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:
Engraulis encrasicolus	Anchovy	[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:		

Angelini S.[1], Arneri E.[2], Belardinelli A.[1], Biagiotti I.[1], Bratina P.[5], Brunel T.[7], Canduci G.[1], Cacciamani R.[1], Calì F.[1], Colella S.[1], Costantini I.[1], Croci C.[1], De Felice A.[1], Domenichetti F.[1], Donato F.[1], Gašparević D.[3], Hintzen N.[7], Ibaibarraga L.8, Juretic T.[3], Leonori I.[1], Martinelli M.[1], Milone N.[2], Modic T.[5], Pallaoro A.[3], Panfili M.[1], Pesic A.[4], Ikica Z.[4], Santojanni A.[1], Tesauro C.[1], Ticina V.[3], Palluqi A.[6], Kule M.[6]

Affiliation:

[1] CNR – ISMAR (National Research Council - Institute of Marine Science), Italy
[2] FAO-AdriaMed, Rome, Italy
[3] Institute of Oceanography and Fisheries, Croatia
[4] Institute of Marine Biology, University of Montenegro, Kotor, Montenegro
[5] Fisheries Research Institute of Slovenia
[6] Ministry of Agriculture and Rural Development, Albania
[7] Wageningen Marine Research (WMR), Ijmuiden, The Netherlands
[8] Azti, Spain

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):

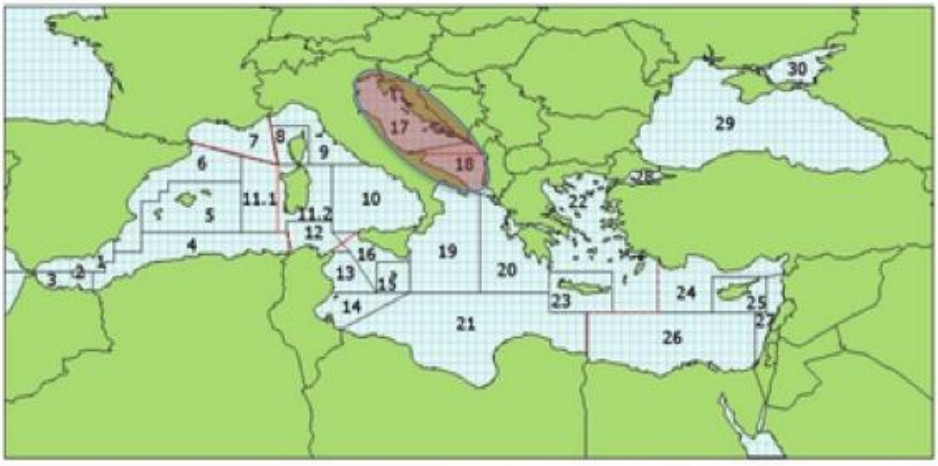
- SAM

2. Stock identification and biological information

2.1. *Stock unit*

Many studies have been carried out regarding the presence of a unique stock or different sub-populations of anchovy in the Adriatic Sea (GSAs 17 and 18). This has several implications for the management, i.e. differences in the growth features between sub-populations imply the necessity of ad hoc strategies in the management. The hypothesis of two distinct populations claims the evidence of morphometric differences between northern and southern Adriatic anchovy, such as colour and length, and some variability in their genetic structure (Bembo et al., 1996). Nevertheless, many authors warn against the use of morphological data in studies on population structure (Tudela, 1999) and, a recent study from Magoulas et al. (2006), revealed the presence of two different clades in the Mediterranean, one of those is characterized by a high frequency in the Adriatic Sea (higher than 85%) with a low nucleotide diversity (around 1%). Also, outcomes of EU project STOCKMED indicated existence of one single stock of anchovy in GSA17 and western part of GSA18 (Fiorentino et al., 2014).

More recently Ruggeri et al. (2016) analysed genetic markers from anchovy samples from Adriatic Sea and Tyrrhenian Sea and didn't find clear evidence of two distinct anchovy populations in these areas, even if in the northern Adriatic Sea geographic gradients in sea temperature, salinity and dissolved oxygen appear to drive adaptive differences in spawning time and early larval development among populations. Moreover, recent outcomes of EU project STOCKMED and EWG 17-02 indicated existence of one single stock of anchovy in the Adriatic Sea also. Therefore, also according to the fact that a lot of vessels registered in GSA 18 fish in GSA 17, it was decided to merge the two GSAs and thus carry out an assessment for anchovy in GSA 17-18. (Figure 2.1.1.).



01 - Northern Alboran Sea	07 - Gulf of Lions	13 - Gulf of Hammamet	19 - Western Ionian Sea	25 - Cyprus Island
02 - Alboran Island	08 - Corsica Island	14 - Gulf of Gabes	20 - Eastern Ionian Sea	26 - South Levant
03 - Southern Alboran Sea	09 - Ligurian and North Tyrrhenian Sea	15 - Malta Island	21 - Southern Ionian Sea	27 - Levant
04 - Algeria	10 - South and Central Tyrrhenian Sea	16 - South of Sicily	22 - Aegean Sea	28 - Marmara Sea
05 - Balearic Island	11.1 - Sardinia (west) 11.2 - Sardinia (east)	17 - Northern Adriatic	23 - Crete Island	29 - Black Sea
06 - Northern Spain	12 - Northern Tunisia	18 - Southern Adriatic Sea	24 - North Levant	30 - Azov Sea

Figure 2.1.1*: Geographical location of GSAs 17 and 18.*

2.2. *Growth and maturity*

The growth parameters used for the estimation of natural mortality are the same already used in past assessments and are shown in Table 2.2.1 and 2.2.3.

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**	**April-October**
Maximum size observed			19 cm	**Recruitment season**	
Size at first maturity			6-8 cm	**Spawning area**	Adriatic Sea, over continental shelf
Recruitment size to the fishery			7.5 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	*2.36*	*0.5*
1	*1.10*	*1*
2	*0.81*	*1*
3	*0.69*	*1*
4+	*0.625*	*1*

The natural mortality value for age 4+ is the mean value between the natural mortality vale of age 4 and 5.

Table 2.2.3: Growth and length weight model parameters

			Sex			
		Units	female	male	Combined	Years
Growth model	L_∞	cm			19.4	
	K	y^{-1}			0.57	
	t_0	y			-0.5	
	Data source	Sinovcic, 2000				
Length weight relationship	a				0.0032	
	b				3.2339	
	M (scalar)					
	sex ratio (% females/total)					

3. Fisheries information

3.1 Description of the fleet

Anchovy 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 128 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 115 active purse seiners targeting small pelagics (mainly sardine) while in Slovenia only 2 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 Italian catches of anchovy represent the majority of the catches, while the Croatian small pelagic fishery concentrates mainly on sardine.

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_1718	Italy	GSA17-18	PTM_0640	Pelagic Trawler	Small pelagic	*E. encrasicolus* *S. pilchardus* *Mugilidae* spp.
ITA_PS_1718	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*	20,199		< 1%		
ITA_PS_1718	33*			< 1%		
HRV_PS_17	115**	13,240		< 1%		
SLO_PS_17	2*	0.01		< 1%		
ALB_PS_18		1,516		< 1%		
MNE_PS_18		189		< 1%		
Total		35,143				

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

3.2 Historical trends

The catch of anchovy shows a fluctuating trend over the years (1975 – 2018), reaching the lowest value in 1987 (4,848 tonnes) and higher value in 2007 (65,317 tonnes). The stock is exploited mostly by the countries located on the western side of the Adriatic Sea (Italy GSA 17 and 18 and Slovenia), while catches (Croatia, Montenegro and Albania) from the eastern side of the Adriatic Sea account for lower value increasing their catches since 2000s. Slovenian catches of the most recent years accounts for very low values.

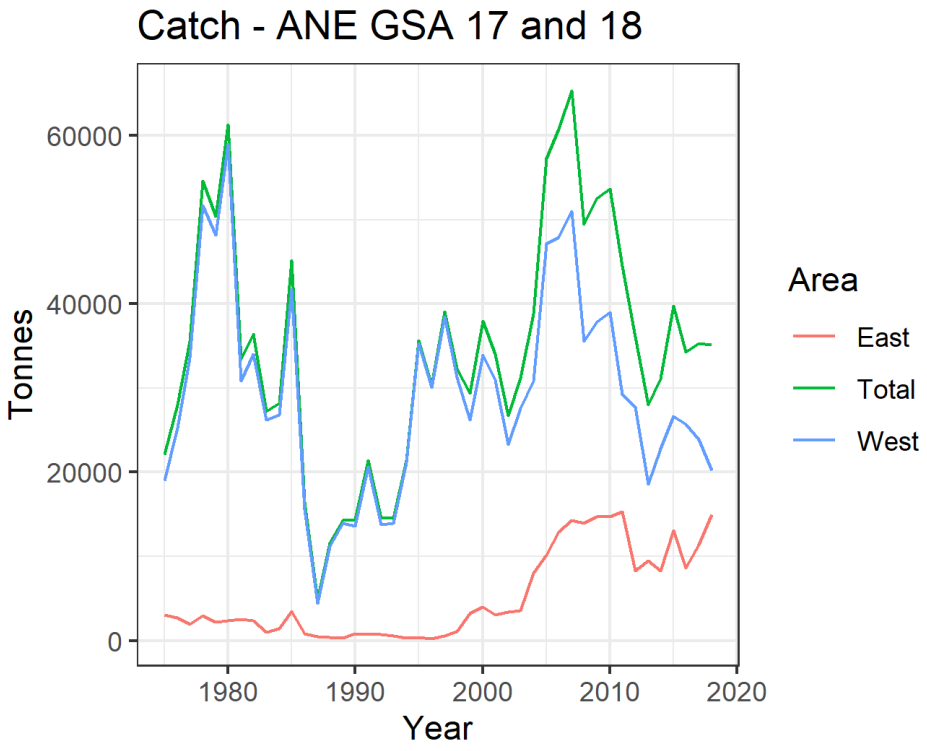


Figure 3.2.1: Adriatic catches for the whole period assessed (1975-2018) for the Eastern and Western side of GSA17-18.

In figure 3.2.2 the trend in the cohorts of the total catches is shown. Age 1 is the fully recruited age in great part of the time series.

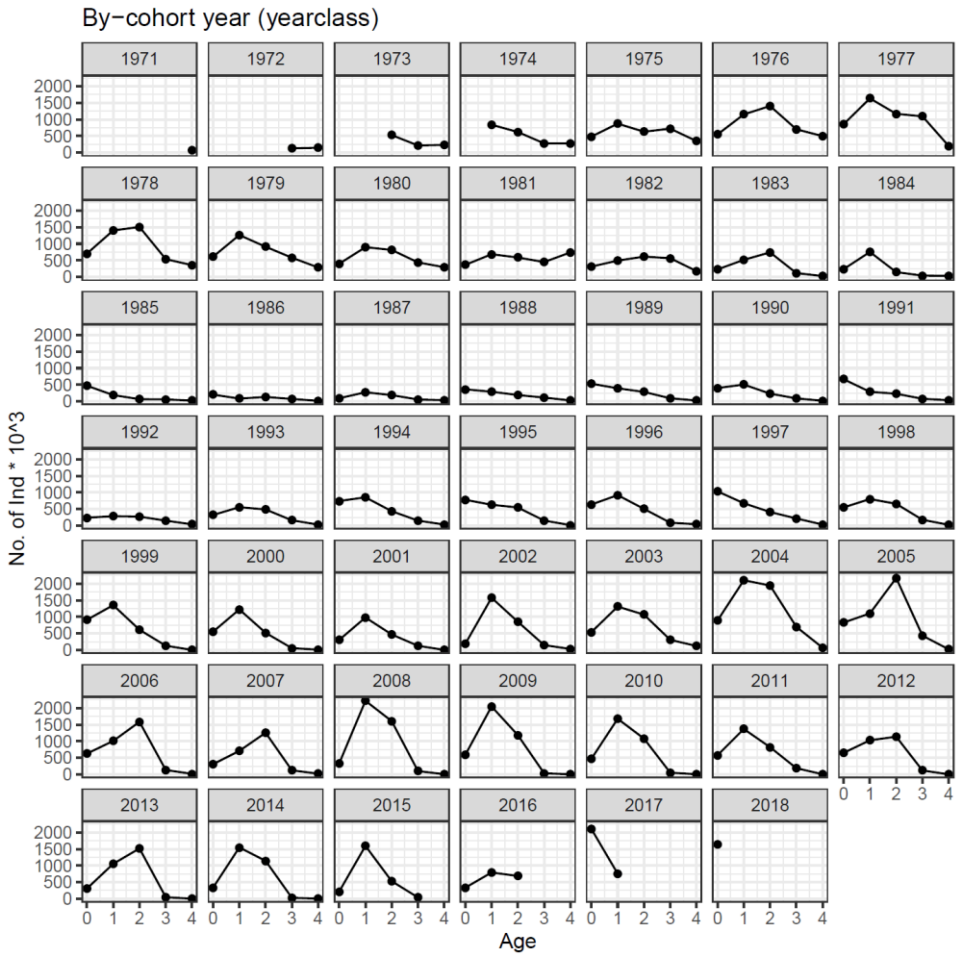


Figure 3.2.2: Catch-at-age cohort plots for GSA 17-18 anchovy.

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 2020, 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.

2.3. *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}	45,936	B_{pa}	91,872	2015 GFCM benchmark assessment
F			F_{MSY}	0.554	2015 GFCM benchmark assessment
			F corresponding to E = 0.4	0.57	STECF EWG 17-15
Y					
CPUE					
Index of Biomass at sea					

4. Fisheries independent information

4.1. *MEDIAS ACOUSTIC 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 GSA 18 in the form of numbers-at-age from 2004 to 2018;
2) Acoustic survey East, that includes the eastern side of GSA 17 in the form of numbers-at-age from 2013 to 2018;
3) Acoustic survey East biomass, that includes the eastern side of GSA 17 in the form of total biomass from 2003 to 2010.

The surveys results have been aggregated as follows:

- Western GSA 17 + Western GSA 18 + Eastern GSA 18;
- Eastern GSA 17.

Due to the different time series available for the Western and Eastern GSA 18 (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 GSA17-18 west).

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

The abundance at age for the West acoustic survey was estimated using the ALK 2016, the same used during the previous stock assessment. The abundance at age for the East Echosurvey was determined following the ICES WKARA2 age-reading protocol, and ALK is determined for every year separately.

The standardized methodology followed during MEDIAS surveys are given in the MEDIAS handbook (MEDIAS, April 2019) revised annually (MEDIAS Steering Committee report, 2019).

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	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 from acoustic survey for the years 2004-2018.

Year	Age 0	Age 1	Age 2	Age 3	Age 4
2004	35560684.9	18764019.5	613692.291	5645.13828	2540.31222
2005	40787856.7	10033202.1	134556.873	4071.97436	1832.38846
2006	76696622	26700887.6	3988381.17	151803.213	61547.1085
2007	73618537.8	28091727.7	2747682.06	70127.2059	25026.4262
2008	64723232.3	44561925.9	1557485.57	64161.2556	13155.999
2009	73769476.8	21903650.5	429700.55	16420.985	19589.947

2010	45236307.6	26066281.5	566015.614	21459.645	25600.98
2011	49485704.4	23424898.2	305349.909	17105.153	13497.9207
2012	86799211	18037774.1	62577.0285	6364.26054	6914.5557
2013	43260113.2	18805485.3	480455.723	946.02643	157.671072
2014	28448152.9	18667773.4	273617.197	133.277938	0
2015	18458762.2	14705983.8	656549.151	50714.4937	24457.4282
2016	11384027.6	4493346.54	21872.2315	0	0

2017	27733834.5	8706505	214688.197	18573.7058	7508.17109
2018	33767344.8	13904764.5	558891.303	27371.2254	13574.5224

4.1.2. Spatial distribution of the resources

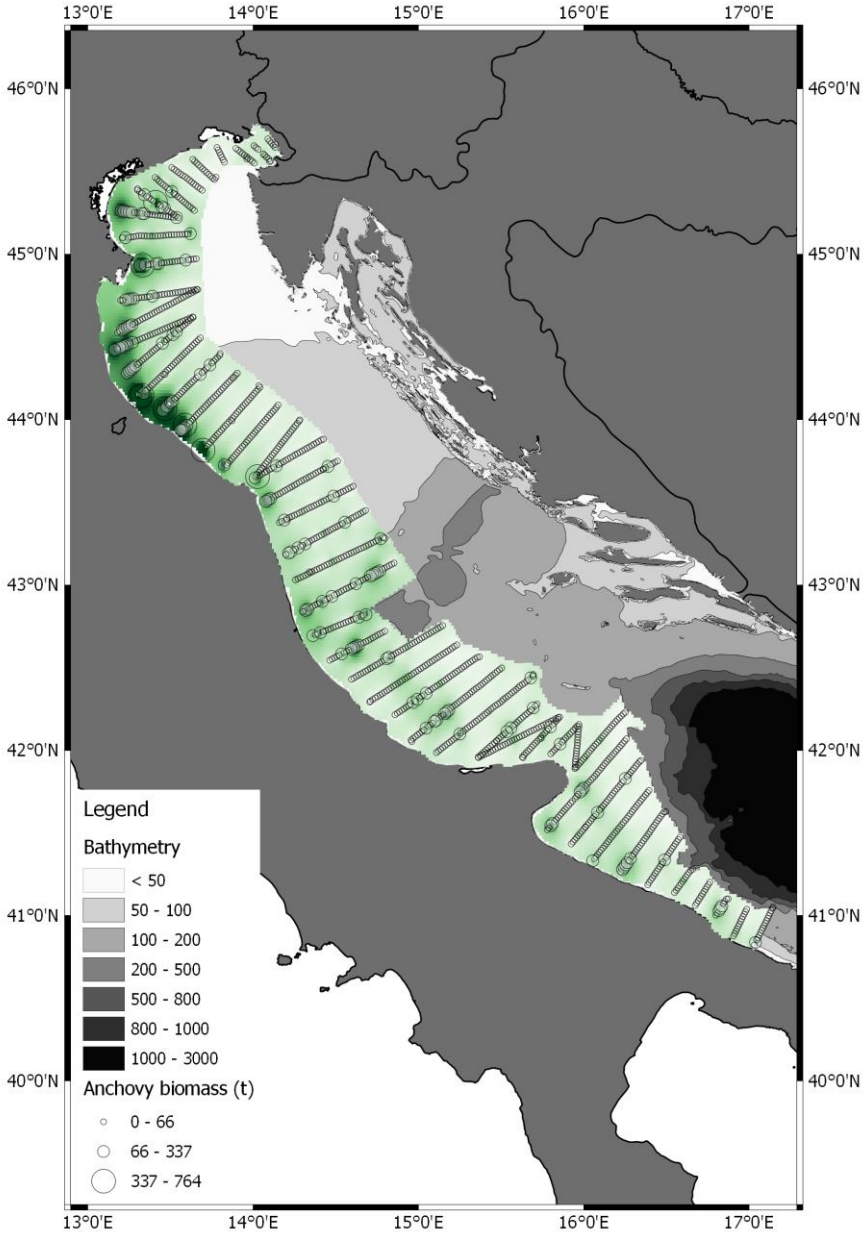


Figure 4.1.2.1. Spatial distribution of Anchovy in GSA17 and GSA 18 West for acoustic survey of 2018.

4.1.3. Historical trends

GSA 17 WEST + GSA 18 WEST-EAST

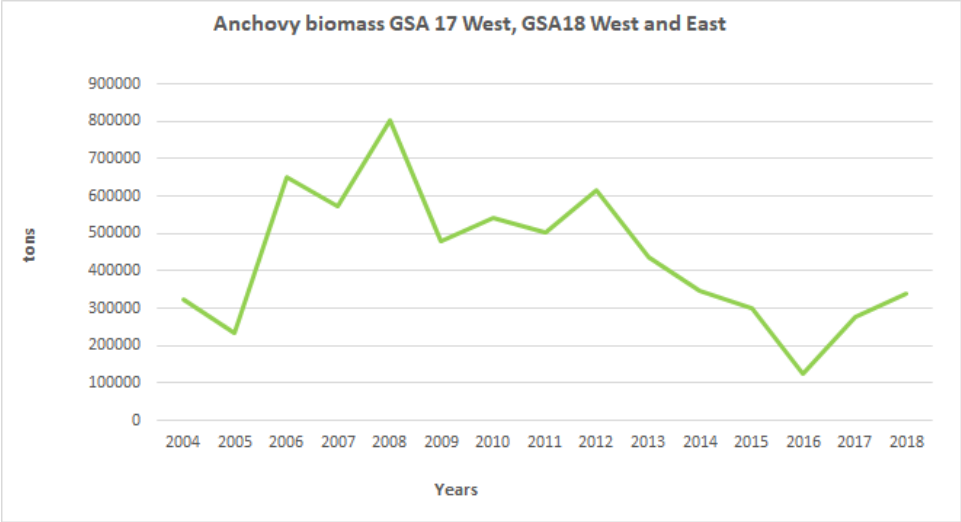


Figure 4.1.3.1. Biomass (tonnes) of anchovy in the Western GSA 17 and Western and Eastern GSA 18 from acoustic surveys carried out from 2004 to 2018.

4.1.4. Anchovy LFD from 2004 to 2018 for GSA 17 West, GSA18 West and East

In the plot below the length frequency distributions observed in the acoustic survey for the three areas (GSA17 West, GSA18 East and GSA18 West) from 2004 to 2018 are shown (Figure 4.1.4.1).

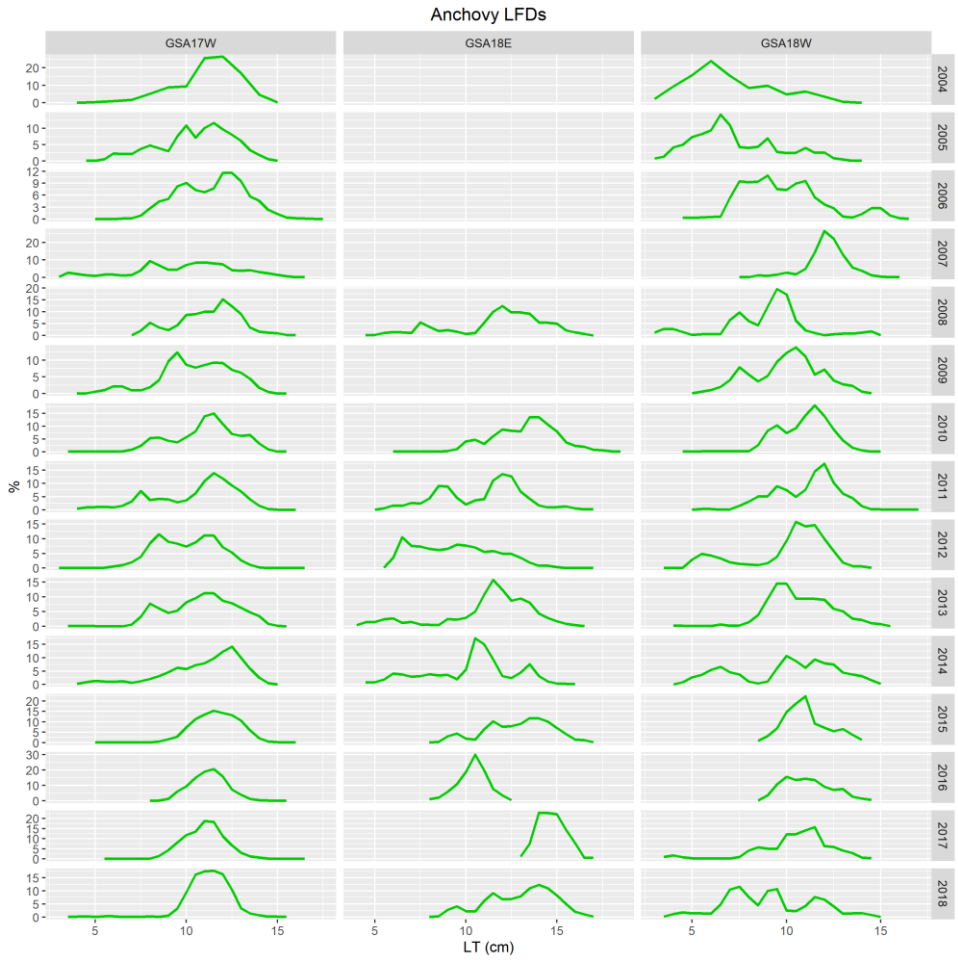


Figure 4.1.4.1. LFD observed in the acoustic survey for GSA 17 West, GSA 18 West and GSA 18 East from 2004 to 2018.

II. GSA 17 EAST

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 net		
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 nm		
TS (Target Strength)/species	Anchovy b20: -74.6		
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, LFD, sex and age structure in numbers and biomass		
Age slicing method	Age-length key by otolith reading		
Maturity ogive used	Macroscopic gonad identification		

4.1.5. Biological parameters and LFD

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. Age reading is performed based on ICES WKARA2 meeting (2016) age-

reading guidelines, and ALKs are determined on annual basis, i.e. for each acoustic survey separately, in line with MEDIAS protocol.

Table 4.1.5.1: Abundance (in thousands) at age from acoustic survey (eastern GSA17) for the years 2013-2018.

Year	Age group 0	Age group 1	Agegroup 2
2013	2477404	2384276	1846
2014	8202814	1417362	1531
2015	3024067	1585048	1875
2016	3410073	1220159	15772
2017	1186925	1344073	0
2018	840929	3381384	0

Spatial distribution of the resources

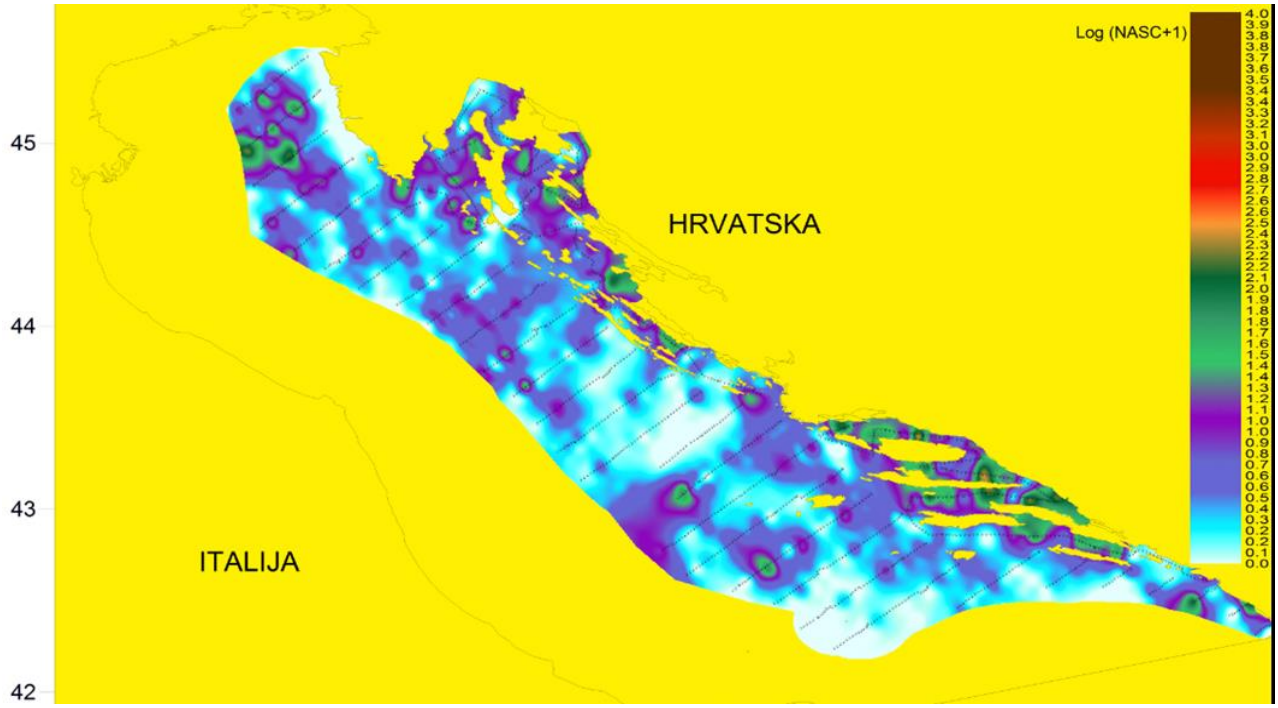


Figure 4.1.4.2. Spatial distribution of anchovy in the eastern part of GSA17 (September, 2018).

Historical trends

Figure 4.1.4.2 shows the biomass trend for the East Echosurvey carried out as Croatian national monitoring programme PELMON.

This year, the stock assessment model includes also the biomass estimates of this survey from years 2003 to 2010. It was chosen to include this third index because the biomass information are the only valid information available coming from this survey for these years. However, it should be noted that in 2011 and 2012 the echosuveys were 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.

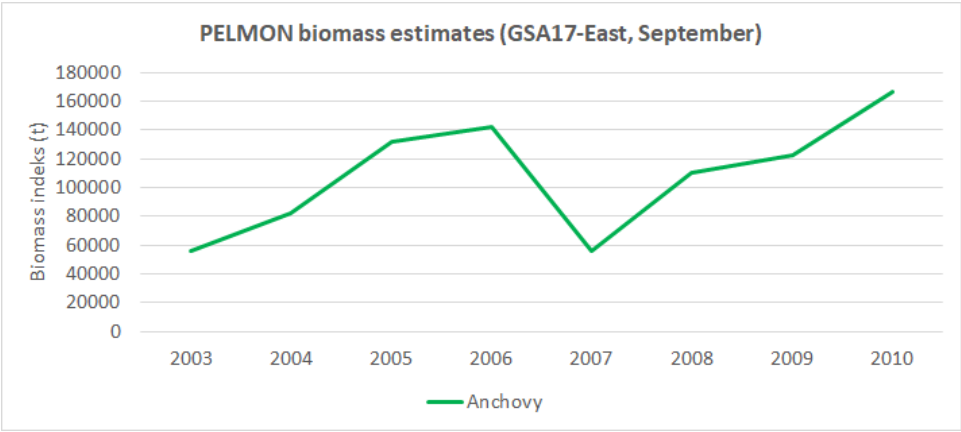


Figure 4.1.4.3. Biomass (tonnes) of anchovy in the Eastern side of GSA 17 estimated by the acoustic surveys carried out from years 2003 to 2010 as used in assessment for tuning purpose.

Anchovy LFD from 2013 to 2018 for East Echosurvey GSA 17

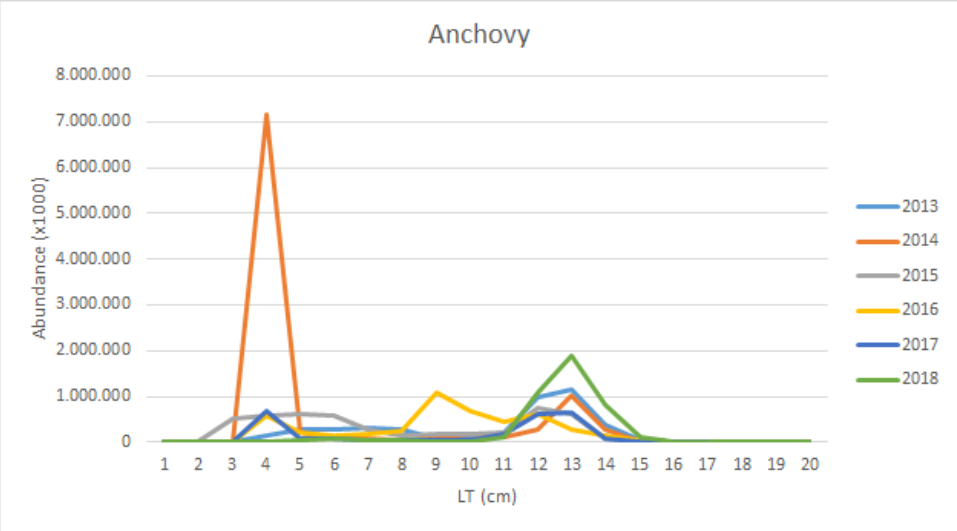


Figure 4.1.4.4. Anchovy LFD from MEDIAS 2013-2018 carried out in the eastern part of GSA17.

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 anchovy in GSA 17 from 1975 to 2018.
Acoustic surveys data were available and used as tuning indices from 2004 to 2018.

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. MEDIAS estimates were included in the assessment model considering three tuning indexes:

1) Acoustic survey West that includes the western side of GSA 17 and the entire GSA 18 in the form of numbers-at-age from 2004 to 2018 obtained with the ALK of 2016;
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 (2019).
3) Acoustic survey East biomass that includes the eastern side of GSA 17 in the form of total biomass from 2003 to 2012.

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

The control file with the final settings is shown below:

```
################################################
An object of class "FLSAM.control"
Slot "name":
[1] "Anchovy - Adriatic Sea - GSA 17 and 18"


Slot "desc":
[1] "Imported from a VPA file. ( D:/FAO/ANE/update/Ane17_18.ndx ).  Fri May 17 11:01:22
2019"


Slot "range":
    min     max plusgroup   minyear   maxyear   minfbar   maxfbar
      0       4         4      1975      2018         1         2


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    0  1  2  3  3
  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
0 0 0 0 0

Slot "logP.vars":
numeric(0)

Slot "catchabilities":
	age				
fleet	0	1	2	3	4
catch unique	-1	-1	-1	-1	-1
Echo West	0	1	2	3	3
Echo East	4	5	6	-1	-1
Echo East Biomass	7	-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	0	0	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 "obs.vars":
	age				
fleet	0	1	2	3	4
catch unique	0	1	2	3	3
Echo West	4	5	6	6	7
Echo East	8	9	10	-1	-1
Echo East Biomass	11	-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] 0


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

The catch and indices numbers at age used in the assessment are reported in tables from 6.1.3.1 to 6.1.3.3.

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	482092	546700	855182	703778	608478	396695	363550	311340	226546	235759
1	838593	871860	1151096	1635116	1401892	1263525	897099	684511	491870	515742
2	526958	620105	628420	1405033	1169253	1507232	909873	813774	585420	612714
3	126873	212748	276774	721213	701390	1093211	536268	580203	437479	448569
4	67692	143470	230727	276345	346055	496358	195789	354486	285655	293053
Age	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**
0	469534	199939	91551	360736	529317	399513	664502	239126	321326	743359
1	752725	186764	80929	271133	287824	391977	503464	285232	285794	557188
2	739741	144217	62344	129518	185917	187817	281725	229990	227184	272533
3	564111	115497	39121	56632	69425	53015	111255	89614	86514	74472
4	739260	175410	25316	31938	18800	13257	33338	25370	23056	15473
Age	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
0	779560	637643	1033852	550646	910877	551555	303874	185243	540595	889913
1	854068	629839	921285	675040	802753	1352876	1223921	980195	1576735	1310272
2	488011	436178	547882	505319	411223	658685	610490	517524	468440	852746
3	149939	160960	150329	152831	88520	215994	176276	128525	54943	126502
4	32304	39182	30795	32790	15399	42218	32814	24269	1473	9896
Age	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
0	828627	625804	306937	328454	588808	470353	578464	648892	306895	332484
1	2105130	1104045	1008445	708483	2220233	2048993	1678148	1369598	1029190	1053303
2	1067552	1945985	2172848	1584265	1255758	1606682	1183670	1079939	819622	1136174
3	147358	305944	698241	432828	130538	121756	98578	32647	51239	186128
4	1814	30817	121239	67849	19687	15213	19466	4065	1570	3169
Age	**2015**	**2016**	**2017**	**2018**						
0	215147	332131	2103659	1641336						
1	1547601	1594711	791204	791204						
2	1517949	1142627	528361	528361						
3	116784	45008	27852	27852						
4	3219	478	270	1324						

Table 6.1.3.2. 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	35560684.9	18764019.5	613692.291	5645.13828	2540.31222
2005	40787856.7	10033202.1	134556.873	4071.97436	1832.38846
2006	76696622	26700887.6	3988381.17	151803.213	61547.1085
2007	73618537.8	28091727.7	2747682.06	70127.2059	25026.4262
2008	64723232.3	44561925.9	1557485.57	64161.2556	13155.999
2009	73769476.8	21903650.5	429700.55	16420.985	19589.947

2010	45236307.6	26066281.5	566015.614	21459.645	25600.98
2011	49485704.4	23424898.2	305349.909	17105.153	13497.9207
2012	86799211	18037774.1	62577.0285	6364.26054	6914.5557
2013	43260113.2	18805485.3	480455.723	946.02643	157.671072
2014	28448152.9	18667773.4	273617.197	133.277938	0
2015	18458762.2	14705983.8	656549.151	50714.4937	24457.4282
2016	11384027.6	4493346.54	21872.2315	0	0

2017	27733834.5	8706505	214688.197	18573.7058	7508.17109
2018	33767344.8	13904764.5	558891.303	27371.2254	13574.5224

Table 6.1.3.3. 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**		
0	2477404	8202814	3024067	3410073		
1	2384276	1417362	1585048	1220159		
2	1846	1531	1875	15772		

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.).

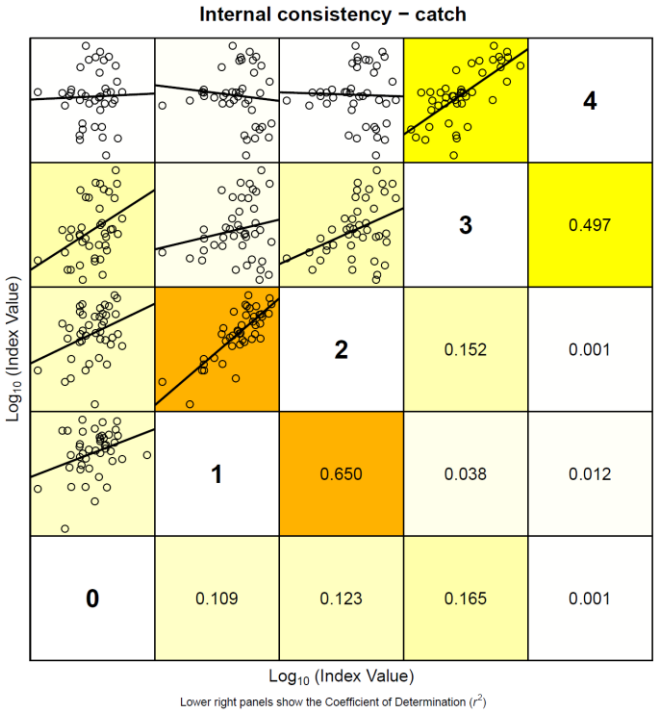


Figure 6.1.3.1. Catch at age data (numbers at age) between-year consistency plot for GSA 17 West-East and GSA 18 West-East anchovy.

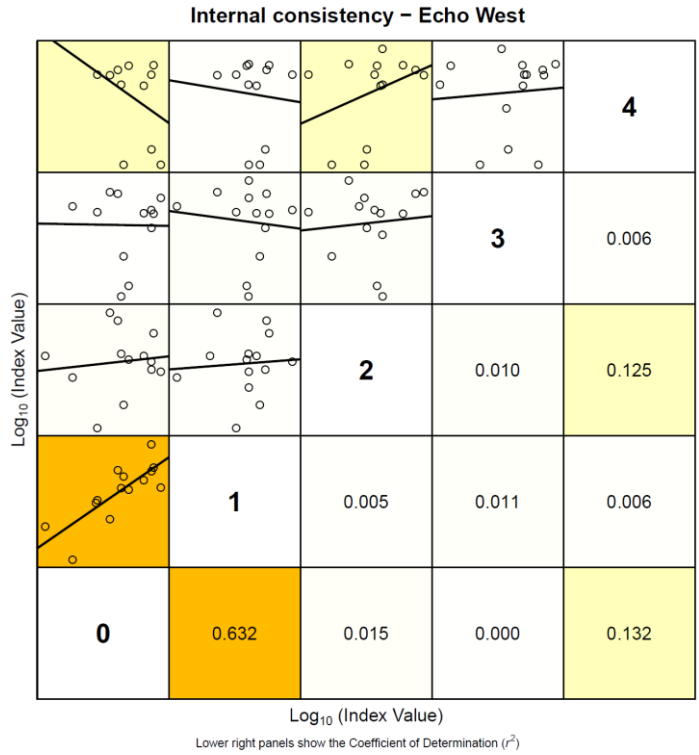


Figure 6.1.3.2. MEDIAS acoustic survey index (numbers at age) between-year consistency plot for GSA 17 West and GSA 18 West-East anchovy.

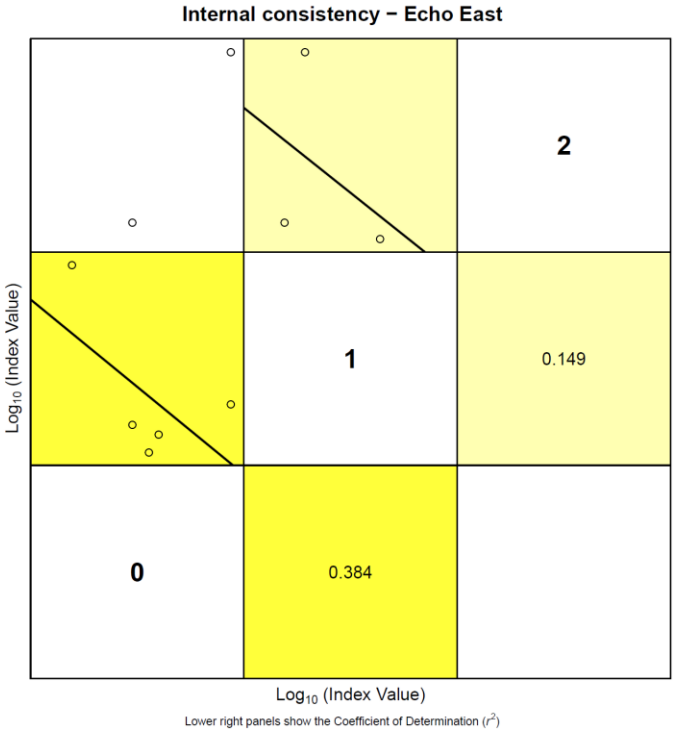


Figure 6.1.3.3. MEDIAS acoustic survey index between-year consistency plot for GSA 17 East anchovy.

6.1.4 Results

The average fishing mortality for ages 1-2 (presented in figure 6.1.4.1., middle) shows an increasing trend over the considered time series reaching a first peak in 2011 (F=1.439) and a second one in 2015 (F=1.545). In the following years a slight decreasing trend is depicting reaching the value of 1.075 in 2018.

The spawning stock biomass (figure 6.1.4.1., top) fluctuates from the highest values in the late seventies (about 348,574 tonnes) to a first drop in the 1987 with a biomass of 46,451 tonnes. After that the stock recovers and peaks again in 2005 with a biomass of 201,720 tonnes. From then on, it shows a generally descending trend reaching a new drop in 2015 (56,188). The value for year 2028 accounts for 113,353 tonnes.

The recruitment (age 0 – figure 6.1.4.1., bottom) follows the trend of the SSB, showing however less fluctuations. After a big peak in the seventies (223,942,191 number of individuals) and a drop in the late eighties (23,401,552 number of individuals), the recruitment shows a more or less constant increase reaching a peak in 2005 (113,071,263 number or individuals). Afterwards, it shows a mild but constant decrease. The current value (2018) is 62,608,989 number of individuals.

Table 6.1.4. Results of the final FLSAM assessment of anchovy 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	1.91E+08	1.19E+08	3.09E+08	983853.9	647184.3	1495661	246642.1	164327.2	370190.3
1976	2.13E+08	1.4E+08	3.26E+08	1353685	916860.1	1998630	320856.7	219775.3	468428.6
1977	2.24E+08	1.5E+08	3.35E+08	1333496	932812.9	1906289	348573.9	245288.3	495350.9
1978	2.07E+08	1.41E+08	3.05E+08	1281570	915760	1793506	343843.4	247306.5	478063.8

1979	1.71E+08	1.17E+08	2.5E+08	1130378	821048.9	1556247	316819.3	231512.2	433560
1980	1.33E+08	91776022	1.94E+08	872236.9	642980.5	1183235	256766.4	189290	348296.1
1981	1.03E+08	70972347	1.48E+08	760543.8	560256.3	1032433	209231.3	155716.7	281137
1982	77487612	54066777	1.11E+08	574943.2	430410.1	768010.9	166661.1	124853.2	222468.7
1983	57229970	39936071	82012811	435014.8	328493.9	576077.3	126409.1	96132.54	166221.1
1984	39490441	27512975	56682164	318472.1	242654.8	417978.4	95585.94	73171.76	124866.1
1985	28266058	19611539	40739794	179800.4	138595.8	233255.2	57422.74	42460.04	77658.21
1986	23401552	16229711	33742601	215876.6	159198.5	292733.3	54865.92	40270.9	74750.46
1987	24747317	17247756	35507791	210348.9	151941.7	291208	46450.84	34251.64	62994.96

1988	29988874	21199446	42422455	238083.6	176538.8	321084.3	56678.52	42844.96	74978.58
1989	34806664	24662203	49123911	273743.9	203799.3	367693.6	64375.14	49017.21	84544.96
1990	35569879	25282826	50042518	282264.4	211882.4	376025.4	69613.4	53166.92	91147.36
1991	36226659	25785376	50895936	245663.8	187244.2	322310.1	65586.42	50306.26	85507.83
1992	36198206	25728461	50928430	267825	201953.4	355182.1	66575.69	51206.47	86557.88
1993	44023450	31494984	61535645	296920	224154.5	393306.6	71651.92	55262.87	92901.41
1994	52443199	37685750	72979552	359349.8	274107.8	471100.5	90268.71	70011.4	116387.3
1995	54914582	39536179	76274729	487003.2	371195.5	638941.2	115154.5	89708.84	147817.7
1996	56343137	40628691	78135650	483117.7	368150	633988.1	112489.6	87803.58	144116.2

1997	57497038	41440017	79775772	456214.3	350594	593653.9	110540.4	86436.7	141365.5
1998	58514558	42246533	81046970	554428.6	420071	731759.9	121180.2	94315.07	155697.8
1999	62891398	45613510	86713955	558734.3	424449	735504.1	120919.4	94400.05	154888.8
2000	60238014	43829401	82789594	342028.9	267145.5	437902.7	83085.64	65695.84	105078.6
2001	59111422	42908798	81432256	384280.5	296298.4	498387.7	84516.51	66510.58	107397.1
2002	70152067	50597848	97263277	453881	342685.6	601157.2	91982.27	71427.28	118452.5
2003	89736525	65473088	1.23E+08	546320.9	416870.3	715969.7	115665.4	90390.36	148007.8
2004	1.08E+08	79034858	1.47E+08	723235.5	554474.8	943360.5	152826.6	120438.5	193924.4
2005	1.13E+08	83938105	1.52E+08	873521.7	680301.5	1121620	201719.6	158796.8	256244.3

2006	1.12E+08	83606861	1.51E+08	845187.3	664292.4	1075342	193735.2	155367.8	241577.3
2007	1.02E+08	75702617	1.38E+08	607806.7	481259.2	767630.1	141769.2	114737.8	175169.1
2008	1.07E+08	79443678	1.45E+08	644525.5	503931.7	824344.2	137755.9	110350.4	171967.5
2009	1.06E+08	78344347	1.44E+08	607608.9	475080.3	777107.8	135336.9	108269.4	169171.4
2010	93032232	69241047	1.25E+08	522830.2	414087.3	660130	115768.9	92784.23	144447.3
2011	84737218	62999721	1.14E+08	483934.3	381495.7	613879.5	104719.3	83695.69	131023.8
2012	82881478	61095715	1.12E+08	329589.5	260852.4	416439.6	75971.75	60571.23	95287.92
2013	70586661	52689181	94563563	369202.2	293466.8	464482.8	85866.11	69236.83	106489.4
2014	62657972	46449628	84522128	504932.1	390455.6	652971.5	100882.9	79520.2	127984.6

2015	49089038	35628499	67635005	362779.4	281163	468087.5	76913.75	61181.22	96691.85
2016	47114949	33689384	65890738	272974.3	208322.9	357689.7	56187.54	43964.28	71809.19
2017	61658693	42480987	89494021	447999.5	326049.1	615562.5	92509.9	69482.49	123168.9
2018	62608989	39368914	99568036	504447.2	337748	753422.7	113353	76233.33	168547.2

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 1-2 Mean**	**Mean F ages 1-2 Low**	**Mean F ages 1-2 High**	**Mean F ages 0-1**	**SoP (%)**
1975	22830.8	18619.98	27993.88	0.0926	0.1133	0.0756	0.1609	0.0952	0.2720	0.0516	1
1976	28884.58	23990.56	34776.97	0.0900	0.1092	0.0742	0.1596	0.1006	0.2532	0.0505	1

1977	36473.64	29947.74	44421.6	0.1046	0.1221	0.0897	0.1580	0.1008	0.2478	0.0520	1
1978	48618.48	39810.73	59374.86	0.1414	0.1610	0.1242	0.1996	0.1366	0.2916	0.0616	1
1979	50819.56	41708.37	61921.08	0.1604	0.1802	0.1428	0.2052	0.1412	0.2984	0.0618	1
1980	52270.74	41982.91	65079.59	0.2036	0.2218	0.1869	0.2308	0.1608	0.3311	0.0661	1
1981	37338.02	30142.92	46250.58	0.1785	0.1936	0.1645	0.2159	0.1496	0.3116	0.0644	1
1982	34775.04	28127.6	42993.49	0.2087	0.2253	0.1933	0.2212	0.1543	0.3172	0.0657	1
1983	28268.21	22553.6	35430.78	0.2236	0.2346	0.2132	0.2283	0.1576	0.3307	0.0689	1
1984	27481.09	21879.86	34516.24	0.2875	0.2990	0.2764	0.2955	0.2118	0.4122	0.0893	1

1985	27334.89	18415.33	40574.7	0.4760	0.4337	0.5225	0.4235	0.2454	0.7310	0.1451	1
1986	17393.69	13139.31	23025.59	0.3170	0.3263	0.3080	0.2877	0.1980	0.4180	0.1049	1
1987	7585.061	5162.103	11145.29	0.1633	0.1507	0.1769	0.2167	0.1359	0.3453	0.0705	1
1988	10538.99	8743.648	12702.98	0.1859	0.2041	0.1694	0.2891	0.2057	0.4065	0.0979	1
1989	13402.33	11144.54	16117.51	0.2082	0.2274	0.1906	0.3249	0.2332	0.4527	0.1113	1
1990	15272.87	12582.5	18538.48	0.2194	0.2367	0.2034	0.3427	0.2484	0.4728	0.1216	1
1991	18400.9	14914.23	22702.7	0.2806	0.2965	0.2655	0.3925	0.2792	0.5517	0.1347	1
1992	15965.78	13109.67	19444.13	0.2398	0.2560	0.2246	0.3648	0.2635	0.5050	0.1080	1

1993	15766.73	12855.14	19337.77	0.2200	0.2326	0.2082	0.3603	0.2602	0.4990	0.1034	1
1994	21405.72	17768.72	25787.18	0.2371	0.2538	0.2216	0.3901	0.2853	0.5333	0.1245	1
1995	32147.34	26192.78	39455.59	0.2792	0.2920	0.2669	0.4717	0.3483	0.6390	0.1518	1
1996	31502.6	26316.75	37710.34	0.2800	0.2997	0.2617	0.4787	0.3545	0.6464	0.1442	1
1997	36064.19	29812.88	43626.3	0.3263	0.3449	0.3086	0.5490	0.4049	0.7444	0.1641	1
1998	33523.01	28017.3	40110.65	0.2766	0.2971	0.2576	0.5332	0.3959	0.7183	0.1565	1
1999	30647.29	24957.47	37634.3	0.2535	0.2644	0.2430	0.5201	0.3758	0.7197	0.1658	1
2000	34573.42	28316.24	42213.29	0.4161	0.4310	0.4017	0.6731	0.5044	0.8982	0.2163	1

2001	33609.54	27654.06	40847.57	0.3977	0.4158	0.3803	0.8071	0.5960	1.0931	0.2292	1
2002	27492.53	22683.34	33321.34	0.2989	0.3176	0.2813	0.7950	0.5930	1.0657	0.2123	1
2003	30450.89	24337.51	38099.9	0.2633	0.2692	0.2574	0.7553	0.5645	1.0106	0.1915	1
2004	37539.39	31454.16	44801.88	0.2456	0.2612	0.2310	0.6575	0.4966	0.8705	0.1539	1
2005	53218.01	43250.02	65483.37	0.2638	0.2724	0.2556	0.5917	0.4359	0.8030	0.1430	1
2006	60588.85	50501.95	72690.43	0.3127	0.3250	0.3009	0.6157	0.4554	0.8326	0.1030	1
2007	57402.45	45676.61	72138.47	0.4049	0.3981	0.4118	0.7491	0.5648	0.9936	0.0985	1
2008	48423.87	40509.49	57884.49	0.3515	0.3671	0.3366	0.8610	0.6496	1.1410	0.1015	1

2009	50406.94	41187.34	61690.3	0.3725	0.3804	0.3647	0.9668	0.7464	1.2522	0.1715	1
2010	53385.91	44320.23	64305.96	0.4611	0.4777	0.4452	1.2288	0.9603	1.5723	0.2092	1
2011	45445.08	37612.54	54908.69	0.4340	0.4494	0.4191	1.4389	1.1101	1.8650	0.2096	1
2012	36016.49	30003.69	43234.28	0.4741	0.4953	0.4537	1.2780	1.0041	1.6267	0.1970	1
2013	30865.35	24015.84	39668.39	0.3595	0.3469	0.3725	0.9992	0.6883	1.4505	0.1626	1
2014	31730.33	26479.94	38021.76	0.3145	0.3330	0.2971	1.2271	0.9269	1.6245	0.1719	1
2015	37380.43	29327.78	47644.13	0.4860	0.4794	0.4927	1.5449	1.2282	1.9432	0.2272	1
2016	30550	23073.84	40448.5	0.5437	0.5248	0.5633	1.4922	1.1607	1.9184	0.2864	1

2017	30483.36	24409.34	38068.84	0.3295	0.3513	0.3091	1.1505	0.8511	1.5553	0.2036	1.000002
2018	34974.78	27989.72	43703.02	0.3085	0.3672	0.2593	1.0749	0.6504	1.7764	0.1553	0.999993

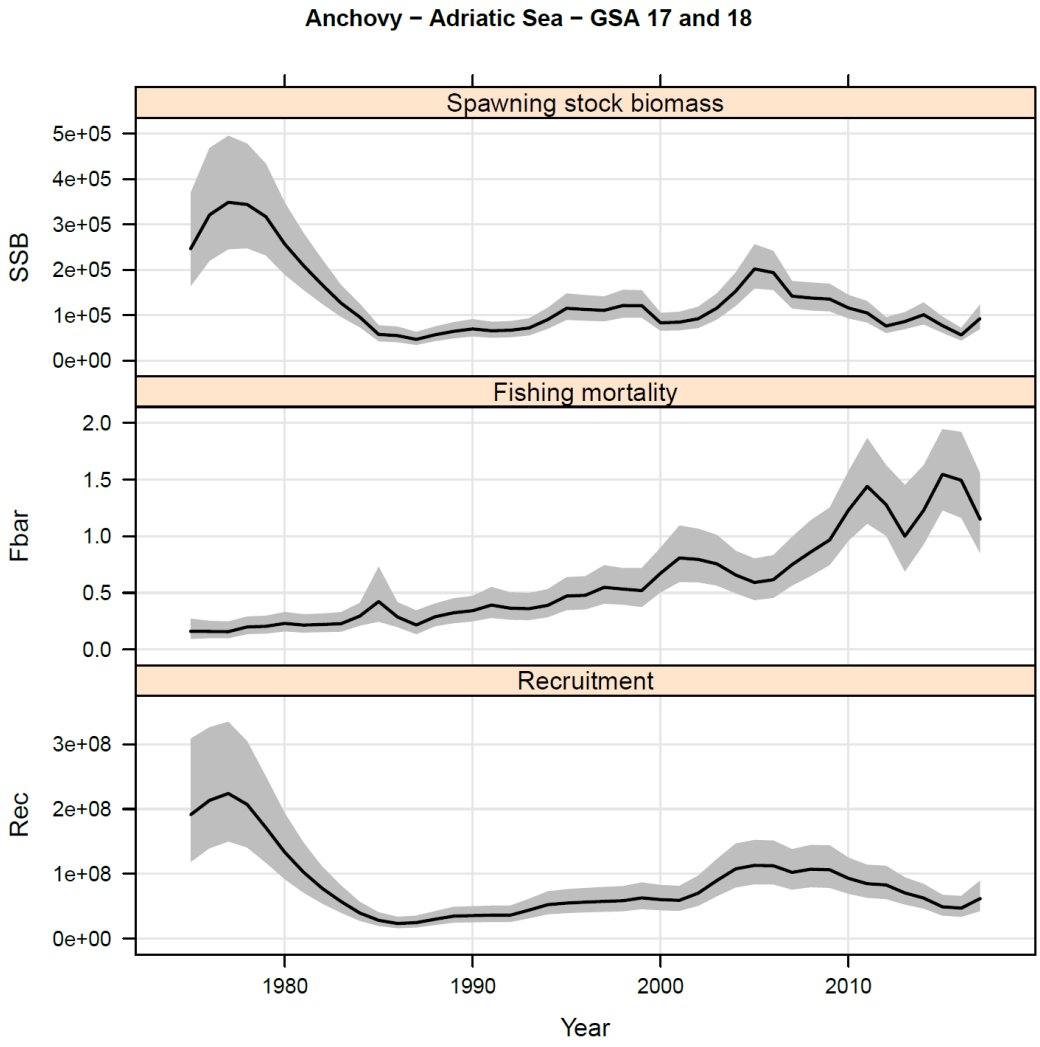


Figure 6.1.4.1. Anchovy results from SAM model: SSB, F and recruitment estimates.

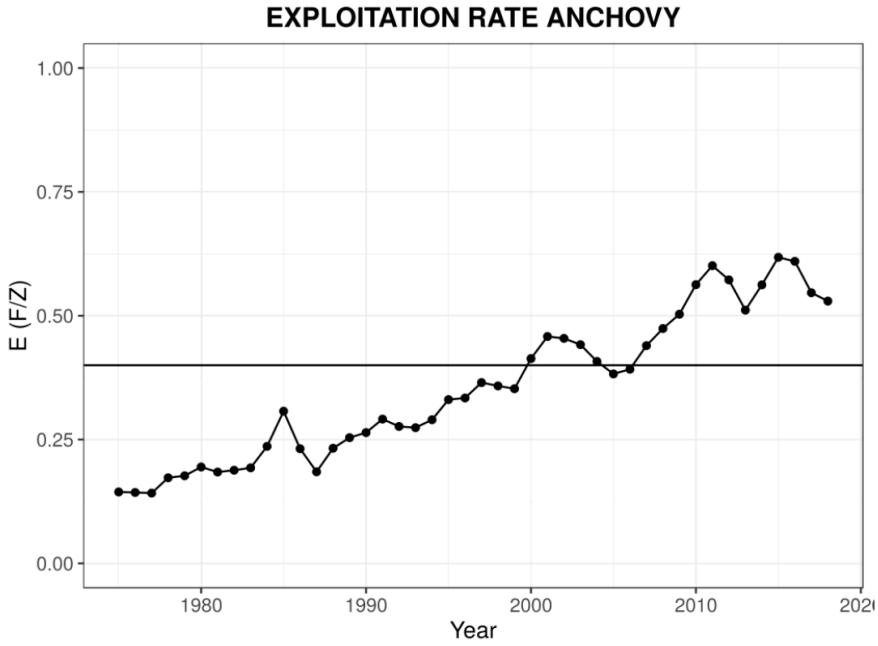


Figure 6.1.4.2 Trends in exploitation rate for anchovy in GSA 17-18. Horizontal line indicates the Patterson's reference points used for advice (E = 0.4)

7. *Robustness analysis*

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

The retrospective analysis was run on 4 year. The outputs are shown in Figure 8.1. and describe a consistent behavior of the assessment model.

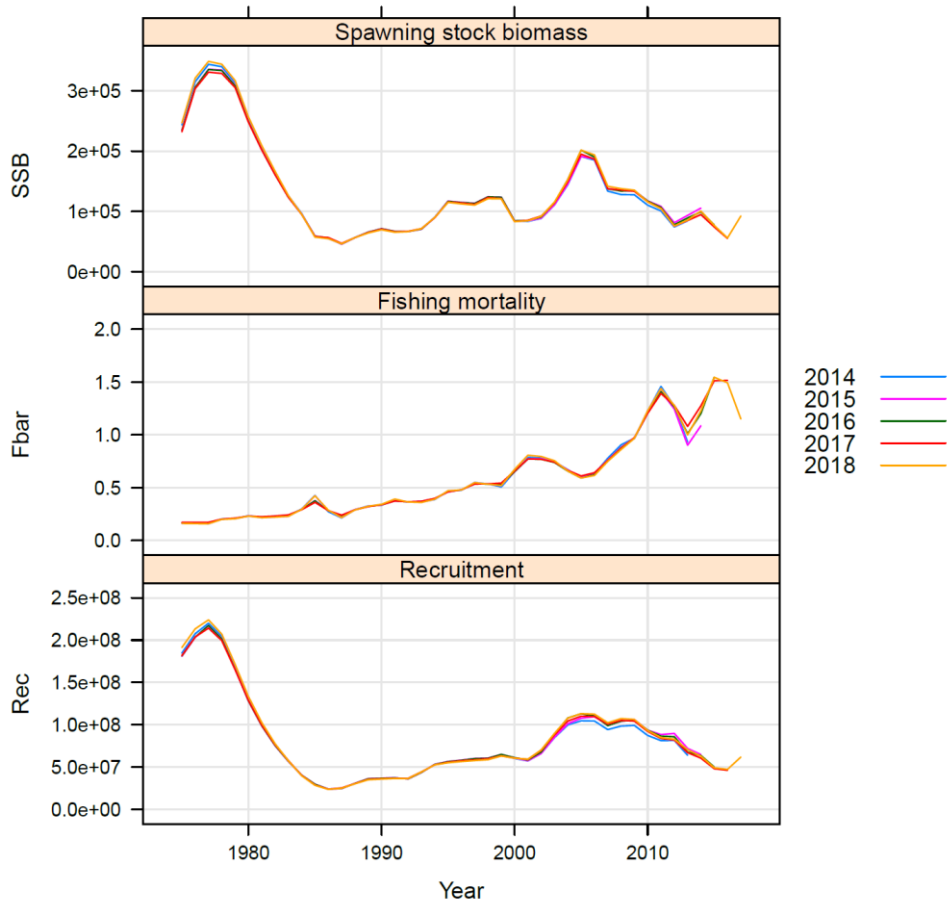


Figure 8.1. FLSAM retrospective patterns for currently accepted assessment.

Figure 8.2 shows the weight given to the different input data. Catch data from age 2 and 1 account for the slowest observation variance, then we have Echo East age 1, catch data age 0, Echo West age 0 and 1, catch data age 3 and 4. The other information account for higher observation variance.

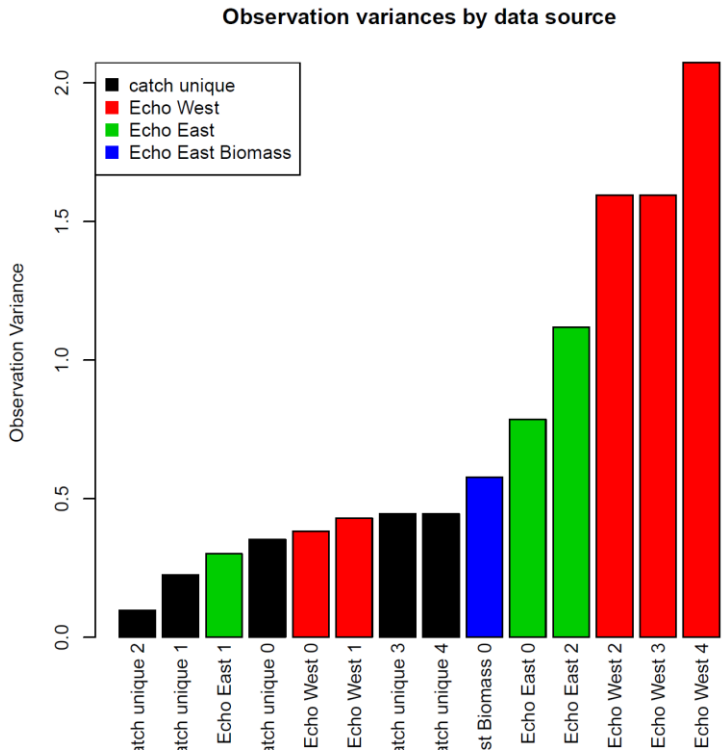


Figure 8.2 Observation variances by data source of anchovy in GSA17-18.

9. *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.; catch at age for 2017 reported with the old ALK by Italy and Croatia; catch at age for 2018 estimated using assumed ALK

b. **Revised dataset.** Time series: 1975 – 2018. Features: new ageing criteria and birthdate applied; all commercial catches revised using new ALK; Italian surveys revised using new ALK; Croatian surveys used old ALK.

c. **Revised short time series.** Time series: 2001 – 2018. Features: revised dataset truncated.

The revised short time series scenario was attempted but the model did not converge with the different parameter specifications tested and therefore results were not provided for this scenario. 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.

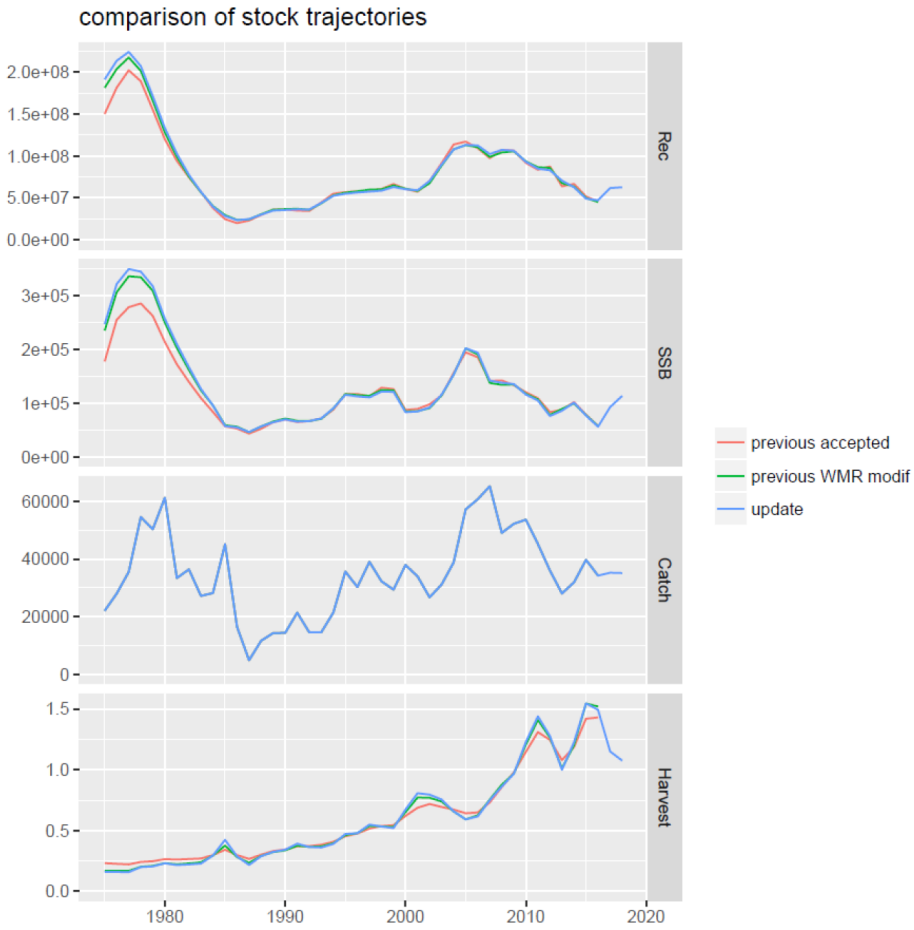


Figure 9.1 Outputs of the assessment for anchovy in GSA17-18. From top to bottom, trends in Recruitment, Spawning Stock Biomass (SSB), catches and fishing mortality (Harvest). The blue line represents the updated assessment including data up to 2018, the red line represents the previously GFCM advice (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.

10. Stock Simulations

11. 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 11.1 Short term forecast for anchovy. 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} = 0.52)

Fmult	Fbar	Catch 2018	Catch 2019	Catch 2020	Catch 2021	SSB 2019	SSB 2020	SSB 2021	SSB change	Catch change
0.00	0.00	35144	39721	0	0	91040	104821	119353	13.86	-100.00
0.10	0.12	35144	39721	5128	7219	91040	102430	113260	10.57	-85.41
0.20	0.25	35144	39721	9724	12785	91040	100202	108200	7.98	-72.33
0.30	0.37	35144	39721	13873	17181	91040	98120	103944	5.94	-60.53
0.40	0.49	35144	39721	17645	20738	91040	96173	100319	4.31	-49.79
0.50	0.61	35144	39721	21098	23689	91040	94347	97191	3.01	-39.97
0.60	0.74	35144	39721	24280	26193	91040	92633	94462	1.97	-30.91
0.70	0.86	35144	39721	27231	28366	91040	91019	92053	1.14	-22.52
0.80	0.98	35144	39721	29983	30288	91040	89498	89906	0.45	-14.69
0.90	1.10	35144	39721	32564	32018	91040	88062	87972	-0.10	-7.34
1.00	1.23	35144	39721	34996	33596	91040	86702	86217	-0.56	-0.42
1.10	1.35	35144	39721	37298	35054	91040	85413	84610	-0.94	6.13
1.20	1.47	35144	39721	39487	36414	91040	84189	83130	-1.26	12.36
1.30	1.59	35144	39721	41575	37693	91040	83024	81756	-1.53	18.30
1.40	1.72	35144	39721	43573	38904	91040	81913	80474	-1.76	23.99
1.50	1.84	35144	39721	45491	40056	91040	80852	79272	-1.95	29.44
1.60	1.96	35144	39721	47338	41157	91040	79838	78140	-2.13	34.70
1.70	2.09	35144	39721	49118	42214	91040	78865	77069	-2.28	39.76
1.80	2.21	35144	39721	50840	43230	91040	77932	76052	-2.41	44.66
1.90	2.33	35144	39721	52507	44210	91040	77036	75083	-2.54	49.41
2.00	2.45	35144	39721	54124	45157	91040	76172	74157	-2.65	54.01
0.52	**0.64**	**35144**	**39721**	**21724**	**24196**	**91040**	**94012**	**96643**	**2.80**	**-38.19**

12. Medium term predictions

13. Long term predictions

14. Draft scientific advice

The current fishing mortality results to be 1.075 accounting for an exploitation pattern of 0.53. Considering the reference point of 0.4 (Patterson, 1992), the current E exceed the reference point thus the stock is in an overexploitation. Instead the current SSB is above the reference points (B_{lim} and B_{pa}) describing a relative high biomass for this stock.

(Examples in blue)

Based on	Indicator	Analytical 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} = 1.075 E_{2018} = 0.530		I	IO_H
	Fishing effort					
	Catch				D	
Stock abundance	Biomass					
	SSB	B_{lim}=45,936 B_{pa}=91,872	B_{cur}= 113,353		D	SO_H
Recruitment						
Final Diagnosis		In overfishing with relative high biomass.				

1.1. Explanation of codes

Trend categories

1) N - No trend
2) I - Increasing
3) D – Decreasing
4) C - Cyclic

Stock Status

Based on Fishing mortality related indicators

1) **N - Not known or uncertain** – Not much information is available to make a judgment;
2) **U - undeveloped or new fishery** - Believed to have a significant potential for expansion in total production;
3) **S - Sustainable exploitation**- fishing mortality or effort below an agreed fishing mortality or effort based Reference Point;
4) **IO –In Overfishing status**– fishing mortality or effort above the value of the agreed fishing mortality or effort based Reference Point. An agreed range of overfishing levels is provided;

Range of Overfishing levels based on fishery reference points

In order to assess the level of overfishing status when $F_{0.1}$ from a Y/R model is used as LRP, the following operational approach is proposed:

- If $Fc^*/F_{0.1}$ is below or equal to 1.33 the stock is in **(O_L): Low overfishing**
- If the $Fc/F_{0.1}$ is between 1.33 and 1.66 the stock is in **(O_I): Intermediate overfishing**
- If the $Fc/F_{0.1}$ is equal or above to 1.66 the stock is in **(O_H): High overfishing**

*Fc is current level of F

5) **C- Collapsed**- no or very few catches;

Based on Stock related indicators

1) **N - Not known or uncertain:** Not much information is available to make a judgment
2) **S - Sustainably exploited:** Standing stock above an agreed biomass based Reference Point;
3) **O - Overexploited**: Standing stock below the value of the agreed biomass based Reference Point. An agreed range of overexploited status is provided;

Empirical Reference framework for the relative level of stock biomass index

- **Relative low biomass:** Values lower than or equal to 33rd percentile of biomass index in the time series **(O_L)**

- **Relative intermediate biomass:** Values falling within this limit and 66th percentile **(O_I)**
- **Relative high biomass:** Values higher than the 66th percentile **(O_H)**

4) **D – Depleted**: Standing stock is at lowest historical levels, irrespective of the amount of fishing effort exerted;
5) **R –Recovering:** Biomass are increasing after having been depleted from a previous period;

Agreed definitions as per SAC Glossary

Overfished (or overexploited) *- A stock is considered to be overfished when its abundance is below an agreed biomass based reference target point, like B0.1 or BMSY. To apply this denomination, it should be assumed that the current state of the stock (in biomass) arises from the application of excessive fishing pressure in previous years. This classification is independent of the current level of fishing mortality.*

Stock subjected to overfishing (or overexploitation) *- A stock is subjected to overfishing if the fishing mortality applied to it exceeds the one it can sustainably stand, for a longer period. In other words, the current fishing mortality exceeds the fishing mortality that, if applied during a long period, under stable conditions, would lead the stock abundance to the reference point of the target abundance (either in terms of biomass or numbers).*