Stock Assessment Form version 0.1

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Assessment form content for each stock

1 Basic Identification Data

Scientific name:	Common name:	ISCAAP Group:
Sardina pilchardus	Sardine	35 - Herrings, sardines, anchovies
Geographical sub-area:		
GSA 17		
Stock assessment method: (direct, indirect, combined, none)		
Combined		
Authors: Carpi P. (1), (*in alphabetical order)* Angelini S. (1), Belardinelli A. (1), Biagiotti I. (1), Campanella F. (1), Canduci G. (1), Cingolani N. (1), Čikeš Keč V. (2), Colella S. (1), Croci C. (1), De Felice A. (1), Donato F.(1), Leonori I. (1), Martinelli M. (1), Malavolti S. (1), Modic T. (3), Panfili M. (1), Pengal P. (3), Santojanni A. (1), Ticina V. (2), Vasapollo C. (1), Zorica B. (2), Arneri E (4).		
1.		
Affiliation: (1) CNR-ISMAR (Ancona, Italy), (2) Institute of Oceanography and Fisheries (Split, Croatia), (3) Fisheries Research Institute of Slovenia (Ljubjana, Slovenia), (4) FAO-Adriamed (Rome, Italy)		

2 Stock identification and biological information.

2.1 Stock unit

Sardine stock is shared among the countries belonging to GSA 17 (Italy, Croatia and Slovenia) and constitutes a unique stock.
Although there is some evidence of differences on a series of morphometric, meristic, serological and ecological characteristics, the lack of genetic heterogeneity in the Adriatic stock has been demonstrated through allozymic and mitochondrial DNA (mtDNA) surveys (Carvalho et al. 1994) and through sequence variation analysis of a 307-bp cytochrome *b* gene (Tinti et al. 2002a,b). The results of the genetic analyses imply that the different trophic and environmental conditions found in the northern and central Adriatic, may cause differences in growth rates. For this reason a joint assessment between GSA 17 and GSA 18 is advisable.

2.2 Growth and maturity

Table 2: Maximum size, size at first maturity and size at recruitment.

Somatic magnitude measured (LH, LC, etc)*		TL		Units*	cm
Sex	Fem	Mal	Both	Un-sexed	
Maximum size observed			21.5		Reproduction season: October-May
Size at first maturity			8		Reproduction areas: Mainly Central Adriatic, eastern offshore areas. Between Susak Island and Jabuka Pit, and around Palagruza.
Recruitment size			9		Nursery areas: River Po delta, Manfredonia Gulf

Table 2: Growth and length weight model parameters

			Sex			
		Units	female	male	both	unsexed
Growth model	L∞	Cm			20.5	
	K	y^{-1}			0.46	
	t0	y			-0.5	
	Data source	Sinovcic,1984				
Length weight relationship	a				0.0056	
	b				3.0327	

	Age0	Age1	Age2	Age3	Age4	Age5	Age6		
M (vector by age) Gislason *et al*, 2010	2.51	1.10	0.76	0.62	0.56	0.52	0.50		

sex ratio (% females/total)	

3 Fisheries information

3.1 Description of the fleet

Table 3: Description of operational units in the stock

	Country	GSA	Fleet Segment	Fishing Gear Class	Group of Target Species	Species
Operational Unit 1*	Italy	17	Pelagic trawlers	Trawls	35 - Herrings, sardines, anchovies	Sardine pilchardus
Operational Unit 2	Italy	17	Purse Seiners	Surrounding Nets	35 - Herrings, sardines, anchovies	Sardine pilchardus
Operational Unit 3	Croatia	17	Purse Seiners	Surrounding Nets	35 - Herrings, sardines, anchovies	Sardine pilchardus
Operational Unit 4	Slovenia	17	Purse Seiners	Surrounding Nets	35 - Herrings, sardines, anchovies	Sardine pilchardus
Operational Unit 5	Slovenia	17	Pelagic trawlers	Trawls	35 - Herrings, sardines, anchovies	Sardine pilchardus

Table 3: Catch, bycatch, discards and effort by operational unit

Operational Units*	Fleet (n° of boats) *	Kilos or Tons	Catch (species assessed)	Other species caught	Discards (species assessed)	Discards (other species caught)	Effort units
1	84	tons	6800				
2	19	tons	486				
3	NA	tons	46000				
4	5	tons	300				
5	1						
Total	130						

Table 3: Catches as used in the assessment

Classification (age, length, recruit/spawner)	Catch (tn)
2000	23558
2001	21242
2002	24459
2003	22028
2004	21671
2005	19008
2006	19759
2007	20329
2008	25566
2009	33279
2010	33301
2011	52546
Average	26396

3.2 Historical trends

In figure 3.2.1 the trend in landings for Italy and Croatia are shown. Since 2005 the trend is constantly increasing reaching the maximum in the last year: the 2011 catches (52546 tons) are the highest ever registered from 1975. The Slovenian catches are included in the total landings but are not shown here since the quantities are really low (around 300 tons in 2011):

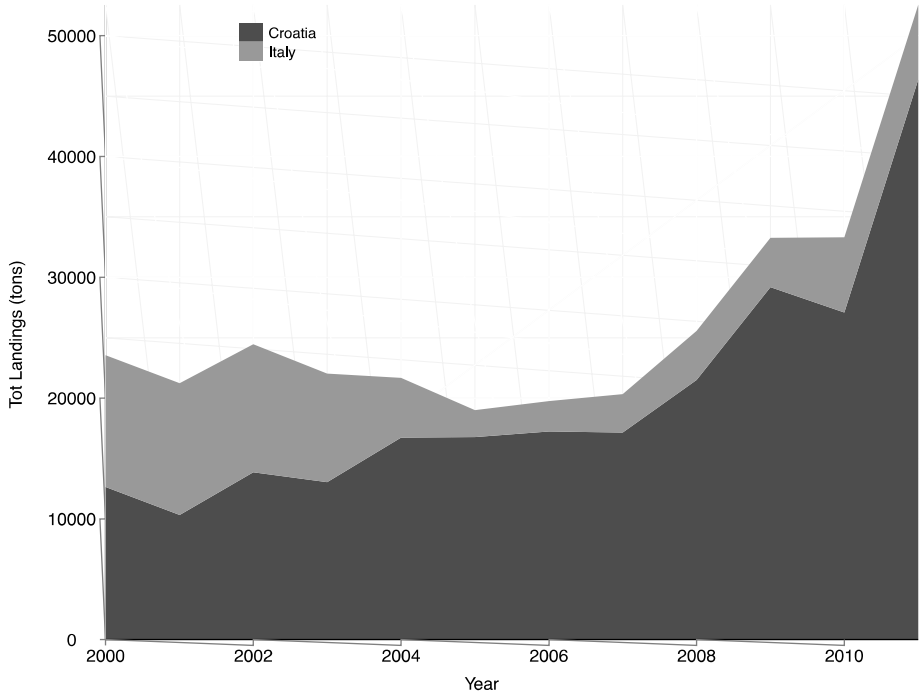

Fig. 3.2. Total landings (in tons) by country for GSA 17 from 2000 to 2011

The trend of the cohorts in the catches is shown in figure 3.2.2. Each plot represents the number of fish of each age born in the same year. Age 2 can be identified as the first fully recruited age.

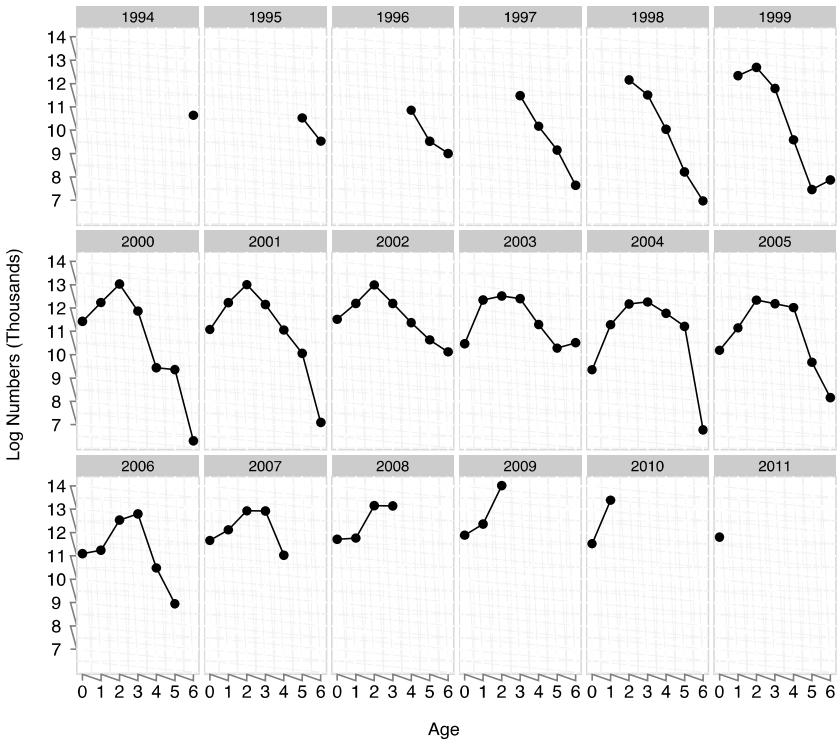

Fig. 3..2 Log numbers at age (thousands) of the catch at age used in the assessment.

The mean weight at age (in kg) as obtained by sampling of commercial catches is given in figure 3.2.3.

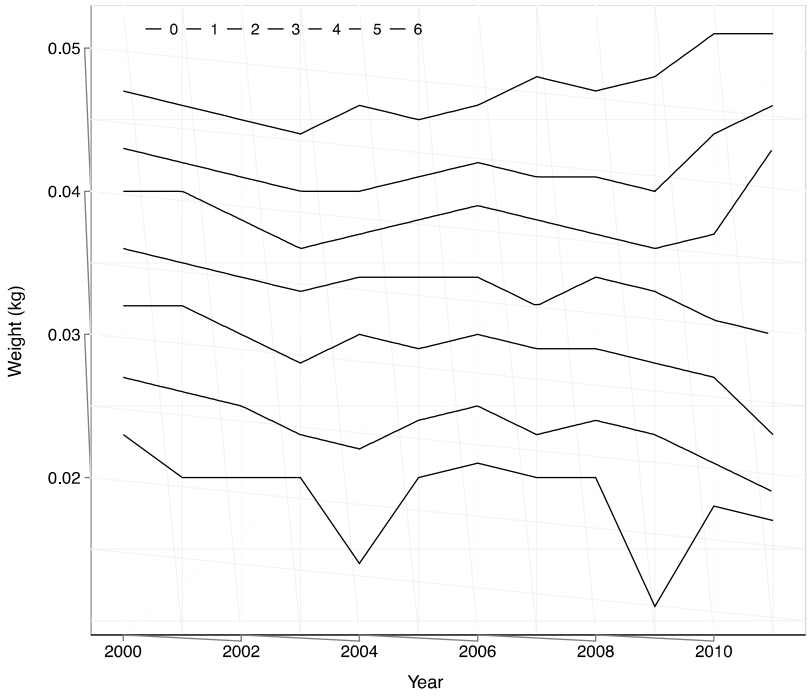

Fig. 3.2.3. Mean weight at age (kg) in the catches.

4 Management regulations

A closure period is observed from the Italian pelagic trawlers on August, and from 15th December to 15th January from the Croatian purse seiners. In 2011 a closure period of 60 days (August and September) was endorsed by the Italian fleet.

4.1 Reference points

The present assessment has been considered as a benchmark assessment for biomass reference points. Up to now, the Patterson's reference point of E=0.4 has been adopted as fishing mortality reference point.

The reference points that were proposed during the working group are B_{lim} and B_{pa}. The criterion adopted for B_{lim} has been the minimum mid year biomass value of the assessed time series, which is of the same magnitude of the minimum value observed since 1976, so it seemed to be reasonable. B_{pa} has been established in relation to B_{lim} using an estimate or assumption on the coefficient of variance of the estimates (see general sections), and assuming that the confidence intervals for the estimate of the assessment model are estimate ± 2 * CV * estimate. In this case a CV of 20 % has been assumed, therefore B_{pa} has been established as 40% above B_{lim}.

Table 4: List of reference points

Crite-rion	Current value	Units	Reference Point	Trend	Comments
B					
SSB					
F					
Y					
CPUE					
E(1-4)	0.52		0.4	Increas-ing	Patterson (1992)
Blim	215050	tons	78000	Increasing	
Bpa	215050	tons	109200	Increas-ing	

5 Fisheries independent information

5.1 MEDIAS ECHOSURVEY (Acoustic survey)

5.1.1 Brief description of the chosen method and assumptions used

Echosurveys were carried out from 2004 to 2011 for the entire GSA 17. In the western part the acoustic survey was carried out since 1976 in the Northern Adriatic (2/3 of the area) and since 1987 also in the Mid Adriatic (1/3 of the area), and it is in the MEDIAS framework since 2009. The eastern part was covered by Croatian national pelagic monitoring program PELMON. The data from both the surveys have been combined to provide an overall estimate of numbers-at-age.

The survey methods for MEDIAS are given in the MEDIAS handbook (MEDIAS, March 2012).

Western Echosurvey:

- Length frequencies distribution available from 2004 onward (no LFD for Mid Adriatic in 2004, so the biomass at length in 2004 was assumed equal to the proportion of biomass at length in the 2005 Mid Adriatic survey).
- ALKs available for 2009-2010-2011;
- Numbers at age for 2004 to 2008 were obtained applying the sum of the 2009-2010-2011 ALKs to the numbers at length.

Eastern Echosurvey:

- Length frequencies distribution available from 2009.
- No ALKs available.
- Numbers at length from 2004 to 2008 were obtained applying the length frequency distribution from the 2009 survey to the total biomass.
- Numbers at age were obtained applying commercial ALK from the eastern catches to the eastern echosurvey length distribution.
- 2011 survey covered only the Northern part of the area (about 52% of the total area), so the estimated biomass was raised to the total using an average percentage from previous years (2004-2010).
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5.1.2 Spatial distribution of the resources

Acoustic sampling transects and the total area covered are shown in figure 5.1.2.1.

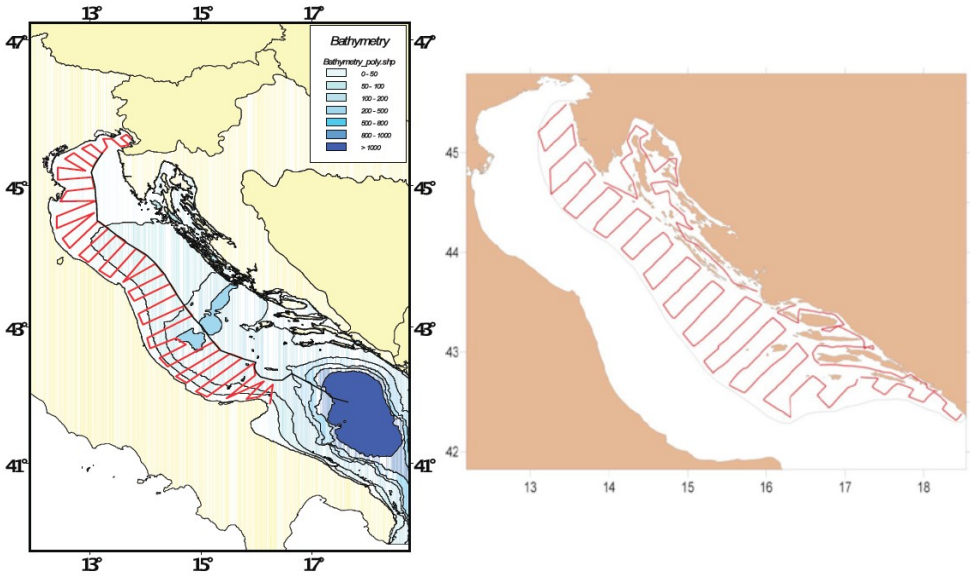

Fig. 5..2.1. Acoustic transects for the western echosurvey (on the left) and the eastern echosurvey (on the right)

5.1.3 Historical trends

Biomass estimates from the two surveys show a general higher occurrence of sardine on the eastern side of the Adriatic. Nevertheless, in 2011 the western survey contributed to about 83% of the total estimated biomass.

Pooled total biomass in tons from eastern and western echosurvey (2004-2011) is given in table 5.1.3.1. and it is shown in figure 5.1.3.1.

Tab. 5..3.1. Total biomass (tons) estimated by the acoustic surveys in GSA 17.

	Tons
2004	287675
2005	140082
2006	312793
2007	217897
2008	272370
2009	365939
2010	258130
2011	483224

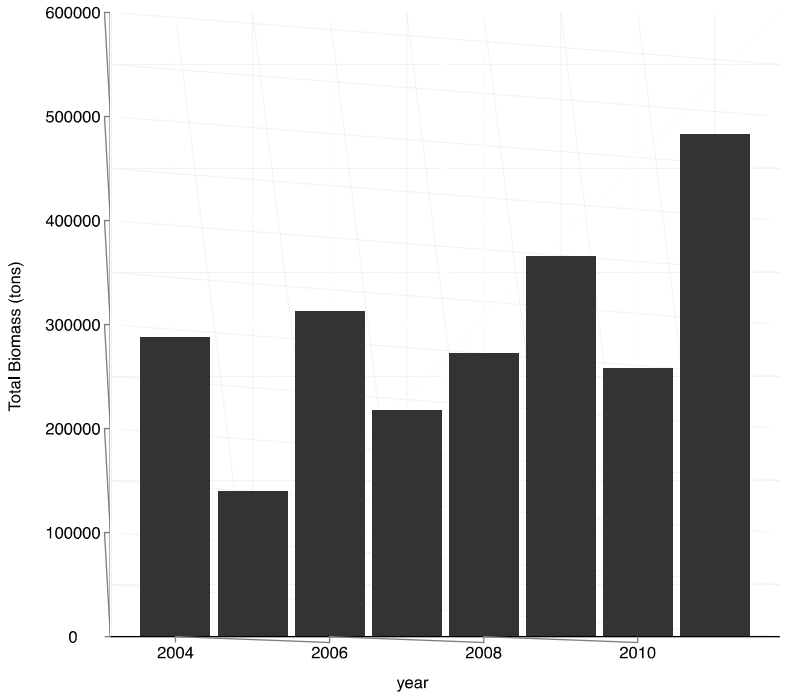

Fig. 5.1.3.1. Total biomass (tons) estimated from the eastern and western echosurvey.

Figure 5.1.3.2 illustrates the proportion by year of each age class from the surveys. In 2009 and 2011 higher percentage of age 0 has occurred. Age 5 and age 6 are scarcely represented in the estimation.

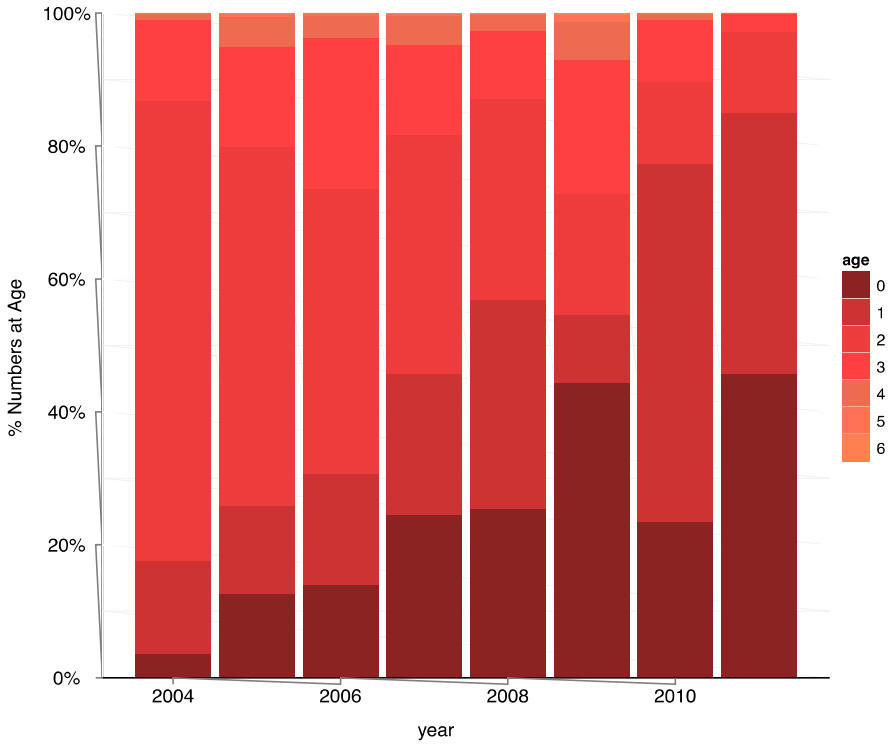

Fig. 5.1.3.2. Total proportion of age classes for the two surveys

In figure 5.1.3.3 the trend of the cohorts in the acoustic survey is shown. Each plot represents the number of fish of each age born in the same year:

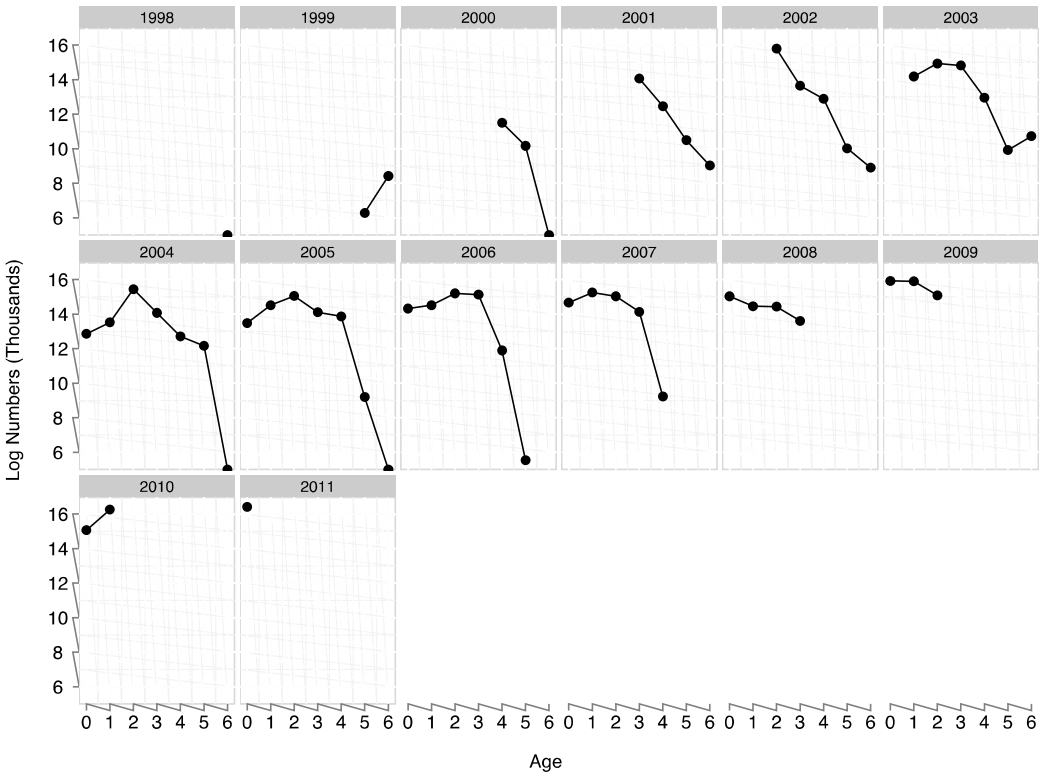

Fig. 5.1.3.3. Log numbers at age (thousands) of the echosurvey index used in the assessment

5.2 MEDITS

5.2.1 Brief description of the chosen method and assumptions used

The MEDITS bottom trawl survey started in 1994 and it has been carried out every year since. It takes place during the summer months (June-July) and it provides indices of fish abundance in the deepest part of water column (i.e. within layer up to 3 m above sea bed). Although this survey is targeted to investigate species living near the bottom, the characteristics of the net employed (high vertical opening of the mouth) allow to regularly catch species living in the water column, as small pelagics (Sbrana *et al.,* 2010).

The survey methodology is given in the MEDITS handbook (MEDITS, April 2012).

5.2.2 Spatial distribution of the resources

The spatial distribution of the Medits stations during the 2010 trawl survey is illustrated in figure 5.2.2.1.

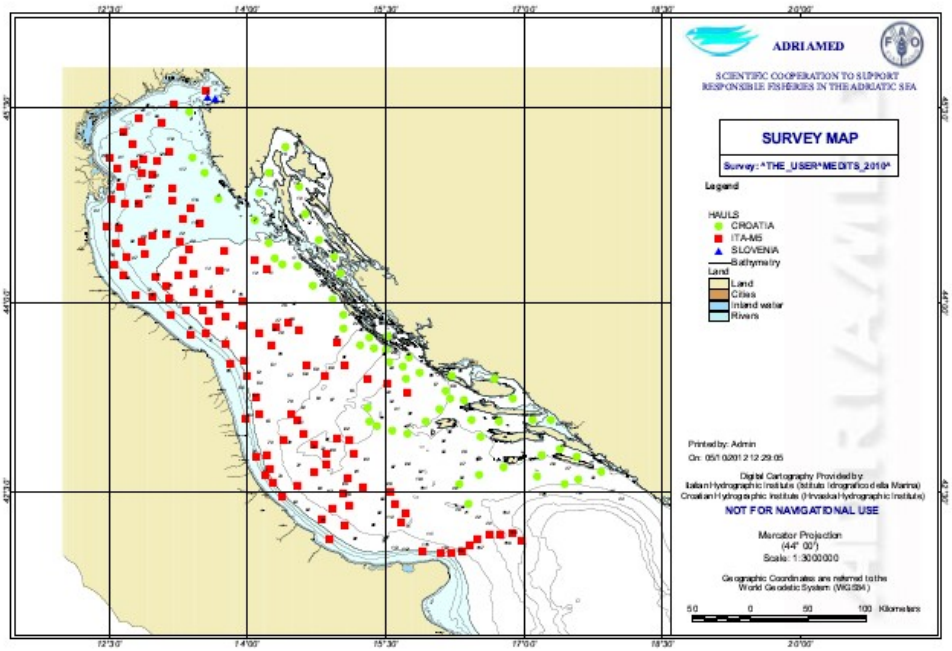

Fig. 5..2.1. Spatial distribution of the MEDITS stations in GSA 17.

5.2.3 Historical trends

The biomass index (kg/km^2) (table 5.2.3.1) shows an overall decreasing trend up to 2007, followed by a constant increase, with a maximum in 2011 (29.97 Kg/km^2).

Tab. 5..3.1. MEDITS index of biomass (kg/km^2) from 2000 to 2011.

Medits biomass index	
	kg/km2
2000	9.85
2001	12.59
2002	15.05
2003	10.96
2004	18.69
2005	4.04
2006	5.90
2007	3.18
2008	6.58
2009	6.89
2010	8.74
2011	29.97

The comparison between the acoustic series of total biomass and the trawl survey biomass index shows a general agreement between the two indices (figure 5.2.3.1). The only exception is 2010, when the bottom trawl survey sees an increasing trend while the acoustic one sees a slightly decrease. In 2011 both the survey show a steep increase, which is reflected in the 2011 landings from the eastern side as well.

The weight given in the assessment to the MEDITS trawl survey is much lower to the weight given to the acoustic survey (see section 7.1.1).

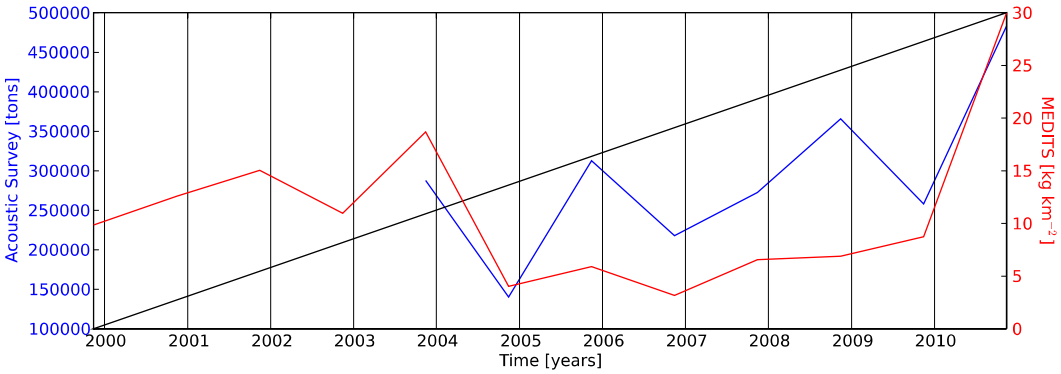

Fig. 5.2.3.1. Comparison between biomass index from the acoustic survey (axis on the left, blue line) and the bottom trawl survey (axis on the right, red line).

6 Ecological information

N/A

6.1 Protected species potentially affected by the fisheries

N/A

6.2 Environmental indexes

N/A

7 Stock Assessment

Integrated Catch Analysis (ICA) and Virtual Population Analysis (VPA) have been performed from 2000 to 2011.

Acoustic and bottom trawl survey were available for the assessment of sardine in GSA 17. The weight given to the bottom trawl survey was decided equal to 0.3, in comparison to weight 1 given to the acoustic survey.

Age 0 wasn't included in the model: the high natural mortality, in fact, drives the biomass to really high –and quite unrealistic- values. Since age 0 is not largely represented in the catches, the WG decided not to include it in the assessment.

7.1 Integrated Catch Analysis

The final assessment of anchovy was carried out by fitting the integrated catch-at age model (ICA) with a separable constraint over a seven-year period, tuned with the Acoustic survey (2004-2011) and bottom trawl survey biomass index (2000-2011).
ICA was performed using the Patterson's software (ICA, version 4.2 – Patterson and Melvin, 1996).

The model settings are presented in section 7.1.1.

7.1.1 Model assumptions

- Ages 1 to 6
- M vector estimated using Gislason's equation (Gislason *et al.*, 2010):

Age1	Age2	Age3	Age4	Age5	Age6
1.10	0.76	0.62	0.56	0.52	0.50

- Maturity at age:

Age1	Age2	Age3	Age4	Age5	Age6
1	1	1	1	1	1

- 7 years for separable constraint
- Reference age for separable constraint = 2
- Constant selection pattern model
- S to be fixed on last age = 1.3
- F_{bar}: 1-4
- Catchability model = Linear
- Weight for surveys: Bottom trawl surveys= 0.3; Acoustic surveys = 1.
- No shrinkage

7.1.2 Scripts

N/A

7.1.3 Results

The fishing mortality for age 2 (presented in figure 7.1.3.1., top-right) shows a steep increase from 2005 (RefF = 0.14) up to 2011 (RefF = 0.80). In 2011 the $F_{bar(1-4)}$ is equal to 1.11.

The mid year biomass (figure 7.1.3.1, bottom-right) is fluctuating between about 100000 t and about 200000 t until 2009, in which the trend starts a constant increase reaching the maximum of 215000 tons in 2011.

The recruitment (age 1 – figure 7.1.3.1, bottom-left) is quite stable as well, but again in 2009 begin to growth up to the value of 16830000 thousands specimens in 2011.

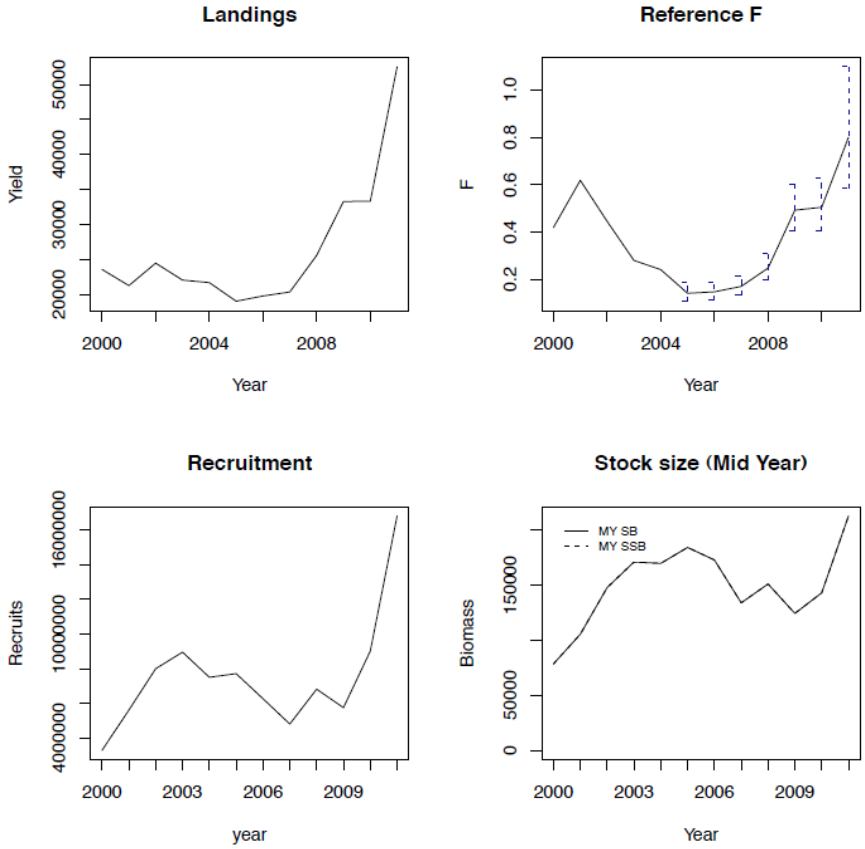

Fig. 7.1.3.1. Total landings in tons (top-left); reference F (F for age 2) with the confidence interval for the separability period (top-right); recruitment (as thousands individuals)(bottom-left); mid year stock biomass and SSB in tons (bottom-right).

Table 7.1.3.1 and 7.1.3.2 give respectively the stock numbers at age by year (in thousand) and the fishing mortality at age by year. In table 7.1.3.3 the mid year stock biomass and the spawning stock biomass in tons are presented.

Tab. 7.1.3.1. Stock numbers at age by year (thousands).

	Age1	Age2	Age3	Age4	Age5	Age6
2000	3276600	769120	278820	140330	136270	151380
2001	5605400	967120	236540	82268	42443	42384
2002	7997100	1753200	243670	58144	27956	24004
2003	8953900	2549900	525200	41413	16735	9388
2004	7500200	2872100	901120	181860	13090	8000
2005	7710200	2371300	1055200	350810	94557	19704
2006	6261900	2526000	962890	406350	149410	3981
2007	4797400	2050100	1019300	365340	170820	7662
2008	6813200	1566600	808550	366370	146450	112770
2009	5742600	2205500	571770	241900	125010	96016
2010	9015800	1808500	630310	95891	49645	2255
2011	16830000	2835500	510630	102720	19191	6610

Tab. 7.1.3.2. Fishing mortality at age by year.

	Age1	Age2	Age3	Age4	Age5	Age6
2000	0.120	0.419	0.601	0.636	0.424	0.424
2001	0.062	0.619	0.783	0.519	0.520	0.520
2002	0.043	0.445	1.152	0.685	0.547	0.547
2003	0.037	0.280	0.441	0.592	0.326	0.326
2004	0.052	0.241	0.323	0.094	0.183	0.183
2005	0.016	0.141	0.334	0.294	0.184	0.184
2006	0.017	0.148	0.349	0.307	0.192	0.192
2007	0.019	0.170	0.403	0.354	0.222	0.222
2008	0.028	0.248	0.587	0.515	0.322	0.322
2009	0.055	0.493	1.166	1.024	0.640	0.640
2010	0.057	0.505	1.194	1.049	0.656	0.656
2011	0.090	0.801	1.894	1.664	1.041	1.041

Tab. 7.1..3. Mid year Stock Biomass and Spawning Stock Biomass (tons). From age 1 all the specimens are mature, so the stock biomass coincide with the SSB.

	MidYear SB /
2000	78183
2001	103588
2002	146993
2003	172860
2004	170213
2005	182150
2006	174702
2007	132326
2008	150551
2009	125542
2010	142541
2011	215050

The exploitation rate (F/(F+M)) is shown in figure 7.1.1.2.

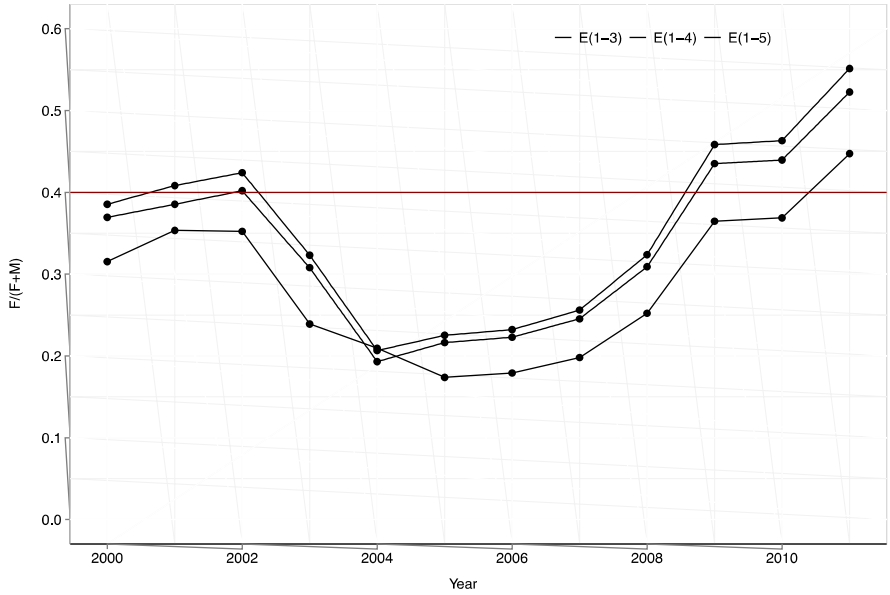

Fig. 7.1.1.2. Exploitation rate (E = F/(F+M)) for age classes 1-3, 1-4 and 1-5 resulting from ICA analysis.

In figure 7.1.1.3 the harvest rate, calculate as the ratio between the catches and the estimates from the ICA model, shows firs a decrease and then an increase starting in 2005. In the last two years the trend looks stable. In 2011 the harvest rate is equal to 0.24. The harvest rate calculated on the acoustic biomass estimates shows instead a fluctuation around a value of 0.1.

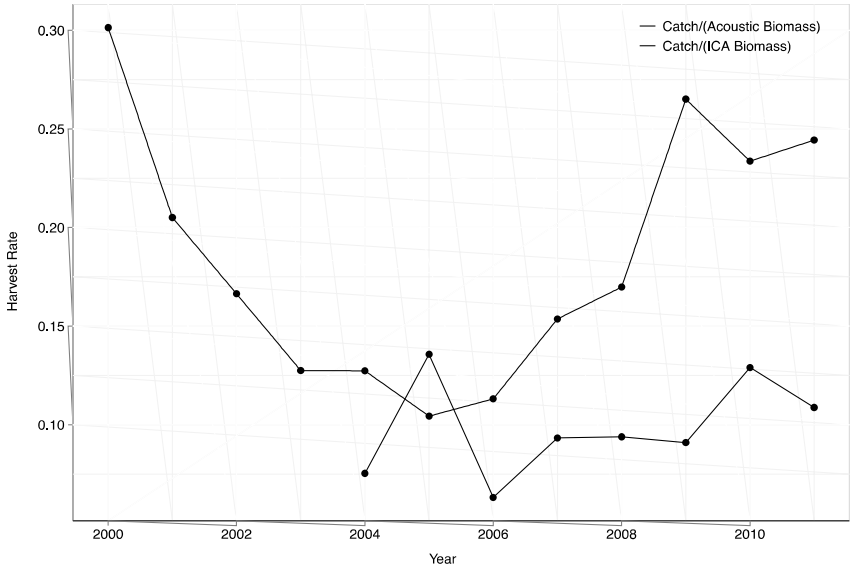

Fig. 7.3.1.3. Harvest rate estimates (C/B) obtained from the mid year ICA biomass (dashed line) and the acoustic biomass (full line).

The trend in biomass relatively to the proposed reference points is illustrated in figure 7.1.1.4.

Fig. 7.1.1.4. Mid year stock biomass from the ICA analysis with the relative reference points (B_{lim} and B_{pa}).

7.2 Virtual Population Analysis

VPA was carried out applying the Laurec-Shepherd tuning with the acoustic survey index. This tuning procedure derives estimates of fishing mortality at age in the final year from an analysis of the logarithms of fleet catchabilities.
The software used for the analysis is the Lowestoft VPA software (Darby and Flatman, Version 3.1).

7.2.1 Model assumptions

- Tuning method: Laurec-Shepherd
- Tuning index: Acoustic Survey
- Ages 1 to 6+
- Oldest age F = 1.300*average of 2 younger ages
- M vector estimated using Gislason's equation (Gislason *et al.*, 2010):

Age1	Age2	Age3	Age4	Age5	Age6
1.10	0.76	0.62	0.56	0.52	0.50

- Maturity at age:

Age1	Age2	Age3	Age4	Age5	Age6
1	1	1	1	1	1

- Shrinkage applied

7.2.2 Results

VPA estimations of mid year stock biomass, spawning stock biomass and trend in F by age are show in figures 7.2.2.1 and 7.2.2.2. The results are given in tables 7.2.2.1 and 7.2.2.2.

The biomass increases constantly since the beginning of the time series from about 66000 tons up to 483000 tons in 2011.

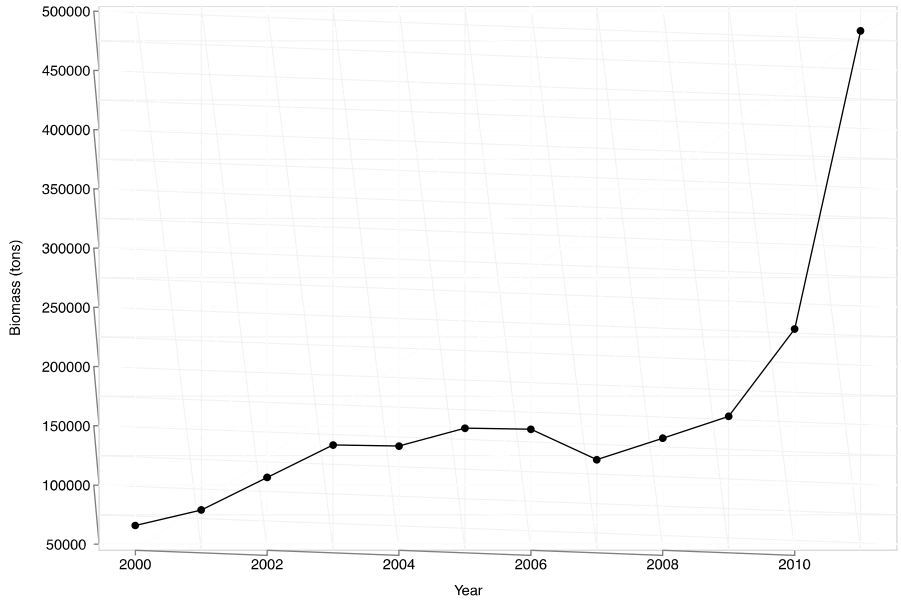

Fig. 7..2.1. Mid year biomass and mid year SSB estimated by the means of the Laurec-Shepherd VPA.

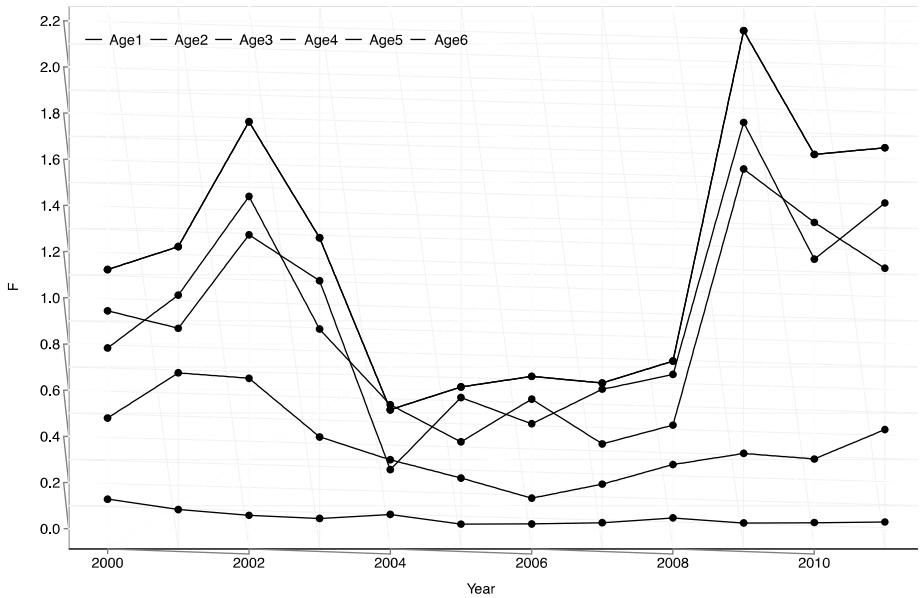

Fig. 7.2.2.2. F by age estimated by the means of the Laurec-Shepherd VPA

Tab. 7.2.2.1. Estimated numbers at age (in thousands).

	Age1	Age2	Age3	Age4	Age5	Age6
2000	3091860	689320	229880	106640	67880	75490
2001	4242330	905730	199670	56540	23710	23700
2002	6002190	1299690	215660	39060	13560	11660
2003	7469620	1886000	316770	27510	6250	3510
2004	6257190	2378110	592730	71810	5370	3280
2005	6770840	1957660	825170	186350	31770	7080
2006	5633020	2210150	735070	304810	60300	1410
2007	4934090	1836970	905560	225600	110560	3200
2008	6530140	1600570	708450	337440	70450	59240
2009	8497430	2074000	566950	243360	98820	48590
2010	14959870	2758580	700150	64210	23920	1300
2011	37250640	4851040	953850	99970	11410	5170

Tab. 7.2.2.2. Estimated F at age.

	Age1	Age2	Age3	Age4	Age5	Age6
2000	0.1278	0.4791	0.7825	0.9438	1.1221	1.1221
2001	0.0830	0.6750	1.0115	0.8682	1.2218	1.2218
2002	0.0577	0.6517	1.4391	1.2730	1.7628	1.7628
2003	0.0445	0.3975	0.8641	1.0736	1.2595	1.2595
2004	0.0620	0.2985	0.5371	0.2557	0.5153	0.5153
2005	0.0196	0.2195	0.3759	0.5683	0.6138	0.6138
2006	0.0205	0.1323	0.5612	0.4541	0.6599	0.6599
2007	0.0258	0.1928	0.3672	0.6038	0.6311	0.6311
2008	0.0469	0.2778	0.4486	0.6680	0.7258	0.7258
2009	0.0250	0.3259	1.5581	1.7597	2.1566	2.1566
2010	0.0262	0.3020	1.3264	1.1673	1.6209	1.6209
2011	0.0291	0.4294	1.1278	1.4105	1.6499	1.6499

7.3 Robustness analysis

7.3.1 ICA

The diagnostic graph of the index SSQ against reference age F (age 2) from a separable VPA is plotted in figure 7.3.1.1. The curves should be U-shaped, with minima fairly close to each other on *x*-axis (Needle, 2000).

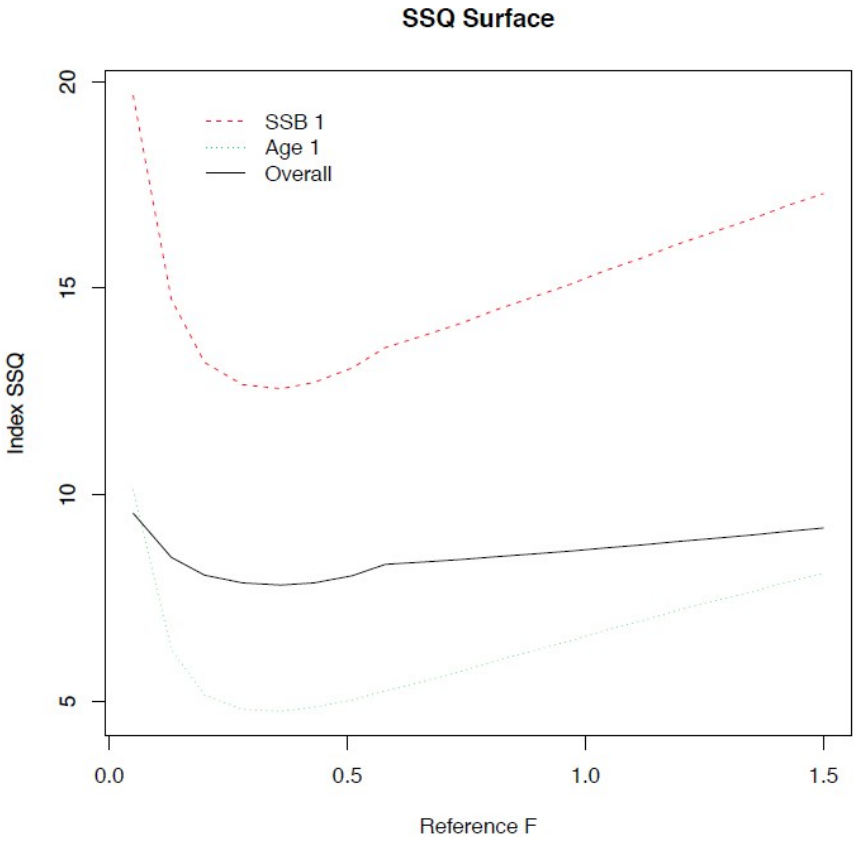

Fig. 7.3.1.1. SSQ surface plot.

The marginal totals of residuals between the catch and the separable model are overall small, as well as reasonably trend-free in the separable period (2005-2011), but for a small degree of year effect (see figure 7.3.1.2).

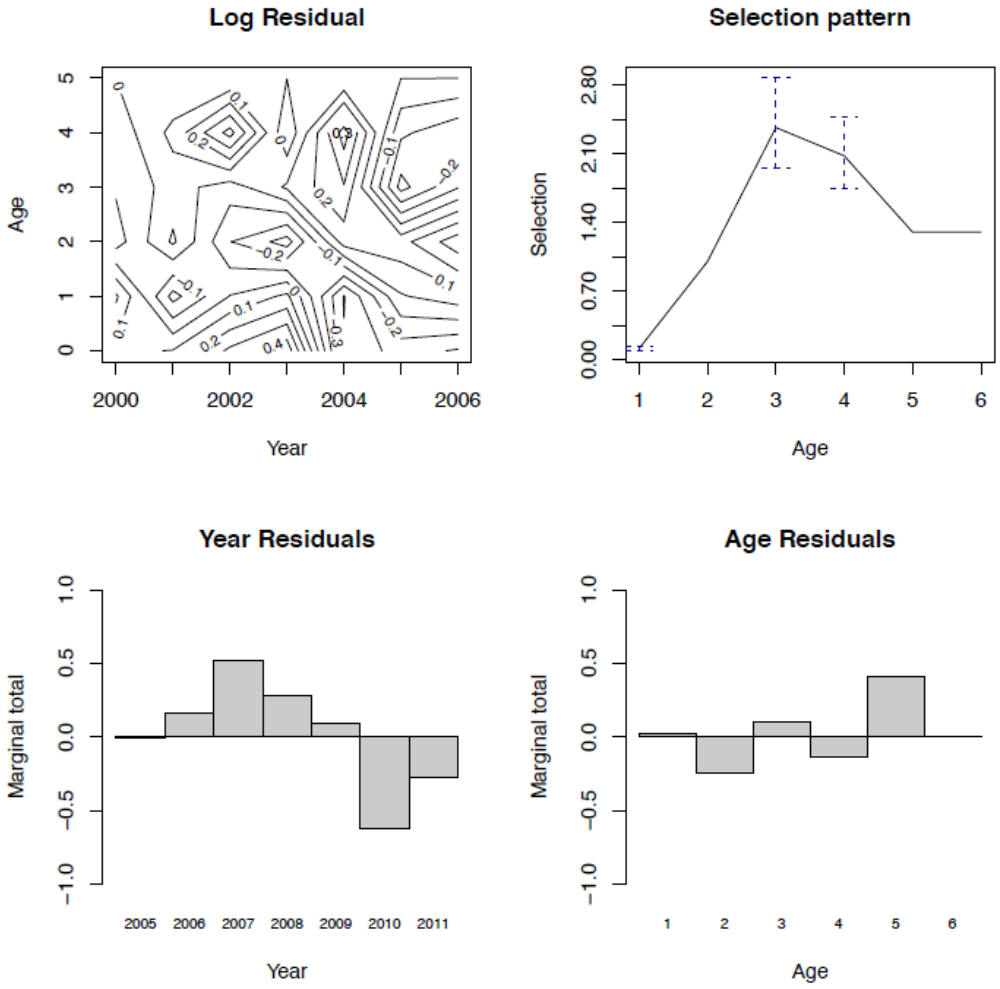

Fig. 7.3.1.2. Diagnostics: log-residual contour plot (top-left); fitted selection pattern (top-right); year residuals for the catches (bottom-left); age residuals for the catches (bottom-right).

The diagnostics tables for the final run are given below (tables 7.3.1.1 and 7.3.1.2).

Tab. 7.3.1.1. Parameters estimates for the ICA run.

Sep model : F by		Maximum Likelh. Estimate	CV %	Lower 95% CL	Upper 95% CL	-s.e.	+s.e.	Mean of Param. Distrib.
1	2005	0.1413	27	0.0832	0.2399	0.1078	0.1851	0.1465
2	2006	0.1475	25	0.0896	0.2429	0.1144	0.1903	0.1524
3	2007	0.1704	23	0.1066	0.2723	0.1342	0.2164	0.1753
4	2008	0.2479	22	0.1592	0.3861	0.1978	0.3108	0.2543
5	2009	0.4925	19	0.3329	0.7286	0.4033	0.6015	0.5025
6	2010	0.5046	21	0.3308	0.7697	0.4068	0.6259	0.5165
7	2011	0.8005	31	0.4308	1.4873	0.5835	1.098	0.8415
Separable Model: Selection (S) by age								
8	1	0.1125	22	0.0721	0.1754	0.0897	0.1411	0.1154
	2	1	Fixed: Reference Age					
9	3	2.3665	19	1.6212	3.4542	1.9512	2.8701	2.4109

10	4	2.0783	17	1.4806	2.9173	1.7482	2.4709	2.1097
	5	1.3	Fied: Last True Age					

Sep model: Populations in year

11	1	16830449	41	7497944	37778891	111412	2542468	18325263
12	2	2835492	28	1620617	4961082	2131451	3772085	2953366
13	3	510628	24	313368	832061	398030	655079	526721
14	4	102722	27	59533	177243	77767	135686	106778
15	5	19189	30	10495	35087	14104	26108	20121

Sep model: populations at

16	2005	94555	42	41047	217818	61771	144740	103526
17	2006	149406	33	77887	286597	107159	208308	157890
18	2007	170818	28	97770	298443	128498	227076	177882
19	2008	146450	26	86413	248199	111892	191683	151852
20	2009	125006	25	76415	204495	97246	160689	129010
21	2010	49644	27	28814	85530	37612	65524	51593

Medits

22	1Q	0.00006	21	5.15E-05	1.19E-04	6.31E-	9.67E-05	7.99E-05

Age-structured index catchabilities (Acoustic Survey)
Linear model fitted. Slopes at

23	1Q	0.9444	34	0.6754	2.6540	0.9444	1.8980	1.4230
24	2Q	4.1430	35	2.9570	11.7200	4.1430	8.3650	6.2610
25	3Q	6.0280	36	4.2540	17.6500	6.0280	12.4600	9.2560
26	4Q	2.3580	38	1.6310	7.3480	2.3580	5.0820	3.7260
27	5Q	0.3224	40	0.2193	1.0570	0.3224	0.7189	0.5217
28	6Q	0.5987	51	0.3664	2.7210	0.5987	1.6650	1.1380

PARAMETERS OF THE DISTRIBUTION OF ln(CATCHES AT AGE)
Separable model fitted

Variance	0.1487
Skewness test stat.	0.5036
Kurtosis test statistic	-0.9945
Partial chi-square	0.1795
Significance in fit	0
Degrees of freedom	14

DISTRIBUTION STATISTICS FOR MEDITS
Linear catchability relationship assumed
Last age is a plus-

Variance	0.1274
Skewness test stat.	-0.4913
Kurtosis test statistic	-0.8465
Partial chi-square	0.6374
Significance in fit	0
Number of	12
Degrees of freedom	11
Weight in the analysis	0.3

PARAMETERS OF THE DISTRIBUTION OF THE AGE-STRUCTURED INDICES (Acoustic Survey)
Linear catchability relationship assumed

Age	1	2	3	4	5	6
Variance	0.0903	0.0134	0.1381	0.1753	0.3037	0.2461
Skewness test stat.	-0.6693	-0.2191	0.4479	0.8021	0.4657	-0.2745
Kurtosis test statisti	-0.3183	-0.6698	-0.482	-0.1637	-0.0758	-0.5743
Partial chi-square	0.0423	0.0062	0.069	0.1063	0.2483	0.0791
Significance in fit	0	0	0	0	0.0001	0.0058
Number of	8	8	8	8	8	4
Degrees of freedom	7	7	7	7	7	3
Weight in the analysis	0.1667	0.1667	0.1667	0.1667	0.1667	0.1667

Unweight

Variance	SSQ	Data	Paramete	d.f.	Variance
Total for	41.4587	91	28	63	0.658
Catches	2.0823	35	21	14	0.149
Medits	4.6727	12	1	11	0.425
Acoustic	34.7037	44	6	38	0.913

Weighted

Variance	SSQ	Data	Paramete	d.f.	Variance
Total for	3.4669	91	28	63	0.055
Catches	2.0823	35	21	14	0.149
Medits	0.4205	12	1	11	0.038
Echo	0.964	44	6	38	0.025

The retrospective analysis (figure 7.3.1.3) shows some degree of variation on the estimates for all the variables, a little bit less for the case of F_{bar}. For the 2009-2010 estimates this trend is stronger. Future investigations will aim to solve this problem.

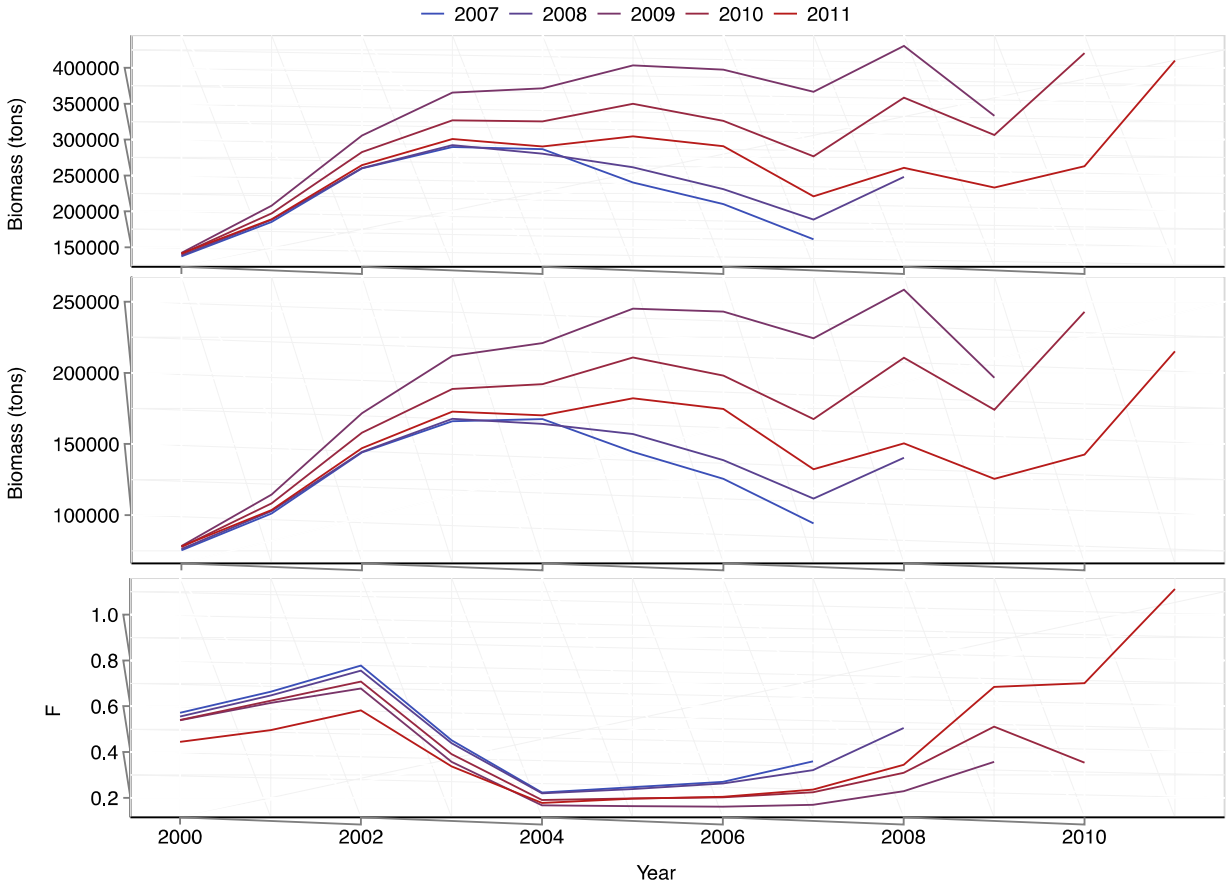

Fig. 7..1.3. ICA Retrospective analysis for total stock biomass at the beginning of the year (on top), mid year SSB (in the middle) and F (at the bottom).

The fitting of the model estimates with the acoustic surveys is shown in figure 7.3.1.4. The predicted numbers at age fit quite well the observed data, except for some disagreement in the 2009 estimates.

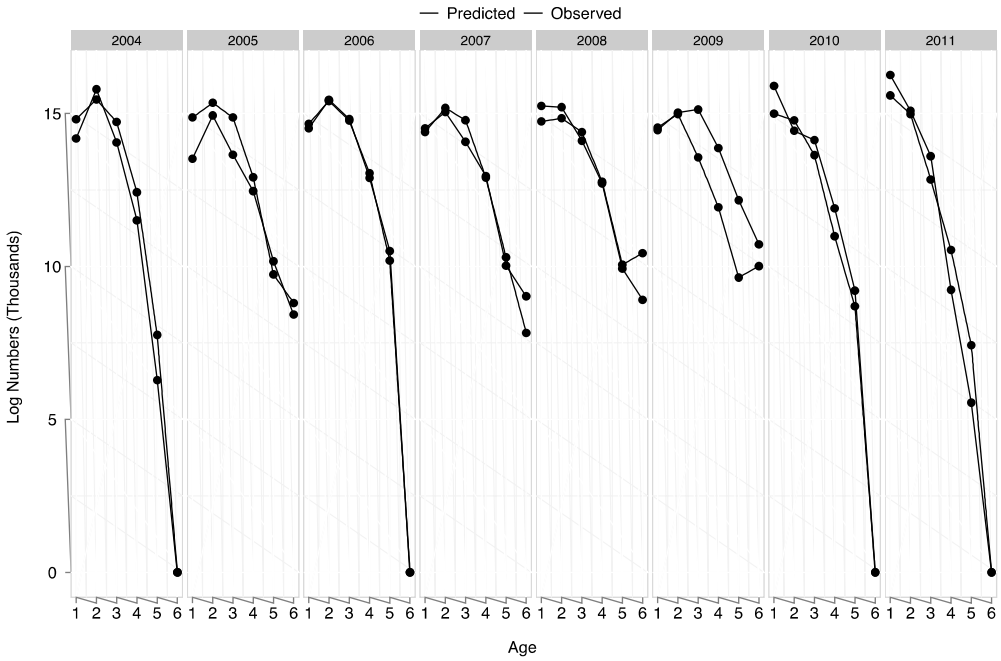

Fig. 7.3.1.4. Predicted VS Expected log numbers at age for the acoustic survey.

7.3.2 VPA

The summary statistic for the VPA run is shown in table 7.3.2.1.

Tab. 7.3.2.1. Summary statistic by age for the Laurec-Shepherd VPA.

SUMMARY STATISTICS FOR								
Fleet	Pred. Log	se (log q)	Partial F	Raised F	Slope	se	Intrcp	se Intrcpt
1	-0.65	0.595	0.5195	0.0293	1.07E-	8.26E-	-	0.198
Fbar	Sigma(int.	Sigma(ext	Sigma(over	Variance ratio				
0.02	0.595	0	0.595	0				
SUMMARY STATISTICS FOR								
Fleet	Pred. Log	se (log q)	Partial F	Raised F	Slope	se	Intrcp	se Intrcpt
1	0.94	0.563	2.5477	0.8704	-	5.62E-	0.935	0.188
Fbar	Sigma(int.	Sigma(ext	Sigma(over	Variance ratio				
0.42	0.563	0	0.563	0				
SUMMARY STATISTICS FOR								
Fleet	Pred. Log	se (log q)	Partial F	Raised F	Slope	se	Intrcp	se Intrcpt
1	1.3	0.8	3.6679	2.3083	3.90E-	1.25E-	1.3	0.267
Fbar	Sigma(int.	Sigma(ext	Sigma(over	Variance ratio				
1.12	0.8	0	0.8	0				
SUMMARY STATISTICS FOR								
Fleet	Pred. Log	se (log q)	Partial F	Raised F	Slope	se	Intrcp	se Intrcpt
1	0.81	1.166	2.2485	******	-	1.80E-	0.81	0.389
Fbar	Sigma(int.	Sigma(ext	Sigma(over	Variance ratio				
1.41	1.17	0	1.17	0				

The restrospective analysis (figure 7.3.2.1) shows lower variability on the estimates than the VPA, with the only exceptions of the estimates including up to 2009, which show a larger divergence respect to the other years.

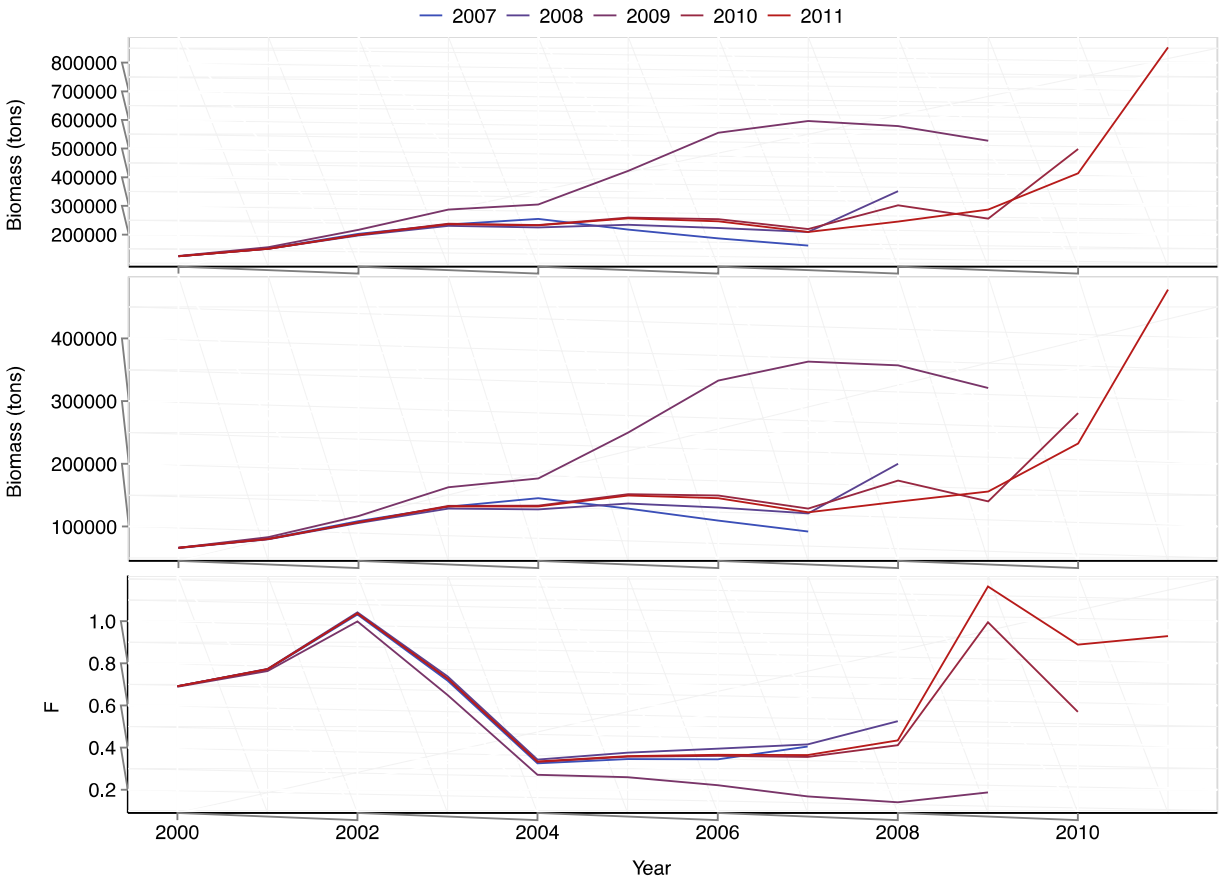

Fig. 7.3.2.1. VPA Retrospective analysis for respectively total stock biomass at beginning of the year (on top), mid year SSB (in the middle) and F (at the bottom).

The residuals for ln(q) (figure 7.3.2.2.) are reasonably trend free with some high values.

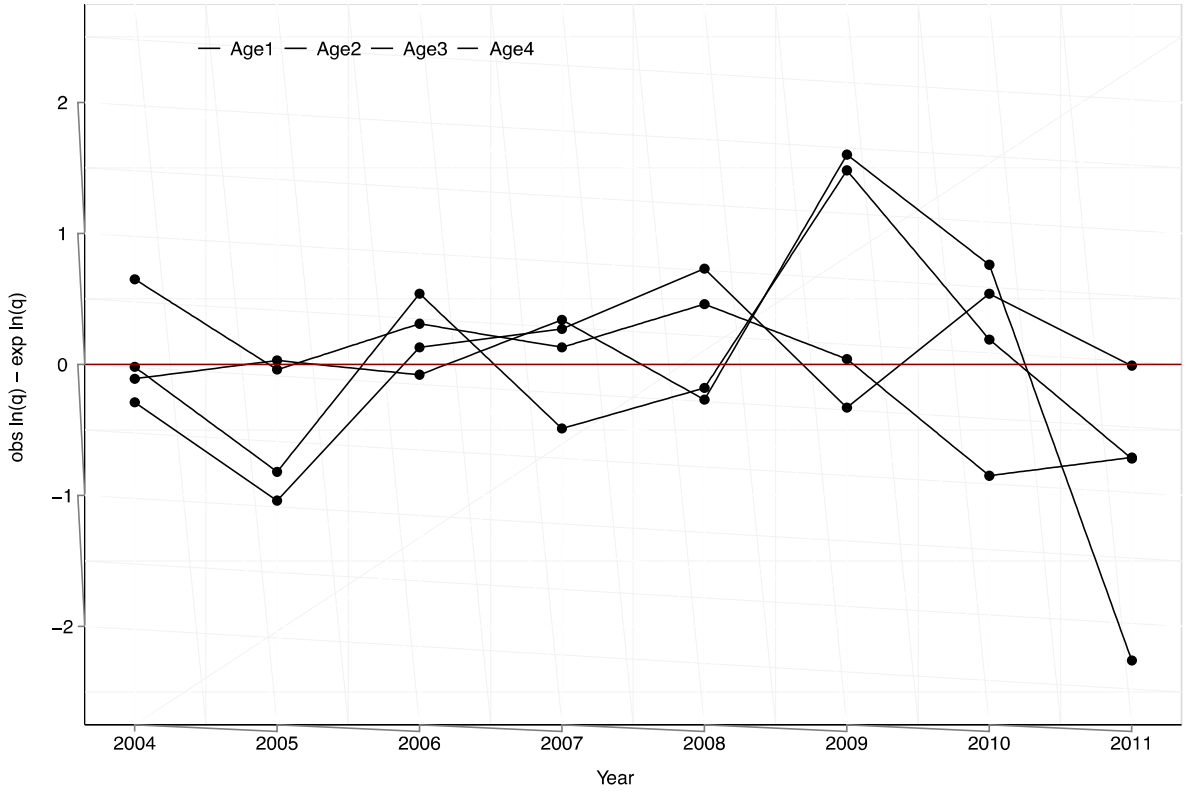

Fig. 7.3.2.2. Observed log(q) – Expexted log(q) by age estimated by VPA analysis.

7.4 Assessment quality

The separable VPA performed well with the data available, even if the analysis revealed some uncertainty in the retrospective analysis, with variable results for previous years. Nevertheless, ICA improved the parameters estimates respect to the Laurec-Shepherd VPA, which in general has high standard error.

The comparison between the resulting biomasses from the two models is shown in figure 7.4.1.

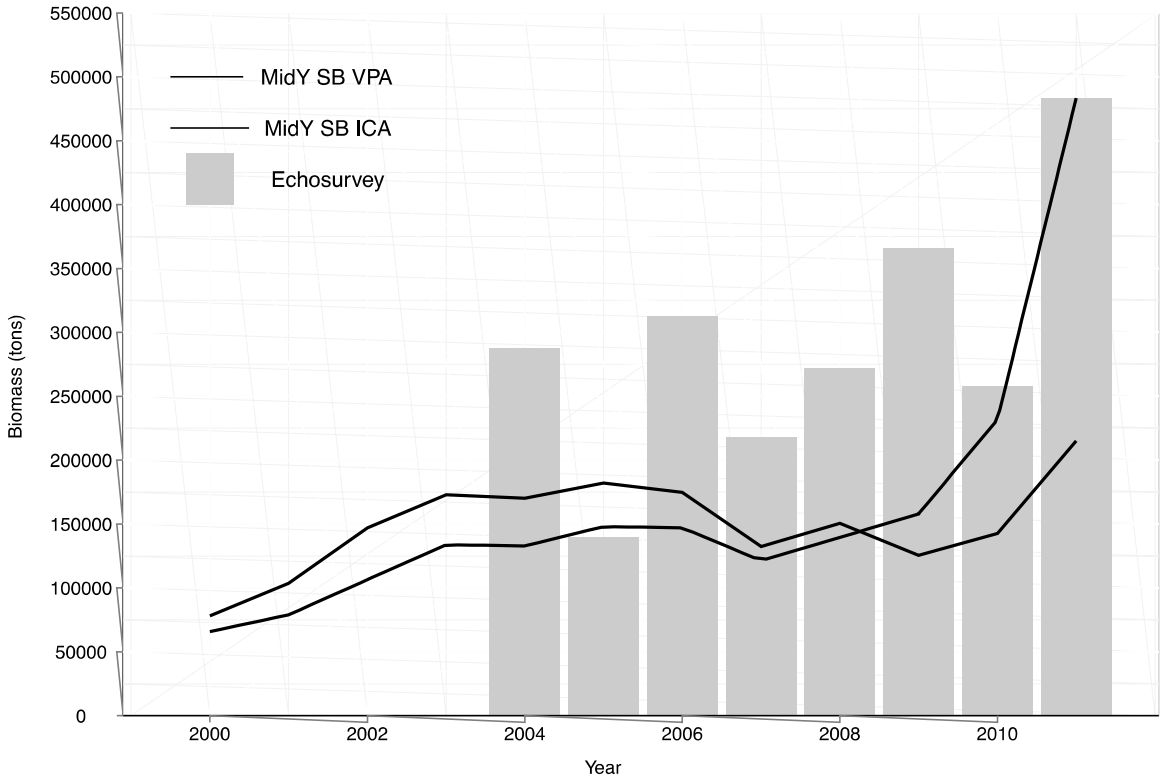

Fig. 7.4.1. Mid year Stock Biomass from VPA (dashed line) and ICA (full line); acoustic biomass estimates are shown as well in the form of background bars.

An ICA run was performed without the bottom trawl survey to test how much the inclusion of this index influences the model results. Despite a slight increase in the SSQ minimization, the CVs of the parameters estimations got worst. Besides, the resulting trend in biomass and F are almost identical, which was expected due to the really low weight gave to the index in the model.

ICA with absolute catchability model for the acoustic survey was attempted: the SSQ and the CVs were really high, the residuals showed clear trends in ages and years with high values and the fitting with the acoustic survey got much worst.

In the present assessment there is improved coherence between the biomass estimated from the model and the survey data respect to last year assessment, although absolute biomass levels for the acoustic survey remain about double the estimates of the assessment model.

8 Stock predictions

N/A

8.1 Short term predictions

8.2 Medium term predictions

8.3 Long term predictions

9 Draft scientific advice

This year we will use the already approve reference point for F (Patterson) and another set of reference points proposed for biomass.

The assessment shows a steep increase in the total biomass trend starting in 2009 and in the recruitment since 2007. The exploitation rate ($E_{(1-4)}$ = 0.52) is higher than the reference point of E = 0.4 from Patterson. On the other hand the 2011 total biomass (215050 tons) is above of both the proposed B_{lim} (78000 tons) and B_{pa} (109200 tons) reference points.

The acoustic surveys in 2011 estimated a really high biomass (about 500000 tons), the highest of the time series up to now.

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

Although F is higher than the RP, the SSB shows an increasing trend, so the current state of the fishery seems to be sustainable. On the overall, the suggestion is not to increase the fishing mortality.

Table : Bidimensional stock advice summary; Exploitation rate and Stock Abundance.

Exploitation rate		Stock Abundance	
[STATE THE PERIOD]		[STATE THE PERIOD]	
	No fishing mortality		Virgin
	Low fishing mortality		High abundance
	Sustainable Fishing Mortality	X	Intermediate abundance
X	High fishing mortality		Low abundance
	Uncertain/Not assessed		Depleted
			Uncertain / Not assessed

Table : Stock advice summary; Historical trends in biomass and recruitment.

Biomass trends		Recruitment trends	
[2000-2011]		[2000-2011]	
[78183 tons-215050 tons]		[3276600 – 16830000 thousands]	
	Stable	X	Stable
X	Increasing		Increasing
	Decreasing		Decreasing

The trend in recruitment shows a stable pattern but in the last year it increased.

Fig. 9.1. Mid year stock biomass and proposed reference points.

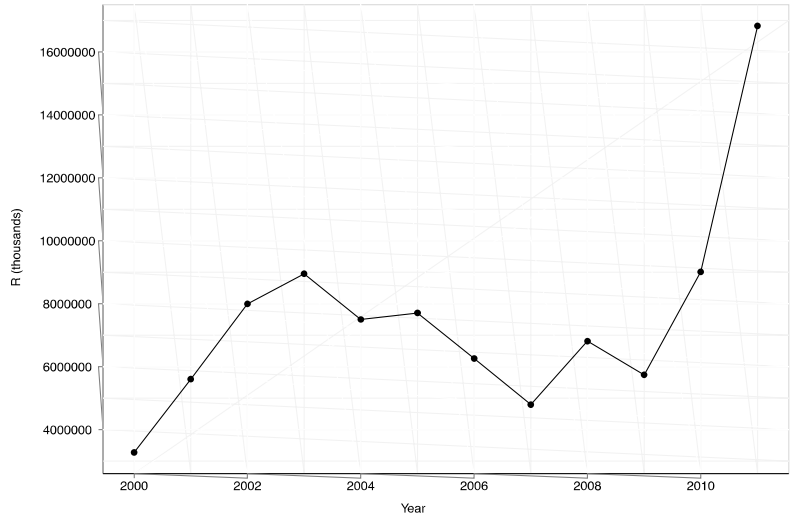

Fig. 9.2. Recruitment estimates (in thousands).

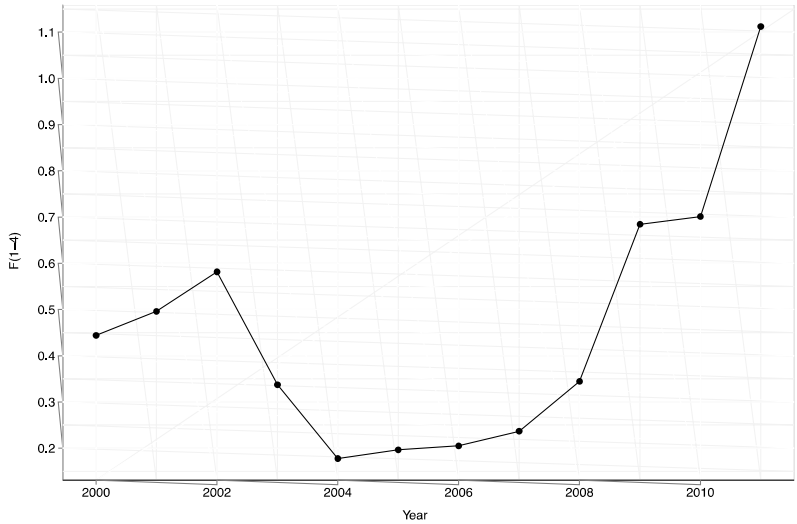

Fig. 9.3. $F_{bar(1-4)}$ estimates.

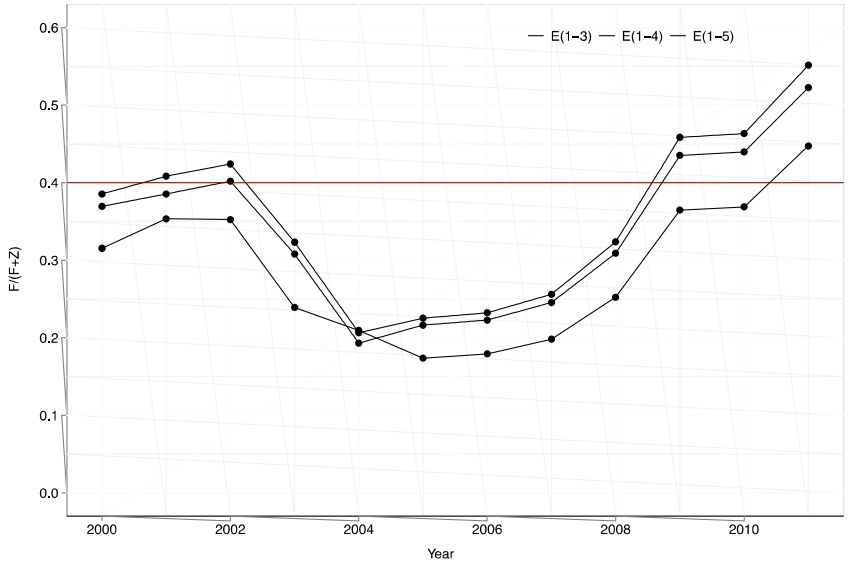

Fig. 9.4. Exploitation rate (F/Z).

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