Stock Assessment Form

Demersal species

Reference year: 2014

Reporting year: 2015

The last assessment of this species in the area has been performed in 2014, during the GFCM stock assessment demersal species working group. For the updating of hake stock status in the whole GSA 18 different methods and different sources of data (fishery dependent and fishery independent) have been used. In the present analysis also the gillnet and trammel nets of Montenegrin fleet and commercial catch length structure for Albanian trawls from biological sampling have been included. An exercise using a simulation approach to explore effects of possible different management scenarios has been performed. Given the results from this analysis, based on the whole information from the area, the stock is in high overfishing (F0.1=0.14; Fcurrent=0.6) and it is necessary to consider that a remarkable reduction of the fishing mortality. The reference point F0.1 can be gradually achieved by multiannual management plans. As observed in 2013, the production of hake in GSA 18 is split in 6% caught by Italian longlines, 82% by Italian trawlers, about 1% by Montenegrin trawlers, about 1% by Montenegrin gillnets and trammel nets and about 10% by Albanian trawlers.

Stock Assessment Form version 1.0 (January 2014)

Uploader: *Zdravko Ikica*

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 18		
4th Geographical sub-area:	5th Geographical sub-area:	6th Geographical sub-area:
1st Country	2nd Country	3rd Country
Italy	Albania	Montenegro
4th Country	5th Country	6th Country
Stock assessment method: (direct, indirect, combined, none)		
Combined (Trawl survey, XSA, a4aSCA, ALADYM)		
Authors:		
Bitetto I.[1], Carbonara P.[1], Casciaro L.[1], Ceriola L.[2], Đurović M.[3], Facchini M. T.[1], Hoxha A.[4], Ikica Z.[3], Joksimović A.[3], Kolitari J.[4], Kroqi G.[4], Lembo G.[1], Marković O.[3], Milone N.[2], Spedicato M. T.[1]		
Affiliation:		
[1] COISPA Tecnologia & ricerca, Bari – Italy; [2] AdriaMed, FAO, Rome – Italy; [3] Institute of Marine Biology, University of Montenegro, Kotor – Montenegro; [4] University of Tirana – Albania		

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)

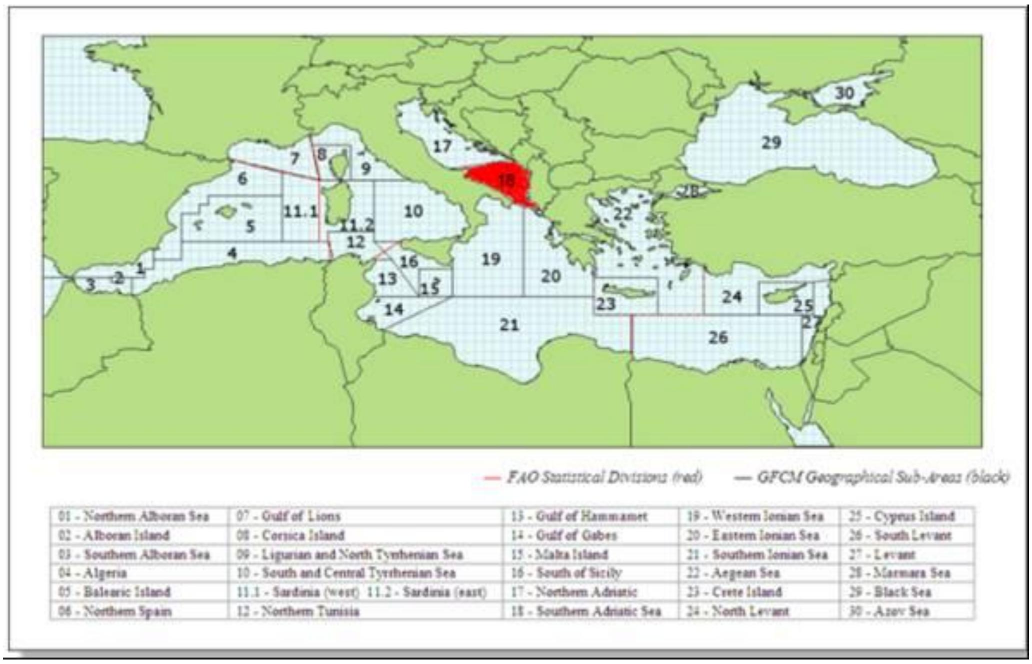
Combined method: you can choose both a direct and an indirect method and the name of the combined method (please specify)

We have applied the direct method using trawl survey data for the estimation of indicators and for tuning. The XSA among the indirect methods and Aladym as simulation model.

Stock identification and biological information

1.1 Stock unit

The Southern Adriatic Sea is characterised by the presence of a deep central depression known as the "South Adriatic Pit" (or Bari Pit) where the seabed reaches a depth of 1,233 m.
The northern and southern portions of the Southern Adriatic Sea feature substantial differences; the first contains a wide continental shelf (the distance between the coastline and a depth of 200 m is around 45 nautical miles) and a very gradual slope; in the second, the isobathic contours
are very close, with a depth of 200 m already found at around 8 miles from the Cape of Otranto.
The continental shelf break is at a depth of around 160-200 m and is furrowed by the heads of canyons running perpendicular to the line of the shelf.
The Adriatic Sea, together with the Levant basin, is one of three areas in the Mediterranean where down-welling processes produced by surface cooling lead to the formation of so-called "dense waters", rich in oxygen, which supply the lower levels.
The stock of European hake was assumed in the boundaries of the whole GSA 18, where it inhabits depths from several meters in the coastal area down to 800 m in the South Adriatic Pit (Kirincic and Lepetic, 1955; Ungaro et al., 1993). though it is most abundant at depths between 100 and 200 m, where the catches are mainly composed of juveniles (Bello et al., 1986; Ungaro et al., 1993). In the southern Adriatic the largest individuals are caught in waters deeper than 200 m, whereas medium-sized fish appear in the waters not deeper than 100 m (Ungaro et al., 1993).



1.2 Growth and maturity

Estimates of growth parameters were achieved during the SAMED project (SAMED, 2002) by the analysis of length frequency distributions. The following von Bertalanffy parameters were estimated by sex: females L_∞=83.4 cm; K=0.15; t_0= -0.11; males: L_∞=58.2cm; K=0.23; t_0= -0.06.

The observed maximum lengths of European hake were 93.5 cm for females and 66.5 cm for males both registered during Medits samplings. In the commercial sampling also a female of 93.5 cm length was observed in 2009. In the DCF framework the growth has been studied ageing fish by otolith readings using the whole sagitta and thin sections for older individuals. Length frequency distributions were also analysed using techniques as Batthacharya for separation of modal components. The estimates of von Bertalanffy growth parameters (Linf=96 cm, K=0.129, t_0= −0.73 for sex combined) were obtained from average length at age using an iterative non-liner procedure that minimizes the sum of the square differences between observed and expected values.

According to the previous assessment in the GSA the fast growth scenario of growth rate was used for sex combined in the following assessment sections: Linf=104 cm, K=0.2, t_0= −0.01. Parameters of the length-weight relationship from the data collected in the DCF were a=0.0036, b=3.2 for length expressed in cm and weight in grams.

M. merluccius spawns throughout the year, but with different intensities. The spawning peaks are in the summer and winter periods (Zupanovic, 1968; Ungaro et al., 1993; Donnaloia, 2009). Recent estimates of the batch fecundity (Donnaloia, 2009) reported higher values in comparison to the fecundity reported by Morua et al.(2006) for the Atlantic Sea and Recasens et al (2008) for the Northern Tyrrhenian Sea.

Karlovac (1965) recorded young hake larvae from October to June, the highest numbers were recorded in January and February. Larvae and post-larvae were mainly distributed between 40 and 200 m; the highest number of individuals was caught mainly between 50 and 100 m.

Recruitment peaks in the winter and late spring (Ungaro et al., 1993; Donnaloia, 2009).

Mature females were found all year round with peaks in early winter and late spring.

An estimate of size at first maturity has been derived by biological sampling within DCF and is reported in the table below. Binomial GLM method has been used for the estimation.

According to the data of the DCF framework, the proportion of mature females (fish belonging to the maturity stage 2 onwards) allowed to estimate a maturity ogive with a size at first maturity varying around 33.4 (±0.15 cm) (maturity range 3.8 ±0.16 cm) (Fig.2.2-1). This size of first maturity is higher that the literature reported for the Adriatic Sea (Zupanovic, 1968; Zupanovic and Jardas, 1986; Alegria Hernandez and Jukic, 1992), while it is in accordance with data reported for other areas along the Italian seas and western Mediterranean.

Information about maximum observed length, size at first maturity and recruitment size are reported in Table 2.2-1 and in Fig. 2.2-1.

Table 1.2-1: Maximum size, size at first maturity and size at recruitment.

Somatic magnitude measured (LT, LC, etc)			**LT**	**Units**	cm
Sex	**Fem**	**Mal**	**Combined**	**Reproduction season**	**All year (peaks in late spring and winter)**
Maximum size observed	93.5	66.5		**Recruitment season**	
Size at first maturity	32			**Spawning area**	
Recruitment size to the fishery			6	**Nursery area**	Continental shelf

Table 1-2.2: M vector and proportion of matures by size or age (Males)

Size/Age	Natural mortality	Proportion of matures
0	1.16	0
1	0.53	0.12
2	0.40	0.92
3	0.35	1.00
4	0.32	1.00
5+	0.32	1.00

Table 1-2.3: M vector and proportion of matures by size or age (Females)

Size/Age	Natural mortality	Proportion of matures
0	1.16	0
1	0.53	0.12
2	0.40	0.92
3	0.35	1.00
4	0.32	1.00
5+	0.32	1.00

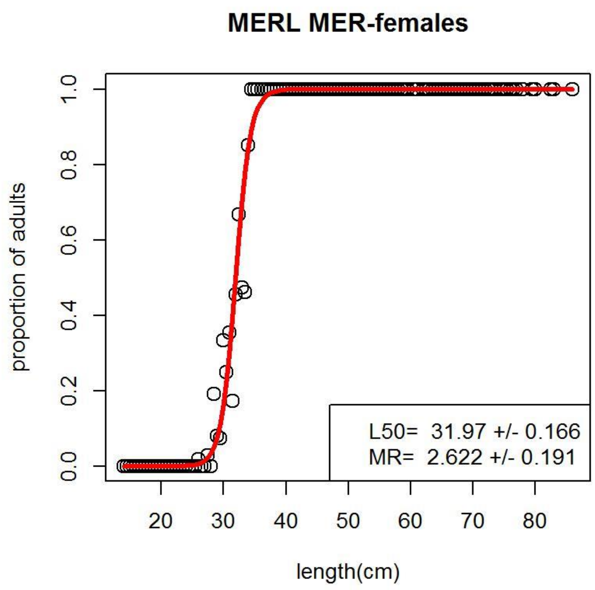


Fig. 2.2-1. Maturity ogive for *M. merluccius* females (DCF 2014).

For the assessment a vector natural mortality estimated by PRODBIOM method (Abella et al., 1997) for sex combined. The vector of proportion of mature individuals by age has been derived slicing the maturity ogive by length with the von Bertalanffy coefficients for sex combined reported above. LFDA (FAO package) algorithm has been used for the age slicing.

Table 1-3: Growth and length weight model parameters

			Sex			
		Units	female	male	Combined	Years
Growth model	L_∞	cm			104	
	K	Year^{-1}			0.2	
	t_0	year			−0.01	
	Data source					
Length weight relationship	a	cm; g			0.0043	
	b	cm; g			3.2	
	M (scalar)					
	sex ratio (% females/total)	0.5				

2 Fisheries information

The Southern Adriatic sea makes a substantial contribution to national fishery production, with an input of about 13%. *Merluccius merluccius* is one of the most important species in the Geographical Sub Area 18 representing more than 20% of landings from trawlers. Trawling represents the most important fishery activity in the southern Adriatic Sea and a yearly catch of around 30,000 tonnes could be estimated for the last decades. Hake is also caught by off-shore bottom long-lines, but these gears are utilised by a low number of boats (less than 5% of the whole South-western Adriatic fleet).
Kirinčić and Lepetić (1955) investigated the catch size structure from experimental bottom long-line fishery in the Southern Adriatic. The average total length of the European hake was 58.6 cm. The average catch rate was 5.6 specimens per 100 hooks.
Currently (2007-2014) weighted mean total length of longliners is varying from: 41 cm of 2013 to 51.5 cm of 2008 (49.5 cm in 2014).
Fishing grounds are located on the soft bottoms of continental shelves and the upper part of continental slope along the coasts of the whole GSA. Catches from trawlers are from a depth range between 50-60 and 500 m and hake occurs with other important commercial species as *Illex coindetii*, *M. barbatus*, *P. longirostris*, *Eledone spp*., *Todaropsis eblanae*, *Lophius spp*., *Pagellus spp*., *P. blennoides*, *N. norvegicus*.

2.1 Description of the fleet

The fleet data are referred to the whole GSA and are from the GFCM Task 1 Statistical Bulletin 2010. Catch data in the table 3.1.2 below reported are referred to the year 2012 (DCF data for Italy, and data from ADRIAMED pilot study and National Statistics for Albania and Montenegro). The operational units ITA18E0333-HKE, ITA18F0333- HKE, ALB 18 E 03 33- HKE and ALB 18 F 03 33- HKE include also demersal slope fishing (mixed demersal according to DCF classification).

The catch data from the whole GSA18 including the east side are below reported:

Table 2-1: Description of operational units exploiting the stock

	Country	GSA	Fleet Segment	Fishing Gear Class	Group of Target Species	Species
Operational Unit 1	ITA	18	D – Trawls (6-12 m)	03 – Trawls	33 – Demersal shelf species	HKE
Operational Unit 2	ITA	18	E – Trawls (12-24 m)	03 – Trawls	33 – Demersal shelf species	HKE
Operational Unit 3	ITA	18	F – Trawls (>24 m)	03 – Trawls	33 – Demersal shelf species	HKE
Operational Unit 4	ITA	18	I – Long-line (12-24 m)	09 – Hooks and lines	33 – Demersal shelf species	HKE
Operational Unit 5	MNE	18	E – Trawls (12-24 m)	03 – Trawls	33 – Demersal shelf species	HKE

Operational Unit 6	MNE	18	B – Minor gear with engine (<6 m)	07 – Gillnets and Entangling Nets	33 – Demersal shelf species	HKE
Operational Unit 7	MNE	18	C – Minor gear with engine (6-12 m)	07 – Gillnets and Entangling Nets	33 – Demersal shelf species	HKE
Operational Unit 8	ALB	18	D – Trawls (6-12 m)	03 – Trawls	33 – Demersal shelf species	HKE
Operational Unit 9	ALB	18	E – Trawls (12-24 m)	03 – Trawls	33 – Demersal shelf species	HKE
Operational Unit 10	ALB	18	F – Trawls (>24 m)	03 – Trawls	33 – Demersal shelf species	HKE

Table 2.1-2: Catch, bycatch, discards and effort by operational unit in the reference year (2014)

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 Operational Units 1+2+3	400	1585 T				
ITA Operational Unit 4	23	279 T				
MNE Operational Units 5	20	41 T				
MNE Operational Units 6+7	90	2.8 T				
ALB Operational Units 8+9+10	199	206 T				
Total	718	2114 T				

Table 3.1-3. Catch values used in the assessments

Classification	Catch (t)
2007 ITA 18 I 03 33	620
2007 ITA 18 D 03 33 – ITA 18 E 03 33 – ITA 18 F 03 33	3497

2007 ALB 18 D 03 33 – ALB 18 E 03 33 – ALB 18 F 03 33	390[1]
2007 MNE 18 D 03 33 – MNE 18 E 03 33 – MNE 18 F 03 33	59[1]
2007 MNE 18 B 03 33 – MNE 18 C 03 33	4.0[1]
2007 Total	**4570**
2008 ITA 18 I 03 33	550
2008 ITA 18 D 03 33 – ITA 18 E 03 33 – ITA 18 F 03 33	3640
2008 ALB 18 D 03 33 – ALB 18 E 03 33 – ALB 18 F 03 33	390[2]
2008 MNE 18 03 33 – MNE 18 E 03 33 – MNE 18 F 03 33	59
2008 MNE 18 B 03 33 – MNE 18 C 03 33	4.0[4]
2008 Total	**4643**
2009 ITA 18 I 03 33	532
2009 ITA 18 D 03 33 – ITA 18 E 03 33 – ITA 18 F 03 33	3540
2009 ALB 18 D 03 33 – ALB 18 E 03 33 – ALB 18 F 03 33	456[2]
2009 MNE 18 03 33 – MNE 18 E 03 33 – MNE 18 F 03 33	52
2009 MNE 18 B 03 33 – MNE 18 C 03 33	3.5[4]
502009 Total	**4584**
2010 ITA 18 I 03 33	597
2010 ITA 18 D 03 33 – ITA 18 E 03 33 – ITA 18 F 03 33	3372
2010 ALB 18 D 03 33 – ALB 18 E 03 33 – ALB 18 F 03 33	375[2]
2010 MNE 18 03 33 – MNE 18 E 03 33 – MNE 18 F 03 33	46
2010 MNE 18 B 03 33 – MNE 18 C 03 33	3.1[4]
2010 Total	**4393**
2011 ITA 18 I 03 33	534
2011 ITA 18 D 03 33 – ITA 18 E 03 33 – ITA 18 F 03 33	3285
2011 ALB 18 D 03 33 – ALB 18 E 03 33 – ALB 18 F 03 33	402[2]
2011 MNE 18 03 33 – MNE 18 E 03 33 – MNE 18 F 03 33	37
2011 MNE 18 B 03 33 – MNE 18 C 03 33	2.5[4]
2011 Total	**4261**
2012 ITA 18 I 03 33	566
2012 ITA 18 D 03 33 – ITA 18 E 03 33 – ITA 18 F 03 33	2520
2012 ALB 18 D 03 33 – ALB 18 E 03 33 – ALB 18 F 03 33	280[3]
2012 MNE 18 03 33 – MNE 18 E 03 33 – MNE 18 F 03 33	39
2012 MNE 18 B 03 33 – MNE 18 C 03 33	2.6[4]
2012 Total	**3408**
2013 ITA 18 I 03 33	188
2013 ITA 18 D 03 33 – ITA 18 E 03 33 – ITA 18 F 03 33	2379
2013 ALB 18 D 03 33 – ALB 18 E 03 33 – ALB 18 F 03 33	280[5]
2013 MNE 18 03 33 – MNE 18 E 03 33 – MNE 18 F 03 33	40
2013 MNE 18 B 03 33 – MNE 18 C 03 33	2.7
2013 Total	**2890**
2014 ITA 18 I 03 33	279
2014 ITA 18 D 03 33 – ITA 18 E 03 33 – ITA 18 F 03 33	1585
2014 ALB 18 D 03 33 – ALB 18 E 03 33 – ALB 18 F 03 33	206
2014 MNE 18 03 33 – MNE 18 E 03 33 – MNE 18 F 03 33	41
2014 MNE 18 B 03 33 – MNE 18 C 03 33	2.8
2014 Total	**2114**

[1] Due to the lack of data, the 2007 catch for Albania and Montenegro was assumed to be identical to the catch of 2008

[2] Catches in Albania were based on export data, which was assumed to equal 64% of the total catch (FAO Fisheries and Aquaculture Department. 2013. Global Capture Fisheries Production Statistics for the year 2011 ftp://ftp.fao.org/FI/news/GlobalCaptureProductionStatistics2011.pdf)

[3] Preliminary data of Ministry of Environment, forests and Water Management of Albania for 2012.

[4] Due to the lack of data, the total production of fleet segments MNE 18 B 03 33 and MNE 18 C 03 33 for period 2008–2012 and 2014 was estimated based on the data from 2013
[5] Due to the lack of data, the total production of Albania in 2013 was assumed to be identical to that of 2012.

Historical trends

Available time series for European hake landings in GSA 18 is relatively short (Table 3.2-1), consisting of only eight years (2007-2014), and even not complete for all countries in question. The reduction of landings present since 2008 continued, and was even more pronounced in 2014, marking the lowest point in the time series.

Also the nominal fishing effort (kW×days) shows a decrease (Fig. 3.2-1).

Table 3.2-1. Landing data for GSA 18 by year and country

Year	Italy-LLS	Italy-OTB	Montenegro -OTB	Montenegro -GEN	Albania	Total Landings
2007	620	3497	59	4.0	390	4570
2008	550	3640	59	4.0	390	4643
2009	532	3540	52	3.5	456	4584
2010	597	3372	46	3.1	375	4393
2011	534	3285	37	2.5	402	4261
2012	566	2520	39	2.6	280	3408
2013	188	2379	40	2.7	280	2890
2014	279	1585	41	2.8	206	2114

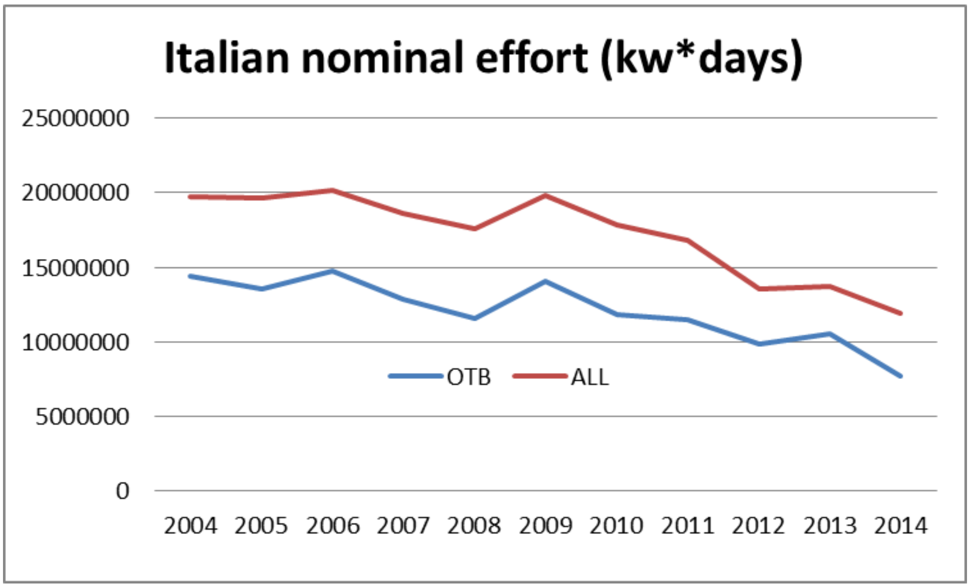


Fig. 4.1.3-1. Nominal fishing effort in kW×days by fishing technique for the western side (Italian coast) of GSA 18 from DCF. In “all” are included GNS, GTR and LLS.

2.2 Management regulations

In Italy management regulations are based on technical measures, closed number of fishing licenses for the fleet and area limitation (distance from the coast and depth). In order to limit the over-capacity of fishing fleet, the Italian fishing licenses have been fixed since the late eighties and the fishing capacity has been gradually reduced. Other measures on which the management regulations are based regards technical measures (mesh size), minimum landing sizes (EC 1967/06) and seasonal fishing ban, that in southern Adriatic has been mandatory since the late eighties. Regarding long-lines the management regulations are based on technical measures related to the number of hooks and the minimum landing sizes (EC 1967/06), besides the regulated number of fishing licences. Regarding small scale fishery management regulations are based on technical measures related to the height and length of the gears as well as the mesh size opening, minimum landing sizes and number of fishing licenses for the fleet. In 2008 a management plan was adopted, that foresaw the reduction of fleet capacity associated with a reduction of the time at sea. Two biological conservation zone (ZTB) were permanently established in 2009 (Decree of Ministry of Agriculture, Food and Forestry Policy of 22.01.2009; GU n. 37 of 14.02.2009) along the mainland, offshore Bari (180 km^2, between about 100 and 180 m depth), and in the vicinity of Tremiti Islands (115 km^2 along the bathymetry of 100 m) on the northern border of the GSA where a marine protected area (MPA) had been established in 1989. In the former only the professional small scale fishery using fixed nets and long-lines is allowed, from January 1st to June 30th, while in the latter the trawling fishery is allowed from November 1st to March 31 and the small scale fishery all year round. Recreational fishery using no more than 5 hooks is allowed in both the areas. Since June 2010 the rules implemented in the EU regulation (EC 1967/06) regarding the cod-end mesh size and the operative distance of fishing from the coasts are enforced.

In Montenegro, management regulations are based on technical regulations, such as mesh size (Official Gazette of Montenegro, 8/2011), including the minimum landing sizes (Official Gazette of Montenegro, 8/2011), and a regulated number of fishing licenses and area limitation (no–fishing zone up to 3 NM from the coastline or 8 NM for trawlers of 24+ m LOA). Currently there are no MPAs or fishing bans in Montenegrin waters.

In Albania, a new law “On fishery” has now been approved, repealing the Law n. 7908. The new law is based on the main principles of the CFP, it reflects Reg. 1224/2009 CE ; Reg.1005/2008 CE; Reg. 2371/2002 CE; Reg. 1198/2006 CE; Reg. 1967/2006 CE; Reg. 104/2000; Reg. 1543/2000 as well as the GFCM recommendations. The legal regime governing access to marine resources is being regulated by a licensing system. Regarding conservation and management measures, minimum legal sizes and minimum mesh sizes is those reflected in the CE Regulations. Albania has already an operational vessel register system. It is forbidden to trawl at less than 3 nautical miles (nm) from the coast or inside the 50m isobath when this distance is reached at a smaller distance from the shore.

2.3 Reference points

Table 2.4-1: 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			$F_{0.1}$	0.18	
Y					
CPUE					
Index of Biomass at sea					

3 Fisheries independent information

3.1 MEDITS Trawl Survey

3.1.1 Brief description of the direct method used

The sampling design is random stratified with number of haul by stratum proportional to stratum surface. Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Hauls noted as valid were used only, including stations with no catches (zero catches are included).
The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). The variation of the stratified mean is then expressed as coefficient of variation respect to the mean.

Direct methods: trawl based abundance indices

Table 3.1-1: Trawl survey basic information

Survey	MEDITS	**Trawler/RV**	PEC
Sampling season	Summer		
Sampling design	Stratified sampling design with the number of hauls proportionate to the strata surface		
Sampler (gear used)	GOC 73		
Cod –end mesh size as opening in mm	20 mm		
Investigated depth range (m)	10 – 800 m		

Table 3.1-2: Trawl survey sampling area and number of hauls

Stratum	**Total surface (km^2)**	**Trawlable surface (km^2)**	**Swept area (km^2)**	**Number of hauls**
10 – 50 m	3430			12
50 – 100 m	6435			20
100 – 200 m	9664			31
200 – 500 m	4761			13
500 – 800 m	4718			14
Total (10 – 800 m)	29008			90

The haul positions are represented in the map below.

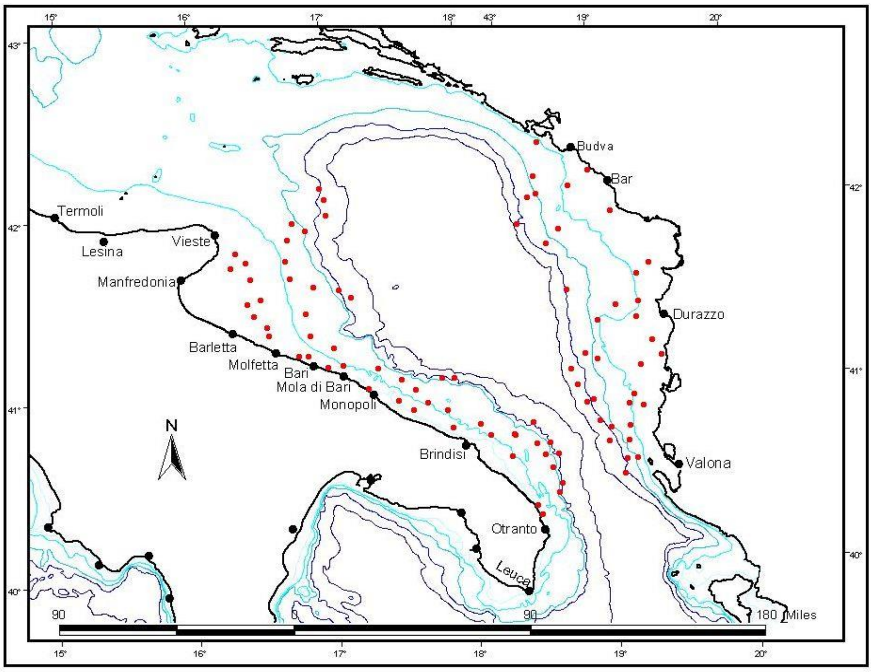


Fig. 4.1-1. Map of MEDITS haul positions in the GSA 18

The abundance indices and the associated coefficient of variation for 2014 are reported in the table below.

Table 3.1-3: Trawl survey abundance and biomass results (MEDITS 2014)

Depth Stratum	Years	kg per km^2	CV (%)	N per km^2	CV (%)
10 – 50 m	2014	4.0	45.8	125	38.6
50 – 100 m	2014	13.7	17.8	349	14.9
100 – 200 m	2014	27.4	12.1	1105	19.9
200 – 500 m	2014	38.9	22.9	275	32.7
500 – 800 m	2014	20.1	29.2	19	25.8
Total (10 – 800 m)	2014	22.3	9.6	508	14.9

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

Slicing method

The maturity scale used for the maturity stages of this species is MEDITS scale (Medits Handbook 2013, version 7).

The age slicing method used for this stock is the LFDA (FAO package) algorithm implemented by means of a routine in R.

Table 3.1-4: Trawl survey results by length or age class

N/km² (Total or sex combined) by Length or Age class	Year							
	2007	2008	2009	2010	2011	2012	2013	2014
0	416.51	918.92	564.34	479.98	319.15	1344.65	444.60	430.50
1	104.05	150.54	199.78	109.03	87.36	89.72	98.26	63.26
2	6.89	5.12	14.27	6.55	4.33	5.24	10.55	10.66
3	2.08	1.93	2.03	2.56	1.68	1.08	1.50	2.70
4	0.63	0.37	1.01	0.84	0.97	0.61	0.69	0.94
5+	0.75	0.16	0.36	0.58	0.12	0.34	0.58	0.24
Total	530.91	1077.04	781.78	599.55	413.60	1441.65	556.18	508.06

Sex ratio by Length or Age class	Year		
	2007-2013	….	…..
Total	0.5		

The number are standardised to the square km but not raised to the overall area assuming the same catchability (=1).

Direct methods: trawl based Recruitment analysis

Table 3.1-5: Trawl surveys; recruitment analysis summary

Survey	**MEDITS**	**Trawler/RV**	**PEC**
Survey season		summer	
Cod –end mesh size as opening in mm		20	
Investigated depth range (m)		10-800	
Recruitment season and peak (months)		winter and late spring	
Age at fishing-grounds recruitment			

Length at fishing-grounds recruitment	

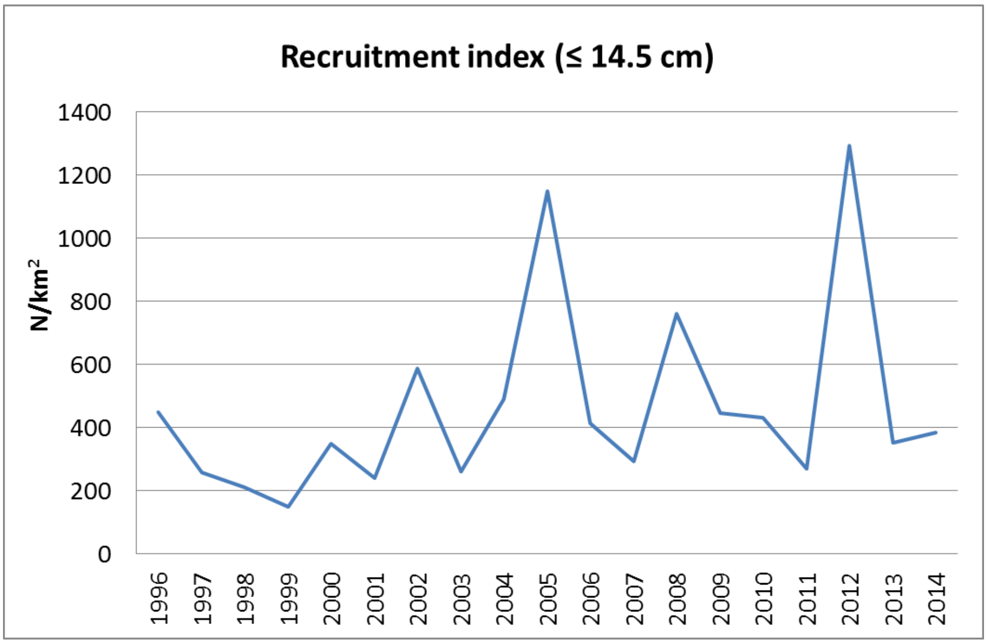
Table 3.1-6: Trawl surveys; recruitment analysis results (<=14.5 cm)

Years	Area in km^2	N of recruit per km^2	CV
1996	29008	449	15.5
1997	29008	257	20.9
1998	29008	213	14.8
1999	29008	148	11.1
2000	29008	350	14.9
2001	29008	239	10.4
2002	29008	587	22.1
2003	29008	261	27.0
2004	29008	491	28.5
2005	29008	1148	10.5
2006	29008	414	15.9
2007	29008	294	13.0
2008	29008	762	16.5
2009	29008	448	22.7
2010	29008	431	18.4
2011	29008	270	19.3
2012	29008	1294	17.3
2013	29008	353	23.7
2014	29008	384	19.1

Recruitment follows a quasi-continuous pattern with main peaks in winter and late spring. Recruits mainly occur between 100 and 200 m depth. Size of recruits ranged between 12 cm and 17.5 mm CL.

The threshold size (14.5 mm) to extract recruitment indices has been derived by the separation of length frequency distribution (Batthacharya method) applied to the years when the first mode was well detectable. The abundance index of individuals <=14.5 cm has been considered has recruitment index.

Indices are related to the total area.



Direct methods: trawl based Spawner analysis

Table 3.1-7: Trawl surveys; spawners analysis summary

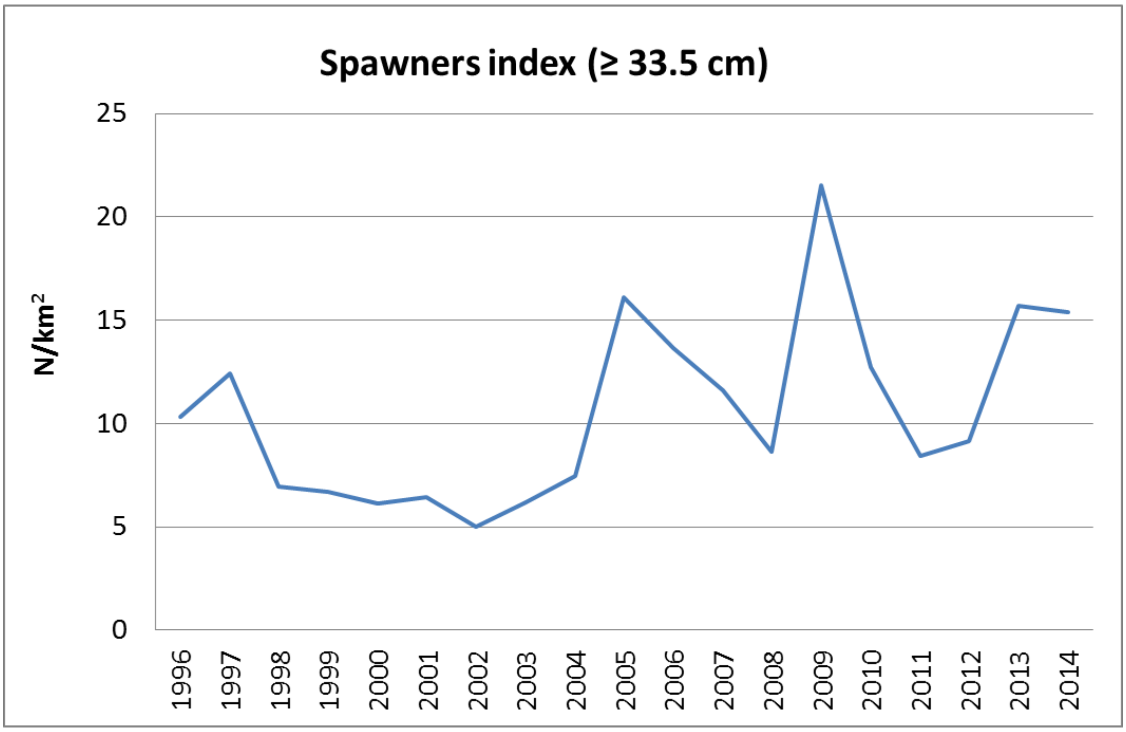
Survey	MEDITS	Trawler/RV	PEC
Survey season			summer
Investigated depth range (m)			10-800
Spawning season and peak (months)			summer and winter

Table 3.1-8: Trawl surveys; spawners analysis results (>= 33.5 cm)

Years	Area in km^2	N of spawners per km^2	CV
1996	29008	10	17.0
1997	29008	12	15.6
1998	29008	7	20.0
1999	29008	7	20.1
2000	29008	6	16.7
2001	29008	6	16.3
2002	29008	5	35.7
2003	29008	6	23.1
2004	29008	7	20.3
2005	29008	16	16.3
2006	29008	14	19.1

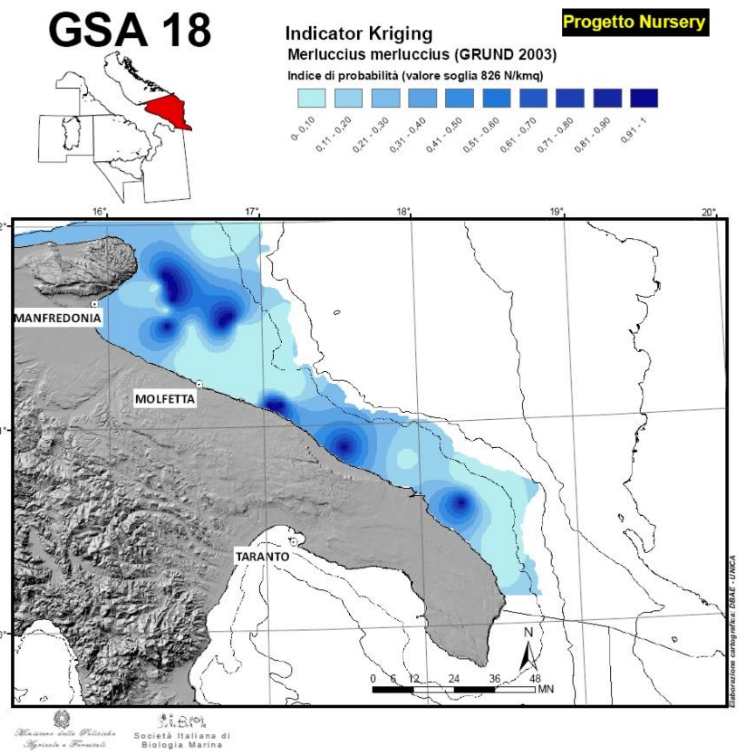
2007	29008	12	20.5
2008	29008	9	23.2
2009	29008	22	11.4
2010	29008	13	15.6
2011	29008	8	14.9
2012	29008	9	16.2
2013	29008	16	16.5
2014	29008	15	18.4

M. merluccius is a sequential spawners, spawning all year round with peaks in summer and winter. Indices are related to the total area.



3.1.2 Spatial distribution of the resources

In the GSA 18 the geographical distribution pattern of the hake recruits has been studied using the spatial indicator approach (Woillez et al., 2009; Spedicato et al., 2007) and geostatistical methods (Lembo, 2010) applied to GRUND and MEDITS data. A Gravity Centre of recruit density of hake was stably localised in the northernmost part of the GSA with significant relationships between Gravity Centre, abundance of recruits and Positive Area. Spatial continuity appeared higher in the GRUND series. Nursery areas of *M. merluccius* were identified within 100-200 m depth in the Gulf of Manfredonia and off Gargano Promontory. Other less relevant nuclei were also identified in the central and southern part of the GSA.



In the MEDISEH project (DG MARE Specific Contract SI2.600741, call for tenders MARE/2009/05) the nursery localised off-shore Gargano Promontory were found to be persistent over 17 years, while new high density nuclei were identified in the southernmost part of the GSA both eastward (off-shore Vlora) and westward, mainly between 100 and 200 m depth. (Fig. 4.1.2-1). Other nuclei are located along the border of Otranto Channel and off-shore Dürres. The bottom is muddy characterized by the detritic bottom biocenosis (DL). The direction of the current in the sampling period (spring) is from north to south on the west side and viceversa on the east side.

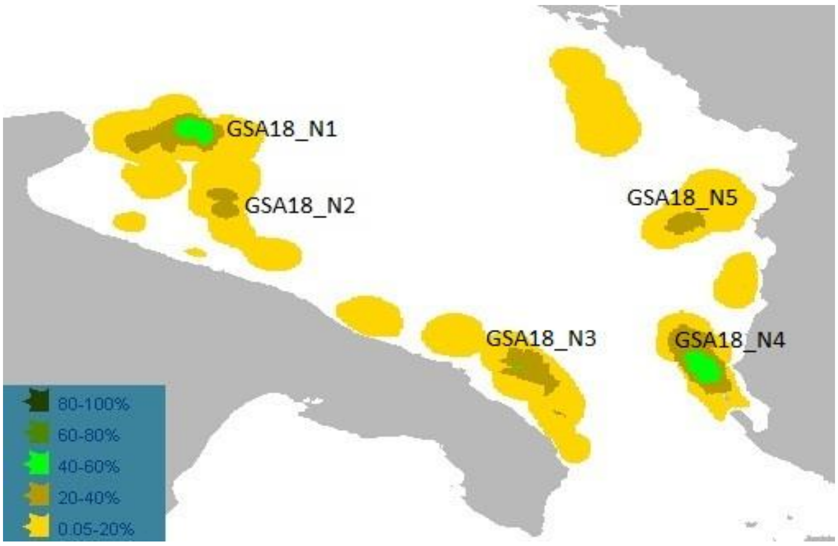


Fig. 4.1.2-1. Locations of persistent nurseries of *M. merluccius* in GSA 18 (MEDISEH project – MAREA framework)

3.1.3 Historical trends

The estimated abundance indices do not reveal any significant trends since 1995 until 2004. Peaks of abundance indices were observed in 2005, 2008 and 2012, while biomass indices were highest in 2005 and 2010.

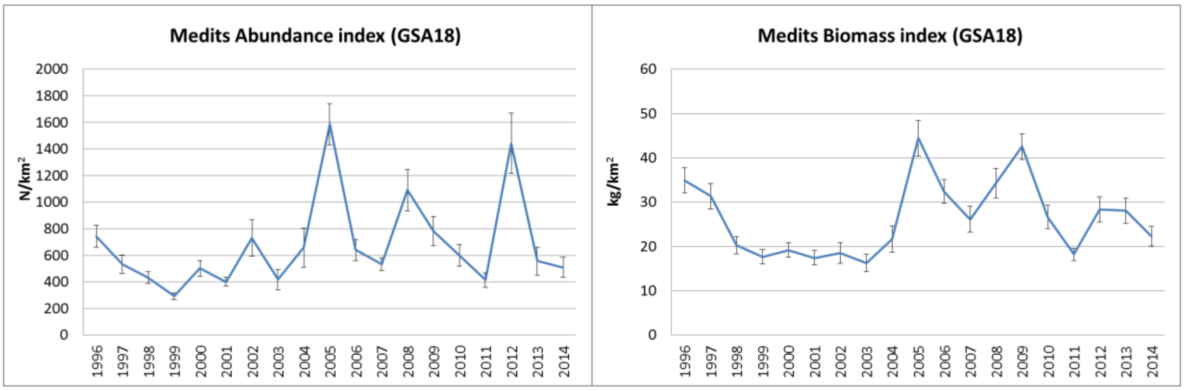


Fig. 4.1.3-1.Abundance (N/km^2) and biomass(Kg/km^2) MEDITS indices from 1996 to 2014.

4 Ecological information

4.1 Protected species potentially affected by the fisheries

This analysis has not been carried out.

4.2 Environmental indexes

None environmental index used.

5 Stock Assessment

5.1 XSA analysis

5.1.1 Model assumptions

The major assumption of the method is the flat selectivity for the oldest ages (selectivity as classical ogive). The method performs a tuning by survey index by age.

The method was applied using the age data obtained by the slicing of the length frequency distributions of the landing and, as tuning indices, MEDITS survey data.

5.1.2 Scripts

The rows related to the best run (shrinkage 2) are reported.

```
library(FLCore)
library(FLEDA)
library(FLXSA)
library(FLAssess)
library(FLash)
require(ggplotFL)
require(plyr)
require(FLBRP)

hke.stk <- readFLStock("HKE18.IND", no.discards=TRUE)
units(harvest(hke.stk))<-"f"
```

```
range(hke.stk)["minfbar"] <- 0
range(hke.stk)["maxfbar"] <- 5
hke.stk <- setPlusGroup(hke.stk, 6)
hke.idx <- readFLIndices("HKE18TUN.DAT")

#settings of XSA
FLXSA.control.hke_2 <- FLXSA.control(x=NULL, tol=1e-09, maxit=30, min.nse=0.3,
fse=2, rage=0, qage=4, shk.n=TRUE, shk.f=TRUE, shk.yrs=2, shk.ages=2,
window=100, tsrange=20, tspower=3, vpa=FALSE)

#plot of the final results
hke.xsa_2 <- FLXSA(hke.stk, hke.idx, FLXSA.control.hke_2)
hke.stk_2 <- hke.stk+hke.xsa_2
plot(hke.stk_2,main="Shrinkage 2")

#diagnostics and residuals
diagnostics(hke.xsa_2)
res2<-as.data.frame(index.res(hke.xsa_2))
res2[["sign"]] = ifelse(res05[["data"]] >= 0, "positive", "negative")
ggplot(data = res2)+geom_point(aes(x=year, y = age,size=abs(data),
colour=sign),shape=16)+    scale_colour_manual(values = c("positive" = "red",
"negative" = "darkblue"))+scale_size_continuous(breaks= seq(-2, 2, by =
0.2))+ggtitle("Log catchability residuals at age by year Sh2")

#retrospective analysis
hke.stk.retro_2 <- retro(hke.stk, hke.idx, FLXSA.control.hke_2, 3)
plot(hke.stk.retro_2)
```

5.1.3 Input data and Parameters

XSA uses catch-at-age, mean weight at age, landing, proportion of mature individuals by age, natural mortality by age and mean weight at age in stock to perform the analysis, which is tuned by survey data (MEDITS) by age. Catch-at-age and tuning data are presented in tables 6.1.3-1, 6.1.3-2 and 6.1.3-3, respectively. Differently from last year, we prefer to use age plus group 6 because considered more appropriate for a stock so long living.

Table 6.1.3-1. Landings-at-age

Catch-at-age (thousands)								
Age class	2007	2008	2009	2010	2011	2012	2013	2014
0	46478	25787	27733	29045	21733	42778	18883	27376
1	28125	34709	30410	26889	27651	16445	20954	11874
2	684	689	912	1039	1033	680	539	438
3	113	271	161	256	195	228	65	52
4	100	105	71	105	66	34	30	39
5	59	24	56	58	91	47	14	43

Table 6.1.3-2. Tuning data MEDITS

Catch-at-age (N/km^2) MEDITS								
Age class	2007	2008	2009	2010	2011	2012	2013	2014
0	416.51	918.92	564.34	479.98	319.15	1344.65	444.60	430.50
1	104.05	150.54	199.78	109.03	87.36	89.72	98.26	63.26
2	6.89	5.12	14.27	6.55	4.33	5.24	10.55	10.66

3	2.08	1.93	2.03	2.56	1.68	1.08	1.50	2.70
4	0.63	0.37	1.01	0.84	0.97	0.61	0.69	0.94
5+	0.75	0.16	0.36	0.58	0.12	0.34	0.58	0.24

Discards data of 2009, 2010, 2011, 2012, 2013 and 2014 were available for the western side. The proportion of the discards of hake in the GSA 18 was generally less than 10%. Considering the amount of discards and the fact that the collection of discard data was not foreseen in DCF in 2007 and 2008 and discards data are not available for the east side these data were not used in the analyses.

Additional settings for XSA are listed below:

- Catchability independent of size for ages > 0
- Catchability independent of age for ages > 4
- S.E. of the mean to which the estimates are shrunk = 2
- Minimum standard error for population estimates derived from each fleet = 0.3

5.1.4 Results

Fishing mortality (F) shows the minimum value of 0.2 ($\bar{F}$ or F_{bar}) in 2011, and a maximum of 0.96 in 2009. Average F for the period of last three years (2012-2014) was 0.85.
The $F_{0.1}$ value estimated on the basis of the XSA was 0.17 by FLBRP package (FLR library).
The summary of the best run, chosen for the advice is reported below in Fig. 6.1.5-1.

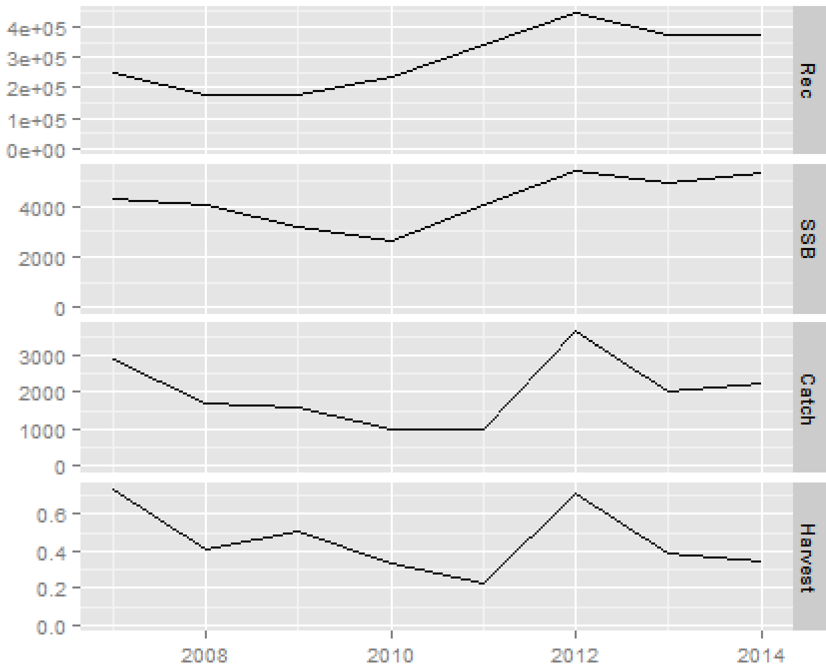


Fig. 6.1.5-1. Summary XSA results for *M. barbatus* in GSA 18.

5.1.5 Robustness analysis

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

Sensitivity analysis with shrinkage values of 0.5, 1.0, 1.5 and 2.0 was performed. A shrinkage of 2.0 (Fig. 6.1.6-1) was taken as the best choice on the basis of both the residuals and the retrospective analysis.

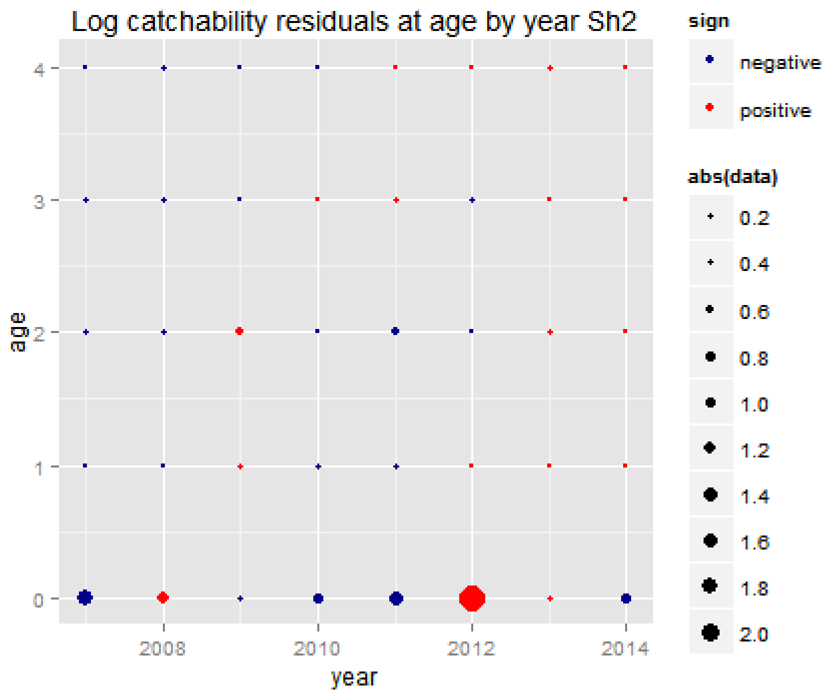


Fig. 6.1.6-1. Log catchability residuals at shrinkage 2.0

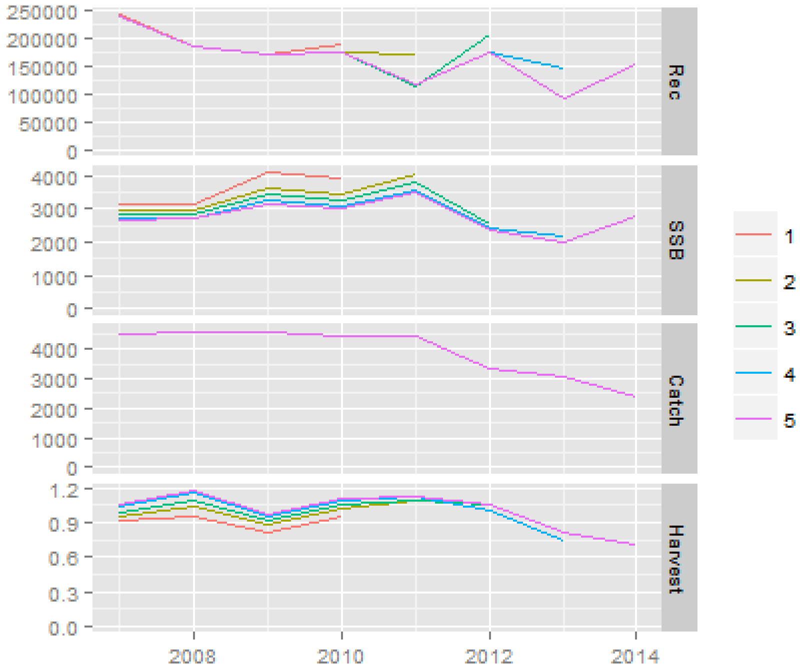


Fig. 6.1.6-2. Retrospective analysis results

The residuals do not shows any particular trend and the retrospective analysis seems to be consistent.

In addition a good agreement was observed between the estimates of the number of recruits by the model and the observed abundance indices of recruits from the MEDITS data (Fig. 6.1.6-3).

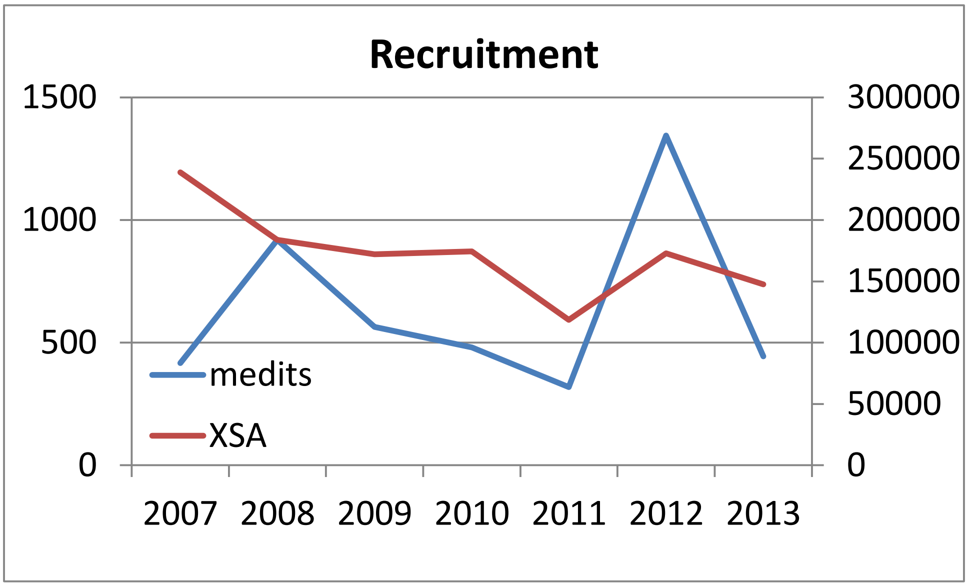


Fig. 6.1.6-3. Recruitment estimates from the XSA model and abundance indices from MEDITS data

5.1.7 Assessment quality

In XSA the assumption of ogive selectivity for this species seems not fully consistent with the likely selectivity pattern of the fleet segments exploiting the stock, especially for the fraction of the population caught by longliners. The length of the time series cover once the lifespan of the species, allowing a first attempt with XSA model for this stock.

5.2 a4aSCA (Assessment for all statistical catch at age, FLR library)

5.2.1 Model assumptions

5.2.2 Scripts

5.2.3 Input data and Parameters

5.2.4 Results

5.2.5 Robustness analysis

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

5.3 ALADYM

5.3.1 Model assumptions

A simulation was also carried out using ALADYM simulation model to evaluate the possible effects of the delay of the size at first capture for the examined stock. This delay can be represented by changes of technical parameters of the trawl gears as well as by the closure of area and /or fishing season. The model belongs to the family of pool-dynamic models, uses a monthly time scale and multi-fleet/gear approach.

This scenario was carried out under the assumption of stable but randomly varying recruitment in the medium terms. This was accomplished projecting forward the geometric mean of recruitment of the last three years. To take into account the uncertainty due to the process error a multiplicative log-normal error with mean 0 and standard deviation 0.3 was applied to the geometric mean of recruitment. Runs were accepted when observed and simulated catches showed lower residuals.

ALADYM model was parameterised using the same inputs as the assessment model: the total mortality by year, the natural mortality at length, the maturity parameters at length, the growth parameters and a selectivity function among the different options of ALADYM, to simulate the commercial catches (for European hake an ogive with deselection effects at larger size, to mimic the species avoidance to the gear and/or accessibility; for red mullet and deep water rose shrimp a usual ogive). For the present and past time the structure of the catches was used to verify the suitability of the selectivity functions of the model, thus taking into account the current selectivity. The change of selectivity was applied to the trawl fleet segments only and effects were estimated on SSB and catches, under the assumptions of 100% survival of individuals escaped from the codend. The change in selectivity in the forecasts was shaped using the size at first capture that would be determined by a 50 mm square mesh size, on the basis of literature.

5.3.2 Scripts

Version 10.1.3 has been used for the assessment. Inputs and parameters are specified in the following paragraphs.

5.3.3 Input data and Parameters

Ten main fleet segments considered in the simulation were:

- ITA_DTS_0612
- ITA_DTS_1218
- ITA_DTS_1824_2440
- ITA_HOK_1218
- ITA_PGP_0006_0612
- ALB_DTS_1224
- MNE_DFN_0012
- MNE_DTS_0612
- MNE_DTS_1224
- MNE_HOK_0012

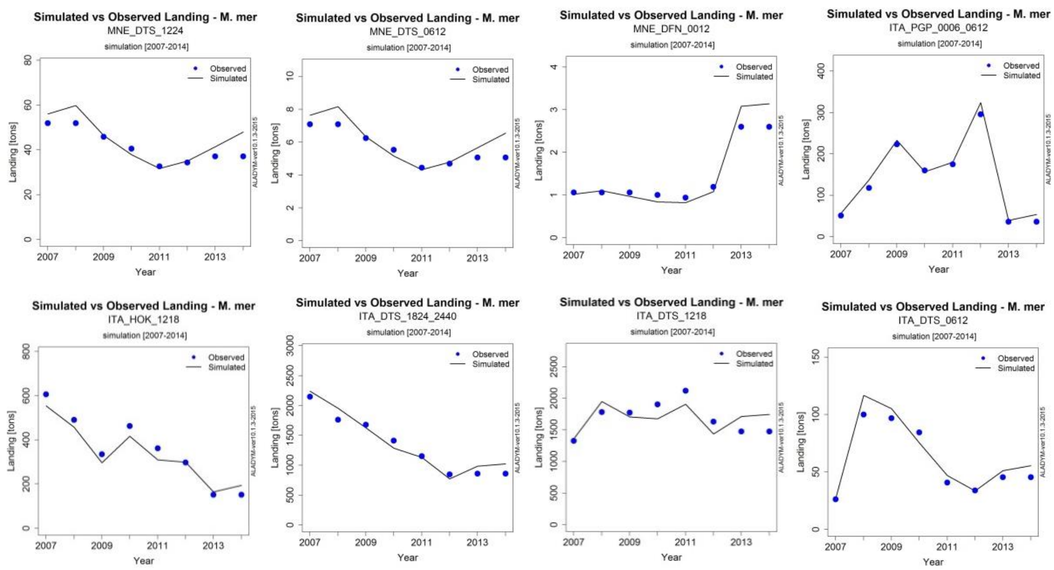
Among these only to DTS the management measure was applied.

For European hake selectivity was modelled using an ogive with deselection; the set of selectivity parameters in the projection was:

- $L_{50\%}$ = 182.2 mm total length
- Selection range 10 mm
- Deselection length 50% 500 mm
- Change was applied only to $L_{50\%}$

5.3.4 Results

Comparison between observed and values simulated by ALADYM model for all the fleet segments are provided on Fig. 6.3.4-1.



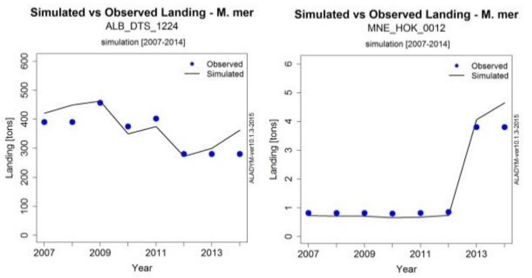


Fig. 6.3.4-1. Simulated vs. observed landing for various fleet segments used in the assessment.

5.3.5 Robustness analysis

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

5.3.7 Assessment quality

6 Stock predictions

Recruitment was considered stable, but varying randomly. This effect was simulated by forward projections of the geometric mean of the recruitment values of the previous three years. Uncertainty due to the process error was represented by a multiplicative log-normal error with a mean value of 0 and a standard deviation of 0.3.

The scenario focused on applying the 50 mm square mesh size to all trawl fleet segments.

6.1 Short term predictions

6.2 Medium term predictions

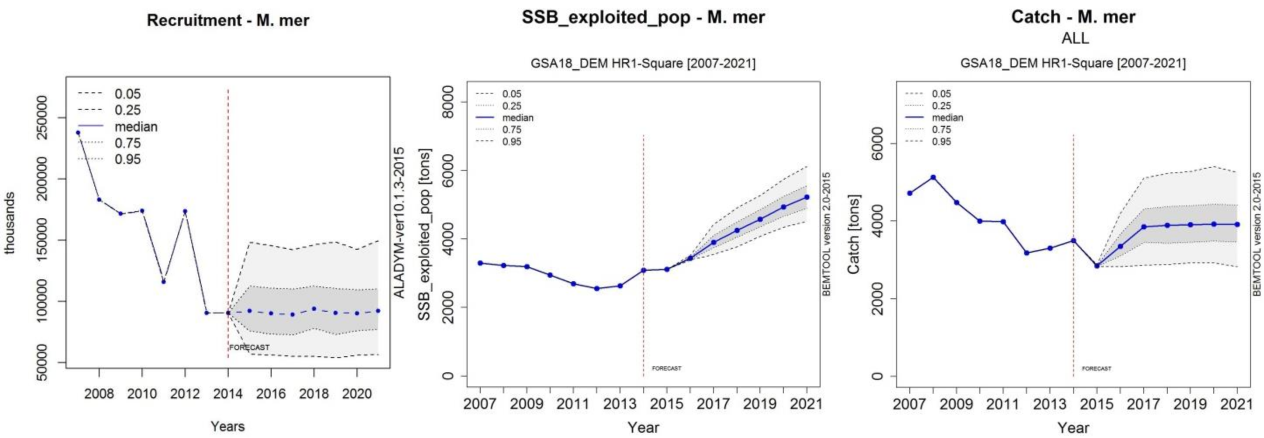


Fig. 7.2-1. Results of the ALADYM simulation

Results showed 70% increase of the spawning stock biomass in 2021, and an increase of the overall catches of 12%, after a slight decrease just after the application of the management measure.

6.3 Long term predictions

7 Draft scientific advice

Based on	Indicator	Analytic al 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	$F_{0.1}$ = 0.18 (XSA)	F_{curr} = 0.85			O_H
	Fishing effort					
	Catch					
Stock abundance	Biomass		Biomass index =	33 percentile = 22 Kg/Km^2 66 percentile = 31.9 Kg/Km^2 Current= 22.3 Kg/Km^2		
	SSB					
Recruitment						
Final Diagnosis		The stock is in overexploitation ($F_{curr}/F_{0.1}$ = 4.8 (XSA)) with intermediate level of bio mass according to MEDITS survey data.				

The stock is in overexploitation as current fishing mortality exceeds the $F_{0.1}$ levels (0.85 vs. 0.18) and thus it is necessary to consider a considerable reduction of the fishing mortality to allow the achievement of $F_{0.1}$. The reference point $F_{0.1}$ can be gradually achieved by multiannual management plans.
Objectives of a more sustainable harvest strategy could be achieved with a multiannual plan that foresees a reduction of fishing mortality through fishing limitations.
The production of hake in GSA 18 is split in 13% caught by Italian longlines, 75% by Italian trawlers (about 85% for Italy in total), about 2% by Montenegrin trawlers, about 0.1% by Montenegrin gillnets and trammel nets and about 10% by Albanian trawlers.

7.1 *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)*

8 References

Abella, A., Caddy, J.F., Serena, F., 1997 – Do natural mortality and availability decline with age? An alternative yield paradigm for juvenile fisheries, illustrated by the hake Merluccius merluccius fishery in the Mediterranean. Aquat. Liv. Res. 10: 257–269.

Abella A.J., F. Serena. (1998) - Selettività e vulnerabilità del nasello nella pesca a strascico. Biol. Mar. Medit. Vol. 5 (2).

Alegria Hernandez, V., Jukić, S. (1992) Abundance dynamics of the hake (*Merluccius merluccius* L.) from the middle Adriatic Sea. Bull. Inst. Oceanogr., Monaco, n. special 11: 161pp.

Bello, G., Marano, G., Rizzi., Jukić, S., Piccinetti, C. (1986) Preliminary survey on the Adriatic hake, *Merluccius merluccius*, within the Demersal Resources Assessment Programme, Spring 1985 survey. FAO Fish. Rep., 345: 200-204.

Carlucci R., Lembo G., P. Maiorano, F. Capezzuto, A.M.C. Marano, L. Sion, M.T. Spedicato, N. Ungano, a. Tursi, G. D'Onghia. 2009 Nursery areas of red mullet (*Mullus barbatus*), hake (*Merluccius merluccius*) and deep-water rose shrimp (*Parapenaeus longirostris*) in the Eastern-Central Mediterranean Sea, Estuarine, Coastal and Shelf Science (2009), doi: 10.1016/j.ecss.2009.04.034

Cheilari A. and H-J Rätz 2008. Coincidence between trends in MEDITS biomass indices and landings of selected demersal Mediterranean stocks and its potential use for data validation and short term predictions Working paper, Ponza, STECF SGMED-08-04

De Zio V., Ungaro, N., Vlora, A., Strippoli, G. (1998) Lo stock di nasello del basso Adriatico: Struttura demografica e rendimenti di pesca della frazione catturata con palangaro di fondo. Biol. Mar. Medit., 5 (2): 128-135.

Donnaloia M. (2009). Strategie riproduttive del nasello (*Merluccius merluccius,* L. 1758) nel Mediterraneo occidentale e centrale. Tesi di laurea, Università degli Studi di Bari.

FAO Fisheries and Aquaculture Department . 2013. Global Capture Fisheries Production Statistics for the year 2011 ftp://ftp.fao.org/FI/news/GlobalCaptureProductionStatistics2011.pdf

Frattini, C., Paolini, M. (1995) Ruolo delle acque profonde quale nursery per *Merluccius merluccius* (L.). Biol. Mar. Medit., 2(2): 281-286.

Hilborn & Walters (1992). Statistical catch-at-age methods. Quantitative Fishery Stock Assessment.

Karlovac, J. (1965) Contribution à la conaissance de l'oecologie du merlu, *Merluccius merluccius* L., dans le stade planctonique de vie en Adriatique. Rapp. Comm. int. mer Medit., 18 (2): 461-464.

Kirinčić, J., Lepetić, V. (1955) Recherches sur l'ichthyobentos dans les profondeurs de l'Adriatique méridionale et possibilité d'exploitation au moyen des palangres. Acta Adriat., 7 (1): 1-113.

Lembo G. (coord.) (2010) – Identification of spatio-temporal aggregations of juvenile of the main demersal species and localization of nursery areas along the Italian seas – NURSERY. Società Italiana di Biologia Marina – S.I.B.M., Genova: pag. 1-119.

Lembo G., Silecchia T., Carbonara P., Spedicato M.T. (2000) – Nursery areas of *Merluccius merluccius* in the Italian Seas and in the East Side of the Adriatic Sea. *Biol. Mar. Medit*., 7 (3): 98-116.

Lembo G., A. Abella, F. Fiorentino, S. Martino and M.-T. Spedicato. 2009 ALADYM: an age and length-based single species simulator for exploring alternative management strategies. Aquat. Living Resour. 22, 233–241.

Morua H., Lucio P., Santurtùn M., Motos L. (2006) Seasonal variation in egg production and butch fecundity of European hake *Merluccius merluccius* (L.) in the Bay of Biscay. *Jour. Fish. Biol.*, 69: 1304-1316.

Quinn, T. J. II, and R. B. Deriso. 1999. Quantitative fish dynamics. Oxford University Press, Oxford, New York.

Recasens L., Chiericoni V., Belcari P. (2008) Spawning pattern and batch fecundity of the European hake (*Merluccius merluccius*) in the western Mediterranean. Sci. Mar. 72(4): 721-732.

SAMED, 2002. Stock Assessment in the MEDiterranean. European Commission – DG XIV, Project 99/047 – Draft final Report.

Spedicato, M.-T., Woillez, M., Rivoirard, J., Petitgas, P., Carbonara, P. and Lembo, G. 2007. Usefulness of the spatial indices to define the distribution pattern of key life stages: an application to the red mullet (*Mullus barbatus*) population in the south Tyrrhenian sea. ICES CM 2007/O: 10p.

Spedicato M.T., J-C Poulard, C-Yianna Politou, K. Radtke, G. Lembo, and P. Petitgas. 2010. Using the ALADYM simulation model for exploring the effects of management scenarios on fish population metrics. Aquat. Living Resour. 23, 153–165.

Ungaro, N., Rizzi, E., Marano, G. (1993) Note sulla biologia e pesca di *Merluccius merluccius* (L.) nell'Adriatico pugliese. Biologia Marina, suppl., 1: 329-334.

Woillez M., Rivoirard J., and Petitgas P., 2009. Notes on survey-based spatial indicators for monitoring fish populations. *Aquatic Living Resources,* 22: 155-164.

Županović, Š. (1968) Study of hake (*Merluccius merluccius*) biology and population dynamics in the Central Adriatic. Stud. Rev. Gen. Fish. Coun. Medit., 32: 24 pp.

Županović, Š., Jardas, I. (1986) A contribution to the study of biology and population dynamics of the Adriatic hake, *Merluccius merluccius* (L). Acta Adriat. 27(1/2): 97-146