Stock Assessment Form

Demersal species

Reference year:2015

Reporting year:2016

STOCK ASSESSMENT OF RED MULLET IN GSA17

In the Adriatic, red mullet is one of the main target species of the trawler fleets. The species is mainly fished by otter bottom trawl nets and smaller quantities are also caught with set nets and *rapido* trawl. Different management regulations are applied in Italian and in Croatian waters. Fishing closure for Italian trawlers for 45 days in late summer have been enforced in 2011-2015 for the Italian fleet. Before 2011 the closure period was 30 days in summer. Minimum landing sizes: EC regulation 1967/2006 defined 11 cm TL as minimum legal landing size for red mullet. Along Croatian coast bottom trawl fisheries is mainly regulated by spatial and temporal fisheries regulation measures, and about 1/3 of territorial sea is closed for bottom trawl fisheries over whole year. Also bottom trawl fishery is closed half year in the majority of the inner sea. Minimum landing size for red mullet is the same like in the EC regulation. Landings data for the Italian and Slovenia fleet were reported through the Data Collection Framework, while Croatian data comes from official statistics of Fisheries Department and data were collected through logbooks. The catches of red mullet, in the GSA17, remained above the 4000 t from 2006 to 2008 and then started to decrease, reaching the minimum in 2010 with 3000 t; after that there was a stable increasing trend with a maximum in 2015 (around 3000 t). Considering the results of the SS3 analyses conducted, the red mullet stock in GSA 17 is subjected to low overfishing, being the current F estimated higher than the proposed reference point (F0.1 SS3 = 0.31 as a proxy of FMSY; $F_{current(2013-2015)}$ = 0.39). From 2011 it was observed a decreasing trend of the fishing mortality, both for Italian and Croatian and Slovenian fleets. For this reason, a further reduction of fishing mortality towards the proposed reference point is advised. Considering, although low, the overfishing situation of the red mullet stock, a reduction of fishing pressure and an improvement in exploitation pattern especially of Italian trawlers exploiting a larger amount of Age 0+ group than Croatian and Slovenian trawlers is advisable. However, from the analysis of the relative spawning biomass observed in 2015 from SS3, is possible to conclude that the abundance of the stock is high and there is not risk of stock depletion.

Stock Assessment Form version 1.0 (January 2014)

Uploader: *Giuseppe Scarcella*

Stock assessment form

1 Basic Identification Data

Scientific name:	Common name:	ISCAAP Group:
Mullus barbatus	Red mullet	31
1st Geographical sub-area:	**2nd Geographical sub-area:**	**3rd Geographical sub-area:**
17		
4th Geographical sub-area:	**5th Geographical sub-area:**	**6th Geographical sub-area:**
1st Country	**2nd Country**	**3rd Country**
Italy	Croatia	Slovenia
4th Country	**5th Country**	**6th Country**
Stock assessment method: (direct, indirect, combined, none)		
Indirect: XSA – SCAA (SS3)		
Authors:		
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2 Stock identification and biological information

Red mullet (*Mullus barbatus*) is uniformly distributed in the whole Adriatic and the isolation of the Adriatic population was assessed by molecular and Bayesian analysis (Maggio *et al.*, 2009). This study proved a limited gene flow attributable to really low adult migration and a reduced passive drift of pelagic larvae from and to the Adriatic Sea. A previous study from Garoia *et al.* (2004) developed a set of dinucleotide microsatellite markers and revealed a significant overall heterogeneity within the red mullet Adriatic stock: this result indicates that this species may constitute local subpopulations that remain partly isolated from each other. However, the randomness of genetic differences among samples indicated that red mullet in the Adriatic likely belongs to a single population. Besides, no correlation between geographic distance and genetic differentiation has been detected. The observed genetic fragmentation could be explained by a passive dispersion of larvae due to marine currents, from random changes in allele frequencies or from fishing pressure. Although the red mullet is distributed in the entire Adriatic, the density of the population is not the same in space. For example, Arneri and Jukić (1986) found that the biomass index between Italian and Croatian waters is about 1:4.

2.1 Stock unit

According to the stock configuration reported in StockMed project (Fiorentino et al., 2015) there are some border zones in the southernmost side of the Adriatic Sea (GSA18) where some elements of the cluster from the GSA 17 expand, possibly as a local effect of the combination of the indicators used in the constrained clustering and the thematic descriptors related to genetics and growth. However, in the present assessment the GSA 17 has been considered as a stock unit.

2.2 Growth and maturity

According to Jardas (1996), red mullet grow up to 30 cm, with females growing faster and bigger than males. The Von Bertalanffy Growth Function parameters available for this species are presented in table 1.

Table 1 – The Adriatic Sea (the references of the table are from Vrgoc *et al.*, 2004).

Author	Sex	L_∞ (cm)	K (yr^{-1})	t_0 (yr)	Φ'
Scaccini (in Levi *et al.*, 1994)	M+F	27.49	0.5	-0.25	5.93
Jukić and Piccinetti, 1988	M+F	27.0	1.8		7.18
Marano, 1994; Ungaro *et al.*, 1994	M+F	19.70	0.360	-1.18	4.94
Vrgoč, 1995 ("Hvar")	M+F	27.75	0.274	-0.616	5.35
Marano, 1996; Marano *et al.*, 1998b, c	M	27	0.184	-1.92	4.90
	F	34.5	0.156	-1.53	5.22
	M+F	31.5	0.182	-1.45	5.19
	M+F (Bhatt)	26.3	0.45		5.74
Ardizzone, 1998	M+F	27.50	0.50		5.93
Marano, 1998b, c	M	22.5	0.24	-1.29	4.80
	F	26.2	0.23	-1.41	5.06
	M+F	22.5	0.38	-0.63	5.26
	M+F (Bhatt)	25.4	0.25		5.08
	M+F (Surf.)	23	0.52		5.62
Vrgoč, 2000	M+F	26.86	0.295		5.36
EC XIV/298/96-EN, Ionian and Southern Adriatic	M+F	21.72	0.31		4.99
EC XIV/298/96-EN, Adriatic Sea	M+F	27.5	0.50		5.94

Length frequency distributions from the Croatian fleet as well as from survey data were converted into catch at age according to slicing using the growth parameters obtained independently for males and females reported in table 2.3 (Vrgoc N., 2008: PHARE 2005 EuropeAid/123624/D/SER/HR). Red mullet reproduction in GSA 17 occurs in late spring and summer. Specimens reach sexual maturity during the first year of life, at length between 10 and 14 cm (Županović, 1963; Haidar, 1970; Jukić and Piccinetti, 1981; Marano et al., 1998; Vrgoč, 2000). The maturity at age utilized in the assessment is reported in Table 2.2-2.

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 to August
Maximum size observed			28.5	**Recruitment season**	late summer-autumn
Size at first maturity			11.7	**Spawning area**	Figure 0
Recruitment size to the fishery			6	**Nursery area**	Figure 0

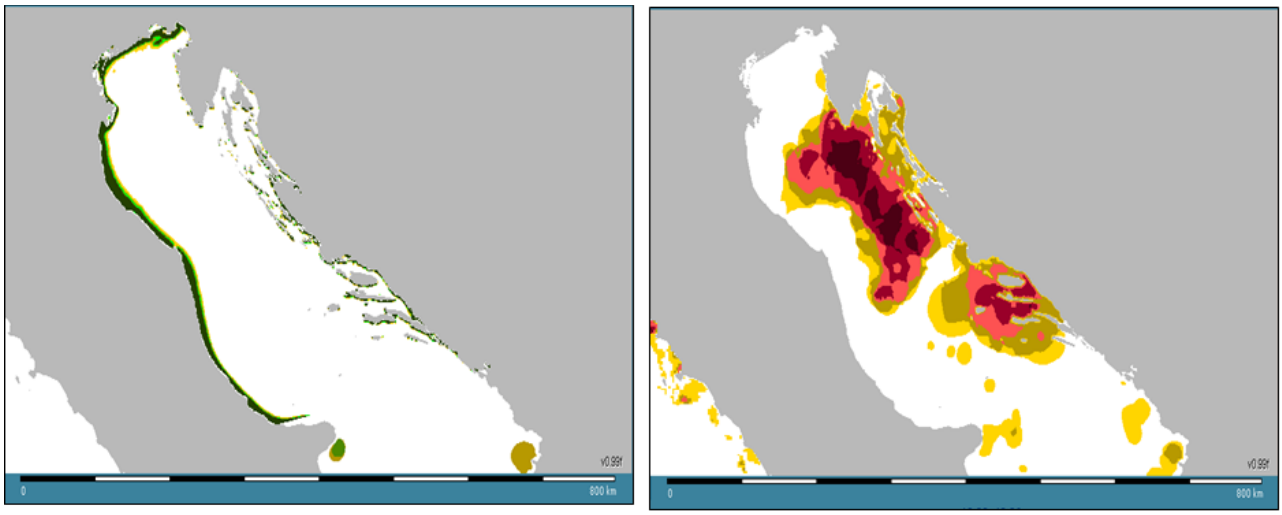


Figure 0 – Distribution of red mullet recruits (left graph) and spawners (right graph) in the spring/summer period (MEDITS SURVEY, from MEDISEH MAREA project).

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

Age	Natural mortality	Proportion of matures
0	1.2	0.1
1	0.71	0.9
2	0.54	1
3	0.46	1
4	0.4	1
5	0.35	1
6+	0.4	1

Table 2.2-3: Growth and length weight model parameters

			Sex			
		Units	**female**	**male**	**Combined**	**Years**
Growth model	**L_∞**				27	
	K				0.34	
	t_0				-0.4	
	Data source	Carbonara *et al.*, 2014				
Length weight relationship	**a**				0.0103	
	b				3.009	
	M (scalar)					
	sex ratio (% females/total)					

3 Fisheries information

3.1 Description of the fleet

In the Adriatic, red mullet is mainly fished by bottom trawl nets. Smaller quantities are also caught with trammel-nets and gill nets.

Fishing closure for Italian trawlers: 45 days in late summer have been enforced in 2011-2014 for the Italian fleet. Before 2011 the closure period was 30 days in summer. Minimum landing sizes: EC regulation 1967/2006 defined 11 cm TL as minimum legal landing size for red mullet.

Along Croatian coast bottom trawl fisheries is mainly regulated by spatial and temporal fisheries regulation measures, and about 1/3 of territorial sea is closed for bottom trawl fisheries over whole year. Also, bottom trawl fishery is closed half year in the majority of the inner sea. Minimum landing size for red mullet is the same like in the EC regulation.

Mannini and Massa (2000) analyzed trends of the red mullet landings in the Adriatic from 1972 to 1997. In that period, the landings showed an overall increase. This positive trend was constant in the Western Adriatic, while in the Eastern Adriatic landings decreased during the second half of the 1990s.

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*	Italy	17		OTB	[ISCAAP Group]	*Mullus barbtus*
Operational Unit 2	Croatia	17		OTB	[ISCAAP Group]	*Mullus barbtus*
Operational Unit 3	Slovenia	17		OTB	[ISCAAP Group]	*Mullus barbtus*

Table 3.1-2: Catch, by-catch, 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)
Italian OTB		Tons	*Squilla mantis, Merluccius merluccius, Sepia officinalis, Nephrops norvegicus*			GT_DAYS_AT_SEA
Croatian OTB						
Slovenian OTB			Squilla mantis, Merluccius merluccius, Sepia officinalis, Nephrops norvegicus			GT_DAYS_AT_SEA
Total						

3.2 Historical trends

Landings data for the Italian and Slovenia fleet were reported through the Data Collection Framework, while Croatian data comes from official statistics of Fisheries Department and data were collected through logbooks. The Italian catches remained above the 3000 t from 2006 to 2008 and then started to decrease, reaching the minimum in 2012 with less than 2000 t (Tab. 2); after that there was an increase in the last two years (2323 tons in 2014). The Croatian catches remain lower than 1000 tons until 2010, followed by a general increment in the next years (Fig. 2).

Table 2 – Annual landings (t) by fishing gear as reported through the DCF data call for Italy and Slovenia, and official statistic data from Croatian Fisheries Department.

Country	Gear	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
ITA	OTB	3100	3299	3158	2433	1796	1822	1463	1946	2323	2143
ITA	TBB	n/a	n/a	n/a	n/a	n/a	36	43	30	63	77
CRO+SLO	OTB	806.9	956.4	744	802.6	751.2	1106	1321.5	1087.4	1160.2	1126.93

Discard data for the Italian fleet are available only for OTB in the period 2010-2014 (Tab. 3). The amount of discard for the Croatian bottom trawl fisheries is available only for the last two years due to the fact that the minimum size in the catches is bigger than the minimum landing size allowed (i.e. there are no juveniles in the catches; Fig. 3).

Table 3 – Discard data (t) by fishing gear as reported through the DCF data call.

Country	Gear	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
ITA	OTB	n/a	n/a	n/a	n/a	183	796	324	291	446	910
ITA	TBB	n/a	n/a	n/a	n/a	n/a	7.39	n/a	n/a	n/a	n/a
CRO+SLO	OTB	0.037	0.255	0.043	0.058	0.024	0.221	0.104	162.078	555.101	299.62

In the Italian catches the discard proportion varied between 9 and 30% in the period 2010-2014. The TL of the discards ranged between 4 and 16 cm. For the years without discard data the Italian data has been modified assuming the discard proportion observed in the years where discards data were available.

In Fig.3 is showed the length frequency distributions for Italian, Croatian and Slovenian OTB.

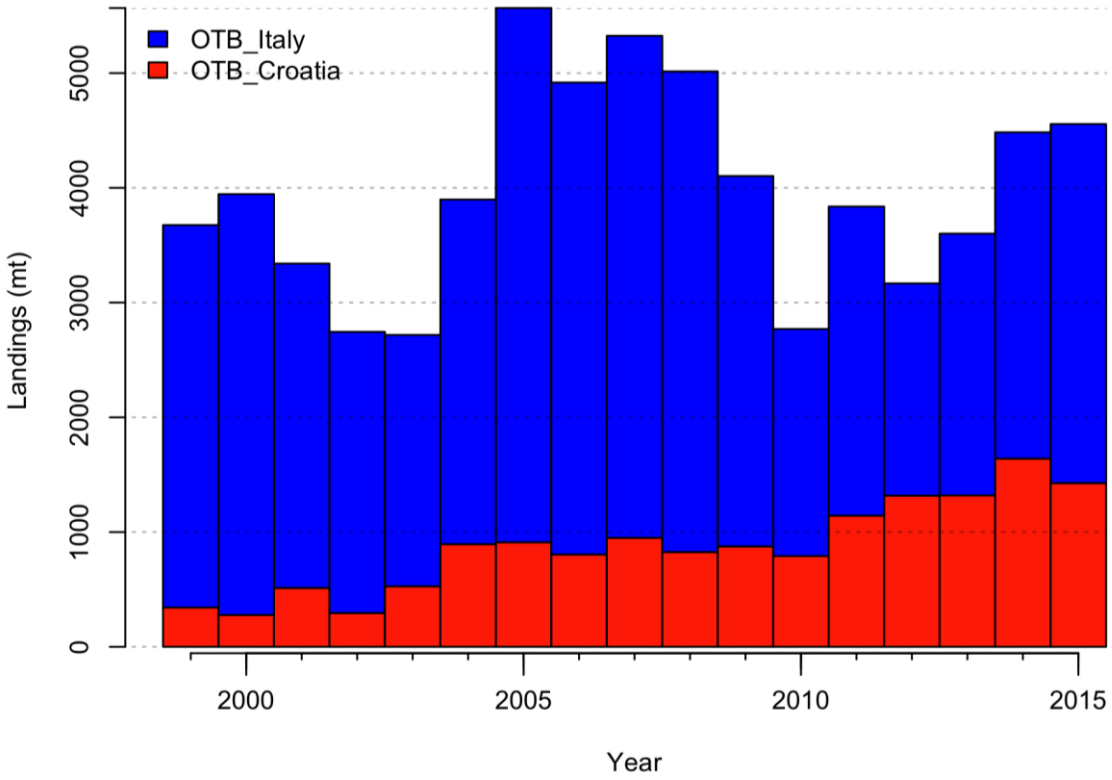
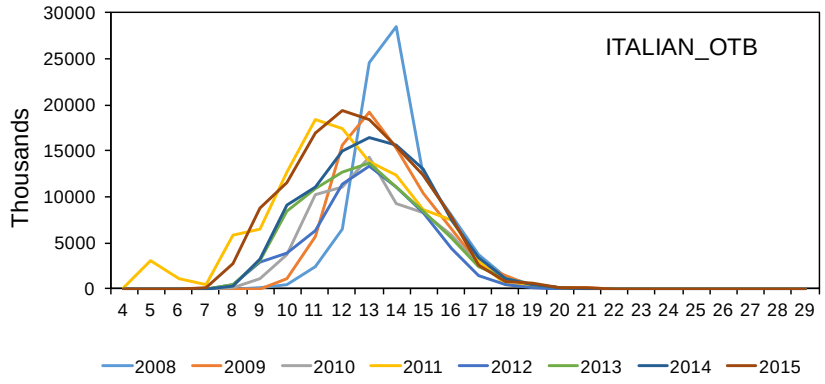


Figure 2 – Total landings of Italian and Croatian OTB fleets.



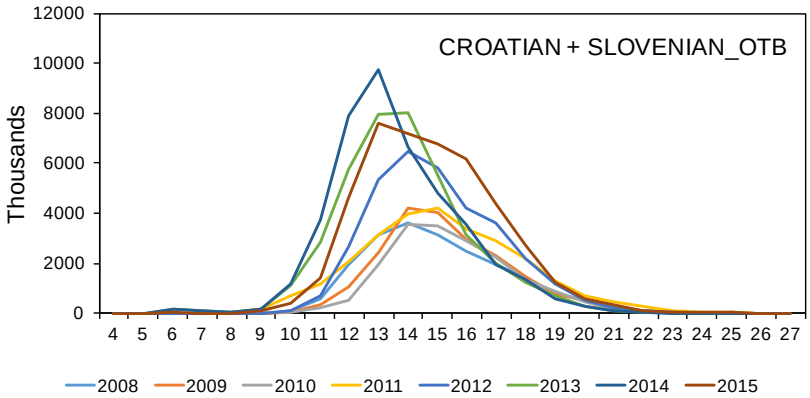


Figure 3 – Length frequency distributions of Italian, Croatian and Slovenian catches (landings

+ discards)

3.3 Management regulations

Italy and Slovenia:

- In Italy and Slovenia the main rules in force are based on the applicable EU regulations (mainly EC regulation 1967/206):
- Minimum landing sizes: 11 cm TL for red mullet (valid also for Croatia).
- Cod-end mesh size of trawl nets: 40 mm (stretched, diamond meshes) till 30/05/2010. From 1/6/2010 the existing nets have been replaced with a cod end with 40 mm (stretched) square meshes or a cod-end with 50 mm (stretched) diamond meshes.
- Towed gears are not allowed within three nautical miles from the coast or at depths less than 50 m when this depth is reached at a distance less than 3 miles from the coast.
- Set net minimum mesh size: 16 mm stretched.
- Set net maximum length x vessel x day: 5,000 m

Croatia

Since the accession of Croatia to the EU the 1st if July 2013, the same regulations of Italy and Slovenia are implemented. Furthermore the following regulation for OTB are applied, especially in specific areas (Fig. 4):

1. Ordinance on Commercial Fishing at Sea (Official Journal no. 63/2010, 141/2010, 148/2010, 52/2011 and 144/2011) in parts which remain in force after the Croatian entry into the European Union:

- Article 3, paragraph 1 (minimum size of cod-end in the inner sea)
- Article 4 (spatial regulation considering the power of propelling engine)
- Article 5, paragraph 1 (permanent ban for certain zones)
- Article 6 and 7 (spatial-temporal ban to protect immature fish and other marine organisms)
- Article 8 and 9 – regulation in E zone
- Article 10 – regulation in F zone
- Article 11 – regulation in G zone
- Article 32 - ban on the issuance of new licences and entry of new types of fishing (fishing tools and equipment) to the valid licences.

2. Ordinance on fishing gear and equipment for commercial fishing in the sea (Official Journal, no. 148/2010, 25/2010) in parts which provide design and technical characteristics of the fishing gear and equipment, and the amount of gear that can be used in fishing (if it is not regulated by EC Regulations).

3. Ordinance on privileges for commercial fishing at the sea and the register of issued privileges (Official Journal no. 144/2010, 123/2011, 53/2012 and 98/2012.) which defines the conditions for transfer of rights from one valid licence to another valid licence and the terms of transfer of licences from one fishing vessel to another.

4. Ordinance on special habitats of fish and other marine organisms, and regulation of fishing in the Velebit Channel, Novigrad and Karin Sea, Prokljan Lake, Marina Bay and Neretva Channel (Official Journal, no. 148/2004, 152/2004, 55/2005, 96/2006, 123/2009 and 130/2009) which prohibits fishing by bottom trawling tools in specific habitats and in areas of the fishing sea with a special fishing regulation (Velebit Channel, Novigrad and Karin Sea, Prokljan Lake, Marina Bay and the Neretva Channel).

Figure 4 – Red mullet GSA 17 - Administrative classification of the fishing sea in the Republic of Croatia.

3.4 Reference points

Table 3.4-1: List of reference points and empirical reference values previously agreed (if any).

Indicator	Limit Reference point/empirical reference value	Value	Target Reference point/empirical reference value	Value	Comments
B					
SSB					
F	F0.1	0.31 (SS3)			
Y					
CPUE					
Index of Biomass at sea					

4 Fisheries independent information

4.1 MEDITS

Based on the DCF data call, abundance and biomass indices were calculated. In GSA 17 (including Italian, Slovenian and Croatian parts of Adriatic Sea) the following number of hauls was reported per depth stratum.

4.1.1 Brief description of the direct method used

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized at the Km^2. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$Yst = \sum (Yi*Ai) / A$

$V(Yst) = \sum (Ai^2 * si^2 / ni) / A^2$

Where:

A=total survey area

Ai=area of the i-th stratum

si=standard deviation of the i-th stratum

ni=number of valid hauls of the i-th stratum

n=number of hauls in the GSA

Yi=mean of the i-th stratum

Yst=stratified mean abundance

V(Yst)=variance of the stratified mean

Direct methods: trawl based abundance indices

Table 4.1-1: Trawl survey basic information

Survey	**MEDITS**	**Trawler/RV**	**Andrea**
Sampling season	Spring		
Sampling design	Random		
Sampler (gear used)	GOC73		
Cod –end mesh size as opening in mm	20 mm		
Investigated depth range (m)	10 - 500		

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)				

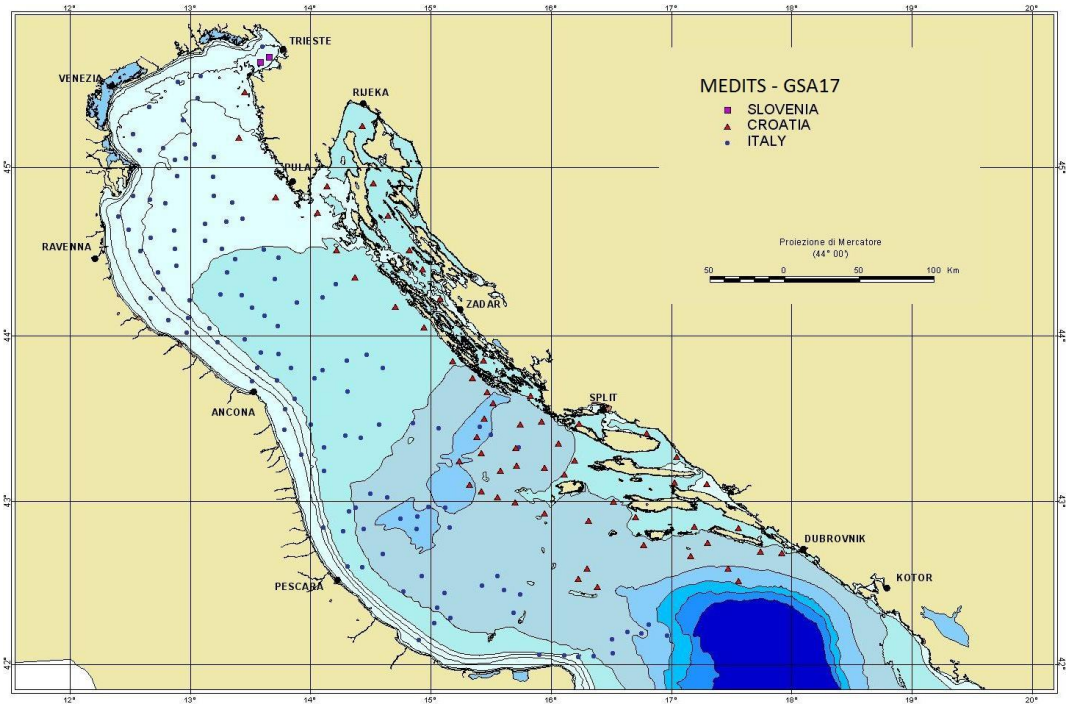


Figure 5 - Map of hauls positions during MEDITS survey.

Table 4.1-3: Trawl survey abundance and biomass results

Depth Stratum	Years	ITA - kg per km²	CV or other	ITA - N per km²	CV or other		CRO - kg per km²	CV or other	CRO - N per km²	CV or other
	1994	6.31	1.55	193.98	47.42					
	1995	10.11	2.73	385.68	109.88					
	1996	7.94	2.29	255.07	84.28		14.49	2.41	436.85	77.43
	1997	8.67	2.35	260.19	68.76		22.87	3.27	601.49	91.67
	1998	7.72	1.68	223.64	52.49		14.26	2.21	371.46	61.30
	1999	51.99	12.98	3004.59	702.05					
	2000	11.16	2.44	641.10	227.88		20.50	2.80	813.96	170.33
	2001	13.83	2.54	425.31	82.52		25.40	3.04	737.17	92.90
	2002	16.51	7.00	761.04	333.84		19.45	4.82	698.51	220.74
	2003	7.93	1.14	297.81	93.99		18.95	2.63	534.05	89.01
	2004	7.11	1.26	320.99	66.78		23.65	5.35	753.89	171.99
	2005	7.47	1.42	300.00	63.61		22.29	3.58	649.29	107.73

	2006	16.55	8.96	757.68	454.34	30.11	7.25	1017.65	321.45
	2007	5.97	0.96	284.68	85.22	15.83	1.79	491.40	71.76
	2008	10.43	1.69	352.66	61.59	31.30	3.80	925.03	115.58
	2009	9.57	1.73	300.41	61.06	23.90	3.19	689.06	94.66
	2010	9.60	2.02	356.44	78.73	29.00	3.73	870.93	110.17
	2011	14.43	3.22	879.46	374.64	23.70	2.67	1022.63	250.86
	2012	24.44	5.60	1199.88	272.09	47.41	5.57	1938.38	245.43
	2013	40.72	6.51	2141.41	361.19	68.65	8.90	3121.04	454.30
	2014	83.40	11.53	4079.04	728.65	108.55	11.85	4567.00	614.89

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

Table 4.1-4: Trawl survey results by length or age class

N (Total or sex combined) by Length or Age class	**Year**		
	….	**….**	**…..**
Total			

Sex ratio by Length or Age class	**Year**		
	….	**….**	**…..**

Total			

Direct methods: trawl based Recruitment analysis

Table 4.1-5: Trawl surveys; recruitment analysis summary

Survey	**MEDITS**	**Trawler/RV**	**Andrea**
Survey season		Spring	
Cod –end mesh size as opening in mm		20	
Investigated depth range (m)			
Recruitment season and peak (months)			
Age at fishing-grounds recruitment			
Length at fishing-grounds recruitment		12 cm	

Table 4.1-6: Trawl surveys; recruitment analysis results

Years	Area in km²	ITA - N of recruit per km²	CV or other		CRO - N of recruit per km²	CV or other
1994		35.68	15.83			
1995		124.59	33.58			
1996		32.90	12.90		43.61	10.63
1997		45.91	14.13		73.50	16.17
1998		22.45	5.99		36.20	10.54
1999		2092.31	532.41			
2000		377.03	217.15		302.76	142.66
2001		61.53	14.37		74.47	13.09
2002		448.48	225.97		303.62	147.08
2003		101.84	86.84		85.87	56.82
2004		163.88	43.71		173.05	36.76
2005		109.04	30.33		96.63	22.75
2006		359.80	266.61		290.35	177.98
2007		123.41	78.01		89.15	50.92
2008		57.85	13.46		60.76	10.81
2009		40.43	12.85		40.26	9.08
2010		78.53	17.93		61.97	12.09
2011		515.96	351.81		385.93	229.35
2012		640.36	144.40		618.06	107.63
2013		1029.14	182.87		1366.11	258.66
2014		2251.00	590.65		1938.73	415.86

The recruitment is mainly localised in the coastal water, in the west side of the sub-basin (Fig. 8). In Figure 6 is showed the trend of recruitment abundance.

Direct methods: trawl based Spawner analysis

Table 4.1-7: Trawl surveys; spawners analysis summary

Survey	**MEDITS**	**Trawler/RV**	**Andrea**
Survey season			Spring (specimens >= 15 cm)
Investigated depth range (m)			
Spawning season and peak (months)			

Table 4.1-8: Trawl surveys; spawners analysis results

Surveys	Area in km²	ITA - N (N of individuals) of spawners per km²	CV or other		CRO - N (N of individuals) of spawners per km²	CV or other
1994		64.13	18.51			
1995		79.98	21.07			
1996		74.14	17.83		245.95	56.17
1997		83.38	27.16		542.63	104.47
1998		74.99	16.36		304.56	61.12
1999		100.52	23.33			
2000		82.60	19.90		329.55	49.71
2001		118.52	24.02		391.52	66.21
2002		67.49	12.01		328.05	62
2003		73.34	11.46		412.12	69.9
2004		34.74	6.79		531.75	128.54
2005		48.14	8.49		573.26	115.06
2006		45.13	8.30		689.74	168.97
2007		42.33	7.18		424.64	62.58
2008		89.36	14.69		1062.82	158.85
2009		81.09	12.22		729.85	124.11
2010		68.79	12.25		920.55	157.58
2011		75.81	14.60		484.66	64.09
2012		85.09	18.78		801.57	106.09
2013		201.48	30.83		1038.72	174.75
2014		293.88	40.42		1503.3	266.69

Spawners aggregate offshore in the east side of the sub-basin (Fig. 8).

4.1.2 Spatial distribution of the resources

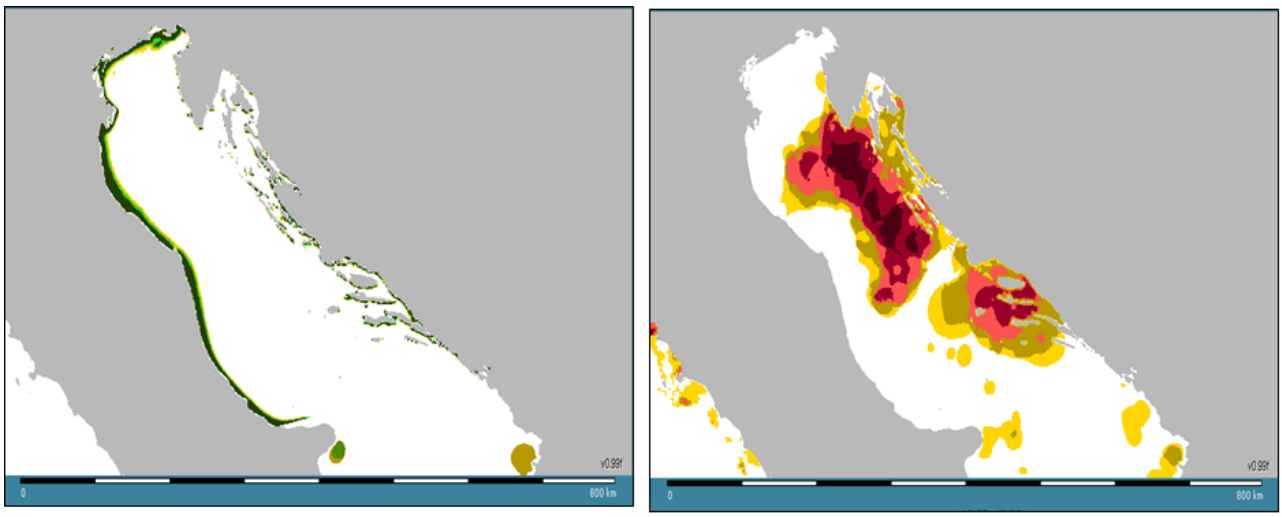


Figure 8 – Distribution of red mullet recruits (≤ 71 mm; left graph) and spawners (Maturity stage 3; right graph) in the spring/summer period (MEDITS SURVEY, from MEDISEH MAREA project).

4.1.3 Historical trends

The MEDITS surveys provided data either on red mullet total abundance and biomass as well as on important biological events (recruitment, spawning).

Figure 9 shows the abundance and biomass indices of red mullet obtained from 1994 to 2014 for Italy and from 1996 to 2014 for Croatia. During the survey was observed a fluctuating trend till to 2011, after that there was an increasing in the last three years.

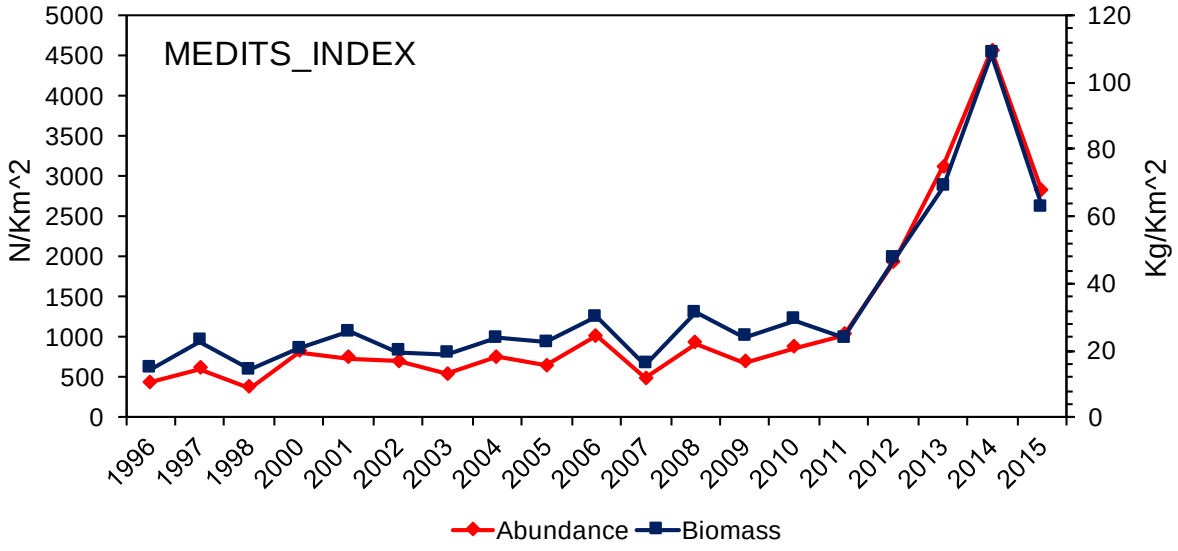


Figure 6 – Abundance and biomass indices (± s.d.) of red mullet obtained from MEDITS surveys.

4.2 GRUND

4.2.1 Brief description of the direct method used

Direct methods: trawl based abundance indices

Table 4.2-9: Trawl survey basic information

Survey	GRUND	**Trawler/RV**	
Sampling season	Fall		
Sampling design	Random		
Sampler (gear used)	Italian commercial net		
Cod –end mesh size as opening in mm	40 mm		
Investigated depth range (m)	10-500m		

Table 4.2-10: 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)				

Table 4.2-11: Trawl survey abundance and biomass results

Depth Stratum	Years	ITA - kg per km²	CV or other	ITA - N per km²	CV or other		CRO - kg per km²	CV or other	CRO - N per km²	CV or other
	2001	17.72	2.34	552.8	79.7		114.31	67.81	1286.17	352.01
	2002	45.34	9.39	1469.75	318.47		47.23	28.02	531.47	145.45
	2003	17.23	2.00	806.01	92.95		34.57	6.92	1372.3	444.47
	2004	24.93	2.35	941.68	96.59		59.82	15.86	1664.66	422.72
	2005	13.43	1.88	450.67	65.35		46.2	14.3	1263.9	456.53
	2006	7.33	0.98	279.57	39.82					
	2007	11.35	1.42	387.96	56.81		28.2	4.05	718.75	128.43

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

Table 4.2-12: Trawl survey results by length or age class

N (Total or sex combined) by Length or Age class	Year		
	….	….	…..
Total			

Sex ratio by Length or Age class	Year		
	….	….	…..
Total			

Direct methods: trawl based Recruitment analysis

Table 4.2-13: Trawl surveys; recruitment analysis summary

Survey	**GRUND**	**Trawler/RV**	
Survey season		Fall	
Cod –end mesh size as opening in mm		40mm	
Investigated depth range (m)			
Recruitment season and peak (months)			
Age at fishing-grounds recruitment			
Length at fishing-grounds recruitment			

Table 4.12-14: Trawl surveys; recruitment analysis results

Years	**Area in km²**	**ITA - N of recruit per km²**	**CV or other**		**CRO - N of recruit per km²**	**CV or other**
2001		133.38	27.47			
2002		372.57	97.63			
2003		487.67	61.31			
2004		421.16	48.57		222.91	58.95
2005		130.23	20.72		121.2	68.1
2006		99.19	15.14			
2007		100.09	22.11		44.04	16.92

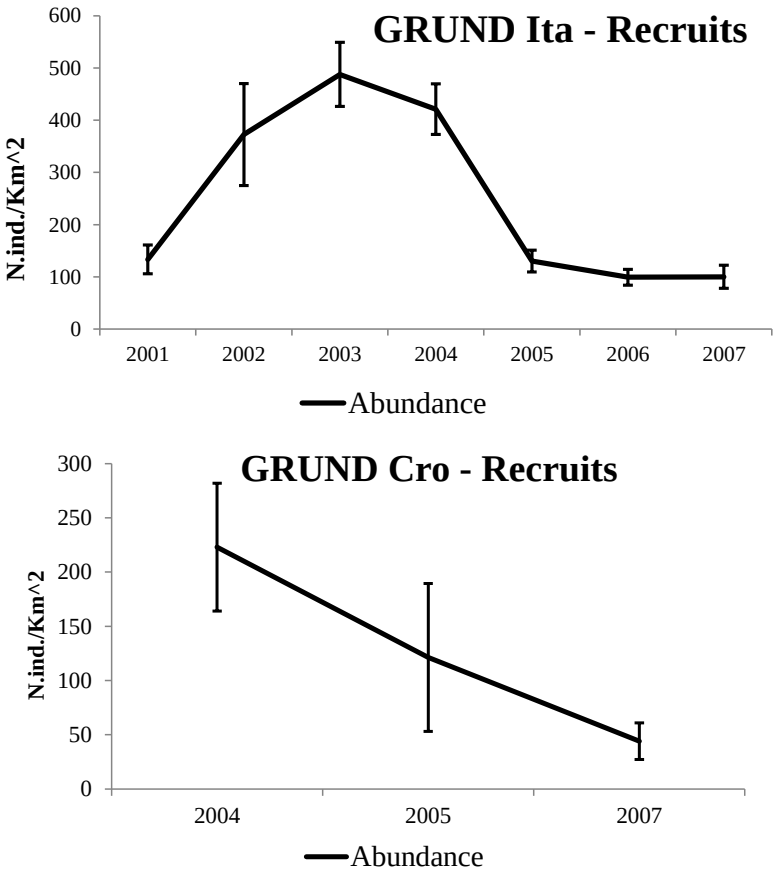


Figure 7 – Abundance index (± s.d.) of red mullet recruits obtained from GRUND surveys; (Italian survey above, Croatian survey below).

Direct methods: trawl based Spawner analysis

Table 4.12-15: Trawl surveys; spawners analysis summary

Survey		**Trawler/RV**	
Survey season			
Investigated depth range (m)			
Spawning season and peak (months)			

Table 4.12-16: Trawl surveys; spawners analysis results

Surveys	Area in km²	ITA - N (N of individuals) of spawners per km²	CV or other		CRO - N (N of individuals) of spawners per km²	CV or other
2001		137.55	16.33			
2002		215.68	34.40			
2003		77.00	13.26			
2004		136.28	13.96		583.68	160.33
2005		102.86	12.80		536.62	142.1
2006		45.56	5.60			
2007		89.37	9.68		327.81	47.07

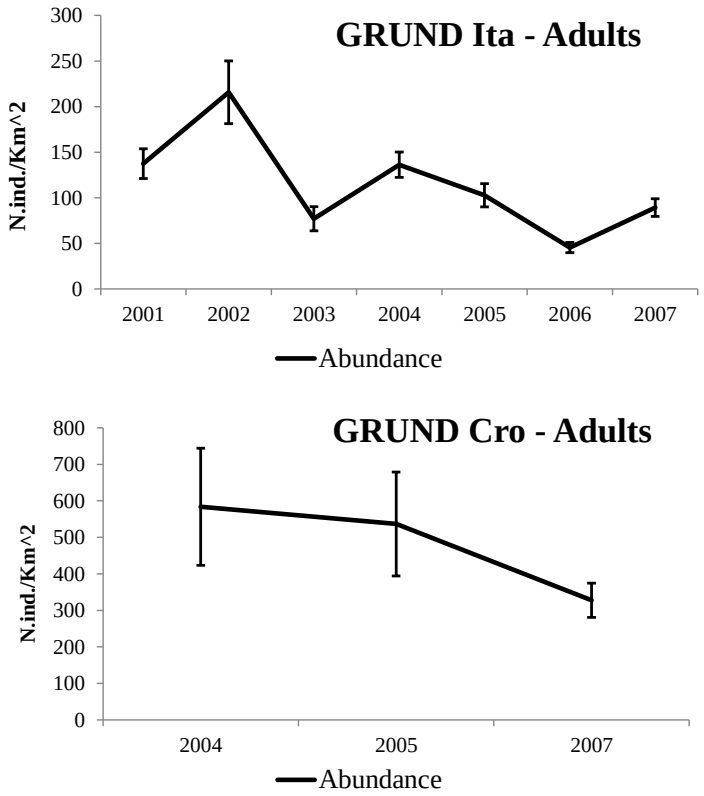


Figure 8 – Abundance index (± s.d.) of red mullet adults obtained from GRUND surveys; (Italian survey above; Croatian survey below).

4.2.2 Historical trends

The GRUND surveys provided data either on red mullet total abundance and biomass as well as on important biological events (recruitment, spawning).

Figure 12 shows the abundance and biomass indices of red mullet obtained from 2001 to 2007 for Italy and Croatia. During the Croatian survey was reached a minimum in 2002 and a pick in 2004; after that was observed a decreasing trend till to 2007.

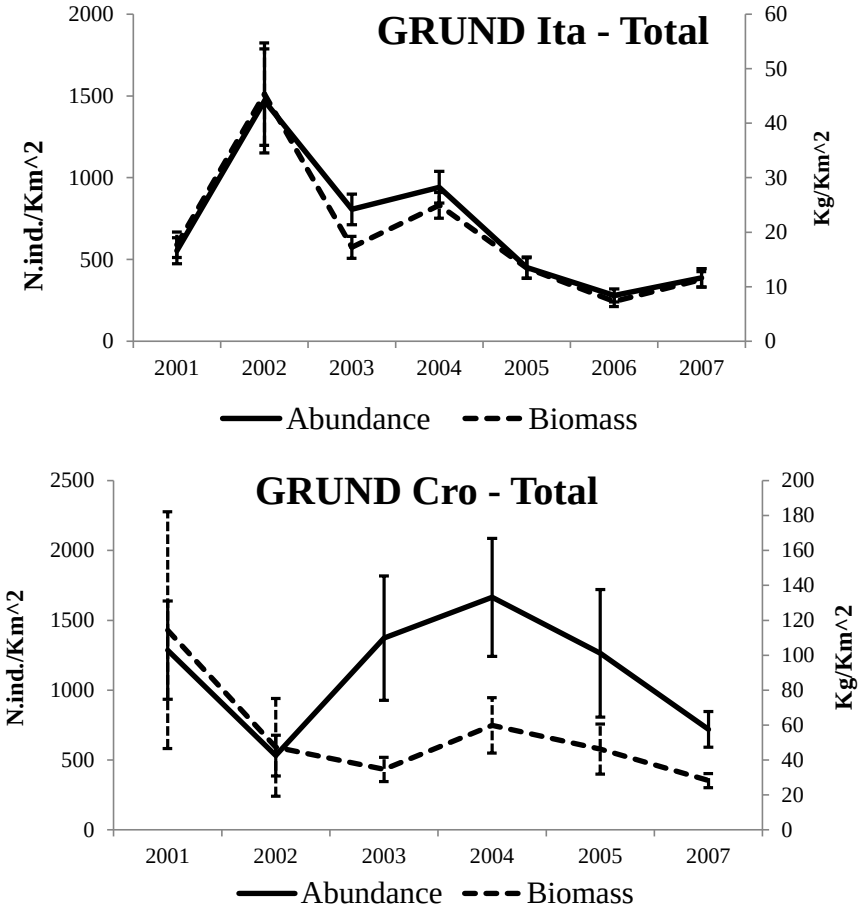


Figure 9 – Abundance and biomass indices (± s.d.) of red mullet obtained from GRUND surveys.

5 Ecological information

5.1 Protected species potentially affected by the fisheries

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 XSA

6.1.1 Model assumptions

Data coming from DCF and Croatian Fisheries Department for the period 2008-2015 were used to perform an Extended Survivor Analysis (XSA) calibrated with fishery independent data (i.e. MEDITS) and using FLR (www.r-project.org). Data included information on total landings and catch at age of *M. barbatus* in GSA 17 for both the Italian, Croatian and Slovenia OTB fleets. Discard data from the Italian fleet (available for 2010-2015) were also included in the analyses.

The XSA runs were made using the following settings:

- Catchability dependent on stock size for ages = 0
- Catchability independent of age for ages >= 3
- S.E. of the mean to which the estimates are shrunk = 0.5
- Minimum standard error for population estimates derived from each fleet = 0.300
- The number of ages and years used for the shrinkage mean: 3
- Fbar: 1-3

6.1.2 Scripts

```
#load libraries
library(FLCore)
library(FLEDA)
library(FLXSA)
library(FLAssess)
library(FLash)
library(ggplotFL)
#read stock file
data.dir <-
"C:/Users/s.leoni/Desktop/GFCM_WG_Demersal(2)/Mullus/XSA_MULLUS_GFCM_2014"
mut.stk <- readFLStock(paste(data.dir."MUT17IND.DAT".sep="/"). no.discards=TRUE)
#set up the stock (create the empty matrix)
units(harvest(mut.stk))<-"f"
range(mut.stk)["minfbar"] <- 1
range(mut.stk)["maxfbar"] <- 3
#Set the plus group
mut.stk <- setPlusGroup(mut.stk. 4)
#read index (tuning file)
mut.idx <- readFLIndices(paste(data.dir."TUNEFF2.DAT".sep="/"))
### shrinkage 0.5
FLXSA.control.mut1 <- FLXSA.control(x=NULL. tol=1e-09. maxit=30. min.nse=0.3. fse=0.5
rage=0. qage=3. shk.n=TRUE. shk.f=TRUE. shk.yrs=3. shk.ages=3.
window=100. tsrange=20. tspower=3. vpa=FALSE)
#Running the assessments with different settings
mut.xsa <- FLXSA(mut.stk. mut.idx. FLXSA.control.mut1)
#Add the results to the stock files
mut.stk <- mut.stk+mut.xsa
plot(mut.stk. main="Sh0.5")
```

6.1.3 Input data and Parameters

Catch at age were estimated from an age slicing of the length data series of the period 2008-2014 provided by official statistics from the 2015 DCF data call and using the growth parameters reported in Table 2.2-3 (Fig. 13). In the case discards data were missing for some years, they have been estimated on the base of the proportions of the available data.

The total catch numbers at age were rescaled based on a SOP correction carried out because of the differences (around 10%) observed between the reconstructed total catch and the total catch provided by 2016 DCF official call.

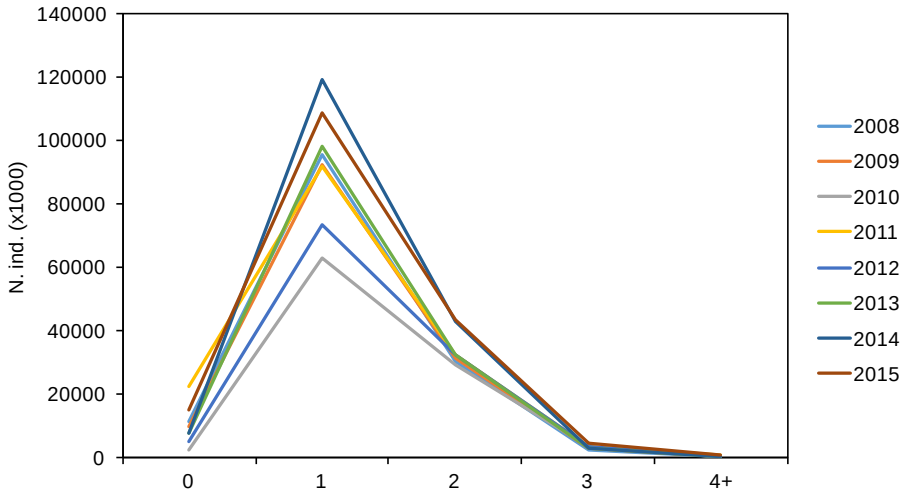


Figure 10 – Catch at age data utilized in the XSA.

Maturity at age and weight at age for stocks and catches were provided in the framework 2016 official data call.

Tuning data were provided by MEDITS survey, carried out in spring/summer the first for the years 2006-2014.

A vector of natural mortality rate at age was estimated using Chen and Watanabe spreadsheet (Chen and Watanabe, 1988).

Input data e parameters.

Catch at age in numbers (x1000)					
OTB	0	1	2	3	4+
2008	11198.5534	95367.3228	30579.6291	2546.44282	390.734665
2009	9859.30748	92403.9362	31195.1614	2932.33854	431.951297
2010	2414.29449	63105.8342	29229.2662	3314.21532	394.470105
2011	22688.8464	92059.2824	32341.5999	3641.00606	943.099504
2012	5231.93412	73466.5067	32503.5683	3469.85052	450.412198
2013	7503.78685	97986.4858	32271.4337	3001.82453	204.75707
2014	7932.52582	119058.834	42960.6479	3180.17783	241.575436
2015	15238.8837	108496.673	43585.8213	4518.62653	664.485335

Mean weight in catches (kg)					
Period	0	1	2	3	4+
2008-2014	0.017	0.022	0.043	0.072	0.1

Mean weight in stock (kg)					
PERIOD	0	1	2	3	4+
2008-2014	0.01	0.019	0.043	0.072	0.1

Abundance index at age (N. ind. / km^2)					
OTB	0	1	2	3	4
2008	16.787	1211.228	982.089	122.111	22.385
2009	4.92	920.782	634.094	142.637	18.068
2010	6.341	1220.096	799.752	140.968	26.273
2011	350.26	1276.121	437.618	100.188	10.074
2012	157.915	3468.043	763.755	72.321	10.225
2013	1224.944	4680.51	1025.543	158.069	20.034
2014	689.217	3175.732	637.887	105.005	20.528
2015	620.135	1727.096	411.85	63.912	19.348

Natural mortality (M)					
PERIOD	0	1	2	3	4+
2008-2014	1.03	0.71	0.65	0.62	0.62

6.1.4 Results

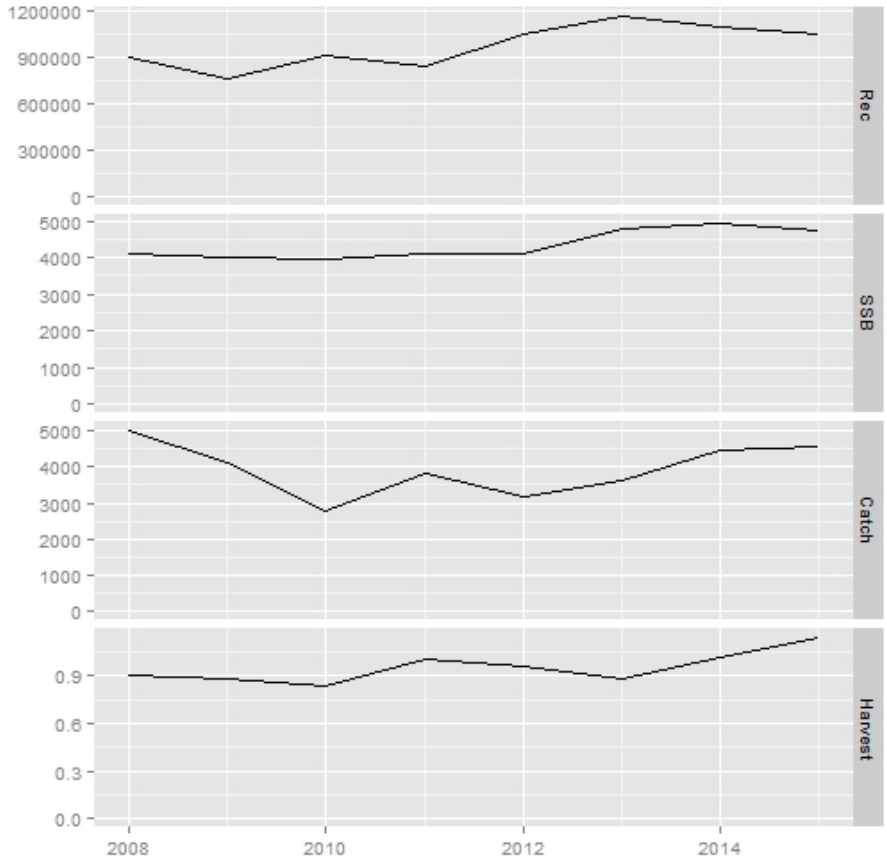


Figure 11 – Final assessment results XSA run.

State of exploitation: Exploitation pattern fluctuated between 0.9 and 1.13 from the beginning of the time-series reaching a minimum in 2010 (0.83). From 2013 it was observed an increasing trend of the harvest. The mean value of the last 3 years of F is 1.01.

State of the juveniles (recruits): Recruitment varied without any trend in the years 2008-2014, reaching a peak in 2013, followed by a decrease in the last two years.

State of the adult biomass: The SSB showed a more or less costant trend from 2008 to 2012. The last estimate of SSB in 2014 is 4731.0 tons.

Table 6.1.4-1 Fishing mortality by age estimated from the XSA.

age	2008	2009	2010	2011	2012	2013	2014	2015
0	0.024	0.025	0.005	0.053	0.010	0.012	0.014	0.028
1	0.780	0.802	0.588	0.752	0.654	0.675	0.776	0.750
2	1.321	1.279	1.300	1.451	1.343	1.416	1.557	1.620
3	0.599	0.570	0.606	0.794	0.863	0.564	0.707	1.047
4	0.599	0.570	0.606	0.794	0.863	0.564	0.707	1.047

6.1.5 Robustness analysis

Retrospective analysis comparison between model runs sensitivity analysis.

XSA Diagnostics in the form of residuals by survey and retrospective analyses are shown in Figures below. No particular trends are evidenced in residuals and the retrospective analyses is adequate.

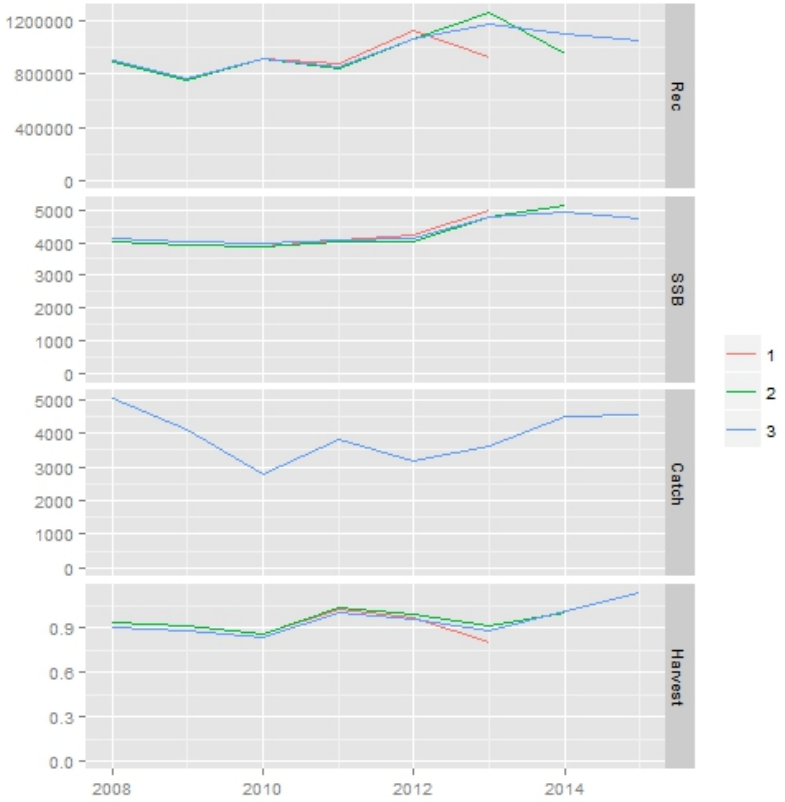


Figure 12 – Retrospective analyses on rescaled data.

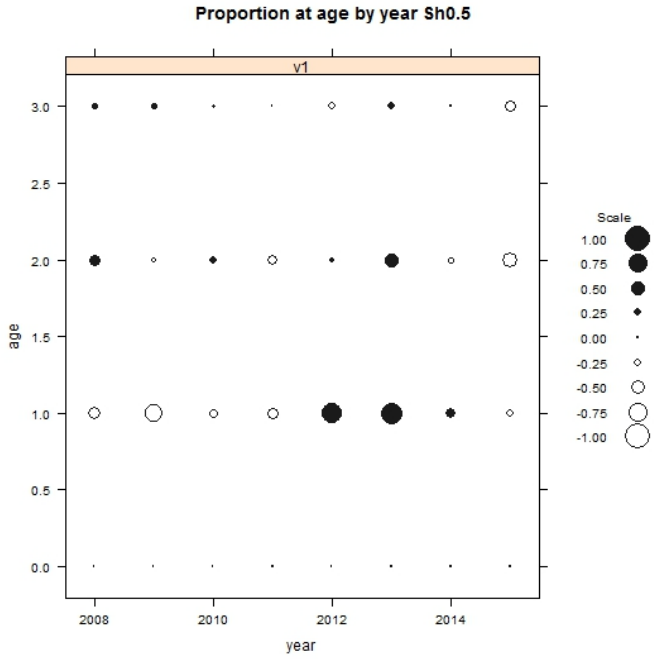


Figure 13 – Residuals by survey.

6.1.6 Assessment quality

The retrospective analysis and the residuals confirm the stability of the estimates of XSA.

6.2 Statistical catch at age (SS3 model)

6.2.1 Model assumptions

Stock Synthesis 3 provides a statistical framework for the calibration of a population dynamics model using fishery and survey data. It is designed to accommodate both population age and size structure data and multiple stock sub-areas can be analysed. It uses forward projection of population in the "statistical catch-at-age" (hereafter SCAA) approach. SCAA estimates initial abundance at age, recruitments, fishing mortality and selectivity. Differently from VPA based approaches (e.g. by XSA) SCAA calculates abundance forward in time and allows for errors in the catch at age matrices. Selectivity has been generated as age-specific by fleet, with the ability to capture the major effect of age-specific survivorship. The overall model contains subcomponents which simulate the population dynamics of the stock and fisheries, derive the expected values for the various observed data, and quantify the magnitude of difference between observed and expected data. Some SS features include ageing error, growth estimation, spawner-recruitment relationship, movement between areas; in the present assessment, such features are not summarized in the results. The ADMB C++ software in which SS is written searches for the set of parameter values that maximize the goodness-of-fit, then calculates the variance of these parameters using inverse Hessian methods. In the present assessment, the variance is not shown for fishing mortality results, because the model outputs provide F values (called continuous F) within a year as standardized into selection coefficients by dividing each F value by the maximum value observed for any age class in the year (e.g., Derio et *al.*, 1985; Sampson and Scott, 2011). For a better comparison with the results of previous assessments carried out both in the framework of STECF-EWGs and GFCM-WGs and with the outputs of the XSA carried out in the present assessment, the F values are standardized by dividing by the average

(called F_{bar}) of the F values observed over a defined range of age classes (e.g., Darby and Flatman, 1994; Sampson and Scott, 2011).

The model allowed to specify the different source of data, providing different uncertainties estimates for each data set. The total landings from 2000 to 2005, used in the model, come from FAO-FishstatJ source, after this year, for Italian and Slovenian from DCF; while Croatian data for the period 2008-2012 derive from Fish Primo Project, from 2013 from DCF. Also in this case the model considered the different sources of the data sets and treated the error separately for each period. In order to facilitate the convergence of the model a higher number of ages (until age 7) has been employed in the assessment.

The SS3 analyses has been carried out considering the following two fleets:

1. Italian otter trawler
2. Croatian and Slovenia otter trawler.

6.2.2 Input data and Parameters

Input data and parameters are the same used for the XSA.

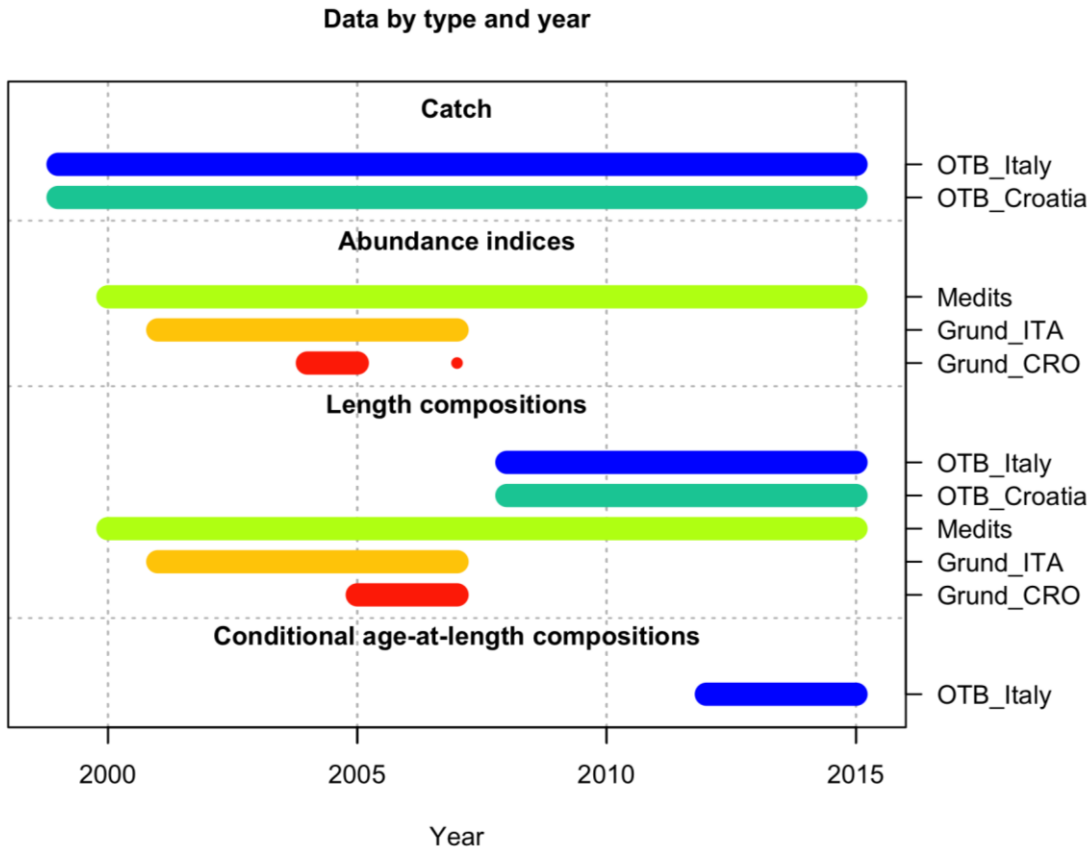


Figure 14 - input data (the red squares represent DCF data, graph on the left)

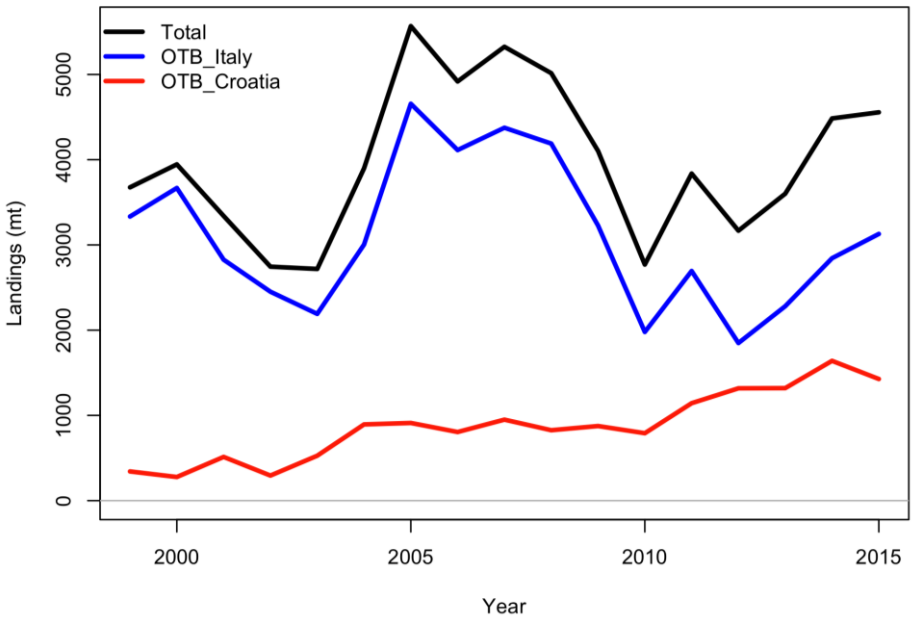


Figure 15 – Input data (the red squares represent DCF data, graph above) and landings imputed in the SS3 model (graph below).

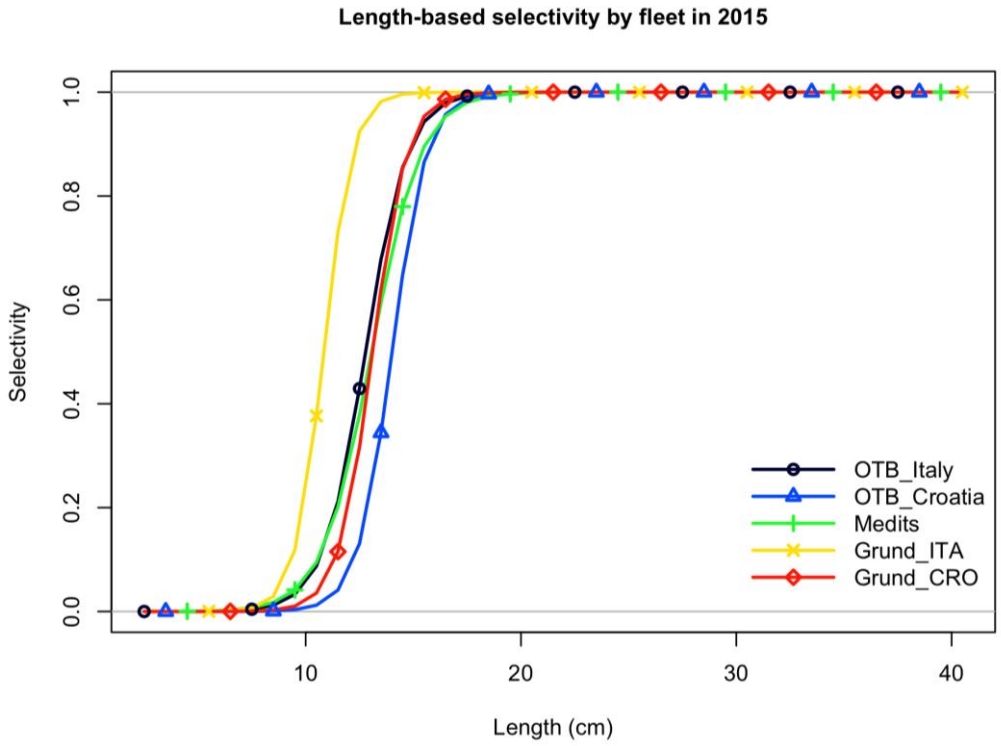


Figure 16 – Selectivity by age utilized in the SS3 model.

SCAA Diagnostics in the form of residuals by survey and fleet data are shown in Fig. 20.

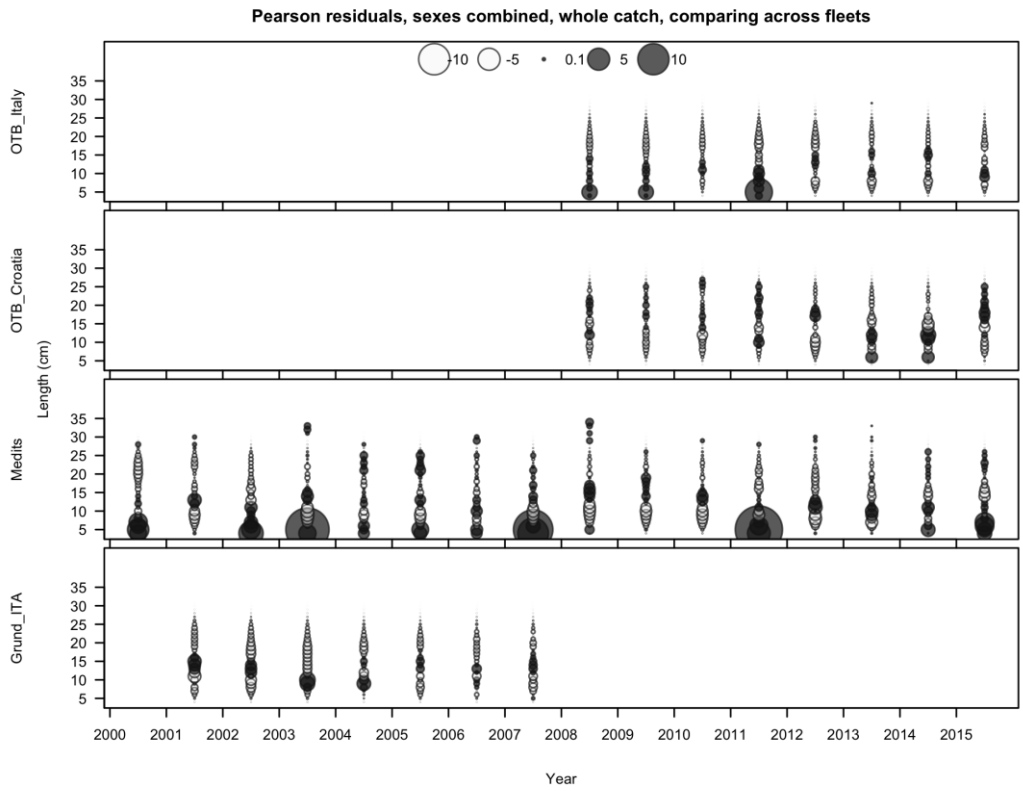
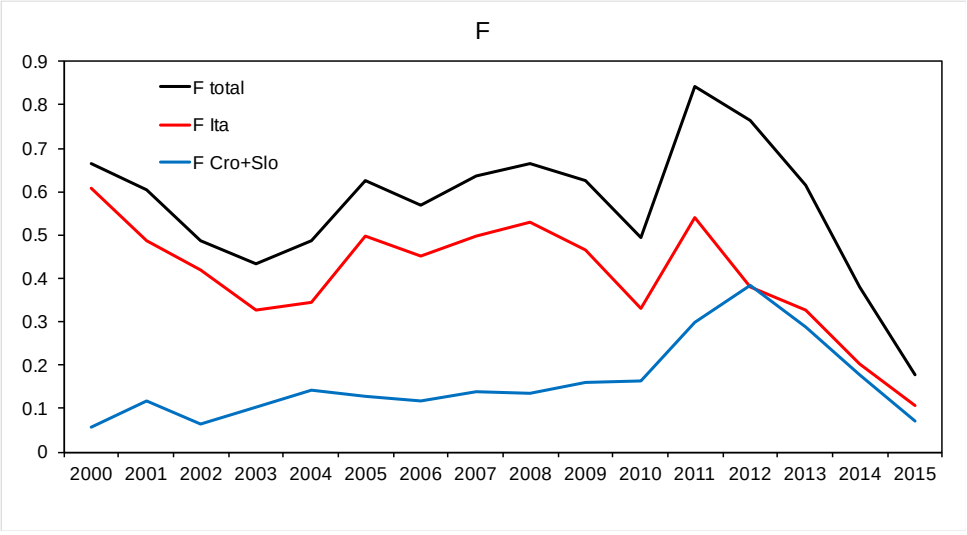


Figure 17 - Pearson residuals for MEDITS and GRUND surveys and the fleets.

Fig. 18 presents the main results from the SS3 run: fishing mortality ($Fbar_{1-3}$ and by fleet), recruitment and spawning stock biomass (SSB).



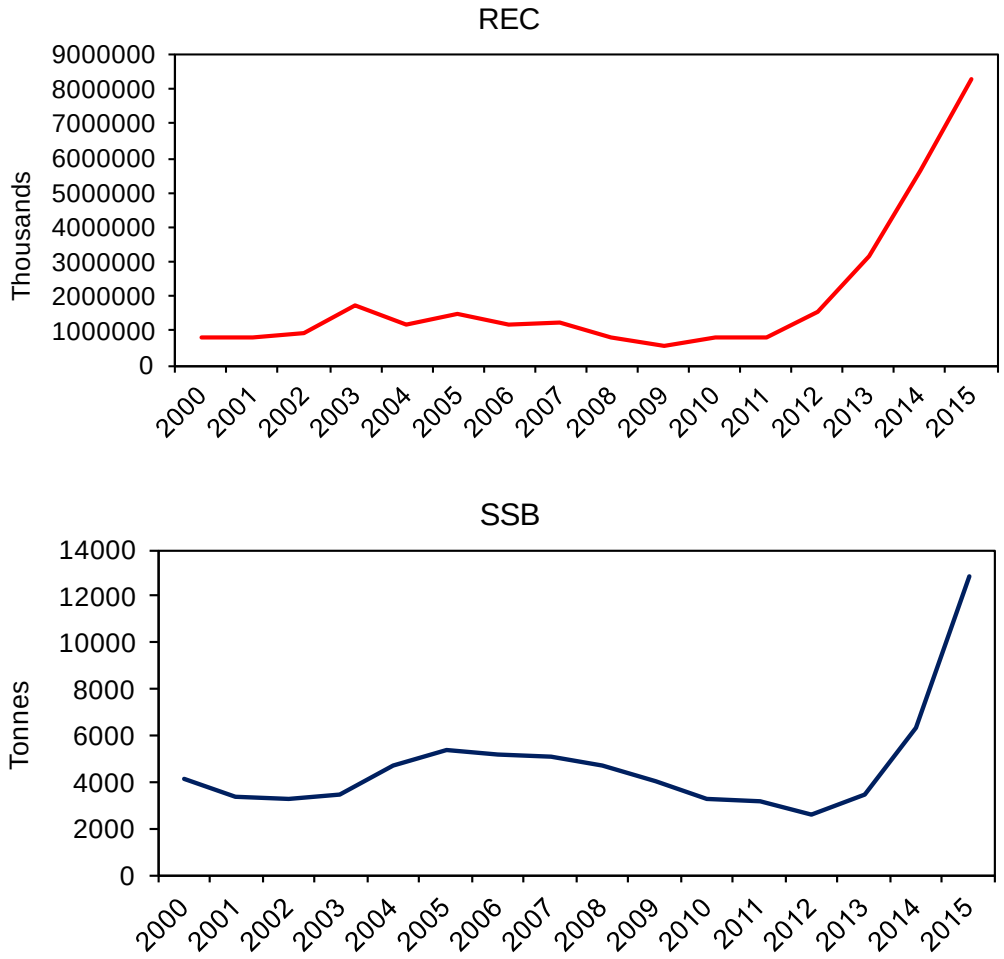


Figure 18 – Final assessment results SS3 run.

State of exploitation: for the exploitation pattern it was observed a variable trend from the beginning of the time-series, with a more pronounced increase in 2011. From 2011 to 2014 there was a costant decreasing pattern reaching a value of F of 0.39 (average of the last three years). The partial F for each fleet is 0.10 for Italian trawlers and 0.07 for Croatian and Slovenian trawlers.

State of the juveniles (recruits): Recruitment varied without any trend in the years 2000-2011, reaching a minimum in 2009; after 2011 there was an increasing trend.

State of the adult biomass: The SSB showed such as the recruitment an increasing trend but, from 2012. The last estimate of SSB in 2015 is around 12831.7 tons.

7 Stock predictions

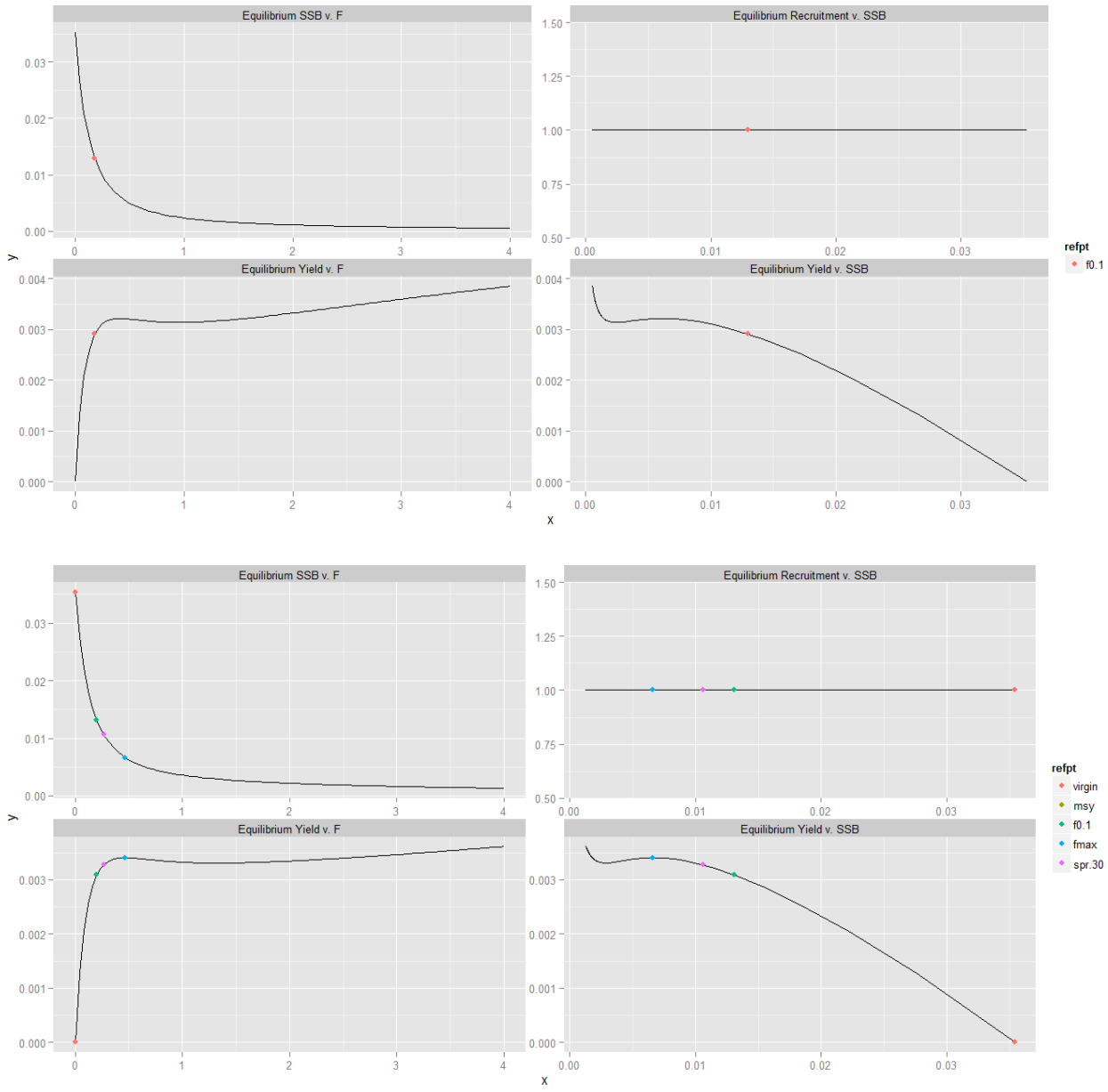


Fig 22 - Yield per Recruit graphs for SCAA (above) and XSA (below)

Table 7.1 - Yield per Recruit outputs for XSA and SCAA.

	Current F ($F_{BAR\ 1\text{-}3}$)	**Reference Points**	**Harvest**
XSA	1.01	$F_{0.1}$	0.45
SS3	0.39	$F_{0.1}$	0.31

7.1 Short term predictions

7.2 Medium term predictions

7.3 Long term predictions

8 Draft scientific advice

Considering the results of the analyses conducted, the red mullet stock in GSA 17 is subjected to overfishing being the current F estimated higher than the proposed reference point ($F_{0.1}$ SS3 = 0.31 as a proxy of FMSY). From 2011 it was observed a decreasing trend of the fishing mortality, both for Italian and Croatian and Slovenian fleets. For this reason, a further reduction of fishing mortality towards the proposed reference point is advised. Considering, although low, the overfishing situation of the red mullet stock, a reduction of fishing pressure and an improvement in exploitation pattern especially of Italian trawlers exploiting a larger amount of Age 0+ group than Croatian and Slovenian trawlers is advisable. However, from the analysis of the relative spawning biomass observed in 2015 from SS3, is possible to conclude that the abundance of the stock is high and there is not risk of stock depletion.

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	($F_{0.1}$ = 0.45) ($F_{0.1}$ = 0.31)	1.01 XSA 0.39 SCAA		D	O_L
	Fishing effort					
	Catch					
Stock abundance	Relative Biomass	The current value is higher than 66th percentile	12381.7 tons SCAA			O_H
Recruitment						
Final Diagnosis		Low overfishing and high stock abundance				

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
5) the amount of fishing effort exerted;
6) **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)*