Stock Assessment Form

Demersal species

Reference year: 2013

Reporting year: 2014

M. merluccius is with red mullet and deep-water rose shrimp a key species of the fishing assemblages in the central-southern Tyrrhenian Sea (GSA 10). It is a long lived fish mainly exploited by trawlers, especially on the continental shelves of the Gulfs (e.g. Gaeta, Salerno, Palermo) but also by artisanal fishers using fixed gears (gillnets, bottom long-line). Trawl-survey data have evidenced highest biomass indices on the continental shelf of the GSA 10 (100-200 m), where juveniles (less than 12 cm total length) are mainly concentrated. For the assessment of the status of the stock of M. merluccius in the GSA 10 different sources of data (fishery dependent and fishery independent) have been used. Given the results from this analysis the stock appears subject to overfishing. A considerable reduction in fishing mortality is necessary to approach the reference point.

Stock Assessment Form version 1.0 (January 2014)

Uploader: Isabella Bitetto

Stock assessment form

1 Basic Identification Data

Scientific name:	Common name:	ISCAAP Group:
M. merluccius	European hake	32
1st Geographical sub-area:	**2nd Geographical sub-area:**	**3rd Geographical sub-area:**
GSA10		
4th Geographical sub-area:	**5th Geographical sub-area:**	**6th Geographical sub-area:**
1st Country	**2nd Country**	**3rd Country**
ITA		
4th Country	**5th Country**	**6th Country**
Stock assessment method: (direct, indirect, combined, none)		
XSA		
Authors:		
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Affiliation:		
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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

2.1 Stock unit

The South and Central Tyrrhenian Sea features one of the most complex structures in the seas around the Italian peninsula, due to its morphological and geophysical characteristics and water mass dynamics (Cataudella S. and Spagnolo M., 2011). The stock of European hake was assumed in the boundaries of the whole GSA 10, lacking specific information on stock identification. In the central-southern Tyrrhenian Sea (GSA 10) the main demersal resources on the continental shelf are European hake (*Merluccius merluccius*), red mullet (*Mullus barbatus*), pandora (particularly *Pagellus erythrinus*) and, among cephalopods, squids (e.g. *Todarodes sagittatus*, *Illex coindetii*) and octopus (*Octopus vulgaris*). European hake is generally also ranked among species with higher abundance indices in the trawl surveys (e.g. Spedicato *et al*., 2003). It is a long lived fish mainly exploited by trawlers, especially on the continental shelves of the Gulfs (e.g. Gaeta, Salerno, Palermo) but also by artisanal fishers using fixed gears (gillnets, bottom long-line). Trawl-survey data have evidenced highest biomass indices on the continental shelf of the GSA 10 (100-200 m; Spedicato et al., 2003), where juveniles (less than 12 cm total length) are mainly concentrated. During autumn trawl surveys, one of the main recruitment pulses of this species is observed. Two main recruitment events (in spring and autumn; Spedicato et al. 2003) are reported in GSA 10 as for other Mediterranean areas (Orsi Relini *et al*., 2002). European hake is considered fully recruited to the bottom at 10 cm TL (from SAMED, 2002). The length structures from trawl surveys are generally dominated by juveniles, while large size individuals are rare. This pattern might be also due to the different vulnerability of older fish (Abella and Serena, 1998) beside the effect of high exploitation rates. The few large European hake caught during trawl surveys are generally females and inhabit deeper waters. The overall sex ratio (~0.41-0.47) estimated from trawl survey data is slightly skewed towards males.

2.2 Growth and maturity

Estimates of growth parameters were achieved during the SAMED project (SAMED, 2002) by the analysis of length frequency distributions. Historically, the following von Bertalanffy parameters were estimated by sex: females L_∞=74.2 cm; K=0.178; t_0= -0.20; males: L_∞=46.3cm; K=0.285; t_0= -0.20. 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 analyzed using techniques as Batthacharya for separation of modal components. The observed maximum length of European hake was 88 cm for females and 58 cm for males both registered in the landings (bottom long-lines). DCF Von Bertalanffy growth parameters for each sex were estimated from average length at age using an iterative non-liner procedure that minimizes the sum of the square differences between observed and expected values (excel): females: L_∞=97.9 cm, K=0.135, t_0= -0.4; males: L_∞=50.8 cm, K=0.25, t_0= -0.4. Parameters of the length-weight relationship were a=0.00350, b=3.2 for females and a=0.0086, b=3.215 for males, for length expressed in cm.

A proxy of size at first maturity was estimated in the SAMED project (SAMED, 2002) using the average length at stage 2 (females with gonads at developing stage) that indicates an average length of about 30 cm. According to the data obtained in the DCF of 2008, the proportion of mature females (fish belonging to the maturity stage 2b onwards macroscopically classified using a 8 stage scale (Medits-Handbook_2007.v5) by length class in 2013 is reported in the table below together with the estimated maturity ogive which indicates a $L_{m50\%}$ of about 33.2 cm (±0.29 cm) estimated from DCF commercial data (Fig. Fig. 2.2-1). These estimates are similar to those of 2003-2005 (Lm50%=32.9±0.8) and those of 2006-2009 (Lm50%=33 cm).

Table 2.2-1: 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 the year
Maximum size observed	88	58		**Recruitment season**	Peak in the late autumn and winter months (December to March)
Size at first maturity	33.2			**Spawning area**	The most relevant spawners aggregations are in the Naples and Gaeta Gulfs and along the North Sicily coasts.
Recruitment size to the fishery			~14 cm	**Nursery area**	

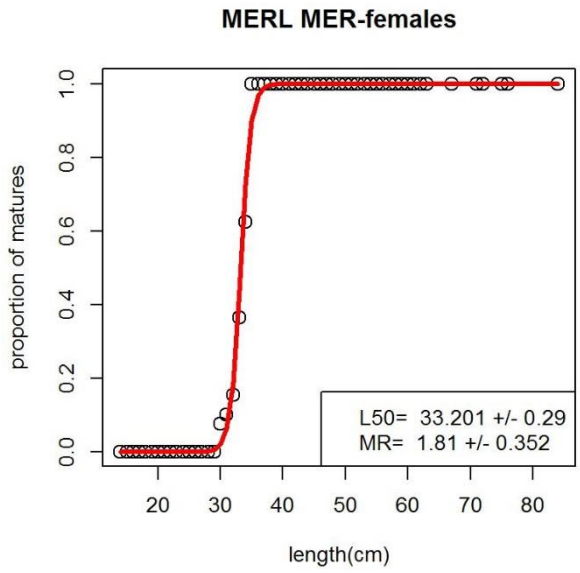

Fig. 2.2-1 Maturity ogives and proportions of mature female of red mullet in the GSA 10 (MR indicates the difference $Lm_{75\%}$-$Lm_{25\%}$) from DCF commercial data 2013.

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

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
6+	0.32	1.00

Table 2-3: Growth and length weight model parameters

			Sex			
		Units	female	male	Combined	Years
Growth model	**L_∞**	cm			104	2006-2013
	K	year^-1			0.2	2006-2013
	t_0	year			-0.01	2006-2013
	Data source	DCF				
Length weight relationship	**a**				0.0043	2006-2013
	b				3.2	2006-2013
	M (scalar)					
	sex ratio (% females/total)	0.5				

3 Fisheries information

3.1 Description of the fleet

European hake is mostly targeted by trawlers, but also by small scale fisheries using nets and bottom long-lines. 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*.

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	GSA10	E – Trawls (12-24 m)	03 – Trawls	33	HKE
Operational Unit 2	ITA	GSA10	E – Trawls (< 12 m)	03 – Trawls	33	HKE
Operational Unit 3	ITA	GSA10	B - Polyvalent small-scale vessels with engine (< 6 m)	07 - Nets	33	HKE
Operational Unit 4	ITA	GSA10	C - Polyvalent small-scale vessels with engine (6-12 m)	07 - Nets	33	HKE
Operational Unit 5	ITA	GSA10	I – Long-line (12-24 m)	09 – Hooks and lines	33	HKE
Operational Unit 6						

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)
Operation Unit 1	251	307.52 T				
Operation Unit 2	31	6.9 T				
Operation Unit 3	126	94.85 T				
Operation Unit 4	228	474.21 T				
Operation Unit 4	38	80.15 T				
Total	674	788.63 T				

* Number of vessels from Fisheries and Maritime Affairs' Fleet Register, 2014.

3.2 Historical trends

Time series analysis with tables and figures showing the observed trends in catches, landings, fishing capacity or effort .

Available landing data collected under the DCF framework ranged from 1521 tons in 2006 to 1077 tons in 2009, the latter being the lowest value registered (Tab. 3.2-1). Most part of the landings of European hake was from trawlers up to 2012 , while in 2013 it was from GTR. Since 2010 the total catches are decreasing.

Tab. 3.2-1 Annual landings by major fishing techniques in tons for European hake in the GSA 10 (2006-2013).

Year	GNS	GTR	OTB	LLS	Total
2006	326	148	759	288	1521
2007	213	157	641	240	1251
2008	311	68	501	232	1112
2009	282	107	441	247	1077
2010	431	202	475	184	1292
2011	287	153	443	318	1201
2012	311	138	419	214	1082
2013	222	355	314	145	1037

3.3 Management regulations

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. Other measures on which the management regulations are based regard technical measures (mesh size) and minimum landing sizes (EC 1967/06).

After 2000, in agreement with the European Common Policy of Fisheries, a gradual decreasing of the fleet capacity was implemented. Along northern Sicily coasts two main Gulfs (Patti and Castellammare) have been closed to the trawl fishery up 200 m depth, since 1990. In the GSA 10 the fishing ban has not been mandatory along the time, and from one year to the other it was adopted on a voluntary basis by fishers, whilst in the last three years it was mandatory. 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 licenses.

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). One is located along the mainland, in front of Sorrento peninsula in the vicinity of the MPA of Punta Campanella (Napoli Gulf, 60 km^2, within 200 m depth) and a second one is along the coasts of Amantea (Calabrian coasts, 75 km^2 up to 250 m depth). In these areas trawling is forbidden and other fishing activities are allowed under permission. 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.

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			F0.1	0.14	Assessment presented during STEC Expert Working Group 13-09
Y					
CPUE					
Index of Biomass at sea					

4 Fisheries independent information

4.1 MEDITS

4.1.1 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 4.1-1: 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 4.1-2: 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	1816			7
50 – 100 m	2227			7
100 – 200 m	3319			14
200 – 500 m	5204			18
500 – 800 m	7689			23

Total (10 – 800 m)	20255			69

Map of hauls positions

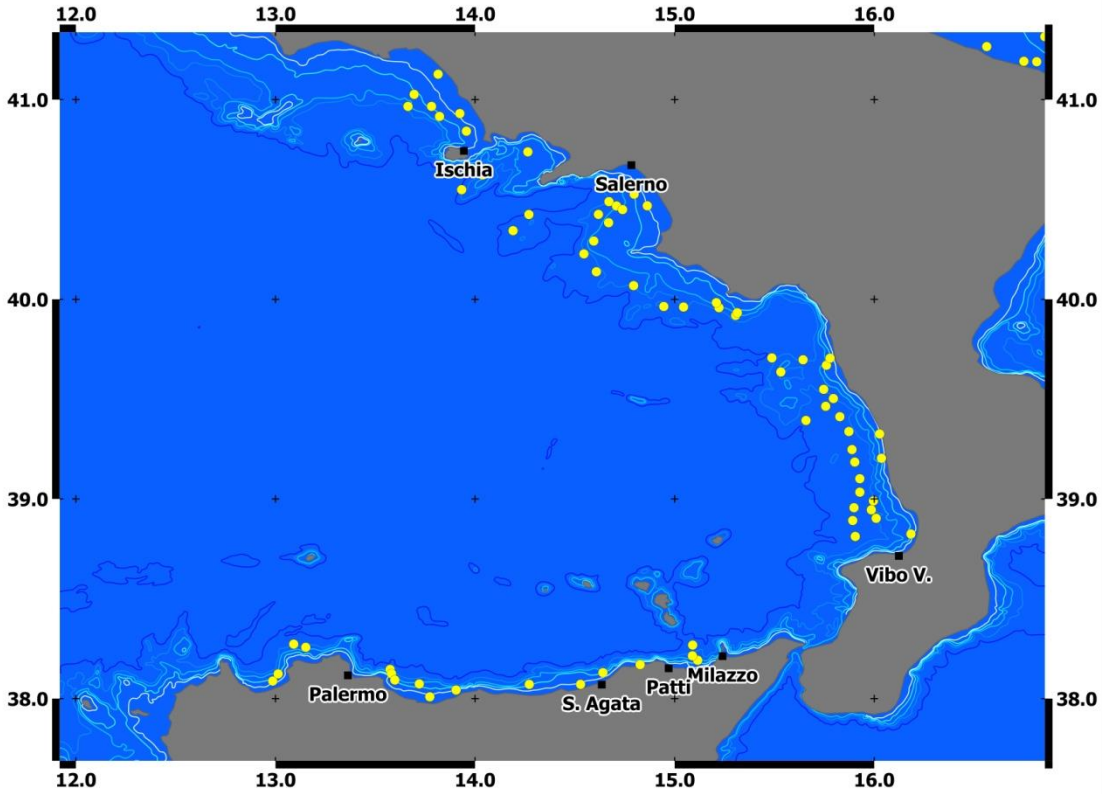

Fig. 4.1-1. Map of MEDITS haul positions in the GSA 10

The abundance indices and the associated coefficient of variation for 2013 are reported in the table below.

Table 4.1-3: Trawl survey abundance and biomass results (MEDITS 2013)

Depth Stratum	Years	kg per km^2	CV (%)	N per km^2	CV (%)
10 – 50 m	2013	2. 7	88.5	84.6	88.5
50 – 100 m	2013	30.7	18.1	1312.8	33.2
100 – 200 m	2013	49.5	21.8	4686.4	27.4
200 – 500 m	2013	29.6	22.0	1566.9	47.8
500 – 800 m	2013	2.8	25.9	5.1	26.5
Total (10 – 800 m)	2013	20.4	12.4	1324.4	21.8

Comments

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

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 4.1-4: Trawl survey results by age class

N (Total or sex combined) by Age class	Year							
	2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
0	1250.42	1907.19	1544.78	1890.43	813.51	639.35	907.4	1252.29
1	99.67	51.52	92.69	78.11	131.46	67.18	56.44	67.21
2	2.32	0.95	2.97	0.38	1.46	2.45	2.37	4.37
3	0.49	0.97	1.52	0.32	0.3	1.2	0.29	0.29
4	0	0.14	0	0	0.17	0	0	0
5	0	0.14	0	0.32	0.15	0	0.16	0.22
6+	0	0	0.4	0	0.24	0	0	0
Total	1352.9	1960.91	1642.36	1969.56	947.29	710.18	966.66	1324.38

Sex ratio by Length or Age class	Year		
	2007-2012		
Total	0.5		

Comments

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 4.1-5: 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)		late autumn and winter months	
Age at fishing-grounds recruitment		0	
Length at fishing-grounds recruitment		~14 cm TL	

Table 4.1-6: Trawl surveys; recruitment analysis results (<=14 cm, 10-800 m)

Years	**Area in km²**	**N of recruit per km²**	**CV or other**
1994	6372	505.8	25.1
1995	6372	882.2	33.7
1996	6372	504.0	30.6
1997	6372	932.4	41.8
1998	6372	385.6	28.3
1999	6372	440.4	26.2
2000	6372	632.4	21.9
2001	6372	185.4	18.5
2002	6372	442.1	22.7
2003	6372	947.1	28.6
2004	6372	626.5	26.9

2005	6372	2043.9	26.4
2006	6372	1077.6	30.9
2007	6372	1819.9	37.7
2008	6372	1261.3	27.7
2009	6372	1366.7	25.9
2010	6372	547.0	28.2
2011	6372	482.2	29.5
2012	6372	834.4	35.0
2013	6372	1099	26.3

Comments

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 TL. The threshold size (14 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 cm has been considered has recruitment index. Indices are related to the total area (N/km^2).

Direct methods: trawl based Spawner analysis

Table 4.1-7: Trawl surveys; spawners analysis summary

Survey	**MEDITS**	**PEC**	**PEC**
Survey season			summer
Investigated depth range (m)			10-800
Spawning season and peak (months)			late autumn and winter months

Table 4.1-8: Trawl surveys; spawners analysis results (F>= 33.5 cm)

Years	Area in km^2	N of spawners per km^2	CV or other
1994	6372	3.68	37.50
1995	6372	2.13	34.44
1996	6372	2.87	27.02
1997	6372	2.49	25.71
1998	6372	2.36	23.55
1999	6372	2.56	31.53
2000	6372	4.10	25.89
2001	6372	2.90	23.51
2002	6372	1.09	50.00
2003	6372	3.58	22.38
2004	6372	2.02	31.49
2005	6372	3.03	26.44
2006	6372	3.06	41.52
2007	6372	2.99	27.87
2008	6372	4.62	34.36
2009	6372	1.47	42.62
2010	6372	2.74	28.44
2011	6372	4.22	21.31
2012	6372	2.95	31.25
2013	6372	4.79	19.09

Comments

Individuals females with length greater or equal to the size at first maturity (33.5 cm) have been considered as spawners.
M. merluccius is a sequential spawners, spawning all year round with peaks in summer and winter.

Indices are N/km^2.

4.1.2 Spatial distribution of the resources

The geographical distribution pattern of European hake has been studied in the area using trawl-survey data and applying geostatistical methods. In these studies both the total abundance indices (Lembo et al., 1998a) and the abundance indices of recruits were analyzed (Lembo *et al.*, 1998b, 2000). The higher concentration of recruits in the GSA 10 were localized in the northern side (Gulfs of Napoli and Gaeta). Recent estimations have confirmed the presence of important zone for recruits in the northernmost part of the GSA, although sites with a high probability of locating a nursery appeared also along the coasts of southern part of the mainland and North Sicily. From GRUND data (autumn survey) the higher abundance of recruits were instead localized in the central part of the GSA, along the mainland coasts. Persistence of the nursery areas along the time was estimated from the indicator kriging.

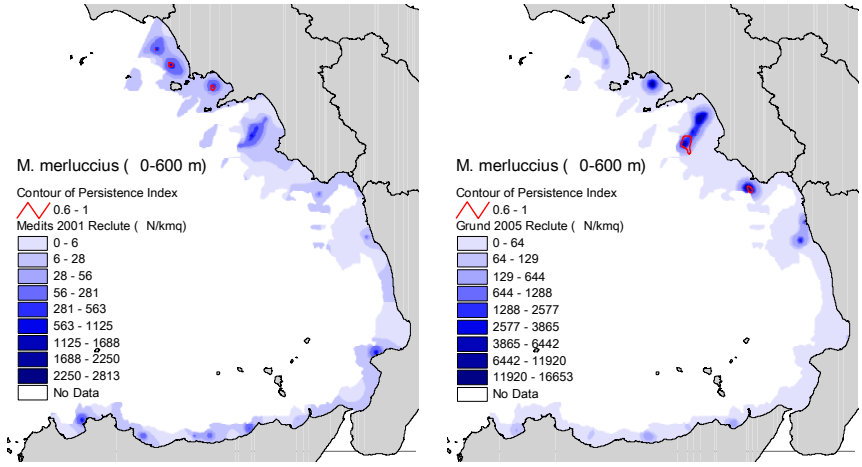

Fig. 4.1.2-1. Locations of persistent nurseries of *M. merluccius* in GSA 10 (Progetto Nursery, Lembo *et al.*, 1998b, 2000)

In the MEDISEH project (DG MARE Specific Contract SI2.600741, call for tenders MARE/2009/05) the locations of the most persistent nurseries of hake in GSA10 were confirmed to be in the Gaeta, Napoli and to a lesser extent Salerno Gulf, at 100-200 depth as already observed in previous studies. It is remarkable a persistence in a temporal horizon of 17 years.

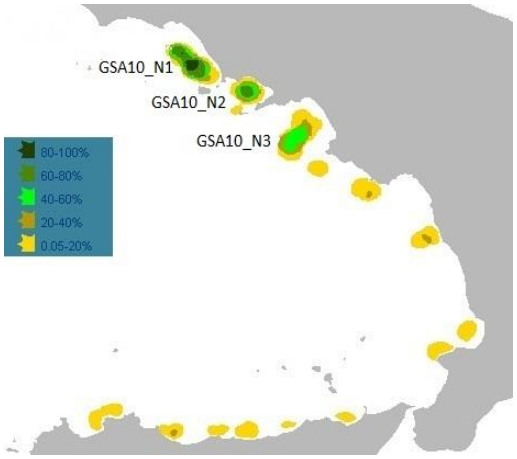

Fig. 4.1.2-2. Locations of persistent nurseries of *M. merluccius* in GSA 10 (MEDISEH project)

4.1.3 Historical trends

Observed abundance and biomass indices of *M. merluccius* are given on the figures below (Fig. 4.1.3-1, 4.1.3-2).

The density and biomass indices show higher values from 2005 to 2009 and then a decrease followed by an improvement in the last year for both indices.

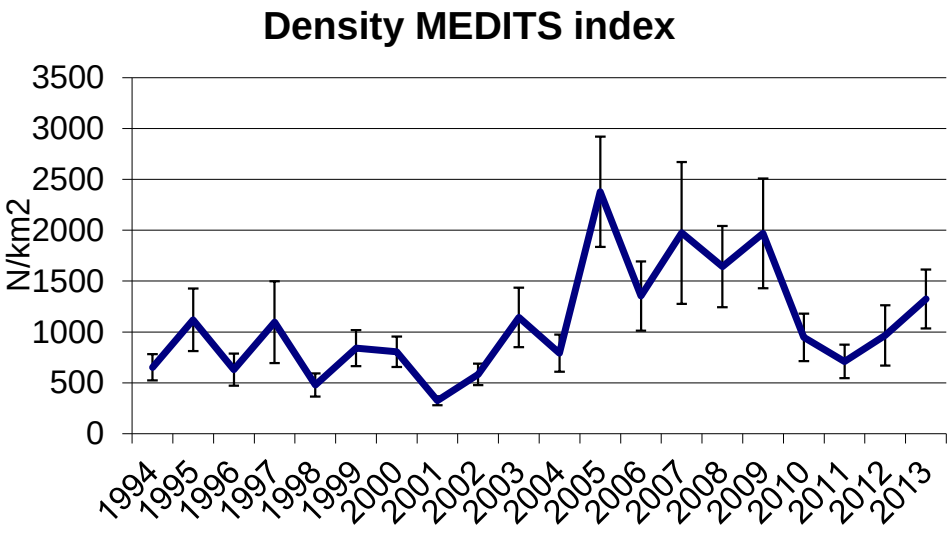

Fig. 4.1.3-1. Estimated abundance indices (N/km2) of *M. merluccius* in GSA 10, 1994–2013

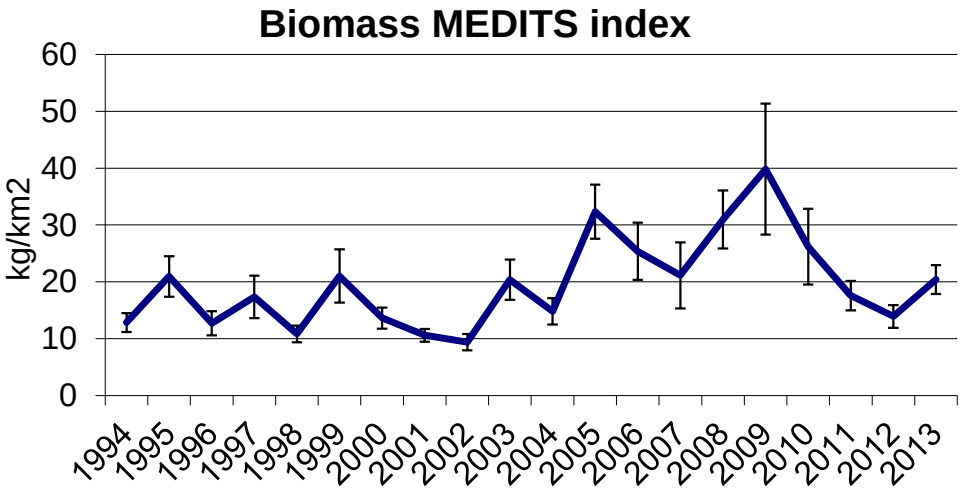

Fig. 4.1.3-2. Estimated biomass indices (kg/km2) of *M. merluccius* in GSA 10, 1994-2013.

Both indices show an increasing trend (Spearman rho).

5 Ecological information

5.1 Protected species potentially affected by the fisheries

This analysis has not been carried out.

5.2 Environmental indexes

None environmental index used.

6 Stock Assessment

6.1 XSA

6.1.1 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.

6.1.2 Scripts

```
library(FLCore)
library(FLEDA)
library(FLXSA)
library(FLAssess)
library(FLash)

#read stock file
hke.stk <- readFLStock("HKE10.IND", no.discards=TRUE)
```

```
#Set the age range for Fbar and set the plus group
units(harvest(hke.stk))<-"f"
range(hke.stk)["minfbar"] <- 0
range(hke.stk)["maxfbar"] <- 5
hke.stk <- setPlusGroup(hke.stk, 6)

#read index (tuning file)
hke.idx <- readFLIndices("HKE10TUN.DAT")

# XSA settings
FLXSA.control.hke2_2 <- FLXSA.control(x=NULL, tol=1e-09, maxit=30, min.nse=0.3,
fse=2,rage=0, qage=5, shk.n=TRUE, shk.f=TRUE, shk.yrs=2, shk.ages=2, window=100,
tsrange=20, tspower=3, vpa=FALSE)
hke.xsa2_2 <- FLXSA(hke.stk, hke.idx, FLXSA.control.hke2_2)
hke.stk2_2 <- hke.stk+hke.xsa2_2
plot(hke.stk2_2,main="Shrinkage 2")

#diagnostics and residuals
diagnostics(hke.xsa2_2)
bubbles(age ~ year|qname, data = index.res(hke.xsa2_2) , main = "Log
catchability residuals_MEDITS and CPUE LLS  sh 2")

#retrospective analysis
hke.stk.retro2_2 <- retro(hke.stk, hke.idx, FLXSA.control.hke2_2, 3)
plot(hke.stk.retro2_2)
```

6.1.3 Input data and Parameters

XSA uses catch-at-age, mean weight at age, catch, 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 and 6.1.3-2, respectively.

In the analysis also discard has been included.

Table 6.1.3-1. Catch-at-age data used in the assessment.

	Catch-at-age (thousands)							
Age class	2006	2007	2008	2009	2010	2011	2012	2013
0	15744	20385	13857	24961	13062	10180	15988	10750
1	6355	4805	3865	4206	6268	3712	4896	4711
2	562	451	368	317	724	507	449	326
3	89	122	138	58	66	175	117	77
4	35	41	54	34	7	46	18	28
5	19	9	22	10	9	23	5	3

6+	0	2	4	7	6	6	1	3

6.1.3-2. Tuning data used in the assessment.

	Catch-at-age (N/km^2)							
Age class	2006	2007	2008	2009	2010	2011	2012	2013
1	1250.42	1907.19	1544.78	1890.43	813.51	639.35	907.4	1252.29
2	99.67	51.52	92.69	78.11	131.46	67.18	56.44	67.21
3	2.32	0.95	2.97	0.38	1.46	2.45	2.37	4.37
4	0.49	0.97	1.52	0.32	0.3	1.2	0.29	0.29
5	0	0.14	0	0	0.17	0	0	0
6+	0	0.14	0	0.32	0.15	0	0.16	0.22

6.1.3-2. Tuning data used in the assessment (LLS CPUE).

	Catch-at-age (N/km^2)							
Age class	2006	2007	2008	2009	2010	2011	2012	2013
1	0.0048	0	0.0034	0.0018	0	0.0001	0.0035	0.0007
2	0.0077	0	0.0073	0.0354	0.0045	0.0047	0.0106	0.021
3	0.0111	0.0041	0.0024	0.0082	0.0241	0.0051	0.006	0.0166
4	0.0022	0.0026	0.0013	0.0022	0.0029	0.0032	0.0071	0.0097
5	0.004	0.0077	0.0018	0.0026	0.0021	0.0048	0.0046	0.0072
6+	0.0035	0.0063	0.0028	0.0044	0.0031	0.005	0.002	0.0085

Natural mortality and maturity vectors are reported in section 2.2.

The additional settings for XSA are listed below:

- Catchability independent of size for ages > 0
- Catchability independent of age for ages > 5
- S.E. of the mean to which the estimates are shrunk = 2
- Minimum standard error for population estimates derived from each fleet = 0.3.

6.1.4 Results

The results obtained with XSA method showed a global decreasing pattern in fishing mortality from 2008 to 2013 and a consequent increase in SSB from 2009. Recruitment shows a big peak in 2009 and a smaller peak in 2012 followed by a value in 2013 smaller than the previous year.

The last value of fishing mortality (0.61) is slightly below the the average of the last 3 years (0.74) that, however is smaller of the previous years; this decrease in F seems to be consistent with the decrease in effort (Fig.6.1.4-3).

The $F_{0.1}$ value estimated on the basis of the XSA in the last year was 0.16 by FLBRP package (FLR library) .

The summary of the best run, chosen for the advice is reported below in Fig. 6.1.5-1.

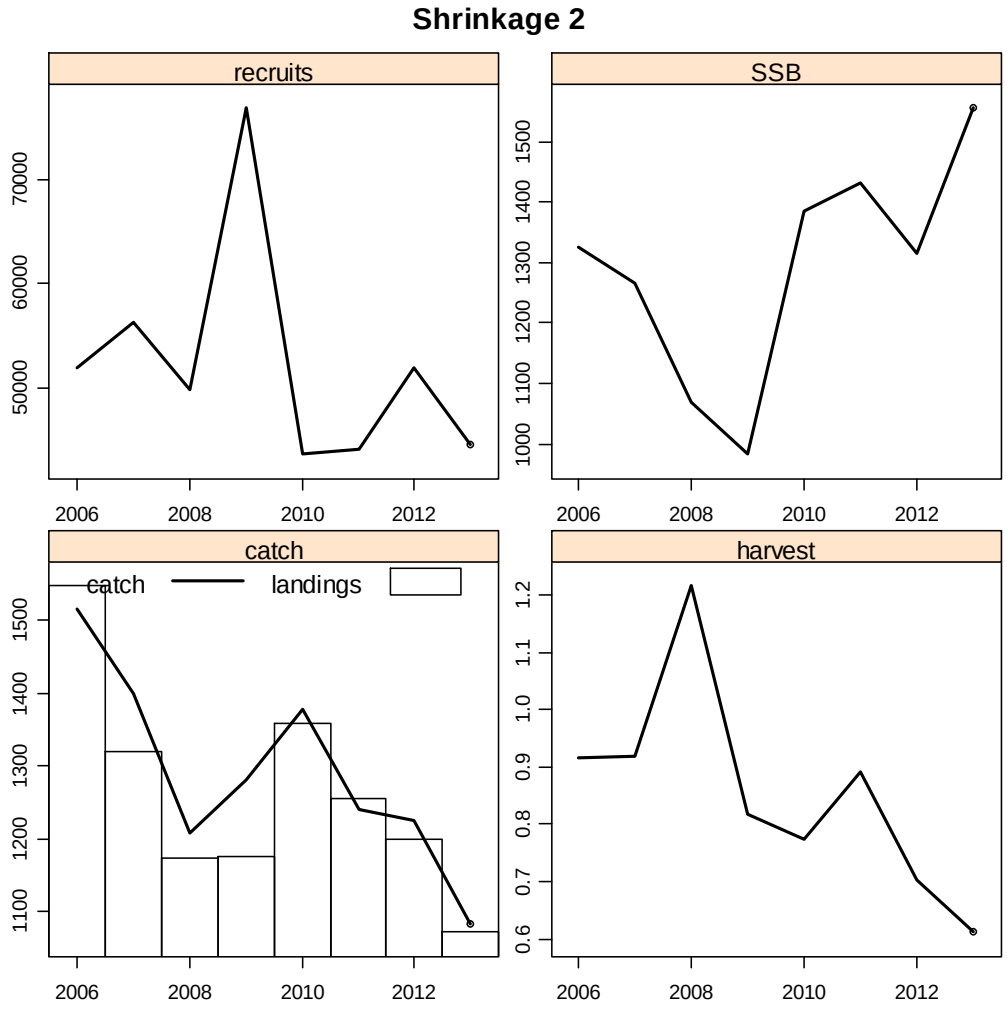

Fig. 6.1.5-1. Summary XSA results for *M. merluccius* in GSA 10.

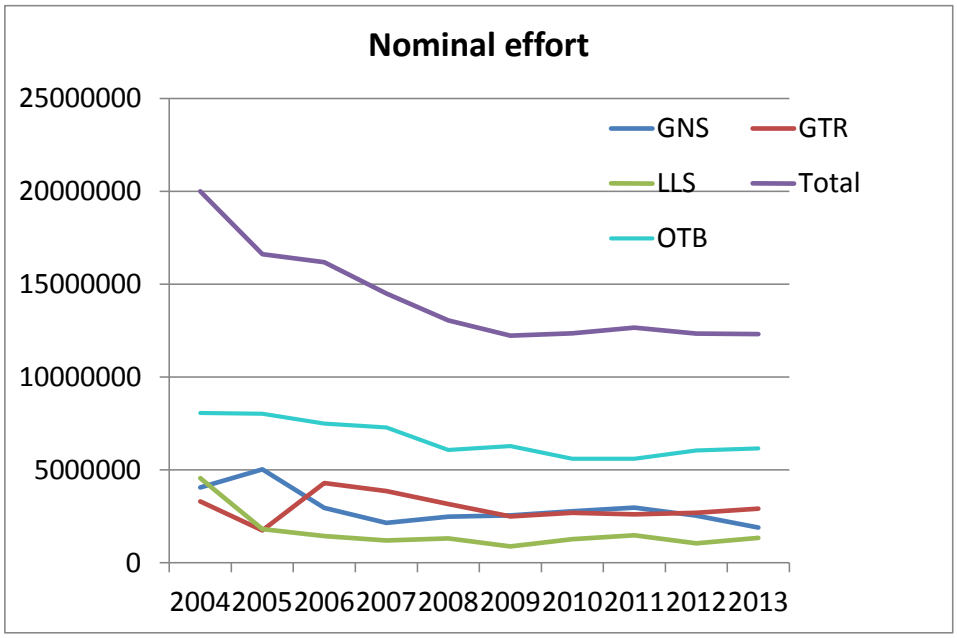

Fig. 6.4.5-3 Nominal fishing effort in kW×days by fishing technique for GSA10 from DCF.

6.1.5 Robustness analysis

6.1.6 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 on the results, and on the basis of the residuals and of the retrospective analyses, shrinkage of 2 (Fig. 6.1.6-1) was chosen as the best one.

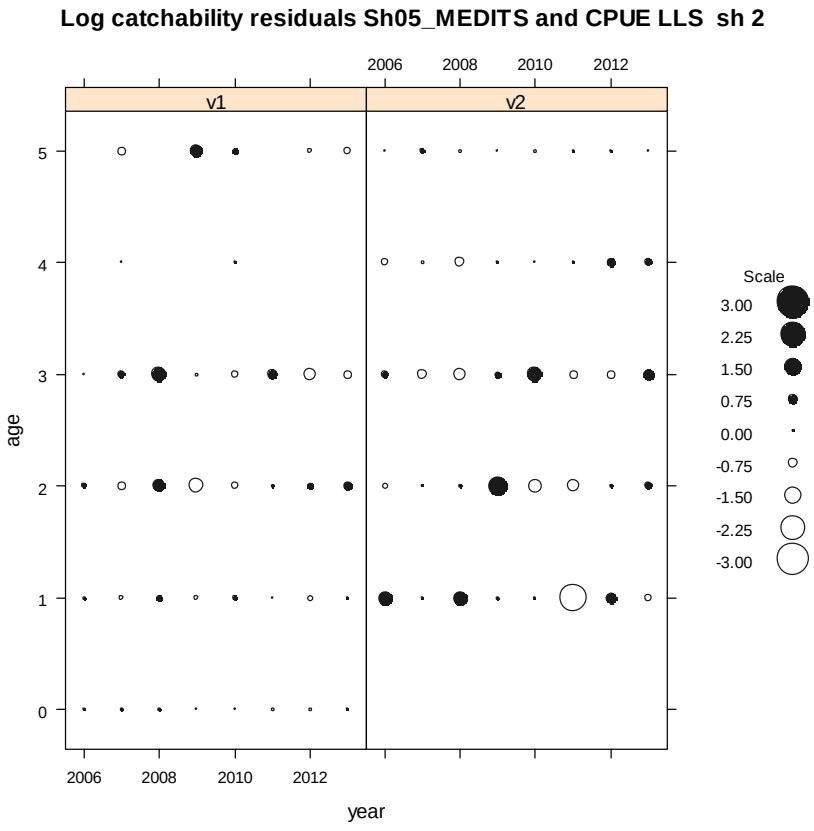

Fig. 6.1.6-1. Log catchability residuals at shrinkage 2.

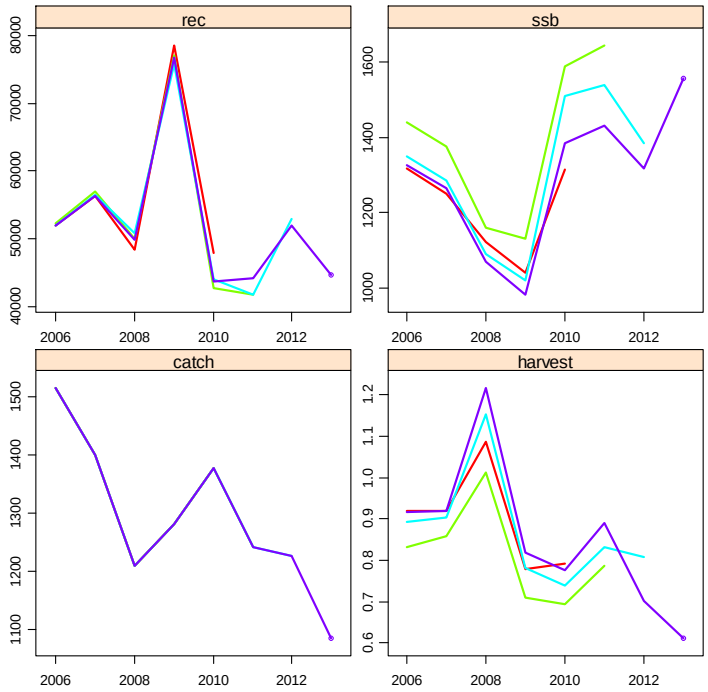

Fig. 6.1.6-2. Retrospective analysis results.

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

6.1.7 Assessment quality

The assumption of ogive selectivity for this species seems not completely consistent, especially for the fraction of the population caught by gillnets, trammel nets and longlines. The length of the time series cover once the number of age classes in catch data of the species, allowing to apply XSA model for this stock.

7 Stock predictions

7.1 Short term predictions

7.2 Medium term predictions

7.3 Long term predictions

8 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	$F_{0.1}$ = 0.16	Fc=0.74			O
	Fishing effort					
	Catch					
Stock abundance	Biomass			Percentiles MEDITS biomass index (Kg/km^2): 33rd : 14 66th : 21 Current: 20.4		
	SSB					
Recruitment						
Final Diagnosis		The current fishing mortality estimated averaged on the last three years is higher than the agreed Reference Point (F0.1) with intermediate level of biomass according to MEDITS survey data.				

Given the results of the present analysis, the stock seems in overexploitation, being exploited at level of F (0.74) above the reference point (0.16).

It is recommended to reduce the relevant fleets' effort and/or catches and to avoid future loss in stock productivity and landings.

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)*

9 References

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