SAC GFCM
Sub-Committee on Stock Assessment

Date*	**1**	**November**	**2010**	**Code***	**PIL1710Doc**

Authors*

Document prepared by the AdriaMed (MIPAAF-FAO project) working group for small pelagics:
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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: PIL1710Doc

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Species Scientific name*	Sardina pilchardus - PIL	Species common name*	Sardine

Data Source

GSA*	17 - Northern Adriatic	Period of time*	1975-2009

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	---	1	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.

Sinovcic 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.

Leonori 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.

Sinovcic 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.

Sinovcic 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.

SAC GFCM - Sub-Committee on Stock Assessment (SCSA)	
Assessment form	**Sheet B** **Biology of the species**

Code: PIL1710Doc

Biology

Somatic magnitude measured (LH, LC, etc)*	Total length.	Units*	cm

Sex	Fem	Mal	Both	Unsexed		
Maximum size observed					Reproduction season	Autumn-winter.
Size at first maturity			8		Reproduction areas	
Recruitment size			13		Nursery areas	

Parameters used (state units and information sources)

			Sex			
		Units	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:

$\ln M = a + b \ln L + c \ln Linf + d \ln k$

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, Linf = 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
5	0.52
6+	0.50

where 6+ is the plus-group, which includes individuals of the age classes equal to and higher than 6.

In the previous assessment discussed in the SCSA meeting held in Malaga, in 2009, the values of M at age were estimated using the growth curve (Linf = 18.783, k = 0.379, t0 = -2.302) obtained for the Italian DCR by Santojanni et al. (2008):

Age	M
0	0.75
1	0.68

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 tmax

"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.

tmax (year)	predicted Z
1	4.22
2	2.14
3	1.43
4	1.08
5	0.87
6	0.73
7	0.62
8	0.55
9	0.49
10	0.44
11	0.40
12	0.37

Hoenig J.M. 1983. Empirical use of longevity data to estimate mortality rates. Fishery Bulletin, 82: 898-903.

Hewitt D.A., Hoenig J.M. 2005. Comparison of two approaches for estimating natural mortality based on longevity. Fishery Bulletin, 103: 433-437.

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

Assessment form

Sheet P1
General information about the fishery

Code: PIL1710Doc

Data source*	Database (containing data from different sources) shared by the three research institutes of Ancona, Ljubljana, Split.	Year (s)*	1975-2009
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)

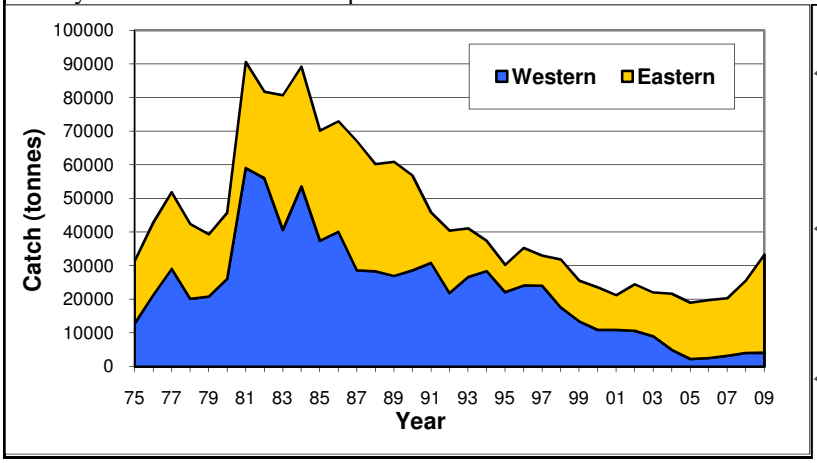
	Country	GSA	Fleet Segment	Fishing Gear Class	Group of Target Species	Species
Operational Unit 1*						
Operational Unit 2						
Operational Unit 3						
Operational Unit 4						
Operational Unit 5						

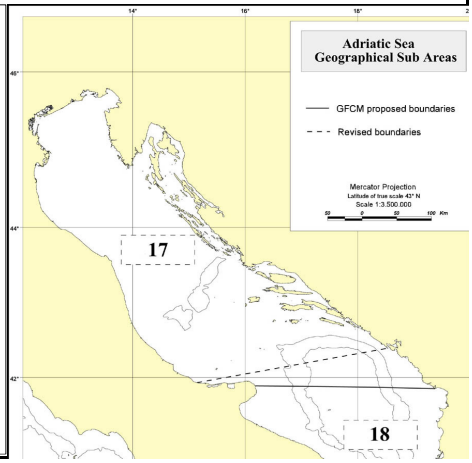
Operational Units*	Fleet (n° of boats)*	Kilos or Tons	Catch (species assessed)	Other species caught	Discards (species assessed)	Discards (other species caught)	Effort units
Total							

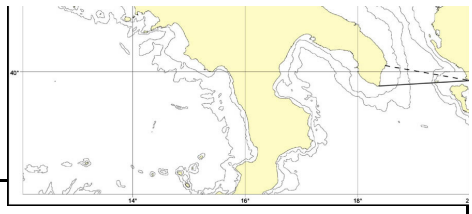
Legal minimum size	

Comments

Fishery: mid-water trawlers and purse seiners.

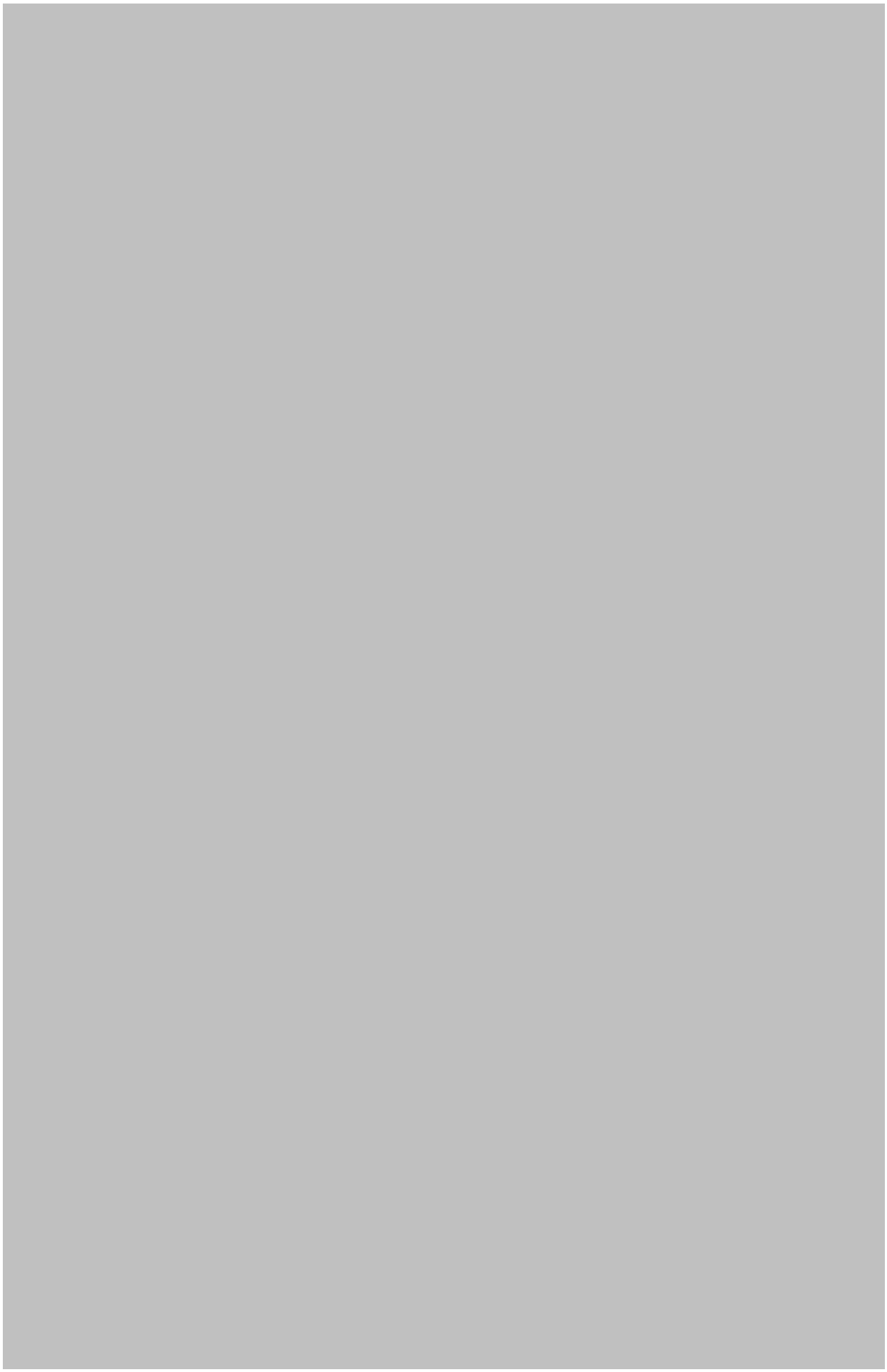






Comments

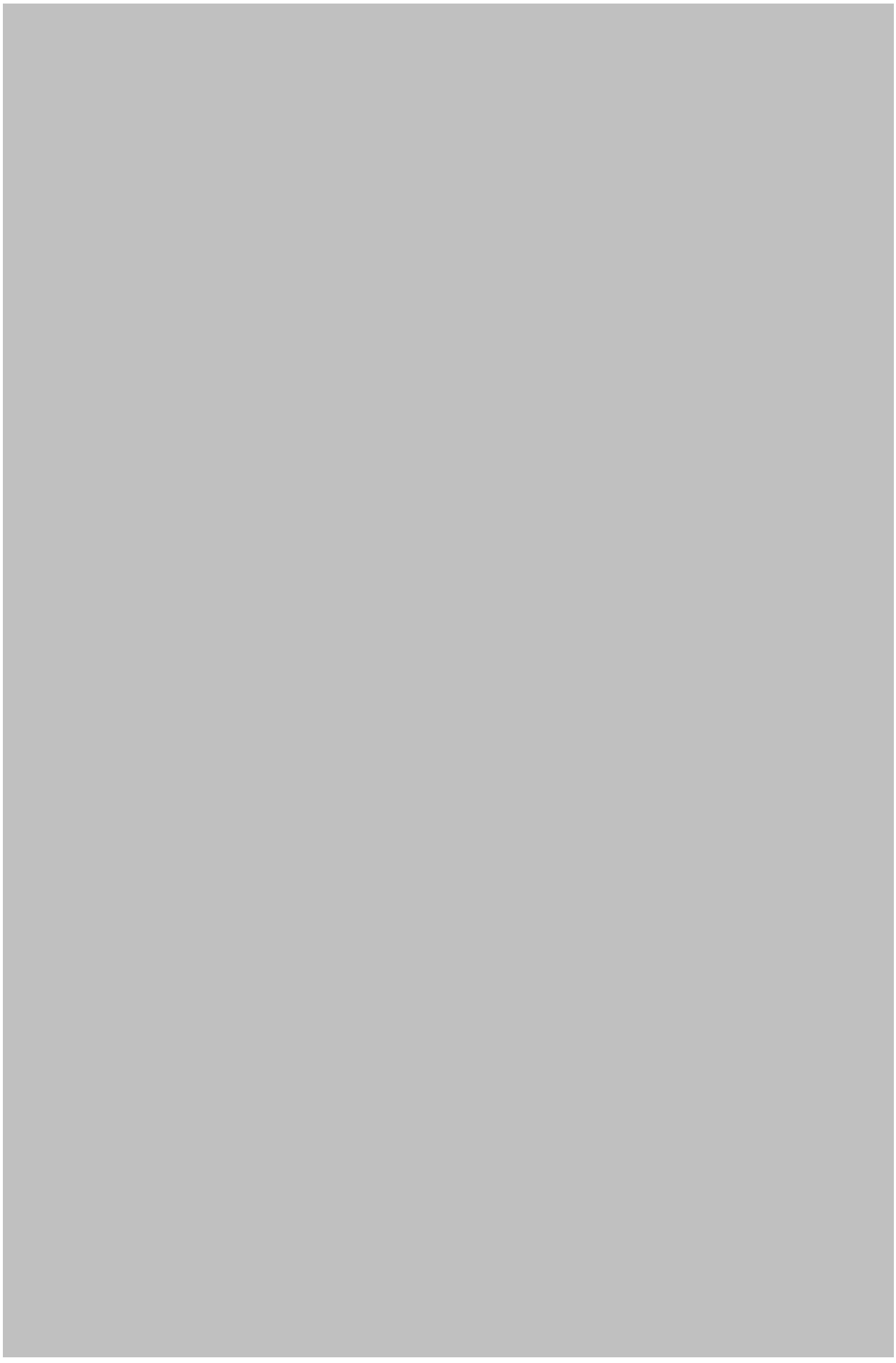
This sheet will be activated once the Operational Unit information (P1 section) will be successfully filled in



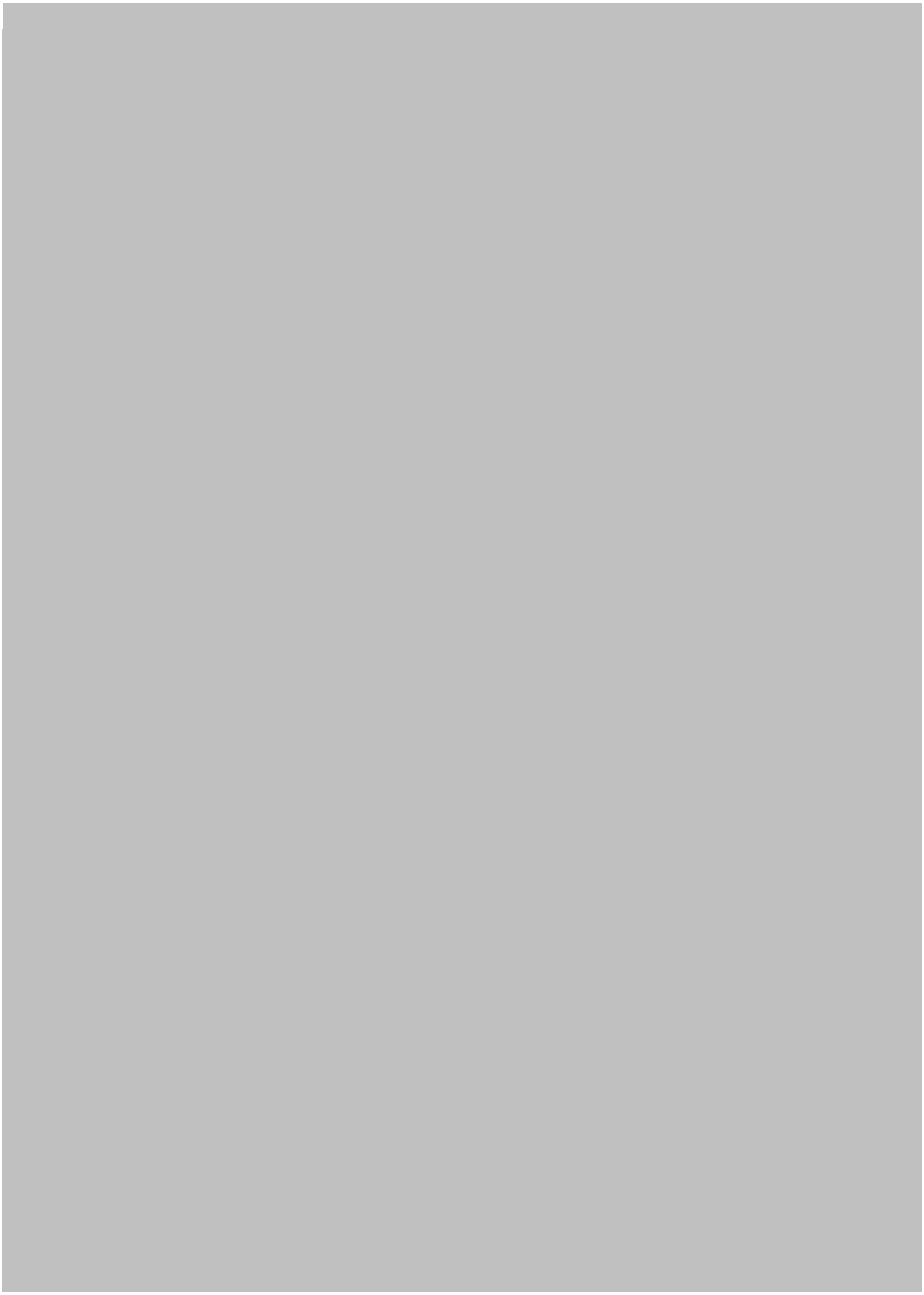
SAC GFCM - Sub-Committee on Stock Assessment (SCSA)	
Assessment form	**Sheet P2a** **Fishery by Operational Unit**

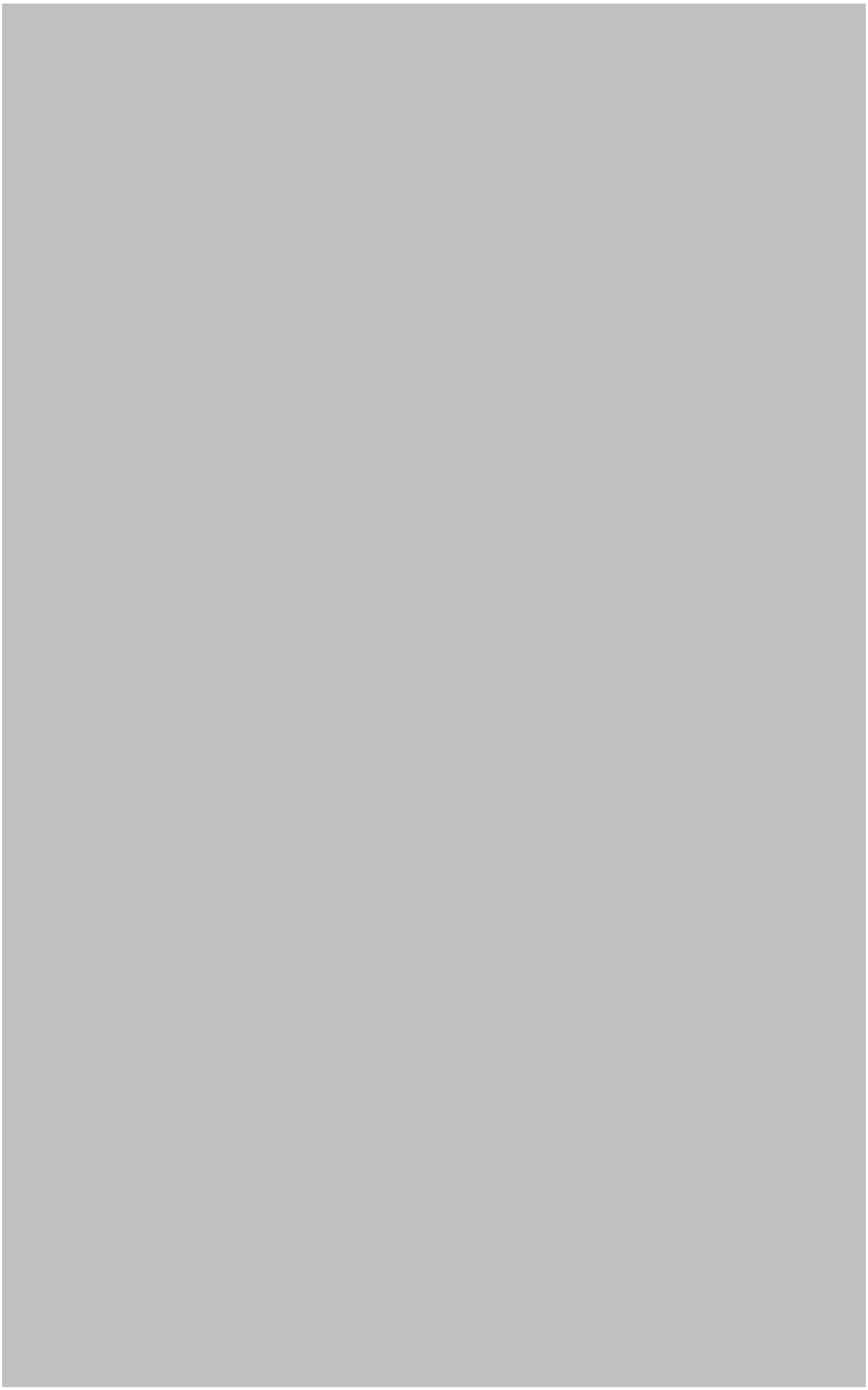
This sheet will be activated once the Operational Unit information (P1 section) will be successfully filled in

Code: PIL1710Doc



This sheet will be activated once the Operational Unit information (P1 section) will be successfully filled in





SAC GFCM - Sub-Committee on Stock Assessment (SCSA)	
Assessment form	**Sheet P2b** **Fishery by Operational Unit**

This sheet will be activated once the Operational Unit information (P1 section) will be successfully filled in

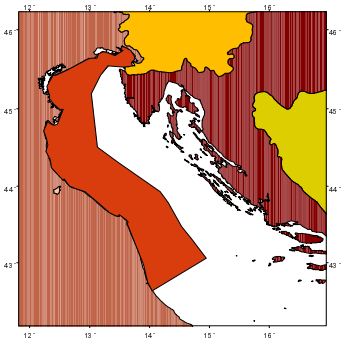
Code: PIL1710Doc

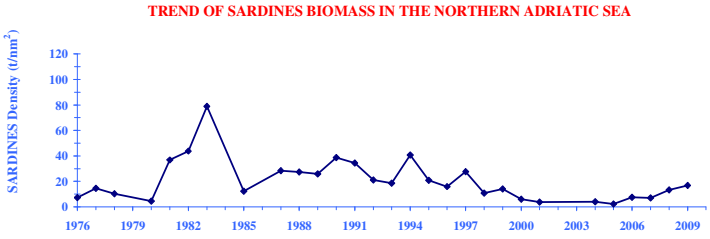
Other assessment methods

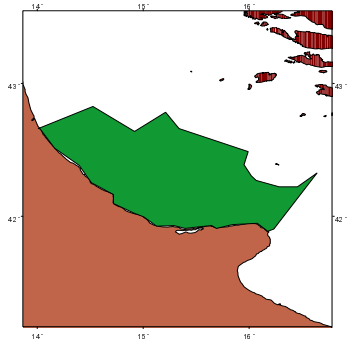
Additional information on western echo-survey.

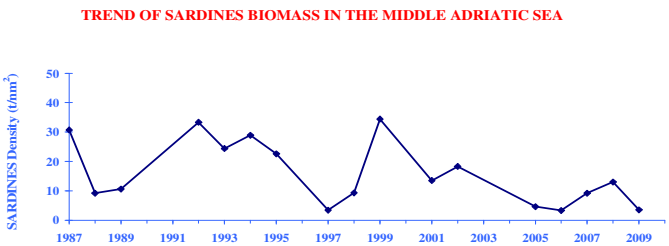
The trend of sardine biomass density in the North Adriatic Sea (see figure below) in the period 1976-2009 derived from acoustic surveys is represented in the graph below. The average biomass density value was estimated in 20.4 t/nm2. Sardine started from low levels of biomass in the period 1976-80 reaching 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 seems to start recovering and in 2009 biomass density was estimated 6. t/nm2, 82% of the average value of the series.

The trend of sardine biomass density in the Middle Adriatic Sea (see figure below) in the period 1987-2009 derived from acoustic surveys is represented in the graph below. The average biomass density value was estimated in 16 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 2009 sardine biomass density presented the very low value of 3.5 t/nm2.









SAC GFCM - Sub-Committee on Stock Assessment (SCSA)	
Assessment form	**Sheet D Diagnosis**

Code: PIL1710Doc

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

☐	? - (or blank) **Not known or uncertain**. Not much information is available to make a judgment;
☐	U - **Underexploited, undeveloped or new fishery**. Believed to have a significant potential for expansion in total production;
☉	M - **Moderately exploited**, exploited with a low level of fishing effort. Believed to have some limited potential for expansion in total production;
☐	F - **Fully exploited**. The fishery is operating at or close to an optimal yield level, with no expected room for further expansion;
☐	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;
☐	D - **Depleted**. Catches are well below historical levels, irrespective of the amount of fishing effort exerted;
☐	R - **Recovering**. Catches are again increasing after having been depleted or a collapse from a previous;

Bidimensional

Exploitation rate

☐	No or low fishing
☉	Moderate fishing
☐	High fishing mortality
☐	Uncertain / Not assessed

Stock abundance

☐	Virgin or high abundance
☐	Intermediate abundance
☉	Low abundance

☐	Depleted
☐	Uncertain / Not assessed

Comments

Code: PIL1710Doc

Management advice and recommendations*

The recent exploitation rate F/Z is under the Patterson's threshold 0.4 (Patterson, 1992).

The biomass of sardine has been decreasing continously 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 at all an increase in the exploitation of this stock. Thus, the stock can be considered as moderately exploited, but it is recommended not to increase the fishing effort in the near future.

Moreover it should be noted that 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, 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 Linf (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 coutries 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 2010

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
2	0.76
3	0.62
4	0.56
5	0.52
6+	0.50

The threshold exploitation rate F/Z = 0.4, suggested by Patterson (1992) for the management of small pelagics, was used as biological reference point.

Stock Status*

M - Moderately exploited, exploited with a low level of fishing effort. Believed to have some limited potential for expansion in total production;

Exploitation rate

Moderate fishing mortality

Stock abundance

Low abundance

Comments

Management advice and recommendations*

The recent exploitation rate F/Z is under the Patterson's threshold 0.4 (Patterson, 1992).

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In conclusion, it is recommended not to increase the fishing effort in next future.

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Further more the Adriatic coutries 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.