Stock Assessment Form
Demersal species

Reference year: 2016

Reporting year: 2017

ABSTRACT

The Working Group between Spain and Morocco on blackspot seabream (*Pagellus bogaraveo*) stock of the Strait of Gibraltar area was held in Tangier (Morocco) from 22 t o 23 October 2017. The main objective of this WG was to update the existing data and information and to carry out an update joint stock assessment of this stock shared by this two countries (GSA 01 and GSA 03).
Three different assessment approaches wer e conducted during the WG : [1]a Cohort Analysis (LCA-VPA) with the YPR and SSP/R , [2]a global model (BioDyn) and [3]a gadget model. The results of those 3 methods attempted on the blackspot seabream population of the Strait of Gibraltar showed the same stock statu s: overexploitation of this resource . The reference point estimates ($F_{0.1}$ = 0.12 – 0.17) is below from current fishing pressure (about 0.3).

After the presentation of the assessment exercises within the WGSAD 2017, it was only accepted in terms of "qualitative advice" . Anyway, the reduction offishing effort towards fishing mortality sustainability levels is desirable. Besides, a (Spain-Morocco) specific/joint management plan for the blackspot seabream of the Strait of Gibraltar should be agreed/implemented ASAP.

Stock Assessment Form version 1.0 (January 2014)

Uploader: Juan Gil Herrera

Stock assessment form

Sommario

1 Basic Identification Data

Scientific name:	Common name:	ISCAAP Group:
Pagellus bogaraveo	Blackspot (=red) seabream, dorade rose, besugo de la pinta, voraz, مرجان وردي	33
1st Geographical sub-area:	**2nd Geographical sub-area:**	**3rd Geographical sub-area:**
GSA 01	GSA 03	
1st Country	**2nd Country**	**3rd Country**
Spain	Morocco	
Stock assessment method: (direct, indirect, combined, none)		
Indirect (LCA/VPA, gadget, BioDyn and YPR)		
Authors:		
J. Gil Herrera[1], S. Benchoucha[2], J.L. Pérez Gil[3], S. el Arraf[2] and B.T. Elvarsson[4]		
Affiliation:		
[1] Spanish Institute of Oceanography (IEO), Oceanographic Center of Cadiz. Spain [2] National Institute of Fisheries Research (INRH), INRH-Tangier Center. Morocco [3] Spanish Institute for of Oceanography (IEO), Oceanographic Center of Málaga. Spain [4] Institute of Marine Research (HAFRO), Reykjavik. Iceland		

2 Stock identification and biological information

2.1 Stock unit

Blackspot seabream (*Pagellus bogaraveo*) is found in the NE Atlantic, from South of Norway to Cape Blanc, in the Mediterranean Sea, and in the Azores, Madeira, and Canary Archipelagos (Desbrosses, 1938). Adults inhabit depths ranging around 300-700 m. The vertical distribution of this species varies according to individual size (Desbrosses, 1938; Guegen, 1974; Silva et al., 1994 and Gil, 2006)

This species is one of the most important commercial demersal species in the Strait of Gibraltar area. However, there is not much information available on the stock structure of *P. bogaraveo* in this narrow site. So, the usual way of stock separation (GFCM and ICES) is based in subareas boundaries that does not pre-suppose different stocks but it offers a better way of recording the available information. Migration patterns have been studied using tagging surveys in the GSA 01 Spanish Southern Mediterranean region and the Strait of Gibraltar area (Gil *et al*., 2001; Sobrino and Gil, 2001). Since 1997, 7066 individuals were tagged (juveniles + adults) and, at the moment, 545 recaptures were notified. Recaptures from juveniles showed displacements from GSA 01 nursery areas towards the Strait of Gibraltar fishing grounds. However, recaptures from tagged adults did not reflect big displacements, which are limited to feeding movements among the different fishing grounds where the "*voracera*" fleets works (Gil, 2006).

Six main fishing areas (Figure 2.1.1) were identified for the Spanish fleet based on the information provided by the Location and Track System for Andalusian Fishing Vessels (SLSEPA) of the Junta de Andalucía in the period August 2007-December 2009.

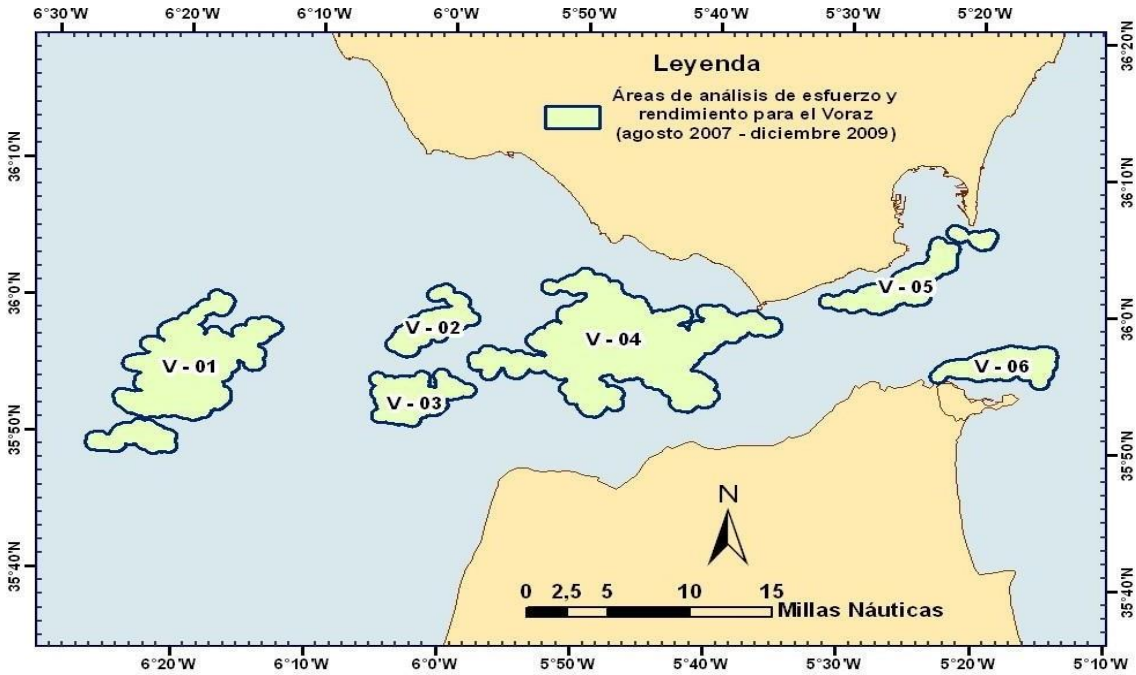


Figure 2.1.1- Main fishing grounds of the Spanish blackspot seabream fishery. Information from the Location and Track System for Andalusian Fishing Vessels (SLSEPA) of the Junta de Andalucía.

INRH experts identified the areas V-02, V-03, V-04 and V-06 from the Spanish fishing grounds as the main important fishing areas for the Moroccan fleets. Based on the available information the area for the joint assessment exercises are delimited around the Strait of Gibraltar, where 90% of the landings come from.

The following two main fishing areas (Figure 2.1.2) were identified in the Strait of Gibraltar area from the investigations with Moroccan fishermen: West of Cap Spartel to the East of Benyounech and Fnideq to Martil.

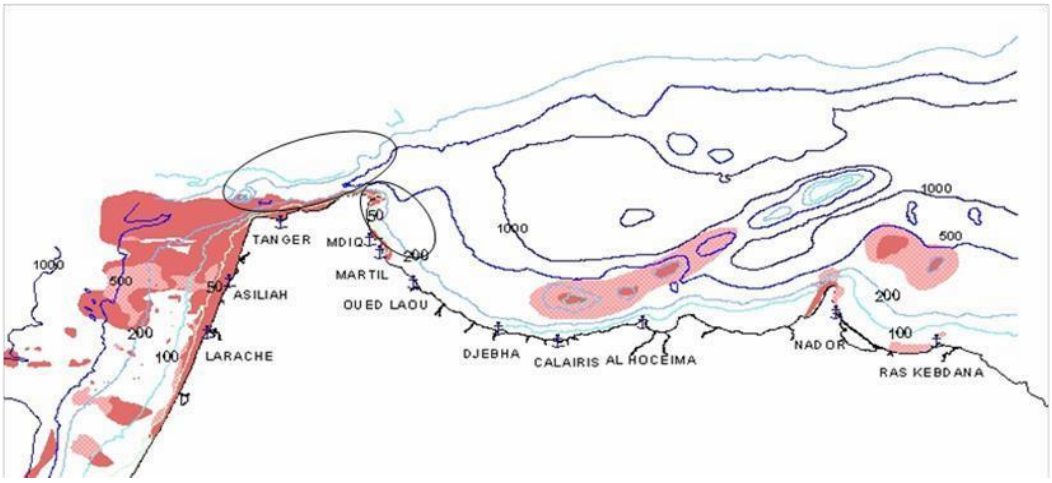


Figure 2.1.2- Map of the main Moroccan fleet fishing grounds. The circles present the most important fishing grounds of the Moroccan longliners and artisanal fleet in the Strait of Gibraltar area.

Until now, there was a lack of information on the geographical distribution pattern distribution and stock (Atlantic and Mediterranean) boundaries of the blackspot seabream population fished in the Strait of Gibraltar.

2.2 Growth and maturity

Blackspot seabream is a species belonging to the Sparidae family. They are bentho-pelagic species, inhabiting depth ranges from 300 to 700m throughout the eastern Atlantic and western Mediterranean. They are hermaphrodites, starting life as males but changing into females at 30 -35 cm, when got 4 to 6 years old. They grow slowly to a maximum size of 70 cm, weight of 4 kg and an age of about 15 years. Blackspot seabream have a low resilience to exploitation due to their being sequential hermaphrodites and a slow growing species (ICES, 2014).

Biological parameters used in the assessments were taken from the previous studies because there is not new biological information available. Natural mortality was assumed constant (0.2) for all ages, length classes and years. Parameters estimates on the length-weight relationship (*a* and *b*) and the von Bertalanffy growth function (L_{inf}, k and t_o) are presented in the Tables 2.2-1 and 2.2-1).

The information on landings length distribution came from both countries (Spain and Morocco) sampling plans to cover North and South region of Strait of Gibraltar. Sampling program covered the two main landing ports, Tarifa (Spain) and Tangier (Morocco): total length of fish (TL) was measured to the nearest 1cm. To estimate the

demographic structure of the whole catches, length frequency samples were raised to the total landing per fleet (and/or market category) and fishing region.

Figures 2.2.1 and Figure 2.2.2 presents the landings length frequencies distribution in the Strait of Gibraltar area (GSA 01-Spain and GSA 02-Morocco) from 2005 onwards.

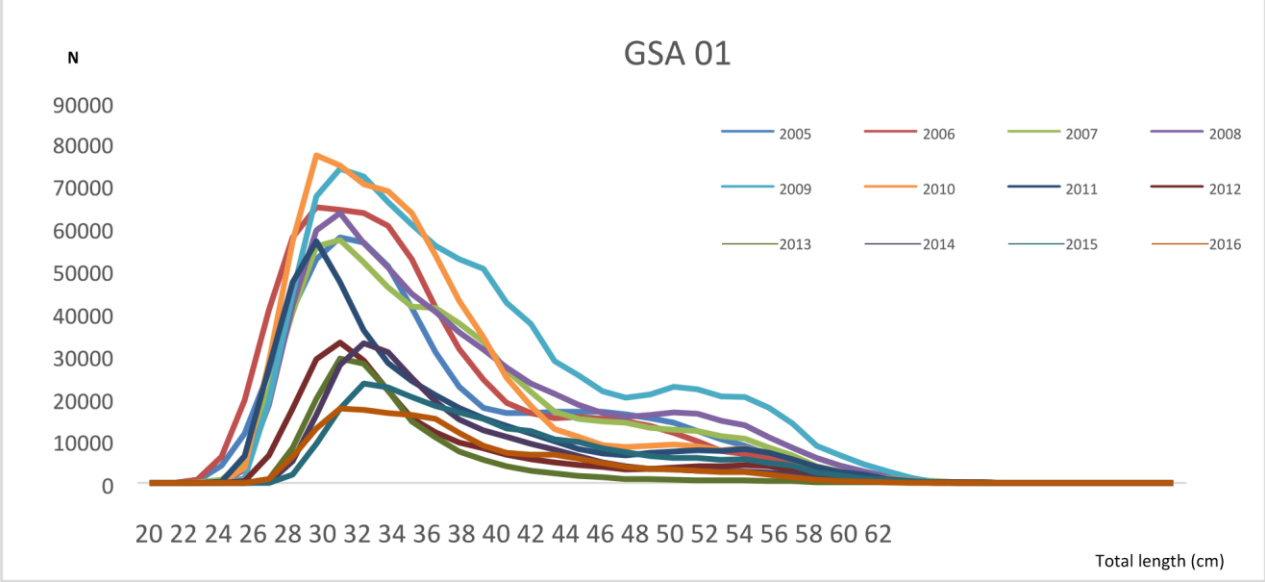


Figure 2.2.1 - Pagellus bogaraveo: 2005-2016 length frequency distribution in the Strait of Gibraltar area (GSA 01)

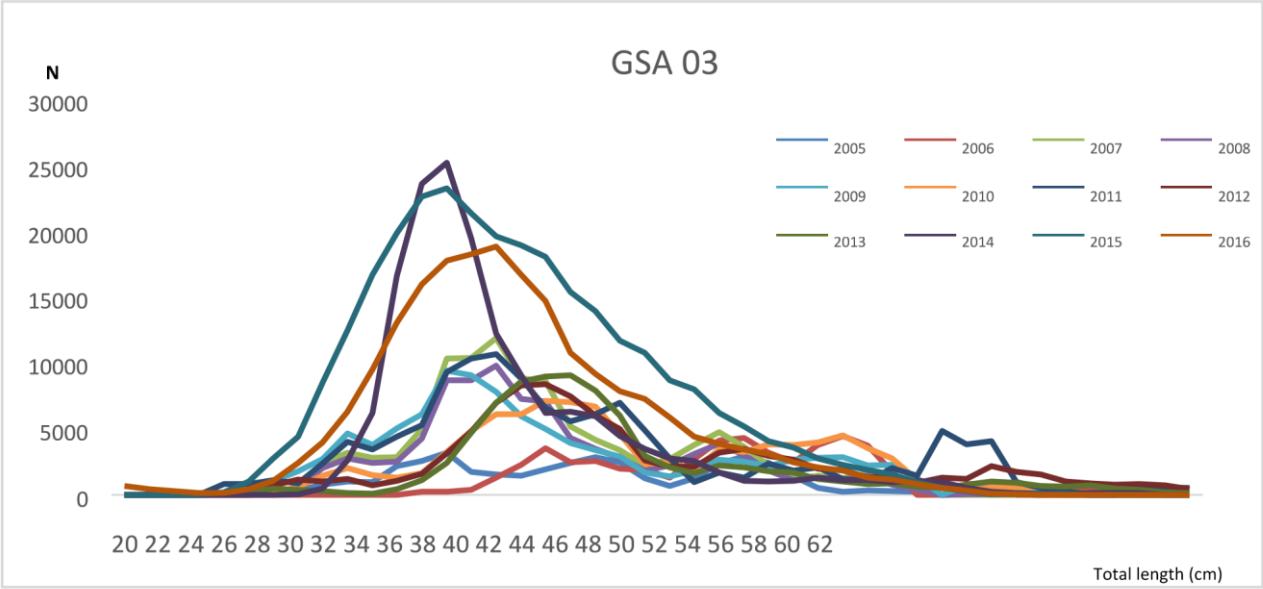


Figure 2.2.2 - Pagellus bogaraveo: 2005-2016 length frequency distribution in the Strait of Gibraltar area (GSA 03)

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

Somatic magnitude measured (LT, LC, etc)			Total Length	**Units**	cm
Sex	**Fem**	**Mal**	**Combined**	**Reproduction season**	January-March*
Maximum size observed			62*	**Recruitment season**	
Size at first maturity	±35	±30*		**Spawning area**	Strait of Gibraltar area*
Recruitment size to the fishery				**Nursery area**	Shallower bottoms at both sides of the Strait of Gibraltar, mostly Mediterranean one

*Gil J., 2010

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

Age	Natural mortality*	Proportion of matures**
0	0.2	0.020
1	0.2	0.13
2	0.2	0.49
3	0.2	0.84
4	0.2	0.98
5	0.2	0.99
6	0.2	1.000
7	0.2	1.000
8+	0.2	1.000

*ICES WGDEEP Report 2008

**Gil, 2006

Table 2.2-3: Growth and length weight model parameters

			Sex			
		Units	**female**	**male**	**Combined**	**Years**
Growth model	**L_∞**	cm			62	
	K	$Year^{-1}$			0.162	
	t_0	year			-0.34	
	Data source	Spanish info from certain biological samplings				
Length weight relationship	**a**				0.008	
	b				3.178	
	M (scalar)				0.2	
	sex ratio (% females/total)	Hermaphrodite				

3 Fisheries information

3.1 Description of the fleet

Blackspot seabream is one of the principal demersal species targeted in the Strait of Gibraltar for its highest commercial value compared to others demersal resources. The fishing hook gears used are known as ‘‘*voracera*’’ in both countries involved in the fishery (Morocco and Spain).

Spanish fleet:

The Spanish fishery targeting blackspot seabream has been developing along the Strait of Gibraltar area (Gil *et al*., 2000) since the earliest 1980´s. Its fishery in the Strait of Gibraltar is almost a mono- specific one, with one clear target species which represents the 74% from the total landed species which constitutes a métier by itself (Silva *et al*., 2002). The “*voracera*”, a local mechanized hook line baited with sardine, is the gear used by the fleet from Tarifa and Algeciras ports (see Figure below). Fishing is carried out taking advantage of the turnover of the tides in bottoms from 200 to 400 fathoms. Every boat can only use a maximum of 30 lines per day (each line attached a maximum of 100 hooks, usually ±70) with a maximum legal length of 120 m. The legal dimensions of the hooks are a minimum length of 3.95 ± 0.39 cm and a minimum width of 1.4 ± 0.14 cm. Number of boats decrease in the last years and its mean technical characteristics are: Length= 9.80 meters, GRT= 6.36 and HP= 47.23.

Moroccan fleet:

The most important Moroccan fleets targeting blackspot seabream are the longliners mainly based at the port of Tangier and the artisanal fleet of the Strait of Gibraltar area. In the past years, the longliners fleet was more or less stable (78 to 101 vessels). The number of the longliners fleet in 2016 was approximately 84 and 76 artisanal boats. The fishery is carried out at 200-700 m depth and the gear used is the longline known as “*voracera*”. The number of hooks by boat is between 200 and 2000 and the size of the hooks is between 8 and 11.

The blacksopt seabream represent +18% in weight and 46% in commercial value of to the total catches provided by this fleet in last year: the first species landed by the longliners are *Lepidopus caudatus* and squalidae fishes. The blacksopt seabream fishery is carried out at 200-700 m depth and the gear used is a longline known as “*voracera*”. Some artisanal boats are targeting *Pagellus bogaraveo* in the Strait of Gibraltar too. There are 435 artisanal boats landing seasonally *Pagellus bogaraveo* and many other species, the mean annual catch of this fleet is about 17 tons.

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	GSA 01	Artisanal	Handlines (“*voracera*”)	Demersal shelf species	Blackspot seabream
Operational Unit 2	MAR	GSA 03	Longliners and artisanal	Longlines (“*voracera*”)	Demersal shelf species	Blackspot seabream

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

Operational Units*	Fleet (n° of boats)*	Catch (T or kg of the species assessed)	Other species caught (names and weight)	Discards (species assessed)	Discards (other species caught)	Effort (units)
ESP 01 -HL	58 (2016)	104 t (2016)	*Lepidopus caudatus, Helicolenus dactylopterus, Brama brama, Trachurus spp, Phycis spp., Polyprion americanus* *Thunnus thynnus**	Negligible	Unknown	(Fishing days) 2418 (2016)
MAR 03 -LL	84 (2016)	159 t (2016)	*Lepidopus caudatus* (250 t) *Squalidae (*229 t) *Scorpaena scrofa* (52 t) *Conger conger* (34t) *Polyprion americanus* (25 t) *Xiphias gladius** (12 t) Others (93 t)	Negligible	Unknown	(Fishing days) 4614 (2016)
Total	142	269				6832

*Same boats but different gear (not “*voracera*” one)

3.2 Historical trends

Fishery Information about the Spanish landings were compiled from the two main ports (Tarifa and Algeciras), where *Pagellus bogaraveo* was landed from 1983-to 2016 (Figure 3.2.1). Landings are distributed in 4 different commercial categories, owing to the wide range of sizes and for market reasons. The trend of the catches shows a big decline in the Spanish fishery, from 600 tons in 2009 to 130 tons in 2013 and only 104 t in 2016 (Table 3.2-1).

Catches from the Moroccan fisheries were low at the beginning to remain more or less stables for the whole series (Figure 3.2.1). From 2013 onwards it showed an increasing trend setting the highest value on 2015 with 219 tons and 159 t in 2016. The 2010-2016 mean production of this fishing resource is about 142 tons (Table 3.2-2).

At the start of the series Spanish fishing effort was very high in comparison with the Moroccan one, but since 2009 declined and reached the same level of the Moroccan one. Moroccan fishing effort have increased and became highest in the last two years (Figure 3.2.2).

The CPUE was more or less stable for both countries (Spain and Morocco) with an average of 51 and 36 k/fishing trip, respectively (Tables 3.2-1 and 3.2-2).

Table 3.2-1: Landings and CPUE of Pagellus bogaraveo in GSA 01 (Strait of Gibraltar area)

YEAR	*Pagellus bogaraveo* landings (t)	CPUE (k/fishing day)
2005	334	69
2006	350	71
2007	366	52
2008	420	52
2009	583	66
2010	370	53
2011	244	43
2012	130	36
2013	70	32
2014	142	40
2015	172	51
2016	104	43

Table 3.2-2: Landings and CPUE of Pagellus bogaraveo in GSA 03(Strait of Gibraltar area)

YEAR	*Pagellus bogaraveo* landings (t)	CPUE k/fishing day
2005	39	40
2006	74	39
2007	89	35
2008	76	34
2009	99	40
2010	105	38
2011	136	34
2012	122	32
2013	92	33
2014	118	33
2015	219	44
2016	159	34

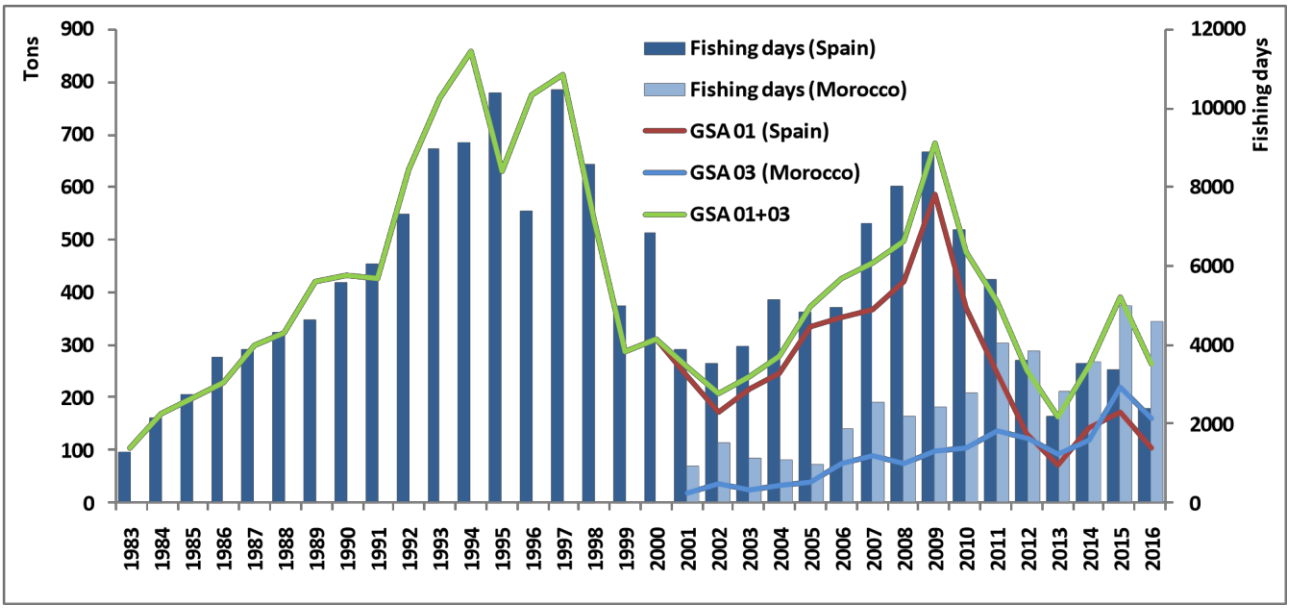


Figure 3.2.1 - Landings and effort on Pagellus bogaraveo (1983-2106) in the Strait of Gibraltar area (GSAs 01 and 03) historical series.

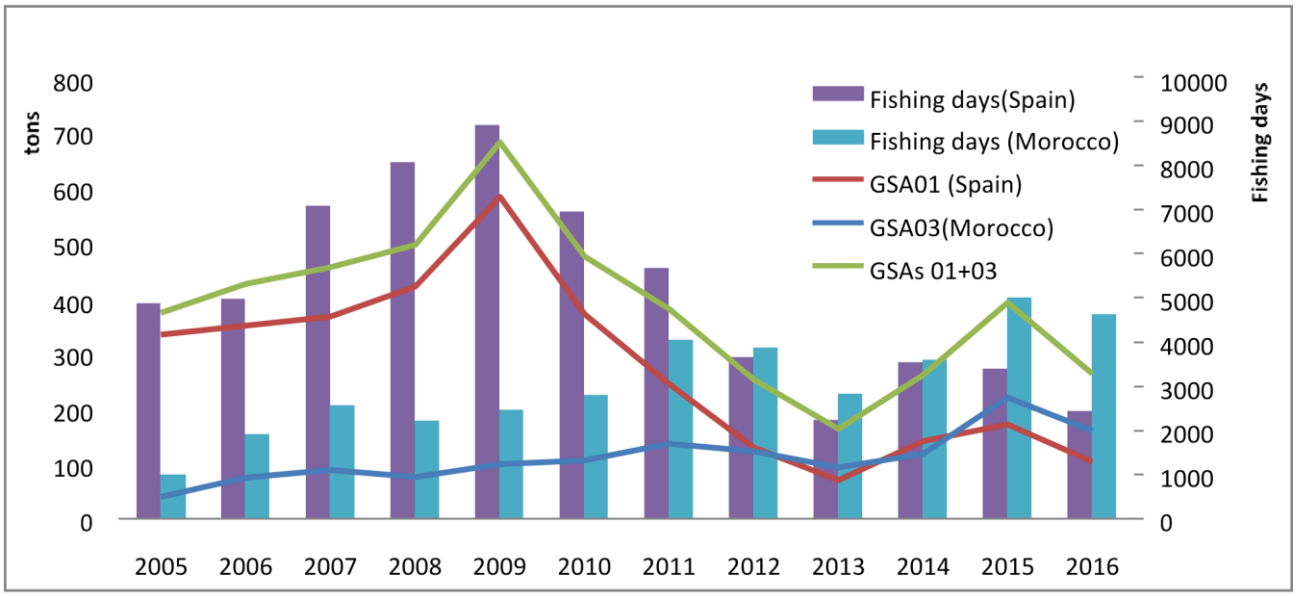


Figure 3.2.2 - Annual landings and effort on Pagellus bogaraveo in the Strait of Gibraltar area (GSAs 01 and 03) data series used in LCA-VPA and BioDyn assessment exercises.

3.3 Management regulations

Spain (GSA 01):

A management plan for this fishery was established by the AAA/1589/2012 Order of July 17, establishing a plan for the blackspot seabream fishery in certain areas of the Strait of Gibraltar regulating the area, gear ("*voracera*") and the fleet. This plan includes an authorized "*voracera*" fleet, fishing gear technical characteristics (that was stated above), a seasonal fishery closure between February 1st and March 31st and the regulation of the effort by week. Minimum landing size and the annual Total Allowable Catch (TAC) are related to the EU Regulation a minimum size for blackspot seabream of 33 cm (Total length) currently applies in the Mediterranean and also in the North-East Atlantic since May 2018 [Commission Implementing Regulation (EU) 2017/787 of 8 May 2017 establishing a minimum conservation reference size for red (blackspot) seabream in the North- East Atlantic Ocean].

Morocco (GSA03):

The main regulations enforced by Morocco are: the gel of investment since 1992; the interdiction of fishing beyond 80 m depth in the area between Tangier and Al Hoceima and below 3 miles in the area between Al Hoceima and Saidia; the minimal landing size (25 cm Fork Length, about 28 cm Total Length); trawls mesh size ≥ 50 mm; nets regulations (L = 1000 m, mesh size = 70 mm) and, the protection of areas (marine protected area) and anti-trawling artificial reefs.

3.4 Reference points

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

Indicator	Limit Reference point/empirical reference value	Value	Target Reference point/empirical reference value	Value	Comments
B					
SSB					
F					
Y					
CPUE					
Index of Biomass at sea					

4 Fisheries independent information

None

5 Ecological information

5.1 Protected species potentially affected by the fisheries

Not relevant for the case of the blackspot seabream fishery of the Strait of Gibraltar, because the fishery do not interact with these kind of species. Anyway the table below shows the list of species which occur in the area included in several protection agreements (Ocaña *et al.*, 2010).

Phylum	**Species**	**Protection Agreement**
Chordata	*Polyprion americanus*	**RL**: DD
	Thunnus thynnus	**RL**: DD /**OSPAR**: V/ **UNCLOS**: YES / **BARCOM**: III
	Pagrus pagrus	**RL**: EN
	Xiphias gladius	**RL**: DD / **UNCLOS**: YES/ **BARCOM**: III
	Galeorhinus galeus	**RL**: VU / **UNCLOS**: YES
	Isurus oxyrhinchus	**RL**: VU / **CMS:** II / **BERN:** II / **UNCLOS**: YES/ **BARCOM**: III
Cnidaria	*Caryophyllia spp.*	**CITES:** II
	Lophelia pertusa	**CITES:** II / **OSPAR:** All
	Dendrophyllia cornigera	**CITES:** II
	Dendrophyllia ramea	**CITES:** II
	Madrepora oculata	**CITES:** II
	Errina aspera	**CITES:** II / **BERN:** II (Med.) / **BARCOM:** II
Echinodermata	*Ophidiaster ophidianus*	**BERN:** II (Med.) / **BARCOM:** II
	Paracentrotus lividus	**BERN:** III / **BARCOM:** III
Mollusca	*Charonia lampas*	**BERN:** II / **BARCOM:** II
	Ranella olearia	**BERN:** II (Med.) / **BARCOM:** II
Porifera	*Axinella polypoides*	**BARCOM:** II

RL: IUCN Red List of Threatened Species: EN (Endangered), VU (Vulnerable), DD (Data Deficient) **CITES:** Convention on International Trade in Endangered Species of Wild Fauna and Flora: Appendix **OSPAR:** Convention for the Protection of the marine Environment of the North-East Atlantic: Annex **UNCLOS:** United Nations Convention on the Law of the Sea - Annex I (highly migratory species) **BARCOM:** Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean (Barcelona Convention): Annex **BERN:** Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention): Appendix **CMS:** Convention on Migratory Species: Appendix

So, despite the absence of interactions with the fishery, the presence/inventory of corals (as well as sponges) should be update/improve: Figure 5.1.1 shows the Strait of Gibraltar area where blackspot seabream were fished by the Spanish "*voracera*" fleet (yellow dots).

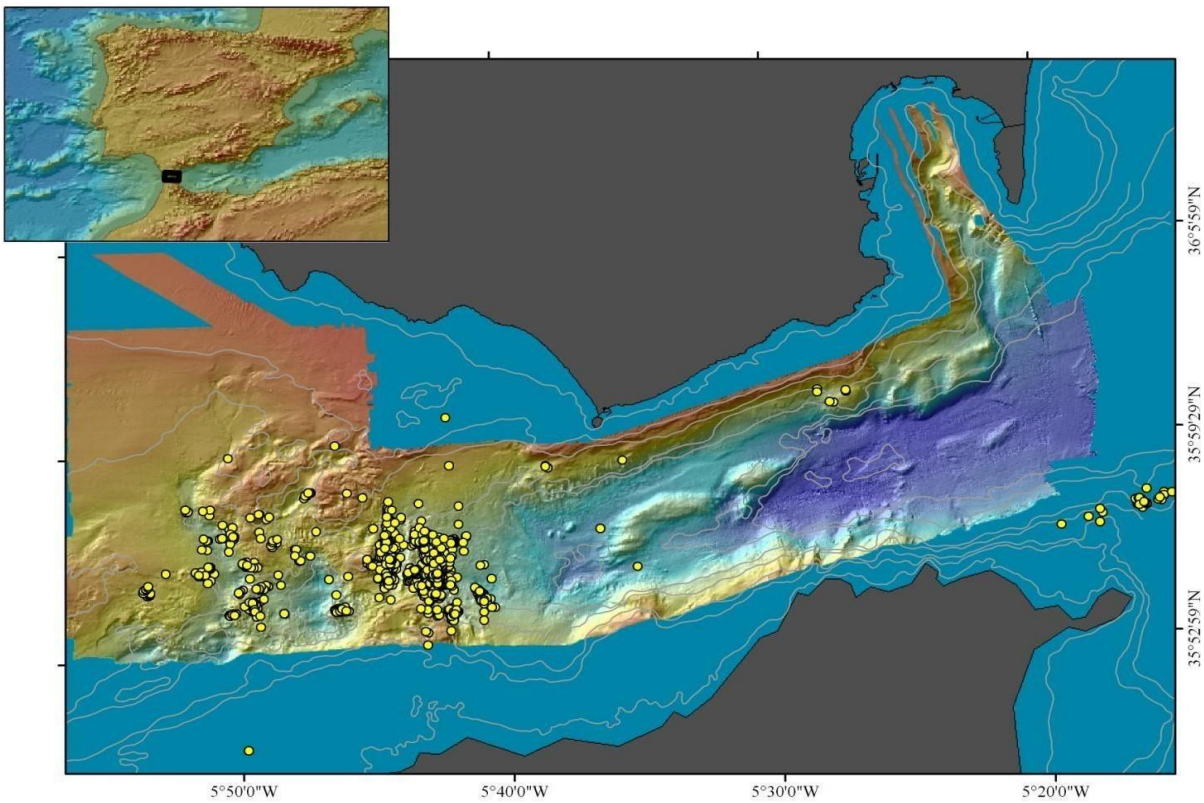


Figure 5.1.1 - Strait of Gibraltar area: Coral distribution (adapted from Álvarez-Pérez et al. in Freiwald and Roberts eds, 2005) and Spanish "voracera" fleet main fishing grounds (yellow dots).

5.2 Environmental indexes

None. However, the special features of the Strait of Gibraltar area as well as environmental parameters could affect the stock abundance or the gear catchability might be taken into consideration (i.e. currents´ strength).

6 Stock Assessment

The estimation of the blackspot seabream population dynamics and exploitation patterns was performed by using different approaches (analytical and global assessments). Three different methods to evaluate the current status of the stock were attempted to compare the results obtained using the joint data from Morocco and Spain.

The first was based on Length Cohort Analysis (LCA) and Virtual Population Analysis (VPA): from the results obtained a Yield per Recruit (YpR) analyses was run to estimate *ad hoc* reference points (F_{MAX} and $F_{0.1}$).

Second approach was carried out with using a global model "BioDyn" based on the Schaeffer production model.

And, the third was the development of a gadget model.

Every methodology, data inputs and the main outputs are

detailed below.

6.1 Length Cohort and Virtual Population Analyses (LCA and VPA)

6.1.1 Model assumptions

In a Cohort Analysis or VPA, the stock is considered to be composed of several annual cohorts and every cohort of the stock is analyzed and followed separately. It is based on backward calculations through time and ages given knowledge of all ages in the last year and the last age group in all years; by adding the number of individuals lost to fishing and natural mortality during a year to the number of individuals at the end of the year to estimate the number of individuals at the beginning of the year.

Length Cohort Analysis (LCA) assessment was attempted using the VIT software (Lleonart and Salat, 1992). VIT is a program created for the analysis of fisheries where information is limited. VIT program was designed to analyze exploited marine populations based on catch data, structured by ages or sizes, from one or several gears. The main assumption is that of the steady state (equilibrium conditions) because the program works with pseudo-cohorts, therefore it is not suitable for historic series. From the catch data with some auxiliary parameters and using VPA, the program rebuilds the population and mortality vectors. After this first step, the user has several analysis tools and reporting options available: obtaining comprehensive VPA results, Yield-perRecruit analyses based on the fishing mortality (F) vector, analyses of sensitivity to parameters inputs, and transition analyses - outside the equilibrium - due to changes in the pattern of exploitation or recruitment. The stock size estimates, which include recruitment estimates for every year, can be used for a yield per recruit analysis. The use of this software is only recommended when the model is applied to short time series of consecutive annual data and the resulting variation in the estimated stock parameters appears reasonably low. (Ratz *et al*., 2010).

Analytical assessment (VPA) requires catch at age numbers. Lengths distributions were transformed into ages by the “slicing technique” implemented in the VIT software. The value of age plus was set at 24+.

6.1.2 Input data and Parameters

Before the exercise a preparation (SOP correction) and harmonization (smoothing) of the available data was done. Then, LCA-VPA test was done for every two year separately backwards (from 2005 to 2016, we can call it a sequential one) to check stability of parameters. Afterwards, a 2014-2016 pseudocohort was created for a last LCA run. Table 6.1.2-1 shows the combined (GSA 01 and GSA 03) length frequency distribution used in this assessment.

Table 6.1.2-1: Summary of input parameters and the pseudo-cohort 2014-2016 of blackspot seabream used in the Length Cohort Analysis (LCA).

L_∞	k	t_0	a	b	F_t
62 cm	0.162 $Year^{-1}$	-0.34 year	0.008	3.178	0.5

length class (2 cm)	Spain-Morocco			Pseudocohort (2014-2016)
	2014	2015	2016	
20	0	0	1169	390
22	0	110	468	193
24	203	1248	1656	1036
26	21214	18397	22665	20758
28	63662	61850	44955	56822
30	78416	79288	54951	70885
32	82941	80593	60672	74736
34	55090	68976	52972	59013
36	32448	59470	44730	45549
38	23645	47187	30483	33772
40	15234	36132	22347	24571
42	11434	28508	16418	18787
44	8238	22430	12562	14410
46	6589	16343	9136	10689
48	5087	9458	5238	6595
50	3605	5413	2910	3976
52	2539	2195	1541	2092
54	892	464	476	611
56	311	142	42	165
58	242	61	65	122
60	363	0	32	132
tonnes	259	391	263	304

Table 6.1.2-2 presents the 2014-2016 pseudo cohort age distributions resulting from the slicing procedure.

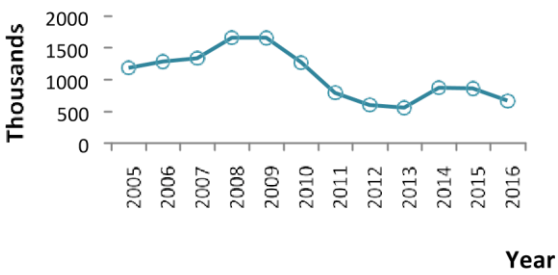
Table 6.1.2-2: Blackspot seabream of the Strait of Gibraltar area - Pseudo cohort catch at age, mean weight at age (g), maturity ratio and natural mortality (M) in the assessment exercise

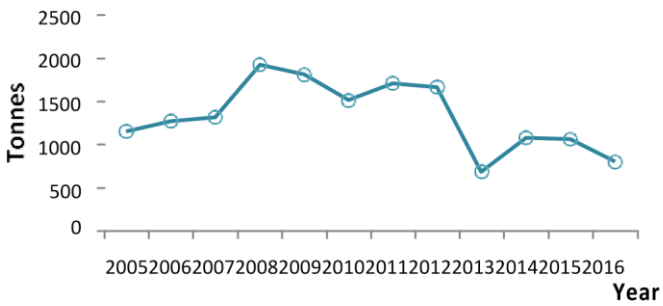
Class	Catches (n°)	Mean Weight	Maturity ratio	M
0	938	167	0.0	0.2
1	79262	341	0.1	0.2
2	143575	561	0.5	0.2
3	81591	820	0.8	0.2
4	40925	1098	1.0	0.2
5	21778	1381	1.0	0.2
6	13178	1656	1.0	0.2
7	7189	1918	1.0	0.2
8	3788	2163	1.0	0.2
9	2110	2387	1.0	0.2
10	1170	2590	1.0	0.2
11	385	2774	1.0	0.2
12	247	2935	1.0	0.2
13	90	3078	1.0	0.2
14	48	3203	1.0	0.2
15	41	3311	1.0	0.2
16	29	3405	1.0	0.2

17	22	3486	1.0	0.2
18	19	3556	1.0	0.2
19	16	3617	1.0	0.2
20	14	3669	1.0	0.2
21	12	3713	1.0	0.2
22	10	3750	1.0	0.2
23+	1	3785	1.0	0.2

6.1.3 Results

Figure 6.1.3.1 presents the results from this assessment approach. Recruitment and Biomass (B) shows decreasing trend and are close to the lower values of the whole series. The Spawning Stock Biomass (SSB) levels are quite stable in the last three years and its values are similar to the starting year. While, fishing mortality ($F_{4\text{-}11}$), fluctuates between 0.1 and 0.8 and decrease after the last 2013 and 2015 peaks.

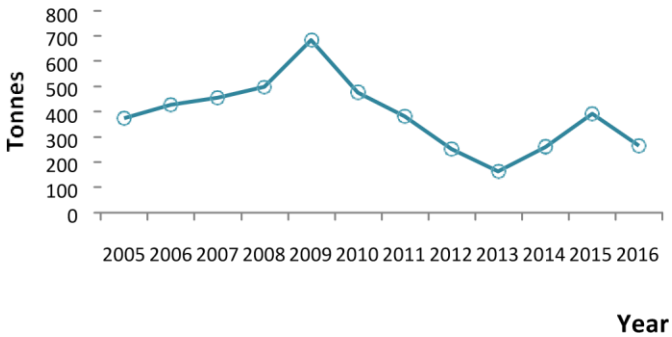




(B)

R

(SSB) (Y)



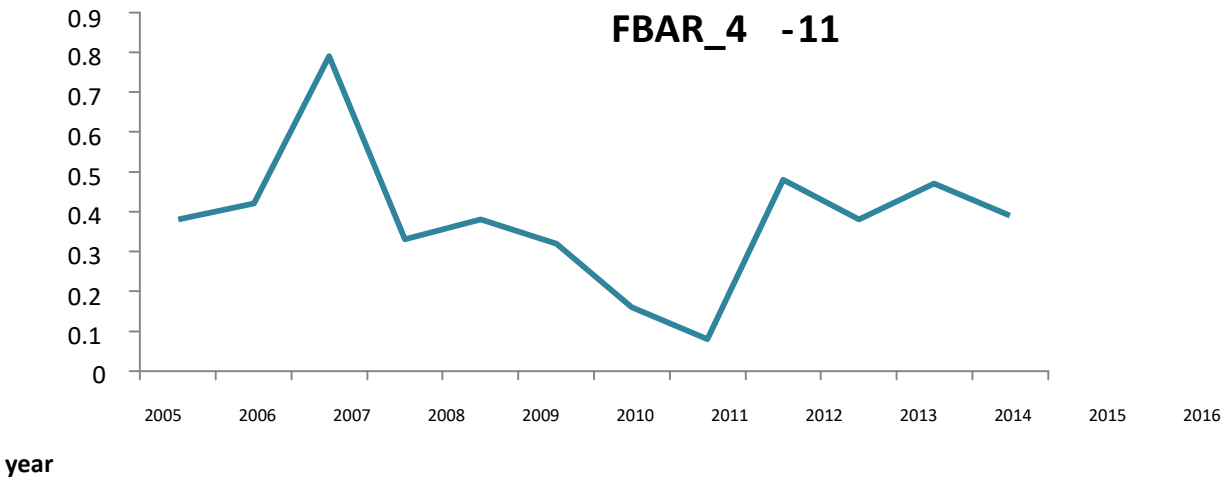


Figure 6.1.3.1 - Blackspot seabream of the Strait of Gibraltar area: VPA estimates of Recruitment (R), Total biomass (B), Spawning Stock biomass (SSB), fishing mortality (F4-11) and yield (Y).

Yield per-Recruit (Beverton and Holt, 1957) and Spawning Stock Biomass per Recruit (Gabriel *et al*., 1989) analysis is commonly used to test alternative management strategies when historical information on recruitment for the fish population being studied is limited. By combining length/age data over years it provide the estimation of reference points for management purposes, and also can be extended to analyses the contribution of a fixed number of individuals to the spawning component of population (spawning stock biomass per recruit). So from the VPA outputs, a Yield per Recruit analyses (YpR) and Spawning Stock Biomass per Recruit (SSBpR) were carried out to estimate the biological reference points (F_{MAX} and $F_{0.1}$). Figure 6.1.3.2 presents the model curve estimated using the NOAA Yield Per Recruit software (NOAA Fisheries Toolbox).

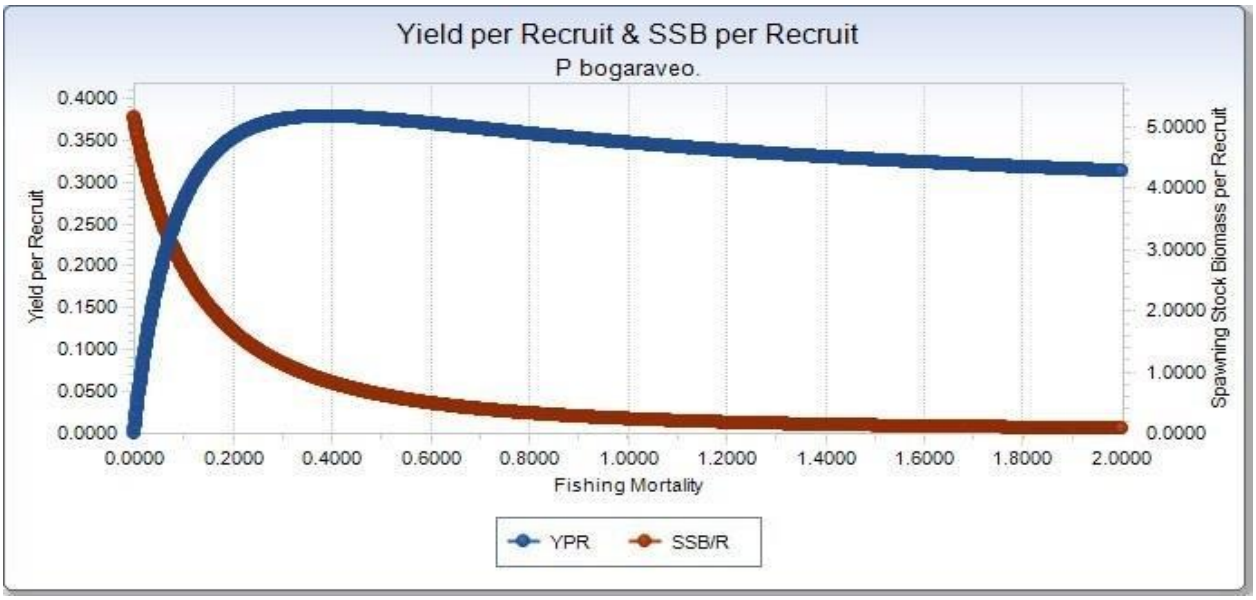


Figure 6.1.3.2 - Blackspot seabream of the Strait of Gibraltar area: Yield (g) per Recruit (YpR) and Spawner (g) per Recruit (SSB/R) analysis curves performed using NOAA Fisheries Toolbox.

Table 6.1.3-1: Biological References Points estimates from virtual population analysis (VPA)

$F_{0.1}$	F_{MAX}	$F_{current}$
0.141	0.267	0.3

Fishing mortality level ($F_{CURRENT}$=0.3) is far above from the values estimated for the F_{MSY} proxy: $F_{0.1}$ = 0.14

6.2 Production model (BioDyn)

6.2.1 Model assumptions

Stock can be described solely by its biomass such as the "natural" rate of change in biomass depends on current biomass only. There is a maximum biomass that the system can support (K): the relative rate of increase of biomass (r) is maximum when the biomass is close to zero, and zero when the biomass is at the maximum level.

An exploratory trial was carried out with the Schaefer's model (dynamic) using BioDyn. This model is implemented in an Excel spreadsheet, improved and performed by Pedro Barros. The *P. bogaraveo* population of the Strait of Gibraltar was assessed using a production model based on four basic parameters: virgin biomass (K), intrinsic growth rate of the population (r), initial depletion rate (starting biomass related to K: BI/K) and catchability (q). All other estimated parameters derive from these four. After giving the best estimates of these parameters, the model calculates the reference points MSY, BMSY and FMSY. It also calculates some reference points as B ratios: $B_{CURRENT}B_{MSY}$ and $B_{CURRENT}B_{MSY,0.1}$ (ratio between the estimated biomass for the last year data sets and B_{MSY} or $B_{0.1}$) and F ratios: $F_{CURRENT}F_{MSY}$ and $F_{CURRENT}F_{0.1}$ (ratio between fishing mortality value from the last year data sets and optimal level of fishing mortality F_{MSY} or target fishing $F_{0.1}$).

6.2.2 Input data and Parameters

Landings time series 2005-2016 (GSAs 01 and 03: Spain and Morocco official landings, respectively) and LPUE from Spanish commercial fleet 2005-2016.

6.2.3 Results

Biomass level estimate resulted of the assessment by the production model represents 45% of the target biomass ($B_{0.1}$) and 49% of the MSY Biomass (B_{MSY}). So, the stock is currently over exploited.

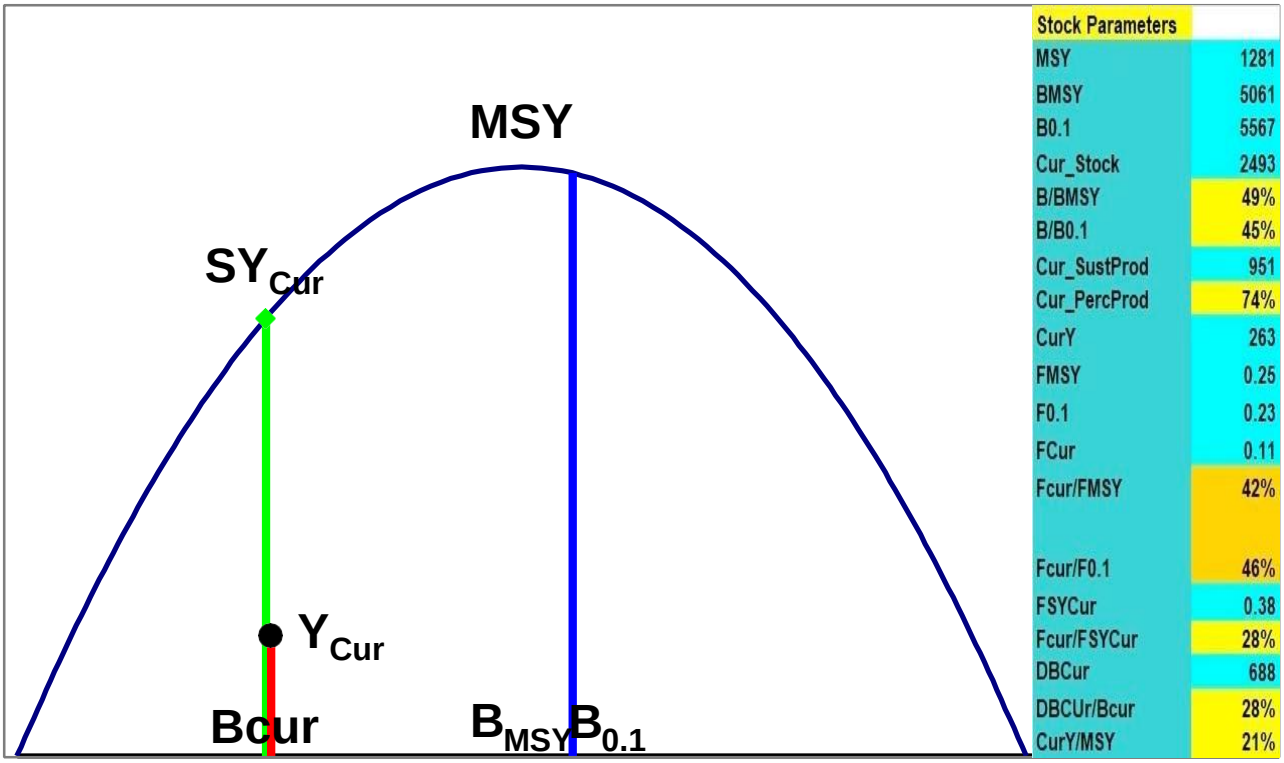


Figure 6.2.3-1: Blackspot seabream assessment results from the production model applied to the fishery of the Strait of Gibraltar

6.3 Gadget model

6.3.1 Model assumptions

Globally applicable Area Disaggregated General Ecosystem Toolbox (gadget) is a statistical model of marine ecosystems: is a forward simulation where the processes are usually modeled as dependent on length (but also age can be tracked) and could be structured by length (but age is tracked in the model) and data can be compared on either a length and/or an age scale. The framework allows for the creation of multi-area / multi-fleets models, capable to include predation and mixed fisheries issues unless it can be used on a single species basis too. A gadget detailed manual and further information can be found at www.github.com/hafro/gadget and the model structure and a formal mathematical description are given in Begeley and Howel (2004) and Froysa *et al*. (2002). In summary, gadget has essentially three components: an [1]ecosystem simulator, a [2]likelihood function that takes the output (from the

ecosystem simulator) and compares the data, and a [3]function minimizer (optimization routines to find the best set of the model parameters values).

6.3.2 Scripts

All the required input files are available at the sharepoint. Rgadgtet package can be installed in R directly from devtools using the command: devtools:: install_github("hafro/rgadget"). Besides there is an R file (run.R) at the sharepoint with the command lines to run the assessment (with the required files).

6.3.3 Input data and Parameters

Blackspot seabream is caught by Moroccan and Spanish fleets ("voraceras") in the Strait of Gibraltar area. The species is marketed fresh and has a large economic (and social) interest. Model definition and the estimated parameters are conditioned by the available information: this model was developed with the Moroccan and Spanish target fishery information, from "voraceras" fleets. In the case of Spain, because the species are sold by 4 different market categories the available information is also disaggregated by market category, which in fact are considered as different fleets.

So, the information comes from the following sources:

- <u>Morocco data</u>:
- Landings
- 1 fleet ("*voracera*")
- 1 area (Strait of Gibraltar)
- Quarterly from 2001 to 2016
- Effort "*voracera*" fleet
- Days at sea (quarterly) from 2001 to 2016 • Length distribution (from 2014 to 2016):
  raw data
- <u>Spanish data</u>:
- Landings
- 1 fleet ("*voracera*") but disaggregated in 4 market categories
- 1 area (Strait of Gibraltar)
- Quarterly from 1983 to 2016
- Effort "*voracera*" fleet
- Days at sea (from sale sheets info): quarterly from 1990 to 2008
- Days at sea (from VMS info): quarterly from 2009 to 2016
- Length distribution by market category (from 1997 to 2016)

- Biological data (from biological samplings, and also by market category, certain years since 1997)

As gadget works as a forward projection, among other parameters, needs initial estimates of recruitment (age 0) every year (1983 to 2016) and initial abundances by age (from 0 to 17) in the first year (1983). Population dynamics follows this order: fish are caught by the "*voracera*" fleet with a five different selection patterns (1 for Morocco and 4 for Spain), afterwards it dies by natural mortality and eventually growths and ages.

As is stated above, model parameters are estimated minimizing differences among observations and model results within an optimization process. Gadget´s likelihood process the output from the ecosystem simulation based on aggregate dimensions: so within this module a number of datasets can be compared to the model output with a suite of different types of functions (i.e. length distribution). Each raw dataset is included at its own aggregation level, with missing data handled in a robust manner. The blackspot seabream model includes 4 different types of data to enter the likelihood: [1]length distribution from commercial fleets (Morocco and Spain), [2]age-length distribution and [3]sex ratio at length (from biological samplings) and [4]fleets effort (in fishing days).

Thus the likelihood included a total of 20 different components, detailed below:

Component Description

lengthdist.S	1997-2016 quarterly Spanish "*voracera*" fleet market category "small" landings length distribution by 1 cm length
lengthdist.M	1997-2016 quarterly Spanish "*voracera*" fleet market category "medium" landings length distribution by 1 cm length
lengthdist.L	1997-2016 quarterly Spanish "*voracera*" fleet market category "large" landings length distribution by 1 cm length
lengthdist.XL	1997-2016 quarterly Spanish "*voracera*" fleet market category "extra large" landings length distribution by 1 cm length
lengthdist.MOR	2014-2016 quarterly Moroccan "*voracera*" fleet landings length distribution by 1 cm length

sbr.age.s	1997-2016 quarterly Spanish "*voracera*" fleet market category "small" age distribution, from otoliths reading (where available)
sbr.age.m	1997-2016 quarterly Spanish "*voracera*" fleet market category "medium" age distribution, from otoliths reading (where available)
sbr.age.l	1997-2016 quarterly Spanish "*voracera*" fleet market category "large" age distribution, from otoliths reading (where available)
sbr.age.xl	1997-2016 quarterly Spanish "*voracera*" fleet market category "extra large" age distribution, from otoliths reading (where available)
sbr.bio.s	1997-2016 quarterly Spanish "*voracera*" fleet market category "small" sex ratio, from biological samplings (where available)
sbr.bio.m	1997-2016 quarterly Spanish "*voracera*" fleet market category "medium" sex ratio, from biological samplings (where available)
sbr.bio.l	1997-2016 quarterly Spanish "*voracera*" fleet market category "large" sex ratio, from biological samplings (where available)
sbr.bio.xl	1997-2016 quarterly Spanish "*voracera*" fleet market category "extra large" sex ratio, from biological samplings (where available)
SPeffort.S	1983-2016 quarterly fishing days from Spanish "*voracera*" fleet
SPeffort.M	1983-2016 quarterly fishing days from Spanish "*voracera*" fleet
SPeffort.L	1983-2016 quarterly fishing days from Spanish "*voracera*" fleet
SPeffort.XL	1983-2016 quarterly fishing days from Spanish "*voracera*" fleet
MOReffort	2001-2016 quarterly fishing days from Moroccan "*voracera*" fleet

understocking	applied when there is not enough preys (fish modelled) to meet the requirements of the predator (fish landed)
bounds	penalty weight to parameters that have moved beyond the bounds

For model comparisons the ability to handle length data directly means that the gadget model should be useful for those stocks, like the blacspot seabream in the Strait of Gibraltar, where age data are scarce and/or unreliable. The model is able to combine a wide selection of the available information using a maximum likelihood approach to find the best fit to the weighted data sets. Assigning likelihood weights is not a trivial matter and, in the past, has been done using somehow of "*expert judgement*". Recently general heuristics have been developed to estimate these weights more objectively: the iterative re-weighting function (gadget.iterative), available in Rgadget package, was used to obtain the final weights of every likelihood component.

Blackspot seabream of the Strait of Gibraltar is assumed to be a long live species, so the maximum age is set at 17 (for males and females). While the model length range was from 0 to 62 centimeters, in 1 cm length intervals, with females population start at 20 cm. See Annex to get an overview of the model parameters used (params.file): 109 parameters, but 11 of them are fixed (L_∞ and M, among others).

6.3.4 Results

Gadget allows describing the suitability of each fleet considered in the model. The resulting modeled suitability curves are shown in Figure 6.3.4.1.

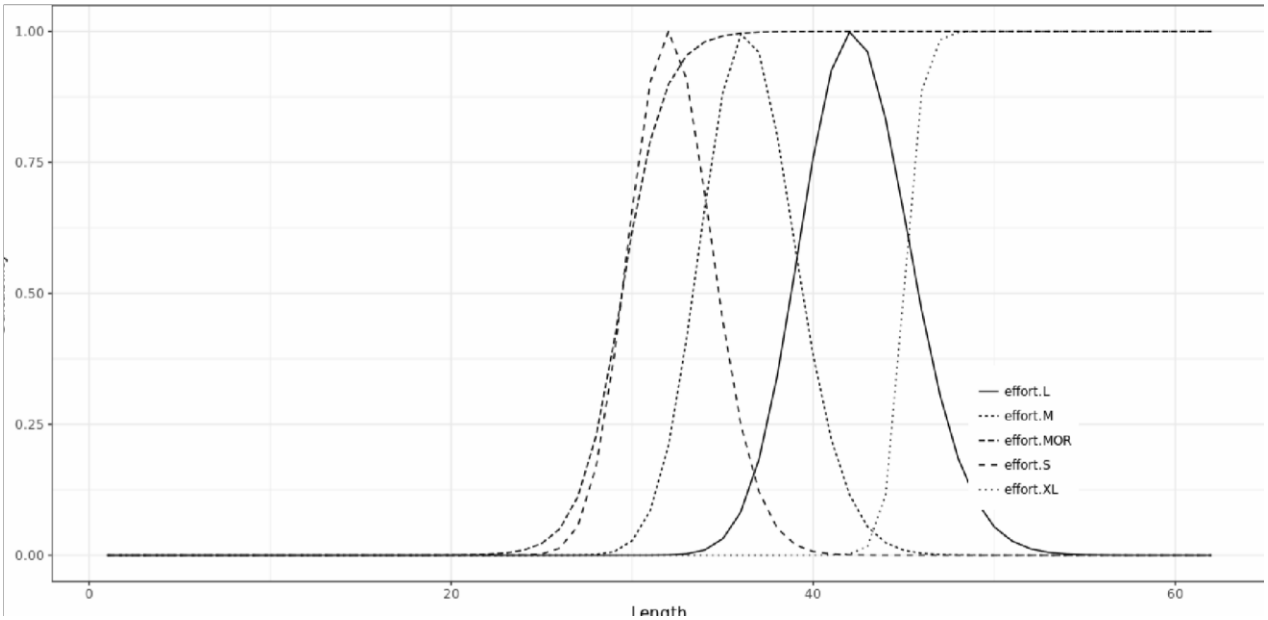


Figure 6.3.4-1 Selectivity pattern for "voracera" fleet (Morocco and Spain)

<u>Length distribution</u>

Figures 6.3.4.2 to 6.3.4.6 present the model fitting to the available landings length distribution information (raw data). Considering the differences between fleets (and market categories) the model has a really good fit to the observed data.

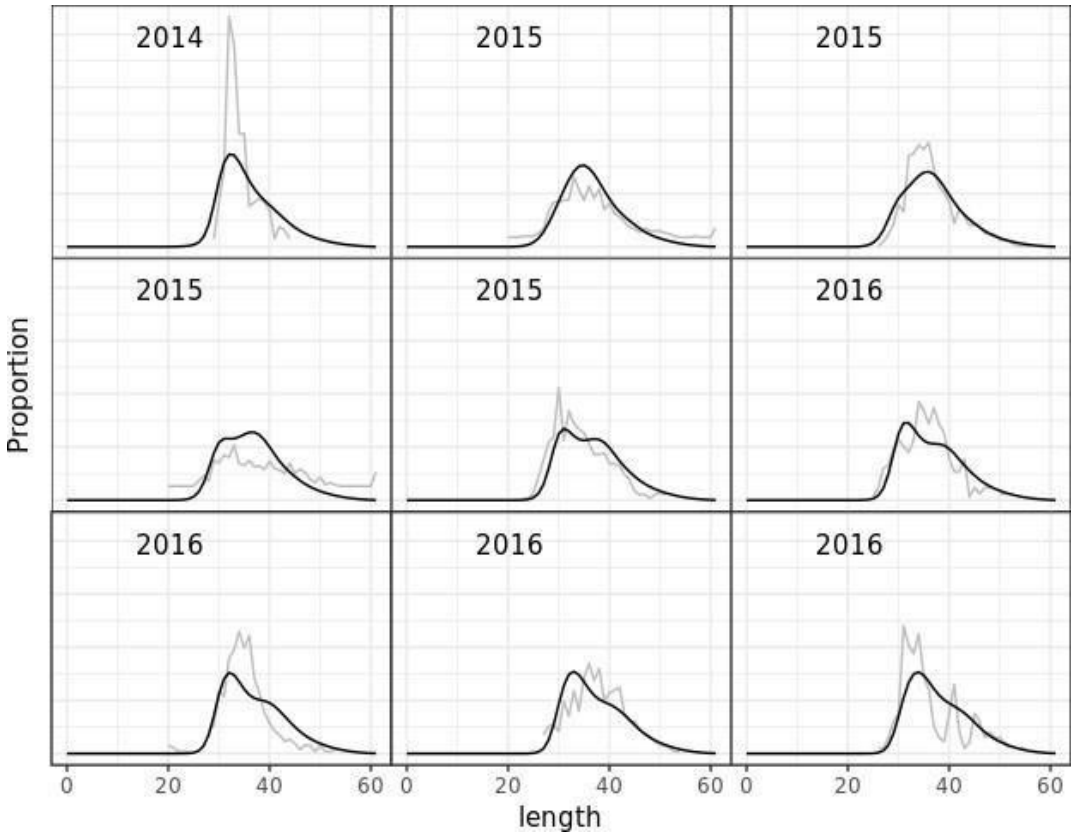


Figure 6.3.4.2 - Length distribution from Moroccan "voracera" fleet. Grey lines denote the observed values while solid (black) lines corresponds to the model predictions.

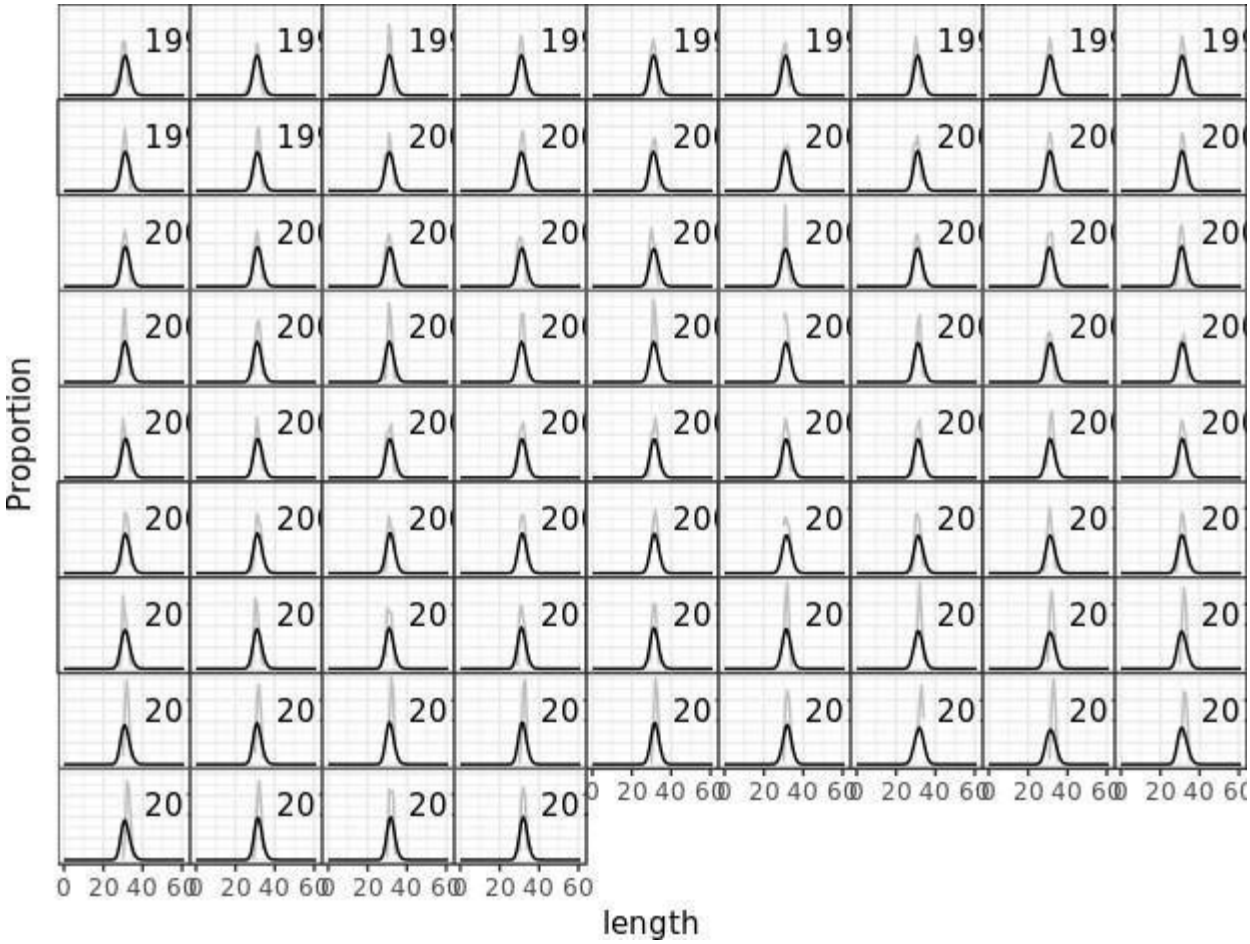


Figure to 6.3.4.3 - Length distribution from Spanish "voracera" fleet (market category S). Grey lines denote the observed values while solid (black) lines corresponds to the model predictions.

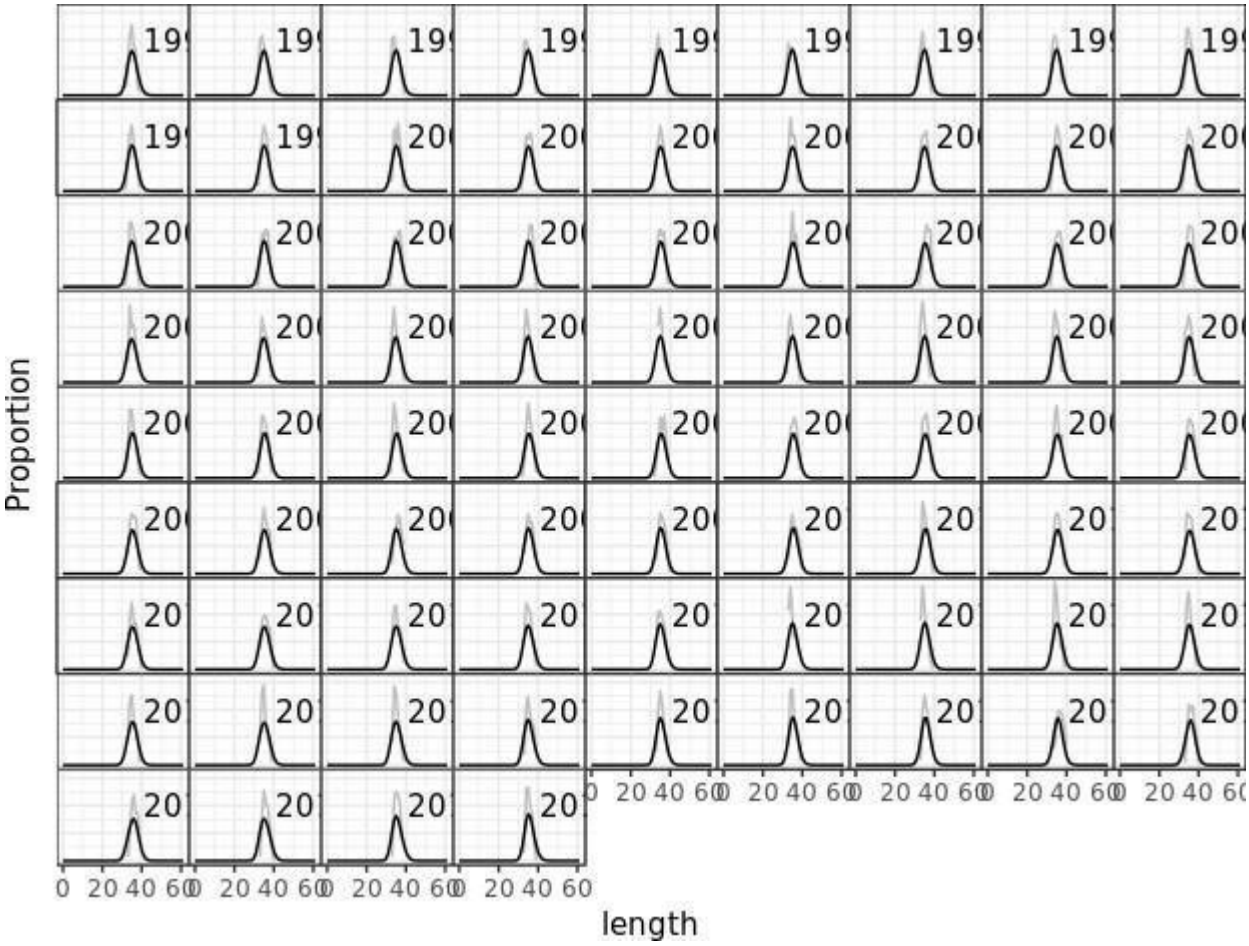


Figure 6.3.4.4 - Length distribution from Spanish "voracera" fleet (market category M). Grey lines denote the observed values while solid (black) lines corresponds to the model predictions.

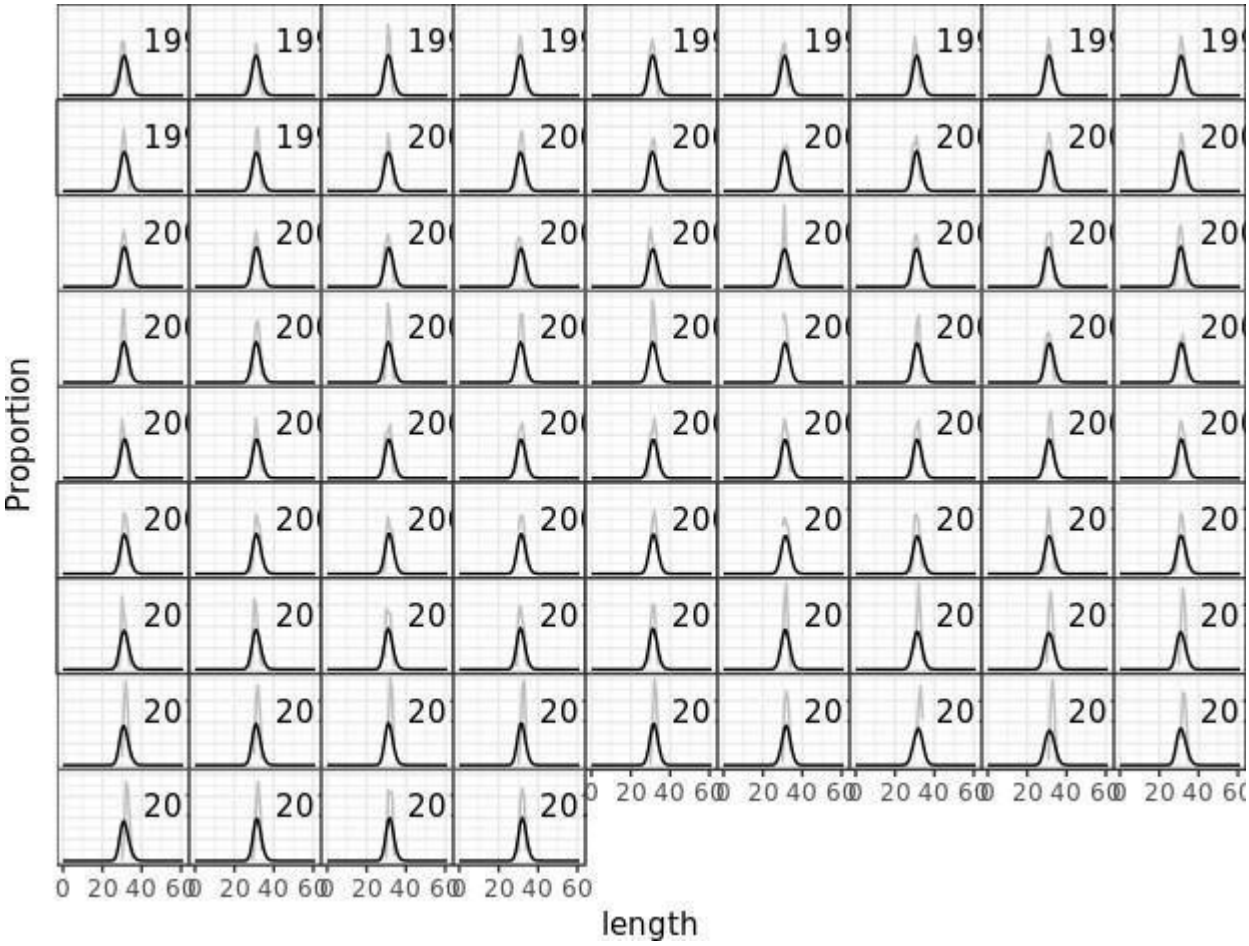


Figure 6.3.4.5 - Length distribution from Spanish "voracera" fleet (market category L). Grey lines denote the observed values while solid (black) lines corresponds to the model predictions.

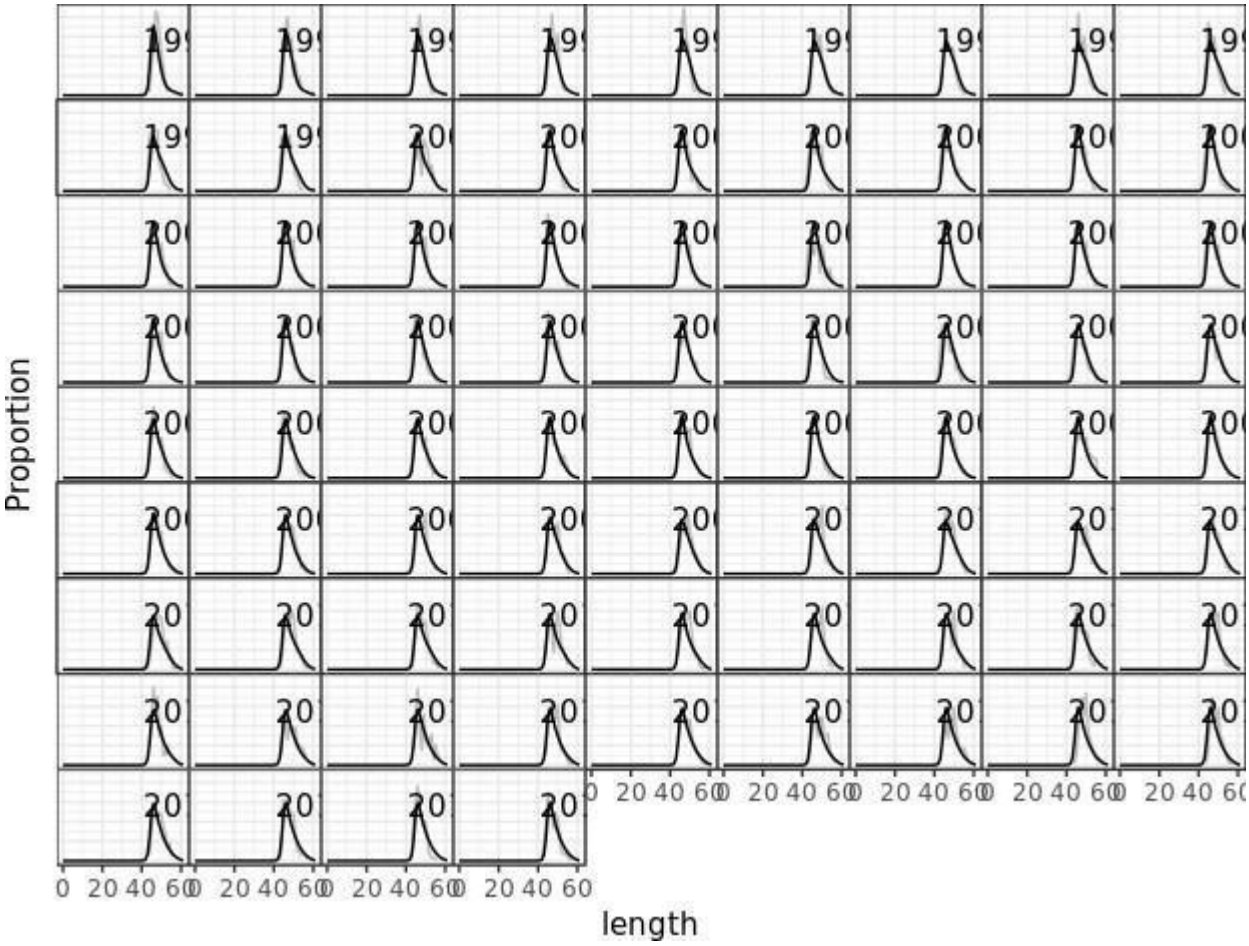


Figure 6.3.4.6 - Length distribution from Spanish "voracera" fleet (market category XL). Grey lines denote the observed values while solid (black) lines corresponds to the model predictions.

<u>Age distribution and growth</u>

Figures 6.3.4.7 to 6.3.4.10 show the comparison between the proportions at age (from agreed otoliths readings) with model estimates. The model fit to the available information on growth can be observed in Figure 6.3.4.11. In general the model appears to fit the observed growth quite well, at least better than expected.

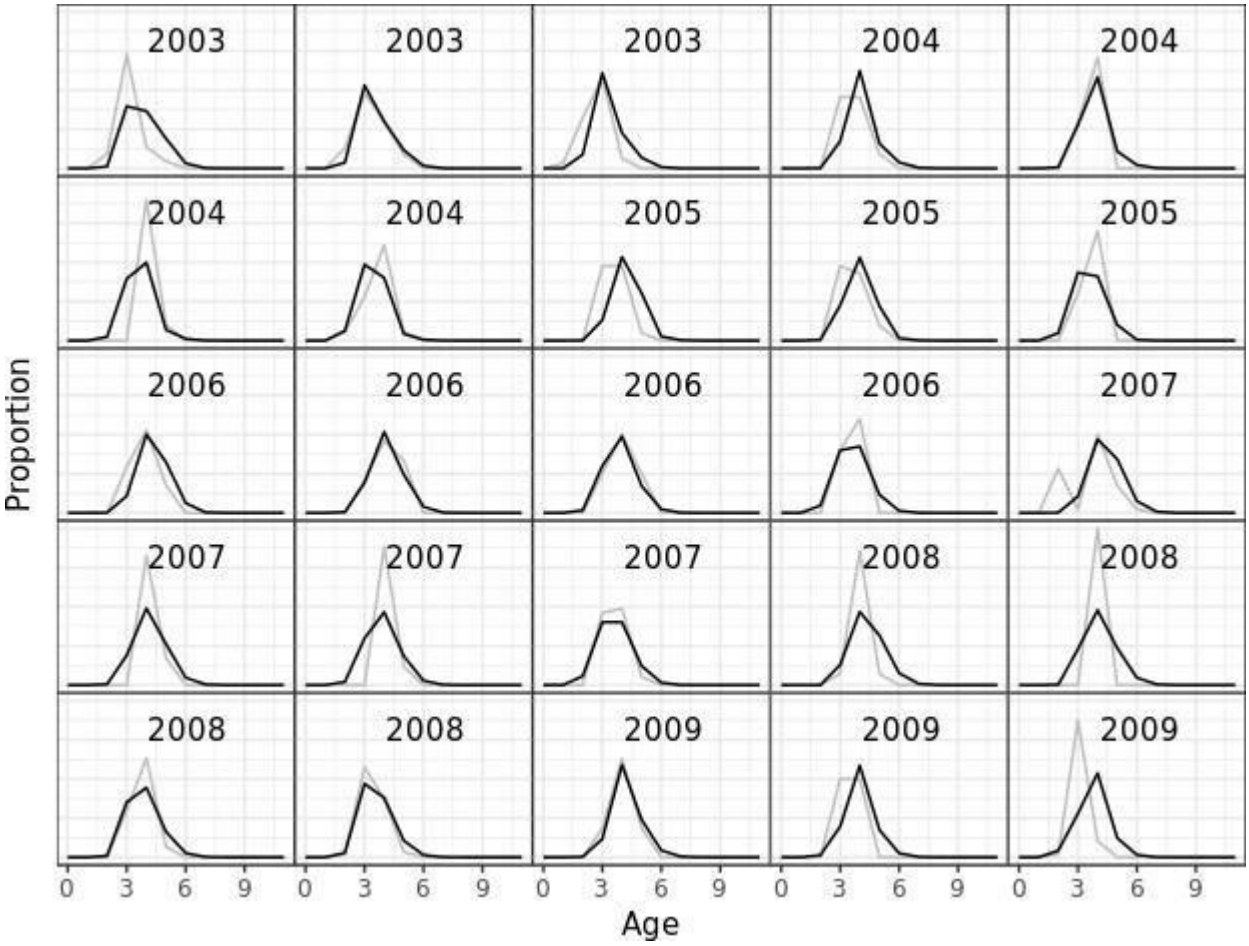


Figure 6.3.4.7 - Age distribution from Spanish "voracera" fleet (market category S). Grey lines denote the observed values while solid (black) lines corresponds to the model predictions.

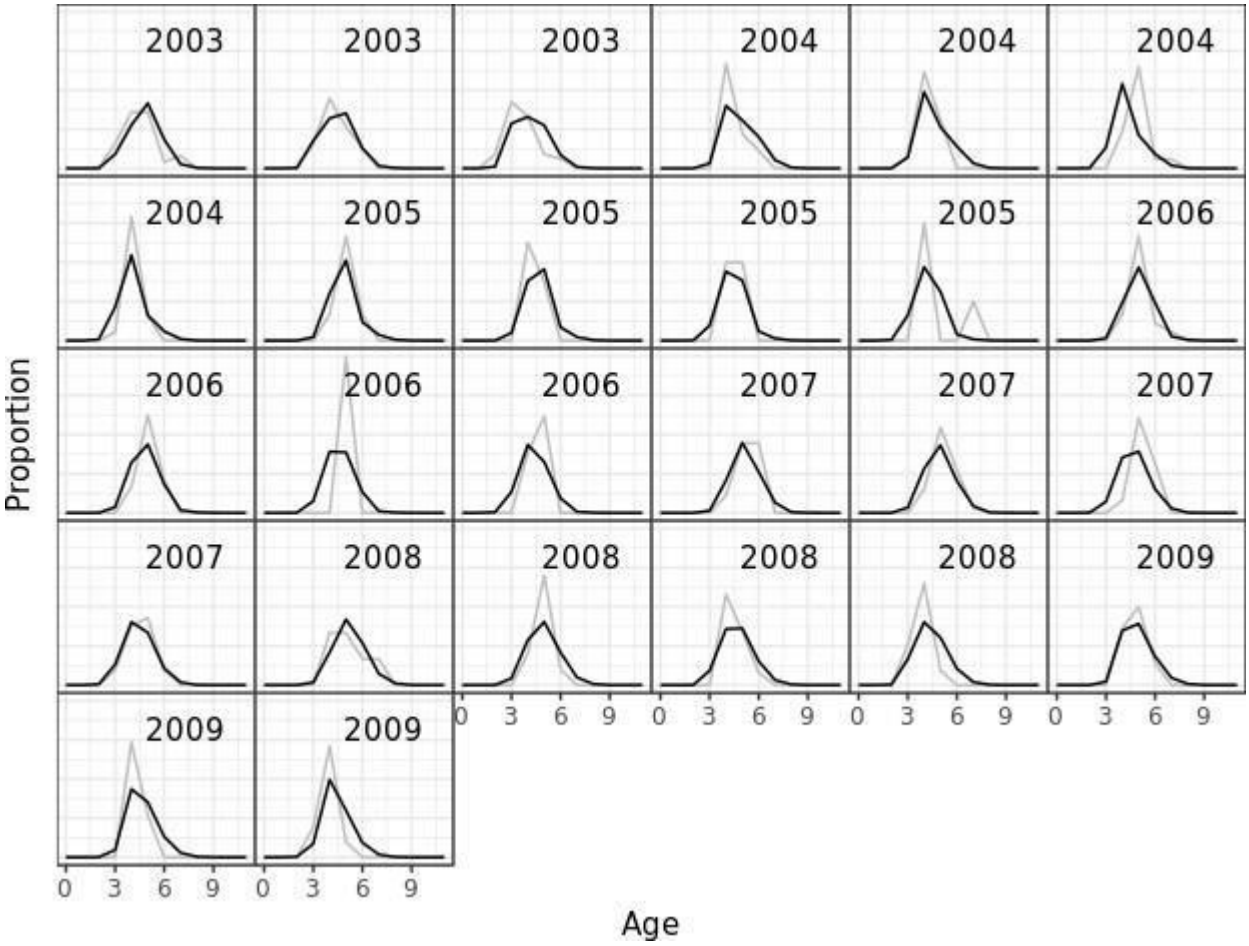


Figure 6.3.4.8 - Age distribution from Spanish "voracera" fleet (market category M). Grey lines denote the observed values while solid (black) lines corresponds to the model predictions.

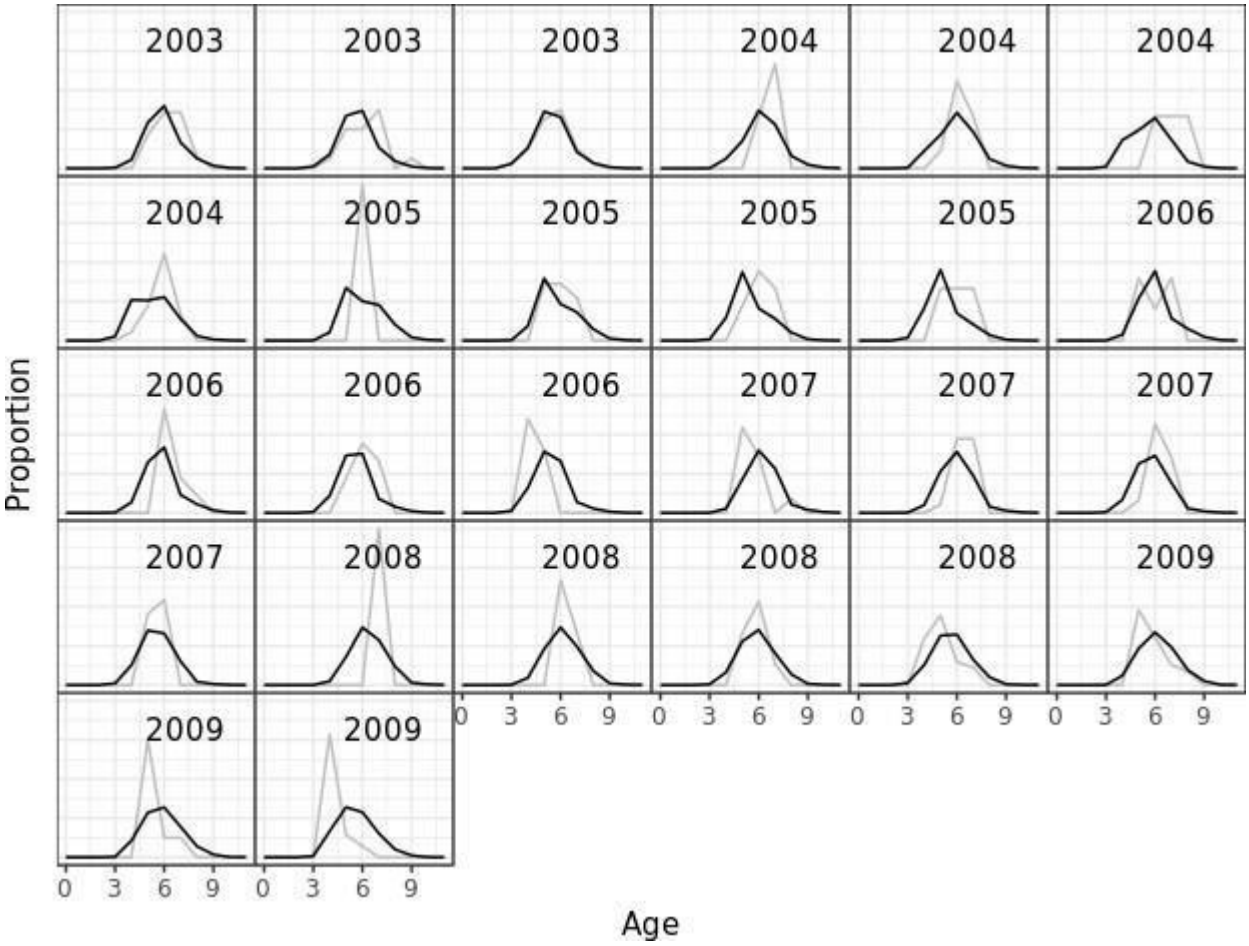


Figure 6.3.4.9 - Age distribution from Spanish "voracera" fleet (market category L). Grey lines denote the observed values while solid (black) lines corresponds to the model predictions.

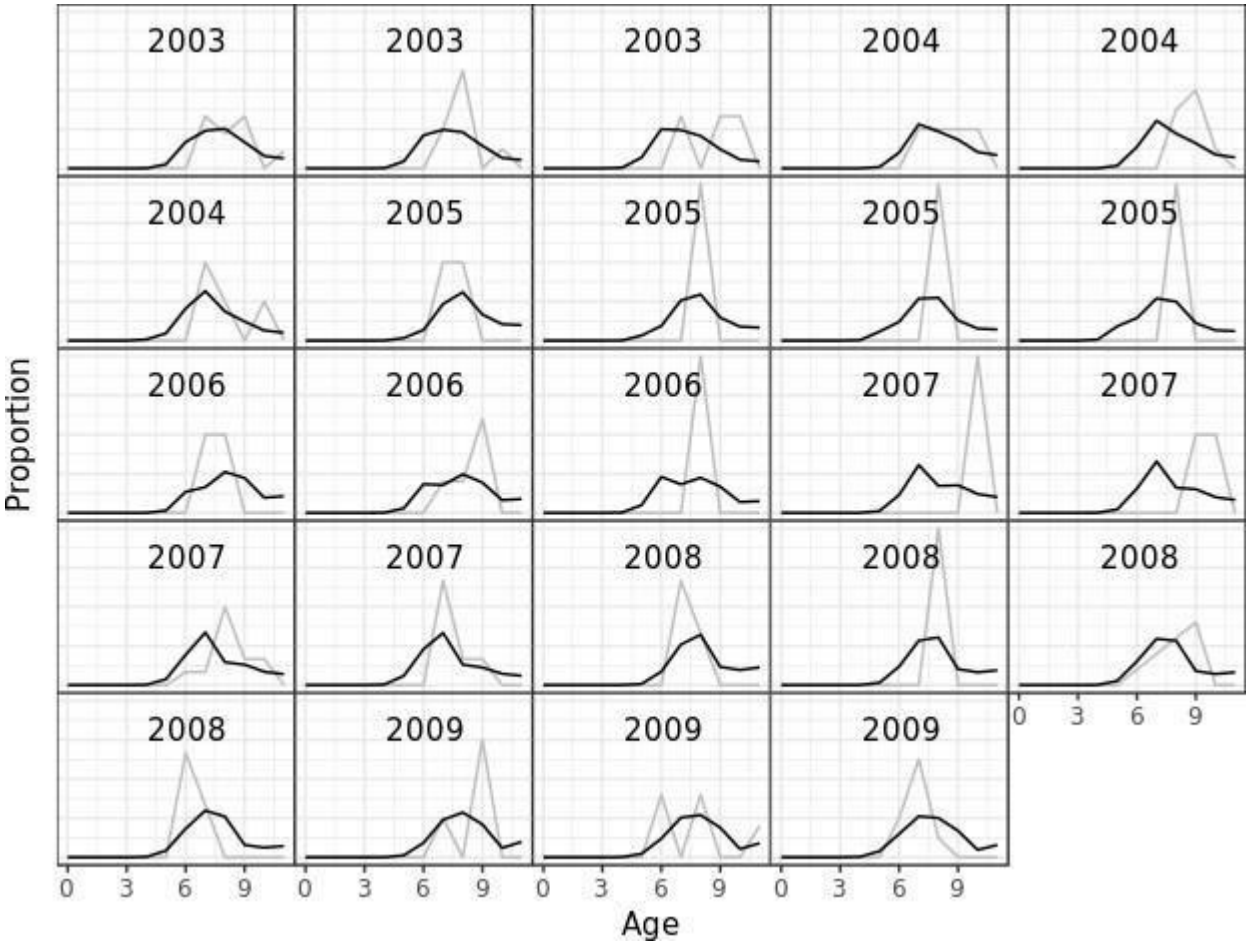


Figure 6.3.4.10 - Age distribution from Spanish "voracera" fleet (market category XL). Grey lines denote the observed values while solid (black) lines corresponds to the model predictions.

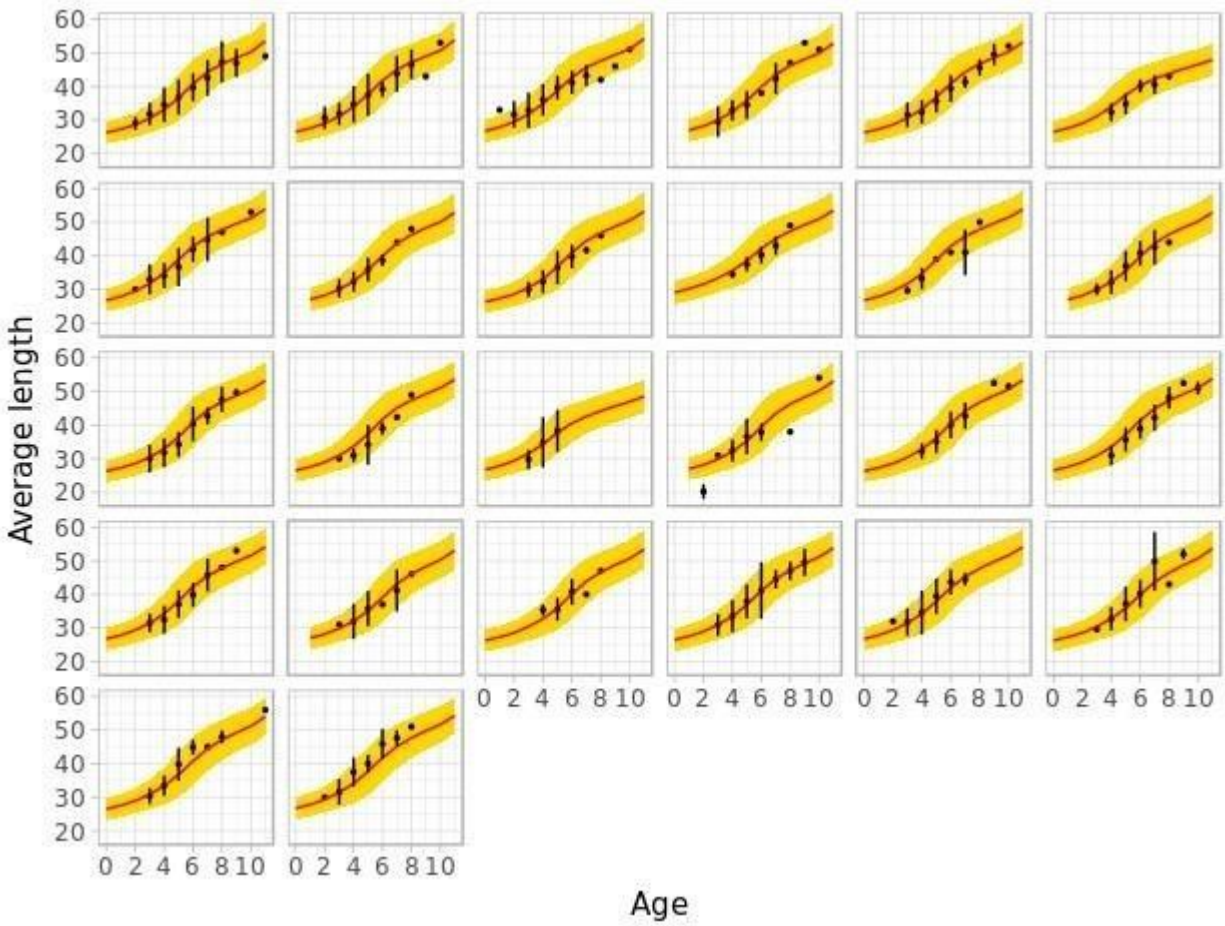


Figure 6.3.4.11 - Mean length (by quarter) at age distribution from biological samplings. Black points and vertical bars denotes the observed (from agreed otolith readings) mean and 95% intervals of length at age while the red line and its golden ribbon indicates the model estimates.

<u>Sexratio</u>

Figure 6.3.4.12 shows the sexratio values (modeled vs. observed). The model for the blackspot seabream split the population in two components: males and females because the species hermaphroditism. Larger individuals are (in theory) generally females and lower percentages in observed ratios are a consequence of the sampling level.

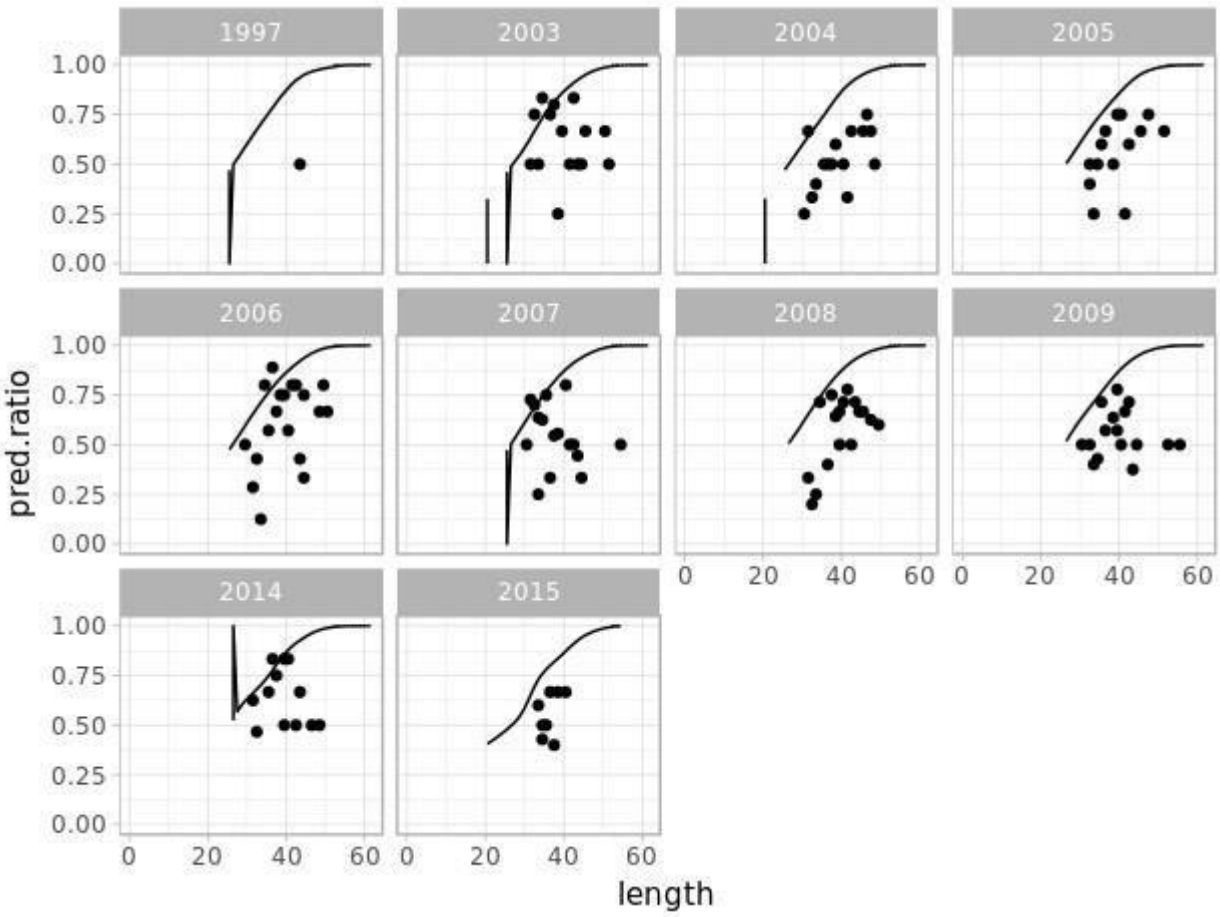


Figure 6.3.4.12 – Sex ratio at length distribution from biological samplings. Black points are the observed values while the continuous line represents the model estimates.

<u>Predicted catches and biomass estimates</u>

Figure 6.3.4.13 represents the estimated catches from the 5 fleets included in the model: note that catches are disaggregated by the two components of the exploited population (males and females).

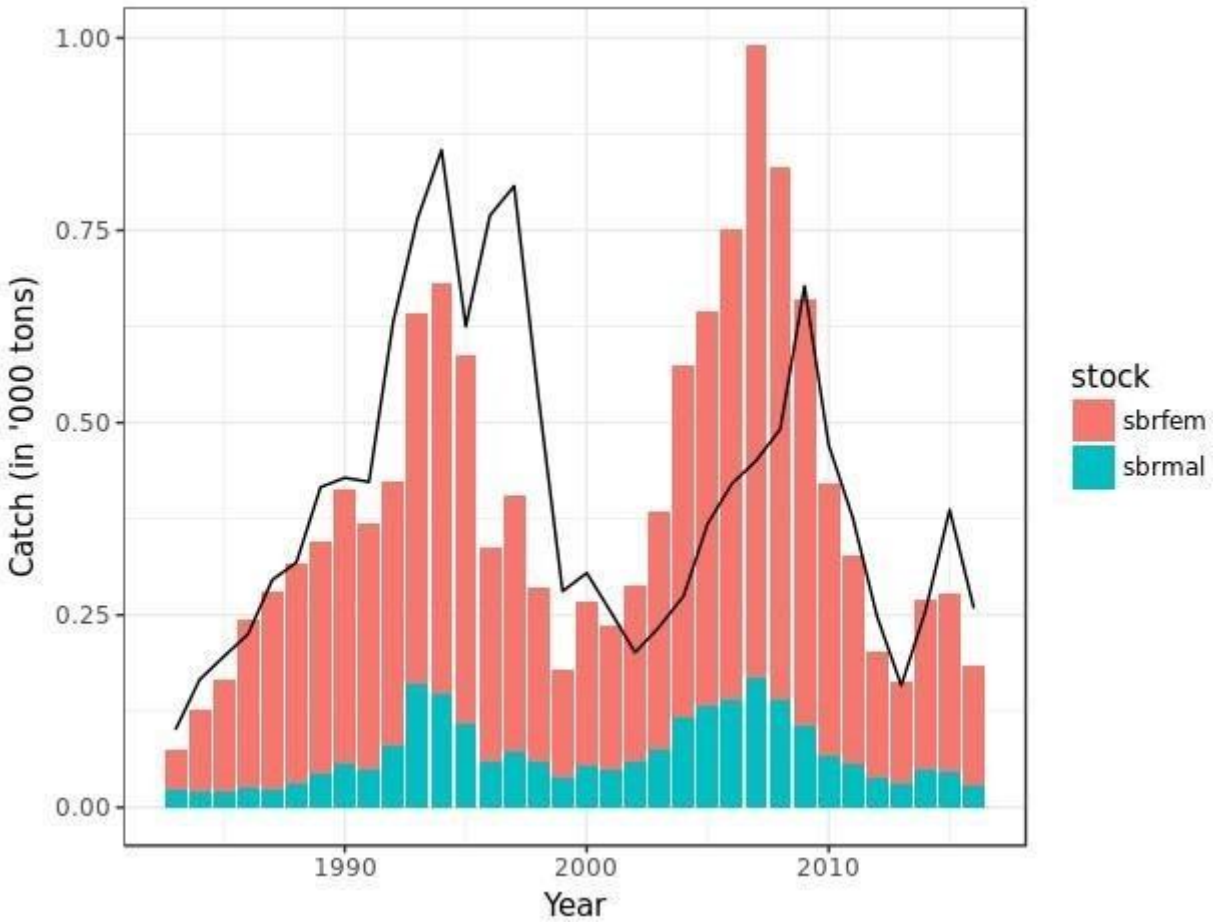


Figure 6.3.4.13 - Comparison between catches predicted from the gadget model (blue and red bars) and the Strait of Gibraltar reported landings (Morocco and Spain) of blackspot seabream (black line).

The gadget model shows that the population total biomass (males and females) is decreasing after having peaked to its highest level in 2005 and 2006 (Figure 6.3.4.14). Figure 6.3.4.15 shows the evolution of the fishing mortalities while Figure 6.3.4.16 present the recruitment estimates at age

0. The values of the most recent years are close to the bounds of the parameters file and looks unreliable, or at least with a lot of uncertainty.

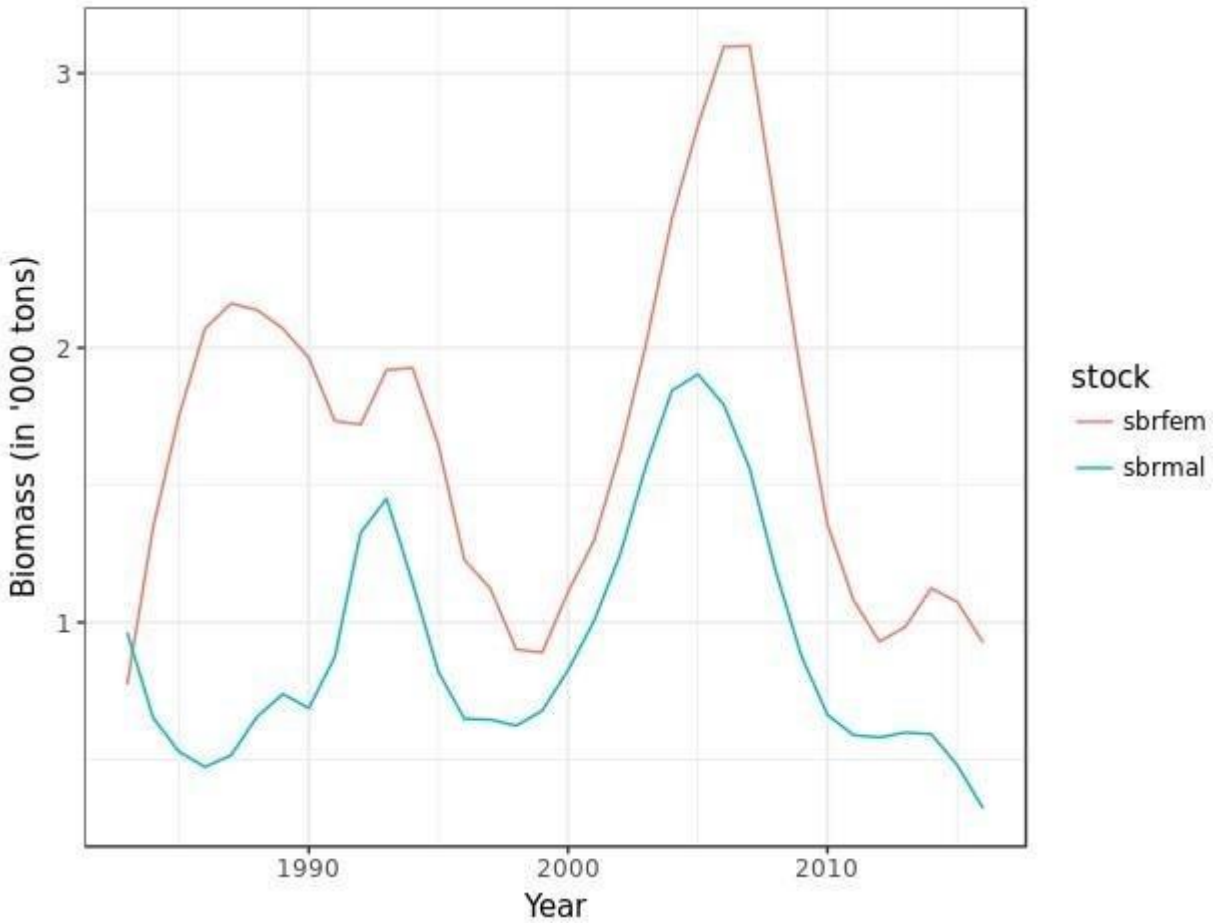


Figure 6.3.4.14 - Biomass estimates (gadget model) for the two components of the stock (males and females).

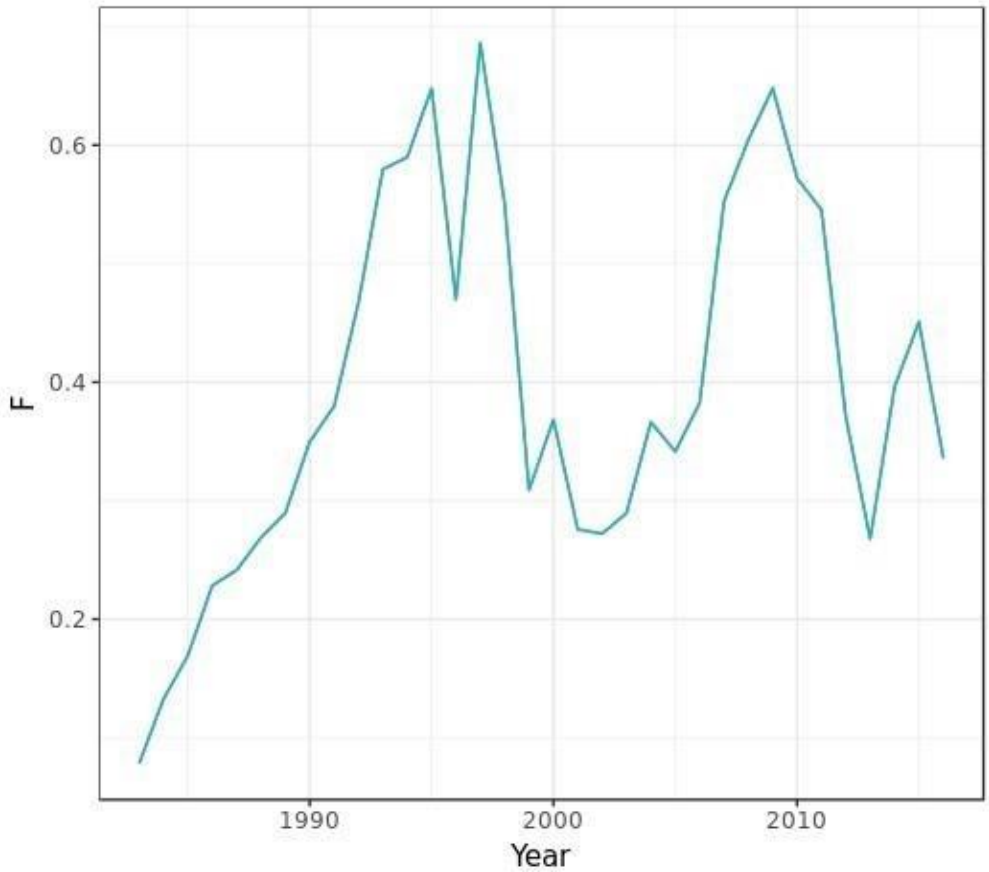


Figure 6.3.4.15 - Fishing mortality (F) estimates (gadget model)

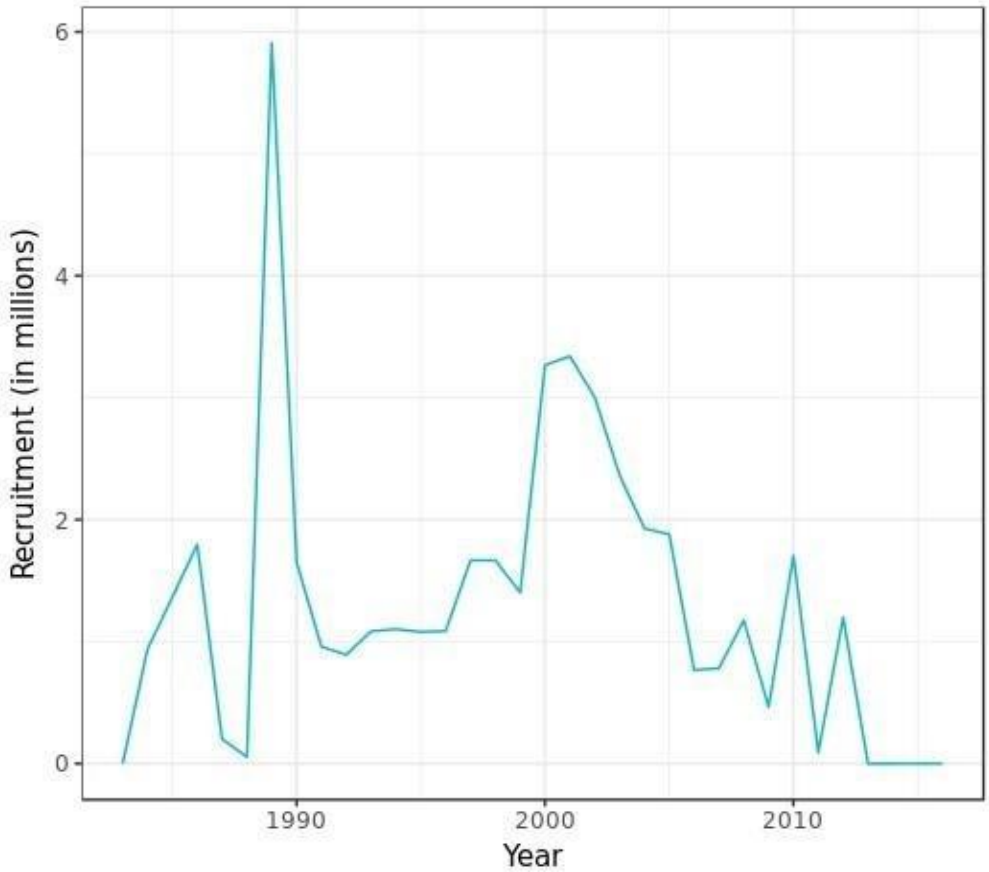


Figure 6.3.4.16 - Recruitment (at age 0) estimates (gadget model).

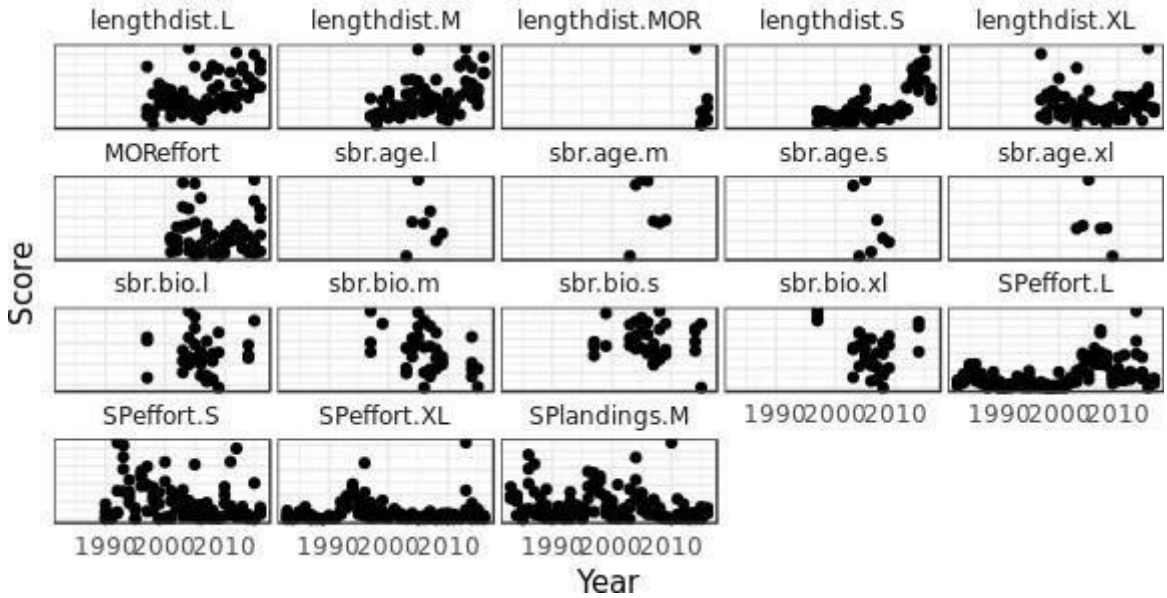


Figure 6.3.4.17 – Blackspot seabream fishery of the Strait of Gibraltar: gadget likelihood scores.

In summary, blackspot seabream population of the Strait of Gibraltar shows a concerning biomass level: in fact the total biomass get the lowest value in the last year analyzed 2016 (Figure 6.3.4.18).

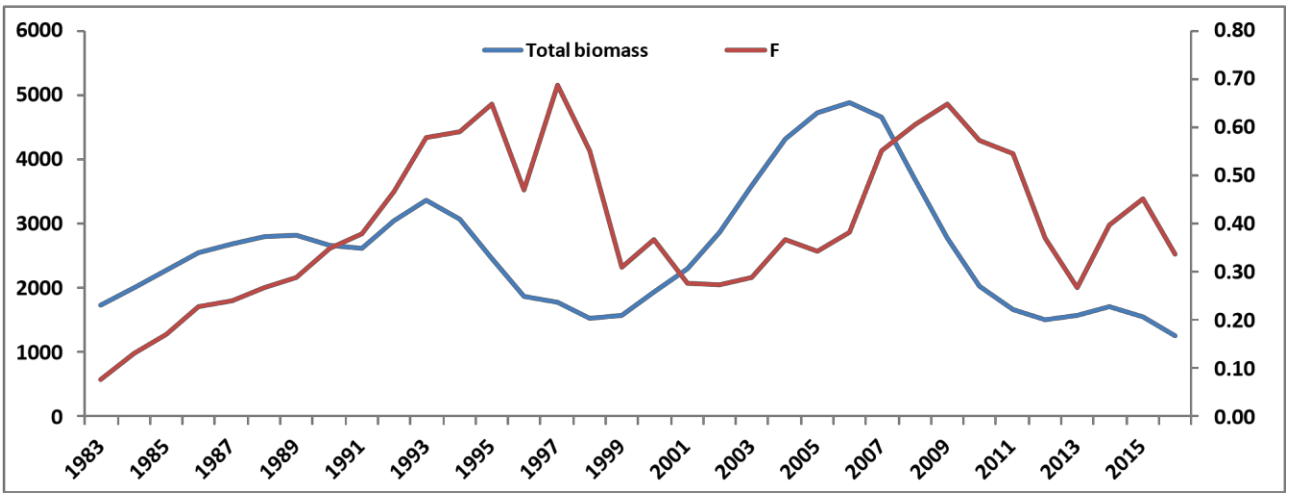


Figure 6.3.4.18 - Assesment summary (gadget model) for the blackspot seabream of the Strait of Gibraltar fishery.

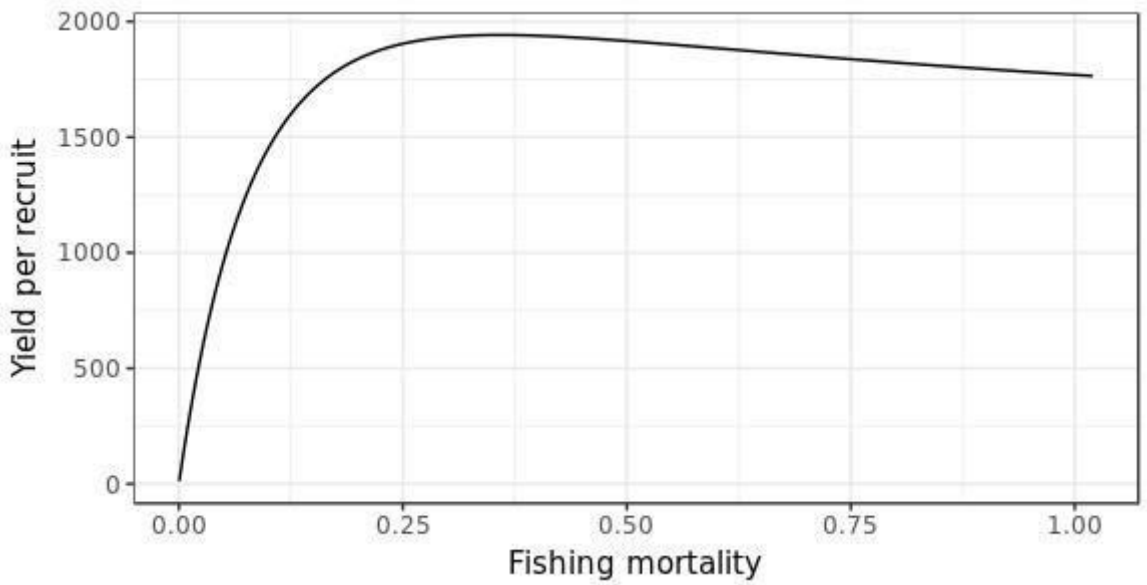


Figure 6.3.4.19 –YpR curve from gadget model for the blackspot seabream of the Strait of Gibraltar.

Table 6.3.4-1: Biological References Points estimates from gadget model

$F_{0.1}$	F_{MAX}	$F_{current(4-11)}$
0.17	0.35	0.34

6.4 State of exploitation

Figure 6.3.4.18 shows the results obtained from two different assessment approaches: VIT and gadget. Total biomass and F estimates are quite similar in the most recent years.

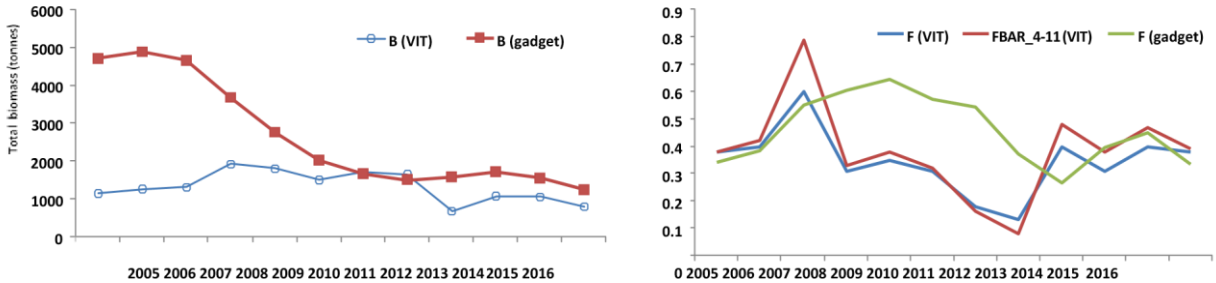


Figure 6.3.4.18 - Comparison of results from two different approaches (VIT and gadget) used for the assessment of the blackspot seabream population of the Strait of Gibraltar.

Fishery sustainability could be compromise at current levels because $F_{current}$ seems to be about 0.3 in both analytical approaches (LCA/VPA and gadget), far above from the reference point $F_{0.1}$ estimated value (0.14 and 0.17, in YpR respectively models).

The preliminary gadget model should be improved to get more accurate recruitment values as well as the catches´ estimates from the fleets considered (possible changes in catchability should be explored).

6.4.1 Robustness analysis

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

6.4.3 Assessment quality

7 Stock predictions

7.1 Short term predictions

7.2 Medium term predictions

7.3 Long term predictions

8 Draft scientific advice

Signal from 3 different assessment approaches attempted are the same: clear overexploitation of the resource. Estimates of the reference point ($F_{0.1}$ = 0.12-0.17) from two of the assessment exercises (LCA-VPA and gadget) is far above from current fishing pressure (about 0.3). However, because the preliminarily of the gadget exercise the assessment was only accepted in terms of "qualitative advice".

In accordance to all the sated above, fishing effort level should be reduced to set the fishing mortality level in a more sustainable value: it might be gradually achieved by multiannual management plans that foresee a reduction of fishing mortality through fishing limitations. There is not a specific/joint management plan for the blackspot seabream of the Strait of Gibraltar already implemented. Both countries have different management measures on the target fisheries but there are not any common ones towards its sustainability. So, a management plan for this species in the Strait of Gibraltar area (GSA 01 and GSA 03) should be agreed ASAP.

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					
	Fishing effort					
	Landings				D	
Stock abundance	Biomass					
	SSB					
Recruitment						
Final s Diagnosi		The population presents low levels of biomass because the resource overexploitation.				

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)*