Stock Assessment Form

Demersal species

Red mullet – GSA01

Reference years:2003-2019

Reporting year:2020

Trawl and trammel net fishery data for the period 2003-2019 have been used to assess the *Mullus barbatus* stock in the GSA01.The assessment has been carried out applying statistical catch at age model (a4a) and Y/R analysis. To this aim, FLR libraries under R language were used. Results indicate that average fishing mortality for ages 1-2 showed increase trend until 2009 decreasing from 2010 to 2013 raising afterward again until 2019.Fcurr (1.9) is higher than F0.1 (0.29), chosen as proxy of FMSY, which indicates that red mullet stock in GSA 01 is in high overfishing with relative low biomass and spawning stock biomass.

Stock Assessment Form version 1.0 (January 2014)

Uploader: *Cristina García Ruiz*

Stock assessment form

1 Basic Identification Data

Scientific name:	Common name:	ISCAAP Group:
Mullus barbatus	Red mullet	33 MUT[
1st Geographical sub-area:	**2nd Geographical sub-area:**	**3rd Geographical sub-area:**
[GSA_1]		
4th Geographical sub-area:	**5th Geographical sub-area:**	**6th Geographical sub-area:**
1st Country	**2nd Country**	**3rd Country**
Spain		
4thCountry	**5thCountry**	**6thCountry**
Stock assessment method: (direct, indirect, combined, none)		
SCAA (a4a)		
Authors:		
GARCÍA-RUIZ, Cristina[1]; PÉREZ GIL José Luis[1]; GARCÍA-RODRÍGUEZ, Encarnación[2], GONZÁLEZ María[1];TORRES Pedro[1]; SERNA J.Miguel[1]; ACOSTA, Jesús[1]; CIERCOLES Cristina[1]; LEON Estefanía[1]		
Affiliation:		
(1) Instituto Español de Oceanografía (IEO). Málaga. Spain. (2) Instituto Español de Oceanografía (IEO). Murcia. Spain.		

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

2 Stock identification and biological information

Specify whether the assessment is considered to cover a complete stock unit. If the stock unit limits are more or less known, but for technical reasons the assessment only covers part of the stock (e.g. a GSA area but stock spreads to other GSAs), explain the state of the art of the stock unit knowledge. If there are doubts about the stock unit, state them here. If there is knowledge on migration rates between different stock units that affect the stock state them here.

2.1 Stock unit

Due to the lack of information about the structure of the population in the Western Mediterranean, it is considered that the stock limits of the assessed *Mullus barbatus* are in agreement with the limits of GSA 01.

2.2 Growth and maturity

Incorporate different tables if there are different maturity ogives (e.g. catch and survey). Also incorporate figures with the ogives if appropriate. Modify the table caption to identify the origin of the data (catches, survey). Incorporate names of spawning and nursery areas and maps if available.

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**	May-July
Maximum size observed			32 (1)	**Recruitment season**	October-December
Size at first maturity			13.7 (2)	**Spawning area**	Continental shelf (4)
Recruitment size to the fishery			7.8 for the period 2004-2010 13.7 for the period 2011-2016 (3)	**Nursery area**	Coastal areas

(1) Size composition of trawl catches in GSA01.

(2) From the Spanish DCF National Programme (2016)

(3) García-Rodriguez, M. and Fernández, A.M.2005.

(4) Lombarte, A.; L. Recasens; M. González and L. Gil de Sola (2000)

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

Table 2.2-3-: M vector and proportion of matures by size or age (females)

Table 2.2-4: M vector and proportion of matures by size or age (both sex)

Size/Age	Natural mortality	Proportion of matures
Age 0	*1.73*	*0.127*
Age 1	*0.57*	*0.929*
Age 2	*0.47*	*0.999*
Age 3+	*0.42*	*1.000*

Table 2.2-5: Growth and length weight model parameters

			Sex			
		Units	**female**	**male**	**Combined**	**Years**
Growth model	**L_∞**	cm			34.5	cm
	K				0.34	
	t_0				-0.143	
	Data source	Demestre *et al*., 1997 (adopted by SGMED-08-03)				
Length weight relationship	**a**				0.0075	
	b				3.1278	
	M (scalar)	0.42				
	sex ratio (% females/total)	0.69	L/W relationship from DCF; M from Chen & Watanabe			

3 Fisheries information

3.1 Description of the fleet

In GSA 01, red mullet are among the most important target species for the trawl fisheries. It is largely exploited in all the trawlable areas, both sandy and muddy bottoms mainly by trawlers on the shelf, but also by small-scale fisheries in particular trammel nets (about the 12% of the catches). The amount of discards reported is very low and considered to be negligible. Trawl fisheries developed along the continental shelf and upper slope are multi-specific. Smaller vessels operate almost exclusively on the continental shelf (targeting red mullets, octopus, hake and sea breams) and bigger vessels operate almost exclusively on the continental slope). Remaining can operate on the continental shelf and slope fishing grounds. Red mullet is intensively exploited during its recruitment from September to November. The total trawl fleet has declined from 2003 to 2019, from a maximum number of 188 trawlers in 2006, the GSA 1 fleet catching red mullet is nowadays composed by 88 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*	ESP	01	E – Trawl (12-24 m)	03 - Trawl	33-Demersal shelf species	MUT
Operational Unit 2*	ESP	01	C- Minor Gears	0?– Trammel nets	33-Demersal shelf species	MUT

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

Operational Units*	Fleet (n° of boats. Average 2015-2019)*	Catch (T average 2015-2019 of the species assessed)	Other species caught (names and weight)	Discards (species assessed)	Discards (other species caught)	Effort average2015-2019 (days)
03 Trawls GSA 01	105	154				6117
Trammel nets GSA 01	177	38				2343
Total	282	192				8460

3.2 Historical trends

In the period assessed landings from trawler showed inter annual oscillations without any clear trend (Figure 3.2-1). Total catch increased from 2005 to 2009; after this period decreased with a very sharp decline during 2012. Afterwards, there was an increment trend until 2017 and it decreased until 2019. Landings from trammel net fisheries did not show any trends either with a peak during 2016 decreasing also until 2019.

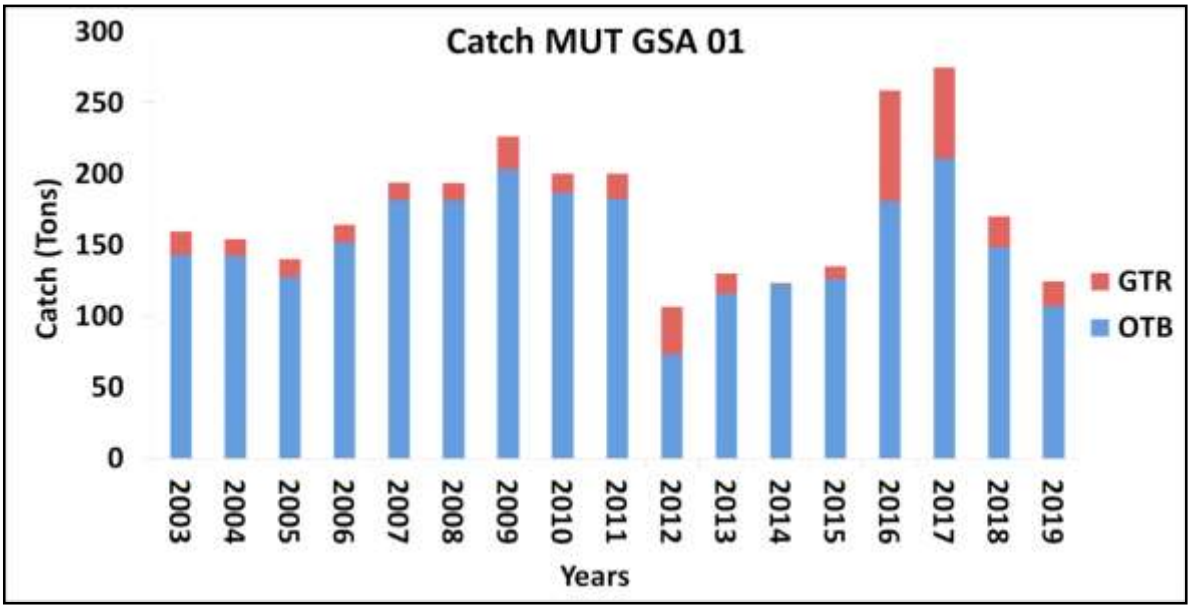

Figure 3.2-1 Catch of red mullet in the GSA 01 for trawler (blue) and trammel net fisheries (red) (2003-2019)

3.3 Management regulations

Trawl fisheries

- Engine power limited to 316 KW or 500 CV.
- Mesh size in the cod-end (50 mm diamond or 40 mm square).
- Fishing forbidden less 50 m depth
- Time at sea: 12 hours per day and 5 days per week
- Temporal bans depending on years

Trammel nets fisheries

- Minimum size of net: 14 mm

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		242		596	B mean as a referent point (B low = 242
SSB		161		295	SSB mean as a referent point (SSB low = 161)
F		1.94		0.30	F0.1 as a referent point
Y		125		174	Y mean as a referent point (Y low = 106)

4 Fisheries independent information

4.1 MEDITS

4.1.1. Brief description of the direct method used

Fishery independent information was based on MEDITS (International Trawl Survey in the Mediterranean Sea) carried out during the spring from 1994 to 2019. The covered area was between 30 and 800 m depth. The randomized stratified sampling design defined five bathymetric strata: 30–50 m ,51–100 m, 101–200 m , 201–500 m and 501–800 m. Haul duration varied according to depth: 30 min at depths above 200 m and 60 min below 200 m. All the surveys were carried out with the same otter bottom trawler (GOC-73) using a net with a cod mesh size of 20 mm. Mean towing speed of the vessels was 3.0 knots. The values of the vertical and horizontal opening of the gear were monitored by a trawl sensor device.

Table 4.1.1-1 Trawl survey basic information

Survey	MEDITS 2019	**Trawler/RV**	Miguel Oliver
Sampling season	SPRING		
Sampling design	Random stratified with number of haul by stratum proportional to stratum surface		
Sampler (gear used)	GOC-73		
Cod –end mesh size as opening in mm	20		
Investigated depth range (m)	30-800		

Table 4.1.1-2 Trawl survey sampling area and number of hauls during MEDITS carried out in 2019

Stratum	**Trawlable surface (km^2)**	**Swept area (km^2)**	**Number of hauls**
A (-50m)	510	0.1356	3
B (50-100m)	1951	0.6537	13
C (100-200m)	1086	0.4661	10
D (200-500 m)	3461	1.844689	17
E (+500m)	4912	1.7210	15
Total (km^2)	**11920**	**4.8213**	**58**

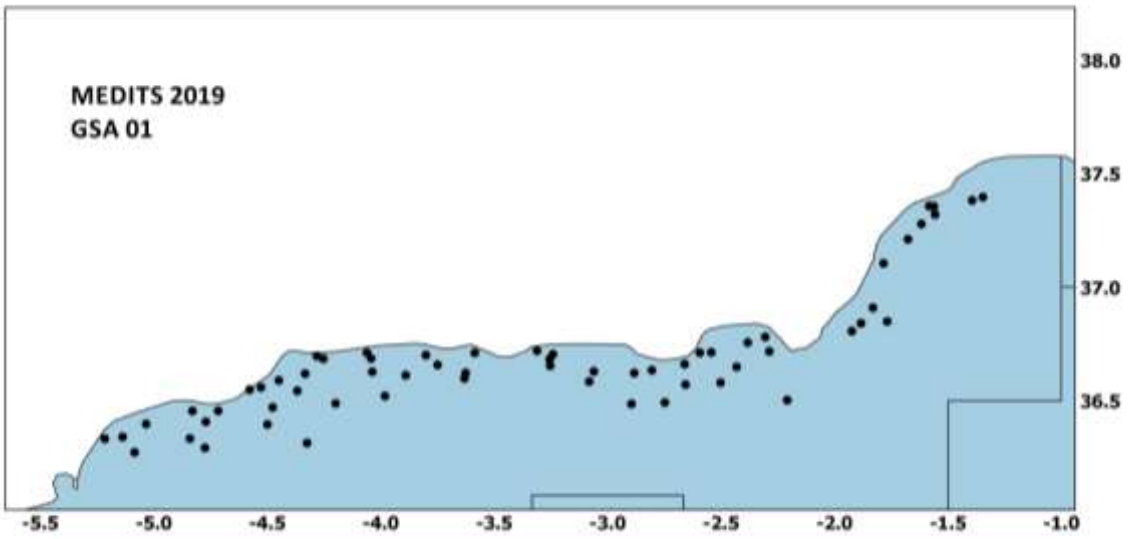

Figure 4.1.1-1 Hauls position carried out in MEDITS during 2019

4.1.2. Spatial distribution of the resources

During MEDITS surveys carried out in Alboran Sea in 2019, red mullet was caught between 45-150 m depth being more abundant on the eastern part of Alboran Sea and in the inner continental shelf (30-100 m)(Figure 4.1.2-1).

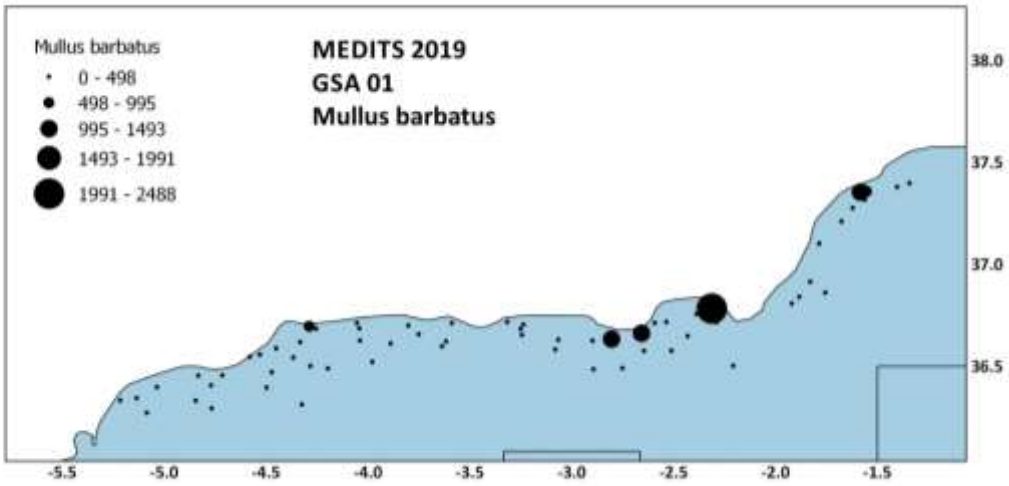

Figure 4.1.2-1 Map of the distribution of red mullet collected during MEDITS (2019)

4.1.3 Historical trends

Figures 4.1.3-1 show the estimated trend of red mullet from MEDITS for the assessed period. Abundance and biomass indices showed several oscillations with a sharp increase during 2006 decreasing afterwards with more stable values until 2019. There is a decrease trend from 2016.

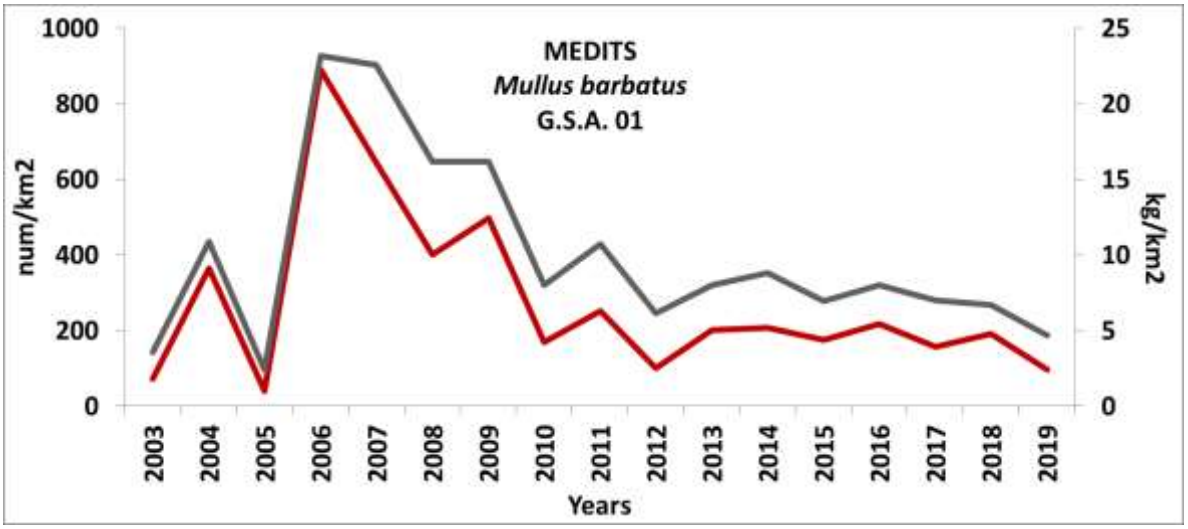

Figure 4.1.3-1 Red mullet abundance (red) (num/km^2) and biomass (black) (kg/km^2) indices from MEDITS (2003-2019)

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. Chla or other that may affect catchability, etc.) can be reported here.

6 Stock Assessment

In this section there will be one subsection for each different model used, and also different model assumptions runs should be documented when all are presented as alternative assessment options.

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

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

The assessment by means of a4a was carried out using as input data the period 2003-2019 for the catch data and 2003-2019 for the tuning file (MEDITS indices).
A natural mortality vector computed using Chen & Watanabe methodology. Length-frequency distributions of commercial catches and surveys were split by sex and then transformed in age classes (plus group was set at age 3) using length-to-age slicing.

Input parameters and model settings

Age group	M (Chen & Watanabe)	Maturity (DCF)
0	1.73	0.127
1	0.57	0.929
2	0.47	0.999
3+	0.42	1.000

Growth parameters (Demestre et al, 1997)

L inf = 34.5; K = 0.34; T_0 = -0.143

L/W relationship (DCF)

a = 0.0075; b 3.1278

Model:

For the assessment purposes, the following a4a sub model was chosen to obtain the best fit:

Fishing mortality sub-model:**fmod<- ~s(age, k=4, by = breakpts(year, 2009)) + s(year, k=4)**

Catchability sub-model:**qmod<- list(~factor(replace(age,age>1,1)))**

srmod<- ~ s(year,k=7)

6.1.4 Results

Figure 6.1.5-1 shows the results of the assessment run using a4a. Recruits showed fluctuations from 2003 to 2019 peaking on 2015 and decreasing afterwards. SSB showed fluctuations during assessed period with lowest values from 2011 to 2013-and highest values during 2016 and 2017, decreasing until 2019. Similar pattern was observed on catch. Fishing mortality showed increase trend until 2009 decreasing on 2010 raising after 2013 with maximum values during 2018 and 2019.

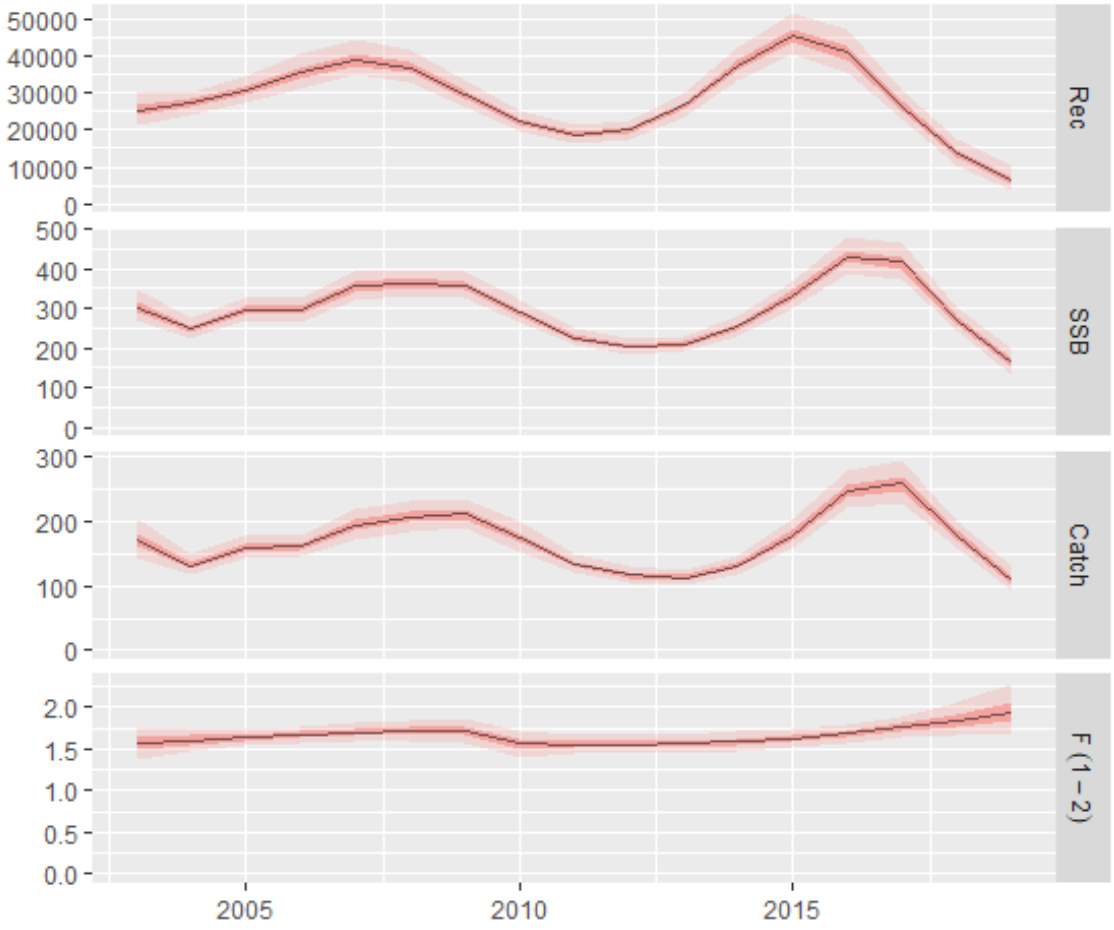

Figure 6.1.4-1: Red mullet in GSA 01 a4a results: Recruits (number), SSB (Stock Spawning Biomass) and catch (tons) and fishing mortality (2003-2019)

Table 6.1.4-1-Estimated fishing mortality at age

Year/age	0	1	2	3
2003	0.01	1.08	2.05	2.35
2004	0.01	1.10	2.10	2.41
2005	0.01	1.13	2.15	2.46
2006	0.01	1.15	2.19	2.51
2007	0.01	1.17	2.23	2.55
2008	0.01	1.18	2.24	2.57
2009	0.01	1.18	2.25	2.57
2010	0.01	1.18	1.94	2.70
2011	0.01	1.18	1.93	2.69
2012	0.01	1.18	1.93	2.69
2013	0.01	1.18	1.94	2.71
2014	0.01	1.20	1.97	2.75
2015	0.01	1.23	2.02	2.82
2016	0.01	1.27	2.09	2.92
2017	0.01	1.33	2.19	3.05
2018	0.01	1.40	2.29	3.20
2019	0.01	1.47	2.41	3.37

Table 6.1.4-2 Summary table: Recruitment, Spawning stock biomass and Fbar(1-2)

Year	Recruit.	SSB	fbar(1-2)
2003	25353	299	1.56
2004	27235	247	1.60
2005	30624	297	1.64
2006	35584	295	1.67
2007	39134	355	1.70
2008	36932	365	1.71
2009	29483	358	1.71
2010	22183	290	1.56
2011	18706	226	1.55
2012	19982	203	1.55
2013	26555	210	1.56
2014	37484	252	1.59
2015	45546	334	1.63
2016	40974	432	1.68
2017	26564	417	1.76
2018	13505	271	1.85
2019	6131	161	1.94

6.1.5 *Robustness analysis*:

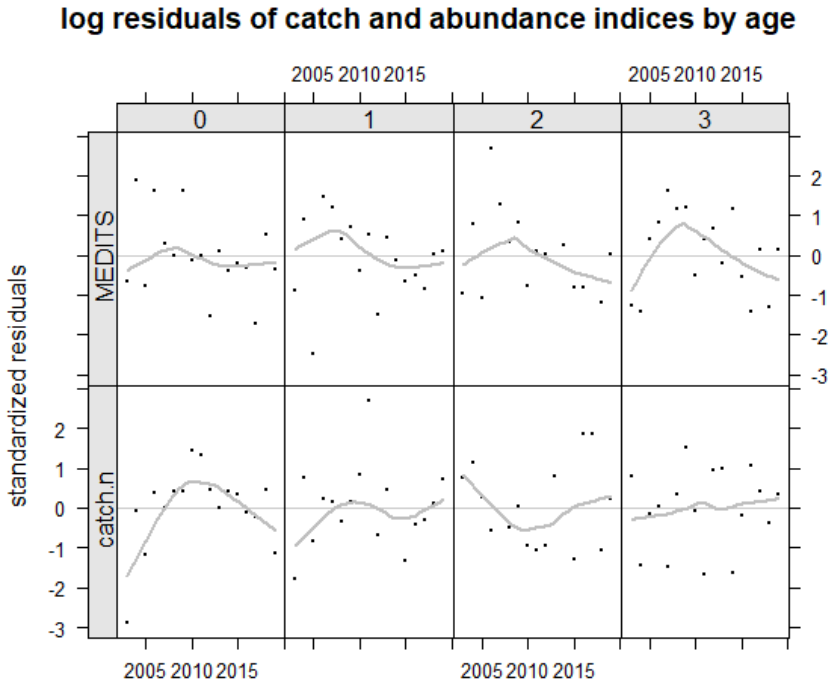

Figure 6.1.5-1 Red mullet in GSA 01. Log residuals of catch and survey indices by age

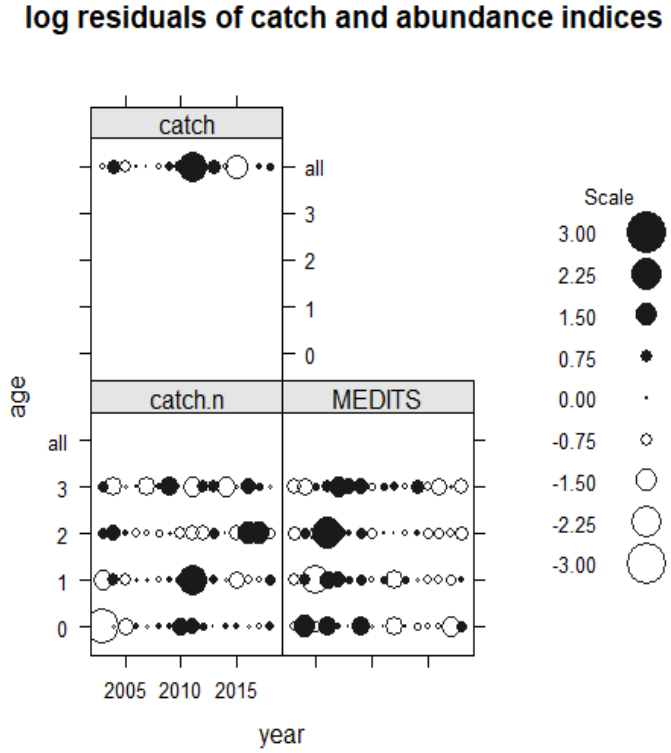

Figure 6.1.5-2 *Red mullet in GSA 01. Bubble plot of log residuals of catch and survey indices by age.*

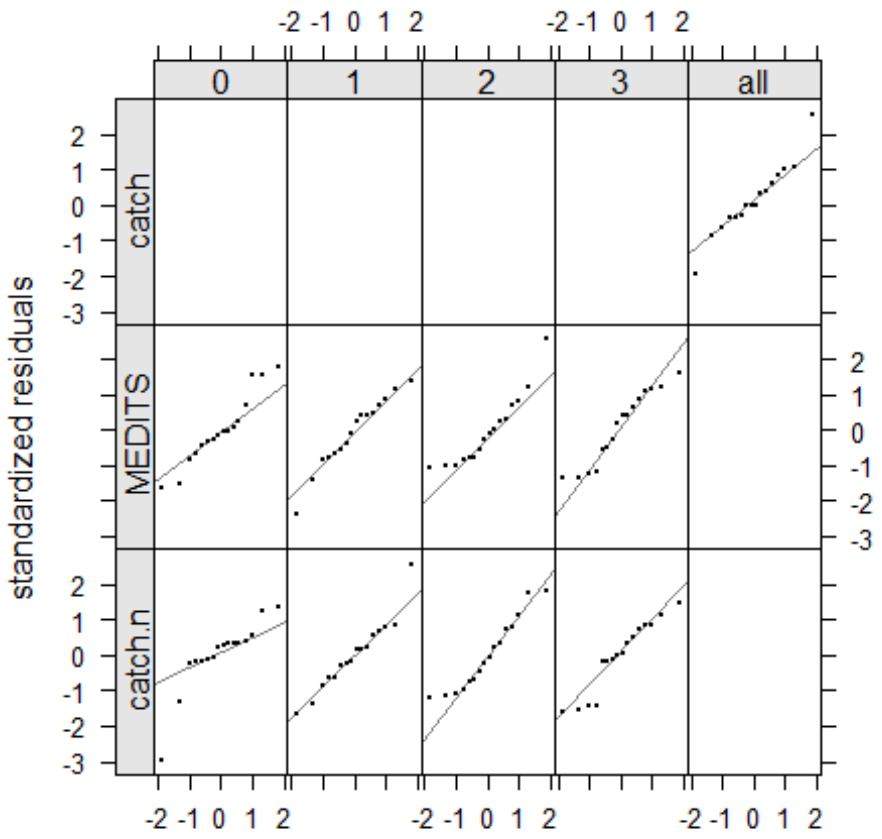

Figure 6.1.5-3 *Red mullet in GSA 01. QQ plot of log residuals of catch and survey indices.*

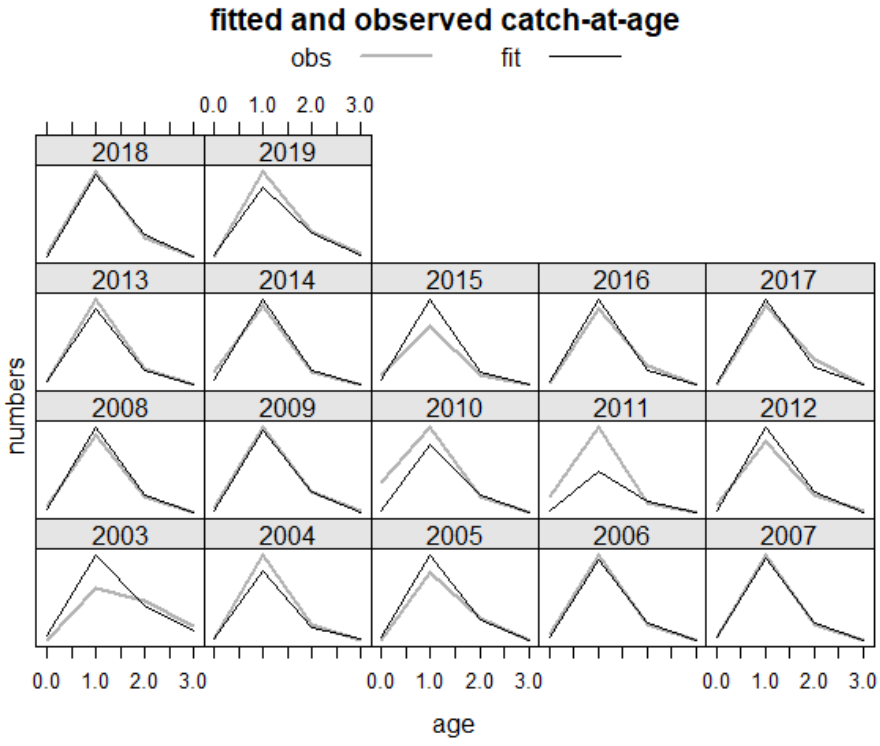

*Figure*6.1.5-4 *Red mullet in GSA 01 Fitted vs observed catch-at-age.*

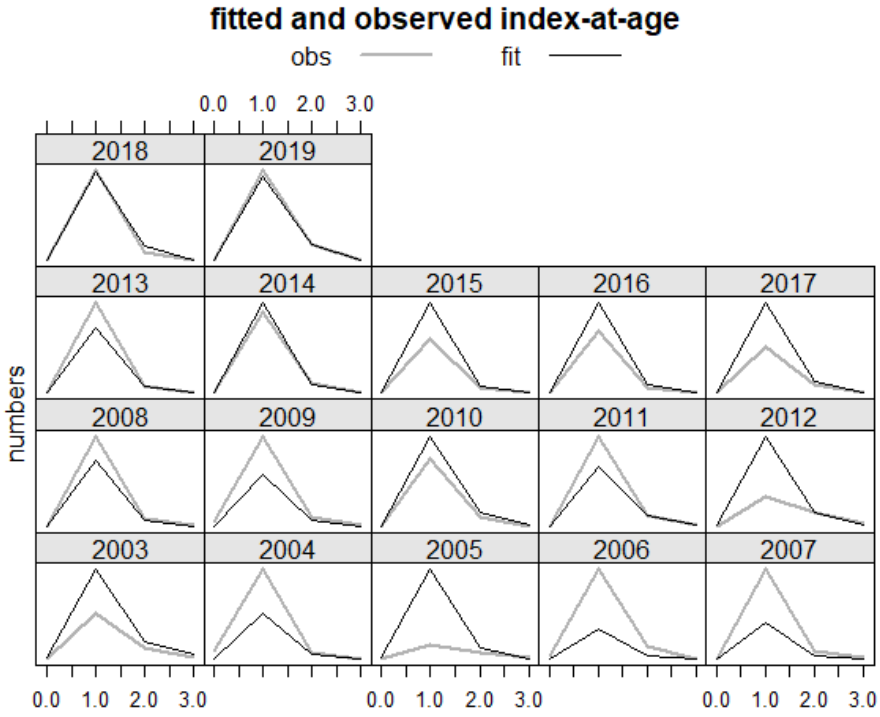

Figure 6.1.5-5 *Red mullet in GSA 01. Fitted vs observed survey indices-at-age.*

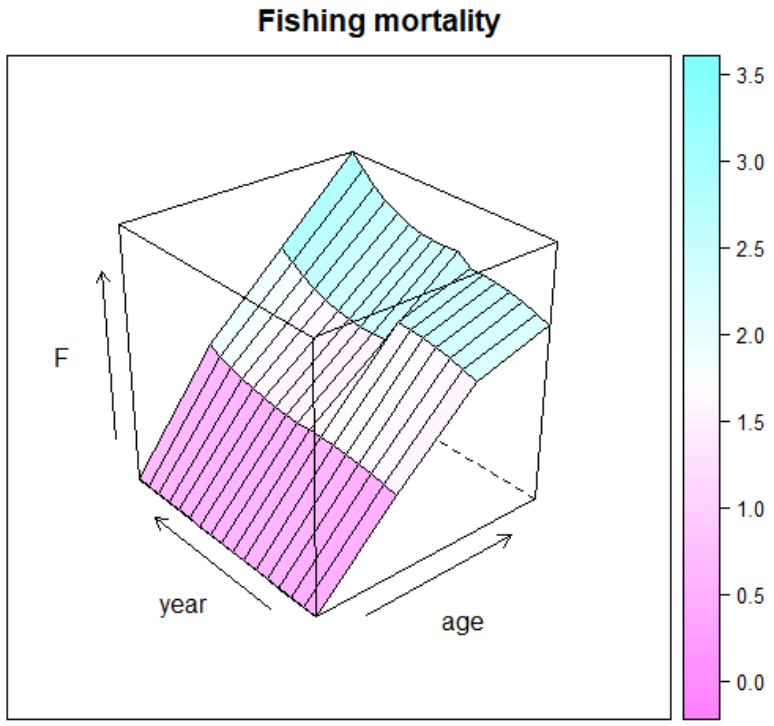

Figure 6.1.5-6 *Red mullet in GSA 01. Fishing mortality by age and year*

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

etc.

A retrospective analysis was conducted (Figure 6.1.6-1) to ensure the robustness of the final estimates.

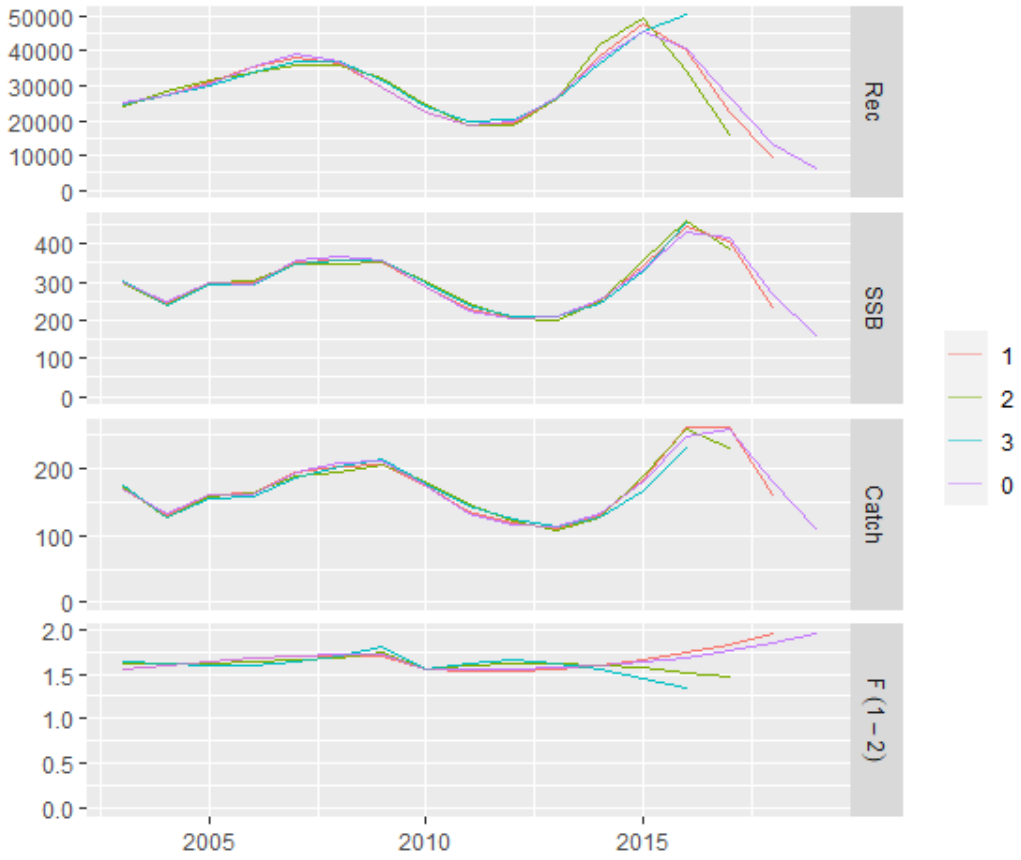

Figure 6.1.6-1.*Red mullet in GSA 01.Retrospective analysis on the a4a model.*

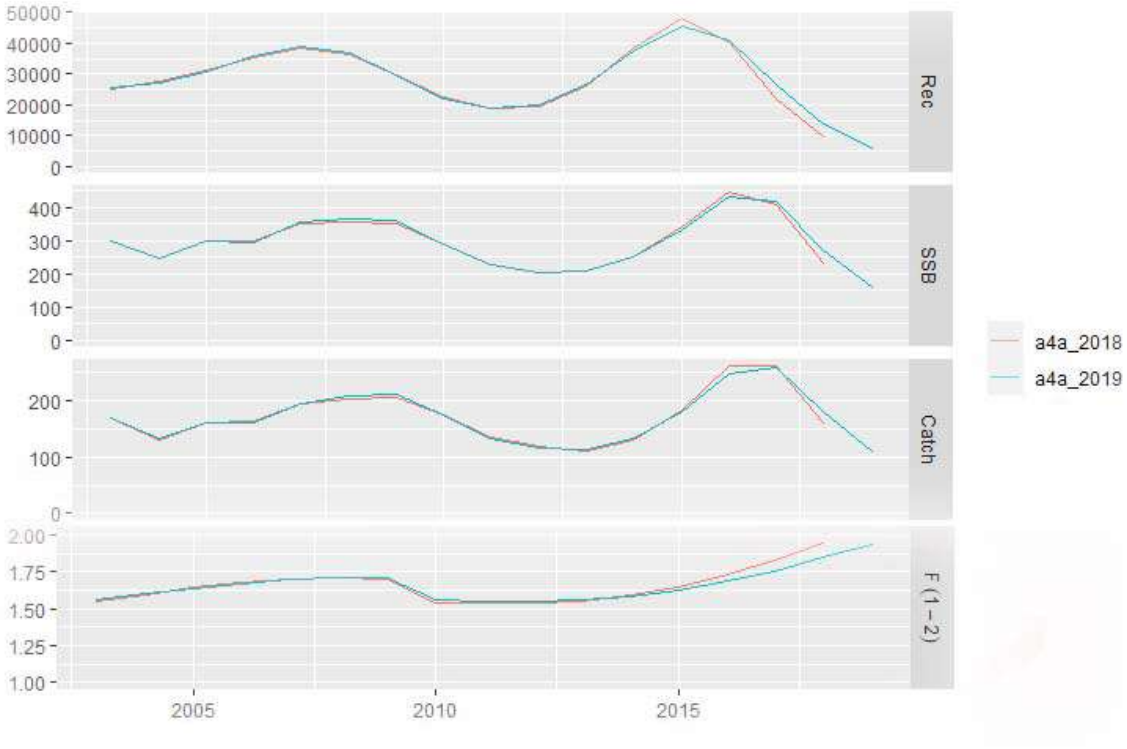

Figure 6.1.6-2.*Red mullet in GSA 01. Comparison between 2018 and 2019 models*

6.1.7 Assessment quality

Discards were not used in the assessment as they are considered negligible for this species. Figure 6.1.7-1 shows the internal consistency of the catch-at-age matrix, while Figure 6.1.7-2 shows the internal consistency of the MEDITS survey used as tuning fleet in the a4a model.

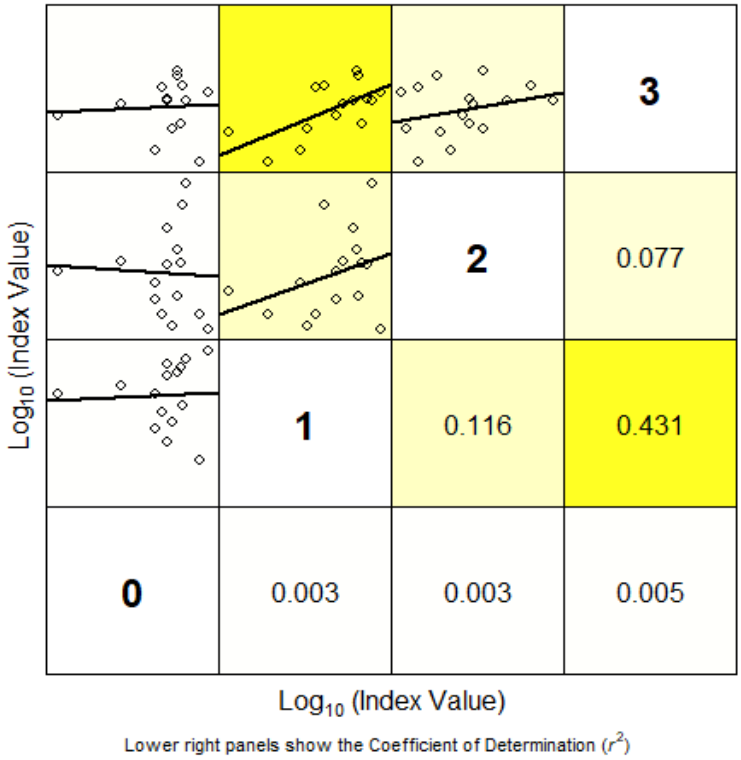

Figure 6.1.7-1 Red mullet in GSA 01. Internal consistency of the fleet catch

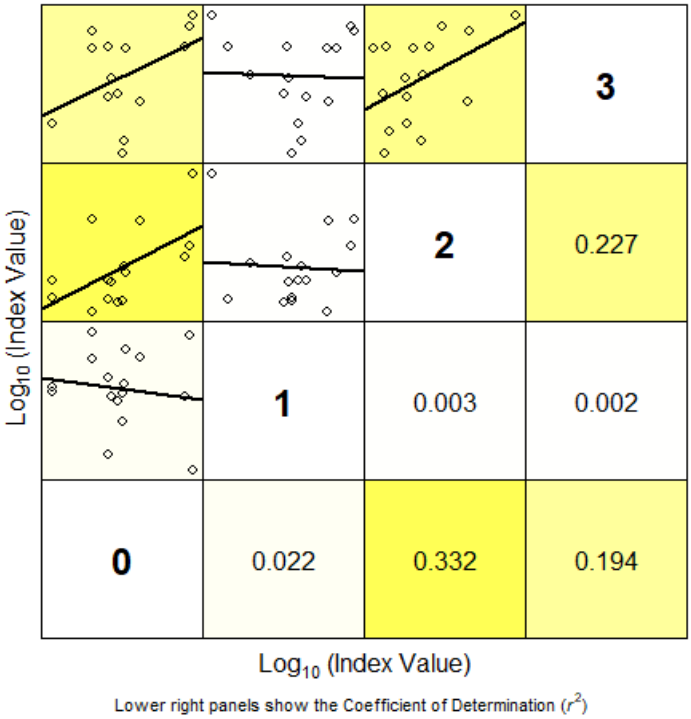

Figure 6.1.7-2 Red mullet in GSA 01. Internal consistency of the tuning fleet (MEDITS).

7 Stock predictions

When an analytical assessment exists, predictions should be attempted. All scenarios tested (recruitment and/or fishing mortality) should be reported. The source of information/model used to predict recruitment should be documented.

7.1 Short term predictions

7.2 Medium term predictions

7.3 Long term predictions

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	$F_{0.1}$=0.30	F_{cur}(2019,ages 1-2) =1.94	F_{cur}/F_{01}=6.5	I(2013-2019)	IO_H
Stock abundance	Total Biomass(t)		241(2019)	33^{th} percentile=510 66^{th} percentile=657		
	SSB (t)		161 (2019)	33^{th} percentile = 257 66^{th} percentile =318		O_L
Recruitment			6130(2019)			
Final Diagnosis		In high overfishing status (Fcurrent> F0.1) Relative low SSB (SSB<33^{rd} percentile SSB)				

State the rationale behind that diagnoses, explaining if it is based on analytical or on empirical references

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)*

9. Literature cited