# Stock Assessment Form

# Demersal species

## Reference year: 2013

## Reporting year: 2014

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 Montegrin 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: *Isabella Bitetto*

## 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], Đuroviæ M.[3], Facchini M. T.[1], Hoxha A.[4], Ikica Z.[3], Joksimoviæ A.[3], Kolitari J.[4], Kroqi G.[4], Lembo G.[1], Markoviæ 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)

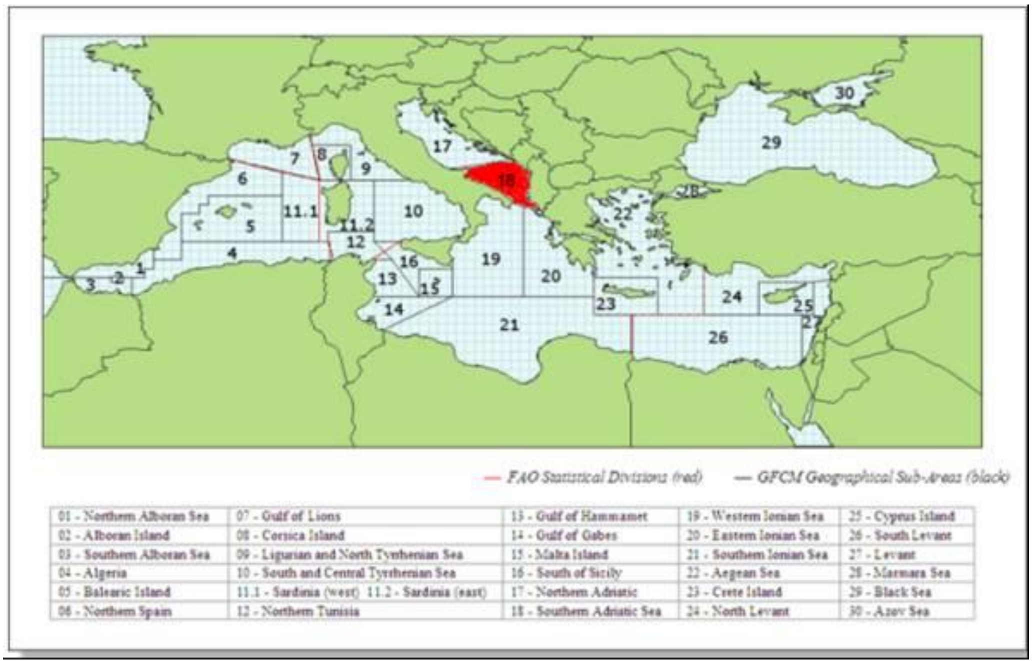
Combined method: you can choose both a direct and an indirect method and the name of the combined method (please specify)

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.

# 2 Stock identification and biological information

## *2.1 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).




## *2.2 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 $L_\infty$=83.4 cm; K=0.15; $t_0$= -0.11; males: $L_\infty$=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, t0= -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, t0= -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 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 year (peaks in late spring and winter)** |
| **Maximum size observed** | 93.5 | 66.5 | | **Recruitment season** | |
| **Size at first maturity** | 33 | | | **Spawning area** | |
| **Recruitment size to the fishery** | | | 6 | **Nursery area** | Continental shelf |

*Table 2-2.2: 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 |
| 6+ | 0.32 | 1.00 |

*Table 2-2.3: M vector and proportion of matures by size or age (Females)*

| Size/Age | Natural mortality | Proportion of matures |
|---|---|---|
| 0 | 1.16 | 0.08 |
| 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 |

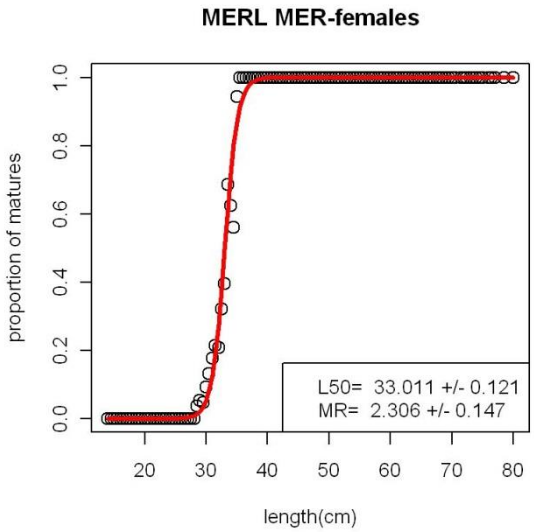



Fig. 2.2-1. Maturity ogive for M. merluccius females (DCF 2013).

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 2-3: Growth and length weight model parameters*

| | | | Sex | | | |
|---|---|---|---|---|---|---|
| | | Units | female | male | Combined | Years |
| Growth model | $L_\infty$ | 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 | | | | |

# 3 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 (2007-2012) weighted mean total length of longliners is varying from: 41 cm of 2013 to 51.5 cm of 2008.

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*.

## 3.1 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 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 | 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 3.1-2: Catch, bycatch, discards and effort by operational unit in the reference year (2013)*

| 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 | 2379 T | | | | |
| **ITA Operational Unit 4** | 23 | 188 T | | | | |
| **MNE Operational Units 5** | 20 | 40 T | | | | |
| **MNE Operational Units 6+7** | 50 | 20 T | | | | |
| **ALB Operational Units 8+9+10** | 199 | 280 T | | | | |
| **Total** | 718 | 2907 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 | 29[1] |
| **2007 Total** | **4566** |
| 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 | 29[4] |
| **2008 Total** | **4639** |
| 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 | 26[4] |
| **502009 Total** | **4580** |
| 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 | 23[4] |
| **2010 Total** | **4390** |
| 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 | 18[4] |
| **2011 Total** | **4258** |
| 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 | 19[4] |
| **2012 Total** | **3406** |
| 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 | 20 |
| **2013 Total** | **2907** |

[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 was estimated based on the data from 2013

[5] Due to the lack of data, the total production of Albania was assumed to be identical to that of 2012.

## 3.2 Historical trends

Available time series for European hake landings in GSA 18 is relatively short (Table 3.2-1), consisting of only seven years (2007-2013), and even not complete for all countries in question. The reduction of landings present since 2008 continued, and was even more pronounced in 2012, 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 | 29 | 390 | 4566 |
| **2008** | 550 | 3640 | 59 | 29 | 390 | 4639 |
| **2009** | 532 | 3540 | 52 | 26 | 456 | 4580 |
| **2010** | 597 | 3372 | 46 | 23 | 375 | 4390 |
| **2011** | 534 | 3285 | 37 | 18 | 402 | 4258 |
| **2012** | 566 | 2520 | 39 | 19 | 280 | 3424 |
| **2013** | 188 | 2379 | 40 | 20 | 280 | 2907 |

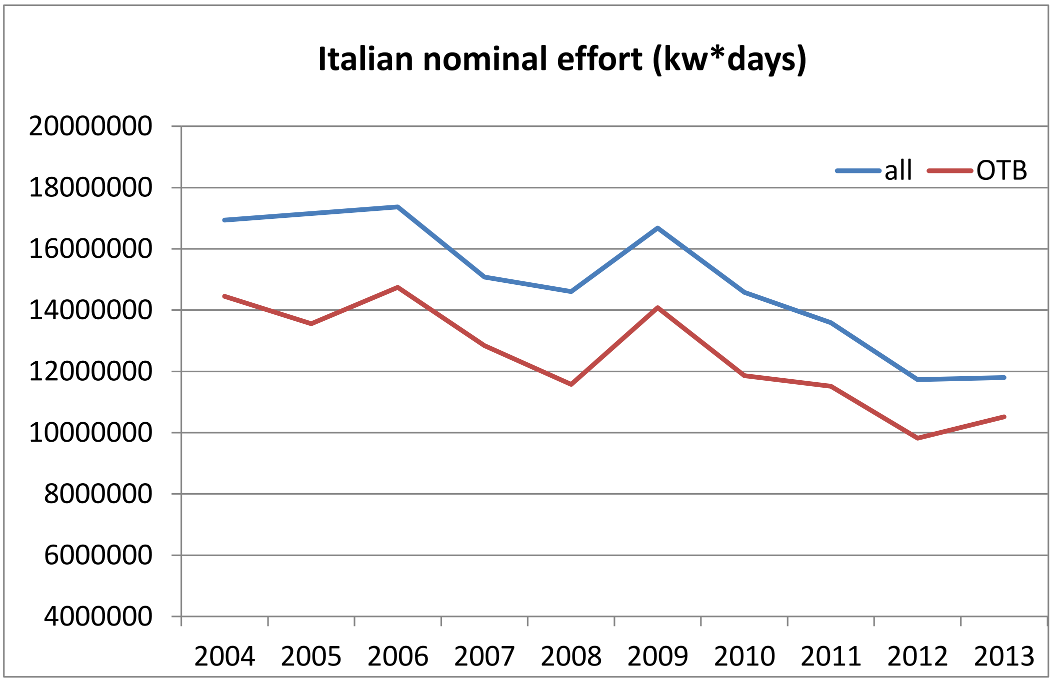



Fig. 4.1.3-1. Nominal fishing effort in kW×days by fishing technique for the western side (Italian coast) of GSA 18 from DCF. In “all” are included GNS, GTR and LLS.

## 3.3 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.

## *3.4 Reference points*

*Table 3.4-1: 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 | | | F0.1 | 0.18 | Assessment presented during GFCM Working Group Demersal held d in Bar, Montenegro, 28 January – 1 February 2014 |
| Y | | | | | |
| CPUE | | | | | |
| Index of Biomass at sea | | | | | |

# 4 Fisheries independent information

## *4.1 MEDITS Trawl Survey*

### 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** | 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.

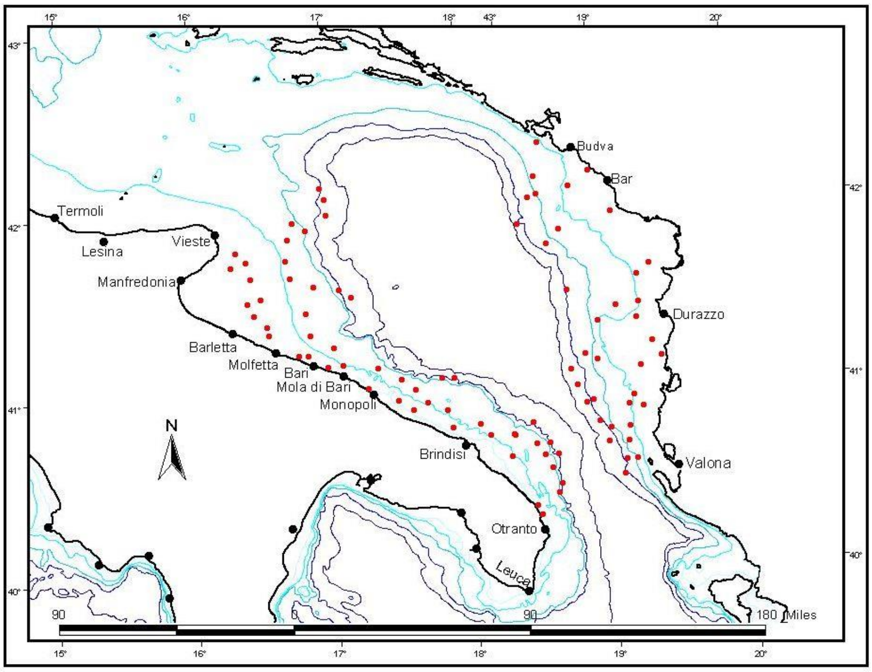



Fig. 4.1-1. Map of MEDITS haul positions in the GSA 18

The abundance indices and the associated coefficient of variation for 2012 are reported in the table below.

Table 4.1-3: Trawl survey abundance and biomass results (MEDITS 2012)

| Depth Stratum | Years | kg per km² | CV (%) | N per km² | CV (%) |
|---|---|---|---|---|---|
| **10 – 50 m** | 2013 | 5.29 | 61.52 | 146.91 | 64.90 |
| **50 – 100 m** | 2013 | 13.69 | 18.66 | 294.84 | 22.13 |
| **100 – 200 m** | 2013 | 39.18 | 17.64 | 1062.89 | 26.21 |
| **200 – 500 m** | 2013 | 43.39 | 15.78 | 696.38 | 39.23 |
| **500 – 800 m** | 2013 | 23.20 | 26.36 | 30.77 | 20.44 |
| **Total (10 – 800 m)** | 2013 | 27.61 | 10.26 | 556.18 | 18.82 |

## 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 length or age class

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

| 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 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) | | winter and late spring | |
| Age at fishing-grounds recruitment | | | |
| Length at fishing-grounds recruitment | | | |

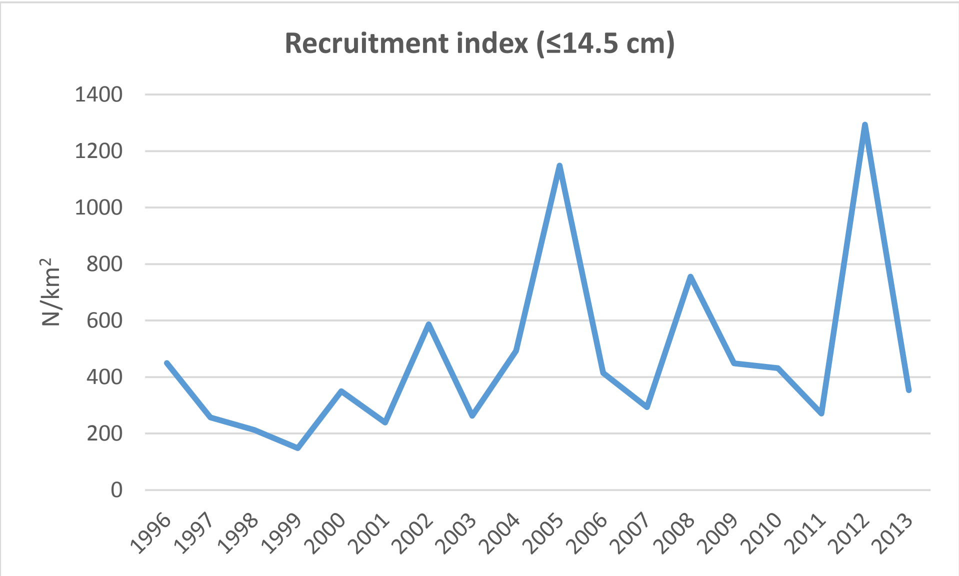
Table 4.1-6: Trawl surveys; recruitment analysis results (<=14.5 cm)

| Years | Area in $km^2$ | N of recruit per $km^2$ | CV or other |
|---|---|---|---|
| **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 | 262 | 26.4 |
| **2004** | 29008 | 493 | 28.4 |
| **2005** | 29008 | 1149 | 10.6 |
| **2006** | 29008 | 414 | 16.0 |
| **2007** | 29008 | 293 | 12.9 |
| **2008** | 29008 | 755 | 16.2 |
| **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 |

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*

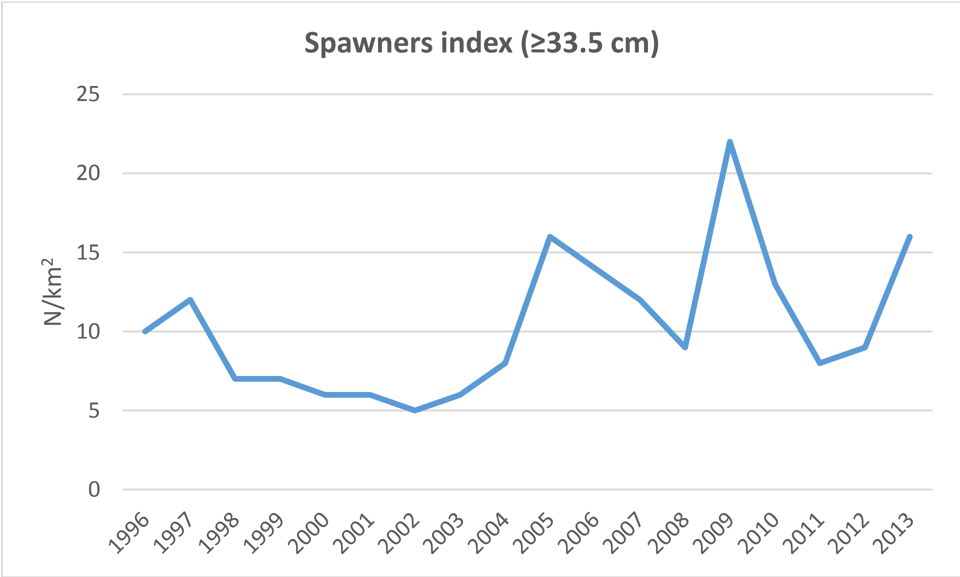
Table 4.1-7: Trawl surveys; spawners analysis summary

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

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

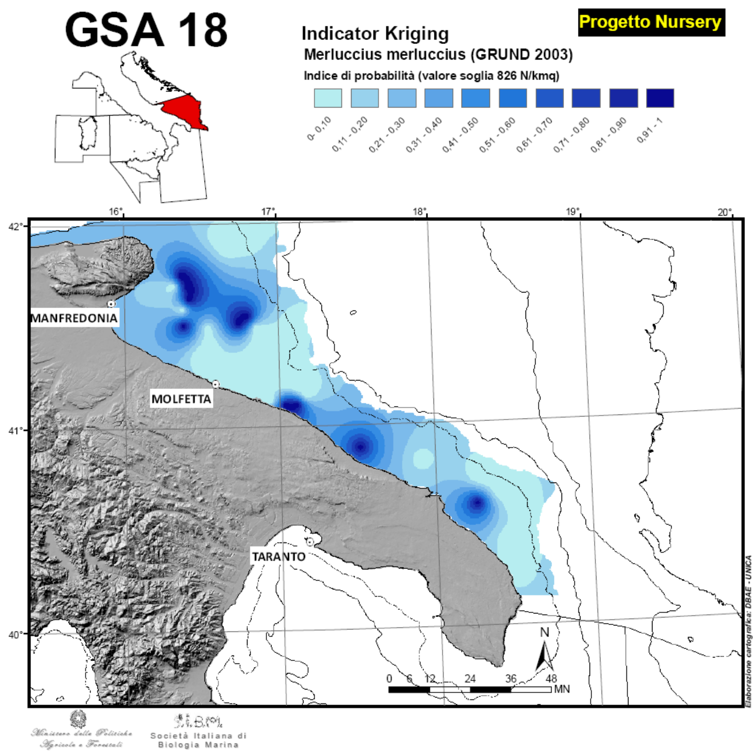
| **Years** | **Area in km²** | **N of recruit per km²** | **CV or other** |
|---|---|---|---|
| **1996** | 29008 | 10 | 17.0 |
| **1997** | 29008 | 12 | 15.6 |
| **1998** | 29008 | 7 | 20.0 |
| **1999** | 29008 | 7 | 20.1 |
| **2000** | 29008 | 6 | 16.7 |
| **2001** | 29008 | 6 | 16.3 |
| **2002** | 29008 | 5 | 35.7 |
| **2003** | 29008 | 6 | 22.8 |
| **2004** | 29008 | 8 | 20.5 |
| **2005** | 29008 | 16 | 16.3 |
| **2006** | 29008 | 14 | 19.1 |
| **2007** | 29008 | 12 | 20.4 |
| **2008** | 29008 | 9 | 22.8 |
| **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 |

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




## 4.1.2 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.

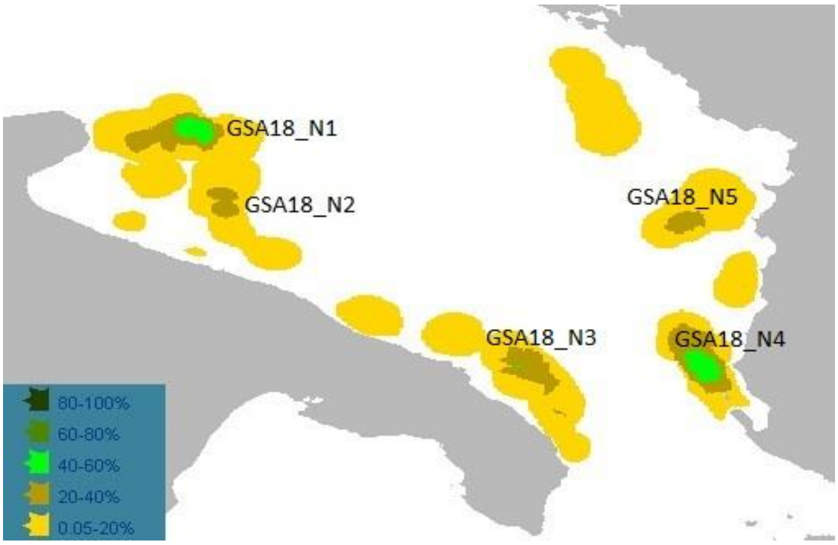



Fig. 4.1.2-1. Locations of persistent nurseries of *M. merluccius* in GSA 18 (MEDISEH project – MAREA framework)

### 4.1.3 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.

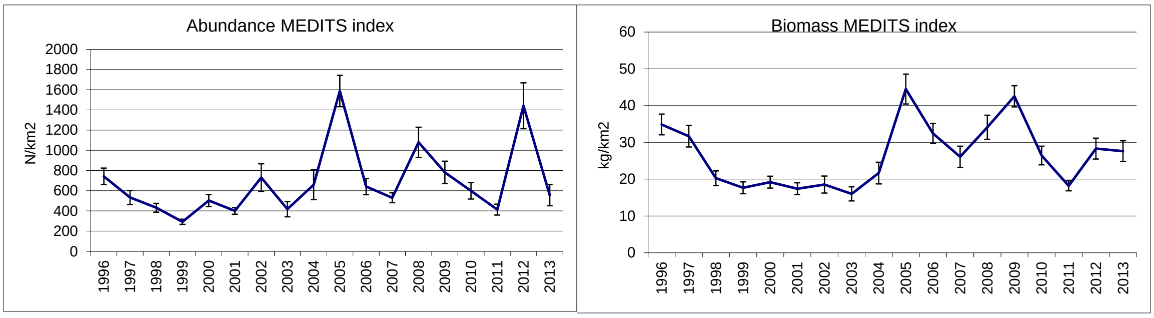



Fig. 4.1.3-1.Abundance (N/km^2) and biomass(Kg/km^2) MEDITS indices from 1996 to 2013.

# 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 analysis*

### 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

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)
```

### 6.1.3 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 |
| 0 | 46478 | 25787 | 27733 | 29045 | 21733 | 42778 | 18883 |
| 1 | 28125 | 34709 | 30410 | 26889 | 27651 | 16445 | 20954 |
| 2 | 684 | 689 | 912 | 1039 | 1033 | 680 | 539 |
| 3 | 113 | 271 | 161 | 256 | 195 | 228 | 65 |
| 4 | 100 | 105 | 71 | 105 | 66 | 34 | 30 |
| 5 | 29 | 22 | 46 | 36 | 59 | 29 | 14 |
| 6+ | 29 | 2 | 10 | 23 | 32 | 19 | 0.00 |

Table 6.1.3-2. Tuning data MEDITS

| | | | | Catch-at-age (N/km$^2$) MEDITS | | | |
|---|---|---|---|---|---|---|---|
| Age class | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
| 0 | 416.51 | 918.92 | 564.34 | 479.98 | 319.15 | 1344.65 | 444.60 |
| 1 | 104.05 | 150.54 | 199.78 | 109.03 | 87.36 | 89.72 | 98.26 |
| 2 | 6.89 | 5.12 | 14.27 | 6.55 | 4.33 | 5.24 | 10.55 |
| 3 | 2.08 | 1.93 | 2.03 | 2.56 | 1.68 | 1.08 | 1.50 |
| 4 | 0.63 | 0.37 | 1.01 | 0.84 | 0.97 | 0.61 | 0.69 |
| 5+ | 0.75 | 0.16 | 0.36 | 0.58 | 0.12 | 0.34 | 0.58 |

Discards data of 2009, 2010, 2011, 2012 and 2013 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

## 6.1.4 Results

Fishing mortality (F) shows the minimum value of 0.6 ($\overline{F}$ or $F_{bar}$) in 2013, and a maximum of 1.1 in 2011. Average F for the period of last three years (2011-2013) was 0.83.

The $F_{0.1}$ value estimated on the basis of the XSA was 0.14 by FLBRP package (FLR library), same as in 2012.

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

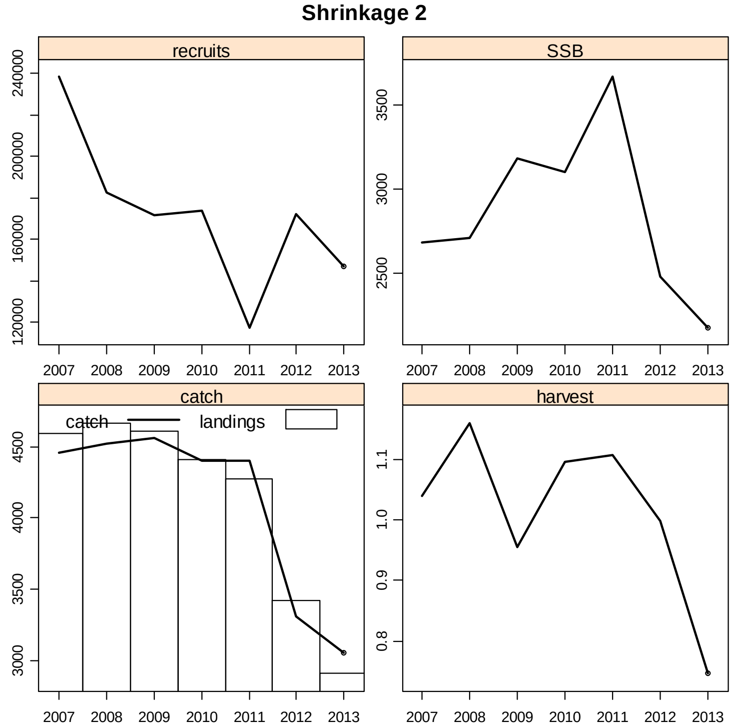



Fig. 6.1.5-1. Summary XSA results for *M. merluccius* in GSA 18.

## *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. 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.

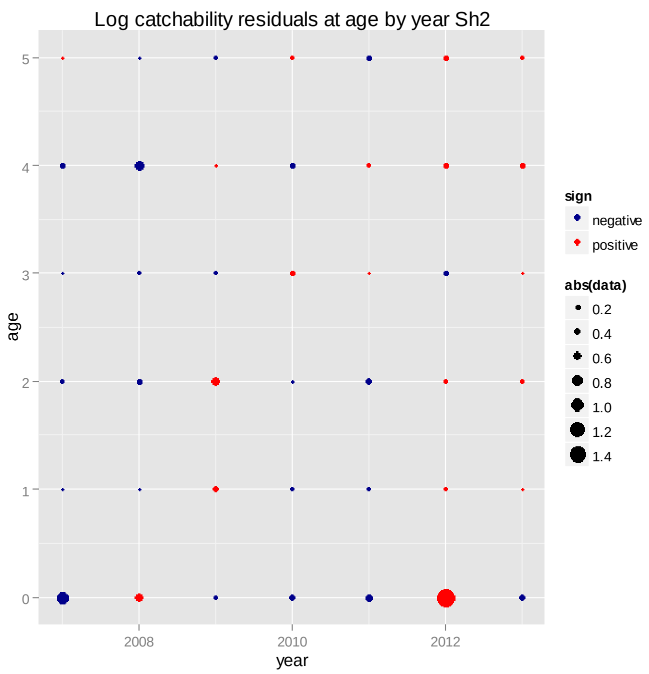



Fig. 6.1.6-1. Log catchability residuals at shrinkage 2.0

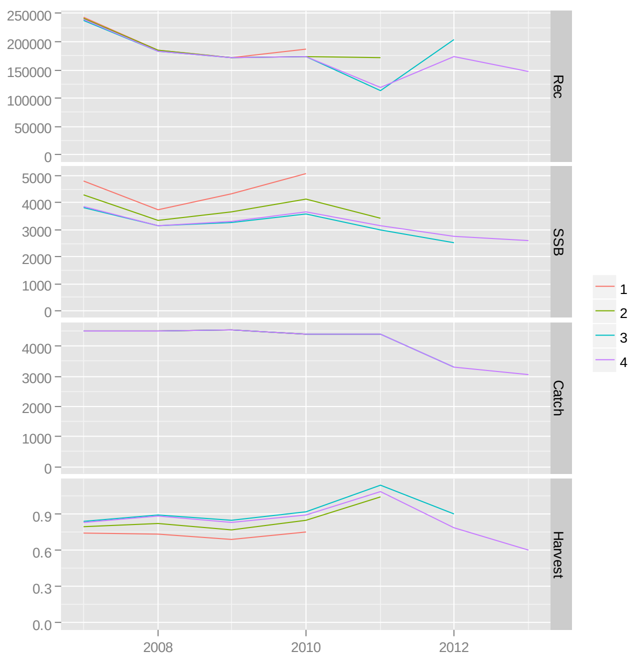



Fig. 6.1.6-2. Retrospective analysis results

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).

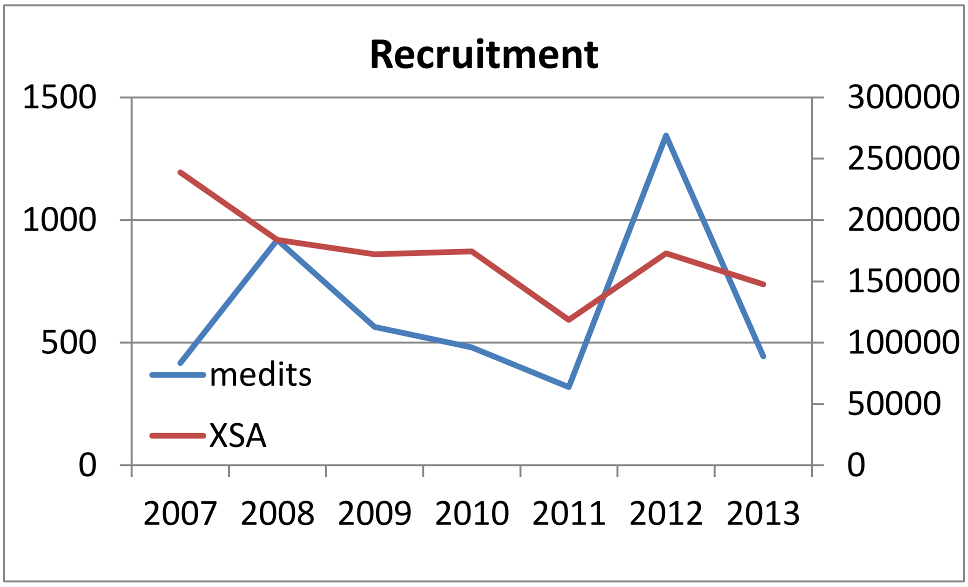



Fig. 6.1.6-3. Recruitment estimates from the XSA model and abundance indices from MEDITS data

### *6.1.7 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.

## *6.2 a4aSCA (Assessment for all statistical catch at age, FLR library)*

### 6.2.1 Model assumptions

Statistical catch-at-age analysis (SCAA) is widely viewed as a state-of-the-art assessment approach (e.g., Hilborn and Walters 1992 and Quinn and Deriso 1999).

The a4aSCA is a statistical catch-at-age model written in R and ADMB. Each fitted stock assessment model is defined by sub-models, which specify the different parts of the statistical catch-at-age model. It is a likelihood-based assessment model for joint analyses of age-specific fishery and survey data. Age-structured population stock dynamics are modelled using standard forward-projection methods for statistical catch-at-age analyses. The population dynamics model is fit to observed fishery and survey data using an iterative maximum likelihood estimation approach.

In our analysis we tested 3 models, that are combination of the following sub-models:

• 1 models for F-at-age: one depending additively on age and years;

• 1 model for abundance indices catchability-at-age: depending on ages and constant from age 4 to 6+;

• 2 models for recruitment: hockey stick stock-recruitment function and a smoother depending on the year;

• 1 model for starting population: on model depending on age vector.

### 6.2.2 Scripts

```
# qmodel
qmodel1 <- list(~ factor( replace(age, age>4, 4) ))
```

```
#fmodel
fmodel1 <- ~ factor(age) + factor(year)
fmodel2 <- ~ te(age, year, k = c(4,4))

#srmodels
srmodel1 <- ~ hockey(CV=0.05)
srmodel2 <- ~ s(year,k=6)

# n1model
n1model <-~factor(age)

# models
fit1 <- a4aSCA(hke_age,hke_index_age, fmodel1, qmodel1, srmodel1,n1model)
fit2 <- a4aSCA(hke_age,hke_index_age, fmodel2, qmodel1, srmodel2,n1model)
fit3 <- a4aSCA(hke_age,hke_index_age, fmodel1, qmodel1, srmodel2,n1model)
```

### 6.2.3 Input data and Parameters

The same input used for XSA analysis have been used to run a4aSCA model.

### 6.2.4 Results

The best model according to AIC are fit1, as well as according to residuals the best model.

The difference between fit1 reconstructed and observed landing is on average around 3.4 %.

The recruitment and SSB estimated by the model according to hockey-stick stock-recruitment relationship is shown in the figure below:

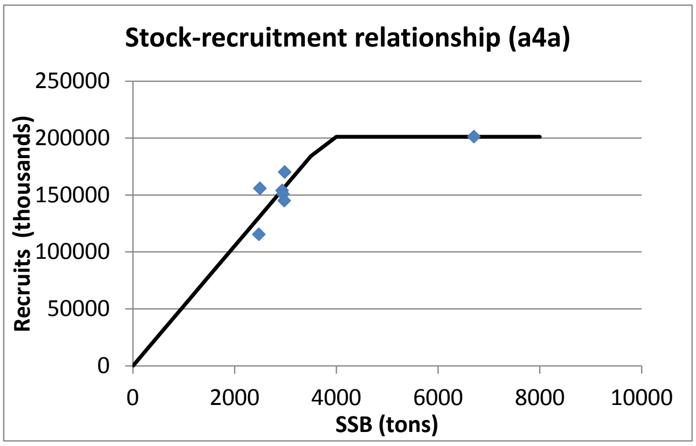



Fig. 6.2.6.1 Stock-recruitment relationship from fit1 a4a model.

Considering that the stock-recruitment relationship is derived by the model according only 7 years of data, fit 3 is preferred for the advice, even if its AIC is slightly higher than fit1, being the residuals and the reconstructed commercial and survey catch quite equivalent. The difference between fit3 reconstructed and observed landing is on average around 2.7 %.

Both models reveal some difference more pronounced in 2012. The models seem not capture the peak in recruitment of 2012 and consequently estimates a smaller number of individuals of age 0 in the catch. On an overall basis, the fitting of both models has been considered satisfactory.

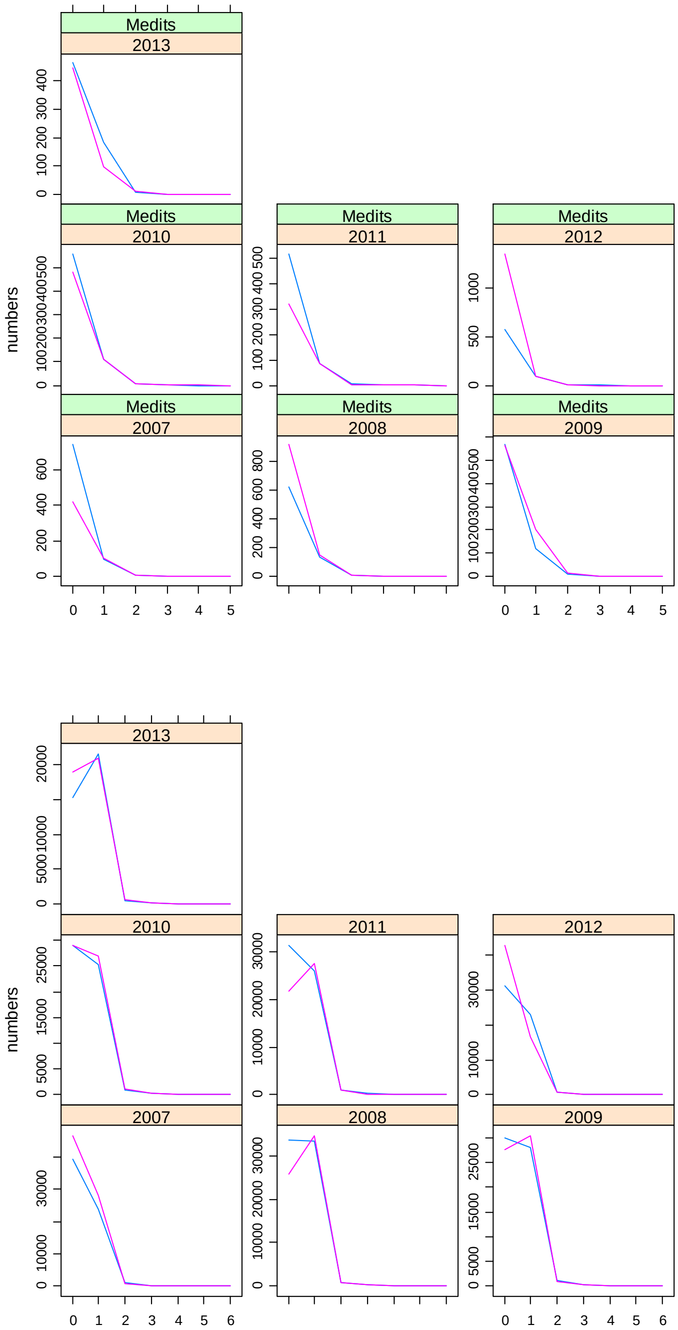
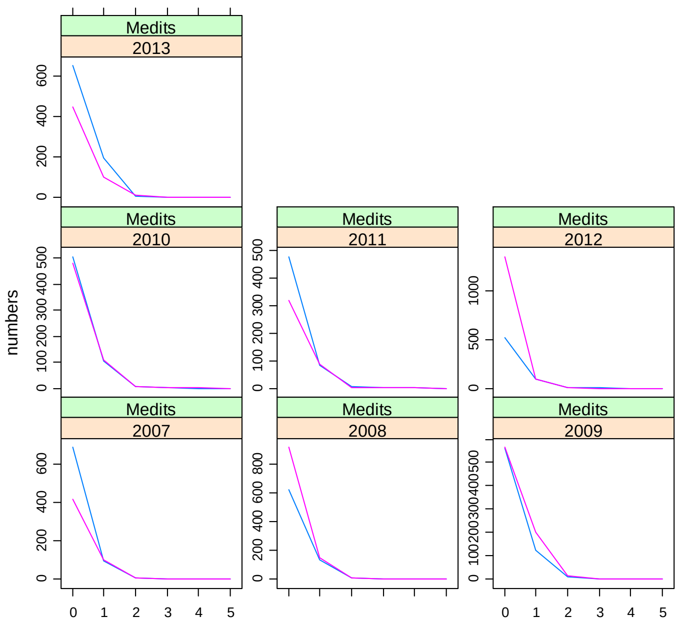



Fig. 6.2.4.2 – Comparison between reconstructed and observed catches and indices for fit1 (pink are the observed and blue the estimated values)



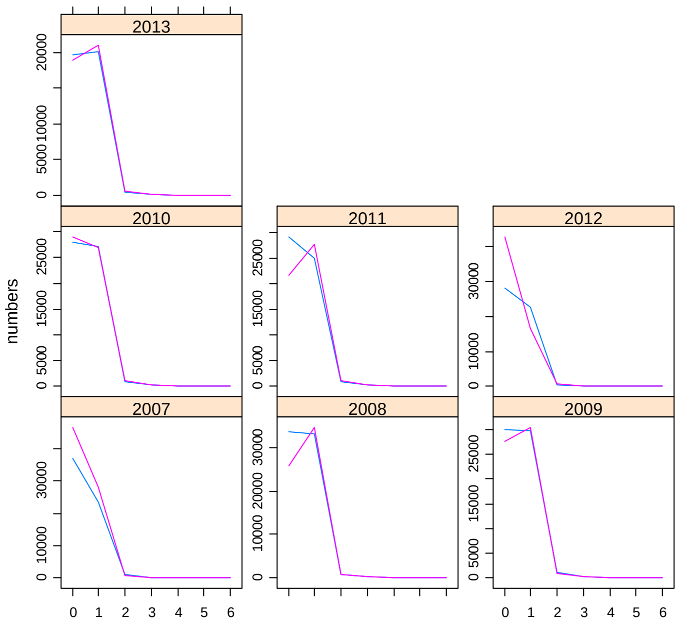




Fig. 6.2.4.3 – Comparison between reconstructed and observed catches and indices for fit3 (pink are the observed and blue the estimated values)

In the figure below is shown a comparison between XSA and a4aSCA fit 3 results; the results of the two methods seem quite consistent.

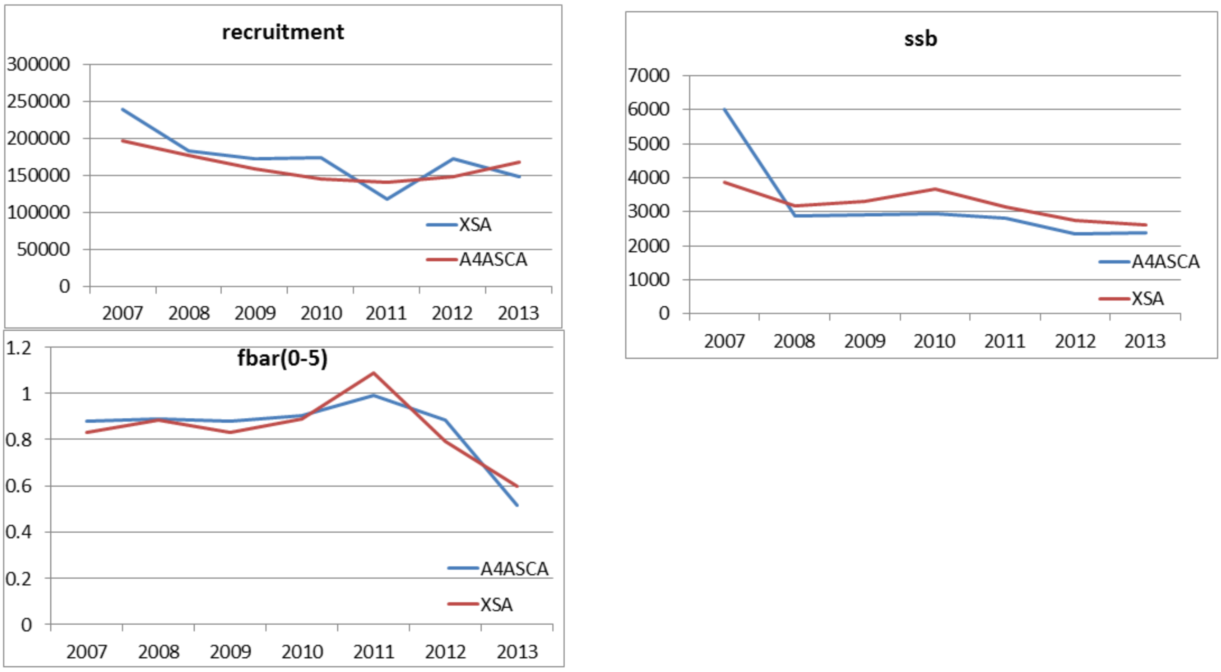


Fig. 6.2.4.4 – Comparison between recruitment, fbar (0-5) and SSB estimated by XSA and a4aSCA model (fit3).

### *6.2.5 Robustness analysis*

### 6.2.6 Retrospective analysis, comparison between model runs, sensitivity analysis, etc.

Sensitivity analysis models combining the different sub-models and obtaining 3 different models. The choice of the best model (fit1) has been taken according to AIC (Tab. 6.2.6.1) and residuals (Fig. 6.2.6.1).

Tab. 6.2.6.1 - AIC table for the 3 models tested.

| fit | AIC |
|---|---|
| **fit1** | **138** |
| fit2 | 151 |
| fit3 | 192 |

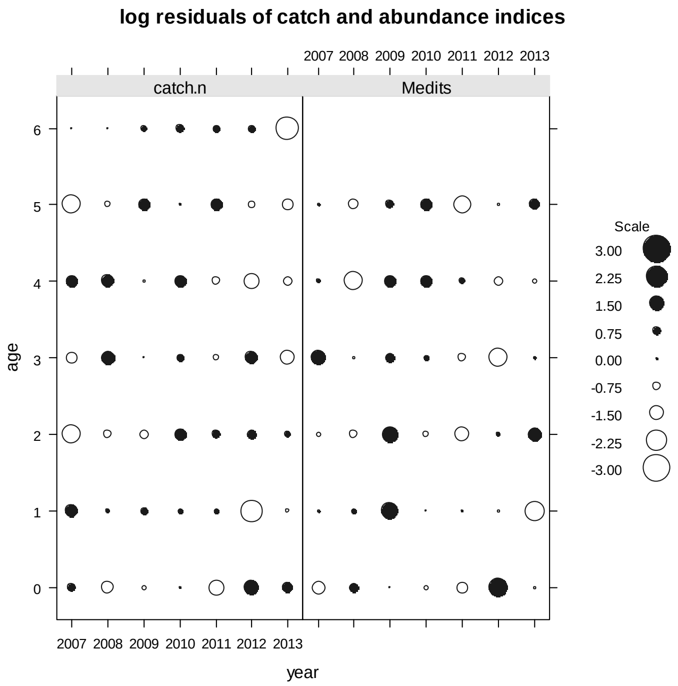



Fig. 6.2.6.1 – Residuals of fit1 model.

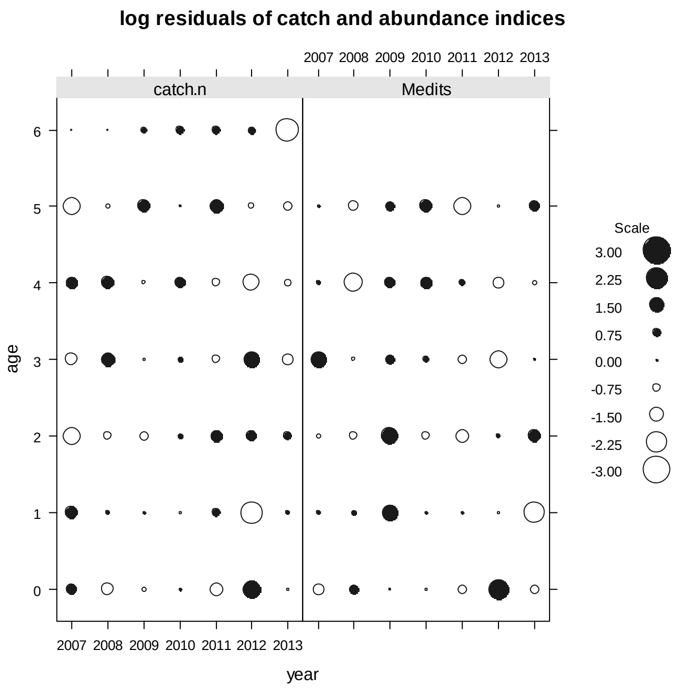



Fig. 6.2.6.2 – Residuals of fit3 model.

## *6.3 ALADYM*

### 6.3.1 Model assumptions

An exercise was accomplished using ALADYM (Lembo et al., 2009) simulation model, to figure out effects of possible management measures. The model is belonging to the family of pool-dynamic models, uses a monthly time scale and the a multi-fleet/gear approach. For this assessment an ogive with de-selection selectivity function has been assumed for all the trawlers fleet segments, with different parameters

according to the mesh size used by each fleet segment. For longliners and nets selectivity function with a normal distribution has been assumed.
The recruitment is assumed constant (equal to the average of the last three years) in the projections.
The hind-casting approach has been used for this assessment for comparison with the a4a and XSA results in the period 2007-2013 and to perform the projections for the future.

### 6.3.2 Scripts

Version 10.1.0 has been used for the assessment. Inputs and parameters are specified in the following paragraphs.

### 6.3.3 Input data and Parameters

For the ALADYM analysis, four fleet segments have been considered:

- Italian trawlers <24 m
- Italian trawlers >24 m
- Italian long-liners
- Albanian trawlers
- Montenegrin trawlers
- Montenegrin nets

Until 2010, selectivity of all fleet segments was assumed to correspond to the ogive with de-selection with $SL_{50\%}$ = 120 mm, selectivity range (SR) of 10 mm and DSL = 500 mm. From 2011, all trawlers fleet segments apart from Montenegrin trawlers are assumed to use diamond mesh size of 50 mm and corresponding parameters of $SL_{50\%}$ = 160 mm, SR = 10 mm and DSL = 500 mm. Montenegro continues to use 40 mm diamond mesh size, as until 2010.

Longline selectivity has been modelled according to a gaussian distribution with mean equal to the weighted mean total length in landing (varying from 44.5 and 51.5 cm) and 100 mm of standard deviation.

Nets selectivity has been modelled according to a gaussian distribution with mean equal to the mean total length in landing (30 cm) and 150 mm of standard deviation.

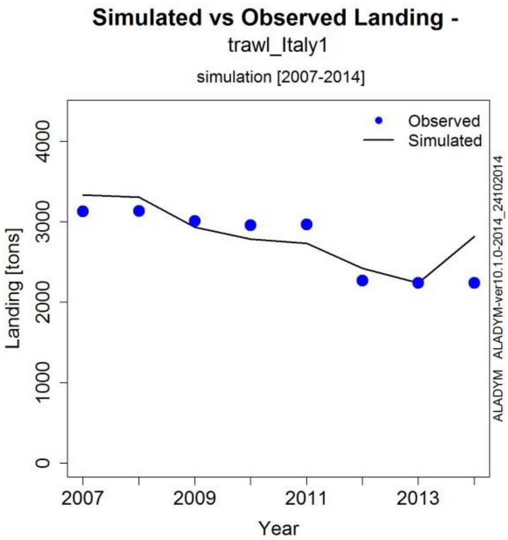
Monthly production and effort data from national DCF data have been used for Italian fleet segments. For Albania and Montenegro, annual production data has been equally split to 12 months. For Montenegro, monthly effort data has been used, while constant effort has been assumed for Albania.

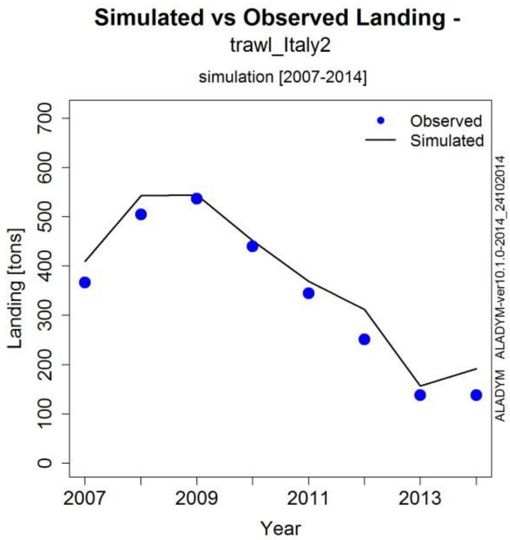
Natural mortality (M), maturity, and other relevant data used are the same as for the XSA and a4a. The recruitment, fishing (F) and total mortality (Z) correspond to the results obtained by a4a with fit3.

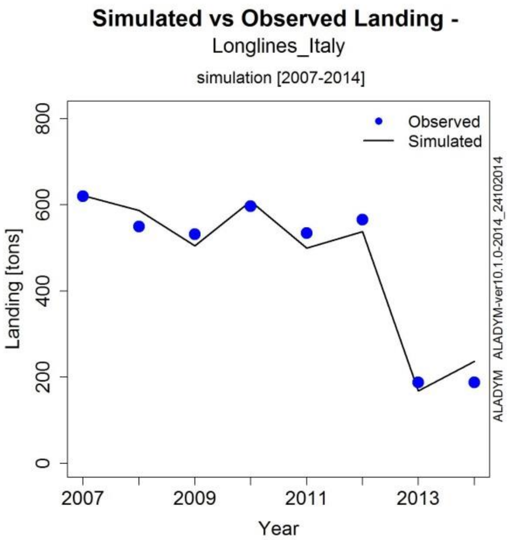
### 6.3.4 Results

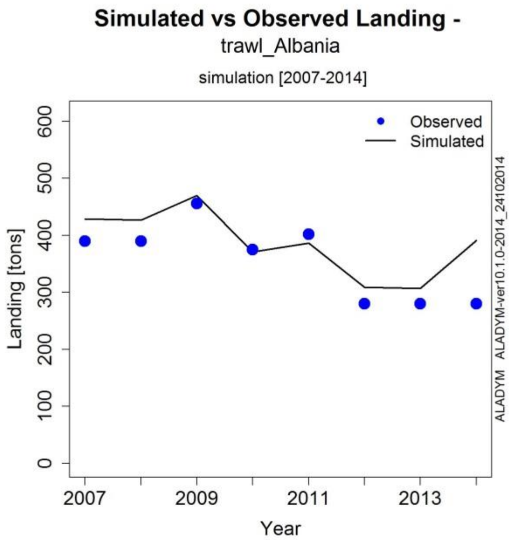
A satisfactory fit has been obtained with ALADYM simulation model for all the fleet segments with a mean of 4% of percentage difference between simulated and observed landing.

Comparison between observed yield values and values simulated by ALADYM model for all the fleet segments are provided on Fig. 6.3.7-1.


Simulated vs Observed Landing -
trawl_Italy1
simulation [2007-2014]
Observed
Simulated
Landing [tons]
Year
ALADYM ALADYM-ver10.1.0-2014_24102014


Simulated vs Observed Landing -
trawl_Italy2
simulation [2007-2014]
Observed
Simulated
Landing [tons]
Year
ALADYM ALADYM-ver10.1.0-2014_24102014


Simulated vs Observed Landing -
Longlines_Italy
simulation [2007-2014]
Observed
Simulated
Landing [tons]
Year
ALADYM ALADYM-ver10.1.0-2014_24102014


Simulated vs Observed Landing -
trawl_Albania
simulation [2007-2014]
Observed
Simulated
Landing [tons]
Year
ALADYM ALADYM-ver10.1.0-2014_24102014

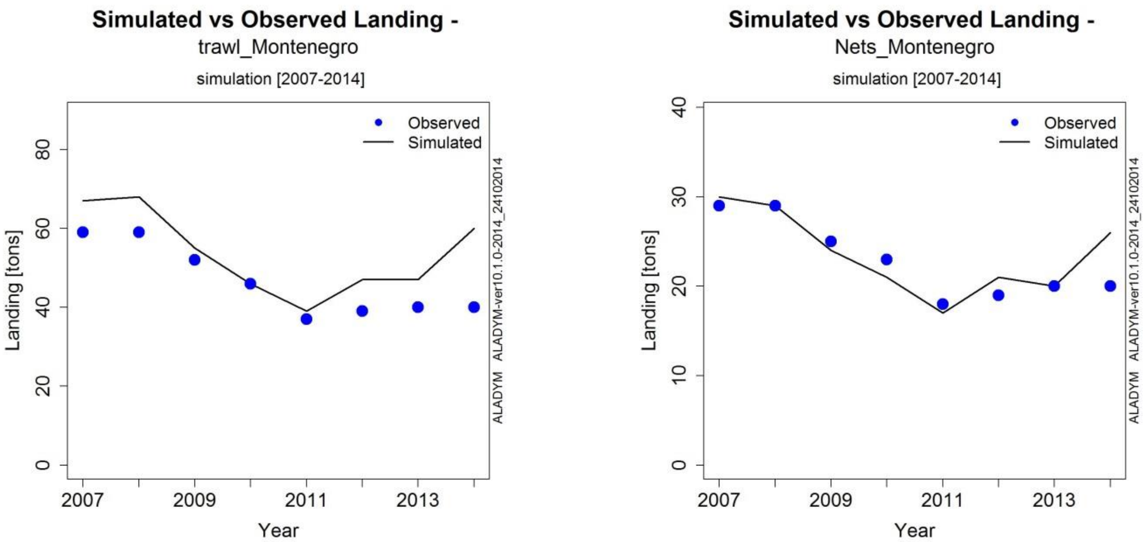



Fig. 6.3.4-1. Simulated vs. observed yield for various fleet segments used in the assessment. In 2014 has been assumed the same observed landing of 2013.

### *6.3.5 Robustness analysis*

### 6.3.6 Retrospective analysis, comparison between model runs, sensitivity analysis, etc.

### *6.3.7 Assessment quality*

The assumptions used for the simulations tried to accommodate different hypothesis of selectivity according to the gear used.

Furthermore, the hind-casting approach used for this assessment was accomplished to supporting the validity of the combined assessment.

## 7 Stock predictions

The recruitment has been assumed equal to geometric mean of the last three year (151 949 thousands) in the projections, being lacking a reliable stock recruitment relationship.

Four different scenarios were assumed:

- Scenario 1 – "status quo" or no changes until 2021;
- Scenario 2 – Gradual reduction of F towards $F_{0.1}$ in 2020;
- Scenario 3 – Increase in mesh size (60 mm diamond mesh size for Italy and Albania, 50 mm for Montenegro);
- Scenario 4 – Introduction of fishing ban in order to have at least one month for the trawlers.

All the measures are applied in 2015; while 2014 was parameterised as 2013 (recruitment, mortality, proportion due to the different fleet segments, etc…).

## 7.1 Short term predictions

## 7.2 Medium term predictions

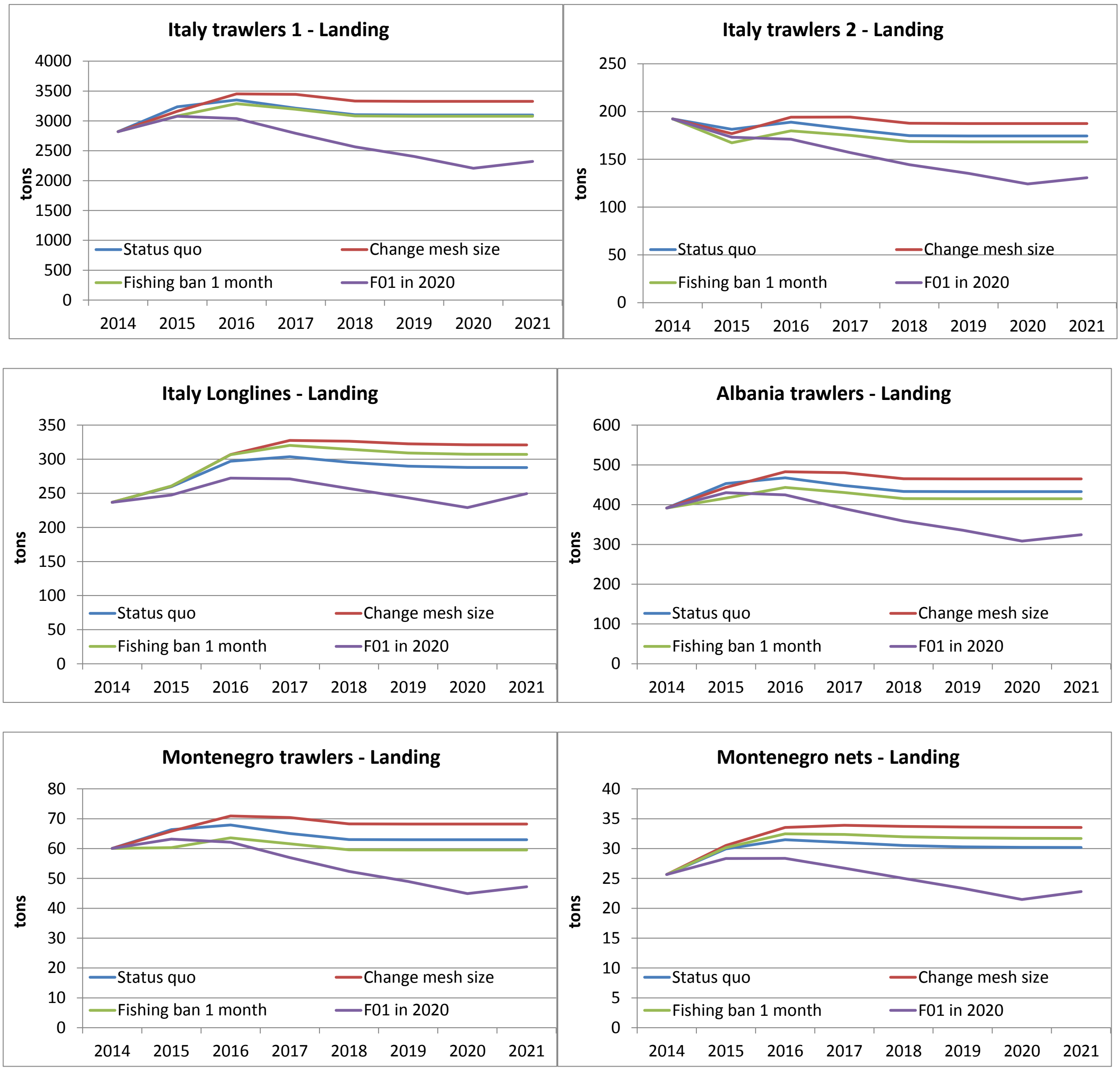



Fig. 7.2-1. Simulation of the four scenarios (status quo, increase of mesh size, introduction of the fishing ban and reaching target value of $F_{0.1}$ by 2020) for the entire GSA18, and separately by fleet segments and country. Weights in tons.

Having a look to the landings of the different fleet segments, the results in medium term show that the best performances for catches given by the mesh size increase scenario, followed by the fishing ban and the reduction towards F0.1 in 2020.

On an overall basis, increasing the mesh size (to 60 mm diamond mesh size for Italy and Albania and 50 mm diamond mesh size for Montenegro) could, according to the analyses performed, lead to increased landings in the entire GSA from 2017, as well as for all trawlers (Fig. 7.2-1), under the assumption of total survival of all the escaped individuals from the codend.

The better effect to SSB is given instead by the scenario based on the gradual reduction of F towards F0.1 in 2020 (Fig. 7.2-2).

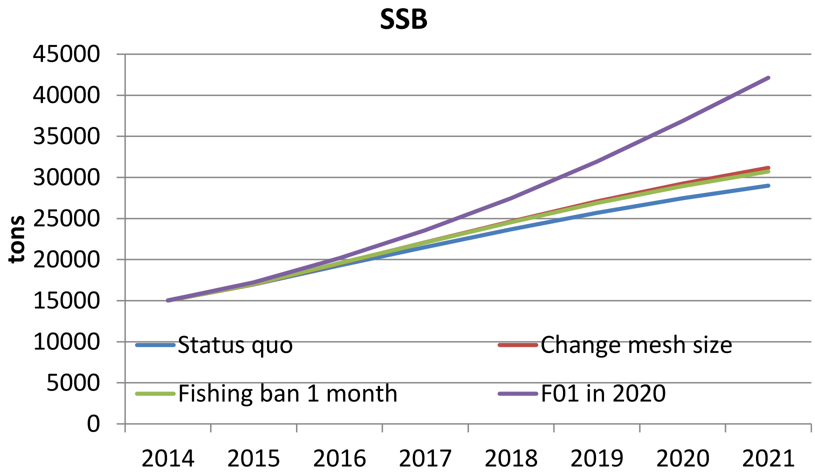
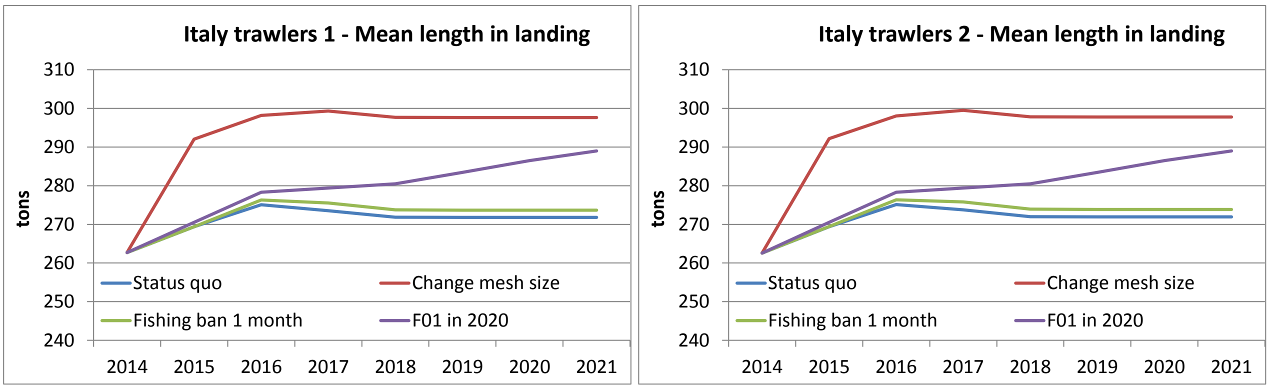



Fig. 7.2-2. Spawning stock biomass (SSB) according to the four simulated scenarios (status quo, increase of mesh size, introduction of the fishing and reaching target value of $F_{0.1}$ by 2020) for the GSA 18

Table 7.2-1. Percentage variation in spawning stock biomass estimated for 2021 expressed in respect to "status quo" in 2021.

| Scenario | % ratio |
|---|---|
| Increase mesh size | 7 |
| Fishing ban | 6 |
| $F_{0.1}$ in 2020 | 45 |

Under the assumption of total survival of all the escaped individuals from the codend, simulations showed that the mean length of European hake in landings would increase most significantly in all segments and in entire GSA 18 under the scenario change in selectivity. However, for all trawlers increasing mesh size (to 60 mm diamond mesh size for Italy and Albania and 50 mm diamond mesh size for Montenegro) would have benefit in short and medium term higher than fishing ban (Fig. 7.2-3).



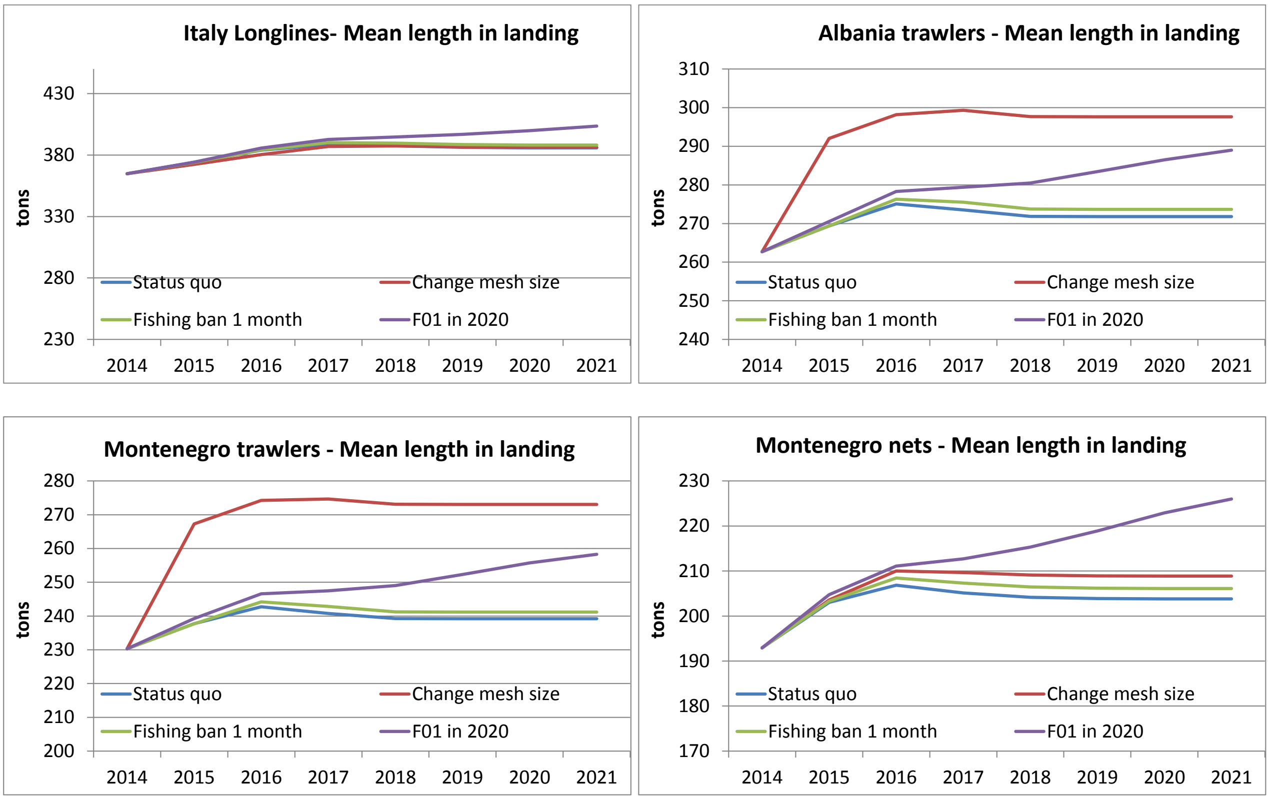



Fig. 7.2-3. Mean length of hake (in mm) in landing by country and/or fleet segment according to the four simulated scenarios (status quo, increase of mesh size, introduction of the fishing ban and reaching target value of $F_{0.1}$ by 2020) for GSA 18.

## 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 | $F_{0.1}$ = 0.2 (a4aSCA) | $F_{curr}$ = 0.8 | | | $O_H$ |
| | Fishing effort | | | | | |
| | Catch | | | | | |
| | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Stock abundance** | Biomass | | Biomass index = | 33 percentile = 20 Kg/Km^2<br><br>66 percentile = 29 Kg/Km^2<br><br>Current= 27.61 Kg/Km^2 | | |
| | SSB | | | | | |
| **Recruitment** | | | | | | |
| **Final Diagnosis** | | The stock is in overexploitation ($F_{curr}/F_{0.1} = 4$ (a4aSCA) ) with intermediate level of bio<br><br>mass according to MEDITS survey data. | | | | |

The stock is in overexploitation as current fishing mortality exceed the F0.1 levels (0.8 vs. 0.24) and thus it is necessary to consider a considerable reduction of the fishing mortality to allow the achievement of F0.1.
The reference point F0.1 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 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.

## 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


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