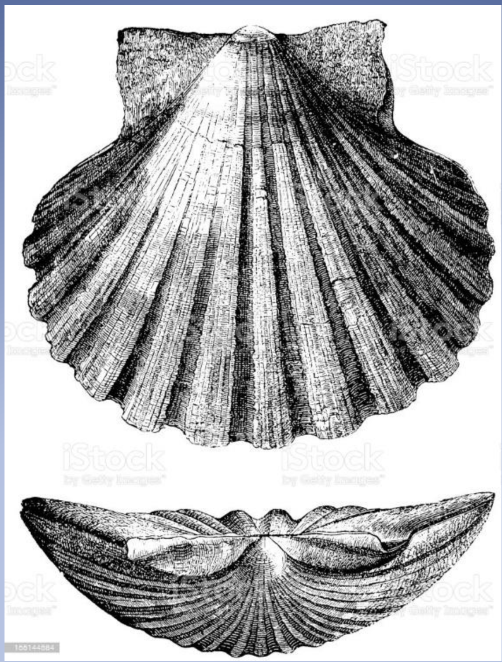


Stock Assessment Form

Demersal stocks

Reference Year: 2019

Reporting Year: 2021

Pecten jacobeus in GSA17 is an important shellfish resource especially in the northern sector of thed GSA, where is mainly exploited by the rapido/rampon trawl fishery both in Italy and Croatia. In 2019 Italian rapido trawl fishery accounted for the 55% of the landings followed by Italian otter trawl (29%) and Croatian dredges (“rampon”, 13%). In the past, the species in the northern Adriatic Sea showed wide fluctuactions in term of landings, reaching almost 2000 tons in the 80’s. The resource has suffered due to unfavourable environmental condition such as anoxia or algal blooms as well as overexploitation by the fishery and since the begin of 2000 the landigs are quite low (around 200 tons).

Stock Assessment Form version 1.0 (January 2014)

Uploader: *Please include your name*

Stock assessment form

Basic Identification Data

Scientific name:	Common name:	ISCAAP Group:
Pecten jacobeus	Great Mediterranean scallop	[ISCAAP Group]
1st Geographical sub-area:	**2nd Geographical sub-area:**	**3rd Geographical sub-area:**
GSA 17		
4th Geographical sub-area:	**5th Geographical sub-area:**	**6th Geographical sub-area:**
1st Country	**2nd Country**	**3rd Country**
Italy	Slovenia	Croatia
4th Country	**5th Country**	**6th Country**
Stock assessment method: (direct, indirect, combined, none)		
Stock Synthesis (SS3)		
Authors:		
Scarcella G.[1], Angelini S.[1], Armelloni E.[1,2], Arneri E.[3], Cardinale M.[4], Froglia C.[1], Isajlovic I.[5], Masnadi F.[1,2], Mazzoldi., C[6], Milone N.[3], Scanu M.[1,2], Vrgoc N.[5]		
Affiliation:		
[1] 1Institute for Biological Resources and Marine Biotechnologies - National Research Council of Italy (IRBIM-CNR) Ancona, Italy [2] Department of Biological, Geological and Environmental Sciences, University of Bologna, Italy [3] FAO-AdriaMed, Rome, Italy [4] Swedish University of Agricultural Science (SLU), Lysekil, Sweden [5] Institute of Oceanography and Fisheries, Croatia [6] University of Padova, Department of Biology, Italy		

The ISSCAAP code is assigned according to the FAO 'International Standard Statistical Classification for Aquatic Animals and Plants' (ISSCAAP) which divides commercial species into 50 groups on the basis of their taxonomic, ecological and economic characteristics. This can be provided by the GFCM secretariat if needed. A list of groups can be found here:

http://www.fao.org/fishery/collection/asfis/en

Direct methods (you can choose more than one):

- **Trawl survey**

Indirect method (you can choose more than one):

- CMSY
- AMSY
- **SS3**

Combined method: you can choose both a direct and an indirect method and the name of the combined method (please specify)

1 Stock identification and biological information

1.1 Stock unit

The stock of great Mediterranean scallop was assumed in the boundaries of the Northern Adriatic Sea (GSA 17), as suggested by the spatial distribution observed from SoleMon survey (see figures in chapter 4). The northern Adriatic Sea is characterized by generally shallow waters, whereas the central part hosts a three consecutive depressions, called Pomo/Jabuka Pits, which reach ca. 270 m in their deepest part.

Pecten jacobaeus can reach a length of about 120–140 millimetres (4.7–5.5 in). The two valves have different shapes. The lower valve, with which the animal rests on the bottom, is very convex and light-colored, while the upper valve is flat and brown. They show 14 to 16 ribs (radial wrinkles) with a more or less rectangular cross section. The inside of the valves is porcelain-like smooth. The mollusc has at the edge of the mantle many short tentacles, between which there are a total of 60 blue-millimeter lens eyes. By quickly closing of the two valves it can swim away several meters in case of danger. These scallops eat planktonic organisms and other floating food particles, which they obtain by filtering sea water with their gills.

1.2 Growth and maturity

Age and growth of the scallop in were investigated by Peharda et al. (2003) on specimens collected from a commercial catch in the northern Adriatic during January and February 2003. Shells were aged based on ligament scars and formation of growth rings on the external shell surface, and data were fitted to the von Bertalanffy growth function. In addition, age and growth were estimated from growth increments using Gulland-Holt plot and relative growth function was constructed.

Length of analyzed Pecten jacobaeus ranged from 75.1 to 142.0 mm, while estimated age ranged from 2 to 13 y. With respect to two methods applied, obtained von Bertalanffy equations for height were: $H_t = 108.79\ (1-e^{-0.47t+0.16})$ and $H_t = 110.08\ (1-e^{-0.53\ (t-t0)})$. The asymptotic shell lengths were estimated to be 127.93 and 127.35 mm, respectively.

Mattei and Pellizzato in 1996, explored the stocks of *Pecten jacobeus* in the Adriatic sea and monitored scallop size for 42 months with the aim of determining the effect of fishing the the stock. Sexual maturity is achieved at a length of about 5-6 cm (Renzoni, 1991; Valli, 1979). The Mediterranean scallop, *P. jacobaeus*, can theoretically reach commercial size (9 cm) in about 20 months and show a longevity of more than 13 years and a maximum size 142 mm (shell lenght). Natural mortality is not precisely known but in common with other fish and shellfish stocks of similar longevity (up to 20 years) it is assumed to be 0.15 yr^{-1} for all ages (Cook et al., 1990).

Table 1.1: Maximum size, size at first maturity and size at recruitment.

Somatic magnitude measured (LT, LC, etc)				Units	
Sex	Fem	Mal	Combined	Reproduction season	
Maximum size observed			142 (mm)	Recruitment season	
Size at first maturity			60 (mm)	Spawning area	
Recruitment size to the fishery				Nursery area	

Table 1.2: M vector and proportion of matures by size or age

Size/Age	Natural mortality	Proportion of matures
	Combined	
All	*0.15*	

Table 1.3: Growth and length weight model parameters

		Units	Sex			
			female	male	Combined	Years
Growth model	L_∞	cm			12.74	
	K	y^{-1}			0.53	
	t_0	y			0	
	Data source	Peharda et al., 2003				
Length weight relationship	a				0.0002	
	b				2.7744	
	M (scalar)				0.15	

2 Fisheries information

2.1 Description of the fleet

Pecten jacobeus is one of the principal benthic molluscs fished in the Adriatic Sea, accounting for high landing quantity in the past. Fishing grounds mostly correspond to the distribution of the stock. The principal gears exploiting this stock is rapido trawl in Italy and rampon in Croatia.

Table 2-1: 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 – Trawlers (12- 24 metres)	TBB	33 – Demersal shelf species	
Operational Unit 2	ITA	17	E – Trawlers (12- 24 metres)	OTB	33 – Demersal shelf species	
Operational Unit 3	HRV	17	E – Trawlers (12- 24 metres)	DRB	33 – Demersal shelf species	

Table 2.2 Catch, bycatch, discards and effort by operational unit in the reference year

Operational Units*	Fleet (n° of boats)*	Catch (T of the species assessed)	Other species caught (names and weight)	Discards (species assessed)	Discards (other species caught)	Effort (units)
ITA 17 TBB		113				
ITA 17 OTB		59				
HRV 17 DRB		27				
Total		200				

2.2 *Historical trends*

The catch of scallop shows a generally increasing trend in the first period of the considered time series up to 1.8 kt with wide oscillations due to envinomental factors, but since 2002 the landing were generally low (around 200 tons). Italian data before 2004 reconstructed based on Chioggia harbour landings (on average ≈ 80% of total catches). Confirmed by data from other markets (Caorle, Goro, etc.). Landing data are available in the Clodia database of Chioggia market and represent official monthly statistics of fish and seafood catches landed from 1945 onward at the fish market of Chioggia. Landings refer only to fish and seafood caught by local fishermen from the Chioggia's fleet, that operates in the Adriatic Sea. Landing data are grouped in categories that may refer to single or multiple species. Landing data of *Pecten jacobeus* are species-specific.

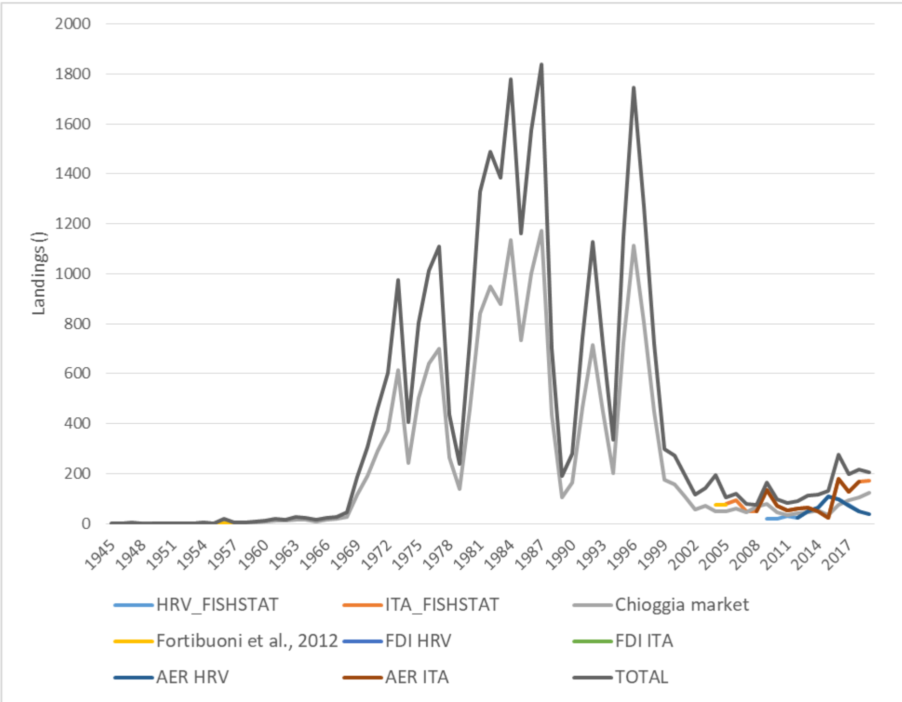


Figure 2.1 – Landings of *Pecten jacobeus* in GSA 17.

2.3 *Management regulations*

The Minimum Conservation Reference Size MCRS is equal to 10 cm as shell length.

3 Fisheries independent information

3.1 SoleMon

Solemon survey is a trawl fishing survey conducted with a modified beam trawl (Rapido), carried out in GSA 17 from 2005 to 2019: one systematic “pre-surveys” (fall 2005) and the rest random surveys (fall 2006 to fall 2017) stratified on the basis of depth (0-30 m, 30-50 m, 50-100m). 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. 3.1.1). Due to the low representation of HRV stratum, these hauls are not used to calculate the index.

Table 3.1-1 Number of hauls per year and depth stratum in GSA 17, 2005-2019

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	40	39
30-50	12	20	19	18	18	18	18	18	18	18	18	18	16	15	16
50-120	15	8	11	10	10	10	10	10	10	10	10	10	10	11	11
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	66	68

Abundance and biomass indexes from *rapido* trawl surveys were computed using TRUST software (https://www.kosmosambiente.it/scientifictrawlsurveys/). 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 in this report.

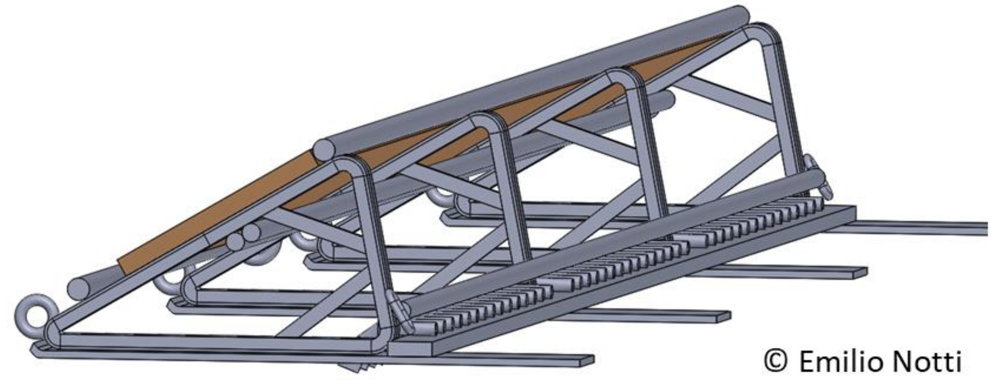


Figure 3.1: the mouth of the “Rapido” gear

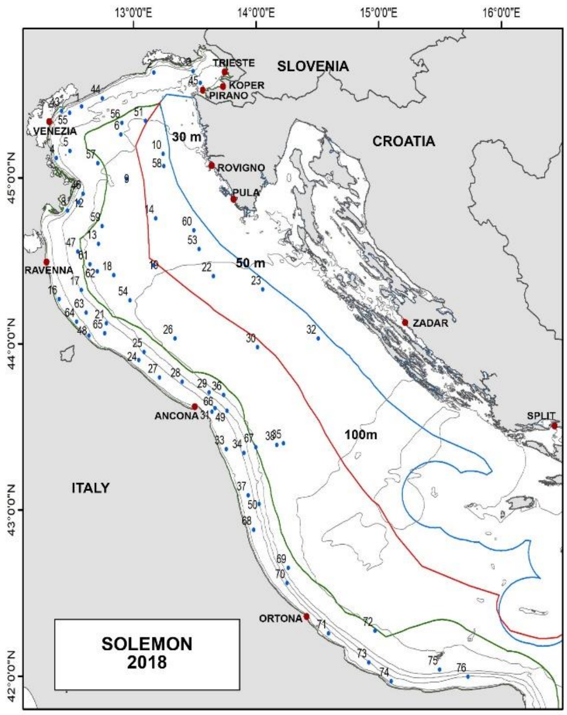


Figure 3.2: Solemon map of hauls positions in 2018. Image credits: C. Ferrà

Direct methods: trawl based abundance indices

Table 3.1-2 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	46
Investigated depth range (m)	5-120

Table 3.1-3 Trawl survey sampling area and number of hauls 2018. Note that hauls in HRV stratum have been removed from the analyses.

Stratum	Total surface (km^2)	Trawlable surface (km^2)	Swept area (km^2)	Number of hauls
1	11512		1.343	39
2	8410		0.55	16
3	22466		0.36	11
HRV	6000		0.09	0

Table 3.1-4 Trawl survey biomass data

Years	kg per km^2	St Dev	Relative * biomass All age groups	CV	N per km^2	St Dev	Relative * abundanc e All age groups	CV
2005	2.23	0.45						
2006	3.18	0.41						
2007	2.59	0.34						
2008	3.38	0.42						
2009	1.38	0.56						
2010	1.58	0.32						
2011	1.89	0.41						
2012	1.94	0.38						
2013	4.96	0.61						
2014	2.45	0.37						

2015	4.28	0.38						
2016	6.27	0.38						
2017	5.84	0.39						
2018	6.1	0.28						
2019	7.22	0.31						

3.1.1 Spatial distribution of the resources

According to data collected during SoleMon surveys, scallop aggregates in the northern sector of GSA 17.

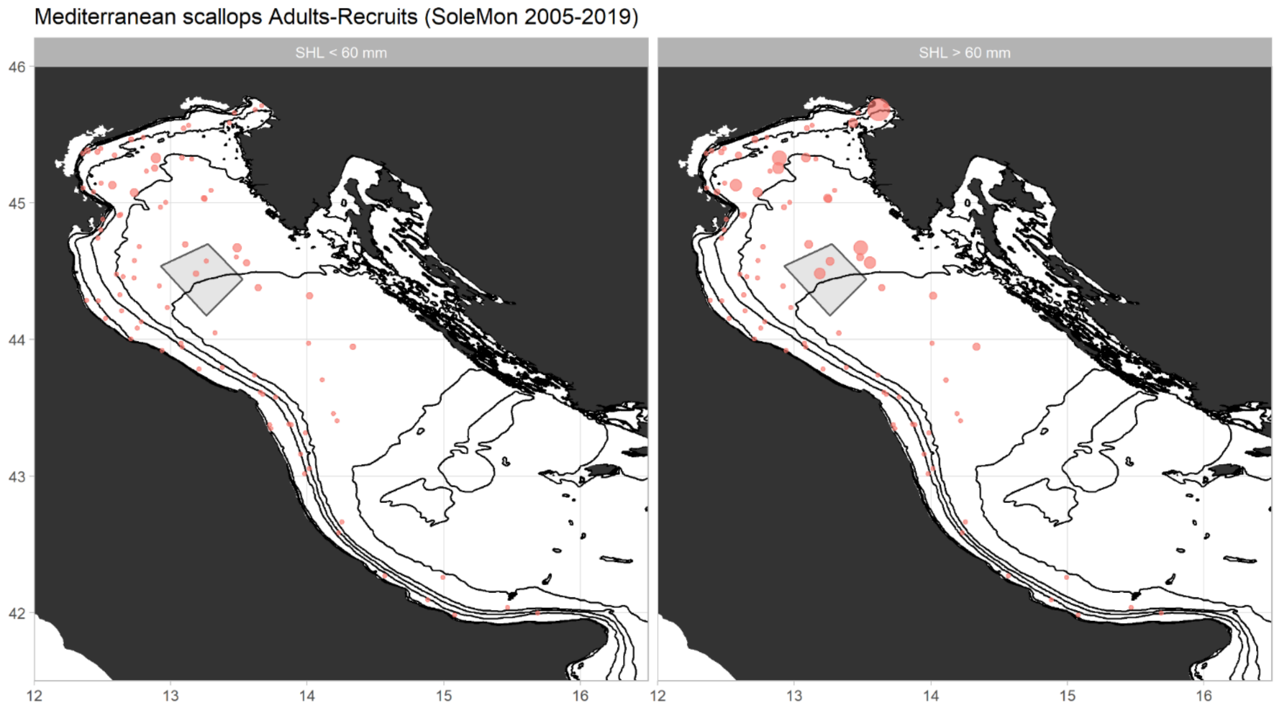


Figure 3.1.1: Maps distribution of scallop in GSA 17 (bubbles: N km^{-2}), based on Solemon data.

3.1.2 Historical trends

The SoleMon trawl surveys provided data either of scallop total abundance as well as on important biological events (recruitment, spawning). Figures 3.1.2.1-2 show the indices of scallop obtained from 2005 to 2019 and the annual LFDs.

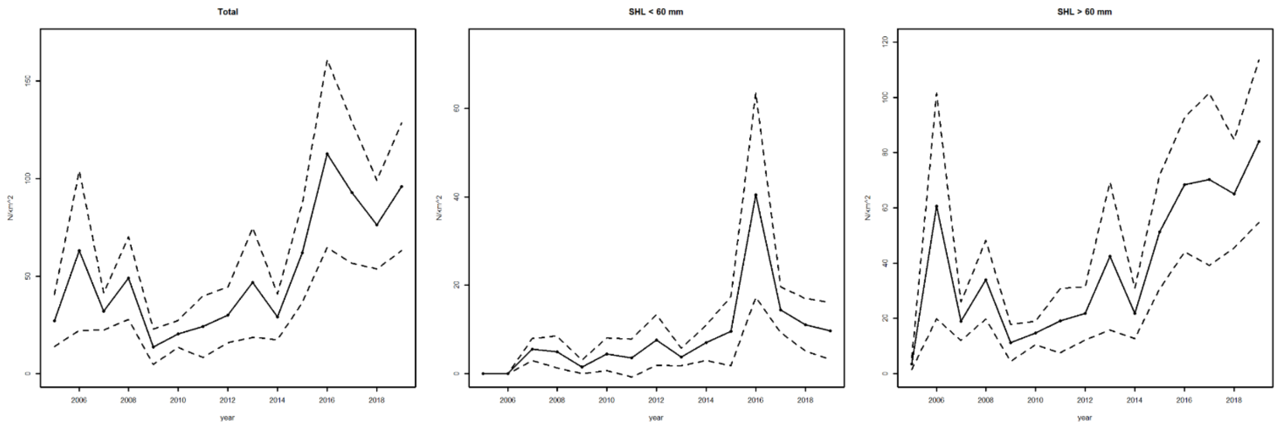


Figure 3.1.2-1: Density and Biomass indices (± s.d.) of scallop obtained from SoleMon surveys.

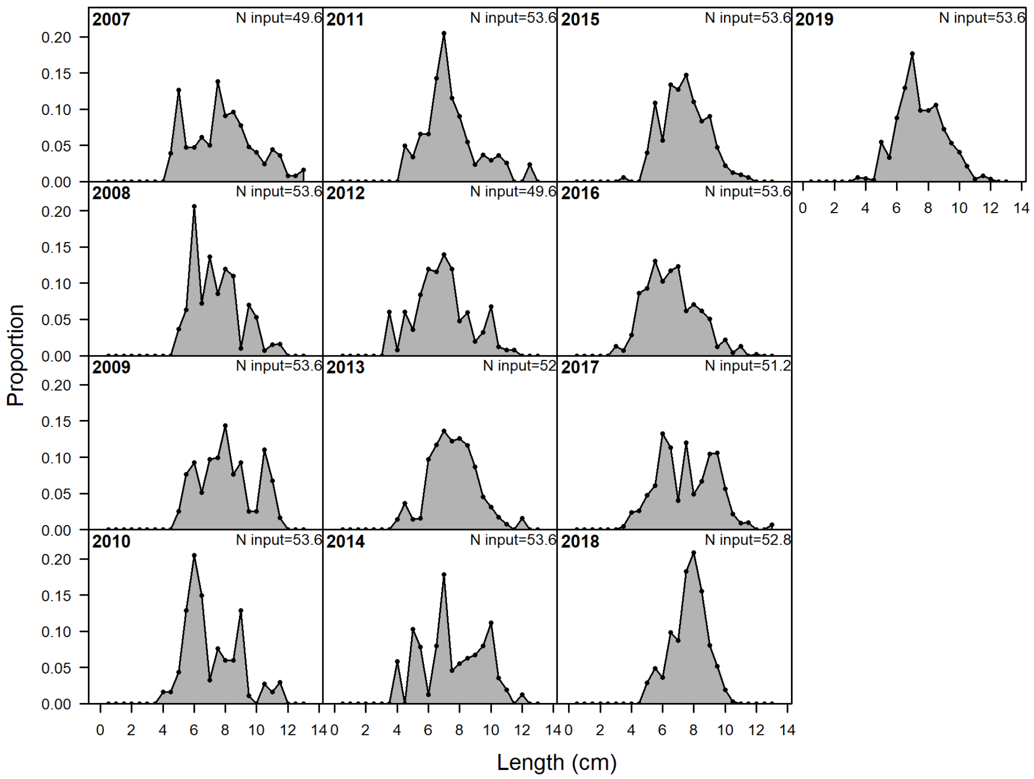


Figure 3.1.2-2 Stratified abundance indices by size, 2007-2019.

3.2 Other rapido trawl surveys carried out in GSA 17

Other rapido trawls survey were conducted in 1995 (4 hauls) and 2002 (10 hauls) in the norther Adriatic Sea (Fig. 3.2; see Hall-Spencer et al. (1999) for survey description).

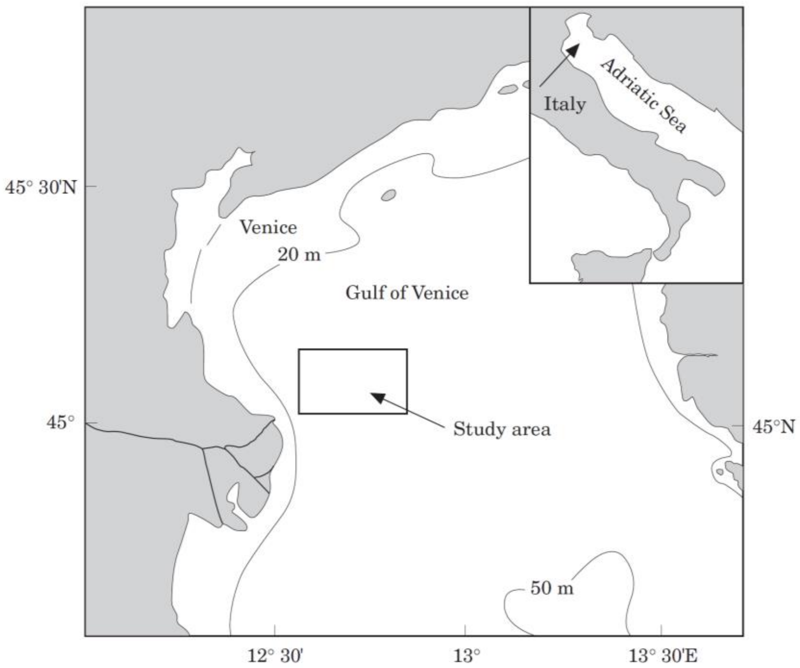
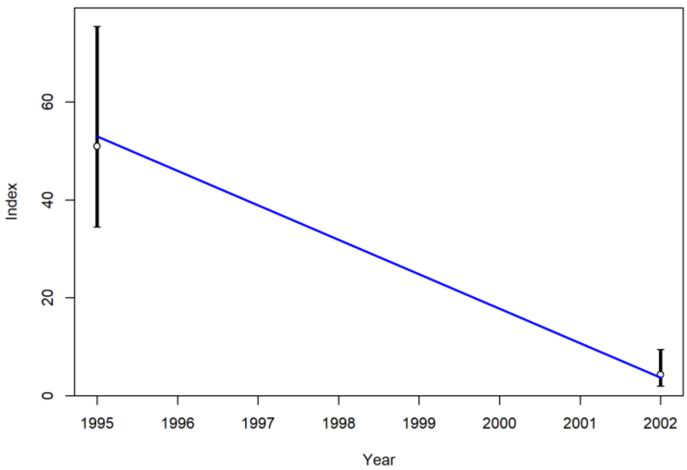


Figure 3.2 - Location of the scallop ground studied, Gulf of Venice.

The data were made available by dott. Carlo Froglia and are showed in figure 3.3



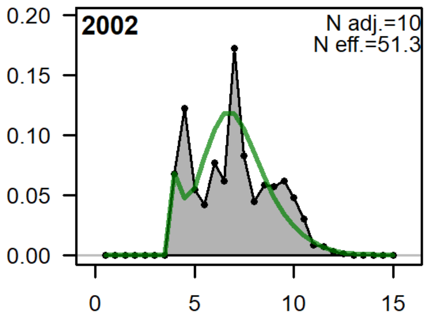


Figure 3.3 – Biomass indexes (left) and LFD (right) obeserved in the surveys carried out in the scallop ground studied by Hall-Spencer et al (1999).

4 Ecological information

4.1 Protected species potentially affected by the fisheries

According to the expert knowledge, there should not be any protected or endengeredd species potentially affected by the fisheries

4.2 Environmental indexes

According to Mattei and Pellizzato (1996), Gradual environmental deterioration and increasing eutrophication of Northern Adriatic marine ecosystem is altering the chemical and physical parameters of the benthos, with repercussions on the whole life cycle, and the reproductive phase in particular, of benthic organisms. The progressive reduction in the populations of exploited species such as P. jucobaeus is therefore not surprising. Physical and chemical data collected in Gulf of Trieste, with time series ranging from 1983, 1986 and 1989 to 2016, were analyzed by Kralj et al. (2019) in order to detect trends and frequency of occurrence of hypoxia events in bottom waters of the Gulf. The results of the analysis of 30-years data show a tendency toward increasing oxygen concentration in the bottom waters, nevertheless two hypoxic events were recorded during the summers of 2015 and 2016 even in a relatively shallow area of the Gulf. The spatial and temporal extent of these events was analyzed by coupling oceanographic surveys with automatic oceanographic measurements. During both summers, the area was characterized by high seawater temperature (up to 28.4 °C at the surface) and salinity (38.1 at the bottom) and a marked stratification of the water column, which prevented the mixing of oxygen-rich surface water with oxygen-poor deep water. The main contribution to oxygen depletion in the bottom waters was attributed to plankton respiration (54–61%) and to benthic oxygen consumption (39–46%), which exceeded the oxygen produced by planktonic and benthic microalgae and the one diffused from the overlying oxygenated water. These events of marked oxygen depletion in shallow coastal ecosystems are possibly favored by the positive temperature trend in bottom waters, coupled with the increase in riverine discharges in late spring, limiting vertical mixing and bottom water renewal. Such events had probably an impact on scallops landings and abundance at sea.

5 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.

5.1 Statistical catch at age (SS3 model)

5.1.1 Model assumptions

The assessment of *Pecten jacobeous* in the Northern Adriatic Sea (GSA 17) was conducted using the Stock Synthesis (SS) model (Methot & Wetzel 2013). Stock Synthesis is programmed in the ADMB C++ software and searches for the set of parameter values that maximizes the goodness-of-fit, then calculates the variance of these parameters using inverse Hessian and MCMC methods. The SS model of *Pecten jacobeous* in GSA 17 is a one-area yearly model where the population is comprised of 15+ age-classes with combined sexes. The model is a length-based model where the numbers at length in the survey data are converted into ages using the von Bertalanffy growth function. SS assumes multinomial likelihood for the proportions-at-length in catches and survey data. The last age-class (i.e. 15 +) represents a "plus group" in which mortality and other characteristics are assumed to be constant.

The model starts in 1945 and the initial population was assumed to be in an unexploited equilibrium state. Fishing mortality was modelled using the Baranov's continuous F method with each F as a model parameter (Method and Wetzel, 2013). Option 5 was selected for the F report basis, that allows to calculate Fbar (1-4) as the simple average of F of the age classes chosen to represent Fbar.

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

1. Fishing
    a) All fleets toghether;
2. Survey
    a) SoleMon GSA 17
    b) Froglia 1995 and 2002

5.1.2 Scripts

All the input files and the software are available in the share point.

5.1.3 Input data and Parameters

The following figures represent the length frequency distributions of each fleet and each year, together with the fitting of the model and the corresponding Pearson residuals.

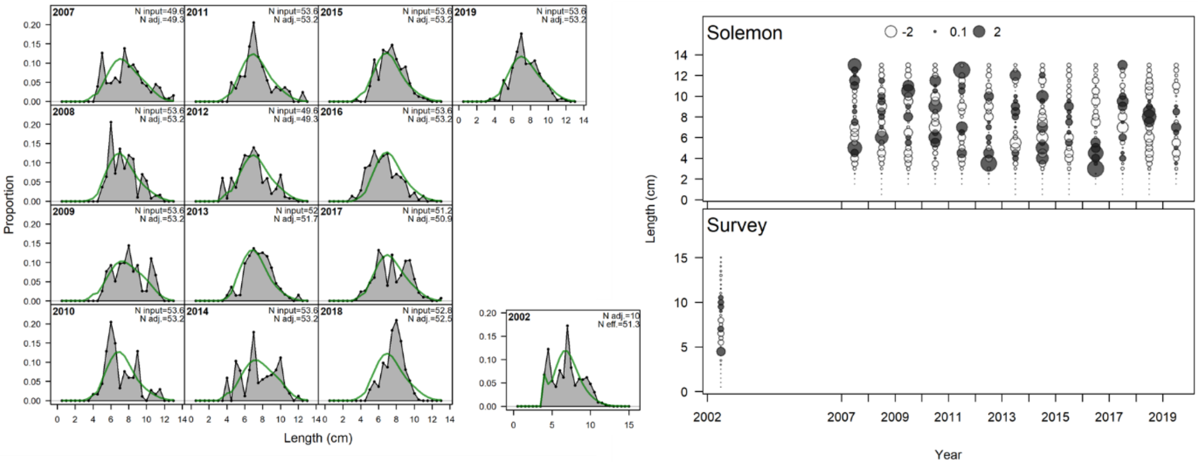


Figure 5.1.3-1 Length frequency distribution on the left and residuals on the right for SoleMon and Froglia surveys in GSA 17

SS3 allows to describe the selectivity for each fishery considered in the model. All the surveys present a dome shaped selectivity, while the fishery a logistic selectivity is considered. The resulting selectivity curves are showed in the next figure (Fig. 5.1.3-2).

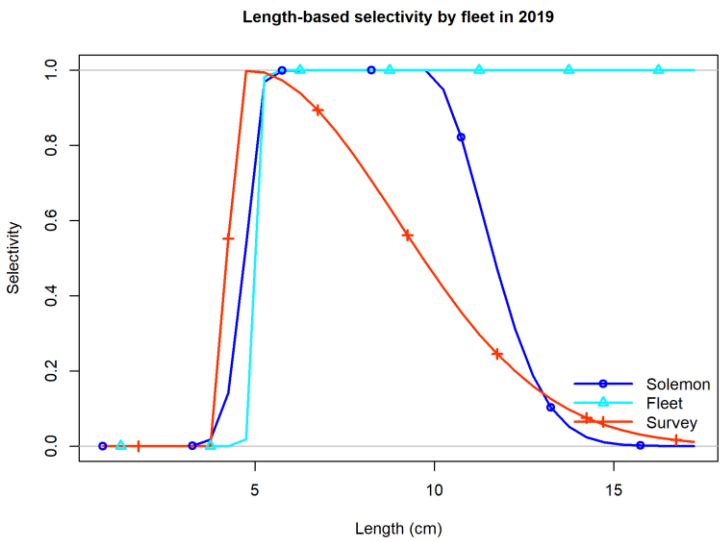


Figure 5.1.3-2 Selectivity at length for multiple fleets

Fitting between obseved and reconstructed survey data are in Figure 5.1.3-3.

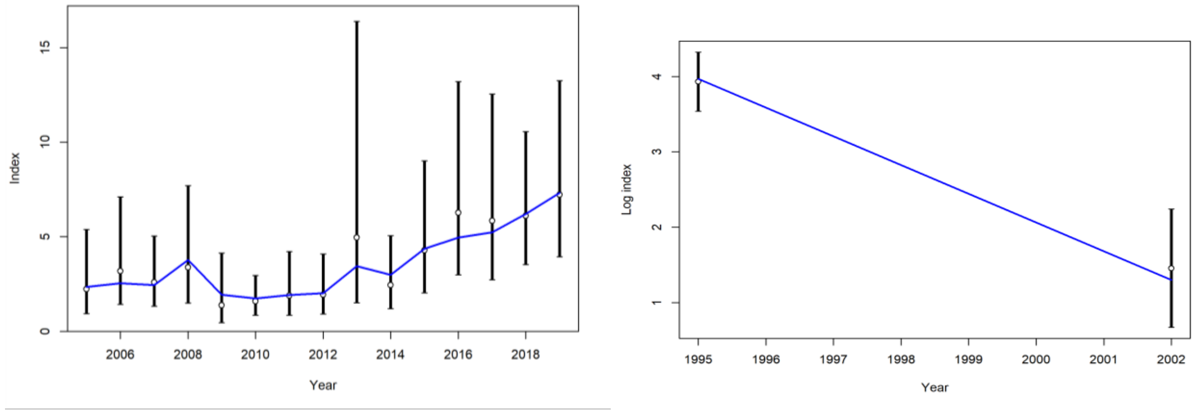


Figure 5.1.3-3 Summary of input data used in the SS3 model

The figures above show that model fitting to the data was quite good.

5.1.4 Results

The stock of *Pecten jacobeous* in GSA 17 presents a decreasing trend in term of SSB and since 2000, SSB describes really low values. SSB in 2020 corresponds to 232 tonnes. Recruitment (Fig. 5.1.4-1) shows a fluctuating trend, generally decreasing since 1995. Fishing mortality showed an increasing pattern until the 90's followed by a decrasing trend until 2019, reaching the value of 0.71.

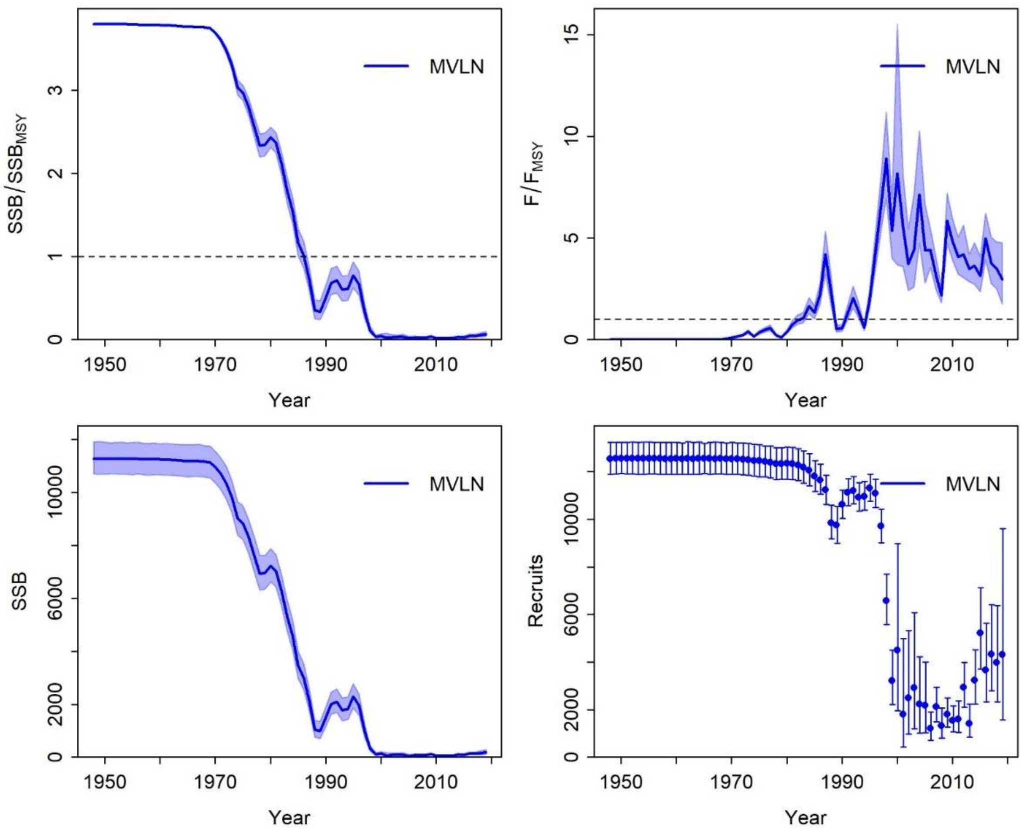


Figure 5.1.4-1 SS3 outputs

5.1.5 Robustness analysis

Retrospective, hincast and residuals analyses

The SS3.3 framework allows to carry on the retrospective analysis, the results are showed in the figures below. The retrospective analysis was carried out considering the removals of four years. The analysis show the stability of the model. The Mohn's rho index (Mohn, 1999) values were (SSB: 0.02) in the limits as suggested in Hurtado-Ferro (2015) for species as scallop. Also the hincast analysis showedc acceptable results.

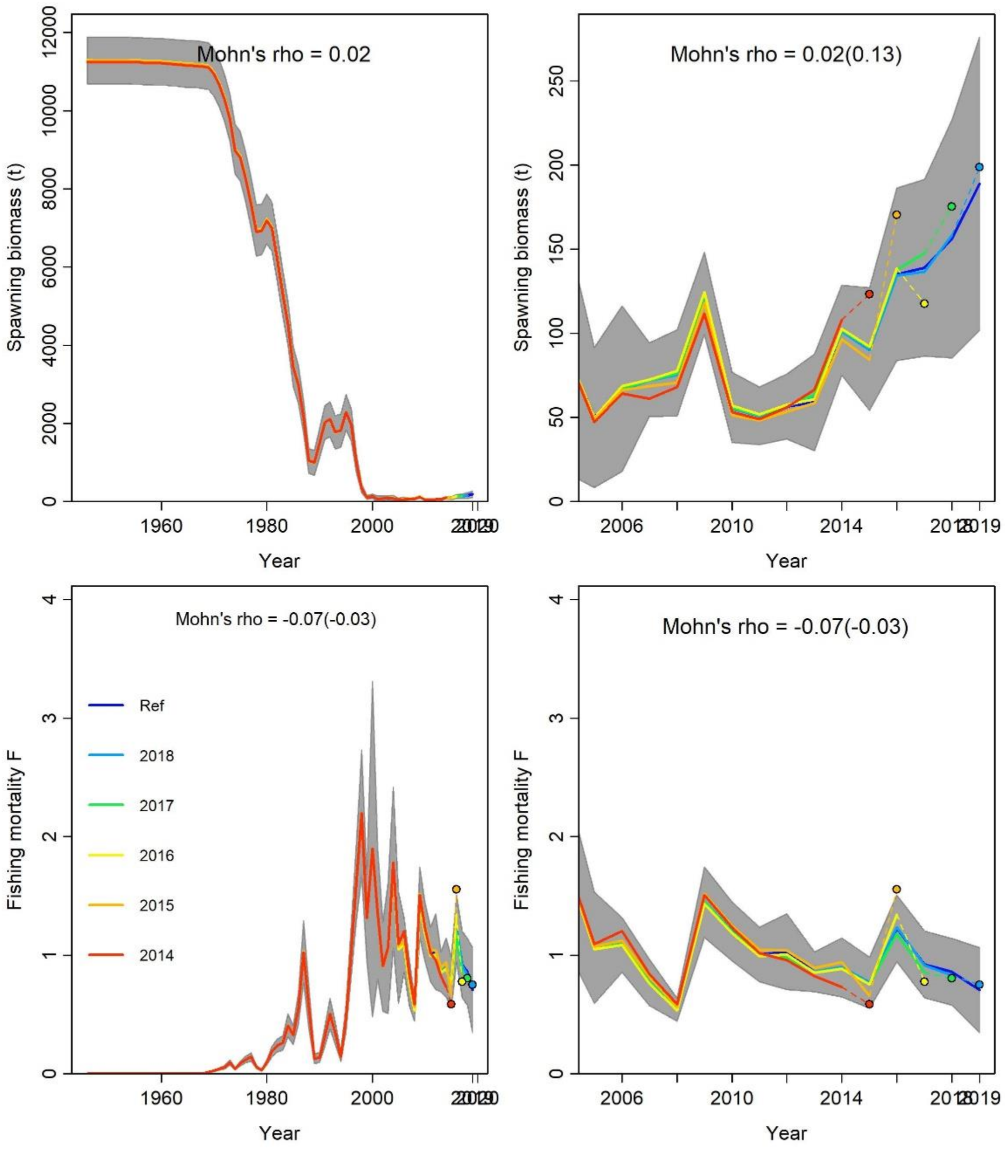


Figure 5.1.5-1 Retrospective analysis

RMSE was less than 30%, indicating a random pattern of the surveys residuals and the lenght frequency distributions.

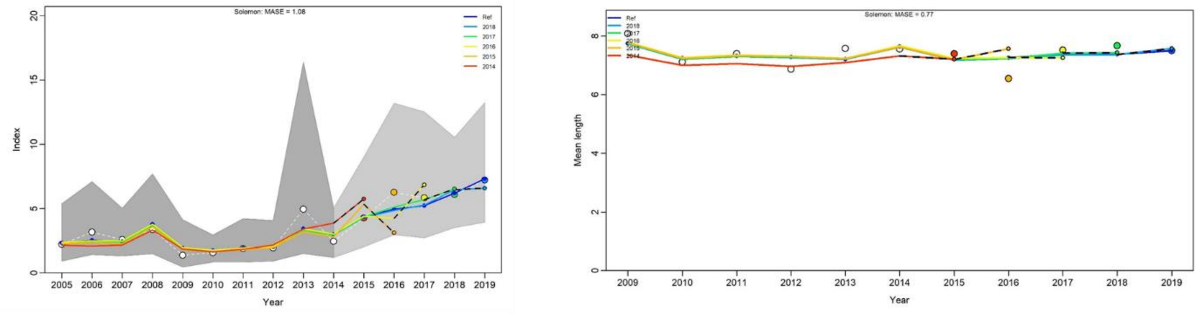


Figure 5.1.6-2 Hindcast analysis

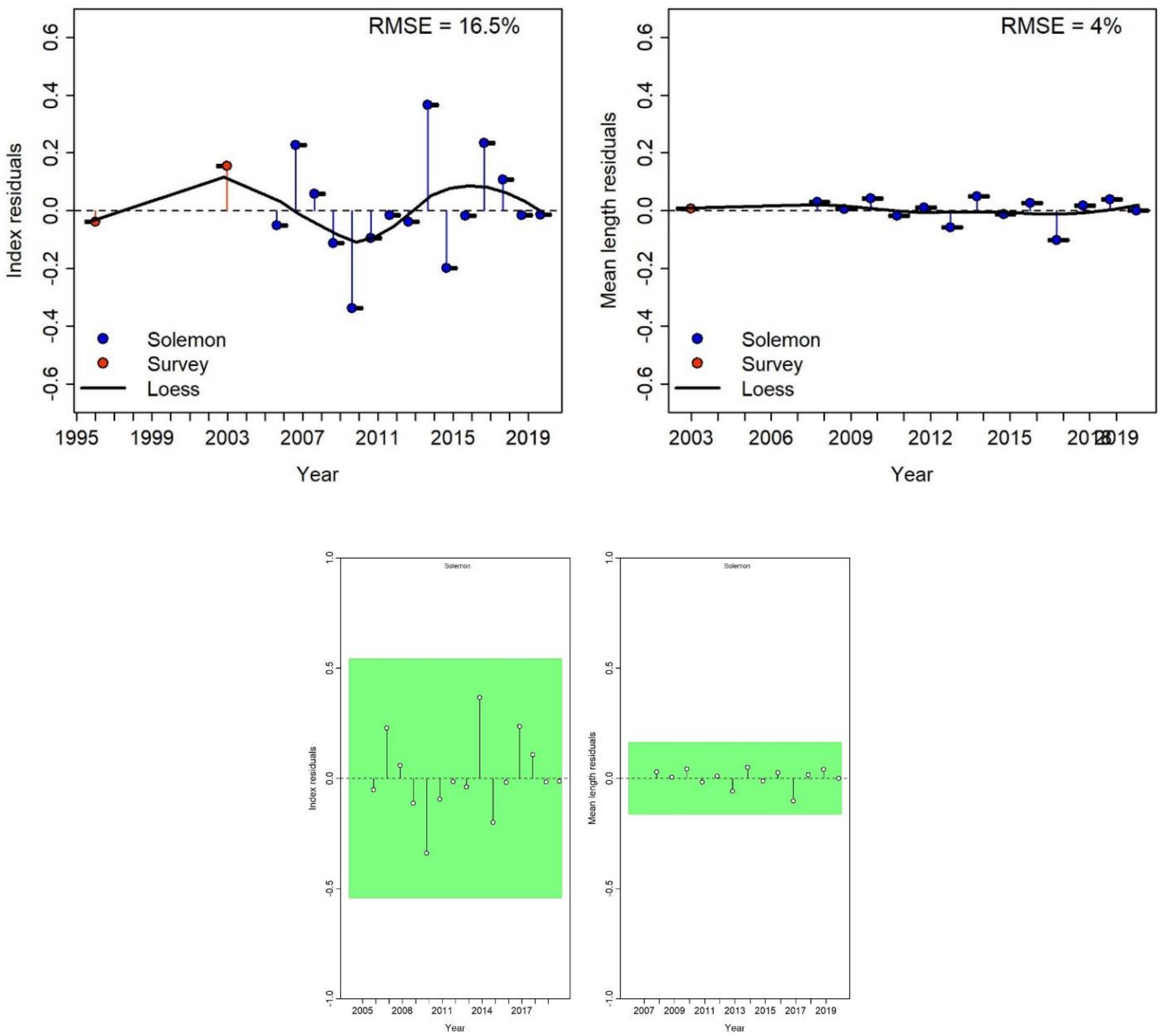


Figure 5.1.6-3 Residual analysis

5.2 Production model (CMSY model)

5.2.1 Model assumptions

The assessment of great Mediterranean scallop in GSA 17 was conducted using also the CMSY model (Froese et al., 2018). CMSY+ 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, a prior for resilience or productivity (r), and broad priors for the ratio of biomass to unfished biomass (B/k) at the beginning, an intermediate year and the end of the time series. Part of the CMSY package is an advanced Bayesian state-space implementation of the Schaefer surplus production model (BSM).

The model starts in 1945 and the initial population was assumed to be in an unexploited equilibrium state. The resilience of the species is considered as Medium (SeaLifebase). Setting priors for biomass were:

Begin: Nearly unexploited

Intermediate (2012): Low biomass (from LBB)

End: Low biomass (from LBB)

5.2.2 Scripts

All the input files and the software are available in the share point.

5.2.3 Input data and Parameters

The same data used for the SS3 model were used also for CMSY, with the exception of Froglia survey, which was not used.

5.2.4 Results

The stock of *Pecten jacobeous* in GSA 17 presents a decreasing trend in term of biomass and since 2000 biomass shows really low values. The table below show the main outputs of CMSY model.

Status / Reference points	Values
FMSY	0.218
F2019	0.090
F/FMSY	0.415
Bcurrent (2019)	2301 (t)
BMSY	4197 (t)
Bcurrent 2019/BMSY	0.548

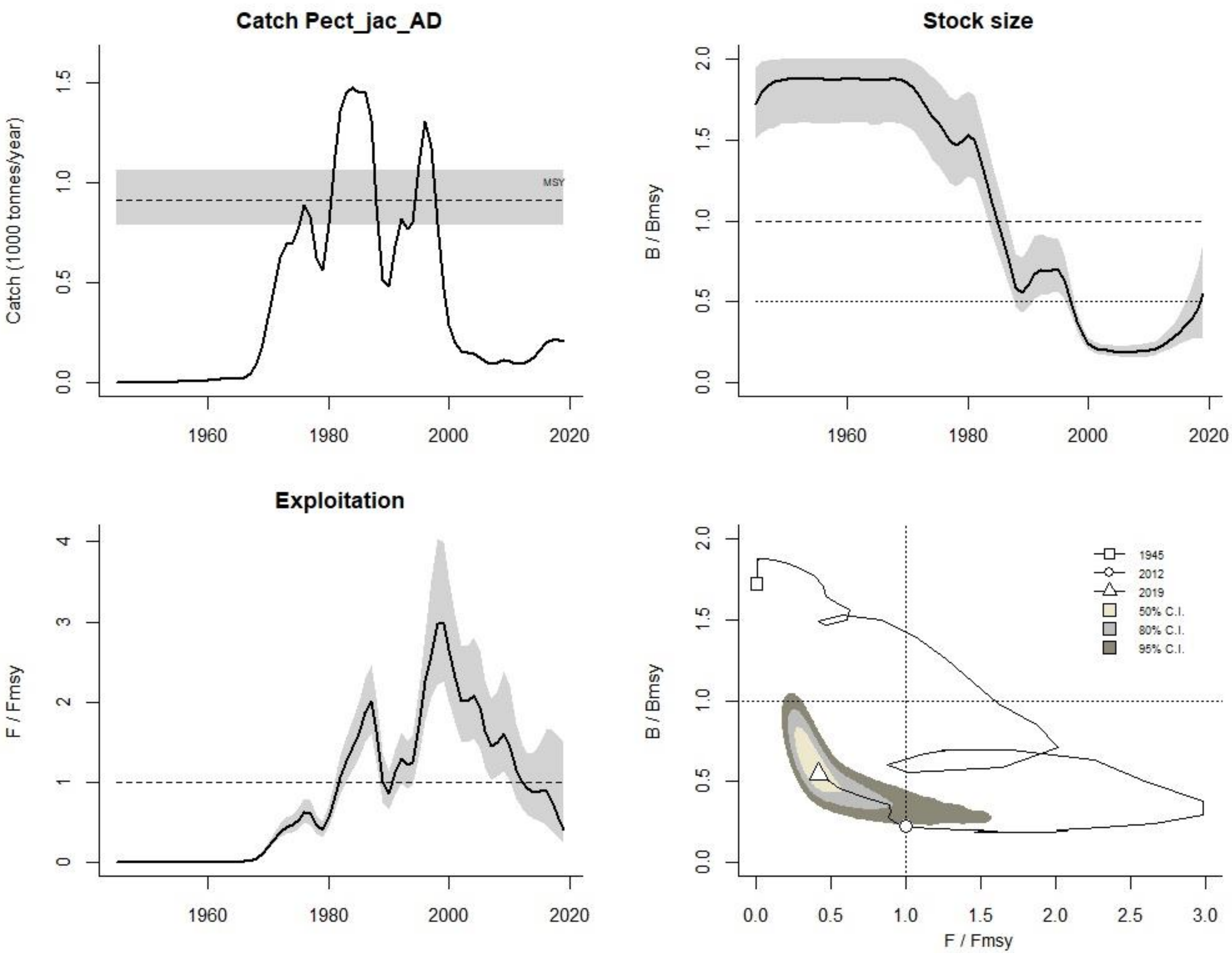


Figure 5.2.4. CMSY outputs

5.2.5 Robustness analysis

Retrospective and residuals analyses

The retrospective analysis was carried out considering the removals of four years. The analysis show the stability of the model. Also the residuals showed acceptable results.

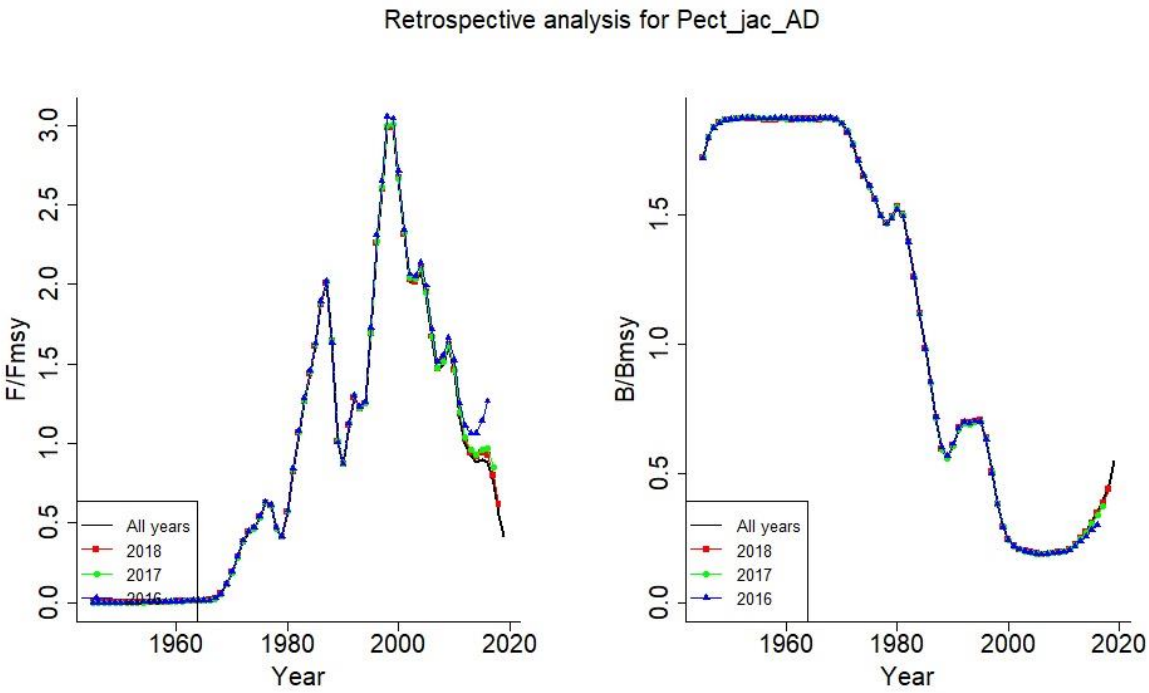


Figure 5.2.5-1 Retrospective analysis

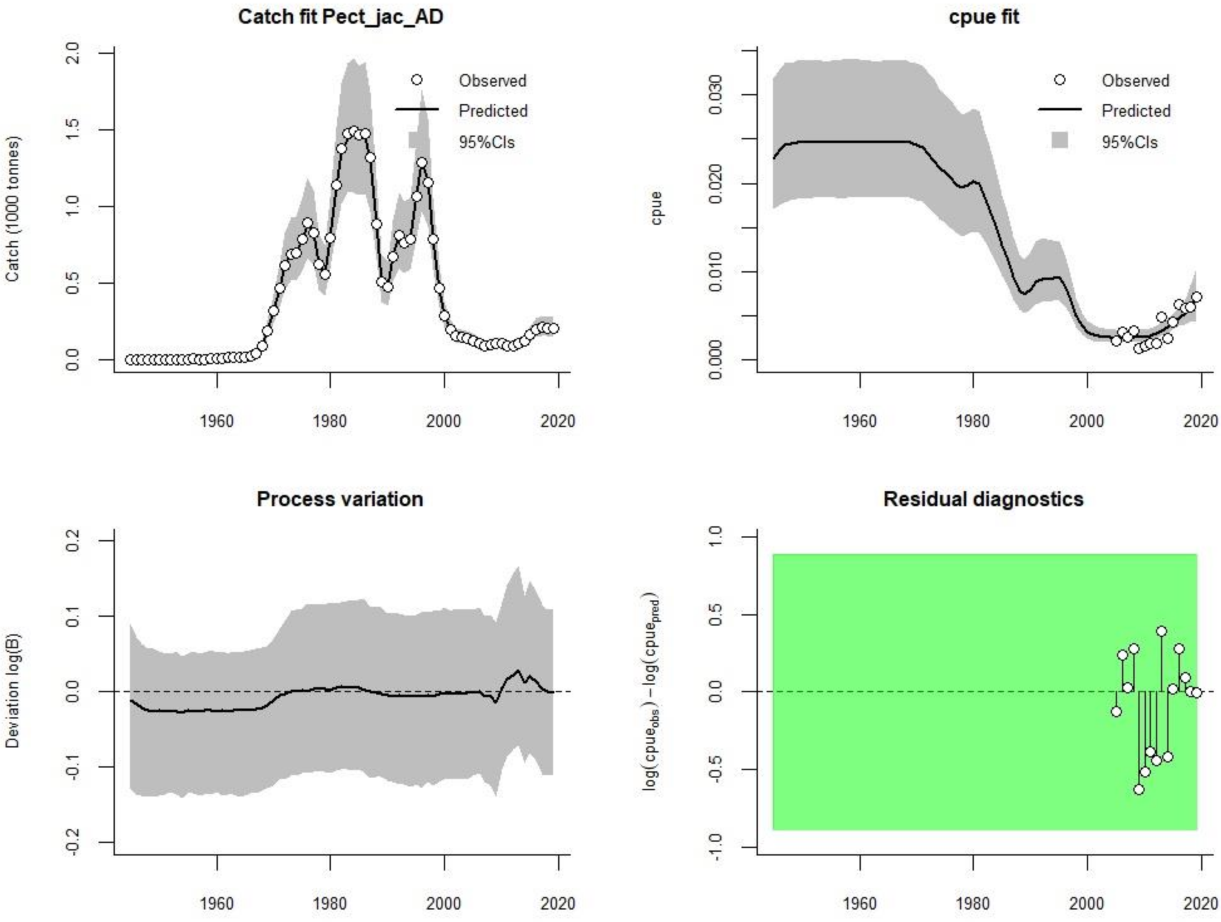


Figure 5.2.5-2 Residual analysis

5.3 Production model *(*AMSY model)

5.3.1 Model assumptions

The assessment of great Mediterranean scallop in GSA 17 was conducted using also the AMSY model (Froese et al., 2020). AMSY is a new data-limited method that estimates fisheries reference points (Fmsy, F/Fmsy, B/Bmsy) from catch-per-unit-of-effort (CPUE) data combined with prior estimates of resilience, such as can be found in FishBase (www.fishbase.org) for fishes and in SealifeBase (www.sealifebase.org) for invertebrates. AMSY is meant for wide-ranging or migratory stocks where CPUE is known from surveys or from observers on some of the commercial boats, but where total catch is unknown or unreliable. It is also meant for bycatch species where CPUE may be available from surveys. In addition to CPUE and resilience, AMSY needs a prior for relative stock size (range of B/B0, between 0 and 1) for one of the years in the time series

The model starts in 2005 using SoleMon data. The resilience of the species is considered as Medium (SeaLifebase). Setting priors for biomass were at the end (2019): Low biomass (from LBB))

5.3.2 Scripts

All the input files and the software are available in the share point.

5.3.3 Input data and Parameters

The same survey data used for CMSY.

5.3.4 Results

The stock of *Pecten jacobeous* in GSA 17 presents an increasing trend in term of biomass, but this is still below the reference point. The table below show the main outputs of AMSY model.

Status / Reference points	Values
F/FMSY	0.912
Bcurrent 2019/BMSY	0.663

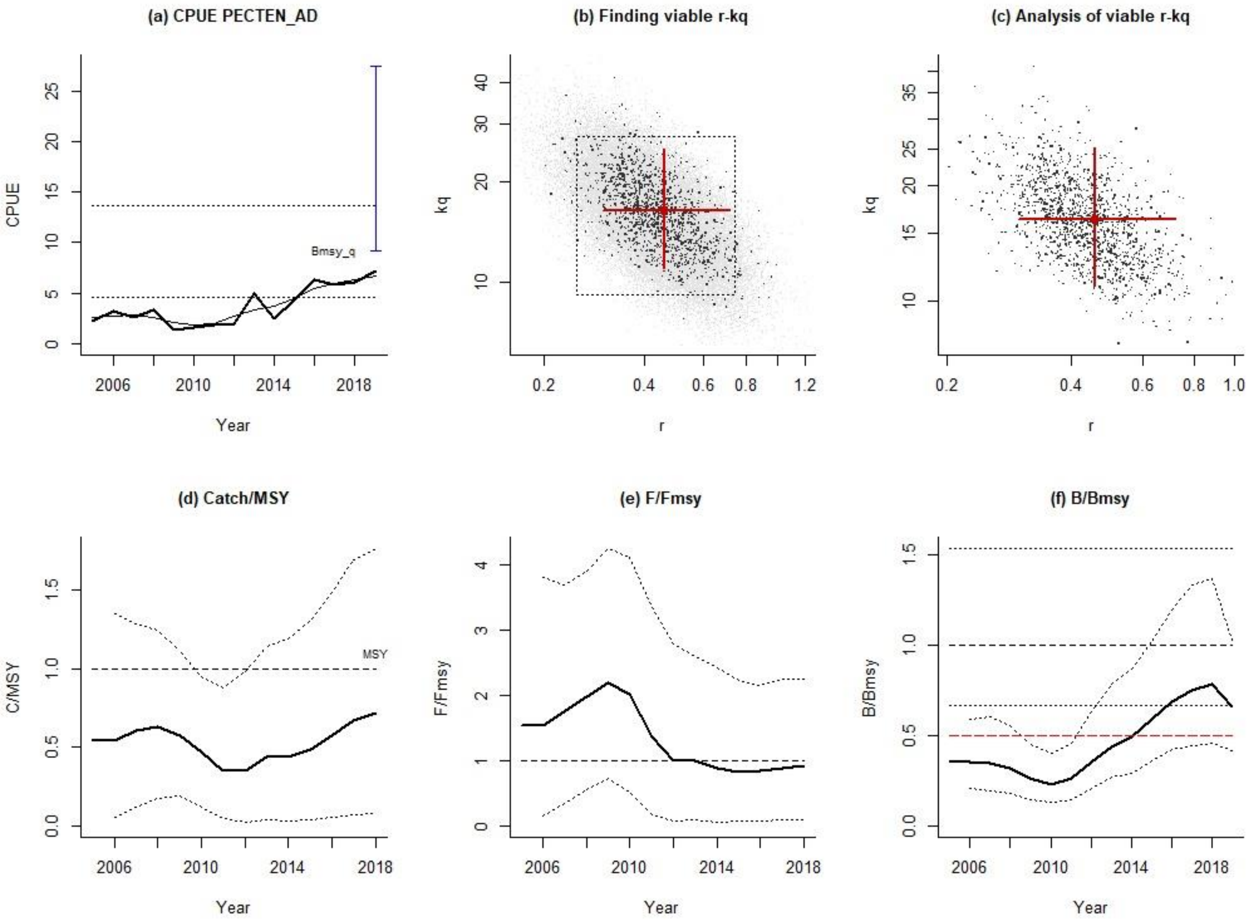


Figure 6.1.4. AMSY outputs

6 Stock predictions

The WGSAD decided to use SS3 outputs for the diagnosis of the stock. SS3 RPs suggest an overfishing situation for the scallop stock, since fishing mortality exceeds the reference value. SSB suggests an alarming situation since it shows a depleted status (SSB below 20% of SSB_{MSY}) in 2020.

Table 6.1 Estimated fishing mortality and reference points for Pecten jacobeus in GSA 17

	Reference point	SS3
SS3	F_{MSY}	0.248
	$F_{bar(1-4)}$	0.708 (0.18)
	F_{bar} /F_{MSY}	2.80
	$SSB_{current\ (2019)}$	189 (t)
	$SSB_{current\ (2020)}$	232 (t)
	SSB_{MSY}	2971 (t)
	$B_{current\ (2020)}$/ SSB_{MSY}	0.077

Figure 7.1 show the kobe plot using the biomass reference value estimated from the SS3, CMSY and AMSY models.

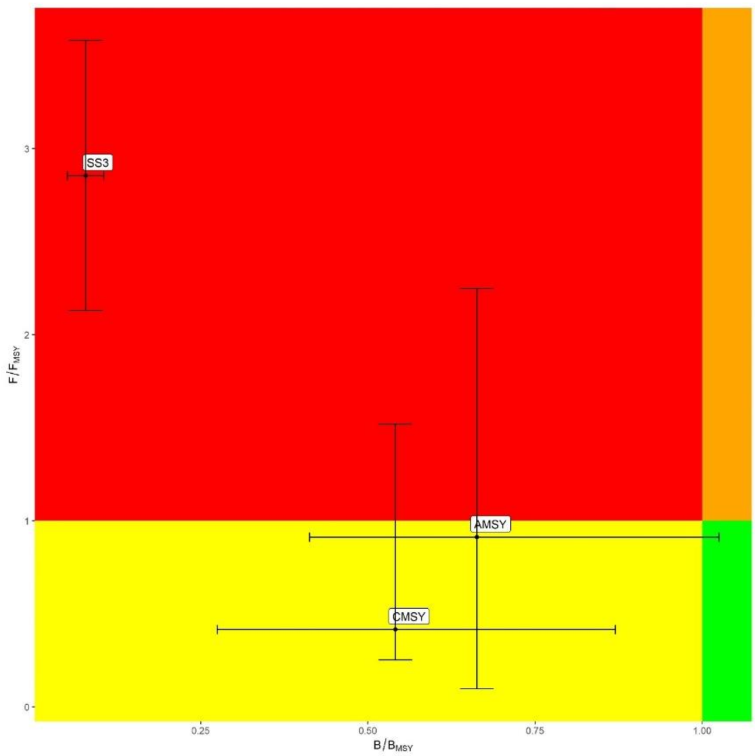


Figure 6.1 Kobe plot reference points for the 3 model used. SS3 is the model accepted by WGSAD for the advice.

6.1 Short term predictions

Not carried out.

6.2 Medium term predictions

Not carried out.

6.3 Long term predictions

Not carried out.

7 Draft scientific advice

Based on	Indicator	Analytic al reference point	Current value from the analysis	Empirical reference value	Trend 2010-2019	Status
Fishing mortality	Fishing mortality	F_{msy}= 0.248	F_{cur} = 0.708		D	O_H
	Fishing effort					
	Catch					
Stock abundance	Biomass					
	SSB	SSB_{MSY} = 2971 (t)	SSB_{2020} = 232 (t)		I	D
Recruitment					I	
Final Diagnosis		The stock is in overfishing and SSB shows a depleted status (SSB below 20% of SSBMSY)				

8 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)*