SAC GFCM
Sub-Committee on Stock Assessment

Date*	27	October	2011		Code*	ANE1711Doc

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 *Engraulis encrasicolus - ANE*
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

Code: ANE1711Doc

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Species Scientific name*	Engraulis encrasicolus - ANE	Species common name*	Anchovy

Data Source

GSA*	17 - Northern Adriatic	Period of time*	1975-2010

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	3	---	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.

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.

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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.

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.

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Santojanni A., Arneri E., Barry C., Belardinelli A., Cingolani N., Giannetti G., Kirkwood G. 2003. Trends of anchovy (Engraulis encrasicolus, L.) biomass in the northern and central Adriatic Sea. Scientia Marina, 67(3): 327-340.

Santojanni A., Arneri E., Bernardini V., Cingolani N., Di Marco M., Russo A. 2006. Effects of environmental variables on recruitment of anchovy in the Adriatic Sea. Climate Research, 31(2-3): 181-193.

Sinovcic G., Zorica B. 2006. Reproductive cycle and minimal length at sexual maturity of Engraulis encrasicolus (L.) in the Zrmanja River estuary (Adriatic Sea, Croatia). Estuarine, Coastal and Shelf Science, 69: 439-448.

Code: ANE1711Doc

Biology

Somatic magnitude measured (LH, LC, etc)*				Total length.		Units*	cm
Sex	Fem	Mal	Both	Unsexed			
Maximum size observed				18.5	Reproduction season		Spring-summer.
Size at first maturity			8		Reproduction areas		
Recruitment size			9		Nursery areas		

Parameters used (state units and information sources)

		Units	Sex			
			female	male	both	unsexed
Growth model	L∞				16.147	
	K				0.4	
	t0				-2.041	
	Data source	Santojanni et al (2008) - Italian DCR.				
Length weight relationship	a					
	b					

M					

sex ratio (mal/fem)	

Comments

Natural mortality rates, M, at age (in years) were estimated by the 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 = 16.147 and k = 0.400, obtained by Santojanni et al. (2008) for the Italian DCR, were used, although Linf = 16,147 is lower than expected for this stock. The following values of M at age were estimated:

Age	M
0	1.02
1	0.82
2	0.67
3	0.57
4+	0.54

Comments

In previous assessments M = 0.6 and M = 0.8 were used for all the age classes, according to literature and Hoenig's equation. The first value was preferred according to the precautionary approach.

1) Literature:

Anchovy: M = 0.54 and M = 0.81 were reported for the Catalan Sea by Pertierra and Lleonart (1996).

Pertierra J.P., Lleonart J. 1996. NW Mediterranean anchovy fisheries. Scientia Marina, 60 (Suppl. 2): 257-267.

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 4 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

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Data source*	Database (containing data from different sources) shared by the three research institutes of Ancona, Ljubljana, Split.	Year (s)*	1976-2010
Data aggregation (by year, average figures between years, etc.)*	Catch data are relative to the total fleet (Italy, Croatia, Slovenia). Split-year was used assuming the first of June as the birth date of anchovy, e.g. split-year 1976 was formed by Jun-Dec of 1975 and Jan-May 1976.		

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	9 cm

Comments
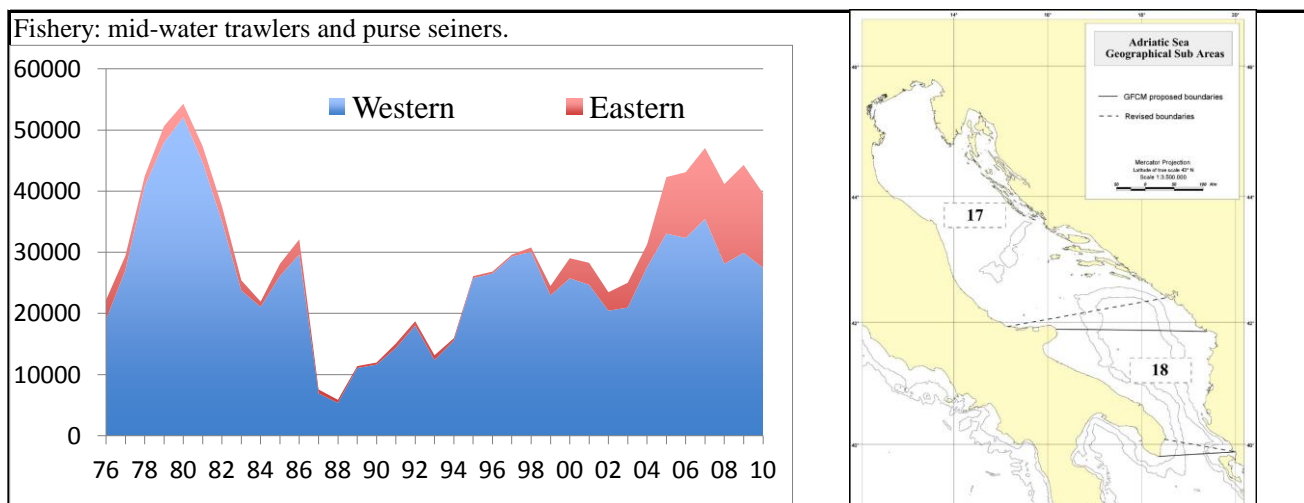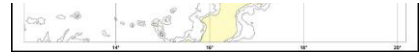
Fishery: mid-water trawlers and purse seiners.

Adriatic Sea Geographical Sub Areas

GFCM proposed boundaries
Revised boundaries

Mercator Projection

17

18

Comments

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Sex*	M+F

Analysis # *	**VPA**

Time series

Data	Size	Age
(mark with X)		x

Model	Cohorts	Pseudocohorts
(mark with X)	x	

Equation used		Tunig 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 0.50 for the age class 0 and 0.75 for 1 and 1.00 for 2-4+.

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 from the eastern echo-survey carried out in 2009-2010 (assumed to be the same for the whole period) 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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| Sex*	M+F	Gear*	Mid-water trawlers and purse seiners.	Analysis # *	VPA

Data source	

Data

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

| Split year	Age 0	Age 1	Age 2	Age 3	Age 4+
76	296691	686091	480224	221629	83577
77	362899	768650	587692	339326	190485
78	629137	1303524	843825	418961	201054
79	962994	1868703	1025407	376911	117188
80	594600	1524697	1153558	595074	270313
81	460310	1294987	1092606	600133	299005
82	581166	1045453	736400	392667	186551
83	538138	719903	413727	211638	91843
84	585801	626031	285235	137334	50293
85	903238	803134	277163	120871	28520
86	507957	638687	401614	266062	108615
87	123399	114640	77416	70299	42427
88	316468	117550	47454	26896	9133
89	525159	279251	109436	40112	7356
90	404575	268710	140347	70441	16149
91	386111	371134	174825	88455	36519
92	489542	310754	183858	150916	110267
93	147249	308002	151684	114463	106191
94	341049	478188	177472	108763	65023
95	422169	892358	316490	154855	78699
96	217939	834866	377253	197706	111294
97	500532	751743	305104	245281	158812
98	472876	747334	360525	271427	169079
99	422169	622278	302634	226727	98775
00	813325	906112	416398	115379	9098
01	754071	1050164	340092	65643	3235
02	440144	862964	387591	69170	6216
03	361837	1184318	460288	72766	4342
04	937742	1566232	414941	82271	7881
05	1270095	1534611	754955	90644	9803
06	840354	1442839	784111	181755	84980
07	348001	918557	1708298	303673	28836
08	402565	1060100	1324708	290665	40427
09	414062	1478567	1317734	268714	31303
10	506828	1821542	839853	90589	16009

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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.

Split year	Age 0	Age 1	Age 2	Age 3	Age 4+
2005	6214643	14272125	5730601	1098199	71910
2006	14262102	11180795	4289525	930957	92716
2007	18866465	21402724	14747319	2591264	150568
2008	17771615	24049428	18052641	1689255	31699
2009	16538514	25791112	28482881	6021449	619155
2010	12245794	17927877	16430615	2493457	150302
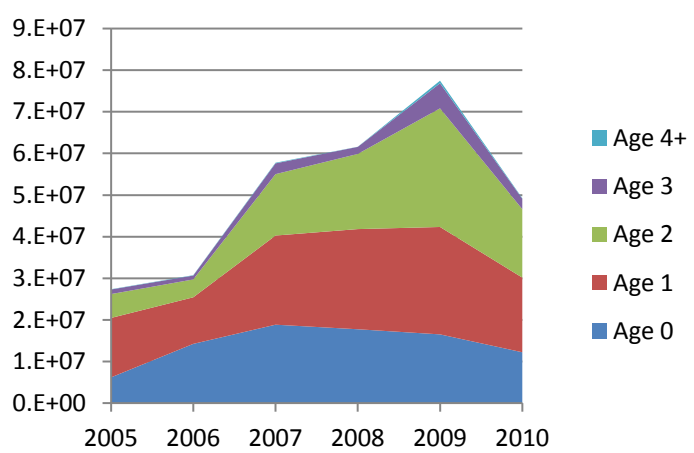
Population in biomass
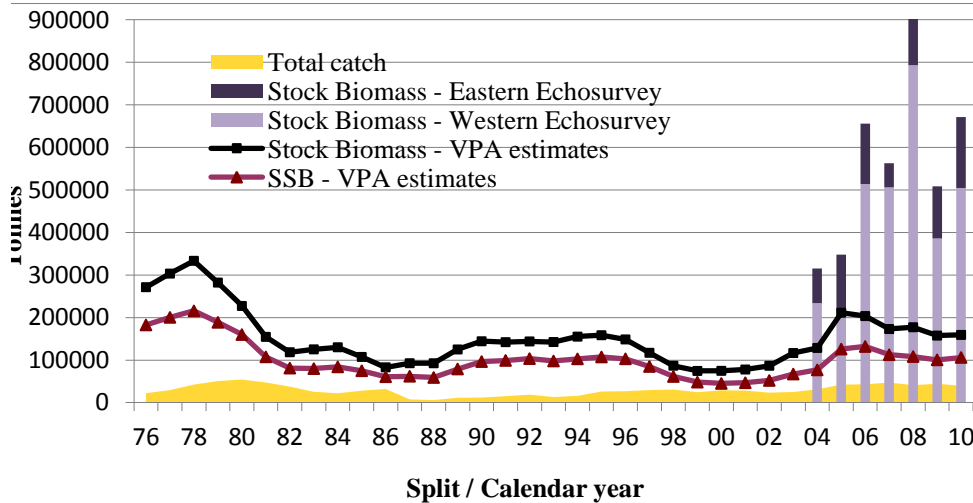
Average total catch
| 1976-10 | 29244 | tonnes |
| 2008-10 | 41690 | tonnes |

Average stock biomass
| 1976-10 | 152160 | tonnes |
| 2008-10 | 164633 | tonnes |

Fishing mortality rates
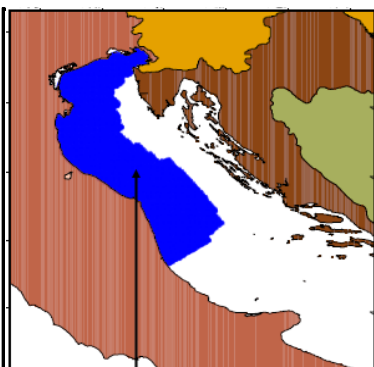
Area of the Historical West echo-survey.

Area of the West Echosurvey
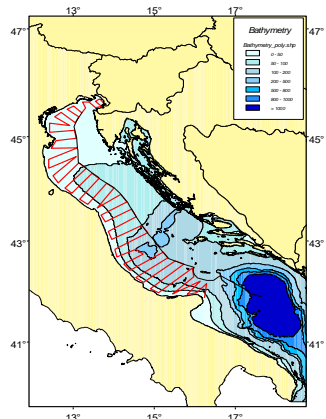
Area of the East Echosurvey
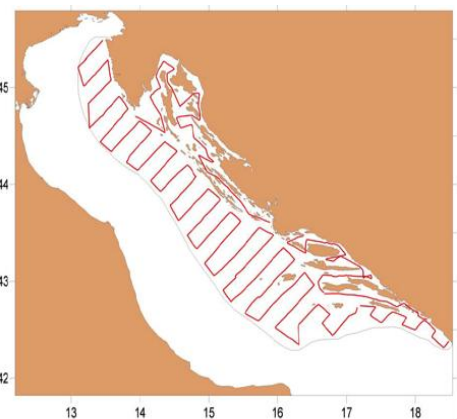
Code: ANE1711Doc

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 1.6 and 2, respectively.
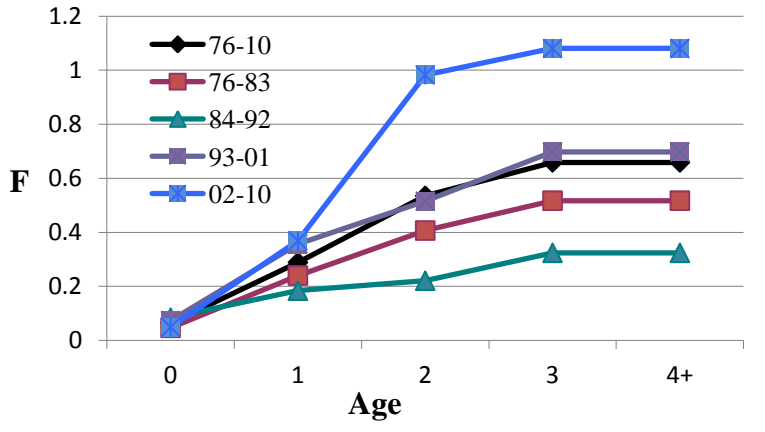
Population in biomass

Exploitation rate F/(F+M) = F/Z as a function of time; the threshold 0.4 suggested by Patterson (1992) for the manageme
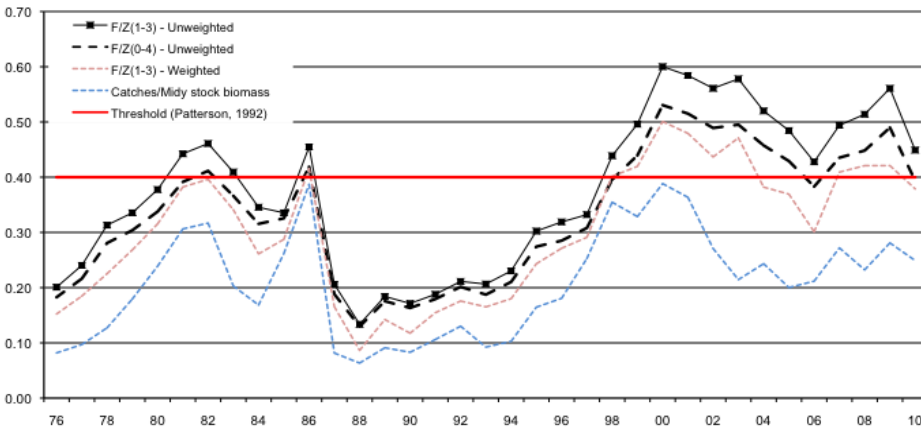
Average F/Z 1-3 unweighte

1976-10	0.37
2008-10	0.51

Fishing mortality rates

Recruitment (R, individuals with age 1) and spawning stock biomass (SSB).
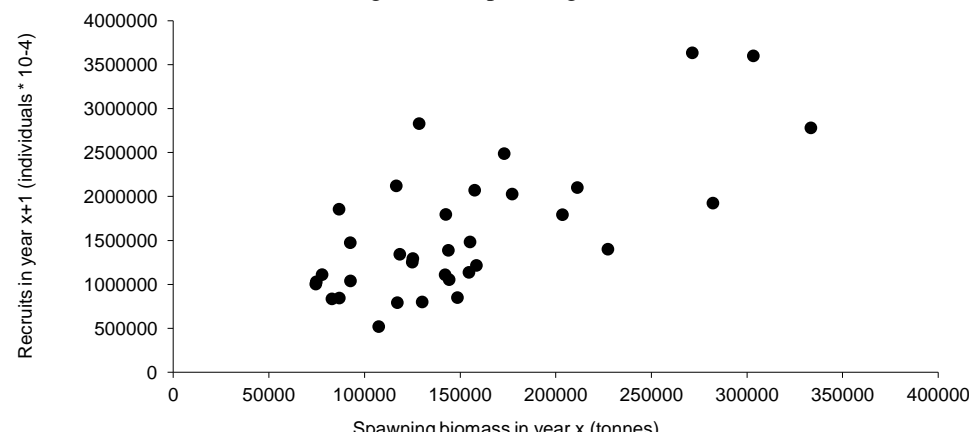
Sex*	M+F	Gear*	Mid-water trawlers and purse seiners.	Analysis #*	VPA

Population in figures

Calculations of F on the odest age for each year x, i.e. Fx in the following proportion:
non riesco a sostituire questa riga protetta

Population in biomass

Fishing mortality rates

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| Sex* | | Gear* | | Analysis #* | |

Population in figures

Population in biomass

Fishing mortality rates

Other assessment methods

Explorative runs by the means of integrated catch analysis have been 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: 0.5 for age 0; 1 for age 1,2,3; 0.5 for age 4; 0.05 for age 5.
The catchability model: Linear.
Weight for the survey data at age 4 equal to 0.5.
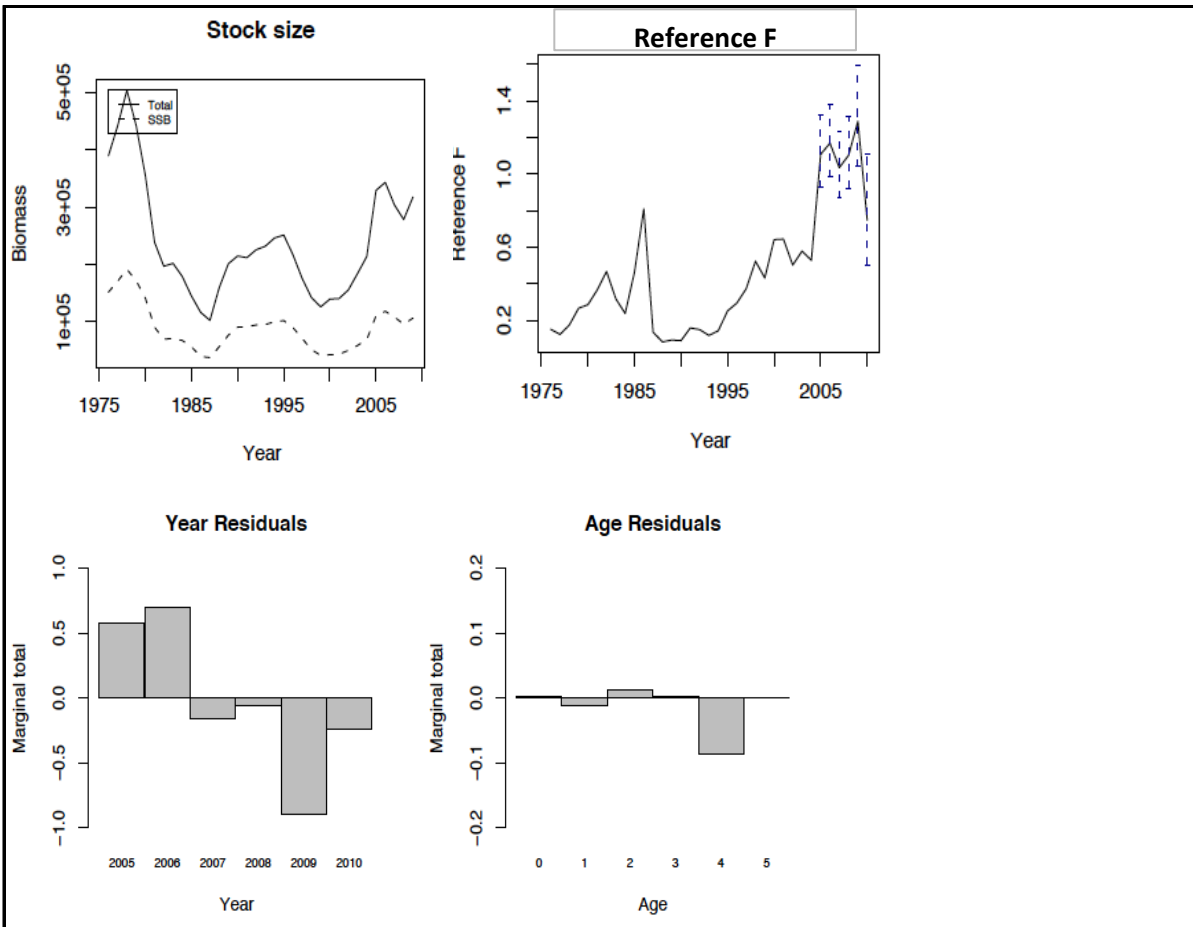
Other assessment methods

Additional information on western echo-survey.

The trend of anchovy biomass density in the North Adriatic Sea (see figure below, upper part) in the period 1976-2010 derived from acoustic surveys is represented in the graph below. The average biomass density value was estimated in 27 t/nm2. After a peak in 1978 anchovy biomass began to decrease until the collapse of the years 1986-90; the recovery started in 1991 and proceeded until now with two peaks (2001, 2008) and one relative minimum value (2005). Biomass density in 2010 resulted 64.3 t/nm2, an high value second only to the 2008 one in this historical series.

The trend of anchovy 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 29.2 t/nm2. Anchovy biomass presents very low levels in the years 1987-93; the change happens in 1994 with a significant increase in biomass. In more recent years the stock maintained good levels of biomass even if presenting fluctuations particularly evident in 2005-07 with a relative minimum value followed by a peak and then a minimum again. In 2010 anchovy biomass density level decreased to a very low level of 2.2 t/nm2, similar to those at the start of the studied period at the end of the '80.
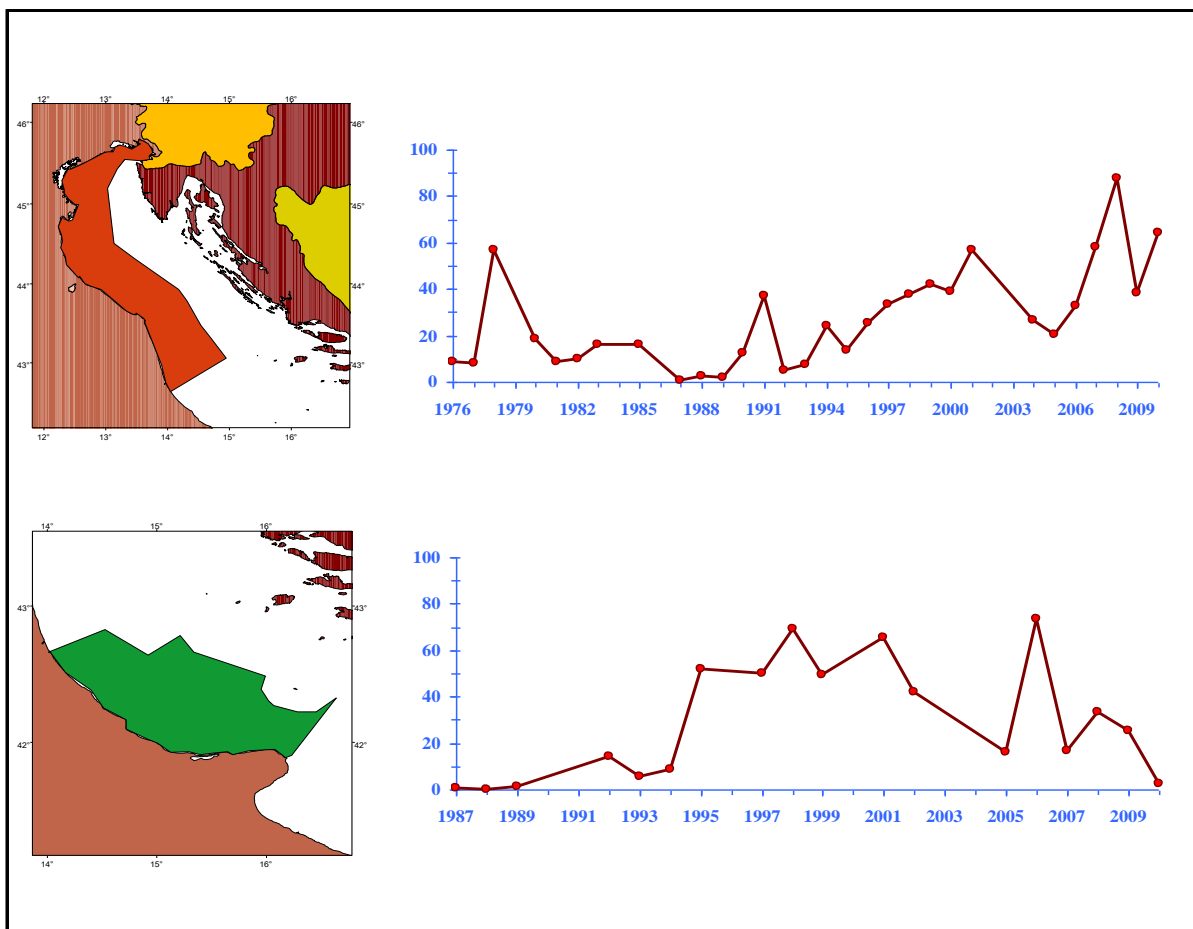
Code: ANE1711Doc

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;

	Exploitation rate	**Stock abundance**	
Bidimensional	○ No or low fishing	○ Virgin or high abundance	○ Depleted
	◉ Moderate fishing	◉ Intermediate abundance	○ Uncertain / Not assessed
	○ High fishing mortality	○ Low abundance	
	○ Uncertain / Not assessed		

Comments

Comments

Code: ANE1711Doc

Management advice and recommendations*

Strong changes and fluctuations over time are commonly observed in the abundance of small pelagics (Jacobson et al., 2001), with an important role being played by environmental factors. In the past, the biomass of anchovy stock dropped at very low level in 1987 with consequent crisis of Italian fishery. After this collapse, recovery took place, but fluctuations still occurred, in particular in recent years

The recent exploitation rate F/Z is over 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 2 and 3; this is evident if the corresponding F/Zs weighted on abundance at sea are taken into account: in recent years, these F/Zs are exactly around the threshold 0.4 just because the mentioned effects are smoothed. Also, the ratio between total catch and stock biomass is not particularly high: below 0.3. Thus, anchovy stock can be considered as fully exploited.

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

It is recommended not to increase the fishing effort in the near 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) 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.

2) 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** | 2011

Species Scientific name | Engraulis encrasicolus - ANE

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.

Average total catch in the time interval 1976-2009 is 29000 tonnes.

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 1976 to 2009 (split year) 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 2008 (due to the split year, information from surveys carried out in 2009 did not enter in the tuning data set).

Natural mortality at age was estimated by means of Gislason's method:

Age   M

0   1.02

1   0.82

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

Intermediate abundance

Comments

Management advice and recommendations*

Advice for scientific research*