Stock Assessment Form
Demersal species

Reference year:2019

Reporting year:2020

STOCK ASSESSMENT OF PURPLE DYE MUREX IN GSA17

The purple dye murex is an important commercial accessory species in the central and northern Adriatic Sea sole fishery, representing on average 2.5 million of euros in term of landing value. In particular circumstance and period purple dye murex can also become the target species of the fishery. In the Adriatic, 83% of the catches is provided by the Italian “rapido” trawl fleets (TBB), 9% from the Italian otter trawlers (OTB), 6% from set netters (GNS) and the remaining 3% is due to bycatch of mixed gear (es. Fyke and pots).

The CMSY model used in this assessment based on landings data from 1972 to 2019 (reconstructed from 1972 to 2003). Considering the results of the analyses conducted the purple dye murex in GSA 17 is in slight overfishing being the current F higher than the proposed reference point in the last year (F/FMSY = 1.08). Base on the biomass level the stock is still over the reference point (B/BMSY = 1.12); however the stock trajectory is going into overfishing direction in the last years.

Stock Assessment Form version 1.0 (January 2021)

Uploader: *Francesco Masnadi*

Stock assessment form of *Bolinus brandaris* in GSA17

1 Basic Identification Data

Scientific name:	Common name:	ISCAAP Group:
Bolinus brandaris	Purple dye murex	
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		
4th Country	**5th Country**	**6th Country**
Stock assessment method: (direct, indirect, combined, none)		
CMSY		
Authors:		
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2 Stock identification and biological information

Bolinus brandaris (Linnaeus, 1758) is a gastropod mollusk belonging to the Muricidae family.
It is a common species on sandy bottoms, up to a maximum of 100 m. It 'is present in the Eastern Atlantic and the Mediterranean Sea: from Portugal to central Morocco in the Atlantic, and east to Lebanon.
The shell is about 6-8 cm, equipped with thorny extensions and with an elongated swollen shape in one end of the siphon, which instead is long and straight. The external surface is wrinkled and crossed by numerous irregular spiral cords. The external color varies from yellow to brown, the stoma is oval, notched on the external margin, from yellow to orange.
Carnivorous and feeds on bivalves and other gastropods (Ramon & Amor 2001). Showed an annual reproductive cycle in the Catalan coast. During the reproductive period (June-July) it is not uncommon to observe numerous groups with specimens of different sex that mate. The individuals of this species are proterandral hermaphrodites, that is, first they are male and then, if necessary, they become female. The eggs are laid on the rocks of the cliffs organized in a more or less gelatinous whitish mass.

2.1 Stock unit

The stocks have been considered to be confined in the central and northern sector of the Adriatic Sea (FAO-GFCM Geographical Sub-Area 17), where the rapido trawl fishery is operating. Moreover, the specie is characterized by a low rate of mobility.

2.2 Growth and maturity

Max length from survey in Sant Carles de le Ràpita, > 39 mm length without siphonal canal (Ramon & Amor 2002).

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	June-July
Maximum size observed			39 mm	Recruitment season	
Size at first maturity				Spawning area	
Recruitment size to the fishery				Nursery area	

Fisheries dependent information

2.3 Description of the fleet

The purple dye murex has high economic value since ancient times because it is used to produce a purple dye (Bizio, 1833; Schunck, 1879). Nowadays, is an important commercial accessory species in the central and northern Adriatic Sea sole fishery, representing on average 2.5 million of euros in term of landing value (FDI data 2015-2019). In particular circumstance and period (e.g. Low value of common sole at local market), purple dye murex can also become the target species of the fishery.

In the Adriatic, 83% of the catches is provided by the Italian "rapido" trawl fleets (TBB), 9% from the Italian otter trawlers (OTB), 6% from set netters (GNS) operating mostly within 3 nautical miles from the coast and the remaining 3% is due to bycatch of mixed gear (es. Fyke and pots).

The Italian rapido trawl fleet operating in GSA 17 ranges from 9 to 30 m in vessel length, GRT ranges from 4 to 100 and the engine power from 60 to 1000 HP. Each vessel can tow from 2 to 4 rapido trawls depending on its dimensions. The *rapido* trawl is a gear used specifically for catching flatfish and other benthic species (e.g. cuttlefish, mantis shrimp, etc.). It resembles a toothed beam-trawl and is made of an iron frame provided with 3-5 skids and a toothed bar on its lower side. These gears are usually towed at a greater speed (up to 10-13 km h^{-1}) in comparison to the otter trawl nets; this is the reason of the name "*rapido*", the Italian word for "fast". The mesh opening of the codend used by the Italian *rapido* trawlers is the same or larger (usually 50 mm stretched diamond mesh) than the legal one. About 90% of the *rapido* trawlers can be found in the maritime compartments located between Ancona and Venice, while some are located in the compartments of Trieste and Pescara. The main port are: Chioggia (VE), Ancona, Rimini.

In the last years also in Croatia a gear similar to rapido, called "Rampon" is employed in the area in front of Istria peninsula.

Table 0-1: Description of operational units exploiting the stock

	Country	GSA	Fleet Segment	Fishing Gear Class	Group of Target Species	Species
Operational Unit 1	ITA	17	E - Trawl (12-24 metres)	98 - Other Gear (rapido trawl)	33 - Demersal shelf species	Sole
Operational Unit 2	ITA	17	E - Trawl (12-24 metres)	Otter trawl	33 - Demersal shelf species	Mixed fisheries
Operational Unit 3	ITA	17	C - Minor gear with engine (6-12 metres)	07 - Gillnets and Entangling Nets	33 - Demersal shelf species	Sole

Table 0.1-2: 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)
Italian OTB		274 tons	*Solea solea, Chelidonichthys lucernus, Sepia officinalis, Squilla mantis, Pecten jacobeus, Melicertus kerathurus*			
Italian TBB		1363 tons	*Solea solea, Chelidonichthys lucernus, Sepia officinalis, Squilla mantis, Pecten jacobeus, Melicertus kerathurus*		*Aporrhais pespelecani, Ostrea edulis, Liocarcinus depurator, Anadara inaequivalvis, Anadara demiri*	
Italian Netters		53 tons	*Solea solea, Chelidonichthys lucernus, Squilla mantis*			

Spatial distribution of rapido trawl fishing effort

Figure 1a shows the rapido-trawl effort of Italian vessels over the year 2017 in GSA 17. As already observed in previous studies (Scarcella et al., 2014), the effort was distributed in accordance with the distribution of *Solea solea* (Figure 1b, reconstruction based on Solemon data), recording the maximum effort intensity in the northern sector of the GSA.

The first zone of effort concentration is inshore between 3 and 9 nautical miles from the Italian coast, between 43° and 44° latitude, and is mainly exploited by vessels belonging to Ancona and Rimini harbors. The second zone is between Po river mouth and Venice lagoon and is concentrated at the same distance from the coast as the first region. This region is mainly exploited by the Chioggia rapido trawl fleet. The third area of effort concentration is offshore, near Istria peninsula and is exploited by both Chioggia and Rimini rapido trawl fleets. The area southward of this last region is not exploited by rapido trawlers mainly due to the high concentrations of debris and benthic communities that are dominated by holothurians (Despalatović *et al.*, 2009; Santelli *et al.*, 2017).

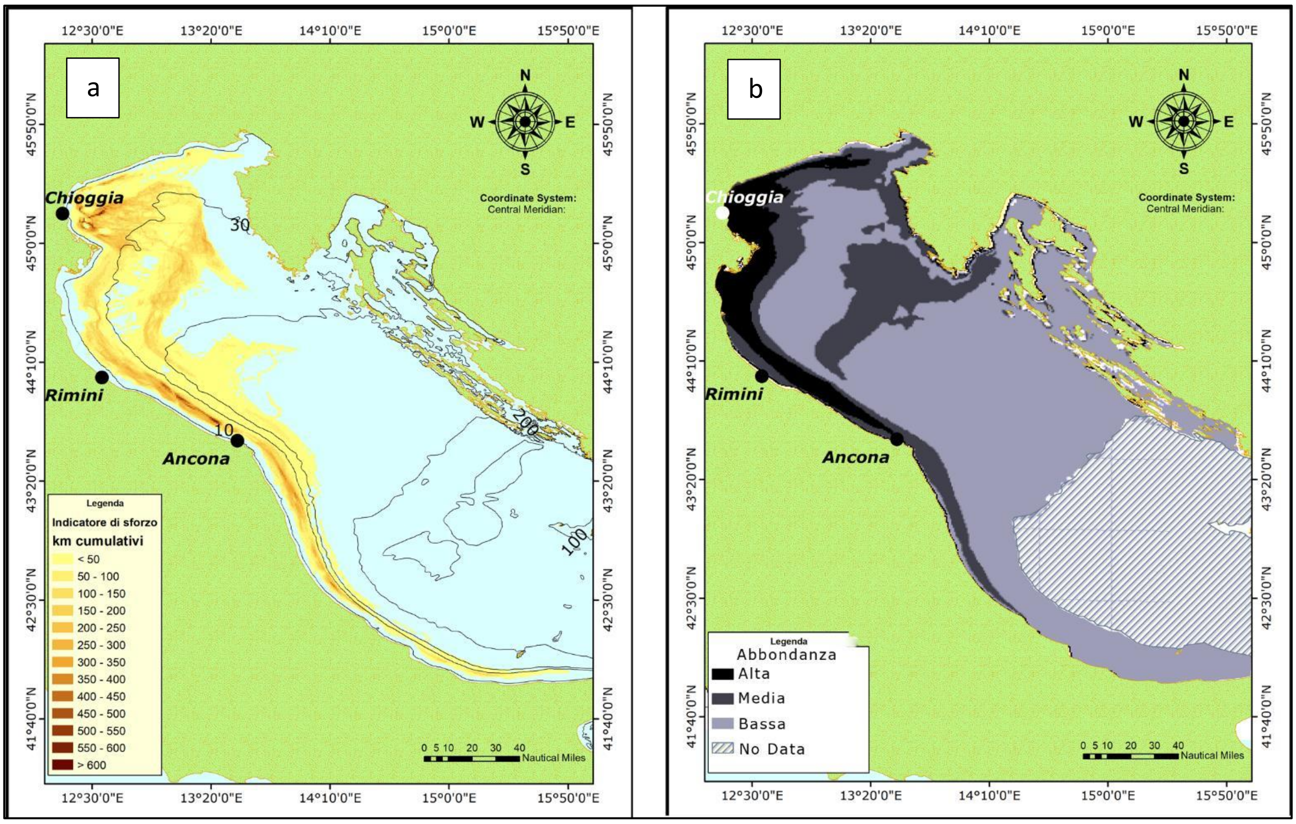

Figure 1 – a) Intensity of fishing effort exercised by vessel > 15 m, métier "rapido", referred to the year 2017; b) Abundance (n individuals/km2) of *Solea solea* predicted with Solemon data (2009-2017)

The “rapido” trawl effort expressed as days at sea and gross tonnage per day at sea is showed in figure 2a and 2b respectively: in both cases the trend is decreasing from the beginning of the series until 2013 and then slightly increase in recent period.

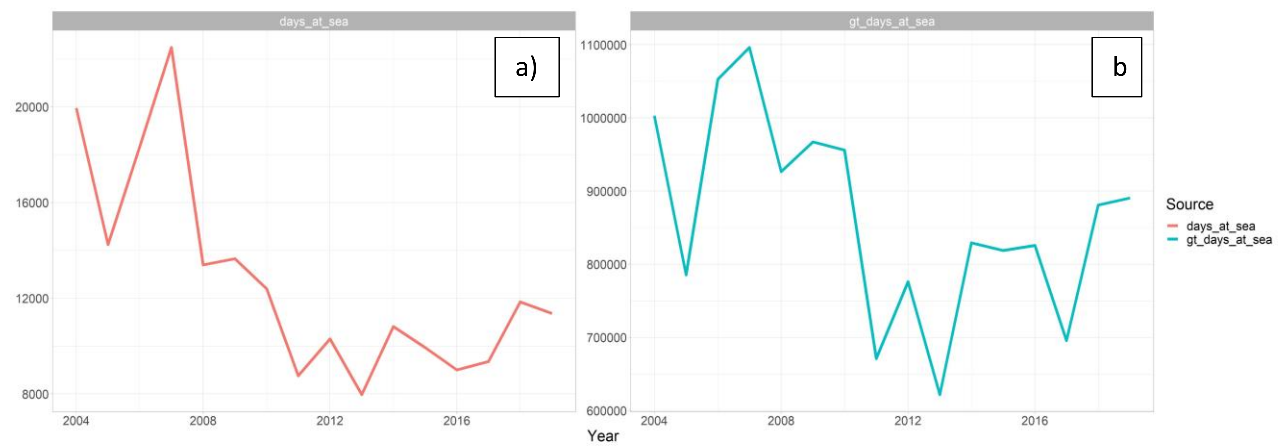

Figure 2 – GSA17 rapido trawl fishing effort in days at sea (a) and gross tonnage*days at sea (b).

2.4 Historical trends

Market statistics for purple dye murex are available only for years from 2004 to 2019 (DCF data). Landing data for year 1972 to 2003 were estimated as follows starting from historical time series from ISTAT-IREPA revised by Fortibuoni et al 2017. First, the proportion of landing of these species was calculate on the total landing of all mollusk for years from 2004 to 2019. Then the mean proportion was applied to the landing value of mollusks species for years from 1972 to 2003, thus obtaining the total landing for murex in GSA 17 also for these years. No Length Frequency Distribution (LFD) are available for this specie.

Discards of the considered stock can be assumed negligible or very low and a high rate of survivability can be expected.

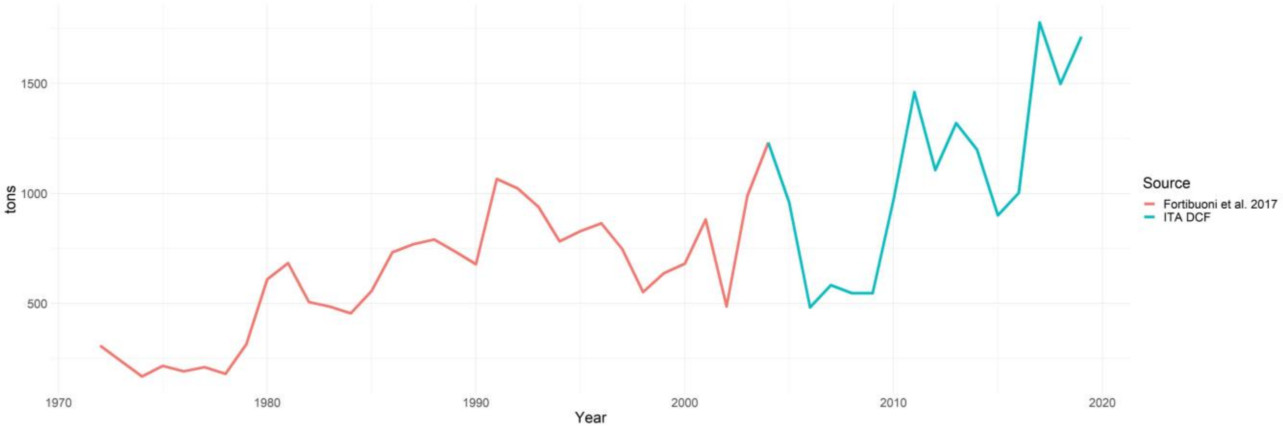

Figure 3 – Landings reconstruction for purple dye murex in GSA 17 used as input data in the assessment model.

2.5 Management regulations

In Italy and Slovenia the main rules in force are based on the applicable EU regulations (mainly EC regulation 1967/206):

- Codend 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 codend with 40 mm (stretched) square meshes or a codend 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

Italy has also a national regulation:

- Fishing closure for trawling: 30-45 days in late summer (not every year the same days)
- Trawling activity banned up to 6 nautical miles 3 months after the summer closure.

2.6 Reference points

Table 0.4-1: 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					
Y					
CPUE					
Index of Biomass at sea					

3 Fisheries independent information

3.1 SoleMon

Sixteens *rapido* trawl fishing surveys were carried out in GSA 17 from 2005 to 2019: two systematic "pre-surveys" (spring and fall 2005) and thirteen random surveys (spring and fall 2006, fall 2007-2013) stratified on the basis of depth (0-30 m, 30-50 m, 50-120m). Hauls were carried out by day using 2-4 *rapido* trawls simultaneously (stretched codend mesh size = 46). The following number of hauls was reported per depth stratum (Tab. 4.1).

Tab. 4.1 Number of hauls per year and depth stratum in GSA 17, 2005-2016

Depth strata	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
0-30	30	35	32	39	39	39	39	35	37	39	39	39	38	41	41
30-50	12	20	19	18	18	18	18	18	18	18	18	18	16	15	15
50-120	15	8	11	10	10	10	10	10	10	10	10	10	10	12	12
HRV	5	4	0	0	0	0	0	0	0	0	0	7	6	0	0
Total	62	67	62	67	67	67	67	63	65	67	67	74	70	68	68

Abundance and biomass indexes from *rapido* trawl surveys were computed using TruST software (https://www.kosmosambiente.it) which also allowed drawing GIS maps of the spatial distribution of the stock, spawning females and juveniles. The abundance and biomass indices by GSA 17 were calculated through stratified means (Cochran et al. 1954; Saville 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum area in the GSA 17:

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

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

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

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial. Length distributions represented an aggregation (sum) of all standardized length frequencies over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance and finally aggregated (sum) over the strata to the GSA. Given the sheer number of plots generated, these distributions are not presented here.

Direct methods: trawl based abundance indices

Table 3.1-1: Trawl survey basic information

Survey	SoleMon	**Trawler/RV**	Dallaporta
Sampling season	Fall		
Sampling design	Random stratified		
Sampler (gear used)	Rapido trawl		
Codend mesh size as opening in mm	40		
Investigated depth range (m)	5-120		

Table 3.1-2: Trawl survey sampling area and number of hauls 2018

Stratum	Total surface (km^2)	Trawlable surface (km^2)	Swept area (km^2)	Number of hauls
1	11512		1.343	41
2	8410		0.55	15
3	22466		0.41	12
HRV	6000		0.09	0

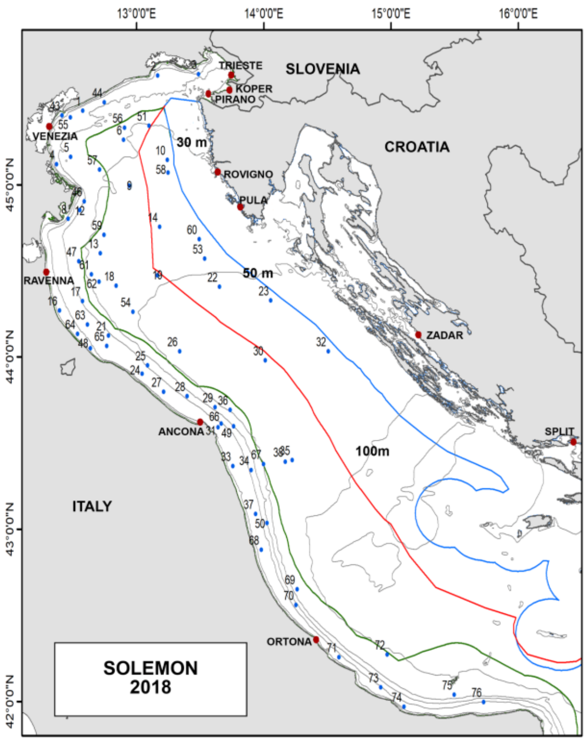

Figure 4 – Solemon map of hauls positions (2018 survey)

Table 3.1-3: Trawl survey abundance and biomass results

	Years	N per km^2	SD	Kg per km^2	SD
	2005	5920.7334	2361.89151	52.4772263	22.791126
	2006	4528.31299	2215.10316	39.8196869	14.6271251
	2007	769.579956	201.710953	9.300354	2.03635961
	2008	5045.58789	2102.24095	51.3416672	19.6147893
	2009	10229.0088	4647.35452	92.5297775	33.7692906
	2010	8012.36328	4091.94978	66.8780365	26.1880326
	2011	6211.16699	1447.04945	66.4398041	14.0344778
	2012	6487.65479	1662.00248	67.1472473	17.479186
	2013	3430.84473	713.089011	34.6159058	6.0883001
	2014	12517.7207	2905.17211	107.342293	23.5401839
	2015	4153.2373	933.394142	54.2231102	10.8776295
	2016	4644.00342	1383.32588	107.975853	45.757337

	2017	3931.24146	748.701292	43.8296394	7.97164565
	2018	6557.28613	1524.01329	57.1850319	12.594583
	2019	5624.46143	1048.26714	59.3600578	11.4722785

3.1.1 Spatial distribution of the resources

According to data collected during SoleMon surveys (Scarcella *et al.*, 2014), the murex aggregates in shallow areas within 50 m depth. The presence is higher near Po river delta and between 3 and 9 nautical miles from the Italian coast, between 43° and 44° latitude (Fig. 5).

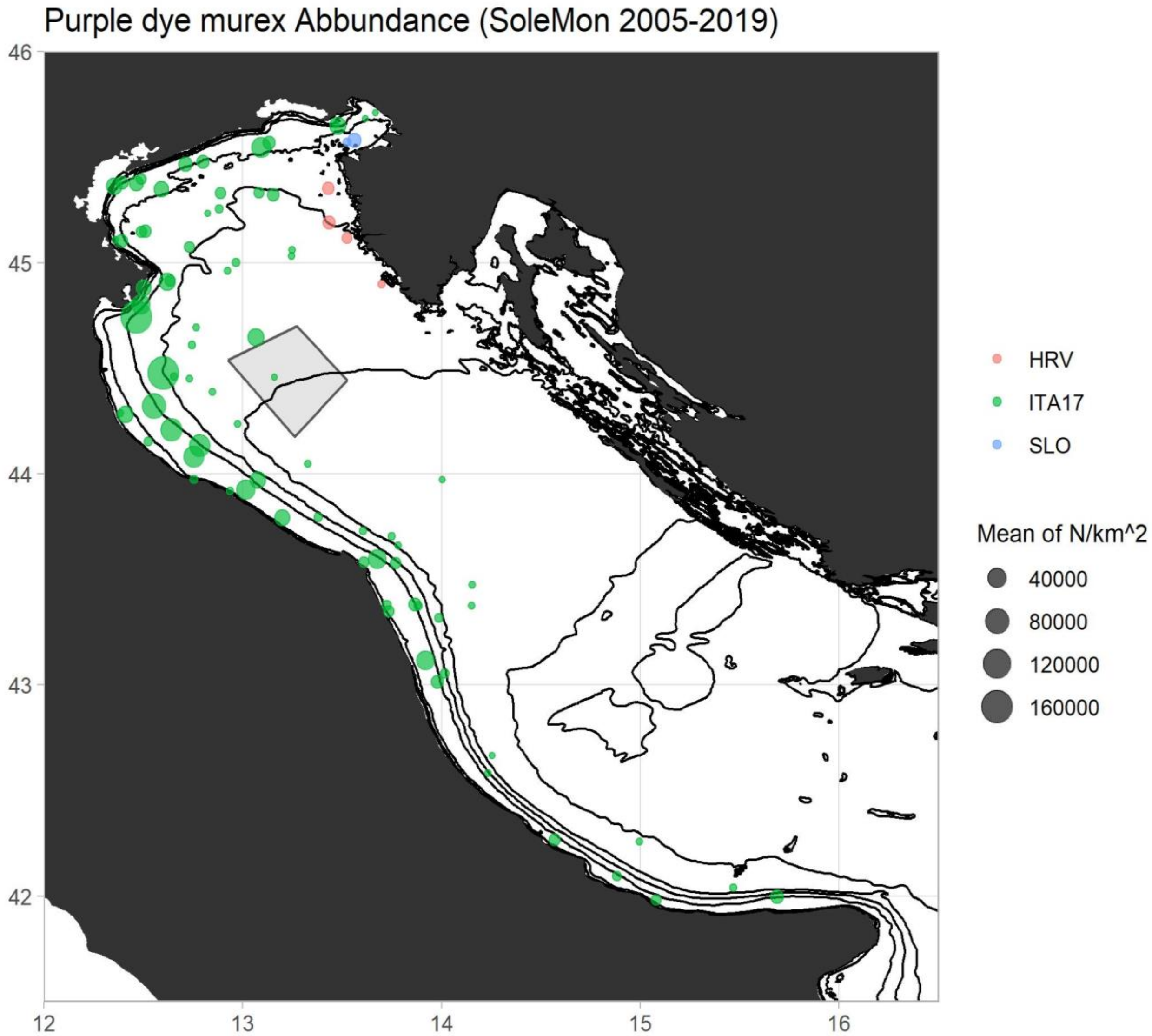

Figure 5 – Bubble plots showing the mean abundance index by hauls of purple dye murex calculated from Solemon surveys (all years together).

3.1.2 Historical trends

The SoleMon trawl surveys provided data for murex total abundance and biomass. Figure 6 and 7 shows the biomass and abundance indices obtained from 2005 to 2019. Both trends are quite stable with a minimum in 2007; in this year the survey has been conducted outside the time limits set by the protocol (October - February).

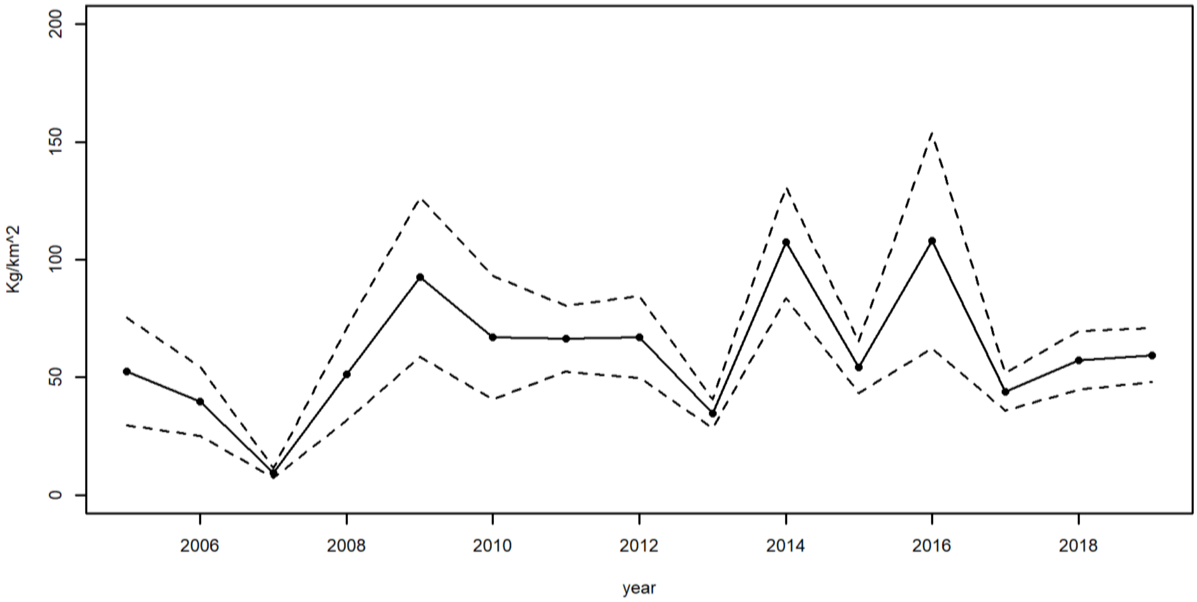

Figure 6 – Biomass index (± s.d.) of purple dye murex obtained from SoleMon surveys, 2005-2019.

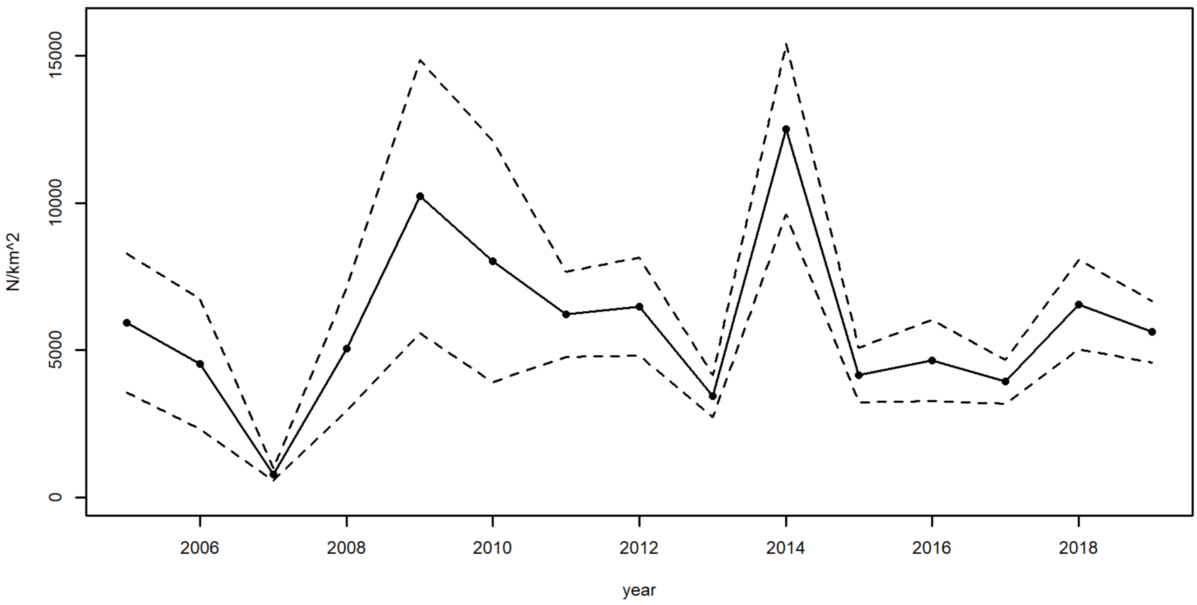

Figure 7 – Abundance index (± s.d.) of purple dye murex obtained from SoleMon surveys, 2005-2019.

4 Stock Assessment

4.1 *Surplus production model: C-MSY*

4.1.1 Model assumptions

CMSY (Froese et al., 2017) is a Monte-Carlo method that estimates fisheries reference points (MSY, Fmsy, Bmsy) as well as relative stock size (B/Bmsy) and exploitation (F/Fmsy) from catch data and broad priors for resilience or productivity (r) and for stock status (B/k) at the beginning and the end of the time series. A prior can be seen as the numerical translation of the expert knowledge about a certain topic in the form of a mean and a standard deviation, and in Bayesian statistics the reliability of a result depends on the use of an appropriate prior distribution (Myers et al. 2002). Probable ranges for the maximum intrinsic rate of population increase (r) and for unexploited population size or carrying capacity (k) are filtered with a Monte Carlo approach to detect 'viable' r-k pairs. Part of the CMSY package is an advanced Bayesian state-space implementation of the Schaefer surplus production model (BSM). The main advantage of BSM compared to other implementations of surplus production models is the focus on informative priors and the acceptance of short and incomplete (= fragmented) abundance data. The CMSY version referred in the present assessment (CMSY_2019_8q.R, available at http://oceanrep.geomar.de/33076/) is newer than the one used in Froese et al. (2017). The main differences are faster execution because of parallel processing, new diagnostic plots and more emphasis on management by the addition of the Kobe plot.

4.1.2 Input data and Parameters

- **Assessment model run**

Italian GSA17 data are available for the time series 1972-2019. Market statistics for purple dye murex are available only for years from 2004 to 2019 (DCF data). Landing data for year 1972 to 2003 were estimated as follows starting from historical time series from ISTAT-IREPA revised by Fortibuoni et al 2017. First, the proportion of landing of these species was calculate on the total landing of all mollusk for years from 2004 to 2019. Then the mean proportion was applied to the landing value of mollusks species for years from 1972 to 2003, thus obtaining the total landing for murex in GSA 17 also for these years. Biomass index data were provided by SoleMon surveys, carried out in fall for the years 2005-2019.

CMSY was run using the following settings:

Timeframe	Tuning index	Resilience	B/k Initial	B/k Int	B/k Final
1972-2019	SOLEMON	0.64-1.46	0.7-1	2011; 0.6-1	0.4-0.8

The resilience has been set as equal of Sealifebase (https://www.sealifebase.ca/summary/Bolinus-brandaris.html) and taking into account the high spawning potential of this species. The priors for the relative biomass (B/k) range in the final model have been set to mimic an increasing exploitation trend all along the time series.

4.1.3 Model results and diagnostics

Figure 8 shows the diagnostic panels. The good overlap of the blue (CMSY) and red (BSM) crosses (panels B and C) and lines (panels D and E) support the coherence between stock trajectories estimated by the BSM (based on Catches + CPUE) and by the CMSY model (Catch only model).

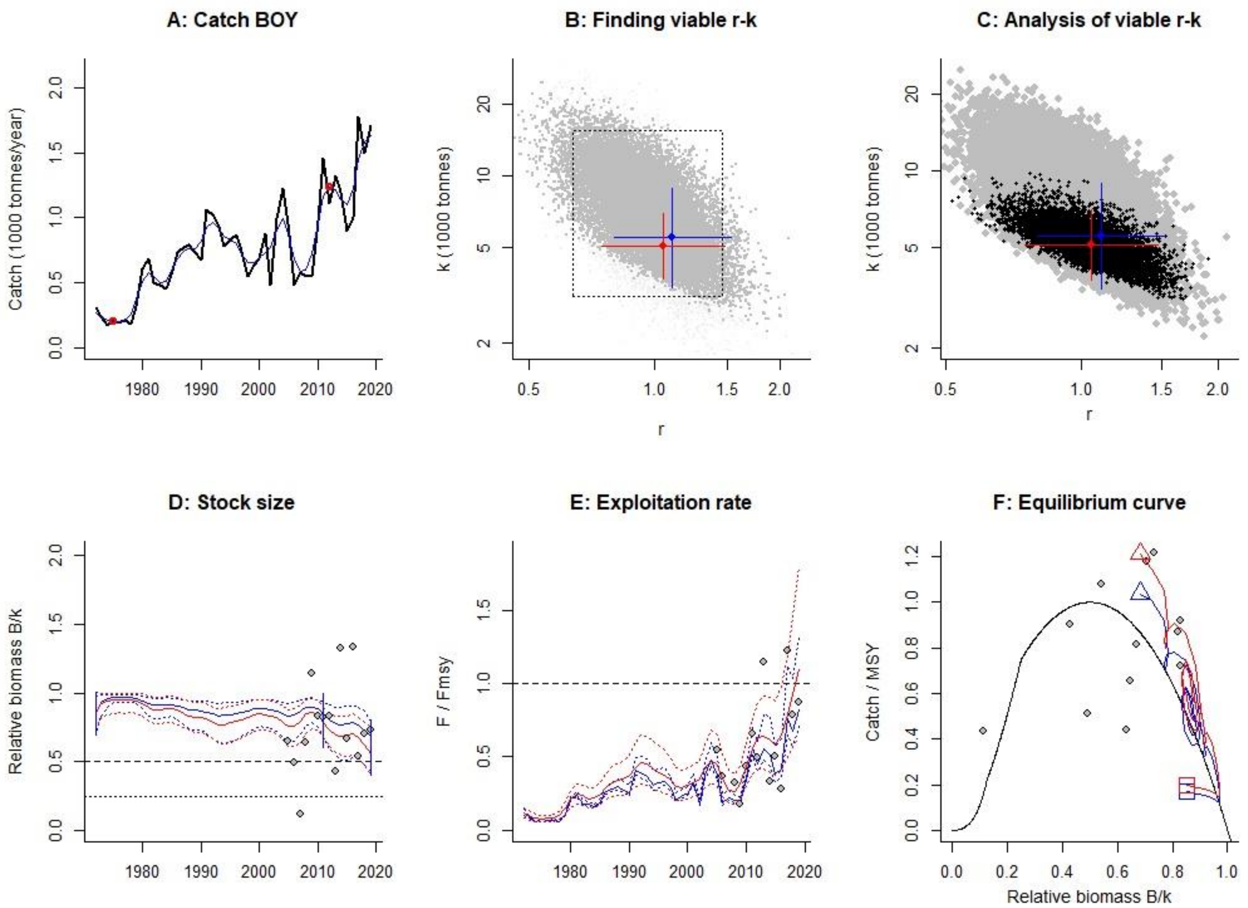

Figure 8 - Assessments for purple dye murex in GSA 17. Panel A shows in black the time series of catches and in blue the three-years moving average with indication of highest and lowest catch, as used in the estimation of prior biomass by the default rules. Panel B shows the explored r-k log space and in dark grey the r-k pairs which were found by the CMSY model to be compatible with the catches and the prior information. Panel C shows the most probable r-k pair and its approximate 95% confidence limits in blue. The black dots are possible r-k pairs found by the BSM model, with a red cross indicating the most probable r-k pair and its 95% confidence limits. Panel D shows the available abundance data in red, scaled to the BSM estimate of Bmsy = 0.5 k, and in blue the biomass trajectory estimated by CMSY. Dotted lines indicate the 2.5th and 97.5th percentiles. Vertical blue lines indicate the prior biomass ranges. Panel E shows in red the harvest rate (catch/abundance) scaled to the r/2 estimate of BSM, and in blue the corresponding harvest rate from CMSY. Panel F shows the Schaefer equilibrium curve of catch/MSY relative to B/k, here indented at B/k < 0.25 to account for reduced recruitment at low stock sizes. The red dots are scaled by BSM estimates and the blue dots are scaled by CMSY estimates.

Figure 9 shows additional information on model diagnostic. The catch fit is good, whereas the CPUE fit present some issues. In particular, the CPUE trend (Solemon survey biomass index) was so oscillatory that the most extreme value (2007) was out of residuals scale. Other sensitivity runs never solved this issue (see 4.1.4).

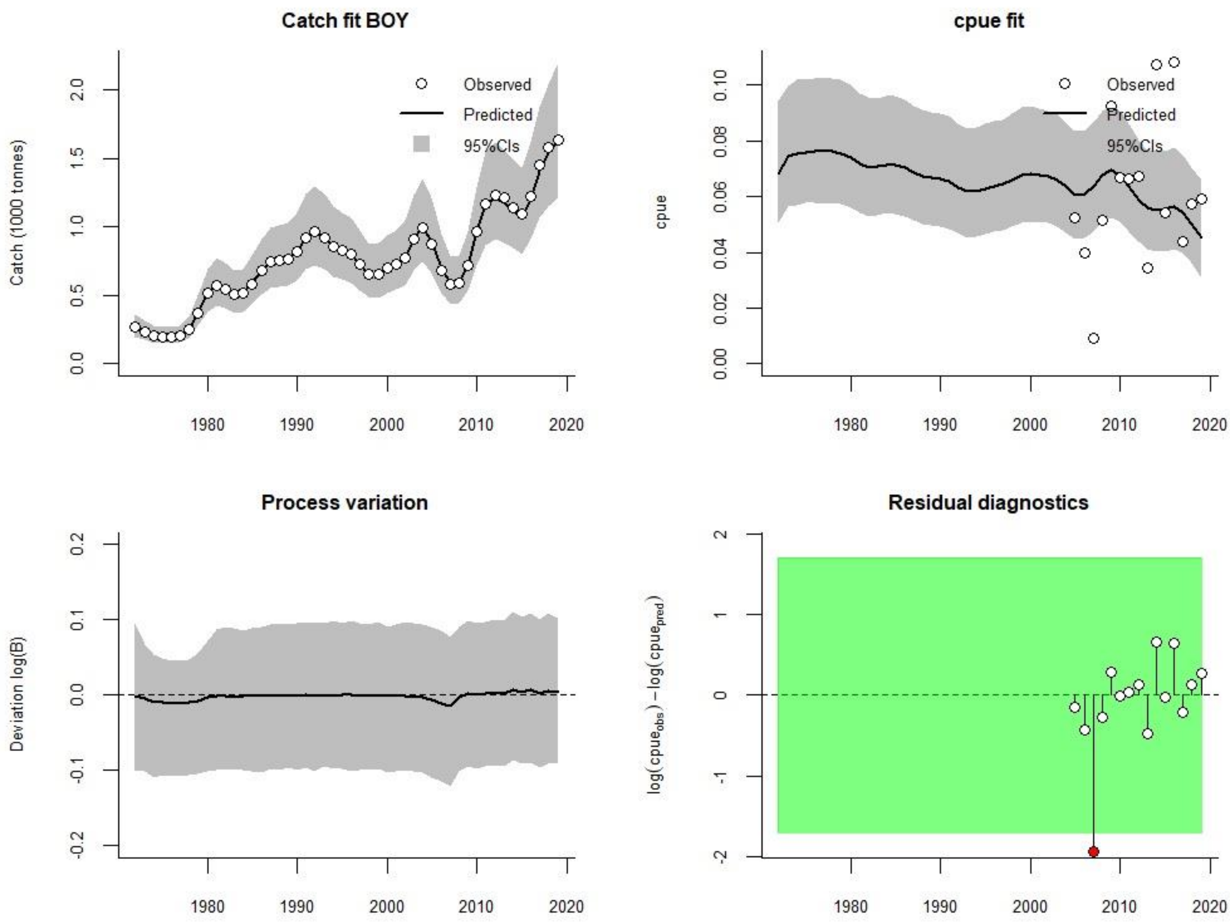

Figure 9 - On the upper panels are compared the observed data to the trajectories estimated by the model for Catch (left) and CPUE (right). On the right lower panel are shown the residuals for the CPUE on a colored background, where red indicates some issues on the model fit. On the left lower panels is shown the variation of production given by the stochastic model in respect to the trajectory described by the Schaefer curve.

Figure 10 shows the posteriors and the assumed prior distribution for the key model parameters providing no evidence of severe prior misspecification.

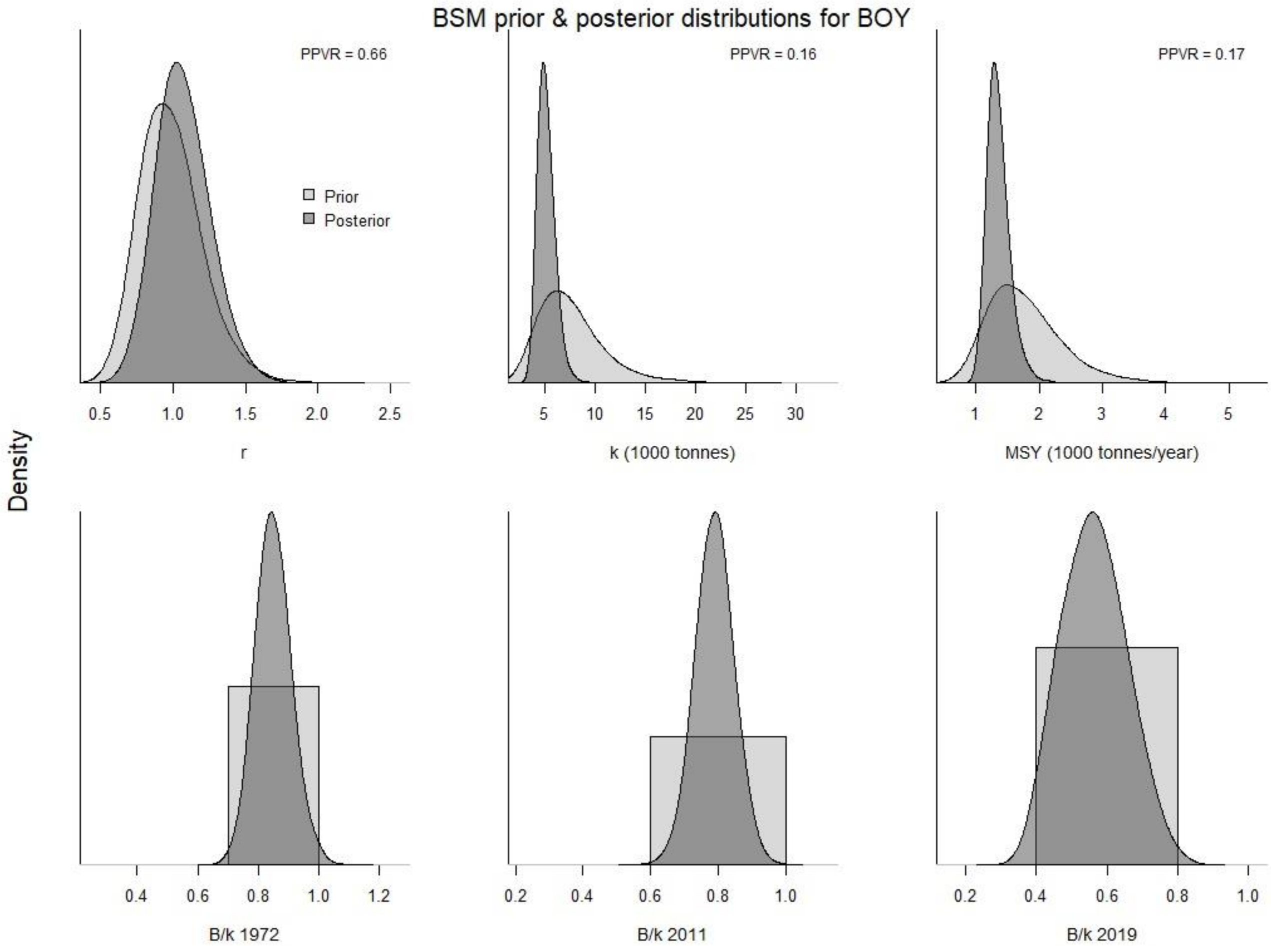

Figure 10 - Prior and posterior distributions of key model parameters for the final run. Posteriors distributions are plotted using generic kernel densities.

Figure 11 shows the graphs meant to inform management. 4

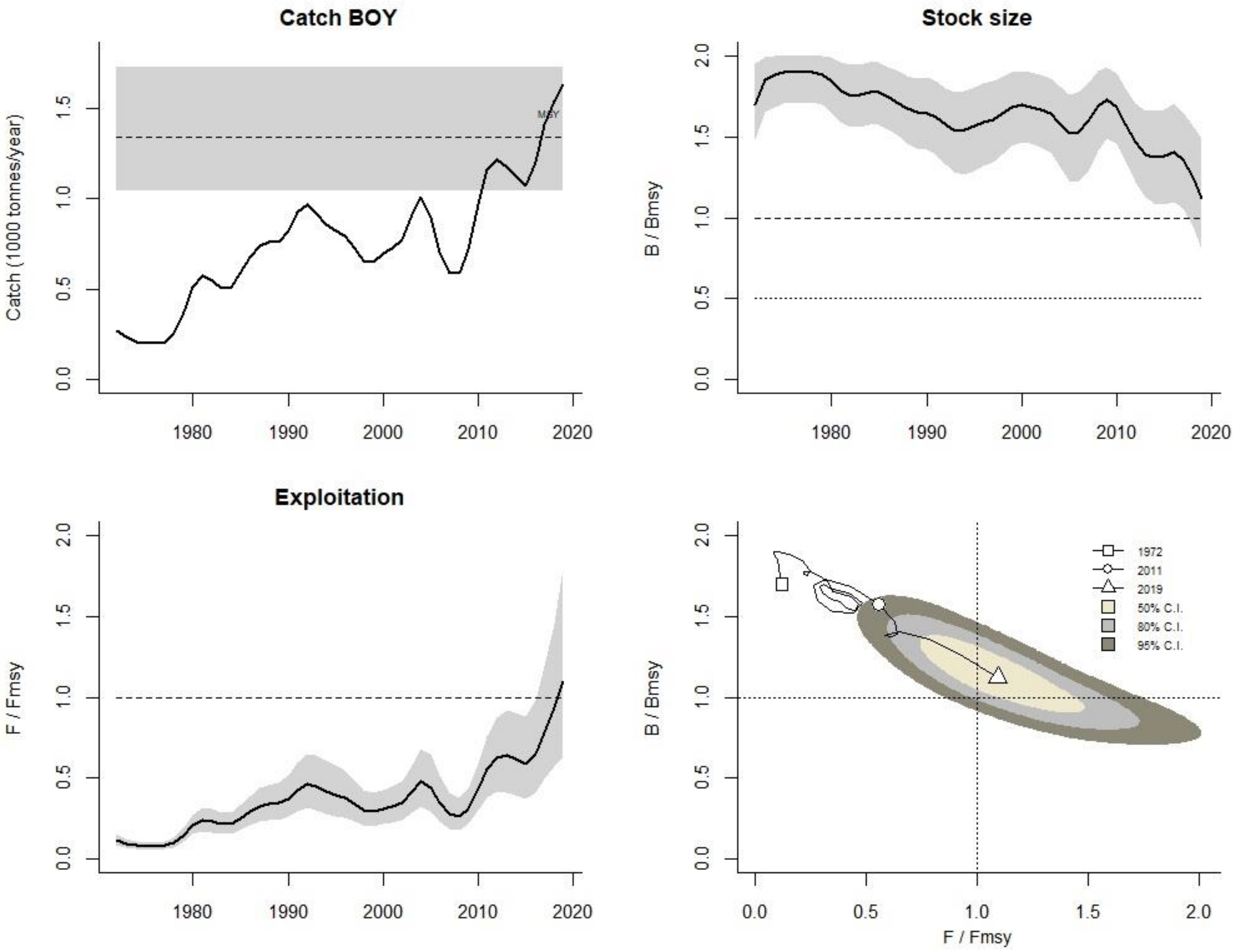

Figure 11 - Results of final run. The upper left panel shows catches relative to the BSM estimate of MSY, with indication of 95% confidence limits in grey. The upper right panel shows the development of relative total biomass (B/Bmsy), with the grey area indicating uncertainty. The lower left graph shows relative exploitation (F/Fmsy), with Fmsy corrected for reduced recruitment below 0.5 Bmsy. The lower-right shows a not colored version of the Kobe plot, with the trajectory of relative stock size (B/Bmsy) over relative exploitation (F/Fmsy).

Figure 12 represent the Kobe plot. The timeserie begun in 1972 when the biomass was quite higher than the Bmsy. During the period considered, the F level registered an increasing trend that resulted in a progressive erosion of the stock size. 2019 is the first year in wich the the stock status is located in the orange panel (with 37.6 % of probabilities). In conclusion, the trajectory of the purple dye murex is sustainable during the majority of the time series but goes into overfishing direction in the last years.

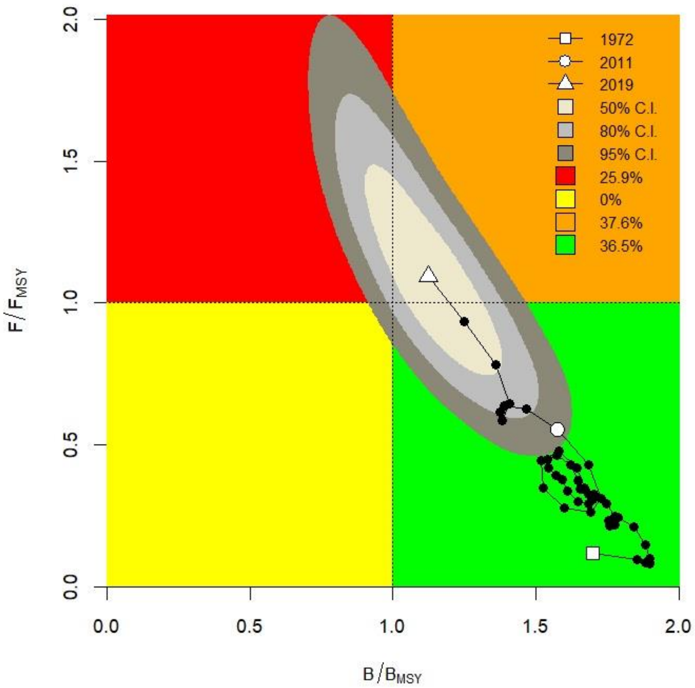

Figure 12 - Kobe plot representing the time series of pressure (F/FMSY) on the Y-axis and of state of the Biomass (B/BMSY) on the X-axis. The orange area indicates healthy stock sizes that are about to be depleted by overfishing. The red area indicates ongoing overfishing while the stock is too small to produce maximum sustainable yields. The yellow area indicates reduced fishing pressure on stocks recovering from still too small biomass. The green area is the target area for management, indicating sustainable fishing pressure and healthy stock size capable of producing high yields close to MSY.

State of exploitation: Exploitation highly increased during the whole timeseries. During last years the F is over the Fmsy but wide ranges of uncertainties are observed going from under exploitation to overexploitation levels.

State of the biomass: biomass trend showed a decreasing trend in whole the timeseries. In the final years it was observed a steep decline which led the biomass range of uncertanly to fall below BMSY.

Table 4.1.3: Summary of final results from C-MSY model

$F_{current}$	0.568
Lower limit (95% ci)	0.428
Upper limit (95% ci)	0.797
F_{MSY}	0.526
$F_{current}/F_{MSY}$	**1.079**
Lower limit F/F_{MSY} (95% ci)	0.635
Upper limit F/F_{MSY} (95% ci)	1.799
$B_{current}$ (1000s tons)	2.863
B_{MSY} (1000s tons)	2.549
$B_{current}/B_{MSY}$	**1.123**
Lower limit B/B_{MSY} (95% ci)	0.801
Upper limit B/B_{MSY} (95% ci)	1.491
MSY (1000s tons)	1.343
Lower limit MSY (95% ci)	1.043
Upper limit MSY (95% ci)	1.728
Catches 2019 (1000s tons)	1.712

4.1.4 Retrospective analysis, comparison between model runs, sensitivity analysis

A sensitivity analysis was carried out by testing four runs with different catches timeseries and priors for stock status (Table 4.1.4). First two runs (L1 and L2) used the longest reconstructed time series of data while S4 used only official DCF data starting from 2004. L1 and S4 simulate an stable exploitation during the whole time series (0.4-0.8) while L2 an increasing trend (from 0.7-1 in the initial year to 0.2-0.6 in the final year).

Table 4.1.4: Setting of sensitivity analysis runs. L3 is the selected final model run.

Runs	Timeframe	Tuning index	Resilience	B/k Initial	B/k Int	B/k Final
L1	1972-2019	SOLEMON	0.64-1.46	0.4-0.8	2011; 0.4-0.8	0.4-0.8
L2	1972-2019	SOLEMON	0.64-1.46	0.7-1	2011; 0.4-0.8	0.2-0.6
L3 *	**1972-2019**	**SOLEMON**	**0.64-1.46**	**0.7-1**	**2011; 0.6-1**	**0.4-0.8**
S4	2004-2019	SOLEMON	0.64-1.46	0.4-0.8	2011; 0.4-0.8	0.4-0.8

* final run

Figure 13 shows that results are quite consistent despite L2 run (slightly more pessimistic). L3 run has been selected to give advice because of the longest time series and the better diagnostic respect to the others.

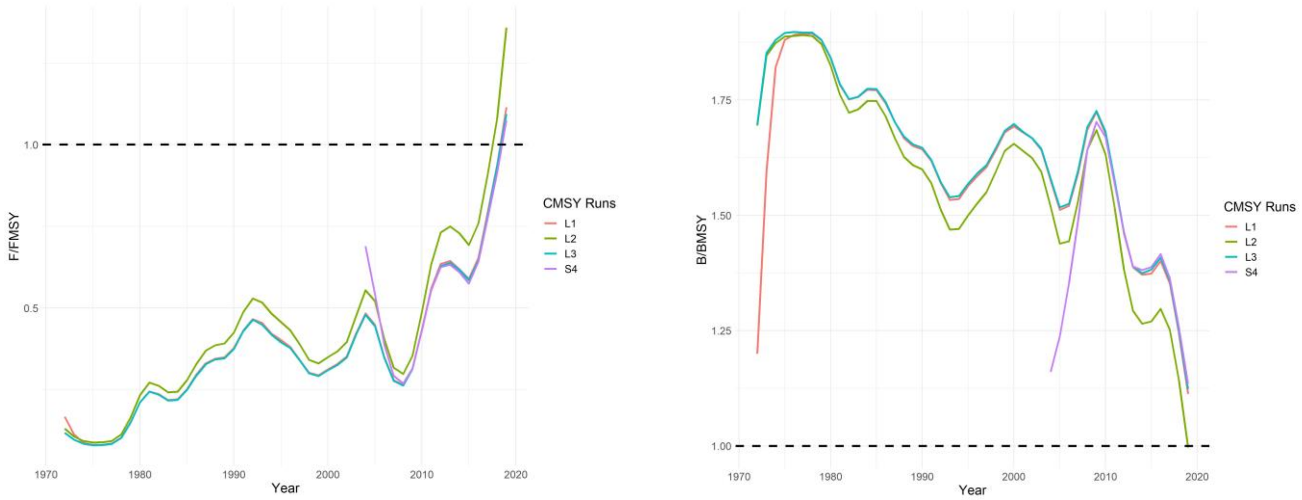

Figure 13 – Main outputs of the sensitivity analysis. Trajectories of F/FMSY and B/BMSY for the 4 model tested. L3 is the one selected as final model.

4.1.5 Assessment quality

The result given in the advice are coherent with the output of the sensitivity analysis. Nevertheless, landings reconstruction had to be taken with care: the fishing grounds for *B. brandaris* have been regulated during recent years (see 2.5), so the amount of landing might not be representative of past periods.

Draft scientific advice

The scientific advices in the following table are based on the BSM analysis using CMSY model results and on the Biomass index from Solemon survey. The scientific advice from the Working Group is to reduce fishing mortality to avoid going under BMSY.

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_{MSY} = 0.536	F_{cur} = 0.568		I	IO
Stock abundance	Biomass	B_{MSY} = 2.549	B_{cur} = 2.863		D	S
Recruitment						
Final Diagnosis		Biomass above the reference point and in overexploitation				

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 33^{rd} percentile of biomass index in the time series **(O_L)**
- **Relative intermediate biomass:** Values falling within this limit and 66^{th} percentile **(O_I)**
- **Relative high biomass:** Values higher than the 66^{th} 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)*

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