Stock Assessment Form
Demersal species

Mullus barbatus in GSA 10

Reference year: 2017

Reporting year: 2018

The status of the stock was assessed applying statistical catch at age (a4a) over the period 2004-2016. MEDITS index was used for tuning. The stock is sustainably exploited with relative high level of biomass.

Stock Assessment Form version 1.0 (January 2014)

Uploader: *Please include your name*

Stock assessment form

1 Basic Identification Data

Scientific name:	Common name:	ISCAAP Group:
	Red mullet	33
1st Geographical sub-area:	**2nd Geographical sub-area:**	**3rd Geographical sub-area:**
[GSA_10]		
4th Geographical sub-area:	**5th Geographical sub-area:**	**6th Geographical sub-area:**
1st Country	**2nd Country**	**3rd Country**
Italy		
4th Country	**5th Country**	**6th Country**
Stock assessment method: (direct, indirect, combined, none)		
Indirect		
Authors:		
STECF-18-12		
Affiliation:		
For more details please refer to https://stecf.jrc.ec.europa.eu/reports/medbs		

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):

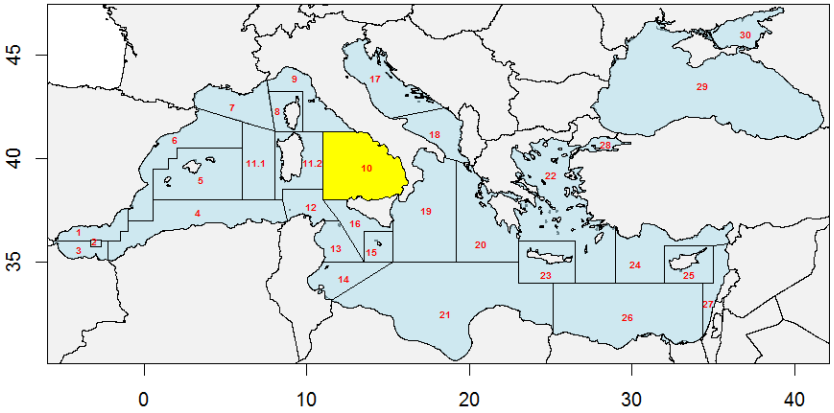
- Acoustics survey
- Egg production survey
- Trawl survey
- SURBA
- Other (please specify)

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*) is distributed in GSA 10 along the shelf at depths up to 200m, but mainly concentrated in the depth range 0-100 m. The area of GSA 10 extends in the South and Central Tyrrhenian Sea, that features one of the most complex structures in the seas around the Italian peninsula, due to its morphological and geophysical characteristics and water mass dynamics (Cataudella S. and Spagnolo M., 2011). Available spatial information from MEDITS show continuous distribution of the red mullets along western Italian coast (i.e. continuity in spatial distribution in GSA10 and GSA9).

2.1 Stock unit

Assumed here that inside the GSA 9 boundaries inhabits a single, homogeneous red mullet stock that behaves as a single well-mixed and self-perpetuating population.

2.2 Growth and maturity

The information on the age-length key (ALK) and on the growth von Bertalanffy parameters was available from 2002 and appeared consistent with the recent paper of Carbonara et al. (2018) on age validation of red mullet in Adriatic Sea.

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

Somatic magnitude measured (LT, LC, etc)				**Units**	
Sex	**Fem**	**Mal**	**Combined**	**Reproduction season**	
Maximum size observed				**Recruitment season**	
Size at first maturity				**Spawning area**	
Recruitment size to the fishery				**Nursery area**	

Maturity ogives by length and age were available from 2002 to 2017 by sex and they are consistent with the maturity vector agreed within the EWG 18-12.

Natural mortality (M) was estimated according to Chen and Watanabe (1989).

Considering the fact that the assignment of the age in the ALK considered the middle of the year as birthday of red mullet, while the a4a model was parameterized with calendar year, the EWG18-12 agreed to shift growth curve by adding 0.5 to t0 for internal consistency in the stock assessment model. Therefore, adjusted t0 values for females and males were -0.12 and -0.4 respectively.

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

Size/Age	Natural mortality	Proportion of matures
0	1.44	0
1	0.75	1
2	0.57	1
3	0.48	1
4+	0.43	1

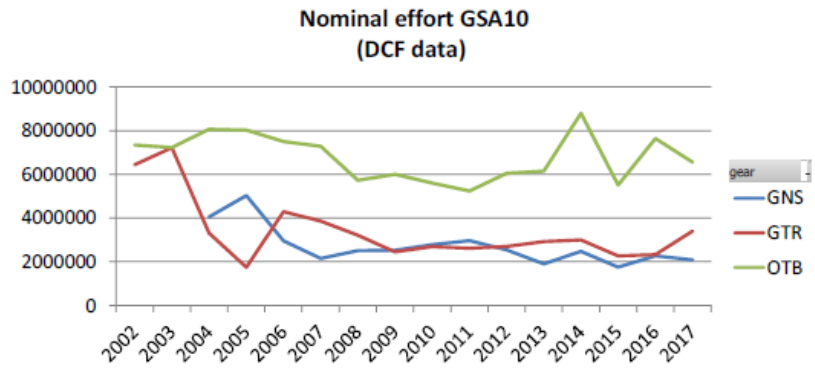
Table 2-3: Growth and length weight model parameters

			Sex			
		Units	female	male	Combined	Years
Growth model	L_∞		30.0	26.0		
	K		0.243	0.237		
	t_0		-0.62	-0.9		
	Data source	DCF call 2018.				
Length weight relationship	a		0.012	0.017		
	b		3.0	2.84		
	M (scalar)					
	sex ratio (% females/total)					

3 Fisheries information

3.1 Description of the fleet

Red mullet is caught by mixed fisheries, using more than a fishing gear (gillnets, trammel nets, trawls), by fishing boats of different sizes (different métiers, VL0006 - VL1824). In such situation, being red mullet only one component of entire catch, fishing effort related to red mullet only cannot be obtained.



Nominal effort in GSA 10 in the period from 2002 to 2017 by fishing gear.

Table 3-1: Description of operational units exploiting the stock

	Country	GSA	Fleet Segment	Fishing Gear Class	Group of Target Species	Species
Operational Unit 1*	Italy	GSA 10			[ISCAAP Group]	

Table 3.1-2: Catch, bycatch, 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)
[Operational Unit1]						
[Operational Unit2]						
[Operational Unit3]						
[Operational Unit4]						
[Operational Unit5]						
Total						

3.2 Historical trends

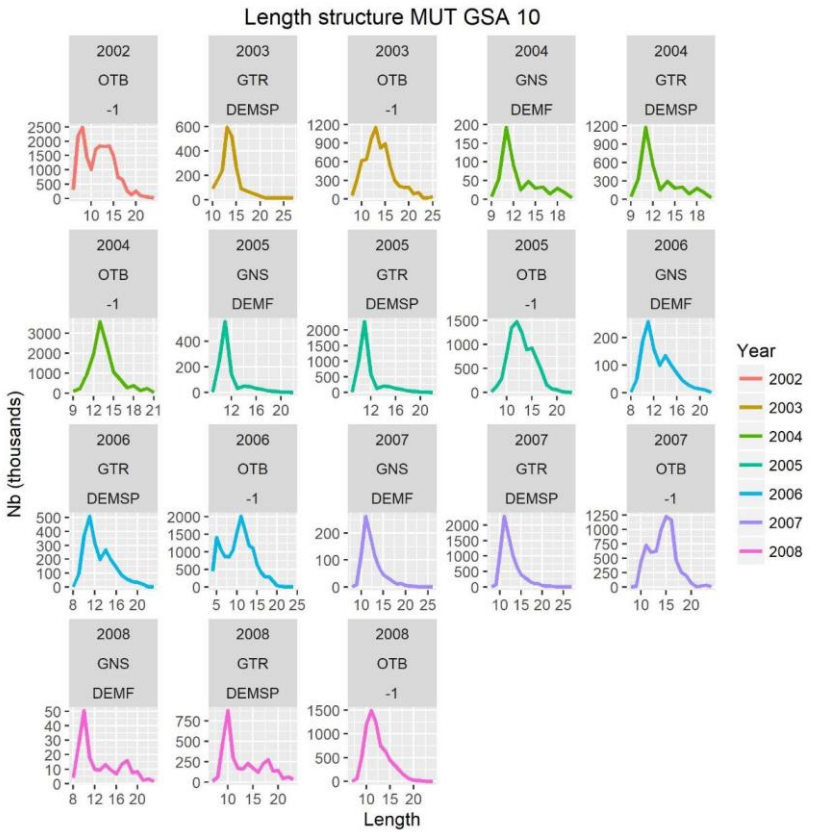
Red mullet in GSA 10: Commercial landings and discards (reported and STECF estimated), in tonnes .

Year	ITALY GSA10	Discard	Total
2002	819.4		819.4
2003	419		419
2004	512	9.67*	521.67
2005	382	7.21*	389.21
2006	392	3.25	395.25
2007	502	9.47*	510.47
2008	315	5.94*	319.94
2009	279	12.46	290.46
2010	177	0.30	177.3
2011	207	0.04	206.04
2012	263	17.91	280.91
2013	380	1.04	380.04
2014	421	1.25	421.25
2015	400	16.04	416.04
2016	352	1.17	353.17

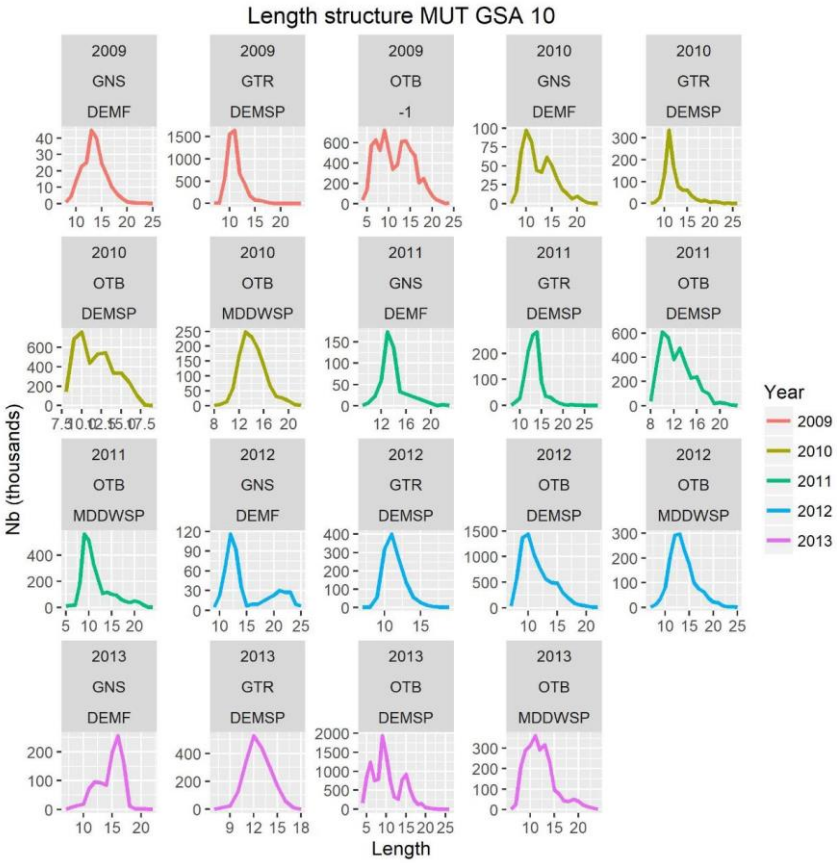
*Estimated on the basis of the available data.

Red mullet in GSA 10: Catch and effort distribution by fleet in YEAR 2016

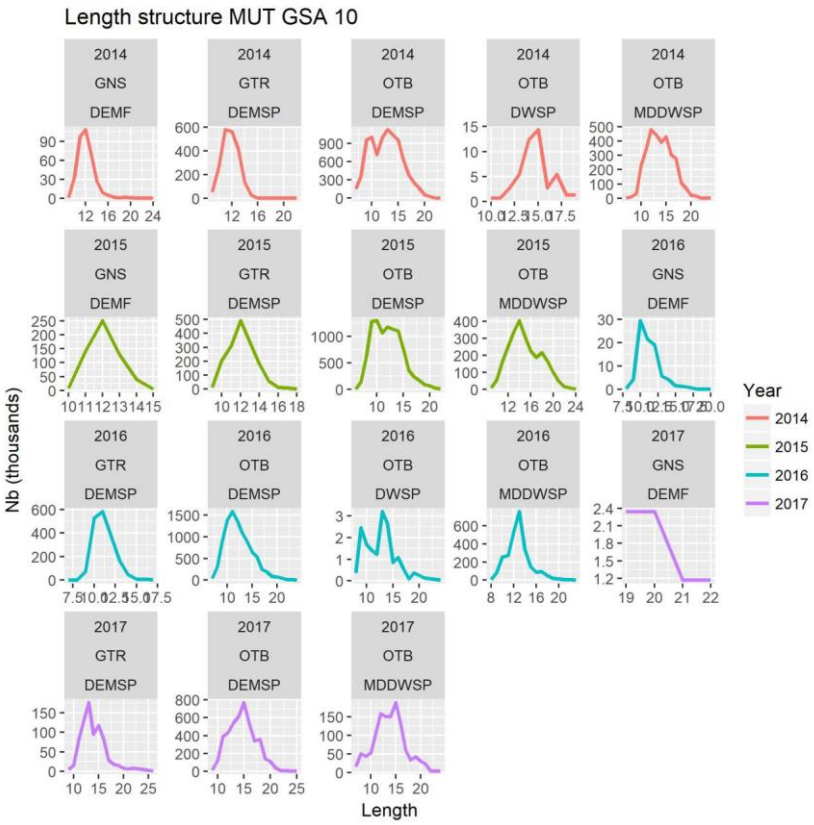
2016	Landings				Discards
Catch (t)	trawl 91% 319 tons	Gillnets 0%	Trammel nets 1 % 31.4 tons	Other 0%	1.17 tons (only OTB)
	Tonnes				



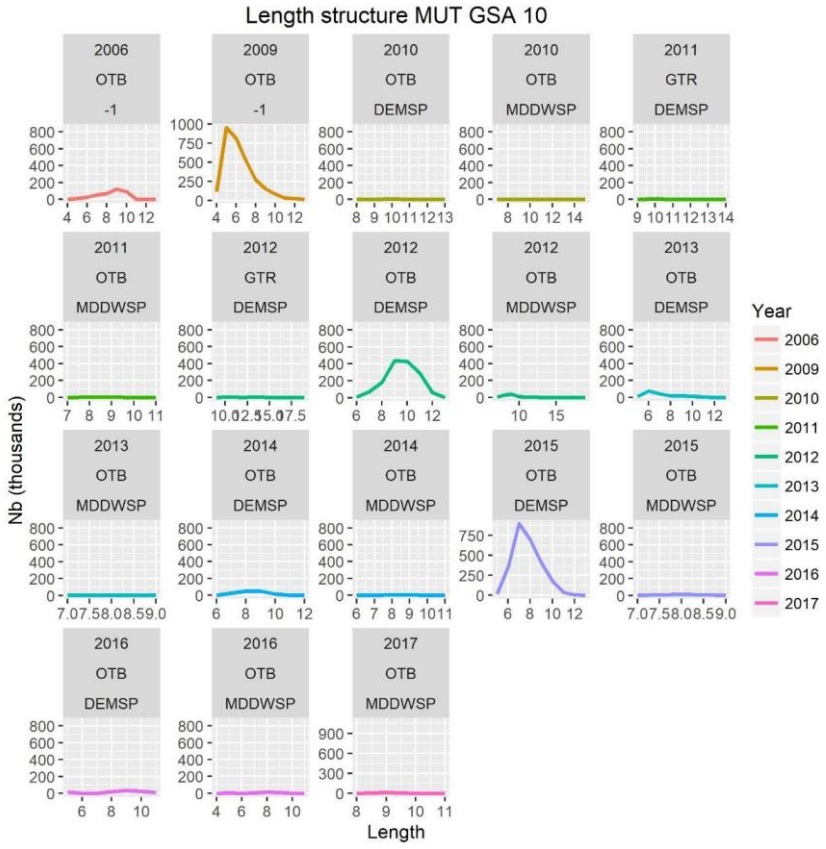
Length structure of red mullet landed in GSA 10 in the period from 2002 to 2008 by fishing gear and fishery.



Length structure of red mullet landed in GSA 10 in the period from 2009 to 2013 by fishing gear and fishery.



Length structure of red mullet landed in GSA 10 in the period from 2014 to 2017 by fishing gear and fishery.



Length structure of red mullet catch discarded in GSA 10 in the period from 2006 to 2017 by fishing gear and fishery.

The discard data, in the years where it was not due, were reconstructed on the basis of the discard data available, and included in the assessment.

3.3 Management regulations

3.4 Reference points

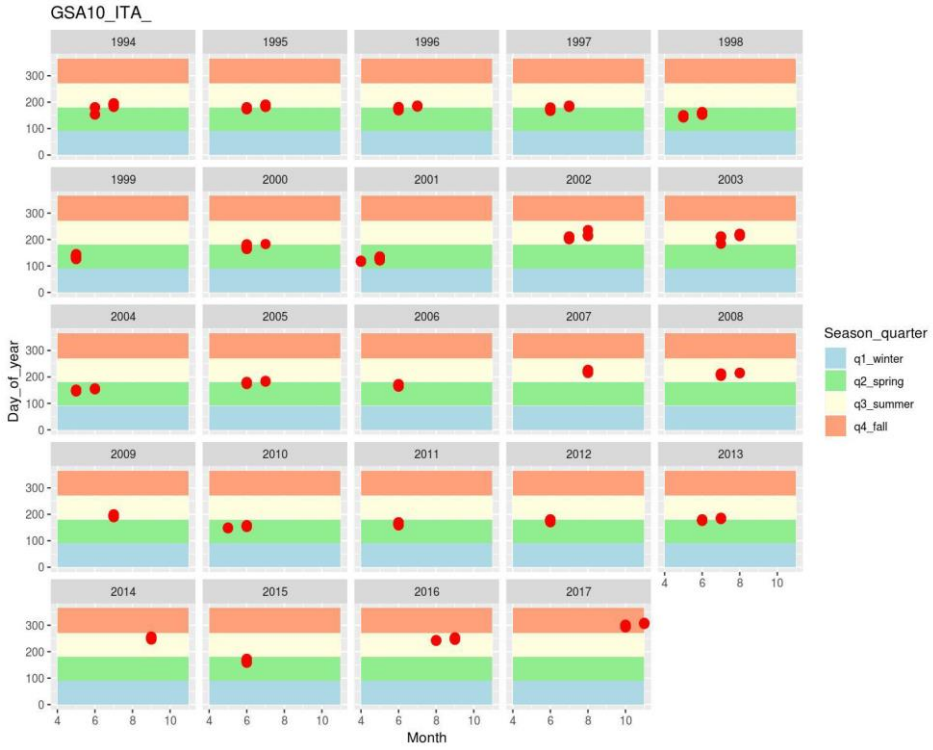
Table 3.3-1: List of reference points and empirical reference values previously agreed (if any)

Indicator	Limit Reference point/empirical reference value	Value	Target Reference point/empirical reference value	Value	Comments
B					
SSB					
F			$F_{0.1}$	0.54	STECF-18-12
Y					
CPUE					
Index of Biomass at sea					

4 Fisheries independent information

4.1 MEDITS bottom trawl surveys

Survey indices used in this assessment originate from MEDITS scientific bottom trawl survey. These surveys in GSA10 took place in different seasons of the year. EWG18-12 considered this fact during interpretation of available survey indices in the assessment.



Survey periods of MEDITS in GSA 10.

4.1.1 Brief description of the direct method used

Direct methods: trawl based abundance indices

Table 4.1-1: Trawl survey basic information

Survey		**Trawler/RV**	
Sampling season			
Sampling design			
Sampler (gear used)			
Cod –end mesh size as opening in mm			
Investigated depth range (m)			

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
Total (… – … m)				

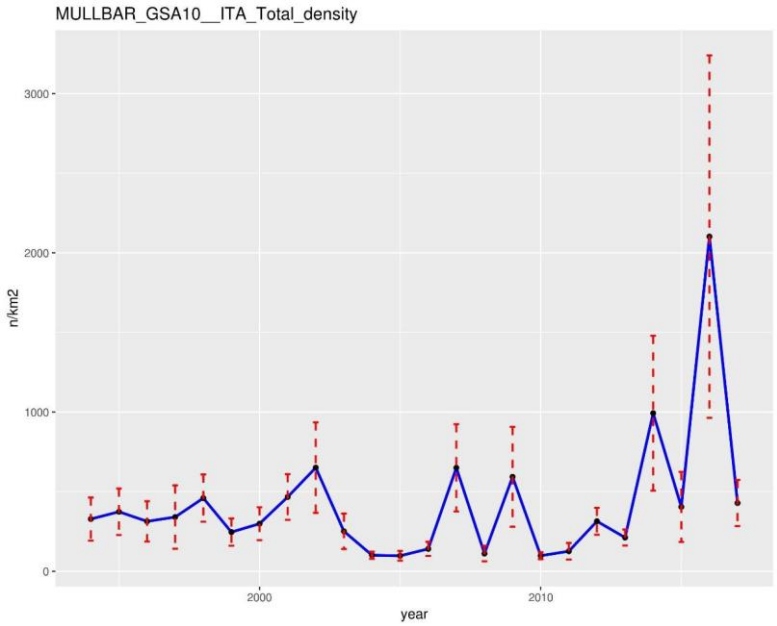
Map of hauls positions

4.1.2 Spatial distribution of the resources

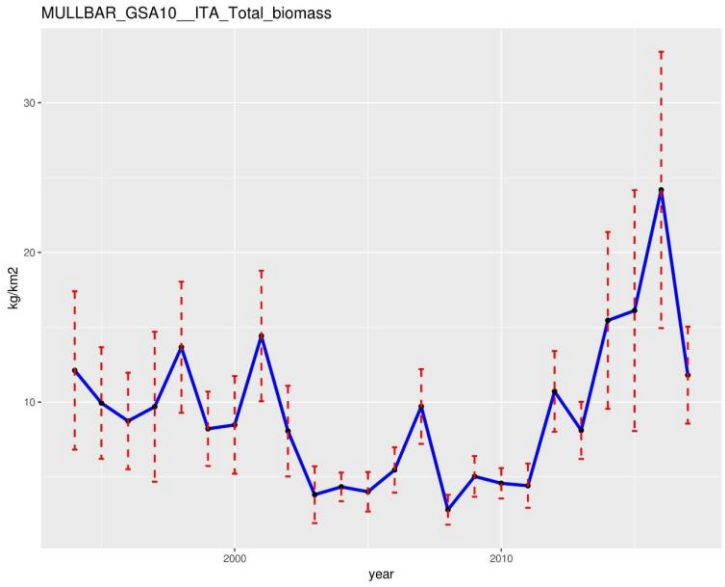
Include maps with distribution of total abundance, spawners and recruits (if available)

4.1.3 Historical trends

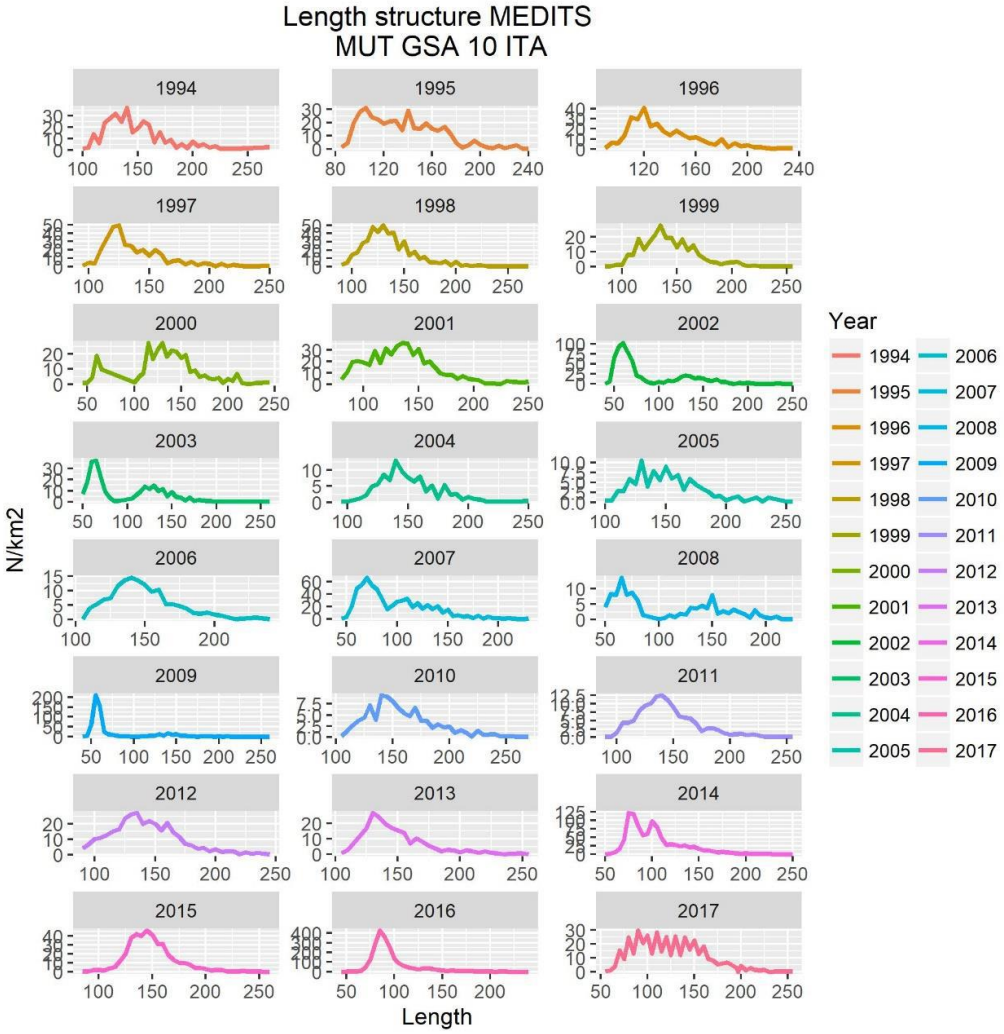
Analyses of available MEDITS data show large variations between years. However, EWG1812 noticed that after 2010 year both survey density indices, in terms of abundance and biomass, generally show positive trend with large inter-annual variations .



Abundance indices (n/km2) of red mullet in GSA 10 as derived from trawl surveys (MEDITS, 1994-2017).



Biomass indices (kg/km2) of red mullet in GSA 10 as derived from trawl surveys (MEDITS, 1994-2017).



Size structure indices of red mullet in GSA 10 as derived from trawl surveys (MEDITS, 1994-2017).

5 Ecological information

5.1 Protected species potentially affected by the fisheries

A list of protected species that can be potentially affected by the fishery should be incorporated here. This should also be completed with the potential effect and if available an associated value (e.g. bycatch of these species in T)

5.2 Environmental indexes

If any environmental index is used as i) a proxy for recruitment strength, ii) a proxy for carrying capacity, or any other index that is incorporated in the assessment, then it should be included here.

Other environmental indexes that are considered important for the fishery (e.g. Chl a or other that may affect catchability, etc.) can be reported here.

6 Stock Assessment

6.1 Statistical catch at age a4a (Jardim et al. 2015)

The present assessment of red mullet in GSA 10 has been based on a4a model. The a4a model is a flexible statistical catch at age stock assessment model, based on linear modelling techniques, not working by gear. The method was developed within FLR framework.

6.1.1 Model assumptions

6.1.2 Scripts

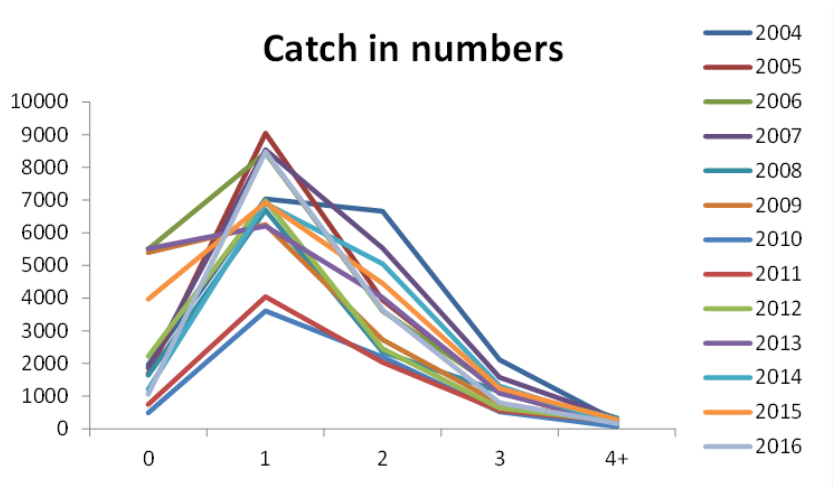
If a script is available which incorporates the stock assessment run (e.g. if using FLR in R) it should be provided here in order to create a library of scripts.

6.1.3 Input data and Parameters

Input data considered (landing, discard, age, maturity, MEDITS) originate from DCF Med&BS data call. Despite availability of commercial fishery data since 2002, the assessment was carried out from 2004 because the inclusion of 2002 and 2003 seemed to make worse the a4a fitting.

Age slicing of the length frequency distributions of landing, discard and survey has been done by sex (in combination with sex ratio at length) using a4aGr model and then data were combined.

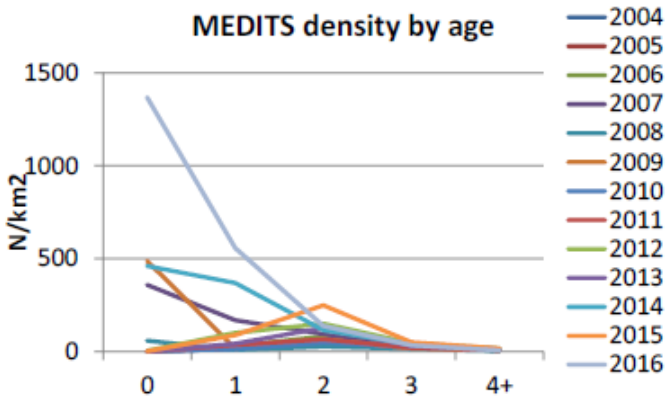
The landing and discard of 2017 data was incomplete, because the third quarter data missing. However, an attempt to run the a4a model, using only the MEDITS data for 2017 and assuming that the total catch in 2017 was an average of total catch 2014-2016 was made, but the model returned values for 2017 that are incomparably higher than the ones estimated for the whole time series.



Catch-at-age data of red mullet in GSA10.

Survey indices (density by age) from MEDITS were used considering that spring surveys are not designed to detect recruitment of red mullet. Recruitment (age class 0) was detected just in some years when surveys were carried out in late summer or autumn. Due to the variability of survey timing, age 0 class was not included in the tuning indices used for the assessment.

6.1.4 Tuning data



MEDITS indices describing density by age of red mullet in GSA 10 by year.

6.1.5 Results

For the assessment purposes, the following a4a submodels were tested:

Fmodels
fmod1 <- ~ factor(replace(age,age>2,2)) + s(year, k = 3)
fmod2<- ~ s(age, k=3) + s(year, k = 3) + te(age, year)

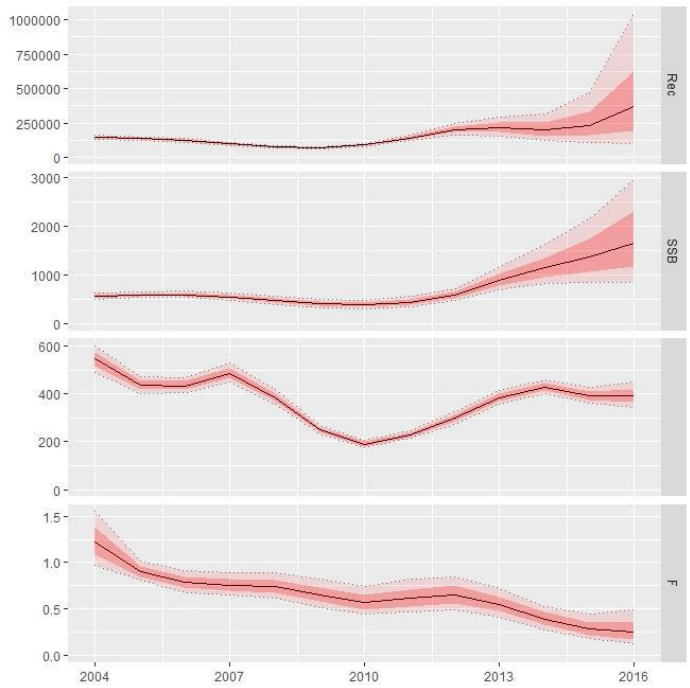
qmodels
qmod1 <- list(~factor(replace(age,age>2,2)))
qmod2<- list(~factor(replace(age, age > 3, 3)))

SRmodels
srmod1 <- ~factor(year)
srmod2 <- ~s(year,k=7)

All the combinations of the 6 sub-models were tested, compared and evaluated according to the quality of residuals and retrospective analysis.

The best fit was obtained in 6th run using:
fmodel: ~s(age, k = 3) + s(year, k = 3) + te(age, year),
srmodel: ~s(year, k = 7)
qmodel: ~factor(replace(age, age > 2, 2).

Results are shown below:



Results of the best a4a model for red mullet in GSA10: Recruitment, SSB, catch and fishing mortality.

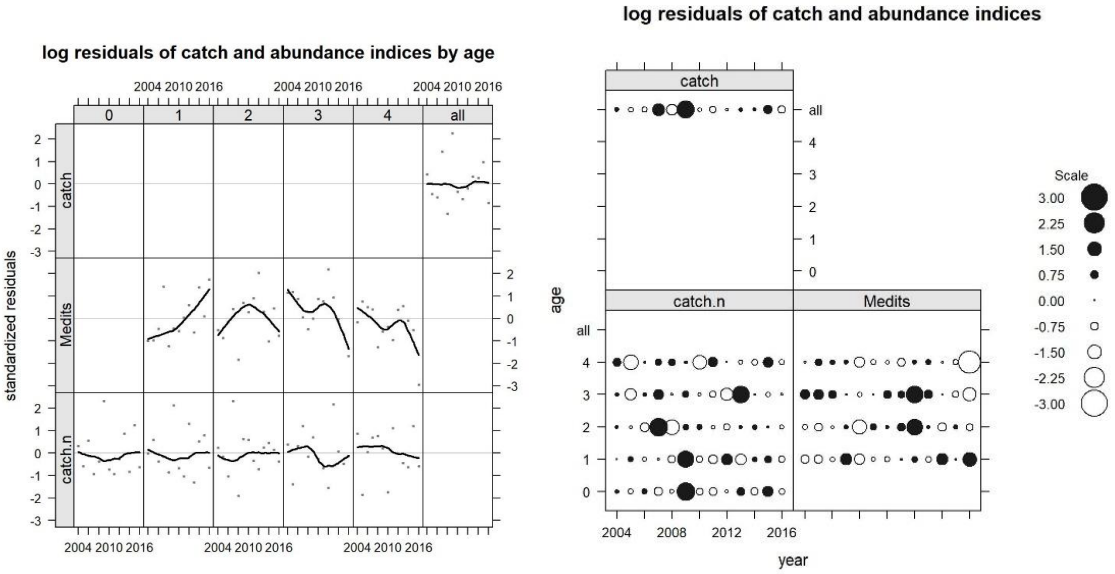
Final results of the red mullet assessment in GSA10.

Year	Recruitment age 0 (housands)	SSB tonnes	Catch tonnes	F ages 1-3
2004	146922	558	522	1.21
2005	138524	582	389	0.90
2006	124262	595	396	0.78
2007	100479	554	511	0.76
2008	77791	475	321	0.74
2009	71239	408	291	0.65
2010	91053	384	177	0.57
2011	144671	446	207	0.61
2012	205261	583	281	0.65
2013	216042	896	381	0.55
2014	202470	1150	422	0.39
2015	233026	1374	417	0.28
2016	347898	1639	353	0.25

The estimated SSB and recruitment show an increase in recent years, current values are the highest of the time series. This is consistent with the increase in the MEDITS abundance indices and the decrease in the fishing mortality, the latter being well below the reference point F0.1, used as proxy of FMSY.

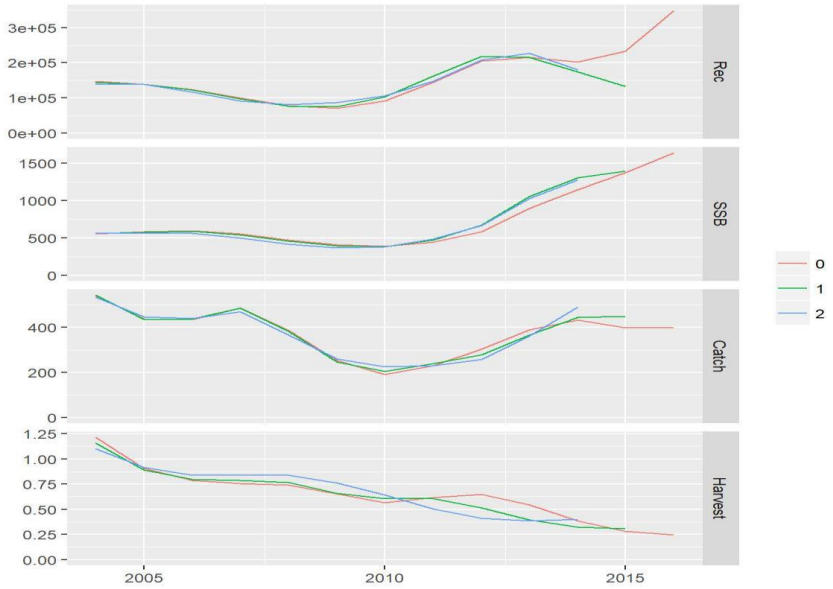
6.1.6 Robustness analysis

Log residuals of the catch and MEDITS abundance indices related to the best run do not show any particular trends over time with the possible exception of MEDITS ages 1, 3 and 4, which might be due to the change in timing for the survey over time. However the fit to catch was without trend. It was considered preferable to accept possible trend in the survey while obtaing a good fit to the catch. This choice is supported by the reasonable retrospective performance.



Log residuals of catch and MEDITS abundance indices for red mullet in GSA 10.

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



Retrospective analysis of the selected a4a model for red mullet in GSA 10.

6.1.8 Assessment quality

The current assessment results align well with the observed trends in the surveys (biomass and density indices). The catch data for 2017, being not complete (third quarter lacking) were derived on the basis of a recruitment hypothesis in 2017 equal to the mean on the whole time series and an F by age equal to the average of the last three years. Growth and natural mortality of red mullet are assumed constant over the time-series. The MEDITS surveys are assumed to have the same catchability for all the years. As the recruitment (age 0) is not detected by the survey every year, the age 0 was excluded from the tuning indices, and thus performs poorly in the retrospective. The retrospective did not show any important anomalies and the inspection of residuals did not show any trend.

Red Mullet in GSA 10 is increasing and the stock is being fished below Fmsy. Catches in 2017 are not known, but indications are that an increase in catch would be possible in 2019 while staying below Fmsy.

7 Stock predictions

STECF EWG 18-12 advises that when MSY considerations are applied the fishing mortality in 2019 should be no more than 0.54 and corresponding catches in 2019 should be no more than 1 056 tonnes.

Reference points

In red mulled assessment in GSA 10, F0.1 has been considered as a proxy of Fmsy reference point, not existing a reliable stock-recruitment relationship due to the shortness of the time series. Values of F0.1 calculated by FLBRP package on the a4a assessment results is equal to 0.54.

The F value estimated for 2016, as calculated by a4a, is 0.25, indicating that the current fishing mortality (F) is below F0.1 reference point. This seems also consistent with the increasing trend reported by MEDITS survey, though the weighted residuals do suggest that the survey is seeing less of a stock increase than inferred from the catch.

7.1 Short term predictions

Red mullet in GSA 10: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
Fages 1–3 (2017 and 2018)	0.3	F mean 2014 to 2016
SSB (2017 and 2018)	2094 tons in 2017 and 2171 tons in 2018	based on F=0.3
Rage0 (2017-2020)	254 139 thousands	Geometric mean recruitment
Total catch (2017 and 2018)	596 and 646 tons respectively	based on F=0.3

The short term forecast was carried out estimating a catch for 2017 and 2018 (596 and 646 tons, respectively) on the basis of a recruitment hypothesis constant and equal to the mean on the whole time series and an F by age equal to the average of the last three years. These assumptions resulted in an SSB in 2017 and 2018 equal to 2094 and 2171 tons, respectively. These 2 hypotheses were maintained until 2020.

The analysis, carried out with stf.r FLR script made available to the EWG, shows that fishing at a level equal to F0.1 (=0.54) would increase the catch of the 77%, while decreasing the SSB of only the 22%.

Short term forecast table for red mullet in GSA 10.

Scenario	Fbar	Catch 2019	Catch 2020	SSB 2019	SSB 2020	SSB change 2018-2020 (%)	Catch change 2018-2019(%)
F0.1	0.54	1056	881	1964	1698	-21.8	77.2
F0.1 upper	0.74	1340	1000	1802	1395	-35.7	124.8
F0.1 lower	0.36	753	702	2127	2051	-5.5	26.4
Other scenarios	0.00	0	0	2496	3054	40.7	-100.0
	0.03	71	83	2463	2952	35.9	-88.0
	0.06	141	161	2430	2853	31.4	-76.4
	0.09	209	233	2398	2759	27.1	-65.0
	0.12	275	301	2366	2668	22.9	-53.9
	0.15	339	364	2335	2581	18.8	-43.0
	0.18	402	423	2304	2496	15.0	-32.5
	0.21	464	477	2274	2416	11.3	-22.2
	0.24	524	529	2244	2338	7.7	-12.1
	0.27	582	576	2215	2263	4.2	-2.3
	0.30	639	620	2186	2191	0.9	7.3
	0.33	695	662	2157	2122	-2.3	16.6
	0.36	749	700	2129	2056	-5.3	25.8
	0.39	803	735	2101	1991	-8.3	34.7
	0.42	854	768	2073	1930	-11.1	43.4
	0.45	905	799	2046	1870	-13.9	51.9
	0.48	954	827	2020	1813	-16.5	60.1
	0.51	1003	854	1993	1758	-19.0	68.2
	0.54	1050	878	1967	1705	-21.5	76.2
	0.57	1096	901	1942	1654	-23.8	83.9
	0.60	1141	921	1917	1605	-26.1	91.4

7.2 Medium term predictions

7.3 Long term predictions

8 Draft scientific advice

(Examples in blue)

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	$F_{0.1}$ = 0.54			D	S
	Fishing effort				N	
	Catch				N in the most recent yr	
Stock abundance	Biomass			66th percentile		S_H
	SSB					
Recruitment					I	
Final Diagnosis		The stock is sustainably exploited with relative high level of biomass.				

For more details please refer to

https://stecf.jrc.ec.europa.eu/reports/medbs

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)*