

SAC GFCM

Sub-Committee on Stock Assessment

Date* 27 October 2011

Code* PIL1711Doc

Authors*

Document prepared by the AdriaMed (MIPAAF-FAO project) working group for small pelagics:
 Santojanni A. (1), Leonori I. (1), Carpi P. (1), De Felice A. (1), Angelini S. (1), Belardinelli A. (1), Biagiotti I. (1), Canduci G., Cikes Kec V. (3), Cingolani N. (1), Colella S. (1), Donato F. (1), Marceta B. (2), Modic T. (2), Panfili M. (1), Pengal P. (2), Ticina V. (3), Zorica B. (3)

Affiliation*

1) CNR-ISMAR, Ancona (Italy)
 2) Fisheries Research Institute of Slovenia, Ljubljana (Slovenia)
 3) Institute of Oceanography and Fisheries, Split (Croatia)

Species Scientific name*

- 1** *Sardina pilchardus* - *PIL*
 Source: GFCM Priority Species
- 2**
 Source: -
- 3**
 Source: -

Geographical area*

Northern and central Adriatic Sea (southern limit: Gargano Promontory).

Geographical Sub-Area (GSA)*

17 - Northern Adriatic

Combination of GSAs 1
 2
 3

SAC GFCM - Sub-Committee on Stock Assessment (SCSA)

Assessment form

Sheet #0

Basic data on the assessment

Code: PIL1711Doc

Date*	27	Oct	2011	Authors*	Document prepared by the AdriaMed (MIPAAF-FAO project) working group for small pelagics: Santojanni A. (1), Leonori I. (1), Carpi P. (1), De Felice A. (1),
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Species Scientific name*	Sardina pilchardus - PIL	Species common name*	Sardine
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Data Source

GSA*	17 - Northern Adriatic	Period of time*	1975-2010
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Description of the analysis

Type of data*	Catch at age and echo-survey abundance index for tuning.	Data source*	Database (containing data from different sources) shared by the three research institutes of Ancona, Ljubljana, Split.
Method of assessment*	Virtual Population Analysis (VPA) with Laurec-Shepherd tuning.	Software used*	Lowestoft MAFF-VPA by Darby and Flatman (1994).

Sheets filled out

B	P1	P2a	P2b	G	A1	A2	A3	Y	Other	D	Z	C
1	---	---	---	---	1	1	2	---	2	1	1	---

Comments, bibliography, etc.

Darby C.D., Flatman S. 1994. Virtual Population Analysis: version 3.1 (Windows/Dos) user guide. Information Technology Series, MAFF Directorate of Fisheries Research, Lowestoft, 1: 85 pp.

Gislason H., N. Daan, J.C. Rice, J.G. Pope. 2008. Does natural mortality depend on individual size? ICES CM 2008/F:16.

Patterson K. 1992. Fisheries for small pelagic species: an empirical approach to management targets. Review of Fish Biology and Fisheries, 2: 321-338.

Santojanni A, Cingolani N., Arneri A., Donato F., Colella S., Giannetti G., Belardinelli A., Panfili M. 2008. Biological sampling of commercial catches in the GSA 17, Italian Data Collection Regulation, year 2007 (in Italian). 70 pp.

Sinovic G. 1986. Estimation of growth, mortality, production and stock size of sardine, *Sardina pilchardus* (Walb.), from the middle Adriatic. Acta Adriatica, 27(1-2): 67-74.

Comments, bibliography, etc.

Additional bibliography:

Cardinale M., Abella A., Bartolino V., Colloca F., Bellido J.M., Di Natale A., Bigot J.L., Fiorentino F., Garcia Rodriguez M., Giannoulaki M., Petrakis G., Gil de Sola L., Pilling G., Martin P., Quintanilla L.F., Murenu M., Osio G.C., Santojanni A., Sartor P., Spedicato M.T., Ticina V., Rätz H.J., Cheilari A. 2008. Report of the SGMED-08-04 Working group on the Mediterranean, Part IV. Editors: Cardinale M., Rätz H.J., Cheilari A. EUR - Scientific and Technical Research Series. 728 pp.

Jacobson L.D., De Oliveira J.A.A., Barange M., Cisneros-Mata M.A., Félix-Uraga R., Hunter J.R., Kim J.Y., Matsuura Y., Ñiquen M., Porteiro C., Rothschild B., Sanchez R.P., Serra R., Uriarte A., Wada T. 2001. Surplus production, variability, and climate change in the great sardine and anchovy fisheries. *Canadian Journal of Fisheries and Aquatic Science*, 58(9): 1891-1903.

Leonor I., Azzali M., De Felice A., Parmiggiani F., Marini M., Grilli F., Gramolini R. 2009. Small pelagic fish biomass in relation to environmental parameters in the Adriatic Sea. Proceedings of the Joint AIOL - SITE Meeting, Ancona, 17-20 September 2007.
<http://www.ecologia.it/congressi/XVII/articles/> 213-217.

Morello E.B., Arneri E. 2009. Anchovy and sardine in the Adriatic Sea - An Ecological Review. *Oceanography and Marine Biology: An Annual Review*, 47: 209-256.

Santojanni A., Cingolani N., Arneri E., Kirkwood G., Belardinelli A., Giannetti G., Colella S., Donato F., Barry C. 2005. Stock assessment of sardine (*Sardina pilchardus*, WALB.) in the Adriatic Sea, with an estimate of discards. *Scientia Marina*, 69(4): 603-617.

Sinovic G., Cikes Kec V., Zorica B. 2008. Population structure, size at maturity and condition of sardine, *Sardina pilchardus* (Walb., 1792), in the nursery ground of the eastern Adriatic Sea (Krka River Estuary, Croatia). *Estuarine, Coastal and Shelf Science* 76: 739-744.

Sinovic G., Zorica B., Cikes Kec V., Mustac B. 2009. Inter-annual fluctuations of the population structure, condition, length-weight relationship and abundance of sardine, *Sardina pilchardus* (Walb., 1792), in the nursery and spawning round (coastal and open sea waters) of the eastern Adriatic Sea (Croatia) *Acta Adriatica*, 50(1): 11-22.

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Assessment form

Sheet B
Biology of the species

Code: PIL1711Doc

Biology

Somatic magnitude measured (LH, LC, etc)*				Total length.	Units*	cm
Sex	Fem	Mal	Both	Unsexed		
Maximum size observed				21	Reproduction season	Autumn-winter.
Size at first maturity			8		Reproduction areas	
Recruitment size			13		Nursery areas	

Parameters used (state units and information sources)

		Units	Sex			
			female	male	both	unsexed
Growth model	L_{∞}				20.5	
	K				0.46	
	t0				-0.5	
	Data source	Sinovcic (1986).				
Length weight relationship	a					
	b					
M						
sex ratio (mal/fem)						

Comments

Natural mortality rates, M, at age (in years) were estimated by Gislason's method (Gislason et al., 2008), which is based on the empirical equation:

$$\ln M = a + b \ln L + c \ln L_{inf} + d \ln k$$

where a, b, c, d were estimated by means of the statistical analysis performed by Gislason et al. (2008):

$$a = 0.659, b = -1.691, c = 1.444, d = 0.898.$$

The growth parameters reported above, $L_{inf} = 20.5$ and $k = 0.46$, obtained by Sinovcic (1986) for the eastern Adriatic, were used. The following values of M at age were estimated:

Age	M
0	2.51
1	1.10
2	0.76
3	0.62
4	0.56

Comments

In previous assessments $M = 0.5$ was used for all the age classes, according to literature and Hoenig's equation.

1) Literature:

Sardine: $M = 0.5$ was obtained in the Adriatic Sea by Sinovcic (1986). Values of M from 0.29 to 0.62 were reported for the Catalan Sea by Pertierra and Perrotta (1993).

Pertierra J.P., Perrotta R.G. 1993. On the population dynamics of sardine, *Sardina pilchardus* Walbaum, 1792, from the Catalan Sea (northwestern Mediterranean). *Scientia Marina*, 57: 235-241.

Sinovcic G. 1986. Estimation of growth, mortality, production and stock size of sardine, *Sardina pilchardus* (Walb.), from the middle Adriatic. *Acta Adriatica*, 27: 67-74.

2) Hoenig's equation:

$$\ln Z = 1.44 - 0.982 \ln t_{\max}$$

"based largely on data from unexploited stocks", thus with Z being very close to M (Hoenig, 1983; Hewitt and Hoenig, 2005).

Individuals older than 6 are found in the catches of this stock.

t_{\max} (year)	predicted Z
1	4.22
2	2.14
3	1.43
4	1.08

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Assessment form

Sheet P1

General information about the fishery

Code: PIL1711Doc

Data source*	Database (containing data from different sources) shared by the three research institutes of Ancona, Ljubljana, Split.	Year (s)*	1975-2010
Data aggregation (by year, average figures between years, etc.)*	Catch data are relative to the total fleet (Italy, Croatia, Slovenia).		

Fleet and catches (please state units)

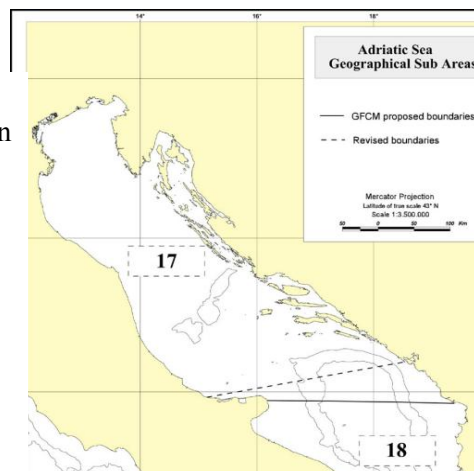
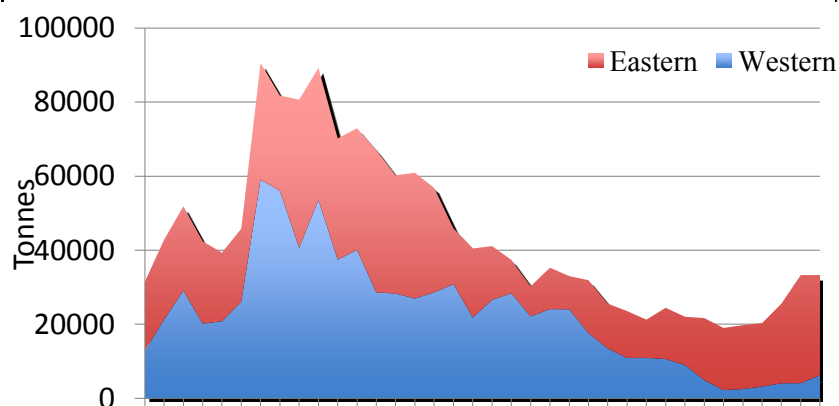
	Country	GSA	Fleet Segment	Fishing Gear Class	Group of Target Species	Species
Operational Unit 1*						
Operational Unit 2						
Operational Unit 3						
Operational Unit 4						
Operational Unit 5						

Operational Units*	Fleet (n° of boats)*	Kilos or Tons	Catch (species assessed)	Other species caught	Discards (species assessed)	Discards (other species caught)	Effort units
Total							

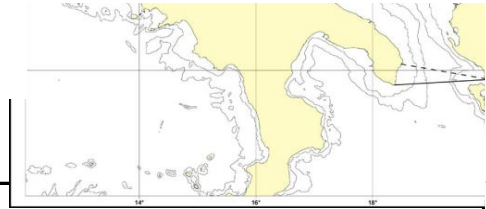
Legal minimum size	11 cm
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Comments

Fishery: mid-water trawlers and purse seiners.



75 77 79 81 83 85 87 89 91 93 95 97 99 01 03 05 07 09
Year



Comments

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Assessment form

Sheet A1
Indirect methods: VPA, LCA

Sex* M+F

Code: PIL1711Doc

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Time series

Analysis # * VPA

Data	Size	Age
(mark with X)		x

Model	Cohorts	Pseudocohorts
(mark with X)	x	

Equation used		Tuning method	Laurec-Shepherd tuning.
# of gears		Software	Darby C.D., Flatman S. 1994.
F _{terminal}			

Population results (please state units)

	Sizes	Ages		Amount	Biomass
Minimum			Recruitment		
Average			Average population		
Maximum			Virgin population		
Critical			Turnover		

Average mortality

	Total	Gear				
F ₁						
F ₂						
Z						

(F1 and F2 represent different possible calculations. Please state them)

Comments

Catch at age data (see also the sheet A2):

- amounts: for both western and eastern sides of Adriatic are available since 1975;
- biological data needed to distribute numbers of caught individuals into age classes: for the western side of Adriatic are available since 1975 while for the eastern one since 2001.

Proportion of sexually mature individuals. This proportion was taken as equal to 1.00 for all the age classes from 1 onwards (0.50 for the age class).

Tuning data:

- Laurec-Shepherd VPA was tuned on abundance (number of fish) at age derived from echo-surveys carried out in both western and eastern sides of Adriatic. All the GSA 17 was thus covered by the surveys;
- western echo-survey abundances were distributed into age classes by means of length frequencies from the western echo-survey and age-length keys from the Italian commercial fleet;
- eastern echo-survey abundances were distributed into age classes by means of length frequencies and age-length keys from the Croatian commercial fleet;
- the data series is from calendar year 2004 onwards, with surveys being carried out in September.

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Assessment form

Sheet A2
Indirect methods: data

Code: PIL1711Doc

Sex*	M+F	Gear*	Mid-water trawlers and purse seiners.	Analysis # *	VPA
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Data source	
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Data

Total catch at age (numbers in thousands) used as input data for VPA calculations.

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6+
75	7585	169567	168809	133637	111767	57349	101185
76	32674	325425	262716	240229	178982	50674	49174
77	38311	390846	286255	293502	225872	66399	63126
78	56203	237503	191355	241149	206344	77865	86317
79	17371	223353	211007	210192	167858	58922	70146
80	34213	191096	239748	274783	220395	74540	83558
81	90126	900152	558533	455718	351636	115444	129101
82	67953	830415	523066	375817	286187	98067	118146
83	54307	835931	533989	337134	252708	90895	117826
84	45549	944959	619572	342244	248612	94093	130938
85	13544	542745	622565	343080	217535	59584	71576
86	3982	202553	402509	497431	404964	145442	168290
87	88835	533147	298747	465766	368575	109178	113598
88	19605	211508	492882	253874	354199	289823	136351
89	7739	242067	806193	351688	219265	149582	70539
90	3004	149813	661602	422933	231691	118764	52015
91	1109	51418	417914	427739	266029	104863	30532
92	8577	52194	295811	379281	225554	92045	34310
93	35680	127134	242700	327819	249316	119111	47053
94	24216	129380	247673	272042	195019	103236	44028
95	8404	41136	160331	241258	193086	101514	46134
96	27103	105687	157413	225860	227896	144333	72568
97	25272	114328	174086	218736	195818	117145	55102
98	42932	146871	173147	202282	177559	107280	51867
99	70321	153580	119382	132549	129604	90379	53378
00	91446	227543	189318	96714	52050	37405	41908
01	64787	206423	324603	99569	26133	13715	13810
02	100550	205041	453768	131496	22790	9400	8138
03	35091	198099	444112	142622	14551	3676	2080
04	11544	229349	437905	188641	12553	1724	1063
05	26670	79693	274008	196415	63490	11662	2621
06	65837	69530	193385	242056	86982	23361	551
07	116311	76402	228352	211308	80496	41446	1209
08	121442	182371	276715	195238	129803	29236	24779
09	144569	127750	412365	359634	166459	74147	36676
10	100666	234943	513169	408995	35679	15983	877

Note: the age class 0 was not taken into account.

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Assessment form

Sheet A3
Indirect methods: VPA results

Code: PIL1711Doc

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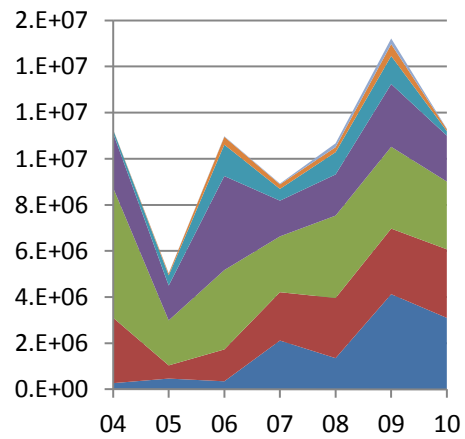
Sex*	M+F	Gear*	Mid-water trawlers and purse seiners.	Analysis #*	VPA
------	-----	-------	---------------------------------------	-------------	-----

Population in figures

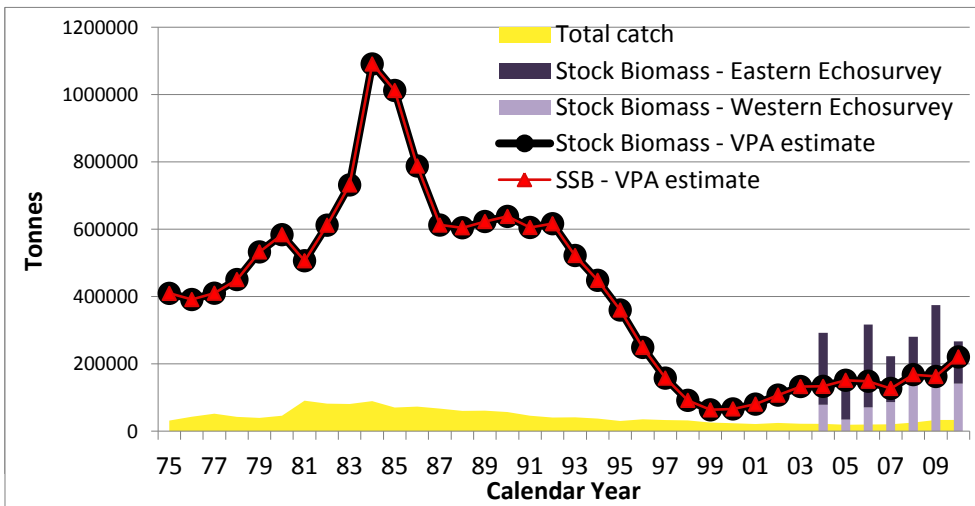
Abundance at age (numbers in thousands) from West and East echo-surveys used for the VPA tuning.

	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6+
04	267305	2838572	5641657	2363071	152720	10033	2900
05	464442	573254	1951868	1510323	443309	75824	14343
06	346437	1383573	3441462	4077930	1361665	339685	24127
07	2115043	2095964	2421715	1549694	509193	198683	32349
08	1350896	2608986	3573681	1785799	964225	217788	167842
09	4126322	2844146	3548416	2721228	1217592	515074	243565
10	3097384	2974824	2938603	1994091	197840	82935	18579

Note: the age class 0 was not taken into account.



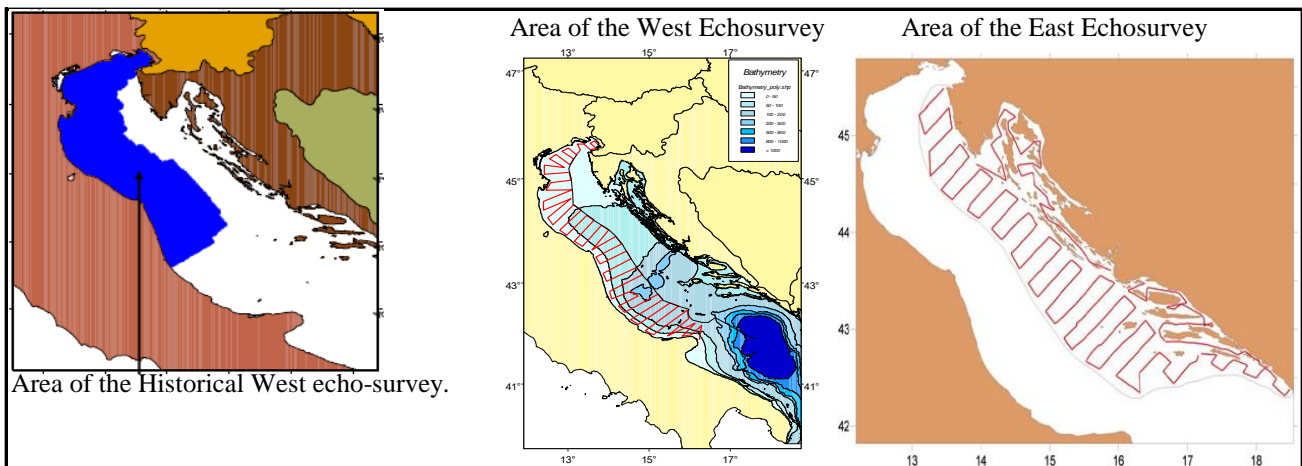
Population in biomass



Average total catch
1975-10 43584 tonnes
2008-10 30715 tonnes

Average stock biomass
1975-10 405567 tonnes
2008-10 183631 tonnes

Fishing mortality rates



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Assessment form

Sheet A3
Indirect methods: VPA results

Code: PIL1711Doc

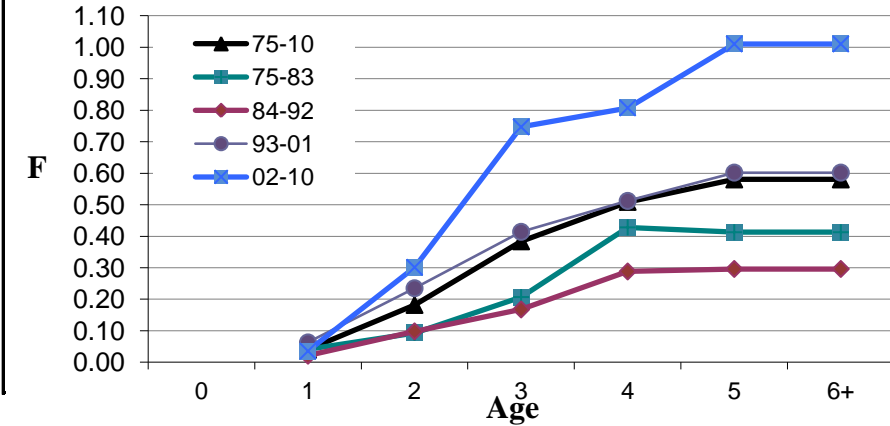
Page 2 / 2

Sex*	M+F	Gear*	Mid-water trawlers and purse seiners.	Analysis #*	VPA
------	-----	-------	---------------------------------------	-------------	-----

Population in figures

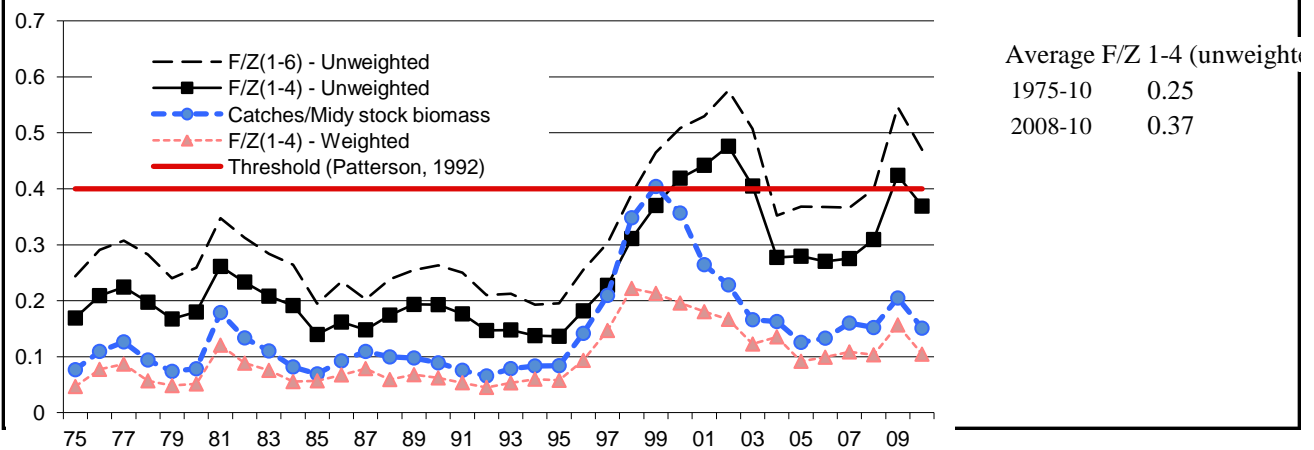
Fishing mortality rate as a function of age (average for different periods).

The parameters k and n which allow to link F on the oldest age to F in some previous ages were 1.3 and 2, respectively.



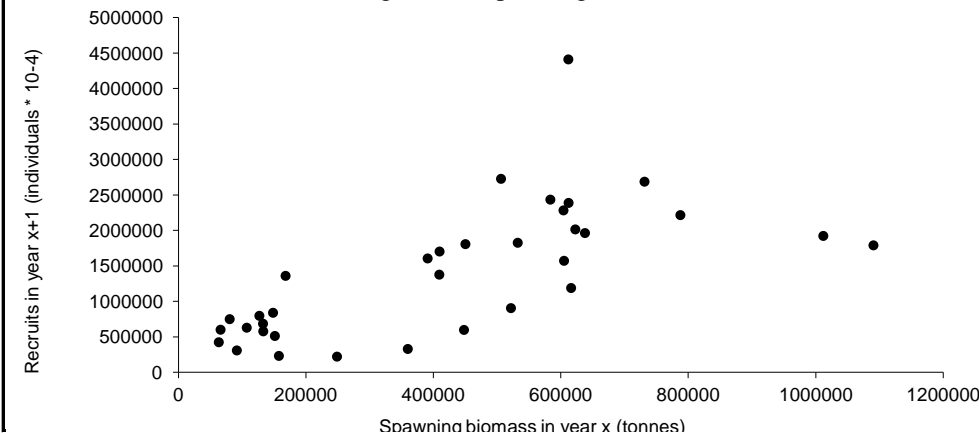
Population in biomass

Exploitation rate $F/(F+M) = F/Z$ as a function of time; the threshold 0.4 suggested by Patterson (1992)



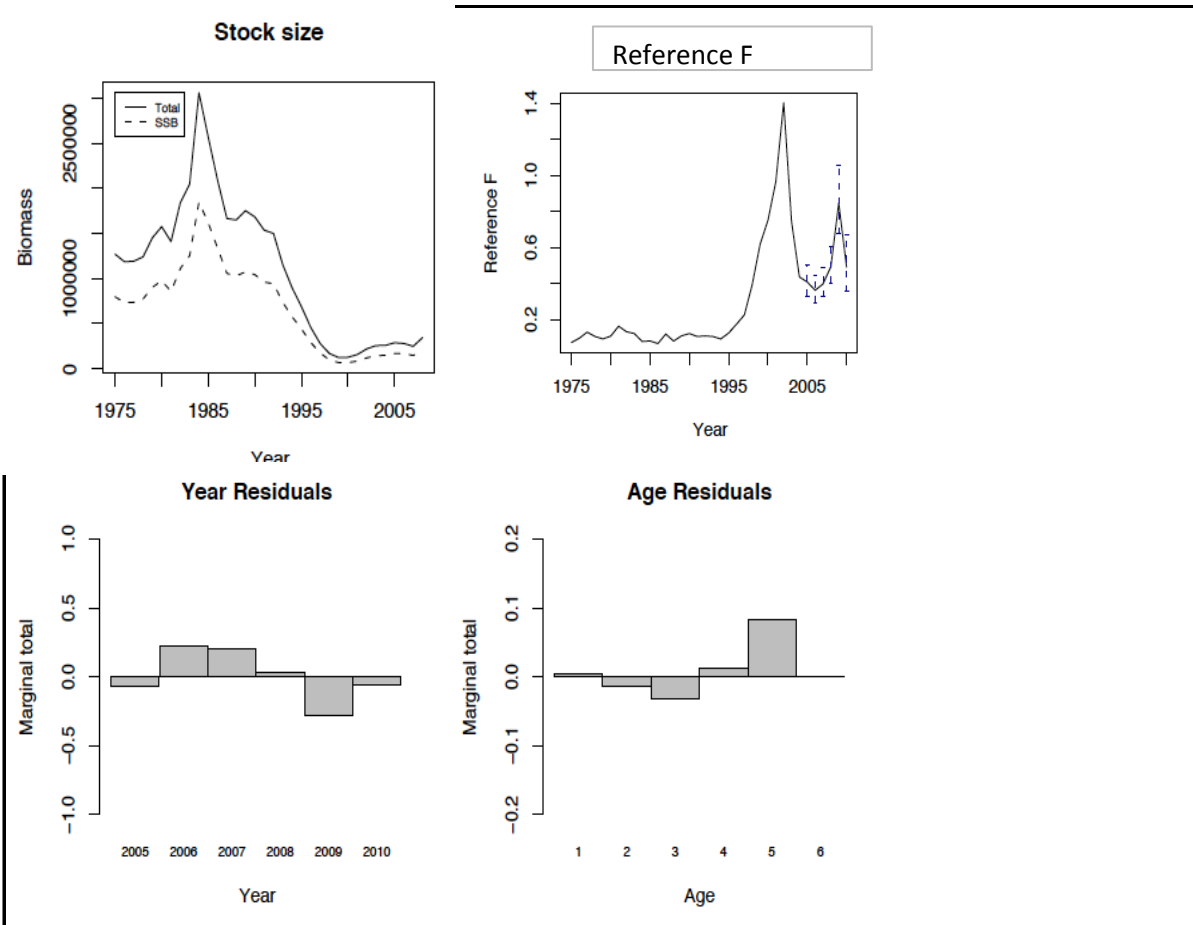
Fishing mortality rates

Recruitment (R, individuals with age 1) and spawning stock biomass (SSB).



Other assessment methods

Explorative runs by the means of Integrated Catch Analysis (ICA) were also performed. The following assumptions have been used in the model:
 6 years of separability period.
 Selectivity on the last age fixed to 1.
 Relative weight at age: 1 for all the ages.
 The catchability model: Linear.
 Weight for the survey data: 1.

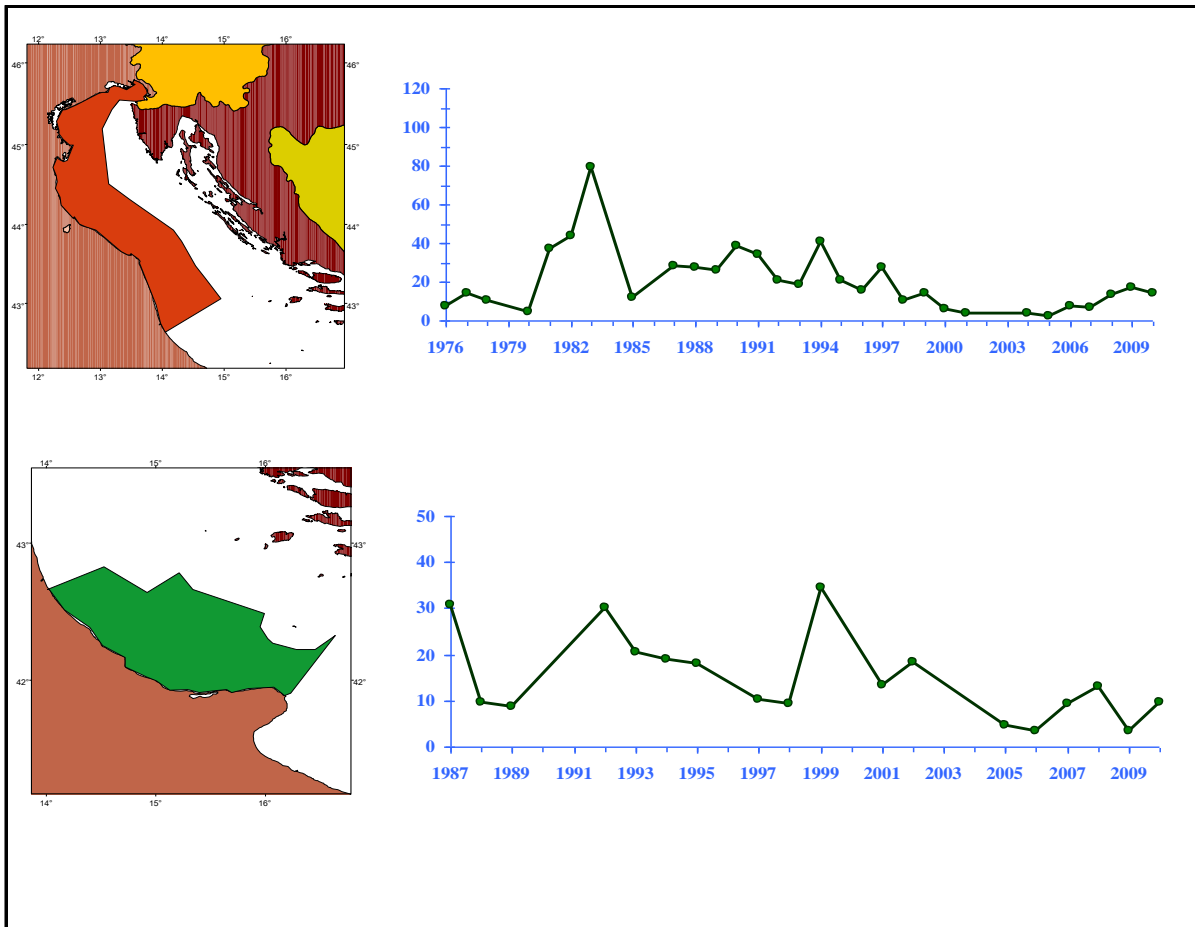


Other assessment methods

Additional information on western echo-survey.

The trend of sardine biomass density in the North Adriatic Sea in the period 1976-2010 derived from acoustic surveys is represented in the graph below (upper part). The average biomass density value was estimated in 20.2 t/nm². Sardine started from low levels of biomass in the period 1976-80 reaching shortly after the absolute maximum of the series in 1983. After that the stock presented a decrease immediately before the anchovy collapse, but recovered fastly maintaining values near to the average of the series in the years 1987-97. From 1998 up to now sardine biomass shows low levels; in these last years (2006-09) sardine started to recover, even if in 2010 the estimated biomass was a bit lower respect to 2009 (13.9 t/nm²).

The trend of sardine biomass density in the Middle Adriatic Sea (see figure below, lower part) in the period 1987-2010 derived from acoustic surveys is represented in the graph below. The average biomass density value was estimated in 14.8 t/nm². Sardine biomass density presents high fluctuations in the years 1987-95, then in 1997-98 there was a decline and a subsequent peak in 1999. After that we assist to minor fluctuations with values below the average of the series. In 2010 sardine biomass density presented a value of 9.5 t/nm².



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Assessment form

Sheet D
Diagnosis

Code: PIL1711Doc

Indicators and reference points

Criterion	Current value	Units	Reference Point	Trend	Comments
B					
SSB					
F					
Y					
CPUE					

Stock Status* Use one (or both) of the following two systems for the stock assessment status description

Unidimensional	<input type="radio"/>	? - (or blank) Not known or uncertain. Not much information is available to make a judgment;
	<input type="radio"/>	U - Underexploited, undeveloped or new fishery. Believed to have a significant potential for expansion in total production;
	<input type="radio"/>	M - Moderately exploited, exploited with a low level of fishing effort. Believed to have some limited potential for expansion in total production;
	<input checked="" type="radio"/>	F - Fully exploited. The fishery is operating at or close to an optimal yield level, with no expected room for further expansion;
	<input type="radio"/>	O - Overexploited. The fishery is being exploited at above a level which is believed to be sustainable in the long term, with no potential room for further expansion and a higher risk of stock depletion/collapse;
	<input type="radio"/>	D - Depleted. Catches are well below historical levels, irrespective of the amount of fishing effort exerted;
	<input type="radio"/>	R - Recovering. Catches are again increasing after having been depleted or a collapse from a previous;

Bidimensional	Exploitation rate		Stock abundance	
	<input type="radio"/>	No or low fishing	<input type="radio"/>	Virgin or high abundance
	<input checked="" type="radio"/>	Moderate fishing	<input type="radio"/>	Intermediate abundance
	<input type="radio"/>	High fishing mortality	<input checked="" type="radio"/>	Low abundance
	<input type="radio"/>	Uncertain / Not assessed	<input type="radio"/>	Depleted
			<input type="radio"/>	Uncertain / Not assessed

Comments

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Assessment form

Sheet Z

Objectives and recommendations

Code: PIL1711Doc

Management advice and recommendations*

The recent exploitation rate F/Z is slightly under the Patterson's threshold 0.4 (Patterson, 1992). However, the picture of F/Z over years is too "negative" due to the effects of some high estimates of F in the oldest ages 3 and 4; this is evident if the corresponding F/Z s weighted on abundance at sea are taken into account: in recent years, these F/Z s are well below the threshold 0.4 just because the mentioned effects are strongly smoothed. Also, the ratio between total catch and stock biomass is not particularly high: around 0.2. Thus, sardine stock can be considered as fully exploited.

The biomass of sardine has been decreasing continuously since the 1980s and F/Z was estimated over the Patterson's threshold in 2000-2002. In the most recent years, a moderate recovery of the stock, a slight increase in the catches and in the recruitment have been observed. However, these trends don't justify an increase in the exploitation of this stock.

Adriatic small pelagic fishery is multispecies and effort on sardine cannot be separated from effort on anchovy, so that most of the management decisions have to be taken considering both species.

In conclusion, taking into account the strong decline observed over time for sardine and the fully exploited state of anchovy (see corresponding stock assessment forms), it is recommended not to increase the fishing effort in next future.

Advice for scientific research*

Present improvements.

In comparison with the previous assessment presented in the SCSA meeting held in Malaga in 2009, the following improvements in the methodology were introduced.

- 1) Natural mortality at age estimated by means of Gislason's method was based on a different growth curve, with the parameter L_{inf} (required by the Gislason's method) being more reliable than the value used for the previous estimates of M at age.
- 2) Echo-survey data used for VPA tuning, just like in the previous assessment, were relative to both western and eastern sides of Adriatic; however, in the present assessment, it was possible to split eastern echo-survey abundance into age classes using length frequencies and age-length keys (although coming from the commercial fleet) coming from the eastern side. Thus, it was possible to avoid the assumption that western echo-survey abundance index can be used for all the GSA 17.
- 3) Finally, the calculation of length frequencies for the western echo-surveys was improved since it was possible to include some distributions for the middle Adriatic (i.e. area between Giulianova and Vieste).

For the future.

The ongoing exercise with Integrated Catch Analysis (ICA) should be improved in order to set up another powerful tool for the small pelagic stock assessment in the Adriatic.

Further more the Adriatic countries are developing a common protocol to apply in the next future the Daily Egg Production Method (DEPM) to improve the assessment techniques for small pelagics.

Abstract for SCSA reporting

Authors Document prepared by the AdriaMed (MIPAAF-FAO project) working group for small pelagics:
Santojanni A. (1), Leonori I. (1), Carpi P. (1), De

Year 2011

Species Scientific name Sardina pilchardus - PIL
Source: GFCM Priority Species

Source: -

Source: -

Geographical Sub-Area 17 - Northern Adriatic

Fisheries (brief description of the fishery)*

Fishery: mid-water trawlers and purse seiners.

The average total catch in the time interval 1975-2009 is 26000 tonnes.

The average total catch in the time interval 2007-2009 is 44000 tonnes.

Source of management advice*

(brief description of material -data- and methods used for the assessment)

VPA based on Laurec-Shepherd tuning was carried out, by means of the software developed by Darby and Flatman (1994).

The total catch at age from 1975 to 2009 used were relative to both western and eastern sides of Adriatic.

Tuning was performed using abundance at age data from echo-surveys carried out in both western and eastern sides of Adriatic, from 2004 to 2009.

Natural mortality at age was estimated by means of Gislason's method (the age class 0 was not taken into account in the VPA runs):

Age	M
0	2.51
1	1.10

Stock Status*

F - Fully exploited. The fishery is operating at or close to an optimal yield level, with no expected room for further expansion;

Exploitation rate

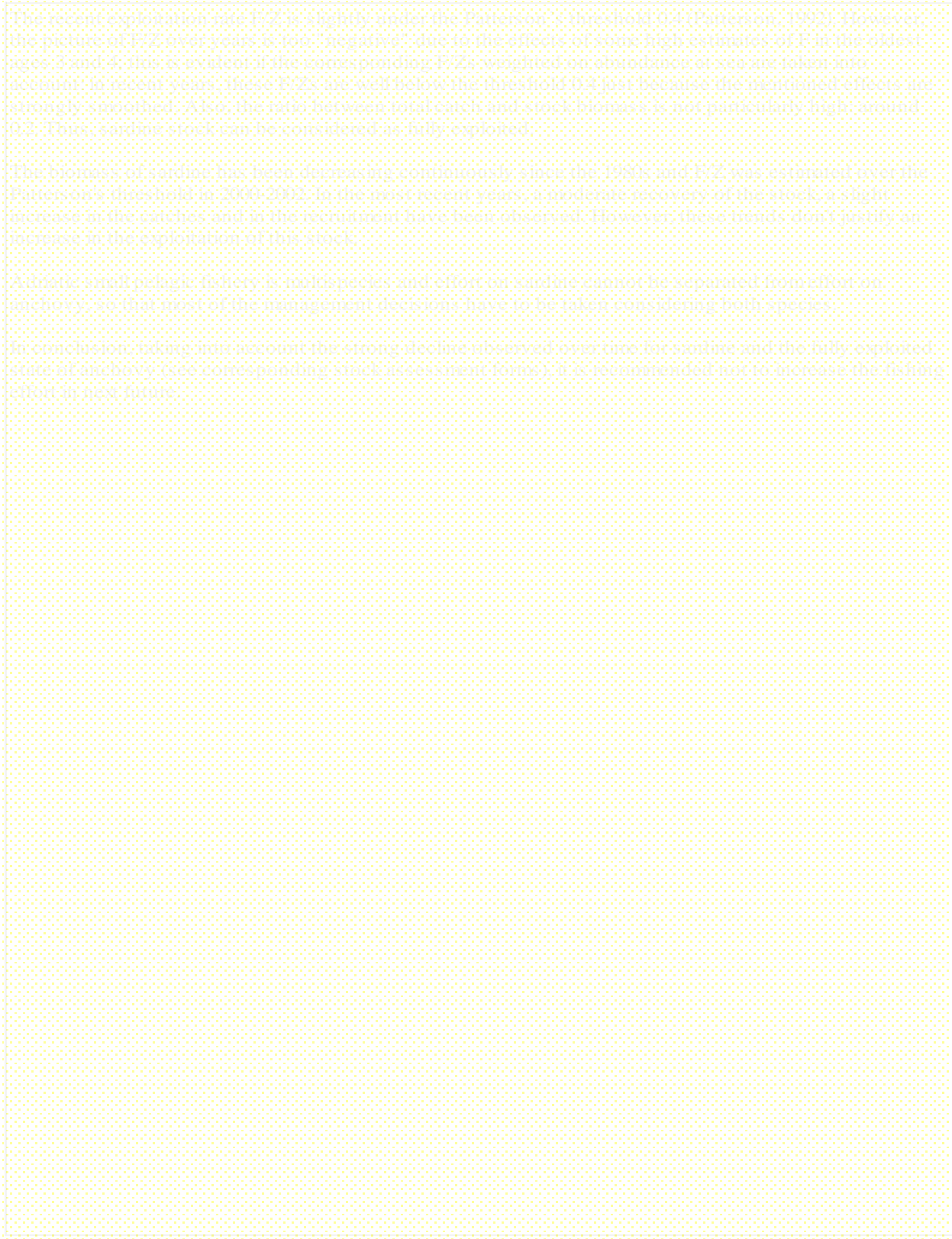
Moderate fishing mortality

Stock abundance

Low abundance

Comments

Management advice and recommendations*



Advice for scientific research*

[This area contains a large, faint watermark reading "SCSA" diagonally across the page.]