Stock Assessment Form

Demersal species

HAKE – GSA6

Reference year: 1995 - 2017

Reportingyear: 2018

José Luis Pérez Gil*, Antonio Esteban**, Encarnación García**, **Miguel Vivas**, Esther Herrera**,** ***Jose Miguel Serna-Quintero*,*** **and** ***María José Meléndez**.**

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European hake is a target demersal species of the Mediterranean fishing fleets. It is largely exploited in GSA06, mainly by trawlers on the shelf and slope (91% landings), but also by small-scale fisheries using long lines (6%) and gillnets and trammel nets (3%) (averagepercents estimated between 2015 and 2017).

According to official statistics around 1000 boats are involved in this fishery, with total annual landings oscillating around an average value of 2200 tons for the period 2012-2017 (1743 tons in 2016). The trawler fleet is the largest in number of boats and landings (437 trawlers and 1617 tons in 2017).

The assessment was carried out using official landings and data on the size composition of trawl, long lines and set gillnet catches for the years 1995-2017. Tuning was performed using Abundance index series from MEDITS trawl surveyswere used as indices of abundance independent of the fishery.

The state of exploitation of this stock was assessed by means of VPA Extended Survivor Analysis (XSA) (Shepherd, 1999) and statistical catch-at-age stock assessment model (a4a) (Jardim and Millar, 2014).

Fishing mortality (F_{bar0-3}) shows a increasing trend from 2004 and keeping in values close to 1.4 in the last seven years
Y/R analysis shows that the F_{ref}= $F_{current}$ (1.4) exceeds the Y/R $F_{0.1}$ reference point (0.2).

Stock Assessment Form version 1.0 (January 2014)

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Stock assessment form

1. Basic Identification Data

Scientific name:	Common name:	ISCAAP Group:
Merlucciusmerluccius - HKE	European hake	32 HKE
1st Geographical sub-area:	**2nd Geographical sub-area:**	**3rd Geographical sub-area:**
Northern Spain GSA_6		
4th Geographical sub-area:	**5th Geographical sub-area:**	**6th Geographical sub-area:**
1st Country	**2nd Country**	**3rd Country**
SPAIN		
4th Country	**5th Country**	**6th Country**
Stock assessment method: (direct, indirect, combined, none)		
XSA and a4a (tuned with MEDITS indices) and Y/R		
Authors:		
José Luis Pérez Gil*, María González*, Antonio Esteban**, Encarnación García**, José Miguel Serna *,Miguel Vivas**,Ester Herrera** and María José Meléndez *. .		
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2. Stock identification and biological information

2.1 Stock unit

The Northern Spain subarea (GSA06) is used as an individualized area for assessment and management purposes in the western Mediterranean. However no study currently allows to state that hake stock is isolated from neighboring areas, for instance from GSAs 01, 05 and 07.

2.2 Growth and maturity

Table 2.2-1: Maximum size, size at first maturity and size at recruitment.

Somatic magnitude measured (LT, LC, etc)			Total length (LT)	**Units**	cm
Sex	**Fem**	**Mal**	**Combined**	**Reproduction season**	All year: Feb and June
Maximum size observed	90	61	90	**Recruitment season**	All year (higher picks in winter and spring)
Size at first maturity			26	**Spawning area**	Shelf and upper Slope
Recruitment size to the fishery			14.5	**Nursery area**	Continental Shelf

Table 2-2.2: M vector and proportion of matures by size or age (Combined Males-Females))

Age	Natural mortality **	Proportion of matures
0	*1.24*	*0*
1	*0.58*	*0.2965*
2	*0.45*	*0.9855*
3	*0.4*	*0.99*
4	*0.37*	*1*
5+	*0.35*	*1*

**Natural mortality vector, PROBIOM. Abella A, Caddy J.F, Serena F. 1999.

Table 2-3: Growth and length weight model parameters

			Sex			
		Units	female	male	Combined	Years
Growth model	**L_∞**				110*	
	K				0.178*	
	t_0					
	Data source	*Mellon-Duval *et al.* (2010) (tagging surveys). **DCF-EU (Spain. 2012)				
Length weight relationship	**a**				0.00677**	
	b				3.035097**	
	M (scalar)				0.4 (Vector average)	
	sex ratio (% females/total)	0.36				

3. Fisheries information

3.1 Description of the fleet

European hake is a target demersal species of the Mediterranean fishing fleets. It is largely exploited in GSA06, mainly by trawlers on the shelf and slope (91% landings), but also by small-scale fisheries using long lines (6%) and gillnets and trammel nets (3%) (averagepercents estimated between 2015 and 2017).

According to official statistics around 1000 boats are involved in this fishery, with total annual landings oscillating around an average value of 2200 tons for the period 2012-2017 (1743 tons in 2016). The trawler fleet is the largest in number of boats and landings (437 trawlers and 1617 tons in 2017).

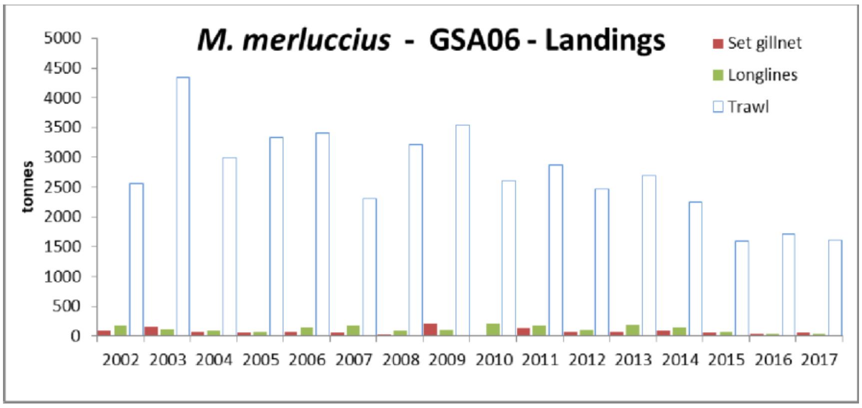
The total annual landings used in the assessment come from the official data.

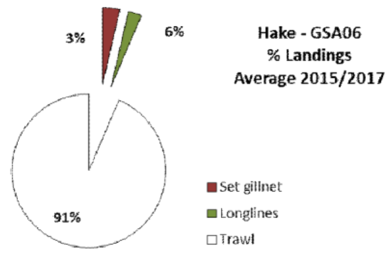
Table 3-1: Description of operational units exploiting the stock

	Country	GSA	Fleet Segment	Fishing Gear Class	Group of Target Species	Species
Operational Unit 1*	ESP	06	E-Trawl 12-24 m	03-Trawls	33 – Demersal shelf species	HKE
Operational Unit 2	ESP	06	M-Polyvalent 12-24 metres	07-Gillnets and Entangling Nets	33 – Demersal shelf species	HKE
Operational Unit 3	ESP	06	I-Long line 12-24 metres	09-Hooks and Lines	33 – Demersal shelf species	HKE

Table 3.1-2: Catch, bycatch, discards and effort by operational unit in the reference year

Operational Units	Fleet (n° of boats. - 2017)	Catch (T average 2015-2017 species assessed)	Other species caught (names and weight)	Discards (species assessed)	Discards (other species caught)	Effort average 2015-2017 (days)
03-Trawls	437	1643				75640
07-Gillnets and Entangling Nets	385	56				5219
09-Hooks and Lines	88	55				1954
Total 2017	910	1617OTB_62GNS_49LLS				86736





a **b**

Figure 1.a/Hake landings by fishing gear.b/ Hake % landings by fishing gear.

3.2Historical trends

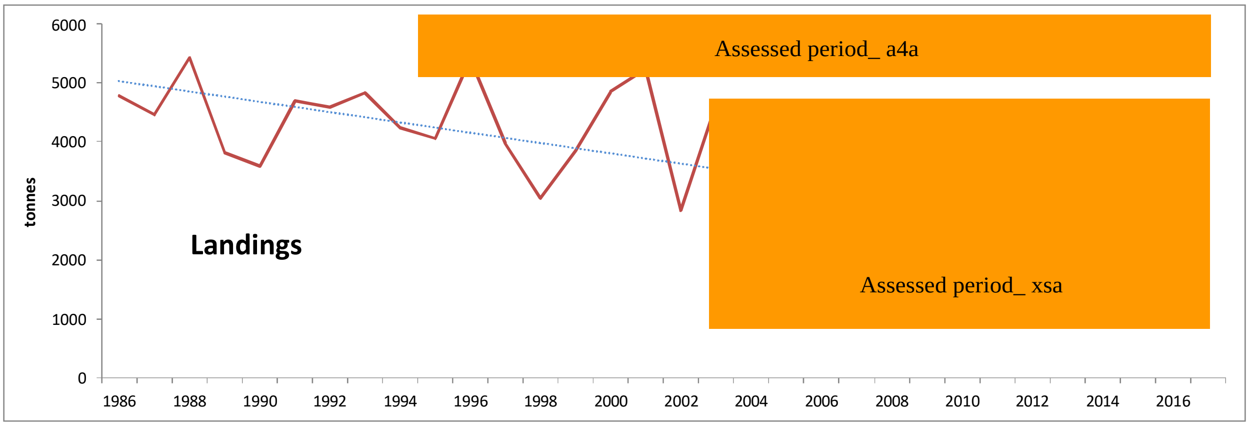


Figure 2. Hake total landings 1986-2017 - GSA 6

Landings have shown important oscillations along the period of the data series. However, in the last years from 2009 onwards, a decreasing trend in landings is observed with the minimum values in the time series data.

Table 3-2: Catches as used in the assessment

Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Catch (t)	2836	4633	3150	3473	3627	2531	3341	3847	2821	3182	2641	2941	2489	1726	1810	1728
Minimumsize*	4	4	4	5	5	5	5	5	5	7	5	4	6	5	5	8
Averagesize *	11.5	15.3	14	16	16	16	15	17	16	22	21	22	22	22	20	22
Maximumsize*	72	77	90	74	89	85	72	88	77	82	69	87	72	64	69	77

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017
Fleet; OTB/LLS/GNS-GTR	559/215/307	538/209/314	512/169/310	484/155/250	472/190/320	461/162/210	453/156/303	438/250/483	437/88/385

Table 3-4: Selectivity

L25*	12.8
L50*	14.6
L75*	16.8
Selection factor	3.55

*It corresponds to 40 mm square mesh in the codend in force from 2012.

Data source: García-Rodriguez M. and Fernández A.M. 2005. Influencia de la geometría de la malla del copo en las captura,selectividad y rendimientos de algunas especies de peces comerciales en el Golfo de Alicante (SE de la península Ibérica). Inf.Tec.Ins.Esp.Oceanogr. 185.

Discards

Discards were not included in the assessment. There is only available the last 7 years (Fig X).For the 2011-2016 period the percentage of discards (mainly caught by trawlers) wasaround 4-5%.

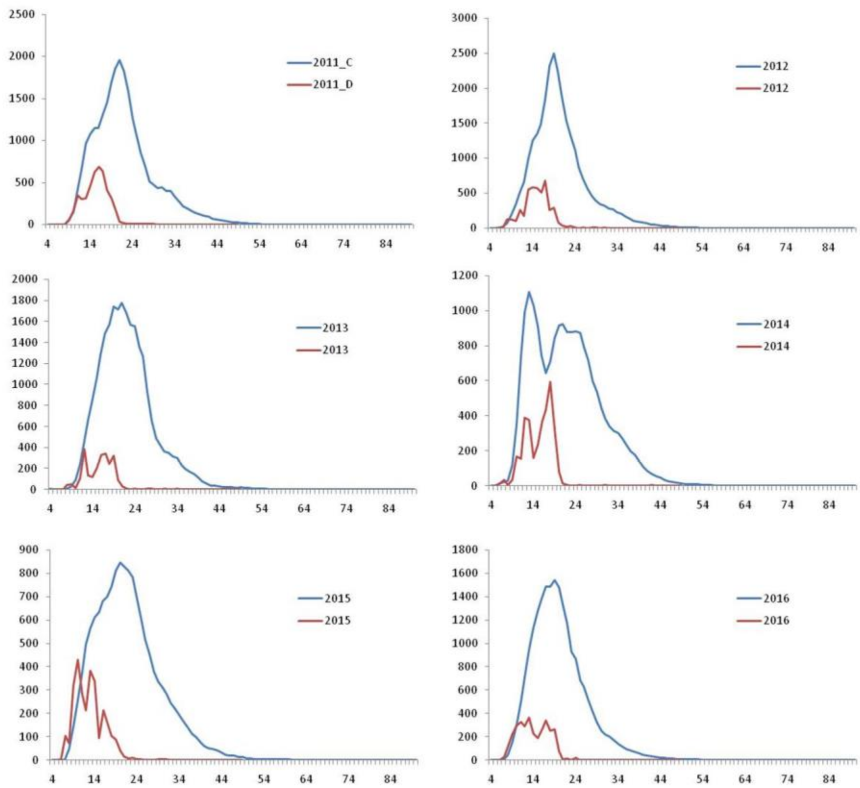


Figure 3. Length frequency distribution (commercial and discard fraction) for the 2011-2016 period from commercial trawl fleet in the geographical sub-area 06 (Northern Spain).

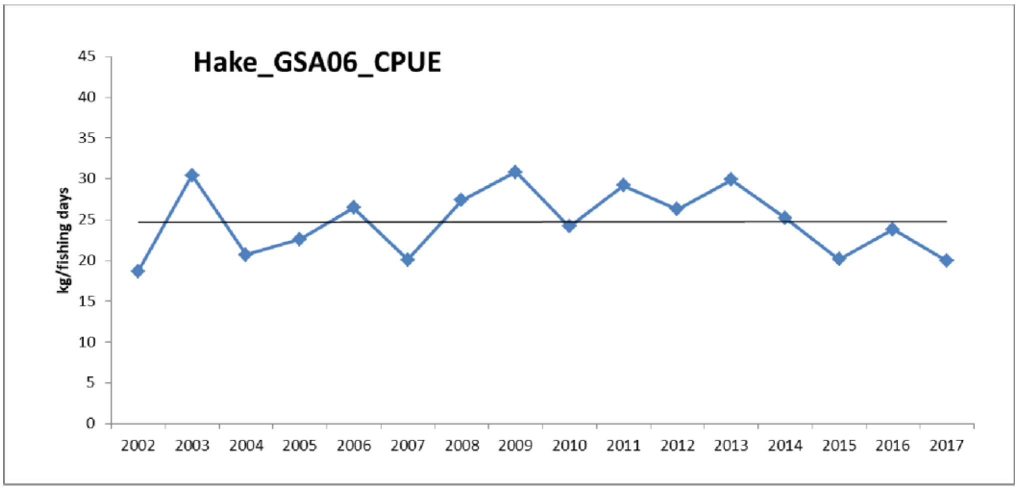
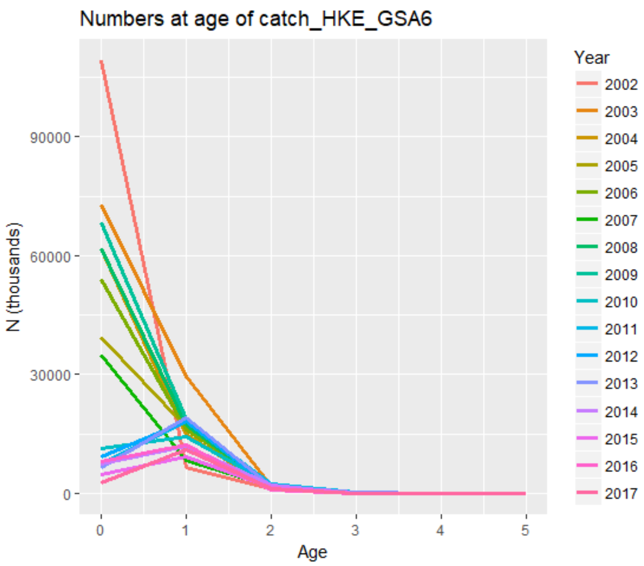
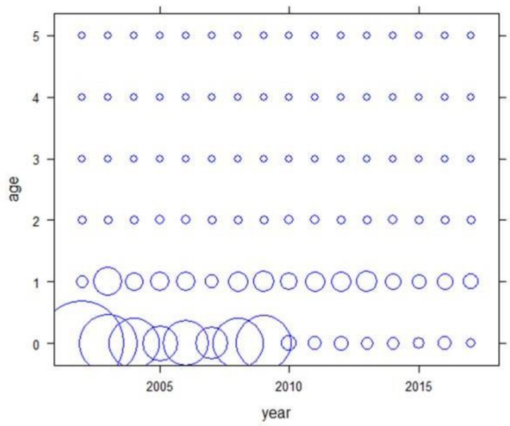


Figure 4.CPUE (kg/day) for the GSA06 subarea. (Trawl, Long lines and Set gillnet fleets)

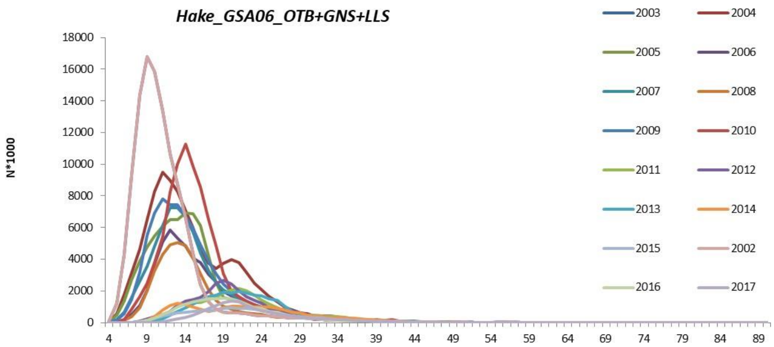


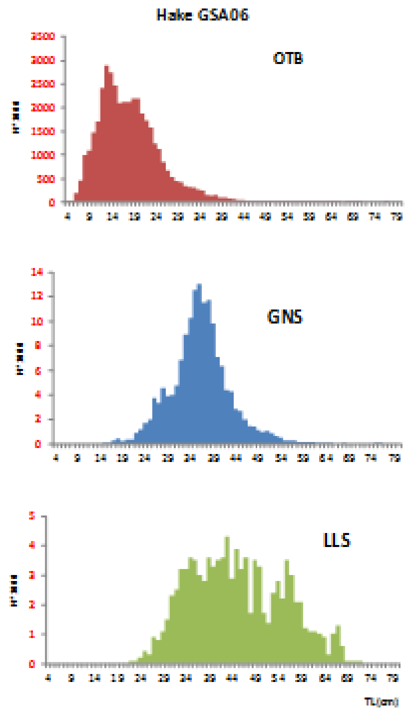


a **b**

Figure 5. a- Catch Trends in the period assessed (Total landings by year. b- Catch matrix (Total landings by age and year).

Landings werelargelycomposed of age 0 immature individuals from 2003 to 2009. However, this pattern changed from age 0 to age 1 from 2010 onwards.





a **b**

Figure 6. a- Length frequency distribution (Total length) of Traw, Long linesl and Gillnet catches in the geographical sub-area 06 (Northern Spain) for the period (2003-2017). b- Length frequency distribution of hake catches by gear in the GSA06 area (average 2014/2016).

Management regulations

- Fishing license: fully observed
- Engine power limited to 316 KW or 500 HP: not fully observed
- Mesh size in the codend (40 mm square or 50 mm rhomboidal): fully observed
- Fishing forbidden within upper 50 m depth: not fully observed
- Time at sea (12 hours per day and 5 days per week): fully observed
- Minimum landing size (20 mm CL), (EC regulation 1967/2006): mostly fully observed

4. Fisheries independent information

4.1 MEDITS_ES

4.1.1 Brief description of the direct method used

The Spanish Institute of Oceanography carries out two scientific surveys under the Data Collection Regulation: MEDITS and MEDIAS. Both are international coordinated surveys.

MEDITS is an international bottom trawl survey, the IEO is involved in it from 1994. The survey takes place in all EuropeanMediterranean countries and the main target species are the demersal species.

The Spanish Medits survey carries out about 170 – 180 hauls in spring. It samples 4 GSAs, including Balearic Islands, and the sampling procedure is based on the common methodology included in the MEDITS instruction manual. The GSAs sampled are: GSA1, GSA2, GSA5 and GSA6.

Direct methods: trawl based abundance indices

Table 4.1-1: Trawl survey basic information

Survey	MEDITS_ES	**Trawler/RV**	Trawler
Sampling season	MAY-JUN		
Sampling design	Random stratified with number of haul by stratum proportional to stratum surface		
Sampler (gear used)	GOC-73		
Cod –end mesh size as opening in mm	20		
Investigated depth range (m)	40-750		

Table 4.1-2: Trawl survey sampling area and number of hauls

Stratum	Total surface (km^2)	Trawlable surface (km^2)	Swept area (km^2)	Number of hauls
A (-50m)	3026			9
B (50-100m)	11314			34
C (100-200m)	6889			22
D (200-500 m)	6719			17
E (+500m)	4558			8
Total (km^2)	32506			90

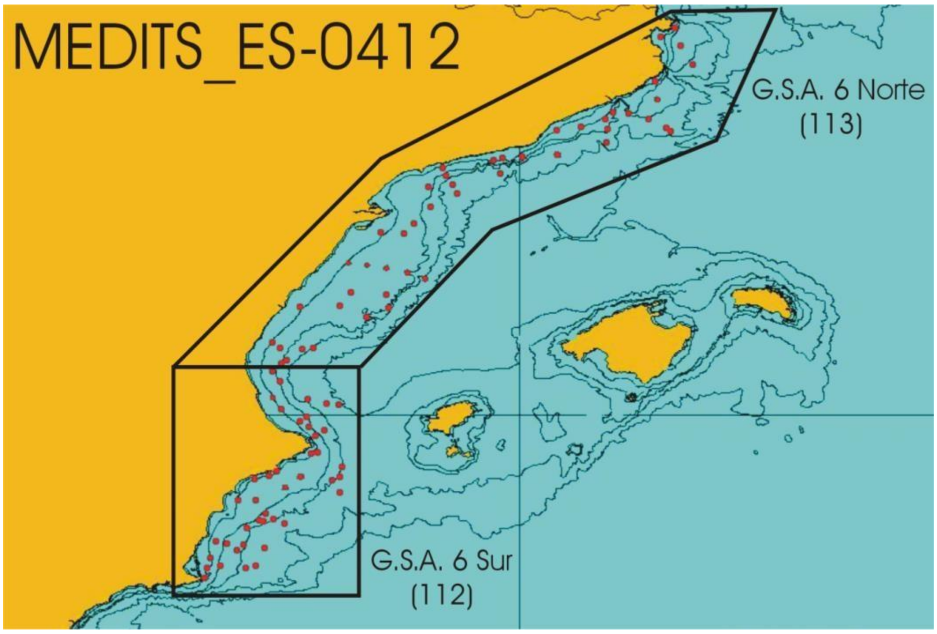


Figure 7.MEDITS_ES in the GSA 6 “Northern Spain”.Hauls.

4.1.2 Spatial distribution of the resources

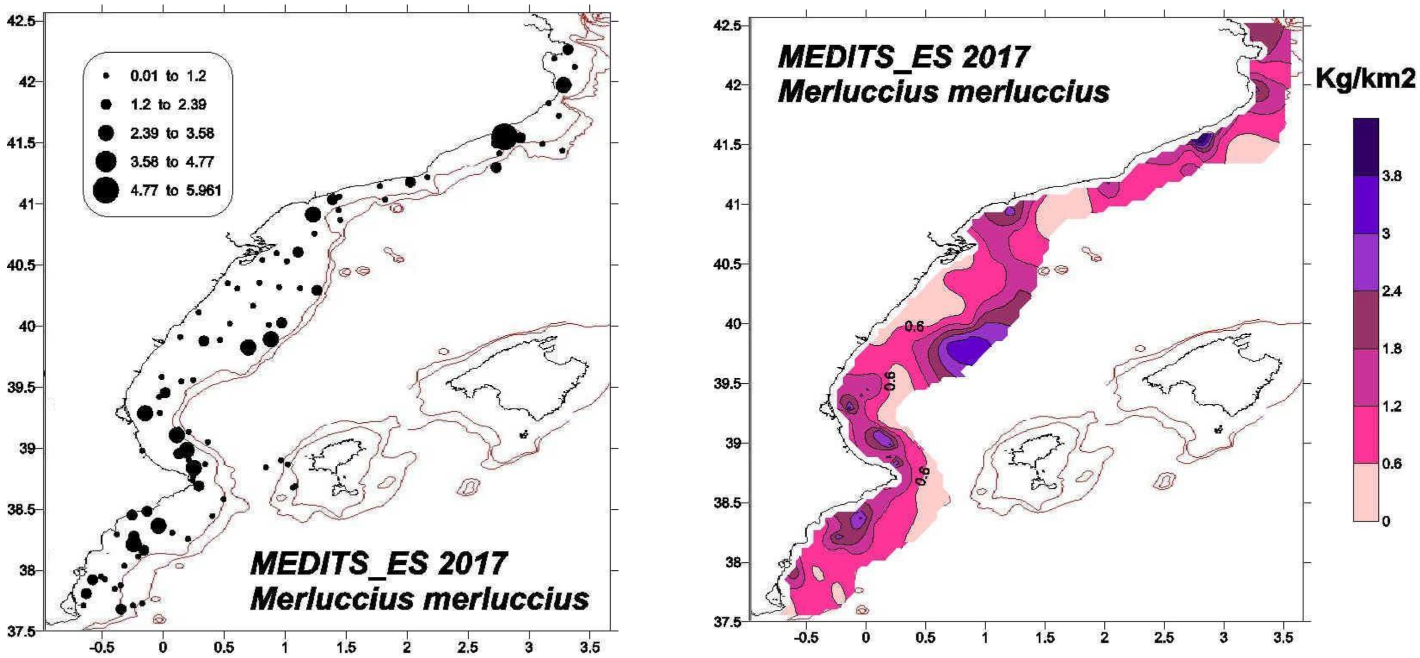


Figure 8.MEDTIS_ES trawl survey 2017. Spatial distribution of estimated abundances.

4.1.3 Historical trends

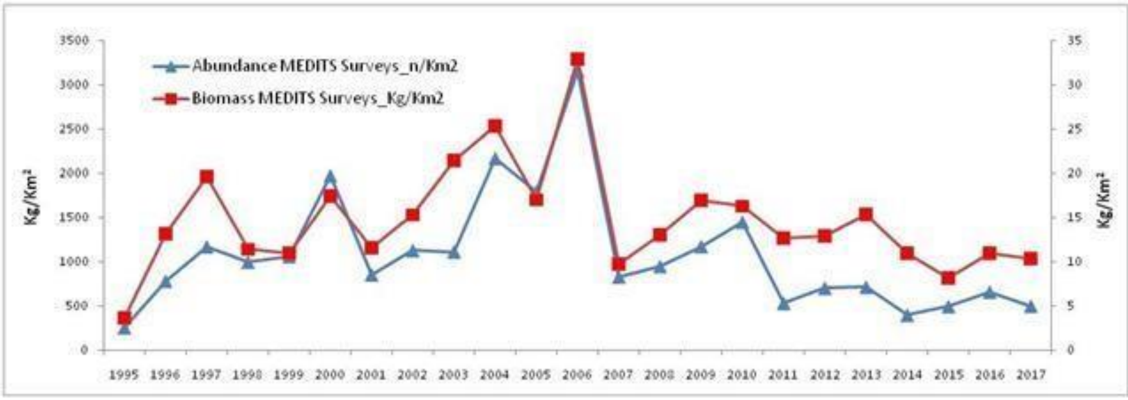


Figure 9. MEDITS_ES survey indices.Trends in abundance indices by age for the assessed period (above) and biomass and abundance indices (kg/day) &(n/km^2) for 1995-2017 period (below).

5. Ecological information

5.1Protected species potentially affected by the fisheries

5.2Environmental indexes

6. Stock Assessment

An Extended Survivor Analysis (XSA) tuned with MEDITS survey data was carried out over the period 2002-2017, considering age classes from 0 to 5+. The statistical catch at age model a4a, (non-linear model implemented in R/FLR/ADMB, (flr-project.com)), was also used to model the stock (1995-2017 period).The results obtained including the quality indicators of the adjustment using a4a, as well as the comparison with the XSA results, can be found in the section 6.1.9.

6.1 Extended Survivor Analysis (XSA)

Ad hoc methods for tuning single species VPA's to fleet catch per unit effort (CPUE) data are sensitive to observation errors in the final year because they make the assumption that the data for that year are exact. In addition, the methods fail to utilize all of the year class strength information contained within the catches taken from a cohort by the tuning fleets.

Extended Survivors Analysis (XSA), (Shepherd, 1992,1999), an extension of Survivors Analysis (Doubleday, 1981), is an alternative approach which overcomes these deficiencies. In general, the algorithms used within the *ad hoc* tuning procedures, exploit the relationship between fishing effort and fishing mortality.

XSA focuses on the relationship between catch per unit effort and population abundance, allowing the use of a more complicated model for the relationship between CPUE and year class strength at the youngest ages. (Darby and Flatman, 1994).

The XSA assessments can be performed using the Lowestoft VPA Suite stock assessment software package (Darby and Flatman, 1994) and the open-source framework FLR (Fisheries Library for R) (Kett*et al*, 2007). FLR packages were also can used to perform Exploratory Data Analysis, Sensitivity Analysis, Retrospective Analysis, Reference Points Estimation and Short Term Projections.

Shepherd J. G., 1999. Extended survivors analysis: An improved method for the analysis of catch-at-age data and abundance indices. ICES J. Mar. Sci 56: 584–591.

Darby, C. D., and S. Flatman. "1994. Virtual population analysis: version 3.1 (Windows/DOS) user guide." *Info.Tech. Ser. MAFF Direct.Fish. Res., Lowestoft* 1: 85.

Kell L.T., Mosqueira I., Grosjean P., Fromentin J-M., Garcia D., Hillary R., Jardim E., Pastoors M., Poos J.J., Scott F. & Scott R.D. 2007. FLR: an open-source framework for the evaluation and development of management strategies. *ICES J. of Mar. Sci. 20: 289-290.*

6.1.1 Model assumptions

✓ *Imput Parameters*

- Landings time series 1995-2017 (official landings).
- Length distributions 2002-2017 (monthly onboard and port sampling).
- Catch-at-Length data converted to Catch-at-Age data using cohort slicing.
- Growth Parameters from Mellon et al, 2010 and DCF-Spain (2012).
- Biological sampling 2003-2017 for Maturity and Length-Weight relationships.
- M vector by age using PROBION spreadsheet *(Abella et al, 1997*).
- Tuning data 1995-2017 from MEDITS survey and commercial fleet.

✓ *Main Settings*

- Ages 0 to 5+ (Age 5 is a Plus Group)
- Fbar 0-3.
- Catchability independent of size and age for ages older than 1 and 2 respectively.
- Survivor estimates shrunk towards the mean F of the final 3yrs or the 3 oldest ages.
- S.E. of the mean to which the estimates are shrunk = 1.5.
- Minimum standard error for population estimates derived from each fleet = 0.3.

6.1.2 Scripts

FLR (Fisheries Libraries in R)

FLR Project -http://flr-project.org/

6.1.3 Input data and Parameters

6.1.4 Tuning data

6.1.5 Results

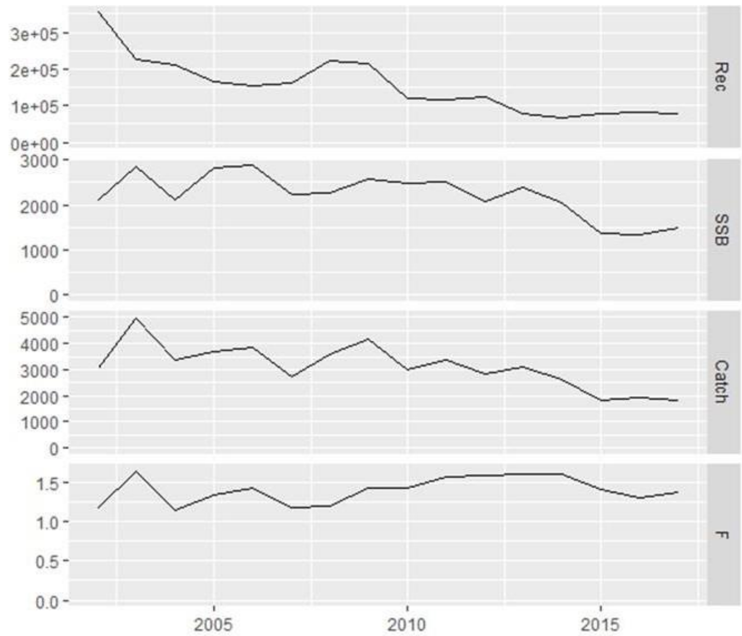


Figure 10.XSA results.Total spawning stockbiomass (SSB) and yield (Y) showed a decreasing trend from 2009 to 2015. Recruitment (R) showed a drastic decline from the maximum observed in 2002. but seems to have stabilized during the last three years (around 238000 thousands).

Fishing mortality (F_{bar0-3}) shows an increasing trend from 2004 to 2012 and keeping in values close to 1.4in the last seven years.

6.1.6 Robustness analysis

6.1.7 Retrospective analysis, comparison between model runs, sensitivity analysis, etc.

6.1.7.1 Retrospective analysis.

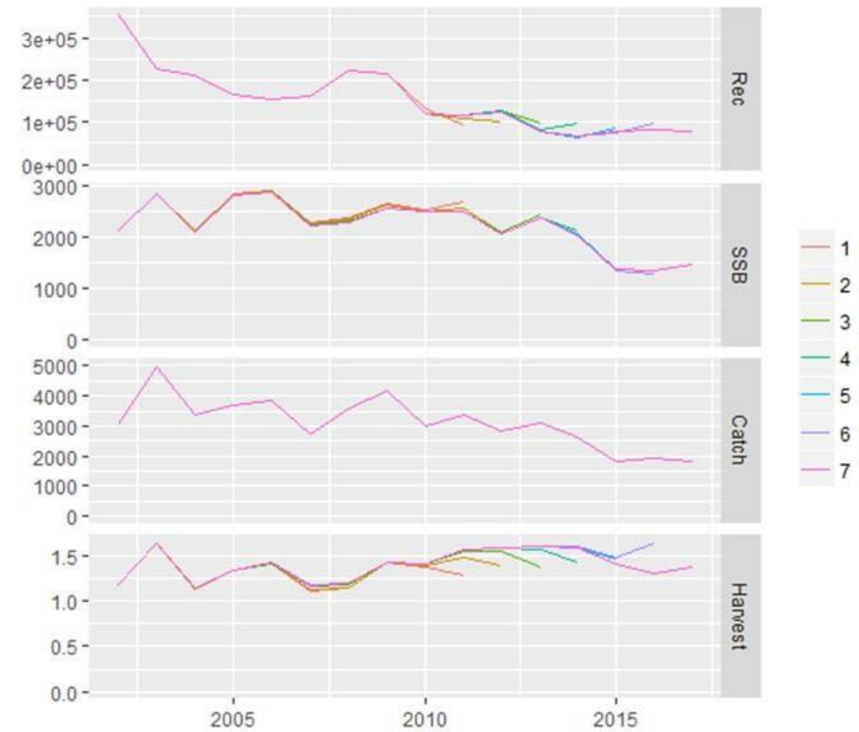


Figure 11. Retrospective analysis was applied in the XSA model for the hake in GSA06 and the period 2011-2017 up to 7 years backward. Results show no particular retrospective bias in spawning biomass (SSB) and recruitment (R). Fishing mortality(F)seems to be slightly overestimated in 2016.

6.1.7.2 Sensitivity analysis.

Sensitivity analysis on different qage, fse and shk.ages values.

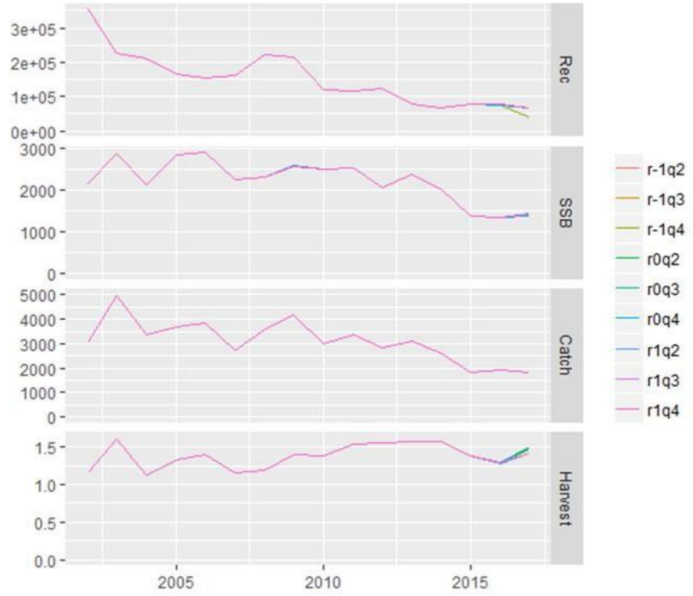


Figure 12. Sensitivity analysis on different *catchability independent of “rage” and “qage”* values.

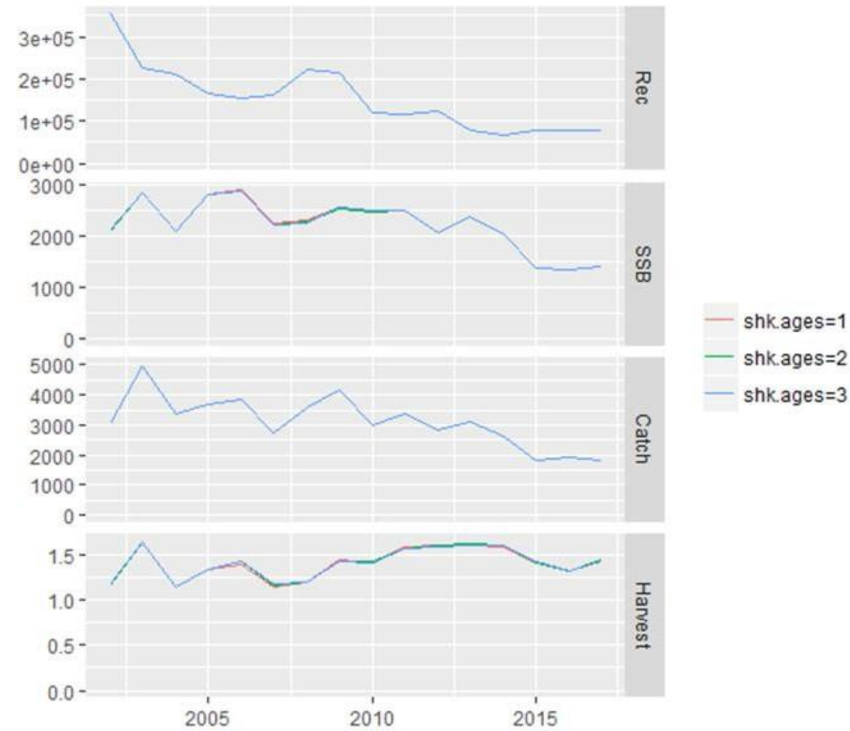


Figure 13. Sensitivity analysis on different *shrinkage ages “shk.ages”*values.

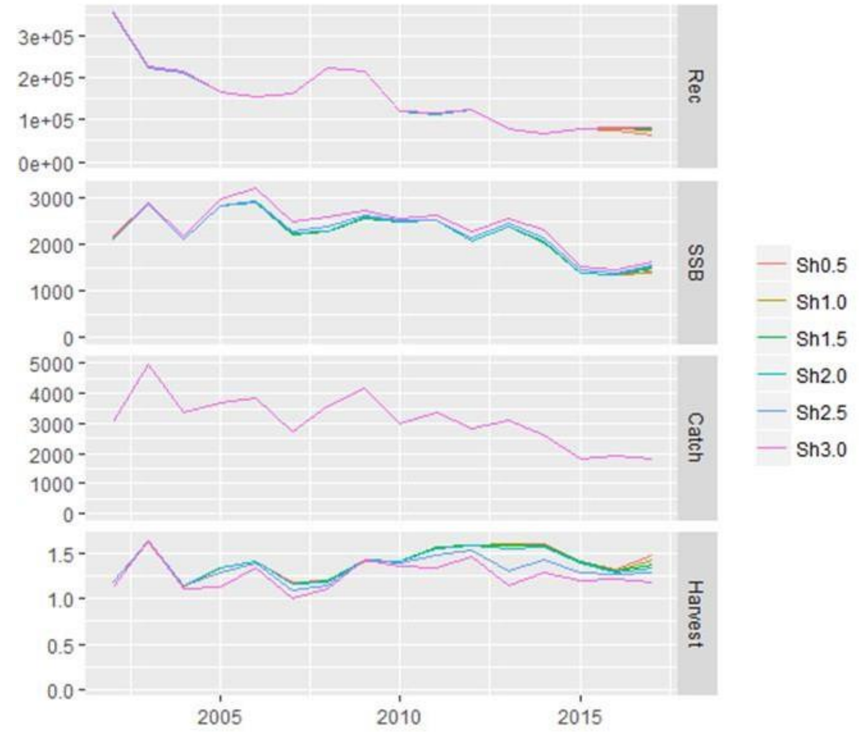


Figure 14. Sensitivity analysis on different *shrinkage weight "fse" values.*

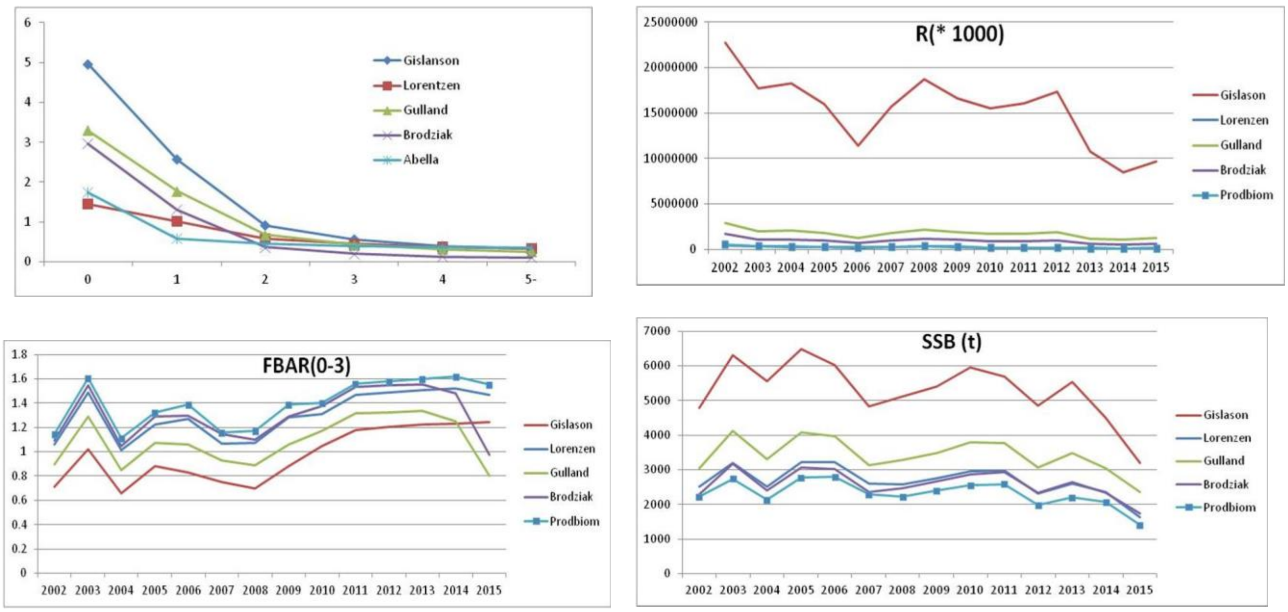


Figure 15.Natural mortality (M). Sensitivity analysis carried out using the stock assessment (2002-2015).

6.1.8 Assessment quality

Tunning Data analysis.

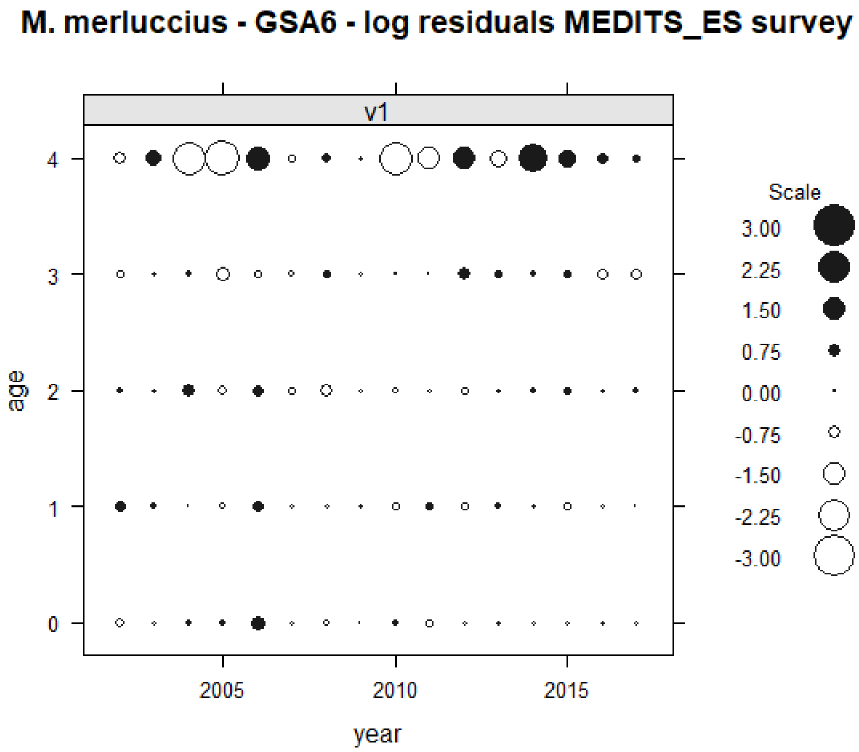


Figure 16. Catchability residuals plotsby fleet (MEDITS_ES Surveys in the GSA06 area.

6.1.9 Stock assessment using statistical cacth at age model (a4a)

In order to improve the stock assessment process by a reliability test, a statistical catch-at age model implemented in R (a4a), making use of the FLR platform (Kell*et al*., 2007), was used using the XSA inputs data set (2002-2017 period) and adding the landings and surveys data for the 1995-2001 period, rebuilding the mean weights with the 2002-2008 period (Fig17).

The results obtained using both models, showed relative good fit for most of the years and stock variables. Using a4a, it was possible to adding to the model the landings and surveys abundance indices series for the 1995-2001 period. (Fig 18).

The Y/R comparison analysis showed also good fit, the main difference was observed for the Y/R absolute values obtained. The calculated reference points $F_{0.1}$ and F_{max} were similar. (Fig. 19). Compared to XSA, a4a runs forward and allow to reach a better stability for last years estimates, thus the final model considered for the assessment was a4a.

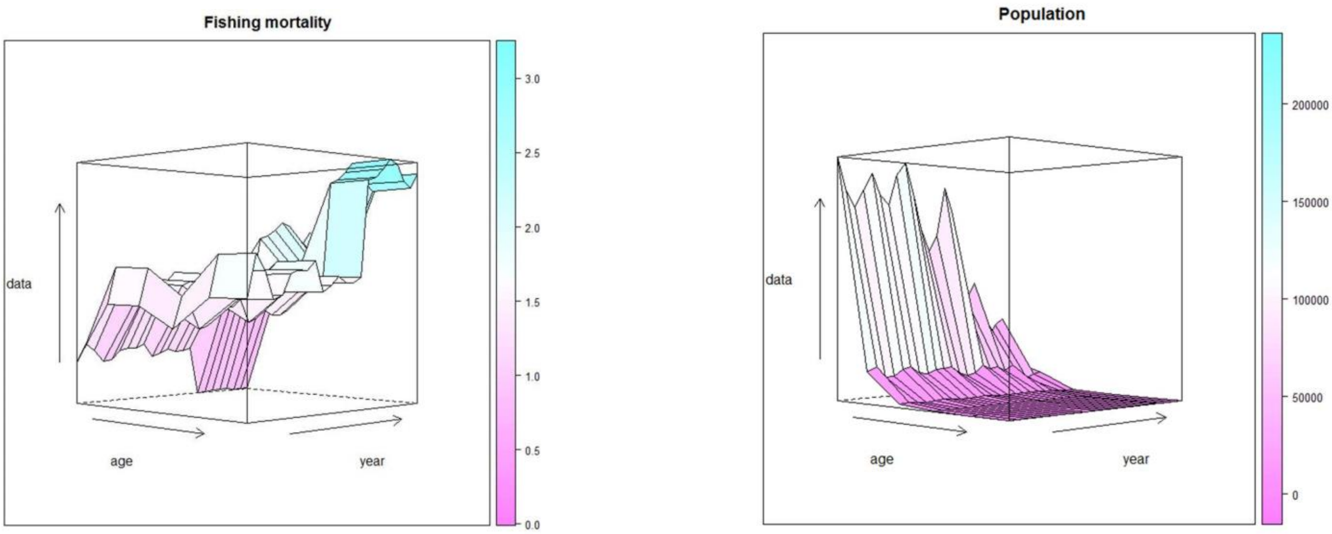


Fig. 17. 3D contour plot of estimated fishing mortality (F) (separable model) at age and year (left); and population abundance by age and year. (Catchabillty smoother age model) for *Merlucciusmerluccius* in the GSA6 (Northern Spain)

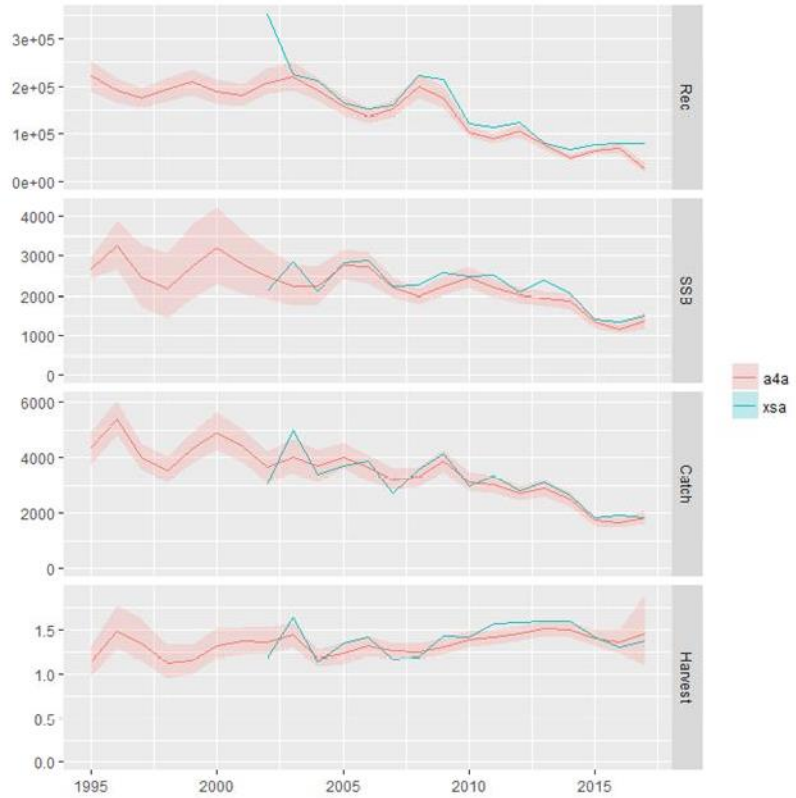


Figure 18 Hake in GSA6. Comparative stock summary results from XSA and a4a.

a4a. Diagnostic

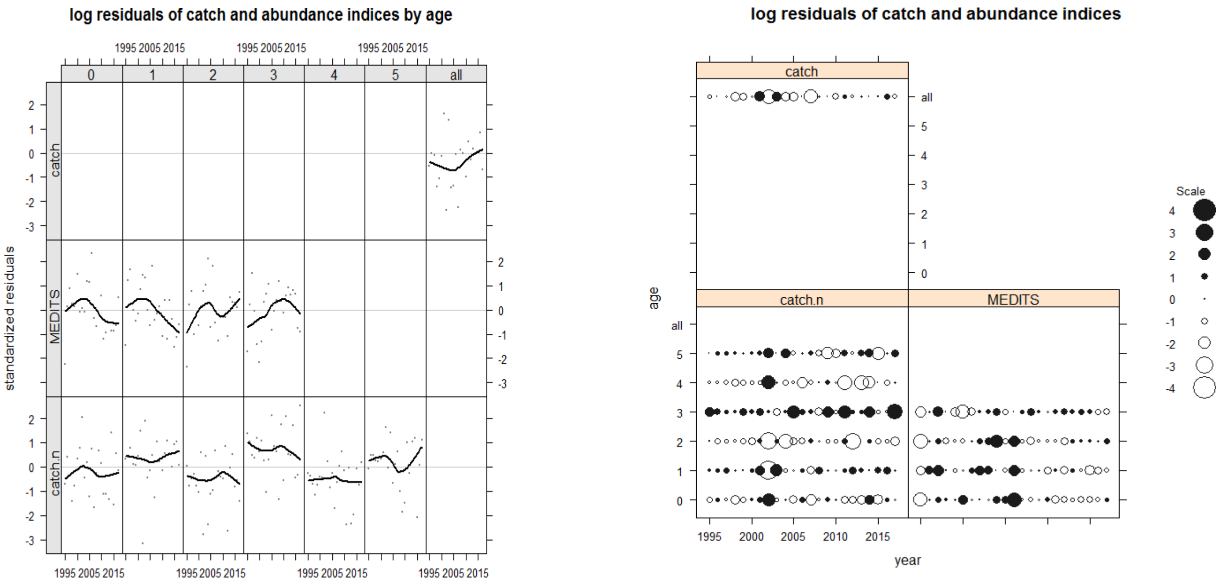


Figure 19. Standardized residuals for abundance indices (MEDITS survey in GSA6) and for catch numbers for hake in GSA6 (left) and bubbles plot of standardized residuals for abundance indices (MEDITS GSA6)Standardized residuals for abundance indices (MEDITS survey in GSA6) and for catch numbers for hake in GSA6(right).

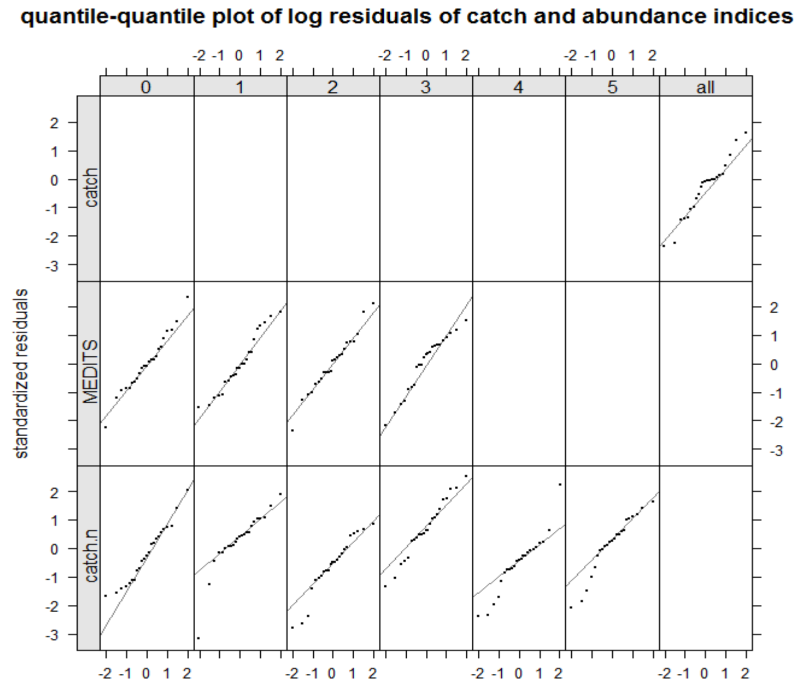


Figure20. Quantile-quantile plot of standardized residuals for abundance indices (MEDITS survey in GSA6) and for catch numbers. Each panel is coded by age class, ots represent standardized residuals and lines the normal distributions quantiles.

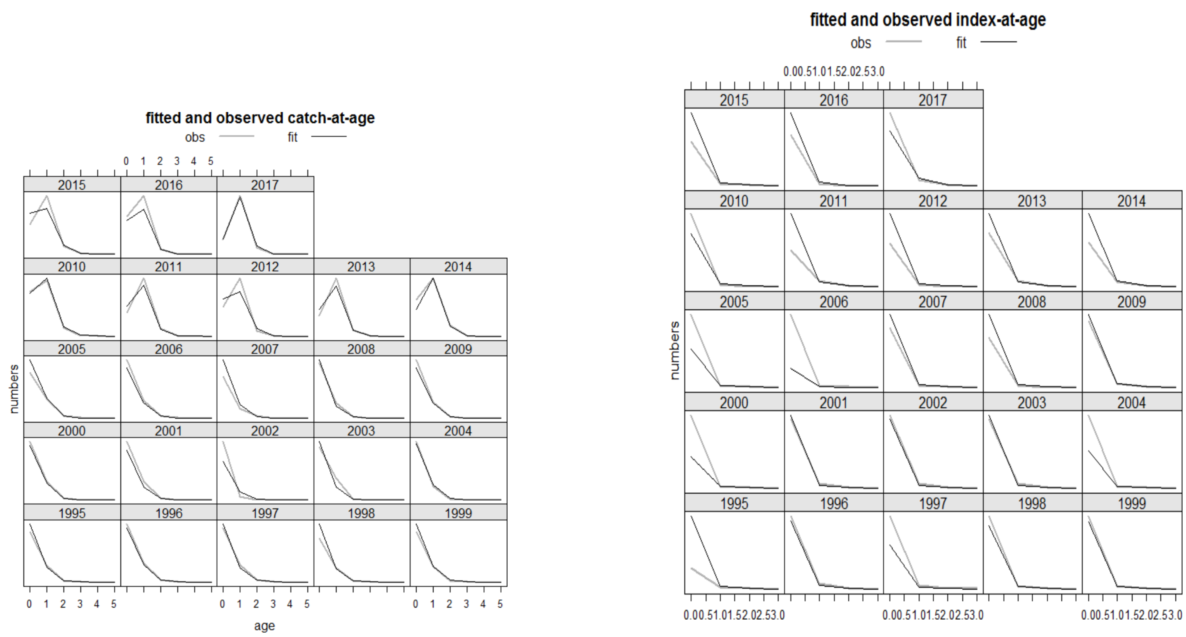
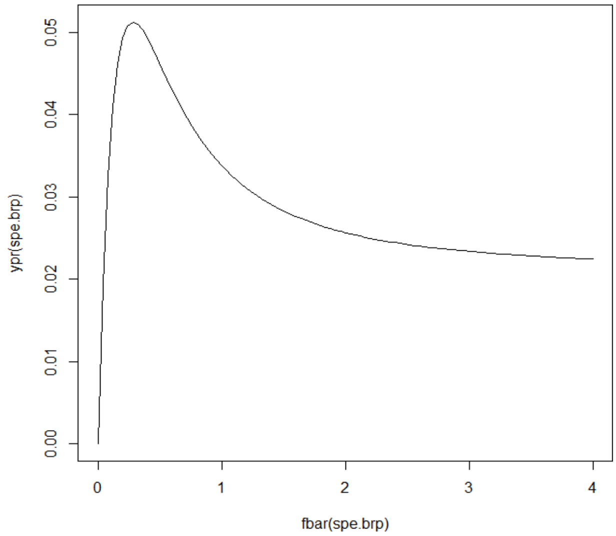
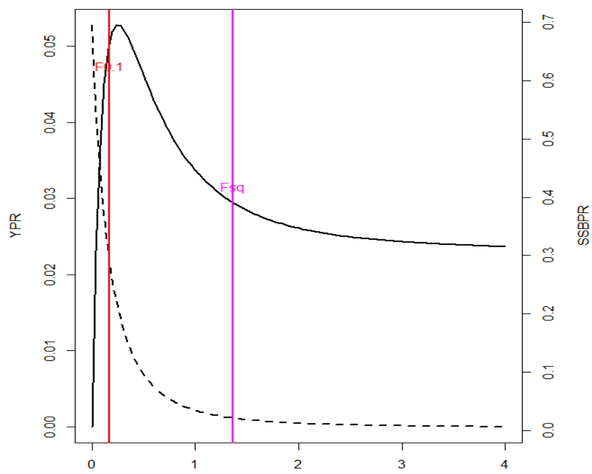


Figure 21. Predict and observed catch-at-age (left) and abundance-at-age (right).

Yield per recruit analysis.

Yield per recruit analysis was conducted based on the exploitation pattern resulting from the XSA and a4a model and population parameters. Minimum and maximum ages for the analysis were considered to be age group 0 and 5. Stock weight at age, catch weight at age and maturity ogive was estimated as mean values between 2002 and 2017. Natural mortality vector values were applied per age group using ProBiom (Abella et al., 1998). Fishing mortalities were the mean exploitation pattern F between 2015 and 2017. Reference F ($F_{current}$) was considered to be F for ages 0 to 3 during the last years. The result was obtained using FLR libraries for the XSA outputs and VBYPR/NOOA software for the a4a outputs.





rp_table	F	Yield	Recruitment	SSB	Biomass
virgin	0	0	136529	94905	101178
msy	0.253	7204	136529	28687	34790
crash	198.240	3420	136529	0	3277
f0.1	0.195	6834	136529	40865	47021
fmax	0.253	7204	136529	28686	34790
spr.30	0.255	7204	136529	28471	34574
Fcurrent (SQ)	1.400				

rp_table (a4a)	F	Yield	Recruitment	SSB	Biomass
virgin	0.000	0	130357	51296	57789
msy	0.283	6680	130357	19969	26248
crash	136.060	3267	130357	0	3476
f0.1	0.196	6396	130357	25987	32324
fmax	0.283	6680	130357	19969	26248
spr.30	0.376	6502	130357	15389	21610
Fcurrent (SQ)	1.400				

Figure22 Equilibrium Yield (t) vs F. Tables including the corresponding $F_{0.1}$ reference point calculated with a4a (left) and XSA (right) outputs.

Current F (F_{ref}= $F_{BAR\ 0\text{-}3}$= 1.4) exceeds $F_{0.1}$ reference point (0.2) indicating the stock is subjected to over-fishing (or overexploitation) from a precautionary point of view.

7. Stock predictions

7.1Short term predictions

Deterministic projections for three years (2018-2020) were produced using XSA outsputs ($F_{current}$= 1.4). These projections are based on the arithmetic mean of recruitment, catches and weights at age of the last three years (2015-2017). F current is the geometric mean of $Fbar_{0\text{-}3}$ during the last three years.

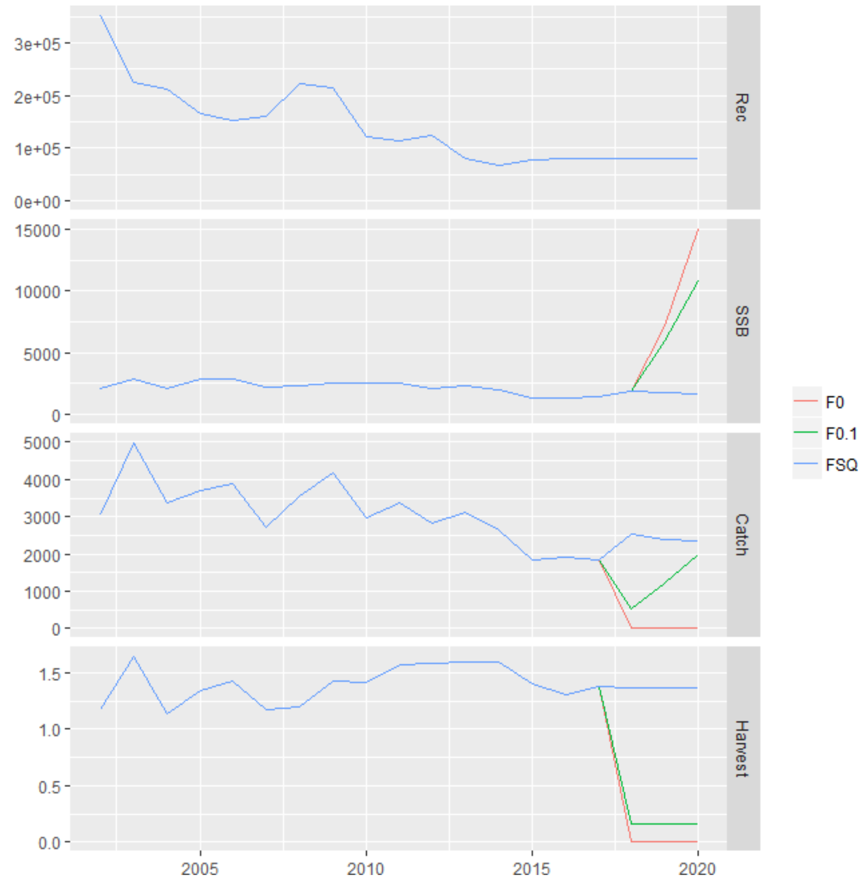


Figure 23.Short term predictions results.

Fishing at $F_{0.1}$ from 2018 to 2020 would generate a decrease in catches in 2018 but increase in the follow two years and a significativeincrease in SSB for the 2018-2019 period.

7.2Medium term predictions

7.3Long term predictions

Medium and long term forecast depends on having a reasonable Stock-Recruitment relationship (SSR). European hake *Merlucciusmerluccius*does not show a reasonable SRR (Fig 25) and therefore no medium or long term predictions were performed for this species.

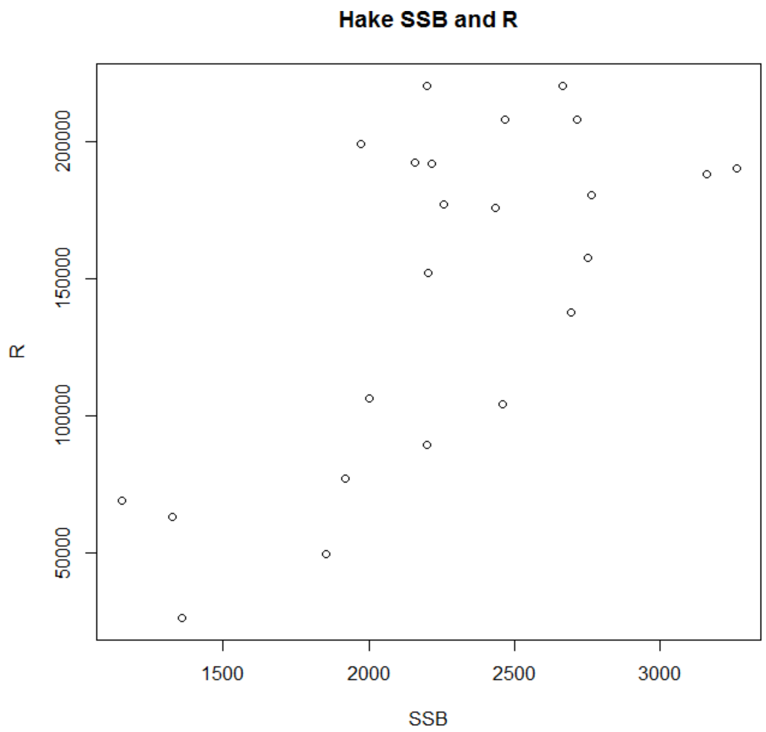


Figure 24. Stock-Recruitment Relationship

Draft scientific advice. a4a results.

Based on	Indicator	Analytic al reference point(name and value)	Current value from the analysis(name and value)	Empirical reference value(name and value)	Trend(time period)	Stock Status
Fishing mortality	Fishing mortality a4a analysis Fc= Last 3 year	($F_{0.1}$ = 0.2) (Fc=1.4 (±0.3))	Fc/$F_{0.1}$=7		3	IO _O_h
	Catch (t) (2017)		1859	33% percentile, 3158 66% percentile, 3934	22 22	
Stock abundance	Biomass(t) (2017)		3344	33% percentile; 6391 66% percentile; 7783	22 22	O_ O_l
	SSB (t) (2017)		1353 (+/- 178)	33% percentile; 2196 66% percentile; 2475	22 22	O_ O_l
Recruitment	$R_{(2017)}$	thousands	26048	33% percentile; 114455 66% percentile; 189378	22 22	
Final Diagnosis		- In overexplotation($F_{current}$>$F_{0.1}$) - Relative lowbiomass;$SSB_{current(2017)}$ = 1353 (t); SSB at 33rd percentile = 2196(t)				
Scientific advice for management		- Reduce $F_{current}$ towards $F_{0.1}$ - Progressive reduction of the fishing effort				

Explanation of codes

Trend categories

1) N - No trend
2) I - Increasing
3) D – Decreasing
4) C - Cyclic

Stock Status

Based on Fishing mortality related indicators

1) **N - Not known or uncertain** – Not much information is available to make a judgment;
2) **U - undeveloped or new fishery** - Believed to have a significant potential for expansion in total production;
3) **S - Sustainable exploitation**- fishing mortality or effort below an agreed fishing mortality or effort based Reference Point;
4) **IO –In Overfishing status**– fishing mortality or effort above the value of the agreed fishing mortality or effort based Reference Point. An agreed range of overfishing levels is provided;

Range of Overfishing levels based on fishery reference points

In order to assess the level of overfishing status when $F_{0.1}$ from a Y/R model is used as LRP, the following operational approach is proposed:

- If $Fc^*/F_{0.1}$ is below or equal to 1.33 the stock is in **(O_L): Low overfishing**
- If the $Fc/F_{0.1}$ is between 1.33 and 1.66 the stock is in **(O_I): Intermediate overfishing**
- If the $Fc/F_{0.1}$ is equal or above to 1.66 the stock is in **(O_H): High overfishing**

*Fc is current level of F

5) **C- Collapsed**- no or very few catches;

Based on Stock related indicators

1) **N - Not known or uncertain:** Not much information is available to make a judgment
2) **S - Sustainably exploited:** Standing stock above an agreed biomass based Reference Point;
3) **O - Overexploited**: Standing stock below the value of the agreed biomass based Reference Point. An agreed range of overexploited status is provided;

Empirical Reference framework for the relative level of stock biomass index

- **Relative low biomass:** Values lower than or equal to 33rd percentile of biomass index in the time series **(O_L)**
- **Relative intermediate biomass:**Values falling within this limit and 66th percentile **(O_I)**
- **Relative high biomass:**Values higher than the 66th percentile **(O_H)**

4) **D – Depleted**: Standing stock is at lowest historical levels, irrespective of the amount of fishing effort exerted;
5) **R –Recovering:** Biomass are increasing after having been depleted from a previous period;

Agreed definitions as per SAC Glossary

Overfished (or overexploited) *- A stock is considered to be overfished when its abundance is below an agreed biomass based reference target point, like B0.1 or BMSY. To apply this denomination, it should be assumed that the current state of the stock (in biomass) arises from the application of excessive fishing pressure in previous years. This classification is independent of the current level of fishing mortality.*

Stock subjected to overfishing (or overexploitation) *- A stock is subjected to overfishing if the fishing mortality applied to it exceeds the one it can sustainably stand, for a longer period. In other words, the current fishing mortality exceeds the fishing mortality that, if applied during a long period, under stable conditions, would lead the stock abundance to the reference point of the target abundance (either in terms of biomass or numbers)*