Stock Assessment Form
Demersal species

Reference year: 2015

Reporting year: 2016

The stock of red mullet - *Mullus barbatus* around Cyprus island (GSA25) was assessed by means of an Extended Survivor Analysis (XSA) run using FLR libraries. The assessment was carried out using as input data official landings and biological data collected under the Cyprus National Data Collection Programme, covering the period 2005-2015. Medits survey data for the years 2006-2015 were used for the tuning file. Yield per recruit analysis was performed for the estimation of the reference point F0.1 as proxy of F_{MSY}. The results of the assessment suggest that the stock is in sustainable exploitation, with a current F_{bar1-2} (0.26) lower than $F_{0.1}$ (0.32).

Stock Assessment Form version 1.0 (January 2014)

Uploader: *Charis Charilaou*

Stock assessment form

1 Basic Identification Data

Scientific name:	Common name:	ISCAAP Group:
Mullus barbatus	Red mullet	33
1st Geographical sub-area:	**2nd Geographical sub-area:**	**3rd Geographical sub-area:**
GSA25		
4th Geographical sub-area:	**5th Geographical sub-area:**	**6th Geographical sub-area:**
1st Country	**2nd Country**	**3rd Country**
Cyprus		
4th Country	**5th Country**	**6th Country**
Stock assessment method: (direct, indirect, combined, none)		
Indirect: XSA (using trawl survey data for tuning), Y/R analysis, Short term prediction		
Authors:		
Charilaou C., Thasitis I.		
Affiliation:		
Department of Fisheries and Marine Research (DFMR), Ministry of Agriculture, Rural Development and Environment, Cyprus		

2 Stock identification and biological information

2.1 Stock unit

The assessment is considered to cover a complete stock unit; it is assumed that the stock limits of the assessed *Mullus barbatus* are in agreement with the limits of GSA 25.

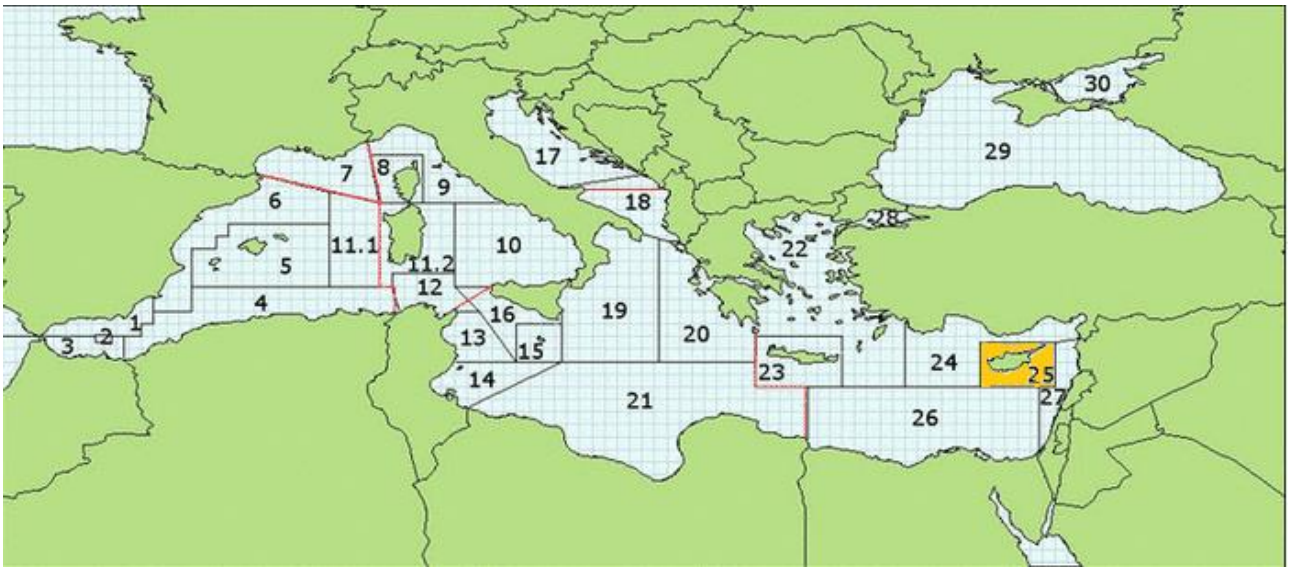


Figure 2.1-1: Geographical location of GSA25.

2.2 Growth and maturity

The following tables provide growth and maturity information on the stock, based on combined data from commercial catches and fisheries-independent survey. All information is based on data collected under the Cyprus National Data Collection Programme.

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

Somatic magnitude measured (LT, LC, etc)				Units	cm
Sex	Fem	Mal	Combined	Reproduction season	April - July
Maximum size observed			26	Recruitment season	Summer – early autumn
Size at first maturity			10	Spawning area	Shelf
Recruitment size to the fishery				Nursery area	Shelf

Table 2.2-2: M vector and proportion of matures by age (Combined sex)

Age	Natural mortality	Proportion of matures
0	*0.85*	*0.58*
1	*0.39*	*0.80*
2	*0.29*	*1.00*
3	*0.25*	*1.00*
4+	*0.23*	*1.00*

As shown in Table 2.2-2, an M vector at age is used, calculated from Caddy (1991) equation using the PRODBIOM Excel spreadsheet (Abella et al., 1997)[1]. The growth parameters and the length weight relationship used for the estimation of M are those provided in Table 2.2-3. The proportion of matures at age were estimated using the estimated maturity ogive at length, converted to age by ALK and weighted by length distribution. Data used cover the period 2006-2015.

Different length weight relationships were applied along the years; the one provided in Table 2.2-3 refers to 2015.

Table 2.2-3: Growth and length weight model parameters

			Sex			
		Units	**female**	**male**	**Combined**	**Years**
Growth model	**L_∞**	cm			24.208	2011-2015
	K	Years -1			0.413	
	t_0	years			-0.314	
	Data source	Cyprus National Data Collection Programme under EU Data Collection Framework.				
Length weight relationship	**a**				0.006	2015
	b				3.197	2015
	M (scalar)					
	sex ratio (% females/total)					

[11] Abella, A., Caddy, J.F., Serena F. (1997). Do natural mortality and availability decline with age? An alterantive yield paradigm for juvenile fisheries, illustrated by the hake *Merluccius merluccius* fishery in the Mediterranean. IFREMER Aquatic Living Resources. 10: 257-269

3 Fisheries information

3.1 Description of the fleet

As indicated in Table 3.1-1, the stock is exploited by different Operational Units, the trawlers and polyvalent vessels operating with passive gears with length basically below 12m.

For the trawlers fishing in territorial waters a limited number of licenses is issued every year, and an extended closed season is employed. Since 2012 the trawlers operating in territorial waters are limited to two. Further information on the restrictions applied on this fleet is provided in Section 3.3.

The small scale polyvalent fleet operates mainly with bottom set nets and bottom longlines, targeting demersal species. Vessels under this fleet represent the large majority of the fishing vessels in the Cyprus Fleet Register (96%). Most vessels have length 6-<12m and are allowed to operate every day all year round, with a number of restriction measures on the use of fishing gears and minimum landing sizes, according to the national and community law (see Section 3.3). During 2015 there were 393 licenses (33 with length 0-<6m, 360 with length 6-<12m).

Polyvalent vessels fishing with passive gears over 12m are mainly involved in the large pelagic fishery, but may also target demersal shelf species using nets and bottom longlines.

As shown in Table 3.1-2, red mullet in GSA25 is exploited with a number of other demersal species for all operational units.

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	CYP	GSA25	F – Trawlers (>24 metres)	03 - Trawls	33 – Demersal shelf species	*Mullus barbatus* (MUT)
Operational Unit 2	CYP	GSA25	C-Polyvalent small-scale vessels with engine (6-12 metres)	07 – Gillnets and Entangling Nets	33 – Demersal shelf species	*Mullus barbatus* (MUT)
Operational Unit 3	CYP	GSA25	B – Polyvalent small-scale vessels with engine (<6 metres)	07 – Gillnets and Entangling Nets	33 – Demersal shelf species	*Mullus barbatus* (MUT)
Operational Unit 4	CYP	GSA25	M – Polyvalent vessels (>12 metres)	07 – Gillnets and Entangling Nets	33 – Demersal shelf species	*Mullus barbatus* (MUT)

Table 3.1-2: Catch, bycatch, discards and effort by operational unit in 2015

Operational Units*	Fleet (n° of boats)*	Catch (T or kg of the species assessed)	Other species caught (names and weight)	Discards (species assessed)	Discards (other species caught)	Effort (units)
Trawlers	2	14.4 T	*Boops boops* (12t), *Spicara smaris* (49t), *Pagellus erythrinus* (5t), P. acarne (9 t) *Mullus surmuletus* (3t), Serranus cabrilla (4T), *Merluccius merluccius* (0.7t), *Octopus vulgaris* (1T)	0.015 t, (included in Catch)	*Boops boops, Pagellus erythrinus, P. acarne, Spicara smaris, Serranus cabrilla, Merluccius merluccius*	375 (days)
Polyvalent small-scale vessels (6-12 metres)	360	7.3 T	*Boobs boops* (88T), *Mullus surmuletus* (27 T), *Pagellus erythrinus (5.8T), Sparisoma cretense (22 T), Pagellus acarne* (15.4T), *Siganus rivulatus (13.2T), Spicara maena (49 T), Serranus cabrilla* (67.6 T), *Diplodus sargus* (10.8T), *Spicara smaris (40.3 T), Octopus vulgaris (20 T), Sepia officinalis (13.4T), Loligo vulgaris (3.5T)*	No discards	*Lagocephalus* spp.	20341 (days)
Polyvalent small-scale vessels (0-6m)	33	0.2 T	*Boobs boops* (5.5T), *Mullus surmuletus* (1 T), *Pagellus erythrinus (0.06 T), Siganus rivulatus (1.2T), Sparisoma cretense (2.5 T), Diplodus sargus* (0.8 T), *Spicara smaris (2.6 T), Spicara maena (3*	No discards	*Lagocephalus* spp.	1240 (days)

			T), Pagellus acarne (0.01T), *Serranus cabrilla* (3.1 T), *Octopus vulgaris* (2T), *Sepia officinalis (3.4T), Loligo vulgaris (0.2T)*			
Polyvalent vessels (>12 metres)	26	0.3 T	*Boobs boops* (8.1T), *Mullus surmuletus* (0.66 T), *Spicara smaris (0.6 T)*	No discards	*Lagocephalus* spp.	515
Total		22.2				

3.2 Historical trends

Table 3.2.1 provides the catches of *M. barbatus* from both fisheries for the reference period of the current stock assessment study, 2005-2014. The catches are estimated as sum of products of numbers at age multiplied with weight at age. Discards data from the bottom trawlers are included in the catches.

Table 3.2-1: Red mullet GSA 25. Total annual catches (t) in 2005-2015.

	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Net fishery	25.3	18.2	24.3	12.6	10.3	9.9	9.55	8.5	12.0	8.3	7.8
Bottom trawl fishery	18.2	15.5	23.0	20.2	14.5	16.3	7.56	6.7	11.7	11.6	14.4
Total	43.5	33.7	47.3	32.8	24.8	26.2	17.1	15.2	23.7	19.9	22.2

Figures 3.2-1 and 3.2-2 show respectively the trends in landings and LPUE for the period 1985-2015. As shown in Figure 3.2-1, for the relevant period there is fluctuation with clear decreasing trend in the landings of red mullet, especially for the net fishery, with the lowest total value in 2012.

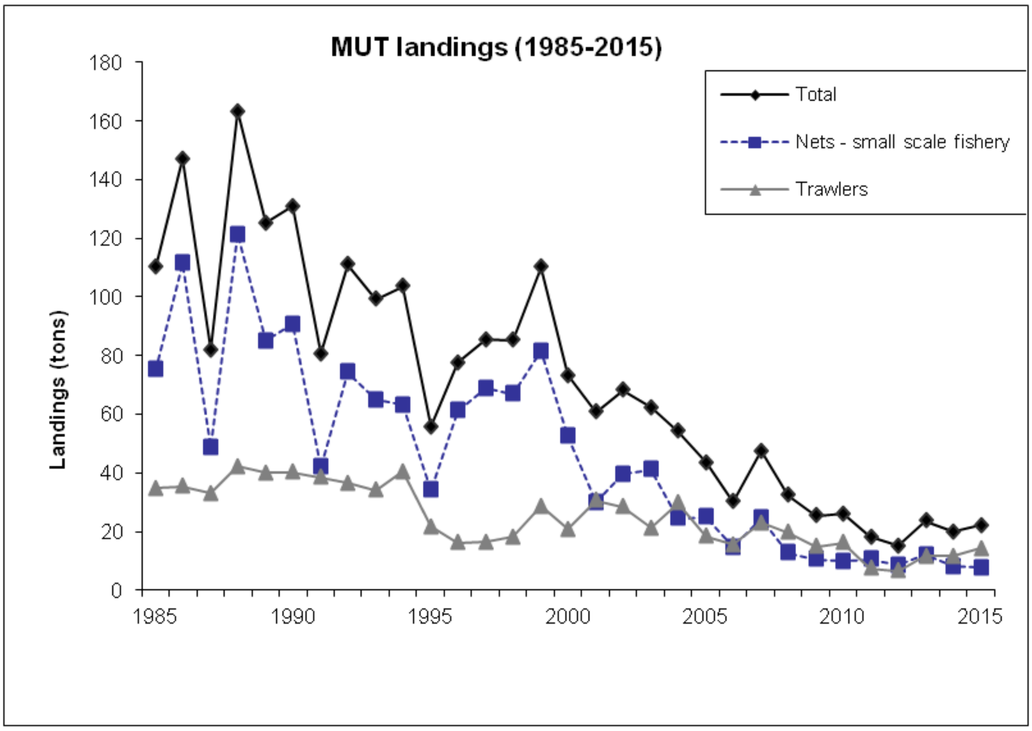


Figure 3.2-1: Landings of red mullet in GSA25 for the period 1985-2015.

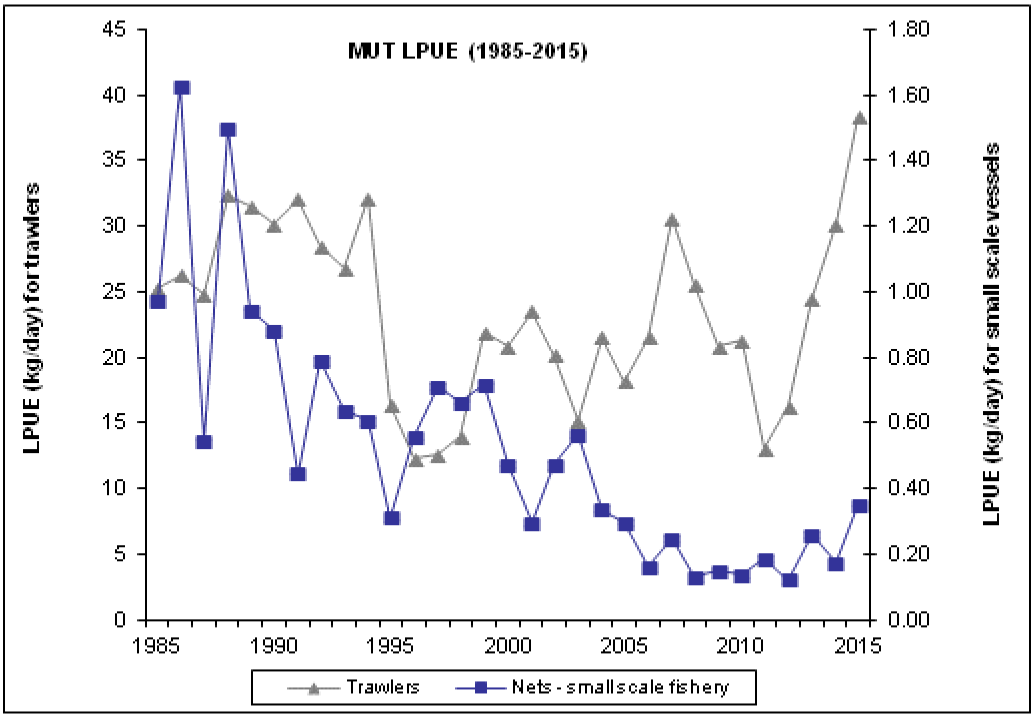


Figure 3.2-2: Landings per Unit Effort (LPUE) in terms of fishing days for red mullet in GSA25 (1985-2015).

Figure 3.2-2 shows fluctuations in the landings per unit effort (LPUE - kg/day) of the net fishery, with a declining trend; from 2006 the values remain at similar low values while in 2015 there is an increase. Fluctuations are evident also for the LPUE of the bottom trawl fishery, with a sharp decrease in 1995; from 2011 there seems to be an increasing trend.

Information on the length distribution of the catches from the two fisheries is provided in Figures 3.2-3 and 3.2-4, while information on the age distribution of the catches by fishery is given in

Figures 3.2-5 and 3.2-6.

As shown in Figures 3.2-3 and 3.2-5, the mean length of the catches from the net fishery has increased during the years, and the main age representing the catches in the recent years is age 2.

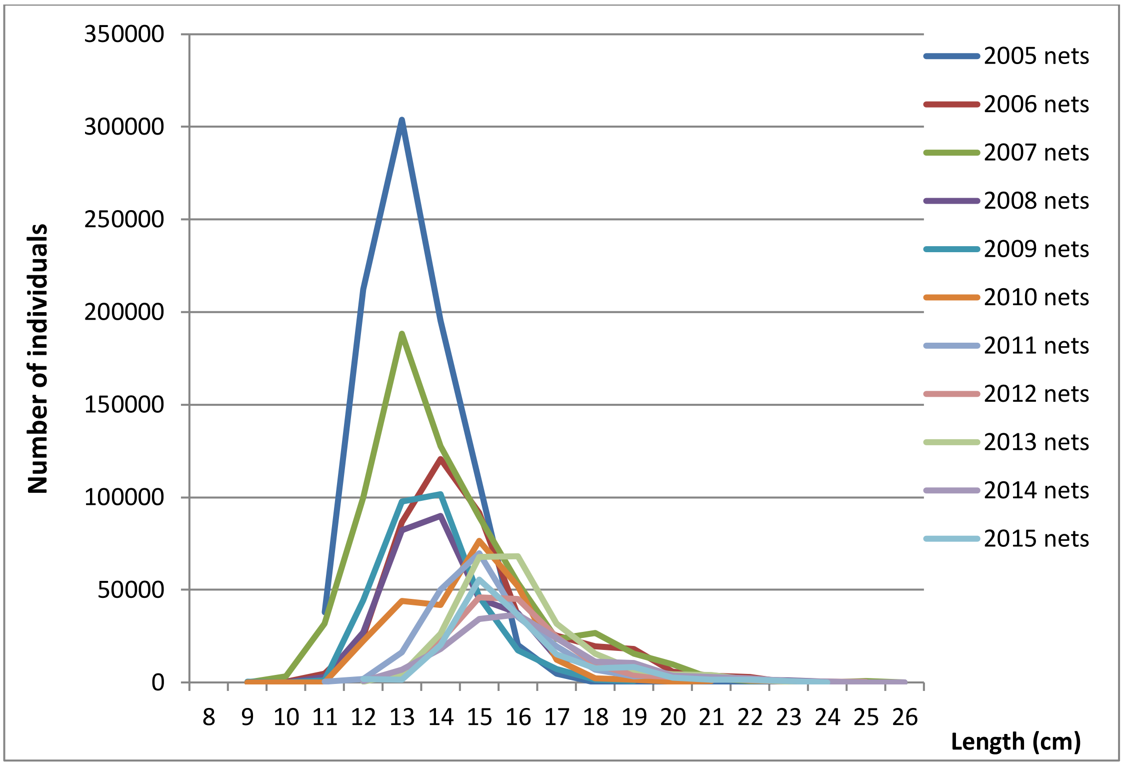


Figure 3.2-3: Length distribution of MUT catches from the net fishery in GSA25 (2005-2015)

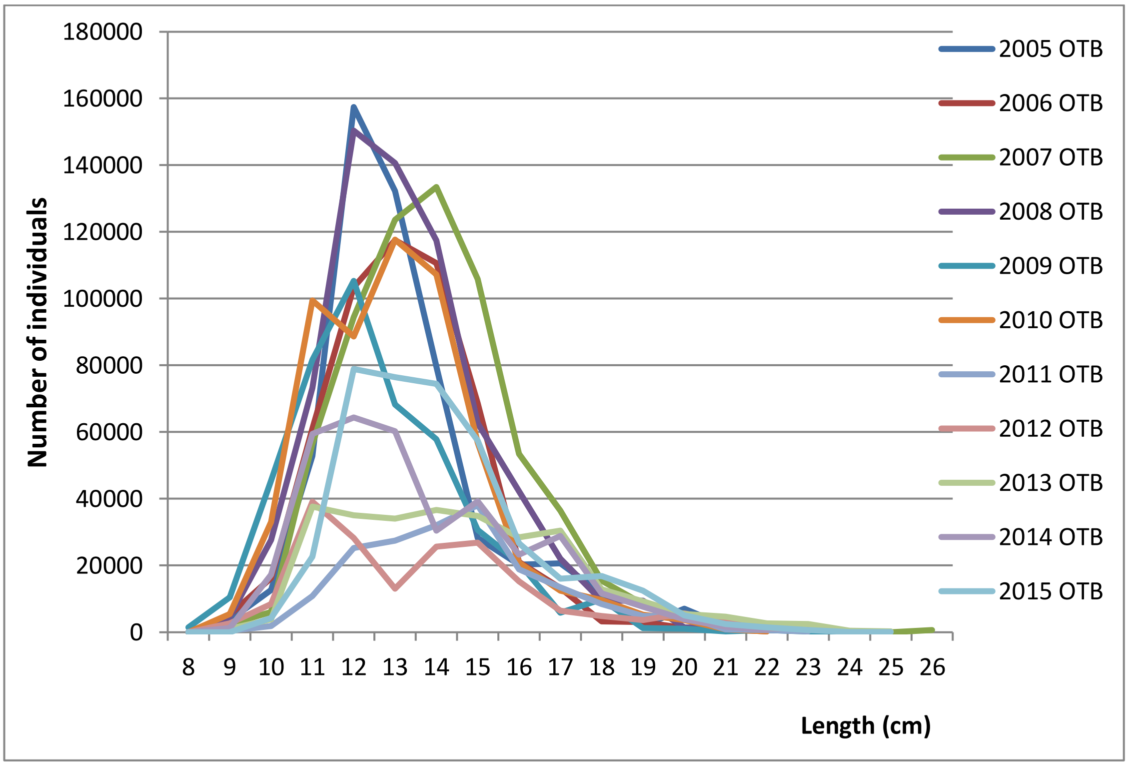


Figure 3.2-4: Length distribution of MUT catches from the OTB fleet in GSA25 (2005-2015).

As shown in Figure 3.2-6, catches of the species from the trawl fishery are mainly represented by age 1, and also by age 2.

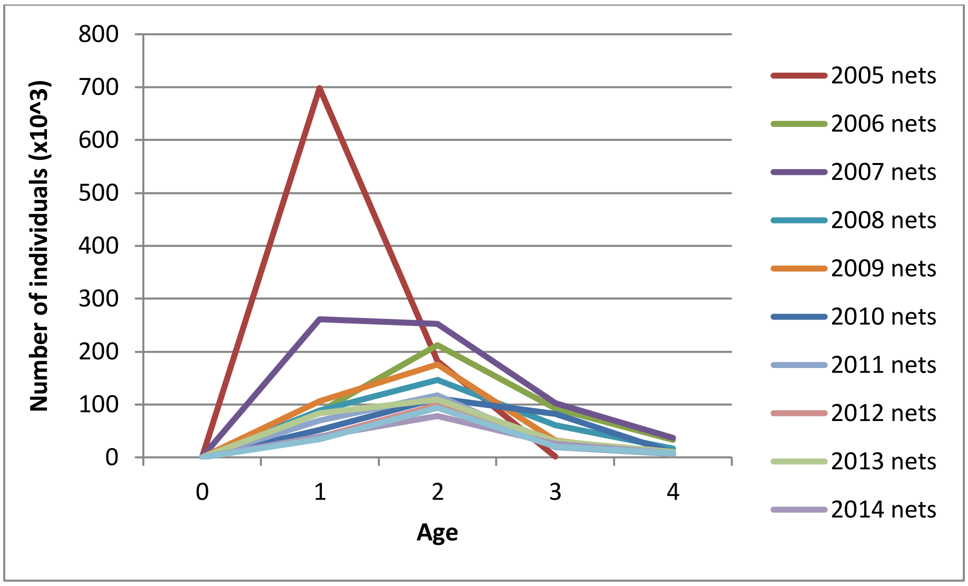


Figure 3.2-5: *Age composition of MUT catches from the net fishery in GSA 25 (2005-2015).*

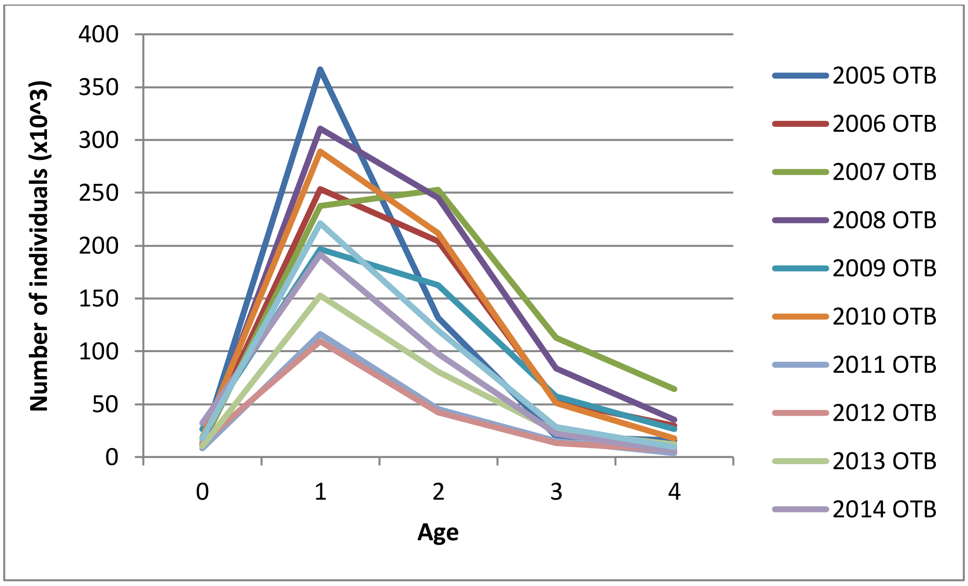


Figure 3.2-6: *Age composition of MUT catches from the trawl fishery in GSA 25 (2005-2015).*

3.3 Management regulations

Current and past management regulations:

1. Polyvalent small-scale vessels (0-6m, 6-12m)

- Restriction of the maximum number of licenses.

  Small scale inshore vessel licenses (Category A&B) are restricted to 500 by legislation;

however, the maximum number is further reduced in accordance with the number of vessels that are permanently removed from the fleet through adjustment schemes.

During 2013, 107 vessels were scrapped with public aid, in accordance with an effort adjustment plan based on Article 21 (a) of Regulation (EC) 1198/2006 on the *European Fisheries Fund* –EFF. In 2014 the maximum number of licenses was reduced accordingly to 393 licenses. During 2015 additional 66 vessels were scrapped with public aid, under the Operational Programme 2014-2020 of the European Marine and Fisheries Fund. From 2016 the maximum number of licenses has been reduced accordingly to 327 licenses.

- Restrictions on the use of fishing gears depending on the fishing license category.

  Until March 2011 minimum mesh size of nets was set at 32mm (open mesh size). From March 2011 minimum mesh size of nets is set at 38mm (open mesh size).

  Maximum length of nets: For boats with license A is 5000m, for boats with license B is 3000m.

  Maximum height of nets: 4m.

  Restrictions on the time and duration of fishing, depending on mesh sizes.

  Additional restrictions on the use of monofilament nets (mesh sizes, length of nets).

2. Bottom Trawlers in territorial waters

- Restriction of the maximum number of licenses. Before 2006 the maximum number of licenses was restricted to 8, while from 2006 until 2011 the maximum number was reduced to 4. From November 2011 maximum number of licenses is restricted to 2.
- Minimum mesh size: From June 2010 the 40mm diamond shape trawl net has been replaced by a diamond meshed net of 50mm at the cod-end. From November 2011 minimum mesh size of 50mm diamond in any part of the net.
- Depth and distance from the cost restrictions: Prohibition of bottom trawling at depths less than 50m and at distances less than 0.7 nautical miles off the coast.
- Seasonal and Area restrictions:
  - Closed trawling period in territorial waters from 1st of June until the 7th of November (in force since the mid '80s).
  - Prohibition of bottom trawling in the Zygi coastal area, at a distance of 3 nautical miles from the coast.
  - Restriction of 2 areas from fishing with trawl nets, on a rotational basis (northwest part of Cyprus from 8 November – 15 February, southeastern part from 16 February – 31 May every year). Applied from November 2011.

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 International Trawl Survey in the Mediterranean (MEDITS)

4.1.1 Brief description of the direct method used

The Medits survey is performed annually since 2005 between June – July, as part of the National Data Collection Programme under the EU Data Collection Framework (Regulations (EC) 199/2008, 665/2008 and Decision 2010/93/EU). In general the survey involves the collection of total weight and total number of individuals per species, as well as individual length and biological parameters (sex, maturity, individual weight and age), in accordance with the MEDITS reference list of target species groups. For *M. barbatus,* all the above parameters are collected.

The specificities of the Medits survey (sampling gear characteristics, design of survey, sampling methodology and processing of samples are described in the MEDITS manual (MEDITS-Handbook. Version n. 8, 2016, MEDITS Working Group: 177 pp.)

It is noted that the Medits survey was not carried out in 2014, while in 2005 and 2015 the survey was carried out in August.

The abundance indices used in the applied XSA model derived from the Cyprus Medits trawl survey data, for the period 2006-2013 and for 2015 separately.

Direct methods: trawl based abundance indices

Table 4.1-1: Trawl survey basic information

Survey	MEDITS	**Trawler/RV**	Trawler
Sampling season	June - July		
Sampling design	Depth stratified sampling with random drawing of the hauls (that remain stable through the years). The number of hauls in each stratum is proportional to stratum surface (taking into account trawlability). Details are provided in the MEDITS manual.		
Sampler (gear used)	IFREMER reference GOC73		
Cod –end mesh size as opening in mm	20mm.		
Investigated depth range (m)	10-800m.		

Table 4.1-2: Trawl survey sampling area and number of hauls.

Stratum	**Total surface (km^2)**	**Trawlable surface (km^2)**	**Swept area (km^2)**	**Number of hauls**
10-50m	796			5
50-100m	717			9
100-200m	918			5
200-500m	2245			3
500-800m	6430			4
Total (10 – 800 m)	11106			26

Figure 4.1-1: Cyprus (GSA 25) Medits survey - Distribution of sampling hauls.

Table 4.1-3: Trawl survey abundance and biomass results

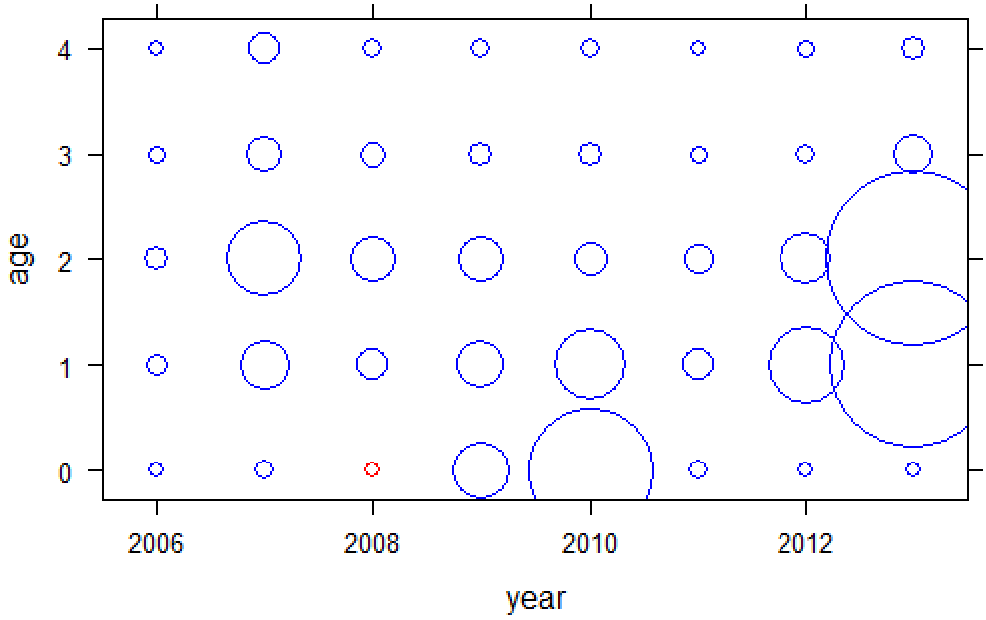
Depth Stratum	Years	kg per km²	CV or other	N per km²	CV or other
10-200 m	2005	16.14	0.53	1188	0.53
10-200 m	2006	3.36	0.73	121	0.72
10-200 m	2007	16.12	0.38	941	0.59
10-200 m	2008	12.46	0.49	412	0.47
10-200 m	2009	19.11	0.41	818	0.42
10-200 m	2010	15.88	0.43	1370	0.55
10-200 m	2011	6.77	0.53	253	0.50
10-200 m	2012	20.03	0.52	718	0.58
10-200 m	2013	76.09	0.58	2380	0.55
10-200 m	2015	18.42	0.535	848	0.485

Direct methods: trawl based length/age structure of population at sea

The age structure of the red mullet population at sea, as recorded during the Medits survey, is provided in Table 4.1.-4. It is specified that numbers are provided per km^2. The age structure was estimated based on An Age Length Key.

Table 4.1-4: Trawl survey results by age class (N/km2).

Age class	2006	2007	2008	2009	2010	2011	2012	2013	2015
0	1	26	0	285	759	32	1	4	450
1	47	241	117	225	392	110	434	1044	211
2	55	421	210	213	128	97	245	1105	144
3	13	143	63	62	61	10	23	170	29
4	5	110	22	33	31	3	15	57	15



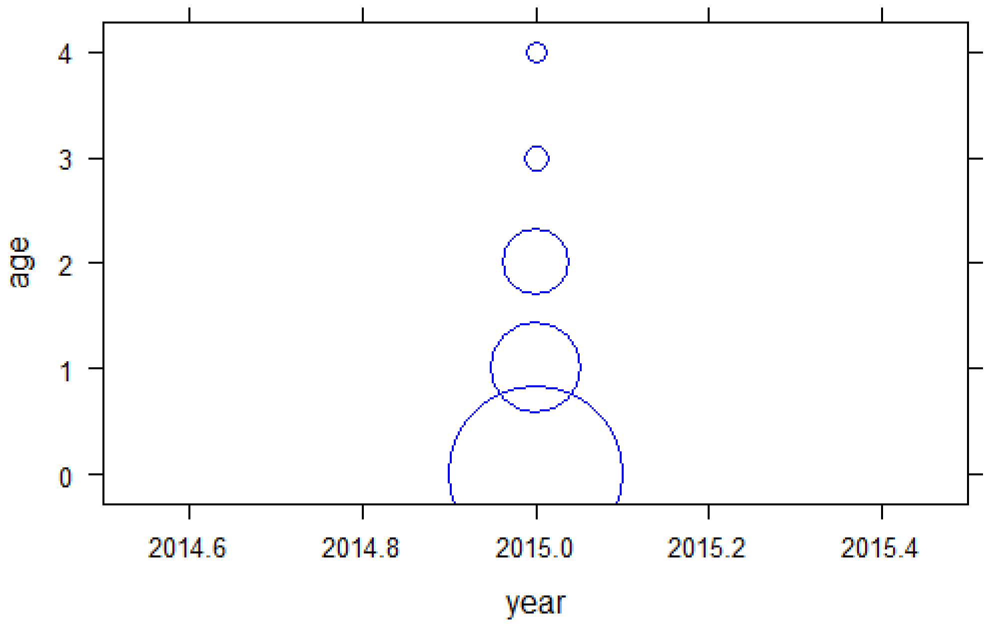


Figure 4.1-1: *Mullus barbatus* in GSA25 - *Medits Catch-at-age matrix for the period 2006-2013, and for 2015.*

Direct methods: trawl based Recruitment analysis

No recruitment analysis was done.

Direct methods: trawl based Spawner analysis

No spawner analysis was done.

4.1.2 Spatial distribution of the resources

The spatial distribution of *Mullus barbatus* in GSA25, as recorded during Medits survey in 2013 and in 2015, is provided in Figure **4.1.2-1** and **4.1.2-2** respectively.

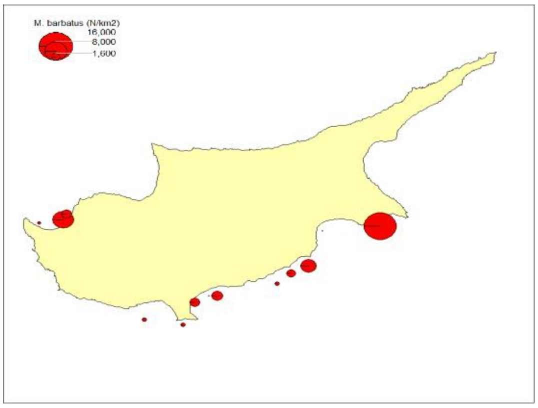


Figure 4.1.2-1. *Mullus barbatus* in GSA25 - Abundance distribution *(Medits 2013).*

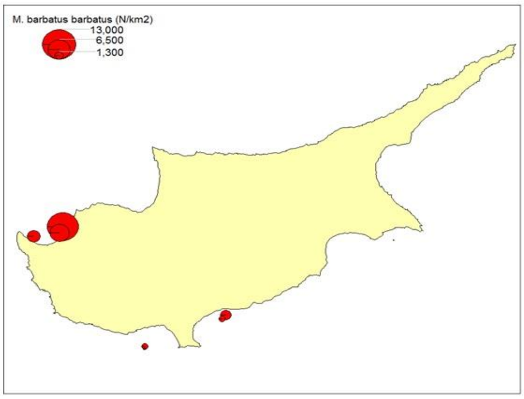


Figure 4.1.2-2. *Mullus barbatus* in GSA25 - Abundance distribution *(Medits 2015).*

4.1.3 Historical trends

MEDITS abundance and biomass indices calculated for the period 2005-2013 and 2015 show fluctuation, with a relatively very high value in 2013 (Figures 4.1.3-1, 4.1.3-2).

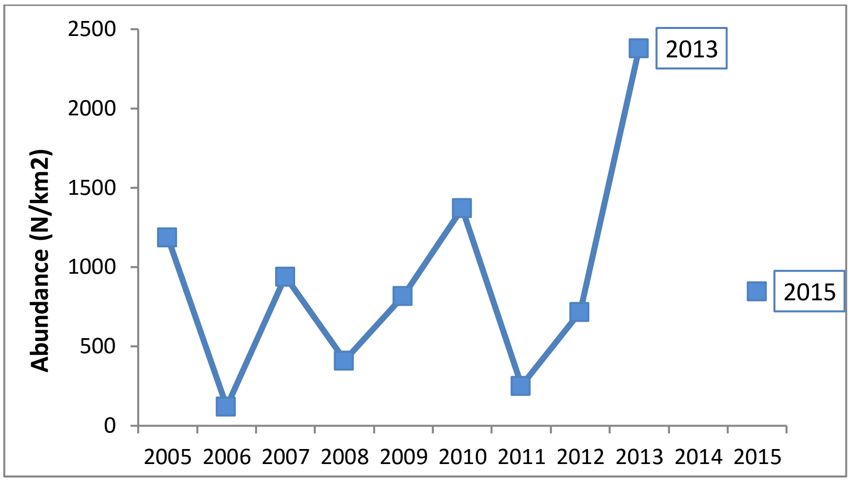


Fig. 4.1.3-1. *Mullus barbatus* in GSA25 - Abundance (n/km^2) derived from the sampling hauls of MEDITS survey in 2005 -2013 and 2015.

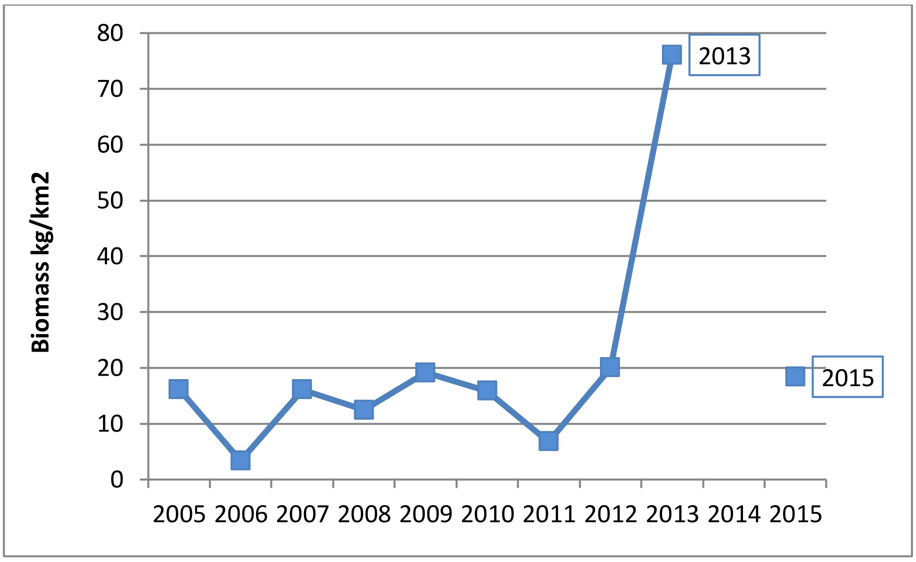


Fig. 4.1.3.2. *Mullus barbatus* in GSA25 - Biomass (kg/km^2) derived from the sampling hauls of MEDITS survey in 2005 -2013 and 2015.

5 Ecological information

5.1 Protected species potentially affected by the fisheries

The protected species that are potentially affected by the fisheries are the two turtle species (*Chelonia mydas*, *Caretta caretta)* encountered in Cyprus waters, and cetaceans (*Tursiops truncatus).* The interaction of the net fisheries with cetaceans involves mostly the damage of fishing gear and caught fish eaten by the dolphins.

In general, the catch of protected species (shark species, turtles, monk seal, cetaceans) is prohibited in accordance with international obligations (including relevant GFCM recommendations), and data on incidental catches are collected.

5.2 Environmental indexes

No environmental indices are used in the assessment.

6 Stock Assessment

FLR libraries were employed in order to carry out an Extended Survivor Analysis (XSA) assessment (Darby and Flatman, 1994).

6.1 Extended Survivor Analysis (XSA)

6.1.1 Model assumptions

Different options were tested concerning catchability and shrinkage of the weighted estimates (Shrinkage weight - fse, Shrinkage ages “shk.ages”, combinations on qage and rage). The final model settings that were selected for the assessment are the following:

F_{bar}	fse	rage	qage	shk.yrs	shk.age
1-2	2	1	2	2	2

6.1.2 Scripts

The script has been uploaded on the GFCM sharepoint.

6.1.3 Input data and Parameters

The assessment by means of XSA was performed using the following input data and parameters for the period 2005-2015:

- Catch-at-age matrix
- Mean weight-at-age in the catch
- Mean weight-at-age in the stock
- Natural mortality at age
- Maturity ogive at age

The relevant files used for the assessment are available on the GFCM sharepoint.

The catch-at-age matrix used in the model is provided in Table 6.1.3-1. Discard data are included in the matrix. Length distribution of the catches was converted to age distribution with the use of ALKs.

Mean weight-at-age in the catch (Table 6.1.3-2) was estimated using the length-weight relationship and the ALK; for each age class, the average weight was weighted by the length distribution that formulated the age class.

Mean weight-at-age in the stock (Table 6.1.3-3) was estimated from the relationship $Wt=W_{inf}(1-e^{-k(t-t0)})^b$, where Winf=240.95 g, k=0.2898, t0=-0.6; this relationship was calculated from age readings using inbio2.0 software developed in R by IEO.

M vector at age used (Table 6.1.3-4) was calculated using PRODBIOM. The growth parameters and the length-weight relationship used for the estimation of M are those provided in Table 2.2-3. The proportion of matures at age used in the model (Table 6.1.3-4) was estimated using the maturity ogive at length, converted to age by ALK and weighted by length distribution.

Table 6.1.3-1: *Mullus barbatus* in GSA25 - Catch-at age numbers (thousands) used in XSA model.

Age class	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
0	12.9	22.6	16.6	28.9	50.2	33.0	8.5	14.1	10.2	12.5	17.8
1	1065.0	589.2	811.1	647.4	512.6	513.6	185.5	147.8	235.7	246.8	254.8
2	314.2	309.4	417.8	274.9	218.8	253.8	162.7	112.9	189.5	185.6	213.1
3	20.5	35.3	55.3	30.4	16.5	17.9	34.2	35.0	54.9	35.3	49.0
4+	15.4	20.6	32.6	17.3	29.2	7.7	10.0	14.6	22.3	21.6	16.6

Table 6.1.3-2: *Mullus barbatus* in GSA25 - Mean weight at age (kg) in the catch used in XSA model.

Age class	0	1	2	3	4+
2005	0.011	0.026	0.041	0.068	0.121
2006	0.011	0.026	0.043	0.073	0.102
2007	0.011	0.026	0.045	0.071	0.106
2008	0.011	0.025	0.044	0.071	0.108
2009	0.007	0.026	0.043	0.071	0.106
2010	0.011	0.025	0.044	0.069	0.098
2011	0.016	0.033	0.044	0.074	0.106
2012	0.013	0.029	0.045	0.073	0.116
2013	0.014	0.033	0.048	0.074	0.115
2014	0.013	0.029	0.044	0.069	0.108
2015	0.017	0.029	0.043	0.075	0.104

Table 6.1.3-3: *Mullus barbatus* in GSA25 - Mean weight at age (kg) in the stock used in XSA model.

Age class	0	1	2	3	4+
2005	0.005	0.023	0.051	0.081	0.111
2006	0.005	0.023	0.051	0.081	0.111
2007	0.005	0.023	0.051	0.081	0.111
2008	0.005	0.023	0.051	0.081	0.111
2009	0.005	0.023	0.051	0.081	0.111
2010	0.005	0.023	0.051	0.081	0.111
2011	0.005	0.023	0.051	0.081	0.111
2012	0.005	0.023	0.051	0.081	0.111
2013	0.005	0.023	0.051	0.081	0.111
2014	0.005	0.023	0.051	0.081	0.111
2015	0.005	0.023	0.051	0.081	0.111

Table 6.1.3-4: *Mullus barbatus* in GSA25 - Natural mortality and maturity ogive at age used in XSA model.

Age	Natural mortality	Proportion of matures
0	*0.85*	*0.58*
1	*0.39*	*0.80*
2	*0.29*	*1.00*
3	*0.25*	*1.00*
4+	*0.23*	*1.00*

6.1.4 Tuning data

The tuning data used in the assessment derived from the MEDITS survey and refer to the period 2006-2013, and 2015. Data from 2015 were used as a second tuning fleet, since in 2014 no survey was carried out, and the 2015 survey was carried out in August while the usual period of the survey is during June-early July. Assignment of length distribution to ages was done with the use of ALKs.

Table 6.1.4-1: *Mullus barbatus* in GSA25 - Medits catch-at-age (N/km2) used as tuning data in XSA model.

Catch-at-age									
Age class	2006	2007	2008	2009	2010	2011	2012	2013	2015
0	1	26	0	285	759	32	1	4	450
1	47	241	117	225	392	110	434	1044	211
2	55	421	210	213	128	97	245	1105	144
3	13	143	63	62	61	10	23	170	29
4	5	110	22	33	31	3	15	57	15

6.1.5 Results

The results of the XSA assessment are shown in Figure 6.1.5-1 and Tables 6.1.5-1 – 6.1.5-3.

Current fishing mortality ($F_{current(1-2)}$) was calculated as the average of the last 3 years and has a value of 0.26. This fishing mortality value corresponds to both fishing fleets that exploit red mullet, and it was further allocated to each fleet by using the estimated F-at-age matrix (Table 6.1.5-3) and the proportion of catches at age by each fleet (Tables 3.2-2 & 3.2-3). The $F_{current(1-2)}$ attributed to the bottom trawlers was calculated as the 65% of $F_{current(1-2)}$, and has a value of 0.17. The $F_{current(1-2)}$ attributed to the small scale inshore fleet has a value of 0.09.

As it is shown in Figure 6.1.5-1, spawning stock biomass showed a high increasing trend from 2011 until 2014, while recruitment shows an oscillation. Catches had a decreasing trend from 2007 until

2012, while they remain relatively stable in the last three years. Fishing mortality had a high decreasing trend over the years 2010-2012, remained at similar levels in 2013-2014 while showed an increase in the last year of the assessment.

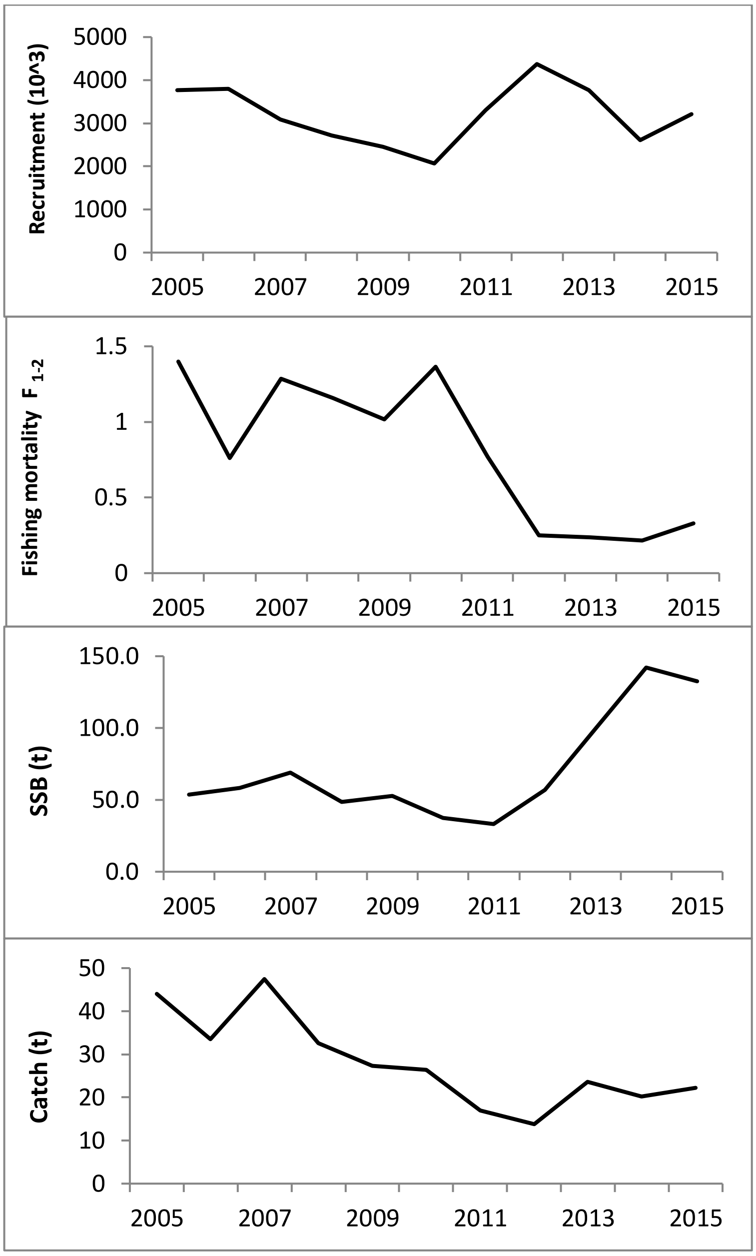


Figure 6.1.5-1: Mullus barbatus in GSA 25 - XSA results on recruitment, SSB, catch and fishing mortality.

Table 6.1.5-1: : *Mullus barbatus* in GSA 25 - Stock numbers-at-age (thousands).

age	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
0	3774	3799	3093	2723	2452	2068	3312	4374	3772	2609	3218
1	2166	1605	1609	1311	1145	1015	862	1410	1860	1606	1107
2	428	590	602	422	355	353	265	431	833	1066	884
3	31	48	174	89	78	76	45	57	225	459	637
4+	22	27	101	50	137	33	13	23	90	279	214

Table 6.1.5-2: *Mullus barbatus* in GSA 25 - XSA summary results.

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
F (1-2)	1.40	0.76	1.29	1.16	1.02	1.36	0.77	0.25	0.24	0.22	0.33
Stock biomass (t)	95.5	93.0	108.5	78.0	78.2	61.5	54.9	83.5	132.4	172.5	162.0
SSB (t)	53.6	58.4	68.8	48.5	52.6	37.5	33.2	56.7	99.8	142.1	132.5
Recruitment (10^3)	3774.1	3798.8	3093.4	2722.7	2452	2067.6	3312.1	4374	3772.1	2608.6	3218.3

Table 6.1.5-3: *Mullus barbatus* in GSA 25 - XSA results on F-at age matrix.

age	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
0	0.005	0.009	0.008	0.016	0.032	0.025	0.004	0.005	0.004	0.007	0.009
1	0.910	0.591	0.948	0.916	0.786	0.954	0.303	0.136	0.167	0.207	0.328
2	1.888	0.931	1.624	1.399	1.246	1.774	1.240	0.360	0.305	0.225	0.327
3	1.422	1.746	0.447	0.492	0.275	0.309	1.996	1.178	0.324	0.091	0.091
4+	1.422	1.746	0.447	0.492	0.275	0.309	1.996	1.178	0.324	0.091	0.091

6.1.6 Robustness analysis

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

Sensitivity analysis was performed, testing different options concerning catchability and shrinkage. The following options were tested:

- Different values and combinations of r-age and q-age (Figure 6.1.7-1),
- Different values and combinations of *shrinkage age* and *shrinkage years (Figure 6.1.7-2),*
- *Different weights of shrinkage (Figure 6.1.7-3)*.

The log-catchability residuals of the tuning fleets (MEDITS survey) from the different runs were used for selecting the parameters of the final model. The residuals pattern of the MEDITS trawl survey of the selected model is shown in Figure 6.1.7-4.

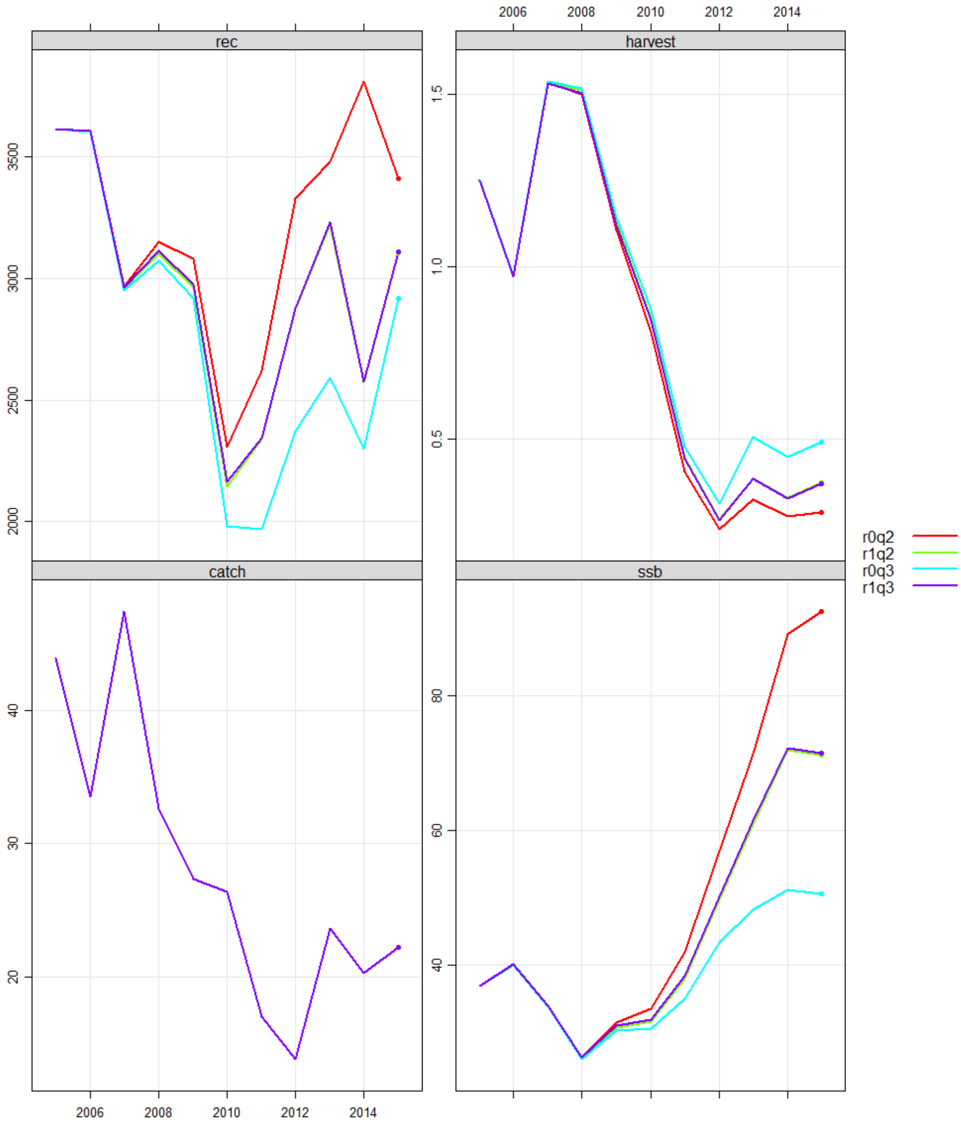


Figure 6.1.7-1: Mullus barbatus in *GSA 25 - Sensitivity analysis on q_{age} and r_{age}.*

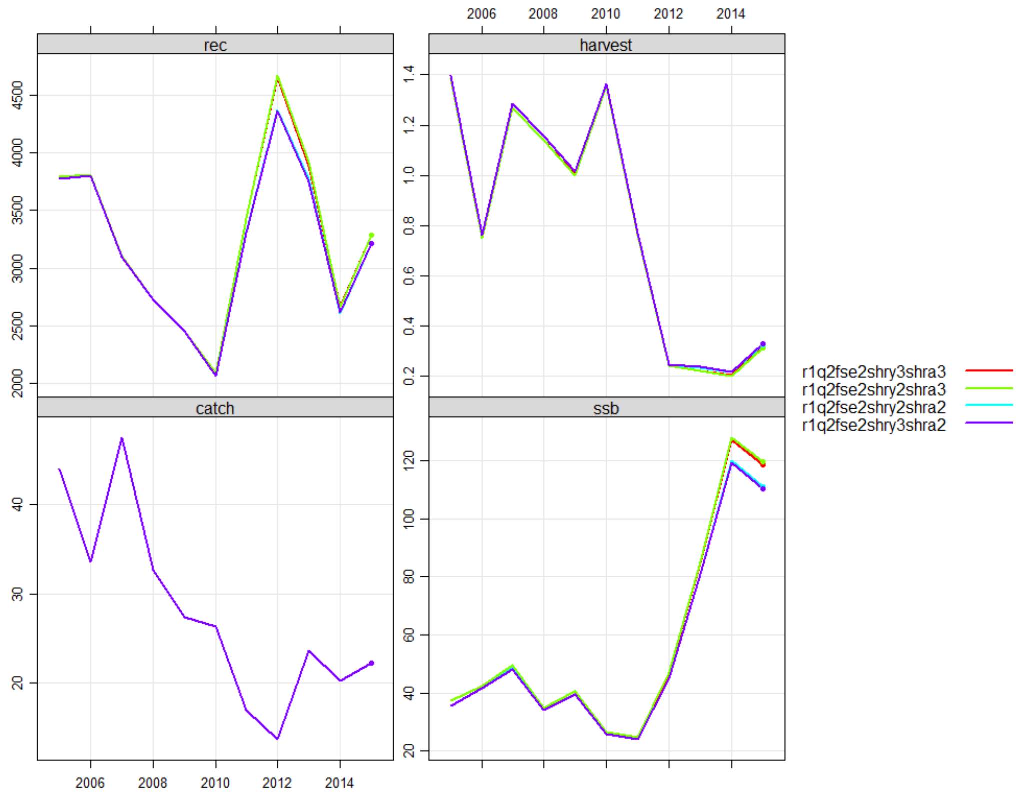


Figure 6.1.7-2: Mullus barbatus in GSA 25 - Sensitivity on shrinkage age and shrinkage years.

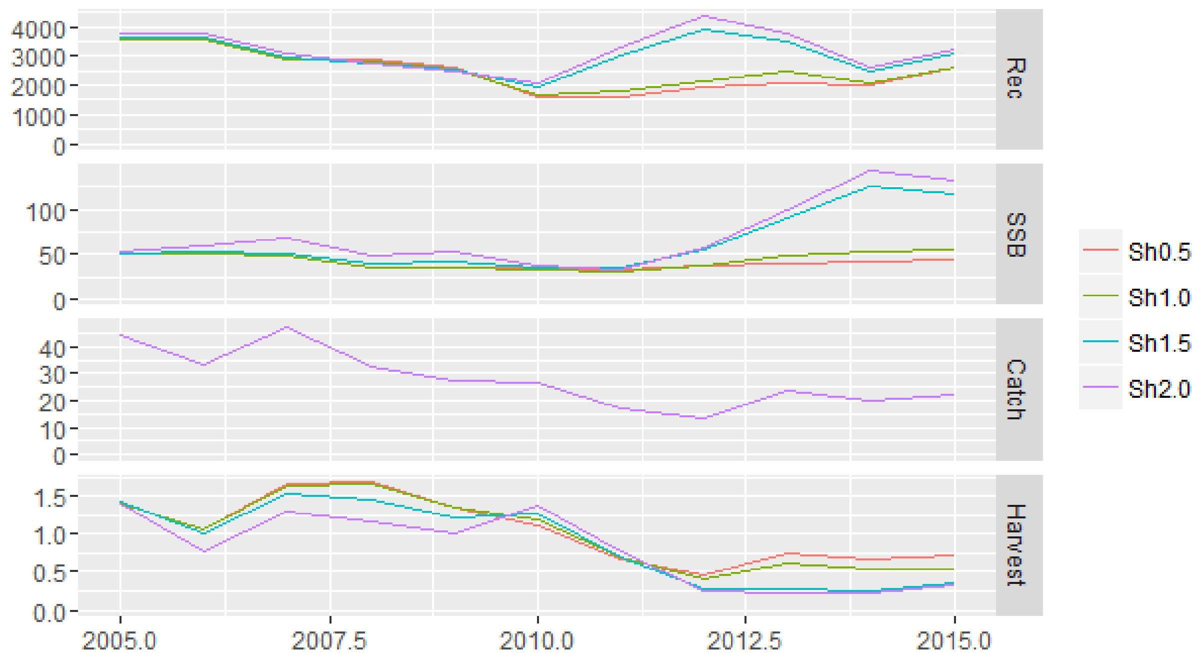


Figure 6.1.7-3: Mullus barbatus in GSA 25 - *Sensitivity on shrinkage weight.*

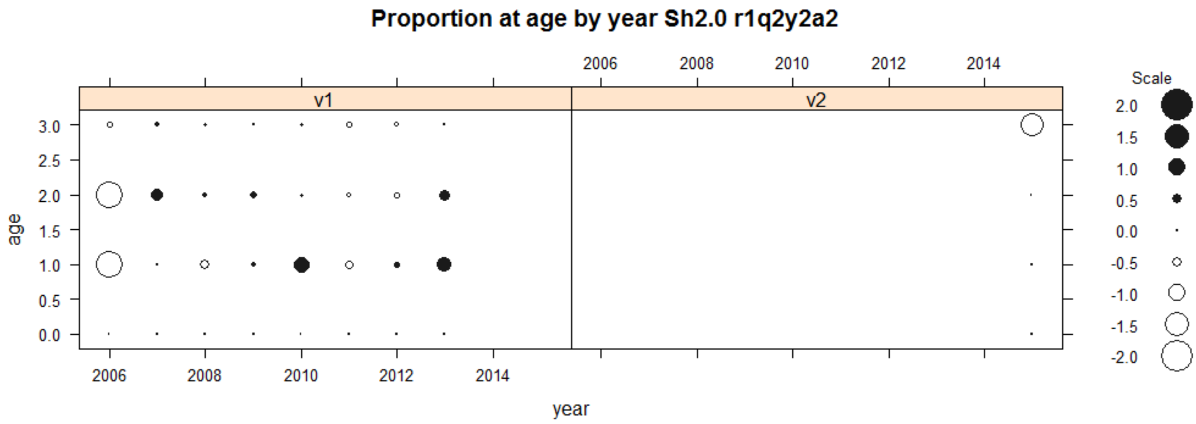


Figure 6.1.7-4: *Mullus barbatus* in GSA 25 – Residuals at age for the MEDITS survey from 2006 to 2013 and for 2015, obtained with the final settings of the model.

As mentioned before, the settings that were selected for the final assessment are:

Fbar	fse	rage	qage	shk.yrs	shk.age
1-2	2.0	1	2	2	2

Retrospective analysis of the final model generally showed a good agreement in the trend of recruitment, spawning stock biomass (ssb) and fishing mortality (harvest), indicating that the assessment is consistent (Figure 6.1.7-5).

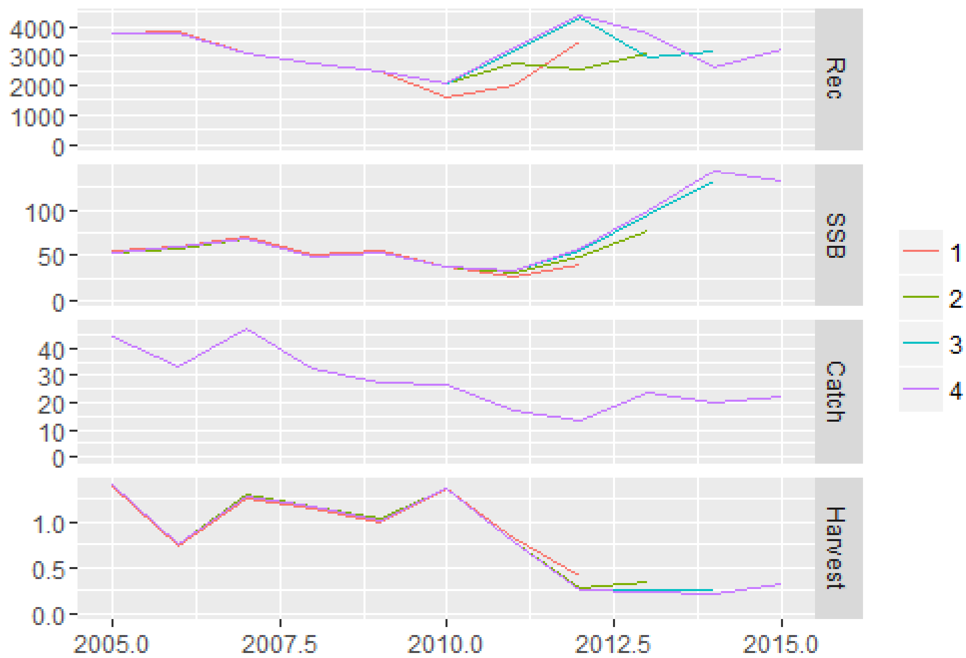


Figure 6.1.7-5: *Mullus barbatus* in GSA25- XSA retrospective analysis of the final selected scenario.

Concerning natural mortality (M), alternative methods to the ProdBiom method were used for estimating M vectors by age, specifically Gislason et al. (2010) and Chen & Watanabe (1989). The different estimations of the M vector are provided in Figure 6.1.7-6. M values resulting from Gislason method were rejected due to the very high value in 0 ages, and were not used in the model. Instead, an additional run of the assessment model was made using the M vector resulting from Chen & Watanabe (1989); comparison of the results of the two assessments is shown in Figure 6.1.7-7. The two models provide similar trends on recruitment (R), spawning stock biomass (SSB) and fishing mortality (Fbar), though the values of R obtained with the Chen Watanabe M vectors are higher.

Table 6.1.6-1 provides the values of Fcurrent and $F_{0.1}$ (reference point used as proxy of F_{MSY}), obtained from the two XSA runs with the ProdBiom and Chen & Watanabe M vector. The $F_{0.1}$ value obtained with Chen & Watanabe M vector is relatively high; it was decided to use the ProdBiom M vector for the final run of the XSA model.

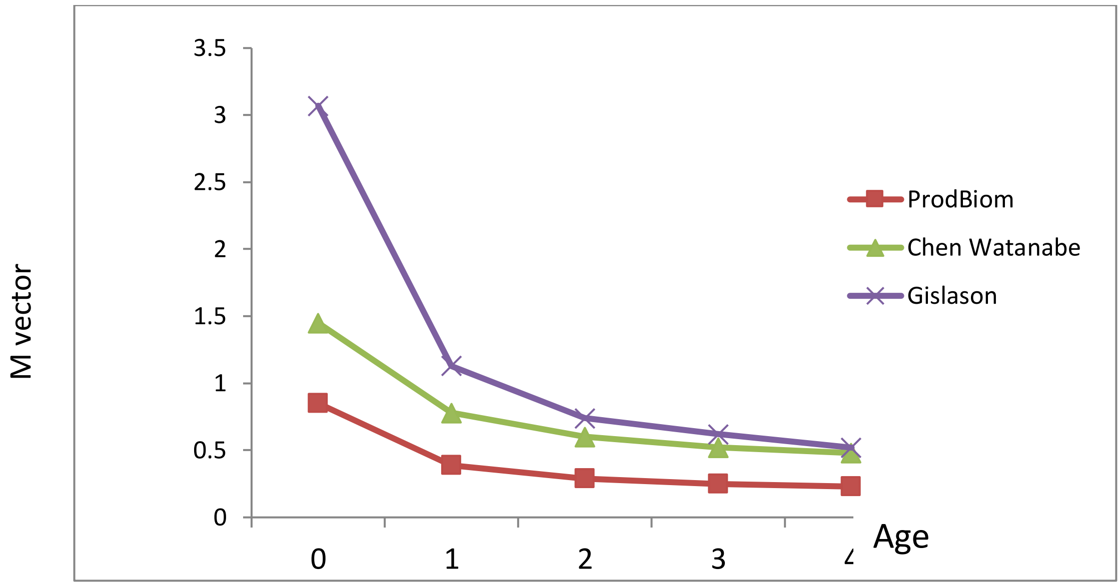


Figure 6.1.7-6: *Mullus barbatus* in GSA25 - Natural mortality vectors from ProdBiom, Gislason *et al.* (2010) and Chen & Watanabe (1989).

Table 6.1.7-1: *Mullus barbatus* in GSA 25- Summary table of $F_{current}$ and $F_{0.1}$ values from XSA models with different M vector.

XSA Model	$F_{0.1}$	$F_{current}$
M vector - ProdBiom method	0.32	0.26
M vector Chen & Watanabe method	0.67	0.21

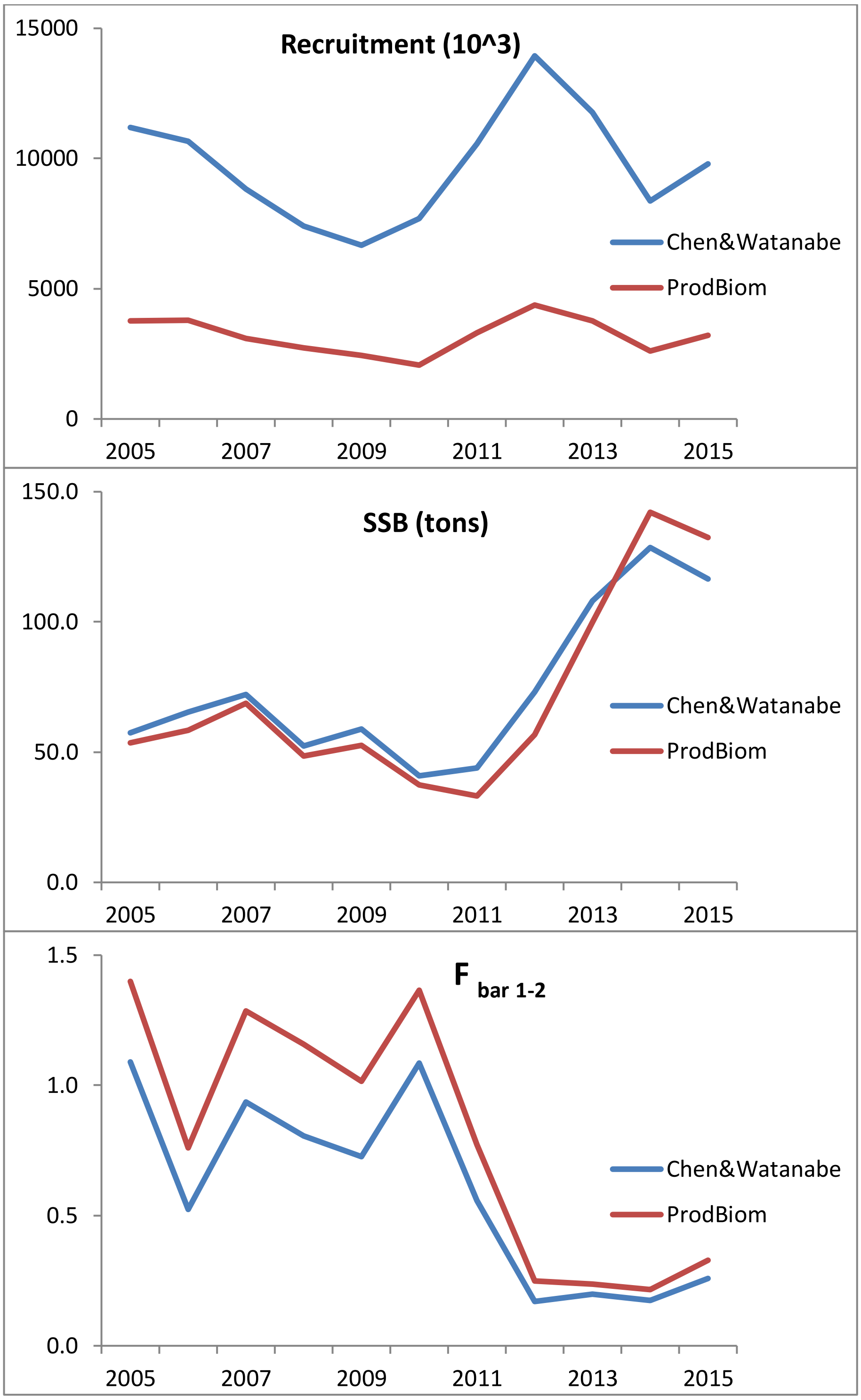


Figure 6.1.7-7: *Mullus barbatus* in GSA25 – XSA results on R, SSB and F_{bar} from the two XSA runs with different M vectors.

6.1.8 Assessment quality

Input data derive from the official landings and effort data collected by the Department of Fisheries and Marine Research, and from the biological data collected under the Cyprus National Data Collection Programme. It is considered that the best available data have been used.

The assumptions of the final model seem reliable.

6.2 Yield per Recruit Analysis

Yield per recruit analysis was carried out based on the results from the XSA model, using FLR Libraries. Current fishing mortality was considered as the mean F for ages 1-2 during the last 3 years (2013-2015). The calculated F0.1 reference point (0.32) is higher than the $F_{current}$ (0.26).

Figure 6.2-1 presents the results of the analysis.

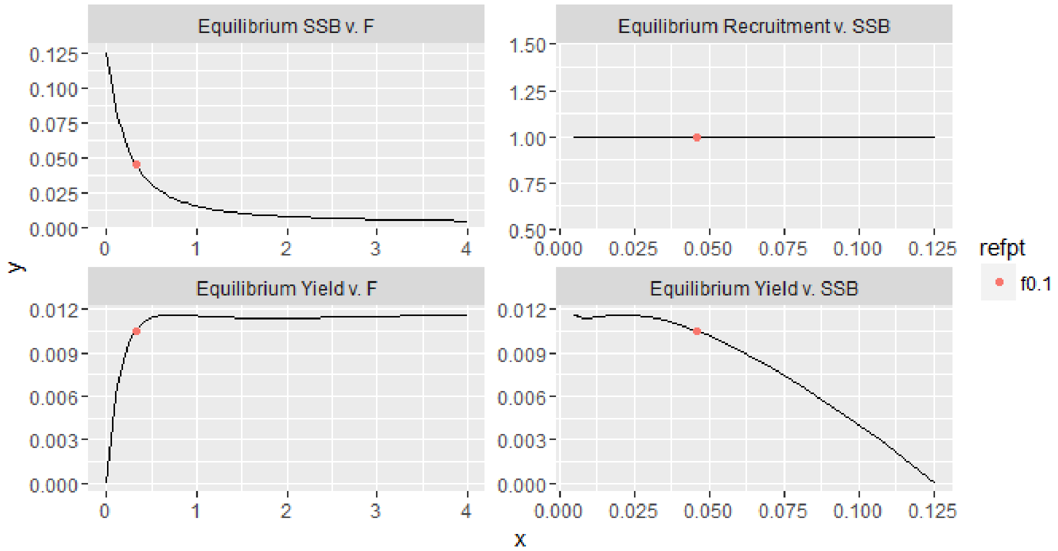


Figure 6.2-1: *Mullus barbatus* in GSA25 - Results from the Yield per Recruit analysis.

7 Stock predictions

7.1 Short term predictions

A deterministic short term prediction for the period 2016 to 2018 was performed using the FLR routines and based on the results of the XSA stock assessment ($F_{current(1-2)}$ =0.26).

According to the predictions:

- Fishing at the $F_{current}$(0.26) generates an increase in the catch of about 30% from 2015-2017, and an increase of the spawning stock biomass of about 3% from 2017-2018.
- Fishing at $F_{0.1}$ (0.22) results a decrease in the catch of about 38% from 2014-2016, and an increase of the spawning stock biomass of about 23% from 2016-2017.

Table 7.1-1: Short term predictions on catch and SSB for MUT in GSA 25.

Scenario	Ffactor	Fbar	Catch 2016	Catch 2017	Catch 2018	SSB 2017	SSB 2018	Change SSB 2017-2018 (%)	Change Catch 2015-2017 (%)
Zero catch	0	0	26.3	0.0	0.0	163.7	200.1	22.2	-100.0
High long-term yield (F0.1)	1.25	0.32	26.3	34.3	33.5	154.2	151.5	-1.8	54.2
Status quo	1.00	0.26	26.3	28.1	28.5	156.1	160.0	2.5	26.2
Different scenarios	0.10	0.03	26.3	3.1	3.6	162.9	195.6	20.0	-86.2
	0.20	0.05	26.3	6.1	7.0	162.2	191.2	17.9	-72.7
	0.30	0.08	26.3	9.0	10.2	161.4	186.9	15.8	-59.5
	0.40	0.10	26.3	11.9	13.3	160.6	182.8	13.8	-46.5
	0.50	0.13	26.3	14.7	16.2	159.9	178.7	11.8	-33.8
	0.60	0.15	26.3	17.5	19.0	159.1	174.8	9.9	-21.3
	0.70	0.18	26.3	20.2	21.6	158.3	171.0	8.0	-9.1
	0.80	0.20	26.3	22.9	24.0	157.6	167.2	6.1	2.9
	0.90	0.23	26.3	25.5	26.3	156.8	163.6	4.3	14.7
	1.10	0.28	26.3	30.6	30.6	155.3	156.5	0.8	37.5
	1.20	0.31	26.3	33.1	32.5	154.6	153.2	-0.9	48.6
	1.30	0.33	26.3	35.5	34.4	153.9	149.9	-2.6	59.5
	1.40	0.36	26.3	37.8	36.1	153.1	146.7	-4.2	70.1
	1.50	0.38	26.3	40.2	37.8	152.4	143.6	-5.8	80.6
	1.60	0.41	26.3	42.5	39.3	151.7	140.5	-7.4	90.8
	1.70	0.43	26.3	44.7	40.7	151.0	137.5	-8.9	100.9
	1.80	0.46	26.3	46.9	42.1	150.2	134.7	-10.4	110.7
	1.90	0.49	26.3	49.0	43.4	149.5	131.8	-11.8	120.4
	2.00	0.51	26.3	51.1	44.6	148.8	129.1	-13.3	129.8

7.2 Medium term predictions

No medium term predictions were carried out for this stock.

7.3 Long term predictions

No long term predictions were carried out for this stock.

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	$F_{0.1}$ = 0.32	$F_{bar(1-2)}$ =0.26		N	S
Stock abundance						
	SSB $_{2013-2015}$		SSB= 124.8 t	SSB_{33p}= 52.9 t SSB_{66p}= 64.6 t	N	
Recruitment						
Final Diagnosis		In sustainable exploitation, with relative high biomass.				

9 Explanation of codes

Trend categories

1) N - No trend
2) I - Increasing
3) D – Decreasing
4) C - Cyclic

Stock Status

Based on Fishing mortality related indicators

1) **N - Not known or uncertain** – Not much information is available to make a judgment;
2) **U - undeveloped or new fishery** - Believed to have a significant potential for expansion in total production;
3) **S - Sustainable exploitation**- fishing mortality or effort below an agreed fishing mortality or effort based Reference Point;
4) **IO –In Overfishing status**– fishing mortality or effort above the value of the agreed fishing mortality or effort based Reference Point. An agreed range of overfishing levels is provided;

   Range of Overfishing levels based on fishery reference points

   In order to assess the level of overfishing status when $F_{0.1}$ from a Y/R model is used as LRP, the following operational approach is proposed:

   - If $Fc^*/F_{0.1}$ is below or equal to 1.33 the stock is in **(O_L): Low overfishing**
   - If the $Fc/F_{0.1}$ is between 1.33 and 1.66 the stock is in **(O_I): Intermediate overfishing**
   - If the $Fc/F_{0.1}$ is equal or above to 1.66 the stock is in **(O_H): High overfishing**

   *Fc is current level of F

5) **C- Collapsed**- no or very few catches;

Based on Stock related indicators

1) **N - Not known or uncertain:** Not much information is available to make a judgment
2) **S - Sustainably exploited:** Standing stock above an agreed biomass based Reference Point;
3) **O - Overexploited**: Standing stock below the value of the agreed biomass based Reference Point. An agreed range of overexploited status is provided;

   Empirical Reference framework for the relative level of stock biomass index

   - **Relative low biomass:** Values lower than or equal to 33rd percentile of biomass index in the time series **(O_L)**
   - **Relative intermediate biomass:** Values falling within this limit and 66th percentile **(O_I)**
   - **Relative high biomass:** Values higher than the 66th percentile **(O_H)**

4) **D – Depleted**: Standing stock is at lowest historical levels, irrespective of the amount of fishing effort exerted;
5) **R –Recovering:** Biomass are increasing after having been depleted from a previous period;

Agreed definitions as per SAC Glossary

Overfished (or overexploited) *- A stock is considered to be overfished when its abundance is below an agreed biomass based reference target point, like B0.1 or BMSY. To apply this denomination, it should be assumed that the current state of the stock (in biomass) arises from the application of excessive fishing pressure in previous years. This classification is independent of the current level of fishing mortality.*

Stock subjected to overfishing (or overexploitation) *- A stock is subjected to overfishing if the fishing mortality applied to it exceeds the one it can sustainably stand, for a longer period. In other words, the current fishing mortality exceeds the fishing mortality that, if applied during a long period, under stable conditions, would lead the stock abundance to the reference point of the target abundance (either in terms of biomass or numbers)*