Stock Assessment Form

Demersal species

HAKE – GSA1

Reference year:2019

Reportingyear:2021

Pérez Gil, J.L., Serna-Quintero, J.M., García, C., González, M., Torres, P., García, T., Acosta, J., Galindo, M., León, E., Ciércoles, C., Meléndez, M.J. and Martínez, G.

**** IEO- Centro Oceanográfico de Málaga, Puerto pesquero S/N, Fuengirola,Málaga. (Spain.)***

European hake (*Merluccius merluccius* (Linnaeus, 1758)) is one of the target demersal species of the Mediterranean fishing fleets, largely exploited in GSA1 mainly by otter bottom trawlers (91% landings) on the shelf and slope, and by small-scale fisheries using gillnets (6%) and long lines (3%) on the shelf (average 2017-2019). The bottom trawl fleet segment in the GSA1 area is made up of 120 boats (2019), averaging 35 GRT and 176 HP. Catches of European hake show a decreasing trend from 2012 to 2017, with a slight increase in 2018. In 2019 there has been a decrease to 274 tons.

The state of exploitation of this stock was assessed by means of VPA Extended Survivor Analysis (XSA) (Shepherd, 1999). The software used was the Lowestoft suite (Darby and Flatman 1994) and FLR (Fisheries Libraries in R). The XSA tuning was performed using abundance indices series from MEDITS bottom trawl surveys. Yield-per-Recruit (Y/R) analyses was conducted based on the exploitation pattern resulting from XSA model and population parameters.

The assessment was revised from previous assessment done in 2015. A new set of growth parameters (absolute and relative) was incorporated in the update assessment.
Catches and SSB of European hake show a decreasing trend from 2012 to 2017, with a slight increase in 2018. Recruitment (R) showed fluctuations over the series and steep decline in recent years. Fbar (0-2) in last yearsfluctuates around values close to 1.

Y/R analysis showed that the $F_{current}$= (1.2) exceeds the Y/R $F_{0.1}$ reference point = (0.2). The resulting ratio $F_{0.1}/F_{current}$ = 6, suggesting that for *Merlucciusmerluccius* stock in GSA1, the current exploitation level is in over exploitation and the stock size is overexploited (Relative low biomass).

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Stock assessmentform

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 Alboran Sea GSA 1		
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 (tuning with MEDITS indices) and Y/R		
Authors:		
Pérez Gil, J.L., Serna-Quintero, J.M., García, C., González, M., Torres, P., García, T., Acosta, J., Galindo, M., León, E., Ciércoles, C., Meléndez, M.J. and Martínez, G.		
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2 Stock identification and biological information

2.1 Stock unit

The assessment cover the complete stock unit in the GSA1 (Northern Alboran Sea).

Currently, European hake stock boundaries are not evident according to dynamic biological spatial structure. Among some subregions of the Alboran sea, GSA1 and GSA3, connectivity processes have been detected (Muñoz et al., 2018; Hidalgo et al., 2019)

Muñoz M., Reul A., Gil de Sola L., Lauerburg R. A. M., Tello O., Gimpel A.,& Stelzenmüller V. (2018). A spatial risk approach towards integrated marine spatial planning: A case study on European hake nursery areas in the North Alboran Sea. Marine Environmental Research, 142, 190–207. https://doi.org/10.1016/j.marenvres.2018.10.008

Hidalgo M., Ligas A., Bellido J.M., Bitetto I., Carbonara P., Carlucci R., Guijarro B., Jadaud A., Lembo J., Manfredi C., Esteban A., Garofalo G., Ikica Z., García C., Gil de Sola L., Kavadas S., Maina I., Sion L., Vittori S., Vrgoc N. (2020). Size-dependent survival of European hake juveniles in the Mediterranean Sea. Sci. Mar. 83S1: 207-221.

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 peacks 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	*1.9*	*0*
1	*0.7*	*0.2965*
2	*0.39*	*0.9855*
3	*0.29*	*0.9999*
4+	*0.23*	*1*

**It was decided to assume natural mortality (M) to be age-dependent and to derive the mortality vector applying the same procedure for all the age-based analytical assessments considered at the benchmark. Given the large uncertainty around the actual values of natural mortality, it was decided to derive this vector as an ensemble estimate (here a simple average) of different methods, similarly to what was done at the recent benchmark of European hake in the Adriatic Sea. The different methods selected are mostly based on life history invariants, linking mortality rates with different aspects of growth (i.e., von Bertalanffy growth parameters, longevity, mean weight and length at first maturity), and are those described in Gulland (1987), Chen and Watanabe (1989), Lorenzen (1996), the revised version of Abella*et al.* (1997) by Martiradonna (2012), Gislason*et al.* (2008) and Brodziak*et al.* (2011). The reviewers support the group decision to derive natural mortalities using this common rationale. It is important to note that, with this approach, uncertainties in ageing and estimation of growth also affect the value derived for M.

Table 2-2.3: Growth and length weight model parameters

			Sex			
		Units	female	male	Combined	Years
Growth model	L_∞				108*	
	K				0.21*	
	t_0				0.115	
	Data source	*García et al, 2002 **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

The total fishing fleet in GSA01 and GSA02 accounts for a total of 645 vessels. The fleet is composed mainly of artisanal vessels between 6 and 12 m of overall length and trawlers and purse seiners between 18 and 24 m of overall length. The number of vessels in this area has been continuously decreasing in the last decades, from more than 1045 vessels in 2004 to 645 in 2017. The biggest reductions have taken place in the set longliners, purse seiners, and bottom trawlers.
Bottom otter trawl is the second fleet in the number of vessels with respect to the other fishing modalities developed in the area, being 120, the biggest in tonnage and power. Also it is thesecond fleet in landings(the first one of the demersal fisheries) and the first fleet in economic value of the landings. (González et al, 2020)*.

*González Aguilar, M., García Ruiz, C., García Jiménez, M.T., Serna Quintero, J.M., CiércolesAntonell, C. & Baro Domínguez, J. (2021). Demersal Resources. In: Alboran Sea, Ecosystems and Marine Resources (J.C. Báez; J.T. Vázquez; J.A. Camiñas& M. Malouli, Eds.). Springer.In press.

European hake (*Merlucciusmerluccius* (Linnaeus, 1758)) is one of the target demersal species of the Mediterranean fishing fleets, largely exploited in GSA1 mainly by otter bottom trawlers (91% landings) on the shelf and slope, and by small-scale fisheries using gillnets (6%) and long lines (3%) on the shelf (average 2017-2019). The bottom trawl fleet segment in the GSA1 area is made up of 120 boats (2019), averaging 35 GRT and 176 HP. Catches of European hake show a decreasing trend from 2012 to 2017, with a slight increase in 2018.In the last year there has been a decrease to 274 tons. (Average 2017-2019, 336 tons).

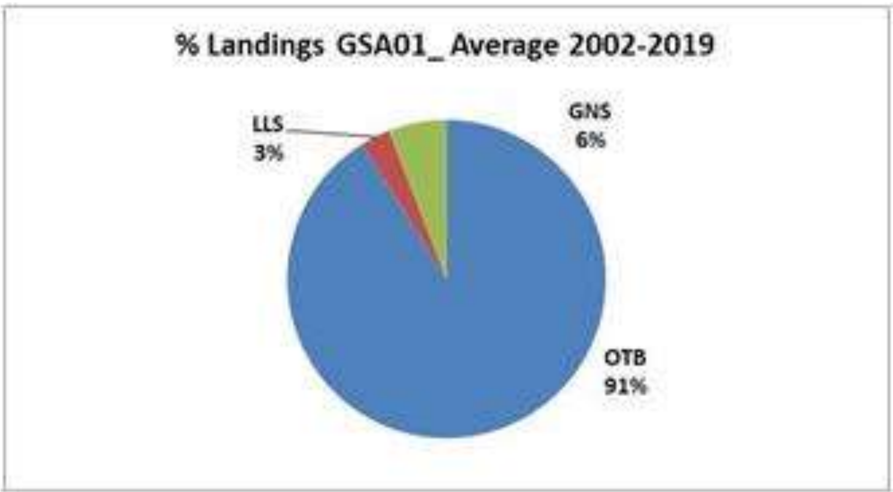


Figure 1.- Percentage landings by fleet in GSA01 for hake (Average 2002-2019). LLS: Set- Longline ; GNS: Gillnet; OTB: Bottom Otter Trawl.

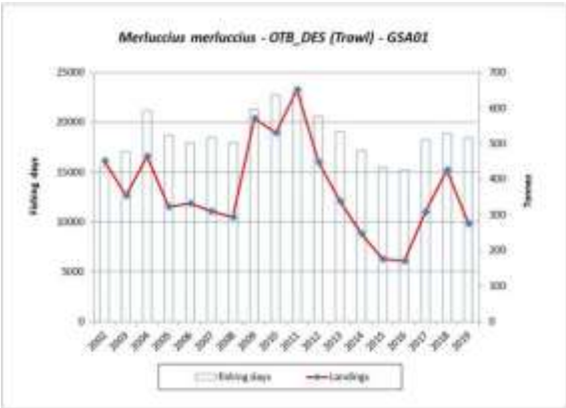
Table 3-1.1: Description of operational units exploiting the stock

	Country	GSA	Fleet Segment	Fishing Gear Class	Group of Target Species	Species
Operational Unit 1*	ESP	01	E-Trawl 12-24 m	03-Trawls	33 – Demersal shelf species	HKE

3-1.2: Catch, bycatch, discards and effort by operational unit in the reference year

Operational Units	Fleet (n° of boats. 2019	Catch (t) average 2017-2019& 2019 species assessed)	Other species caught (names and weight)	Discards (t) average 2017-2019& 2019 (species assessed)	Discards (other species caught)	Effort average 2012-2014 (days)
03-Trawls	120	336 (2017-2019) 274 (2019)		19 (2017-2019) 10 (2019)		18400
Total						

3.2 Historical trends



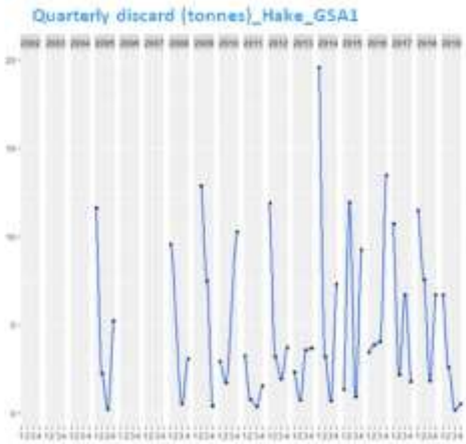


Figure 2.- Hake total landings (left) and quarterly discard (right) for the 2002-2019 period in the GSA1 area.

Landings have shown important oscillations along the period of the data series. However, from 2011 to 2016, a decreasing trend in landings is observed with the minimum values observed in the time series data (170t).

Table 3-2.1: Catches, Landings and Discard as used in the assessment (tonnes)

yeartonnes	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Total Catch - AllGears	496	397.5	503.4	359.4	384.7	340.4	330.5	619.2	576.3	683	461	374.4	282.5	183.4	175.8	299	409.7	289.7
Landings- Assessment segment (OTB)	427.2	353.3	464.2	322.7	332.3	301.7	291.2	563.7	529.9	647.8	437.2	336.8	244.6	172.2	168.5	287.7	397.9	264.5
Discard- Assessment segment (OTB)	0	0.1	0.4	0.2	0.7	8.5	2.2	7	0.9	4.9	10.5	0.8	3.6	2.9	2	21.3	27.6	10
Catch- Assessment segment (OTB)	427.2	353.4	464.5	322.9	333	310.2	293.4	570.7	530.8	652.7	447.7	337.7	248.2	175.1	170.5	309	425.4	274.5
Minimumsize*	-	5	8	6	5	7	8	6	5	6	5	5	5	8	6	6	6	9
Averagesize	-	23.1	21.5	26.3	18.2	24.3	26	24.4	28.1	26.2	26.1	28.4	27.8	26.9	25.5	22.1	23.4	27.1
Maximumsize	-	68	76	76	72	65	76	69	75	71	67	74	76	76	71	62	63	61

*Including discard fraction.

Table 3-2.2: Catches as used in the assessment (tonnes)

Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Fleet; OTB	353.4	464.5	322.9	333	310.2	293.4	570.7	530.8	652.7	447.7	337.7	248.2	175.1	170.5	309	425.4	274.5

Table 3-2.3: Selectivity

L25*	12.19 cm
L50*	13.55 cm
L75*	14.99 cm
Selection factor	2.8

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

Baro J. & I. Muñoz de los Reyes.- 2007. Comparación de los rendimientos pesqueros y la selectividad del arte de arrastre empleando mallas cuadradas y rómbicas en el copo. InformesTécnicos. InstitutoEspañol de Oceanografía, 188: 23 pp.

Discards

Discards were included in the assessment. The percentage of discards (mainly caught by trawlers) wasaround 4% (average 2015-2019).

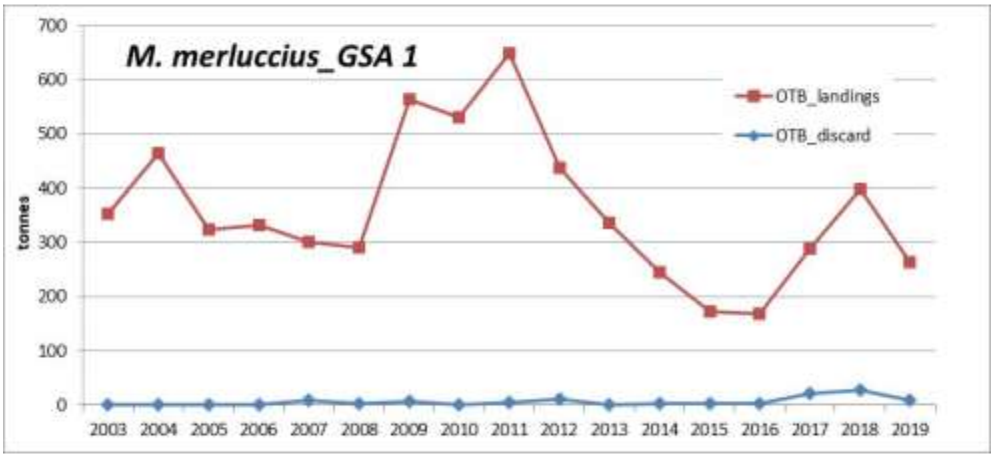


Figure 3.-Catch an landings for Hake in GSA 1 (Bottom otter trawl fleet).

3.3 Imput data.

Information at length is available from 2003 onwards (Figure 4). Discards have been included in the total catches and the catches at length raised to the total with the sum of products correction. SOP corrections were similar in all years

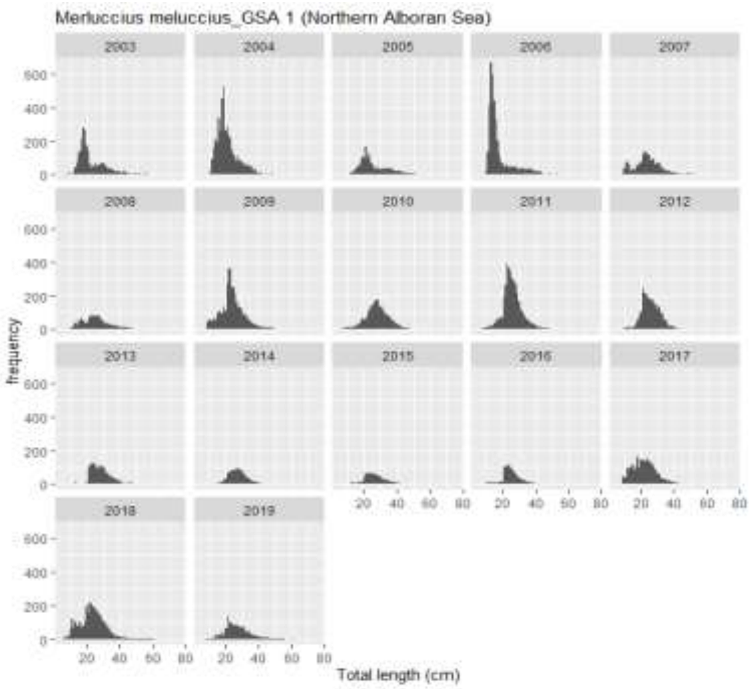


Figure 4.-*Merlucciusmerluccius* length frequency distribution (Total length) of bottom otterTrawlers catches in the geographical sub-area 1 (Northern Alboran Sea) for the period (2003-2019).

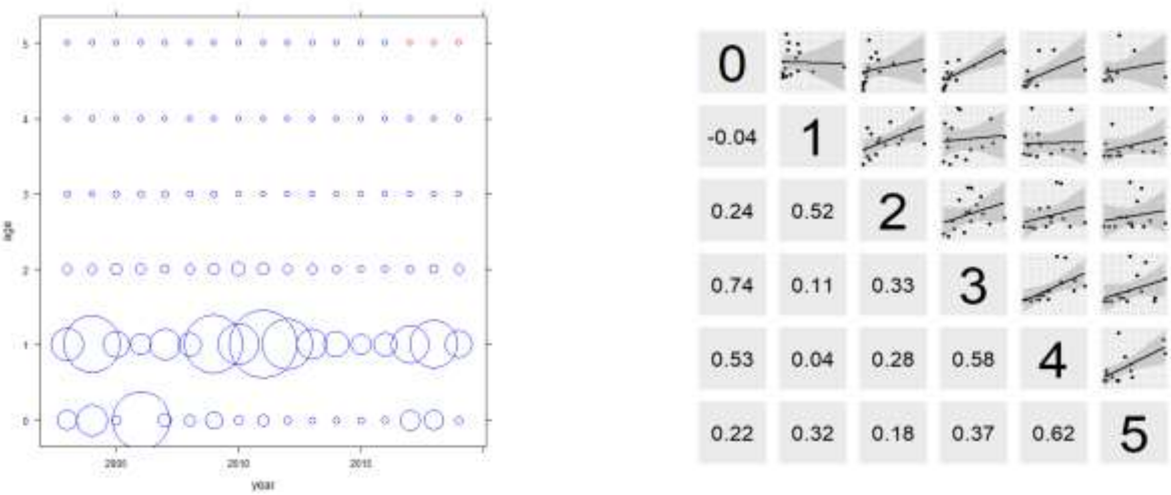


Figure 5.-Catch age matrix (left) and Consistency between cohorts (right) for Hake (Bottom otter trawlers) in the geographical sub-area 1 (Northern Alboran Sea) for the period (2003-2019).

Composition Landings were largely composed of age 0 from 2003 to 2008. However, this pattern changed from age 0 to age 1 from 2009 onwards.

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 cm TL), (EC regulation 1967/2006): mostly fully observed

- In force a multiannual plan for the fisheries exploiting demersal stocks in the western Mediterranean Sea and amending Regulation (EU) No 508/2014, in Spain from May 2020 (Orden APA, 423/2020).

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)		510		4
B (50-100m)		1951		16
C (100-200m)		1086		7
D (200-500 m)		3461		14
E (500-800m)		4912		14
Total (km^2)		2384		55

4.1.2 Spatial distribution of the resources

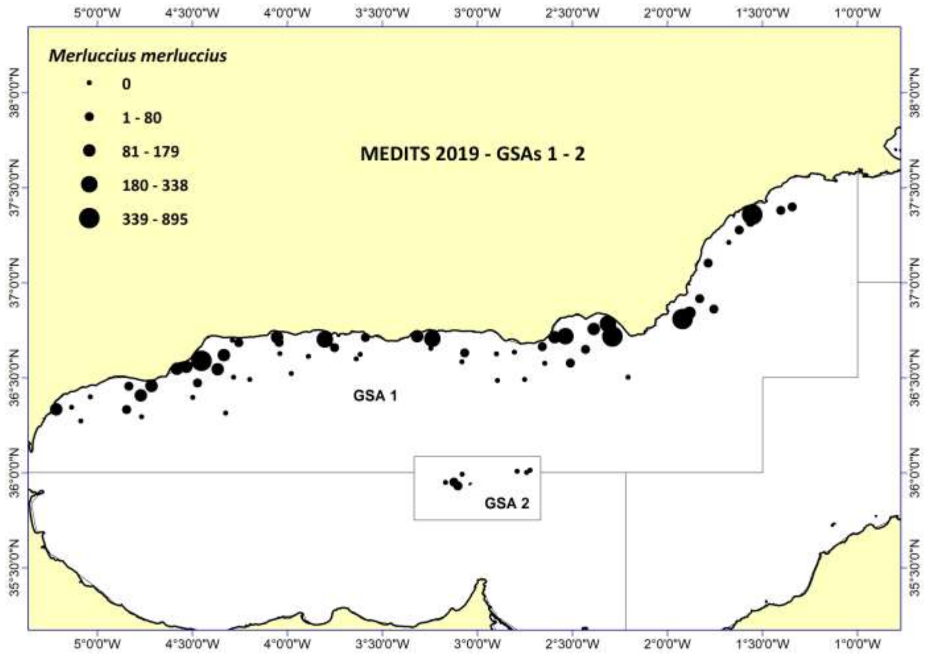


Figure 6.-Medits hauls (2019 survey). in the GSA1 and GSA2, including the spatial distribution of estimated abundances.

4.1.3 Historical trends

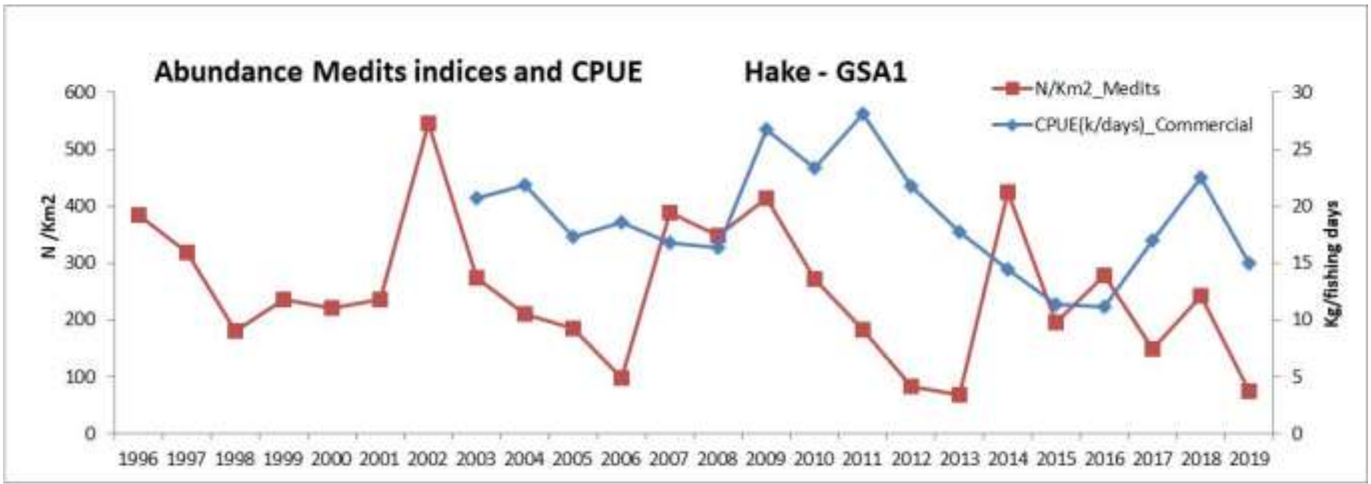


Figure 7.- MEDITS_ES (1995-2013). Trends in abundance indices (n/km^2) and biomass indices (kg/day).

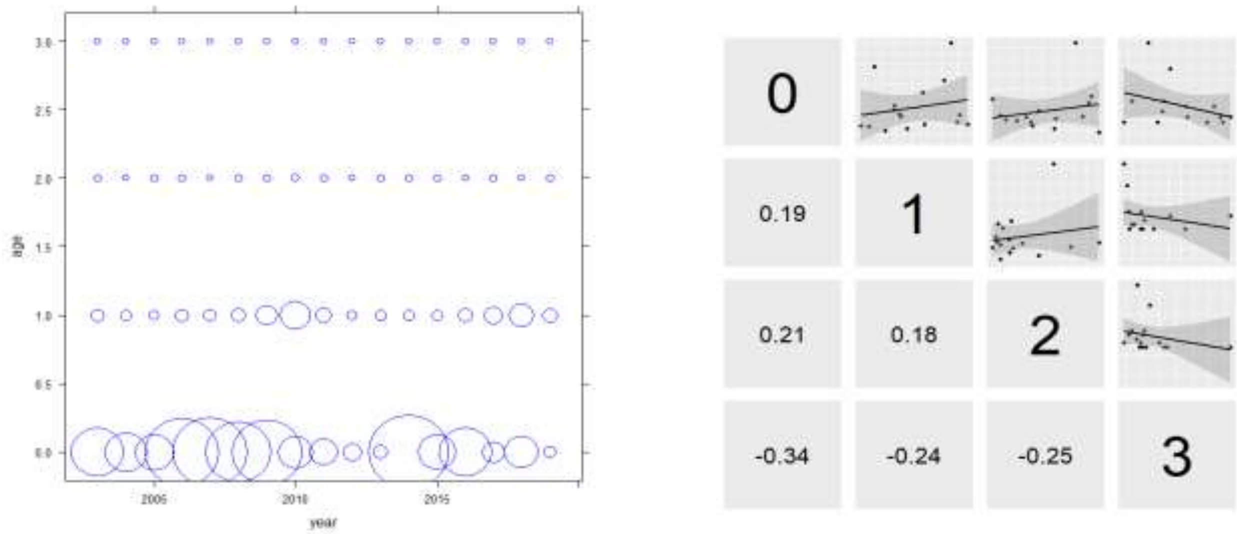


Figure 8.-Survey abundance age matrix (left) and Consistency between cohorts (right) for Hake (Medits survey) in the geographical sub-area 1 (Northern Alboran Sea) for the period (2003-2019).

5 Ecological information

5.1 Protected species potentially affected by the fisheries

During the MEDITS surveys carried out in the Northern Alboran Sea, species was453 caught between 30 and 700 m, but its abundance drops considerably below 300 m, and it is more abundant in the outer continental shelf (100–200 m), jointly with species as *Capros aper, Gadiculus argenteus, Maurolicus muelleri, Pagellus acarne, Micromesistius poutassou, Helicolenus dactylopterus, and Scyliorhinus canicula* (García-Ruiz et al. 2015). It is heterogeneously distributed throughout the Alboran Sea, being very abundant in the Almeria area declining sharply in Estepona (Fig. 9). The size of catches ranges between 1 and 80 cm total length (TL) with a4 general prevalence of small sizes and mean values around 14 cm TL (MEDITS surveys).

García-Ruiz C, Lloris D, Rueda JL et al (2015) Spatial distribution of ichthyofauna in the northern Alboran Sea (western Mediterranean). J Nat Hist 49:1191–1224.

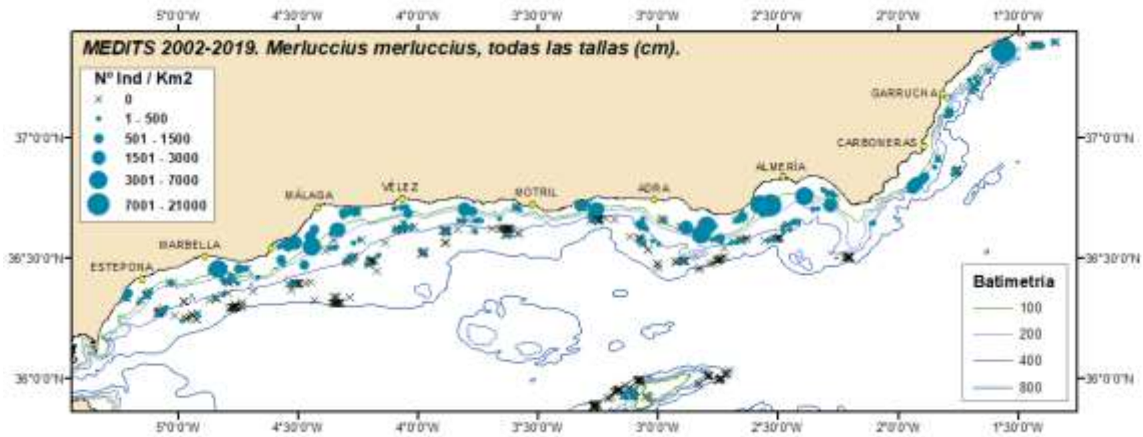


Figure 9.- Estimated abundances for *Merlucciusmerluccius* (Medits survey, mean 2002 -2019) in the GSA1 and GSA2, including the spatial distribution.

6 Stock Assessment

Although the WGSAD recommends in recent years moving towards analytical models such as SCAA or integral, both with a more statistical approach, this year it has opted to update the previous stock assessment carried out in 2015 using the same methodology, also used in the assessment of the joint stock GSA1-3.Next year an approach to models such as a4a or SS3 will be tried.

An Extended Survivor Analysis (XSA) tuned with MEDITS survey data was carried out over the period 2003-2019, for the bottom otter trawl fleet data, considering age classes from 0 to 4+.

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 were 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). Their results were analyzed and compared. FLR packages were also 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 assumption

- *Imput Parameters*
  - Catch time series 2003-2019 (official landings and Discard data) from trawl fleet.
  - Length distributions 2003-2019 (monthly onboard and port sampling).
  - Catch-at-Length data converted to Catch-at-Age data using cohort slicing.
  - Growth Parameters from García et al, 2002 and DCF-Spain (2012).
  - Biological sampling 2003-2018 for Maturity and Length-Weight relationships.
  - M vector by age using ensemble estimate (average) of different methods. (Benchmark, 2019).
  - Tuning data 1996-2019 from MEDITS survey and commercial fleet.

- *Main Settings*
  - Ages 0 to 4+ (Age 4 is a Plus Group)
  - Fbar 0-2.
  - Catchability independent of size and age for ages older than -1 and 3 respectively.
  - Survivor estimates shrunk towards the mean F of the final 4 years or the 1 oldest ages.
  - S.E. of the mean to which the estimates are shrunk = 2.5
  - 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

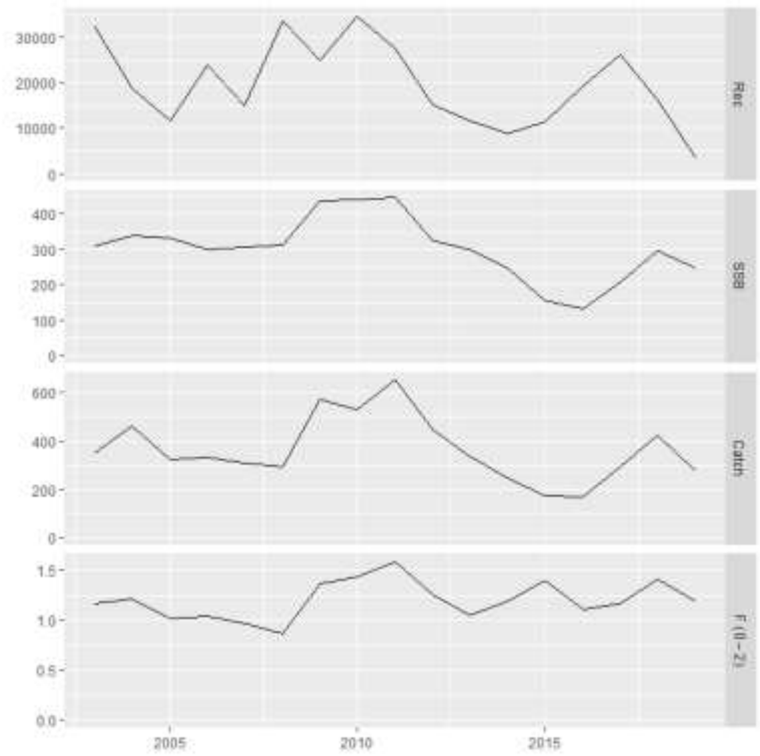


Figure 10.-XSA results. Catches and SSB of European hake show a decreasing trend from 2012 to 2017, with a slight increase in 2018. Recruitment (R) showed fluctuations over the series and steep decline in recent years. Fbar (0-2) in recent years, fluctuates around values close to1.2.

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

6.1.6.1 Retrospective analysis.

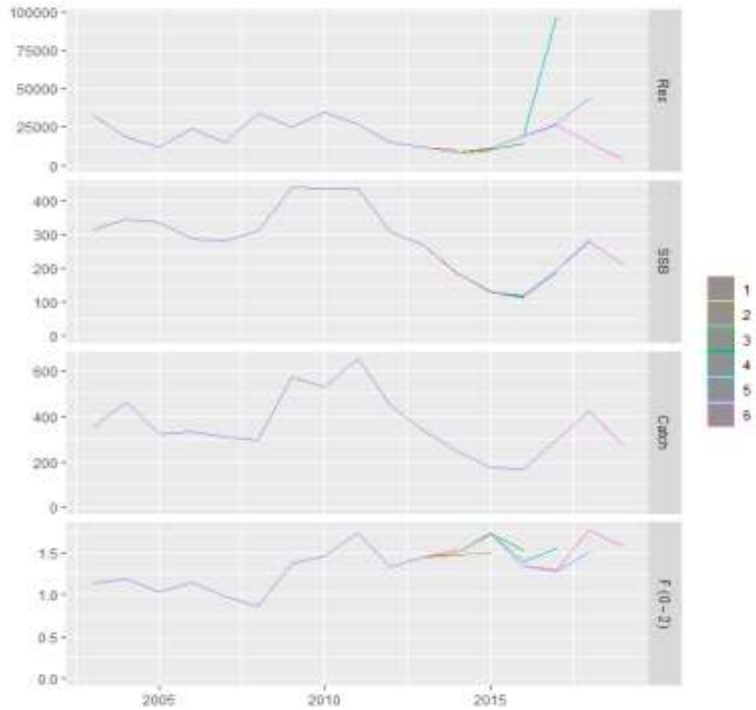


Figure 11.- Retrospective analysis was applied in the XSA model for the hake in GSA01 and the period 2003-2014 up to 6 years backward. Results show no particular retrospective bias.

6.1.6.2 Sensitivity analysis

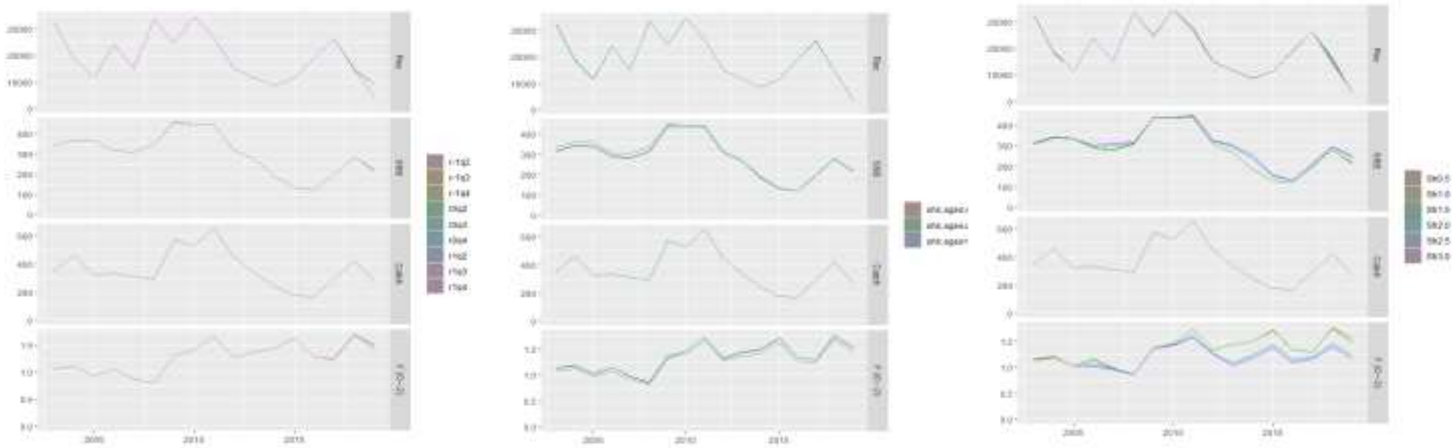


Figure 12.- Sensitivity analysis on different qage (catchability independent of age), fse (shrinkage weight) and shk.ages (shrinkage ages) values.

6.1.6.3 Residuals analysis

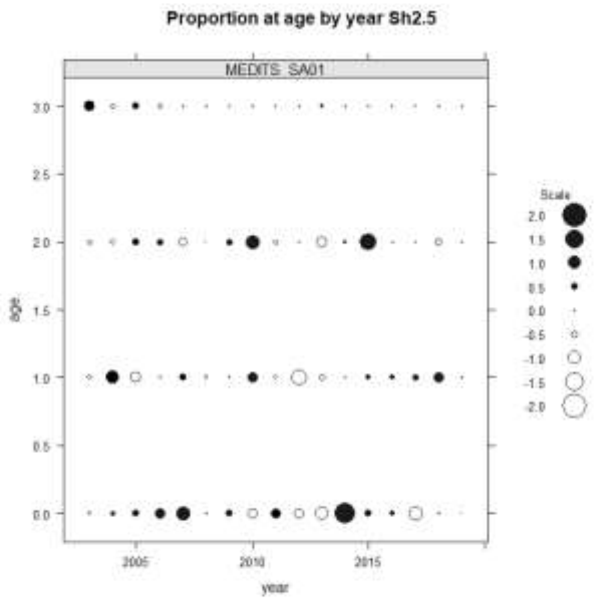
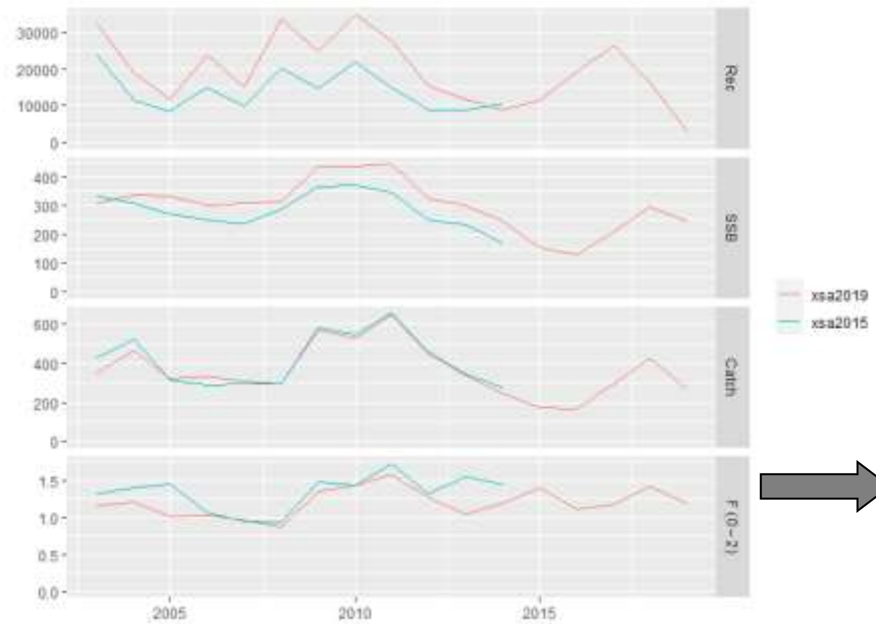


***Figure 13**.- Catchability residuals plots by fleet (MEDITS Surveys and Commercial Fleet).*

6.1.7 Assessment quality

The assessment was revised from previous assessment done in 2015. A new set of growth parameters (absolute and relative) was incorporated in the update assessment.



	XSA 2015	XSA 2020
$F_{0.1}$	0.2	0.2
$F_{current}$	1.4 (2013-2015,0-2)	1.2 (2018-2020, 0-2)
$F_c/F_{0.1}$	7	6

Figure 14.-XSA Stock summary of the assessment carried out in 2015 compared to the update made in 2021, including (right) the reference points and exploitation levels obtained.

Yield per recruit analysis.

Yield per recruit analyses was conducted based on the exploitation pattern resulting from the XSA model and population parameters. Minimum and maximum ages for the analysis were considered to be age group 0 and 4 stock weight at age, catch weight at age and maturity ogive was estimated as mean values between 2003 and 2019. Natural mortality vector values were applied per age group.. Fishing mortalities were the mean exploitation pattern F between 2017 and 2019. Reference F was considered to be mean F for ages 0 to 2 during the last 3 years (2017-2019).

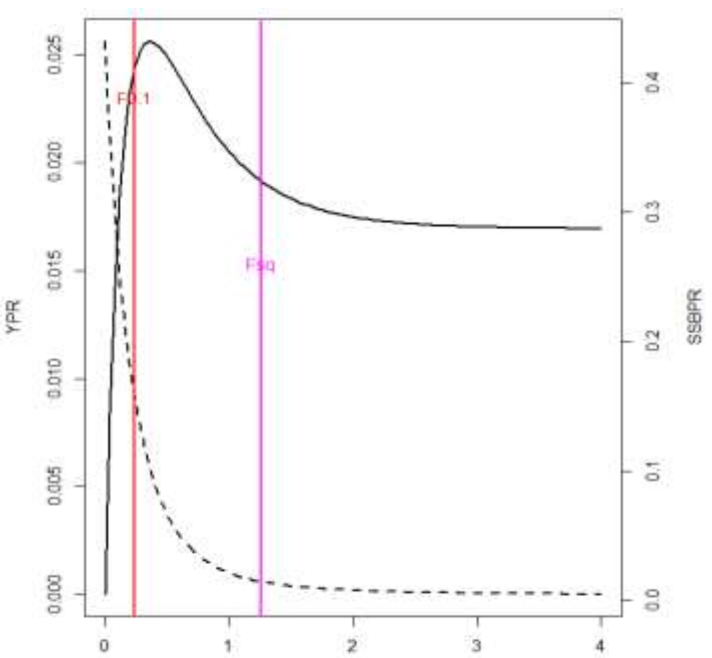


Figure 15.-Y/R analysis showed that the $F_{current}$= (1.2) exceeds the Y/R $F_{0.1}$ reference point = (0.2). The resulting ratio $F_{0.1}/F_{current}$ = 6, suggesting that for *Merlucciusmerluccius* stock in GSA1, the current exploitation level is in over exploitation and the stock size is overexploited (Relative low biomass).

7 Stock predictions

7.1 Short term predictions

Deterministic projections for three years (2020-2022) were produced. These projections are based on the arithmetic mean of recruitment, catches and weights at age of the last three years (2017-2019). F Status Quo is the geometric mean of $FBAR_{0-2}$during the last three years (2017-2019).

To evaluate MSY ranges for stocks in this assessment, has been uses the values of F associatedwith $F=F_{0.1}$ which are given from the most updated assessments carried out on Mediterranean stocks assessment. Those values were then used in the formulas provided by STECF EWG 15-06 (STECF, 2015) to derive F_{MSY} range (F_{low} and F_{upp}). The empirical relationships used to estimate F_{MSY} range are the following: (F_{low} = 0.0029663+ 0.660214 x $F_{0.1}$), F_{upp} = 0.0078015 + 1.3494017 x $F_{0.1}$

Table 7.1.1: Short term prediction results.

	Catch				SSB		change_SSB	change_Catch
Fbar	**Catch2019**	**Catch2020**	**Catch2021**	**Catch2022**	**SSB2021**	**SSB2022**	**2020-2022(%)**	**2019-2021(%)**
0.00	274.50	180.34	0.00	0.00	159.89	688.24	330.45	-100
0.13	274.50	180.34	40.93	107.49	159.89	600.05	275.29	-85.09
0.16 (F_lower)	274.50	180.34	51.22	130.10	159.89	578.25	261.66	-81.34
0.23	274.50	180.34	73.08	172.57	159.89	532.48	233.03	-73.38
0.25 (F0.1)*	274.50	180.34	76.61	178.74	159.89	525.16	228.46	-72.09
0.32 (F_upper)	274.50	180.34	96.39	209.87	159.89	484.56	203.06	-64.89
0.38	274.50	180.34	107.78	225.23	159.89	461.53	188.66	-60.74
0.50	274.50	180.34	135.09	254.92	159.89	407.41	154.81	-50.79
0.63	274.50	180.34	159.10	273.27	159.89	361.34	125.99	-42.04
0.75	274.50	180.34	180.27	284.05	159.89	322.08	101.44	-34.33
0.88	274.50	180.34	199.00	289.83	159.89	288.58	80.49	-27.50
1.00	274.50	180.34	215.63	292.39	159.89	259.96	62.59	-21.44
1.13	274.50	180.34	230.45	292.90	159.89	235.48	47.28	-16.05
1.2 (F_current)	274.50	180.34	243.71	292.17	159.89	214.50	34.16	-11.22
1.38	274.50	180.34	255.61	290.73	159.89	196.50	22.89	-6.88
1.50	274.50	180.34	266.33	288.92	159.89	181.01	13.21	-2.98
1.63	274.50	180.34	276.04	286.97	159.89	167.67	4.86	0.56
1.75	274.50	180.34	284.86	285.02	159.89	156.14	-2.34	3.77
1.88	274.50	180.34	292.90	283.15	159.89	146.16	-8.59	6.70
2.01	274.50	180.34	300.27	281.39	159.89	137.49	-14.01	9.39
2.13	274.50	180.34	307.04	279.78	159.89	129.95	-18.73	11.85
2.26	274.50	180.34	313.29	278.31	159.89	123.35	-22.85	14.13
2.38	274.50	180.34	319.08	276.97	159.89	117.57	-26.47	16.24
2.51	274.50	180.34	324.47	275.77	159.89	112.49	-29.65	18.20

*proxy of F_{MSY}.

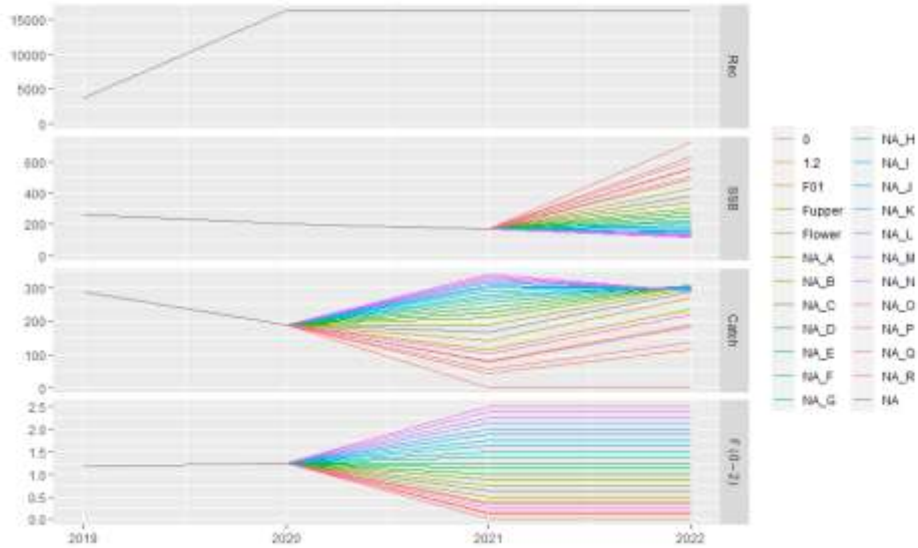


Figure 16.Short term predictions results.

Fishing at $F_{current}$ from 2019 to 2021 would produce an decrease in catches of -11% with anincrease in SSB for the 2020-2022 period 34%).

Fishing at F0.1 from 2019 to 2021 would generate a decrease in catches of 72% of the catches and an increase of 228% in SSB for the 2020-2022period.

7.2 Medium and Long term predictions

Medium and long term forecast depends on having a reasonable Stock-Recruitment relationship (SRR). European hake *Merlucciusmerluccius*does not show a clear SRR (Fig 17) and therefore no medium or long term predictions were performed for this species.

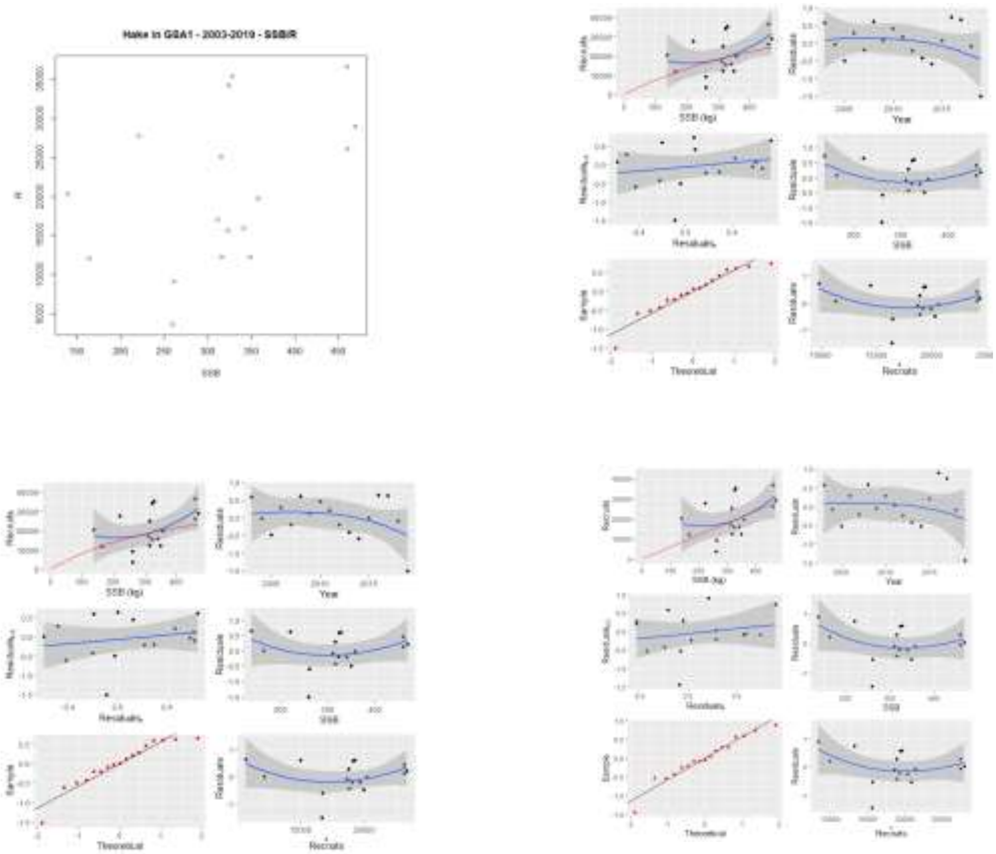


Figure 17.-Stock-Recruitment Relationship for Hake in the GSA1 (top left), showing different approaches to adjust this relation ship: Beverton& Holt model (top right), Ricker model (bottom left) and Segmented regression (bottom right).

Draft scientific advice

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	($F_{0.1}$ = 0.2) (F_c=1.2)	$F_c/F_{0.1}$=6		N 5	IO _O_h
	Catch (t) (17years)		275	33% percentile, 308 66% percentile, 474	N 17	O_I
Stock abundance **tonnes**	Biomass_1(t) (17years)		581	33% percentile; 878 66% percentile; 1221	N 6	O_L
	SSB_1 (t) (17years)		247	33% percentile; 296 66% percentile; 319	N 17	O_L
Recruitment **thousands**	R1 (6 years) R2 (2019)	thousands	14230 3481			
Final Diagnosis		- In overexplotation(F_{curren}=1.2>$F_{0.1}$=0.2) - Relative low biomass; $SSB_{current}$= 274(t); SSB at 33rd percentile = 296(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)*