Stock Assessment Form

Demersal species

Mullus barbatus in GSA 17 & 18

Reference year: 2017

Reporting year: 2018

An $F_{0.1}$ of 0.41 was estimated using the FLBRP package. Considering that the F estimated by the a4a model for 2017 is 0.48, the stock is considered slightly overexploited.

Stock Assessment Form version 1.0 (January 2014)

Uploader: STECF EWG 18-16

Stock assessment form

I 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_17]	[GSA_18]	
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-18-16		
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:

Direct methods (you can choose more than one):

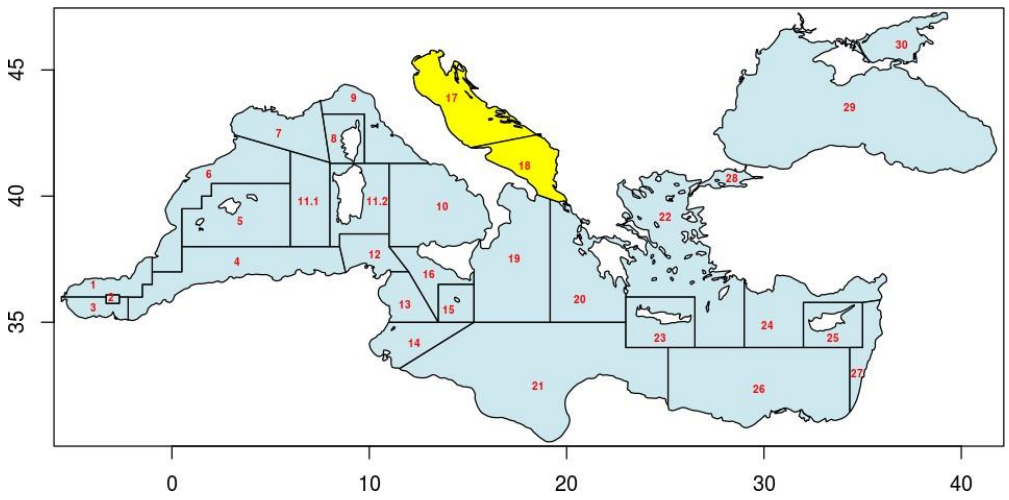
- Acoustics survey
- Egg production survey
- Trawl survey
- SURBA
- Other (please specify)

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



2.1Stock unit

STECF 18-16, after analysing the results of the STOCKMED project, concluded that the region represented by the GSAs 17 and 18, corresponding to the Adriatic Sea Sea, is considered inhabited by a unique stock unit. During the GFCM Working Group on Demersal Species (WGSAD) in 2017, a first attempt of joint assessment with Stock Synthesis model was presented. This attempt was made on the basis of the analysis of the survey indices, showing a very similar increasing trend in both areas in the recent years, and considering that the Western side of both GSAs was characterized by a decrease in effort from 2004 to 2016.

2.2Growth and maturity

Table 2-1.-1: Maximum size, size at first maturity and size at recruitment.

Somatic magnitude measured (LT, LC, etc)			**Units**	
Sex	**Mal**	**Combine d**	**Reproducti on season**	
Maximu m size observe d			**Recruitme nt season**	
Size at first			**Spawning**	
Maturity			**Area**	
Recruitment size to the fishery			**Nursery area**	

Maturity

The vector of proportion of mature individuals by age has been derived associating the proportion of matures of the length from DCF derived by von Bertalanffy calculated in the middle of age class. The assessment was carried out using the maturity at age estimated in GSA 18 from DCF data.

Table Red mullet in GSAs 17 and 18. Maturity at age.

Age	Prop. mature
0	0.0
1	0.7
2	1.0
3	1.0
4+	1.0

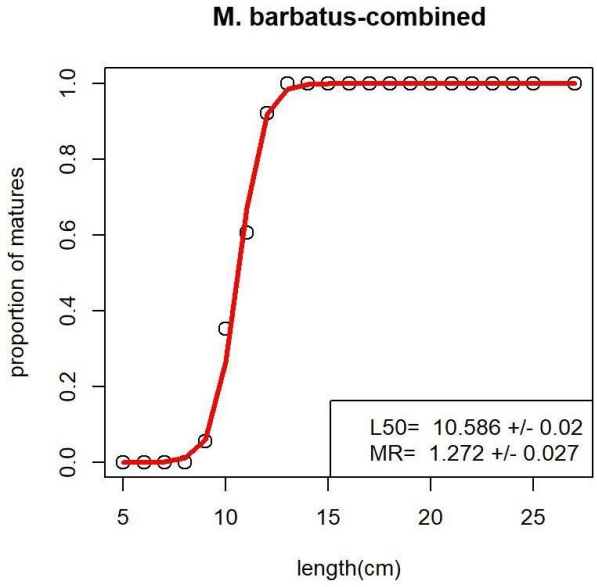


Figure Red mullet in GSAs 17 and 18. Maturity at length (sex combined) from DCF 2016.

Natural mortality

The natural mortality vector has been estimated as a weighted average by sex using the Chen and Watanabe method to be consistent with the benchmark assessments of GFCM WGSAD 2016 (where a sensitivity analysis on natural mortality vectors was carried out).

Table Red mullet in GSAs 17 and 18. Natural mortality at age (Chen and Watanabe model).

Age	M
0	1.41
1	0.71
2	0.52
3	0.42
4+	0.37

The parameters have been estimated in GSA 18 for sex combined, using the mean lengths from Age-Length key from commercial sampling (discard and landing) and MEDITS survey from 2011 to 2016. A constraint has been included in the VBF fitting to take into account the exceptional finding of 4 cm-sized metamorphosed individuals during MEDITS trawl survey.

Table 2-5: Growth and length weight model parameters

			Sex			
		Units	**female**	**male**	**Combined**	**Years**
Growth model	**L_∞**		29.185	22.725		
	K		0.247	0.328		
	t_0		-0.768	-0.816		
	Data source	DCF call 2018.				
Length weight relationship	**a**					
	b					
	M (scalar)					
	sex ratio (% females/total)					

3 Fisheries information

3.1Description of the fleet

The effort data are available for GSA17 (Italy and Croatia) and 18 (Italy). The fishing effort for the gears targeting red mullet in terms of GT*fishing days and fishing days is reported in following tables.

Table Red mullet in GSA 17 and 18. Fishing effort (GT*days at sea)/fishing gear/year in GSA 17-18 of the gears targeting red mullet in the same area.

Country/GSA	Year	GNS	GTR	OTB	TOTAL
HRV_17	2012	161601	126635	1289335	1577571
HRV_17	2013	146238	130299	1373511	1650048
HRV_17	2014	150427	116713	1381570	1648710
HRV_17	2015	144366	128027	1346257	1618650
HRV_17	2016	145114	109194	1231785	1486093
ITA_17	2006	216424	79544	4079669	4375637
ITA_17	2007	156782	101669	4056776	4315227
ITA_17	2008	135113	56788	4082465	4274366
ITA_17	2009	173403	65074	3830475	4068952
ITA_17	2010	190223	66358	3837446	4094027
ITA_17	2011	236375	79984	3482614	3798973
ITA_17	2012	259488	78308	3130643	3468439
ITA_17	2013	167797	64034	2645415	2877246
ITA_17	2014	233376	45568	2836181	3115125
ITA_17	2015	139371	55459	2872228	3067058
ITA_17	2016	178800	59674	3014054	3252528
ITA_18	2006	117032	31528	2662179	2810739
ITA_18	2007	70224	45292	229424	240975

ITA_18	2008	51447	83968	2039422	2174837
ITA_18	2009	79662	80946	2386555	2547163
ITA_18	2010	57056	79765	2068044	2204865
ITA_18	2011	44943	79593	1900240	2024776
ITA_18	2012	38287	60542	1668749	1767578
ITA_18	2013	78862	8196	1994855	2081913
ITA_18	2014	21679	51077	1463644	1536400
ITA_18	2015	78693	12679	1355193	1446565
ITA_18	2016	88202	5609	1429243	1523054

Table Red mullet in GSA 17 and 18. Fishing effort (Days at sea)/fishing gear/year in GSA 17-18 of the gear targeting red mullet in the same area.

Country/GSA	Year	GNS	GTR	OTB	TOTAL
HRV_17	2012	60504	34888	39128	134520
HRV_17	2013	56041	37239	39226	132506
HRV_17	2014	57411	34860	40553	132824
HRV_17	2015	56695	36132	39074	131901
HRV_17	2016	56630	32426	37201	126257
ITA_17	2006	323310	244244	434655	1002209
ITA_17	2007	224242	224242	382493	830977
ITA_17	2008	270057	197633	354510	822200
ITA_17	2009	526142	261673	345095	1132911
ITA_17	2010	424178	231216	329764	985157
ITA_17	2011	419686	344909	333303	1097898
ITA_17	2012	514255	227536	322785	1064577
ITA_17	2013	224894	245016	292130	762039
ITA_17	2014	258913	167612	259502	686027

ITA_17	2015	220612	140111	265839	626562
ITA_17	2016	266064	145210	258656	669930
ITA_18	2006	109714	80000	201679	391394
ITA_18	2007	71797	71797	176345	319940
ITA_18	2008	121136	81506	253577	456218
ITA_18	2009	124844	87533	316411	528788
ITA_18	2010	88940	88940	292887	470766
ITA_18	2011	87234	87234	222708	397177
ITA_18	2012	76470	76470	157792	310731
ITA_18	2013	82110	23036	143901	249047
ITA_18	2014	73021	73021	157301	303344
ITA_18	2015	63400	60311	154211	277922
ITA_18	2016	54072	47977	160570	262619

Table 3-2: Description of operational units exploiting the stock

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

Table 3.1-3: 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						

3.2Historical trends

- **Catch (landings and discards)**

Red mullet landings in GSAs come predominantly from OTB; a small amount is reported for small-scale fishing gears (gillnet and trammel net).

Table Red mullet in GSAs 17 and 18. Landings in GSA 17 by fishing gear and country over 2006-2017 as reported in the DCF (tonnes; GNS=gillnet; GTR=trammel net; PTM=mid-water pair trawl; TBB=beam trawl; OTB=otter bottom trawl).

	GSA 17 ITA	GSA 17 ITA	GSA 17 ITA	GSA 17 ITA	GSA 17 HVR	GSA 17 SLV	GSA 17 MLT	GSA 17
year	GNS	OTB	PTM	TBB	OTB	OTB	OTB	Total
2006		3100.6				1.9		3102.5
2007		3298.5				6.4		3304.9
2008		3158.3				2.0		3160.3
2009		2433.4				2.7		2436.1
2010		1796.2				1.3		1797.4
2011	31.2	1822.9		36.2		6.1		1896.3
2012	17.6	1463.6		43.2		3.6		1527.9
2013		1946.1	2.4	31.0	1084.3	2.4		3066.1
2014	7.6	2323.9	2.5	63.6	1151.7	3.3		3552.7
2015	15.6	2142.8		60.9	1128.1	3.4	0.5	3351.3
2016	4.5	2036.8			953.4	2.3		2997.0
2017	9.0	2659.0		4.0	985.5	3.4		3660.8

Table Red mullet in GSAs 17 and 18. Landings in GSA 18 by fishing gear and country over 2002-2017 as reported in the DCF (tonnes; GNS=gillnet; GTR=trammel net; OTB=otter bottom trawl).

year	GSA 18 ITA -1	GSA 18 ITA GNS	GSA 18 ITA GTR	GSA 18 ITA OTB	GSA 18 Total
2002	1707.3	89.6		3114.2	4911.1
2003	307.8	312.0		1749.8	2369.5
2004		82.5		1981.1	2063.6
2005		99.3		1350.0	1449.5
2006	1.2	123.5	6.3	1803.5	1934.4
2007	0.1	119.8	2.7	1679.6	1802.2
2008		41.9	4.7	914.2	960.8
2009		75.9	0.8	954.6	1031.3
2010		44.0	1.4	600.8	646.2
2011		37.1	0.4	494.2	531.7
2012		7.1	0.6	2088.6	2096.3
2013		47.0		1202.8	1249.8
2014		4.5	18.1	1249.6	1272.2
2015		15.3		1572.1	1587.4
2016		50.5		1397.6	1448.0
2017		0.2	66.3	553.0	619.5

Table Red mullet in GSAs 17 and 18. Discards by GSA, fishing gear and country as reported in the DCF (tonnes; GNS=gillnet;TBB=beam trawl; OTB=otter bottom trawl). Note the high amount OTB discards in GSA 17 in relation to landings.

year	GSA 17 ITA OTB	GSA 17 ITA TBB	GSA 17 SLV OTB	GSA 17 HRV OTB	GSA 17 Total	GSA 18 ITA GNS	GSA 18 ITA OTB	GSA 18 Total
2005			0.1					
2006			0.0					
2007			0.2					
2008			0.0					
2009			0.0				14.7	14.7
2010	183.0		0.0		183.0		35.0	35.0
2011	795.9	7.4	0.1		803.5	5.4	13.9	19.3
2012	324.6		0.1		324.6		434.1	434.1
2013	291.1		0.0	3.1	294.2	1.4	18.1	19.4
2014	446.4		0.1	2.2	448.7		119.6	119.6
2015	909.8		0.1	0.9	910.8		89.4	89.4
2016	499.2		0.0	1.1	500.3	87.4	87.4	
2017	1069.0	3.0	0.1	3.6	1075.7	13.2	13.2	

For Montenegro and Albania, the annual proportions in the length classes of GSA 17 and 18 were applied to the landing times series available from the same report (2007-2016). LFDs from Croatia were available from 2013; for landings from Croatia of previous years (2009-2012) the annual proportions in the length classes of GSA 17 and 18 were applied. No discard data were available for Albania and Montenegro.

Table Red mullet in GSAs 17 and 18. Total catch (tonnes). Albania and Montenegro data were obtained from GFCM WGSAD 2017.

	SA17 OTB_ITA	SA17 OTB_HRV	SA18 OTB_ALB	OTB_MTN	NET_MTN	SA18 OTB_ITA	SA18 NET_ITA	TOTAL
2006	3101.0					1803.0	130.0	5034.0
2007	3299.0		171.0			1680.0	123.0	5273.0
2008	3158.0	767.0	149.0	38.0	3.7	914.0	47.0	5076.7
2009	2433.0	818.0	154.0	36.0	3.6	969.7	77.0	4491.3
2010	1979.0	763.0	90.0	35.0	3.4	636.0	45.0	3551.4
2011	2694.0	1086.0	110.0	32.0	3.2	507.9	43.4	4476.5
2012	1849.0	1248.0	375.0	35.0	3.5	2523.1	8.0	6041.6
2013	2271.0	1086.0	373.0	32.0	3.1	1221.1	48.4	5034.6
2014	2844.0	1158.0	317.0	41.0	4.0	1369.6	23.0	5756.6
2015	3129.0	1127.0	388.0	36.0	3.6	1661.4	15.0	6360.0
2016	2541.0	951.0	396.0	36.0	3.6	1485.4	50.0	5463.0
2017	3744.0	990.0	392.0	36.0	3.6	566.0	67.0	5798.6

Red mullet LFDs of landings and discards by GSA and fishing gear as reported in the DCF are presented in following figures.

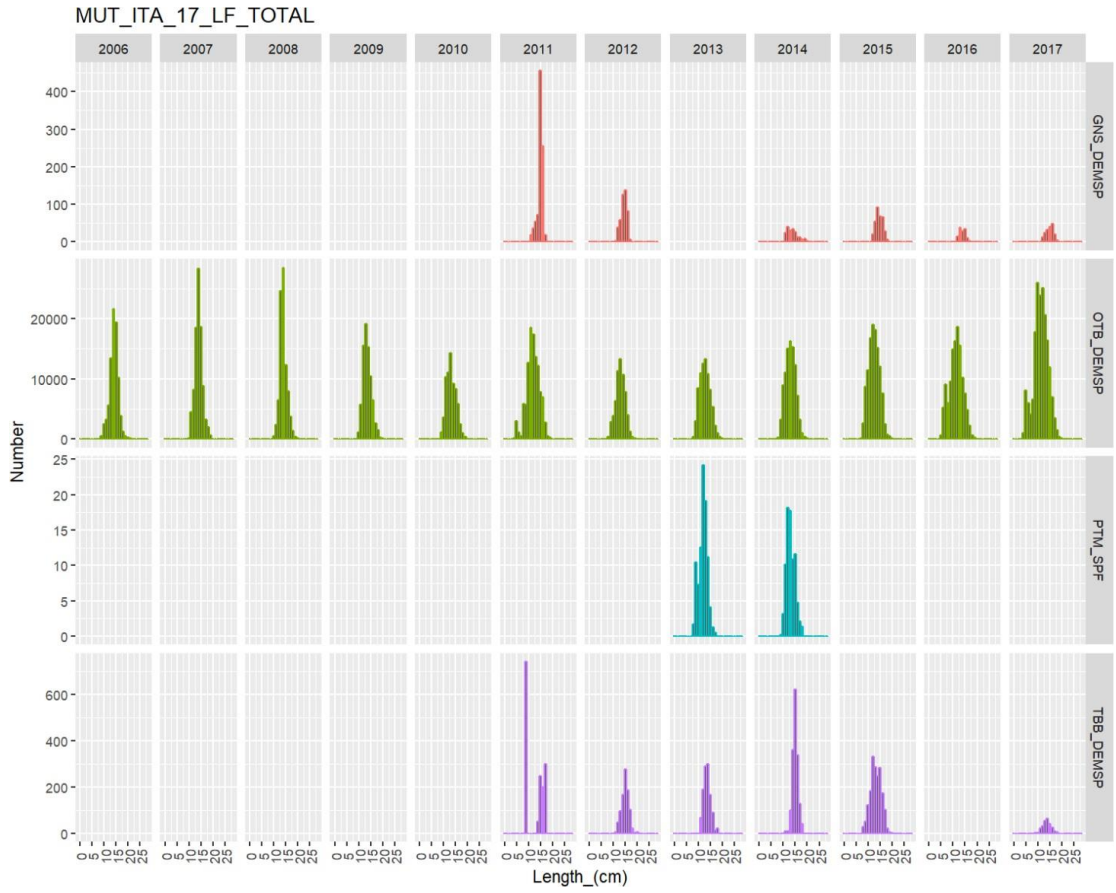


Figure Red mullet in GSAs 17 and 18. Catch (landings+discards) LFD in GSA 17, Italy.

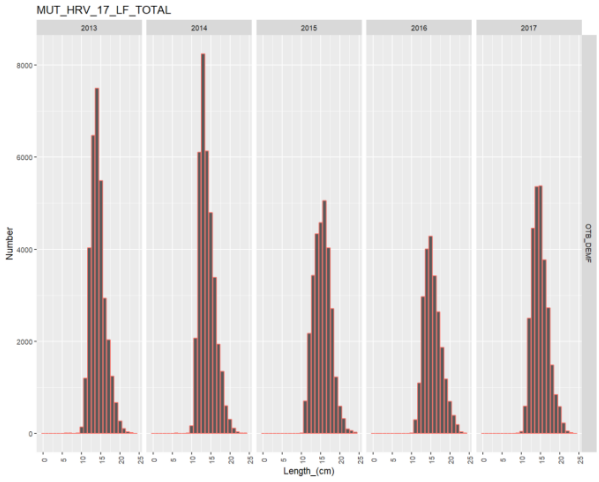


Figure Red mullet in GSAs 17 and 18. Catch (landings+discards) LFD in GSA 17, Croatia.

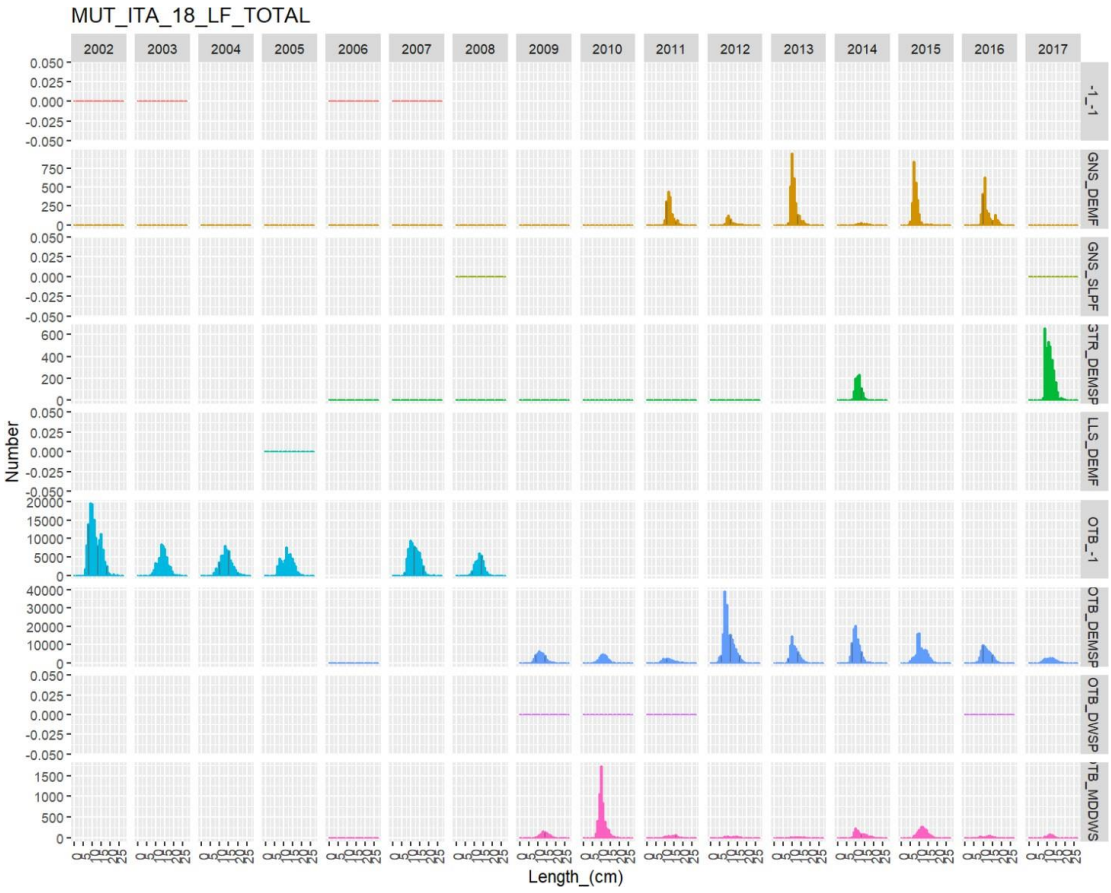


Figure Red mullet in GSAs 17 and 18. Catch (landings+discards) LFD in GSA 18, Italy.

3.3Management regulations

3.4Reference 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 Referen ce point/e mpirical referenc e value	Value	Comments
B					
SSB					
F			$F_{0.1}$	0.41	STECF-18-16
Y					
CPUE					
Index of Biomass at sea					

4 Fisheries independent information

MEDITS survey data are available from the official Data call for GSA 17 and for GSA 18 from 1994. All the Countries are covered by the survey data. For the present assessment the data from 2006 to 2017 were used.

The long duration and the shift in the survey time in some years (Italy) may be critical for species such as red mullet, with a short spawning period, in late spring, and recruitment in autumn. Thus, in the years when the survey ends in summer recruits will be absent or their presence very low, while when the survey ends in autumn recruits will be present in the catches.

All the surveys explored reveal a strong increase in the density and in the biomass indices from 2011 onwards.

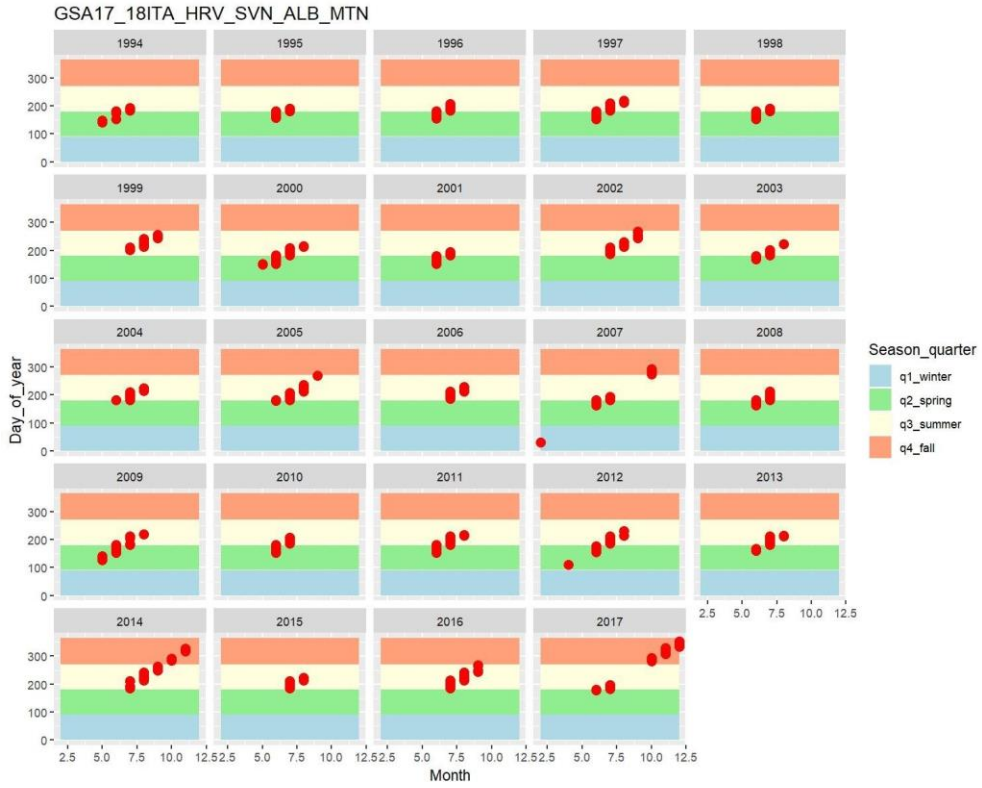


Figure Red mullet in GSAs 17 and 18. MEDITS survey period over 1994-2017. Note that the duration of the MEDITS survey, depending on the year, extends over different quarters.

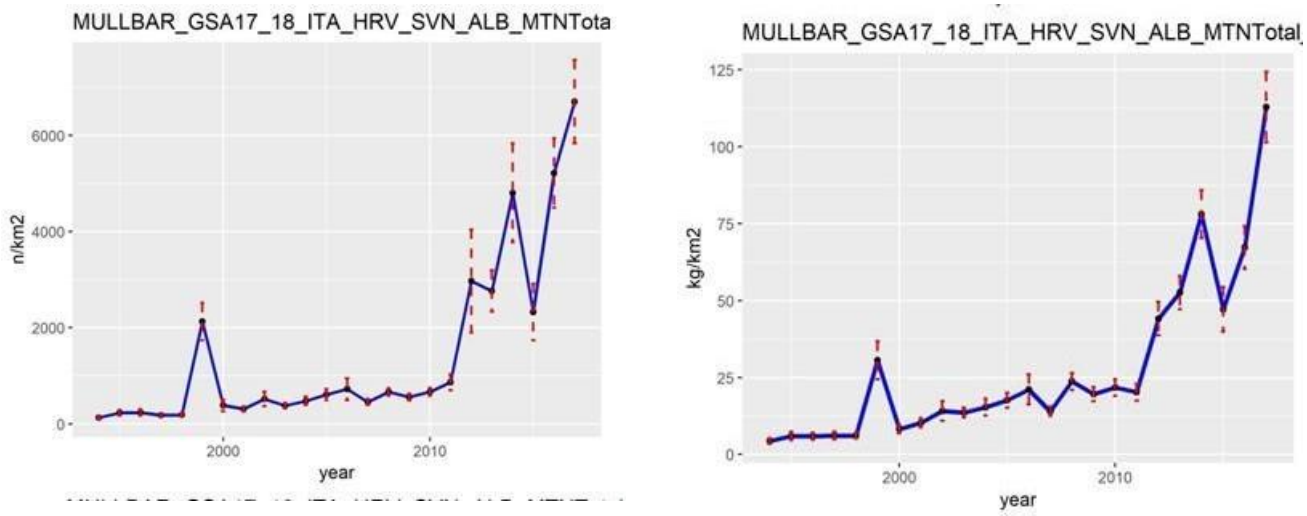


Figure Red mullet in GSAs 17 and 18. MEDITS abundance (n/km^2) and biomass (kg/km^2) over 1994-2017.

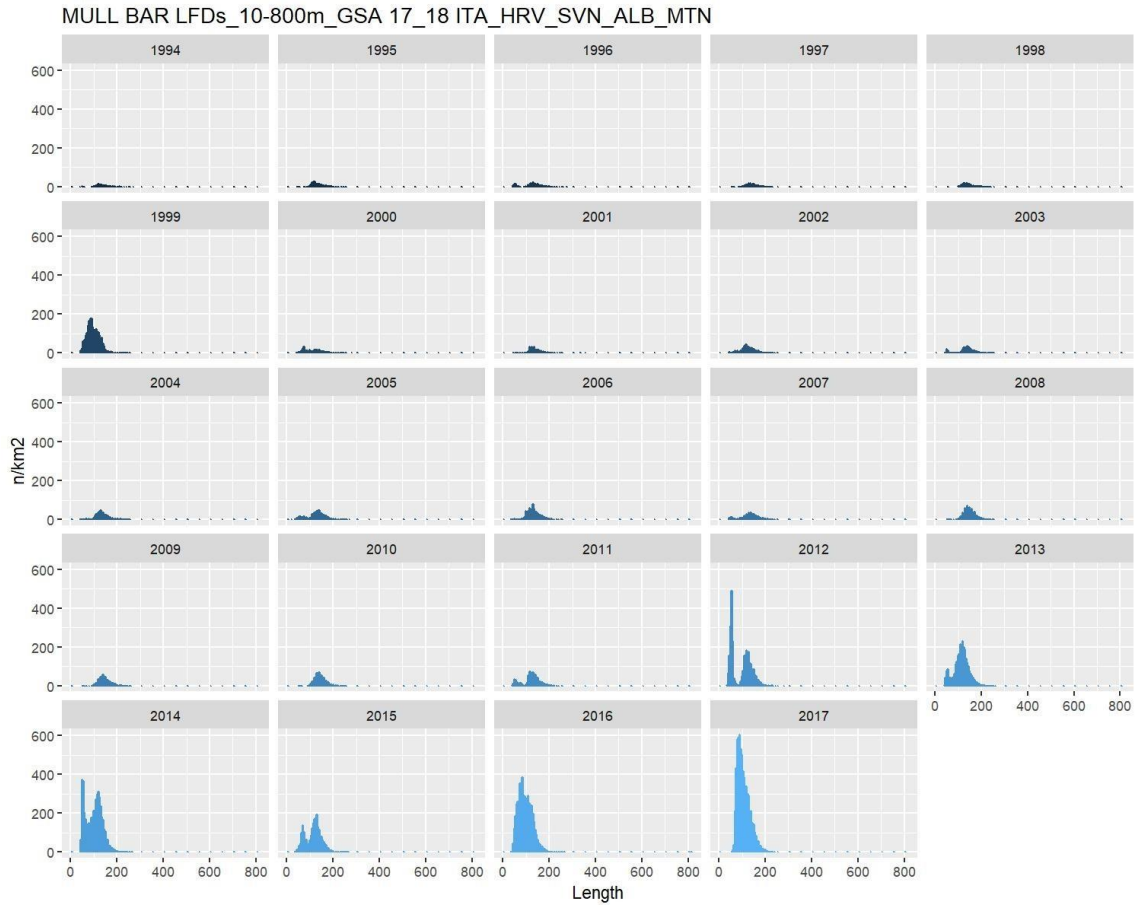


Figure Red mullet in GSAs 17 and 18. MEDITS Length frequency distribution (TL mm; n/km^2).

5 Ecological information

6 Stock Assessment

Methods: a4a (Assessment for all)

A4a is a flexible statistical catch at age stock assessment model, based on linear modelling techniques, not working by fleet. The method was developed within FLR framework.

Input data

The MEDITS indices by length were estimated treating the two GSAs combined as a unique area, starting from the TC files and re-stratifying the single hauls in the TA files.

Commercial catch, LFDs were available from 2002 only in GSA 18 (Italy); therefore, it was decided to use data from 2006 onwards, as LFDs are available in the two GSAs from most of the countries.

The length frequency distributions of all the fleets and the MEDITS LFDs on the whole area were age sliced by means of a deterministic slicing (l2a function available in FLR) using the von Bertalanffy parameters reported in the EU DCF database for GSA18. The LW relationship parameters available on the DCF database were used to calculate the mean weight-at-age. Age slicing and the computation of mean weight-at-age were performed by sex, then age structures were pulled together, while the mean weight-at-age for sex combined was estimated as a weighted average of the mean weight-at-age by sex.

The catch-at-age matrices,overall catch in weight by year and age structure of catch and survey are reported in following tables.

The natural mortality vector and the maturity at age are the same reported in previous paragraphs. The M and F before spawning were set equal to 0.5. The mean weights-at-age for the stock and for the catch are reported.

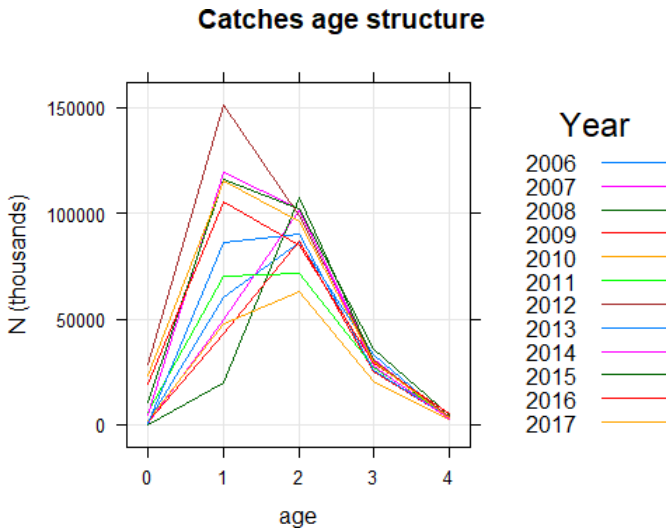


Figure Red mullet in GSAs 17 and 18. Catch at age (landings+discards), all gears and GSAs combined.

Table Red mullet in GSAs 17 and 18. Commercial catch in numbers at age used in the a4a assessment (thousands).

Year/Age	0	1	2	3	4+
2006	1054	60486	86284	33093	2749
2007	808	49414	101541	31337	2444
2008	45	19932	107572	30437	2789
2009	1143	42817	87199	25381	3245
2010	1703	48071	62838	20328	2522
2011	5779	70435	71646	27023	3688
2012	28732	151177	98598	30612	3961
2013	411	86459	90197	26008	2987
2014	4879	119347	102445	27779	2874
2015	10372	116230	102103	36029	4869
2016	18968	105241	85230	29244	4964
2017	23307	115277	96361	29854	3521

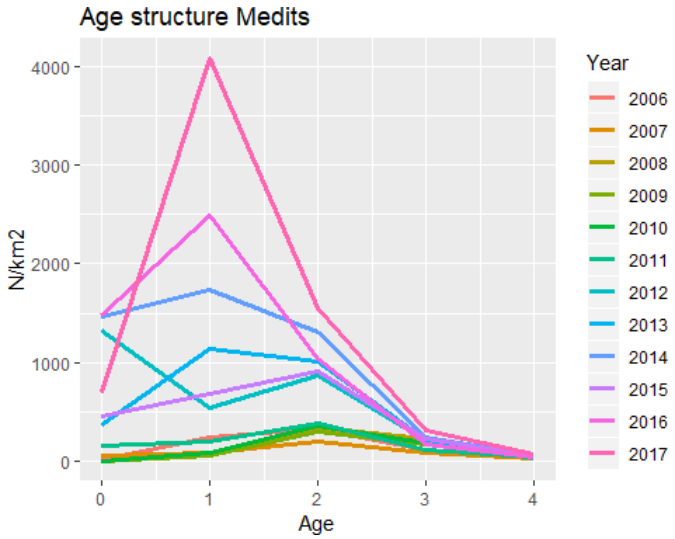


Figure Red mullet in GSAs 17 and 18. Catch at age in the MEDITS survey (GSA17 and 18 combined).

Table Red mullet in GSAs 17 and 18. MEDITS catch in numbers at age used in the a4a assessment (N/km^2).

Year/Age	0	1	2	3	4+
2006	8.2	236.1	325.9	113.0	38.3
2007	50.3	87.5	199.8	87.1	28.1
2008	1.5	57.2	331.8	219.6	52.6
2009	0.6	54.2	290.4	162.2	46.8
2010	0.3	84.5	355.5	184.4	41.2
2011	146.0	194.7	382.1	111.5	32.4
2012	1325.3	531.5	864.5	207.5	28.4
2013	371.8	1129.5	1010.7	208.9	41.0
2014	1463.7	1729.2	1311.2	244.3	52.4
2015	452.9	677.9	909.5	227.8	56.6
2016	1477.4	2489.8	1038.0	173.4	42.9
2017	695.3	4082.9	1548.5	306.8	66.1

Table Red mullet in GSAs 17 and 18. Catch in weight by year (tons).

Year	**Catch (tons)**
2006	5034
2007	5272
2008	5077
2009	4491
2010	3552
2011	4476
2012	6041
2013	5034
2014	5756
2015	6361
2016	5462
2017	5798

Table Red mullet in GSAs 17 and 18. Individual weight at age for the in the catch and stock (kg).

Year	0	1	2	3	4+
2006	0.004	0.012	0.029	0.048	0.075
2007	0.004	0.012	0.029	0.048	0.075
2008	0.004	0.014	0.029	0.049	0.078
2009	0.003	0.014	0.027	0.050	0.080
2010	0.003	0.013	0.027	0.049	0.081
2011	0.002	0.012	0.027	0.049	0.081
2012	0.003	0.010	0.027	0.049	0.079
2013	0.003	0.012	0.027	0.049	0.078
2014	0.003	0.012	0.027	0.049	0.079
2015	0.003	0.012	0.028	0.049	0.080
2016	0.003	0.012	0.027	0.049	0.082
2017	0.002	0.012	0.027	0.050	0.079

Different combinations of F, q and stock-recruitment sub-models were explored. The list of the sub-models is reported below:

F sub-model:

~ te(age, year, k = c(3,5)) + s(year, k = 4, by = as.numeric(age==0))

~s(age, k = 3) + s(year, k = 5,6,7)

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

~s(age, k = 3) + s(year, k = 5) + s(year, k = 5, by = as.numeric(age == 0))

~ s(replace(age,age>3,3),k = 3, by = breakpts(year, c(2014))) + s(year, k = 5) + s(year, k = 5, by = as.numeric(age==0))

q sub-models:

~s(replace(age, age > 3, 3), k = 3)

~factor(age)

~factor(replace(age, age > 3, 3))

~s(age, k=4, by = breakpts(year, 2012))

~ s(replace(age,age>3,3),k = 3, by = breakpts(year, 2012))

SR sub-models:

~factor(year)

~s(year, k = 4)

An F_{bar} range between age 1 and 3 was used. Age 0 was removed from the survey index.

The best model (combination of the sub-models in bold) was chosen on the basis of retrospective analysis and residuals.

In the best model, it was assumed a change in survey catchability from 2012, due to a change in the survey period, and a change in the behaviour of the fleet from 2014, due to the enforcement of the regulation that does not allow to fishermen to fish within the 3 nautical miles (where the smaller individuals are generally distributed). A specific term in the F sub-model is dedicated to the fitting of the F at age 0.

The F time series estimated by a4a ranges between 1.10 and 0.48, with an overall decrease with time. In the last years, the model estimates a strong increase in SSB and recruitment.

The fishing mortality at age shows the maximum values in age 2 and 3, decreasing in time.

In general, the fitting of the commercial catch at age and survey index at age is acceptable. The internal consistency of both catches and survey indices is good, particularly for ages 0,1 and 2 which dominate the population.

The residuals are generally small (between -3 and 3) and quite random distributed by age, but a signal of a trend in the fit is shown by the bubble plot of residuals in the last years.

Table Red mullet in GSAs 17 and 18. Results of the final a4a run: F_{bar} (1-3) overall, SSB, Recruitment and total biomass.

Year	F_{bar} (1-3)	Recruitment (thousands)	SSB (tons)	Total biomass (tons)
2006	1.10	1526151	5602	18432
2007	1.08	1526428	5370	17855
2008	1.06	1558639	5280	17737
2009	1.03	1654707	5035	16982
2010	0.99	1836043	5126	17249
2011	0.95	2101404	5375	16044
2012	0.91	2411939	5319	19058
2013	0.85	2685772	6764	23109
2014	0.77	2828251	7645	26216
2015	0.67	2793590	9015	26220
2016	0.57	2619415	10306	27956
2017	0.48	2391365	11433	25860

Table Red mullet in GSAs 17 and 18. Results of the final a4a run: F-at-age.

Year	0	1	2	3	4+
2006	0.00	0.17	1.00	2.13	2.49
2007	0.00	0.15	1.04	2.05	1.88
2008	0.00	0.14	1.06	1.98	1.56
2009	0.00	0.15	1.04	1.90	1.56
2010	0.00	0.19	0.97	1.82	1.89
2011	0.00	0.25	0.90	1.72	2.25
2012	0.00	0.28	0.87	1.59	2.12
2013	0.00	0.27	0.87	1.41	1.52
2014	0.00	0.25	0.87	1.20	0.94
2015	0.00	0.23	0.82	0.96	0.57
2016	0.01	0.23	0.74	0.73	0.35
2017	0.02	0.23	0.65	0.55	0.22

Table Red mullet in GSAs 17 and 18. Results of the final a4a run: Stock numbers-at-age.

Year	0	1	2	3	4+
2006	1526151	475163	179101	41122	3500
2007	1526428	372300	196473	39167	3415
2008	1558639	372450	157852	41167	3670
2009	1654707	380334	159672	32405	4284
2010	1836044	403707	161219	33663	3798
2011	2101404	447635	164362	36481	3969
2012	2411939	511616	172226	39862	4569
2013	2685772	586661	190085	43034	5730
2014	2828251	653467	219459	47275	7756
2015	2793590	688248	250217	54703	11482
2016	2619415	678957	267625	65315	18286
2017	2391365	633687	265319	75827	29535

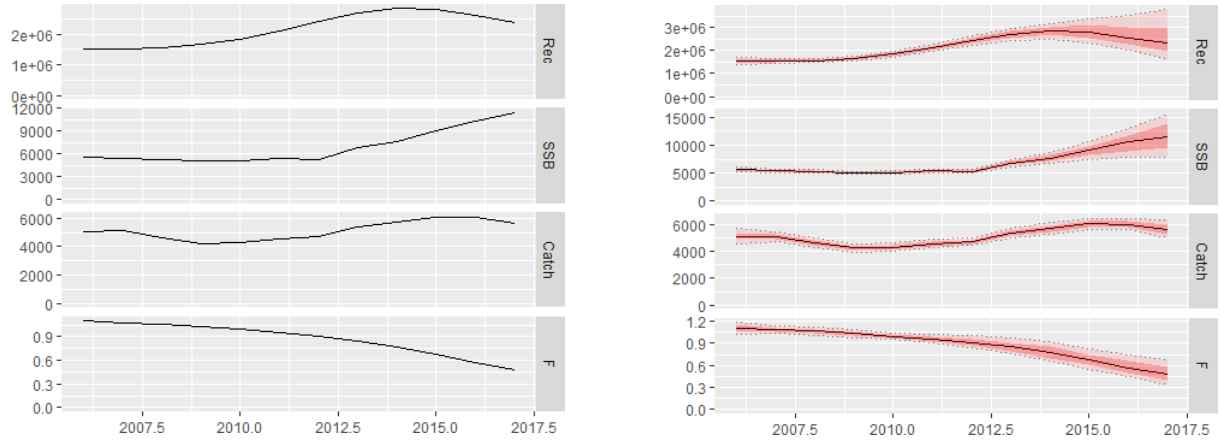


Figure Red mullet in GSAs 17 and 18. Summary of the results.

6.1Robustness analysis

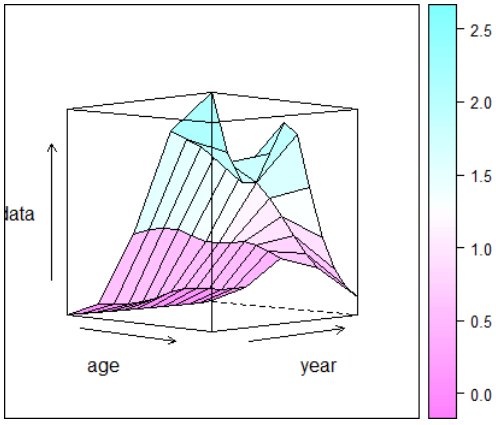


Figure R**ed mullet in GSAs 17 and 18.** Fishing mortality (left) and catchability (right) by age and year.

Figure Red mullet in GSAs 17 and 18. Comparison between observed and fitted catch (left) and index (right) at age

Figure Red mullet in GSAs 17 and 18. Log-residuals (left) and qq-plot (right) of catch and abundance indices by age.

Figure Red mullet in GSAs 17 and 18. Bubble plot of residuals.

- **Retrospective analysis, comparison between model runs, sensitivity analysis, etc.**

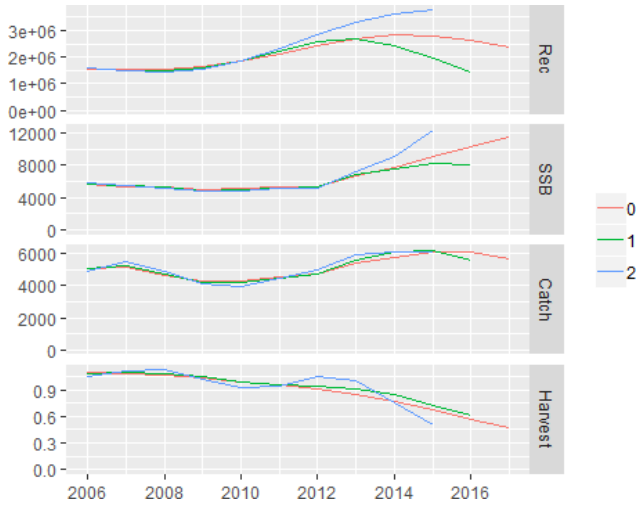


Figure Red mullet in GSAs 17 and 18. Retrospective analysis

7 Stock predictions

An $F_{0.1}$ of 0.41 was estimated using the FLBRP package. Considering that the F estimated by the a4a model for 2017 is 0.48, the stock is considered slightly overexploited.

7.1Short term predictions

A deterministic short-term prediction for the period 2018 to 2020 was performed using the FLR libraries and scripts, and based on the results of the a4a stock assessment.

The input parameters for the deterministic short-term predictions for the period 2016 to 2018 were the same used for the a4a stock assessment and its results. An average of the last three years has been used for weight at age, maturity at age, while the F_{bar} terminal from the a4a assessment was used due to a clear decreasing trend in F in the whole time series.

Recruitment (age 0) has been estimated from the population results as the geometric mean of the last 7 years (2535525 thousand individuals). It was decided to use the last 7 years as they showed a clear shift in recruitment abundance compared to the first part of the time series. Catch in 2017 is 5652 from the a4a assessment, catch in 2018 is 5773 assuming Status quo F based F 2017 for F in 2018.

Table Red mullet in GSAs 17-18. Short term forecast in different F scenarios.

Rationale	Ffactor	Fbar	Catch 2019	Catch 2020	SSB 2019	SSB 2020	Change SSB 2018-2020 (%)	Change Catch 2017-2019 (%)
Zero catch	0.0	0.00	0.0	0.0	15141.9	21396.0	80.0	-100.0
High long term yield ($F_{0.1}$)	0.9	0.41	5083.2	5423.5	12537.5	13334.4	12.2	-10.1
F_{upper}	1.2	0.56	6519.2	6301.8	11714.1	11374.0	-4.3	15.3
F_{lower}	0.6	0.27	3606.0	4228.7	13340.0	15501.5	30.4	-36.2
Status quo	1.0	0.48	5746.2	5862.9	12162.9	12411.0	4.4	1.7
Different Scenarios	0.1	0.05	699.1	969.8	14808.0	20188.7	69.8	-87.6
	0.2	0.10	1366.5	1827.4	14482.7	19064.4	60.4	-75.8
	0.3	0.14	2003.9	2584.9	14165.8	18017.2	51.6	-64.5
	0.4	0.19	2612.9	3253.2	13857.0	17041.1	43.3	-53.8
	0.5	0.24	3194.8	3841.9	13556.1	16131.0	35.7	-43.5
	0.6	0.29	3751.2	4359.6	13262.9	15281.9	28.6	-33.6
	0.7	0.33	4283.3	4814.0	12977.2	14489.3	21.9	-24.2
	0.8	0.38	4792.4	5212.0	12698.8	13749.1	15.7	-15.2
	0.9	0.43	5279.7	5559.8	12427.4	13057.5	9.8	-6.6
	1.1	0.52	6193.1	6126.2	11905.1	11806.2	-0.7	9.6
	1.2	0.57	6621.4	6354.0	11653.8	11240.1	-5.4	17.1
	1.3	0.62	7031.9	6550.4	11408.7	10710.1	-9.9	24.4
	1.4	0.67	7425.6	6718.8	11169.8	10213.5	-14.1	31.4
	1.5	0.71	7803.3	6862.3	10936.9	9747.9	-18.0	38.1
	1.6	0.76	8165.7	6983.8	10709.8	9311.3	-21.7	44.5
	1.7	0.81	8513.8	7085.7	10488.3	8901.4	-25.1	50.6
	1.8	0.86	8848.1	7170.4	10272.3	8516.6	-28.4	56.5
	1.9	0.90	9169.3	7239.7	10061.7	8154.9	-31.4	62.2
	2.0	0.95	9478.1	7295.5	9856.2	7814.9	-34.3	67.7

7.2Medium term predictions

7.3Long term predictions

8 Draft scientific advice (Examples in blue)

Based on	Indicator	Analytical 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	$F_{0.1}$ = 0.41			Last year	IO
	Fishing effort					
	Catch					
Stock abundance	Biomass			66th percentile		S_H
	SSB					
Recruitment					I	
Final Diagnosis		An $F_{0.1}$ of 0.41 was estimated using the FLBRP package. Considering that the F estimated by the a4a model for 2017 is 0.48, the stock is considered slightly overexploited.				

For more information see:

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

8.1Explanation 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)*