Stock Assessment Form

Demersal species

Reference year:2013

Reporting year:2013

The Italian fleets exploit hake with bottom trawl, whereas different gears are used by Croatia, in particular bottom trawl and longline. Hake is the most important demersal species for the Adriatic fishery, both for catches and commercial value. Landings present a fluctuating trend from 2002 to 2013, they reached 5462 tonnes in 2006 then decreased to 2323 tonnes in 2011. In 2013 landings of hake were 3533 tonnes, more than 60% constituted by the Italian fishery.

A Statistical Catch At Age (SCAA) was done for assessing the stock of hake in GSA 17. Input data were provided by the Italian and Croatia DCF official data call and tuning data were provided by the GRUND and MEDITS surveys. According to the SCAA analysis, biomass is decreasing over the years as the spawning stock biomass, whereas recruitment has a fluctuating trend with a peak in 1993 and 2005. Moreover fishing mortality accounts for high values, in particular in the last decade. It can be concluded that the resource is in overfishing.

A reduction of fishing pressure would be recommended, also taking into account that the exploitation is mainly orientated towards juveniles.

Stock Assessment Form version 1.0 (January 2014)

Uploader: *Please include your name*

Stock assessment form

1 Basic Identification Data

Scientific name:	Common name:	ISCAAP Group:
Merluccius merluccius	European hake	32
1st Geographical sub-area:	**2nd Geographical sub-area:**	**3rd Geographical sub-area:**
GSA 17	[GSA_2]	[GSA_3]
4th Geographical sub-area:	**5th Geographical sub-area:**	**6th Geographical sub-area:**
[GSA_4]		
1st Country	**2nd Country**	**3rd Country**
Italy	Croatia	[Country_3]
4th Country	**5th Country**	**6th Country**
Stock assessment method: (direct, indirect, combined, none)		
Indirect: SCAA (ss3)		
Authors:		
Angelini S.[1], Scarcella G.[1], Bitetto I.[4], Martinelli M.[1], Carpi P.[1], Colella S.[1], Donato F.[1], Panfili M.[1], Belardinelli A.[1], Croci C.[1], Domenichetti F.[1], Tesauro C.[1], Manfredi C.[2], Isajlović I.[3], Piccinetti C.[2], Vrgoč N.[3], Santojanni A.[1]		
Affiliation:		
[1] CNR – ISMAR (National Research Council - Institute of Marine Science), Italy [2] Laboratorio di Biologia Marina e Pesca, University of Bologna, Italy [3] Institute of Oceanography and Fisheries, Croatia [4] COISPA Tecnologia & Ricerca, Bari, Italy **Work conducted in the framework of *FAO AdriaMed Regional Project***		

The ISSCAAP code is assigned according to the FAO 'International Standard Statistical Classification for Aquatic Animals and Plants' (ISSCAAP) which divides commercial species into 50 groups on the basis of their taxonomic, ecological and economic characteristics. This can be provided by the GFCM secretariat if needed. A list of groups can be found here:

http://www.fao.org/fishery/collection/asfis/en

Direct methods (you can choose more than one):

- Acoustics survey
- Egg production survey
- Trawl survey
- SURBA
- Other (please specify)

Indirect method (you can choose more than one):

- ICA
- VPA
- LCA
- AMCI
- XSA
- Biomass models
- Length based models
- Other (please specify)

Combined method: you can choose both a direct and an indirect method and the name of the combined method (please specify)

2 Stock identification and biological information

European hake (*Merluccius merluccius*) is distributed throughout the Adriatic, with the exception of a small area in the northernmost part (Fig.1). This species presents the greatest abundance in the central Adriatic Sea in water deeper than 100 meters, where population is manly composed of juveniles (Fig. 2), whereas the greatest biomass is found in the eastern part of the Adriatic Sea (Fig. 3), where the biggest sizes individuals are concentrated (Piccinetti *et al.*, 2012).

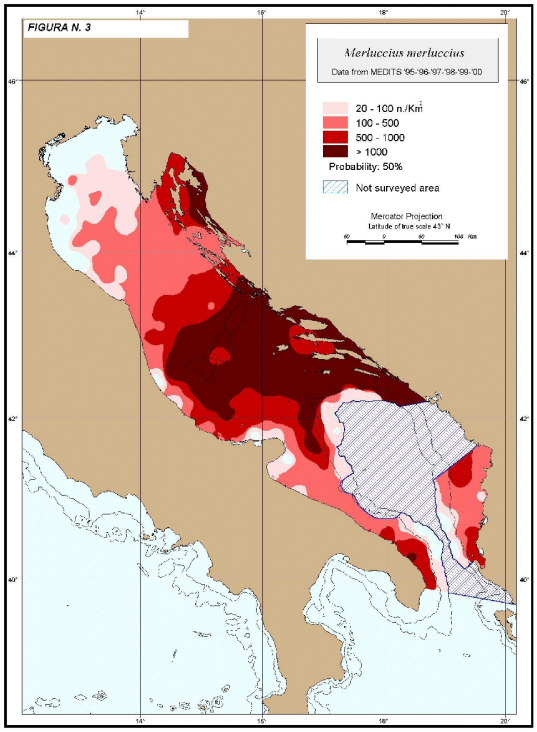


Figure 1 - Distribution map of *Merluccius merluccius* in the Adriatic Sea (Sabatella and Piccinetti, 2005) from Medits Programme

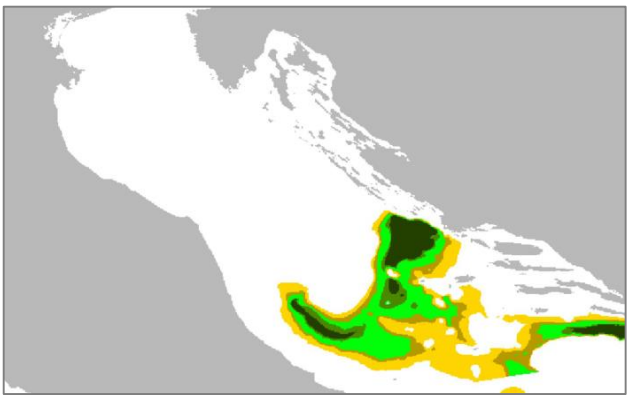


Fig. 2 Position of persistent nursery in the GSA 17 from MEDISEH project

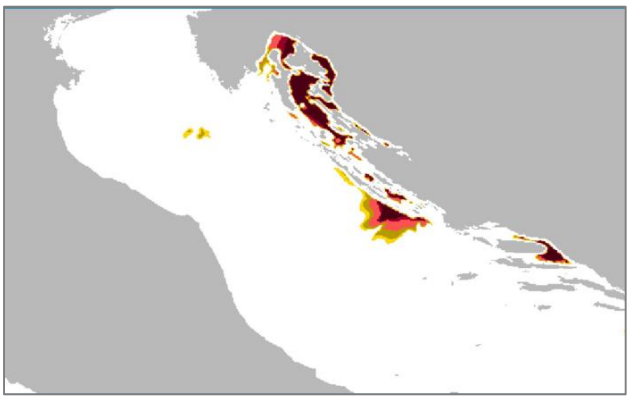


Fig. 3 Position of persistent areas of potential spawners in the GSA 17 from MEDISEH project

2.1 Stock unit

2.2 Growth and maturity

European hake can grow to 107 cm (Grubišić, 1959) of total length. However, its usual length in trawl catches is from 10 to 60 cm. This is a long-lived species, it can live more than 20 years. In the Adriatic, however, the exploited stock is mainly composed in number of 0+, 1+ and 2+ year-old individuals.

Females attain larger size than males, which grow more slowly after maturation at the age of three or four years. Consequently, the proportion of males in the population is higher in the lower length classes and proportion of females is higher for greater lengths. In the central and northern Adriatic, females already start dominating the population at lengths of about 30 to 33 cm. In trawl catches over 38 to 40 cm, almost all the specimens are females (Vrgoć, 2000).

In the Adriatic, European hake spawn throughout the year, but with different intensities. The spawning peaks are in the summer and winter periods (Karlovac, 1965; Županović, 1968; Županović and Jardas, 1986, Županović and Jardas, 1989; Jukić and Piccinetti, 1981; Ungaro *et al.*, 1993). Hake is a partial spawner. Females spawn usually four or five times without ovarian rests. In females in the pre-spawning stage, fish 70 cm long can contain more than 400,000 oocytes (Sarano, 1986). The earliest spawning in the Pomo/Jabuka Pit occurs in winter in deeper water (up to 200 m). As the season progresses into the spring-summer period, spawning occurs in more shallow water. The recruitment of young individuals into the breeding stock has two different maxima. The first one is in the spring and the second one in the autumn.

Table 2.2-1: Maximum size, size at first maturity and size at recruitment.

Somatic magnitude measured (LT, LC, etc)				**Units**	
Sex	**Fem**	**Mal**	**Combined**	**Reproduction season**	**Summer - Winter**
Maximum size observed			107**	**Recruitment season**	Spring - Autumn
Size at first maturity	23.0 – 33.0*	20.00 – 28.00*		**Spawning area**	Eastern Adriatic
Recruitment size to the fishery				**Nursery area**	Pomo / Jabuka Pit

* Županović and Jardas, 1986 ** Grubišić, 1959

Table 2-2.2: M vector and proportion of matures by size or age (Combined)

Age	Natural mortality*	Proportion of matures
0	1.16	0
1	0.58	0.5
2	0.46	0.79
3	0.41	0.89
4	0.39	1
5	0.35	1
6+	0.30	1

*Prodbiom (Abella *et al.*, 1997)

Table 2-3: Growth and length weight model parameters

			Sex			
		Units	female	male	Combined	Years
Growth model	**L_∞**				104	
	K				0.2	
	t_0				-0.01	
	Data source	EWG 13-05				
Length weight relationship	**a**				0.0043	
	b				3.2	
	M (scalar)					
	sex ratio (% females/total)	50				

3 Fisheries information

3.1 Description of the fleet

European hake is one of the principal demersal species fished in GSA 17 and it accounts for the highest landings quantity among demersal species. Fishing grounds mostly correspond to the distribution of the stock. In GSA 17 hake is a target species for bottom trawl nets and Croatian long liners, but it is also caught in smaller quantity in the gill-net fisheries. The activity of Italian longliners for hake in GSA 17 is negligible.

Table 3-1: Description of operational units exploiting the stock

	Country	GSA	Fleet Segment	Fishing Gear Class	Group of Target Species	Species
Operational Unit 1*	ITA	17	E – Trawl (12-24 metres)	03 - Trawls	33 – Demersal shelf species	Hake
Operational Unit 2	HRV	17	E – Trawl (12-24 metres)	03 - Trawls	33 – Demersal shelf species	Hake
Operational Unit 3	HRV	17	I - Long line (12-24 metres)	09 - Hooks and Lines	33 – Demersal shelf species	Hake

Table 3.1-2: Catch, bycatch, discards and effort by operational unit in the reference year

Operational Units*	Fleet (n° of boats)*	Catch (T or kg of the species assessed)	Other species caught (names and weight)	Discards (species assessed)	Discards (other species caught)	Effort (units)
ITA 17 E 03 33 - HKE		Tons				
HRV 17 E 03 33 - HKE		Tons				
HRV 17 I 09 33 - HKE		Tons				

3.2 Historical trends

European hake landings estimated by FishStatJ – GFCM database.

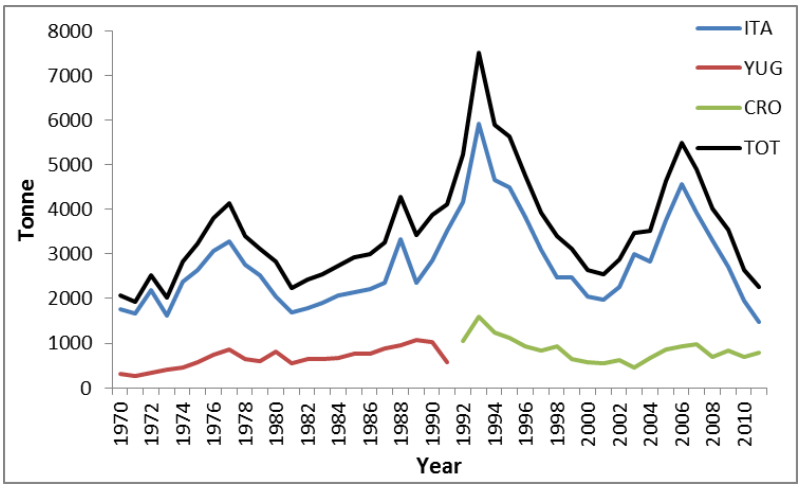


Figure 4 - Landings of European hake in GSA 17

3.3 Management regulations

Italy

Management regulations are determined by the EU regulations (mainly EC regulation 1967/2006):

- Minimum landing sizes: 20 cm TL for European hake
- Fishing closure for trawling: 30-45 days in summer.
- Codend mesh size of trawl nets: 40 mm (stretched, diamond meshes) till 30/05/2010. From 1/6/2010 the existing nets have been replaced with a cod end with 40 mm (stretched) square meshes or a cod end with 50 mm (stretched) diamond meshes
- Towed gears are not allowed within three nautical miles from the coast or at depths less than 50 m when this depth is reached at a distance less than 3 miles from the coast.

Croatia

Since the accession of Croatia to the EU the 1st of July 2013, the same regulations as in the Italy are implemented. Furthermore the following regulations are applied:

- Bottom trawl fisheries is closed one and half NM from the coast and island in inner sea, 2 NM around island on the open sea, and 3 NM about several island in the central Adriatic. For vessel smaller than 15 meters, according derogation in sea deeper than 50 meters bottom trawl fisheries is forbidden till 1NM of the coast. Bottom trawl fishery is closed also in the majority of channel area and bays. About 1/3 of the territorial waters is closed for bottom trawl fisheries over whole year and additionally 10% is closed from 100-300 days per years. Minimum mesh size on the bottom trawl net was 20 mm ("knot to knot") in the open sea, and 24 mm ("knot to knot") in the inner sea. Recently, mesh site regulation is according EC 1967/2006 (ie. 40 mm square or 50 mm diamond).

3.4 Reference points

Table 3.3-1: List of reference points and empirical reference values previously agreed (if any)

Indicator	Limit Reference point/empirical reference value	Value	Target Reference point/empirical reference value	Value	Comments
B					
SSB					
F			$F_{0.1}$	0.2	EWG 13-05
Y					
CPUE					
Index of Biomass at sea					

4 Fisheries independent information

4.1 GRUND ITA and EXT (Extraterritorial water)

4.1.1 Brief description of the direct method used

In 1982 the Laboratory of Marine Biology and Fisheries of Fano in collaboration with scientists from the Institute of Oceanography and Fisheries in Split started the most extensive research of the demersal communities in the Adriatic, known as GRUND program (Pipeta expedition for Croatian side until 1994). This survey was conducted twice a year (spring and autumn) until 1996, after that year GRUND program was carried out as winter demersal survey to 2007. Here it has been considered Italian data of the winter surveys, since they cover the bigger area and the longest time series, from 1984 to 2007 (survey has not been carried out in 1999), and Croatian data from 2002 to 2007 (see point 4.2).

Abundance and biomass indexes from GRUND survey were computed using ATrIS software (Gramolini *et al.*, 2005) which also allow drawing GIS maps of the spatial distribution of the stock, spawning females and juveniles. The abundance and biomass indices by GSA 17 were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum area in the GSA 17:

$Yst = \Sigma (Yi*Ai) / A$

$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$

Where:

A=total survey area

Ai=area of the i-th stratum

si=standard deviation of the i-th stratum

ni=number of valid hauls of the i-th stratum

n=number of hauls in the GSA

Yi=mean of the i-th stratum

Yst=stratified mean abundance

V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = $Yst \pm t(\text{student distribution}) * V(Yst) / n$

Direct methods: trawl based abundance indices – GRUND ITA and EXT

Table 4.1-1: Trawl survey basic information

Survey	GRUND ITA and EXT	**Trawler/RV**	Pipea and Andrea
Sampling season	Fall – Winter		
Sampling design	Random		
Sampler (gear used)	Trawl		
Cod–end mesh size as opening in mm	40		
Investigated depth range (m)	0 – 500		

Table 4.1-2: Trawl survey sampling area and number of hauls

Year	Total surface (km^2)	Trawlable surface (km^2)	Swept area (km^2)	Number of hauls
1984	59400			93
1985	59400			88
1988	55500			85
1991	59400			73
1992	59400			69
1993	59400			68
1994	59400			104
1995	59400			81
1996	59400			182
1997	59400			165
1998	59400			157
2000	60350			162
2001	59400			160
2002	59400			170

2003	59400			164
2004	59400			172
2005	59400			170
2006	59400			174
2007	59400			138

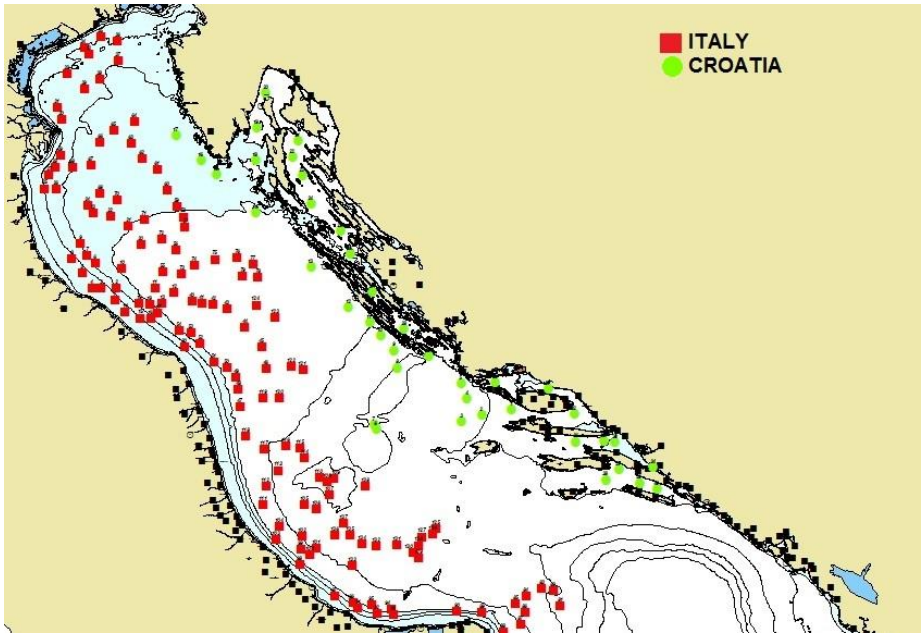


Fig. 5 Map of hauls positions of GRUND survey 2007. The red squares represent hauls in Italian and extraterritorial water, whereas the green circles represent hauls done in Croatian water performed by the AdriaMed Bottom Trawl survey Croatia (GRUND CRO, see point 4.2)

Table 4.1-3: Trawl survey abundance and biomass results GRUND ITA and EXT

Depth Stratum	Years	kg per km^2	CV or other	N per km^2	CV or other
	1984	33.751	0.097	539.260	0.118
	1985	42.704	0.126	416.111	0.132
	1988	35.586	0.090	546.195	0.138
	1991	56.862	0.139	970.487	0.165
	1992	72.003	0.119	804.592	0.140
	1993	77.297	0.145	876.180	0.178
	1994	66.064	0.082	1536.002	0.106
	1995	74.886	0.078	1098.819	0.072
	1996	47.980	0.051	773.227	0.052
	1997	37.725	0.057	590.429	0.080
	1998	40.971	0.058	705.455	0.064
	2000	26.742	0.047	410.981	0.060
	2001	18.148	0.058	313.448	0.059
	2002	23.166	0.053	464.090	0.069
	2003	22.333	0.063	424.747	0.107
	2004	27.109	0.041	479.948	0.067
	2005	54.525	0.056	940.722	0.061
	2006	40.329	0.052	600.896	0.085
	2007	29.546	0.057	402.874	0.066

Direct methods: trawl based length/age structure of population at sea

Slicing method

The length frequency distribution were processed using an age slicing performed by the LFDA 5.0 software. Growth data are reported in Table 2.2-1.

Maturity at age							
PERIOD	0	1	2	3	4	5	6+
All year	0.00	0.50	0.79	0.89	1.00	1.00	1.00

Age	0	1	2	3	4	5	6+
Corresponding length (cm) from LFDA 5.0	0 - 18	20 - 30	31 - 40	41 - 44	45 - 46	47 - 48	50

Table 4.1-4: Trawl survey results by length or age class – GRUND ITA and EXT

N (Total or sex combined) by Length or Age class	**Age**						
	0	**1**	**2**	**3**	**4**	**5**	**6**
Year							
1984	83.946	175.126	12.184	0.471	0	0.162	0
1985	333.52	193.25	12.394	0	0	0	0.096
1988	128.513	236.111	15.863	0.95	0.158	0	0
1991	342.989	172.729	10.01	0.666	0	0	0
1992	366.108	410.077	14.275	0.226	0.146	0	0
1993	321.031	495.942	25.528	2.823	0.358	0.119	0.119
1994	1198.525	320.969	14.748	1.1	0.386	0.274	0
1995	579.802	434.487	19.365	0.348	0	0.078	0
1996	474.077	284.254	13.94	0.558	0.231	0.1	0.068
1997	381.234	195.612	12.903	0.078	0.078	0.058	0.099
1998	425.062	269.533	10.465	0.128	0	0	0.267

2000	243.905	151.258	8.906	0.302	0.045	0	0.095
2001	206.358	99.569	4.116	0.056	0.036	0	0
2002	337.483	102.965	7.082	0.205	0	0	0
2003	308.248	110.258	5.732	0.393	0	0	0
2004	344.756	127.096	5.794	0.122	0.086	0	0.043
2005	590.542	342.99	6.692	0.254	0	0.047	0.198
2006	353.106	238.716	8.621	0.454	0	0	0
2007	238.388	148.568	10.567	0.44	0.083	0	0

Sex ratio by Length or Age class	**All Year**
0	0.5
1	0.5
2	0.5
3	0.5
4	0.5
5	0.5
6+	0.5

Direct methods: trawl based Recruitment analysis

Table 4.1-5: Trawl surveys; recruitment analysis summary

Survey	**GRUND ITA and EXT**	**Trawler/RV**	**Pipeta and Andrea**
Survey season		Fall / Winter	
Cod –end mesh size as opening in mm		40	
Investigated depth range (m)		0 – 500	

Recruitment season and peak (months)	May – June – October - November
Age at fishing-grounds recruitment	0
Length at fishing-grounds recruitment	3

Table 4.1-6: Trawl surveys; recruitment analysis results – GRUND ITA and EXT

Years	Area in km^2	N of recruit per km^2	CV or other
1984		289.734	0.132
1985		176.673	0.194
1988		204.078	0.091
1992		404.852	0.185
1993		375.974	0.279
1994		1246.790	0.123
1995		656.465	0.114
1996		511.409	0.067
1997		401.717	0.116
1998		460.636	0.095
2000		273.493	0.081
2001		224.881	0.070
2002		362.425	0.082
2003		321.266	0.143
2004		362.463	0.088
2005		640.029	0.078
2006		375.683	0.130
2007		249.435	0.095

Recruits have been estimated on the base of the LFD observed from the survey (0 - 20 cm) (Fig. 6). These individuals inhabit the entire Adriatic, with exception for the northernmost part of the basin, and they are particularly abundant in the Central Adriatic Sea (Fig. 2).

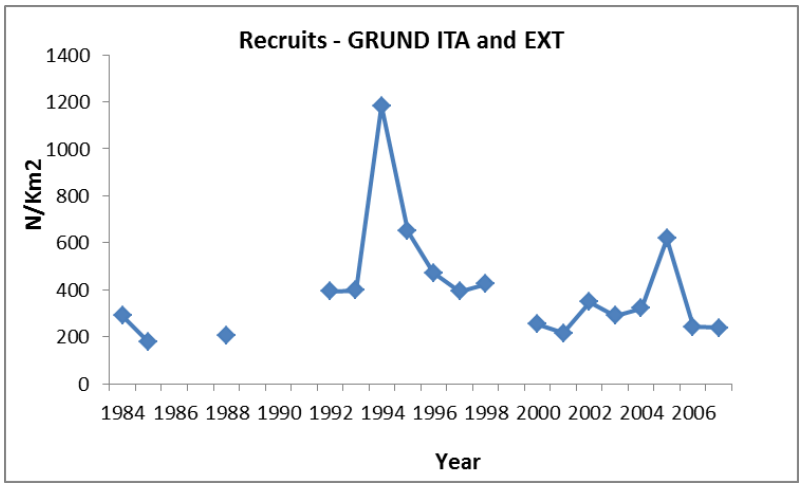


Fig. 6 Abundance indices of hake obtained from the GRUND ITA and EXT survey from 1984 to 2007

Direct methods: trawl based Spawner analysis

Table 4.1-7: Trawl surveys; spawners analysis summary

Survey	**GRUND ITA and EXT**	**Trawler/RV**	**Pipeta and Andrea**
Survey season			Fall / Winter
Investigated depth range (m)			0 – 500
Spawning season and peak (months)			June – July – January – February

Table 4.1-8: Trawl surveys; spawners analysis results – GRUND ITA and EXT

Surveys	**Area in km²**	**N (N of individuals) of spawners per km²**	**CV or other**	**SSB per km²**	**CV or other**
1984		10.567	0.137		
1985		15.363	0.202		
1988		4.421	0.082		
1992		12.106	0.254		
1993		26.663	0.411		
1994		12.352	0.169		
1995		16.758	0.172		
1996		11.910	0.113		
1997		11.650	0.126		
1998		9.049	0.193		
2000		8.482	0.112		
2001		3.535	0.130		
2002		6.520	0.123		
2003		5.037	0.141		
2004		4.698	0.129		

2005		5.375	0.153		
2006		6.956	0.119		
2007		8.189	0.129		

Figure 7 shows the trends of abundance of spawners (individuals ≥ 35 cm) as found in survey's LFD. Spawners are particularly concentrate in Croatian water (Fig. 3).

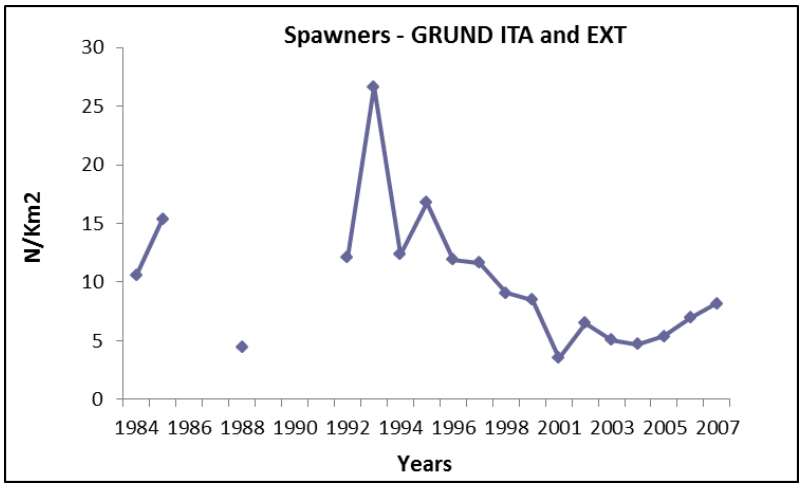


Fig. 7 Abundance indices of hake spawners from the GRUND ITA and EXT survey from 1984 to 2007

4.1.2 Spatial distribution of the resources

(see point 2)

4.1.3 Historical trends

The GRUND ITA and EXT trawl surveys provide data either on hake total abundance and biomass as well as on important biological events (recruitment, spawning).

Figure 8 shows the abundance and biomass indices of hake obtained from 1984 to 2007. Both indices described a fluctuating but decreasing trend all over the years, with a peak in 2005 in correspondence of a high recruitment.

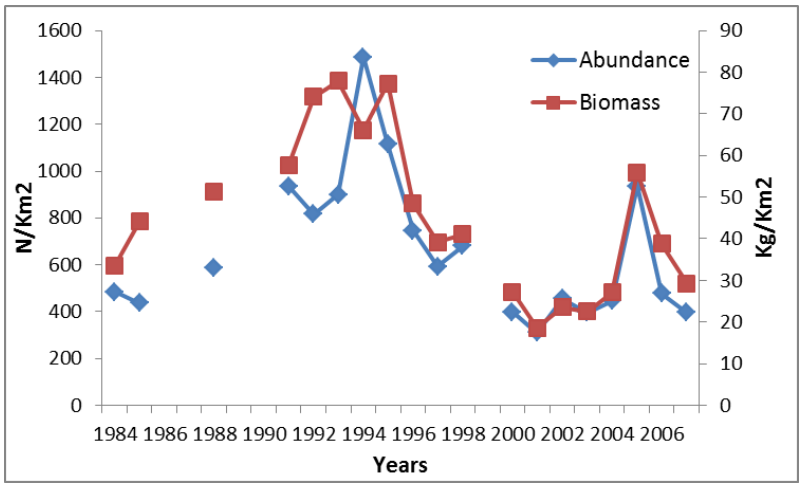


Fig. 8 Abundance and biomass indices of hake obtained from GRUND ITA and EXT survey

4.2 AdriaMed Trawl Survey (GRUND CRO)

4.2.1 Brief description of the direct method used

For the AdriaMed Trawl Survey, also defined GRUND CRO, methodology has already explained in section 4.1.

Direct methods: trawl based abundance indices

Table 4.2-1: Trawl survey basic information

Survey	GRUND CRO	**Trawler/RV**	Andrea
Sampling season	Spring		
Sampling design	Random		
Sampler (gear used)	Trawl		
Cod –end mesh size as opening in mm	40		
Investigated depth range (m)	0 - 500		

Table 4.2-2: Trawl survey sampling area and number of hauls GRUND CRO

Year	Total surface (km^2)	Trawlable surface (km^2)	Swept area (km^2)	Number of hauls
2002	29318			17
2003	31727			41
2004	29318			42
2005	31727			40
2006	31727			40
2007	31727			41

Map of hauls positions of GRUND CRO are represented in figure 5.

Table 4.2-3: Trawl survey abundance and biomass results GRUND CRO

Depth Stratum	Years	kg per km²	CV or other	N per km²	CV or other
	2002	124.884	0.195	1761.908	0.181
	2003	57.337	0.111	1019.676	0.148
	2004	61.922	0.158	909.740	0.170
	2005	67.267	0.136	1290.054	0.146
	2007	88.391	0.097	1243.785	0.090
	2003	57.337	0.111	1019.676	0.148

4.2.3 Historical trends of AdriaMed Trawl Survey (GRUND CRO)

The GRUND trawl surveys provide data either on hake total abundance and biomass.

Figure 9 shows the abundance and biomass indices of hake obtained from 2002 to 2007, year 2006 is missing. Both indices present an increasing trend, with a slight decrease for the abundance in 2004.

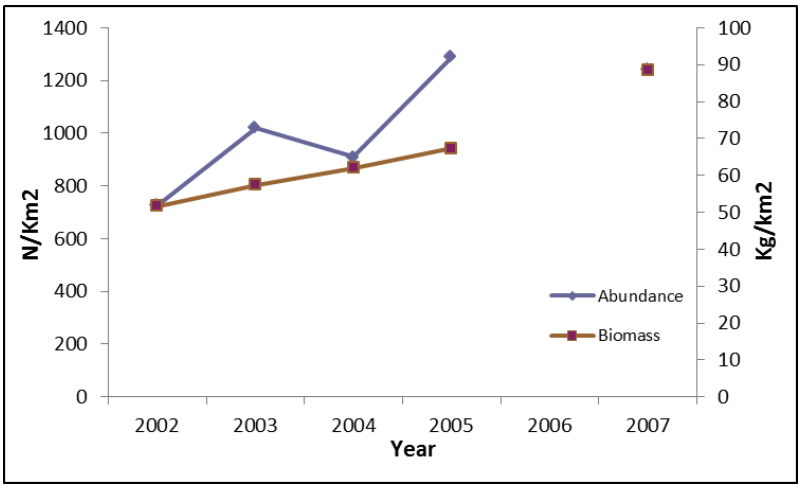


Fig. 9 Abundance and biomass indices of hake obtained from GRUND CRO survey for the Croatian side

4.3 MEDITS

4.3.1 Brief description of the direct method used

European Union funded the MEDITS (MEDiterranean International Trawl Survey) survey in 1994. At the beginning only EU members (Italy, Spain, French and Greece) participated at this program, but from 1996 also Albania, Croatia and Slovenia joined this activity. This survey is included in the Data Collection Framework and it takes place every year during springtime. Its methodological sampling is common to all the counties involved in this project and was defined by Bertrand *et al.* (2002). Stations were selected on the basis of a stratified scheme with random selection of stations in every stratum (10-50m; 50-100m; 100-200m; 200-500m and over 500m). The number of stations in each stratum is proportional to the surface of the stratum. The sampling gear is a bottom trawl made of four panels, called GOC 73 bottom trawl made of four panels.

For this assessment the time series considered goes from year 1996 to year 2013, Italian and Croatian data are included. In 2013 additional hauls were added spread out along the entire GSA and strata: indexes from this year are comparable with those from the previous years.

Abundance and biomass indexes from MEDITS survey were computed using AtrIS software (Gramolini *et al.*, 2005) which also allow drawing GIS maps of the spatial distribution of the stock, spawning females and juveniles. The abundance and biomass indices by GSA 17 were calculated through stratified means (Cochran, 1953; Saville, 1977).

(Methodology has already explained for the GRUND survey, paragraph 4.1).

Direct methods: trawl based abundance indices

Table 4.3-1: Trawl survey basic information

Survey	MEDITS	**Trawler/RV**	Andrea
Sampling season	Spring		
Sampling design	Random		
Sampler (gear used)	Trawl		
Cod –end mesh size as opening in mm	20		
Investigated depth range (m)	0 – 500		

Table 4.3-2: Trawl survey sampling area and number of hauls - MEDITS

Year	Total surface (km^2)	Trawlable surface (km^2)	Swept area (km^2)	Number of hauls
1996	92261			137
1997	92261			139
1998	91311			138
2000	92261			136
2001	92261			136
2002	92261			181
2003	92261			181
2004	92261			181
2005	91311			182
2006	91127			181
2007	91311			191
2008	91311			182
2009	91311			183
2010	91311			183
2011	91311			187
2012	91311			182
2013	91127			237

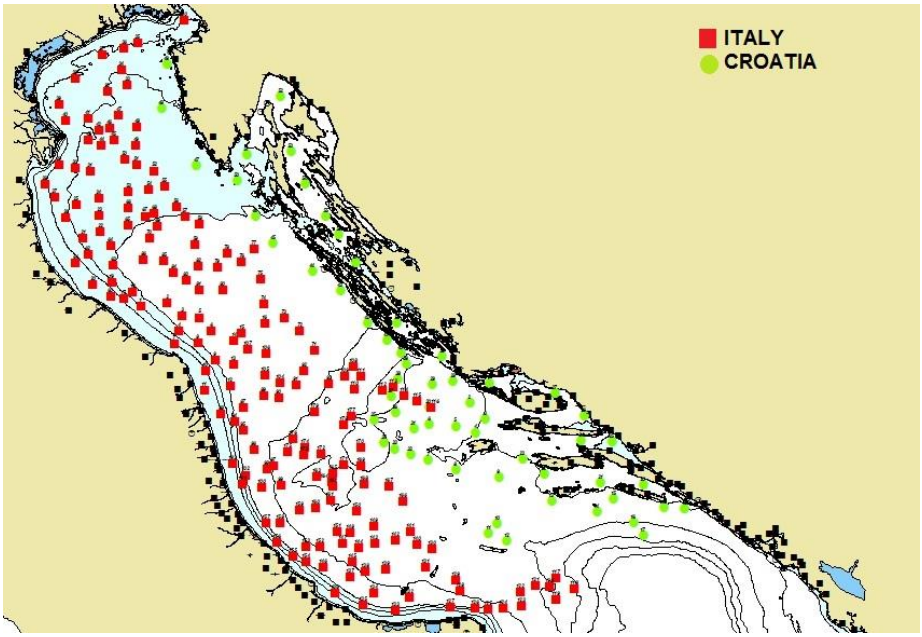


Fig. 10 Map of hauls positions for MEDITS survey 2013. Red squares represent hauls in Italian and International waters and green circles represents hauls in Croatian water.

Table 4.3-3: Trawl survey abundance and biomass results - MEDITS

Depth Stratum	Years	kg per km²	CV or other	N per km²	CV or other
	1996	53.682	0.067	1217.062	0.126
	1997	50.844	0.086	928.233	0.093
	1998	37.362	0.130	786.814	0.097
	2000	24.332	0.088	676.861	0.121
	2001	27.284	0.083	765.258	0.108
	2002	35.325	0.077	994.132	0.094
	2003	29.612	0.071	696.073	0.080
	2004	38.244	0.076	1056.190	0.082
	2005	45.463	0.076	1943.634	0.125
	2006	52.873	0.077	1322.046	0.085
	2007	40.639	0.076	965.110	0.065
	2008	41.882	0.072	1053.826	0.094
	2009	29.689	0.087	380.235	0.086

	2010	17.623	0.077	362.202	0.087
	2011	19.534	0.080	400.695	0.083
	2012	22.691	0.066	615.022	0.107
	2013	33.093	0.084	490.377	0.095

Direct methods: trawl based length/age structure of population at sea

Slicing method

The length frequency distribution were processed using an age slicing performed by the LFDA 5.0 software. Growth data are reported in Table 2.2-1. (Details are reported in point 4.1.1)

Table 4.3-4: Trawl survey results by length or age class - MEDITS

N (Total or sex combined) by Length or Age class	**Age**						
	0	**1**	**2**	**3**	**4**	**5**	**6**
Year							
1996	953.634	231.294	18.586	0.481	0.386	0.497	0
1997	617.447	280.098	20.161	0.838	0	0.052	0.183
1998	574.756	195.517	10.899	0.147	0.062	0	0.153
2000	551.041	109.659	6.995	0.652	0	0.473	0
2001	603.209	144.734	8.879	0.469	0.086	0	0
2002	796.511	164.719	10.884	0.388	0	0	0.101
2003	540.836	139	8.305	0.34	0.534	0	0
2004	811.031	210.404	11.12	0.598	0.146	0	0.129
2005	1715.593	190.112	9.841	0.138	0	0	0
2006	1050.835	252.79	16.558	1.739	0.063	0.063	0
2007	780.181	167.699	16.462	0.627	0	0.141	0

2008	851.285	183.385	16.323	1.326	1.453	0.054	0
2009	200.657	166.837	12.129	0.509	0	0	0.103
2010	238.045	77.728	7.534	0.474	0.066	0.068	0
2011	339.213	84.741	6.31	0.506	0.101	0	0
2012	774.082	93.926	10.327	1.151	0	0	0.52
2013	361.369	155.928	14.001	0.882	0.312	0.039	0.014

Sex ratio by Length or Age class	**All Year**
0	0.5
1	0.5
2	0.5
3	0.5
4	0.5
5	0.5
6+	0.5

Direct methods: trawl based Recruitment analysis

Table 4.3-5: Trawl surveys; recruitment analysis summary

Survey	**MEDITS**	**Trawler/RV**	**Andrea**
Survey season		Spring	
Cod –end mesh size as opening in mm		20	
Investigated depth range (m)		0 – 500	
Recruitment season and peak (months)		May – June – October - November	
Age at fishing-grounds recruitment		0	
Length at fishing-grounds recruitment		3	

Table 4.3-6: Trawl surveys; recruitment analysis results - MEDITS

Years	**Area in km^2**	**N of recruit per km^2**	**CV or other**
1996		1006.202	0.151
1997		681.662	0.116
1998		607.485	0.104
2000		577.855	0.139
2001		632.119	0.126
2002		834.166	0.106
2003		565.501	0.095
2004		868.392	0.094
2005		1749.604	0.137
2006		1090.634	0.098
2007		799.654	0.075
2008		882.898	0.107
2009		223.740	0.091

2010		253.688	0.102
2011		313.495	0.095
2012		520.784	0.124
2013		334.845	0.114

As for the previous direct method, recruits were estimated on the base of the LFD observed from the survey (0 - 20 cm) (Fig. 11). Recruits inhabit the entire Adriatic, with exception for the northernmost part of the basin and particularly abundant in the Central Adriatic Sea and in Croatian waters (Fig. 2).

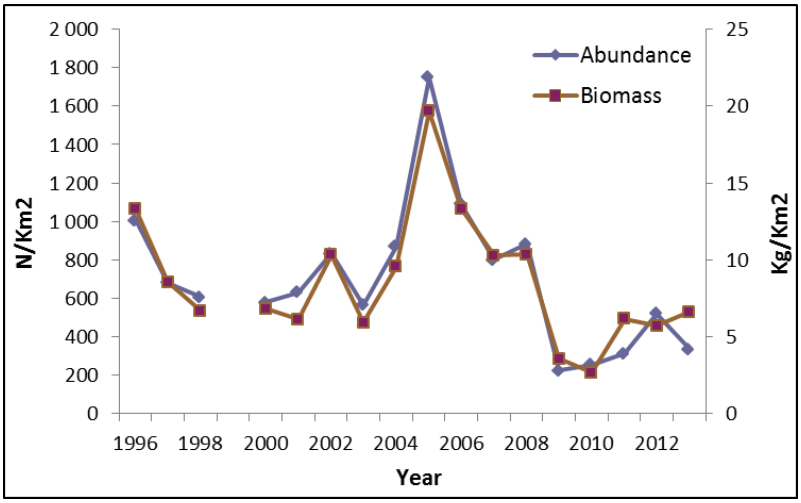


Fig. 11 Abundance and biomass indices of hake obtained from MEDITS surveys

Direct methods: trawl based Spawner analysis

Table 4.3-7: Trawl surveys; spawners analysis summary

Survey	**MEDITS**	**Trawler/RV**	**Andrea**
Survey season			Spring
Investigated depth range (m)			0 – 500
Spawning season and peak (months)			June – July – January – February

Table 4.3-8: Trawl surveys; spawners analysis results - MEDITS

Surveys	Area in km²	N (N of individuals) of spawners per km²	CV or other	SSB per km²	CV or other
1996		18.113	0.119		
1997		19.243	0.205		
1998		9.685	0.296		
2000		7.134	0.200		
2001		8.260	0.168		
2002		10.560	0.151		
2003		7.718	0.128		
2004		10.977	0.175		
2005		8.910	0.182		
2006		16.585	0.142		
2007		15.253	0.139		
2008		17.822	0.144		
2009		11.609	0.156		
2010		7.045	0.162		
2011		6.636	0.154		
2012		9.682	0.118		
2013		12.521	0.106		

Figure 12 shows the trends of abundance and biomass of spawners (individuals ≥ 35 cm). Maps shows that the spawners aggregates in the Central Adriatic, particularly in the Pomo/Jabuka Pit area and in Croatian waters (Fig. 3).

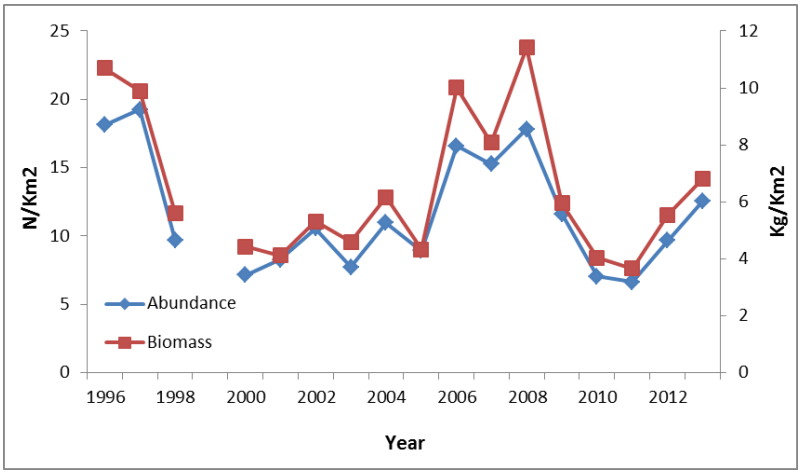


Fig. 12 Abundance and biomass indices of hake spawners obtained from MEDITS surveys

4.3.2 Spatial distribution of the resources

(see point 2)

4.3.3 Historical trends

The MEDITS trawl surveys provide data either on hake total abundance and biomass as well as on important biological events (recruitment, spawning).

Figure 13 shows the abundance and biomass indices of hake obtained from 1996 to 2013. Both indices described a fluctuating trend; hake abundance increases to 2005 whereas hake biomass to 2006, followed by a decrease to 2010. Last three years present an improving trend, expect for the number of individuals count in 2013.

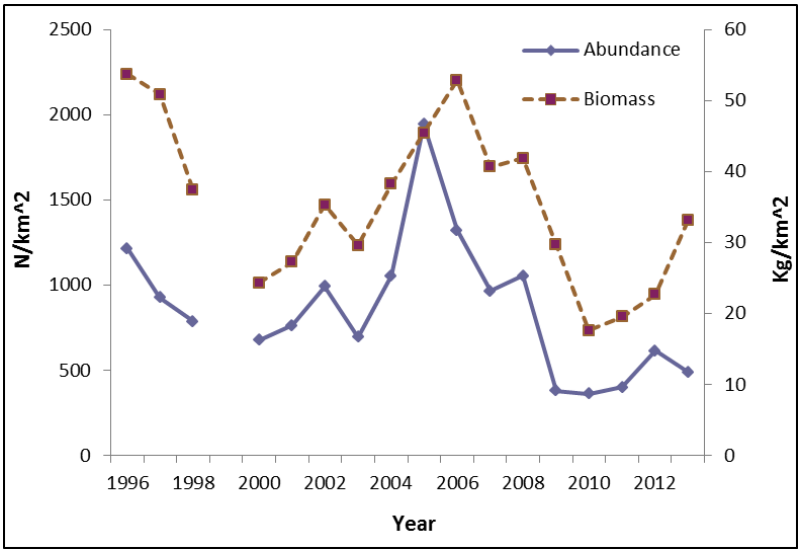


Fig. 13 Abundance and biomass indices of hake obtained from MEDITS survey

5 Ecological information

5.1 Protected species potentially affected by the fisheries

5.2 Environmental indexes

6 Stock Assessment

6.1 Statistical catch at age (SS3 model – Italy and Croatia)

6.1.1 Model assumptions

Stock Synthesis 3 (SS3) provides a statistical framework for the calibration of a population dynamics model using fishery and survey data. It is designed to accommodate both population age and size structure data and multiple stock sub-areas can be analyzed. It uses forward projection of population in the "statistical catch-at-age" (hereafter SCAA) approach. SCAA estimates initial abundance at age, recruitments, fishing mortality and selectivity. Differently from VPA based approaches (e.g. by XSA) SCAA calculates abundance forward in time and allows for errors in the catch at age matrices. Selectivity has been generated as age-specific by fleet, with the ability to capture the major effect of age-specific survivorship. The overall model contains subcomponents which simulate the population dynamics of the stock and fisheries, derive the expected values for the various observed data, and quantify the magnitude of difference between observed and expected data. Some SS3 features include ageing error, growth estimation, spawner-recruitment relationship, movement between areas; in the present assessment such features are not summarized in the results. The ADMB C++ software in which SS is written searches for the set of parameter values that maximize the goodness-of-fit, then calculates the variance of these parameters using inverse Hessian methods. In the present assessment the variance is not shown for fishing mortality results, because the model outputs provide F values (called continuous F) within a year as standardized into selection coefficients by dividing each F value by the maximum value observed for any age class in the year (e.g., Deriso *et al.*, 1985; Sampson and Scott, 2011). For a better comparison with the results of previous assessments carried out both in the framework of STECF-EWGs and GFCM-WG, the F values are standardized by dividing by the average (called Fbar) of the F values observed over a defined range of age classes (e.g., Darby and Flatman, 1994; Sampson and Scott, 2011).

The model allowed to specify the different source of data, providing different uncertainties estimates for each data set. Moreover also the total landings presented from 1983 to 2013 (FAO-FishstatJ source) has been used in the model, together with the DCF and Croatian data for the period 2008-2013. Also in this case the model considered the different sources of the data sets and treated the error separately for each period. In order to facilitate the convergence of the model a higher number of ages has been employed for natural mortality, fecundity and weight at age. Figure 18 sums the time series of input data.

The SS3 analyses has been carried out considering the following three fleets:

1. Italian bottom trawl
2. Croatian bottom trawl
3. Croatian longlines.

The length frequency distributions for each years and gear are shown in figures 14, 15 and 16; the catch at age for the three fleets are summarized in figure 17.

6.1.2 Scripts

6.1.3 Input data and Parameters

Figure 14 shows the Italian length frequency distributions with details on landing and discard composition. Discard was recorded in years 2012 and 2013, then a mean discard ratio was calculated and assumed for the previous years (2008 - 2011).

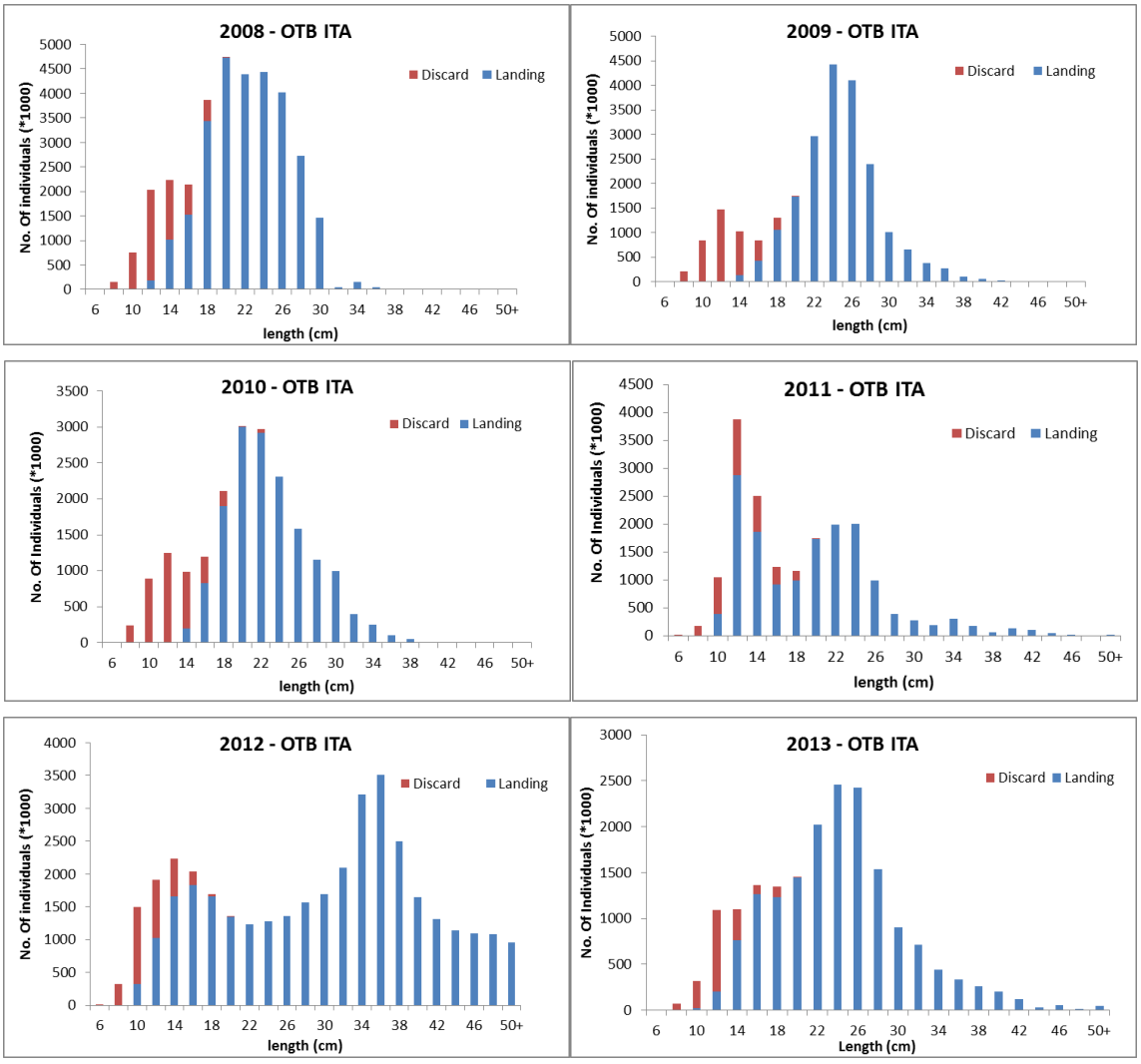


Fig. 14 Length frequency distributions for the Italian bottom trawl for each year

Figure 15 shows the LFDs for Croatian bottom trawl, details on landings and discards composition are reported, whereas figure 16 shows LFDs of Croatian longliners. No discard is recorded for longliners (fig. 16).

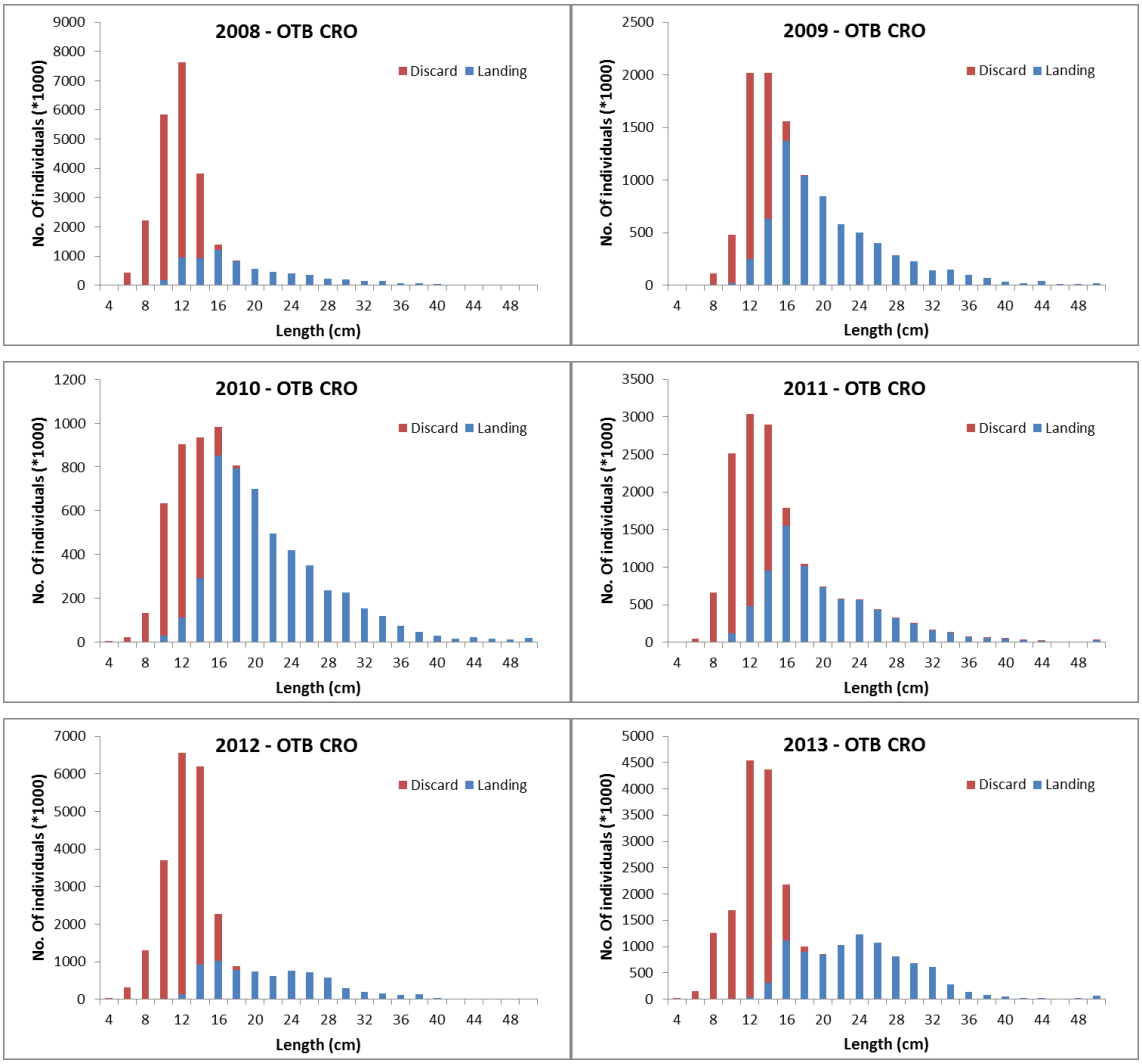
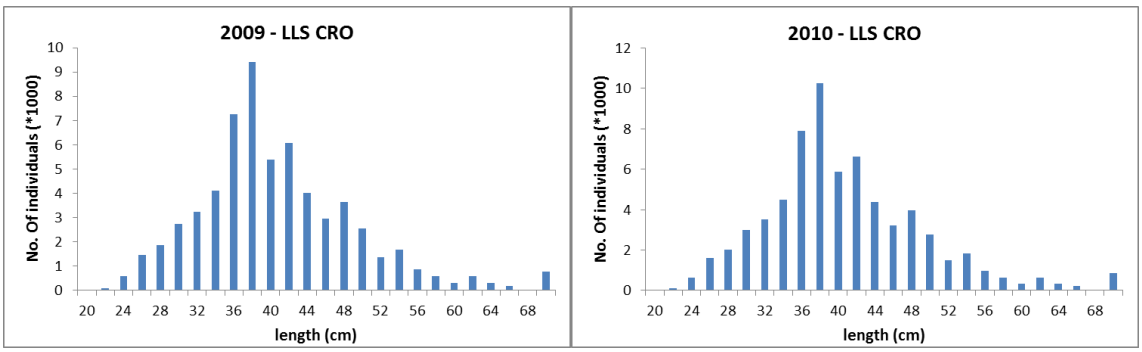


Fig. 15 Length frequency distributions for the Crotian bottom trawl for each year



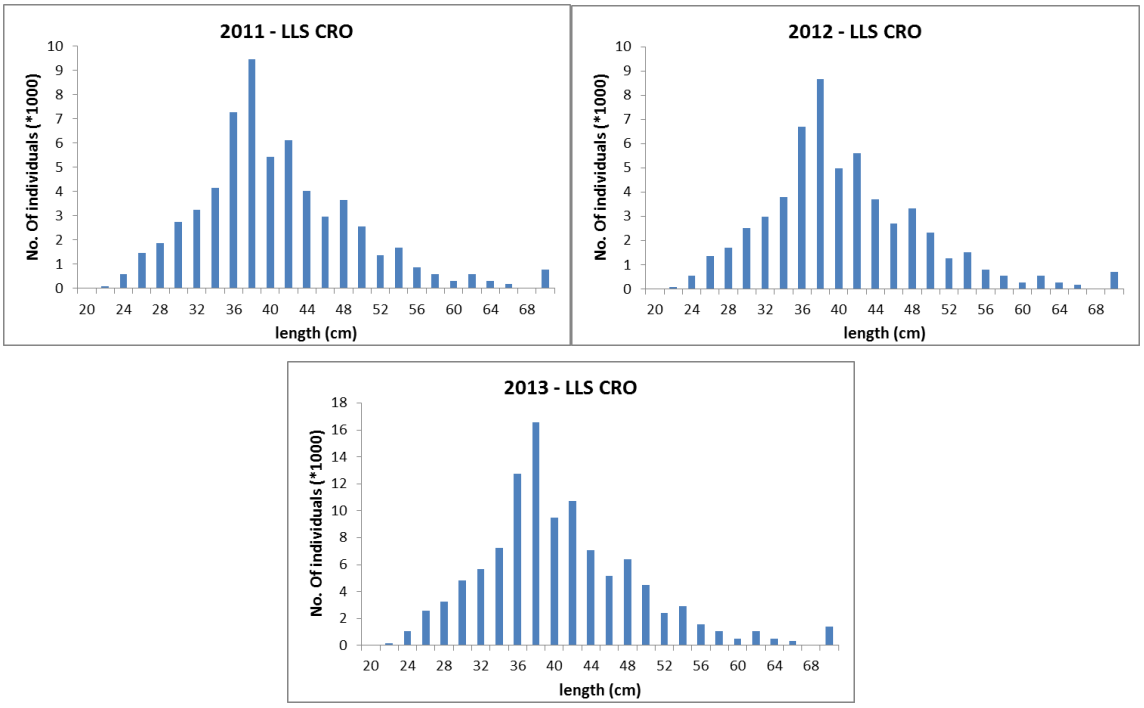


Fig. 16 Length frequency distributions for the Crotian longliners for each year

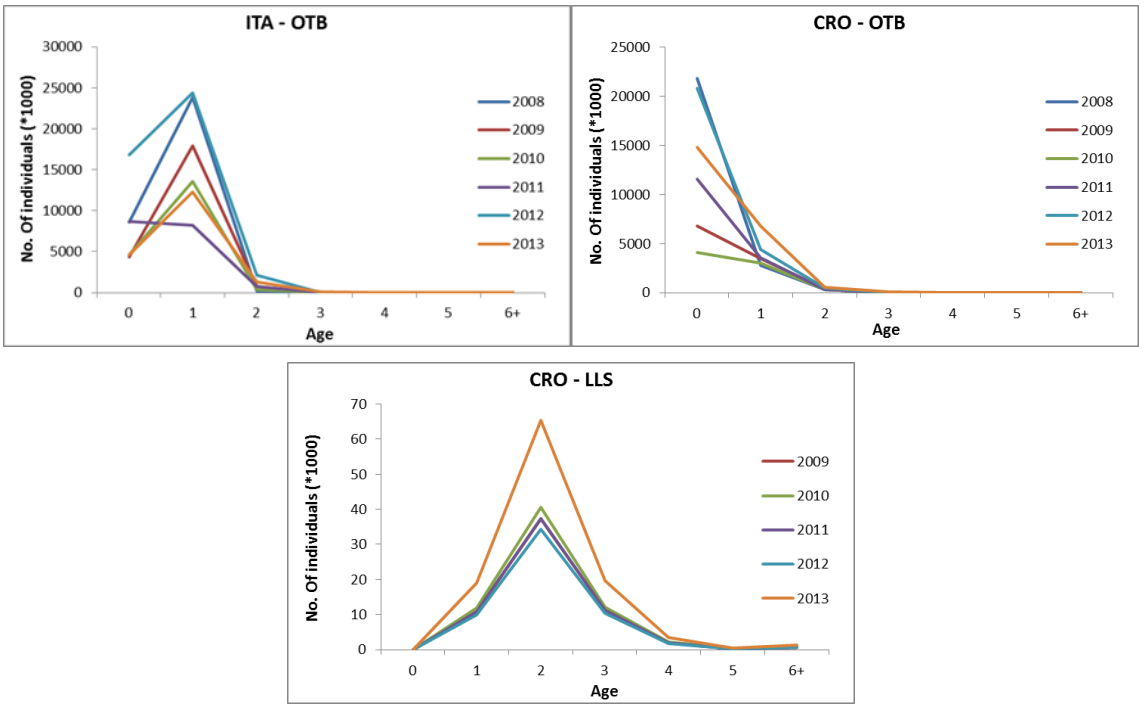


Fig. 17 Catch at age data used in SCAA analysis

6.1.4 Results

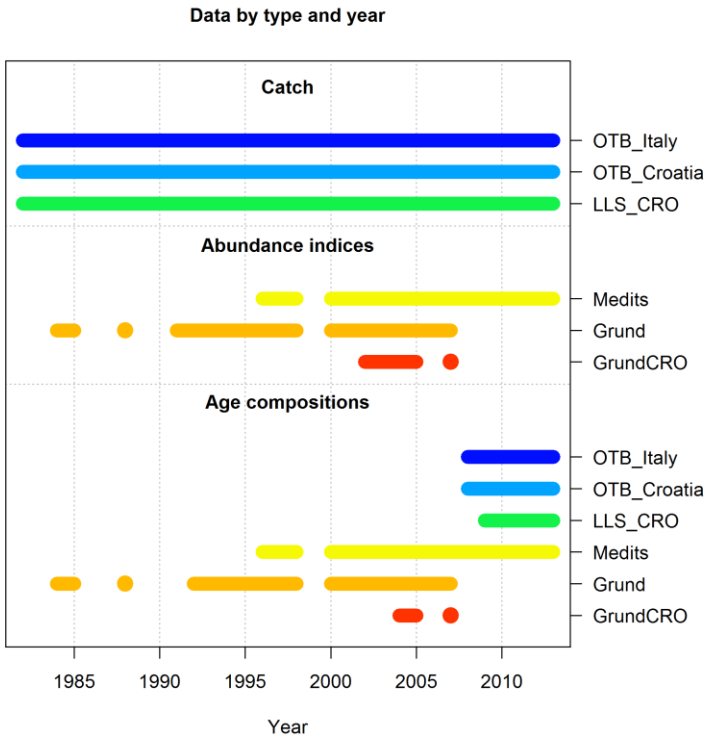


Fig. 18 Summary of input data used in SCAA analysis

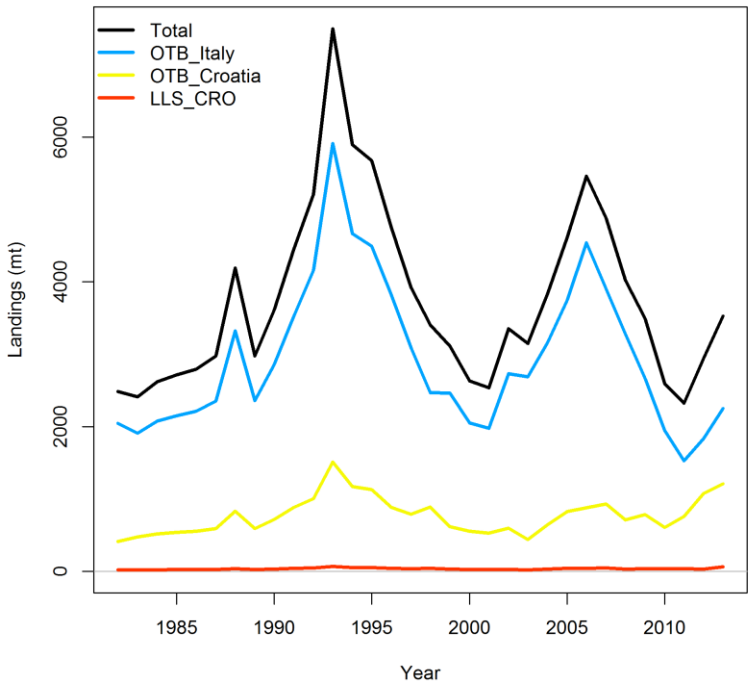


Fig. 19 Input landings data for SS3 model

Landings data come from FishStatJ and for the most recent years (2008 – 2013) they include

discard estimates. Croatian landing data by gear are available from 2008 to 2013. For these years the landings percentages of each gear have been calculated and the mean value has been applied to the total landing of the previous years.

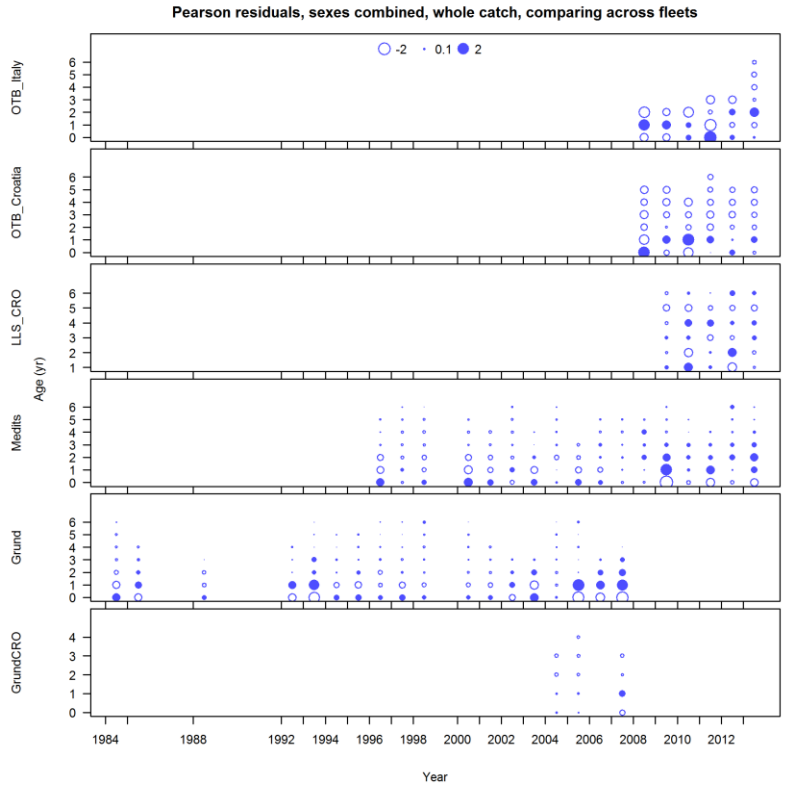
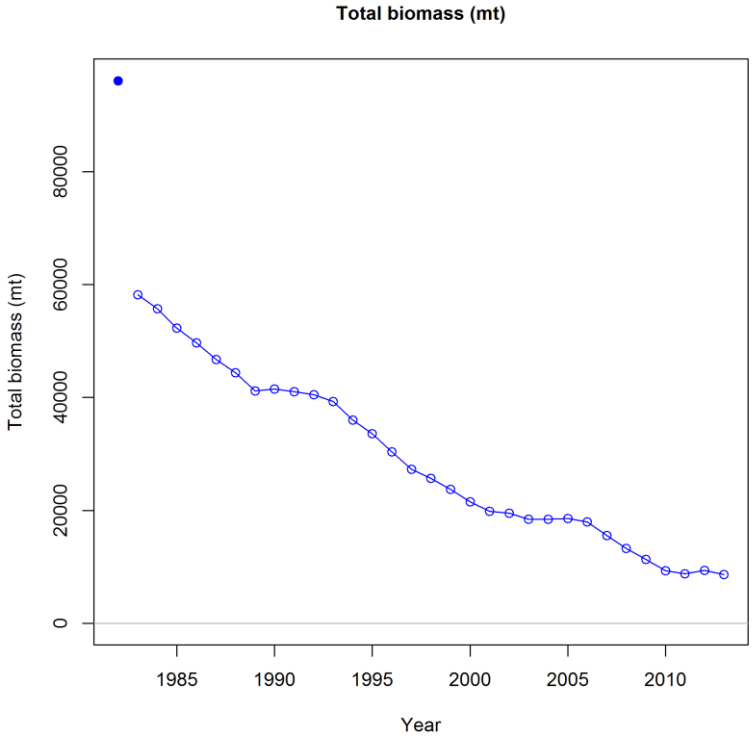
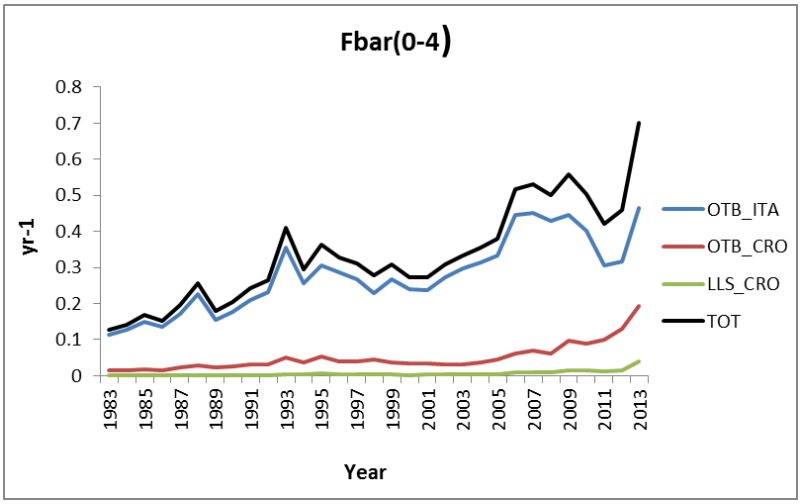


Fig. 20 Pearson residuals for fleets and surveys.

No particular trend are observed.

Figures 21 presents the main results from the SCAA run: total biomass, fishing mortality (Fbar0-4) by fleet, spawning stock biomass (SSB) and recruitment.


Total biomass (mt)
Total biomass (mt)
0
20000
40000
60000
80000
1985
1990
1995
2000
2005
2010
Year


Fbar(0-4)
yr-1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
Year
OTB_ITA
OTB_CRO
LLS_CRO
TOT

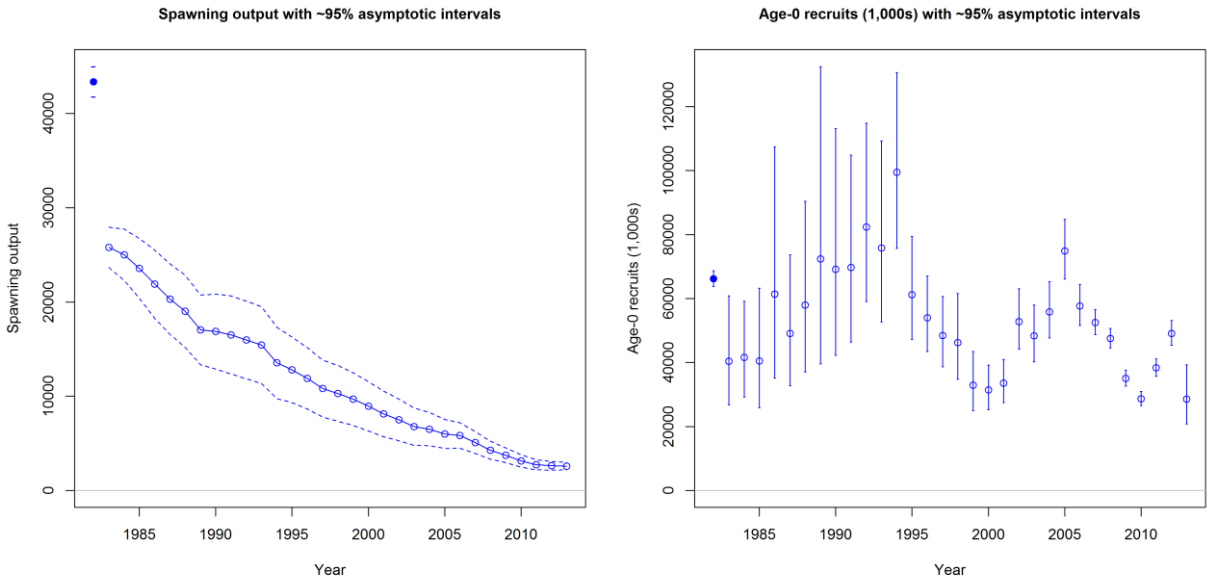


Figure 21 - Final assessment results SCAA run

State of exploitation: exploitation shows an increasing trend over the years reaching a peak of 0.70 in 2013. Italian bottom trawlers are the principal cause of fishing mortality for hake, they account for a peak equal to 0.47 in 2013, whereas the minimum value ($F_{bar(0-4)}$ = 0.11) is recorded in 1983. Croatian bottom trawlers place at the second position for hake exploitation, they show a continuous increasing trend more steeper from 2005, reaching the highest value in 2013 (0.19).Set longlines account for the minor values of fishing mortality, the mean F value for this gear considering the entire time series is 0.01.

State of the juveniles (recruits): recruitment show a fluctuating decreasing trend. The highest value has been estimated in 1994, followed by a decrease to 2000 and a subsequent increase to 2005. A new decay is observed in 2010 and it accounts for the lowest values, 2011 and 2012 show an improving trend but a new decay is described in 2013.

State of the adult biomass: the spawning stock biomass (SSB) showed a continuous decreasing trend all over the year. For the last years estimates are more precise since different information are available. Thus suggests the decreasing trend is less negative that it appears, moreover hake of big sizes and old are absent both in the catches and surveys estimates.

6.1.5 Robustness analysis

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

6.1.7 Assessment quality

7 Stock predictions

The biological reference point has been estimated using the Yield per Recruits approach, where $F_{0.1}$ is considered a proxy of F_{MSY}. Biological reference points have been estimated using the SCAA input data and selectivity patterns.

RPs suggest an overfishing situation for the hake stock.

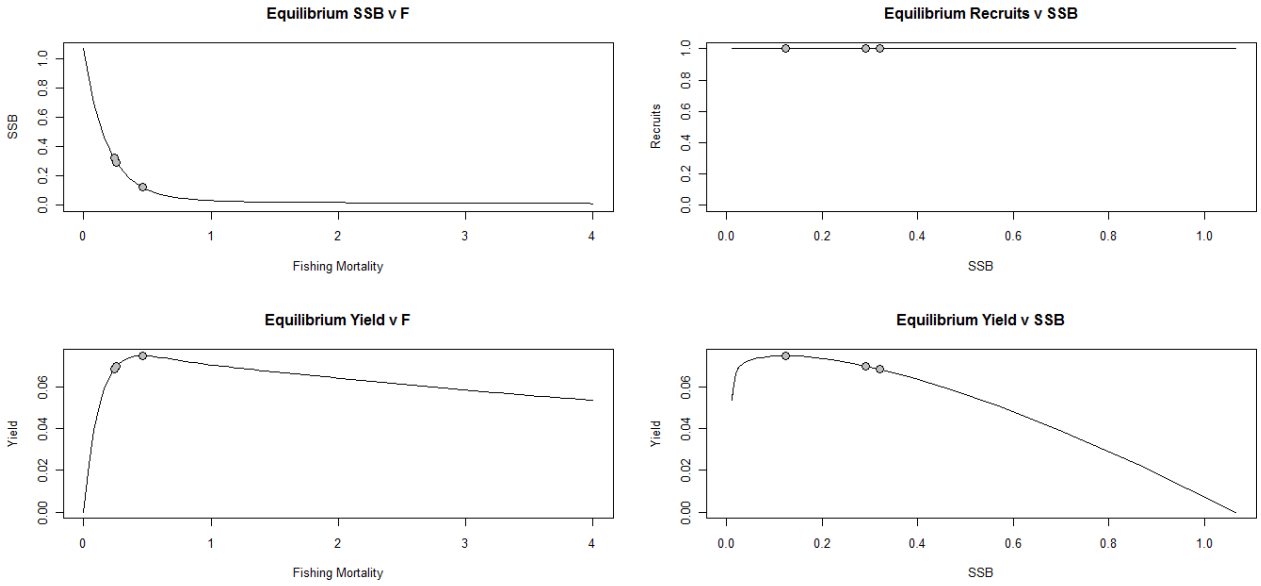


Figure 21 - Yield per Recruit analyses for SCAA

Table 7.1 - Yield per Recruit outputs for SCAA.

	Current F ($F_{BAR\ 0\text{-}4}$)	Reference Points	Harvest	Yield/R	SSB/R	Total biomass/R
SCAA	0.53	$F_{0.1}$	0.258	0.07	0.29	0.441
	(mean F_{bar} 2001-2013)	F_{max}	0.459	0.075	0.122	0.251

7.1 Short term predictions

7.2 Medium term predictions

7.3 Long term predictions

8 Draft scientific advice

Considering the results of SCAA analyses, it can be concluded that the resource is subjected to overfishing. A reduction of fishing mortality is recommended. SSB shows a clear decreasing trend. The SS3 model allows the assumption of a dome-shaped population selection curve, which determines more reliable values of SSB if compared with the historical yields. However we have to consider that the most reliable estimate were obtained for the last years of the time series considered, for which different data sets are available.

According to SCAA results, recruitment shows a fluctuating decreasing trend, accounting for the slowest value in 2013 and a peak in 2005. Survey data from GRUND ITA and EXT support these estimates, whereas MEDITS data show an improving trend in the last years.

Based on the SCAA estimates, in 2013 the fishing mortality appears higher than the respective estimates of $F_{0.1}$ and, hence, it can be concluded that the resource is in overexploitation. In this regard it must be kept in mind the different contribution of the fleets to the total F, since Italian bottom trawlers are the most influent factor.

The calculation of reference point has been updated according to the SCAA methodology and the value proposed is $F_{0.1}$ equal to 0.26. Such value is in accordance with previous analysis ($F_{0.1}$ = 0.2, EWG 13_05). Given the results of the present analysis ($F_{current(2011-2013)}$ is 0.53), the stock appears to be subject to overfishing. A considerable reduction is necessary to approach the reference point.

Considering the overexploited situation and the low values of SSB and biomass of the hake stock in GSA 17 a reduction of fishing mortality and an improvement in exploitation pattern is advisable, especially for bottom trawlers, which mainly exploit juveniles. Moreover, particular management measure can be considered for the Pomo area since it constitutes a nursery area for hake, supporting the entire Adriatic hake stock, and in the eastern part a persistency area for spawners has been revealed from the MEDISEH project.

Based on	**Indicator**	**Analytical reference point (name and value)**	**Current value from the analysis (name and value)**	**Empirical reference value (name and value)**	**Trend (time period)**	**Stock Status**
Fishing mortality	Fishing mortality	$F_{0.1}$, = 0.26 F_{max}= 0.46	0.53 ($F_{current2011-2013}$)		I	IO
	Fishing effort					
	Catch					

Stock abundance	Biomass	29.612 (33rd percentile) 40.639 (66th percentile)	33.093 (Biomass index from MEDITS survey from 2013)		D	O_l
	SSB				D	
Recruitment					D	
Final Diagnosis		In overexploitation				

8.1 Explanation of codes

Trend categories

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

Stock Status

Based on Fishing mortality related indicators

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

Range of Overfishing levels based on fishery reference points

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

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

*Fc is current level of F

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

Based on Stock related indicators

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

Empirical Reference framework for the relative level of stock biomass index

- **Relative low biomass:** Values lower than or equal to 33rd percentile of biomass index in the time series **(O_L)**
- **Relative intermediate biomass:** Values falling within this limit and 66th percentile **(O_I)**
- **Relative high biomass:** Values higher than the 66th percentile **(O_H)**

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

Agreed definitions as per SAC Glossary

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

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