Stock Assessment Form

Demersal species

HAKE – GSA 7

Reference year: 1998-2014

Reporting year: 2015

[A brief abstract may be added here]

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:
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		
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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).

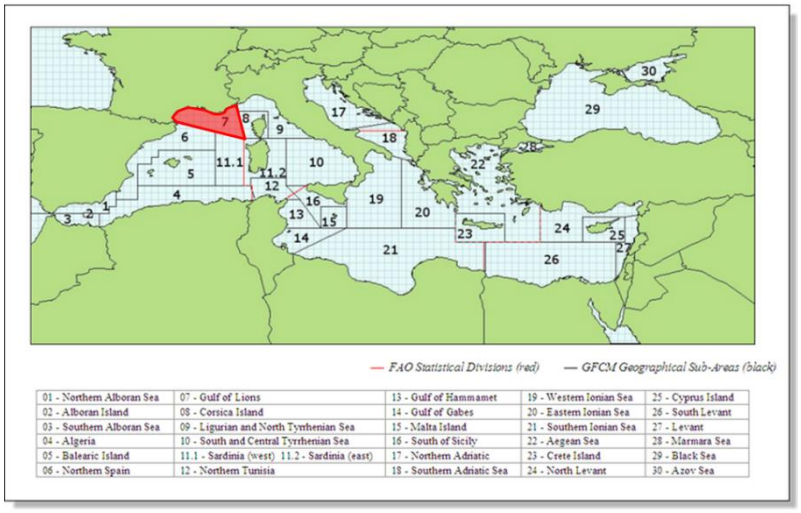


Figure 2-1: Geographical location of GSA 7 – Gulf of Lions

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 2004-2014 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 2.2-1: 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: Hake in GSA 7. Natural Mortality (M) at age estimated using PRODBIOM

Years/Ages	**0**	**1**	**2**	**3**	**4**	**5**
1998	0.88	0.43	0.33	0.25	0.22	0.20
1999	0.88	0.43	0.33	0.25	0.22	0.20
2000	0.88	0.43	0.33	0.25	0.22	0.20
2001	0.88	0.43	0.33	0.25	0.22	0.20
2002	0.88	0.43	0.33	0.25	0.22	0.20
2003	0.88	0.43	0.33	0.25	0.22	0.20
2004	0.88	0.43	0.33	0.25	0.22	0.20
2005	0.88	0.43	0.33	0.25	0.22	0.20
2006	0.88	0.43	0.33	0.25	0.22	0.20
2007	0.88	0.43	0.33	0.25	0.22	0.20
2008	0.88	0.43	0.33	0.25	0.22	0.20
2009	0.88	0.43	0.33	0.25	0.22	0.20
2010	0.88	0.43	0.33	0.25	0.22	0.20
2011	0.88	0.43	0.33	0.25	0.22	0.20
2012	0.88	0.43	0.33	0.25	0.22	0.20
2013	0.88	0.43	0.33	0.25	0.22	0.20
2014	0.88	0.43	0.33	0.25	0.22	0.20

Table 2.2-3: Proportion of matures by size or age (both sexes)

Years/Ages	0	1	2	3	4	5
1998	0.06	0.23	0.72	0.92	0.99	1.00
1999	0.06	0.33	0.69	0.91	0.99	1.00
2000	0.06	0.34	0.74	0.92	0.99	1.00
2001	0.06	0.33	0.70	0.90	0.99	1.00
2002	0.05	0.25	0.67	0.91	0.99	1.00
2003	0.08	0.34	0.67	0.90	0.99	1.00
2004	0.06	0.32	0.70	0.90	0.98	0.99
2005	0.06	0.32	0.71	0.90	0.98	0.99
2006	0.07	0.37	0.78	0.91	0.98	0.99
2007	0.08	0.32	0.70	0.92	0.98	0.99
2008	0.09	0.22	0.65	0.91	0.98	1.00
2009	0.08	0.38	0.69	0.89	0.98	0.99
2010	0.08	0.29	0.65	0.89	0.98	0.99
2011	0.09	0.33	0.64	0.88	0.98	0.99
2012	0.11	0.27	0.64	0.89	0.98	0.99
2013	0.03	0.25	0.61	0.94	1.00	1.00
2014	0.01	0.34	0.68	0.92	1.00	1.00

Table 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 2.2-5: Sex-ratio (*) at length from data collected in GSA 7 (2003-2014) by IFREMER for the DCF was used to compute the number of females and males at length.

Size (cm)	Prop. Of Fem	Size (cm)	Prop. Of Fem
14	0,46	36	0,79
15	0,45	37	0,82
16	0,46	38	0,85
17	0,45	39	0,89
18	0,45	40	0,86
19	0,48	41	0,90
20	0,43	42	0,91
21	0,44	43	0,93
22	0,46	44	0,96
23	0,45	45	0,96
24	0,47	46	0,94
25	0,49	47	0,96
26	0,47	48	0,96
27	0,44	49	0,96
28	0,43	50	1,00
29	0,44	51	0,95
30	0,49	52	0,92
31	0,51	53	0,94
32	0,60	54	0,96
33	0,64	55	0,90
34	0,68	56-96	1,00
35	0,79		

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 1998-2014 have oscillated around an average value of 2012 tons (1983 tons in 2014). 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 2014, 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: 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: Catch, bycatch, discards and effort by operational unit in the reference year (2014)

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	57	1391.7	*S. pilchardus, E. encrasicolus, Mullus spp., Solea spp., Lophius spp., S. aurata, D. labrax, Pagellus spp., M. poutassou, T. m. capelanus and Eledone spp.*	49.2	unknown	unknown
FRA 07 C 07 33 - HKE	141	315.4	*S. scombrus, T. lucerna, T. m. capelanus, Lepidorhombus spp. and S. canicula*	not discarded	unknown	unknown
ESP 07 E 03 33 - HKE	19	200.1	*Solea spp., Mullus spp., Lophius spp., Pagellus spp., M. poutassou, T. m. capelanus and E. cirrhosa*	2.3	unknown	unknown
ESP 07 I 09 34 - HKE	8	23.9	*L. caudatus, H. dactylopterus, C. conger, P. bogaraveo and P. blennoides*	not discarded	unknown	unknown
Total	**225**	**1931.1**		**52**		

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

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

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	-	-	-

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 2014, total catch reached 1983 tons.

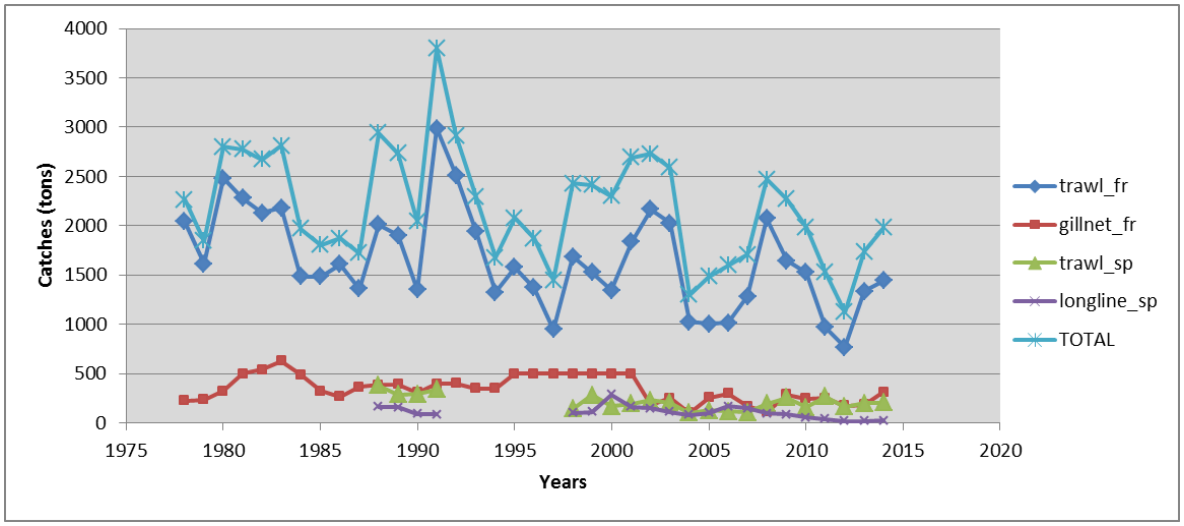


Figure 3.2-1: Hake in GSA 7. Catch (tons) by gear since 1978

3.2.1 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 observed
- 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 (2014, 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).

3.2.2 Reference points

Table 3.2-1: 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.

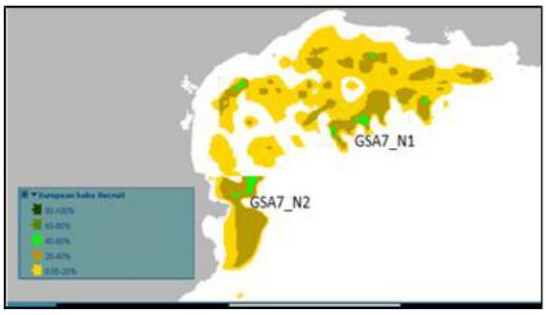


Figure 4.1.2.1. Hake GSA7: Nursery areas (MEDISEH, 2014)

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, nevertheless a slight increase can be observed in 2014. The age structure did not exhibit any substantial change in 2014 compared to the other years (figure 4.1.3-2).

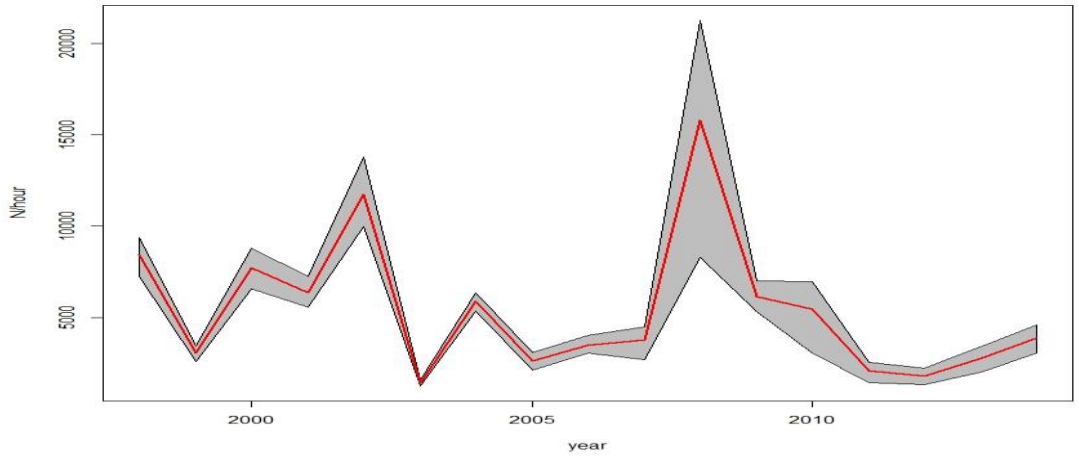


Figure 4.1.3-1: Hake in GSA 7. MEDITS abundance index (n/hour).

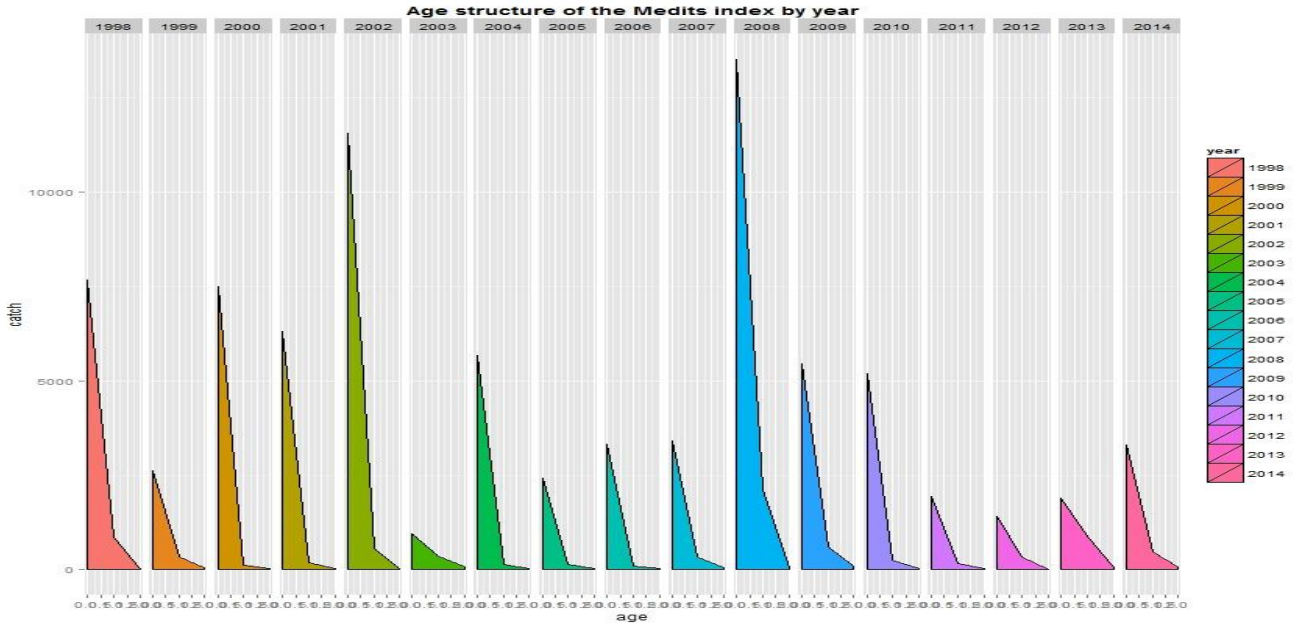


Figure 4.1.3-2: Hake in GSA 7. Age structure of the MEDITS abundance index (n/hour).

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

During EWG 15-11, the stock assessment was performed over the period 1998-2014 using an XSA model over age classes ranging from 0 to 5+ and with MEDITS index, as tuning fleet (ages 0-2). An attempt was made to use the a4a model, developed by the Joint Research Center, instead of XSA for assessing the stock. a4a is a statistical catch at age model, which flexibility allows to fit a wide range of models to the data. A comparison between the 2 methods of the results can be find in the section 6.1.7.3 (comparison with a4a). The final diagnosis is based upon XSA analysis.

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

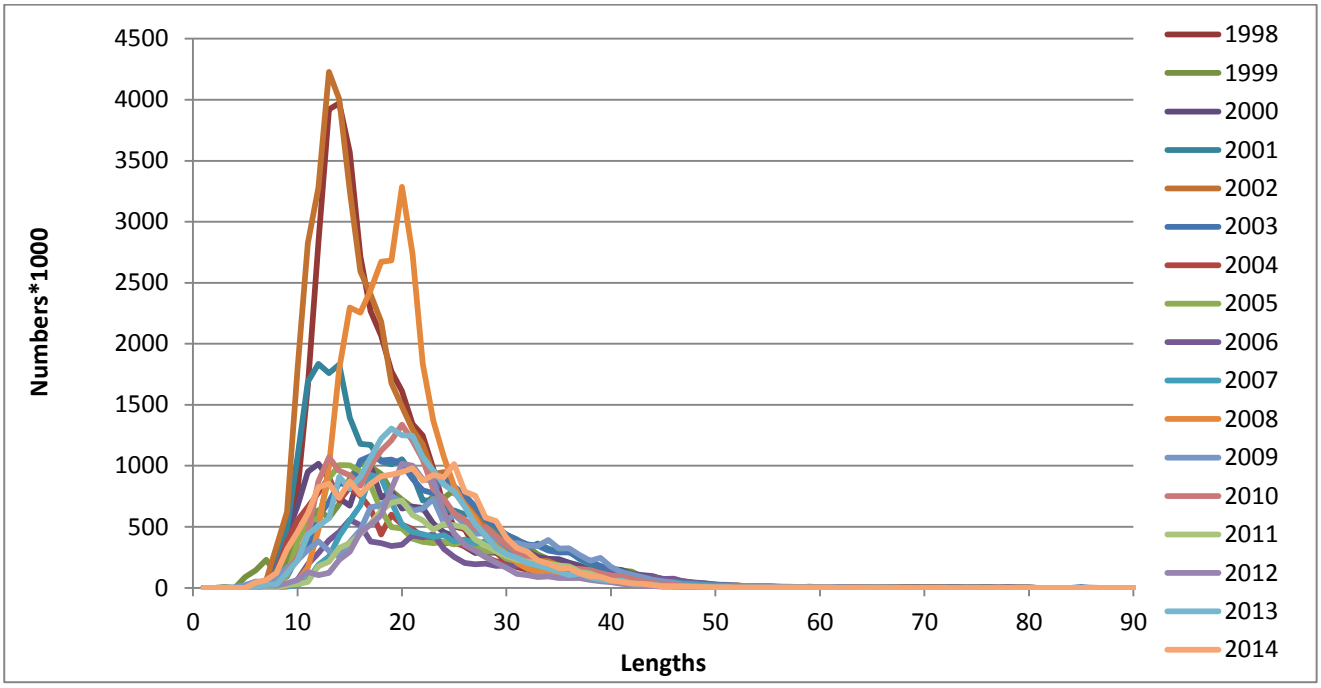


Figure 6.1.3-1: Hake in GSA 7. Length distribution of total catch.

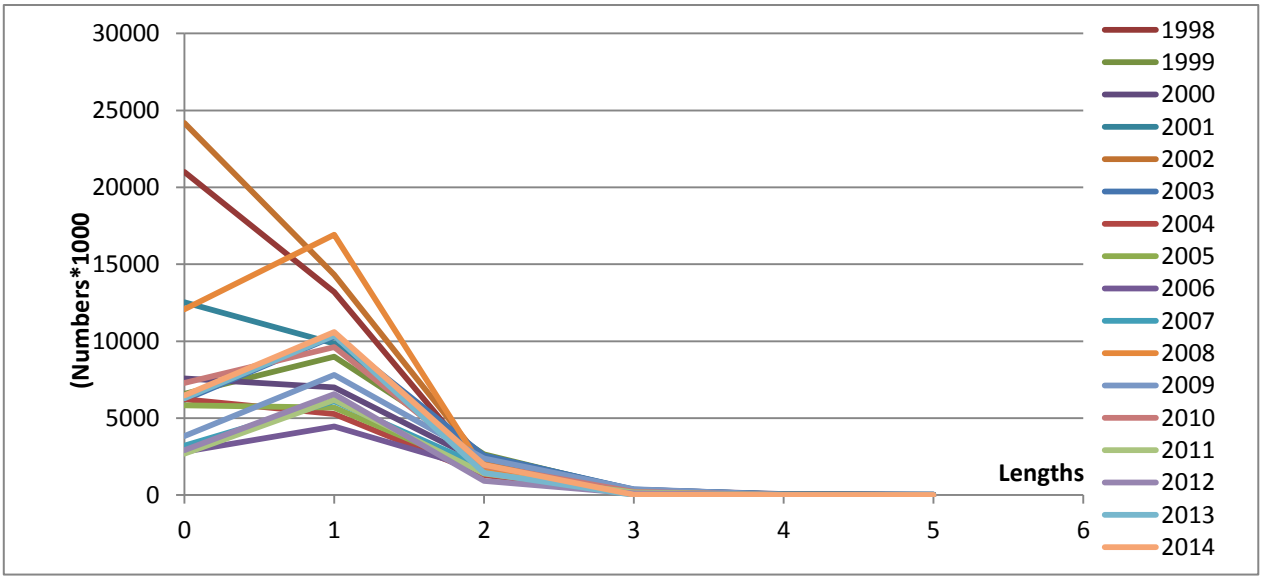


Figure 6.1.3-1: Hake in GSA 7. Age distribution of total catch.

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	21010	13203	1554	228	39	12
1999	6571	8996	2644	281	34	8
2000	7575	6992	2080	330	60	24
2001	12526	9850	2561	344	39	21
2002	24183	14310	2066	231	25	13
2003	6190	10323	2561	347	23	16
2004	6225	5269	1284	162	12	3
2005	5826	5691	1565	177	15	3
2006	2816	4452	1616	240	28	6
2007	3211	6097	1821	232	21	7
2008	12079	16923	1595	148	13	5
2009	3841	7804	2371	375	15	4
2010	7289	9621	1924	210	12	2
2011	2679	6188	1403	163	5	1
2012	2912	6558	915	101	4	1
2013	6287	10374	1440	13	3	0
2014	6476	10591	1953	24	1	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	0.0236	0.0858	0.3509	0.6866	1.7755	2.5426
1999	0.0263	0.1257	0.3283	0.6165	1.5267	2.0843
2000	0.0242	0.1304	0.3788	0.7348	1.8415	2.5966
2001	0.0225	0.1264	0.3300	0.5755	1.7442	2.6060
2002	0.0216	0.0940	0.3088	0.6580	1.6604	2.1780
2003	0.0316	0.1286	0.3024	0.5954	1.6092	2.4015
2004	0.0228	0.1197	0.3234	0.5858	1.1613	1.6772
2005	0.0248	0.1211	0.3397	0.5625	0.9783	1.3058
2006	0.0304	0.1441	0.4206	0.6452	1.0535	1.3081
2007	0.0351	0.1237	0.3492	0.7019	1.1964	1.2715
2008	0.0380	0.0846	0.3047	0.6905	1.3747	1.8235
2009	0.0323	0.1505	0.3170	0.5286	1.0419	1.4363
2010	0.0317	0.1122	0.2850	0.5196	1.2359	1.2238
2011	0.0394	0.1285	0.2694	0.4846	1.2260	1.1589
2012	0.0434	0.1036	0.2793	0.5615	1.1225	1.2012
2013	0.0358	0.1060	0.2705	1.0979	1.2002	1.3687
2014	0.0259	0.1216	0.2571	0.8088	1.2002	1.3687

6.1.4 Tuning data

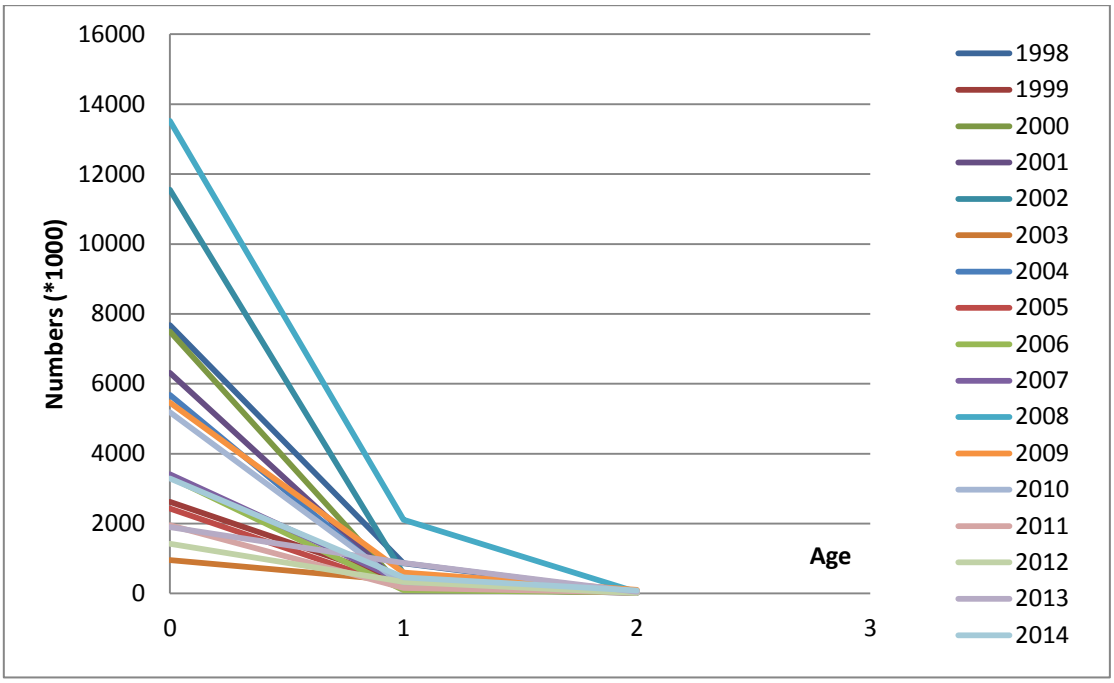


Table 6.1.4-1: Hake in GSA 7. Catch in numbers (thousands) *obtained from MEDITS survey.*

Table 6.1.4-1: Hake in GSA 7. MEDITS index at age (1998-2014).

Years/Ages	0	1	2
1998	7678	860	19
1999	2622	346	51
2000	7493	127	39
2001	6317	181	42
2002	11549	563	41
2003	952	365	74
2004	5681	140	24
2005	2428	150	22
2006	3331	94	30
2007	3414	330	55
2008	13518	2115	43
2009	5460	595	104
2010	5188	247	40
2011	1951	164	35
2012	1425	336	15
2013	1902	877	52
2014	3295	460	84

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).

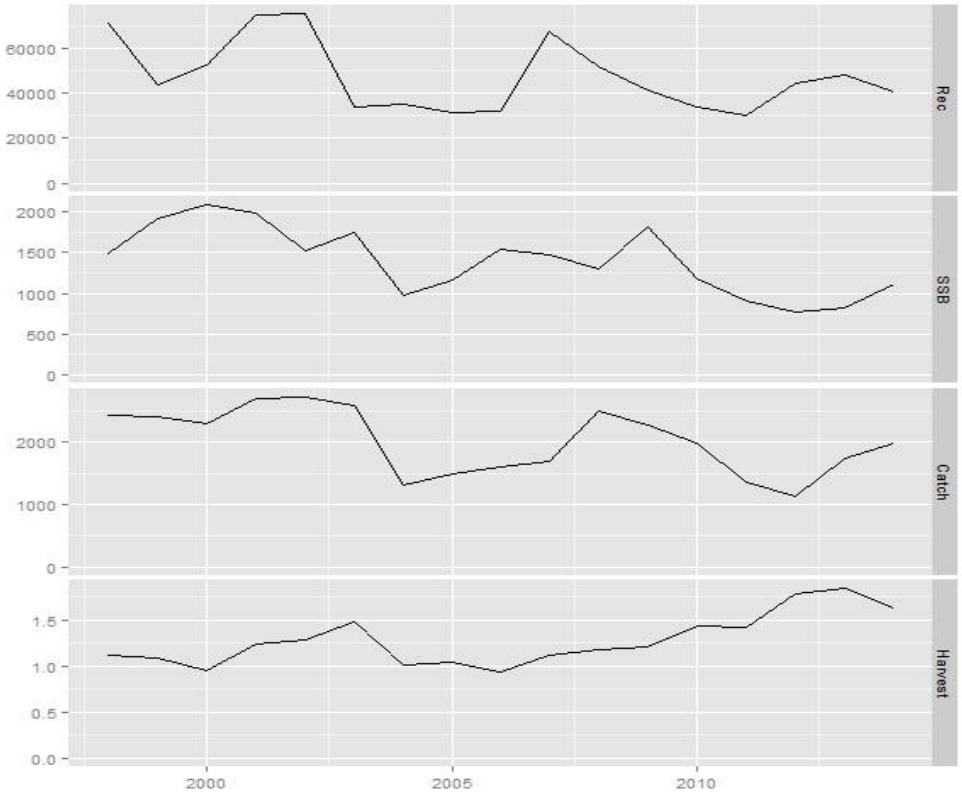


Figure 6.1.5.1: Hake in GSA 7. XSA results: recruitment (numbers in thousands), SSB and catch (tons), fishing mortality

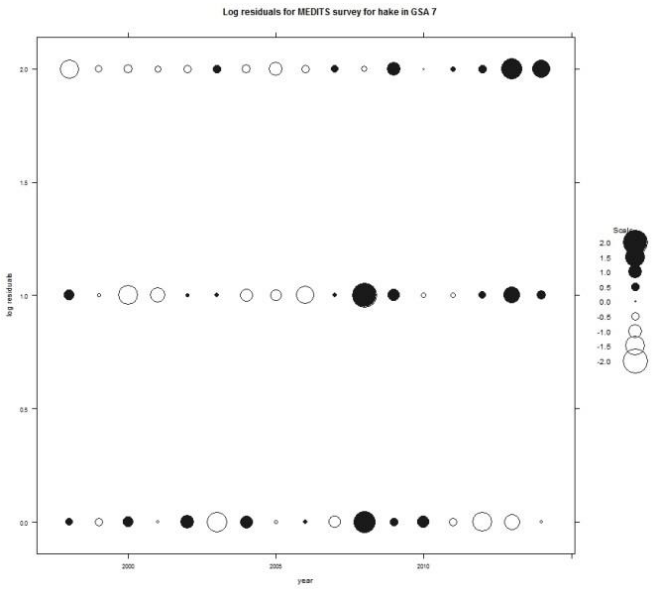


Figure 6.1.5-2: Hake in GSA 7. Log-residuals of MEDITS survey

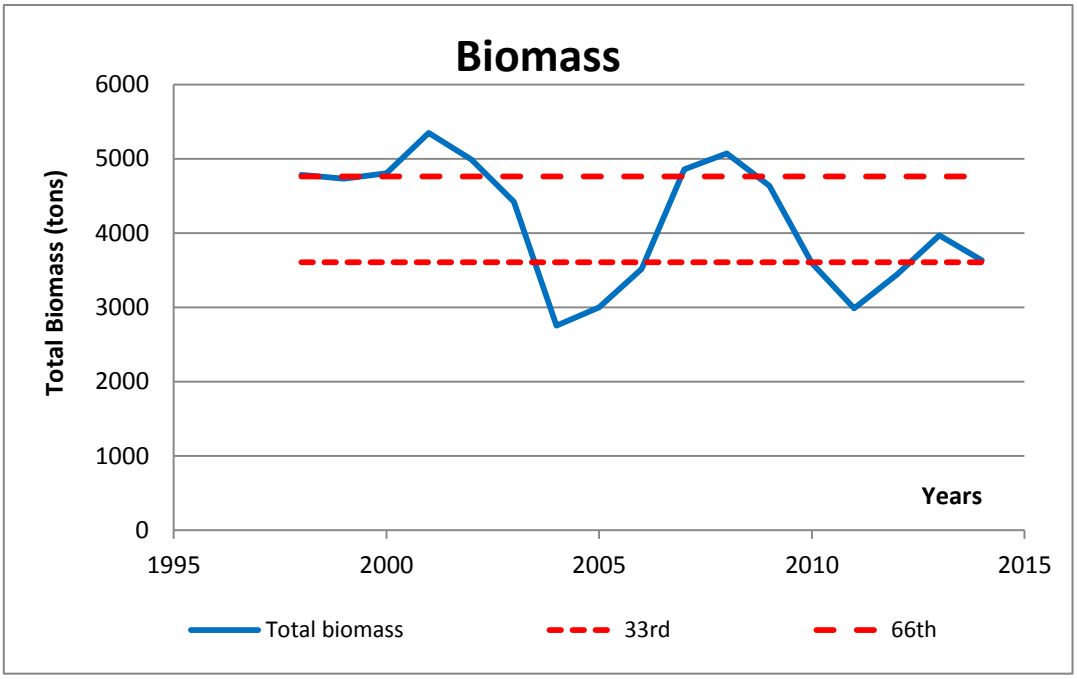


Figure 6.1.5-3: Hake in GSA 7. XSA results: Biomass (tons), 33rd and 66th

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	0.617	1.349	1.407	1.626	1.482	1.482
1999	0.265	1.217	1.808	1.367	1.485	1.485
2000	0.254	0.971	1.625	1.900	1.583	1.583
2001	0.302	1.291	2.111	2.327	1.943	1.943
2002	0.690	1.500	1.654	2.093	1.782	1.782
2003	0.335	1.699	2.420	2.966	2.404	2.404
2004	0.321	1.054	1.677	2.004	1.606	1.606
2005	0.341	1.096	1.672	1.621	1.479	1.479
2006	0.148	0.911	1.758	2.165	1.647	1.647
2007	0.077	1.088	2.199	2.520	1.983	1.983
2008	0.453	1.677	1.399	2.055	1.741	1.741
2009	0.155	1.248	2.218	3.179	2.250	2.250
2010	0.406	1.661	2.255	3.432	2.489	2.489
2011	0.148	1.710	2.402	3.402	2.543	2.543
2012	0.107	1.398	3.856	3.341	2.910	2.910
2013	0.228	1.481	3.817	2.290	2.569	2.569
2014	0.281	1.790	2.842	3.166	2.640	2.640

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	70831	22104	2427	321	57	16
1999	43839	15848	3730	427	49	11
2000	52373	13952	3054	440	85	32
2001	74512	16845	3436	432	51	27
2002	75309	22839	3013	299	33	17
2003	33783	15662	3316	414	29	18
2004	35210	10026	1863	212	17	4
2005	31309	10595	2273	250	22	4
2006	31855	9234	2303	307	39	8
2007	67203	11399	2416	285	27	9
2008	51477	25807	2498	193	18	7
2009	41466	13572	3138	443	19	4
2010	33902	14726	2535	246	14	2
2011	30197	9367	1820	191	6	1
2012	44654	10800	1103	118	5	1
2013	47795	16646	1736	17	3	0
2014	40913	15775	2461	27	1	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	1491	1.12	70831
1999	1920	1.10	43839
2000	2079	0.95	52373
2001	1980	1.24	74512
2002	1529	1.28	75309
2003	1741	1.48	33783
2004	983	1.02	35210
2005	1158	1.04	31309
2006	1545	0.94	31855
2007	1473	1.12	67203
2008	1305	1.18	51477
2009	1809	1.21	41466
2010	1173	1.44	33902
2011	915	1.42	30197
2012	769	1.79	44654
2013	816	1.84	47795
2014	1115	1.64	40913

6.1.6 Robustness analysis

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

6.1.7.1. XSA: Sensitivity analysis

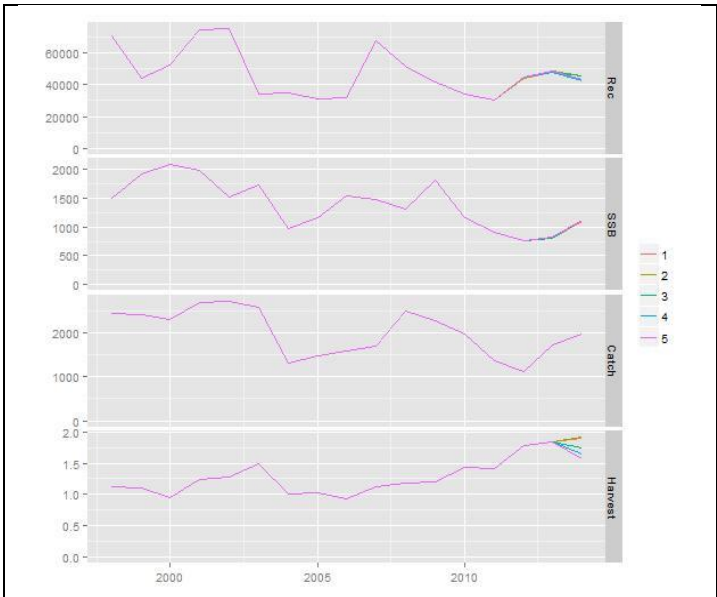
The selection of the suitable parameters for the final XSA run was performed running four sensitivity analysis. The resulting time series SSB, fishing mortality and recruitment were plotted (Figure 6.1.7.1.1.a-d). The first sensitivity analysis (a) was conducted to assess the effect of shrinkage on the 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.

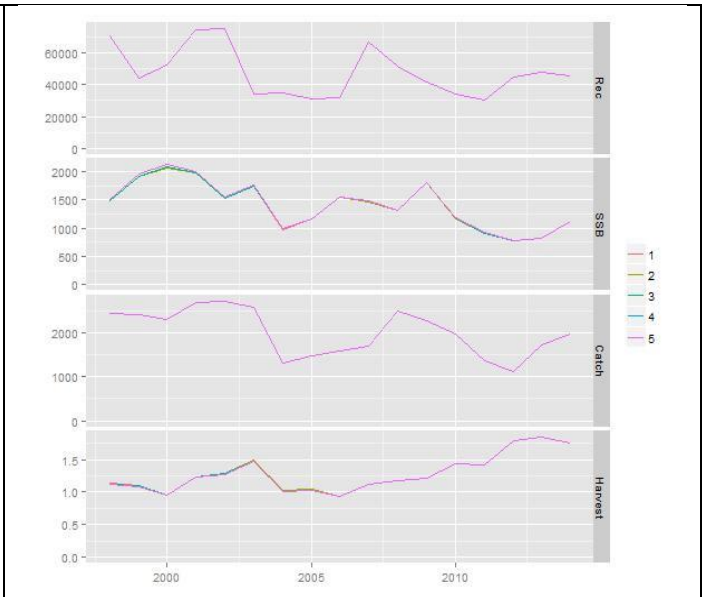
The third analysis (c) was conducted using 5 different shrinkage weight assumptions (i.e. fse 0.5, 1, 1.5, 2 and 2.5). The final setting selected is an intermediate value (1.5), similar to last year assessment.

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.

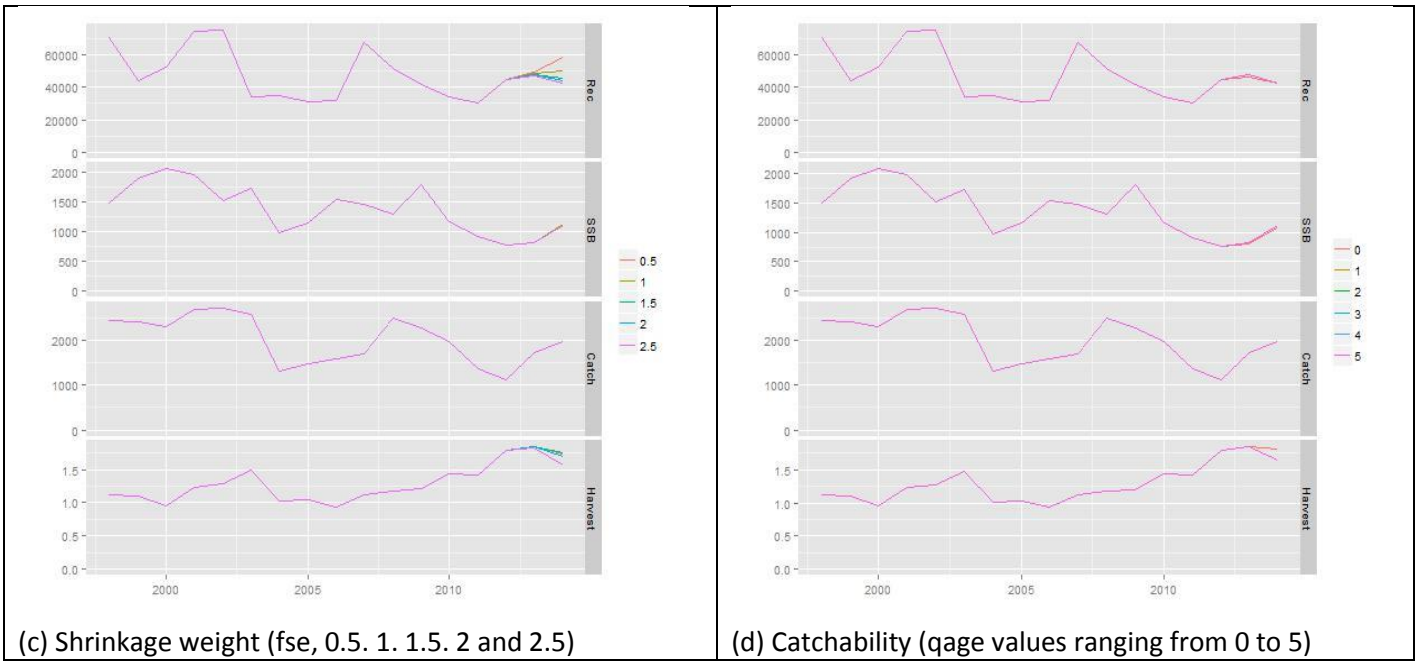
The summary of parameters finally retained for the final XSA run is in Table 6.1.7.1.1.



(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**.**

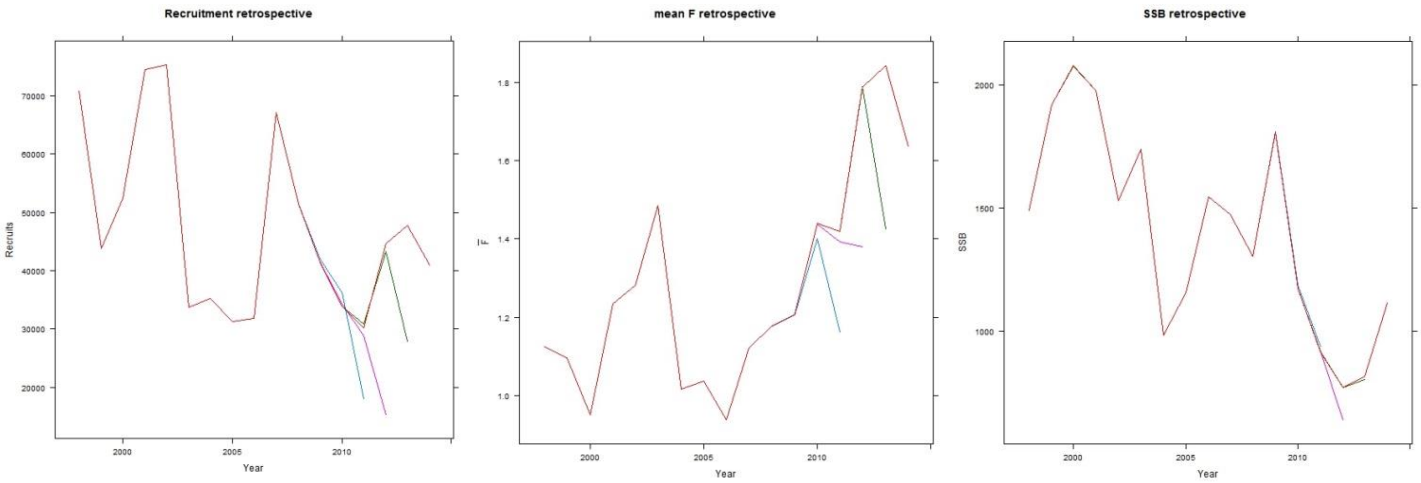


Figure 6.1.7.2.1. Hake in GSA 7. Retrospective analysis performed with XSA (Recruitment, mean F and SSB).

6.1.7.3. Comparison with a4a

The stock assessment was also performed over the period 1998-2014, over age classes ranging from 0 to 5+, using a4a model and the MEDITS index, as tuning fleet. The a4a model, developed by the Joint Research Center is a statistical catch at age model, which flexibility allows fitting a wide range of models to the data. Compared to XSA, a4a runs forward and allows reaching a better stability for last years estimates. The results were compared to XSA run. The general specification of the model in R language was the following:

index <- hke.idx

qmod <- list(~s(age. k = 3. by=breakpts(year. 2011)) + s(year. k=3. by=as.numeric(age==2)))

fmod <- ~ s(year. k=10. by=breakpts(age. 0.5))+ s(age. k=4. by=breakpts(year. 2011)) + te(year. age. k = c(3. 3))

fit <- a4aSCA(stock = hke. indices = index. fmodel = fmod. qmodel = qmod)

This model allowed for an effect of age for the catchability of the MEDITS index (submodel qmod). The model also allowed for an effect of time and age and a combined effect of both these variables on the fishing mortality estimates (submodel fmod). The flexibility parameters for the smoother effects (k) for the qmod and vmod were set to constant values to ensure the fit of a reasonable model. The Trials showed that other values were not as suitable. We assessed the quality of the model fits using model residuals. MEDITS index and catches (figure 6.1.7.3.2). Time series of the estimated parameters from the a4a analysis are presented in figure 6.1.7.3.1.

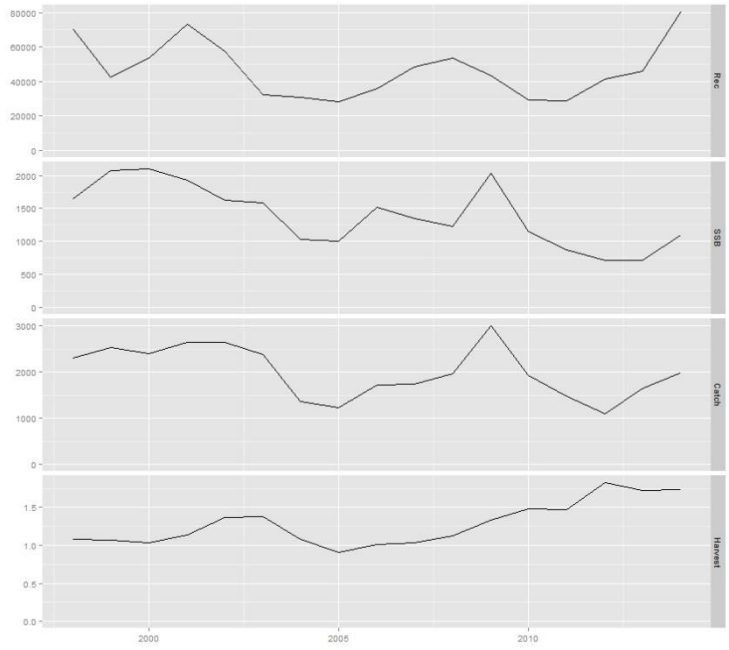


Figure 6.1.7.3.1. Hake in GSA 7. Time series of the estimated parameters from the a4a analysis

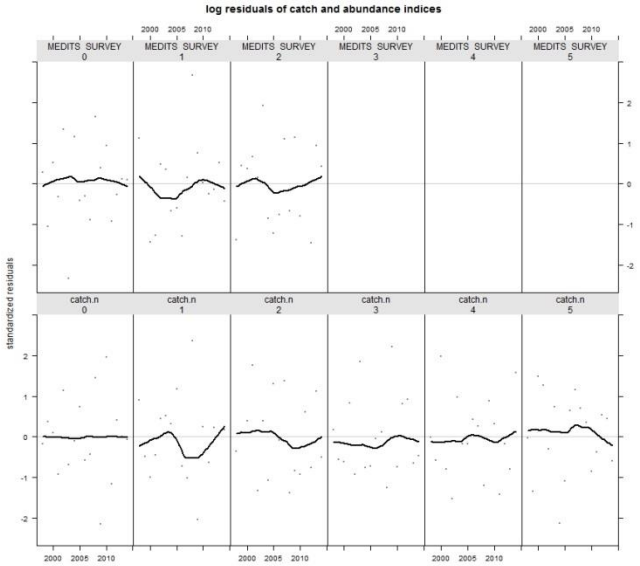


Figure 6.1.7.3.2. Hake in GSA 7. Residuals for the catch and MEDITS data from the a4a analysis

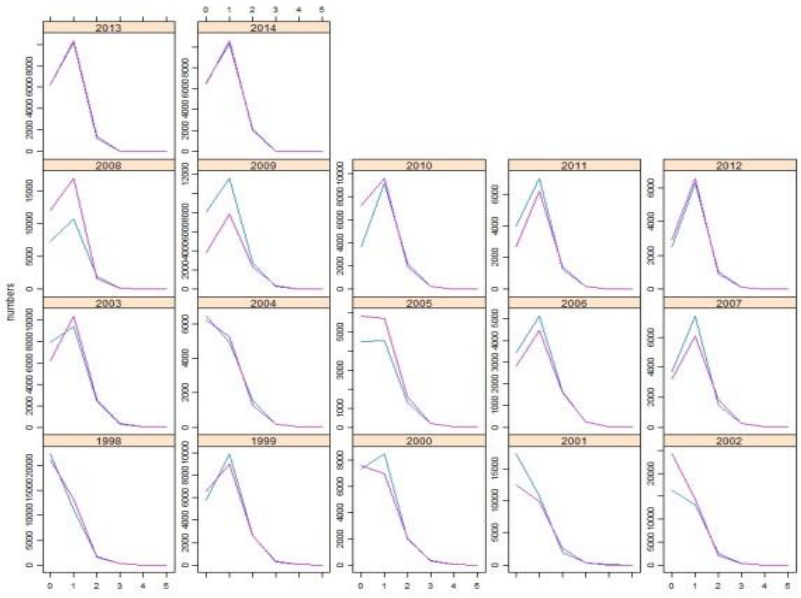


Figure 6.1.7.3.3. Hake in GSA 7. Predicted and observed catch by age class.

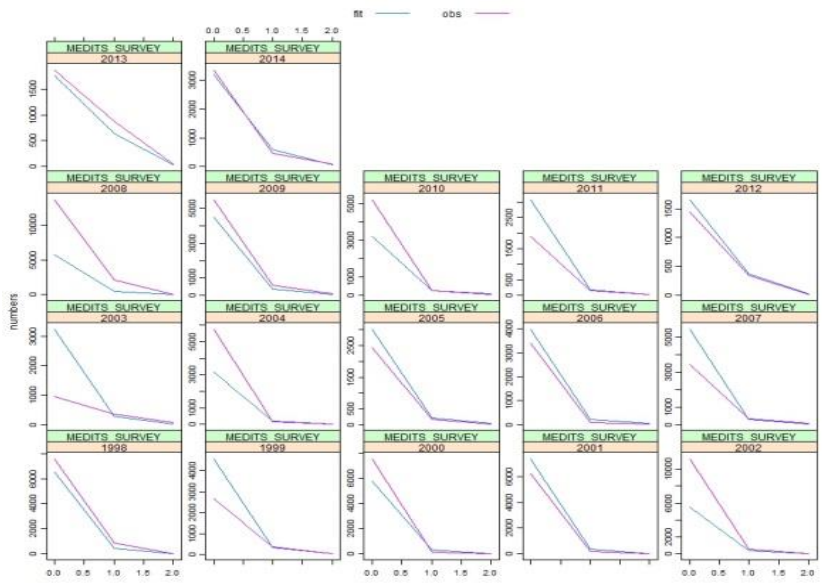


Figure 6.1.7.3.4. Hake in GSA 7. Predicted and observed MEDITS index by age class.

Comparison XSA versus a4a

The 'best' a4a model has similar results to XSA in terms of catch, fishing mortality and spawning stock biomass but gives higher estimates of recruitment, especially the last year (Figure 6.1.7.3.5). Residuals patterns of this model were generally good with no extreme values. The comparison of the a4a and XSA results displayed a good consistency as the trends for the various variables were found to be similar. Nevertheless, because of the overestimation of the last year estimated recruitment by the a4a model, **the WG validated the use of the precautionary XSA approach for this assessment.**

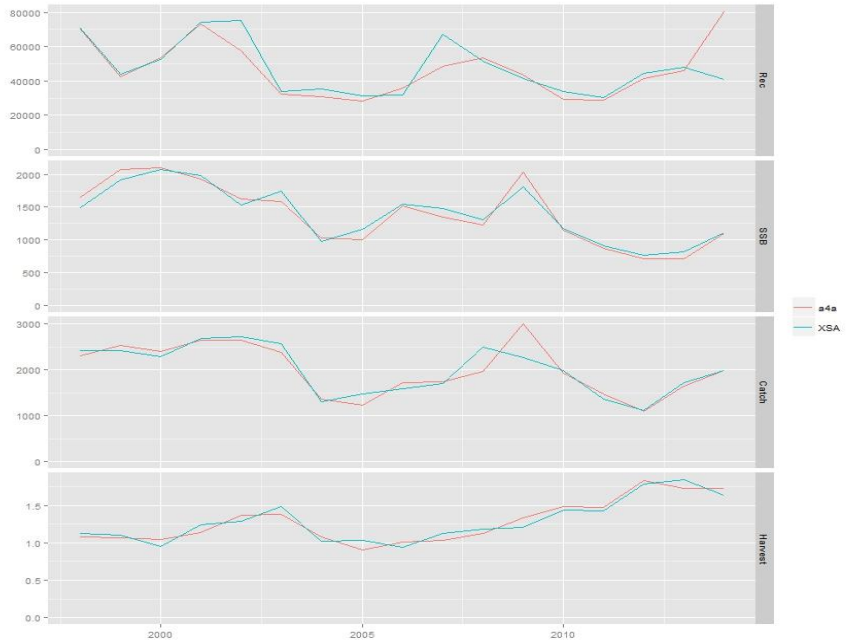


Figure 6.1.7.3.5. Hake in GSA 7. Comparison of the XSA and a4a run.

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, sections.

7 Stock predictions

7.1 Short term predictions 2015-2017

A deterministic short term prediction for the period 2015 to 2017 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 (44364 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 2012-2014	1.75
Recruitment (*)	Geometric mean of recruitment over 2011-2013	44364 thousands
Catch	2014	1981 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 1.75 in 2014 and a recruitment of 44364 (thousands) individuals show that:

Fishing at the F_{stq} (1.75) generates a decrease in catch by 15% from 2014 to 2016 along with a decrease in the spawning stock biomass of 3% from 2016 to 2017.

Fishing at F_{MSY} (0.11) generates a decrease in catch by 89 % from 2014 to 2016 and a spawning stock biomass increase by 238% from 2016 to 2017.

Catches of hake in 2016 consistent with F_{MSY} would not exceed 209 tons.

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

Ffactor	Fbar	Catch 2014	Catch 2015	Catch 2016	Catch 2017	SSB 2016	SSB 2017	Change SSB 2016-2017(%)	Change Catch 2014-2016(%)
0.00	0.00	1981	1871	0	0	740	2798	278	-100.00
0.10	0.18	1981	1871	320	858	740	2343	217	-83.87
0.20	0.35	1981	1871	586	1329	740	1980	168	-70.43
0.30	0.53	1981	1871	809	1578	740	1689	128	-59.16
0.40	0.70	1981	1871	998	1699	740	1455	97	-49.63
0.50	0.88	1981	1871	1159	1749	740	1265	71	-41.51
0.60	1.05	1981	1871	1297	1758	740	1109	50	-34.53
0.70	1.23	1981	1871	1417	1746	740	982	33	-28.50
0.80	1.40	1981	1871	1521	1723	740	877	18	-23.24
0.90	1.58	1981	1871	1612	1695	740	790	7	-18.62
1.00	1.75	1981	1871	1693	1666	740	716	-3	-14.53
1.10	1.93	1981	1871	1766	1637	740	655	-12	-10.89
1.20	2.10	1981	1871	1830	1610	740	602	-19	-7.62
1.30	2.28	1981	1871	1889	1584	740	558	-25	-4.67
1.40	2.45	1981	1871	1942	1560	740	519	-30	-1.98
1.50	2.63	1981	1871	1991	1538	740	486	-34	0.47
1.60	2.81	1981	1871	2035	1518	740	456	-38	2.72
1.70	2.98	1981	1871	2077	1499	740	431	-42	4.81
1.80	3.16	1981	1871	2115	1482	740	408	-45	6.74
1.90	3.33	1981	1871	2151	1466	740	388	-48	8.54
2.00	3.51	1981	1871	2184	1451	740	369	-50	10.23
FMSY	0.11	1981	1871	209	598	740	2499	238	-89.47

7.2 Short term predictions 2015-2017 by fleet

7.2.1 Method

A deterministic short term prediction by fleet for the period 2015 to 2017 was performed using the FLR routines provided by JRC and based on the results of the XSA stock assessments performed during EWG 15-11.

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	2015	1538	1.399
French gillnetters	2015	125	0.170
Spanish trawlers	2015	195	0.160
Spanish longliners	2015	12	0.025
French trawlers	2016	169	0.088
French gillnetters	2016	15	0.011
Spanish trawlers	2016	22	0.010
Spanish longliners	2016	1	0.002
French trawlers	2017	423	0.088
French gillnetters	2017	89	0.011
Spanish trawlers	2017	73	0.010
Spanish longliners	2017	13	0.002

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.

Last year, the final diagnosis was based upon an a4a analysis. It is important to notice that since the reference point ($F_{0.1}$) is model-dependant, the $F_{0.1}$ estimated last year with a4a, could no longer been used this year using XSA. The WG validated the use of $F_{0.1}$ estimated in 2013 with XSA results, since no change appears in the exploitation pattern.

Table 7.4.1. Hake in GSA 7. Reference points

Model - Year	$F_{current\ (2012\text{-}2014,ages\ 0\text{-}2)}$	$F_{0.1(estimated\ in\ 2013)}$	ratio
XSA - 2015	**1.75**	**0.15**	**11.7**
A4a - 2014	*1.67*	*0.17*	*9.8*
XSA - 2013	**1.83**	**0.15**	**16.6**

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	$F_{c(2012\text{-}2014,\ ages\ 0\text{-}2)}$ =1.75	$F_c/F_{0.1}$ = 11.7	D (since 2013)	IO_H
Stock abundance	Biomass		$B_{current,2014}$=3635 tons	B33th=3607 tons B66th=4760 tons	D	O_I
	SSB		$SSB_{current,2014}$=1115 tons			
Recruitment	R		$R_{current\ (Geometric\ mean\ last\ 3\ years)}$ = 44364 (*1000 in numbers)		D	
Final Diagnosis	In an overexploitation status with relative intermediate biomass (empirical reference value)					

This stock is in an overexploitation status with a relative intermediate biomass. Since 2010, the fishing mortality has reached the highest levels of the time series, which seems stabilizing in 2014. Moreover, spawning stock biomass and recruitment are still at low levels, with little signs of improvement. The current exploitation level is well above the level estimated to be sustainable. Despite an important decrease in number of French trawler fleet since 1998 (especially since 2011), reducing the number of boats by almost 50%, the 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

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

8.1 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)*