted vs. fishable biomass has remained stable since 2020, but the year 2019, previous to the management measures associated with the WestMed MAP, shows a higher value. Future directions include exploring this ratio further back in the time series, to look for any significant changes that can be correlated to shifts in management measures or fleet behavior.

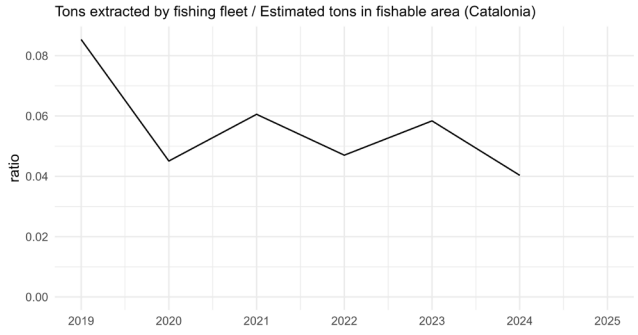


Figure 136. Total extracted biomass over total fishable biomass ratio by year. Total extracted biomass was calculated from on-board samplings taking into account all species in the catch, and total fishable biomass was estimated from MEDITS data in the 50-800 m area of Catalonia.

Link to management measures

Once biomass trends, size structure and extracted biomass ratio have been calculated, and eventually integrated into a straight-forward result representation, this output needs to be related to some form of rule for management decisions. Harvest control rules such as applied in the cases where quantitative assessment is not possible can be a good starting point, but management measures considered cannot be limited to effort control in fishing days. Other ecosystem-based measures such as – but not limited to – selectivity improvement or the establishment of permanent closure areas can greatly improve the state of the exploited system and should be regarded as a primary tool in the path to sustainable fisheries.

Summary

Using observational data, we are in the process of building an indicator that can orient fisheries management decisions in a multispecific context, while maintaining the focus on concepts that are easy to explain and understand for all stakeholders concerned in the process: biomass monitoring, size structure of the community, and extracted vs. fishable biomass. We are confident that further refinement and development of this technical basis can result in a clear, straight-forward tool for use in the decision-making process in Mediterranean fisheries management.

SECTION 6
Conclusions and comments



Conclusions

Results by stock

Five demersal stocks (red mullet, European hake, deep-water rose shrimp, Norway lobster and blue and red shrimp) and two small pelagic fish stocks (European sardine and anchovy) were evaluated using a production model (SPiCT) and a length-based model (LBSPR), with all stocks estimated above biomass limit reference points.

For both models, different scenarios were considered based on alternative data sources, model assumptions, and alternative biological parameter values. The different scenarios were compared to identify those providing both a good fit to the available data and a consistent representation of the observed dynamics of the fisheries.

Fo SPiCT, ICATMAR and MEDITS biomass indices, CPUE indices and historical data were included for demersal stocks where available, with the 2025 autumn MEDITS survey also explored. Uncertainty in the ICATMAR and MEDITS indices was incorporated based on the variability of the survey estimates. In some scenarios, time-varying recruitment (TVR) was included to account for interannual variability in recruitment.

Length-based models like LBSPR use detailed length-structure data available, but their results can be associated with a high level of uncertainty, mainly due to their sensitivity to input data and biological assumptions. Key limitations include the inability to incorporate historical catch data and biomass indices. In contrast, production models can incorporate these additional data sources, although their results may be affected by the limited information available on the length structure of the stocks.

- For red mullet, SPiCT estimates an overall increasing biomass trend, with a slight decline in 2025, while fishing mortality remains stable. LBSPR indicates an increase in spawning potential ratio (SPR) in 2025, potentially related to the increase in individuals observed in 2024, although SPR remains at low levels as in previous years. The biomass index also shows an overall increasing trend, despite some interannual fluctuations.
- For European hake, different biomass indicators show an overall increasing trend. SPiCT estimates biomass slightly above the biomass threshold, with a positive trajectory since 2019, while fishing mortality has generally declined, despite a slight increase in 2025, and remains close to but above F_{msy}. 2025 shows an increase in the number of individuals, while the LBSPR estimated spawning potential ratio (SPR) remains relatively stable compared with previous years. Despite the positive trends in biomass and abundance, the stock remains close to the biomass limit reference point and fishing mortality remains high. Management measures aimed at protecting large spawner individuals and improving selectivity could therefore support continued stock recovery and help maintain recruitment.
- For deep-water rose shrimp, SPiCT estimates a slight but progressive increase in fishing mortality, reaching levels above F_{msy} in 2025, while biomass shows an increasing trend but has remained at relatively stable levels since 2019. LBSPR estimates a slight increase in spawning potential ratio (SPR) in 2025. The estimated position of SPR relative to the reference point varies among scenarios, reflecting the uncertainty associated with the biological parameters used for the species; under the selected scenario, SPR remains above the target reference point. Overall, the results provide contrasting signals, with fishing mortality exceeding F_{msy} in 2025 despite relatively stable biomass and SPR above the target under the selected LBSPR scenario. Environmental factors such as changes in sea temperature and salinity may also influence stock dynamics but are not currently incorporated into the assessment models.
- For Norway lobster, SPiCT estimates an increasing biomass trend since 2020 and a declining fishing mortality since 2018, with F remaining below F_{msy} since 2023 despite some interannual fluctuations. Although catches have increased slightly in recent years, the MEDITS abundance index continues to show an oscillating pattern without a clear trend. LBSPR estimates a slight increase in spawning potential ratio (SPR) in 2025, potentially related to the observation of larger individuals in the most recent survey, but remains under SPR_{lim}. Environmental factors such as the increase of sea temperature may be negatively conditioning the development of the population, however, these effects cannot be directly incorporated into the assessment models as explanatory variables.

- For blue and red shrimp, the MEDITS abundance index shows relatively stable biomass levels since 2020. SPiCT estimates an overall increasing biomass trend since 2015, with biomass remaining above the biomass threshold and close to B_{msy}. Fishing mortality has remained around F_{msy} since 2020, but decreased below F_{msy} in 2025. LBSPR estimates fluctuating spawning potential ratio (SPR) values above SPR_{lim}, with a slight decline in 2025. Overall, the different indicators provide relatively favorable signals, with increasing biomass according to SPiCT and SPR remaining above the limit reference point. The catch limit enforced during 2025 is likely to have influenced the mortality estimates.
- For European sardine, biomass is estimated to be just above B_{lim}, while fishing mortality in 2025 is below F_{msy}. SPR remains above SPR_{lim} and shows a relatively stable trend, suggesting a low but stable spawning potential.
- For anchovy, biomass is estimated to be above B_{msy}, while fishing mortality remains below F_{msy} and shows a decreasing trend. SPR is above SPR_{tgt} and has shown an increasing trend, indicating a favorable spawning potential.

General considerations

Stock assessment models are tools that can give information on the status of different populations, but the uncertainty inherent to all models should prevent decision-makers from taking output values as unquestionable attributes of the stocks. The roadmap for official assessments already considers strategy simulation tools such as Management Strategy Evaluation (MSE), which are able to predict the effect of different management measures in the catches, biomass and fishing mortality of a fishery. However, this is a long and complex process that requires the cooperation of all stakeholders (fisheries scientists, policy makers, fishers, etc.), and, as currently framed, is still dependent on model estimates. In the meantime, Mediterranean fisheries are in need of robust but comprehensive tools that can orient management decisions towards sustainable exploitation.

The advice derived from these models should therefore be considered qualitative and interpreted with caution, as differences in data inputs and assumptions underlying each approach can lead to contrasting perceptions of stock status. Differences between LBSPR and SPiCT highlight the importance of considering multiple sources of information, including survey indices, landings and biological observations. A multispecific indicator based on biological observational data could provide a complementary, integrated and easily interpretable view of the exploited system. Overall, robust but comprehensive tools combining different sources of information are needed to support adaptive fisheries management.

In the context of these constraints, technical grounds for an empirical data-based indicator have been presented, using MEDITS data series and considering biomass trends, biomass spectra and ratio of extracted vs. fishable biomass. Future work will focus on refining the method and building an integrated indicator that can inform on a representative part of the exploited system, while staying appropriate for a multispecific fishery, and easily understandable by all stakeholders that participate in fisheries management decision-making processes. Key challenges include defining biomass safeguards based on empirical data and determining how indicator values should translate into specific fisheries management advice.

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