Stock Assessment Form

Demersal species

Reference year: 2004-2013

Reporting year: 2014

[A brief abstract may be added here]

Stock Assessment Form version 1.0 (January 2014)

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

* 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)

Stock assessment form

1 Basic Identification Data 2
2 Stock identification and biological information 3
2.1 Stock unit 3
2.2 Growth and maturity 3
3 Fisheries information 7
3.1 Description of the fleet 7
3.2 Historical trends 10
3.3 Management regulations 10
3.4 Reference points 10
4 Fisheries independent information 12
4.1 {TYPE OF SURVEY} ..... **Error! Bookmark not defined.**
4.1.1 Brief description of the direct method used 12
4.1.2 Spatial distribution of the resources 13
4.1.3 Historical trends 13
5 Ecological information 14
5.1 Protected species potentially affected by the fisheries 14
5.2 Environmental indexes 14
6 Stock Assessment 15
6.1 {Name of the Model} ..... **Error! Bookmark not defined.**
6.1.1 Model assumptions 15
6.1.2 Scripts 16
6.1.3 Input data and Parameters 16
6.1.4 Tuning data 17
6.1.5 Results 19
6.1.6 Robustness analysis 19
6.1.7 Retrospective analysis, comparison between model runs, sensitivity analysis, etc. 21
6.1.8 Assessment quality 21
7 Stock predictions 22
7.1 Short term predictions 22
7.2 Medium term predictions 24
7.3 Long term predictions 24
8 Draft scientific advice 25
8.1 Explanation of codes 26

1 Basic Identification Data

Scientific name:	Common name:	ISCAAP Group:
Mullus barbatus	Red mullet	33 **MUT**
1st Geographical sub-area:	**2nd Geographical sub-area:**	**3rd Geographical sub-area:**
GSA 07		
1st Country	**2nd Country**	**3rd Country**
France	Spain	
Stock assessment method: (direct, indirect, combined, none)		
Indirect (XSA and Yield per Recruit)		
Authors:		
Jadaud[1] A., Guijarro[2] B., Rouyer[1] T., Massutí[2] E.		
Affiliation:		
1: IFREMER, UMR 212 EME, Avenue Jean Monnet, BP 171, 34203 Sète (France) 2: 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):

- ICA
- VPA
- LCA
- AMCI
- XSA
- Biomass models
- Length based models
- Other (please specify). Combined method: you can choose both a direct and an indirect method and the name of the combined method (please specify)

2 Stock identification and biological information

Red mullet (*Mullus barbatus*) in the Gulf of Lions (GSA 7) is a shared stock exploited by both Spanish and French trawlers, also since very recent years by french gillnetters (2011 and 2013). 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 no study currently allows to state that the red mullet stock is isolated from concomitant areas, for instance from the GSAs 05 and 06.

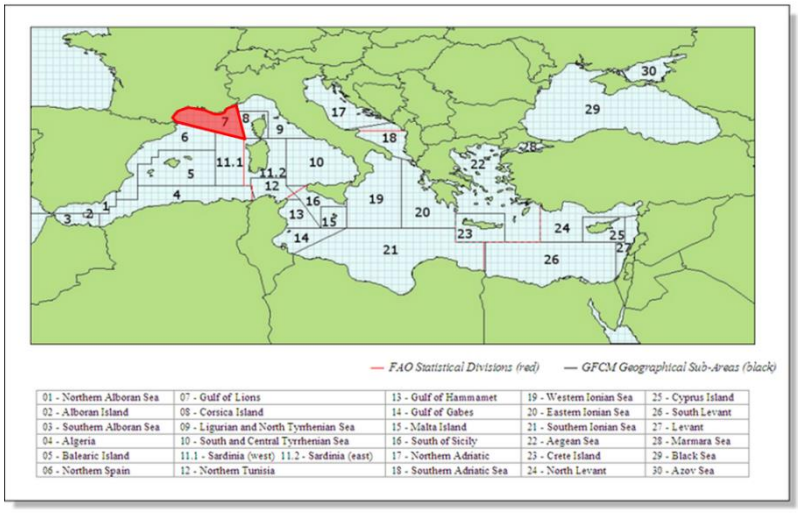


Figure 2-1: Geographical location of GSA 7 – Gulf of Lions

2.1 Stock unit

2.2 Growth and maturity

The growth of red mullet (*Mullus barbatus*) in the Gulf of Lions was estimated with Von Bertalanffy growth curve (DCF) for the beginning of the data series (2004-2011) and then age length key (DCF) for the last two years (2012, 2013). Von Bertalanffy parameters used are indicated in table 2.3.

The maturity was calculated using data collected within the DCF.

Natural mortality was obtained from PRODBIOM (Abella et al., 1997) and the maturity was obtained from DCF data collected in GSA 7 over the period 2004-2013 by IFREMER.

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

Somatic magnitude measured (LT, LC, etc)			**LT**	**Units**	cm
Sex	**Fem**	**Mal**	**Combined**	**Reproduction season**	
Maximum			**29**	**Recruitment**	

size observed				**season**	
Size at first maturity			**8.6**	**Spawning area**	
Recruitment size to the fishery			**5**	**Nursery area**	

Table 2.2-2: M vector and Matrix of proportion of matures by size or age (combined)

	Natural mortality	**Proportion of matures**									
Age/ Year	Vector 2004-2013	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
0	0.83	0.67	0.64	0.69	0.69	0.67	0.64	0.62	0.62	0.63	0.61
1	0.35	0.84	0.85	0.83	0.84	0.86	0.85	0.85	0.86	0.84	0.85
2	0.26	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.95	0.95
3	0.18	0.97	0.98	0.97	0.98	0.97	0.97	0.97	0.97	0.97	0.97
4	0.15	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99

Table 2.2-3: Growth and length weight model parameters

			Sex			
		Units	**female**	**male**	**Combined**	**Years**
Growth model	**L_∞**				**29**	
	K				**0.25**	
	t_0				**-1.28**	
	Data source	**Inbio, based on DCF data collected by IFREMER (2004-2010) in GSA 07**				
Length weight relationship	**a**				**0.0077**	
	b				**3.1315**	
	sex ratio (% females/total)	(*)				

(*) Sex-ratio at length from data collected in the GSA 7 (2004-2013) by IFREMER for the DCF was used to compute the number of females and males at length. The following proportions of females at length were used

Table 2.2-4: Sex-ratio at length

Size (cm)	**1-17**	**18**	**19**	**20**	**21**	**22**	**23**	**24-33**	**34**	**35**
Prop. Of Fem	0.50	0.49	0.48	0.47	0.46	0.45	0.45	0.46	0.47	0.47

From 2004 to 2011 the growth curve derived from age-length keys has been used to slice the data and since 2012 age-length keys were produced based on DCF data collected in GSA 07 and processed using COST tools:

Table 2.2-4: Age-length keys 2012 and 2013

Age	0		1		2		3		4		5	
Size (mm)/Year	2012	**2013**	2012	**2013**	2012	**2013**	2012	**2013**	2012	**2013**	2012	**2013**
7	-	**8**	-	**12**	-	**0**	-	**0**	-	**0**	-	**-**
8	10	**4**	0	**4**	0	**0**	0	**0**	0	**0**	0	**-**
9	10	**7**	1	**31**	0	**0**	0	**0**	0	**0**	0	**-**
10	11	**10**	5	**39**	0	**0**	0	**0**	0	**0**	0	**-**
11	10	**11**	28	**48**	0	**0**	0	**0**	0	**0**	0	**-**
12	10	**9**	42	**55**	2	**0**	0	**0**	0	**0**	0	**-**
13	2	**12**	53	**49**	2	**0**	0	**0**	0	**0**	0	**-**
14	0	**9**	41	**46**	5	**3**	0	**0**	0	**0**	0	**-**
15	2	**4**	39	**42**	22	**14**	0	**1**	0	**0**	0	**-**
16	2	**0**	27	**34**	29	**22**	1	**2**	0	**0**	0	**-**
17	0	**0**	25	**17**	30	**33**	1	**6**	1	**0**	0	**-**
18	0	**0**	13	**12**	42	**16**	3	**5**	0	**0**	0	**-**
19	0	**0**	4	**4**	32	**24**	4	**7**	0	**0**	0	**-**
20	0	**0**	1	**0**	24	**18**	4	**6**	0	**0**	0	**-**
21	0	**0**	0	**0**	20	**15**	3	**9**	0	**1**	0	**-**
22	0	**0**	1	**0**	9	**6**	2	**9**	1	**2**	0	**-**
23	0	**0**	0	**0**	5	**2**	1	**4**	1	**0**	0	**-**
24	0	**0**	0	**0**	0	**0**	0	**5**	2	**0**	0	**-**
25	0	**0**	0	**0**	0	**0**	3	**1**	1	**2**	0	**-**
26	0	**0**	0	**0**	0	**2**	0	**9**	2	**10**	1	**-**
27	0	**0**	0	**0**	0	**0**	0	**7**	1	**13**	0	**-**
28	0	**0**	0	**0**	0	**0**	0	**2**	1	**8**	0	**-**
29	0	**0**	0	**0**	0	**0**	0	**2**	7	**8**	3	**-**
30	0	**-**	0	**-**	0	**-**	0	**-**	6	**9**	4	**-**
31	0	**-**	0	**-**	0	**-**	0	**1**	5	**-**	5	**-**
32	0	**-**	0	**-**	0	**-**	0	**-**	4	**-**	6	**-**
33	0	**-**	0	**-**	0	**-**	0	**-**	3	**-**	7	**-**
34	0	**-**	0	**-**	0	**-**	0	**-**	2	**-**	8	**-**
35	-	**-**	-	**-**	-	**-**	-	**-**	-	**-**	-	**-**
36	-	**-**	-	**-**	-	**-**	-	**-**	-	**-**	-	**-**
37	0	**-**	0	**-**	0	**-**	0	**-**	1	**-**	9	**-**
38	-	**-**	-	**-**	-	**-**	-	**-**	-	**-**	-	**-**
39	0	**-**	0	**-**	0	**-**	0	**-**	0	**-**	10	**-**
40	-	**-**	-	**-**	-	**-**	-	**-**	-	**-**	-	**-**
41	0	**-**	0	**-**	0	**-**	0	**-**	0	**-**	10	**-**

3 Fisheries information

3.1 Description of the fleet

In the Gulf of Lions (GSA 7), red mullet is exploited by both French and Spanish trawlers. Information on French gillnetters is only available for 2011 and 2013, but although it is suspected that they have been fishing red mullet in the past, no data is available to quantify their catches. Between 2004 and 2013, around 100 boats have been involved in the fishery. According to official statistics, during this period the total annual landings have oscillated around an average value of 200 tons and the French trawlers have been dominating the fishery, as they represent 73% of the catches (165 tons) on the period. After 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, this can explain the high catches of 2010. Between 1998 and 2013, the number of French trawlers operating in the GSA 07 has decreased by 39%, while it decreased by more than 30% between 2010 and 2013. From a maximum number of 123 trawlers in 2004, the French fleet catching red mullet is nowadays composed by 61 units. This follows management measures to reduce the number of boats. The mean modal lengths in the catches of the French and Spanish trawlers were 13.9 and 14.9 cm, respectively and the length at first capture is about 6 cm. Catch is mainly composed by individuals of age 0, 1 and 2 (Figure 3.1.2.), while the oldest age class (4+ group) is poorly represented. In GSA 07, the trawl fishery is a multi-specific fishery. In addition to *M. barbatus*, the following species can be considered important by-catches: *Merluccius merluccius, Lophius sp., Pagellus sp., Trachurus sp., Mullus surmuletus, Octopus vulgaris, Eledone sp., Scyliorhinus canicula, G. melastomus, Trachinus sp., Triglidae, Scorpaena sp.*

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*	France	GSA 07	E – trawl (12-24m)	03 - Trawls	33 – Demersal shelf species	MUT
Operational Unit 2	Spain	GSA 07	E – trawl (12-24m)	03 - Trawls	33 – Demersal shelf species	MUT
Operational Unit 3	FRA	07	C - Minor gear with engine (6-12 metres)	07 - Gillnets and Entangling Nets	33 - Demersal shelf species	MUT

Table 3.1-2: Catch, bycatch, discards and effort by operational unit in the reference year (2013)

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 I 03 33 - MUT	61	227 tons	M. merluccius, M. surmuletus, Solea spp., Lophius spp., S. aurata, D. labrax, Pagellus spp., M. poutassou, T. m. capelanus, O. vulgaris and Eledone spp.	16.3	unknown	unknown
ESP 07 I 03 33 - MUT	19	38 tons	*M. merluccius, M. surmuletus, Solea spp., Lophius spp., Pagellus spp., M. poutassou, T. m. capelanus, O. vulgaris and E. cirrhosa*	No	unknown	unknown
FRA 07 C 07 33 - MUT	94	33 tons	*Mullus surmuletus*	No	unknown	unknown
Total	174	226 tons		**Total**		

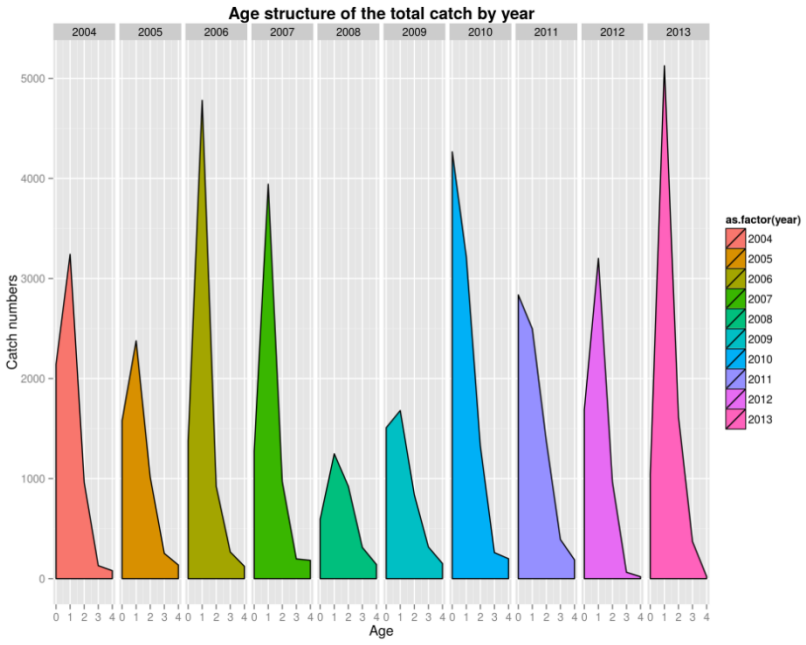


Figure 3.1-1: Red mullet in GSA 7. Total catch by age in tons (2004-2013).

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

Gears/Years	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
OTB-French	151	148	183	172	111	120	219	170	150	227
OTB-Spanish	26	28	33	37	21	26	25	28	29	38
GNS-French	-	-	-	-	-	-	-	30	-	33

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

Gears/Years	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
OTB-French	151	148	183	172	111	120	219	170	135.3	210.5
OTB-Spanish	26	28	33	37	21	26	25	28	29	38
GNS-French	-	-	-	-	-	-	-	30	-	33

No discards were observed before 2011 in France. Considering Spain, landings are almost equal to catches.

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

Gears/Years	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
OTB-French	-	-	-	-	-	-	-	-	14.8	16.3
OTB-Spanish	-	-	-	-	-	-	-	-	-	-
GNS-French	-	-	-	-	-	-	-	-	-	-

3.2 Historical trends

Total catch increase on the period with the higher levels of catch in the very recent years (Figure 3.2.1.). The total catch has been driven by the french trawlers, whose catch accounted for 73% over the period 2004-2013. Information on French gillnetters is only available for 2011 and 2013, but although it is suspected that they have been fishing red mullet in the past, no data is available to quantify their catches. Catch at age structure is stable over time, with mostly age 0-2 targeted (Figure 3.2.6.4.3.2.).

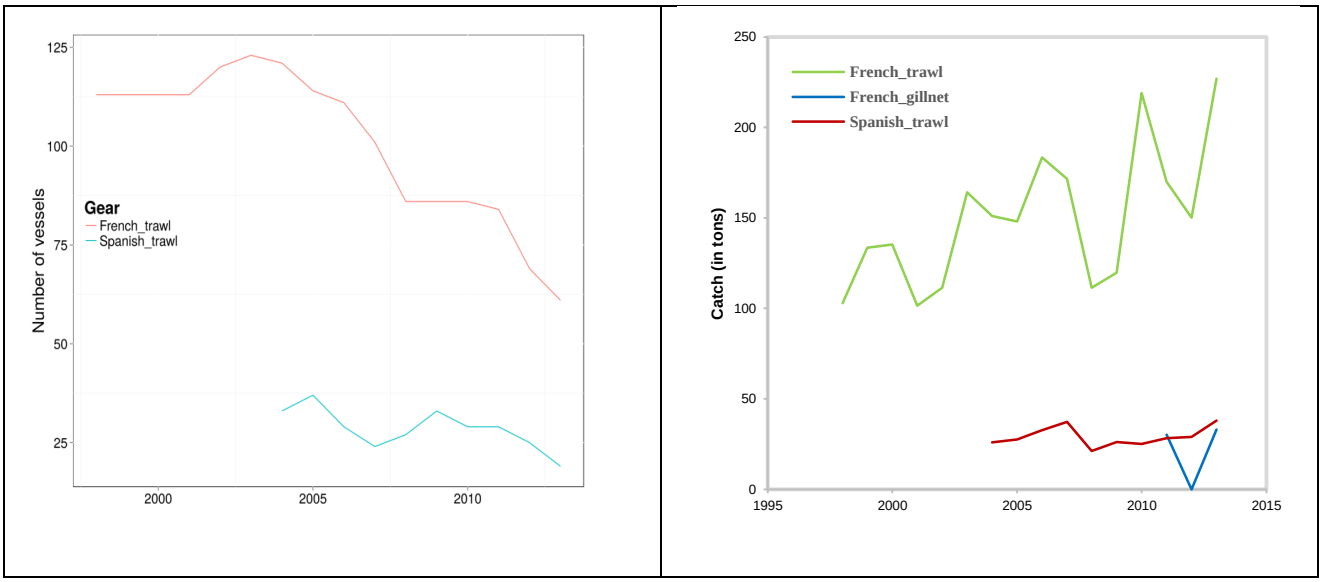


Figure 3.2-1: On the left panel, time series of the number of french and spanish trawlers operating in GSA 07. On the right panel, time series of catch of red mullet in the GSA 07 for french gillnetters and french and spanish trawlers (1998-2013).

3.3 Management regulations

French trawlers

- Fishing license: fully observed
- Engine power limited to 316 KW or 500 CV: not observed
- Cod-end mesh size (bottom trawl: square 40 mm or 50 mm diamond with derogation): not fully observed
- Fishing forbidden within 3 miles (France): not fully observed

Spanish trawlers

- Fishing license: fully observed
- Engine power limited to 316 KW or 500 CV: not observed
- Mesh size in the codend (square 40 mm or 50 mm diamond with derogation): fully observed
- Fishing forbidden <50 m depth: fully observed
- Time at sea: fully observed

French gillnetters:

- Fishing license: fully observed

- Maximum length of net: not fully observed

In 2009, the GFCM proposed to create 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 longliners, 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. The FRA area is 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. This fisheries restricted area was established in article 4 from the EU Regulation No. 1343/2011 of the European Parliament and of the Council of 13 December 2011. 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 the FRA. Moreover a temporary closure of 1 month by year for french trawlers has been enforced in 2011.

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: 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					
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 red mullet in GSA 07 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:

$$\text{Confidence interval} = Yst \pm t(\text{student distribution}) * V(Yst) / n$$

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

No maps are currently available to describe the spatial distribution of the resource.

4.1.3 Historical trends

Fishery independent information regarding the state of the hake in GSA 07 was derived from MEDITS international survey. Figures below display the estimated trend in hake abundance and biomass in GSA 07. The estimated abundance and biomass indices do not reveal a 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).

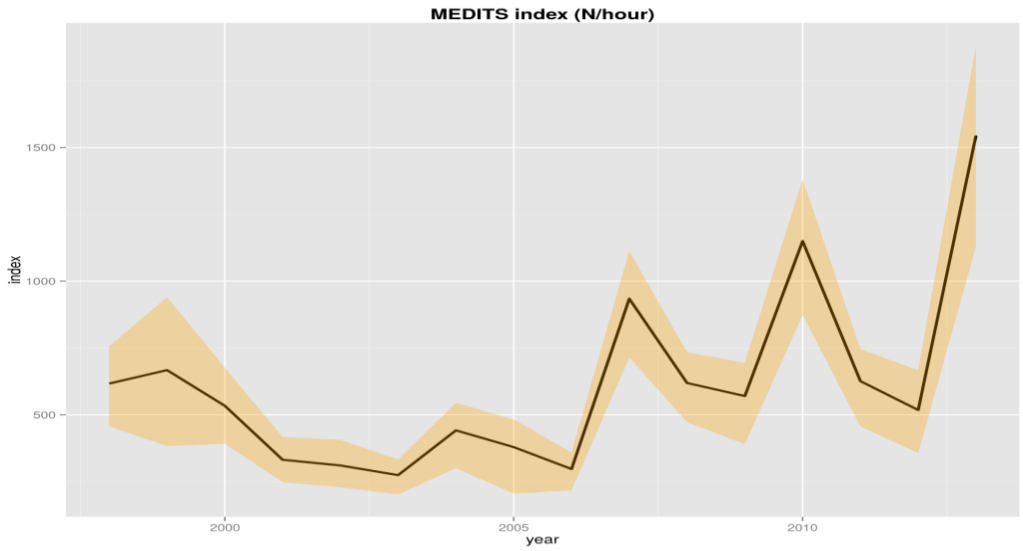


Figure 4.1.3-1: Red mullet in GSA 7. MEDITS abundance index 1994-2013 (n/hour).

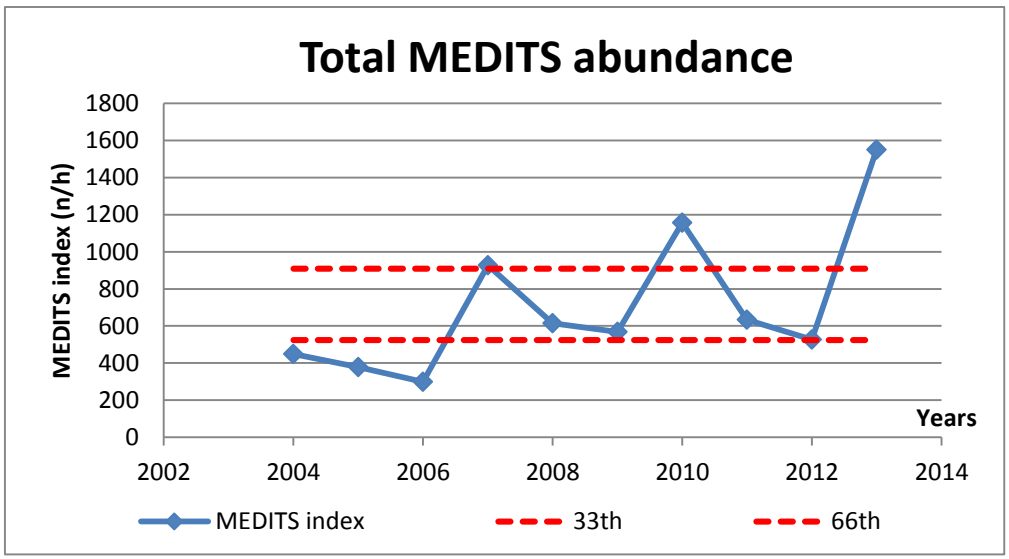


Figure 4.1.3-2: Red mullet in GSA 7. MEDITS abundance indices (2004-2013). The two red dotted lines indicate the 33rd and 66th percentiles of the time series.

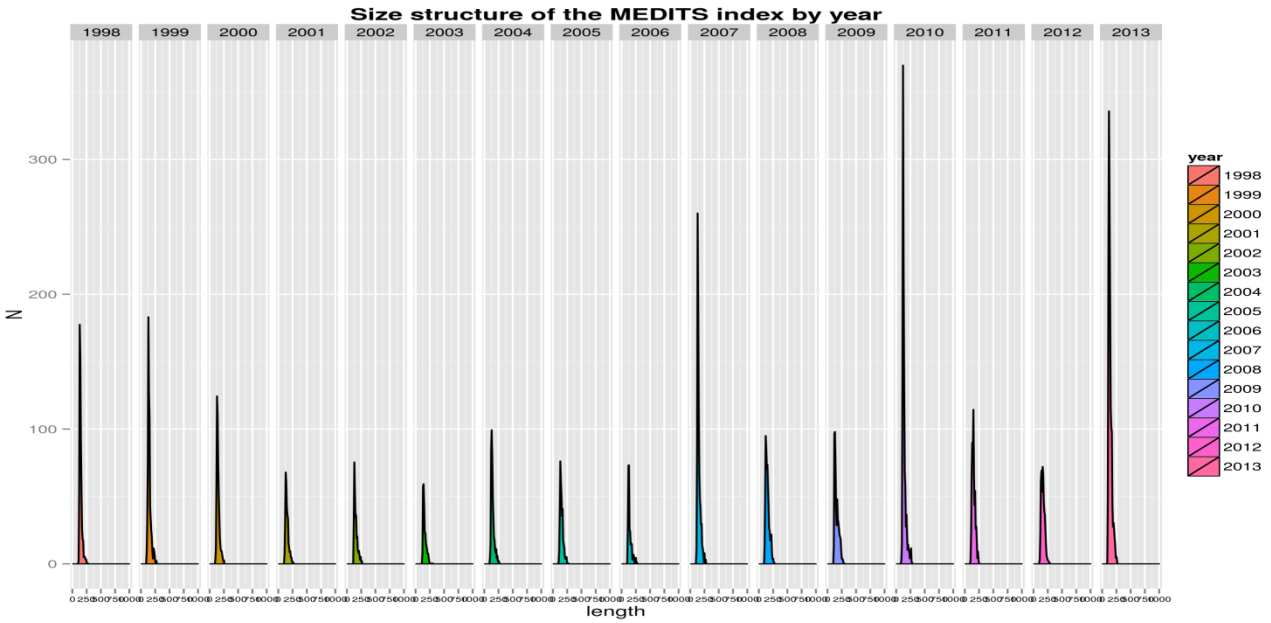


Figure 4.1.3-2: Red mullet in GSA 7. Length frequency distribution obtained from MEDITS survey.

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

1.1 Extended Survivor Analysis (XSA)

6.1.1 Model assumptions

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 6.1.1-1.a-d).

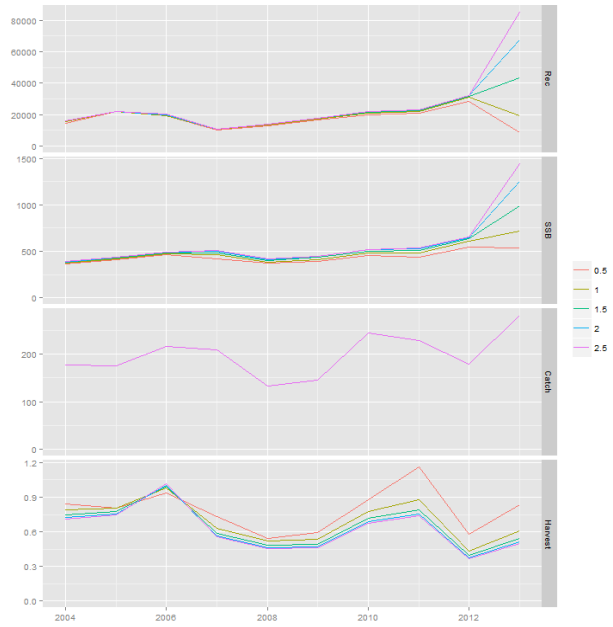
The first sensitivity analysis (a) was conducted using 5 different shrinkage weight assumptions (i.e. fse 0.5, 1, 1.5, 2 and 2.5). The final setting selected is an intermediate value (1.5), similar to last year assessment.

The second analysis (b) 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 4). The final setting selected is a constant catchability for all ages, similar to last year assessment.

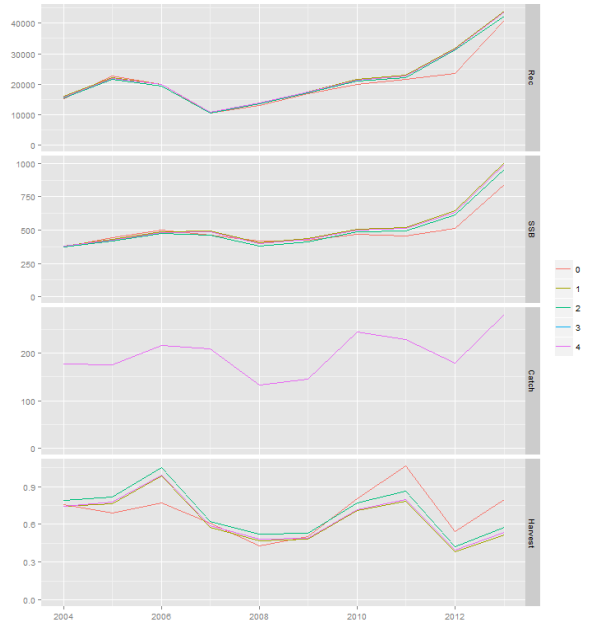
The third analysis (c) was conducted to assess the effect of shrinkage on the last ages (i.e. ranging from 0 to 4). The final setting selected is a shrinkage on the last 3 ages, similar to last year assessment.

The fourth analysis (d) was conducted to assess the effect of shrinkage on the last years (i.e. ranging from 1 to 5. The final setting selected is a shrinkage on the last 4 years, similar to last year assessment.

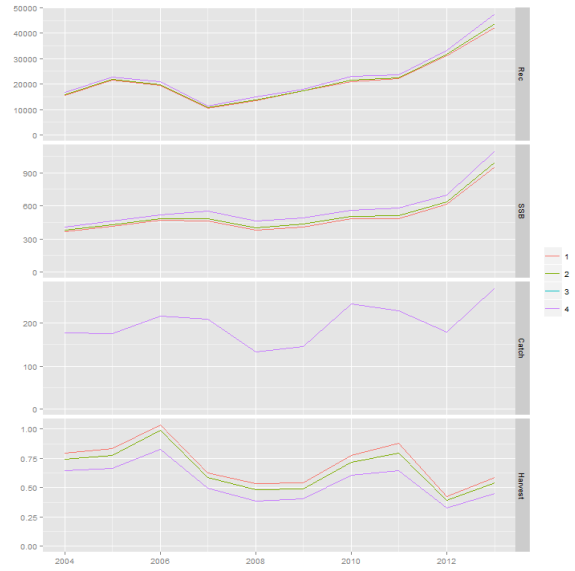
The parameters finally retained for the final run are in Table 6.1.1-1.



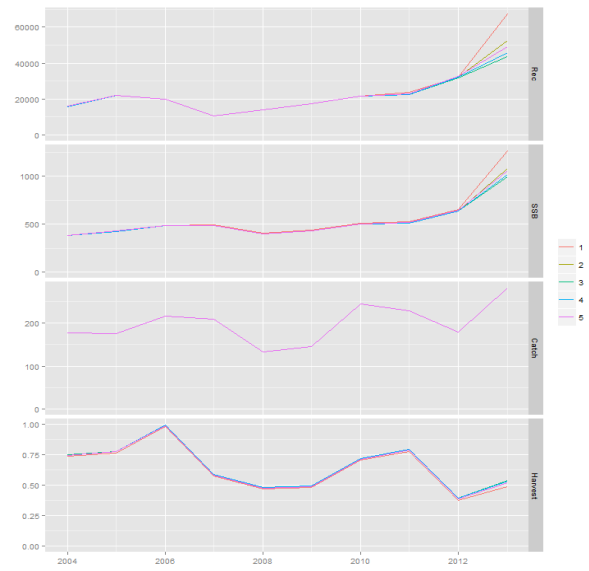
(a)Shrinkage weight (i.e. fse 0.5, 1, 1.5, 2 and 2.5)



(b) Catchability (qage values ranging from 0 to 4)



(c)Shrinkage on the last ages (i.e. ranging from 0 to 4)



(d)Shrinkage on the last years (i.e. ranging from 1 to 5)

Figure 6.1.1-1: Red mullet in GSA 7. Sensitivity analysis on shrinkage weight (a), catchability (b), shrinkage on the last ages (c) and years (d)

Table 6.1.1-1: Red mullet in GSA 7. XSA settings.

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

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

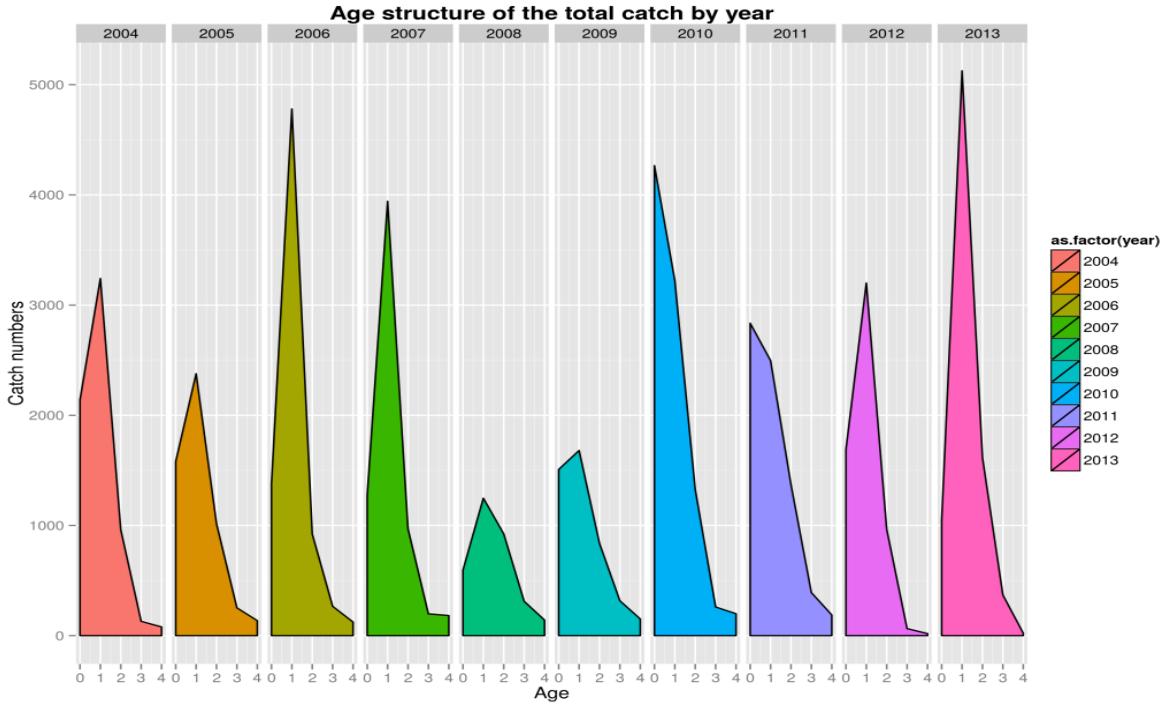


Figure 6.1.3-1: Red mullet in GSA 7. Age structure of the total catch (2004-2013).

Table 6.1.3-1: Catch-at-age (thousands) - Discards not included before 2012

Age class	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
0	2141	1581	1376	1274	595	1509	4266	2836	1688	1045
1	3242	2378	4781	3943	1248	1681	3222	2496	3201	5126
2	961	1016	923	970	924	838	1327	1371	965	1618
3	130	253	267	198	312	317	261	391	64	370
4	80	137	124	183	142	152	199	188	20	23

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

Age class	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
0	0.012	0.011	0.013	0.013	0.012	0.010	0.010	0.010	0.014	0.018
1	0.026	0.027	0.024	0.027	0.029	0.027	0.028	0.029	0.031	0.028
2	0.050	0.053	0.052	0.052	0.053	0.052	0.051	0.054	0.053	0.064
3	0.080	0.083	0.079	0.083	0.081	0.078	0.082	0.082	0.069	0.081
4	0.116	0.138	0.111	0.112	0.112	0.107	0.118	0.121	0.132	0.093

6.1.4 Tuning data

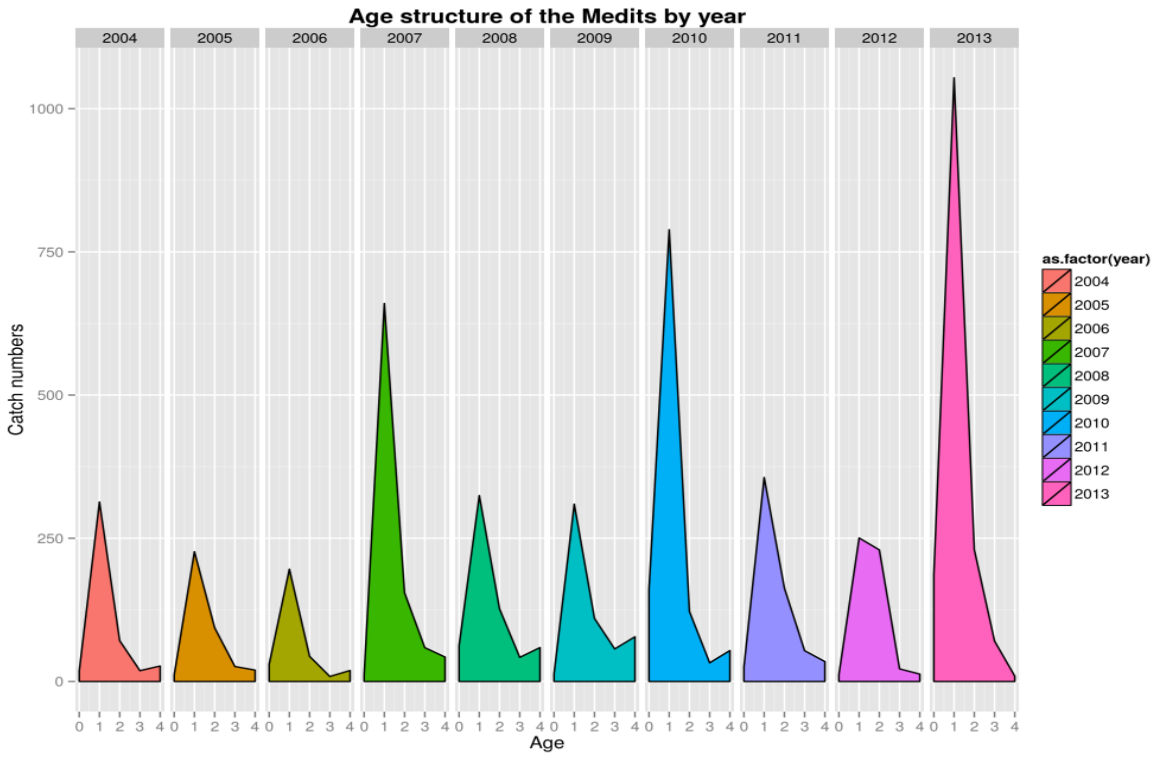


Figure 6.1.4-1: Red mullet in GSA 7. Catch in numbers obtained from MEDITS survey.

Table 6.1.4-1: Tuning data: MEDITS index at age (thousands)

Age	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
0	18	11	30	11	62	13	160	25	12	186
1	313	227	196	660	325	310	789	356	251	1054
2	71	94	44	155	127	110	122	163	230	230
3	19	26	9	59	42	57	32	54	22	71
4	27	20	19	43	59	78	54	35	13	9

6.1.5 Results

The results of the assessment (Fig. 6.1.5-1.) show some increase in recruits in the very recent years (2008) and also on spawning stock biomass (SSB) since 60% of age 0 is SSB. Very recent fishing mortalities are the lowest observed over the period. MEDITS log residuals (fig. 6.1.8-1.) are quite low and no trend can be observed.

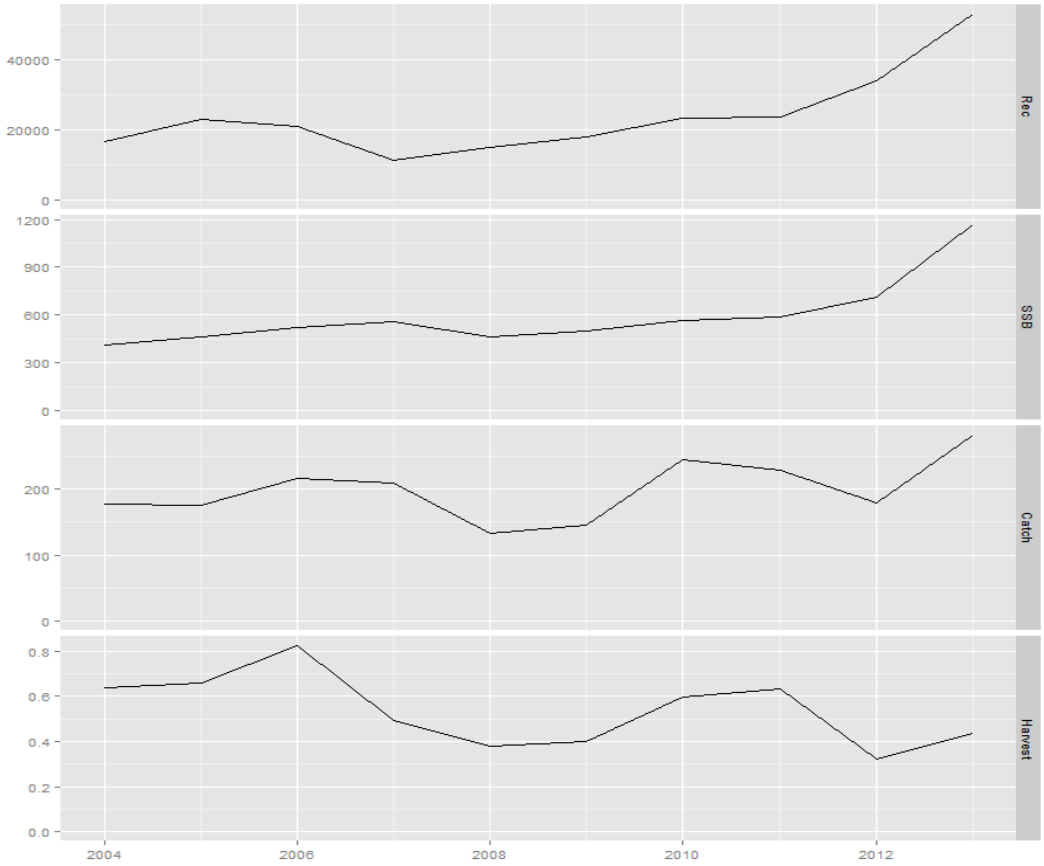


Figure 6.1.5-1: Red mullet in GSA 7. XSA results: Recruitment, SSB, Catch and F.

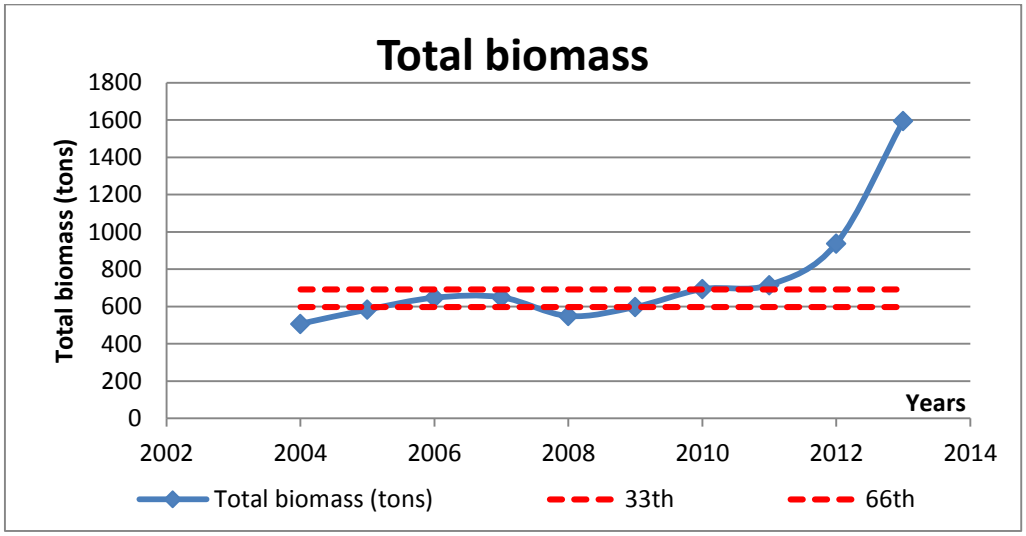


Figure 6.1.5-2: Red mullet in GSA 7. XSA results: Biomass (tons), 33th and 66th

Table 6.1.5-1: Estimated fishing mortality at age

Age class	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
0	0,214	0,111	0,104	0,184	0,062	0,136	0,326	0,199	0,078	0,030
1	0,978	0,650	1,016	0,833	0,442	0,395	0,819	0,523	0,593	0,588
2	0,908	1,221	0,658	0,664	0,534	0,707	0,730	1,318	0,447	0,810
3	0,462	0,663	1,525	0,286	0,475	0,359	0,508	0,503	0,173	0,314
4+	0,462	0,663	1,525	0,286	0,475	0,359	0,508	0,503	0,173	0,314

Table 6.1.5-2: Estimated abundance at age (thousands)

Age class	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
0	16827	22866	21134	11467	14982	18025	23200	23839	34078	53128
1	6191	5924	8927	8307	4159	6140	6864	7299	8522	13745
2	1835	1641	2178	2277	2544	1883	2915	2132	3048	3319
3	385	571	373	870	904	1151	716	1083	440	1503
4+	235	305	169	803	407	547	543	516	136	91

Table 6.1.5-3: Summary table

Year	**Biomass (t)**	**SSB (t)**	**Recruitment (thousands)**	**Abundance (thousands)**	**Fbar (0-3)**	**Catch (t)**
2004	507.00	409.84	16826.66	25472.08	0.64	177
2005	582.97	463.13	22865.99	31306.46	0.66	176
2006	646.71	521.26	21134.13	32781.08	0.83	216
2007	649.19	558.86	11466.88	23723.55	0.49	209
2008	548.69	463.64	14981.59	22995.46	0.38	133
2009	597.26	497.43	18025.09	27745.57	0.40	146
2010	692.91	565.8	23199.53	34237.64	0.60	244
2011	715.10	584.46	23838.99	34869.81	0.64	228
2012	937.15	710.6	34078.17	46224.59	0.32	179
2013	1594.72	1169.17	53128.15	71785.70	0.44	298
Av. 2011-2013	1082.32	821.41	37015.10	50960.03	0.46	235
Av. 2004-2013	747.17	594.42	23954.52	35114.19	0.54	201

6.1.6 Robustness analysis

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

A retrospective analysis was conducted on recruitment, mean F and SSB (Figure 6.1.7-1) to ensure the robustness of the final estimates. The model shows some instability linked to the high recruitment of the last year, moreover 60% of age 0 is SSB.

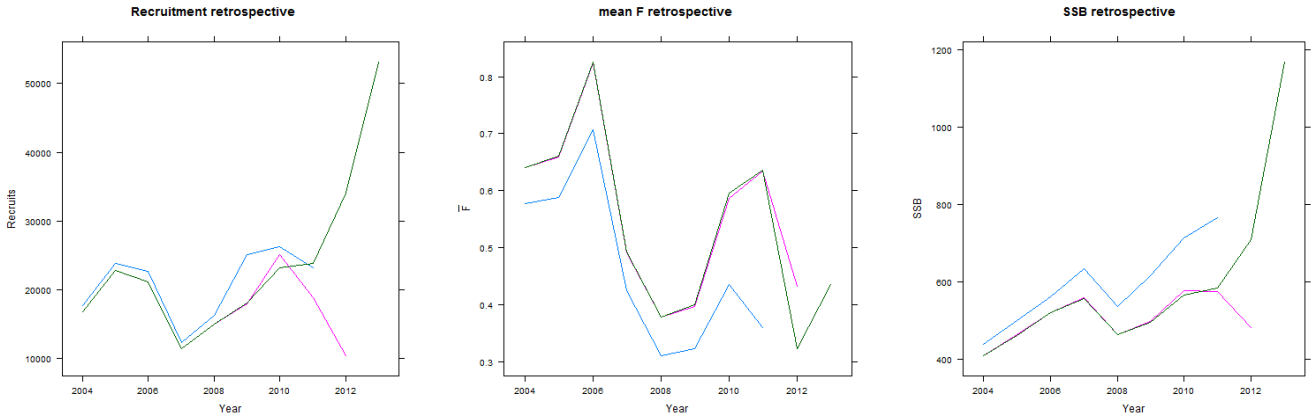


Figure 6.1.7-1: Red mullet in GSA 7. Retrospective analysis (Recruitment, mean F and SSB).

6.1.8 Assessment quality

No clear pattern could be detected in the residuals while their absolute value was not too large.

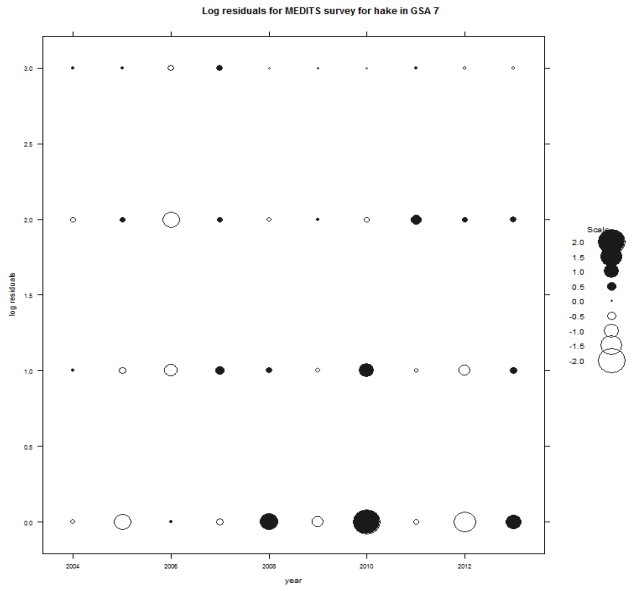


Figure 6.1.8-1. Red mullet in GSA 7. Log catchability residual plots (XSA) for tuning fleet, MEDITS

7 Stock predictions

7.1 Short term predictions

Short term predictions were implemented in R (www.r-project.org) using the FLR libraries and based on the results of the Extended Survivor Analyses (XSA, Darby and Flatman, 1994).

The following data have been used to derive the input data for the short term projection of the red mullet stock in GSA 7:

Table 7.1-1: Red mullet in GSA 7. Maturity at age

Age/Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
0	0.67	0.64	0.69	0.69	0.67	0.64	0.62	0.62	0.63	0.61
1	0.84	0.85	0.83	0.84	0.86	0.85	0.85	0.86	0.84	0.85
2	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.95	0.95
3	0.97	0.98	0.97	0.98	0.97	0.97	0.97	0.97	0.97	0.97
4+	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99

Table 7.1-2: Red mullet in GSA 7. Natural mortality at age

Age/Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
0	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83
1	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
2	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26
3	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
4+	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15

Table 7.1-3: Red mullet in GSA 7. F vector

F vector / Age	0	1	2	3	4
2011-2013	0.102	0.568	0.858	0.330	0.330

Table 7.1-4: Red mullet in GSA 7. Weight-at-age in the stock

Mean weight in stock (kg) / Age	0	1	2	3	4+
2011-2013	0.014	0.029	0.057	0.077	0.115

Table 7.1-5: Red mullet in GSA 7. Weight-at-age in the catch

Mean weight in catch (kg) / Age	0	1	2	3	4+
2011-2013	0.014	0.028	0.056	0.076	0.114

Table 7.1-6: Red mullet in GSA 7. Number at age in the catch

Catch at age in numbers (*1000)	0	1	2	3	4+
2013	1045	5126	1618	370	23

Table 7.1-7: Red mullet in GSA 7. Number at age in the stock

Stock at age in numbers (*1000)	0	1	2	3	4+
2014	35077*	22476	5382	1138	974

* Geometric mean of the recruitment estimated over the 2011-2013 period

A short term projection (Table 7.1-8.), assuming an F_{stq} of 0.45 in 2013 and a recruitment of 35077 (thousands) individuals, shows that:

Fishing at the F_{stq} (0.45) generates an increase in the catch of 73% from 2013 to 2015 along with a decrease in the spawning stock biomass of 2% from 2015 to 2016.

Fishing at F_{MSY} (0.14) generates a decrease in the catch of 35% from 2013 to 2015 and an increase in the spawning stock biomass of 26% from 2015 to 2016.

Catches of red mullet in 2015 consistent with F_{MSY} would not exceed 195 tonnes.

Table 7.1-8: Red mullet in GSA 7. Short term forecast in different F scenarios. Basis: F(2014) = mean(F0-3 2011-2013); R(2014) = mean recruitment of the last 3 years; R = 35077 (thousands); F (2014) = 0.47; SSB(2014)= 1342 t, Catch (2013)= 297 t.

Ffactor	Fbar	Catch 2013	Catch 2014	Catch 2015	Catch 2016	SSB 2015	SSB 2016	Change SSB 2015-2016(%)	Change Catch 2013-2015(%)
0	0	297	472	0	0	1423	2037	43	-100
0.10	0.04	297	472	66	83	1423	1954	37	-78
0.20	0.09	297	472	129	154	1423	1876	32	-57
0.30	0.13	297	472	187	216	1423	1803	27	-37
0.40	0.18	297	472	242	268	1423	1734	22	-18
0.50	0.22	297	472	294	313	1423	1669	17	-1

0.60	0.27	297	472	343	352	1423	1609	13	15
0.70	0.31	297	472	390	385	1423	1552	9	31
0.80	0.36	297	472	433	412	1423	1498	5	46
0.90	0.40	297	472	474	435	1423	1448	2	59
1.00	0.45	297	472	513	455	1423	1400	-2	73
1.10	0.49	297	472	550	471	1423	1355	-5	85
1.20	0.54	297	472	585	484	1423	1313	-8	97
1.30	0.58	297	472	618	495	1423	1273	-11	108
1.40	0.63	297	472	649	504	1423	1235	-13	118
1.50	0.67	297	472	678	511	1423	1200	-16	128
1.60	0.72	297	472	706	516	1423	1166	-18	137
1.70	0.76	297	472	733	520	1423	1135	-20	146
1.80	0.80	297	472	758	522	1423	1105	-22	155
1.90	0.85	297	472	782	524	1423	1076	-24	163
2.00	0.89	297	472	805	525	1423	1049	-26	171
F_{MSY}	0.14	297	472	195	223	1423	1794	26	-35

7.2 Medium term predictions

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

7.3 Long term predictions

Yield per recruit analysis was used (FLBRP) to calculate the reference point ($F_{0.1}$ as a proxy of F_{MSY}) and the estimated reference fishing mortality ($F_{current}$). The referent F was estimated using the default assumptions agreed in the meeting, e.g., weights are means of the last 3 years and future recruitment is the geometric mean of the last 3 years.

Table 7.3-1: Hake in GSA 7. Reference points

$F_{current\ (2011-2013)}$	$F_{0.1}$ estimated in 2012	Ratio ($F_{current\ (2011-2013)}/F_{0.1}$)
0.45	0.14	3.21

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	$F_{0.1}$ = 0.14	$F_{c(2011-2013)}$=0.45	$F_c/F_{0.1}$=3.21	D	IO
	Fishing effort					
	Catch					
Stock abundance	Biomass		$B_{2011-2013}$=1022 tons	B_{33} = 597 tons B_{66} = 690 tons	I	O_H
	SSB					
Recruitment			$R_{current\ (mean\ last\ 3\ years)}$ = 35077 (*1000 in numbers)		D	
Final Diagnosis		In high overfishing status with a relative high biomass.				

The stock is in an **overexploitation status** with **a relative high abundance** and punctually higher recruitments (2005, 2006 and 2013). This diagnostic is based upon analytical results based on fishing mortality. The exploitation level is currently above the level estimated to be sustainable since the referent point $F_{0.1}$ is equal to 0.14 and current fishing mortality ($F_{current\ 2011-2013}$) is equal to 0.45. The current fishing mortality is the lowest of the series and the spawning stock biomass currently follows an upward trend. The exploitation is mainly concentrated on young individuals (age 0-2), moreover 60% of the recruitment (age 0) is mature. The current biomass (2011-2013) is above the 66th percentile.

However computed over a relatively short time-period (2004-2013), the increase in spawning stock biomass and the decrease in fishing mortality have to be noticed. The important decrease in numbers of French trawler fleet since 1998, reducing the number of boats by 39%, is likely to start to have a positive effect on the stock. It is important to notice that this decrease of the numbers of French trawlers follows management measures taken since 2011 (reduction by 30% of the number of trawlers). This measure was over at the end of 2013.

Management advice and recommendations: Reduce fishing mortality

It is important to notice that some management measures have been taken since 2011 (reduction from 2010 to 2013 by more than 30% of the number of trawlers). This measure was over at the end of 2013.

-Improve the fishing pattern of the trawlers so that the minimum length of catches is consistent with the minimum legal landing size

-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)*