Stock Assessment Form

Small Pelagics

Reference Year: 2018

Reporting Year: 2019

[A brief abstract may be added here]

Stock Assessment Form version 1.0 (January 2014)

Uploader: *Please include your name*

Stock assessment form

1. Basic Identification Data

Scientific name:	Common name:	ISCAAP Group:
Sardina pilchardus	Sardine	[ISCAAP Group]
1st Geographical sub-area:	**2nd Geographical sub-area:**	**3rd Geographical sub-area:**
GSA17	GSA18	
4th Geographical sub-area:	**5th Geographical sub-area:**	**6th Geographical sub-area:**
1st Country	**2nd Country**	**3rd Country**
Italy	Croatia	Slovenia
4th Country	**5th Country**	**6th Country**
Albania	Montenegro	
Stock assessment method: (direct, indirect, combined, none)		
SAM		
Authors:		
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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

Indirect method (you can choose more than one):

- SAM

2. Stock identification and biological information

2.1. Stock unit

Although there is some evidence of differences on a series of morphometric, meristic, serological and ecological characteristics, the lack of genetic heterogeneity in the Adriatic stock has been demonstrated through allozymic and mitochondrial DNA (mtDNA) surveys (Carvalho *et al.*, 1994) and through sequence variation analysis of a 307-bp cytochrome b gene (Tinti *et al*., 2002). Also, Ruggeri *et al*. (2013) supports the hypothesis of one stock on the basis of microsatellites DNA, even if suggests that some of the genetic homogeneity observed could be apparent and the identification of a subtle structuring in sardine population could be limited by technical difficulties and by the incomplete knowledge of molecular mechanisms.

In light of these considerations and according to the fact that most of the Italian vessels registered in GSA 18 fish in GSA 17, even though landings occur in GSA18, it was decided to merge the two GSAs and thus carry out an assessment for sardine in GSA 17-18 (Figure 2.1.1).

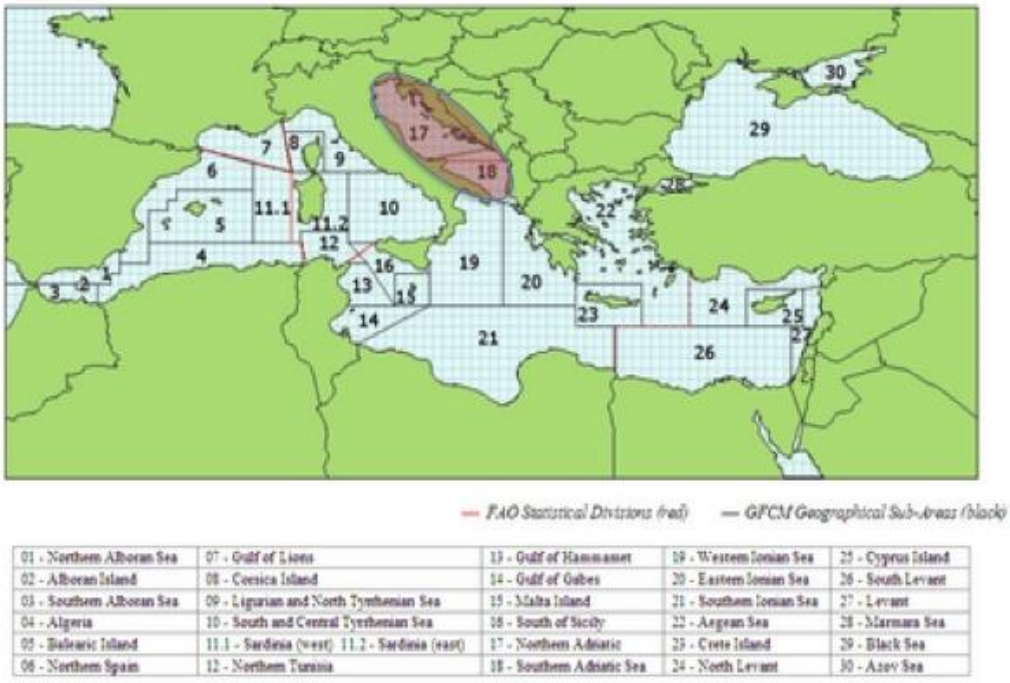

Figure 2.1.1: Geographical location of GSAs 17 and 18.

2.2. *Growth and maturity*

According to the work done in 2014 on otolith reading, the growth parameters used in this assessment are the same, as well as the ALK from 2014 was used to calculate the numbers at age given the length frequency distribution of survey data for the whole data series up to 2014, whereas afterwards is calculated annually. Catch at age data were calculated using the ALK from 2014 up to 2014, whereas afterwards is calculated annually, using the methodology agreed.

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**	**October-April**
Maximum size observed			22 cm	**Recruitment season**	
Size at first maturity			7-8 cm	**Spawning area**	Adriatic Sea, over continental shelf
Recruitment size to the fishery			10 cm	**Nursery area**	Adriatic Sea

Table 2.2.2: M vector and proportion of matures by size or age (Sex combined)

Size/Age	Natural mortality	Proportion of matures
0	*1.06*	*0*
1	*0.83*	*1*
2	*0.69*	*1*
3	*0.61*	*1*
4	*0.48*	*1*

Table 2.2.3: Growth and length weight model parameters

			Sex			
		Units	female	male	Combined	Years
Growth model	L_∞	cm			19.8	2014
	K	y^{-1}			0.38	2014
	t_0	y			-1.785	2014
	Data source	DCF				
Length weight relationship	a				0.0058	
	b				3.119	

	M (scalar)				
	sex ratio (% females/total)				

3. Fisheries information

3.1. Description of the fleet

Sardines are fished by purse seiners and pelagic trawlers belonging to Italy, Croatia and, to a much smaller extent, Slovenia, Albania and Montenegro.
The Italian fleet is composed of about 65 pairs of mid-water trawlers and about 20 purse seiners (with quite different tonnage), with the former being predominant on the latter ones. Most of the Italian boats whose port of registry is located in GSA 18 actually fish and land in GSA 17. Croatia has about 270 active purse seiners targeting small pelagic (mainly sardine) while in Slovenia only 3 purse seiners are currently active. In Montenegro most of the catches are originated from small-scale beach seine fisheries and from small purse seiners fisheries in coastal waters (< 70 m depth).
Exploitation is based on all the age classes from 0 to 4+.
The Croatian catches of sardine represent the great part of the total catches, while the Italian small pelagic fishery concentrate mainly on anchovy (though high amounts were caught by the Italian fleet in the past).

Table 3.1.1: Description of operational units exploiting the stock in 2018

	Country	GSA	Fleet Segment	Fishing Gear Class	Group of Target Species	Species
ITA_PTM_17 18	Italy	GSA17-18	PTM_0640	Pelagic Trawler	Small pelagic	*E. encrasicolus* *S. pilchardus* *Mugilidae* spp.
ITA_PS_17 18	Italy	GSA17-18	PS_0640	Purse seiners	Small pelagic	*E. encrasicolus* *S. pilchardus* *Mugilidae* spp.
HRV_PS_17	Croatia	GSA17	PS_0640	Purse seiners	Small pelagic	*E. encrasicolus* *S. pilchardus*
SLO_PS_17	Slovenia	GSA17	PS_1218	Purse seiners	Small pelagic	*E. encrasicolus* *S. pilchardus*
ALB_18	Albania	GSA18		Purse seiners	Small pelagic	*E. encrasicolus* *S. pilchardus*

MNE_18	Montenegro	GSA18	PS_0624	Purse seiners	Small pelagic	*E. encrasicolus* *S. pilchardus*

Table 3.1.2: Catch, bycatch, discards and effort by operational unit in the reference year (2018)

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)
ITA_PTM_1718	128*	17,844		< 1%		
ITA_PS_1718	33*			< 1%		
HRV_PS_17	115**	46,239		< 1%		
SLO_PS_17	2*	1		< 1%		
ALB_PS_18		460		< 1%		
MNE_PS_18		304		< 1%		
Total		64848				

*source: DCF effort data 2017 ** source: Annual Economic Report 2019

3.2. Historical trends

The catch of sardine shows a fluctuating trend over the years (1975 – 2018). After an intial increasing trend up to 1981 (93,559 tonnes), they showed a continuous decreasing trend until 2006 (20,475 tonnes). A new peak is registered in 2014 (82,538 tonnes), after that a new reduction is described reaching the value of 64,848 tonnes in 2018. The stock is mostly exploited by countries located on the east side of the Adriatic Sea, particularly Croatia. Slovenian catches of the most recent years accounts for very low values.

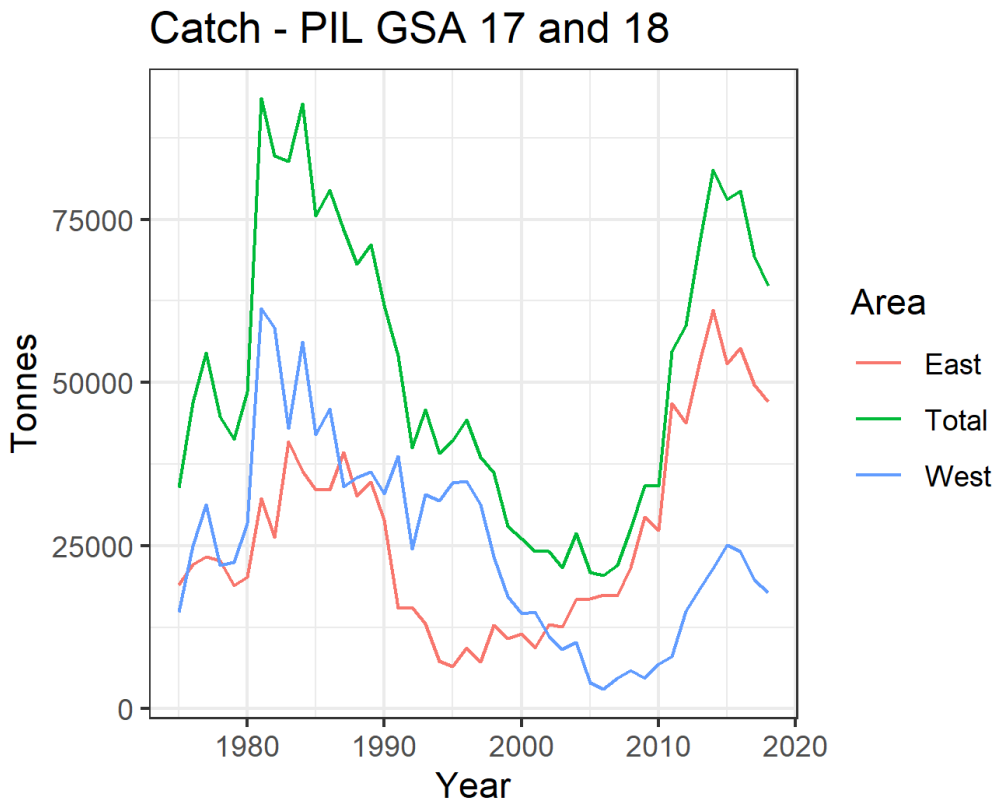

Figure 3.2.1: Total Adriatic catch of sardine for the whole period assessed (1975-2018) for the Eastern side (red line), the Western side (green line) and the total catch (blue line) of GSA17-18.

In figure 3.2.2 the trend in the cohorts of the total catches is shown.

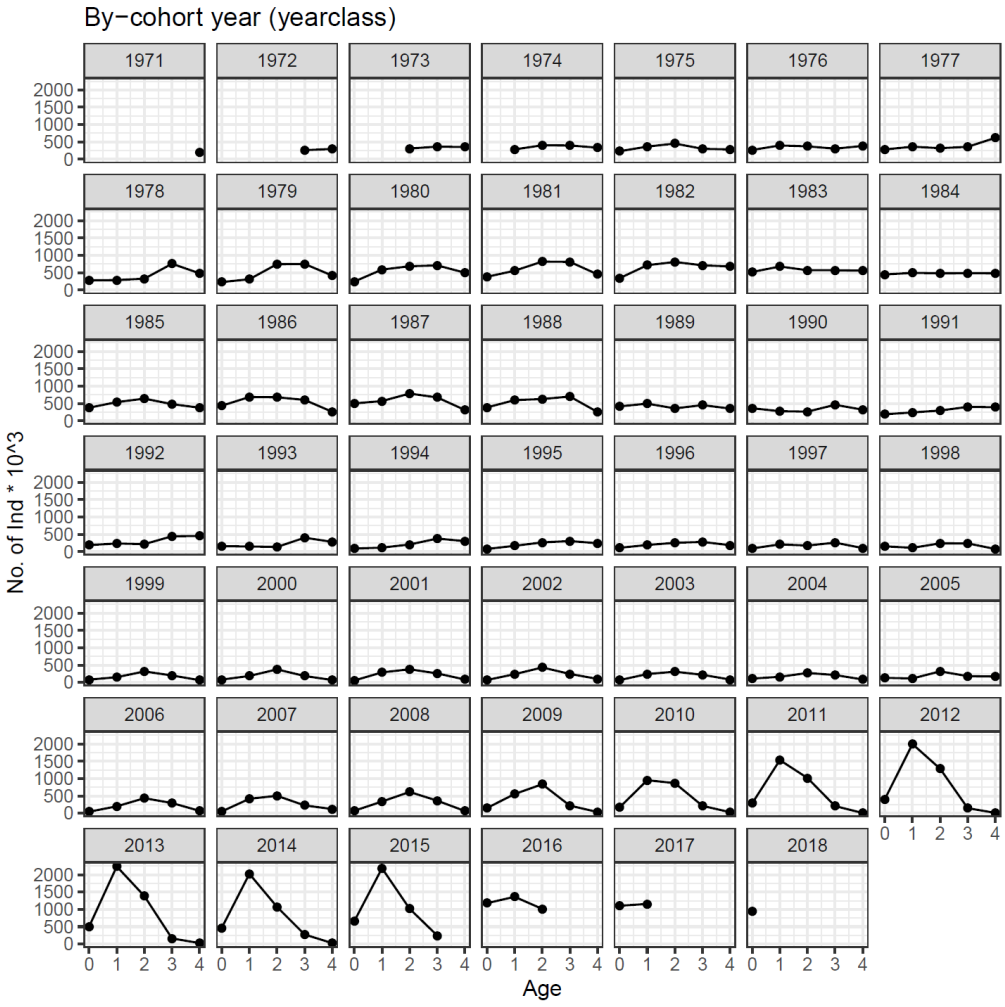

Figure 3.2.2 Catch-at-age cohort plots for GSA 17 -18 sardine.

3.3. Management regulations

In line with the "Recommendation GFCM/42/2018/8" following emergency measures need to be applied and controlled in the period 2019-2021:

a) Fishing vessels targeting small pelagics must not exceed 180 fishing days per year, with maximum of 144 fishing days targeting sardine and with maximum of 144 fishing days targeting anchovy
b) In 2019, 2020 and 2021, the GFCM Contracting Parties and Cooperating non-Contracting Parties (CPCs) shall not exceed the level of catches for small pelagics exerted in 2014 as reported in accordance with Recommendation GFCM/33/2009/3 on the implementation of the GFCM Task 1. Provision does not apply to the CPC's with catches below 2.500 tons in 2014 and these CPC's shall not exceed catches of 2.500 tons in any of the three years covered.
c) The CPCs shall ensure that the overall fleet capacity of trawlers and purse seiners actively fishing for small pelagic stocks in terms of gross tonnage (GT) and/or gross registered tonnage (GRT), engine power (kW) and number of vessels, as recorded both in national and GFCM registers, does not exceed in 2019, 2020 and 2021 the fleet capacity for small pelagics in 2014. Provision does not apply to the national fleets of less than ten purse seiners and/or pelagic trawlers actively fishing for small pelagics stocks. In such case capacity of active fleet may increase for not more than 50 percent in number of vessels and in terms of gross tonnage (GT) and/or gross tonnage (GTR) and engine power (kW).
d) Implementation of a closure that shall cover the entire distribution of small pelagic stocks in the Adriatic Sea, for periods of no less than 30 days per fleet segment. For sardine it must take place in period from 1 October to 31 March. For anchovy it must take place in period from 1 April to 30 September. However, these closures may be implemented for periods of no less than 15 continuous days for national fleets of less than 15 purse seiners and/or pelagic trawlers.

Slovenian authorities monitor the implementation of the measures under the indents a) and b) by regularly checking "InfoRib", which is information system with data on fishing licenses, all the data from logbooks and landing declarations and data on first sales. Data from logbooks which allow for the control of executed fishing days and caught and landed quantities need to be entered into the "InfoRib" within 24 hours after the end of each fishing trip. Dates for a closure period remain the same: from 17th of March to 15th of April.

Regarding the closure period, Italy has been enforcing for years a general regulation concerning the fishing gears and since 1988 a suspension (about 42 days) of fishing activity of pelagic trawlers and purse seiners has implemented in summer. In the most recent years this closure is divided by area. In 2018 the observed closure period was implemented as follows:

- From Trieste to Ancona, from 30 of July to 9 September

- From San Benedetto del Tronto to Termoli, from 13 August to 23 September
- From Manfredonia to Bari, from 27 August to 7 October

These stoppages included the 15 days of arrest for the anchovy species.
In 2018 Croatian small pelagic fleets observed a period of fishing closure for sardine from 1st of January to 15th of February. Additionally, from 15th of February to 28th of February each vessel has a maximum of 5 fishing days with a maximum total catch limit of 35 tonnes per vessel. While the fishing closure for anchovy was observed from 1st of May to 31st of May; means the ban for all relating fishing vessels 15 days in continuity and maximum of 5 fishing days per vessel in the rest of the closure period. Also, since 2015 spatial closures in inner sea were endorsed in the Croatian fishing ground for the fishing vessels above 12 m. In Montenegro a closure period of 15 days was observed from the first to the 15th of April.

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	B_{lim}	125,318	B_{pa}	250,636	2015 GFCM benchmark assessment
F			Fmsy	0.715	2015 GFCM benchmark assessment
			F value corresponding to E = 0.4	0.44	STECF EWG 17-15
Y					

CPUE					
Index of Biomass at sea					

4. Fisheries independent information

4.1. MEDIAS ACUSTIC SURVEY

4.1.1 Brief description of the chosen method and assumptions used

In the western part of the Adriatic Sea, acoustic surveys "ECHOADRI" have been carried out since 1976 in the Northern Adriatic (2/3 of the area: western GSA 17), and since 1987 also in the Mid Adriatic (1/3 of the area: western GSA 17) and South Adriatic (GSA 18). Since 2009, acoustic surveys are carried out under the MEDIAS framework.
Considering that in 2004 only a part of western GSA 17 was monitored (2/3 of the total) by the acoustic survey, the estimation of abundance and biomass for the rest of the area was done taking into account the density and species composition of the monitored area and assuming the same LFD of the covered part.
No acoustic survey in western GSA 18 was conducted in 2004; abundance and biomass were estimated taking into account the ratio between GSA 17 and GSA 18 data in the period 2005-2014 and applying the same ratio to GSA 17 2004 abundance and biomass.

Starting from 2008 and with exception of 2009, 2017 (only for Albania) and 2018, Eastern GSA 18 (Montenegro and Albania waters) were monitored by Italian acoustic survey group in collaboration with local Institutes as extension of the MEDIAS survey.
Due to the different time series available for the Western and Eastern GSA 18 (GSA18 West started in 2005, GSA18 East started in 2008) an average proportion over the years was calculated to estimate the biomass in the Eastern GSA 18 for the years 2004-2007 (~2% of total GSA 17-18 west). The same procedure was applied for 2009. When length frequency distributions were missing, the length structure was assumed equal to the one in the following year.
In 2017 only Montenegro water sector was covered by acoustic survey and Albania data were calculated taking into account the density and species composition of the monitored area and assuming the same LFD of the covered part.
In 2018 no acoustic survey was carried out in Eastern GSA 18, abundance and biomass were calculated applying the average related to numbers at length of 2015, 2016 and 2017.

The eastern part of GSA 17 (except Slovenia) was covered by Croatian national pelagic monitoring program (i.e. acoustic survey) PELMON in the period 2004-2010, but without fish age analysis, resulting in lack of age estimates/data in that period. Changes in research vessel and fish sampling gears in PELMON occurred in 2009 and resulted in significant difference in fish LFD before and after 2009. During two transitional years 2011-2012 (i.e. adaptation and harmonization of PELMON working protocols to MEDIAS protocols), approximately ½ of survey area was covered only. Since

2013 this acoustic survey has been carried out within EU MEDIAS framework, providing results related to eastern part of GSA 17 in line with EU-DCF requirements.

Estimates from acoustic surveys were included in the assessment model considering three tuning indexes:

1) The data from the surveys in GSA 17 West and whole GSA 18 in the form of numbers-at-age from 2004 to 2018. For sardine, in 2014 a revision of otolith readings criteria was done and a revised ALK was applied to the time series, from 2004 to 2014. Since 2015 a new age length key for each year of acoustic survey is produced through annual otoliths readings. All the ALKs are separated for GSA 17 West and GSA 18 West;
2) Acoustic survey East, that includes the eastern side of GSA 17 in the form of numbers-at-age from 2013 to 2018. ALKs from survey on the eastern part of GSA 17 were obtained yearly, based on age readings following the same guidelines of before mentioned AdriaMed workshop (Split, April 2015).
3) Acoustic survey East biomass, that includes the eastern side of GSA 17 in the form of total biomass from 2003 to 2012;

For the purpose of this assessment, these two indices of abundance have been considered separately. The rationale behind it is to be found in the fact that the same boat and the same crew covers the whole Western GSA 17 and the whole GSA 18, while the Eastern part of GSA 17 is carried out on a different vessel, also a different net was used in the past (2004-2008) following the procedure described by Leonori et al. (2012).

Due to the different time series available for the Western and Eastern GSA 18 (GSA 18 West started in 2005, GSA 18 East started in 2008) an average proportion over the years was calculated to estimate the biomass in the Eastern GSA 18 for the years 2004-2007.

When length frequency distributions were missing, the length structure was assumed equal to the one in the following year.

The revised 2014 ALK have been used to split the numbers at length into numbers at age for the entire time series, except for Eastern GSA 17 in which numbers at age for the period 2013-2015 were obtained using annual survey's ALKs based on direct age reading from otoliths. Otoliths from Eastern GSA 17 survey collected during 2013 and 2014 were re-analysed according to outcomes from AdriaMed Study Group on intercalibration of sardine otolith reading and revision of criteria in the Adriatic Sea (Split, Croatia, 8-10 April 2015).

The standardized methodology followed during MEDIAS surveys are given in the MEDIAS handbook (MEDIAS, April 2016) revised annually (MEDIAS Steering Committee report, 2018).

Direct methods: acoustics

I. GSA 17 WEST + GSA 18 WEST-EAST

Table 4.1.1.1: Acoustic cruise information.

Date	From the 16th of June to the 17th of July 2018 (North and South Adriatic: Italy, Slovenia, Montenegro and Albania)		
Cruise	MEDIAS Adriatic GSA 17 and GSA 18	**R/V**	Dallaporta
Target species	Anchovy, Sardine		
Sampling strategy	Parallel grid of transects perpendicular to the coastline		
Sampling season	Spring - Summer		
Investigated depth range (m)	10-200 m		
Echo-sounder	Simrad EK60		
Fish sampler	Pelagic trawl		
Cod –end mesh size as opening (mm)	18		
ESDU (i.e. 1 nautical mile)	1 nautical mile		
TS (Target Strength)/species	Anchovy b20: -74.6; Sardine b20: -72.5		
Software used in the post-processing	Echoview		
Samples (gear used)	Samples of anchovy, sardine and other pelagic species (secondary in occurrence) caught by means of pelagic trawl		
Biological data obtained	Anchovy and sardine numerical abundance and biomass by nautical mile and by total area;		

	anchovy and sardine spatial distribution in numbers and biomass
Age slicing method	Age-length key by otolith reading
Maturity ogive used	Macroscopic gonad identification

Table 4.1.1.2: Abundance at age (in thousands) from acoustic survey for the years 2004-2018.

Year	Age 0	Age 1	Age 2	Age 3	Age 4
2004	673166.4	1717815	1360000	1052370	51409.55
2005	460365.1	1277189	492965.7	627757.9	30813.78
2006	571516.4	1655645	1355049	1370104	124117.9
2007	973234.3	3163262	1937653	1357836	115371.9
2008	3240825	9835685	3161071	1700755	69607.5
2009	2272157	8454229	1543766	472978.6	71726.98
2010	1820492	6998406	2556938	732864.9	45770.63
2011	9559575	23017141	5835002	983415.7	13169.69
2012	9852845	11265300	1547470	290940.3	78441.89
2013	8880658	21421735	3871570	207470.4	4111.774
2014	2536237	16998529	4555000	168620	0
2015	3691899	10059818	5684296	381954	0
2016	6150808	3961372	1012881	82807.69	15759.84
2017	6031741	4058859	243851.4	14004.63	0
2018	6838026	3718702	160131	17782.64	0

4.1.2. Spatial distribution of the resources

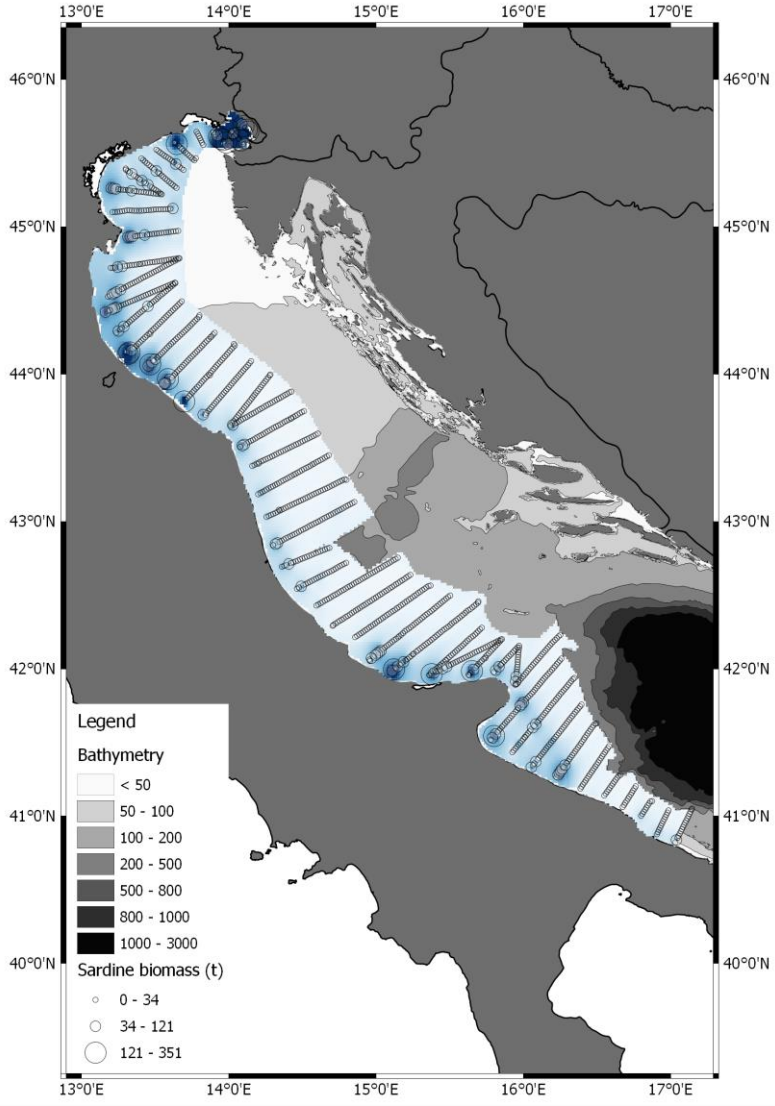

Figure 4.1.2.1. Spatial distribution of Sardine in GSA17 and GSA 18 West for acoustic survey of 2018.

4.1.3. Historical trends

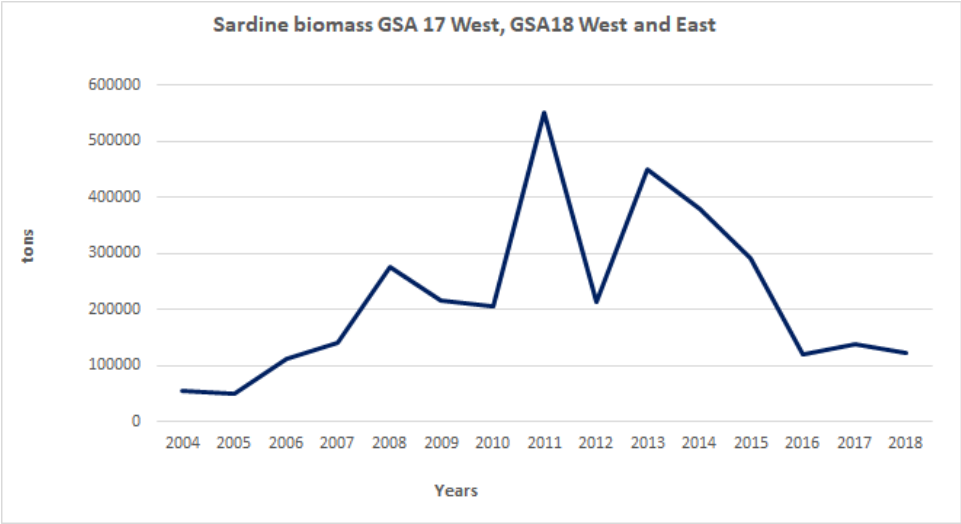

Figure 4.1.3.1. Biomass (t) of sardine in the Western GSA 17 and Western and Eastern GSA 18 from acoustic surveys carried out from 2004 to 2018.

4.1.4. Sardine LFD from 2004 to 2018 for GSA 17 West, GSA 18 West and East

In the plot below the length frequency distributions observed in the acoustic survey for the three areas (GSA 17 West, GSA 18 East and GSA 18 West) from 2004 to 2018 are shown (Figure 4.1.4.1).

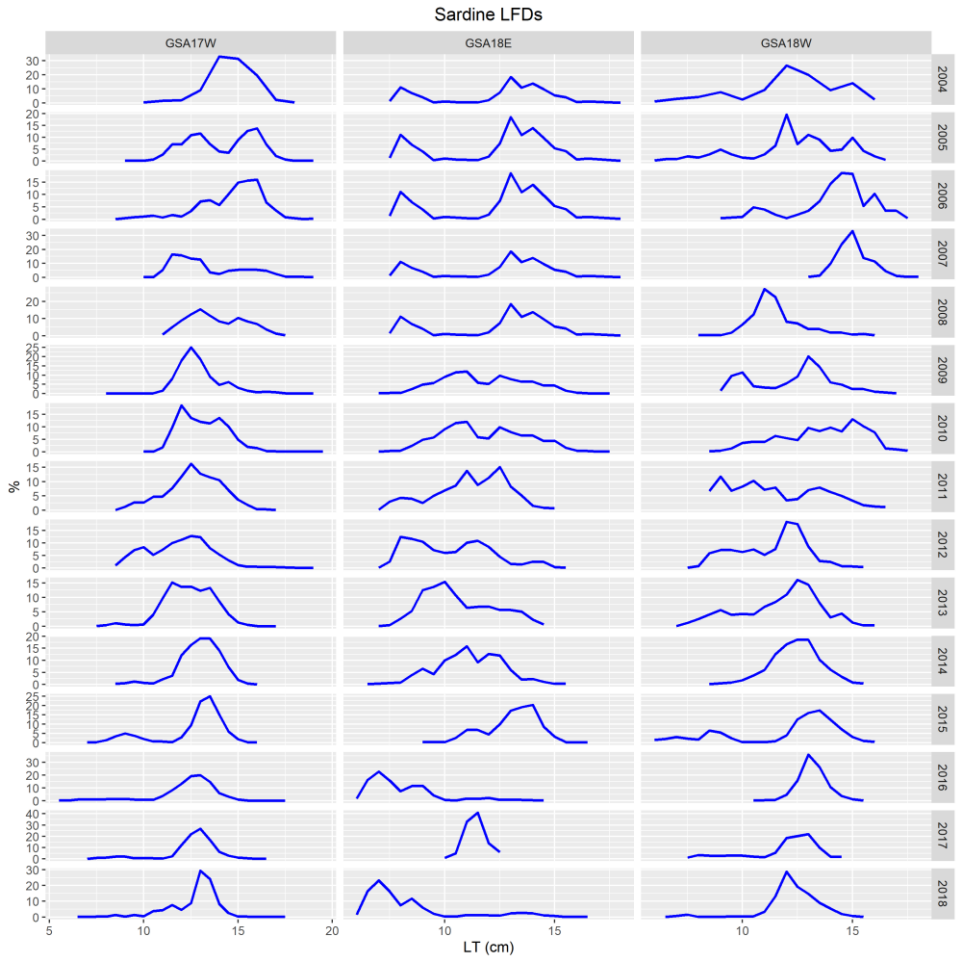

Figure 4.1.4.1. LFD observed in the acoustic survey for GSA 17 West, GSA 18 West and GSA 18 East from 2004 to 2018.

I. GSA 17 EAST

II. Table 4.1.1.4: Acoustic cruise information.

Date	29 August – 23 September 2018		
Cruise	MEDIAS GSA 17 East	**R/V**	BIOS DVA
Target species	Anchovy, Sardine		

Sampling strategy	Partially random; parallel transects in open sea and transects adapted to geomorphology in inner sea
Sampling season	September
Investigated depth range (m)	7 - 200
Echo-sounder	SIMRAD EK60 (38 kHz)
Fish sampler	Pelagic trawl
Cod –end mesh size as opening (mm)	18 mm (with cod-end cover as used in sardine fry fishery - 4 mm)
ESDU (i.e. 1 nautical mile)	1 nautical mile
TS (Target Strength)/species	Sardine b20: -72.6
Software used in the post-processing	Myriax Echoview
Samples (gear used)	Samples of anchovy, sardine and other pelagic species (secondary in occurrence) caught by means of pelagic trawl
Biological data obtained	Anchovy and sardine numerical abundance and biomass by nautical mile and by total area; anchovy and sardine spatial distribution in numbers and biomass
Age slicing method	Age-length key by otolith reading
Maturity ogive used	Macroscopic gonad identification

The table below (Table 4.1.5.1) shows the number at age for the acoustic survey for the eastern

GSA17 area from 2013-2018 (figure 4.1.4.2).

Table 4.1.1.5: Abundance at age (in thousands) from acoustic survey for the years 2013-2018.

Year	Age 0	Age 1	Age 2
2013	4717909.8	3853279.6	3031
2014	1180050.3	4323384.2	64747
2015	12993118.3	2446709.9	3505
2016	13332270	709729	1515.5
2017	9359342	1035159	0
2018	8234312	3422710	757

Spatial distribution of the resources

Figure 4.1.4.2. Acoustic sampling transects in GSA17-East: parallel transects in open sea (blu lines) and transects adapted to geomorphology in inner sea (red lines).

Historical trends

Figure 4.1.4.3 shows the biomass trend for the East Echosurvey from 2003 to 20102. This time series was also included in the stock assessment model. These data represent the only valid information coming from this survey for these years, thus it was decided to include the biomass by year as third tuning index. However, it should be noted that in 2011 and 2012 the echosuvey was not carried out over the entire area, thus the total estimates were related to approximately ½ area only and consequently are not included in this figure.

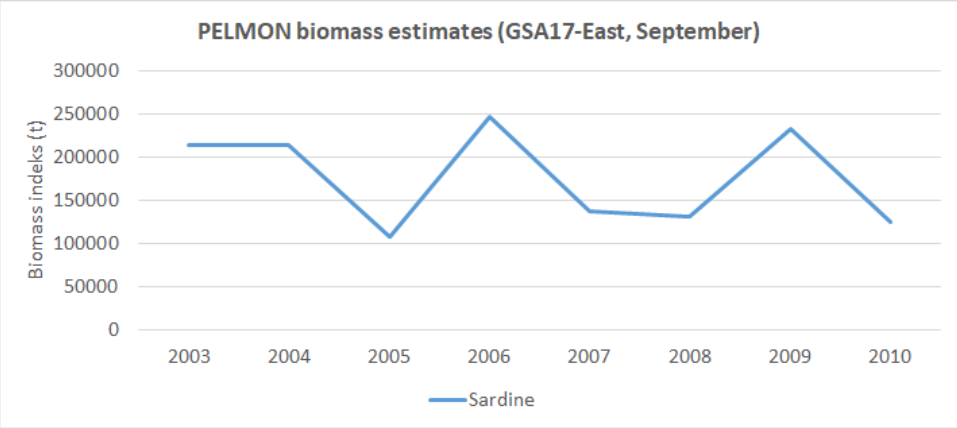

Figure 4.1.4.3. Biomass (tonnes) of sardine in the Eastern side of GSA 17 estimated from the acoustic surveys carried out from years 2003 to 2010.

Sardine LFD from 2013 to 2018 for East Echosurvey GSA 17

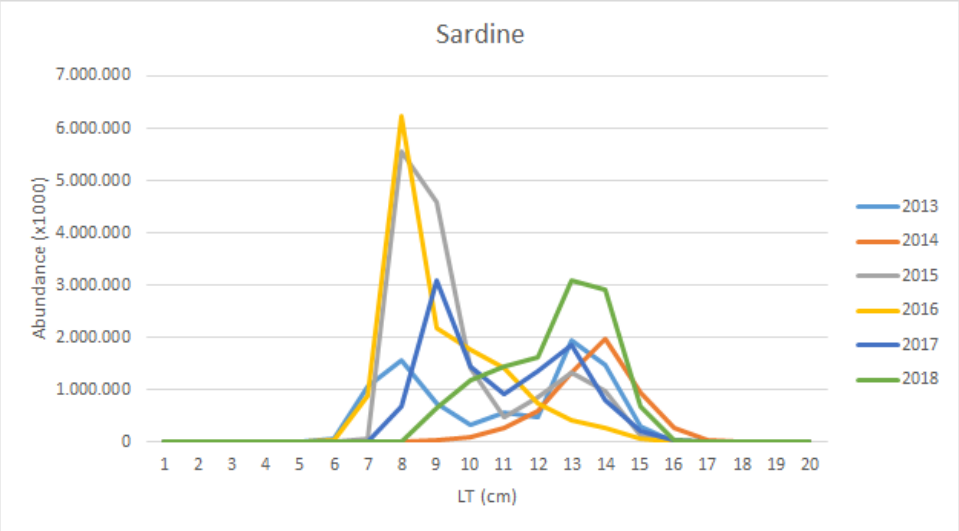

Figure 4.1.4.3. LFD of sardine abundance estimates from MEDIAS in GSA17-East.

5. Ecological information

5.1. Protected species potentially affected by the fisheries

N/A

5.2. Environmental indexes

N/A

6. Stock Assessment

6.1. SAM

6.1.1. Model assumptions

State-Space Assessment Program (SAM) has been performed to assess the stock status of sardine in GSA 17-18 from 1975 to 2018.
Acoustic surveys data were available and used as tuning indices.
The SAM environment is encapsulated into the Fisheries Library in R (FLR) (Kell *et al*., 2007) in the form of the package "FLSAM". The state-space assessment model (SAM) is an assessment model, which is used for several assessments within ICES. The model allows selectivity to evolve gradually over time. It has fewer model parameters than full parametric statistical assessment models, with quantities such as recruitment and fishing mortality modelled as random effects.
Estimates from acoustic surveys were included in the assessment model considering three tuning indexes:

1) The data from the surveys in GSA 17 West, GSA 18 west and GSA 18 East in the form of numbers-at-age from 2004 to 2016. A revised 2014 ALK, following the guidelines of AdriaMed workshop (Split, April 2015) have been used to split the number at length into numbers at age for the 2004 to 2014 in the western part of GSA 17 and GSA 18. For the 2015 and 2016 new ALK is produced each year;
2) Acoustic survey East, that includes the eastern side of GSA 17 in the form of numbers-at-age from 2013 to 2018. ALKs from survey on the eastern part of GSA 17 were obtained on annual basis, in line with survey protocol, following the ICES WKARA2 (2016) guidelines for age readings as agreed by MEDIAS Steering Committee;
3) Acoustic survey East biomass, that includes the eastern side of GSA 17 in the form of total biomass from 2003 to 2010.

All assessments are performed with version 0.99-3 of FLSAM, together with version 2.5 of the FLR library (FLCore).

6.1.2. Scripts

An object of class "FLSAM.control"

Slot "name":
[1] "Final Assessment"

Slot "desc":

[1] "Imported from a VPA file. (D:/FAO/PIL/update/Sar17_18.ndx). Fri May 17 11:06:53 2019"

Slot "range":

min	max	plusgroup	minyear	maxyear	minfbar	maxfbar
0	4	4	1975	2018	1	3

Slot "fleets":

catch unique	Echo West	Echo East	Echo East Biomass
0	2	2	3

Slot "plus.group":

plusgroup
TRUE

Slot "states":

	age				
fleet	0	1	2	3	4
catch unique	1	2	3	4	4
Echo West	-1	-1	-1	-1	-1
Echo East	-1	-1	-1	-1	-1
Echo East Biomass	-1	-1	-1	-1	-1

Slot "logN.vars":

0	1	2	3	4
1	2	2	2	2

Slot "logP.vars":

numeric(0)

Slot "catchabilities":

	age				
fleet	0	1	2	3	4
catch unique	-1	-1	-1	-1	-1
Echo West	501	502	503	504	505
Echo East	506	507	508	-1	-1
Echo East Biomass	6	-1	-1	-1	-1

```
Slot "power.law.exps":
                age
fleet             0  1  2  3  4
  catch unique    -1 -1 -1 -1 -1
  Echo West       -1 -1 -1 -1 -1
  Echo East       -1 -1 -1 -1 -1
  Echo East Biomass -1 -1 -1 -1 -1


Slot "f.vars":
                age
fleet             0  1  2  3  4
  catch unique    11 11 11 12 12
  Echo West       -1 -1 -1 -1 -1
  Echo East       -1 -1 -1 -1 -1
  Echo East Biomass -1 -1 -1 -1 -1


Slot "obs.vars":
                age
fleet             0   1   2   3   4
  catch unique    201 202 203 204 204
  Echo West       205 206 207 207 208
  Echo East       209 210 211  -1  -1
  Echo East Biomass   3  -1  -1  -1  -1


Slot "srr":
[1] 0


Slot "scaleNoYears":
[1] 0


Slot "scaleYears":
[1] NA


Slot "scalePars":
     age
```

years 0 1 2 3 4

Slot "cor.F":
[1] 2

Slot "cor.obs":
                age
fleet   0-1 1-2 2-3 3-4
  catch unique   NA NA NA NA
  Echo West   NA NA NA NA
  Echo East   NA NA -1 -1
  Echo East Biomass -1 -1 -1 -1

Slot "cor.obs.Flag":
[1] ID ID ID ID
Levels: ID AR US

Slot "biomassTreat":
[1] -1 -1 -1 0

Slot "timeout":
[1] 3600

Slot "likFlag":
[1] LN LN LN LN
Levels: LN ALN

Slot "fixVarToWeight":
[1] FALSE

Slot "simulate":
[1] FALSE

Slot "residuals":

[1] FALSE

Slot "sumFleets":
logical(0)

6.1.3. Input data and Parameters

Table 6.1.3.1. Catch numbers at age (in thousands) for the entire GSA17-18.

Catch numbers at age (thousands)											
Age		**1975**	**1976**	**1977**	**1978**	**1979**	**1980**	**1981**	**1982**	**1983**	**1984**
	0	231022.9	267995.8	282511.3	280357.4	229090.2	245252.7	381863.4	341979.4	521857.9	449281.6
	1	283396.9	364272.7	397544.8	361673.6	287281	311915.8	590103.1	557087.2	716120.1	678101.6
	2	309248.4	402305.8	452105.2	371067.5	319110.3	327207.9	746419.3	686194.7	820504.2	809503.2
	3	261505.3	363465.6	397068.5	301658.2	305273.8	358515.6	758172.9	752245.9	710606.1	812475.3
	4	199913.7	296803.1	352147.8	333945.2	282414.7	383437.5	616913.4	481193.2	416684.2	500248.7
Age		**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**
	0	378927.9	435926.7	502774.1	386307.9	416516.4	362614.6	188902.5	188196.4	158560.9	88310.9
	1	494820.3	540285.9	687007.9	570319.2	597292.5	495757.6	277885.6	241577.4	234442.1	147916.1
	2	571134.1	482560.3	640284.8	679412.9	786328.1	628339.3	358623.6	265605	297275.5	215913.9
	3	712743.7	570811.9	486214.1	481061.8	603348.5	674664.2	701200.1	453118.2	462078.2	402172.6
	4	453202.5	680315.3	558572.5	483827.5	378259.4	259922.8	312931.2	254541.4	354022.2	321444.3
Age		**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
	0	77377.2	111004.4	92446.9	152648.3	81158.4	81512.7	56292.9	70298.2	67021.4	110638.3
	1	115543.1	167095.3	190835.3	209162.4	109389.5	150802.4	186400.4	289735.4	237182.7	241222
	2	135497.7	205702.9	265853.4	254400.4	174552	238859	316794.8	376286.9	379031.1	431203.5
	3	443962	401591	376411.5	305339.4	279739.9	259156.3	237756.1	200252.5	185226.9	259503.6
	4	392925.3	450721.4	281167	302554	241390.9	185158.5	102042.6	75504.7	64796.4	69602.5
Age		**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
	0	132093.9	43670.4	50620.7	72541.6	150162.4	169687.7	288048.8	405130.8	504501.3	466091.8
	1	162145.1	114109.7	198980	416636.7	337891.6	553657.8	952090.1	1531999	1994905	2237694
	2	309528.6	272860.1	318630	433896.9	503045.3	613610	836096.7	868708	1015291	1284031

3	244969.2	219861.2	213443.9	180955.2	293697.8	225009.4	361420.7	218559.8	211498.8	205666
4	84154.8	101188.3	83242.6	84931.3	170478.8	67682.7	120453.9	63672.5	34976.9	29425.7

Age	**2015**	**2016**	**2017**	**2018**
0	663116.7	1178434.6	1103331.6	944114.6
1	2024641	2185911.6	1361751.2	1156398.4
2	1382301.9	1070666.7	1016269.7	1013755.0
3	145520	160412.9	274423.0	244024.5
4	6174.3	9727.1	27047.1	25585.2

Table 6.1.3.2. Catch numbers at age (in thousands) for the acoustic survey in GSA 17 West + GSA 18 West-East.

Year	Age 0	Age 1	Age 2	Age 3	Age 4
2004	673166.4	1717815	1360000	1052370	51409.55
2005	460365.1	1277189	492965.7	627757.9	30813.78
2006	571516.4	1655645	1355049	1370104	124117.9
2007	973234.3	3163262	1937653	1357836	115371.9
2008	3240825	9835685	3161071	1700755	69607.5
2009	2272157	8454229	1543766	472978.6	71726.98
2010	1820492	6998406	2556938	732864.9	45770.63
2011	9559575	23017141	5835002	983415.7	13169.69
2012	9852845	11265300	1547470	290940.3	78441.89
2013	8880658	21421735	3871570	207470.4	4111.774
2014	2536237	16998529	4555000	168620	0
2015	3691899	10059818	5684296	381954	0
2016	6150808	3961372	1012881	82807.69	15759.84
2017	6031741	4058859	243851.4	14004.63	0
2018	6838026	3718702	160131	17782.64	0

Table 6.1.3.3. Catch numbers at age (in thousands) for the acoustic survey in GSA 17 East.

Catch numbers at age (thousands) - Acoustic Survey GSA 17 EAST						
Age	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
0	4717909.8	1180050.3	12993118	13332270	9359342	8234312
1	3853279.6	4323384.2	2446710	709729	1035159	3422710
2	3031	64747	3505	1515.5	0	757

The following plots show the internal between year consistency of the age classes in the catch (6.1.3.1.) and in the tuning indices (6.1.3.2. and 6.1.3.3.).

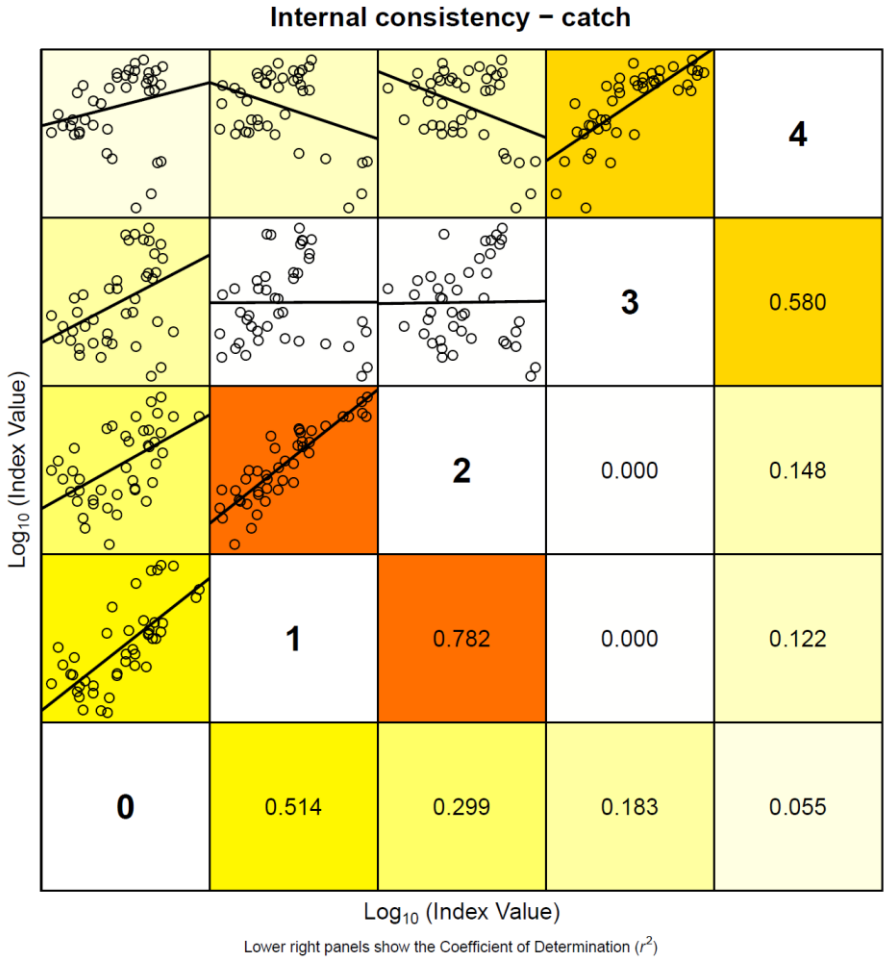

Figure 6.1.3.1. Catch at age data (numbers at age) between-year consistency plot for GSA 17 West-East and GSA 18 West-East sardine.

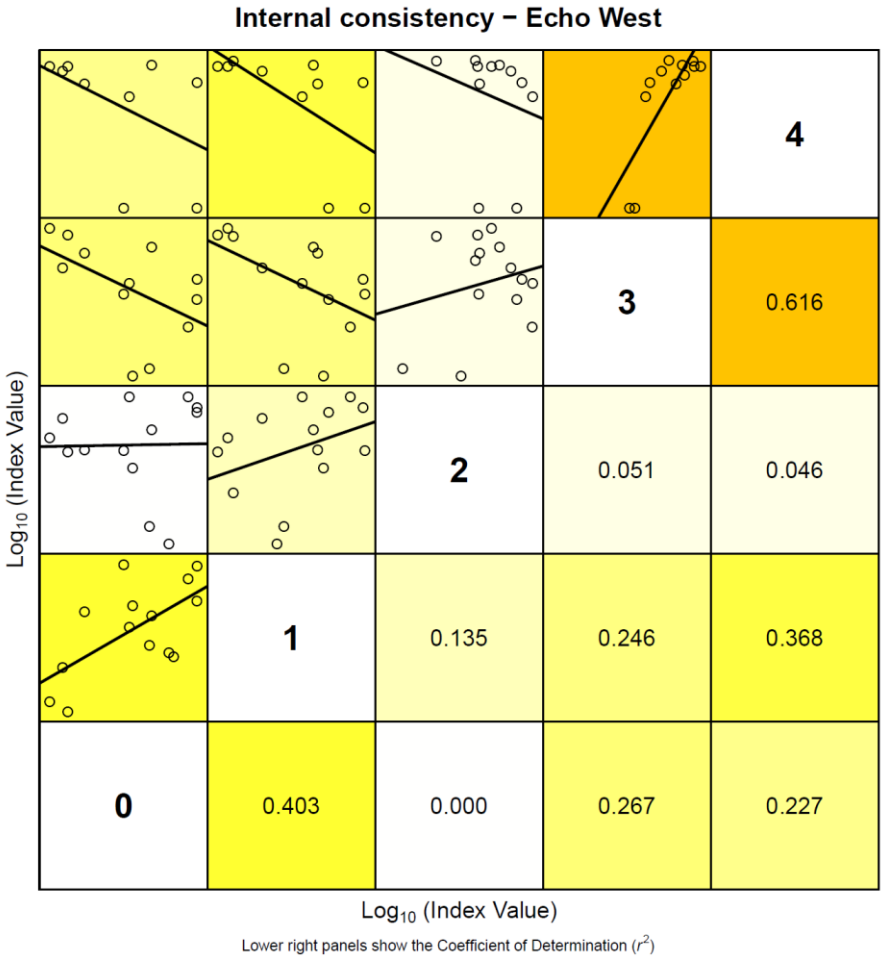

Figure 6.1.3.2. MEDIAS acoustic survey index between-year consistency plot for GSA 17 West and GSA18 West-East sardine.

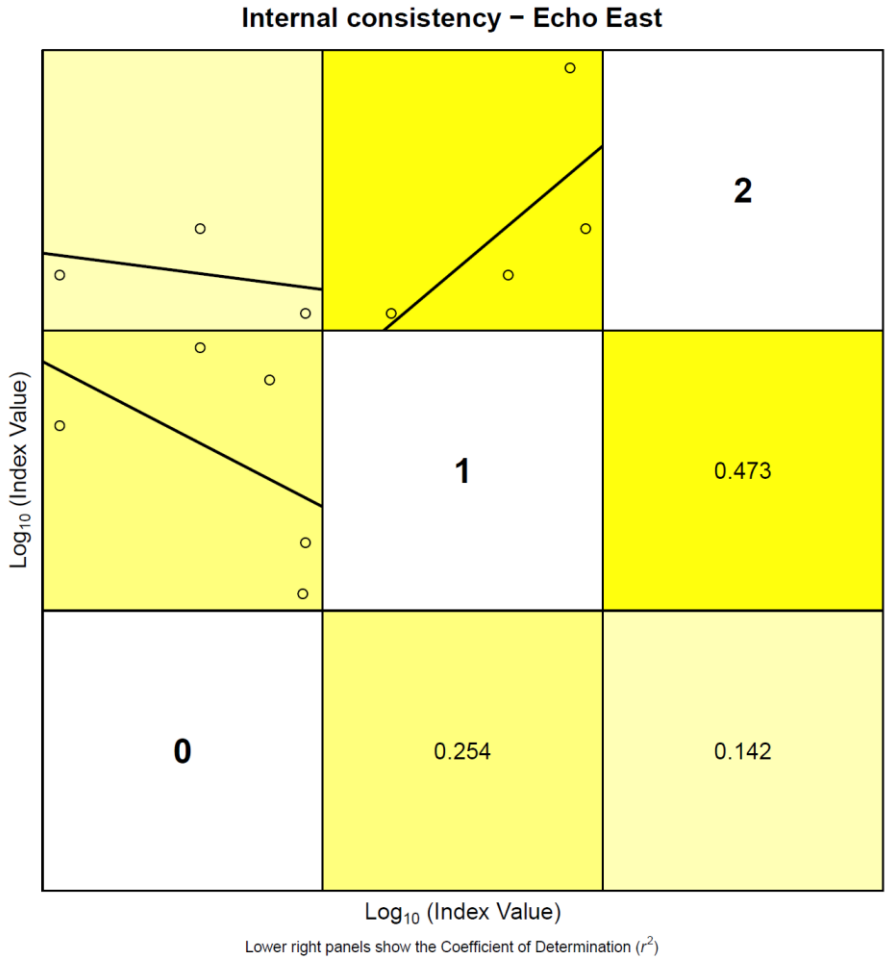

Figure 6.1.3.3. MEDIAS acoustic survey index between-year consistency plot for GSA 17 East sardine.

6.1.4 Results

The average fishing mortality for ages 1-3 (presented in figure 6.1.4.1, middle) shows a constant increase from the beginning of the time series (F_{bar1-3}=0.089 in 1975) up to 2014, when reach the maximum value of 1.664, to then describe a small decrease reaching the value of 1.529 in 2018.

The spawning stock biomass (figure 6.1.4.1, top) fluctuates from the highest values in the early eighties (SSB in 1981= 721,500 tonnes) to a minimum in 2001 of 124,811 tonnes. Afterwards, the

stock slowly recovers, reaching the value of 206,067 tonnes in 2014. The value for 2018 is 157,251 tonnes.

The recruitment (age 0 – figure 6.1.4.1, bottom) follows the trend of the SSB, showing however a stronger recover in the last decade. After a big peak in the early eighties (47,632,203 number of individuals) and a minimum in 1999 (10,786,219 number of individuals thousands), the recruitment shows a quite constant increase reaching the values of 23,163,780 number of individuals 2013. Estimated recruits for 2018 are 21,295,148 tonnes.

The exploitation ratio (E) (Fig. 6.1.4.2) shows a constant increase over the time series, exceeding the reference value of Patterson (Patterson, 1992) since 2009.

Table 6.1.4. Results of the final FLSAM assessment of sardine in GSA17-18.

Year	Recruits Age 0 (Thousands) Mean	Recruits Age 0 (Thousands) Low	Recruits Age 0 (Thousands) High	Total biomass (tonnes) Mean	Total biomass (tonnes) Low	Total biomass (tonnes) High	Spawing biomass (tonnes) Mean	Spawing biomass (tonnes) Low	Spawing biomass (tonnes) High
1975	38805897	30163307	49924819	824384.9	671337.3	1012323	552743.6	437459.1	698409.4
1976	39350517	31346074	49398952	882644.4	728363	1069606	595385.6	484384.4	731823.8
1977	39634484	32037079	49033568	905785.4	754327	1087654	616453.7	506015.5	750995
1978	41022964	33483440	50260176	872894.9	734378.8	1037537	569324.9	471537.9	687390.8
1979	43190199	35457609	52609110	880457.9	749348.8	1034506	578126.5	485562.8	688335.8
1980	45911042	37851817	55686199	949588	817084.2	1103579	614437.4	524007.1	720473.6
1981	47632203	39406239	57575318	1069215	927187.8	1232997	721499.5	621431.6	837681.2
1982	45316495	37600415	54616012	1045527	907760.4	1204202	710185	611448.1	824866
1983	41518585	34539374	49908052	997058.7	868484.1	1144668	698124.9	602662.7	808708.4
1984	36354785	30330445	43575700	949621.4	831404.3	1084648	684231.5	593656.5	788625.7
1985	34322447	28709298	41033061	818415.2	719880.9	930436.4	578158	503853.7	663420.1
1986	35251976	29494139	42133856	820504.4	724400.4	929358.2	517337.4	454497.8	588865.3
1987	36420346	30408843	43620259	734574.7	648098.5	832589.3	465064.1	409271.3	528462.7
1988	35402228	29460319	42542572	719774.9	632464.4	819138.4	468419	410343.6	534713.8
1989	33408349	27693646	40302307	713526.4	623973.8	815931.6	479668	417843.9	550639.5
1990	30060826	24880341	36319970	674315.2	586806.3	774874.1	463889.4	401207.1	536364.8
1991	26412144	21850393	31926262	618335.7	536869.3	712164.1	433450.6	373496.1	503029.3
1992	23848478	19799160	28725960	567945.5	493507.3	653611.7	401006.2	345129.6	465929.2
1993	20171180	16791689	24230825	547436	478793.2	625919.8	406237.7	352269.2	468474.3
1994	17128368	14279168	20546085	484472.3	425916.4	551078.5	364573.7	317978.6	417996.7
1995	15094377	12667073	17986809	419145.1	371547.9	472839.7	313484.5	275784.8	356337.7
1996	13618939	11484143	16150575	373395.3	334264.9	417106.4	276700.8	246105.7	311099.4
1997	11833020	10003552	13997063	332189.7	298789.3	369323.9	244625.4	218818	273476.6
1998	11317028	9575903	13374730	268971.4	243176.5	297502.6	189752.2	171130.2	210400.8
1999	10786219	9145622	12721116	264410.1	238072	293662	169491.3	152375.1	188530.3
2000	11260439	9556655	13267978	206174.4	186192.9	228300.2	132981.5	120071.8	147279.2
2001	11729420	9954582	13820701	224510.9	201571.7	250060.5	124810.8	112384	138611.7
2002	12059833	10229733	14217338	249892.8	223240.5	279727.1	132912.4	118766.1	148743.8
2003	11588672	9814474	13683600	224480.9	200994.2	250712.1	137565.9	122765.4	154150.6
2004	11602913	9822633	13705856	235372	211288.1	262201.2	143709	128971.3	160130.8
2005	11772955	9979461	13888774	199701	178916.6	222899.8	127885.9	114108.4	143326.9

2006	11559044	9795219	13640482	261281.7	232544.6	293570	137599.9	122413.7	154670.1
2007	12829088	10951368	15028762	287437.1	257280.3	321128.7	138619.7	124378.9	154491
2008	13803393	11824473	16113501	349105.4	313330.5	388964.9	153097.2	138446.7	169298
2009	15355039	13228154	17823894	282589.7	256674.7	311121.2	150536.3	136905.8	165524
2010	16677948	14426675	19280530	321439	291963.8	353890	149656.2	136962	163526.9
2011	19313999	16764254	22251547	376927.9	342932.5	414293.3	160611.1	148460.9	173755.7
2012	21807715	18968899	25071378	400357.2	364134.7	440183	162653.1	150116.6	176236.6
2013	23163780	20169637	26602397	433441.3	395458.1	475072.8	185588.9	171549.9	200776.8
2014	22142376	19226122	25500974	454061.9	414676	497188.6	206067.3	190371.3	223057.3
2015	21972150	18921090	25515199	494882.2	446133.9	548957.1	187272.1	172814.1	202939.6
2016	21496875	17860585	25873488	465339.3	409246.9	529119.8	175131.5	161410	190019.3
2017	21336215	16793631	27107541	351808.6	293732.7	421367	136312.8	118548.7	156738.8
2018	21295148	15804569	28693179	423440.8	327835.6	546926.9	157251.4	122648.3	201617.2

Year	**Landings (tonnes) Mean**	**Landings (tonnes) Low**	**Landings (tonnes) High**	**Yield / SSB (ratio) Mean**	**Yield / SSB (ratio) Low**	**Yield / SSB (ratio) High**	**Mean F ages 1-3 Mean**	**Mean F ages 1-3 Low**	**Mean F ages 1-3 High**	**Mean F ages 0-1**	**SoP (%)**
1975	33887.17	33886.62	33887.73	0.061	0.077	0.049	0.089	0.069	0.115	0.020	1.000
1976	46985.35	46984.57	46986.13	0.079	0.097	0.064	0.112	0.089	0.142	0.026	1.000
1977	54576.49	54575.57	54577.4	0.089	0.108	0.073	0.126	0.101	0.157	0.028	1.000
1978	44820.34	44819.59	44821.1	0.079	0.095	0.065	0.110	0.089	0.136	0.026	1.000
1979	41362.21	41361.5	41362.92	0.072	0.085	0.060	0.099	0.081	0.121	0.020	1.000
1980	48593.04	48592.18	48593.9	0.079	0.093	0.067	0.116	0.097	0.139	0.020	1.000
1981	93559.14	93557.55	93560.74	0.130	0.151	0.112	0.220	0.185	0.261	0.033	1.000
1982	84687.75	84686.31	84689.19	0.119	0.139	0.103	0.203	0.170	0.242	0.031	1.000
1983	83926.93	83925.55	83928.31	0.120	0.139	0.104	0.195	0.164	0.231	0.042	1.000
1984	92723.71	92722.16	92725.26	0.136	0.156	0.118	0.205	0.174	0.243	0.047	1.000
1985	75520.79	75519.5	75522.09	0.131	0.150	0.114	0.178	0.152	0.210	0.042	1.000
1986	79547.11	79545.69	79548.52	0.154	0.175	0.135	0.211	0.181	0.246	0.047	1.000
1987	73428.22	73427.01	73429.44	0.158	0.179	0.139	0.249	0.215	0.288	0.055	1.000
1988	68191.02	68189.89	68192.15	0.146	0.166	0.128	0.269	0.232	0.313	0.043	1.000
1989	71097.7	71096.53	71098.86	0.148	0.170	0.129	0.297	0.254	0.347	0.045	1.000
1990	61881.52	61880.47	61882.57	0.133	0.154	0.115	0.246	0.209	0.290	0.042	1.000
1991	54138.19	54137.2	54139.19	0.125	0.145	0.108	0.211	0.177	0.252	0.027	1.000

1992	40049.74	40049.03	40050.45	0.100	0.116	0.086	0.150	0.126	0.179	0.026	1.000
1993	45885.2	45884.37	45886.02	0.113	0.130	0.098	0.169	0.143	0.200	0.027	1.000
1994	39142.88	39142.15	39143.62	0.107	0.123	0.094	0.148	0.126	0.175	0.021	1.000
1995	41128.89	41128.05	41129.73	0.131	0.149	0.115	0.167	0.143	0.196	0.019	1.000
1996	44309.77	44308.9	44310.64	0.160	0.180	0.142	0.230	0.198	0.266	0.030	1.000
1997	38522.34	38521.65	38523.02	0.157	0.176	0.141	0.240	0.210	0.275	0.038	1.000
1998	36138.85	36138.2	36139.49	0.190	0.211	0.172	0.288	0.254	0.327	0.052	1.000
1999	27949.15	27948.65	27949.65	0.165	0.183	0.148	0.308	0.273	0.349	0.030	1.000
2000	26107.1	26106.65	26107.56	0.196	0.217	0.177	0.408	0.364	0.458	0.038	1.000
2001	24138.39	24137.98	24138.81	0.193	0.215	0.174	0.440	0.392	0.494	0.042	1.000
2002	24100.79	24100.37	24101.2	0.181	0.203	0.162	0.444	0.395	0.499	0.056	1.000
2003	21620.5	21620.11	21620.89	0.157	0.176	0.140	0.386	0.343	0.436	0.046	1.000
2004	26929.9	26929.41	26930.38	0.187	0.209	0.168	0.405	0.359	0.457	0.054	1.000
2005	20906.72	20906.36	20907.09	0.163	0.183	0.146	0.352	0.311	0.399	0.041	1.000
2006	20475.45	20475.09	20475.81	0.149	0.167	0.132	0.338	0.296	0.384	0.026	1.000
2007	21984.36	21983.98	21984.74	0.159	0.177	0.142	0.334	0.294	0.379	0.041	1.000
2008	27583.68	27583.2	27584.15	0.180	0.199	0.163	0.363	0.327	0.403	0.073	1.000
2009	34163.7	34163.13	34164.27	0.227	0.250	0.206	0.571	0.518	0.631	0.063	1.000
2010	34213.82	34213.21	34214.44	0.229	0.250	0.209	0.505	0.461	0.553	0.095	1.000
2011	54816.07	54815.12	54817.02	0.341	0.369	0.315	0.904	0.841	0.971	0.155	1.000
2012	58732.7	58731.58	58733.82	0.361	0.391	0.333	1.008	0.942	1.078	0.222	1.000
2013	71643.25	71641.82	71644.68	0.386	0.418	0.357	1.163	1.094	1.236	0.252	1.000
2014	82538.66	82536.97	82540.35	0.401	0.434	0.370	1.664	1.583	1.749	0.258	1.000
2015	78012.43	78010.86	78013.99	0.417	0.451	0.384	1.323	1.246	1.405	0.262	1.000
2016	79405.18	79403.66	79406.69	0.453	0.492	0.418	1.023	0.954	1.096	0.315	1.000
2017	69398.49	69397.28	69399.7	0.509	0.585	0.443	1.199	1.091	1.318	0.234	1.000
2018	64930.48	64929.34	64931.63	0.413	0.529	0.322	1.529	0.997	2.345	0.183	1.001

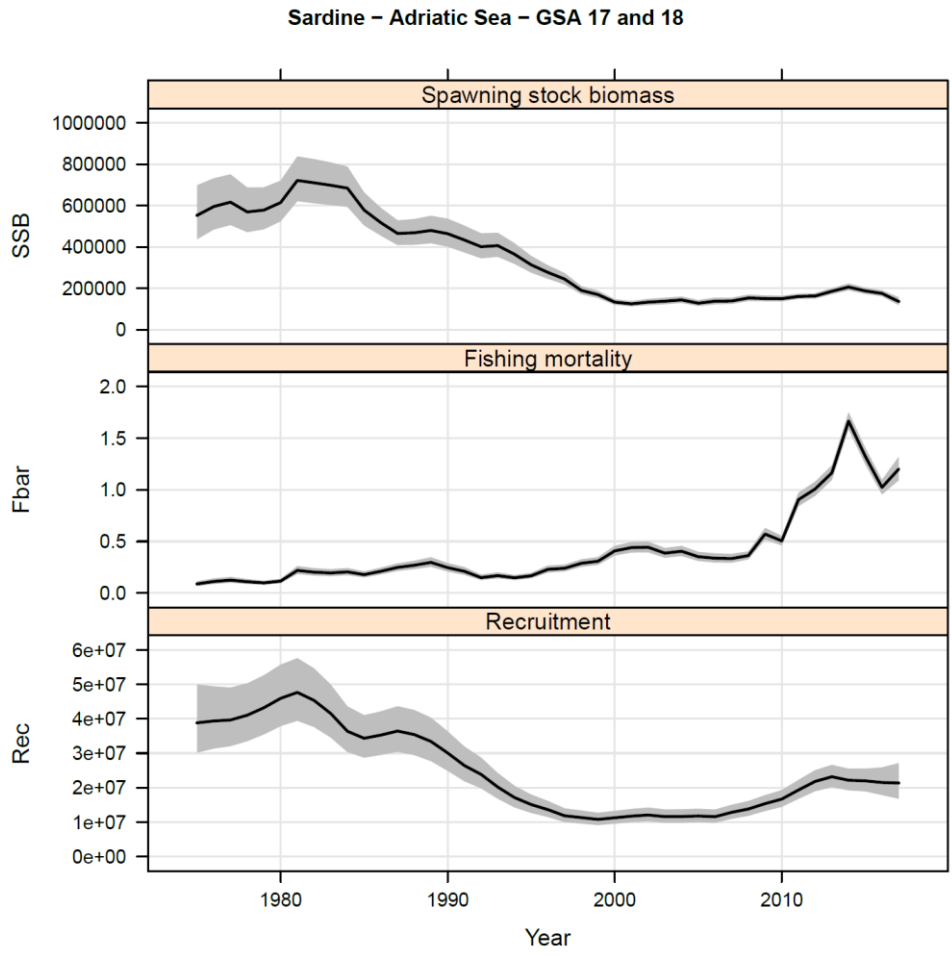

Figure 6.1.4.1. Sardine results from SAM model: SSB, F and recruitment estimates.

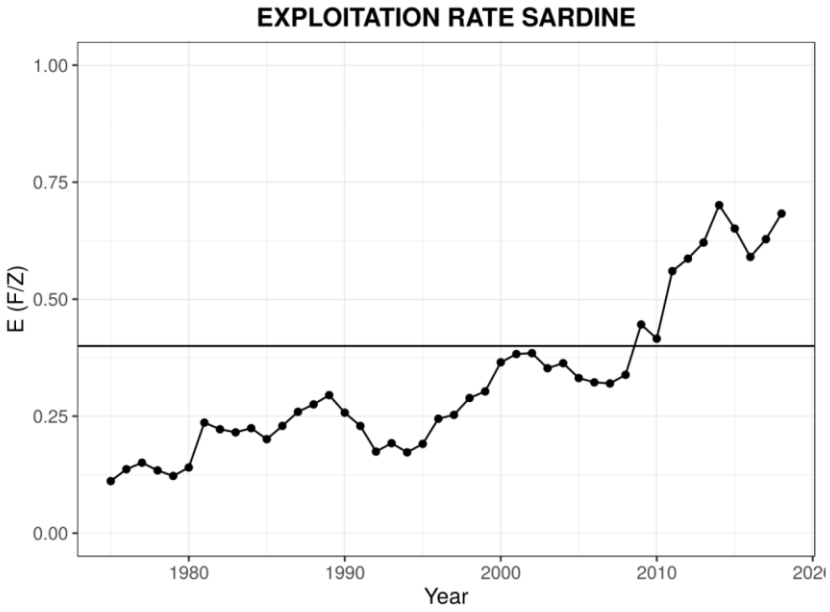

Figure 6.1.4.2. Trends in exploitation rate for sardine in GSA 17-18. Horizontal line indicates the Patterson's reference point used for advice (E = 0.4).

6.1.5 Robustness analysis

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

The retrospective analysis was run on 4 year. The outputs are shown in Figure 6.1.6.1 and describe a consistent behavior of the assessment model.

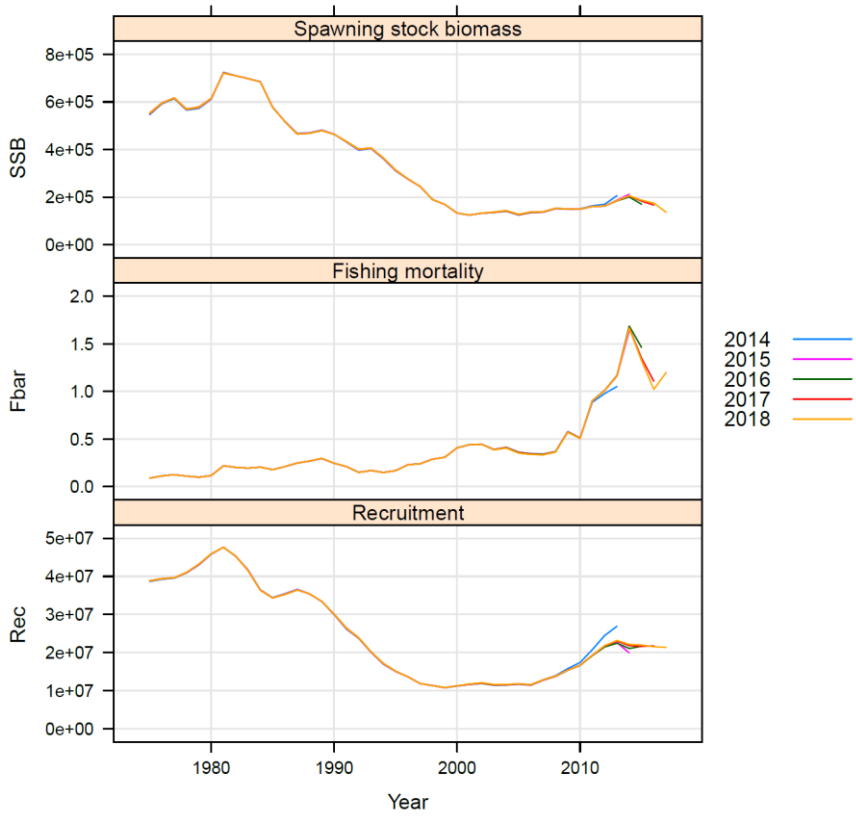

Figure 6.1.6.1. FLSAM retrospective patterns for currently accepted assessment.

The weight given to the input data is shown in the plot below (Fig. 6.1.6.2): a higher weight is given to the catch data, followed by the Echosurvey East biomass. Lower weight is given to the age composition data from the echo survey.

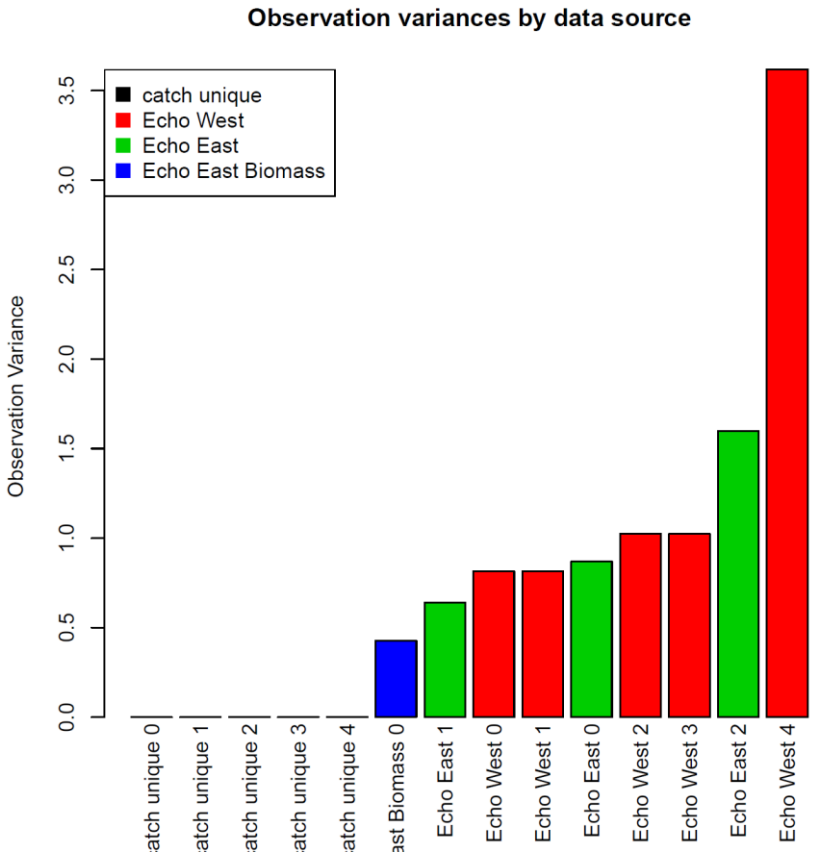

Figure 6.1.6.2. Observation variances by data source of sardine in GSA17-18.

7. Assessment quality

The assessment presented in this document refers to the models accepted during the benchmark meeting held in May 2019. However, some specifications have to be reported.

First, during the benchmark session all the dataset was revised. Each country provided its best data available, however these data been made available very shortly before the benchmark meeting, and therefore experts had limited time available to perform basic data analysis. Thus, it was decided to not use the assessment model including this new dataset. However, different models were tested using an updated version of the stock assessment model SAM:

a. **Update.** Time series: 1975 – 2018. Features: updated 2016 assessment with two more years of data.

b. **Updated short time series.** Time series 2001 – 2018. Features: updated assessment truncated with two more years of data

c. **Revised dataset.** Time series: 1975 – 2018. Features: i) Croatia and Albania reported new landings, ii) Italy updated ALK from 2002 to 2014, iii) Model parameters refined to obtain best fit.

The revised sardine dataset scenario was not run due to lack of time. The group agreed to use the updated assessment as the basis of the advice, pending the final closure of the benchmark. Figure 9.1 shows the comparison among the three assessment models.

The revised sardine dataset scenario was not run due to lack of time. The group agreed to use the updated assessment as the basis of the advice, pending the final closure of the benchmark. Figure 8.1 shows the comparison among the three assessment models.

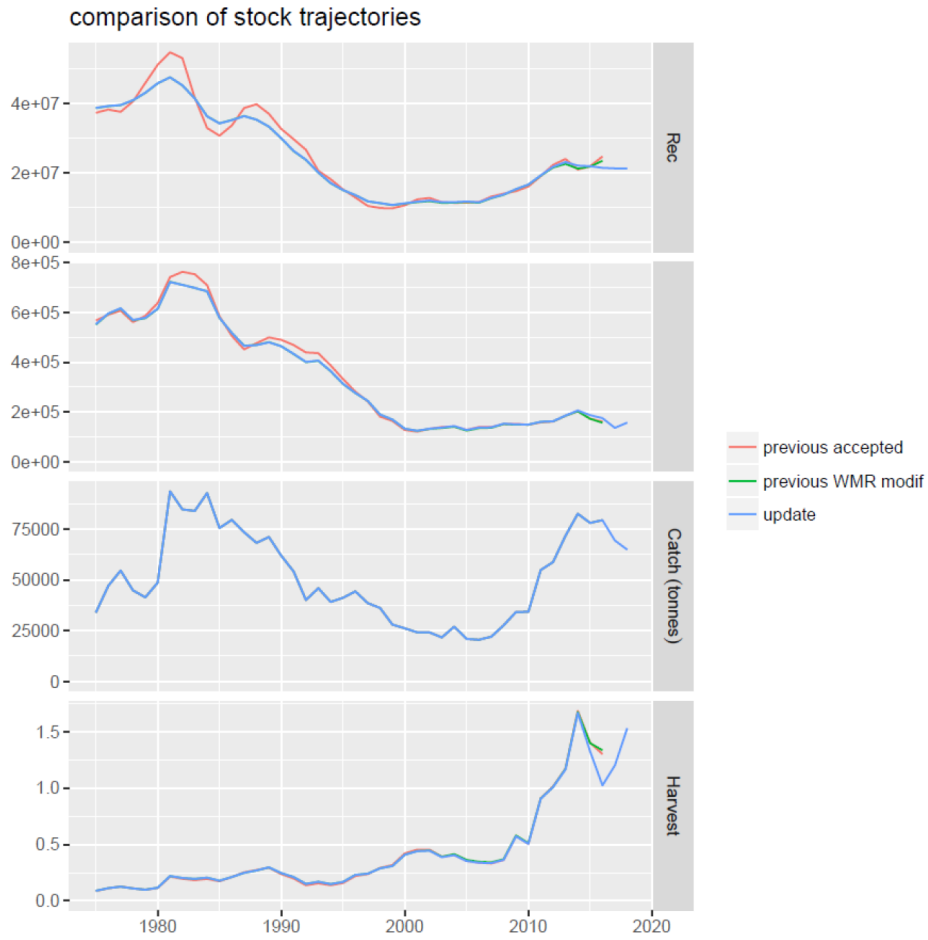

Figure 8.1 Outputs of the assessment for sardine in GSA17-18. From top to bottom, trends in Recruitment, Spawning Stock Biomass (SSB), catches and fishing mortality (Harvest). The blue line represents the updated assessment including data up to 2018, the red line represents the previously GFCM advice (with data up to 2016) and the green line represents the modifications on the model fitting as discussed in the 2018 session of the Subregional Committee for the Adriatic Sea.

8. Stock Simulations

8.1 Short term predictions

The short term forecast was based on the following assumptions:

- Initial population size was taken from the assessment estimates at the final year
- Recruitment in the interim and projection years was assumed constant and equal to the geometric mean of the last 3 years of the assessment
- Mean weight-at-age, maturity-at-age, F and M before the spawning, natural mortality and the selection pattern were assumed to be the average of the last three years
- Fishing mortality in the interim year (2019) was set equal to the status quo fishing mortality, which was calculated as an average of the last three years
- Fishing mortality scenarios for the projection period was defined as the product of status quo F and a multiplier, that ranged from 0 (I.e. no fishing) to 2 with steps of 0.1
- An additional fishing mortality scenario corresponding to an exploitation rate E=F/(F+M)=0.4 (Patterson, 1992) was also run

Table 8.1.1 Short term forecast for sardine. Change in SSB expressed in % change 2021 with respect to 2020. Changes in catch is expressed in % change in 2020 with respect to 2018. The scenario of applying fishing mortality equivalent to Patterson's E = 0.4 is represented at the bottom (F_{mult} = 0.38)

Fmult	Fbar	Catch 2018	Catch 2019	Catch 2020	Catch 2021	SSB 2019	SSB 2020	SSB 2021	SSB change	Catch change
0.00	0.00	64930	71553	0	0	159143	158575	209621	32.19	-100.00
0.10	0.12	64930	71553	9636	14594	159143	158575	202385	27.63	-85.16
0.20	0.25	64930	71553	18550	26233	159143	158575	195778	23.46	-71.43
0.30	0.37	64930	71553	26828	35675	159143	158575	189720	19.64	-58.68
0.40	0.49	64930	71553	34544	43464	159143	158575	184143	16.12	-46.80
0.50	0.62	64930	71553	41762	49996	159143	158575	178989	12.87	-35.68
0.60	0.74	64930	71553	48538	55562	159143	158575	174208	9.86	-25.25
0.70	0.86	64930	71553	54917	60376	159143	158575	169757	7.05	-15.42
0.80	0.99	64930	71553	60942	64595	159143	158575	165600	4.43	-6.14
0.90	1.11	64930	71553	66647	68341	159143	158575	161705	1.97	2.64
1.00	1.23	64930	71553	72063	71702	159143	158575	158044	-0.33	10.99
1.10	1.36	64930	71553	77218	74750	159143	158575	154594	-2.51	18.92
1.20	1.48	64930	71553	82136	77537	159143	158575	151335	-4.57	26.50
1.30	1.60	64930	71553	86836	80105	159143	158575	148247	-6.51	33.74
1.40	1.73	64930	71553	91338	82488	159143	158575	145315	-8.36	40.67
1.50	1.85	64930	71553	95657	84712	159143	158575	142526	-10.12	47.32
1.60	1.97	64930	71553	99808	86799	159143	158575	139866	-11.80	53.72
1.70	2.10	64930	71553	103805	88766	159143	158575	137325	-13.40	59.87
1.80	2.22	64930	71553	107657	90628	159143	158575	134893	-14.93	65.80
1.90	2.34	64930	71553	111377	92397	159143	158575	132561	-16.40	71.53
2.00	2.47	64930	71553	114972	94082	159143	158575	130323	-17.82	77.07
0.38	**0.47**	**64930**	**71553**	**33332**	**42298**	**159143**	**158575**	**185015**	**16.67**	**-48.67**

8.2 Medium term predictions

8.3 Long term predictions

9. Draft scientific advice

Based on	Indicator	Analytic al reference point (name and value)	Current value from the analysis (name and value)	Empirical reference value (name and value)	Trend (time period)	Status
Fishing mortality	Fishing mortality	E = 0.4	F_{cur} = 1.529 E_{2018} = 0.683		I	IO_H
	Fishing effort					
	Catch					
Stock abundance	Biomass					
	SSB	B_{lim}=125,318 B_{pa}=250,636	B_{cur}=157,251		D	O_I
Recruitment						
Final Diagnosis		In overexploitation with relative intermediate biomass				

a. 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)*