Stock Assessment Form

Demersal species

Reference year: 2013

Reporting year: 2014

Striped red mullet (*Mullus surmuletus*) is one of the most important target species in the trawl fishery developed by around 32 vessels off Mallorca (Balearic Islands, GFCM-GSA05). A fraction of the small-scale fleet (~70 boats) also directs to this species during the second semester of the year, using both trammel nets and gillnets. During the last decade, the annual landings of this species have oscillated between 55 and117 tons and 9 and 29 tons in the trawl and small-scale fishery, respectively. This stock has been assessed using data from both the trawl and the small-scale fishery on a time series covering 14 years (2000-2013). The assessment has been carried out applying tuned virtual population analysis (Extended Survivor Analysis, XSA) on the cohorts present during 2000-2013 and a Y/R analysis based on the exploitation pattern resulting from the XSA model and population parameters for the period 2011-2013. These approaches were performed using monthly size composition of catches, official landings and the biological parameters estimated within the framework of the Data Collection Programme. The VPA was tuned with CPUE from commercial trawl fleet (2000-2013) and bottom trawl surveys (2001–2013). The vector of natural mortality by age was calculated from Caddy´s formula, using the PROBIOM Excel spreadsheet. The software used was FLR in R.

Stock Assessment Form version 1.0 (January 2014)

Up loader: *Beatriz Guijarro*

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 5
3.1 Description of the fleet 5
3.2 Historical trends 6
3.3 Management regulations 8
3.4 Reference points 8
4 Fisheries independent information 9
4.1 {TYPE OF SURVEY} ..... **Error! Bookmark not defined.**
4.1.1 Brief description of the direct method used ..... **Error! Bookmark not defined.**
4.1.2 Spatial distribution of the resources 9
4.1.3 Historical trends 10
5 Ecological information 11
5.1 Protected species potentially affected by the fisheries 11
5.2 Environmental indexes 11
6 Stock Assessment 13
6.1 {Name of the Model} ..... **Error! Bookmark not defined.**
6.1.1 Model assumptions 13
6.1.2 Scripts 14
6.1.3 Input data and Parameters 14
6.1.4 Tuning data 14
6.1.5 Results 15
6.1.6 Robustness analysis 16
6.1.7 Retrospective analysis, comparison between model runs, sensitivity analysis, etc. 16
6.1.8 Assessment quality 16
7 Stock predictions 16
7.1 Short term predictions 16
7.2 Medium term predictions 18
7.3 Long term predictions 18
8 Draft scientific advice 19
8.1 Explanation of codes 19

1. Basic Identification Data

Scientific name:	Common name:	ISCAAP Group:
Mullus surmuletus	Striped red mullet	11
1st Geographical sub-area:	**2nd Geographical sub-area:**	**3rd Geographical sub-area:**
GSA 05 – Balearic Islands		
4th Geographical sub-area:	**5th Geographical sub-area:**	**6th Geographical sub-area:**
1st Country	**2nd Country**	**3rd Country**
Spain		
4thCountry	**5thCountry**	**6thCountry**
Stock assessment method: (direct, indirect, combined, none)		
Trawl survey, XSA and Y/R		
Authors:		
Beatriz Guijarro, Natalia González, Vanessa Rubio, Francesc Ordines and Antoni Quetglas		
Affiliation:		
Instituto Español de Oceanografía_Centre Oceanogràfic de Balears; Moll de Ponents/n; 07015; Palma de Mallorca; Illes Balears		

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):

- Trawlsurvey

Indirect method (you can choose more than one):

- XSA

2. Stock identification and biological information

2.1 Stock unit

GSA05 has been pointed as an individualized area for assessment and management purposes in the western Mediterranean (Quetglas *et al.*, 2012) due to its main specificities. These include: 1) Geomorphologically, the Balearic Islands (GSA05) are clearly separated from the Iberian Peninsula (GSA06) by depths between 800 and 2000 m, which would constitute a natural barrier to the interchange of adult stages of demersal resources; 2) Physical geographically-related characteristics, such as the lack of terrigenous inputs from rivers and submarine canyons in GSA05 compared to GSA06, give rise to differences in the structure and composition of the trawling grounds and hence in the benthic assemblages; 3) Owing to these physical differences, the faunistic assemblages exploited by trawl fisheries differ between GSA05 and GSA06, resulting in large differences in the relative importance of the main commercial species; 4) There are no important or general interactions between the demersal fishing fleets in the two areas, with only local cases of vessels targeting red shrimp in GSA05 but landing their catches in GSA06; 5) Trawl fishing exploitation in GSA05 is much lower than in GSA06; the density of trawlers around the Balearic Islands is one order of magnitude lower than in adjacent waters; and 6) Due to this lower fishing exploitation, the demersal resources and ecosystems in GSA05 are in a healthier state than in GSA06, which is reflected in the population structure of the main commercial species (populations from the Balearic Islands have larger modal sizes and lower percentages of small-sized individuals), and in the higher abundance and diversity of elasmobranch assemblages

2.2 Growth and maturity

Table 1.2-1: Maximum size, size at first maturity and size at recruitment.

Somatic magnitude measured (LT, LC, etc)			**Total length**	**Units**	cm
Sex	**Fem**	**Mal**	**Combined**	**Reproduction season**	Spring
Maximum size observed			39	**Recruitment season**	Autumn
Size at first maturity			14.2	**Spawning area**	Continental shelf
Recruitment size to the fishery			10	**Nursery area**	Continental shelf

Table 1-2.2: M vector and proportion of matures by size or age (Combined).

Size/Age	Natural mortality	Proportion of matures
0	*1.0*	*0.15*
1	*0.6*	*0.39*
2	*0.4*	*0.79*
3	*0.3*	*0.95*
4	*0.3*	*1.00*
5+	*0.3*	*1.00*

Table 1-3: Growth and length weight model parameters

			Sex			
		Units	female	male	Combined	Years
Growth model	**L_∞**				40.05	2003-2013
	K				0.164	2003-2013
	t_0				-1.883	2003-2013
	Data source	Otolith readings individuals from the Balearic Islands in the framework of the Spanish National Data Collection Program.				
Length weight relationship	**a**				0.0084	
	b				3.118	
	M (scalar)					
	sex ratio (% females/total)					

3. Fisheries information

3.1 Description of the fleet

In the Balearic Islands (GSA 5), commercial trawlers employ up to four different fishing tactics (Palmer *et al.* 2009), which are associated with the shallow and deep continental shelf, and the upper and middle continental slope (Guijarro and Massutí 2006; Ordines *et al.* 2006). Vessels mainly target striped red mullet (*Mullus sumuletus*) and European hake (*Merluccius merluccius*) on the shallow and deep shelf respectively. However, these two target species are caught along with a large variety of fish and cephalopod species. The Norway lobster (*Nephrops norvegicus*) and the red shrimp (*Aristeus antennatus*) are the main target species on the upper and middle slope respectively. The Norway lobster is caught at the same time as a large number of other fish and crustacean species, but the red shrimp fishery is the only Mediterranean fishery that could be considered mono-specific.

The species assessed, the striped red mullet, is one of the most important target species in the trawl fishery working on the continental shelf off Mallorca (~30 vessels). A fraction of the small-scale fleet (~100 boats) also directs to this species during the second semester of the year (July-December), using both trammel nets and gillnets.

Table3.1-1: Description of operational units exploiting the stock

	Country	GSA	Fleet Segment	Fishing Gear Class	Group of Target Species	Species
Operational Unit 1*	ESP	05	E-Trawl (12-24 meters)	03- Trawls	33- Demersal inshore species	MUR
Operational Unit 2	ESP	05	C- Minor gear with engine (6-12 meters)	07- Gillnets and Entangling Nets	33- Demersal inshore species	MUR

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

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)
Trawl	32 (1)	87(1)	See comments	No (3)	Yes (3)	Fishing trips
Trammel net	70(2)	20(2)	See comments	Yes (4)	Yes (4)	Fishing trips
Total	102	107				

(1) Number of boats refer to: (i) Trawl: mean values 2000-2013 and (ii) mean values 2000-2013 considering boats from the small-scale fleet that targeted the species.
(2) Catch is the average landings, in tons, of Mallorca during the period 2000–2013.
(3) Carbonell (1997).
(4) Since Mas *et al*. (2004), twelve species were discarded at least in one occasion, and the discarded fraction in this fishery was 1.4% in number. *M. surmuletus* were discarded in 19% of the fishing sets and made up the largest fraction of the discards (42.8% in number).

Other species caught

Trawl
Spicarasmaris, Mullus barbatus, Pagellus acarne, Pagellus erythrinus, Trachurusmediterraneus, Scyliorhinuscanicula, *Serranus cabrilla, Trachinus draco, Scorpaena notata, Trigloporus lastoviza, Scorpaena scrofa, Octopus vulgaris, Eledone moschata, Sepia officinalis, Loligo vulgaris.*

Trammel net (Mas *et al.*, 2004): *Diplodus annularis, Spicara maena, Diplodus vulgaris, Serranus scriba.*

3.2 Historical trends

Most landings come from trawlers (80%) and a fifth of total landings come from the small-scale fleet (20%) (Fig. 3.2-1). During 2000 and 2013, the annual landings of striped red mullet in GSA 5 have oscillated between 55 and 117 and 9 and 29 tons in the trawl and small-scale fishery, respectively. However, during the last two years assessed (2012-2013) the landings showed their historical minimums (67 tons), with landings of 55-57 tons and 9-12 tons for the trawl and small-scale fleets, respectively. The population size structure of red mullet taken by the fishery shows a modal size (16-17 cm) above the size at first maturity (14 cm ML) (Fig. 3.2-1).

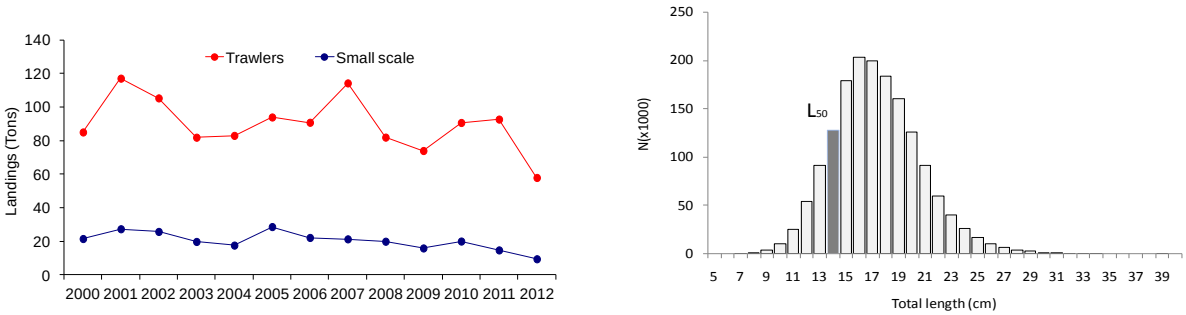


*Fig. 3.2-1.*Mullus surmuletus *GSA05: Annual landings of bottom trawl and small-scale fleets (left) and mean size distribution including L_{50} in grey (right) during 2000-2013.*

No major changes were found in abundance by length during the time series from 2000 to 2013, with modes in 19-20 cm and 16-17 cm for the small scale and trawl fleet respectively (Fig. 3.2-2). Most catches correspond to ages 0-2 (Fig. 3.2-2).

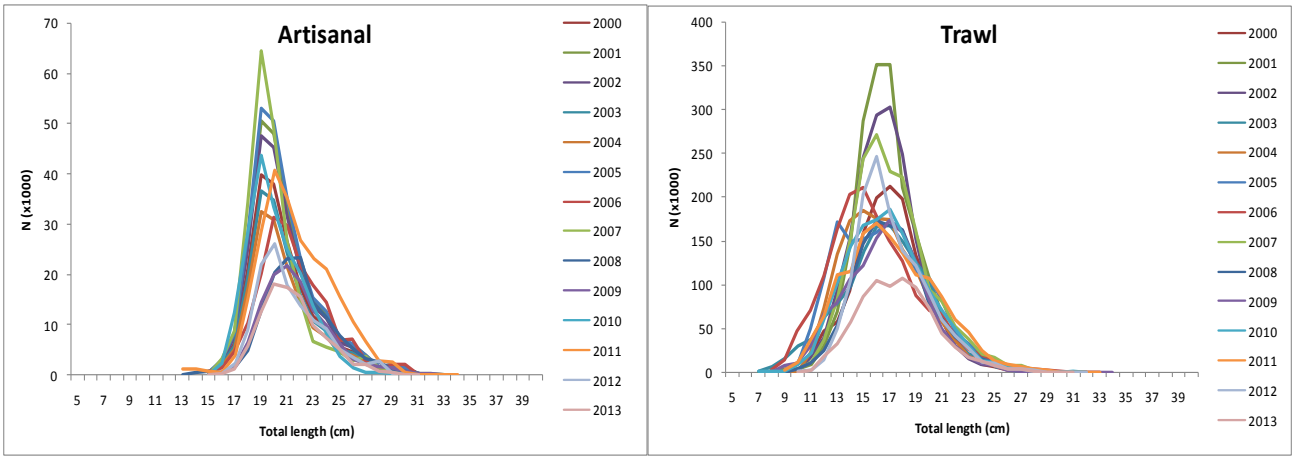


*Fig. 3.2-2.*Mullus surmuletus *GSA05: size-structure of populations from artisanal and bottom trawl fleets during 2000-2013.*

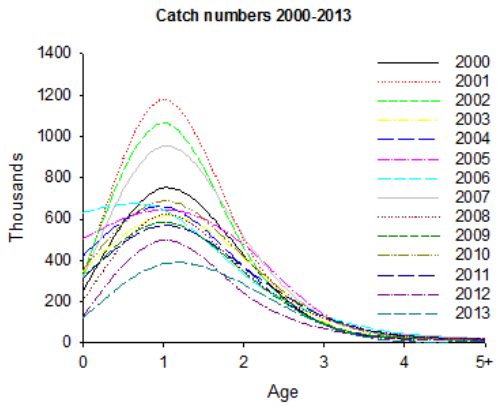


*Fig. 3.2-2.*Mullus surmuletus *GSA05: age-structure by year for all the years included in the assessment.*

3.3 Management regulations

Trawl

- Fishing license: fully observed

- Engine power limited to 316 KW or 500 CV: not observed

- Mesh size in the cod-end (before Jun 1st 2010: 40 mm diamond; from Jun 1st 2010: 40 mm square or 50 mm diamond -by derogation-): fully observed

- Fishing forbidden upper 50 m depth: not fully observed

- Time at sea (12 hours per day and 5 days per week): fully observed

Trammel net

- Fishing license: fully observed

- Fishing season (July to December): No regulated

- Maximum length of nets (2000 m/fisherman and 5000 m/boat): not fully observed

- Minimum mesh size (50 mm): fully observed

- Limitation to 6 fishing days per week: fully observed

- Time at sea (from sunrise to sunset): not fully observed

- Fishing forbidden deeper than 50 m depth: fully observed

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	$F_{0.1}$	0.17			
Y					
CPUE					
Index of Biomass at sea					

4. Fisheries independent information

4.1 BALAR-MEDITS bottom trawl surveys

4.1.1 Brief description of the directmethod used

From 2001, the Spanish Institute of Oceanography has performed annual bottom trawl surveys following the same methodology and sampling gear described in the MEDITS protocol (BALAR surveys, Massutí and Reñones, 2005). Since 2007, this survey has been included in the MEDITS program (Bertrand *et al.*, 2002). Mean stratified abundances and biomasses by km^2 has been computed using the methodology described by Grosslein and Laurec (1982), with the following formula:

- Mean catch by stratum: $$\overline{Y}_{st} = \frac{1}{N_h} * \sum Y_h$$
- Variance by stratum: $$S^2(\overline{Y}_{st}) = \frac{1}{N_{h-1}} * \sum (Y_h - \overline{Y}_{st})^2$$
- Mean total catch: $$Y_t = \frac{1}{A} * \sum (\overline{Y}_{st} * A_h)$$
- Total variance: $$S^2(\overline{Y}_t) = \frac{1}{A^2} * \sum \frac{S^2(\overline{Y}_{st}) * A_h^{\,2}}{N_h}$$
- SE (standard error): $$SE = \sqrt{S^2(\overline{Y}_{st})}$$

Nh: number of hauls in each sub-stratum; Yh: mean catch by haul in each sub-stratum; A: total stratum area; Ah: sub-estratum area; $S^2(\overline{Y}_{st})$ variance in each sub-stratum.

4.1.2 Spatial distribution of the resources

M. surmuletus *is mainly distributed in the fishing grounds sited in the east-north east of Mallorca and in the south-east of Menorca*

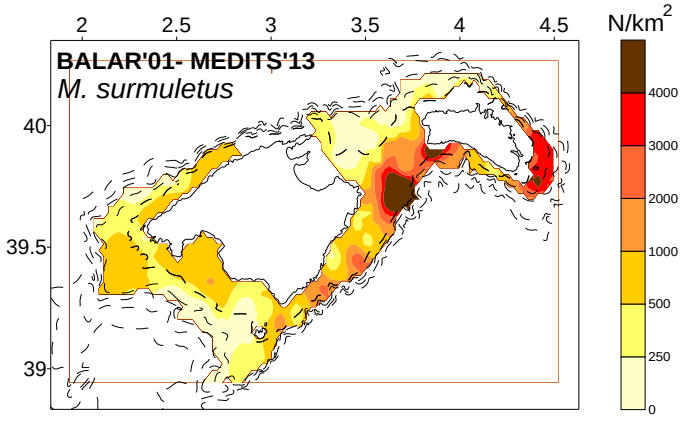


Fig 4.1.2-1. Spatial distribution of M. surmuletus *around the Balearic Islands using information obtained from surveys.*

4.1.3 Historical trends

Biomass abundance indices of *M. surmuletus* in GSA 05 showed a maximum value in 2007 and a decreasing trend since then (Fig. 4.1.3-1). However, there is a slight increasing trend in 2014, but this year is not included in the assessment.

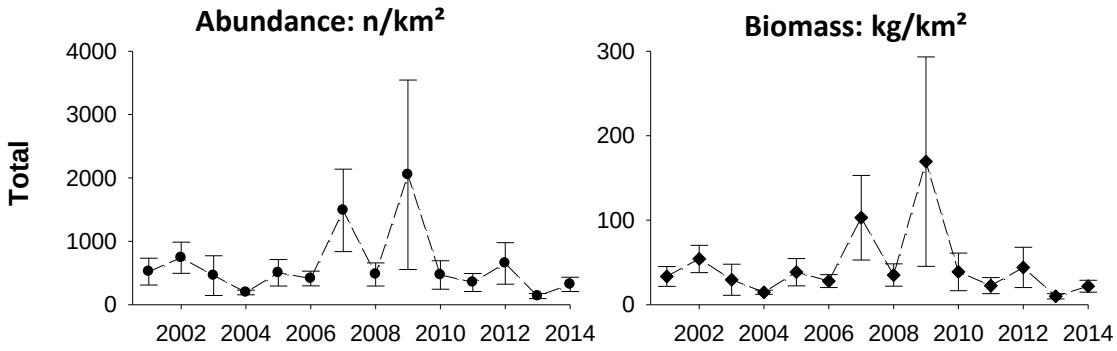


Fig 4.1.3-1. Biomass and abundance indices of M. surmuletus *in GSA 05 from scientific surveys.*

Most of the catches during the survey correspond to age 1 individuals, although ages 0 and 2 are also abundant (Fig 4.1.3-2).

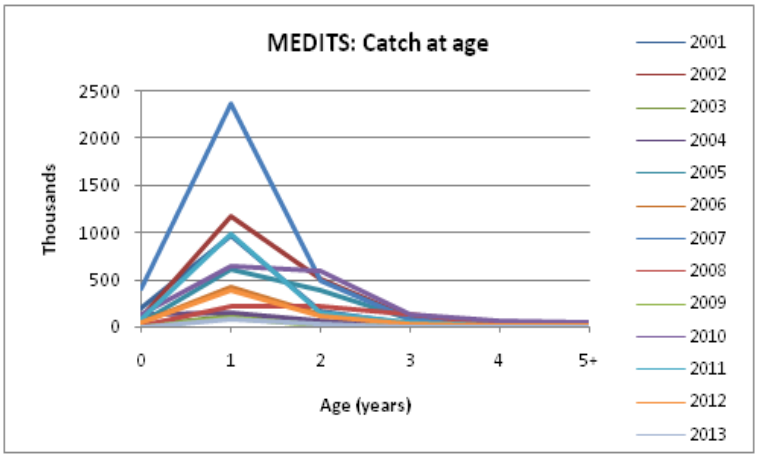


Fig 4.1.3-2. Age structure of of M. surmuletus *in GSA 05 from scientific surveys.*

Other calibration data

XSA tuning was performed using abundance indices from MEDITS surveys (N/km^2) developed during 2001–2013 around the Balearic Islands (*Fig. 4.1.3-1, 4.1.3-2*) and CPUEs of daily landings from the trawling fleet of one port of Mallorca (Santanyí) (*Fig. 4.1.3-2)*. This port, situated in the SE of the island, was used because its fleet works basically on the continental shelf, and thus it can be

considered that their CPUEs are a good indicator of the species abundance (*M. surmuletus* inhabits mainly on the shelf). Length-distributions from Santanyí were also available from onboard sampling. The landings of this port represented 30-50% of the total catch of Mallorca during the assessed period. Abundance indices from surveys were calculated considering different bathymetric strata. For tuning VPA, the values obtained in the stratum corresponding to the continental shelf (<100 m depth) were used because they best reflected the evolution of commercial landings.

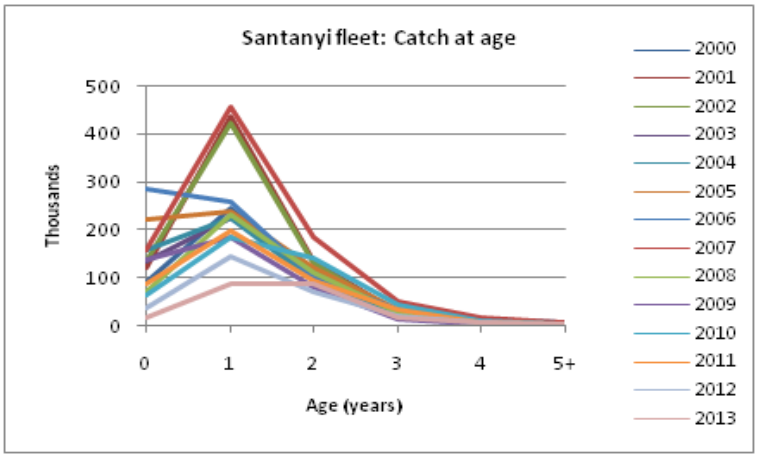


Fig 4.1.3-3.Abundance (thousands) per age and year of M. surmuletus *in GSA 05 from the commercial tuning fleet of Santanyi.*

5. Ecological information

5.1 Protected species potentially affected by the fisheries

5.2 Environmental indexes

The population dynamics of *M. surmuletus* off the Balearic Islands has been shown to be synchronously affected by the combined effect of fishing exploitation and environmental variability (Quetglas *et al*., 2013). A production model showed an early period of underexploitation that shifted to overexploitation in the early 1980s. CPUEs showed an increasing trend during the underexploitation phase (1965-1980) but an oscillatory behavior during the overexploitation (1980-2008) (Fig. 5.2.-1). These natural fluctuations, however, would have been masked during the first part of the series, when landings displayed an exponential growth due to the rapid increase in fishing effort. This phase-transition event (1980) may be also influence by the hydroclimatic changes that also took place in this period in the area (Fernandez de Puelles and Molinero, 2007, 2008; Molinero *et al.*, 2009; Conversi *et al.*, 2010). These changes in the hydrography influenced the seasonal and interannual plankton dynamics around the Balearic Islands (Fernandez de Puelles and Molinero, 2007, 2008) that could have affected the survival of early life stages of exploited species, and, in turn, synergistically magnified the effect of fishing (Hidalgo *et al.*, 2011). To

determine whether the causes of the interannual fluctuations in CPUEs were linked to climatic variability, climate indices at increasing spatial scales (local, meso-, and global-scale) were examined. The analysis, which covered the 1965-2008 period, showed a positive effect of the El Niño/Southern Oscillation index (ENSO) on the population abundance of this species in this area, at a time lag of 6 years. Indeed, the interaction between North Atlantic climate (i.e. NAO) and Pacific modes (i.e. ENSO) has been shown to affect the Mediterranean climate through rainfall (e.g. Mariotti *et al.*, 2002). Recent evidence also demonstrated the influence of ENSO variability on Mediterranean hydrographical characteristics, particularly on the sea surface temperature (Hertig and Jacobeit, 2011). In the Balearic Islands, rainfall and sea surface temperature variability strongly affect the nutrients, phytoplankton, and zooplankton variability (Fernandez de Puelles and Molinero, 2007, 2008). Since the species displaying a close link with ENSO are those inhabiting the shallow continental shelf, they should be more influenced by the interannual dynamics of zooplankton affecting prey-predator relationships and survival of early life stages. Favourable climatic events can produce strong annual cohorts, favouring the recruitment in consecutive years due to the relative good level of reproductive stock. This could magnify the climatic signal in the next generations and thus bring forth population cycles (Tzeng *et al.*, 2012) that could explain the lagged oscillatory response observed.

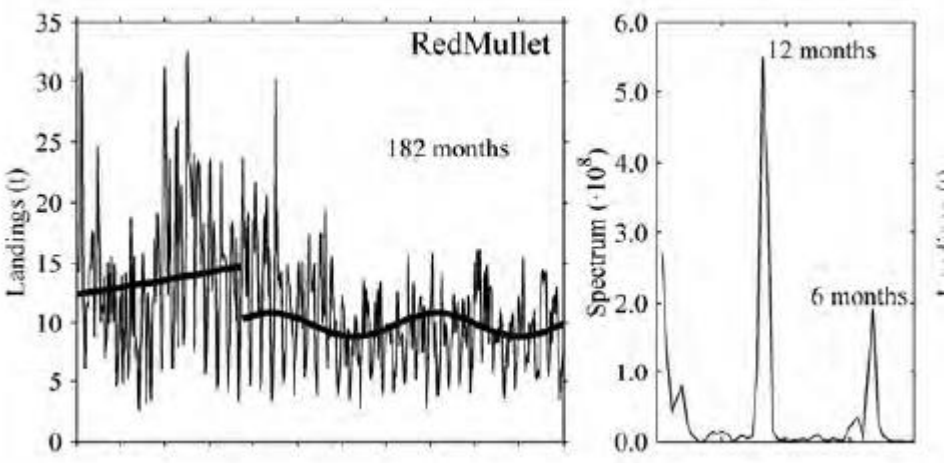


Fig. 5.2.-1 Spectrum analysis and least squares fitting to the monthly data (landings) of M. surmuletus *in the GSA 05 during the period 1965-2008. The best fit to the data is shown superimposed on the landings: an exponential function for the series 1965-1980 and a sinusoidal function for 1980-2008. The periodicity of the oscillations (in months) found in this last period is also shown. (From Quetglas* et al*., 2013)*

1. Stock Assessment

1.1 Extended survivor analysis (XSA)

1.1.1 Model assumptions

Three sensitivity analysis were run before selecting the final settings: i) Different ages after which catchability is no longer estimated; ii) different shrinkage weight (fse= 0.5 to 2.5, Fig. 6.1.1-1) and iii) different shrinkage ages with shrinkage age 0.5 (Fig. 6.1.1-2) and iii) (Fig. 6.1.1-3). The final settings selected were:

Fse	shk.yrs	shk.ages	rage	qage
1.5	3	2	0	2

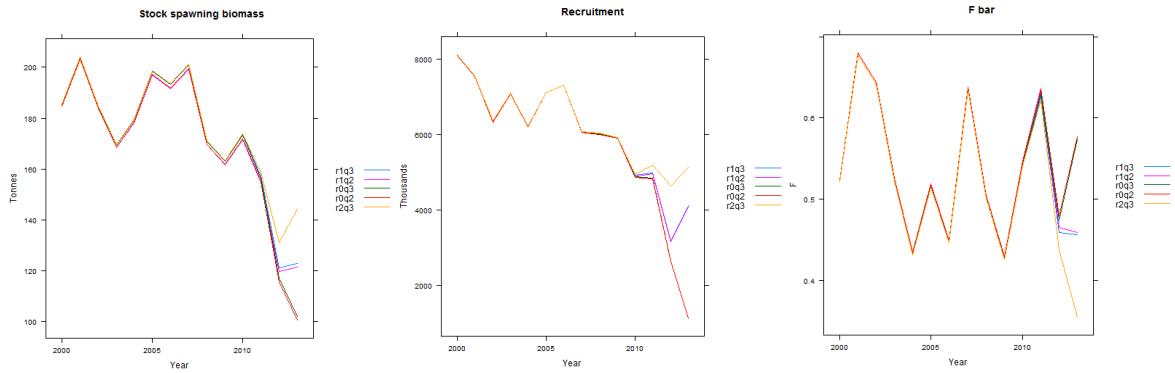


Fig.6.1.1-1. M. surmuletus *GSA05: XSA sensitivity analyses on different rage and qage.*

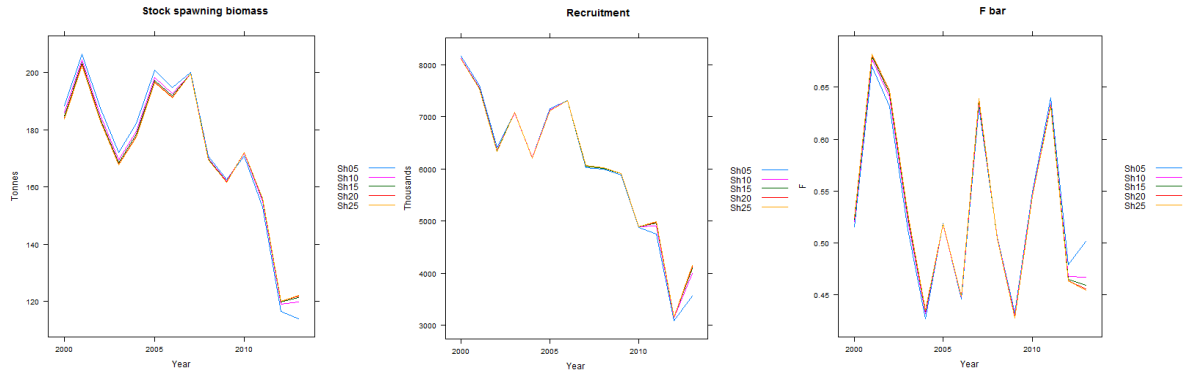


Fig.6.1.1-2. M. surmuletus *GSA05: XSA sensitivity analyses on shrinkage weight.*

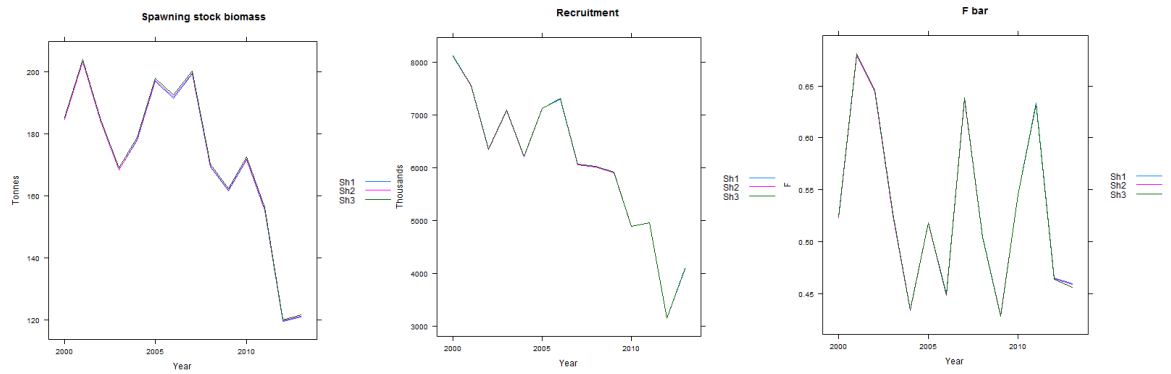


Fig.6.1.1-3. M. surmuletus *GSA05: XSA sensitivity analyses on shrinkage ages with shrinkage weight 1.5.*

1.1.2 Scripts

1.1.3 Input data and Parameters

Table 6.1.3-1. Catch-at-age by year (thousand individuals) for *M. surmuletus* from the commercial fleet from GSA 05.

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
0	245.6	293.8	324.6	344.8	421	504.5	630.5	311.6	203.4	312.2	355.2	311.9	128.2	120.5
1	751.2	1179.6	1065.8	613.7	659.7	645.5	644.7	955.4	621	584	687.8	569	497.4	383.2
2	424.7	502.4	464	414.6	367.4	475.7	331	517.1	348.4	344	418.5	367.7	242.4	283.4
3	90.3	120.2	93.8	101.9	90.5	137.7	130.1	127.8	124.3	92.7	125.7	129.4	70.9	85.9
1	24.7	38.9	28.7	26	25.7	36	44.1	40	36.5	23.9	28.5	35	17.9	23.7
5+	10.7	12.1	14.4	10	9.7	14.5	20.8	19.2	14.6	9.6	9.1	17.9	7.2	10

1.1.4 Tuning data

Table 6.1.4-1. Catch-at-age by year (thousand individuals per km^2) for *M. surmuletus* from scientific surveys from GSA 05.

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
0	197.3	92.5	13.3	118.7	36.7	55.9	414.5	7.5	8.5	120.8	70.8	43.8	5.2
1	967.2	1165.9	115.4	145.1	613.9	417.8	2369	221.2	102	635.2	990.3	379.1	84.9
2	162.7	506.6	36.8	48.3	396.3	139.4	498.4	214.8	21.1	582.8	147	104.4	36.1
3	31.2	97.3	11.6	10.9	72.8	41.2	90.6	137.3	14.3	117.8	43.3	20.9	8.3
4	5.9	23.9	2.6	1.8	7.8	4.3	16.1	28	0	53.6	1.7	7.1	1.1
5+	0	6.6	0	1.5	5.5	0	0	5.1	0	36	3	3.1	0

Table 6.1.4-2. Catch-at-age by year (thousand individuals per km^2) for *M. surmuletus* from the tuning commercial fleet of Santanyi.

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
0	90.1	121.8	133.7	134.7	157.1	219.2	285.8	155.7	70.2	137.7	64.1	86.6	37	17.6
1	243.5	435.2	421.7	224.8	223.7	236.9	258.9	456.6	232.4	182.9	183.7	196.2	143.5	85.9
2	101.6	134.8	129.8	115.2	95	118	99.4	185.3	111.6	79.6	139.1	94.3	69.9	86.4
3	17.6	29	21.8	24.7	22.4	31.6	32.6	51.3	28.6	12.3	44	34.2	20.5	17.7
4	3.9	8.7	5.6	4.7	5.5	6.7	10.5	15.4	6.6	2.9	9.1	8.4	5.2	5.6
5+	1.1	1.2	2.5	1.2	1.6	1.8	5.1	5.9	1.5	0.4	4	4.1	2.1	3.1

1.1.5 Results

XSA results show a clear decreasing trend for all the population parameters since 2006-2007. In fact, last two years of data showed the minimum values of the historical data series, with the SSB values approximately half of the values at the beginning of the data series and recruitment less than half.

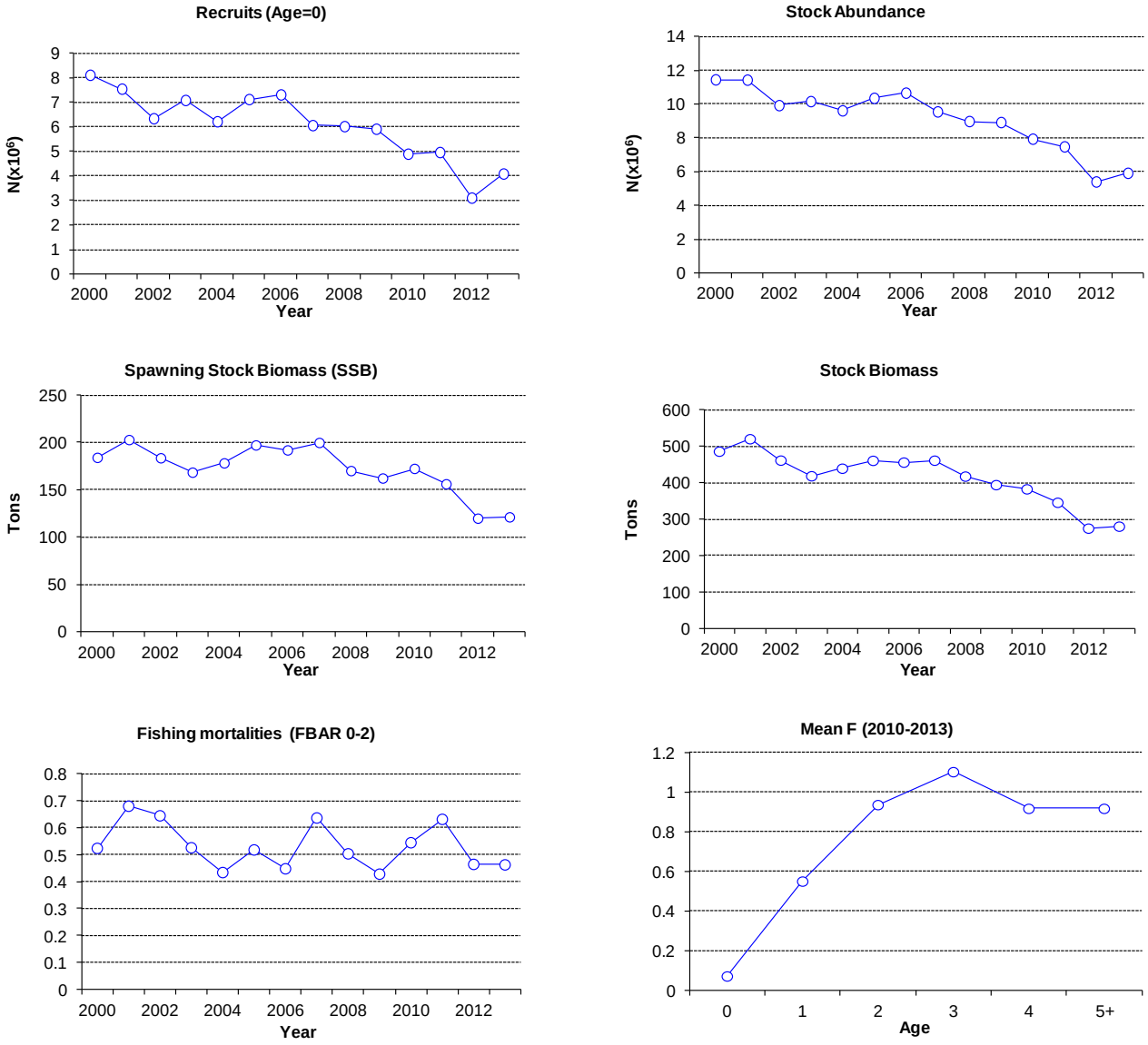


Fig 6.1.5-1. XSA results for M. surmuletus *in GSA 05.*

1.1.6 Robustness analysis

Residuals from both tuning fleets (MEDITS, Santanyí) per age and year were relatively low, ranging from -2 to 2, and did not show any trend with time (Fig. 6.1.6-1).

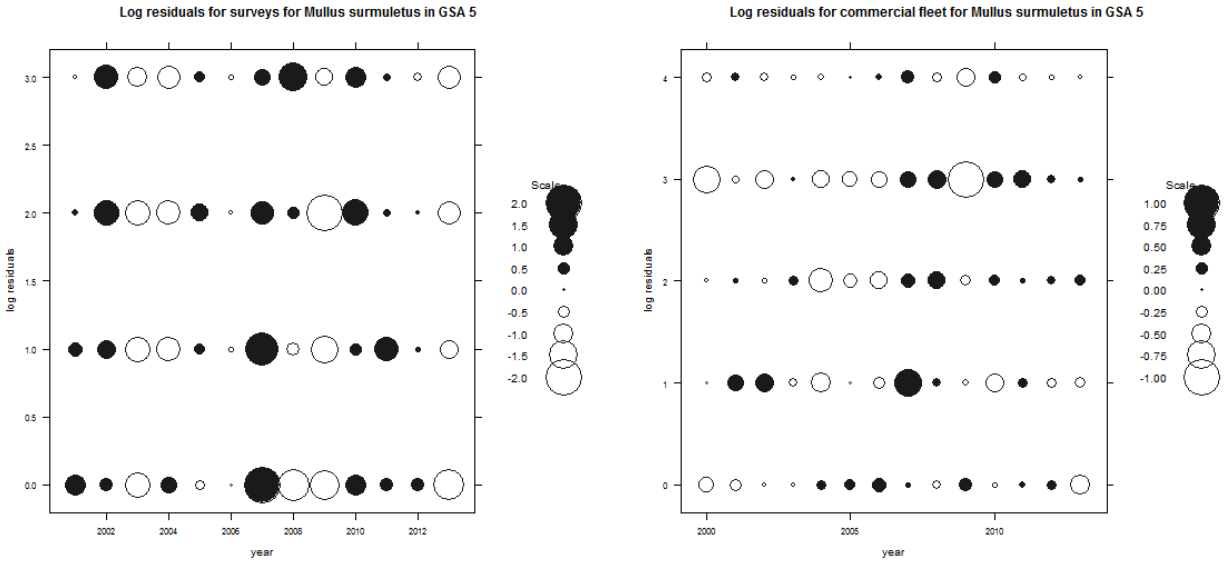


Fig. 6.1.6-1. Mullus surmuletus *GSA05: Log residuals for surveys and the commercial fleet.*

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

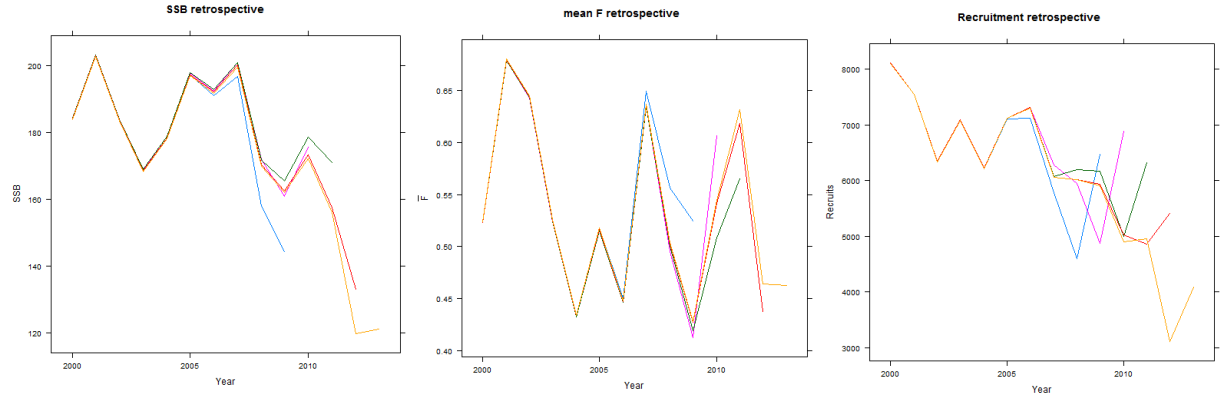


Fig.6.1.7-1. Mullus surmuletus *GSA05: XSA retrospective analyses.*

1.1.8 Assessment quality

2. Stock predictions

2.1 Short term predictions

A deterministic short term prediction was performed using FLR routines, assuming an F_{stq} of 0.51 in 2013 and a recruitment of 3977 thousands individuals shows that:

- Fishing at the F_{stq} (0.51) generates an increase of the catch of 4% from 2013 to 2015 along with a decrease of the spawning stock biomass of 1% from 2014 to 2015.

- Fishing at $F_{0.1}$ (0.17) generates a decrease of the catch of 58% from 2013 to 2015 and an increase of the spawning stock biomass of 36% from 2015 to 2016.

Table 6.2.5.3.1 – Short term forecast in different F scenarios computed for striped red mullet in GSA 5. Basis: F(2013) = mean(F_{bar}0-2 2010-2013)= 0.51; R(2013) = geometric mean of the recruitment of the last 3years; R = 3977 (thousands); SSB(2013) = 121 t,Catch (2013)= 67 t.

Rationale	F_{factor}	F	Catch 2015	Catch 2016	SSB 2015	SSB 2016	Change SSB 2015-2016 (%)	Change Catch 2013-2015 (%)
Zero catch	0	0.00	0.00	0.00	111.63	181.10	62.23	-100.00
High long-term yield ($F_{0.1}$)	0.33	0.17	28.17	39.01	111.63	151.69	35.88	-57.90
Status quo	1	0.51	69.52	69.22	111.63	110.66	-0.87	3.92
Different scenarios	0.1	0.05	9.28	14.69	111.63	171.31	53.46	-86.13
	0.2	0.10	17.93	26.73	111.63	162.27	45.36	-73.20
	0.3	0.15	25.99	36.58	111.63	153.92	37.89	-61.15
	0.4	0.21	33.52	44.62	111.63	146.22	30.98	-49.90
	0.5	0.26	40.55	51.16	111.63	139.09	24.60	-39.39
	0.6	0.31	47.12	56.47	111.63	132.50	18.69	-29.56
	0.7	0.36	53.28	60.76	111.63	126.40	13.23	-20.36
	0.8	0.41	59.04	64.22	111.63	120.75	8.17	-11.75
	0.9	0.46	64.45	67.00	111.63	115.52	3.48	-3.67
	1.1	0.57	74.29	70.97	111.63	106.16	-4.90	11.05
	1.2	0.62	78.77	72.35	111.63	101.98	-8.65	17.75
	1.3	0.67	83.00	73.43	111.63	98.10	-12.12	24.06
	1.4	0.72	86.97	74.26	111.63	94.49	-15.36	30.01
	1.5	0.77	90.73	74.88	111.63	91.13	-18.37	35.62
	1.6	0.82	94.27	75.35	111.63	88.00	-21.17	40.91
	1.7	0.87	97.62	75.69	111.63	85.09	-23.78	45.92
	1.8	0.93	100.79	75.93	111.63	82.38	-26.21	50.66
	1.9	0.98	103.80	76.08	111.63	79.84	-28.48	55.15
	2	1.03	106.64	76.17	111.63	77.48	-30.59	59.41

2.2 Medium term predictions

No long term prediction was carried out due to the lack of a reliable model fit for the spawning stock biomass-recruitment relationship (Fig. 7.2-1).

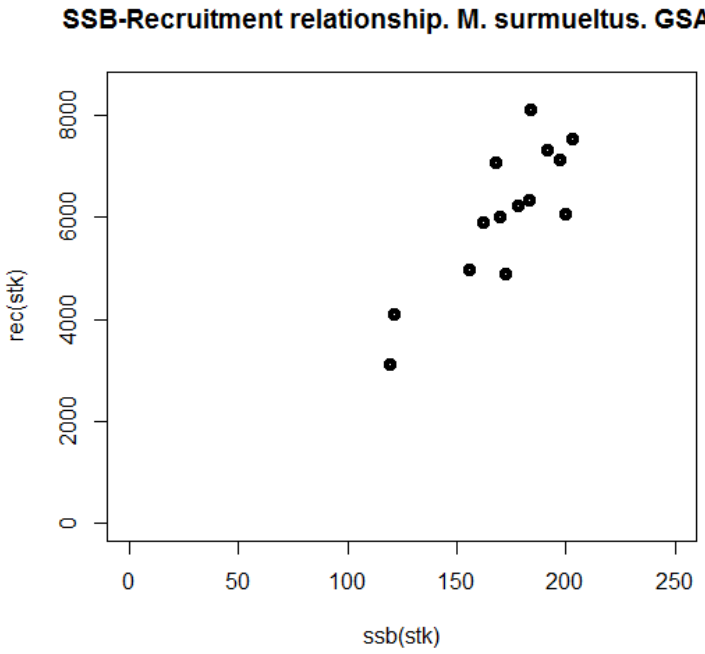
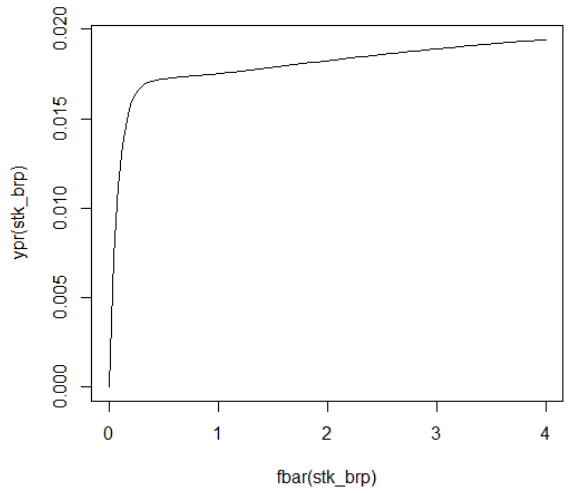


Fig. 7.2-1. Spawing stock biomass – recruitment relationship for M. surmuletus *in GSA 05.*

2.3 Long term predictions

The yield per recruit analyses of *M. surmuletus* in GSA 5 is shown in Fig. 7.3-1.



$F_{0.1}$	0.17
F_{ref} (2011-2013; ages 0-2)	0.51

Fig. 7.3-1.*Mullus surmuletus *GSA05: yield per recruit and Reference F and reference point (F0.1).

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	$F_{0.1}$= 0.17	F= 0.51		N (p>0.05)	IO (O_H)
	Fishing effort				N (p>0.05)	
	Catch				D (p<0.05)	
Stock abundance	Biomass (2011-2013)	300 t		33rd perc= 401 t 66th perc= 459 t	D (p<0.001)	
	SSB (2011-2013)	132 t		33rd perc= 169 t 66th perc=184 t	D (p<0.01)	
Recruitment	Individuals	4.0 millions		33rd perc= 5.9 millions 66th perc= 6.8 millions	D (p<0.001)	
Final Diagnosis		In overexploitation, with relatively low biomass				

2.4 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)*