Stock Assessment Form Demersal species

Mullus barbatus in GSA 9

Reference year: 2019

Reporting year: 2020

The status of the stock was assessed applying statistical catch at age (a4a) over the period 2004-2019. MEDITS index was used for tuning. The stock is in high level of overfishing and overexploited with relative high level of biomass. A deterministic short term forecast was carried for years 2020 to 2022.

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_9]		
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 EWG 20-09		
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):

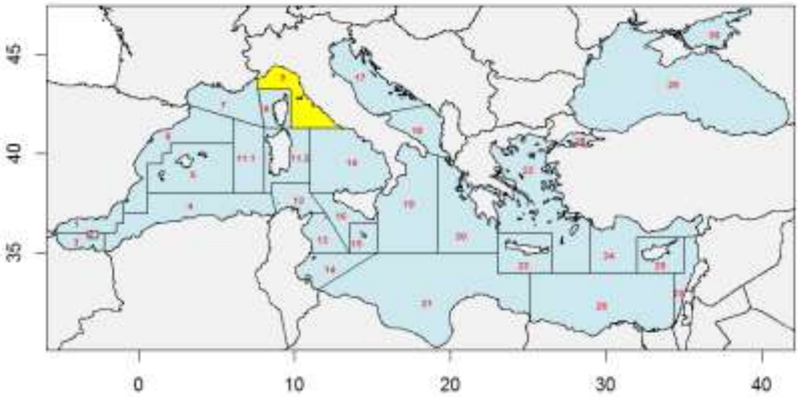
- Acoustics survey
- Egg production survey
- Trawl survey
- SURBA
- Other (please specify)

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 9 along the shelf at depths up to 200m, but mainly concentrated in the depth range 0-100 m. EU project STOCKMED outcomes suggest a single stock unit in the GSA 9 and the rest of Western Mediterranean (see: https://ec.europa.eu/fisheries/documentation/studies/stockmed_en).Available spatial information from MEDITS shows continuous distribution of the red mullets along western Italian coast (i.e. connectivity of GSA9 with GSA 10).

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

Growth parameters of red mullet in GSA 9 were available from 2006 to 2019 from DCF data. For the aim of the stock assessment a set of von Bertalanffy parameters given by the average along the years was used. It should be noticed that these growth parameters are quite different from the ones used for the neighboring area (GSA 10), that were consistent with the parameters estimated and validated by means of a set of different methods in Carbonara et al. (2018). Length-weight parameters used are the average of DCF data along the years 2002-2019.

Differently from the previous assessment, the mean length at age 0 was re-examined in order to associate the age classes to the mean length at the end of the year, being the a4a model parameterized with calendar year. It was then agreed to shift length slicing by adding a value of 0.5 to the t0 value used in previous assessment (set at -0.33 for both females and males) for internal consistency in the stock assessment model. The adjusted parameters, used in L2a length slicing for the assessment, are:

Linf=26.56, k=0.545, t0=0.17 for females; Linf=21.55, k=0.56, t0=0.17 for males (original t0 = -0.33, adjusted with +0.5 correction).

Original growth curves are used to estimate natural mortality see below.

Length-weight relationships for females and males were: females: a = 0.012, b = 3; males: a = 0.017, b = 2.84 (average of DCF data along the years 2002-2019).

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 age were available from 2006 to 2019 in the DCF data. The vector of matures by year and age showed a wide uncertainty especially on maturity at age 0 and 1, that seems inconsistent with the growth curve and the spawning season of the species. For this reason, it was preferred to use the vector of maturity agreed and used for all the red mullet stocks assessed in the working group.

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

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

Size/Age	Natural mortality	Proportion of matures
0	1.52	0
1	0.87	1
2	0.7	1
3	0.63	1
4+	0.59	1

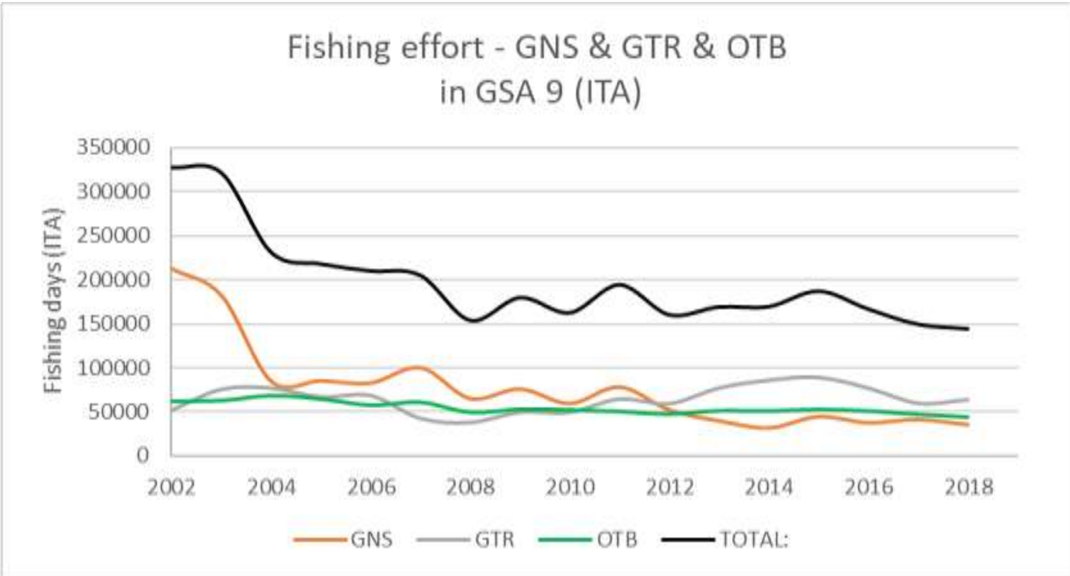
Table 2-3: Growth and length weight model parameters

			Sex			
		Units	**female**	**male**	**Combined**	**Years**
Growth model	**L_∞**		26.56	21.55		
	K		0.545	0.56		
	t_0		-0.33	-0.33		
	Data source	DCF call 2019.				
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 one of the species caught together (mixed catches) with several fishing gears (gillnets, trammel nets, trawls), by using fishing boats of different sizes (different metiers, VL0006 - VL1824). In such situation when mixed fisheries obtain mixed catches, with red mullet as one component of entire catch, fishing effort related to only red mullet cannot be derived.



Nominal effort in GSA 9 in the period from 2002 to 2018 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 9			[ISCAAP Group]	

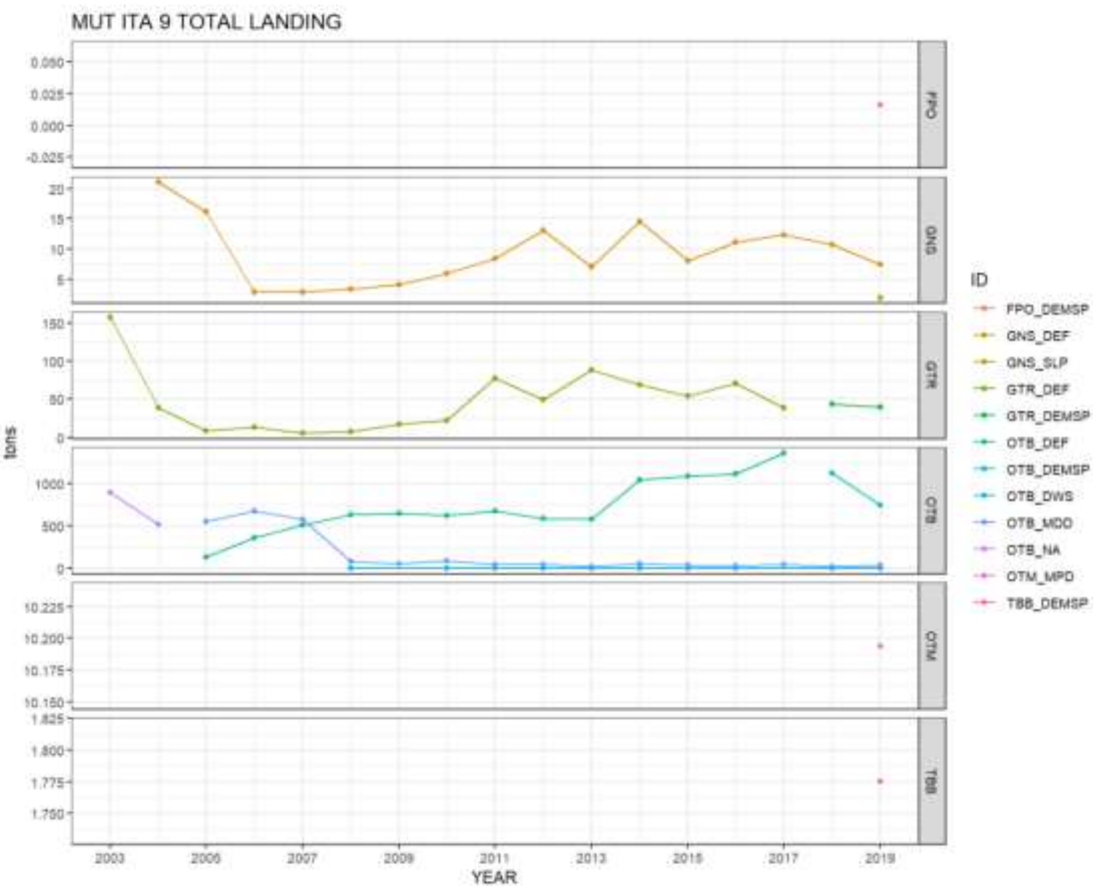
Table 3.1-2: Catch, bycatch, discards and effort by operational unit in the reference year

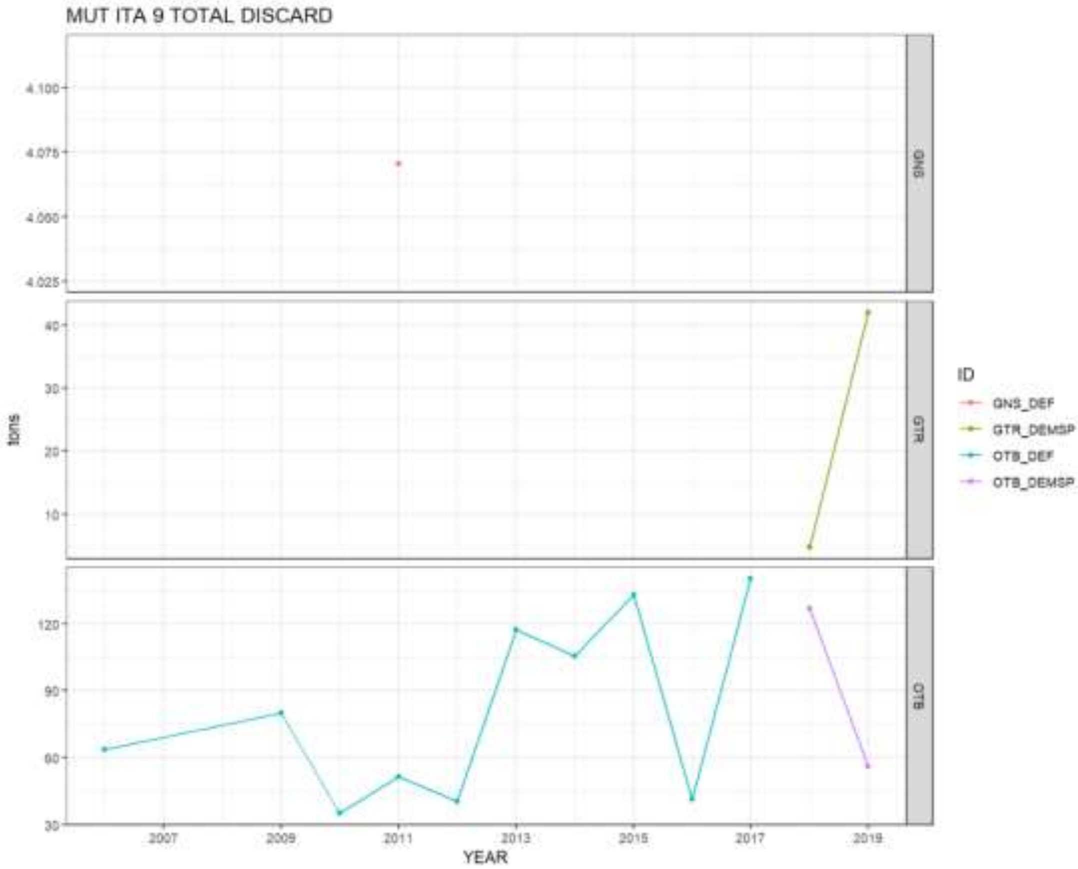
Operational Units*	Fleet (n° of boats)*	Catch (T or kg of the species assessed)	Other species caught (names and weight)	Discards (species assessed)	Discards (other species caught)	Effort (units)
[Operational Unit1]						
[Operational Unit2]						
[Operational Unit3]						
[Operational Unit4]						
[Operational Unit5]						
Total						

3.2 Historical trends

Red mullet in GSA 9: Commercial landings and discards in tonnes.

	Landings (t)					Discards (t)			
year	GNS	GTR	OTB	Others	Total landings	GNS	GTR	OTB	Total discards
2003	0.0	157.0	899.7	0.0	1056.7	0.0	0.0	0.0	-
2004	21.0	38.6	521.1	0.0	580.7	0.0	0.0	**17.0**	**17.0**
2005	16.1	8.4	684.0	0.0	708.5	0.0	0.0	**19.5**	**19.5**
2006	2.9	13.5	1033.2	0.0	1049.6	0.0	0.0	63.6	63.6
2007	2.9	5.6	1087.4	0.0	1096.0	0.0	0.0	**77.0**	**77.0**
2008	3.4	7.4	716.3	0.0	727.1	0.0	0.0	**92.0**	**92.0**
2009	4.1	16.8	707.4	0.0	728.3	0.0	0.0	80.1	80.1
2010	6.0	22.3	719.6	0.0	747.9	0.0	0.0	35.1	35.1
2011	8.4	77.4	719.6	0.0	805.5	4.1	0.0	51.6	55.7
2012	13.1	49.3	630.5	0.0	692.9	0.0	0.0	40.3	40.3
2013	7.0	88.4	597.9	0.0	693.3	0.0	0.0	117.2	117.2
2014	14.5	69.0	1097.9	0.0	1181.4	0.0	0.0	105.6	105.6
2015	8.1	54.1	1121.3	0.0	1183.4	0.0	0.0	132.9	132.9
2016	11.1	70.3	1140.2	0.0	1221.6	0.0	0.0	41.2	41.2
2017	12.3	38.1	1410.3	0.0	1460.7	0.0	0.0	140.1	140.1
2018	10.7	43.0	1151.0	0.0	1204.8	0.0	4.8	126.7	131.5
2019	9.3	39.9	782.8	12.0	844.0	0.0	42.0	56.1	98.1




MUT ITA 9 TOTAL DISCARD
tons
YEAR
GNS
GTR
OTB
ID
GNS_DEF
GTR_DEMSP
OTB_DEF
OTB_DEMSP
4.100
4.075
4.050
4.025
40
30
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10
120
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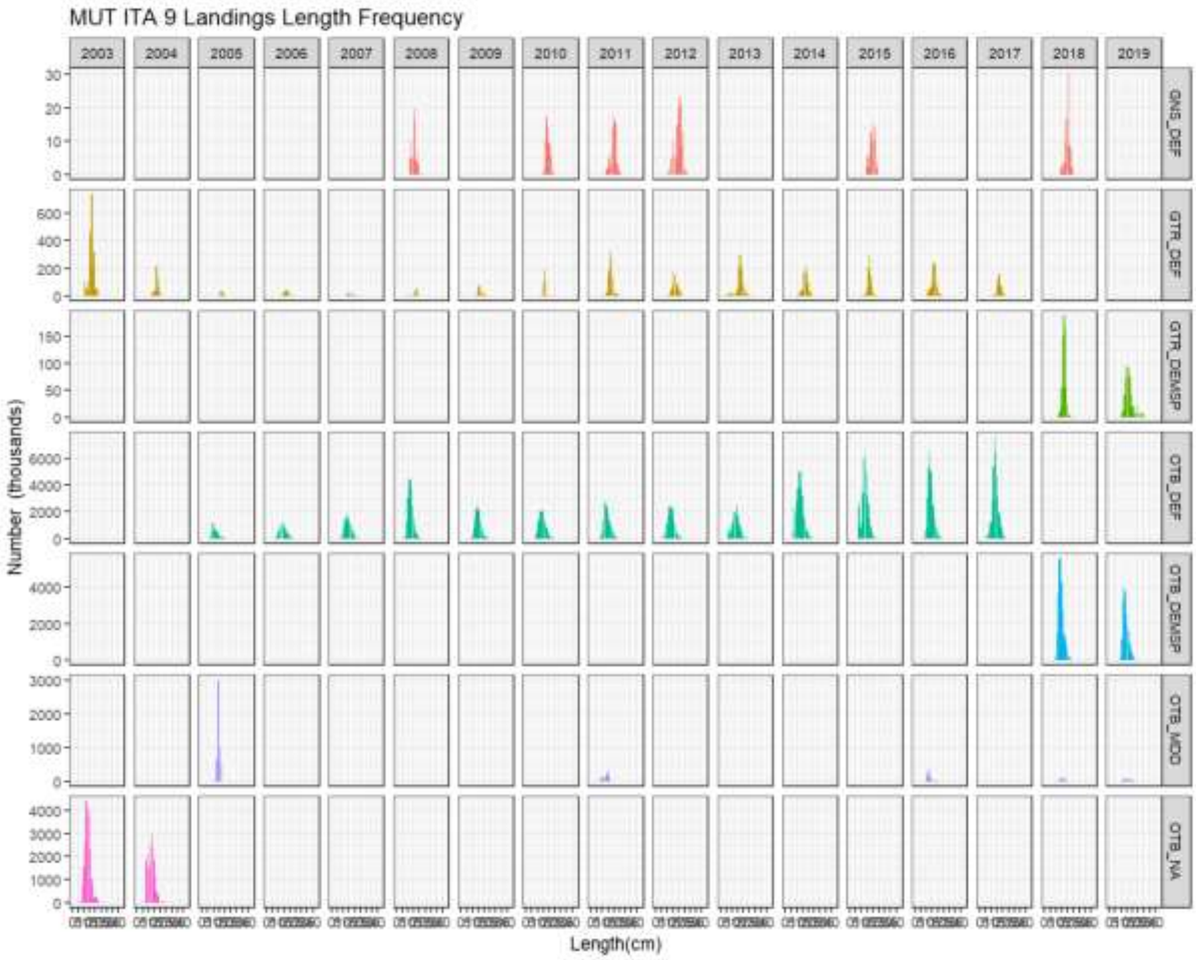
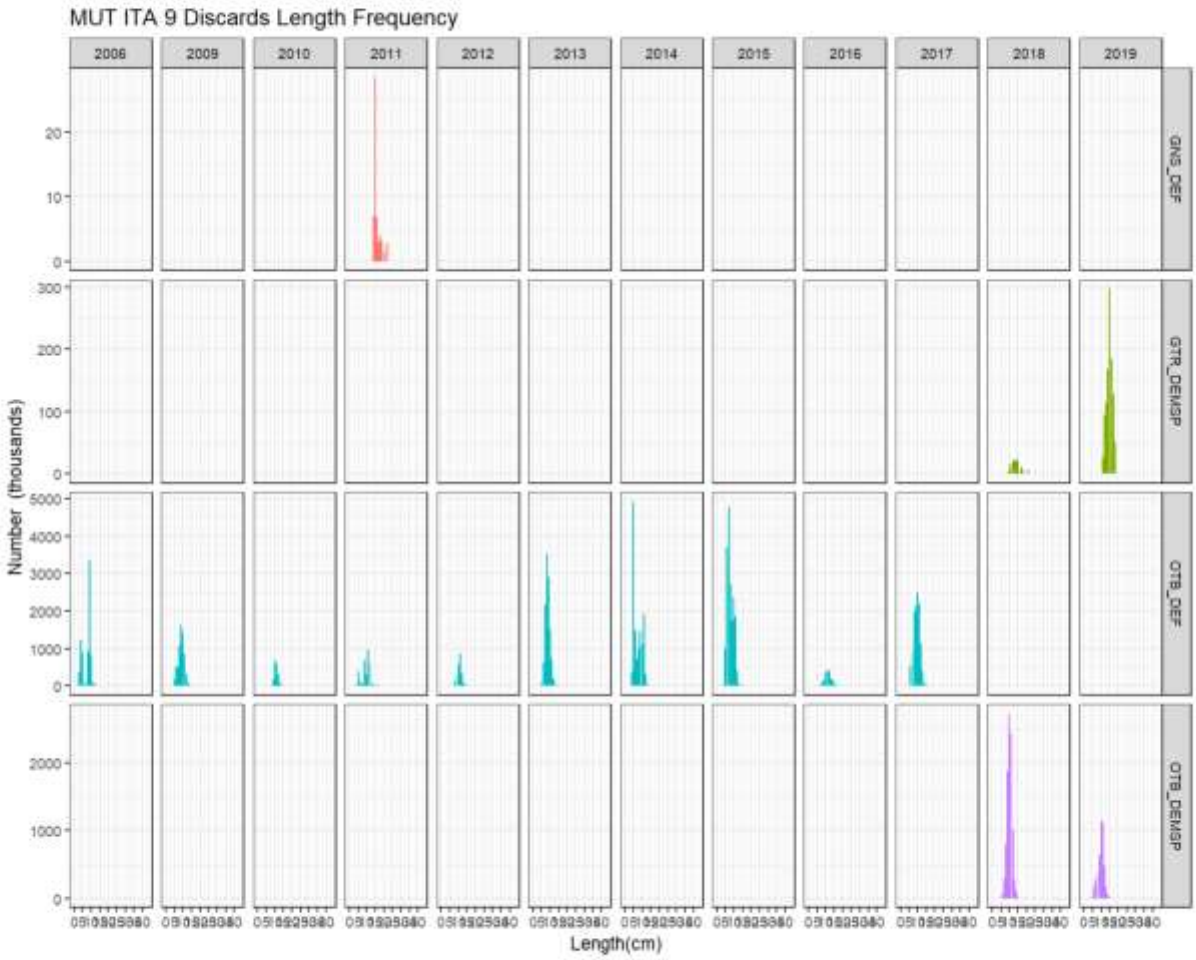
30
2007
2009
2011
2013
2015
2017
2019



Length structure of red mullet landed in GSA 9 in the period from 2003 to 2019 by fishing gear and fishery.



Length structure of red mullet catch discarded in GSA 9 in the period from 2006 to 2019 by fishing gear and fishery.

Discard of red mullet in GSA 9 occurs mainly from the catches of bottom trawls (OTB). Discard data were available in 2006, and for all years since 2009. For the assessment purposes, in the years where discard data were missing, approximations were made taking into account percentage of catch discarded in previous and/or following year.

3.3 Management regulations

In GSA 9, management regulations are based on technical measures, as closed number of fishing licenses and area limitation (distance from the coast and depth). In order to limit the over-capacity of fishing fleet, the Italian fishing licenses have been fixed since the late eighties and the fishing capacity has been gradually reduced.

Other measures on which the management regulations are based regards technical measures (mesh size), minimum landing sizes (EC 1967/06) and seasonal fishing ban (Fishing closure for trawling: 45 days in late summer). Regarding small scale fishery, management regulations are based on technical measures related to the height and length of the gears as well as the mesh size opening, minimum landing sizes and number of fishing licenses for the fleet.

A biological conservation zone (ZTB) was permanently established in 2005 off Giglio Island (50 km^2, between about 160 and 220 m depth) (Decree of Ministry of Agriculture, Food and Forestry Policy of 16.06.1998). Professional small scale fishery using fixed nets and long-lines is permanently allowed, while trawling is allowed from July 1st to December 31st and the small scale fishery all year round; recreational fishery using no more than 5 hooks is allowed (Decree of Ministry of Agriculture, Food and Forestry Policy of 22.01.2009). Another ZTB area has been established off the coasts of southern Latium with the same rules as the above mentioned ZTB off the Giglio Island.

Since June 2010, the rules implemented in the EU regulation (EC 1967/06) regarding the cod-end mesh size and the operative distance of fishing from the coasts are enforced.

This area is now under the western Mediterranean Multiannual Management Plan (Reg. EU 1022/2019) for the conservation and sustainable exploitation of demersal stocks in the western Mediterranean Sea, mainly based on regulation of fishing effort.

3.4 Reference points

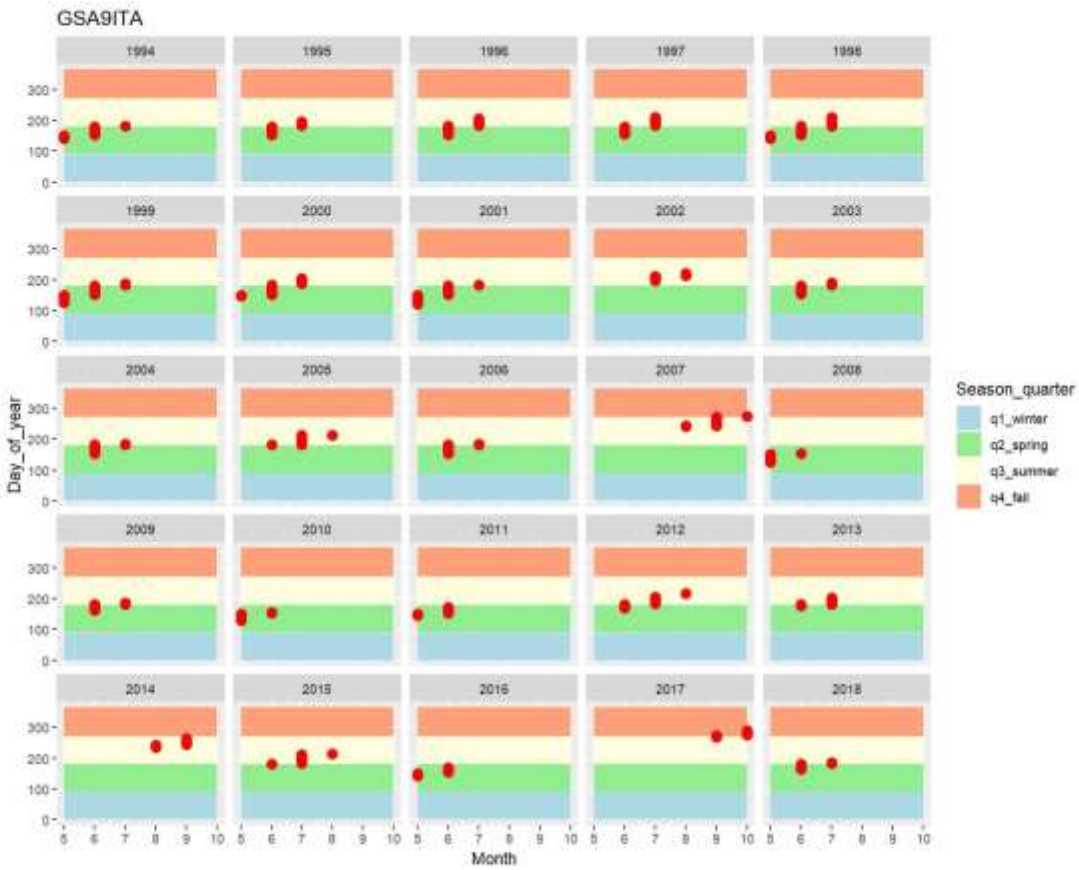
Table 3.3-1: List of reference points and empirical reference values previously agreed (if any)

Indicator	Limit Reference point/empirical reference value	Value	Target Reference point/empirical reference value	Value	Comments
B					
SSB					
F			$F_{0.1}$	0.58	WGSAD 2019
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 GSA9 took place in different seasons of the year. This was considered during interpretation of available survey indices in the assessment.



Survey periods of MEDITS in GSA 9.

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)				

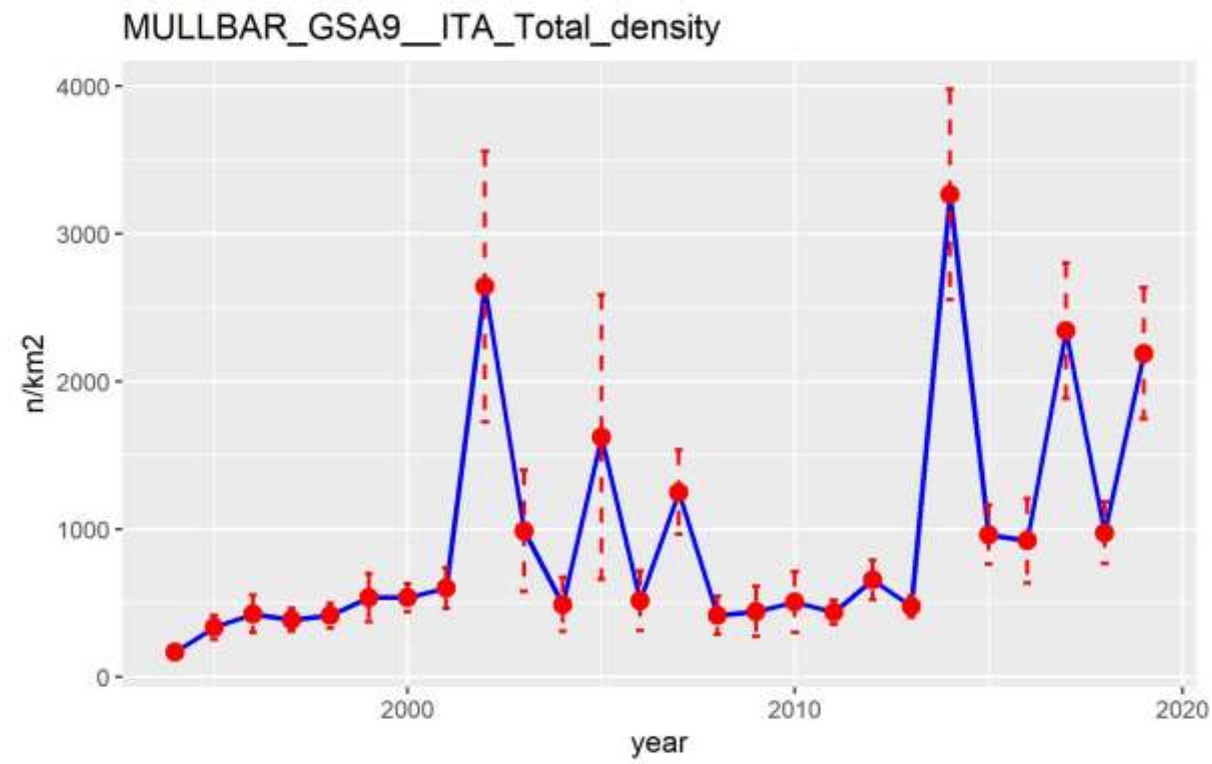
Map of hauls positions

4.1.2 Spatial distribution of the resources

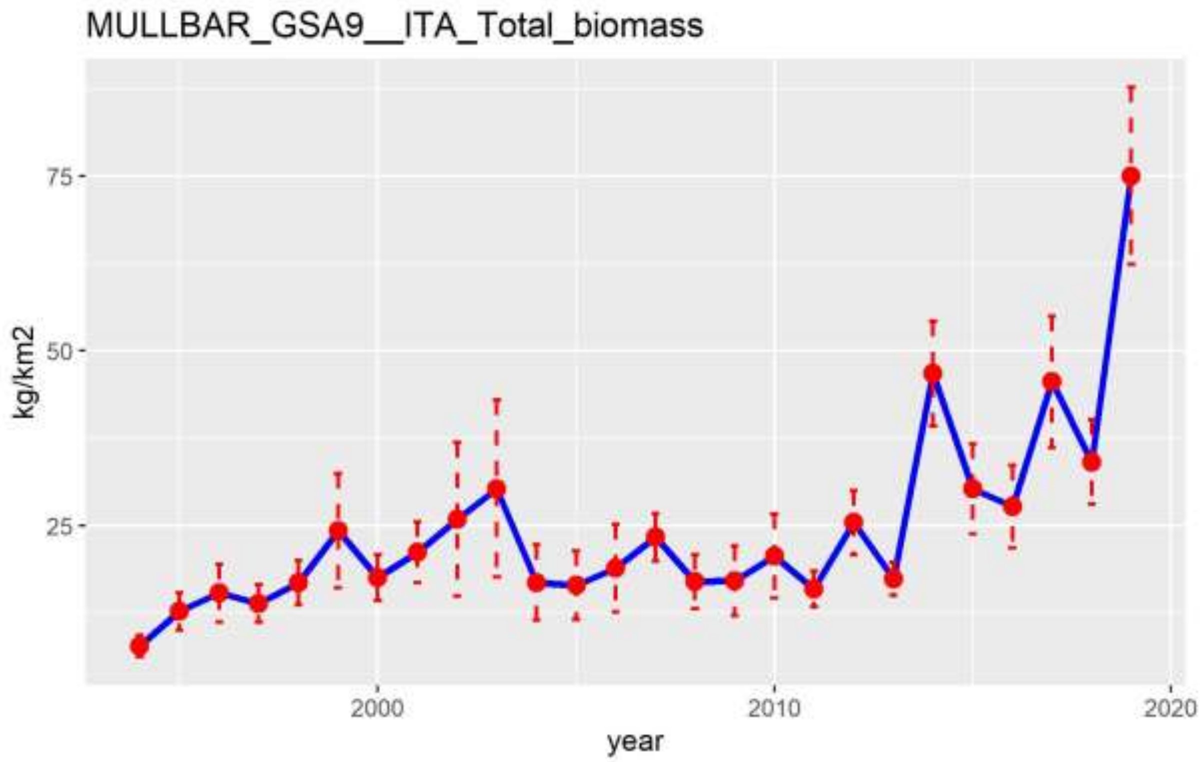
Include maps with distribution of total abundance, spawners and recruits (if available)

4.1.3 Historical trends

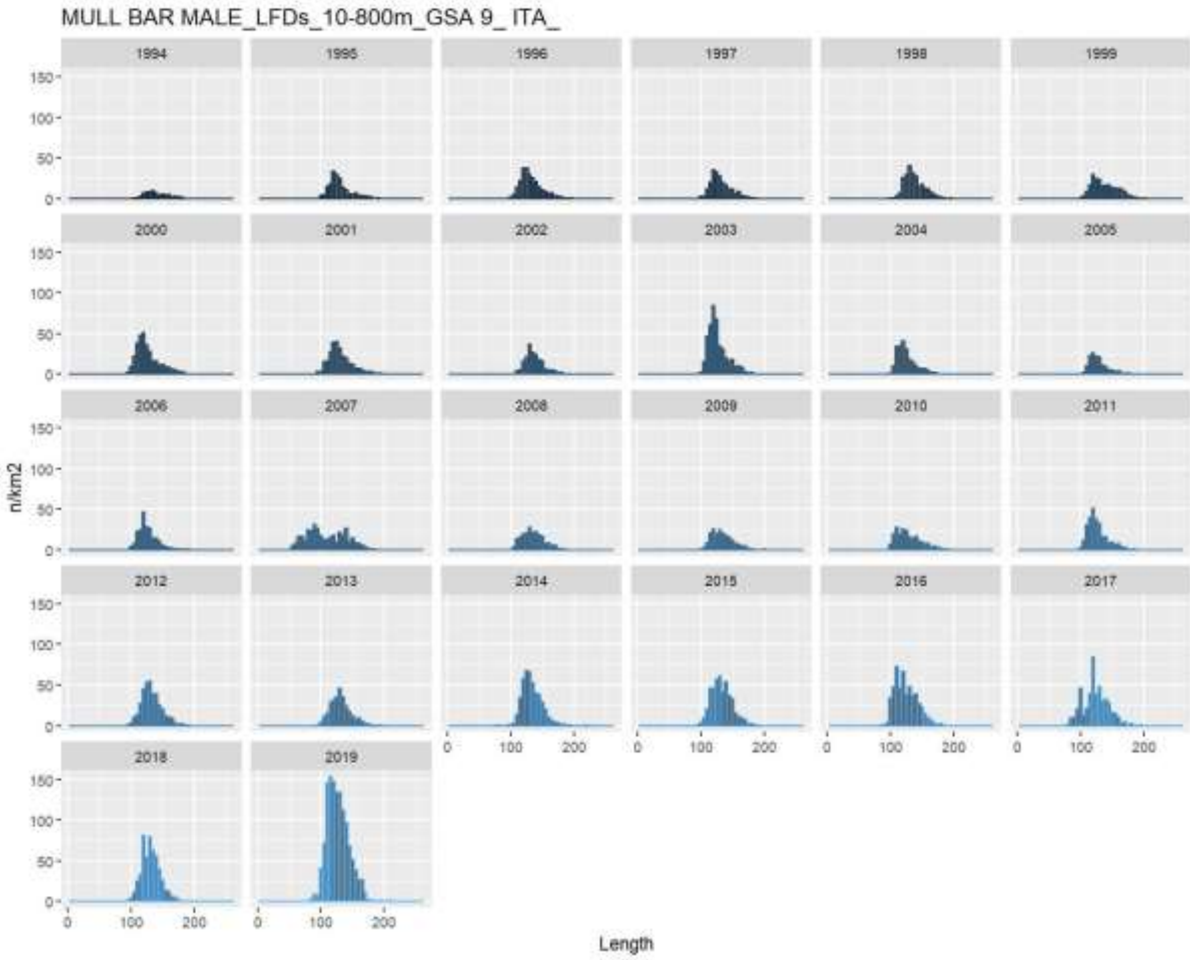
Analyses of available MEDITS data show large variations between years. However, it was noticed that after 2008 year both survey density indices, in terms of abundance and biomass, generally show positive trend with large inter-annual variations similarly to GSA 10. Strong increase in red mullet density index (abundance and biomass) can be noticed from 2010.



Abundance indices of red mullet in GSA 9 as derived from trawl surveys (MEDITS, 1994-2019).



Biomass indices of red mullet in GSA 9 as derived from trawl surveys (MEDITS, 1994-2019).


MULL BAR MALE_LFDs_10-800m_GSA 9_ ITA_
1994
1995
1996
1997
1998
1999
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2002
2003
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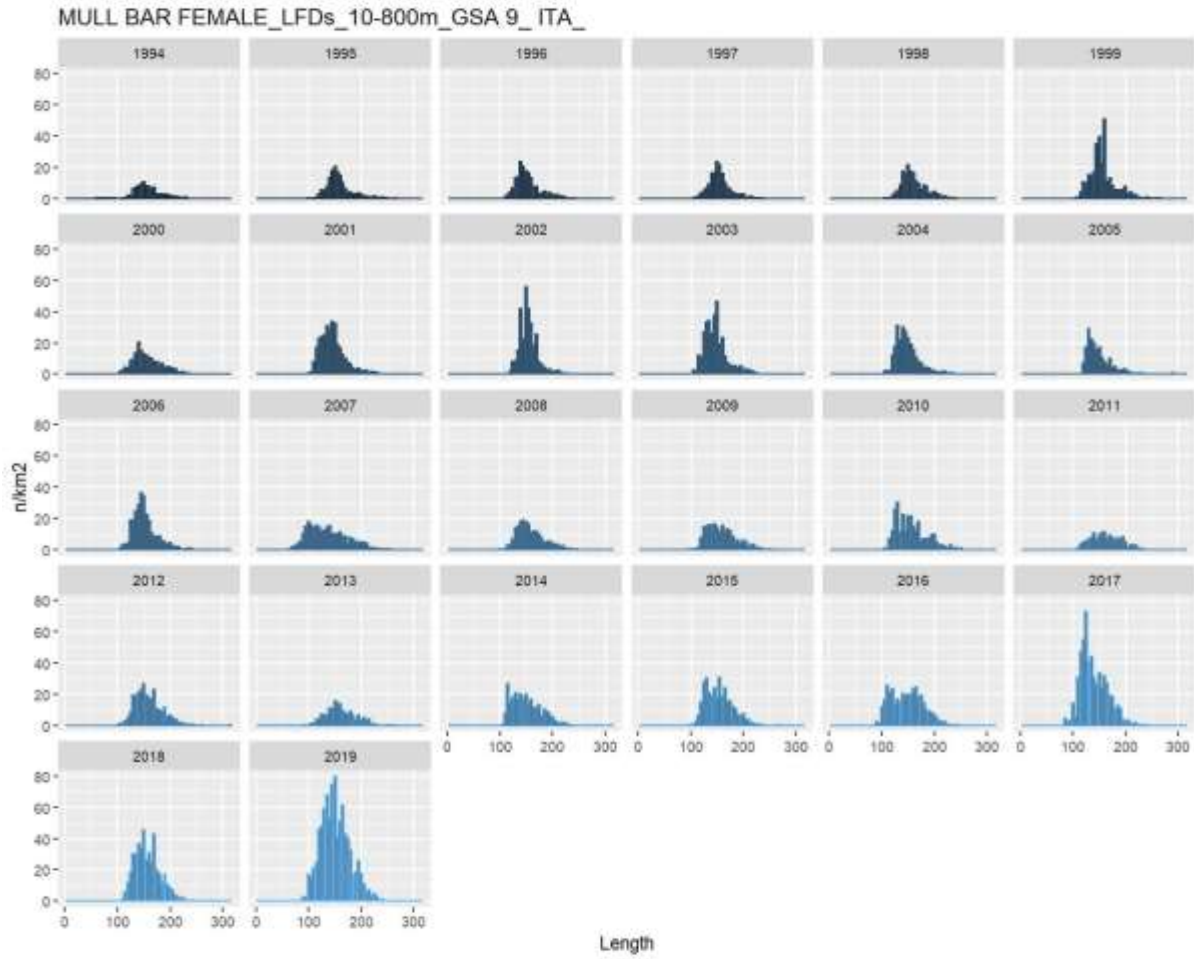
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
n/km2
Length



Size structure indices of red mullet in GSA 9 as derived from trawl surveys (MEDITS, 1994-2019).

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)

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 and cover the years 2003-2018. Despite availability of commercial fishery data since 2003, the assessment was carried out from 2004 because the inclusion of 2003 seemed to make worse the a4a fitting.

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

Values of catch at age per year used in the assessment.

	Age				
Year	0	1	2	3	4+
2004	3214.1	16571.6	3774.3	288.4	110.4
2005	2900.0	16684.4	6222.3	300.6	8.8
2006	5768.4	20336.8	8284.8	1130.4	228.2
2007	3109.7	22881.6	8738.3	1035.6	238.1
2008	3993.7	30744.8	3693.5	291.6	37.1
2009	2894.8	16489.4	5951.2	685.6	156.9
2010	303.3	14872.5	5853.9	709.9	173.8
2011	1258.9	16181.4	6430.1	807.2	123.3
2012	839.7	16205.4	5198.0	579.1	110.6
2013	7705.3	19975.5	5520.9	683.0	109.1
2014	13129.1	34694.1	8061.8	750.0	177.9
2015	15211.0	35045.2	8097.5	777.8	98.3
2016	389.2	27084.7	8883.0	884.4	168.6
2017	4410.7	38164.0	11042.0	1023.7	161.4
2018	1441.3	28316.7	9881.6	934.3	141.9
2019	910.0	18553.7	7185.9	746.2	115.9

Total catches used in the assessment:

Year	Catches (t)
2004	597.71
2005	727.99
2006	1113.21

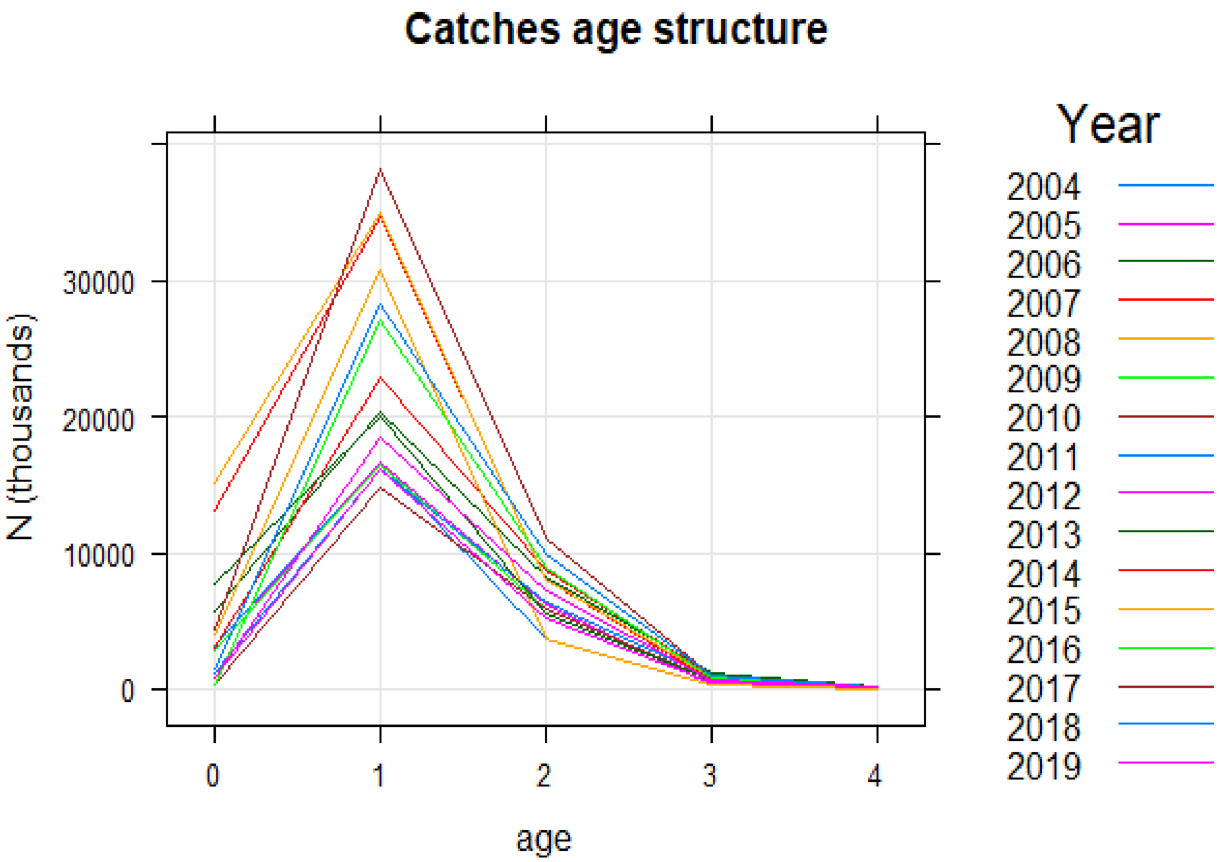
2007	1172.97
2008	819.06
2009	808.45
2010	783.06
2011	861.12
2012	733.23
2013	810.46
2014	1287.03
2015	1316.30
2016	1262.84
2017	1600.77
2018	1336.30
2019	942.12

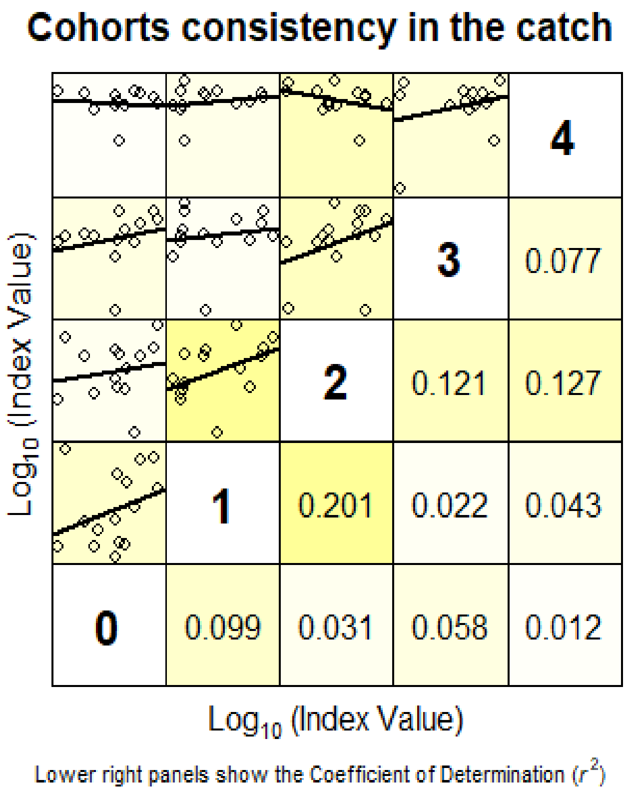
Values of mean weight at age per year used in the assessment.

	Age				
Year	0	1	2	3	4+
2004	0.006	0.022	0.049	0.077	0.132
2005	0.005	0.026	0.040	0.068	0.135
2006	0.004	0.023	0.059	0.089	0.138
2007	0.005	0.024	0.056	0.081	0.139
2008	0.006	0.019	0.046	0.082	0.136
2009	0.005	0.024	0.053	0.083	0.146
2010	0.008	0.025	0.055	0.083	0.156
2011	0.005	0.025	0.057	0.086	0.126
2012	0.006	0.024	0.052	0.083	0.141
2013	0.005	0.020	0.055	0.085	0.136
2014	0.003	0.021	0.054	0.080	0.127
2015	0.004	0.022	0.050	0.079	0.129
2016	0.008	0.026	0.052	0.084	0.130
2017	0.006	0.024	0.051	0.082	0.126
2018	0.007	0.025	0.053	0.085	0.123
2019	0.005	0.026	0.053	0.079	0.146

Survey index (MEDITS) values at age per year used in the assessment.

	Age				
Year	0	1	2	3	4
2004	0.0	407.7	71.7	9.1	1.22
2005	1242.9	308.5	60.4	7.3	1.1
2006	1.5	410.7	89.1	9.4	2.4
2007	435.4	668.6	124.0	17.8	1.6
2008	0.0	261.1	132.3	19.6	0.7
2009	23.2	266.7	127.1	21.1	1.6
2010	0.0	347.7	128.0	23.7	2.9
2011	0.0	311.7	106.1	16.5	1.0
2012	6.9	429.0	199.0	18.0	1.9
2013	0.0	318.8	127.0	15.8	1.0
2014	1398.3	1632.8	213.5	18.8	0.7
2015	94.0	602.7	240.4	22.9	1.0
2016	4.6	687.7	209.5	16.2	1.2
2017	497.7	1620.6	188.0	13.3	1.9
2018	1.3	666.1	287.8	18.5	0.4
2019	2.9	1626.7	513.8	41.2	2.9

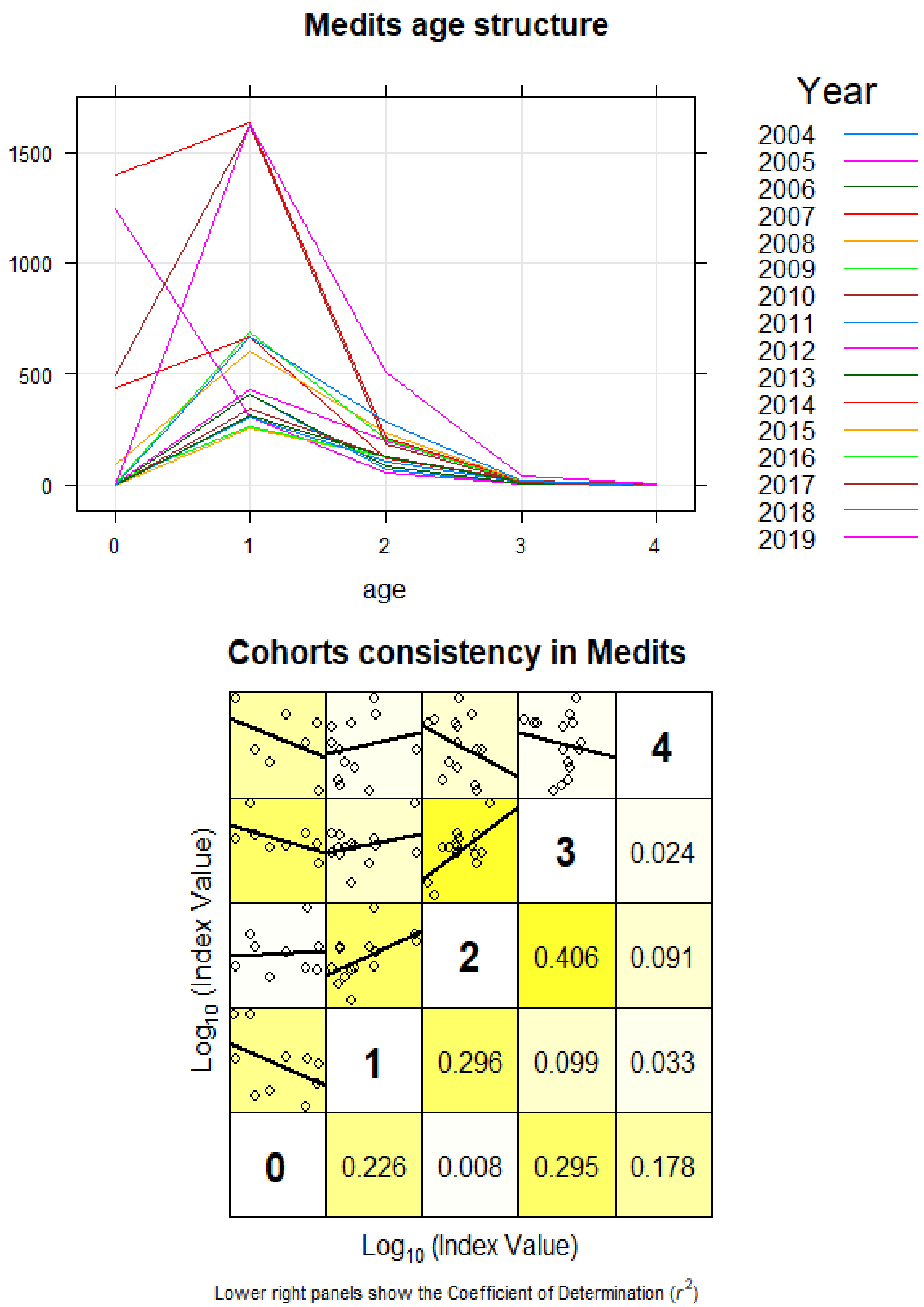




Catch-at-age data of red mullet in GSA9 used in assessment.

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 GSA9 by year.

6.1.5 Results

For the assessment purposes, the model selected by WGSAD 2019 was used for the update. The only difference is the increase of k in the year smoother of the F sub-model from 6 to 7. The age0 was removed from the tuning index, as done at WGSAD 2019. An Fbar range between age1 and age3 was used, as in previous assessments.

Sub-models of the a4a assessment used for MUT9:

fmodel: ~s(replace(age, age > 2, 2), k = 3) + s(year, k = 7)

srmodel: ~geomean(CV = 0.3)

n1model: ~s(age, k = 3)

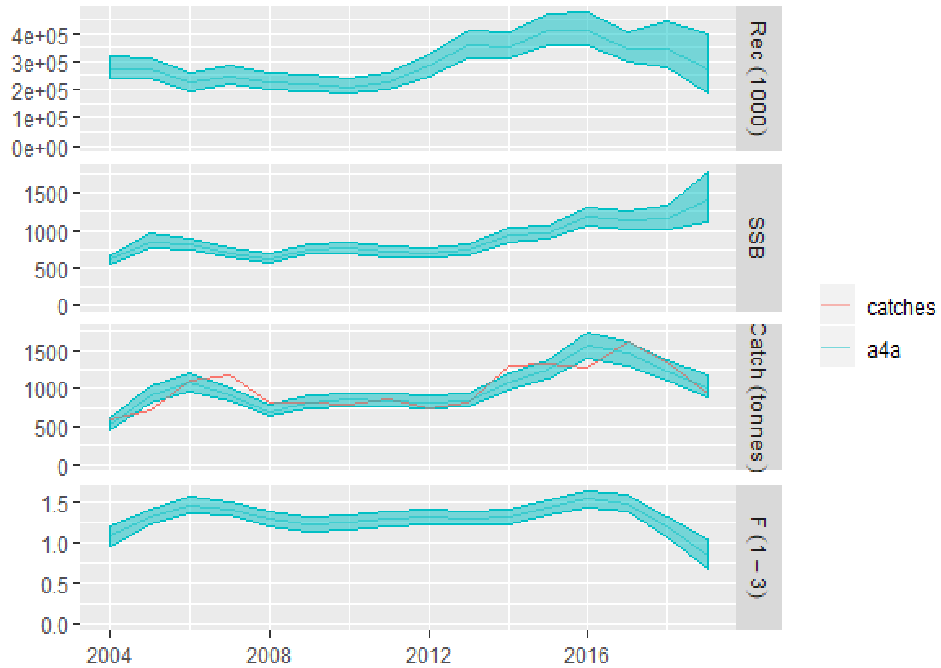
qmodel: ~factor(replace(age, age > 2, 2))

vmodel:

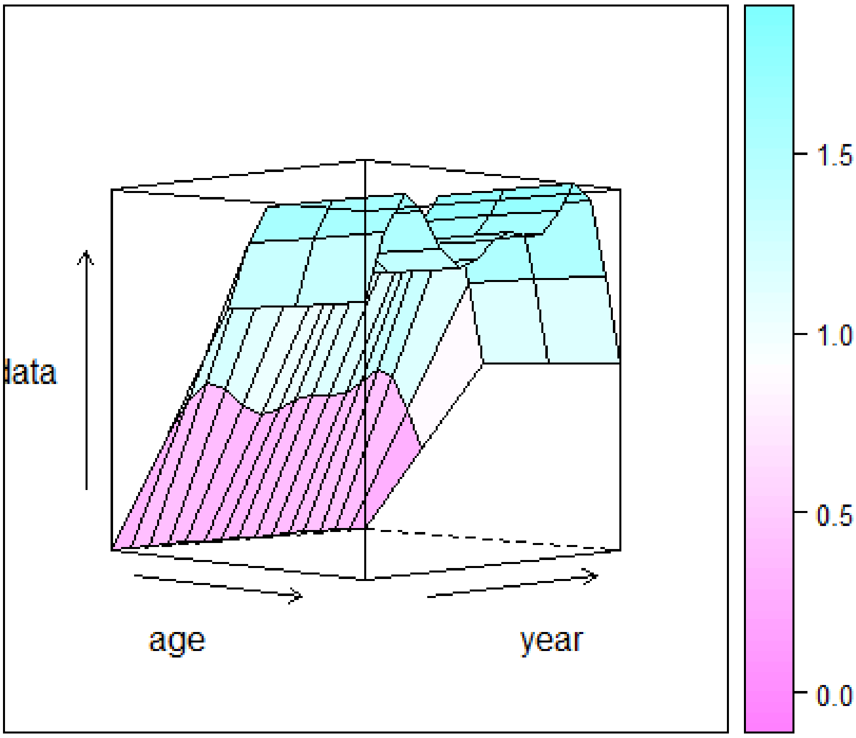
catch: ~s(age, k = 3)

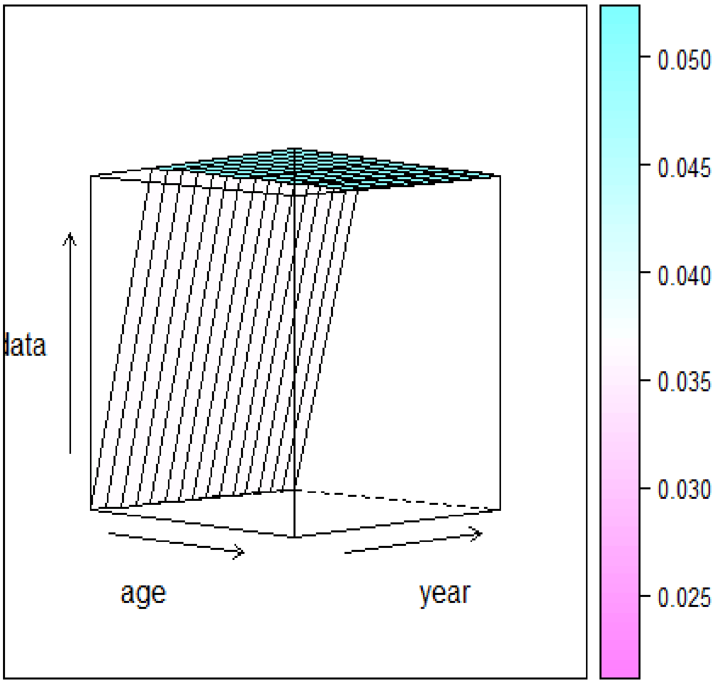
MEDITS_SA09: ~1

Results are shown below:



Results of the best a4a model for red mullet in GSA9: Recruitment, SSB, catch and fishing mortality.





3D contour plots of estimated fishing mortality (top) and estimated catchability (bottom) at age and year.

Final results of the red mullet assessment in GSA9.

Year	Recruitment age 0 (‘000)	High	Low	SSB (t)	High	Low	Catch (t)	F_{bar} ages 1-3	High	Low
2004	274237	305251	243223	609.8	660.9	558.7	528.5	1.08	1.18	0.98
2005	274554	304905	244203	849.5	927.2	771.8	910.8	1.32	1.38	1.26
2006	222784	247444	198124	810.1	875.2	745	1078.0	1.46	1.53	1.39
2007	246943	272036	221850	700.8	757.6	644	915.3	1.42	1.49	1.35
2008	226577	248693	204461	620.4	668.4	572.4	703.9	1.30	1.37	1.23
2009	220550	242780	198320	753.5	810.9	696.1	822.9	1.23	1.30	1.16
2010	210358	231804	188912	760.9	819.4	702.4	852.5	1.25	1.31	1.19
2011	225954	249889	202019	718.9	772	665.8	843.8	1.30	1.37	1.23
2012	283974	311207	256741	705.3	761.8	648.8	814.1	1.32	1.39	1.25
2013	356827	394153	319501	733.0	786.2	679.8	846.6	1.30	1.36	1.24
2014	351139	386899	315379	947.0	1021.2	872.8	1080.5	1.32	1.39	1.25
2015	408721	450445	366997	973.0	1048.1	897.9	1236.5	1.43	1.50	1.36
2016	410882	451317	370447	1186.1	1280.4	1091.8	1554.8	1.54	1.61	1.47
2017	344590	386307	302873	1136.7	1231.6	1041.8	1453.0	1.48	1.56	1.40
2018	346897	413619	280175	1174.6	1298.9	1050.3	1230.1	1.20	1.29	1.11
2019	271663	351613	191713	1408.9	1669.3	1148.5	1011.2	0.85	0.99	0.71

Stock number at age for red mullet in GSA 9.

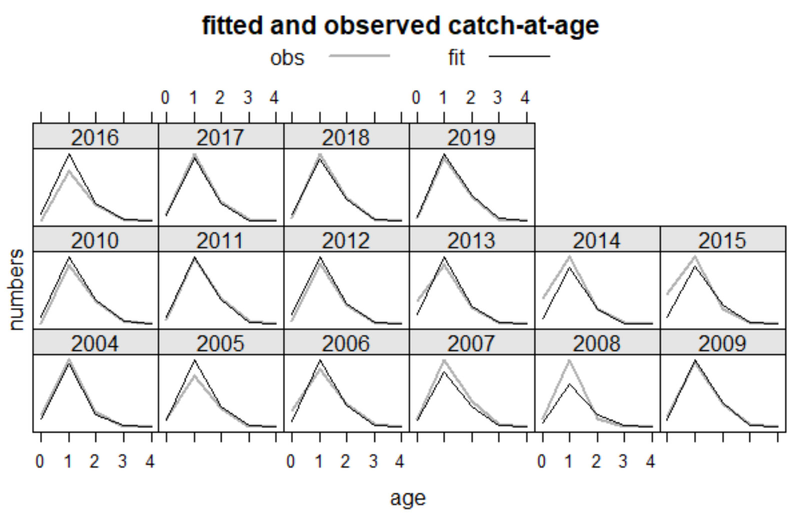
	Age				
Year	0	1	2	3	4+
2004	274236.7	48043.1	5465.733	598.993	63.234
2005	274554	59125.87	10826.54	730.884	95.345
2006	222784.4	59005.76	11602.08	1080.261	88.834
2007	246943.4	47791.39	10688.67	977.458	105.964
2008	226576.7	53003.19	8867.751	947.465	103.411
2009	220549.6	48709.86	10541.09	910.286	116.16
2010	210358.4	47456.55	10070.76	1174.701	123.248
2011	225953.7	45252.46	9707.378	1097.198	152.251
2012	283974.2	48574.37	8987.456	993.62	137.845
2013	356826.9	61034.45	9561.101	902.647	122.483
2014	351138.6	76709.76	12129.62	979.973	113.24
2015	408721.1	75465.21	15055.7	1210.829	117.537
2016	410881.9	87720.89	13962.79	1326.533	125.98
2017	344589.8	88052.81	15211.85	1072.601	120.094
2018	346896.6	73899.45	15752.4	1248.14	105.388
2019	271663.1	74678.54	15597.4	1833.825	169.534

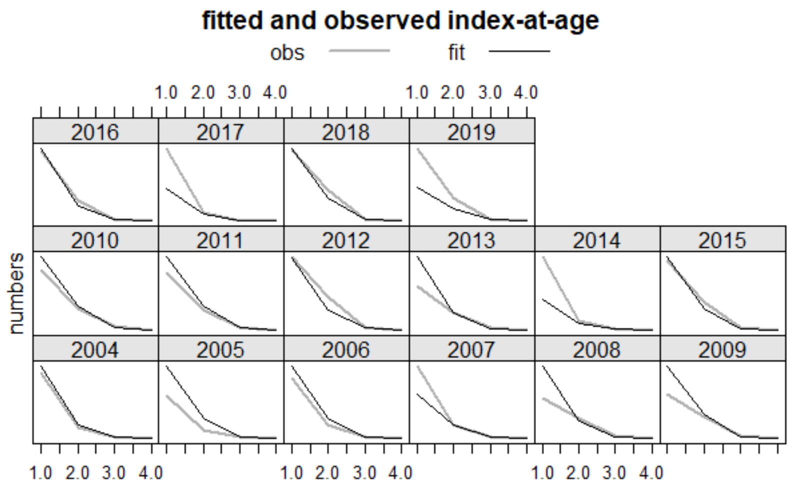
Fishing mortality at age for red mullet in GSA 9.

	Age				
Year	0	1	2	3	4+
2004	0.01	0.62	1.31	1.31	1.31
2005	0.02	0.76	1.60	1.60	1.60
2006	0.02	0.84	1.77	1.77	1.77
2007	0.02	0.81	1.72	1.72	1.72
2008	0.02	0.75	1.58	1.58	1.58
2009	0.02	0.71	1.49	1.49	1.49
2010	0.02	0.72	1.52	1.52	1.52
2011	0.02	0.75	1.58	1.58	1.58
2012	0.02	0.76	1.60	1.60	1.60
2013	0.02	0.75	1.58	1.58	1.58
2014	0.02	0.76	1.60	1.60	1.60
2015	0.02	0.82	1.73	1.73	1.73
2016	0.02	0.88	1.87	1.87	1.87
2017	0.02	0.85	1.80	1.80	1.80
2018	0.02	0.69	1.45	1.45	1.45
2019	0.01	0.48	1.03	1.03	1.03

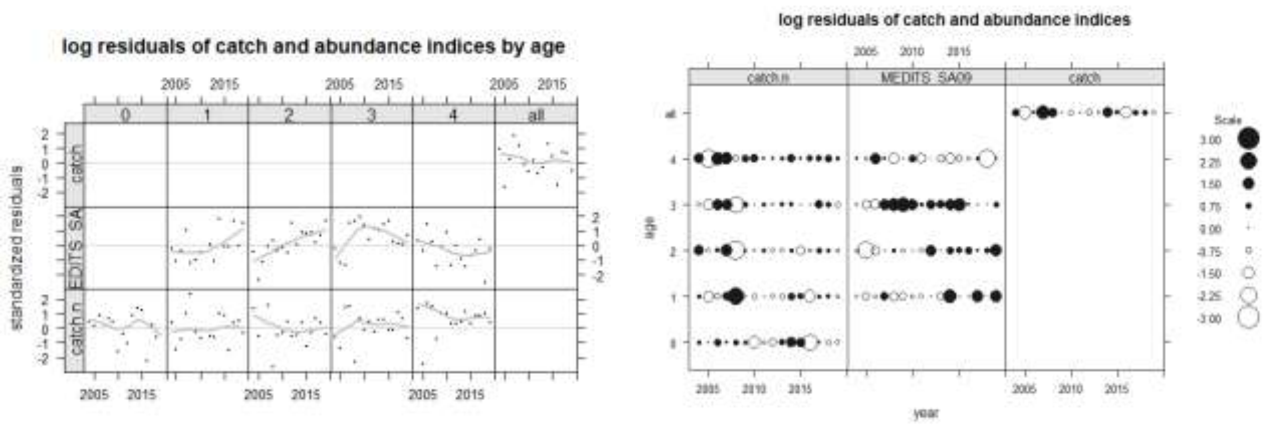
6.1.6 Robustness analysis

The fitting of both the catch-at-age data and the survey indices are good.





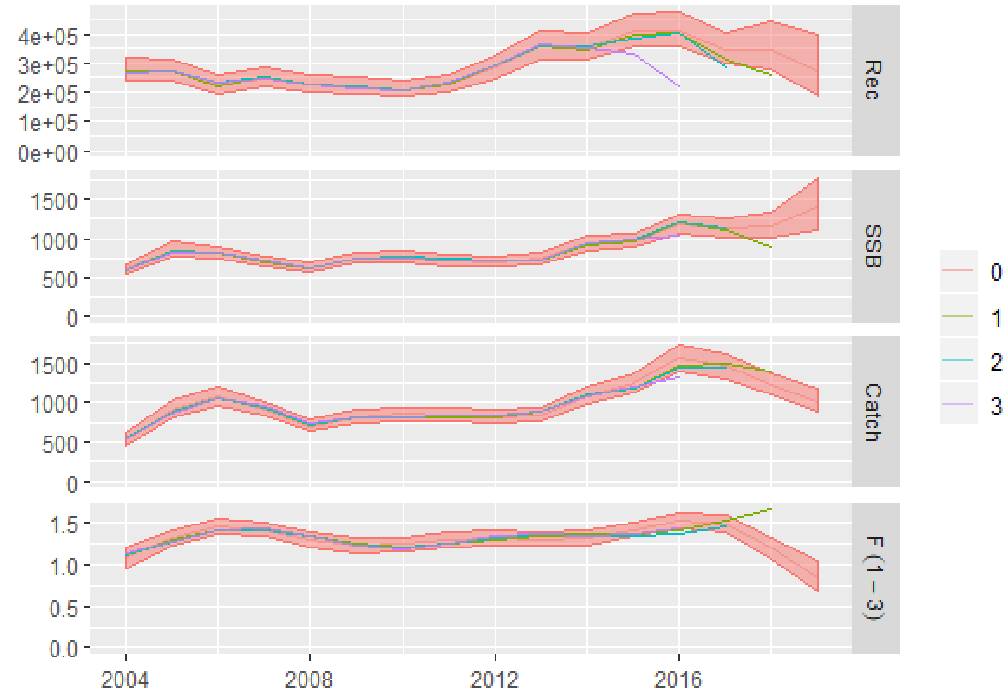
Log residuals of the catch and abundance indices related to outcomes of the best run do not show any particular trend.

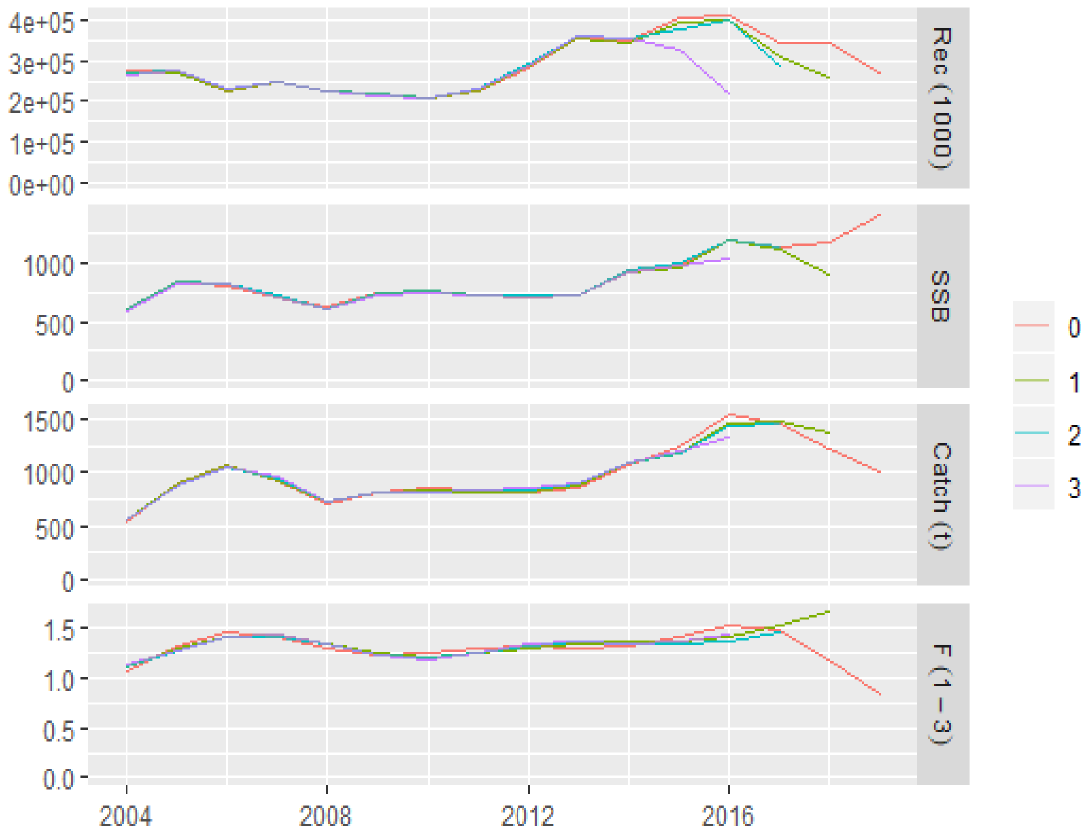


Log residuals of catch and MEDTIS abundance indices for red mullet in GSA9.

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

etc.





Retrospective analysis of the selected a4a model for red mullet in GSA9

The Mohn's Rho test of the retrospective analysis is shown below:

fbar	ssb	rec
0.101	-0.118	-0.297

The retrospective did not show any important anomalies and the inspection of residuals did not show any trend.

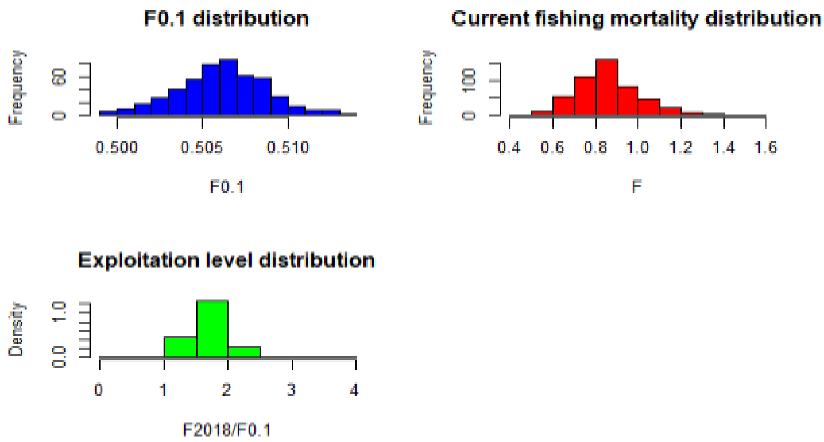
6.1.8 Assessment quality

The current assessment results align well with the observed trends in the surveys (biomass and density indices). 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. Not being the recruitment (age 0) detected by the survey every year, the age 0 was excluded from the tuning indices used in a4a model.

7 Stock predictions

Reference points

The time series is too short to produce meaningful stock recruitment relationship, so reference points are based on equilibrium methods. It is recommended to use F0.1 as proxy of FMSY. The library FLBRP available in FLR was used to estimate F0.1 from the stock object resulting from the outputs of the 6.11.3 assessment. Values of F0.1 calculated by FLBRP package on the a4a assessment results is equal to 0.51. Current F values (2019), as calculated by model a4a, is 0.85 indicating that the stock is being overfished.



7.1 Short term predictions

A deterministic short term prediction for the period 2020 to 2022 was performed using the FLR libraries and scripts, and based on the results of the stock assessment.

The basis for the choice of values is given in Section 4.3. An average of the last three years has been used for weight at age, maturity at age, while the F_{bar} = 0.85 terminal F (2019) from the a4a assessment was used for F in 2020. Recruitment is observed to be fluctutating over the period of the assessment so the average across the whole time series is used as an estimate of recruits from 2020. Recruitment (age 0) for 2020 to 2022 has been estimated from the population results as the geometric mean of the whole time series of 16 years (285136).

Red mullet in GSA 9: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
Biological Parameters	average of 2017-2019	mean weights at age, maturation at age, natural mortality at age and selection at age
$F_{ages\ 1\text{-}3}$ (2020)	0.85	F 2019 used to give F status quo for 2020
SSB (2020)	1289.9	Stock assessment 1 January 2020
R_{age0} (2020,2022)	285136	Geometric mean of the time series (16 years)
Total catch (2020)	1030	Assuming F status quo for 2020

Short term forecast table for red mullet in GSA 9.

The short term forecast was carried out estimating a catch for 2020-2022 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 that of the terminal year. These assumptions resulted in a catch and a SSB in 2020 equal to 1011.2 and 1289.9 tons, respectively.

The analysis shows that fishing at a level equal to $F_{0.1}$ (=0.51) would increase biomass of 28% from 2020 to 2022, while decreasing the catch of the 34% from 2019 to 2021.

Red mullet in GSA 9: Short term forecast table for red mullet in GSA 9.

Rationale	Ffactor	Fbar	Catch 2019	Catch 2021	SSB* 2020	SSB* 2022	Change SSB 2020-2022 (%)	Change Catch 2019-2021 (%)
High long term yield ($F_{0.1}$)	0.6	0.51	1011.2	667.6	1290.0	1650.7	28.0	-34.0
F upper	0.8	0.69	1011.2	851.1	1290.0	1426.5	10.6	-15.8
F lower	0.4	0.34	1011.2	474.7	1290.0	1906.0	47.8	-53.1
F_{MSY} transition (intermediate year)	0.9	0.73	1011.2	889.0	1290.0	1382.5	7.2	-12.1
Zero catch	0.0	0.00	1011.2	0.0	1290.0	2618.4	103.0	-100.0
Status quo	1.0	0.85	1011.2	986.2	1290.0	1273.0	-1.3	-2.5
Different Scenarios	0.1	0.08	1011.2	131.9	1290.0	2408.5	86.7	-87.0
	0.2	0.17	1011.2	254.7	1290.0	2221.3	72.2	-74.8
	0.3	0.25	1011.2	369.2	1290.0	2054.0	59.2	-63.5
	0.4	0.34	1011.2	476.0	1290.0	1904.3	47.6	-52.9
	0.5	0.42	1011.2	575.7	1290.0	1769.9	37.2	-43.1
	0.6	0.51	1011.2	668.9	1290.0	1649.2	27.8	-33.9
	0.7	0.59	1011.2	756.1	1290.0	1540.4	19.4	-25.2
	0.8	0.68	1011.2	837.7	1290.0	1442.3	11.8	-17.2
	0.9	0.76	1011.2	914.3	1290.0	1353.5	4.9	-9.6
	1.1	0.93	1011.2	1053.7	1290.0	1200.0	-7.0	4.2

	1.2	1.01	1011.2	1117.1	1290.0	1133.4	-12.1	10.5
	1.3	1.10	1011.2	1176.9	1290.0	1072.7	-16.8	16.4
	1.4	1.18	1011.2	1233.2	1290.0	1017.1	-21.2	22.0
	1.5	1.27	1011.2	1286.3	1290.0	966.2	-25.1	27.2
	1.6	1.35	1011.2	1336.5	1290.0	919.3	-28.7	32.2
	1.7	1.44	1011.2	1383.9	1290.0	876.2	-32.1	36.9
	1.8	1.52	1011.2	1428.7	1290.0	836.4	-35.2	41.3
	1.9	1.61	1011.2	1471.1	1290.0	799.5	-38.0	45.5
	2.0	1.69	1011.2	1511.4	1290.0	765.3	-40.7	49.5

*SSB at mid year

7.2 Medium term predictions

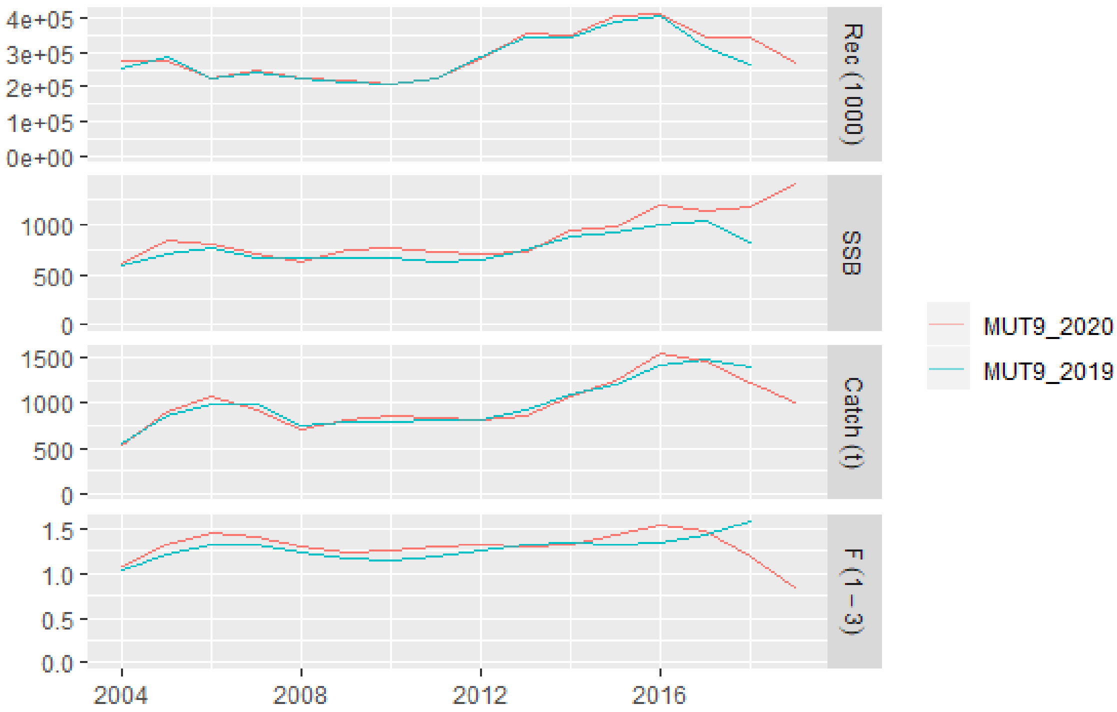
7.3 Long term predictions

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	$F_{0.1}$ = 0.51	$F_{current}$ = 0.85 ($F_{bar\ 1-3}$ in 2019)		D	IO_H
	Fishing effort				OTB N GTR D in the most recent yr	
	Catch				D	
Stock abundance	SSB		SSB2019 = 1409 t	33rd percentile = 732 t		O_H
				66th percentile = 937 t		
Recruitment					I	
Final Diagnosis		In high level of overfishing and overexploited with relative high level of biomass.				

Red Mullet in GSA 9 is increasing but the stock is being overfished.



Comparison of the outputs of the previous year assessment (blue line) and updated assessment performed this year (red line).

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)*