Stock Assessment Form

Demersal species

HAKE – GSA 7

Reference year: 1998-2015

Reporting year: 2016

[A brief abstract may be added here]

Stock Assessment Form version 1.0 (January 2014)

Uploader: Angélique Jadaud*, Beatriz Guijarro**, Enric Massutí*

* IFREMER-UMR MARBEC, 1 rue Jean Monnet, BP 171, 34203 Sète (France); **IEO- Centre Oceanogràfic de les Balears; Moll de Ponent s/n; 07015 Palma de Mallorca (Spain)

Stock assessment form

1. Basic Identification Data

Scientific name:	Common name:	ISCAAP Group:
Merluccius merluccius - HKE	European hake	32 HKE
1st Geographical sub-area:	**2nd Geographical sub-area:**	**3rd Geographical sub-area:**
07 – Gulf of Lions		
1st Country	**2nd Country**	**3rd Country**
France	Spain	
Stock assessment method: (direct, indirect, combined, none)		
XSA (tuning with MEDITS indices) and Y/R		
Authors:		
Angélique Jadaud*, Beatriz Guijarro**, Enric Massutí*		
Affiliation:		
* IFREMER, 1 rue Jean Monnet, BP 171, 34203 Sète (France); **IEO-Centre Oceanogràfic de les Balears; Moll de Ponent s/n; 07015 Palma de Mallorca (Spain)		

The ISSCAAP code is assigned according to the FAO 'International Standard Statistical Classification for Aquatic Animals and Plants' (ISSCAAP) which divides commercial species into 50 groups on the basis of their taxonomic, ecological and economic characteristics. This can be provided by the GFCM secretariat if needed. A list of groups can be found here:

http://www.fao.org/fishery/collection/asfis/en

Direct methods (you can choose more than one):

- Acoustics survey
- Egg production survey
- Trawl survey
- SURBA
- Other (please specify)

Indirect method (you can choose more than one):

- XSA
- A4a

2. Stock identification and biological information

2.1. Stock unit

Hake (*Merluccius merluccius*) in the Gulf of Lions (GSA 7) is a shared stock exploited by both Spanish and French trawlers, French gillnetters and Spanish longliners (Fig. 2-1). The Gulf of Lions (GSA 7) is used as an individualized area for the assessment and management of red mullet in the western Mediterranean. However, recent studies stated that the hake of the Gulf of Lions could not be isolated from concomitant areas, for instance from the GSAs 05 and 06 (STOCKMED, MAREA project, 2014).

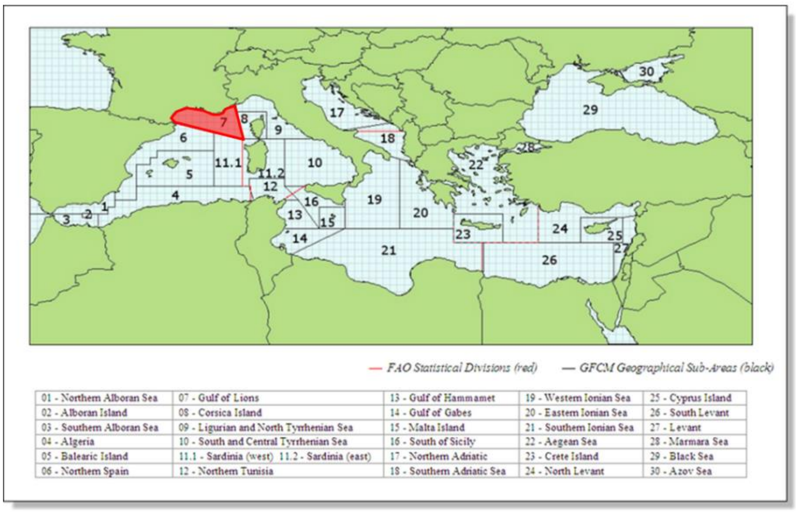


Figure 2-1: Geographical location of GSA 7 – Gulf of Lions

2.2. Growth and maturity

The growth of European Hake (*Merluccius merluccius*) in the Gulf of Lions was recently re-estimated from tagging experiments carried out by IFREMER (Mellon-Duval et al., 2010). The new parameters have not been yet compared to a re-analysis of otoliths readings. Therefore, the data sent to the data call were in length and were converted in age using the length-to-age slicing functions available in the R package a4a. The growth parameters used are indicated in the table 2.3.

The maturity was calculated using data collected in GSA 7 over the period 2004-2015 by IFREMER within the DCF (since 2002).

Natural mortality was obtained from PRODBIOM (Abella et al., 1997) and the maturity was obtained from DCF.

Table 2.2.2-1: Maximum size, size at first maturity and size at recruitment.

Somatic magnitude measured (LT, LC, etc)				Units	centimeters
Sex	Fem	Mal	Combined	Reproduction season	All year with higher picks of spawning at the beginning of spring and end of automn (Oliver, 1991), with a lot of fluctuations from one year to another (Recasens, 1992)
Maximum size observed	96	57	96	Recruitment season	All year (higher picks in winter and spring)
Size at first maturity			29	Spawning area	Shelf & upper slope
Recruitment size to the fishery			5	Nursery area	Shelf

Table 2.2.2-2: Hake in GSA 7. Natural Mortality (M) at age estimated using PRODBIOM

Years/Ages	0	1	2	3	4	5
1998	1.03	0.51	0.33	0.26	0.22	0.20
1999	1.03	0.51	0.33	0.26	0.22	0.20
2000	1.03	0.51	0.33	0.26	0.22	0.20
2001	1.03	0.51	0.33	0.26	0.22	0.20
2002	1.03	0.51	0.33	0.26	0.22	0.20
2003	1.03	0.51	0.33	0.26	0.22	0.20
2004	1.03	0.51	0.33	0.26	0.22	0.20
2005	1.03	0.51	0.33	0.26	0.22	0.20
2006	1.03	0.51	0.33	0.26	0.22	0.20
2007	1.03	0.51	0.33	0.26	0.22	0.20
2008	1.03	0.51	0.33	0.26	0.22	0.20
2009	1.03	0.51	0.33	0.26	0.22	0.20
2010	1.03	0.51	0.33	0.26	0.22	0.20
2011	1.03	0.51	0.33	0.26	0.22	0.20
2012	1.03	0.51	0.33	0.26	0.22	0.20
2013	1.03	0.51	0.33	0.26	0.22	0.20
2014	1.03	0.51	0.33	0.26	0.22	0.20
2015	1.03	0.51	0.33	0.26	0.22	0.20

Table 2.2.2-3: Proportion of matures by size or age (both sexes)

Years/Ages	0	1	2	3	4	5
1998	0,05	0,21	0,75	0,92	0,99	1,00
1999	0,06	0,30	0,72	0,91	0,99	1,00
2000	0,05	0,30	0,76	0,92	0,99	1,00
2001	0,05	0,30	0,73	0,91	0,99	1,00
2002	0,05	0,24	0,69	0,92	0,99	1,00
2003	0,07	0,31	0,70	0,91	0,99	1,00
2004	0,05	0,29	0,72	0,91	0,99	1,00
2005	0,06	0,29	0,73	0,91	0,98	0,99
2006	0,07	0,32	0,79	0,92	0,98	0,99
2007	0,08	0,30	0,72	0,93	0,99	0,99
2008	0,08	0,21	0,68	0,92	0,99	1,00
2009	0,07	0,34	0,73	0,90	0,98	1,00
2010	0,07	0,27	0,69	0,90	0,99	0,99
2011	0,08	0,31	0,67	0,89	0,99	0,99
2012	0,09	0,25	0,67	0,90	0,99	0,99
2013	0,02	0,24	0,64	0,96	1,00	1,00
2014	0,01	0,38	0,75	0,96	1,00	1,00
2015	0,01	0,49	0,86	1,00	1,00	1,00

Table 2.2.2-4: Growth and length weight model parameters

			Sex			
		Units	**female**	**male**	**Combined**	**Years**
Growth model	**L_∞**	cm	100.7	72.8		
	K	years-1	0.236	0.233		
	t_0		-	-		
	Data source	Tagging experiments (Mellon-Duval et al., 2010)				
Length weight relationship	**a**				0.0085	
	b				2.97	
	M (scalar)				0.36	
	sex ratio (% females/total)	(*)				

Table 2.2.2-5: Sex-ratio (*) at length from data collected in GSA 7 (2003-2015) by IFREMER for the DCF was used to compute the number of females and males at length.

Size (cm)	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
14	0,43	0,43	0,43	0,43	0,43	0,43	0,43	0,43	0,43	0,43	0,50	0,67	0,67
15	0,39	0,39	0,39	0,39	0,39	0,39	0,39	0,39	0,39	0,39	0,50	0,73	0,78
16	0,64	0,64	0,64	0,64	0,64	0,64	0,64	0,64	0,64	0,64	0,38	0,49	0,62
17	0,44	0,44	0,44	0,44	0,44	0,44	0,44	0,44	0,44	0,44	0,14	0,52	0,61
18	0,45	0,45	0,45	0,45	0,45	0,45	0,45	0,45	0,45	0,45	0,62	0,34	0,43
19	0,50	0,50	0,50	0,50	0,50	0,50	0,50	0,50	0,50	0,50	0,47	0,40	0,47
20	0,40	0,40	0,40	0,40	0,40	0,40	0,40	0,40	0,40	0,40	0,47	0,46	0,54
21	0,47	0,47	0,47	0,47	0,47	0,47	0,47	0,47	0,47	0,47	0,48	0,36	0,40
22	0,49	0,49	0,49	0,49	0,49	0,49	0,49	0,49	0,49	0,49	0,54	0,29	0,41
23	0,41	0,41	0,41	0,41	0,41	0,41	0,41	0,41	0,41	0,41	0,36	0,48	0,41
24	0,51	0,51	0,51	0,51	0,51	0,51	0,51	0,51	0,51	0,51	0,44	0,35	0,32
25	0,44	0,44	0,44	0,44	0,44	0,44	0,44	0,44	0,44	0,44	0,36	0,50	0,39
26	0,47	0,47	0,47	0,47	0,47	0,47	0,47	0,47	0,47	0,47	0,33	0,29	0,34
27	0,42	0,42	0,42	0,42	0,42	0,42	0,42	0,42	0,42	0,42	0,44	0,36	0,40
28	0,41	0,41	0,41	0,41	0,41	0,41	0,41	0,41	0,41	0,41	0,36	0,28	0,21
29	0,41	0,41	0,41	0,41	0,41	0,41	0,41	0,41	0,41	0,41	0,42	0,49	0,63
30	0,43	0,43	0,43	0,43	0,43	0,43	0,43	0,43	0,43	0,43	0,40	0,71	0,76
31	0,45	0,45	0,45	0,45	0,45	0,45	0,45	0,45	0,45	0,45	0,57	0,56	0,65
32	0,54	0,54	0,54	0,54	0,54	0,54	0,54	0,54	0,54	0,54	0,74	0,70	0,84
33	0,57	0,57	0,57	0,57	0,57	0,57	0,57	0,57	0,57	0,57	0,86	0,89	0,91
34	0,60	0,60	0,60	0,60	0,60	0,60	0,60	0,60	0,60	0,60	0,74	0,89	0,96
35	0,72	0,72	0,72	0,72	0,72	0,72	0,72	0,72	0,72	0,72	0,89	0,98	1,00
36	0,68	0,68	0,68	0,68	0,68	0,68	0,68	0,68	0,68	0,68	1,00	0,95	0,95
37	0,72	0,72	0,72	0,72	0,72	0,72	0,72	0,72	0,72	0,72	1,00	0,98	1,00
38	0,80	0,80	0,80	0,80	0,80	0,80	0,80	0,80	0,80	0,80	0,96	0,95	1,00
39	0,83	0,83	0,83	0,83	0,83	0,83	0,83	0,83	0,83	0,83	1,00	1,00	1,00
40	0,79	0,79	0,79	0,79	0,79	0,79	0,79	0,79	0,79	0,79	1,00	1,00	1,00
41	0,86	0,86	0,86	0,86	0,86	0,86	0,86	0,86	0,86	0,86	1,00	1,00	1,00
42	0,89	0,89	0,89	0,89	0,89	0,89	0,89	0,89	0,89	0,89	1,00	1,00	1,00
43	0,90	0,90	0,90	0,90	0,90	0,90	0,90	0,90	0,90	0,90	1,00	1,00	1,00
44	0,94	0,94	0,94	0,94	0,94	0,94	0,94	0,94	0,94	0,94	1,00	1,00	1,00
45	0,95	0,95	0,95	0,95	0,95	0,95	0,95	0,95	0,95	0,95	1,00	1,00	1,00
46	0,91	0,91	0,91	0,91	0,91	0,91	0,91	0,91	0,91	0,91	1,00	1,00	1,00
47	0,95	0,95	0,95	0,95	0,95	0,95	0,95	0,95	0,95	0,95	1,00	1,00	1,00
48	0,95	0,95	0,95	0,95	0,95	0,95	0,95	0,95	0,95	0,95	1,00	1,00	1,00
49	0,96	0,96	0,96	0,96	0,96	0,96	0,96	0,96	0,96	0,96	1,00	1,00	1,00
50-96	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00

3. Fisheries information

3.1. Description of the fleet

Hake is one of the most important demersal target species for the commercial fisheries in the Gulf of Lions (GSA 7). In this area, hake is exploited by French trawlers, French gillnetters, Spanish trawlers and Spanish longliners. Since 1998, an average of 243 boats are involved in this fishery and, according to official statistics, the total annual catches for the period 1998-2015 have oscillated around an average value of 1961 tons (1139 tons in 2015). In 2009, because of the large decline of small pelagic fish species in the area, the trawlers fishing small pelagic have diverted their effort on demersal species. Between 1998 and 2015, the number of French trawlers operating in the GSA 07 has decreased by 50%. The French trawler fleet is the largest considering catches realized, the proportion of boats and catches are respectively (27% and 73%). The length of hake in the trawler catches ranges between 3 and 92 cm total length (TL), with an average size of 21 cm TL. The second largest fleet is the French gillnetters (41 and 16% respectively, range 13-86 cm TL and average size 39 cm TL), followed by the Spanish trawlers (9 and 10%, respectively, range 5-88 cm TL, and average size 24 cm TL), and the Spanish longliners (4 and 1%, respectively, range 22-96 cm TL and average size 52 cm TL). The hake trawlers exploit a highly diversified species assemblage: Striped red mullet (*Mullus surmuletus*), red mullet (*M. barbatus*), angler fish (*L. piscatorius*), blackbellied angler fish (*L. budegassa*), european conger (*Conger conger*), poor-cod (*Trisopterus minutus capelanus*), fourspotted megrim (*Lepidorhombus boscii*), soles (*Solea spp.*), horned octopus (*Eledone cirrhosa*), squids (*Illex coindetii*), gilthead seabream (*Sparus aurata*), European seabass (*Dicentrarchus labrax*), seabreams (*Pagellus spp.*), blue whiting (*Micromesistius poutassou*), tub gurnard (*Chelidonichtys lucerna*).

Table 3.1.1-1: Description of operational units exploiting the stock

	Country	GSA	Fleet Segment	Fishing Gear Class	Group of Target Species	Species
Operational Unit 1*	FRA	07	E - Trawl (12-24 metres)	03 - Trawls	33 - Demersal shelf species	HKE
Operational Unit 2	FRA	07	C - Minor gear with engine (6-18 metres)	07 - Gillnets and Entangling Nets	33 - Demersal shelf species	HKE
Operational Unit 3	ESP	07	E - Trawl (12-24 metres)	03 - Trawls	33 - Demersal shelf species	HKE
Operational Unit 4	ESP	07	I - Long line (12-24 metres)	09 - Hooks and Lines	34 - Demersal slope species	HKE

Table 3.1.1-1: Catch, bycatch, discards and effort by operational unit in the reference year (2015)

Operational Units*	Fleet (n° of boats)*	Catch (T or kg of the species assessed)	Other species caught (names and weight)	Discards (species assessed)	Discards (other species caught)	Effort (units)
FRA 07 E 03 33 - HKE	58	820.3	*S. pilchardus, E. encrasicolus, Mullus spp., Solea spp., Lophius spp., S. aurata, D. labrax, Pagellus spp., M. poutassou, T. m. capelanus and Eledone spp.*	22.3	unknown	unknown
FRA 07 C 07 33 - HKE	73	119.4	*S. scombrus, T. lucerna, T. m. capelanus, Lepidorhombus spp. and S. canicula*	not discarded	unknown	unknown
ESP 07 E 03 33 - HKE	16	169	*Solea spp., Mullus spp., Lophius spp., Pagellus spp., M. poutassou, T. m. capelanus and E. cirrhosa*	1.3	unknown	unknown
ESP 07 I 09 34 - HKE	6	23.9	*L. caudatus, H. dactylopterus, C. conger, P. bogaraveo and P. blennoides*	not discarded	unknown	unknown
Total	**225**	**1115,7**		**23.6**		

Table 3.1-3: Hake in GSA 7. Annual catches (t) by gear (DCF data).

Gears/Years	OTB-French	OTB-Spanish	GNS-French	GTR-French	LLS-Spanish
1998	1688	140	500	-	101
1999	1525	279	500	-	109
2000	1347	166	500	-	285
2001	1835	196	500	-	163
2002	2168	231	182	-	146
2003	2024	206	248	-	112
2004	1023	101	99	-	78
2005	1002	126	255	-	101
2006	1014	116	299	-	170
2007	1282	107	168	-	143
2008	2071	227	111	-	97
2009	1642	258	286	-	84
2010	1527	156	247	-	54
2011	970	116	245	5	29
2012	768	163	175	-	18
2013	1337	198	161	21	18
2014	1441	202	284	32	24
2015	843	121	153	16	7

Table 3.1-4: Hake in GSA 7. Annual landings (t) by gear (DCF data).

Gears/Years	OTB-French	OTB-Spanish	GNS-French	GTR-French	LLS-Spanish
1998	1688	140	500		101
1999	1525	279	500		109
2000	1347	166	500		285
2001	1835	196	500		163
2002	2168	231	182	-	146
2003	2024	206	248	-	112
2004	1023	101	99	-	78
2005	1002	125	255	-	101
2006	1014	116	299	-	170
2007	1282	107	168	-	143
2008	1898	192	111	-	97
2009	1633	258	286	-	83
2010	1527	156	247	-	53
2011	970	113	245	5	29
2012	759	162	175	-	18
2013	1292	198	161	21	18
2014	1392	200	284	32	24
2015	820,3	119,4	153	16	7

The French discards were not included to the catch before 2008 as they represented a negligible amount.

Table 3.1-5: Hake in GSA 7. Annual discards (t) by gear (DCF data)

Gears/Years	OTB-French	OTB-Spanish	GNS-French	GTR-French	LLS-Spanish
1998	-	-	-	-	-
1999	-	-	-	-	-
2000	-	-	-	-	-
2001	-	-	-	-	-
2002	-	-	-	-	-
2003	-	-	-	-	-
2004	-	-	-	-	-
2005	-	1	-	-	-
2006	-	-	-	-	-
2007	-	-	-	-	-
2008	173	35	-	-	-
2009	9	-	-	-	1
2010	-	-	-	-	1
2011	-	3	-	-	-
2012	9	1	-	-	-
2013	46	-	-	-	-
2014	49	2	-	-	-
2015	22,3	1,3	-	-	-

3.2. Historical trends

The catch is dominated by the French trawlers fleet. Since 1978, a decreasing trend can be observed with rather large fluctuations around it. In 2015, total catch reached 1139 tons.

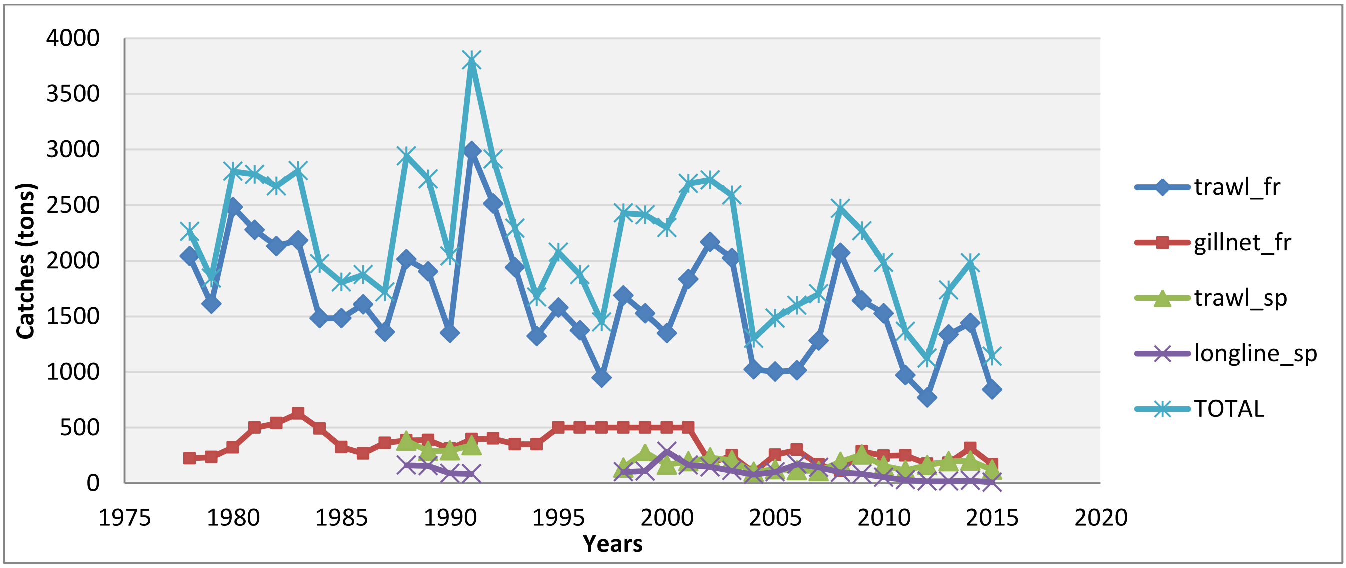


Figure 3.2-1: Hake in GSA 7. Catch (tons) by gear since 1978

3.3. Management regulations

French trawlers

- Fishing license: fully observed
- Engine power limited to 316 KW or 500 CV: Not full compliance
- Cod-end mesh size (bottom trawl: square 40 mm or 50 mm diamond, by derogation): not fully observed
- Fishing forbidden within 3 miles (France): not fully observed
- Time at sea: fully observed
- *Temporal bans depending on years (2011 and 2012, 1 month/year): fully observed*

Spanish trawlers

- Fishing license: fully observed
- Engine power limited to 316 KW or 500 CV: Not full compliance
- Mesh size in the codend (before Jun 1st 2010: 40 mm diamond: after Jun 1st 2010: 40 mm square or 50 mm diamond, by derogation): fully observed
- Fishing forbidden <50 m depth: fully observed
- Time at sea: fully observed
- Temporal bans depending on years (2015, 1 month): fully observed

French gillnetters:

- Fishing license: fully observed
- Maximum length of net: not fully observed

Spanish longliners:

- Fishing license: fully observed
- Number of hook per boat: not fully observed

In 2009, GFCM proposed the creation of a High Sea Fishery Restricted Area (FRA, GFCM/33/2009/1) in which the fishing effort for demersal stocks of vessels using towed nets, bottom and mid-water longlines, bottom-set nets shall not exceed the level of fishing effort applied in 2008 in the fisheries restricted area of the eastern Gulf of Lions as bounded by lines joining the following geographic coordinates: 42°40'N, 4°20' E; 42°40'N, 5°00' E; 43°00'N, 4°20' E; 43°00'N, 5°00' E. In the article 4 from the EU Regulation No. 1343/2011 of the European Parliament and of the Council of 13 December 2011, this fisheries restricted area was established and in 2012 both French (Arrêté du 28 décembre 2012, NOR: TRAM1240493A) and Spanish (Orden AAA/1857/2012 de 22 de Agosto) governments published their own laws regulating this FRA. Moreover an important decrease in capacity of French trawler fleet since 2011, reducing the number of boats by 39% since the beginning of the series (1998).

3.4. Reference points

Table 3.4.1-1: List of reference points and empirical reference values previously agreed (if any)

Indicator	Limit Reference point/empirical reference value	Value	Target Reference point/empirical reference value	Value	Comments
B					
SSB					
F	$F_{0.1}$	0.15 Estimated in 2013			
Y					
CPUE					
Index of Biomass at sea					

4. Fisheries independent information

4.1. MEDITS

4.1.1. Brief description of the direct method used

Fishery independent information regarding the state of the hake in GSA 7 was derived from the international survey MEDITS. MEDITS surveys have been carried out from late spring to middle summer, between 1994 and 2013, following random depth-stratified sampling design. Five depth strata were considered: 10-49 m, 50-99 m, 100-199 m, 200-499 m and 500-800 m. The gear used was a GOC 73, an experimental bottom trawl gear, with a cod-end mesh size of 20 mm. Sampling duration depended on the depth of the sampling station: 30 minutes for the samples on the shelf (10-199 m) and 60 minutes for those in the slope (200-800 m). See Bertrand et al. (2002) for further details.

The data was assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Catches by haul were standardized to 60 minutes hauling duration. The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This involves weighting the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where: A=total survey area

Ai=area of the i-th stratum

si=standard deviation of the i-th stratum

ni=number of valid hauls of the i-th stratum

n=number of hauls in the GSA

Yi=mean of the i-th stratum

Yst=stratified mean abundance

V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval:

Confidence interval = Yst ± t(student distribution) * V(Yst) / n

Length distributions were obtained by the sum of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the GSA strata.

4.1.2. Spatial distribution of the resources

MEDITS campaign can be considered as a good sampler for mapping the juvenile distribution of hake, as it is carried out during a peak of the recruitment period in spring (May-June). Nevertheless it does not allow analyzing possible temporal fluctuations and the annual analysis is limited to year to year.
Considering hake spawners, the low catches of adult hake observed may have several causes, including low catchability of large individuals by MEDITS trawl, the discrepancy between the period of the campaign and reproductive peaks, the presence of adults on untrawlable areas, on the edge of the continental shelf and beginning of the slope. For those reasons, it cannot be used to estimate the spatial distribution of hake spawners.

The figure 4.1.2.1 illustrates the distribution of hake juveniles caught during MEDITS survey from 1998 until 2010. The juvenile's size (10 cm) has been obtained using a Bhattacharya approach. This map shows that during the MEDITS survey (May-June), some spots of higher concentrations can be observed at the end of the shelf and upper slope.

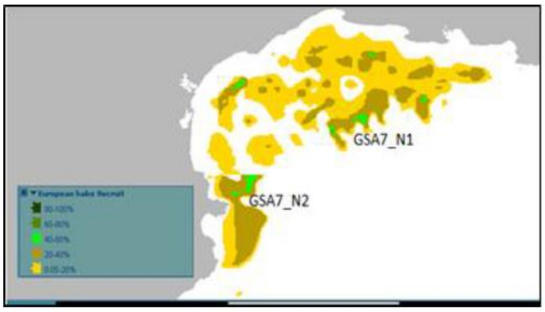


Figure 4.1.2.1. Hake GSA7: Nursery areas (MEDISEH, 2014)

4.1.3. Historical trends

Fishery independent information regarding the state of the hake in GSA 7 was derived from the international survey MEDITS. Figure 4.1.3-1 displays the time series of abundance in GSA 7. The estimated abundance indices do not reveal any clear trend. However higher picks can be observed for some years. These highest values are linked to the highest recruitment observed over the period (1998, 2002-2003 and 2007-2008). Since 2011, values are the lowest observed in the time series. The age structure did not exhibit any substantial change in 2015 compared to the other years (figure 4.1.3-2).

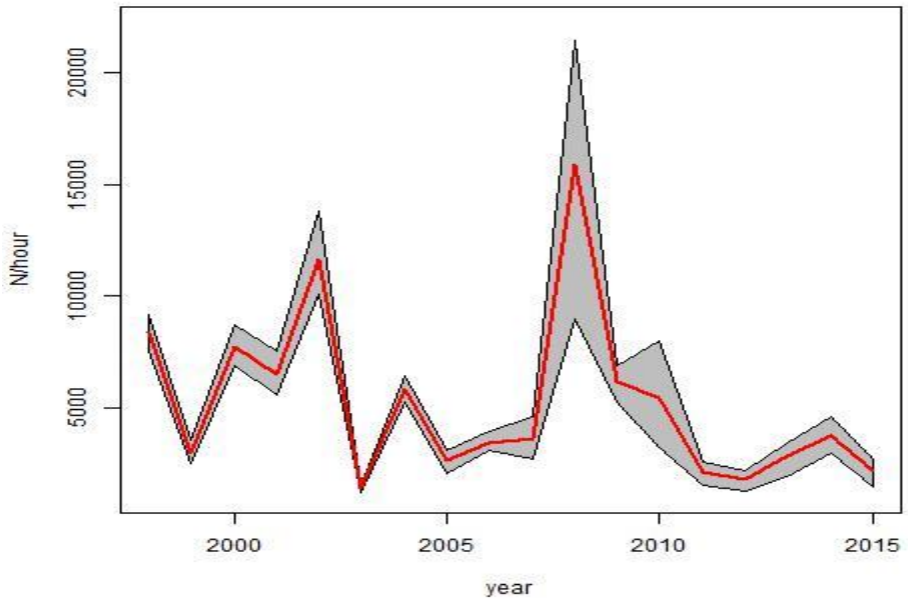


Figure 4.1.3-1: Hake in GSA 7. MEDITS abundance index (n/hour).

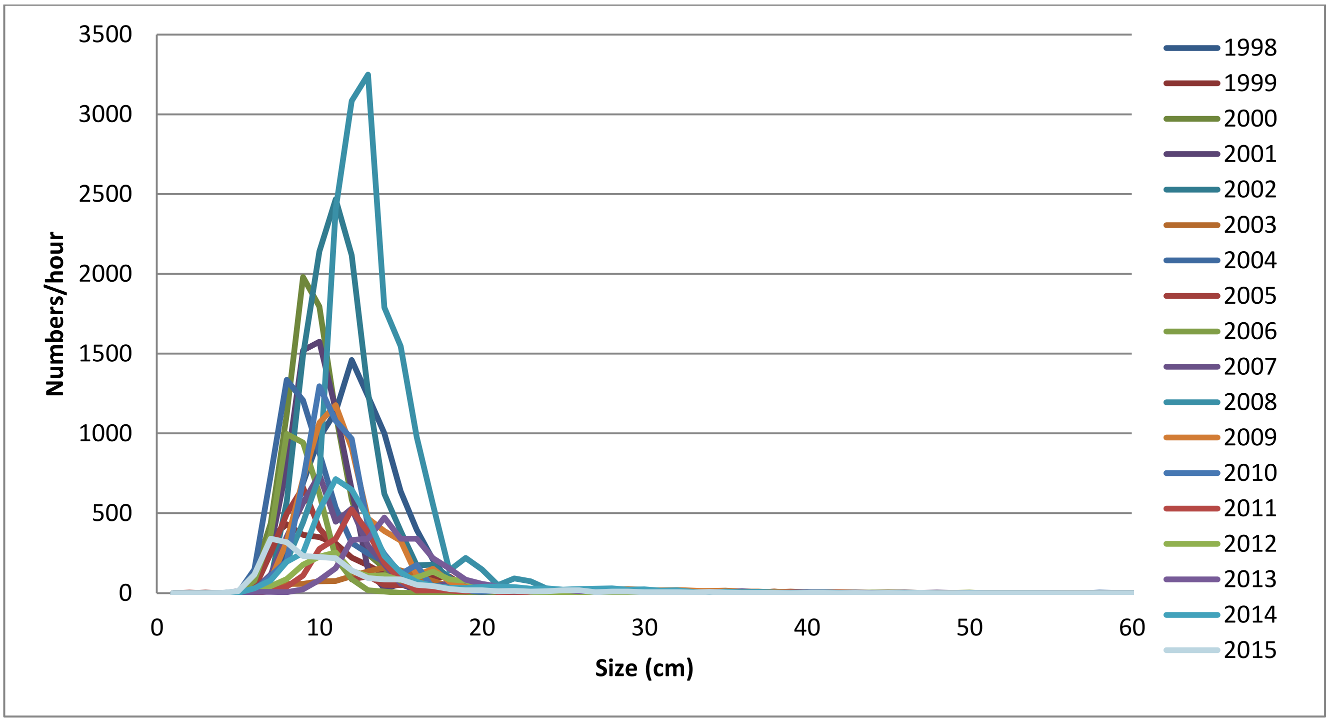


Figure 4.1.3-2: Hake in GSA 7. Size structure of the MEDITS abundance index (n/hour).

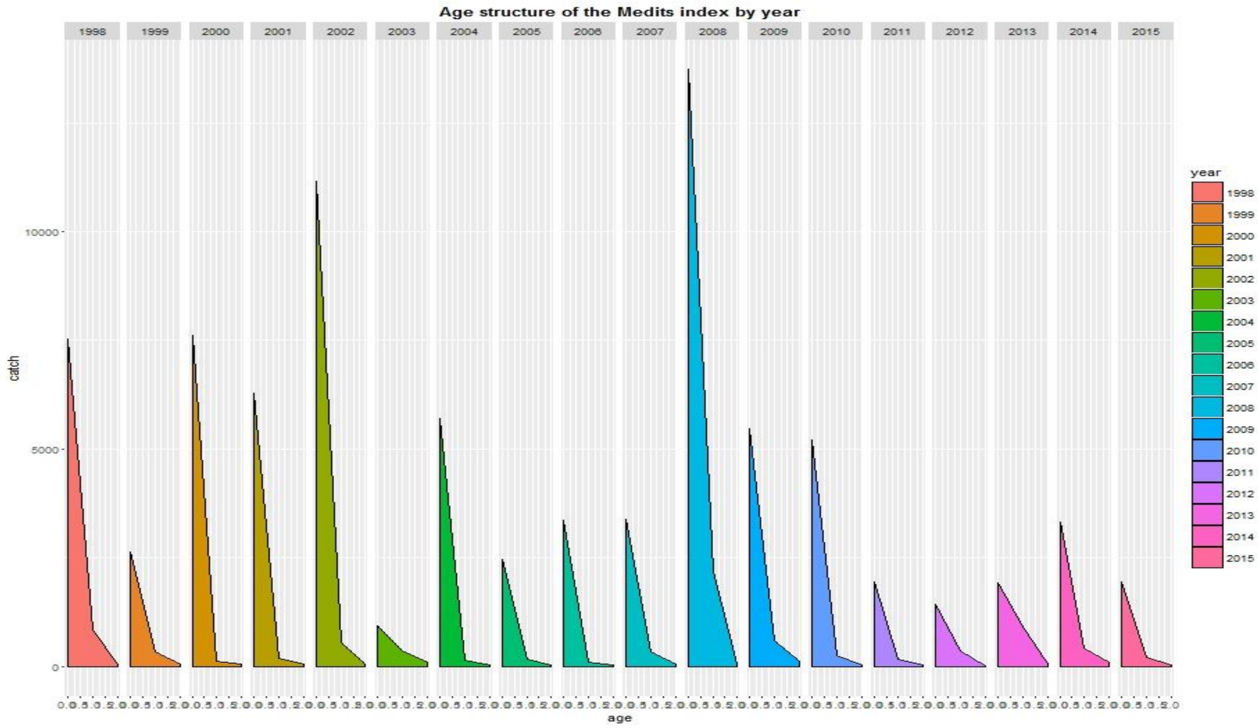


Figure 4.1.3-3: Hake in GSA 7. Age structure of the MEDITS abundance index (n/hour).

5. Ecological information

5.1. Protected species potentially affected by the fisheries

No list of protected species that can be potentially affected by the fishery is currently available.

5.2. Environmental indexes

There is currently no evidence for any environmental index to be relevant for the fishery.

6. Stock Assessment

6.1. XSA

6.1.1. Model assumptions

The stock assessment was performed over the period 1998-2015 using an XSA model over age classes ranging from 0 to 5+ and with MEDITS index, as tuning fleet (ages 0-2). The a4a model, developed by the Joint Research Center, was also used to model the stock (a4a is a statistical catch at age model, whose flexibility allows to fit a wide range of models to the data). However, the final diagnosis is based upon XSA analysis, as the population parameters obtained from XSA were considered as more precautionary than those from a4a. A comparison between the results obtained with both methods can be found in the section 6.1.9.

6.1.2. Scripts

The R script and the data used to perform the final XSA run have been provided to the GFCM.

6.1.3. Input data and Parameters

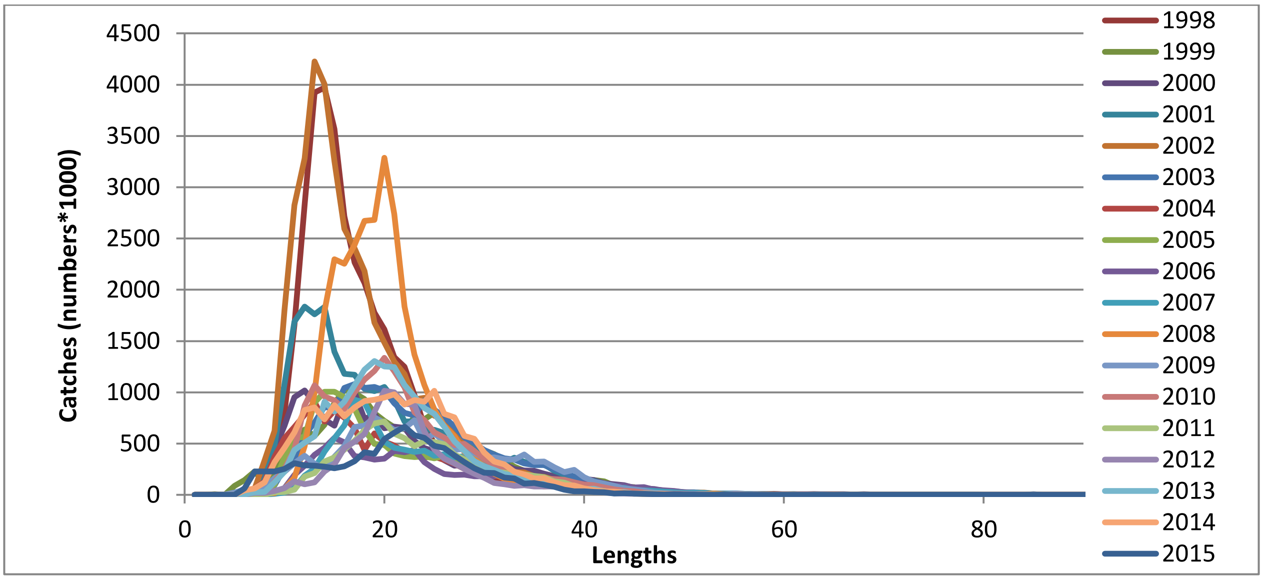


Figure 6.1.3-1: Hake in GSA 7. Length distribution of total catch.

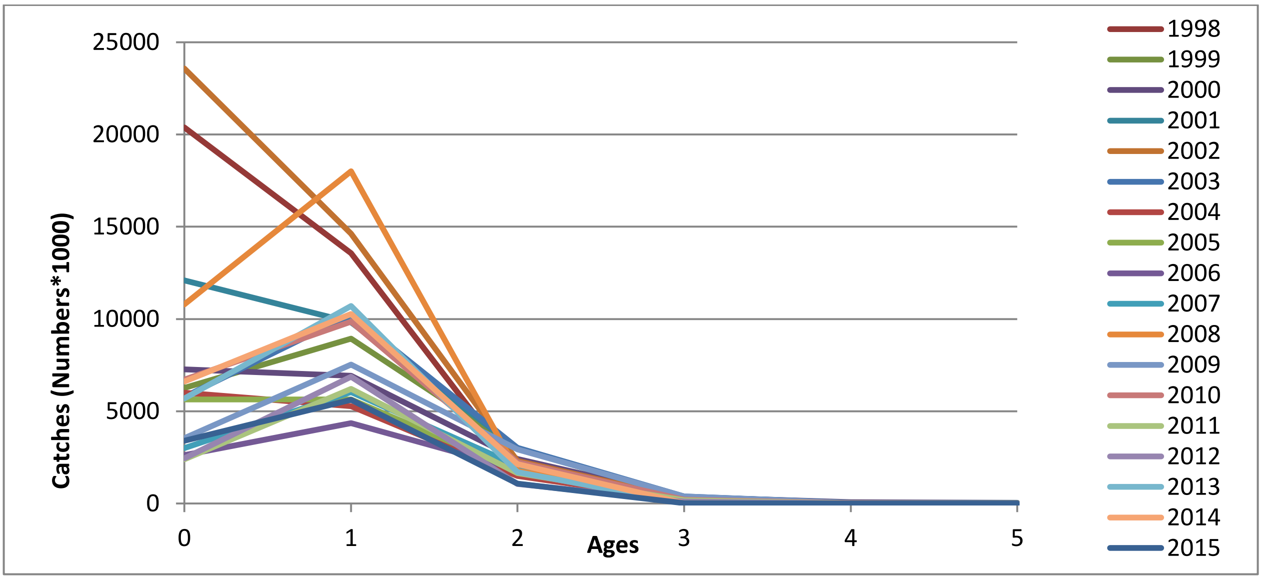


Figure 6.1.3-1: Hake in GSA 7. Age distribution of total catch.

Table 6.1.3-1: Hake in GSA 7. Catch at age in numbers in thousands (discards included).

Years/Ages	0	1	2	3	4	5
1998	20379	13573	1792	233	43	25
1999	6260	8929	2989	303	37	15
2000	7263	6929	2411	349	67	42
2001	12090	9813	2994	374	39	32
2002	23572	14631	2304	271	30	19
2003	5770	10244	3016	376	33	20
2004	5999	5275	1488	173	15	4
2005	5637	5631	1794	193	20	4
2006	2615	4363	1860	277	35	8
2007	2996	6036	2050	268	30	9
2008	10792	18011	1768	166	20	7
2009	3545	7524	2927	388	21	5
2010	6723	9860	2240	216	16	2
2011	2398	6208	1655	169	7	1
2012	2442	6875	1061	104	8	1
2013	5689	10705	1700	19	4	1
2014	6606	10276	2131	28	2	1
2015	3394	5616	1073	18	2	0

Table 6.1.3-2: Hake in GSA 7. Weight at age (kg) in the catch and in the stock (kg).

Years/Ages	0	1	2	3	4	5
1998	0,022	0,078	0,355	0,621	1,590	2,499
1999	0,024	0,112	0,333	0,606	1,418	2,270
2000	0,022	0,112	0,376	0,682	1,620	2,581
2001	0,021	0,111	0,333	0,574	1,477	2,565
2002	0,021	0,087	0,306	0,669	1,483	2,275
2003	0,029	0,113	0,309	0,591	1,532	2,438
2004	0,021	0,105	0,329	0,594	1,259	1,857
2005	0,023	0,106	0,343	0,576	1,121	1,559
2006	0,028	0,122	0,407	0,665	1,165	1,591
2007	0,032	0,109	0,341	0,726	1,258	1,496
2008	0,035	0,080	0,305	0,688	1,431	2,000
2009	0,029	0,128	0,331	0,528	1,166	1,708
2010	0,029	0,100	0,300	0,517	1,351	1,400
2011	0,035	0,115	0,284	0,491	1,364	1,431
2012	0,038	0,095	0,292	0,559	1,338	1,423
2013	0,032	0,097	0,288	0,964	1,330	1,592
2014	0,025	0,116	0,281	0,904	1,418	1,708
2015	0,026	0,126	0,295	1,293	1,607	1,932

6.1.4. Tuning data

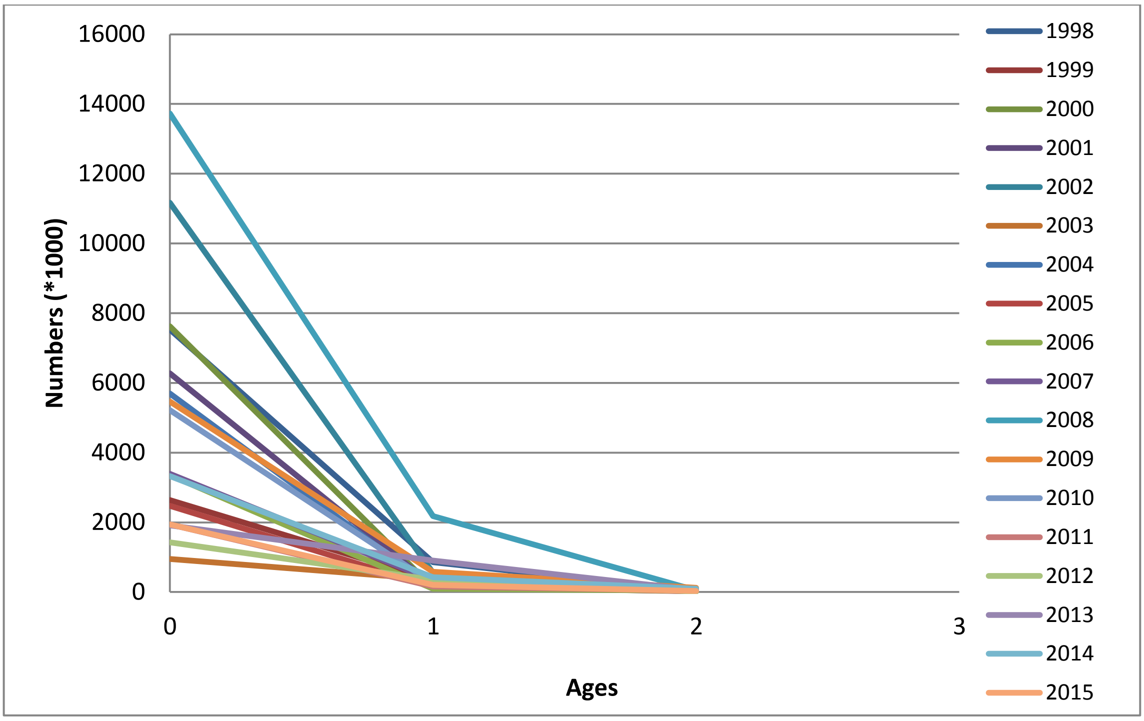


Table 6.1.4-1: Hake in GSA 7. Catch in numbers (thousands) *obtained from MEDITS survey.*

Table 6.1.4-1: Hake in GSA 7. MEDITS index at age (1998-2015).

Years/Ages	0	1	2
1998	7534	854	23
1999	2639	341	63
2000	7626	124	48
2001	6276	188	50
2002	11168	557	46
2003	945	357	93
2004	5697	136	28
2005	2468	153	25
2006	3355	92	36
2007	3390	333	63
2008	13728	2177	51
2009	5470	582	118
2010	5218	251	44
2011	1945	163	37
2012	1427	351	16
2013	1915	905	62
2014	3329	426	91
2015	1939	203	26

6.1.5. Results

After performing a sensitivity analysis (section 6.1.7.1), the same settings as last year were finally chosen for XSA model. The log-residuals of MEDITS survey were found very low and without any trend (Figure 6.1.5-2).

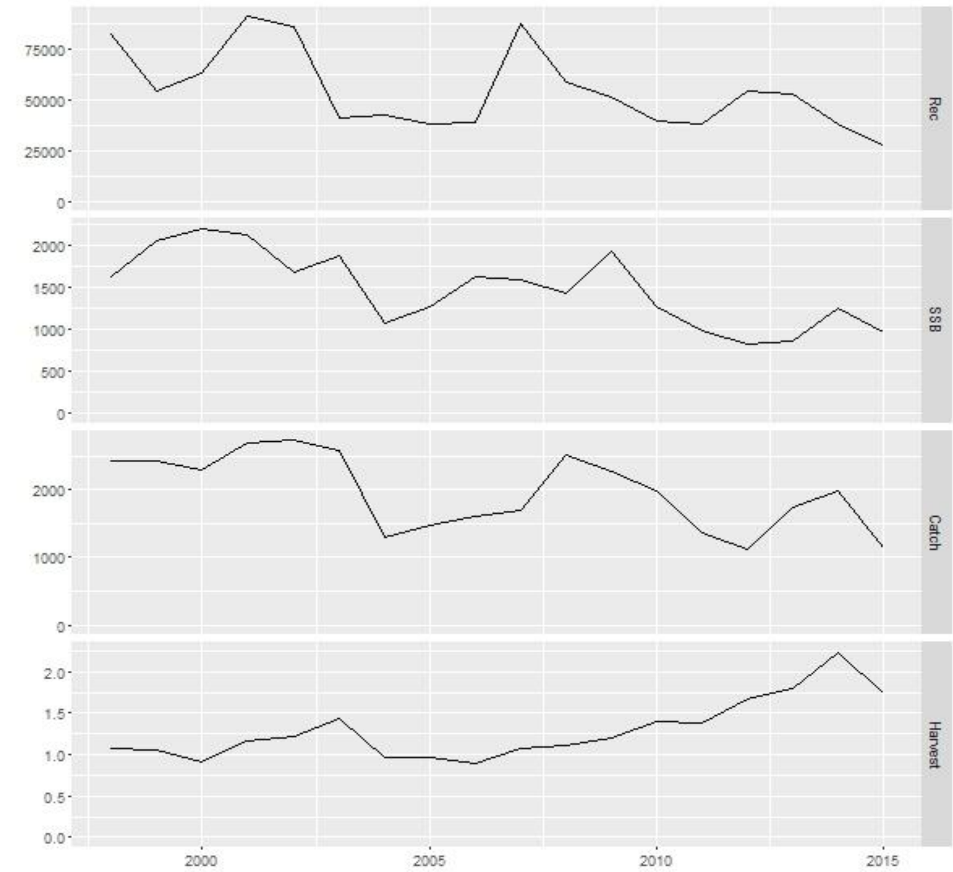


Figure 6.1.5.1: Hake in GSA 7. XSA results: recruitment (numbers in thousands), SSB and catch (tons), fishing mortality

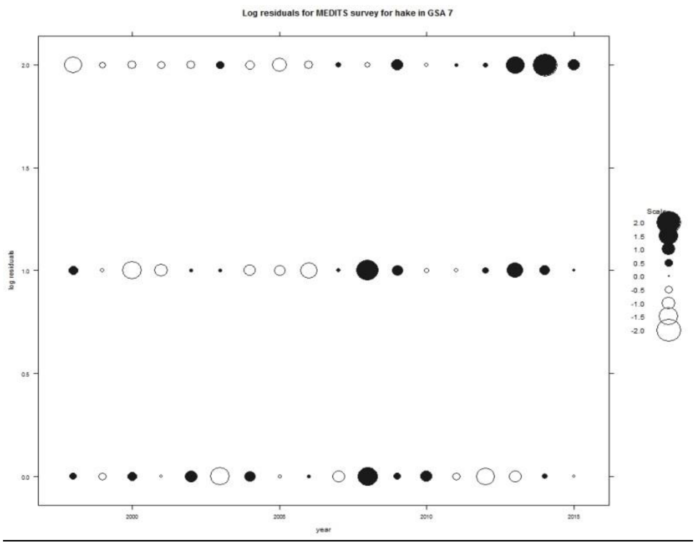


Figure 6.1.5-2: Hake in GSA 7. Log-residuals of MEDITS survey

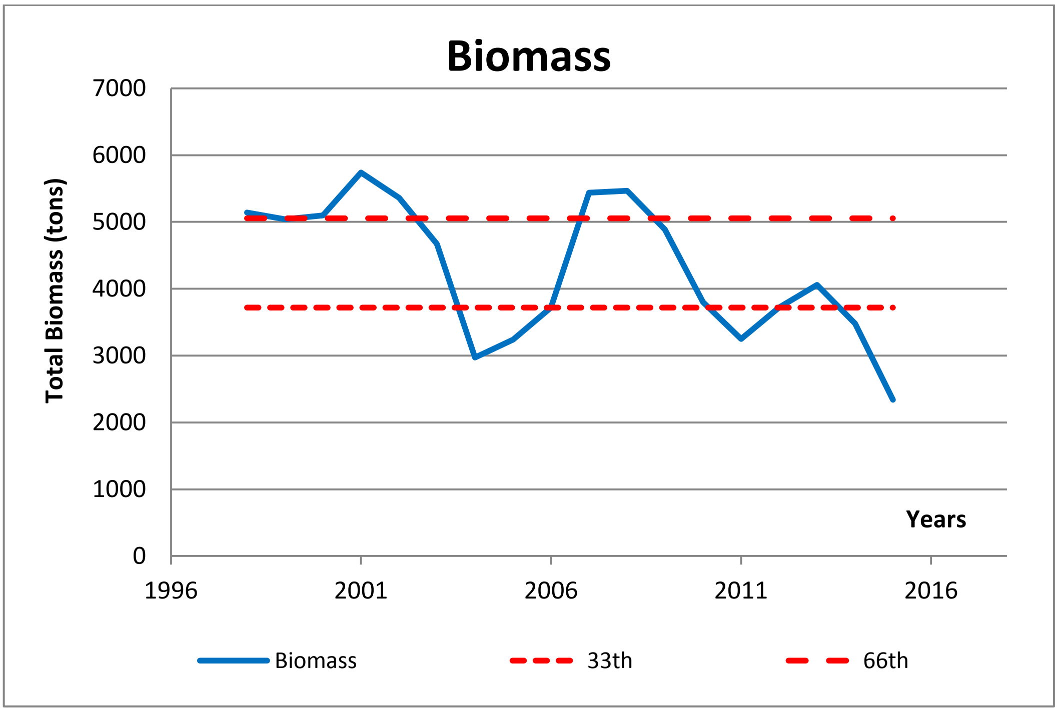


Figure 6.1.5-3: Hake in GSA 7. XSA results: Biomass (tons), 33rd and 66th

Table 6.1.5.1: Hake in GSA 7. Fishing mortality at age estimated by the XSA analysis.

Years/Ages	0	1	2	3	4	5
1998	0.531	1.259	1.446	1.565	1.444	1.444
1999	0.214	1.089	1.864	1.333	1.449	1.449
2000	0.213	0.846	1.660	1.930	1.553	1.553
2001	0.251	1.184	2.082	2.190	1.849	1.849
2002	0.609	1.366	1.663	1.919	1.681	1.681
2003	0.269	1.545	2.472	2.771	2.307	2.307
2004	0.267	0.939	1.692	1.816	1.509	1.509
2005	0.286	0.969	1.638	1.473	1.374	1.374
2006	0.119	0.806	1.728	1.966	1.535	1.535
2007	0.059	0.997	2.172	2.272	1.867	1.867
2008	0.366	1.540	1.436	1.882	1.651	1.651
2009	0.122	1.096	2.368	2.904	2.158	2.158
2010	0.333	1.524	2.331	3.219	2.396	2.396
2011	0.110	1.557	2.500	2.851	2.338	2.338
2012	0.078	1.279	3.682	2.945	2.676	2.676
2013	0.199	1.449	3.731	2.317	2.539	2.539
2014	0.345	1.963	4.408	2.377	2.962	2.962
2015	0.229	1.410	3.581	2.666	2.592	2.592

Table 6.1.5-2: Hake in GSA 7. Stock number at age estimated by the XSA analysis.

Years/Ages	0	1	2	3	4	5
1998	82762	24464	2765	335	63	35
1999	54340	17370	4172	468	54	22
2000	63270	15659	3512	465	95	57
2001	91243	18248	4034	480	52	41
2002	86516	25351	3354	362	41	25
2003	40970	16802	3886	457	41	24
2004	42834	11179	2151	236	22	5
2005	37932	11707	2626	285	30	5
2006	38956	10174	2667	367	50	11
2007	87882	12345	2728	340	40	12
2008	58911	29585	2736	224	27	10
2009	51493	14583	3809	468	26	6
2010	39683	16265	2926	256	20	2
2011	38446	10150	2127	205	8	1
2012	54651	12292	1284	126	9	1
2013	52737	18052	2054	23	5	1
2014	37918	15429	2545	35	2	1
2015	27771	9590	1302	22	3	0

Table 6.1.5-3: Hake in GSA 7. Summary of the a4a analysis.

Years/Ages	SSB (tons)	Fbar(0-2)	Rec. (thousands)
1998	1617	1.08	82762
1999	2045	1.06	54340
2000	2196	0.91	63270
2001	2119	1.17	91243
2002	1669	1.21	86516
2003	1872	1.43	40970
2004	1063	0.97	42834
2005	1259	0.96	37932
2006	1630	0.88	38956
2007	1583	1.08	87882
2008	1426	1.11	58911
2009	1915	1.20	51493
2010	1265	1.40	39683
2011	983	1.39	38446
2012	818	1.68	54651
2013	863	1.79	52737
2014	1250	2.24	37918
2015	970	1.74	27771

6.1.6. Robustness analysis

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

6.1.7.1. XSA: Sensitivity analysis

The selection of the suitable parameters for the final XSA run was performed running four sensitivity analysis. The resulting time series SSB, fishing mortality and recruitment were plotted (Figure 6.1.7.1.1.a-d). The first sensitivity analysis (a) was conducted to assess the effect of shrinkage on the last years (i.e. ranging from 1 to 5. The final setting selected is shrinkage on the last 4 years, similar to last year assessment.

The second analysis (b) was conducted to assess the effect of shrinkage on the last ages (i.e. ranging from 1 to 5). The final setting selected is shrinkage on the last 3 ages, similar to last year assessment.

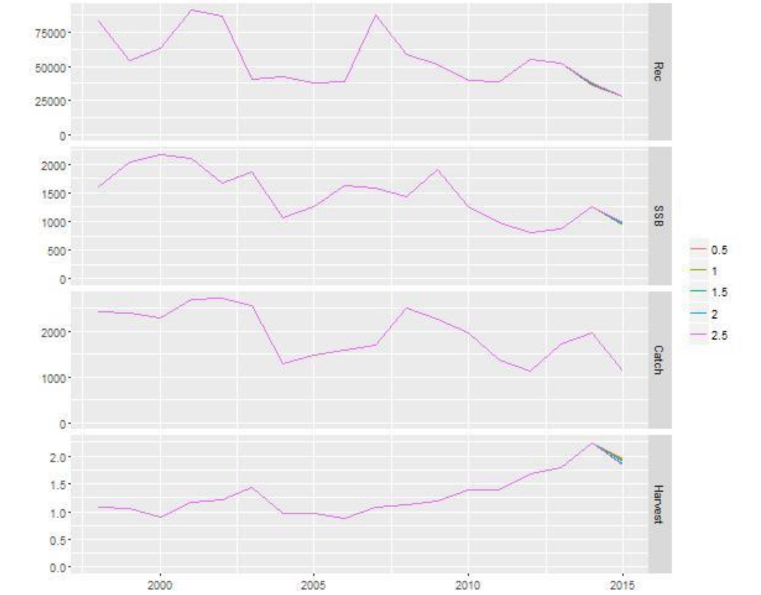
The third analysis (c) was conducted using 5 different shrinkage weight assumptions (i.e. fse 0.5. 1. 1.5. 2 and 2.5). The final setting selected is an intermediate value (1.5), similar to last year assessment.

The fourth analysis (d) was conducted to assess the effect of the age after which catchability is no longer estimated (i.e. qage assigning values ranging from 0 to 5). The final setting selected is a constant catchability for all ages, similar to last year assessment.

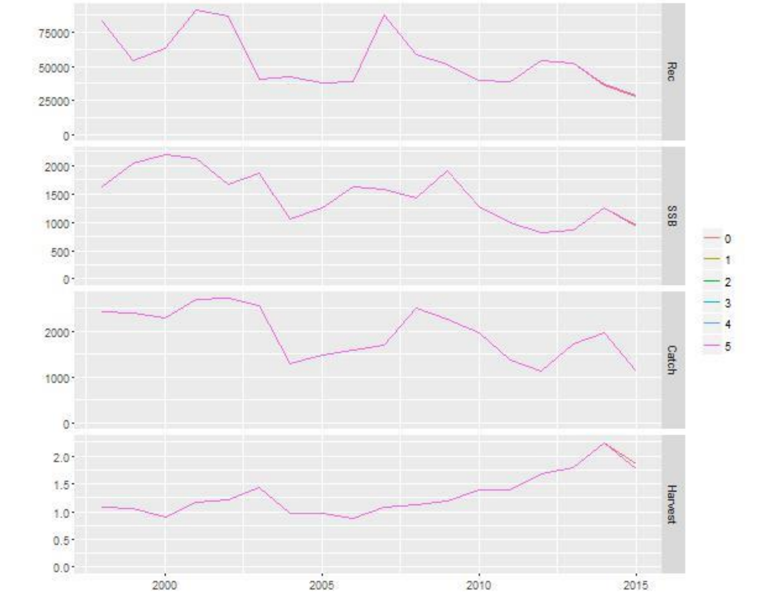
The summary of parameters finally retained for the final XSA run is in Table 6.1.7.1.1.

(a) Shrinkage on the last years (shk.yrs from 1 to 5 years)

(b) Shrinkage on the last ages (shk.age from 1 to 5 ages)



(c) Shrinkage weight (fse. 0.5. 1. 1.5. 2 and 2.5)



(d) Catchability (qage values ranging from 0 to 5)

Figure 6.1.7.1.1. Hake in GSA 7. Sensitivity analysis on shrinkage on the last years (a), last ages (b), weight of the shrinkage (c), catchability at age (d).

Table 6.1.7.1.1: Hake in GSA 7. XSA settings.

Fse	shk.yrs	shk.ages	rage	qage
1.5	4	3	-1	5

6.1.7.2. XSA: Retrospective analysis

A retrospective analysis was conducted on recruitment, mean F and SSB (Figure 6.1.7.2.1) to ensure the robustness of the final estimates. The results considering SSB don't show any particularity, but the recruitment and the mean F seems to be underestimated***.***

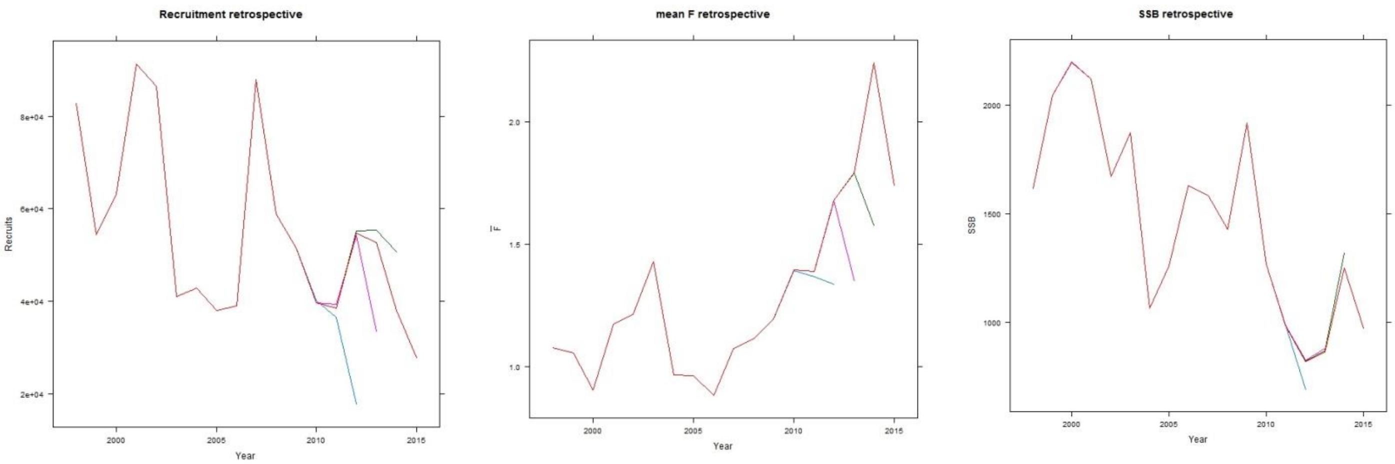


Figure 6.1.7.2.1. Hake in GSA 7. Retrospective analysis performed with XSA (Recruitment. mean F and SSB).

6.1.8. Assessment quality

Stability of the assessment, evaluation of quality of the data and reliability of model assumptions are described in the 6.1.5-7 section.

6.1.9. Comparison between XSA and a4a

The results obtained with both models showed relative good fit for most of the years and population parameters, except for the recruitment and the F especially for the last year. The main differences were observed for Recruitment, which estimates are mostly lower with a4a than with XSA, except the last year which doesn't reflect the observations. The precautionary final model considered for the assessment was XSA.

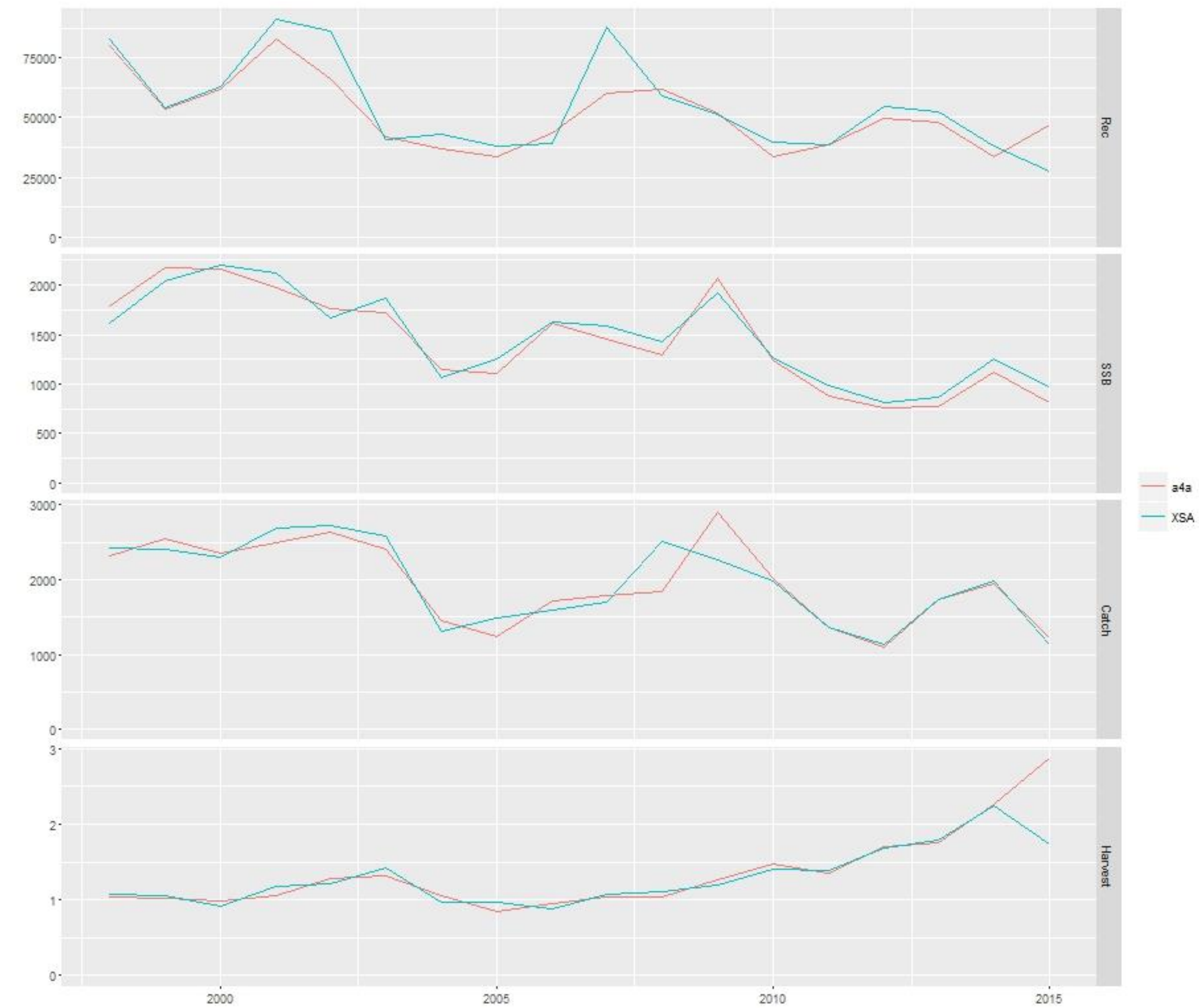


Figure 6.1.9.1 Hake in GSA 7. Comparative results from XSA and a4a.

7. Stock predictions

7.1. Short term predictions 2016-2018

A deterministic short term prediction for the period 2016 to 2018 was performed using the FLR routines (http://www.flr-project.org) by JRC and based on the results of the XSA stock assessments.

The input parameters were the same used for the XSA stock assessment and its results. An average of the last three years has been used for weight at age, maturity at age and F at age, Recruitment (age 0) has been estimated from the population results as geometric mean of the last 3 years (38152 thousands individuals).

Table 7.1-1: Hake in GSA 7. F status quo. recruitment and catch used for the short-term forecast.

Parameter	Method	Value
F status quo	Average over ages 0-2 and years 2013-2015	1.92
Recruitment (*)	Geometric mean of recruitment over 2013-2015	38152 thousands
Catch	2015	1139 tons

For the short-term forecast, all the fleets (Spanish and French bottom trawlers, Spanish longliners, French gillnetters) were combined.

The short term projection (Table 7.1-2), assuming an Fstq of 1.92 in 2015 and a recruitment of 38152 (thousands) individuals show that:

Fishing at the F_{stq} (1.92) generates an increase in catch by 7% from 2015 to 2017 along with an increase in the spawning stock biomass of 9% from 2017 to 2018.

Fishing at F_{MSY} (0.12) generates a decrease in catch by 87 % from 2015 to 2017 and a spawning stock biomass increase by 249% from 2017 to 2018.

Catches of hake in 2017 consistent with F_{MSY} would not exceed 147 tons.

Table 7.1-2: Hake in GSA 7. Short-term forecast in different F scenarios.

Ffactor	Fbar	Catch 2015	Catch 2016	Catch 2017	Catch 2018	SSB 2017	SSB 2018	Change SSB 2017-2018(%)	Change Catch 2015-2017(%)
0	0	1138	1136	0	0	687	2685	291	-100
0,10	0,19	1138	1136	236	720	687	2235	226	-79
0,20	0,38	1138	1136	429	1093	687	1891	175	-62
0,30	0,57	1138	1136	589	1276	687	1622	136	-48
0,40	0,76	1138	1136	723	1356	687	1410	105	-36
0,50	0,96	1138	1136	837	1382	687	1240	81	-26
0,60	1,15	1138	1136	934	1380	687	1102	61	-18
0,70	1,34	1138	1136	1019	1364	687	989	44	-11

0,80	1,53	1138	1136	1093	1342	687	895	30	-4
0,90	1,72	1138	1136	1157	1318	687	816	19	2
1,00	1,91	1138	1136	1215	1293	687	749	9	7
1,10	2,10	1138	1136	1266	1270	687	692	1	11
1,20	2,29	1138	1136	1312	1248	687	643	-6	15
1,30	2,48	1138	1136	1354	1227	687	600	-13	19
1,40	2,68	1138	1136	1392	1209	687	563	-18	22
1,50	2,87	1138	1136	1426	1191	687	530	-23	25
1,60	3,06	1138	1136	1458	1175	687	501	-27	28
1,70	3,25	1138	1136	1487	1160	687	475	-31	31
1,80	3,44	1138	1136	1514	1146	687	452	-34	33
1,90	3,63	1138	1136	1539	1133	687	431	-37	35
2,00	3,82	1138	1136	1563	1121	687	413	-40	37
F0.1	0,12	1138	1136	151	497	687	2394	249	-87

7.2. Short term predictions 2015-2017 by fleet

7.2.1. Method

A deterministic short term prediction by fleet for the period 2016 to 2018 was performed using the FLR routines provided by JRC and based on the results of the XSA stock assessments.

7.2.2. Input parameters

The same parameters used in the short term by single fleet were used.

7.2.3. Results

Table 7.2.3.1 European hake in GSA 7. Short term forecast by fleet.

fleet	year	catches	partial_F
French trawlers	2016	1030	1.50
French gillnetters	2016	81	0.22
Spanish trawlers	2016	117	0.17
Spanish longliners	2016	8	0.02

7.3. Medium term predictions

No medium term forecast has been performed. because of lacking of a reliable stock-recruitment relationship.

7.4. Long term predictions

Yield per recruit analysis was used (FLBRP) to calculate the reference point ($F_{0.1}$ as a proxy of FMSY) and the estimated reference fishing mortality (Fcurrent). The same population parameters used for the XSA model and exploitation pattern derived from the final model were used as input for the yield per recruit analysis. These methods were applied using the FLR libraries in the statistical software R.

Table 7.4.1. Hake in GSA 7. Reference points

Model - Year	$F_{current\ (2013-2015.ages\ 0-2)}$	$F_{0.1}$	ratio
XSA - 2016	**1.92**	**0.15**$_{(estimated\ in\ 2013)}$	**12.8**
XSA - 2015	**1.75**	**0.15**$_{(estimated\ in\ 2013)}$	**11.7**

8. 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	$F_{0.1}$ = 0.15 estimated in 2013	$F_{c(2013-2015.\ ages\ 0-2)}$ =1.92	$F_c/F_{0.1}$ = 12.8	I	IO_H
Stock abundance	Biomass		$B_{current.2015}$=2337 tons	B33th=3719 tons B66th=5053 tons	D	O_L
	SSB		$SSB_{current.2015}$=970 tons			
Recruitment	R		$R_{current}$ (Geometric mean last 3 years) = 38152 (*1000 in numbers)		D	
Final Diagnosis		In an overexploitation status with relative low biomass (empirical reference value)				

This stock is in an overexploitation status with a relative low biomass. Since 2010, the fishing mortality has reached the highest levels of the time series. Moreover, spawning stock biomass and recruitment are at the lowest levels of the series, without any sign of improvement. The current exploitation level is well above the level estimated to be sustainable, despite the important decrease in number of French trawlers since 2011, reducing the number of boats by almost 50%. This stock is still in a high overexploitation status.

Management advice and recommendations: Reduce fishing mortality

-Respect the minimum legal landing size and legal mesh size

-Spatio-temporal closures for the protection of nurseries and spawning zones

-Reduce number of days at sea and/or numbers of boats

-Respect the freezing of the effort in the Fishery Restricted Area

9. 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)*