SCIENTIFIC, TECHNICAL AND ECONOMIC COMMITTEE FOR FISHERIES (STECF)

Assessment of Mediterranean Stocks Part II

13 - 17 DECEMBER 2010, MAZARA DEL VALLO, SICILY, ITALY

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WORKING GROUP ON THE MEDITERRANEAN PART II
13 - 17 December 2010, Mazara del Vallo, Sicily, ITALY

STECF UNDERTOOK THE REVIEW DURING THE PLENARY MEETING

HELD IN BARZA D'ISPRA (ITALY) 11-15 APRIL 2011

1. BACKGROUND

The European Community is expected to establish long-term management plans (LTMP) for relevant Mediterranean demersal and small pelagic fisheries, based on the precautionary approach and adaptive management in taking measures designed to protect and conserve aquatic living resources, to provide for their sustainable exploitation and to minimise the impact of fishing activities on marine ecosystems (target and non target species and habitat) following the Marine Strategy (Directive 2008/56/CE) and the Green Paper on the Reform of the CFP (COM(2009)163 final).

STECF can play an important role in focusing greater contributions for European scientists towards stocks and fisheries assessment, in identifying a common scientific framework regarding specific analyses to advise on Community plans, to be then channeled into or completed by the GFCM working groups.

STECF was requested at its 2007 November plenary session to set up an operational work programme for 2008, beginning in the 1st quarter of 2008, with a view to update the status of the main demersal stocks and evaluate the exploitation levels with respect to their biological and economic production potentials and the sustainability of the stock by using both trawl surveys and commercial catch/landing data as collected through the Community Data Collection regulation N° 1543/2000 as well as other scientific information collected at national level.

The work of STECF's subgroup on Mediterranean Sea and Black Sea continued in 2009 with the SGMED-09-01 meeting on advice reviews for 2009 for sprat and turbot in the Black Sea in Ranco, Italy, 23-27 March 2009, SGMED-09-02 part I in Villasimius, Sardinia, Italy, 8-12 June 2009 on the historic assessments and management advice regarding historic status of Mediterranean stocks, and with SGMED-09-03 part II in Barza d' Ispra, Italy, 14-18 December 2009 dealing mainly with short and medium term forecasts of stock size and landings of Mediterranean stocks under different management options. In 2010, SGMED-10-01 held a dedicated workshop in Barcelona, Spain, 22-26 March 2010 and SGMED-10-02 (Iraklion, Greece, 31 May-4 June 2010) updated assessments and performed new ones of relevant stock parameters and management reference points in the format elaborated in 2008. The work done during SGMED-10-03, which is reflected in the present report, complements such historic and recent trends with short and medium term forecasts of stock sizes and landings under various management scenarios.

2. TERMS OF REFERENCE

STECF is requested to review the report of the SGMED-10-03 Working Group of December 13 - 17, 2010 (Mazara del Vallo, Sicily (Italy)) meeting, evaluate the findings and make any appropriate comments and recommendations.

3. STECF OBSERVATIONS

STECF notes that the STECF-SGMED 10-03 WG provided management advice regarding the stock specific exploitation and stock size status applying the concept of limit reference points consistent with high long term yields and precautionary reference points for stock size, respectively. In addition, the STECF-SGMED 10-03 WG reviewed three stock assessments assessed by the GFCM-SAC. The stock assessments carried out increased the number or updated the assessments presented by the STECF-SGMED-10-02 WG, which were reviewed by STECF during its 2010 autumn plenary meeting (STECF PLEN 10-03).

In total, 79 separate stock assessments for 11 demersal and small pelagic species were performed in STECF-SGMED WGs in 2010. Quantification of a reference point for exploitation and a consistent classification was possible for 45 of the stocks assessed. F_{MSY} and, as an approximation, $F_{0.1}$ were previously defined as stock-specific limit fisheries management reference points consistent with high long term yields. The STECF-SGMED WGs experienced difficulties with the determination of precautionary reference points related to reproductive capability for self renewal, mainly due to the available data being limited to short periods of few years. Consequently, SGMED classified the stock size only for a limited number of stocks. Among the 45 assessed stocks, the great majority (40 stocks representing about 89% of total) were defined as being subject to overfishing. Only 5 stocks (11%) were defined as sustainably exploited.

34 demersal stocks (finfish and crustaceans) were assessed, of which 33 were identified as overfished. Only one demersal stock was assessed as being exploited sustainably. As demersal stocks are caught in mixed fisheries, the consistent management advice concerns the reduction of exploitation towards the proposed reference level through fishing effort regulation by means of multi-annual management plans that account for multi-species effects. Annual catches including discards corresponding to the advised effort reductions can be projected for the short- and medium-term for the relevant fleets and stocks.

Among the 11 small pelagic stocks assessed, exclusively anchovy and sardine, 7 were classified as overfished, while 4 stocks were assessed to be exploited sustainably. STECF notes that the management advice for fisheries targeting small pelagics focuses on the need for a consistent approach to establishing multi-annual management plans to keep fishing mortality at or below the proposed limit management reference points.

The 2010 STECF-SGMED WGs also performed deterministic short and stochastic medium term predictions for 37 stocks for which analytical assessments were carried out during the STECF-SGMED-10-02 and STECF-SGMED-10-03 WG meetings.

The STECF-SGMED-10-03 WG continued to review bio-economic approaches and available models and a bio-economic analysis of the demersal fishery exploiting hake and red mullet in GSA07 (Gulf of Lions) was undertaken as a case study. STECF notes that the inability to provide fully-integrated management advice is related both to design of available models and data shortfalls with regard to timing and the required aggregation.

The suitability of using GLM/GAM for standardization of CPUE or the stratified means approach was addressed. This is an important issue as CPUE indices derived from the MEDITS survey often drive the tuning of the XSA assessment. Furthermore, such indices are used for survey-based modelling approaches where CPUE trends are fundamental indicators of trends in the stocks.
The STECF-SGMED 10-03 WG constructed a common data base on individual condition of exploited Mediterranean fish species using voluntary data submissions from the experts through a request sent in advance of the WG meeting.

As requested a review of several fishing net designs and their technical properties was undertaken. This review is a first attempt to give an overview of such issues in the Mediterranean and it addressed many technological parameters of fishing gear design and geometry which can influence fishing efficiency and fishing effort. It was also discussed some weak aspects of Council Regulation (EC) 1967/2006 and how to improve the effectiveness of technical measures relating to square-mesh codends aimed at reducing mortality of juvenile fish. Some clarifications on the lengths and circumferences of codends and extension pieces currently in use were also provided. Moreover, other technical changes of the gears and the consequences as regards the fishing efficiency as well as the impact on the seabed were addressed. Finally, the introduction of appropriate measures for enforcement and control of the use of multi-rig trawl nets and ground gear characteristics were also tackled.

4. STECF CONCLUSIONS

STECF endorses the work and findings presented in the report of the STECF-SGMED 10-03 WG: Assessment of Mediterranean Stocks Part II.

STECF concludes that the catch data agreed and used by GFCM-SAC to assess the stock status of anchovy and sardine in GSA 17 appear inconsistent. The reasoning for the inconsistencies is explained in the relevant sections of the report of the STECF-SGMED 10-03 WG. STECF concludes that the inconsistencies identified call into question the results of the assessment and the corresponding advice. STECF therefore advises that the assessments and advice for anchovy and sardine in GSA17 should not be accepted as an appropriate basis for management until the inconsistencies in the input catch data have been investigated and resolved. .

Based on the review undertaken by the STECF-SGMED 10-03 WG, STECF concludes that the 2010 Mediterranean DCF data call, although significantly improved compared with earlier calls, did not fully support its work due to late, inconsistent and erroneous data submissions. STECF further concludes that the Mediterranean data call was overly complex, which probably contributed to the observed shortfalls. STECF acknowledges that the updated MEDITS database represents a large improvement over the previously tested versions.

STECF concludes that the estimation of individual fish condition may prove useful as an indicator of stock health status and could provide a complementary variable to the outcomes of standard assessments.

5. STECF RECOMMENDATIONS

STECF considers that management of fisheries targeting stocks of small pelagics in the Mediterranean through effort control alone, runs the risk of not achieving the desired management objectives, as the fleets concerned have the ability to selectively target different stocks. STECF therefore recommends that consideration be given to introduce landing restrictions as a complementary means to achieve desired management objectives on small pelagic species in the Mediterranean.

Recognising that STECF-SGMED WGs has been unable to deliver integrated bio-economic advice STECF recommends to dedicate a specific expert working group meeting with expertise in both stock and fisheries assessments as well as in fisheries economy attending to undertake bio-economic analyses and to provide respective integrated management advice. Such a meeting should be convened in early 2012 after the stock assessments and forecasts of stock size and catches have been accomplished in 2011 and appropriate economic data arising from the 2011 DCF data call have been compiled and quality checked. The Terms of Reference for such an Expert Working Group will be developed and presented in the report of the July 2011 STECF plenum.

STECF recommends that the 2011 Mediterranean and Black Sea DCF data call be revised according to the specifications given in Appendix 3 to the STECF-SGMED10-03 WG report. STECF recommends that the required aggregation of economic parameters that are not mandatory under the provisions of the DCF definitions be highlighted, as they require a pre-agreement (gentlemen agreement) between DG Mare and national administrations.

STECF recommends the voluntary data submission and analyses on individual fish condition of commercially exploited species in the Mediterranean to be continued.

SGMED-10-03 WORKING GROUP REPORT: ASSESSMENTS OF MEDITERRANEAN STOCKS PART II

13 - 17 December 2010, Mazara del Vallo, Sicily, ITALY

This report does not necessarily reflect the view of the European Commission and in no way anticipates the Commission's future policy in this area

1. EXECUTIVE SUMMARY AND RECOMMENDATIONS

With the aim of establishing the scientific evidence required to support development of long-term management plans in the Mediterranean, consistent with the objectives of the Common Fisheries Policy, and to strengthen the Community's scientific input to the work of GFCM, the Commission made a number of requests to STECF. The Terms of Reference (TORs) for SGMED-10-03 were extensive and are listed below in section 2.1.

In accordance with the **ToRs a, b, c, d and e**: SGMED 10-03 provides 16 summary sheets (section 4) presenting stock specific analytical assessments of historic and recent stock parameters of demersal and small pelagic speciess and their fisheries in a short format. Moreover, SGMED provides management advice regarding the stock specific exploitation and stock size status applying the concept of limit references points consistent with high long term yields and precautionary reference points of stock size, respectively. In addition, SGMED 10-03 reviewed three stock assessments assessed by GFCM-SAC (section 5), namely anchovy and sardine in GSA 17 (Northern Adriatic) as well as pink shrimp in GASs 12-16. Detailed stock and fisheries assessments are given in section 7 of this report. Not all of the 16 detailed assessments resulted in stock parameters considered representative of exploitation rates and absolute stock size. However, the presented stock assessments complement and update the assessements presented by SGMED-10-02 and reviewed by STECF at the autumn plenary in 2010.

The overview of the scientific advice provided by SGMED 10-02 and SGMED 10-03, the latter with updates and complementary assessments regarding historic and actual stock status, is provided in the following Table 1.1. It can be taken from this table that 79 stock assessments of 11 demersal and small pelagic species were undertaken in 2010, of which 45 resulted in the quantification of a reference point for exploitation and a consistent classification. SGMED proposed the estimated F_{MSY} and, as a approximation, $F_{0.1}$ as stock specific limit fisheries management points consistent with high long term yields. Contrarily, SGMED experienced difficulties with the determination of precautionary reference points identifing stock sizes at full or reduced reproductive capacities, mainly due to data constraints limiting the available data to short periods of few years. Consequently, SGMED classified the stock size only for the stock of European hake in GSA 6 as implying the risk of reduced reproductive capacity. Among the 45 assessed and classified stocks, the great majority of 40 stocks (89%) was classified as being subject to overfishing. Only 5 stocks (11%) were assessed as sustainably exploited.

The demersal fraction of the assessed fish and crustacean stocks represent 34 stocks, of which 33 (97%) are identified as being overfished. Only one demersal stock is found being exploited in accordance with the sustainablility criterion. As demersal stocks are caught in mixed fisheries together with other species, the consistent management advice concerns the reduction of exploitation to the proposed reference level through fishing effort reductions by means of multi-annual management plans, explicitly designed to account for multi-species effects. Annual catches including discards corresponding to the decided effort reductions shall be projected in short and medium term for the relevant fleets and species caught.

Among the 11 assessed stocks of small pelagic species, exlusively anchovy and sardine, 7 stocks (64%) were classied as overfished, while 4 stocks (36%) were found sustainably exploited. In particular, SGMED 10-03 expressed concern related to the stock status of anchovy and sardine in GSA 17 as assessed by GFCM-SAC. SGMED does not endorse the conclusion that the stocks are exploited sustainably and recommends the catch data being reviewed and the stocks being re-assessed accordingly.

The management advice for fisheries exploiting the assessed stocks of small pelagics focuses on the need for a consistent approach to establishing multi-annual management plans to keep fishing mortality at or below the proposed limit management reference points consistent with high long term yields or to reduce fishing mortality towards such limits. SGMED notes that management of fisheries targeting stocks of small pelagics through effort management alone, runs the risk of not achieving the desired management objectives, as the concerned fleets might switch among their targets. SGMED considers that landing restriction is a more appropriate management tool to control the exploitation rate on small pelagics in the Mediterranean and recommends that consideration be given to introduce landing restrictions as a more effective means to achieve desired exploitation rates on small pelagic species in the Mediterranean. The species of concern are primarily anchovy and sardine.

SGMED 10-03 considers the presented individual stock assessments of a diverse set of fish and invertebrate species inhabiting different habitats (pelagic, demersal, coastal, deep waters) as the the first step towards the ecosystem approach to fisheries management in the Mediterranean. SGMED will continue to follow up with fisheries specific analyses accounting for multispecies and ecologic effects.

When applicable the assessments of stock status and fisheries are based on data obtained through the DCR (until 2008) and DCF (since 2009) and the official call issued in 2010 for fisheries and scientific survey data (published on the STECF homepage https://datacollection.jrc.ec.europa.eu/), also covering data collected during national programmes or projects co-funded by the EU-Commission. SGMED was often unable to verify the origin or quality of the data used in the assessment but will continue its effort to validate them through expert knowledge.

In response to **ToR f)** the present report contains determinstic short or stochastic medium term predictions of 37 stocks (section 6) for which analytically assessments were formulated during the preceeding meeting of SGMED-10-02 or updated and complemented by the additional stock assessements undertaken during the SGMED-10-03 meeting. In the absence of management plans and predefined goals SGMED provides its stock specific advice for fisheries management in 2011 in the Mediterranean Sea in relation to the level of exploitation (limit) consistent with high long term yields, either F_{MSY} or $F_{0.1}$ as its proxy. SGMED emphasises that the precision of the provided short term predictions of catch and stock biomass may be low as the majority of recruitment estimates used reflects a recent average level since no 2010 survey indices were available in many cases to achieve more realistic estimates. Furthermore, the experts expressed concerns about a full implementation of the technical measures by 1 June 2010 as stipulated in COUNCIL REGULATION (EC) No 1967/2006. The potential impact has not been considered during the forecast of stock size and catch. It must be considered that stock size and catches will be pre-dominated by recruiting year classes (i.e. age groups 0 and 1). However, SGMED 10-03 presents the estimated potential selection effects of the technical regulation in specific case studies under the assumption that they are duly and fully implemented. Such estimations can be found in section 6. Furthermore, the forecasts are made under the assumption that potential environmental changes do not affect the input regarding recruitment, growth and distribution patterns in stock abundance.

Table 1.1 Overview of management advice as provided by SGMED 10-02 and SGMED 10-03 expert meetings regarding status of selected exploited stock in the Mediterranean with regard to exploitation (upper panel) and with regard to stock stize (lower panel) by species and geographical subarea (GSA). The overview counts the stocks being assessed, and further identifies how many could be classified as sustainabley exploited or overfished and how many are considered having a full or risk of reduced reproductive capacity in 2009.

Scientific advice regarding the state of the stock regarding exploitation rate

				GFCM GSA																															Overview		
No	**Group**	**Common name**	**Scientific name**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**assessed**	**Sust. expl.**	**Overfished**
1	Dem fish	Europen hake	*Merluccius merluccius*																																**16**	**0**	**10**
2	Dem fish	Red mullet	*Mullus barbatus*																																**16**	**0**	**9**
3	Dem fish	Striped red mullet	*Mullus surmuletus*																																**3**	**0**	**1**
4	Dem fish	Common sole	*Solea solea*																																**1**	**0**	**1**
5	Dem fish	Common pandora	*Pagellus erythrinus*																																**1**	**0**	**1**
6	Dem crust	Pink shrimp	*Parapenaeus longirostris*																																**15**	**1**	**7**
7	Dem crust	Giant red shrimp	*Aristaeomorpha foliacea*																																**5**	**0**	**2**
8	Dem crust	Blue and red shrimp	*Aristeus antennatus*																																**4**	**0**	**0**
9	Dem crust	Norway lobster	*Nephrops norvegicus*																																**7**	**0**	**2**
10	Pel small	Anchovy	*Engraulis encrasicolus*																																**6**	**1**	**5**
11	Pel small	Sardine	*Sardina pilchardus*																																**5**	**3**	**2**
																																		SUM	**79**	**5**	**40**

status unknown: assessment done but still preliminary and/or to be agreed on
status: overfished according to Fmsy or approximation of it
status: sustainably fished according to Fmsy or approximation of it
no information available

Scientific advice regarding the state of the stock regarding stock size

				GFCM GSA																															Overview		
No	**Group**	**Common name**	**Scientific name**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**assessed**	**Full cap**	**Risk red cap**
1	Dem fish	Europen hake	*Merluccius merluccius*																																**16**	**0**	**1**
2	Dem fish	Red mullet	*Mullus barbatus*																																**16**	**0**	**0**
3	Dem fish	Striped red mullet	*Mullus surmuletus*																																**3**	**0**	**0**
4	Dem fish	Common sole	*Solea solea*																																**1**	**0**	**0**
5	Dem fish	Common pandora	*Pagellus erythrinus*																																**1**	**0**	**0**
6	Dem crust	Pink shrimp	*Parapenaeus longirostris*																																**15**	**0**	**0**
7	Dem crust	Giant red shrimp	*Aristaeomorpha foliacea*																																**5**	**0**	**0**
8	Dem crust	Blue and red shrimp	*Aristeus antennatus*																																**4**	**0**	**0**
9	Dem crust	Norway lobster	*Nephrops norvegicus*																																**7**	**0**	**0**
10	Pel small	Anchovy	*Engraulis encrasicolus*																																**6**	**0**	**0**
11	Pel small	Sardine	*Sardina pilchardus*																																**5**	**0**	**0**
																																		SUM	**79**	**0**	**1**

status unknown: assessment done but still preliminary and/or to be agreed on
status: risk of reduced reproductive capacity
status: full reproductive capacity
no information available

In the absence of discard information for many of the stocks listed below, SGMED 10-03 recommends that fishing mortality in 2011 of

- European hake (*Merluccius merluccius*) in GSA 5 should not exceed $F_{0.1} = 0.22$, corresponding to catches of 24 tons.
- European hake (*Merluccius merluccius*) in GSA 6 should not exceed $F_{0.1} = 0.14$, corresponding to catches of 741 tons.
- European hake (*Merluccius merluccius*) in GSA 7 should not exceed $F_{0.1} = 0.09$, corresponding to catches of 734 tons.
- European hake (*Merluccius merluccius*) in GSA 9 should not exceed $F_{0.1} = 0.22$, corresponding to catches of 671 tons.
- European hake (*Merluccius merluccius*) in GSA 10 should not exceed $F_{0.1} = 0.19$, corresponding to catches of 491 tons.
- European hake (*Merluccius merluccius*) in GSA 11 should not exceed $F_{0.1} = 0.38$, corresponding to catches of 234 tons.
- European hake (*Merluccius merluccius*) in GSAs 15 and 16 should not exceed $F_{0.1} = 0.15$, corresponding to catches of 563 tons.
- European hake (*Merluccius merluccius*) in GSA 18 should not exceed $F_{0.1} = 0.21$, corresponding to catches of 1,501 tons.
- European hake (*Merluccius merluccius*) in GSA 22 should not exceed $F_{MSY} = 0.32$, corresponding to catches of 4,150 tons.
- red mullet (*Mullus barbatus*) in GSA 5 should not exceed $F_{0.1} = 0.31$, corresponding to catches of 4 tons.
- red mullet (*Mullus barbatus*) in GSA 6 should not exceed $F_{0.1} = 0.74$, corresponding to catches of 689 tons.
- red mullet (*Mullus barbatus*) in GSA 7 should not exceed $F_{0.1} = 0.33$, corresponding to catches of 95 tons.
- red mullet (*Mullus barbatus*) in GSA 9 should not exceed $F_{0.1} = 0.4$, corresponding to catches of 521 tons.
- red mullet (*Mullus barbatus*) in GSA 10 should not exceed $F_{0.1} = 0.42$, corresponding to catches of 253 tons.
- red mullet (*Mullus barbatus*) in GSA 11 should not exceed $F_{0.1} = 0.47$, corresponding to catches of 211 tons.
- red mullet (*Mullus barbatus*) in GSA 16 should not exceed $F_{0.1} = 0.31$, corresponding to catches of 399 tons.
- red mullet (*Mullus barbatus*) in GSA 22 should not exceed $F_{MSY} = 0.39$, corresponding to catches of 5,290 tons.
- striped red mullet (*Mullus surmuletus*) in GSA 5 should not exceed $F_{0.1} = 0.29$, corresponding to catches of 48 tons.
- striped red mullet (*Mullus surmuletus*) in GSA 22 should not exceed $F_{MSY} = 0.37$, corresponding to catches of 3,000 tons.
- common sole (*Solea solea*) in GSA 17 should not exceed $F_{0.1} = 0.26$, corresponding to catches of 770 tons.
- catches of anchovy (*Engraulis encrasicolus*) in GSA 1 should not exceed the exploitation rate E=0.4, corresponding to catches of 292 tons.
- anchovy (*Engraulis encrasicolus*) in GSA 6 should not exceed the exploitation rate E=0.4, corresponding to catches of 3,594 tons.
- anchovy (*Engraulis encrasicolus*) in GSA 17 should not exceed the exploitation rate E=0.4, corresponding to catches of 75,000 tons. SGMED advises that the short term prediction of catch and stock biomass of the stock of anchovy in GSA 17 and the specific management advice is conditional of the fact that the observed inconsistencies in the catch data (see section 5.1) can be resolved and a re-assessment does not indicate significant changes in the resulting parameters of the stock assessment.
- anchovy (*Engraulis encrasicolus*) in GSA 20 should not exceed the exploitation rate E=0.4, corresponding to catches of 733 tons. Due to a lack of data SGMED was unable to provide an update of the prediction of catch and biomass for the period 2010-2012. Using available data, SGMED provided the short term prediction for the period 2009-2011.

- sardine (*Sardina pilchardus*) in GSA 1 should not exceed the exploitation rate E=0.4, corresponding to catches of 8,128 tons.
- sardine (*Sardina pilchardus*) in GSA 6 should not exceed the exploitation rate E=0.4, corresponding to catches of 4,188 tons.
- sardine (*Sardina pilchardus*) in GSA 17 should not exceed the exploitation rate E=0.4, corresponding to catches of 37,000 tons. SGMED advises that the short term prediction of catch and stock biomass of the stock of sardine in GSA 17 and the specific management advice is conditional of the fact that the observed changes in the recent selection (see section 5.2) can be resolved and a re-assessment does not indicate significant changes in the resulting parameters of the stock assessment.
- sardine (*Sardina pilchardus*) in GSA 20 should not exceed the exploitation rate E=0.4, corresponding to catches of 1,500 tons. Due to a lack of data SGMED was unable to provide an update of the prediction of catch and biomass for the period 2010-2012. Using available data, SGMED provided the short term prediction for the period 2009-2011.
- pink shrimp (*Parapenaeus longirostris*) in GSA 5 should not exceed $F_{0.1}$ = 0.31, corresponding to catches of 2 tons.
- pink shrimp (*Parapenaeus longirostris*) in GSA 9 should not exceed $F_{0.1}$ = 0.7, corresponding to catches of 292 tons.
- pink shrimp (*Parapenaeus longirostris*) in GSA 10 should not exceed $F_{0.1}$ = 0.69, corresponding to catches of 278 tons.
- pink shrimp (*Parapenaeus longirostris*) in GSAs 12-16 should not exceed $F_{0.1}$ = 0.9, corresponding to catches of 4,363 tons.
- pink shrimp (*Parapenaeus longirostris*) in GSA 22 should not exceed F_{MSY} = 0.36, corresponding to catches of 1,920 tons.
- giant red shrimp (*Aristaeomorpha foliacea*) in GSA 15 and 16 should not exceed $F_{0.1}$ = 0.27, corresponding to catches of 900 tons.
- Norway lobster (*Nephrops norvegicus*) in GSA 5 should not exceed $F_{0.1}$ = 0.42, corresponding to catches of 6 tons.
- Norway lobster (*Nephrops norvegicus*) in GSA 9 should not exceed $F_{0.1}$ = 0.21, corresponding to catches of 119 tons.

Medium term secenarios are presented in section 6 with regard to the requirements to achieve F_{MSY} or its proxy $F_{0.1}$ by 2015 (UN 2002 sustainablity summit) or by 2020 (Marine Strategy Framework Directive). Projections of stock size and catches are calculated under the option of a continuous linear reduction of fishing mortality.

SGMED-10-03 continued its work on reviews of bio-economic approaches and available models as requested by **ToRs g and h**. The findings are summarized in section 8 of the present report, including a specific case study on the bioeconomic analysis of GSA07 ("Gulf of Lions") hake and red mullet demersal fishery. However, the reasons for SGMED being unable to provide specific integrated management advice are related to specific model designs, and data shortfalls with regard to timing and the required aggregation. Future data needs are defined and covered by means of the proposed data call revision described in section 3.3 of the present report, which particularly addresses the need for biological, transversal and economic fisheries data at a consistent aggregation level. Given the preparatory needs regarding complete stock and fisheries assessments it appears inappropriate to undertake bio-economic predictions during the ordinary SGMED stock and fisheries assessment expert meetings in 2011. SGMED recommends that only hindcasting modeling of the economic fisheries performance shall be undertaken in parallel to its stock assessment sessions in 2011, EWG 11-05, EWG 11-12 and EWG 11-20. Taking further into account that the economic data are usually available with a 2 years delay, SGMED recommends to dedicate a specific SGMED meeting with expertise in both stock and fisheries assessments as well as in fisheries economy attending to undertake bio-economic analyses and to provide respective integrated management advice. Such SGMED meeting shall be held in the first quarter in 2012, and the work shall be based on the results of the SGMED meetings in 2011 and the biological and economic data compiled at a consistent aggregation level through the 2011 SGMED data call.

With regard to **ToR i)** SGMED concluded that the 2010 Mediterranean DCF data call, although significantly improved as compared to earlier calls, did not fully support its work due to late, inconsistent and erroneous data submissions. SGMED further noted that the Mediterranean data call was overly complex, which has contributed to the observed shortfalls. SGMED therefore recommends the 2011 Mediterranean and Black Sea DCF data call be revised according to the specifications given in Appendix 3 to this report. SGMED recommends to improve the review of DCF data received and to comprehensively report on data accuracy and completeness individually for each of the 14 tables and major parameters defined in the specific data SGMED data call.

SGMED 10-03 notes that the updated MEDITS database is a large improvement over the previous tested versions. This comment is valid for files TA (station data) and TB (catch amounts) while file TC (length and maturity) was untested. We believe that the current available database, albeit some necessary corrections, is sufficiently robust to be used for assessment purposes in general and for the use of the R script without continuous debugging due to database errors.

SGMED 10-03 emphasises that applying the same GLM standardization model to different species and GSAs is not the best approach. For each species and GSA there should be an in depth model exploration and stepwise model selection. This would require with the current species/GSAs combinations an intense work. On a case by case analyses it appeared particularly important to perform CPUE standardization with GLM/GAMs in order to account for sampling unbalance over time and the effect of adding/removing certain hauls and new survey areas. Additionally for the species selected, which in most cases are caught in few tows, zero inflation is certain and to model these species either zero inflated models or other approaches need to be developed.
SGMED recommends that

- if fast and routine use of MEDITS data stored in the SGMED database is a foreseeable goal, a reliable and error free database should be made available for stock assessment. The R script developed for this purpose has been partially adjusted to the new database during the Mazara meeting but further refinement and testing is recommended, in particular for the age slicing function on the new TC file, which remains yet untested.
- it is advisable to assess in which cases it is better to use the GLM/GAM CPUE standardization versus the stratified means approach. This is an important matter as MEDITS CPUE indexes often drive the tuning of XSA assessment, are used for SURBA and can be incorpored into an indicator framework, especially in data poor situations.
- a dedicated working group should perform an in depth effort to standardize MEDITS CPUE for main target and priority species using the GLM/GAM models in the R script. Such work will determine which models work best for certain species and areas. Once this has been done the first time, updating the models the following years will be a routine exercise that requires only re-running the same models.
- the same working group should retain the most common models used to fit MEDITS CPUE data and incorporate them in the R script developed so far so that the end user will be able to use the code of multiple predefined sets of models. These models should be scripted with their corresponding model predictions as this part can be difficult to modify by a non expert user. The new R script will need to be fit Zero inflated models and dealing with heterogeneity (spread of the residuals along an explanatory variable) as both cases are very common with fisheries survey data.

SGMED notes that **ToR l)** has resulted in the first common data base on individual condition of exploited Mediterranean fish species. This data base was constructed by voluntary data submissions from the experts through direct requests in advance of the SGMED-10-03 meeting. The data base can be updated and enlarged in the future with the consideration of other stocks, particularly those identified in the report of SGMED-10-01 as “data poor”. SGMED concludes that, although there remains uncertainty on how to best interpret the causes and consequences of the observed temporal and spatial variability in condition, estimation of individual fish condition might provide an indicator of stock’s health status to be evaluated as a complementary variable to standard assessments or in data poor situations. SGMED recommends that the voluntary data submission on individual fish condition be continued and a joint data base be designed. SGMED further recommends that the ownership of the data remains with the data provider and any exploitation of the data base requires approval by and cooperation with the data providers.

SGMED's review and recommendations regarding the technical fishing net designs and properties (**ToR m**) should be considered as a preliminary attempt to give an overview of the situation in the Mediterranean, therefore the results should be considered with caution.

- Considering the strong increase of headrope length registered in the last two decades, in order to avoid an increment of the fishing effort in terms of swept area during towing operations, the maximum length of the headrope should be fixed to avoid uncontrolled technological creep and thus an increase in fishing efficiency of the fleet. Headrope length should represent a good index of effective fishing effort exerted by a bottom trawl because it is strongly correlated with the net horizontal opening and also because it represents a parameter which is easy to control in fishery inspections. The definition of headrope length is also requested in the EC Reg. 1967/2006 ("*Technical specifications limiting the maximum dimension of floatline, groundrope, circumference or perimeter of trawl nets along with the maximum number of nets in multi-rig trawl nets shall be adopted, by October 2007"*; see Annex II, point 7). In our preliminary analysis maximum headrope of around 100 m was recorded in Spanish trawl fisheries even if most of the trawls have headropes less than 70 m.
- In order to make effective the measures stated in the EC Reg. 1967/06 concerning the codend meshes, the following explanation should be considered: in the case of 40 mm square-mesh codend, the rest of the net should have a mesh opening more than 40 mm. In the case of 50 mm diamond-mesh codend, the rest of the net shall have a mesh opening more than 50 mm. Thus in the case of 50 mm diamond mesh codend all trawl netting panels should be considered legal only if they have a mesh opening greater than 50 mm. On the other hand for the 40 mm square mesh codend the definitions of the EC Reg. 1967/06 did not provide any indication of the codend length and this could lead to make ineffective this technical measures. The review we have done showed that the codend length is generally comprised between 4.5 and 7 m. Therefore in order to avoid misinterpretation of the Regulation some more detailed information on technical measures, such as the codend length, should be provided. For example Italian fisherman use a shorter netting panel (about 50-100 cm) at the final part of the codends with legal mesh size, leaving the rest of the net unchanged and in practice making the normative highly ineffective to reduce mortality of juveniles fish.
- The dimension and the characteristics of the footrope (use of chains, type of joining, use of bobbins, use of tickler chains etc) should be fixed in relation with sea bottom characteristics, in order to avoid an increase in the physical bottom impact.
- The review of bottom trawl characteristics showed a strong increase in the net dimension in the last two decades, thus the CPUE recorded in the past should be compared with present data with caution, considering appropriate conversion factors. Information on the headrope length should be used as index of the swept area.
- Concerning the strengthening bags and chafers, most of the papers and reports collected, did not provide such information and the dimensions of the strengthening bag should be considered carefully. On the contrary the chafer is a question of minor concern because fishermen use chafer only for reducing the friction wear of the trawl.
- A detailed review of net designs and riggings in the Mediterranean should be done in order to obtain information useful for the reasonable management of fishing sector and for a better interpretation of the real fishing effort.
- In Italy a growing number of fishermen starting to change their activity from traditional bottom trawl towards twin trawl since 2004. Actually there is not a complete survey of the situation but it is possible to assume with reasonable certainty that around 20-30 % of the Adriatic trawling fleet is using such kind of nets. SGMED notes that multiple gear rigging represents another example of technological creep and related increases in fishing efficiency.

2. INTRODUCTION

The European Community is expected to establish long-term management plans (LTMP) for relevant Mediterranean demersal and small pelagic fisheries, based on the precautionary approach and adaptive management in taking measures designed to protect and conserve living aquatic resources, to provide for their sustainable exploitation and to minimise the impact of fishing activities on marine ecosystems (target and non-target species and habitats) following the Marine Strategy (Directive 2008/56/CE) and the Green Paper on the Reform of the CFP (COM(2009)163 final).

STECF can play an important role in focusing greater contributions for European scientists towards stocks and fisheries assessment, in identifying a common scientific framework regarding specific analyses to advise on Community plans, to be then channeled into or completed by the GFCM working groups.

STECF was requested at its 2007 November plenary session to set up an operational work programme for 2008, beginning in the 1st quarter of 2008, with a view to update the status of the main demersal stocks and evaluate the exploitation levels with respect to their biological and economic production potentials and the sustainability of the stock by using both trawl surveys and commercial catch/landing data as collected through the Community Data Collection Regulation N° 1543/2000 and the Data Collection Framework Regulation N° 199/2008 as well as other scientific information collected at national level.

To address the requests in 2010, the STECF Subgroup on the Mediterranean met three times. SGMED 10-01 (22-26 March) was held in Barcelona, Spain, with various recommendations regarding new stock assessements, biological parameters and software developments. SGMED 10-02 for assessments of demersal and small pelagic stocks met during 31 May - 4 June 2010, Heraklion, Crete, Greece. The expert group continued its work during the SGMED 10-03 meeting in Mazara del Vallo, Sicily Italy, 13-17 December 2010. The meeting was opened at 9:00 am on the 13st December, and closed at 17:00 on the 17th December. All three meetings built upon the work performed during SGMED meetings conducted during 2008 and 2009 to pursue the Commission's requests. Overall, a total of 27 scientists from several research centers and universities belonging to nine countries attended to the SGMED-10-03 meeting. For the first time, the meeting of SGMED was also attended by an observer from WWF Italy.

In accordance with the ToR related to stock assessments and scientific advice, the SGMED 10-03 report is structured into fife parts. The first main part of the report (section 3) deals with the issues related to data collection with the DCF framework. The second main part (section 4) presents 16 brief summary sheets of assessments of historic stock parameters, stock specific status (species and area) in relation to fisheries management reference points consistent with high long term yields and the respective scientific advice. This information updated and complements the statements of SGMED 10-02. Section 5 presents three reviews of the stock assessments undertaken by GFCM SCSA. Furthermore, section 6 contains deterministic short and stochastic medium term projections of stock size and catches of 37 stocks under various management secenarios along with specific management advice for 2011. The fifth part of this report (section 7) documents 17 assessments in detail with the basic data (as available), methods applied and results, even in cases where stock status could not be assessed and no scientific advice could be formulated. Also the detailed information is regarded as updates and complements of the work accomplished and reported by SGMED 10-02.

Section 8 represents SGMED continous discussions and findings regarding bio-economic model reviews and case studies. Data on individual fish condition, as a potential complementary source of information regarding stock health and status, have been collected by SGMED 10-03 and evaluated (see section 9). Furthermore, SGMED commented in section 10 on the status and aspects of the fishing techniques as used in the Mediterranean Sea.

2.1. Terms of Reference for SGMED-10-03

The overall terms of reference for the SGMED meetings are listed in Appendix 1. The specific terms of reference for SGMED-10-03 were:

During its meeting in Mazara del Vallo (13-17/12/2010), Italy, STECF/SGMED-10-03 is requested to

a) update and assess historic and recent stock parameters for the longest time series possible of the species listed below by GSAs or combined GSAs and parameters of their fisheries (by fleets) in the Mediterranean Sea, with emphasis on stocks previously assessed by SGMED and for which most recent fisheries data (2009) were not available during the SGMED-10-02 meeting in Crete (31/5-4/6/2010), Greece. Assessment data and methods are to be fully documented with particular reference to the completeness and quality of the data submitted by Member States as response to the official Mediterranean DCF data call issued on 29 April 2010 and reminded in October last. Such descriptions are to be forwarded to STECF/SGRN for its review and reconciliation of national programs. Data collected outside the DCF and/or delivered to the meeting by non-EU scientists shall be used as well and merged with DCF data whenever appropriate. Due account shall also be given to data used and assessments carried out within the FAO regional projects co-funded by the European Commission and EU-Member States in particular when using data collected through the DCF/DCR, EU funded research projects, studies and other types of EU funding.

- Sardine (*Sardina pilchardus*)
- Anchovy (*Engraulis encrasicolus*)
- European hake (*Merluccius merluccius*)
- Common sole (*Solea solea*)
- Red mullet (*Mullus barbatus*)
- Deep-water rose shrimp (*Parapenaeus longirostris*)
- Red shrimp (*Aristeus antennatus*)
- Giant red shrimp (*Aristaeomorpha foliacea*)
- Norway lobster (*Nephrops norvegicus*)

b) assess historic and recent stock parameters for the longest time series possible of the species listed below and parameters of their fisheries (by fleets) by all relevant individual GSAs in the Mediterranean Sea or combined GSAs where appropriate. Assessment data and methods are to be fully documented with particular reference to the completeness and quality of the data submitted by Member States as response to the official Mediterranean DCF data call issued on 29 April 2010 and reminded in October last. Data collected outside the DCF and/or delivered to the meeting by non-EU scientists shall be used as well and merged with DCF data whenever necessary. Due account shall also be given to data used and assessments carried out within the FAO regional projects co-funded by the European Commission and EU-Member States in particular when using data collected through the DCF/DCR and EU funded research projects, studies and other types of EU funding.

- Picarel (*Spicara smaris*)
- Other species of the Tables 1 and 2 of the official Mediterranean DCF data call issued on 29 April 2010 (see annex) with particular attention to: Common Pandora (*Pagellus erythrinus*), striped red mullet (*Mullus surmuletus*), bogue (*Boops boops*), sea bass (*Dicentrarchus labrax*), blue whiting (*Micromesistius poutassou*), gilthead seabream (*Sparus aurata*), Blackspot seabream, (*Pagellus bogaraveo*), Poor cod (*Trisopterus minutus*), Sargo breams (*Diplodus spp*), mackerel (*Scomber spp*),.spottail mantis squillid (*Squilla mantis*).

c) review of assessments of historic and recent stock parameters of demersal and small pelagic species listed under a) and b) and assessments of their fisheries in the Mediterranean Sea as conducted by other scientific frameworks including also national framework of non-EU countries. Due account shall be given in particular to data used and assessments carried out within the FAO regional projects co-funded by the European Commission and EU-Member States in particular when using data collected through the DCF/DCR and EU funded research projects, studies and other type of EU funding.

d) assess, review and propose biological fisheries management reference points of exploitation and stock size related to high yields and low risk of fisheries collapse in long term of each of the stocks listed under a) and

b) and assessed by SGMED or other scientific frameworks. Assessment data and methods are to be fully documented with particular reference to the completeness and quality of the data submitted by Member States as response to the official Mediterranean DCF data call issued on 29 April 2010 while also taking into account the outcomes of previous data calls. SGMED is requested to evaluate and comment on the consistency of other reference points with the management goal of high long term yields and low risk of fisheries collapse, i.e. $F_{0.2}$, 2/3 F_{MSY}, Z_{mbp}, F_{mbp}, F_{low}, F_{rep}, E<0.4, F_{pa} ,B_{pa} and B_{MSY}.

SGMED is requested to advice on the limit/threshold reference points, which are points indicating a state of a fishery and /or a resource which is considered to be undesirable and that management action shall avoid, which are more adequate for the Mediterranean fisheries on the basis of the data and time series available. Evaluate, in particular whether the following reference points F_{max}, F_{med}, E≥0.4, Z*, $F_{<25\%B}$ can be considered as adequate limit/threshold reference points.

e) advise on the recent status of exploitation and stock size of the species listed under a), b) and c) in relation to the biological fisheries management reference points F_{MSY} and $F_{0.1}$. SGMED is invited to consider in its advice any additional management reference points as evaluated and found appropriate under ToR d).

f) provide short term, medium term and long term forecasts of stock biomass and yield for the stocks assessed during the SGMED-10-02 meeting and any updated assessments, under different management options with a view to evaluate the consequences for fishing effort/mortality changes on equivalent time scale, by fishery/métier and fleets (i.e. GSA) where possible. Short, medium and long term forecast scenarios should include:

- the status quo

and

- target to F_{MSY} or other appropriate proxies for 2011,2015 and 2020, respectively.

The identification and description of the fisheries/métier to be considered are left to the experts on the basis of their knowledge of fisheries in each GFCM-GSA.
The simulation by fishery for the abovementioned targets shall be driven either by the most relevant stock(s) (either in quantity and/or economic value), or the most vulnerable stock or a scientifically weighed mix of MSY targets for the species involved in the fishery.

To advise on stock-size dependent harvesting strategies and slope based approaches decision control rules to avoid risk situations for the stocks while ensuring high fisheries productivity, taking into account the recommendation of the SGMED-09-02 meeting in June 2009 and the subsequent STECF comments with specific attention to small pelagic stocks (STECF-10-03).

Consequences of important by-caught stocks in mixed fisheries should be quantified if possible or at least indicated. Such analyses should fully document all applied methodologies and data used for the projections in accordance with the achievements of SGMED-09-03.

g) If not yet fully accomplished in previous SGMED and SGECA meetings, and based on the “Survey of existing bio-economic models” under Studies and Pilot Projects for carrying out the Common Fisheries Policy No FISH/2007/07 and data made available by MS, complete the review of existing bio-economic models for producing advice on possible short-term and long-term economic consequences of the selected harvesting strategies. Evaluate the possibility to use existing bioeconomic models for comparing the proposed harvesting strategies with long-term economic profitability (MEY) of the main fisheries exploiting the assessed stocks. SGMED is requested in particular to advise on the appropriateness to dealing with Mediterranean bio-economic analyses within its expertise while improving attendance of economists or to undertake such efforts under the umbrella of STECF SGECA in 2011 and onwards.

h) On the basis of short term, medium term and long-term forecasts for different management scenarios evaluated under point f), to provide economic forecasts for the same fisheries and time scale. With a view to evaluate the bioeconomic consequence of the different scenarios, due account must be given also to other relevant species not yet evaluated and which are caught as by-catch in the same fishery or because the same vessel with the same fishing gear may target two different species during the same fishing trip (e.g. scallop in the "rapido" beam trawl fishery for flatfish).
Whenever possible the technical interactions among trawlers, beam trawlers; longliners and bottom set nets, exploiting one or more of the following species shall be taken into account:
Hake, red mullet, Norway lobster, common sole; blue whiting, common Pandora; deep-water rose shrimp, red giant shrimps, red and violet shrimp, sole.
The identification and description of the fisheries/métier to be considered are left to the experts on the basis of their knowledge of fisheries in each GFCM-GSA.
The simulation by fishery for the abovementioned targets shall be driven either by the most relevant stocks (either in quantity and/or economic value), or the most vulnerable stock or a scientifically weighed mix of MSY targets for the species involved in the fishery.

i) review the DCF data call in 2010 for Mediterranean stocks, fisheries and surveys and suggest adjustments on data needs and quality of data called in the DCF in 2011. JRC will provide a specific working document dealing with improved harmonization and better use of scientific capacities in the different types of research teams (e.g. national fisheries institutes, universities research teams, private research teams, etc.).

l) evaluate the appropriateness of individual fish condition factors as indicator of stock health or status, considering that morphometric condition factors might indicate changes in reproductive potential at both individual and population levels. In particular, SGMED-10-03 is requested to estimate and analyze the variation in time series of historic weight and length data (Fulton's and liver indices) available from various SGMED experts and provided on a voluntary basis. Comparative evaluations focused on the estimated recruitment variation should be undertaken to evaluate the importance of the above described working hypothesis and its impact on sustainable fisheries strategies.

TECHNOLOGICAL ASPECTS OF FISHING GEARS
m) - to provide a synoptic overview of the maximum, minimum and/or average dimensions (length, circumference) of both the cod-end and extension piece used in the Mediterranean bottom trawl nets fisheries of EU countries in particular.

- To provide the relative importance of the cod-end with respect to the entire length of the trawl net
- To provide the relative importance of the lifting bag with respect to the whole cod-end
- To identify what are the technical elements and attachments to a trawl net that allow to distinguish between the cod-end and the extension piece. Specific attention shall be given to the types, positions and numbers of chafers, strengthening bag, lifting strips, round strips etc.
- Annex

TABLE 1: Additional species as included in the data collection regulations.

Species common name	Species scientific name	FAO CODE
1. Bogue	*Boops boops*	BOG
2. Common dolphinfish	*Coryphaena hippurus*	DOL
3. Sea bass	*Dicentrarchus labrax*	BSS
4. Grey gurnard	*Eutrigla gurnardus*	GUG
5. Black-bellied angler	*Lophius budegassa*	ANK
6. Anglerfish	*Lophius piscatorius*	MON
7. Blue whiting	*Micromesistius poutassou*	WHB

8.	Grey mullets (Mugilidae)	Mugilidae	MUL
9.	Common Pandora	*Pagellus erythrinus*	PAC
10.	Caramote prawn	*Penaeus kerathurus*	TGS
11.	Mackerel	*Scomber* spp.	MAZ
12.	Common sole	*Solea solea (=Solea vulgaris*)	SOL
13.	Gilthead seabream	*Sparus aurata*	SBG
14.	Spottail mantis squillids	*Squilla mantis*	MTS
15.	Mediterranean horse mackerel	*Trachurus mediterraneus*	HMM
16.	Horse mackerel	*Trachurus trachurus*	HOM
17.	Tub gurnard	*Trigla lucerna (= Chelidonichthys lucerna)*	GUU

TABLE 2: Additional species not included in the data collection regulations .

Species common name	Species scientific name	FAO CODE
1. Sargo breams	*Diplodus* spp.	SRG
2. Axillary seabream	*Pagellus acarne*	SBA
3. Blackspot seabream	*Pagellus bogaraveo*	SBR
4. Greater forkbeard	*Phycis blennoides*	GFB
5. Poor cod	*Trisopterus minutus*	POD

2.2. Participants

The full list of participants at SGMED-10-03 is presented in Appendix 2.

3. DCF DATA (TOR I)

3.1. Data policy

Working Group members were reminded that data collected under the DCF call and supplied to SGMED-10-03 for all GSAs could not be used outside the meeting. The data are stored by the EU to enable future assessments under the auspices of SGMED or related groups, to be performed without the need to produce further DCF calls.

3.2. Summary of data provided for the Mediterranean through the 2010 DCF call by DG MARE

3.2.1.*Data call*

On the 29th of April 2010 DG MARE launched an official call for data on landings, discards, length and age compositions, fishing effort, scientific trawl and hydro-acoustic surveys in the Mediterranean Sea. A reminder letter for the data call was issued by DG MARE on the 25th of October and forwarded to the National Correspondents by JRC. The 15th of November (21 calendar days) was set as deadline. However this date was already mentioned in the first data call issued in April 2010.

This data call was issued with a view in particular to complete the data transmission of fisheries data and scientific surveys missing from the first submission. It mainly refers to the upload of the 2010 survey data for both demersal and small pelagic stocks (e.g. Medits, Grund, Ecomed, Pelmed, Sardine, Anchovy, Depm, hydro acoustic surveys, and other international and national surveys considered useful to improve stocks and fisheries assessments). Special attention was given to the upload of the 2009 catch data still missing for some Member States (Cyprus and Italy) and the economic files that had not been previously submitted for the bio-economic modelling.

The call covered the years:

- 2002-2009 for fisheries data
- 1994-2010 for MEDITS data
- 1990-2010 for small pelagic surveys
- 2002-2008 (mandatory) and 2009 (if available) for the economic variables

Survey data for 2010 should have been provided before 15 November 2010. Table 3.1 shows the species for which fisheries data were requested for the below stated variables:

- Landings
- Effort
- Length distribution of landings
- Age distribution of landings
- Maturity ogive at length
- Maturity ogive at age
- Growth parameters
- Sex ratio at length
- Sex ratio at age
- Discards
- Length distribution of discards
- Age distribution of discards

Further data on more stocks: i) additional species as included in the data collection regulations and for which Member States are invited to provide relevant data (Table 3.2.1) and ii) additional species not included in the data collection regulations and for which interested Member States are invited to provide relevant data (Table 3.2.2) were also expected to be uploaded before 15 November 2010.

Table 3.2.1 Species for which fisheries data were requested through the data call.

Species common name	Species scientific name	FAO CODE
European hake	*Merluccius merluccius*	HKE
Red mullet	*Mullus barbatus*	MUT
Striped red mullet	*Mullus surmuletus*	MUR
Picarel	*Spicara smaris*	SPC
Deep-sea rose shrimp	*Parapenaeus longirostris*	DPS
Red shrimp	*Aristeus antennatus*	ARA
Giant red shrimp	*Aristaeomorpha foliacea*	ARS
Norway lobster	*Nephrops norvegicus*	NEP
Anchovy	*Engraulis encrasicolus*	ANE
Sardine	*Sardina pilchardus*	PIL

Table 3.2.2 Additional species as included in the data collection regulations and for which Member States are invited to provide relevant data.

Species common name	Species scientific name	FAO CODE
Bogue	*Boops boops*	BOG

Common dolphinfish	*Coryphaena hippurus*	DOL
Sea bass	*Dicentrarchus labrax*	BSS
Grey gurnard	*Eutrigla gurnardus*	GUG
Black-bellied angler	*Lophius budegassa*	ANK
Anglerfish	*Lophius piscatorius*	MON
Blue whiting	*Micromesistius poutassou*	WHB
Grey mullets (Mugilidae)	*Mugilidae*	MUL
Common Pandora	*Pagellus erythrinus*	PAC
Caramote prawn	*Penaeus kerathurus*	TGS
Mackerel	*Scomber spp.*	MAZ
Common sole	*Solea solea (=Solea vulgaris)*	SOL
Gilthead seabream	*Sparus aurata*	SBG
Spottail mantis squillids	*Squilla mantis*	MTS
Mediterranean horse mackerel	*Trachurus mediterraneus*	HMM
Horse mackerel	*Trachurus trachurus*	HOM
Tub gurnard	*Trigla lucerna (= Chelidonichthys lucerna)*	GUU

Table 3.2.3 Additional species not included in the data collection regulations and for which interested Member States are invited to provide relevant data.

Species common name	Species scientific name	FAO CODE
Sargo breams	*Diplodus spp.*	SRG
Axillary seabream	*Pagellus acarne*	SBA
Blackspot seabream	*Pagellus bogaraveo*	SBR
Greater forkbeard	*Phycis blennoides*	GFB
Poor cod	*Trisopterus minutus*	POD

The survey data referred to the International Bottom Trawl Survey in the Mediterranean (MEDITS) and the ECOMED, PELMED, DEPM and all hydro acoustic surveys. The complete MEDITS dataset was requested for all species recorded and involved the following file types:

- Type A file (data on the haul)
- Type B file (catches by haul)
- Type C file (biological parameters)
- Type D file (Temperature data and codes for the temperature measuring systems)
- Type T file (List of hauls by stratum)

From the small pelagic surveys data were requested on the:

- Length structure of the data
- Age structure
- Maturity at age

Economic data were requested for the following indicators:

- Capacity
- Employment
- Income
- Expenditure
- Capital and Investments
- Effort
- Landings

The various definitions for variables, aggregation levels, and legislation by navigating through the data collection website are documented at following link
https://datacollection.jrc.ec.europa.eu/home

3.2.2. *JRC support to the 2010 DCF MED data call (overview)*

Since the beginning of 2010 and following the requirements of the administrative arrangement with DG MARE, JRC further developed the dedicated DCF website (https://datacollection.jrc.ec.europa.eu/) to make it more user-friendly and accessible for data providers, and the appropriate data infrastructures were designed to host the collected data. At the same time, JRC developed quality assurance aspects of the data submitted by Member States by:

a) using **automatic quality checking tool** to check the quality and validate the data provided by Member States,
b) **evaluating the data** provided by Member States,
c) creating **special data structures** (e.g. tables) to allow monitoring of incoming data and its compliance with the requirements of the data call.

More specifically, during the uploading process the following checks were made:

a) **Syntactic** checks: Data type and size (reject any data that does not confirm to the given restrictions, ie. Values > 0, ratios between 0-1, upper and lower bounds of the variables)
b) **Semantic** checks: Constraints on variable values/contents also based on other variables
c) **Completeness** checks (missing values)
d) **Coverage** status of submitted data (years, areas, fleet segments)
e) Data **duplication** checks (double records)

In case of error: an **error message** is produced, with instructions and cell position.

Excel upload files were needed for transmitting the datasets. Upload templates with all the accepted codifications and range of values were made available to download from the data collection website. Experts were advised that the structure of the worksheet templates should not be altered before the uploading procedure.

3.2.3. *Uploading and data delivery*

2010 was the third continous year during wich data were requested from the Member States. The IT uploading features and tools were fully operational. In terms of the completeness of the Member States data submissions, most countries submitted the vast majority of parameters requested under the call.

In terms of quality, the use of the automatic upload of JRC has improved the quality by identifying formatting, codification and duplication errors that existed in the datasets. Those errors had to be corrected before the successful uploading. However, a number of 'errors' for various parameters that were submitted, were detected by JRC. These 'errors' have to be clarified by the Member States and/or corrected.

Cyprus: All the fisheries requested datasets, with the exception of effort, were uploaded the week following the deadline, along with some economic datasets. The second week some economic datasets were submitted, whereas the third week the survey data. However the datasets were also sent by email on the 15th of November. No surveys for small pelagics are taking place in Cyprus, as reported by the National correspondent.

Greece: No datasets requested by the 2010 Mediterranean data call were submitted.

France: All the fisheries requested datasets (with the exception of discards and the related files) were uploaded the day of the deadline, along with the data for small pelagic surveys. The same day the MEDITS files (that were not submitted during the first call) were also submitted but they were successfully uploaded two days later, with the exception of TC file that was successfully uploaded the following week. However the datasets were also sent by email on the 15th of November. The economic variables were submitted successfully during the first call.

Italy: Italy started the upload procedure before the deadline, and submitted the majority if the fisheries data along with some MEDITS files on time. The economic files were uploaded on the 15th of November, with the TB file and the remaining TC was entirely uploaded that week. On the 2nd of December the discards related files and the age distribution of landings were submitted again (although previously successfully uploaded). The TD and TT files were not submitted. Italy resubmitted the economic files with more data compared to the first call. The small pelagics files were not updated during the second call and the maturity at age file is still missing. For the first time Italy managed to upload successfully the fisheries and survey datasets using the JRC server. Major deficiencies were missing landings and discards data for 2009 after the first deadline and missing 2010 survey data after the second deadline.

Malta: Malta uploaded some fisheries datasets, the MEDITS files and the economic variables the third week after the deadline for submission, and finished its uploading the week before the experts group meeting.

According to the national correspondent the late submission was due to the late approval they received to send the data. Malta is exempted from many DCF data provisions.

Slovenia: All the requested files were submitted during the first call in May. Slovenia is exempted from many DCF data provisions.

Spain: Spain submitted only the survey data (MEDITS and small pelagics) at the day of the deadline of the second call and during the following day. All the fisheries data had been uploaded during the first call, except the effort file, which is still missing. Spain did not submit any datasets for the economic variables requested by the 2010 Mediterranean data calls.

In order for JRC to process and prepare the data for the assessment working groups, the datasets need to be available from the EU Member States well in advance (4 weeks) before the beginning of the relevant assessment meetings. No data should be accepted after the deadline for submission. Any progress in data submissions in terms of compliance with uploading procedures and data consistencies will disburden the necessary preparations for the STECF working groups. In addition and in accordance with the provisions of the DCF to allow appropriate data preparation by Member States, SGMED recommends future data calls to be issued at least 2 months in advance of assessment meetings to allow for the necessary data preparations and processes.

3.2.4. *Data quality review*

SGMED-10-03 working group has recognized that the actual DCF data call as defined and conducted in 2010 to support its analysis in accordance with the ToR from DG MARE significantly improved as compared with previous calls but still had limited success with regard to scientific requirements. Certain data submissions continued to be generally late (after the defined submission date) and erroneous in many instances. This applies to the fisheries data as well as to the scientific survey data and economic data. SGMED indentified significant inconsistencies between the landings by species declared in the various tables, which appeared further questionable because the submitted age and length compositions hardly covered the declared landings (checking the sum of products SOP) but rather non-raised portions.

Consequently, SGMED could not base all its deliveries (stock, fisheries assessments and management advice) on DCF data but also frequently relied rather on the expert's data. Data origins are indicated in the relevant follow sections of the analyses presented.

3.3. Proposed changes to the 2011 DCF Mediterranean and Black Sea data call by DG MARE

SGMED 10-03, based on a working document from JRC (Harmonization of DCF data calls for STECF SGMED, SGBlackSea and SGMOS, by Hans-Joachim Rätz, Anna Cheilari, John Anderson, Jordi Guillen, Nikolaos Mitrakis, Franca Contini and Antonella Zanzi) reviewed the the 2010 DCF Mediterranean and Black Sea data call by DG Mare. SGMED 10-03 recognized that the actual DCF data call as defined and conducted in 2010 to support its analysis in accordance with the ToR significantly improved as compared with previous calls but still had limited success with regard to scientific requirements.

SGMED recognized further that the actual DCF data call as defined and conducted in 2010 was very complex (27 individual tables) and also redundant for certain parameters. The complexity and redundancy had created a high workload and thus might have contributed to the late and erroneous data submissions. Given the high complexity of the data call, it was also considered impossible to undertake an effective data quality review during SGMED meetings.

SGMED considered this situation extremely unsatisfactory and assumed that it is unlikely that the data quality would be significantly improved in the coming years. SGMED undertook a thorough review of the DCF data call in 2010 and proposes a substantial re-definition of the DCF data call in 2011 regarding the fisheries data. This re-definition constrains the data call to the essential fisheries, survey and economy data as necessary to cover SGMED's and SGBlackSea analyses and considers a harmonization towards other data calls under the DCF. Additional data sets of general biological parameters shall be added after the submitted data have been reviewed, corrected and checked as error free. As such, the proposed DCF data call 2011 for the SGMED is largely consistent with other European marine regions, i.e. Baltic, North Atlantic (including wider North Sea and western continental slopes) and the Black Sea.

The proposed re-definition of the DCF 2011 data call for SGMED and the Black Sea is summarized below and given in detail in the Appendix 3 of this report. SGMED considers this revision as less work demanding for data creators and reviewers (14 tables defined and requested instead of 27) and, at the same time, more effectively using the national expertise in the various national labs concerned.

3.3.1. *Fisheries data for stock and fisheries assessments*

SGMED concluded that the strictly necessary data are fleet (area, year, quarter, fishing technique, and métier) and species specific landings and discards, each of them broken down by ages 0-20 with mean weight and length at age (Appendix 3.1 A). In addition, SGMED identified the need of length compositions of both landings and discards in order to apply length-based assessment methods (Appendix 3.2 B and 3.3 C). The requested fishing effort data in units of kW*days at sea, GT*days at sea and numbers of vessels being active in the fleet were interpreted as necessary for fisheries assessments (Appendix 3.4 D).

3.3.2. *Economic data*

SGMED has reviewed the economic data call to support the analyses of STECF's fisheries economy experts SGECA, which is consistent with the DCF definitions, in comparison with the economic data called by DG Mare to support SGMED. The parameters of both data calls are laregely identical but the number of parameters called is smaller in the 2010 SGMED data call. The economic experts found that the geographical aggregation level appears inappropriate to elaborate the specific ToRs given to SGMED. SGMED experts therefore requests a revision of the SGMED data call in 2011 towards a finer disaggregation of the parameters by GFCM geographical sub-areas (SA), which is required for the given ToR. Such finer aggregation of economic data is consistent with the fishereies data aggregation defined above, except that the data are requested only by year and not by quarter. SGMED recognizes that such revised data call for economic data is inconsistent with the DCF regulation and that such inconsistency would ideally require pre-agreements with the Member States regarding voluntary aggregation and submission of the economic data at the specific aggregation level defined in Appendixes 3.5 E and 3.6 F.

Parameters previously requested for the SGMED but not required for the evaluations and thus deleted from the proposed data call are:

- Income from fishing rights
- Value of fishing rights

3.3.3. *Scientific survey data*

The review of the Mediterranean and Black Sea data call in 2010 revealed that it is well defined in accordance with the data needs of SGMED and be kept unchanged apart from minor restuctering (flat table structure over requested length or age classes, joining of survey data from the Mediterranean and Black Sea). Such part of the data call dealing with scientific survey data is therefore repeated in Appendixes 3.7 G to 3.14 O.

3.4. Data quality check of new Medits data base

3.4.1. *Introductory notes*

Following the recommendations of SGMED (Barcelona) a new data call was issued in May 2010 for MEDITS data. This call requested the specification of a GSA field in TA, TB and TC files and multiple quality checks. A new MEDITS DB (*SGMED 2010 MEDITS_uploaded tables 06122010.mdb*) was build and has been tested using the R MEDITS standardization script developed by Bartolino, Osio and Scott. The new DB structure differs from the previous one available to SGMED scientist and the main differences are the following: Genus and Species are in separate columns, haul mid position, mean haul depth and swept area are absent and need to be calculated with the R script. The R script (mainly "*db.connection.R*" and other parts of the script) was modified to the maximum extent possible during the meeting but testing was limited. The new script handles the new database and further capabilities were added such as calculating swept area, mean depth and mid haul position automatically.

3.4.2. *Data base testing*

We explored the trends of species not currently under assessment following the official Mediterranean DCF data call issued on 29 April 2010 and TOR b for the present meeting. The following are the investigated species: picarel (*Spicara smaris*), common Pandora (*Pagellus erythrinus*), striped red mullet (*Mullus surmuletus*), bogue (*Boops boops*), sea bass (*Dicentrarchus labrax*), blue whiting (*Micromesistius poutassou*), gilthead seabream (*Sparus aurata*), blackspot seabream, (*Pagellus bogaraveo*), poor cod (*Trisopterus minutus*), sargo breams (*Diplodus spp*), mackerel (*Scomber spp*) and spottail mantis squillid (*Squilla mantis*).

The frequency of occurrence of these species over a total number of 14651 hauls carried out in all GSAs since the beginning of MEDITS is reported in table below.

Specie	N. positive Hauls	Specie	N. positive Hauls
Sparus aurata	97	*Pagellus bogaraveo*	*2498*
Pagellus erythrinus,	3750	*Trisopterus minutus*	*5311*
Mullus surmuletus	3304	*Diplodus annularis*	*1346*
Boops boops	4975	*Diplodus vulgaris*	*319*
Dicentrarchus labrax	*69*	All *Diplodus*	*1724*
Micromesistius poutassou	*3784*	All *Scomber*	*1315*
Squilla mantis	*1338*		

We made a first screening of the species and *Sparus aurata, Dicentrarchus labrax* and *Diplodus* (with the exception of *D. annularis*) occur with such low frequency in MEDITS that cannot be used for assessment purposes and will not be further investigated. *Scomber* spp. length frequency measurements are available in TC file only for GSA 25 and 9, albeit in very low numbers. The remaining species are tested with the R script to explore the temporal trend, spatial distribution of CPUEs and suitability for stock assessment purposes using MEDITS data.

The goal was to explore each species in each GSA, to plot the yearly maps with 0 hauls and the cpue, and construct a plot of the observed and predicted mean annual cpue with their confidence intervals derived from fitting a GLM model. The R script queries the MEDITS database for one species and one GSA at a time. The data by weight was extracted from the MEDITS database via a query using RODBC. The data from file TA and TB are merged and further data manipulations are made in order to run the models (See User Manual). The queries used data only stored in files TA and TB of the MEDITS database but not TC so length frequency data in the new MEDITS db are untested.

We used the same approach developed at SGMED 10-02 and it was decided to adopt the same standardization GLM model for all species and GSAs. A quasi-GLM model estimates the cpue based on the effects of Year, Month, Depth and the interaction of Long and Lat, and, relies on a Poisson family distribution and a log link function. The Quasi-Poisson GLM was used as it can deal with a moderate number of zeroes and over-dispersion in the data. Cpue is defined as $kg \cdot km^{-2}$ and the model in R code is the following:

```
mod       <-       glm(CPUE~factor(YEAR)+factor(MONTH)+Latitude*Longitude+DEPTH,
family=quasipoisson, data=TB)
```

A stepwise model selection and diagnostics checks were not performed as the number of species and GSA's was too high for the time available.

We need to stress an important caveat before showing the results of the models fitted to the new MEDITS data. Most of the species investigated present very low frequencies of occurrence and thus different levels of zero inflation. For example in the case of *Pagellus erythrinus* in GSA 01 out of 604 hauls resulted 511 zero hauls, which is indicative of a strong zero inflation. In such case the number of zeroes is much higher than a quasi Poisson distribution can handle and for this reason the CI's are unrealistic. For many investigated species, if not the majority, zero inflation is severe and on a case by case the researcher should decided appropriate models to estimate realistic trends. The following flow diagram could be followed:

1. No or low zero inflation -> GLM with Gaussian/Poisson family distribution

2. Low to moderate zero inflation-> quasi-GLM with Poisson family distribution or GLM with Negative Binomial distribution

3. Moderate to strong zero inflation-> Zero inflated models where zeroes are modeled separately from the positive values (Delta GLM, ZIP and ZINB models)

In the current exercise zero inflation was not accounted explicitly with Zero Inflated models. As a consequence, in many cases the model and the family distribution used are not appropriate and thus model prediction can return poor predictions of the mean annual cpue and CIs. This can be seen for many species where the trends are flat with ballooning CI's, these most likely are the cases that need zero inflated models and are steps that will need to be carried out in the future.

3.4.2.1. GSA 01

The hauls in this GSA seem correct with the exception of one in one in 2008 and overall the data does not present major errors for the species investigated. However the wing opening in file TA is zero in all hauls of 1994 and prevents the calculation of the cpue.

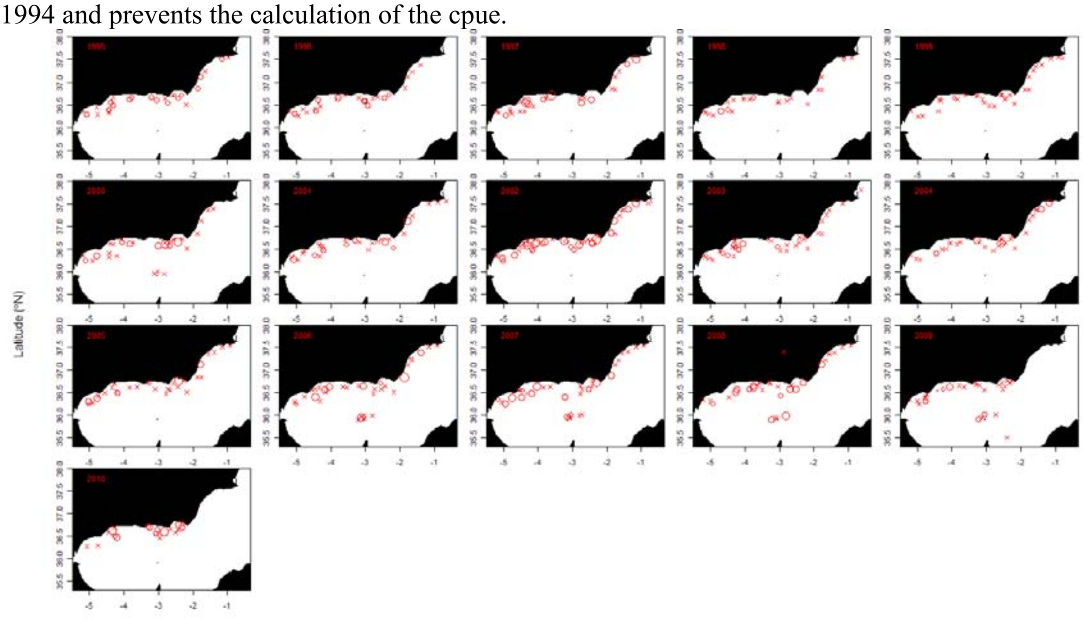


Figure 3.4.2.1.1. Position of zero hauls (cross symbols) and positive hauls (bubbles proportional to CPUE (kg/km^{-2})) for *Micromesistius poutassou* in GSA 01 from MEDITS survey from 1996 to 2010.

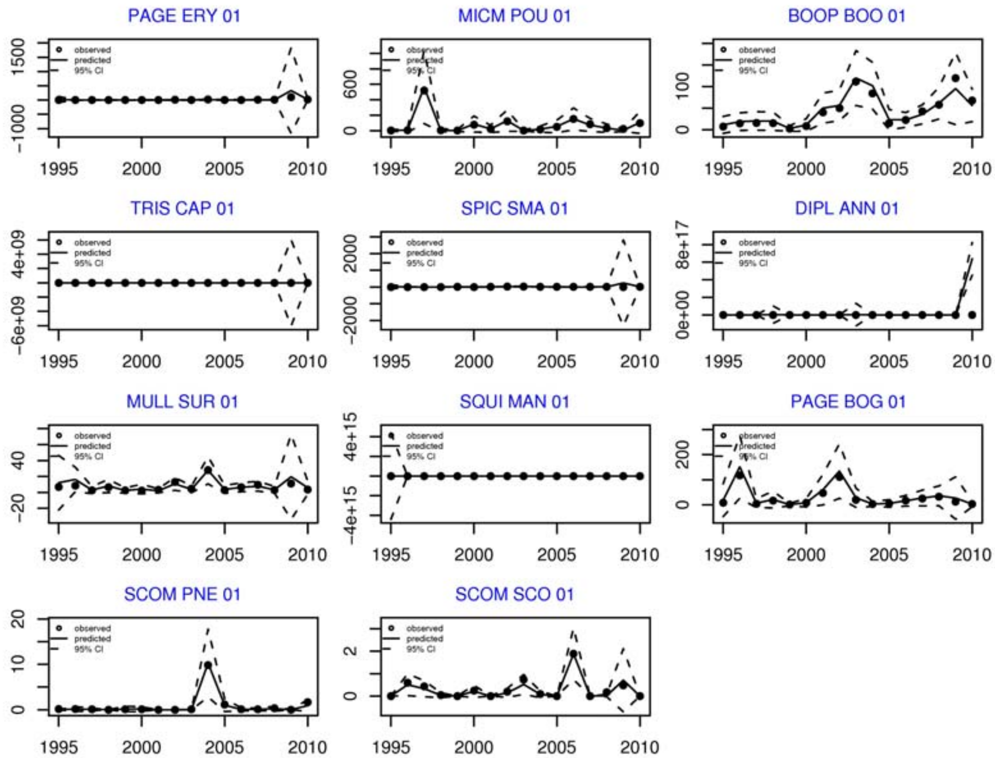


Figure 3.4.2.1.2 Mean observed and predicted (+/- 95% CI) cpue (kg·km^{-2}) trends over time in GSA 01. Species tested are *Pagellus erythrinus* (PAGE ERY), *Micromesistius poutassou (MICM POU), Squilla mantis (SQUI MAN), Boops boops (BOOP BOO), Trispoterus minutus (TRIS CAP), Spicara smaris (SPIC SMA), Mullus surmuletus (MULL SUR), Pagellus bogaraveo (PAGE BOO), Diplodus vulgaris (DIPL VUL), Scomber scomber (SCOM SCO) and Scomber japonicus (SCOM PNE).* Species that do not appear in plot are absent from GSA investigated.

The species that present reliable trends are *Micromesistius poutassou, Mullus surmuletus, Pagellus bogaraveo, Boops boops* and *Scomber scomber* while for the remaining species the numbers of zeroes is too high for the current models.

3.4.2.2. GSA 05

MEDITS data is available for 4 hauls only over the period 1994-2006 and for 50 hauls for the period 2007-2009. This is consistent with the true situation in terms of data collection. The new data base solved the spatial problems present in the old one (SGMED 2009 MEDITS_survey_data_20100601.mdb). Given the low number of hauls in the old period we modeled the CPUEs only for the recent period.

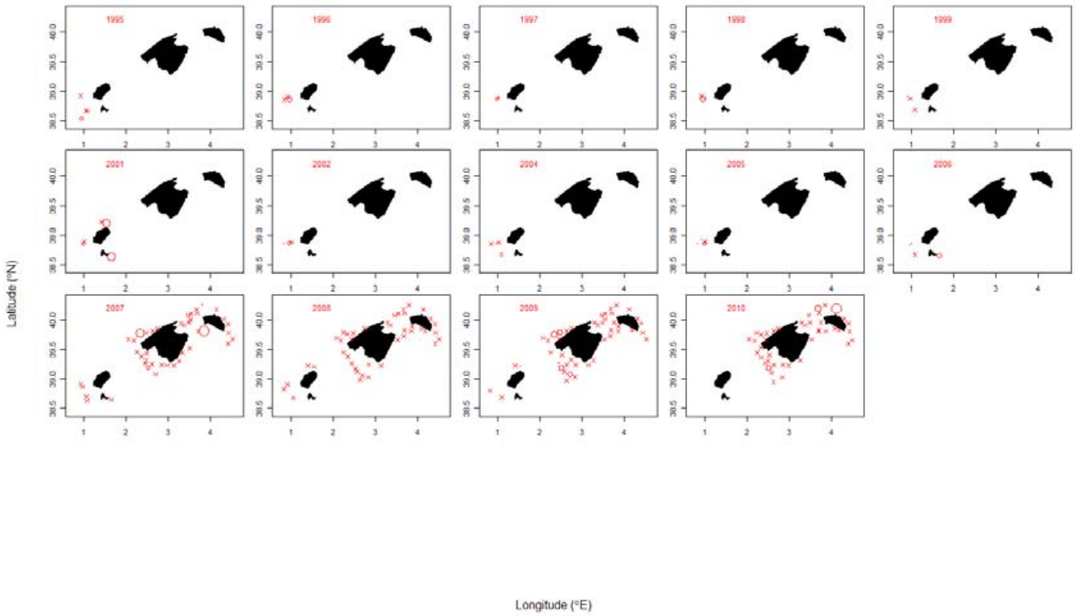


Figure 3.4.2.2.1. Position of zero hauls (cross symbols) and positive hauls (bubbles proportional to CPUE (kg/km^{-2})) for *Micromesistius poutassou* in GSA 05 from MEDITS survey from 1996 to 2010.

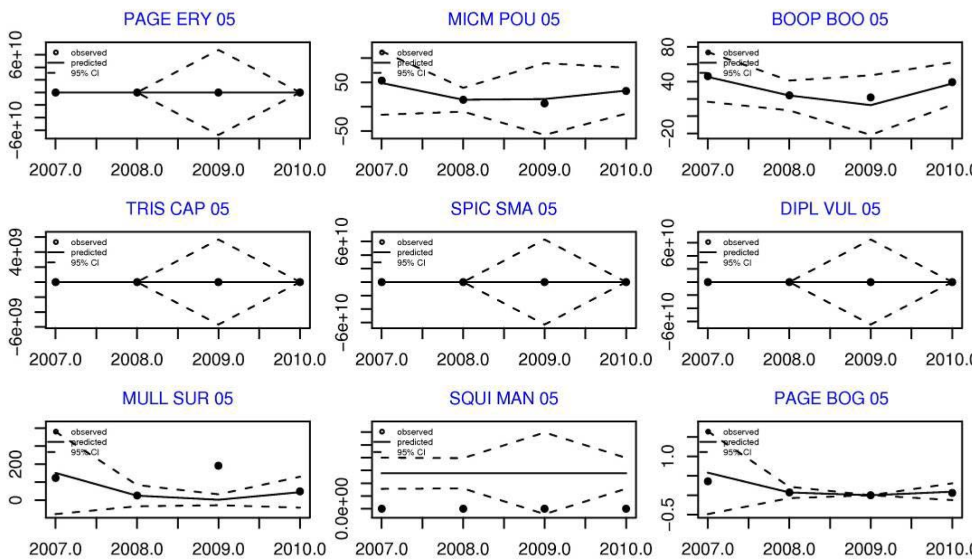


Figure 3.4.2.2.2 Mean observed and predicted (+/- 95% CI) cpue (Kg·Km^{-2}) trends over time in GSA 05. Species tested are *Pagellus erythrinus* (PAGE ERY), *Micromesistius poutassou (MICM POU), Squilla mantis (SQUI MAN), Boops boops (BOOP BOO), Trispoterus minutus (TRIS CAP), Spicara smaris (SPIC SMA), Mullus surmuletus (MULL SUR), Pagellus bogaraveo (PAGE BOO), Diplodus vulgaris (DIPL VUL), Scomber scomber (SCOM SCO) and Scomber japonicus (SCOM PNE).* Species that do not appear in plot are absent from GSA investigated.

The species that present reliable trends are *Micromesistius poutassou, Mullus surmuletus, Pagellus bogaraveo, Boops boops* while for the remaining species the numbers of zeroes is too high for the current models.

3.4.2.3. GSA 06

Most haul positions appear to be correct with the exception of 1 tow in 2000, 2 tows in 2009 and approximately 11 in 2007. The large number of incorrect haul positions in 2007 is likely related to incorrect specification of the shooting/hauling quadrant that is used to determine if Longitude is positive or negative by the R Script. The problems of spatial overlap between GSAs displayed by the previous database are solved in the current version.

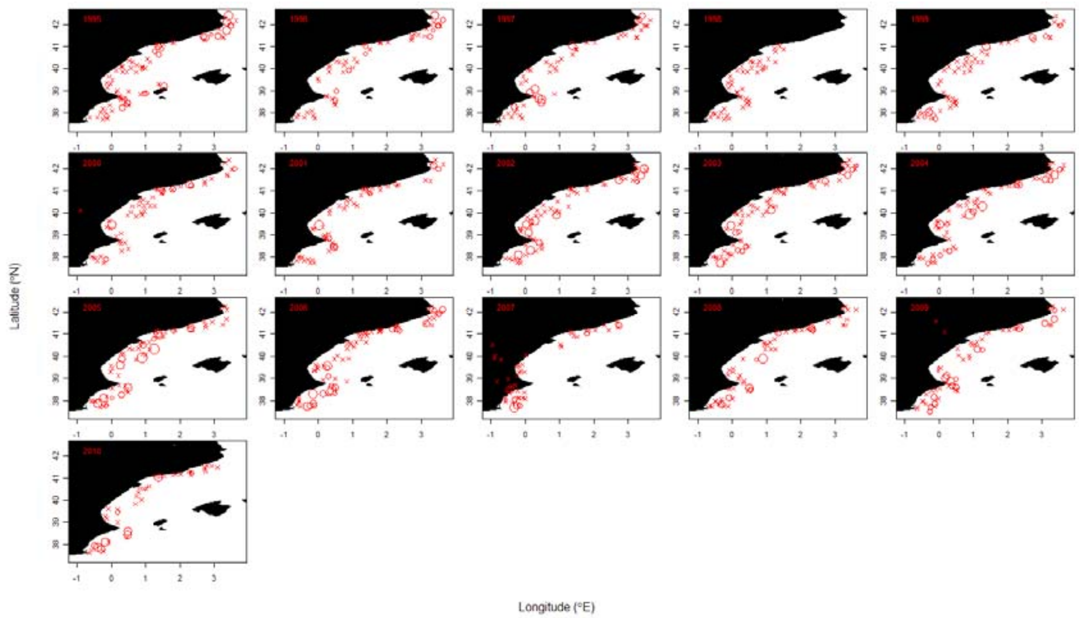


Figure 4.4.2.3.1. Position of zero hauls (cross symbols) and positive hauls (bubbles proportional to CPUE (kg/km^{-2})) for *Micromesistius poutassou* in GSA 06 from MEDITS survey from 1996 to 2010.

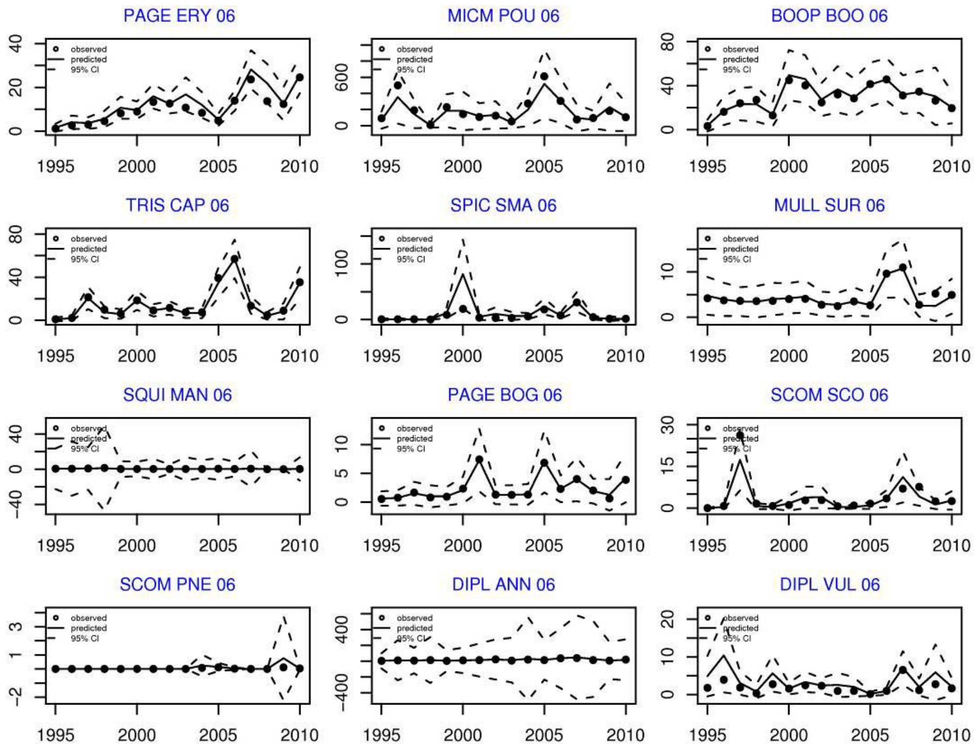
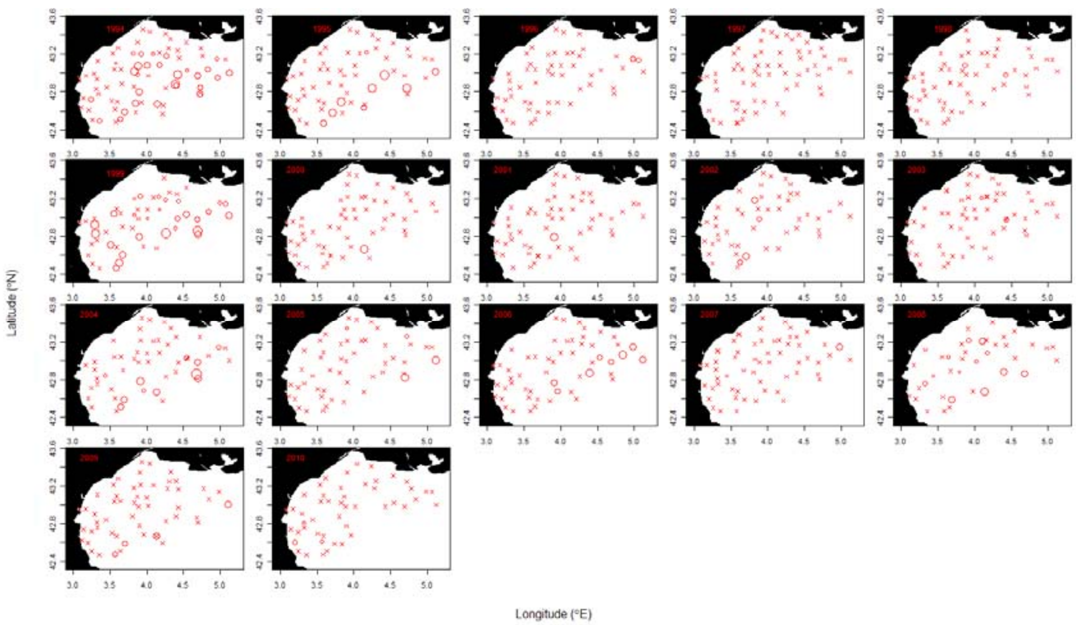


Figure 3.4.2.3.2 Mean observed and predicted (+/- 95% CI) cpue (kg·km^{-2}) trends over time in GSA 06. Species tested are *Pagellus erythrinus* (PAGE ERY), *Micromesistius poutassou (MICM POU), Squilla mantis (SQUI MAN), Boops boops (BOOP BOO), Trispoterus minutus (TRIS CAP), Spicara smaris (SPIC SMA), Mullus surmuletus (MULL SUR), Pagellus bogaraveo (PAGE BOO), Diplodus vulgaris (DIPL VUL), Scomber scomber (SCOM SCO) and Scomber japonicus (SCOM PNE).* Species that do not appear in plot are absent from GSA investigated.

All the species tested return realistic trends with the exceptions of *Scomber japonicus*, *Diplodus annularis* and *Squilla mantis*, which are clearly zero inflated and cannot be modeled with a quasi poisson distribution.

3.4.2.4. GSA 07

The data from GSA 7 does not present problems in the TA and TB files tested and it fixed errors present in prior database (SGMED 2009 MEDITS_survey_data_20100601.mdb).



3.4.2.4.1 Figure 2 Position of zero hauls (cross symbols) and positive hauls (bubbles proportional to CPUE (kg/km^{-2})) for *Pagellus Bogaraveo* in GSA 7 from MEDITS survey from 1994 to 2010.

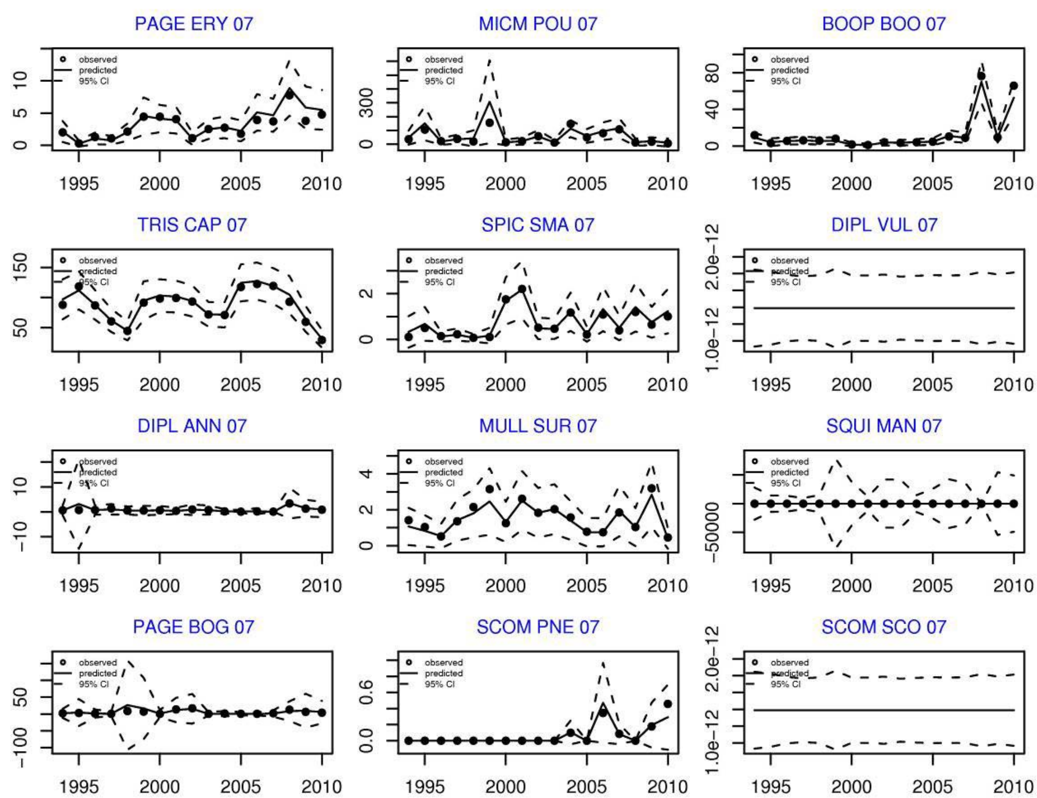


Figure 3.4.2.4.2 Mean observed and predicted (+/- 95% CI) cpue (kg·km^{-2}) trends over time in GSA 07. Species tested are *Pagellus erythrinus* (PAGE ERY), *Micromesistius poutassou (MICM POU), Squilla mantis (SQUI MAN), Boops boops (BOOP BOO), Trispoterus minutus (TRIS CAP), Spicara smaris (SPIC SMA), Mullus surmuletus (MULL SUR), Pagellus bogaraveo (PAGE BOO), Diplodus vulgaris (DIPL VUL),*

Diplodus annularis (DIPL ANN), Scomber scomber (SCOM SCO) and Scomber japonicus (SCOM PNE). Species that do not appear in plot are absent from GSA investigated.

Of the tested species all display realistic trends with the exception of *Diplodus vulgaris*, *Squilla mantis* and *Scomber scomber*, which are clearly zero inflated and cannot be modeled with a quasi poisson distribution.

3.4.2.5. GSA 08

The haul positions appear to be correct and no major errors emerge from TA and TB files for this GSA.

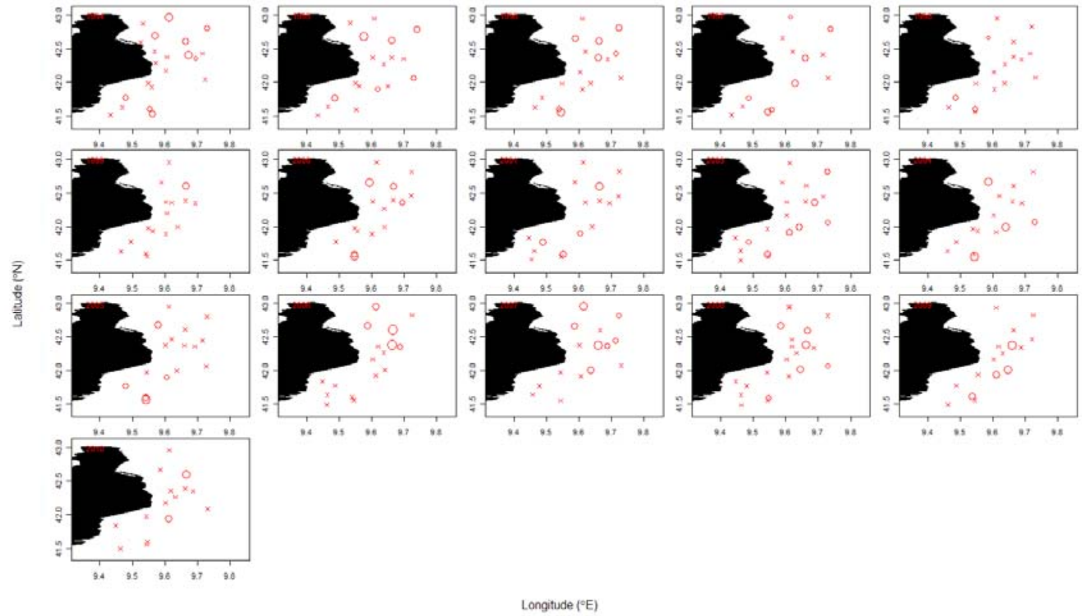


Figure 3.4.2.5.1. Position of zero hauls (cross symbols) and positive hauls (bubbles proportional to CPUE (kg/km^{-2})) for *Micromesistius poutassou* in GSA 08 from MEDITS survey from 1996 to 2010.

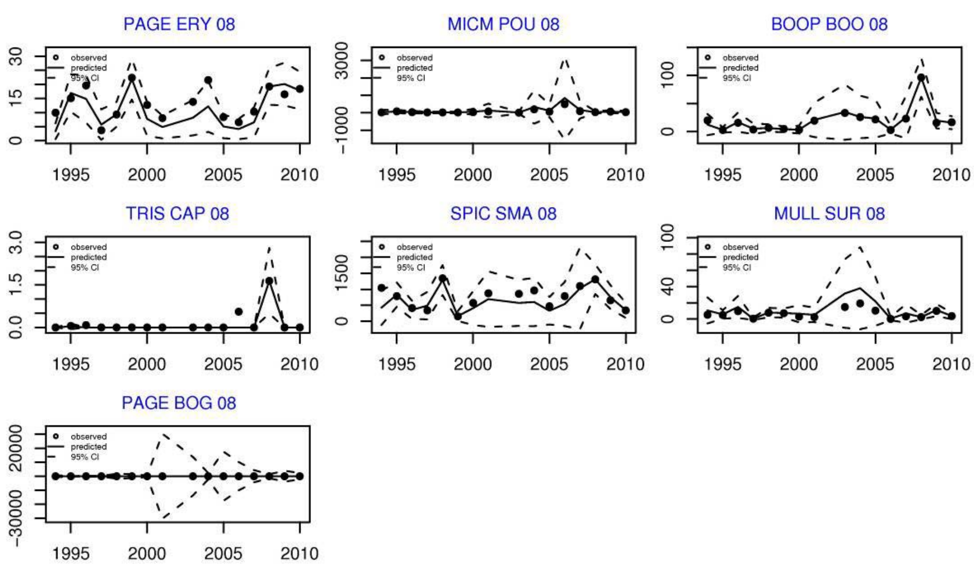


Figure 3.4.2.5.2 Mean observed and predicted (+/- 95% CI) cpue (kg·km^{-2}) trends over time in GSA 08. Species tested are *Pagellus erythrinus* (PAGE ERY), *Micromesistius poutassou (MICM POU), Squilla mantis (SQUI MAN), Boops boops (BOOP BOO), Trispoterus minutus (TRIS CAP), Spicara smaris (SPIC SMA), Mullus surmuletus (MULL SUR), Pagellus bogaraveo (PAGE BOO), Diplodus annularis (DIPL ANN), Diplodus vulgaris (DIPL VUL), Scomber scomber (SCOM SCO) and Scomber japonicus (SCOM PNE).* Species that do not appear in plot are absent from GSA investigated.

The few species present in the database for this GSA present realistic trends with the exceptions of *Micromesistius poutassou* and *Pagellus bogaraveo,* which are clearly zero inflated and cannot be modeled with a quasi poisson distribution.

3.4.2.6. GSA 09

The new MEDITS db thanks to the GSA declaration in both TA and TB file solves the problems of tows overlap with GSA10 that were present in the previous database (SGMED 2009 MEDITS_survey_data_20100601.mdb). There are however the following incorrect tow positions: 2 in 1999, 1 in 2000, 4 in 2001, 3 in 2004 and 4 in 2008. Data for 2010 are missing entirely while in 1994 the Wingspread is 0 in all hauls and swept area and cpue can't be calculated.

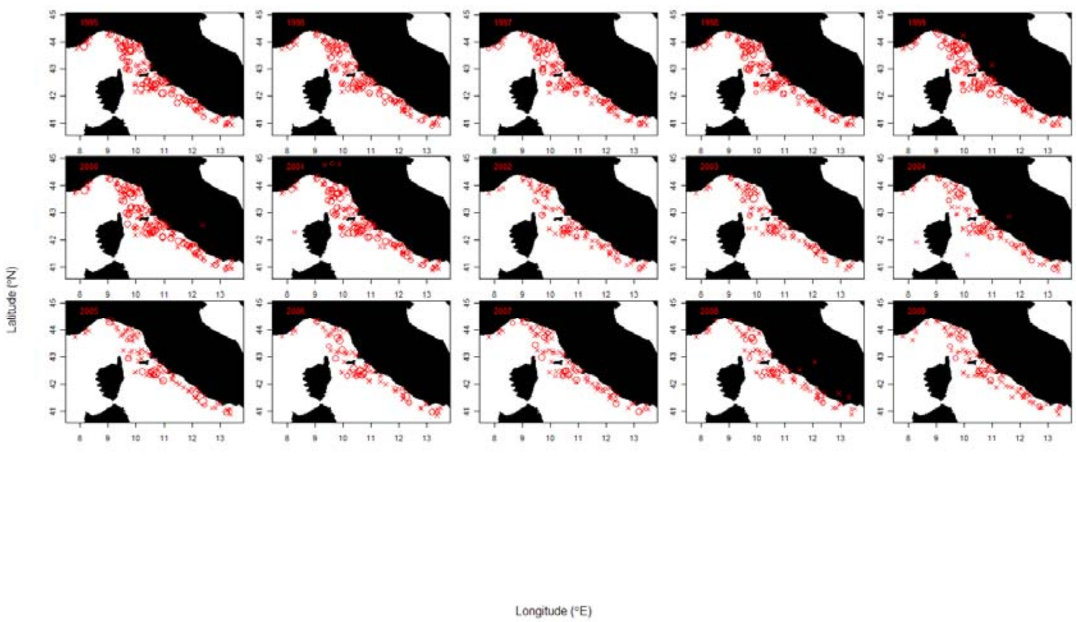


Figure 3.4.2.6.1. Position of zero hauls (cross symbols) and positive hauls (bubbles proportional to CPUE (Kg/km^{-2})) for *Micromesistius poutassou* in GSA 09 from MEDITS survey from 1995 to 2009.

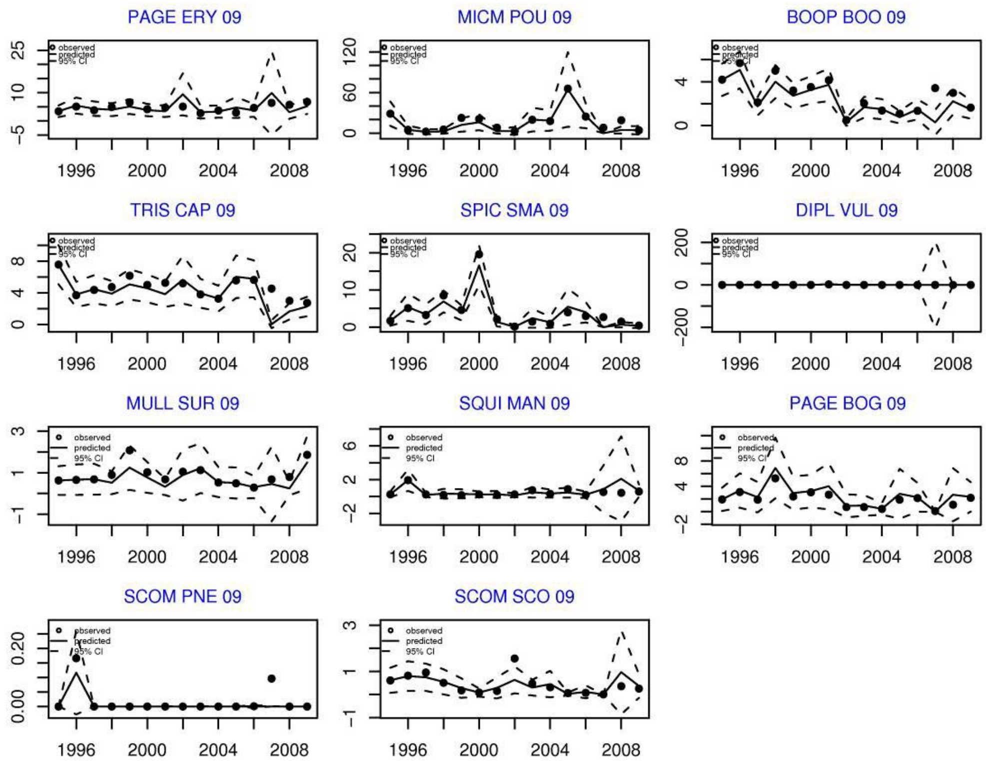


Figure 3.4.2.6.2 Mean observed and predicted (+/- 95% CI) cpue (kg·km^{-2}) trends over time in GSA 08. Species tested are *Pagellus erythrinus* (PAGE ERY), *Micromesistius poutassou (MICM POU), Squilla mantis (SQUI MAN), Boops boops (BOOP BOO), Trispoterus minutus (TRIS CAP), Spicara smaris (SPIC SMA), Mullus surmuletus (MULL SUR), Pagellus bogaraveo (PAGE BOO), Diplodus annularis (DIPL ANN), Diplodus vulgaris (DIPL VUL), Scomber scomber (SCOM SCO) and Scomber japonicus (SCOM PNE).* Species that do not appear in plot are absent from GSA investigated.

With the exceptions of *Diplodus vulgaris* and *Scomber japonicus*, the remaining species present realistic trends although the effect of the few incorrect haul specifications could have an effect in the cpue standardization and should be rectified in the future.

3.4.2.7. GSA 10

The new MEDITS db thanks to the GSA declaration in both TA and TB file solves the problem of tows overlap with GSA09 that were present in the previous database (SGMED 2009 MEDITS_survey_data_20100601.mdb). Data for 2010 is missing.

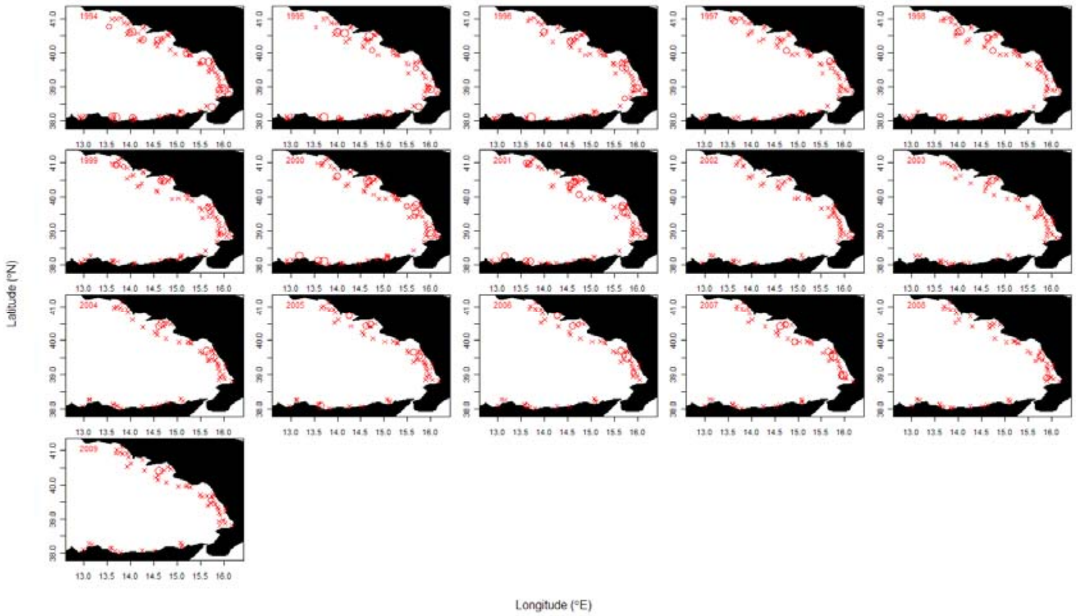


Figure 3.4.2.7.1. Position of zero hauls (cross symbols) and positive hauls (bubbles proportional to CPUE (kg/km^{-2})) for *Micromesistius poutassou* in GSA 10 from MEDITS survey from 1996 to 2010.

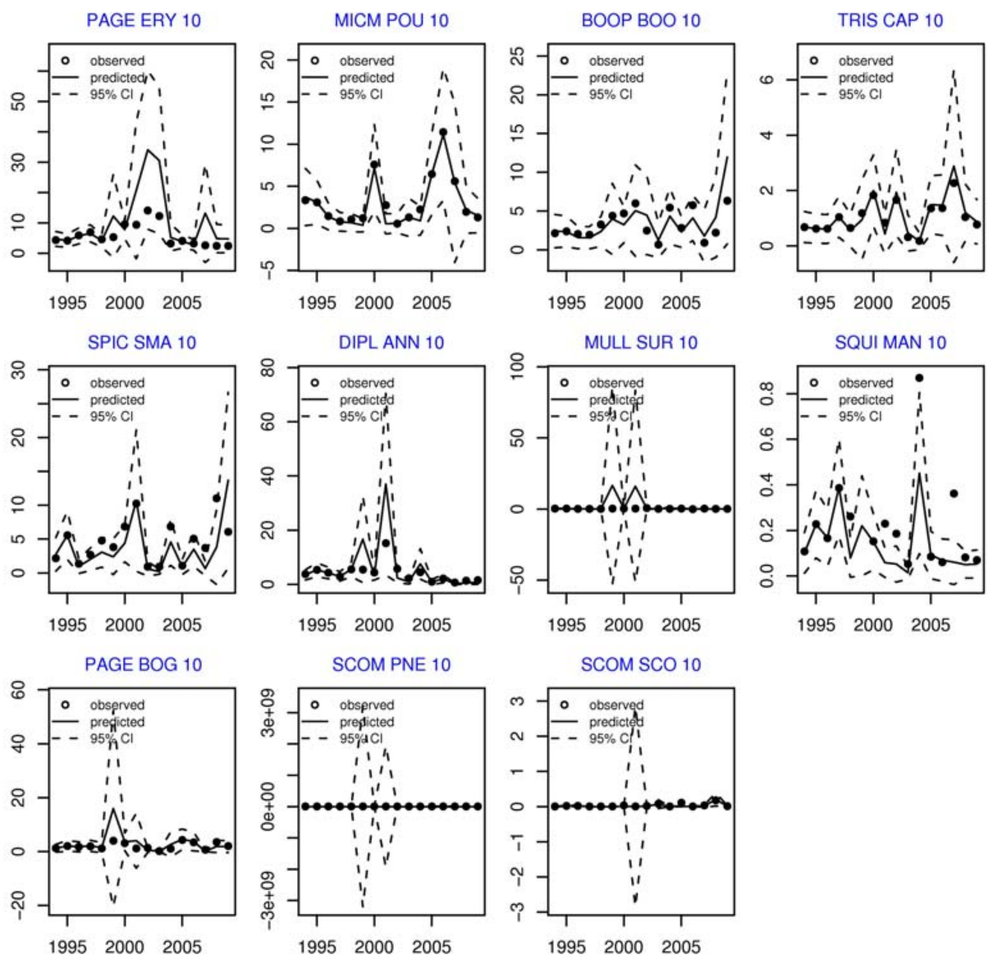


Figure 3.4.2.7.2 Mean observed and predicted (+/- 95% CI) cpue (Kg·Km^{-2}) trends over time in GSA 08. Species tested are *Pagellus erythrinus* (PAGE ERY), *Micromesistius poutassou (MICM POU), Squilla mantis (SQUI MAN), Boops boops (BOOP BOO), Trispoterus minutus (TRIS CAP), Spicara smaris (SPIC SMA), Mullus surmuletus (MULL SUR), Pagellus bogaraveo (PAGE BOO), Diplodus annularis (DIPL ANN), Diplodus vulgaris (DIPL VUL), Scomber scomber (SCOM SCO) and Scomber japonicus (SCOM PNE).* Species that do not appear in plot are absent from GSA investigated.

With the exceptions of *Diplodus annularis*, *Mullus surmuletus*, *Pagellus bogaraveo*, *Scomber japonicus* and *Scomber scomber*, all other species plotted present realistic trends that are suitable for assessment purposes.

3.4.2.8. GSA 11

There is one incorrect haul position in 1999 and 2001 that causes the mapping on a very large spatial scale. Data for year 2010 are missing. Besides this the data for the investigated species does not present evident errors.

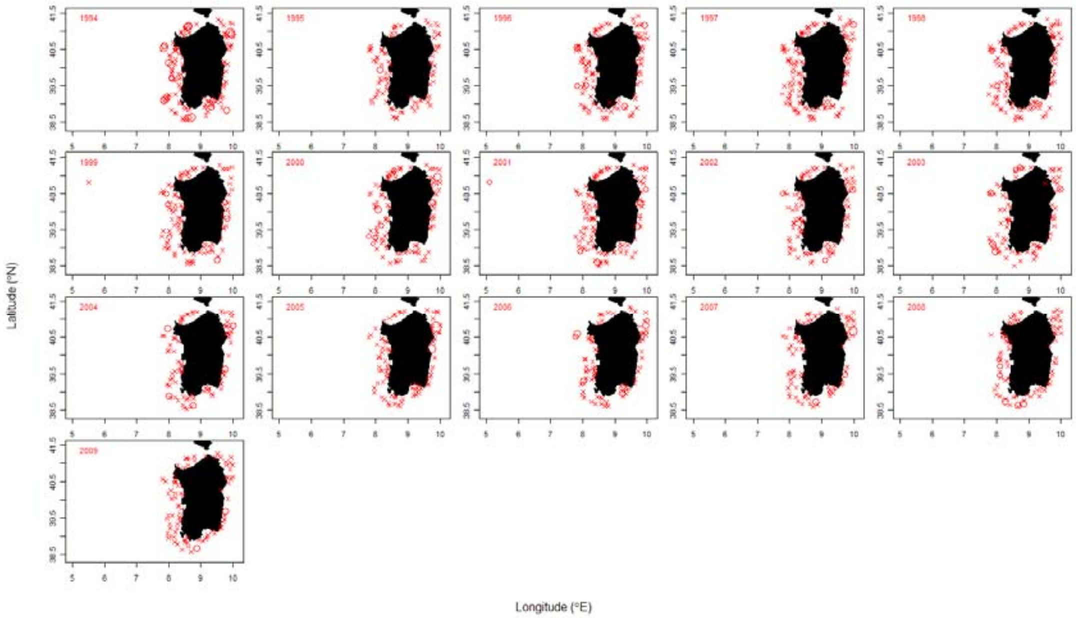


Figure 3.4.2.8.1. Position of zero hauls (cross symbols) and positive hauls (bubbles proportional to CPUE (kg/km^{-2})) for *Micromesistius poutassou* in GSA 11 from MEDITS survey from 1996 to 2009.

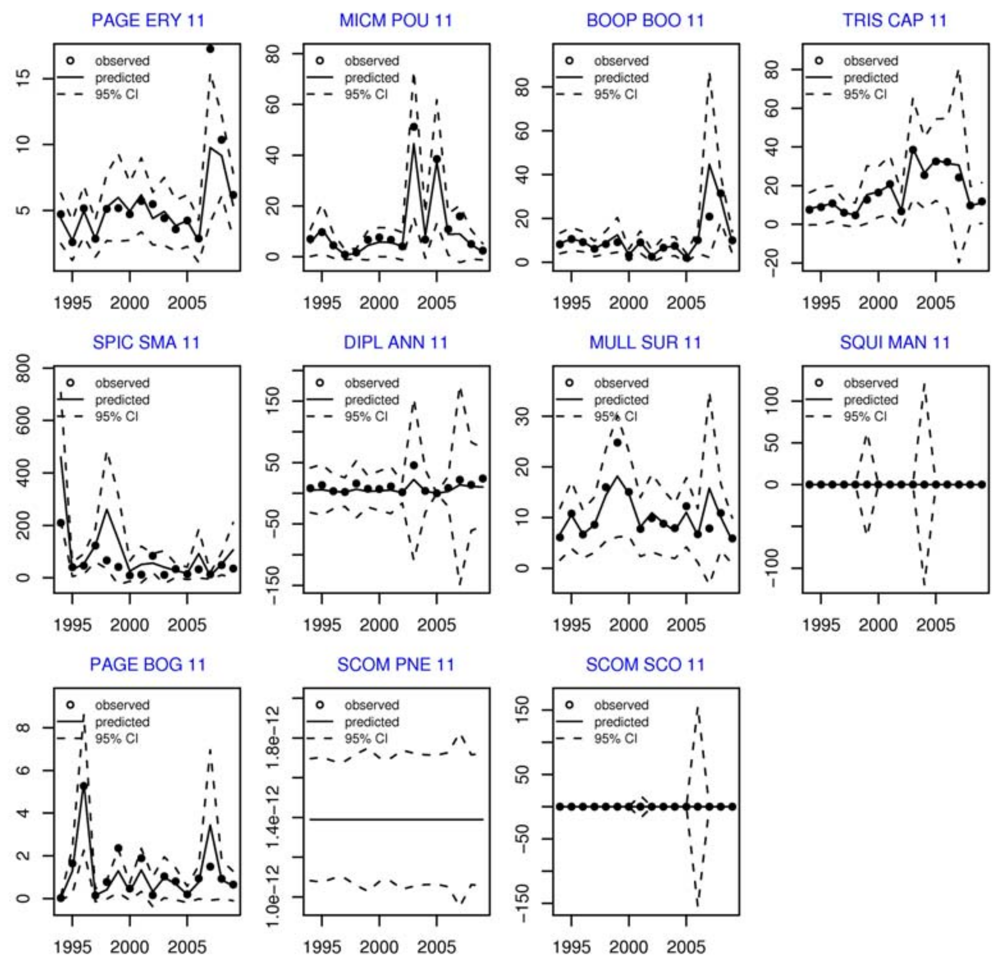


Figure 3.4.2.8.2 Mean observed and predicted (+/- 95% CI) cpue (kg·km^{-2}) trends over time in GSA 08. Species tested are *Pagellus erythrinus* (PAGE ERY), *Micromesistius poutassou (MICM POU), Squilla mantis (SQUI MAN), Boops boops (BOOP BOO), Trispoterus minutus (TRIS CAP), Spicara smaris (SPIC SMA), Mullus surmuletus (MULL SUR), Pagellus bogaraveo (PAGE BOO), Diplodus annularis (DIPL ANN), Diplodus vulgaris (DIPL VUL), Scomber scomber (SCOM SCO) and Scomber japonicus (SCOM PNE).* Species that do not appear in plot are absent from GSA investigated.

Of the investigated species all display realistic trends with the exceptions of the two *Scomber* species and *Squilla mantis*.

3.4.2.9. GSA 15

MEDITS data specific to GSA 15 is available from 2003 to 2010, the haul positions do not present problems and the erroneous overlapping of hauls with GSA16 present in the previous available database is solved.

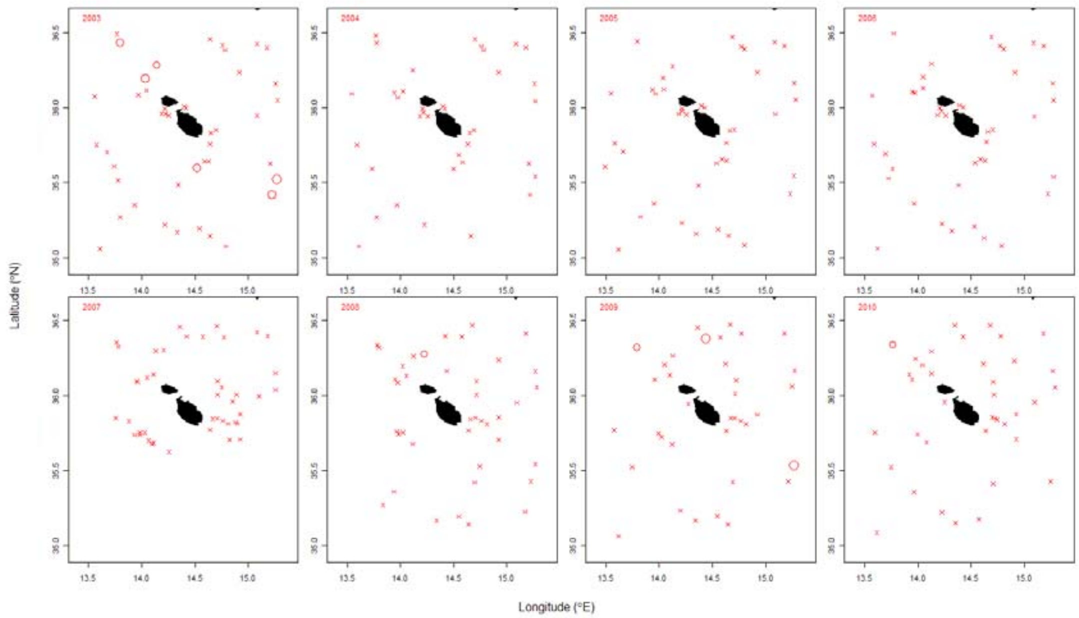


Figure 3.4.2.9.1. Position of zero hauls (cross symbols) and positive hauls (bubbles proportional to CPUE (kg/km^{-2})) for *Micromesistius poutassou* in GSA 15 from MEDITS survey from 1996 to 2010.

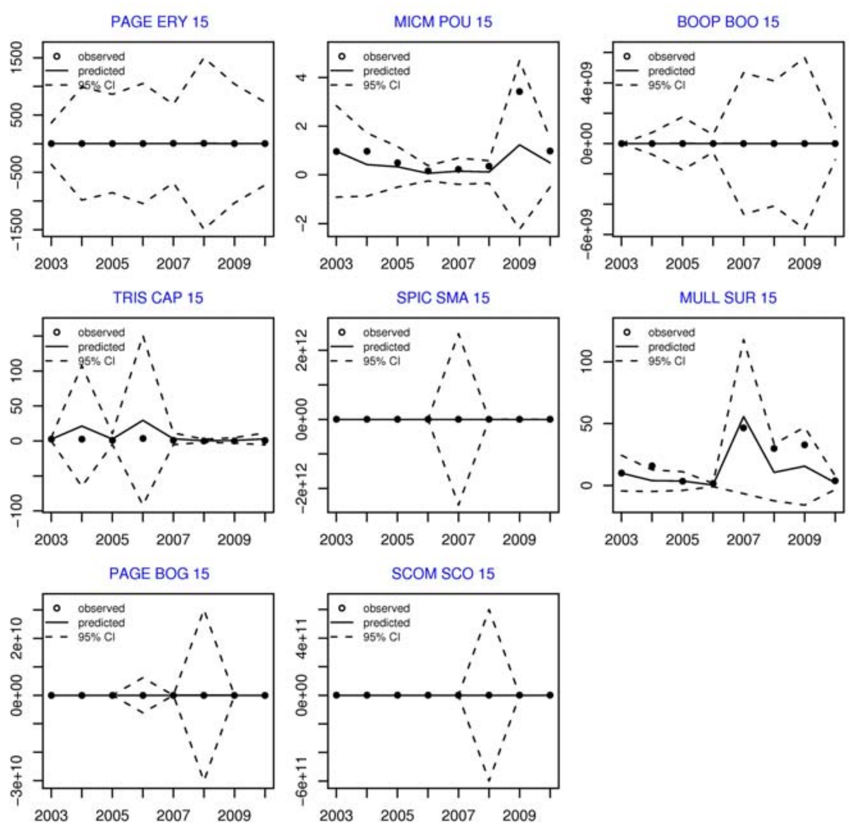


Figure 3.4.2.9.2 Mean observed and predicted (+/- 95% CI) cpue (Kg·Km^{-2}) trends over time in GSA 08. Species tested are *Pagellus erythrinus* (PAGE ERY), *Micromesistius poutassou (MICM POU), Squilla mantis (SQUI MAN), Boops boops (BOOP BOO), Trispoterus minutus (TRIS CAP), Spicara smaris (SPIC SMA), Mullus surmuletus (MULL SUR), Pagellus bogaraveo (PAGE BOO), Diplodus annularis (DIPL*

ANN), Diplodus vulgaris (DIPL VUL), Scomber scomber (SCOM SCO) and Scomber japonicus (SCOM PNE). Species that do not appear in plot are absent from GSA investigated.

Given the short time span and small area it might not be very meaningful to estimate trends for this GSA only. In this case all species with the exception of *Mullus surmuletus* and *Micromesistius poutassou* present a strong zero inflation that the applied quasi-poisson distrbution cannot handle properly.

3.4.2.10. GSA 16

The problems of overlap hauls overlap between GSA 15 and 16 are solved with the new database. All hauls seem correct and no major errors emerge from the db for the species tested. Over time there has been a notable increase in the number of hauls performed. Data for 2010 are missing.

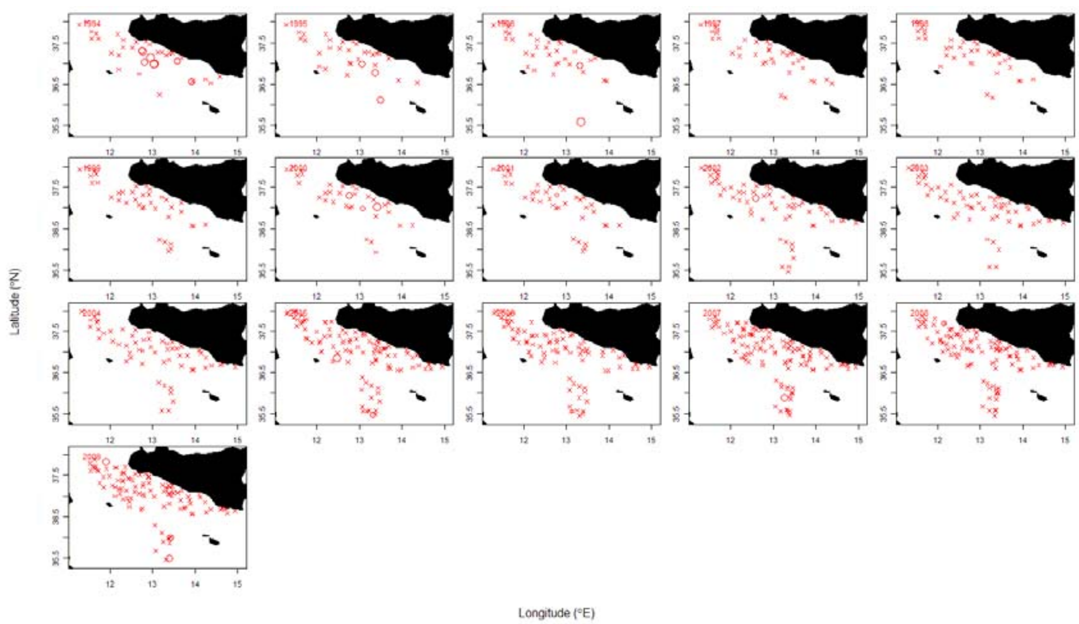


Figure 3.4.2.10.1. Position of zero hauls (cross symbols) and positive hauls (bubbles proportional to CPUE (kg/km^{-2})) for *Micromesistius poutassou* in GSA 16 from MEDITS survey from 1994 to 2009.

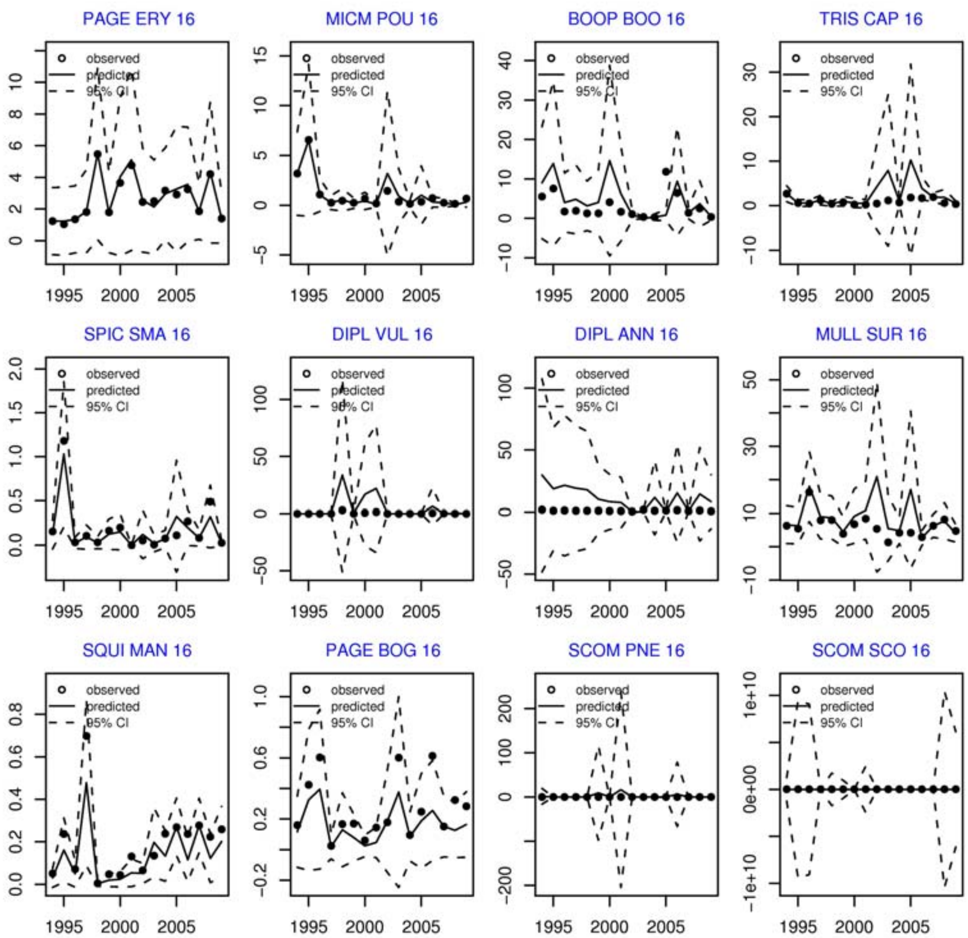


Figure 3.4.2.10.2 Mean observed and predicted (+/- 95% CI) cpue (Kg·Km^{-2}) trends over time in GSA 08. Species tested are *Pagellus erythrinus* (PAGE ERY), *Micromesistius poutassou (MICM POU), Squilla mantis (SQUI MAN), Boops boops (BOOP BOO), Trispoterus minutus (TRIS CAP), Spicara smaris (SPIC SMA), Mullus surmuletus (MULL SUR), Pagellus bogaraveo (PAGE BOO), Diplodus annularis (DIPL ANN), Diplodus vulgaris (DIPL VUL), Scomber scomber (SCOM SCO) and Scomber japonicus (SCOM PNE).* Species that do not appear in plot are absent from GSA investigated.

Except the *Scomber* and *Diplodus* species, all other display realistic trends although the CI's in many cases are very high.

3.4.2.11. GSA 17

The MEDITS data for this GSA is available for the Italian data in TA and TB files for the period 2003-2009 and for TC only for 2003-2008; Slovenian data is available since 1996 till 2009. As the data are pooled in the same GSA the few hauls performed in Slovenia when modeled with the Italian and Croatian data return very unreliable estimates for the period 1996-2002 and are therefore removed in order to produce more realistic CPUEs for the 2002-2009 period. The new database is an improvement over the previous available to SGMED as data now cover also the Croatian side which balances the spatial coverage of the data. The hauls present in the database do not present problems.

The group stresses, as in SGMED 10-02, the complete lack of the MEDITS data for the period 1994-2002.

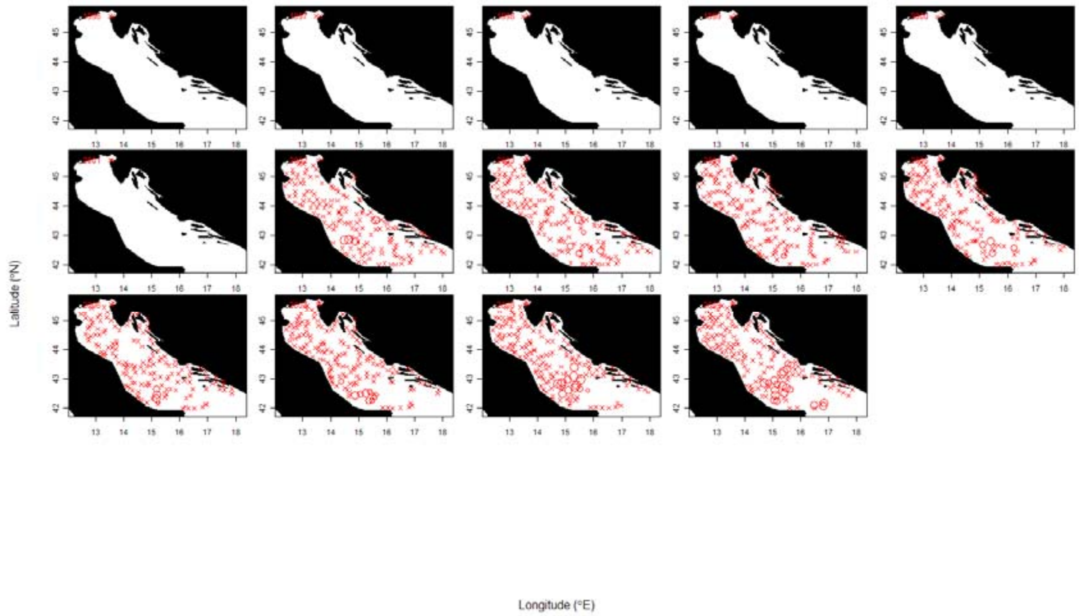


Figure 3.4.2.12.1 Position of zero hauls (cross symbols) and positive hauls (bubbles proportional to CPUE (kg/km^{-2})) for *Micromesistius poutassou* in GSA 17 from MEDITS survey from 1996 to 2009. Data from 1994-2002 (except Slovenia) and 2010 is not available.

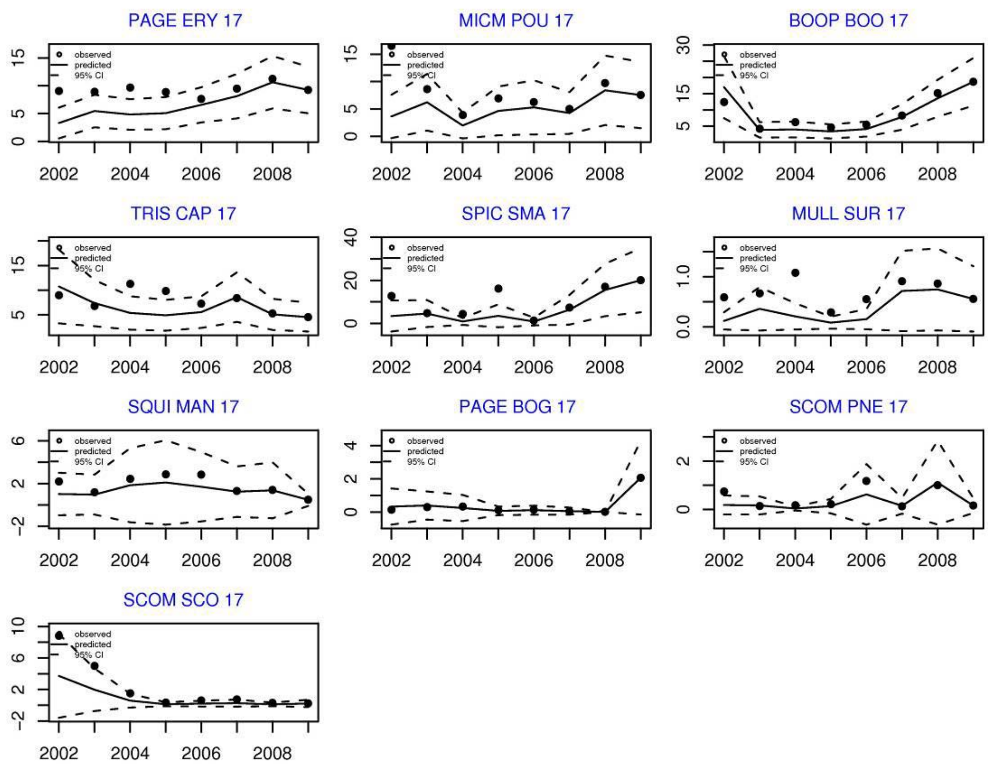


Figure 3.4.2.11.2 Mean observed and predicted (+/- 95% CI) cpue (kg·km^{-2}) trends over time in GSA 17. Species tested are *Pagellus erythrinus* (PAGE ERY), *Micromesistius poutassou (MICM POU), Squilla mantis (SQUI MAN), Boops boops (BOOP BOO), Trispoterus minutus (TRIS CAP), Spicara smaris (SPIC SMA), Mullus surmuletus (MULL SUR), Pagellus bogaraveo (PAGE BOO), Diplodus vulgaris (DIPL VUL), Scomber scomber (SCOM SCO) and Scomber japonicus (SCOM PNE)*. Species that do not appear in plot are absent from GSA investigated.

In this GSA the discrepancies between the estimated yearly mean and the model predicted mean cpue are particularly high in most cases with the exception of *Pagellus bogaraveo* and *Boops boops*. As zero inflation does not appear to be the main problem here, these differences should be further investigated as it might be related to erroneous entries in the database.

3.4.2.12. GSA 18

The new MEDITS database does not present obvious errors although data from 2010 are missing.

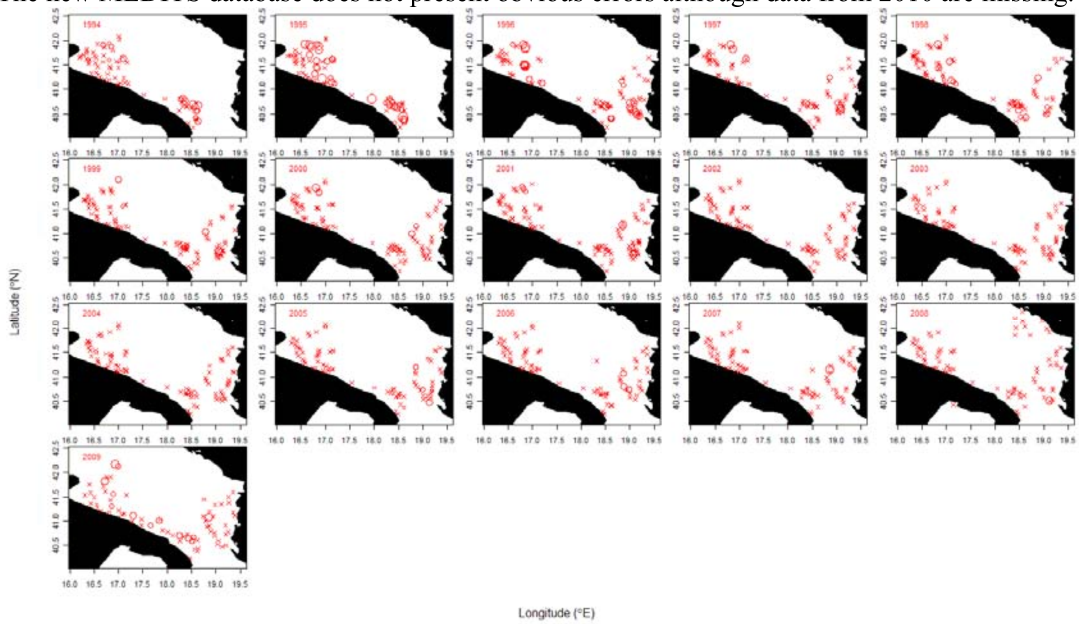


Figure 3.4.2.12.1. Position of zero hauls (cross symbols) and positive hauls (bubbles proportional to CPUE (kg/km^{-2}) for *Micromesistius poutassou* in GSA 18 from MEDITS survey from 1994 to 2009.

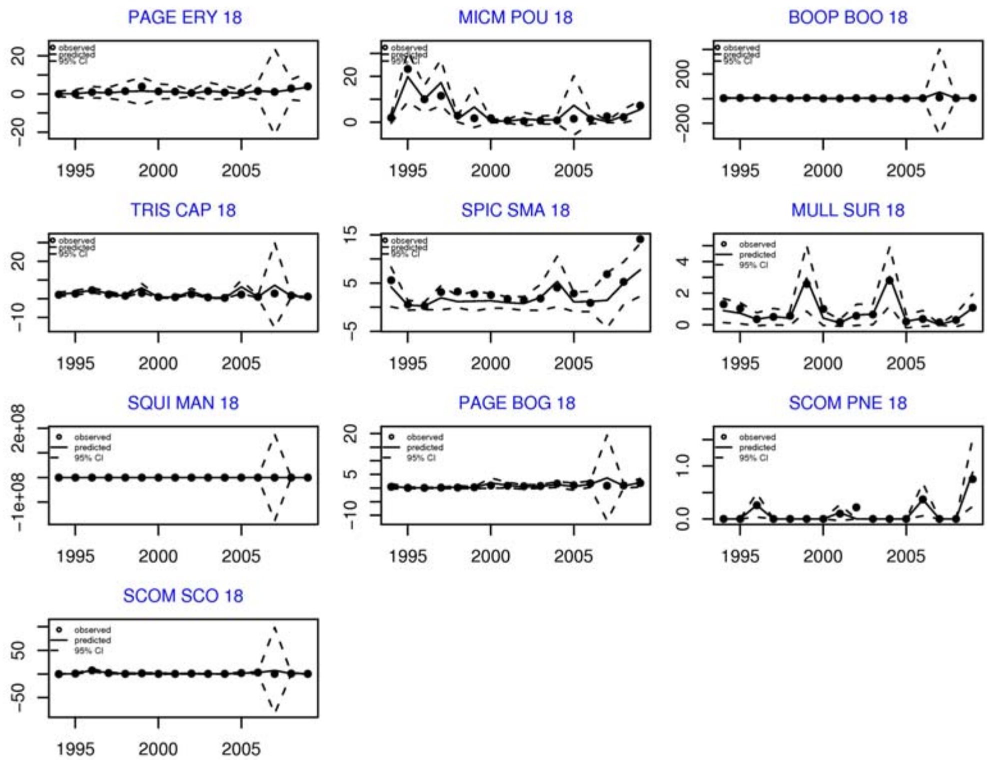


Figure 3.4.2.12.2 Mean observed and predicted (+/- 95% CI) cpue (Kg·Km^{-2}) trends over time in GSA 18. Species tested are *Pagellus erythrinus* (PAGE ERY), *Micromesistius poutassou (MICM POU), Squilla mantis (SQUI MAN), Boops boops (BOOP BOO), Trispoterus minutus (TRIS CAP), Spicara smaris (SPIC SMA), Mullus surmuletus (MULL SUR), Pagellus bogaraveo (PAGE BOO), Diplodus vulgaris (DIPL VUL), Scomber scomber (SCOM SCO) and Scomber japonicus (SCOM PNE).* Species that do not appear in plot are absent from GSA investigated.

Of the modeled species *Pagellus erythrinus*, *Micromesistius poutassou, Trispoterus minutus, Spicara smaris, Mullus surmuletus, Pagellus bogaraveo* and *Scomber japonicus* display realistic fits and appear suitable for use in stock assessment.

3.4.2.13. GSA 19

The haul positions in this GSA seem to be all correct. All data for year 2010 are missing.

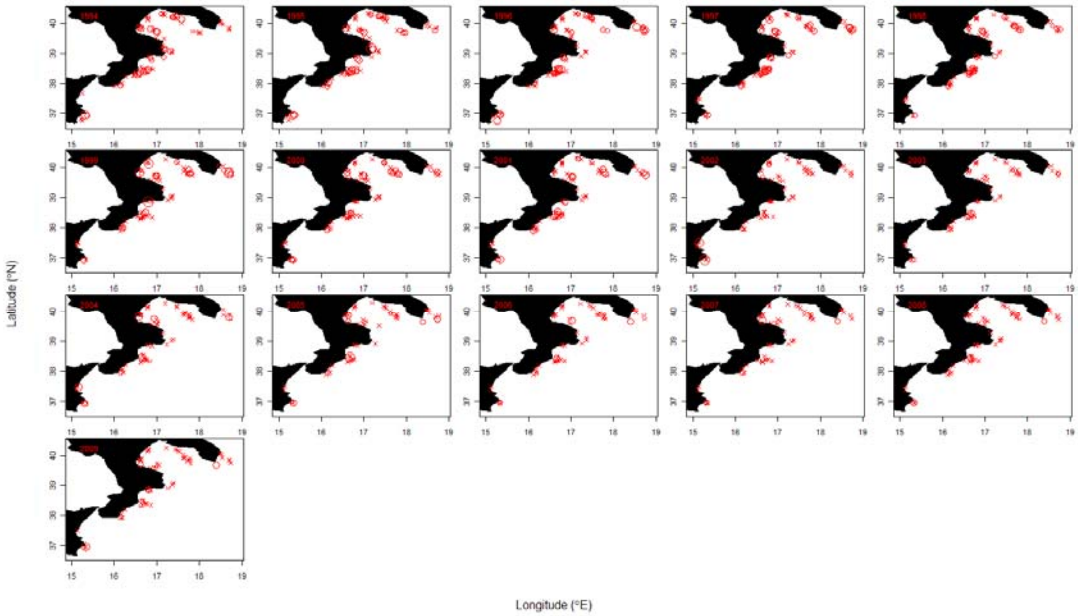


Figure 3.4.2.13.1. Position of zero hauls (cross symbols) and positive hauls (bubbles proportional to CPUE (kg/km^{-2})) for *Micromesistius poutassou* in GSA 19 from MEDITS survey from 1994 to 2009.

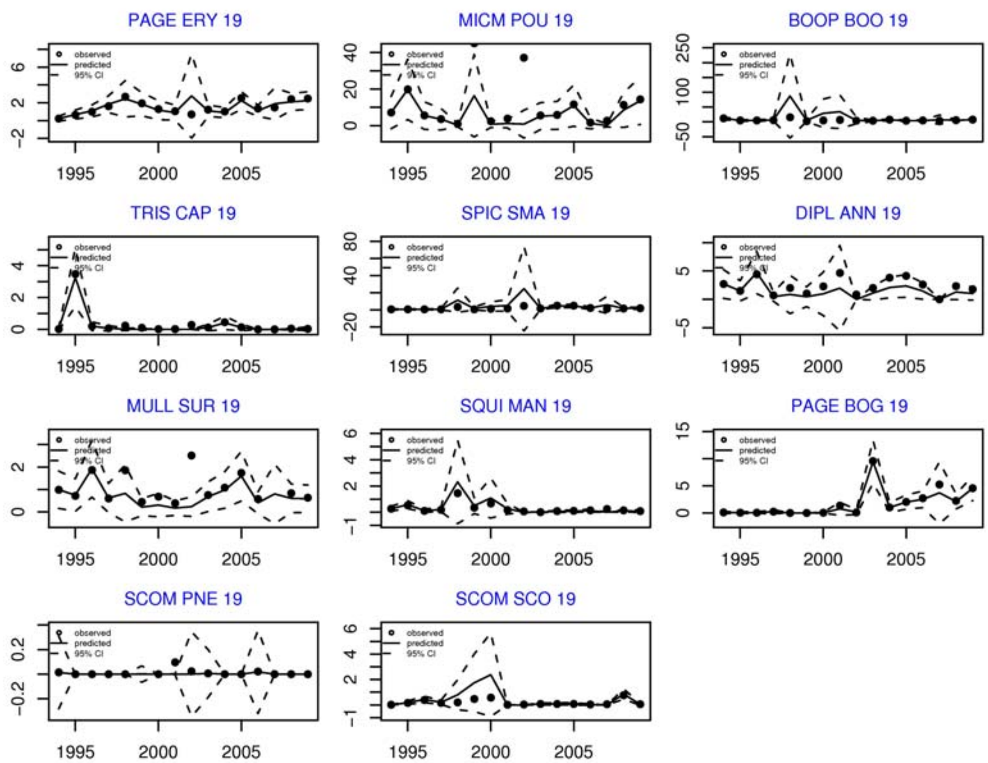


Figure 3.4.2.13.2 Mean observed and predicted (+/- 95% CI) cpue (Kg·Km^{-2}) trends over time in GSA 19. Species tested are *Pagellus erythrinus* (PAGE ERY), *Micromesistius poutassou (MICM POU), Squilla mantis (SQUI MAN), Boops boops (BOOP BOO), Trispoterus minutus (TRIS CAP), Spicara smaris (SPIC SMA), Mullus surmuletus (MULL*

SUR), Pagellus bogaraveo (PAGE BOO), Diplodus vulgaris (DIPL VUL), Scomber scomber (SCOM SCO) and Scomber japonicus (SCOM PNE). Species that do not appear in plot are absent from GSA investigated.

Most of the models fits for this area derive from predictions from a rank-deficient fit and may be misleading, therefore there should be further investigation into these models.

3.4.2.14. GSA 20

The data from this GSA available in the new MEDITS database have not yet been analysed.

3.4.2.15. GSA 22+23

The data from this GSA available in the new MEDITS database have not yet been analysed.

3.4.2.16. GSA 25

The hauls were tested using Pagellus erythrinus as Micomestious poutassou is absent in this area/database. There is one wrong haul in 2005 and substantial errors of Longitude in 2010 data. In 2010 DISTANCE trawled (in file TA) appears to be 30 m in each haul which is impossible and this makes the calculation of swept and consequently cpue impossible for this year. Additionally since 2006 Wing Opening and Vertical Opening have the same values of respectively 25 and 200 in all hauls while these are declared to be measured with SCANMAR (field GEOMETRICAL_PRECISION = M) and should therefore vary by haul.

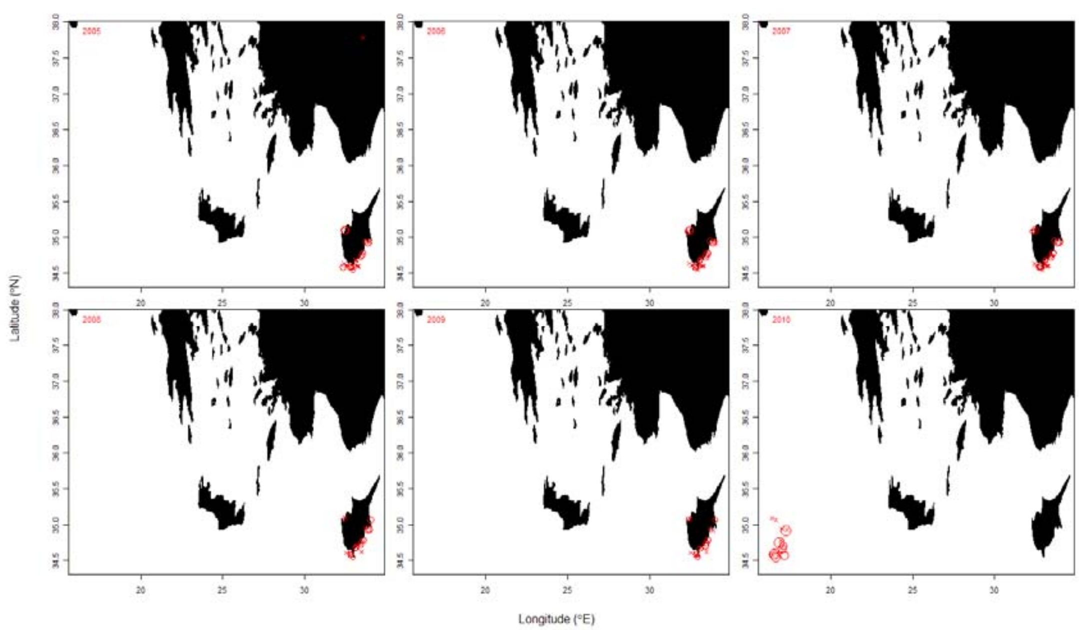


Figure 3.4.2.16.1. Position of zero hauls (cross symbols) and positive hauls (bubbles proportional to CPUE (kg/km^{-2})) for *Pagellus erythrinus* in GSA 25 from MEDITS survey from 2005 to 2010.

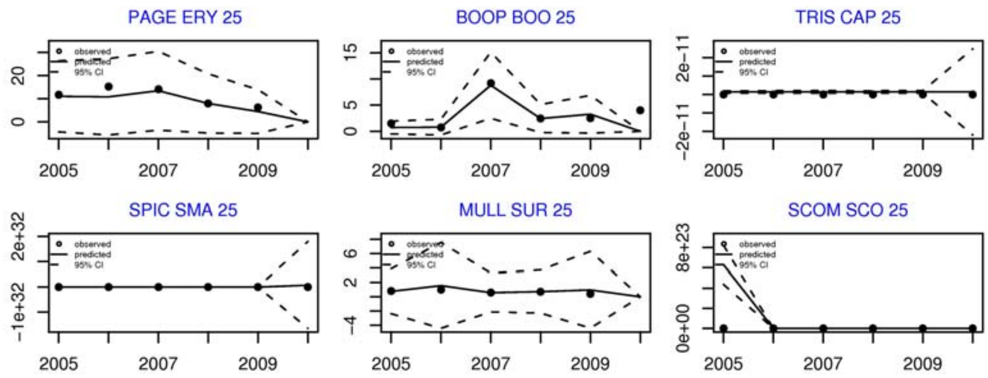


Figure 3.4.16.2 Mean observed and predicted (+/- 95% CI) cpue (kg·km^{-2}) trends over time in GSA 17. Species tested are *Pagellus erythrinus* (PAGE ERY), *Micromesistius poutassou (MICM POU), Squilla mantis (SQUI MAN), Boops boops (BOOP BOO), Trispoterus minutus (TRIS CAP), Spicara smaris (SPIC SMA), Mullus surmuletus (MULL SUR), Pagellus bogaraveo (PAGE BOO), Diplodus vulgaris (DIPL VUL), Scomber scomber (SCOM SCO) and Scomber japonicus (SCOM PNE).* Species that do not appear in plot are absent from GSA investigated.

Due to the errors in the database for 2010 we don't consider the modeled trends reliable, the plots are presented only for the sake of showing the species that are present in the DB for this GSA.

3.4.1. *Comparison between CPUE stratified means and GLM cpue standardization*

Currently within SGMED cpue data from MEDITS survey are standardized using the stratified means method described below. According to the MEDITS protocol (Bertrand *et al*., 2002), trawl surveys were yearly (May-July) carried out, applying a random stratified sampling by depth (5 strata with depth limits at: 50, 100, 200, 500 and 800 m; each haul position randomly selected in small sub-areas and maintained fixed throughout the time). Haul allocation is proportional to the stratum area. All the abundance data (number of fish per surface unit) are standardized to square kilometer, using the swept area method. Data are assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Catches by haul are standardized to 60 minutes hauling duration. Only valid hauls are used, including stations with no catches (zero catches are included).

The abundance and biomass indices by GSA are calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

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

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

Where:

A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum

n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

This is a standard approach however the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien *et al*. 2004).

One of the main reasons for applying a modeling framework such as GLMs or GAMs for the standardization of MEDITS survey indexes instead of the stratified means method is that more family distributions can be used to model the data, that the relation between the mean cpue and the predictors does not need to be linear and that zero inflation can be correctly dealt with. Additionally and very important, in several GSAs but not all, the number of hauls has changed over time in an unbalanced way with respect of the fished areas. In these cases the stratified means can potentially return biased estimates because of the influence of addition or removal of hauls in particular strata.

In the R script developed with the purpose of addressing also such issue we were interested in understanding how the model predicts the yearly mean CPUE and compare it with the survey mean CPUE. For this is needed a common set of points for predictions that must be selected a priori: these points can be selected by: 1) using an estimation grid or 2) using the originally randomly assigned hauls within each stratum. As we don't have a complete estimation grid we are left with the second option. Because in some cases the haul number is simply sequential within a year and is not characteristic of a specific sampling point, we assumed that the year with the highest number of hauls is also the less unbiased. With the maximum number of hauls in a determined year we build a prediction grid and then make a prediction of the CPUE's and the standard errors refitting the best model to it. This is of key importance when the number of hauls has changed over time as the model predicts the cpue for the maximum number of hauls in the survey thus accounting for the effect of the addition/removal of some hauls. Additionally the GLM model takes into account the effect of spatial position change, in the case new areas have been added/dropped to the survey, while the stratified means do not account for it.

3.4.1.1. Case studies

To give an example of the difference between the two methods we standardized the cpue (Kg/Km^{-2}) of Mediterranean hake in GSA 07 (Figure 1) and 16 where over time the number of hauls has respectively remained comparable or has increased (see Tables 3.4.1.1.1 and 2).Hake was chosen as it has a high frequency of capture and thus avoids problems of zero inflation. The same exercise was performed in GSA 18 and 10.
In GSA 16 the number of hauls has almost doubled across strata however with the addition of areas that were not covered in the older part of the survey as can be appreciated in the haul plot(Figure 3.4.1.1.5).

Tab. 3.4.1.1.1. Number of hauls per year and depth stratum in GSA 07, 1994-2009.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GSA07_010-050	12	12	12	14	12	12	12	12	12	13	12	12	12	14	11	11
GSA07_050-100	32	32	32	35	39	32	32	32	31	38	31	30	33	31	24	29
GSA07_100-200	10	9	9	9	9	9	10	9	9	10	13	11	10	10	7	10
GSA07_200-500	6	6	5	5	5	5	5	6	4	5	5	5	5	5	4	5
GSA07_500-800	8	7	4	5	4	4	6	5	4	5	5	5	5	5	5	5

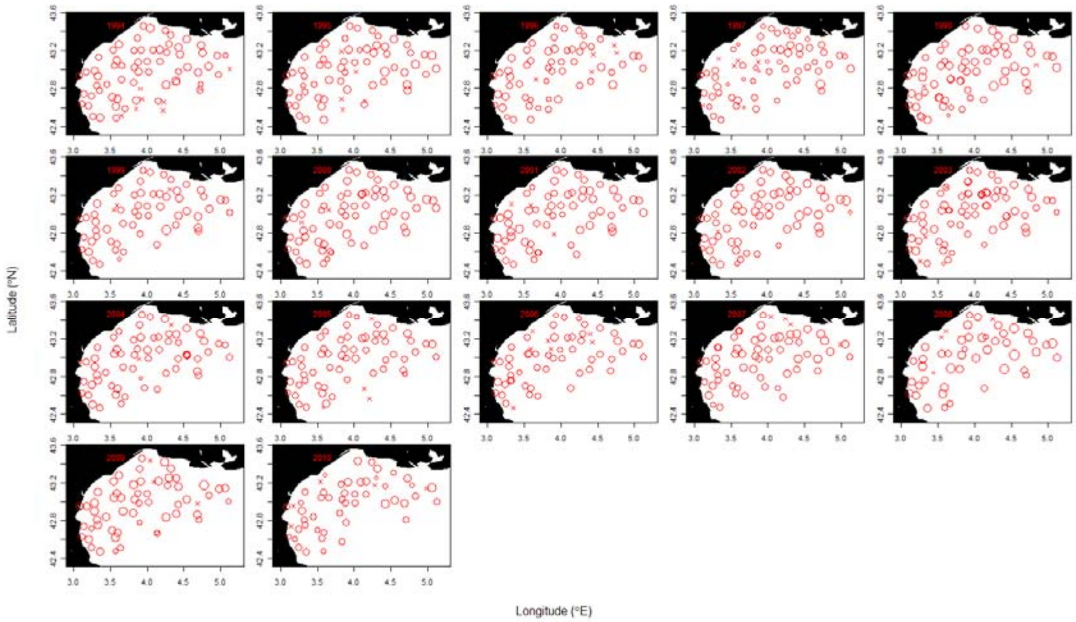


Figure 1. Position of zero hauls (cross symbols) and positive hauls (bubbles proportional to CPUE (kg/km^{-2})) for *Merluccius merluccius* in GSA 07 from MEDITS survey from 1994 to 2010.

We fitted the same GLM model using a quasi-Poisson family distribution as in the previous cases and plotted the predicted mean cpue (Kg/km^{-2}), 95% Confidence Intervals and the observed survey yearly mean cpue calculated without considering the area stratification. The model summary (Table 3.4.1.1.2) and diagnostics (Figure 3.4.1.1.4) show an acceptable model with reasonable residuals. The model output shows consistency between the predicted and observed mean cpue (Figure 3.4.1.1.3). If we compare this plot with the mean cpue produced following the stratified means method (Cochran, 1953; Saville, 1977) (Figure 3.4.1.1.2), standardized to 1 hour fishing, while the absolute values differ, the trends are comparable.

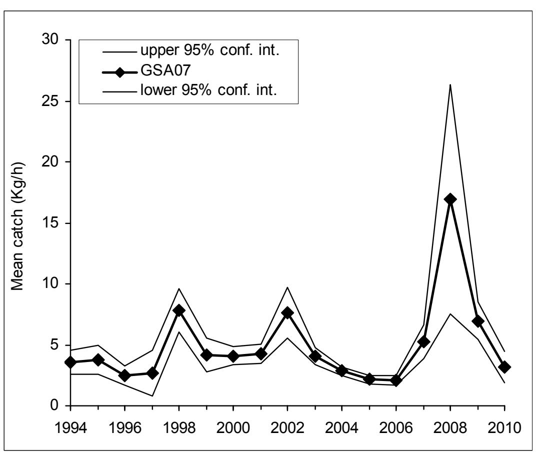


Figure 3.4.1.1.2. Mean observed cpue (Kg/h) +/- 95% CI trends of *Merluccius merluccius* in GSA 07 calculated using the stratified means.

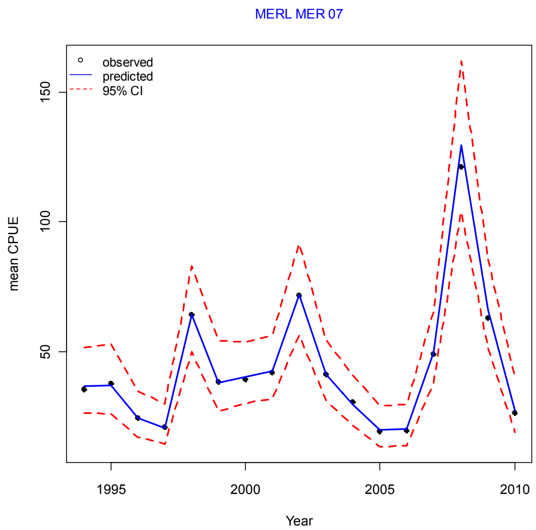


Figure 3.4.1.1.3. Mean observed and predicted (+/- 95% CI) cpue (kg/km^{-2}) of *Merluccius merluccius* in GSA 07 calculated using the quasi-Poisson glm.

Tab. 3.4.1.1.3. GLM model output for Mediterranean hake in GSA 07

```
Call:
glm(formula = CPUE ~ factor(YEAR) + factor(MONTH) + Latitude *
    Longitude + DEPTH, family = quasipoisson, data = TB)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-14.952   -4.035   -1.498    1.845   60.001

Coefficients:
                     Estimate Std. Error t value Pr(>|t|)
(Intercept)        -1.941e+02  5.548e+01  -3.499 0.000485 ***
factor(YEAR)1995    1.144e-02  2.328e-01   0.049 0.960806
factor(YEAR)1996   -4.137e-01  2.262e-01  -1.829 0.067684 .
factor(YEAR)1997   -5.808e-01  2.301e-01  -2.524 0.011746 *
factor(YEAR)1998    5.587e-01  1.682e-01   3.321 0.000925 ***
factor(YEAR)1999    3.612e-02  1.881e-01   0.192 0.847801
factor(YEAR)2000    8.990e-02  1.998e-01   0.450 0.652809
factor(YEAR)2001    1.425e-01  1.983e-01   0.718 0.472654
factor(YEAR)2002    6.712e-01  1.823e-01   3.683 0.000242 ***
factor(YEAR)2003    1.165e-01  1.954e-01   0.596 0.551380
factor(YEAR)2004   -2.154e-01  2.110e-01  -1.021 0.307520
factor(YEAR)2005   -6.209e-01  2.399e-01  -2.588 0.009778 **
factor(YEAR)2006   -6.003e-01  2.397e-01  -2.505 0.012401 *
factor(YEAR)2007    3.039e-01  1.951e-01   1.558 0.119538
factor(YEAR)2008    1.261e+00  1.654e-01   7.625 5.28e-14 ***
factor(YEAR)2009    5.879e-01  1.797e-01   3.271 0.001105 **
factor(YEAR)2010   -2.926e-01  2.184e-01  -1.339 0.180721
factor(MONTH)6     -6.200e-03  1.099e-01  -0.056 0.955027
factor(MONTH)7      6.985e-02  1.895e-01   0.369 0.712545
factor(MONTH)8      8.237e-01  7.675e-01   1.073 0.283392
Latitude            4.523e+00  1.290e+00   3.507 0.000472 ***
Longitude           6.657e+01  1.489e+01   4.470 8.65e-06 ***
DEPTH              -4.100e-03  3.925e-04 -10.445  < 2e-16 ***
Latitude:Longitude -1.526e+00  3.459e-01  -4.410 1.13e-05 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for quasipoisson family taken to be 43.23059)

    Null deviance: 55899  on 1115  degrees of freedom
Residual deviance: 33259  on 1092  degrees of freedom
AIC: NA

Number of Fisher Scoring iterations: 6
```

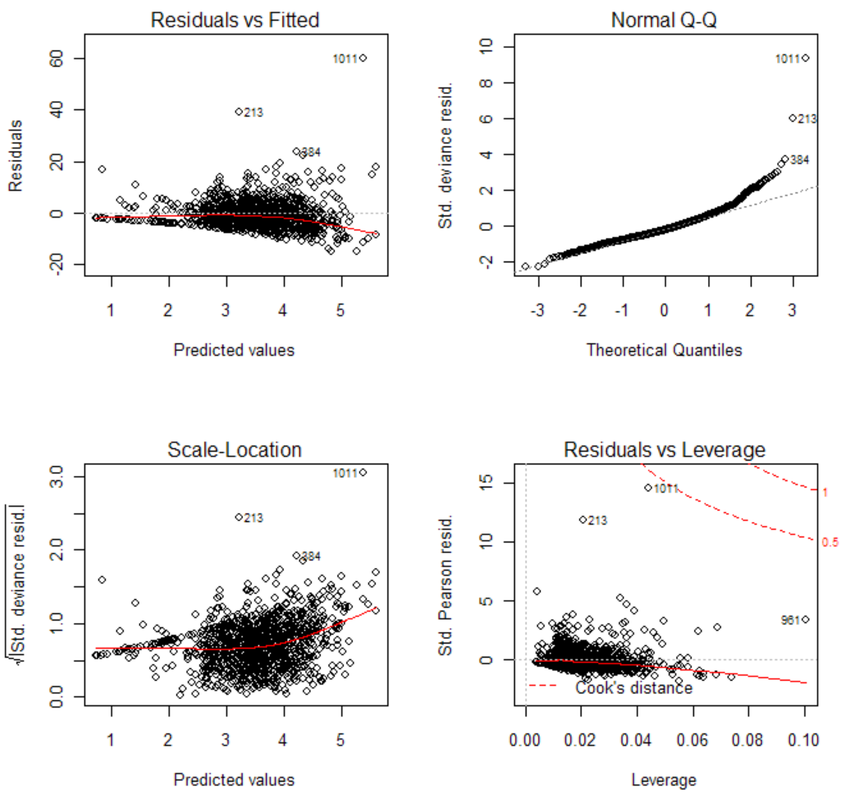


Figure 3.4.1.1.4. Diagnostic plots for the quasi-Poisson MG fitted to *Merluccius merluccius* in GSA 07.

If we apply the same comparison to Mediterranean hake in GSA 16 the results differ more than in GSA 07. The quasi Poisson GLM fits the data reasonably although there is some violation of heterogeneity as the residuals vs fitted show (Figure 3.4.1.1.8 and Table 3.4.1.1.3). The predicted mean cpue results is different from the mean observed cpue especially in the initial years (Figure 3.4.1.1.7) and the prediction changes significantly the overall trend of hake by estimating more biomass in the past and less in the present. Comparing the predicted cpue derived from the GLM model with the stratified means (respectively Figure 3.4.1.1.7 and 6) we can see that again the trend differs with the stratified means being lower in the past and higher in the recent years. It is clear that this is an important issue as one method (GLM) shows that the relative biomass in recent years has returned to the level in 1994 while the other method (stratified means) shows the highest relative biomass in the recent years.

Tab. 3.4.1.1.2. Number of hauls per year and depth stratum in GSA 15 and 16, 1994-2009.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GSA15_010-050									1	2	4	1	1			
GSA15_050-100									6	9	7	5	5	12	6	6
GSA15_100-200									12	23	23	13	13	12	12	15
GSA15_200-500									9	18	16	9	9	4	9	10
GSA15_500-800									18	28	27	17	16	17	17	15
GSA16_010-050	4	4	4	4	4	4	4	4	7	7	7	10	10	11	11	11
GSA16_050-100	9	8	8	8	8	8	7	8	11	12	12	20	22	23	23	23
GSA16_100-200	4	4	4	4	5	5	6	5	11	10	11	20	19	21	21	21
GSA16_200-500	10	11	11	12	11	11	11	11	19	18	26	37	31	27	27	27
GSA16_500-800	10	14	14	13	14	14	14	14	20	20	21	33	33	38	38	38

These case studies have been a quick attempt of showing the potential problems that could arise with the use of stratified means in areas where sampling has changed over time. Given the fact that in many GSAs the number of hauls have changed over time and given the importance that MEDITS indexes have in most assessment, a GLM estimates is preferable. Additionally it would also be useful to identify the cases where stratified means are a simpler but adequate approach and where these return biased cpue estimates.

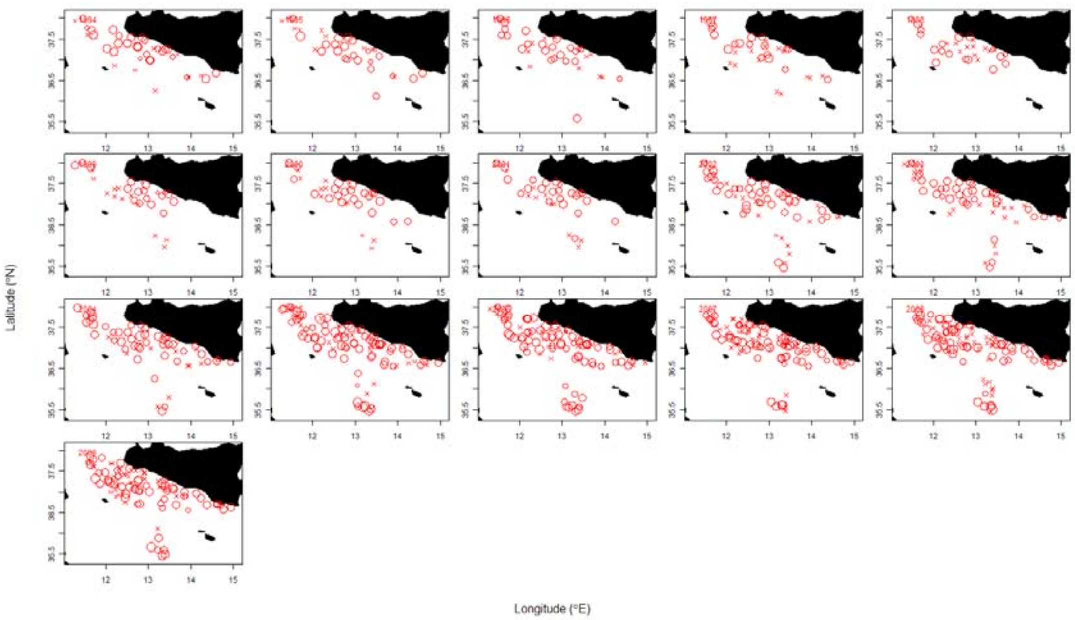


Figure 3.4.1.1.5. Position of zero hauls (cross symbols) and positive hauls (bubbles proportional to CPUE (kg/km^{-2})) for *Merluccius merluccius* in GSA 16 from MEDITS survey from 1994 to 2009.

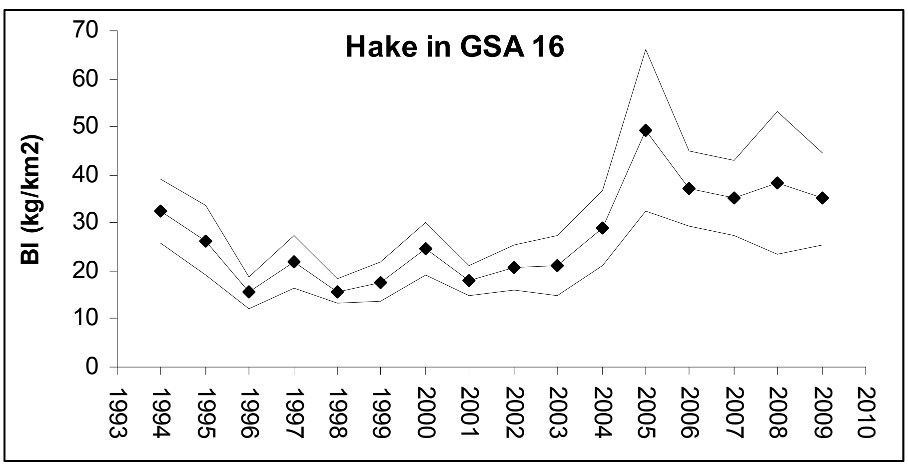


Figure 3.4.1.1.6. Mean observed cpue (kg/h) +/- 95% CI trends of *Merluccius merluccius* in GSA 16 calculated using the stratified means.

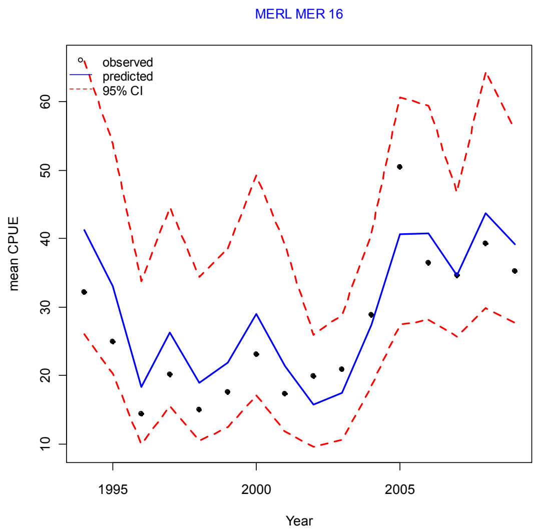


Figure 3.4.1.1.7. Mean observed and predicted (+/- 95% CI) cpue (Kg·Km^{-2}) of *Merluccius merluccius* in GSA 16 calculated using the quasi-Poisson glm.

Tab. 3.4.1.1.3. GLM model output for Mediterranean hake in GSA 16

```
Call:
glm(formula = CPUE ~ factor(YEAR) + factor(MONTH) + Latitude *
    Longitude + DEPTH, family = quasipoisson, data = TB)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-15.025   -5.059   -2.310    1.522   47.575

Coefficients:
                     Estimate Std. Error t value Pr(>|t|)
(Intercept)         6.2177459 65.6818136   0.095  0.92460
factor(YEAR)1995   -0.2245421  0.2941323  -0.763  0.44539
factor(YEAR)1996   -0.8114679  0.3465307  -2.342  0.01938 *
factor(YEAR)1997   -0.4537691  0.3118007  -1.455  0.14587
factor(YEAR)1998   -0.7776378  0.3395166  -2.290  0.02219 *
factor(YEAR)1999   -0.6348762  0.3265179  -1.944  0.05211 .
factor(YEAR)2000   -0.3536171  0.3095889  -1.142  0.25362
factor(YEAR)2001   -0.6555202  0.3419576  -1.917  0.05551 .
factor(YEAR)2002   -0.9649842  0.3356930  -2.875  0.00412 **
factor(YEAR)2003   -0.8621084  0.3365721  -2.561  0.01056 *
factor(YEAR)2004   -0.4102190  0.2800909  -1.465  0.14332
factor(YEAR)2005   -0.0175746  0.3003674  -0.059  0.95335
factor(YEAR)2006   -0.0143179  0.2472414  -0.058  0.95383
factor(YEAR)2007   -0.1769078  0.2365392  -0.748  0.45468
factor(YEAR)2008    0.0570851  0.2507765   0.228  0.81997
factor(YEAR)2009   -0.0519578  0.2390242  -0.217  0.82796
factor(MONTH)6     -0.0141480  0.1349061  -0.105  0.91650
factor(MONTH)7      0.4197614  0.2396619   1.751  0.08015 .
factor(MONTH)8      0.2151400  0.2993077   0.719  0.47242
Latitude            0.1715585  1.7686211   0.097  0.92274
Longitude           2.3847747  5.0831328   0.469  0.63905
DEPTH              -0.0029243  0.0002384 -12.267  < 2e-16 ***
Latitude:Longitude -0.0817039  0.1369133  -0.597  0.55080
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for quasipoisson family taken to be 46.94937)

    Null deviance: 53743  on 1104  degrees of freedom
Residual deviance: 38104  on 1082  degrees of freedom
AIC: NA

Number of Fisher Scoring iterations: 6
```

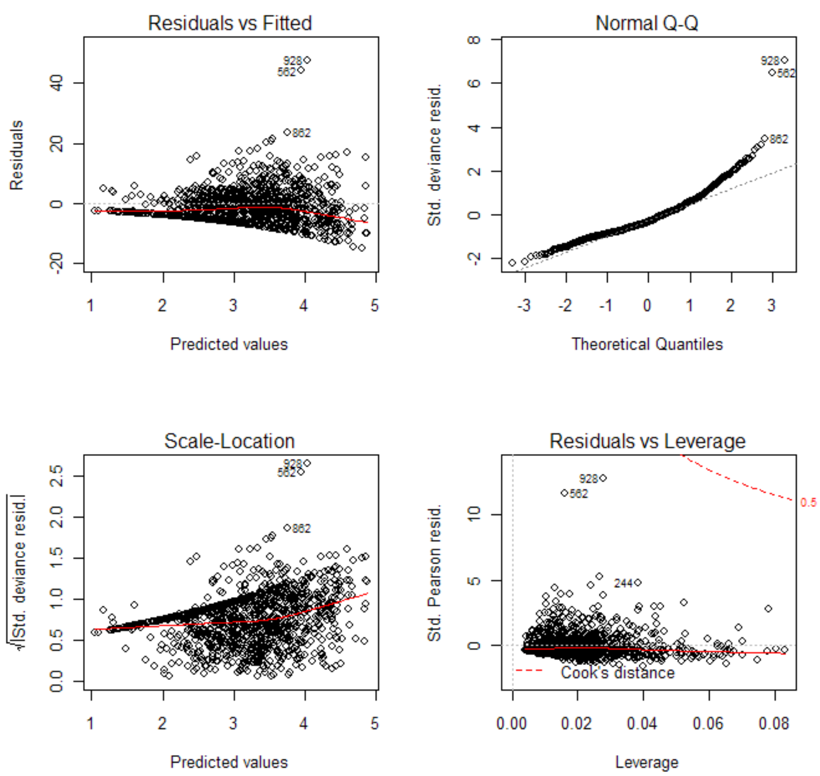


Figure 3.4.1.1.8. Diagnostic plots for the quasi-Poisson GLM fitted to *Merluccius merluccius* in GSA 16.

Case study HAKE in GSA 10 and GSA 18

In order to make a further comparison between the two methods (mean stratified and GLM CPUE standardization method), we analysed the results from hake MEDITS data in GSA 10 and GSA 18. In GSA 10 the number of hauls decreases slightly over the years (1994-2009), but the coverage of all the strata changed in a proportional way (Figure 3.4.1.1.9, Tab. 3.4.1.1.4).

Tab. 3.4.1.1.4. Number of hauls per year and depth stratum in GSA 10, 1994-2009.

GSA 10	Year															
Stratum	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
10-50 m	7	8	8	8	8	8	8	8	6	7	7	7	7	7	7	7
50-100 m	10	10	10	10	10	10	10	10	9	8	8	8	8	8	8	8
100-200 m	17	17	17	17	17	17	17	17	14	14	14	14	14	14	14	14
200-500 m	22	22	22	22	22	22	22	24	18	18	18	18	18	18	19	18
500-800 m	28	28	28	28	28	27	28	26	23	23	23	23	23	23	22	23
Total	84	85	85	85	85	84	85	85	70	70	70	70	70	70	70	70

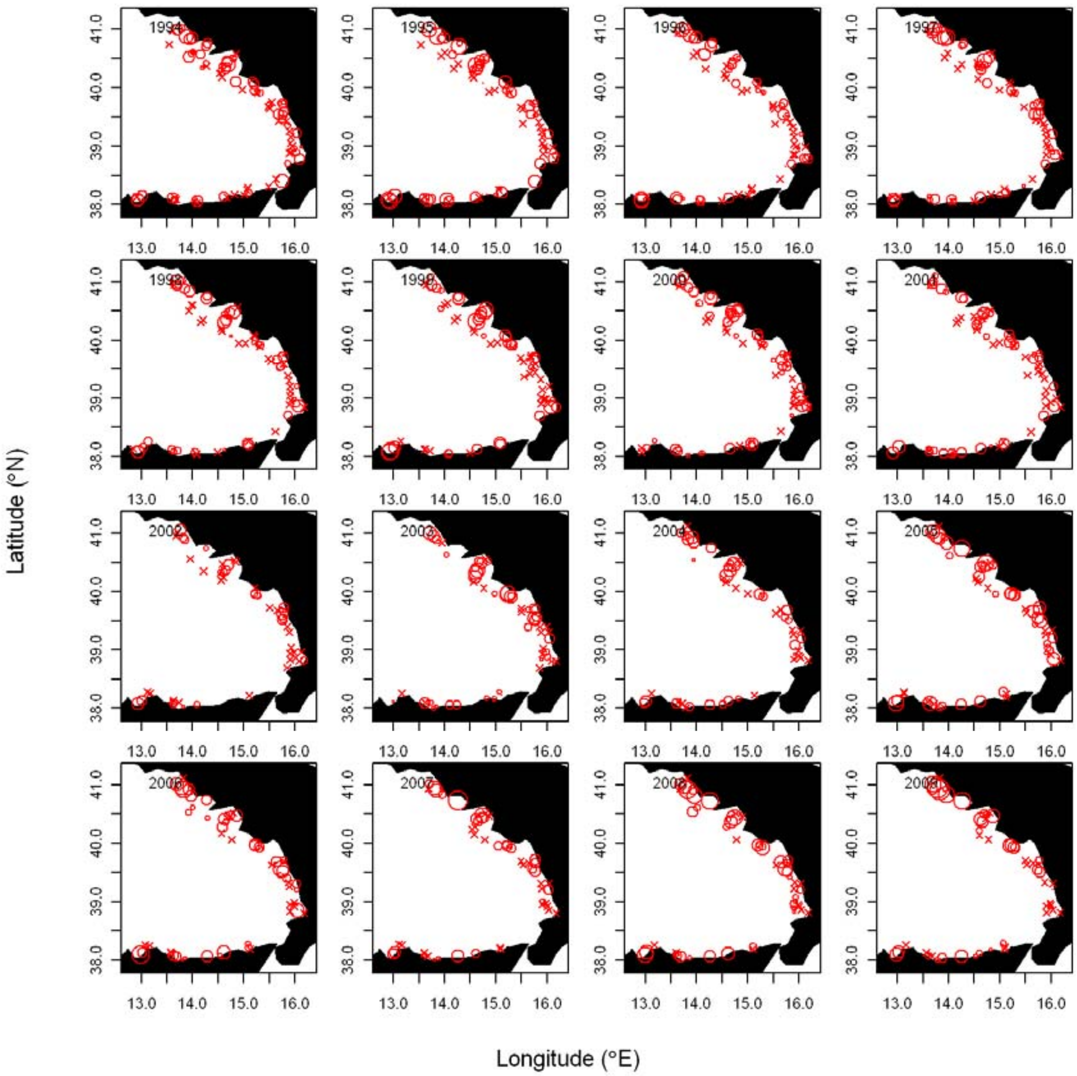


Figure 3.4.1.1.9. Position of zero hauls (cross symbols) and positive hauls (bubbles proportional to CPUE (Kg/km^2) for *Merluccius merluccius* in GSA 10 from MEDITS survey from 1994 to 2009.

We used Kg/Km^2 as CPUE and we fitted the same quasi-GLM model used for the comparison in GSA 07 and GSA 16. Finally, we plotted the predicted values with 95% Confidence Interval and the observed values over the years (Figure 3.4.1.1.10 and 11).

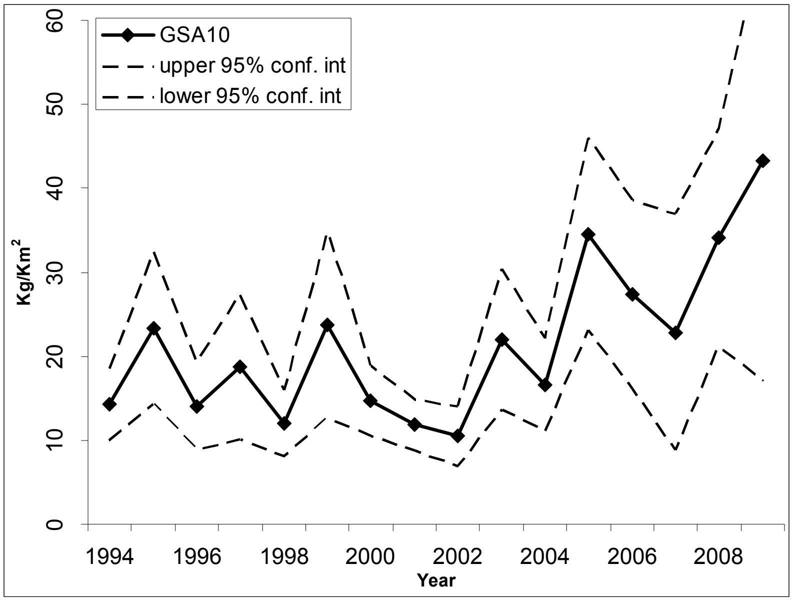


Figure 3.4.1.1.10. Mean observed CPUE (Kg/Km^2) +/- 95% CI trends for *Merluccius merluccius* in GSA 10 calculated using the stratified means.

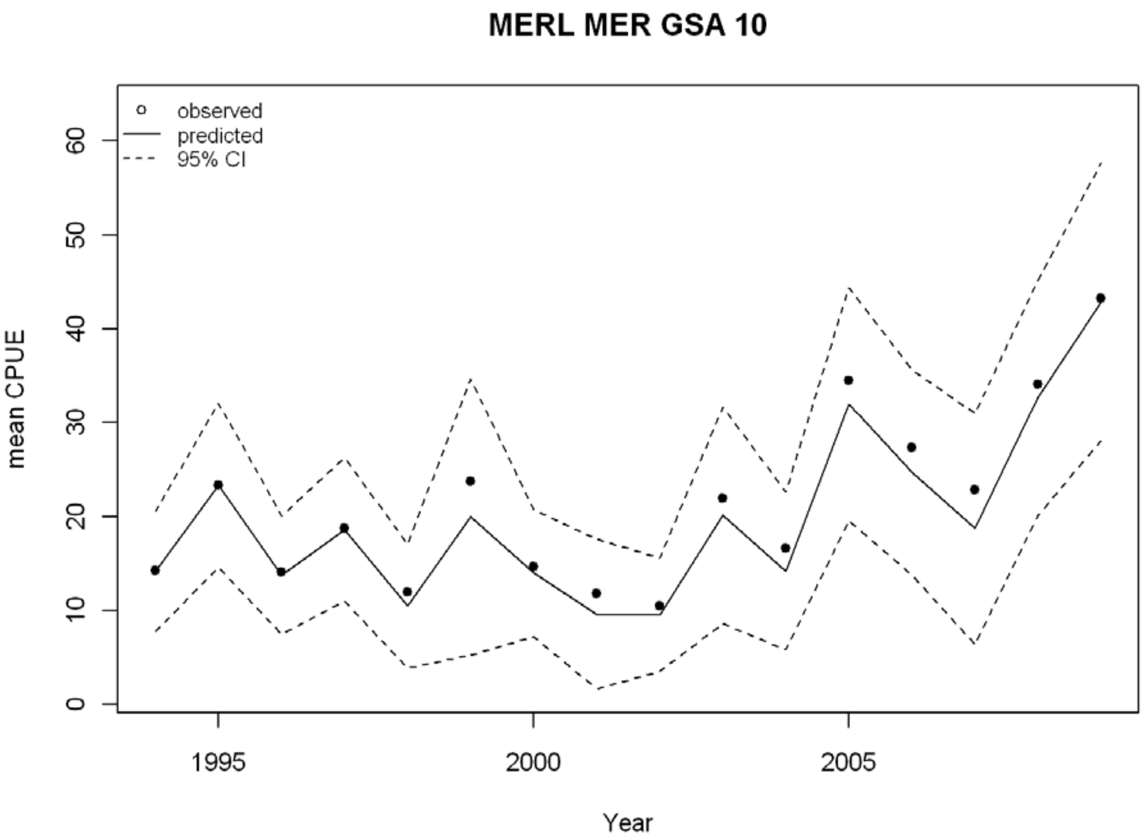


Figure 3.4.1.1.11. Mean observed and predicted (+/- 95% CI) CPUE (Kg/Km^2) for *Merluccius merluccius* in GSA 10 calculated using the quasi-Poisson glm.

The model seems to explain the observed values just in the early part of the time series, in fact most of the observed values from 1999 to 2007 are quite different from the fitted values (Figure 3.4.1.11). The diagnostic plots (Figure 3.4.1.1.12) show a violation of homogeneity hypothesis that should be a sign of not adequacy of the model. In fact, the residuals versus fitted values are not equally distributed above and below the dotted line, but with increasing of the predicted values, the degree of residuals dispersion increases. Also the normal q-q plot shows a behaviour of the data distribution similar to the Gaussian distribution except to the highest theoretical quantiles.
A further investigation about the *ad hoc* GLM for this species in GSA 10 should be done, in order to evaluate the presence of a relationship between the residuals and one or more predictors, as the residuals plots seem to show. In that case should be necessary to apply an appropriate transformation to the data in order to eliminate heterogeneity of variance in the model.

Tab. 3.4.1.1.5. Quasi glm model output for Mediterranean hake in GSA 10

```
Call:
glm(formula = CPUE ~ factor(YEAR) + factor(MONTH) + Latitude *
    Longitude + DEPTH, family = quasipoisson, data = TB)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-16.741   -4.222   -2.419    0.857   38.139

Coefficients:
                    Estimate Std. Error t value Pr(>|t|)
(Intercept)        58.3622695 37.0827699   1.574  0.11579
factor(YEAR)1995    0.4989612  0.2565908   1.945  0.05206 .
factor(YEAR)1996   -0.0274096  0.2908469  -0.094  0.92493
factor(YEAR)1997    0.2729701  0.2713234   1.006  0.31458
factor(YEAR)1998   -0.3006011  0.3686993  -0.815  0.41506
factor(YEAR)1999    0.3439394  0.4172899   0.824  0.40998
factor(YEAR)2000   -0.0133201  0.3059818  -0.044  0.96528
factor(YEAR)2001   -0.3867322  0.4602321  -0.840  0.40091
factor(YEAR)2002   -0.3941170  0.3603079  -1.094  0.27424
factor(YEAR)2003    0.3512858  0.3350736   1.048  0.29467
factor(YEAR)2004    0.0037239  0.3509734   0.011  0.99154
factor(YEAR)2005    0.8139370  0.2672049   3.046  0.00237 **
factor(YEAR)2006    0.5561409  0.2906626   1.913  0.05594 .
factor(YEAR)2007    0.2794293  0.3723891   0.750  0.45318
factor(YEAR)2008    0.8368614  0.2568287   3.258  0.00115 **
factor(YEAR)2009    1.1079671  0.2430763   4.558 5.68e-06 ***
factor(MONTH)5     -0.1114726  0.5361192  -0.208  0.83532
factor(MONTH)6     -0.2307029  0.6138943  -0.376  0.70713
factor(MONTH)7     -0.3284813  0.6379362  -0.515  0.60671
factor(MONTH)8     -0.1353448  0.6872060  -0.197  0.84390
Latitude           -1.2871653  0.9467457  -1.360  0.17422
Longitude          -4.5002492  2.6529473  -1.696  0.09008 .
DEPTH              -0.0030122  0.0002568 -11.729  < 2e-16 ***
Latitude:Longitude  0.1073283  0.0676682   1.586  0.11298
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for quasipoisson family taken to be 48.90057)

    Null deviance: 57543  on 1237  degrees of freedom
Residual deviance: 39302  on 1214  degrees of freedom
AIC: NA

Number of Fisher Scoring iterations: 6
```

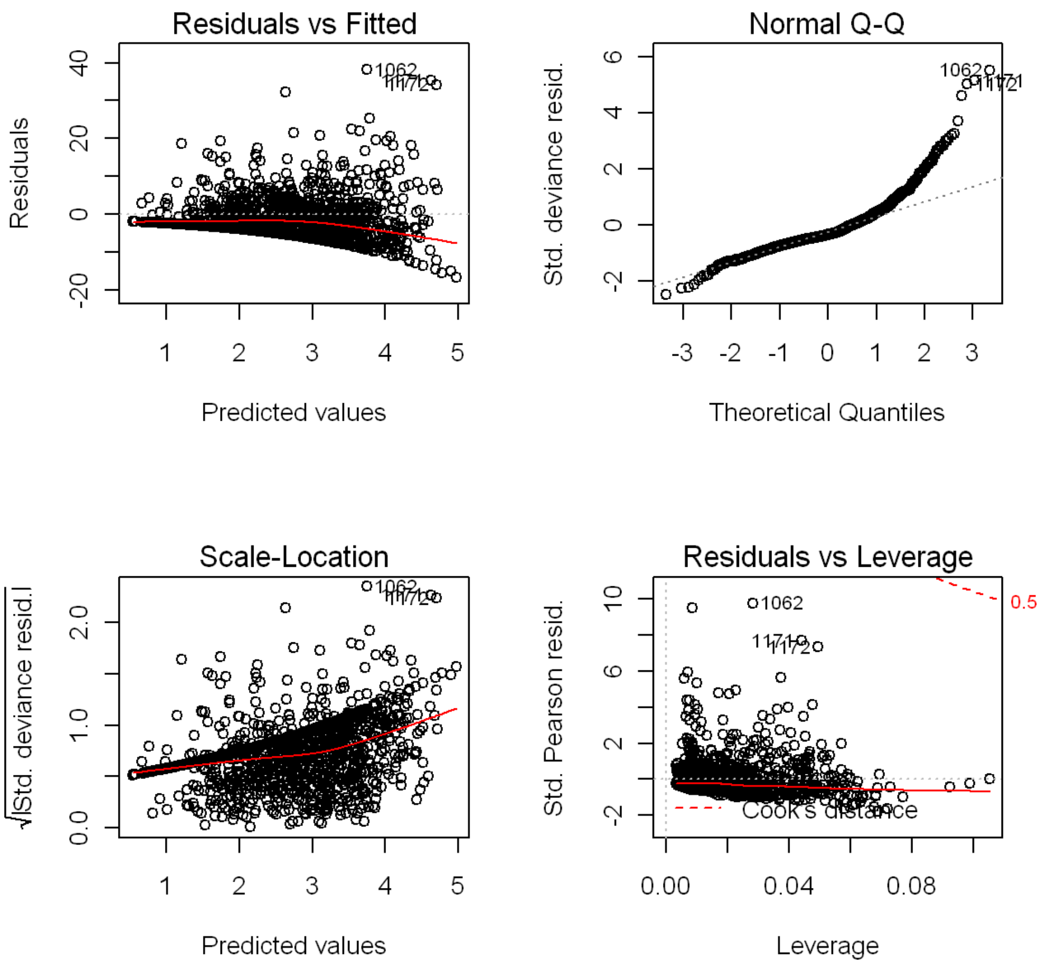


Figure 3.4.1.1.12. Diagnostic plots for the quasi-Poisson glm fitted to *Merluccius merluccius* data in GSA 10.

The same comparison was carried out for hake in GSA 18, where the number of hauls changed over the years, in fact we have 72 hauls in 1994-1995, 112 hauls in 1996-2001 and 90 hauls from 2002 to 2009 (Tab. 3.4.1.1.5). For 2008 obvious errors in the haul coordinates were corrected (Fig. 3.4.1.1.13); then we fitted the same quasi-GLM model used for the other GSAs.

Tab.3.4.1.1.5. Number of hauls per year and depth stratum in GSA 18, 1994-2009.

GSA 18	Year															
Stratum	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
10-50 m	14	14	18	17	17	17	17	18	12	12	11	10	11	10	13	12
50-100 m	14	15	24	25	25	26	25	24	20	19	21	20	21	22	21	20
100-200 m	24	23	33	33	33	32	33	33	31	32	31	33	31	31	33	30
200-500 m	10	10	18	18	18	19	18	18	13	13	13	13	13	13	12	14
500-800 m	10	10	19	19	19	18	19	19	14	14	14	14	14	14	11	14
Total	72	72	112	112	112	112	112	112	90	90	90	90	90	90	90	90

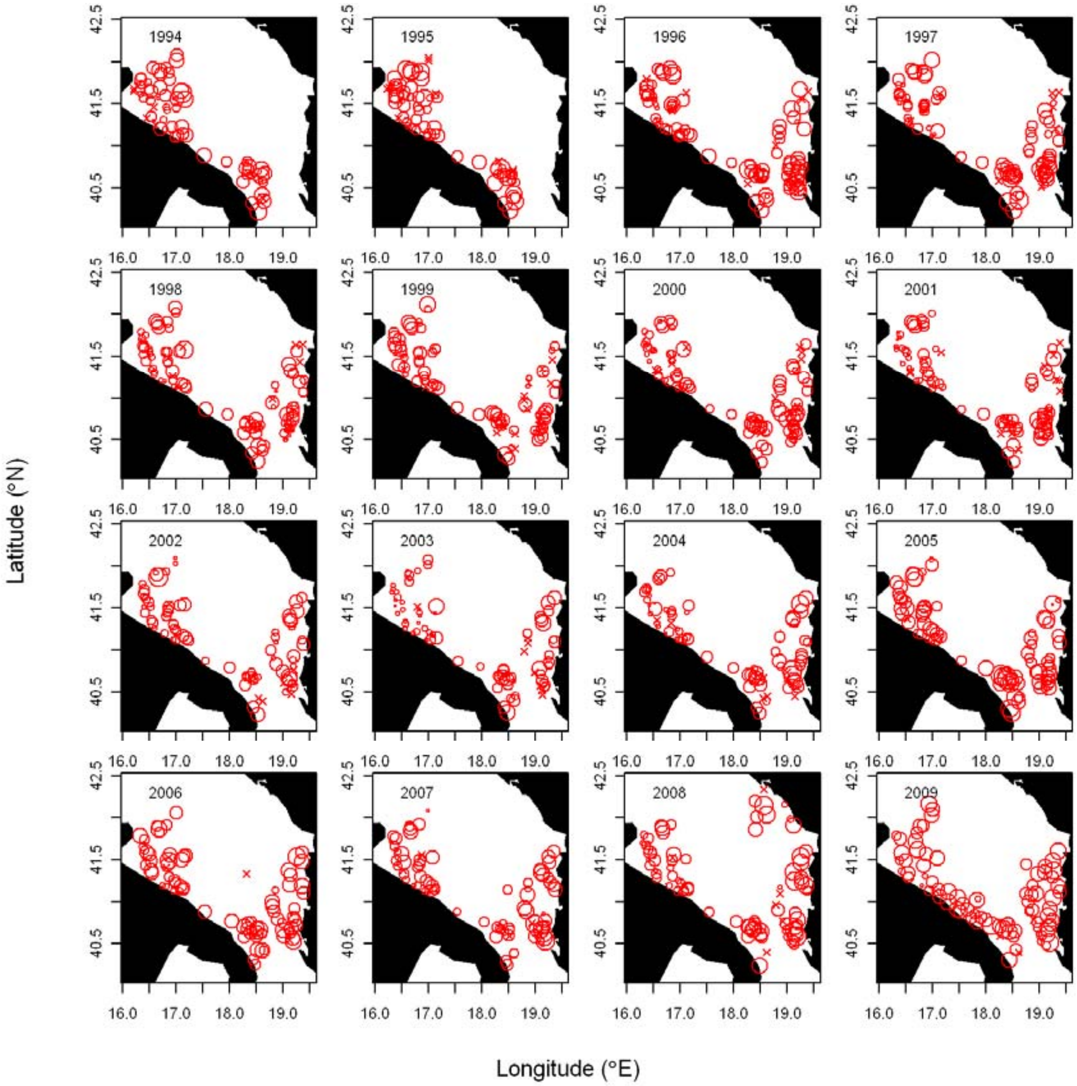


Figure 3.4.1.1.13. Position of zero hauls (cross symbols) and positive hauls (bubbles proportional to CPUE (Kg/Km^2) for *Merluccius merluccius* in GSA 18 from MEDITS survey from 1994 to 2009, after the corrections of haul coordinates in 2008.

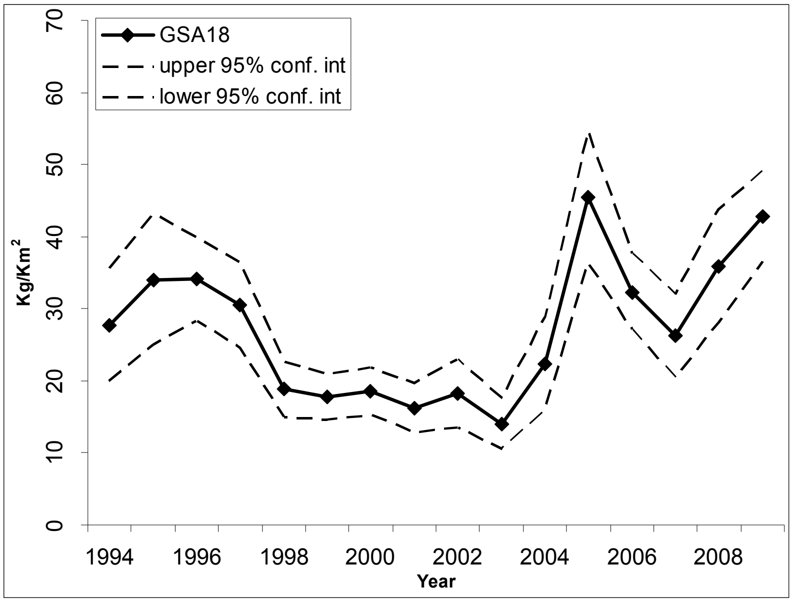


Figure 3.4.1.1.14. Mean observed CPUE (Kg/Km^2) +/- 95% CI trends for *Merluccius merluccius* in GSA 18 calculated using the stratified means.

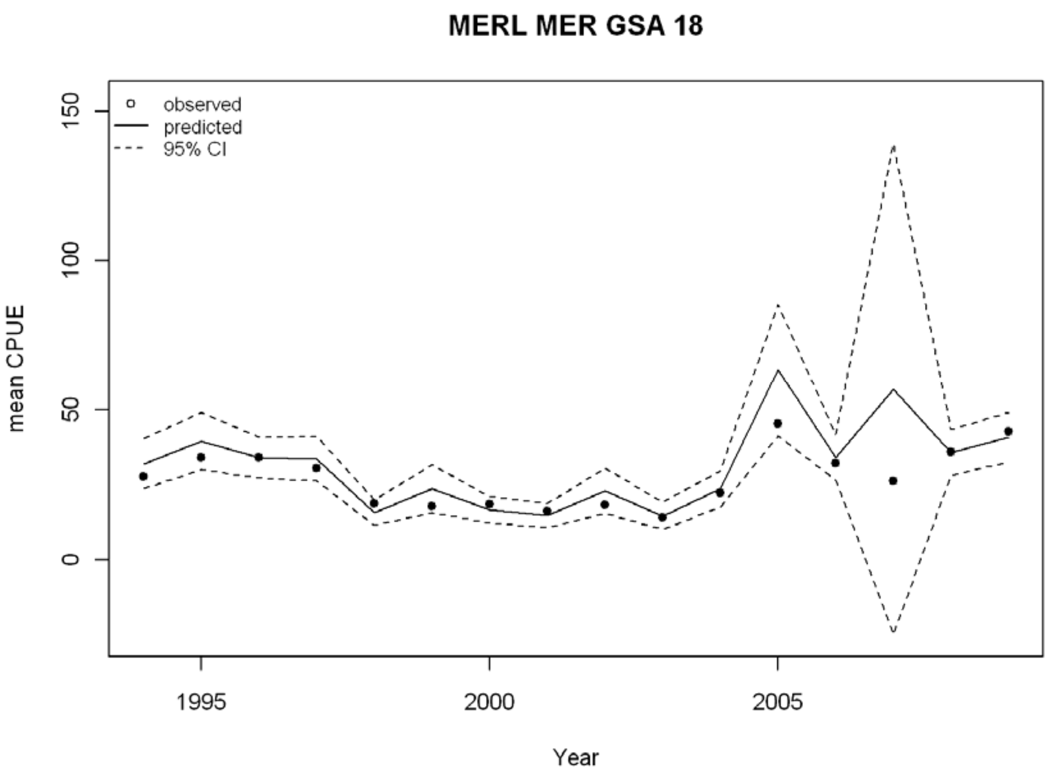


Figure 3.4.1.1.15. Mean observed and predicted (+/- 95% CI) CPUE (Kg/Km^2) for *Merluccius merluccius* in GSA 18 calculated using the quasi-Poisson glm.

The model applied seems quite reliable for hake in GSA 18 until 2004; in particular in 2005 and 2007 the fitted values are very different from the observed values and, in particular for 2007 the CI is very large (Figure 3.4.1.1.15). Maybe, it could be due to some problems in the data of that year. Also the diagnostic plots seem to be better than the residual plots of hake in GSA 10, even if there should be some problems in this fitting as well (Fig. 3.4.1.1.16). Nevertheless, the dispersion of the residuals versus the predicted values increases less than in other cases and the values look more randomly distributed above and below the dotted line. The normal q-q plot is quite good except for the extreme quantiles (the highest and the lowest). Finally, from the summary of the model (Tab. 3.4.1.1.6) is evident that the predictors chosen for the model explain significantly the observed values.

Tab. 3.4.1.1.6. Quasi glm model output for Mediterranean hake in GSA 18

```
Call:
glm(formula = CPUE ~ factor(YEAR) + factor(MONTH) + Latitude *
    Longitude + DEPTH, family = quasipoisson, data = TB)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-11.758   -3.952   -1.411    1.810   28.790

Coefficients: (1 not defined because of singularities)
                     Estimate Std. Error t value Pr(>|t|)
(Intercept)        -2.606e+02  6.209e+01  -4.197 2.86e-05 ***
factor(YEAR)1995    2.118e-01  1.548e-01   1.368 0.171419
factor(YEAR)1996    6.062e-02  1.457e-01   0.416 0.677372
factor(YEAR)1997    4.963e-02  1.523e-01   0.326 0.744613
factor(YEAR)1998   -7.103e-01  1.641e-01  -4.329 1.59e-05 ***
factor(YEAR)1999   -3.039e-01  1.992e-01  -1.525 0.127383
factor(YEAR)2000   -6.506e-01  1.642e-01  -3.963 7.75e-05 ***
factor(YEAR)2001   -7.785e-01  1.676e-01  -4.645 3.69e-06 ***
factor(YEAR)2002   -3.323e-01  1.944e-01  -1.709 0.087677 .
factor(YEAR)2003   -7.831e-01  1.894e-01  -4.135 3.75e-05 ***
factor(YEAR)2004   -3.030e-01  1.690e-01  -1.793 0.073157 .
factor(YEAR)2005    6.834e-01  2.024e-01   3.376 0.000753 ***
factor(YEAR)2006    6.495e-02  1.565e-01   0.415 0.678263
factor(YEAR)2007    5.757e-01  7.416e-01   0.776 0.437755
factor(YEAR)2008    1.103e-01  1.525e-01   0.723 0.469779
factor(YEAR)2009    2.456e-01  1.436e-01   1.710 0.087525 .
factor(MONTH)6      1.024e+00  7.247e-01   1.412 0.158021
factor(MONTH)7      7.191e-01  7.255e-01   0.991 0.321747
factor(MONTH)8      4.409e-01  7.416e-01   0.595 0.552228
factor(MONTH)10            NA         NA      NA       NA
Latitude            6.212e+00  1.499e+00   4.145 3.58e-05 ***
Longitude           1.396e+01  3.383e+00   4.127 3.87e-05 ***
DEPTH              -1.257e-03  1.716e-04  -7.325 3.87e-13 ***
Latitude:Longitude -3.288e-01  8.172e-02  -4.024 6.02e-05 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for quasipoisson family taken to be 26.37620)

    Null deviance: 42824  on 1535  degrees of freedom
Residual deviance: 33101  on 1513  degrees of freedom
AIC: NA

Number of Fisher Scoring iterations: 6
```

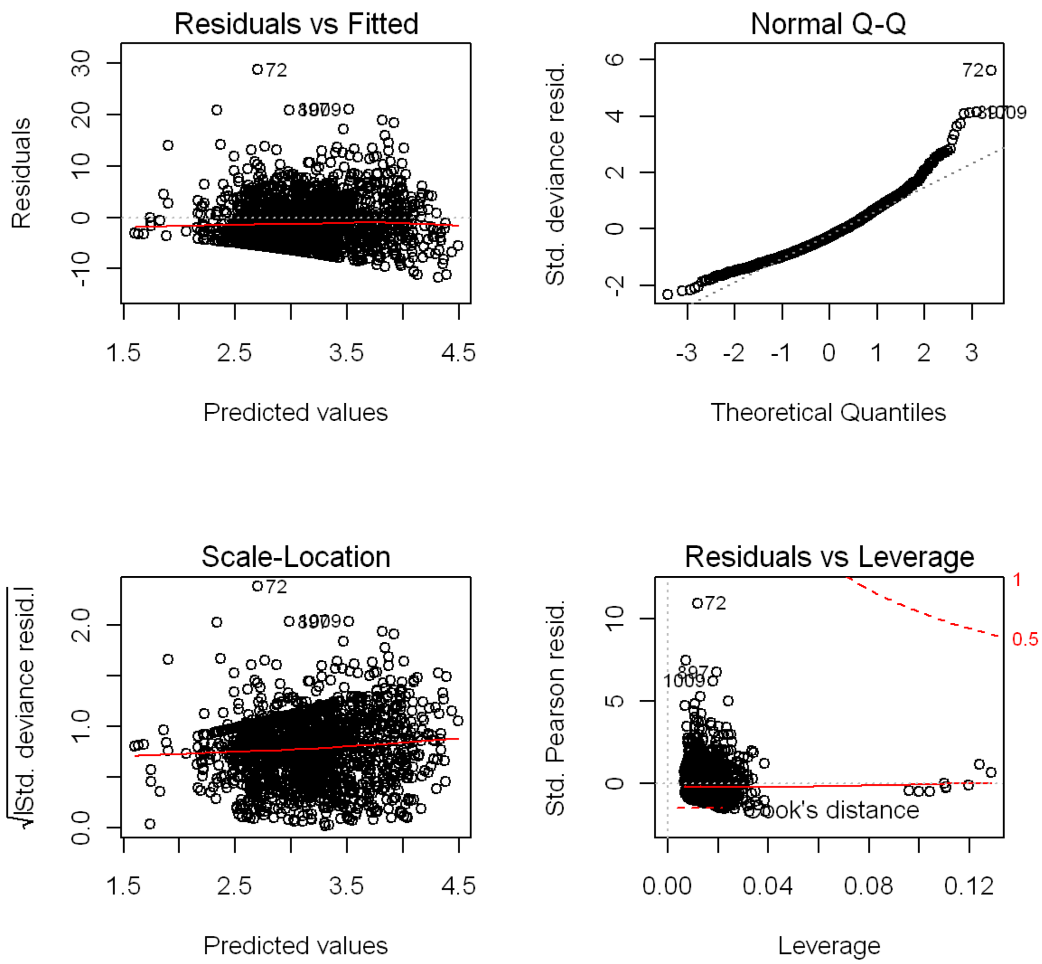


Figure 3.4.1.1.16. Diagnostic plots for the quasi-Poisson glm fitted to *Merluccius merluccius* data in GSA 18.

In summary, even though for MERL MER of GSA 18 data, further investigation for 2007 data should be done, GLM standardization seems to be, especially for this area, between the two compared methods, the most reliable one, because the sampling design changed along the years and the GLM chosen, in general, take into account the spatial distribution of the hauls.

3.4.1.2. Conclusions and Recommendations

Overall MEDITS DB quality

The new MEDITS database (SGMED 2010 MEDITS_uploaded tables 06122010.ldb) is a large improvement over the previous tested version (SGMED 2009 MEDITS_survey_data_20100601.mdb). The main issue which was a database structural problem of GSA identification and misspecification has been solved and now all hauls are correctly identified and no more incorrect merging between haul and catch data seem to happen. In the new db there are overall fewer errors, although few hauls still show problems that need to be corrected. This comment is valid for files TA and TB while file TC was untested. We believe that the current available database, albeit some necessary corrections, is sufficiently robust to be used for assessment purposes in general and for the use of the R script without continuous debugging due to database errors.

Models

It is clear that applying the same model to different species and GSAs is not the best approach. For each specie and GSA there should be an in depth model exploration and stepwise model selection. This would require with the current species/GSAs combinations an intense work. During MEDITS there has been changing number of hauls within the same areas as in GSA 16, 20 and others. As we showed in the comparisons this has a significant impact on the calculation of the cpue using the standard method of stratified means. In these cases it should be particularly important to perform cpue standardization with GLM/GAMs in order to account for sampling unbalance over time and the effect of adding/removing certain hauls. Additionally for the species selected, which in most cases are caught in few tows, zero inflation is certain and to model these species either zero inflated models or other approaches need to be developed.

SGMED recommendations

1. If fast and routine use of MEDITS data stored in the SGMED database is a foreseeable goal, a reliable and error free database should be made available for stock assessment. The R script developed for this purpose has been partially adjusted to the new database during the Mazara meeting but further refinement and testing is recommended, in particular for the age slicing function on the new TC file, which remains untested.
2. It is advisable to assess in which cases it is better to use the GLM/GAM cpue standardization versus the stratified means approach. This is an important matter as MEDITS cpue indexes often drive the tuning of XSA assessment, are used for SURBA and can be used in an indicator based approach especially in data poor situations.
3. A dedicated working group should perform an in depth effort to standardize MEDITS cpue for main target and priority species using the GLM/GAM models in the R script. Such work will determine which models work best for certain species and areas. Once this has been done the first time, updating the models the following years will be a routine exercise that requires only re-running the same models.
4. The same working group should retain the most common models used to fit MEDITS cpue data and incorporate them in the R script developed so far so that the end user will be able to use the code of multiple predefined sets of models. These models should be scripted with their corresponding model predictions as this part can be difficult to modify by a non expert user. The new R script will need to be fit Zero inflated models and dealing with heterogeneity (spread of the residuals along an explanatory variable) as both cases are very common with fisheries survey data.

4. SUMMARY SHEETS OF ASSESSMENTS OF HISTORIC AND RECENT STOCK PARAMETERS AND MANAGEMENT REFERENCE POINTS (TOR A, B, C , D AND E)

4.1. Introductory notes to stock summary sheets

SGMED 10-03 provides 16 stock summary sheets (short versions of the important information from the detailed assessment sections of this report, section 7) only in cases where exploitation rates are estimated analytically. Fisheries management advice is provided if limit management reference points of exploitation consistent with high long term yields or precautionary management reference points of stocks size could be estimated and proposed.

The summary sheets provided in this report of SGMED-10-03 deal with assessment of historic and recent trends in stock parameters (stock size, recruitment and exploitation) and relevant scientific advice only. However, long term forecasts are provided in order to allow stock status reviews with regard to the estimated limit management reference points $F_{0.1}$ and F_{MSY}. In accordance with the ToR deterministic short and stochastic medium term predictions of such parameters including landings and stock size under various management options as well as relevant scientific advice are delivered are in the following section 6.

4.2. Hake in GSA 9

Species common name:	European hake
Species scientific name:	*Merluccius merluccius* (L., 1758)
Geographical Sub-area(s) GSA(s):	GSA 09

Most recent state of the stock

An XSA assessment was carried out during SGMED 10-03 using the catch data collected under DCR from 2005 to 2009. SURBA analysis was also carried out using both MEDITS survey data (1994-2009) and GRUND (1995-2004).

- State of the adult abundance and biomass:

During 2005-2009 SSB oscillated between 948 and 1734 t. SSB peaked in 2008 (2917 t) and at present (2009), SSB is estimated to be around 1000 t. SURBA estimates using MEDITS data, indicate a decreasing pattern since 1994 with the lowest value observed in 2009. In the absence of precautionary reference points SGMED is unable to fully evaluate the state of the stock size.

- State of the juveniles (recruits):

XSA estimates ranged between about $230x10^6$ in 2007 and 77 $x10^6$ recruits in 2009. According to survey data recruitment fluctuated from year to year with an increasing trend in recent years. The largest year classes were observed in 1998 and 2008 (MEDITS data, see fig. below). The XSA instead shows a declining trend in the last 3 years.

- State of exploitation:

SGMED 09-02 recommends F≤0.2 1as target management reference point (basis $F_{0.1}$, F_{MSY} proxy).
The stock appears to be heavily overexploited and F needs a consistent reduction from the current F of 1.3-1.6 (XSA estimates) towards the candidate reference points for long term sustainability based on F between 0.2-0.4 ($F_{0.1}$-F_{max}). A very high F value of 2.4 was obtained in 2009 from survey data. Such high F rate was however not confirmed by XSA which returned a 1.56 for F in 2009.
However, considering the high productivity in terms of incoming year classes, this stock has the potential to recover quickly if F is reduced towards $F_{0.1}$.
The continued lack of older fish in the surveyed population indicates exploitation rates far beyond those considered consistent with high yields and low risk. This fact, on the other hand, may reduce the risk of fisheries collapse.

- Source of data and methods:

Data coming from MEDITS (1994-2008) and GRUND (1994-2004) trawl surveys were used to estimate relative SSB and F with Surba. Data coming from DCR (size distribution of landings for trawl and gillnet data on trawl discards for 2006) for the period 2006-2008 were used to run LCA analyses.

The following parameters were used both for SURBA and VIT analyses:

Growth parameters (Von Bertalanffy)
L∞ = 104 (cm, total length); k = 0.2; $t_{0=}$ - 0.03
L*W: a = 0.006657; b=3.028
M vector Age_1=1.3, Age_2=0.6, Age_3=0.46, Age_4=0.41, Age_5=0.3 (ProBiom)
q(age 1+) = 0.8, q(age 2+) = 1.0, q(age 3+)=0.7, q(age 4+)=0.7, q(age 5+)=0.7
Length at maturity (L_{50}) = 30 cm total length (sex combined)

The state of exploitation was assessed for the period 2005-2009 applying the Extended Survivor Analysis (XSA) method calibrated with fishery independent survey abundance indices (MEDITS). Fishing mortality was also estimated using SURBA. In addition, a yield-per-recruit (Y/R) analysis was carried out.

Outlook and management advice

SGMED recommends the relevant fleets' effort to be reduced until fishing mortality is below or at the proposed level $F_{0.1}$, in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan taking into account mixed-fisheries effects. Catches consistent with the effort reductions should be estimated.

Short and medium term scenarios:
See section 6 of this report.

Fisheries

Hake is the demersal species providing the highest landings and incomes in the GSA 0 9. About 90% of landings of hake are due to bottom trawl vessels; the remaining fraction is caught by artisanal vessels using set nets, in particular gillnets. Hake trawl fishery exploits a highly diversified species assemblage: horned octopus (*Eledone cirrhosa*), poor cod (*Trisopterus minutus capelanus*), squids (*Illex coindetii*), are among the most important species in the by catch. The trawl fleet of GSA 09 at the end of 2007 accounted for 360 vessels. The main trawl fleets of GSA 09 are present in the following continental harbours: Viareggio, Livorno, Porto Santo Stefano (Tuscany), Fiumicino, Terracina, Gaeta (Latium). The fishing capacity of the GSA 09 has shown in these last 20 years a progressive decrease; from 1996 to 2006 the number of bottom trawlers of GSA9 decreased of about 30%. Consequently also fishing effort decreased, even though in a lesser extent, in this period. In the last five years the total landings of hake of GSA 09 fluctuated between 1000 to about 2300 tons. In 2008 and 2009 the landing was 1329 tons.

Landings (t) by year and major gear types, 2002-2009 as reported through DCR.

Type FT_LVL4	2004	2005	2006	2007	2008	2009
GND			4.8			
GNS	249.5	551.0	592.9	580.2	348.9	409.2
GTR	346.4	284.4	404.0	131.9	61.1	54.0
LLD	1.1		56.8	0.2	2.2	4.4
LLS	3.3	5.2	85.1	15.6	2.9	2.0
OTB	552.9	1053.9	1180.0	1025.0	914.8	853.2
PS	0.0		2.8			6.2
SB-SV	1.5		0.1			
Total landing (tons)	1154.7	1894.5	2326.4	1752.8	1329.8	1329.0

Trend in fishing effort (kW*days,) by major gear types, 2002-2009.

Type FT LVL4	2004	2005	2006	2007	2008	2009
GNS	2828257	3887852	3192557	3730816	2897517	3165163
GTR	2930802	3825650	3758552	2840462	2330668	2819133
LLD	435343	795954	872471	485306	576643	326821
OTB	13997398	14737375	12427695	13044590	10602617	11927325
PS	385988	455763	1128366	1117009	976131	1311059

Due to large concentration of hake juveniles in GSA 09, trawl landings are traditionally dominated by small sized specimens; they are basically composed by age groups 0+ and 1+. Gillnet fishery lands mostly age 2 and age 3 fish. High quantities of small size hake are routinely discarded, especially in summer and on fishing grounds located near the main nursery areas of the species. About 450 tons of hake discards were estimated in 2006 for the trawl fishery in GSA 09. Due to the introduction of the EU Regulations on MLS, a progressive increase of the size at which 50% of the specimens caught was discarded has been observed in the last ten years.

Limit and precautionary management reference points

Table of limit and precautionary management reference points **proposed by SGMED**

$F_{0.1}$ (age1-5) ≤ 0.2	
F_{max} (age 1-5) = 0.35	
F_{msy} (age range) =	
B_{msy} (spawning stock) =	
B_{pa} (B_{lim}, spawning stock) =	

Table of limit and precautionary management reference points **agreed by fisheries managers**

$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Comments on assessment

GRUND data prior to 1994 should be standardised and used within this assessment.
The detailed assessment of hake in GSA 9 can be found in section 7.2 of this report.

4.3. Hake in GSA 10

Species common name:	European hake
Species scientific name:	*Merluccius merluccius* (L., 1758)
Geographical Sub-area(s) GSA(s):	GSA 10

Most recent state of the stock

- State of the adult abundance and biomass:

Survey indices indicate a variable pattern of abundance (n/h) and biomass (kg/h) without a clear trend. However, recent values are among the highest observed since 1994. The Aladym model showed instead that the SSB was continuously decreasing. No precautionary biomass reference points have been proposed for this stock. As a result, SGMED-10-03 is unable to fully evaluate the status of the stock with respect to biomass.

- State of the juvenile (recruits):

Recent recruitment since 2005 appears to be above average, as derived directly from the trawl survey estimates considering as recruits the age 0 group and from the SURBA model analysis.

- State of exploitation:

SGMED 10-03 proposes $F \leq 0.2$ as limit management reference point (basis $F_{0.1}$) consistent with high long term yields (proxy of F_{MSY}). Given the results of the present analysis, the stock appeared to be subject to overfishing in 2006-2009, as the estimates of fishing mortality are on average 0.72. Regardless of the growth pattern a considerable reduction is necessary to approach the $F_{0.1}$ reference point (Factor; ~60-70% of the current F value, depending on the year). However, considering the high productivity in terms of incoming year classes, this stock has the potential to recover quickly if F is reduced towards $F_{0.1}$.

- Source of data and methods:

The data used in the analyses were from trawl surveys (time series of MEDITS and GRUND surveys from 1994 to 2009 and from 1994 to 2006 respectively) and from fisheries up to 2009. A check of the hauls allocation between GSA 09 and 10 is needed before the calculation of indices from the JRC MEDITS database.

The analyses on the population were conducted using SURBA, ALADYM and VIT models in a complementary way. Two growth scenarios were tested: Set 1) 'slow' growth: L_∞=97.9 cm, K=0.135, t_0= -0.4; males: L_∞=50.8 cm, K=0.25, t_0= -0.4; length-weight relationship: a=0.00355, b=3.22 for sex combined. Set 2) 'fast' growth: L_∞=104 cm, K=0.2, t_0= -0.01; length-weight relationship: a=0.00355, b=3.22 for sex combined. Natural mortality vector for the two scenarios were obtained applying the Prodbiom method. Size at first maturity was varying around 32 cm (maturity range 2 cm).

Outlook and management advice

SGMED recommends the relevant fleet's effort to be reduced until fishing mortality is below or at $F_{0.1}$ in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan taking into account mixed-fisheries effects.

Fisheries

M. merluccius is with red mullet and deep-water pink shrimp a key species of fishing assemblages in the central-southern Tyrrhenian Sea. 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*. Since 2004, landings of hake increased from 1,338 t to 1,544 t in 2006 and decreased to about 1,091 t in 2009. Most part of the landings of hake is from trawlers and nets (GNS and GTR), but the catches of the demersal long-line fishery are also important.

Annual landings (t) by major gear type, 2004-2009.

Sum di LW					YEAR					
COUNTR	AREA	SPECIE	FT_LVL	FT_LVL5	2004	2005	2006	2007	2008	2009
ITA	10	HKE			198	186	8			
			GND	Small pelagic fish	7		12	11	8	9
			GNS	Demersal species	177	294	323	213	311	282
				Small and large pelagic fish				7	0	2
			GTR	Demersal species	202	124	152	157	68	107
			LLD	Large pelagic fish					2	3
			LLS	Demersal fish	266	269	288	240	232	247
			OTB	Deep water species			14	4	3	8
				Demersal species	186		97	173	351	277
				Mixed demersal and deep water species	300	612	649	464	147	156
			PS	Small pelagic fish	1		2			
			SB-SV	Demersal species	1				1	
Total					1339	1485	1544	1269	1123	1091

Limit and precautionary management reference points

Table of limit and precautionary management reference points **proposed by SGMED**

$F_{0.1}$ (equilibrium)	≤0.2
F_{max} (age range)	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Table of limit and precautionary management reference points **agreed by fisheries managers**

$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Comments on the assessment

The detailed assessment of hake in GSA 10 can be found in section 7.3 of this report.

4.4. Hake in GSA 11

Species common name:	European hake
Species scientific name:	*Merluccius merluccius* (L., 1758)
Geographical Sub-area(s) GSA(s):	GSA 11

Most recent state of the stock

- State of the adult abundance and biomass:

SGMED-10-03 could not estimate the absolute levels of stock abundance. MEDITS abundance (n/km²) and biomass (kg/km²) indices do not indicate a significant trend. The stock SSB calculated using SURBA periodically oscillated during the period and has decreased in the last years showing the lowest value in 2009. In the absence of precautionary reference points SGMED is unable to fully evaluate the state of the stock size

- State of the juvenile (recruits):

SGMED-10-03 could not estimate the absolute levels of recruitment. However, relative indices estimated by SURBA indicated very high fluctuations of recruitment in the period 1994-2009, with a clear decreasing trend in the last five years.

- State of exploitation:

SGMED proposes $F_{0.1}$ as limit reference point consistent with high long term yields (F_{MSY} proxy).The reference points ($F_{0.1}$ and F_{max}) estimated for this species were 0.3 and 0.4, respectively. SGMED notes that the current mean F estimated either by SURBA and LCA (F_{1-3}=1.72 and 0.98) are far in excess of the proposed target reference point $F_{0.1}$ and also exceeds F_{max}, Moreover the high F value obtained in 2009 should be contrasted with landings data, which are at their minimum of the last 6 years. Thus, given the results of the present analysis, SGMED concludes that the stock is overexploited.

Source of data and methods:

The present assessment was derived by both indirect and direct data. By using VIT and SURBA the status stock was assessed considering the same set of parameters reported below. Vectors of natural mortality calculated from ProdBiom was used. Finally the Yield per Recruit (Y/R) analysis was performed by means of the Yield software.

Parameters used both for SURBA and VIT analyses.

VBGF	L_∞=100 cm, K=0.24, t_0= -0.01
L-W relationship	a = 0.004, b= 3.156
M vector	Age_0=1.11, Age_1=0.51, Age_2=0.39, Age_3=0.33, Age_4=0.31, Age_{5+}=0.29
Catchability (q)	q_0 = 0.7, q_{1-3} = 1.0, q_4=0.75, q_5=0.6
Length at maturity (L50)	36 cm (sex combined)

Outlook and management advice

SGMED recommends the relevant fleets' effort to be reduced until fishing mortality is below or at the proposed level $F_{0.1}$, in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan. Catches consistent with the effort reductions should be estimated.

Fisheries

Hake is exploited in all trawlable areas around Sardinia and is one of the most important target species showing the highest landings. According to the scientist's knowledge of the GSA 11 landings of hake derives almost entirely from bottom trawl vessels whereas catches from trammel nets or longlines are negligible.

Small hakes are commonly caught from shallow waters about 50 m to 300 m depth, whereas adults reach the maximum depths exploited (800 m). Both small and adults catches coming from a mixed fishery, then in the GSA there is not a specific Hake fishery. The most important by catch species are horned octopus (*Eledone cirrhosa*), squids (*Illex coindetii*), poor cod (*Trisopterus minutus capelanus*) at depths less than 350 m and (*Chlorophtalmus agassizii*), greater forkbeard (*Phycis blennoides*) and deep-water pink shrimp at greater depth (*Parapenaeus longirostris*).

At the end of 2006 the trawl fleet of GSA11 accounted for 157 vessels (11.7% of the overall Sardinian fishery fleet). The main trawl fleets of GSA11 are present in the following harbors: Cagliari, Alghero, Porto Torres, La Caletta, Sant'antioco, Oristano, Alghero and Arbatax. The fishing capacity of the GSA trawl fleet has shown in these last 15 years remarkable changes. From 1994 to 2004 a general increase in the number of vessels and by the replacement of the old, low tonnage wooden boats by larger steel boats. In the latest years the effort shows a peak in 2005, then continuously decrease and a drop in 2008 and 2009. Since 2004 the annual landings varied between 222 and 346 t, with a consistent drop (-22% of the 6 years mean) in the last year (2009).

Limit and precautionary management reference points

Table of limit and precautionary management reference points **proposed by SGMED**

$F_{0.1}$ (from VIT, average for all age classes)	≤0.30
F_{max} (from VIT, average for all age classes)	≤0.40
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Table of limit and precautionary management reference points **agreed by fisheries managers**

$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Comments on the assessment

To improve the evaluation of the state of the stock direct information on autumn period (GRUND survey) should be standardized and used in the assessment. This will allow to more precisely estimating the recruits. The detailed assessment of hake in GSA 11 can be found in section 7.4 of this report.

4.5. Hake in GSAs 15 and 16

Species common name:	Hake
Species scientific name:	*Merluccius merluccius* (Linnaeus, 1758)
Geographical Sub-area(s) GSA(s):	GSAs 15 and 16

Most recent state of the stock

- State of the adult abundance and biomass: Relative indices derived from both GRUND and MEDITS scientific surveys indicate a small increase of the GSA 16 hake stock from 2003 to 2005, followed by a slight decline from 2006 to 2009. Spawning stock biomass (SSB) calculated using the SURBA approach increased from 1998 to 2005, and has remained stable since. In the absence of precautionary reference points SGMED is unable to fully evaluate the status of the stock size.

- State of the juvenile (recruits): MEDITS results indicate that levels of recruitment in the past decade peaked in 2005-2007, followed by a decline in 2008 and 2009.

- State of exploitation: SGMED proposes $F_{0.1} \leq 0.15$ as limit refenence point consistent with high long term yields (F_{MSY} proxy). Results of analyses performed on fisheries dependent as well as fisheries independent data using different modeling approaches gave consistent results. Models indicate that fishing mortality is far in excess of sustainable levels, and that *Merluccius merluccius* in GSA 16 is overexploited. The continued low abundance of adult fish in the surveyed population as well as commercial catches similarly indicate very high exploitation patterns far in excess of fishing mortalities consistent with sustainable high yields, and a precautionary approach to fisheries management.

- Data quality and availability:
  In terms of data quality and availability, SGMED 10-03 noted that both data from GSA 15 and 2009 commercial data from GSA 16 was now available. However the lack of this data at SGMED 10-02 greatly increased the work of the scientists since assessments planned at SGMED 10-02 had to be run again by SGMED 10-03.

- Source of data and methods: Data was derived both from indirect (fisheries monitoring) and direct (scientific surveys) sources, and stock status was assessed by using VIT, SURBA (Needle 2003) and non-equilibrium surplus production model (Abella 2005). SGMED 10-03 performed an assessment combining survey data (MEDITS) from GSA 15 and GSA 16 using SURBA, however the model fit was very poor. The poor model fit was likely due to the short time series of survey data available from both GSA 15 and GSA 16 (2002-2009), compared to the long time series of survey data available from GSA 16 (1994-2009). The SURBA assessment presented was thus based only on GSA 16 data. Stock parameters were calculated by taking averages of male and female parameters, which were weighed by sex ratio. The combined stock parameters were: L_{inf}= 100cm; k= 0.116; t_0= -0.643; a= 0.0043; b= 3.1525. Vectors of natural mortality (M; using ProdBiom), maturity and weight were calculated and are given in the table below.

Vectors of natural mortality, maturity, weight and catchability for hake (sex combined) in the Strait of Sicily (GSA 16).

	Age					
	0.5	1.5	2.5	3.5	4.5	5.5
Mortality	0.68	0.30	0.22	0.19	0.17	0.16
Weight	12.08	73.40	206.35	415.86	696.04	1035.30
Catchability	0.8	1	1	1	0.75	0.5
Maturity	0.04	0.15	0.36	0.56	0.86	0.98

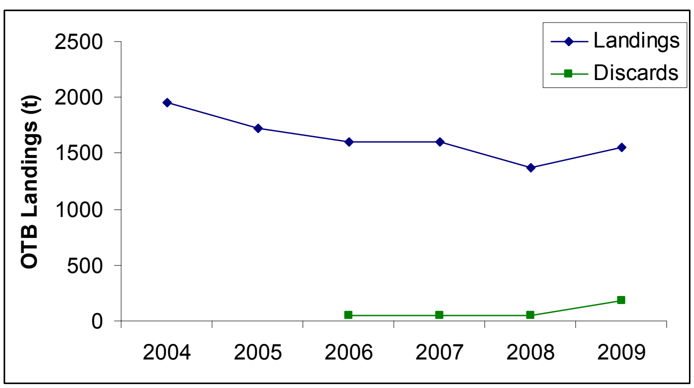
Outlook and management advice

SGMED recommends the relevant fleet's effort to be reduced until fishing mortality is below or at $F_{0.1}$ in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan taking into account mixed-fisheries effects. Based on the biological reference points calculated using VIT and the SURBA / non-equilibrium surplus production model, fishing mortality should be reduced by 77% to reach $F_{01.}$

- Short and medium term scenarios: SGMED-10-03 performed short term projections of stock status.

Fisheries

Although hake is not a target of a specific fishery such as deep water pink shrimp and striped mullet, it is the third species in terms of biomass of Italian yield in GSA 16. Hake is caught by trawlers in a wide depth range (50-500m) together with other important species such as *Nephrops norvegicus*, *Parapenaeus longirostris*, *Eledone* spp., *Illex coindetii, Todaropsis eblanae*, *Lophius* spp., *Mullus* spp., *Pagellus* spp., *Zeus faber, Raja* spp among others. In 2004-2009, 97% of declared catches were caught by demersal otter board trawlers, which is the fleet segment the current assessment is based on. Around 1% of catches were obtained using longlines, and 2% using trammel nets. Italian trawlers, based in the harbors along the southern coasts of Sicily, operate both in GSA 16 and 15 with exclusion of the Maltese Fishing Management Zone (FMZ). Italian trawlers exert the most of fishing effort and in 2002-2009, 99.6% of hake catches declared by all Maltese and Italian fleets combined were landed by the Italian fleet. In the late 1990s Sicilian trawlers fishing off-shore (15–25 days of trip) had higher discard rates of hake (31% in weight of total catch) than the inshore trawlers (1-2 days trips) (9% in weight). The 2009 data shows that the discarded fraction of hake by Sicilian trawlers increased from 2008 to 2009 (3.3% of total landings were discards in 2008 in weight in 2008; 11.6% of total landing were discards in 2009). In 2009, 185 t of hake was discarded in GSA 16, compared to 1 t in GSA 15. Overall landings increased from 2008 to 2009. The trends in fishing effort of the bottom otter trawl fleet increased from 2004 to 2007 by 32%, declined by 25% from 2007 to 2008, and increased by 6% between 2008 and 2009.



Hake landings and discards by Sicilian and Maltese trawlers, fished in GSA 15 and 16.

Limit and precautionary management reference points

Table of limit and precautionary management reference points **proposed by SGMED**

$F_{0.1}$ (0-8+)≤	≤0.15
F_{max} (0-8+)=	≤0.19
Z_{MBP} (1-3)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Table of limit and precautionary management reference points **agreed by fisheries managers**

$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Comments on the assessment

The detailed assessment of hake in GSAs 15 and 16 can be found in section 7.5 of this report.

4.6. Hake in GSA 18

Species common name:	European hake
Species scientific name:	*Merluccius merluccius* (L., 1758)
Geographical Sub-area(s) GSA(s):	GSA 18

Most recent state of the stock

- State of the adult abundance and biomass:

Survey indices indicate a variable pattern of abundance (n/h) and biomass (kg/h) without a clear trend. However, recent values are higher or similar to those observed since 1994. Results from ALADYM model showed also a recent increase of the SSB although the current levels are around 7-8% of the value estimated at F=0. No precautionary biomass reference points have been proposed for this stock. As a result, SGMED-10-03 is unable to fully evaluate the status of the stock with respect to biomass.

- State of the juvenile (recruits):

Recruitment increased to the highest recorded values in 2005 and dropped sharply to an average level of the time series thereafter. In 2008 and 2009 recruitment was slightly higher than the average level of the time series, except in 2005.

- State of exploitation:

SGMED 10-03 proposes $F \leq 0.22$ as limit management reference point (basis $F_{0.1}$) consistent with high long term yields (F_{MSY} proxy). Given the results of the present analysis, the stock appeared to be subject to overfishing in 2006-2009, as the estimates of fishing mortality are on average 0.95. Regardless of the growth pattern a considerable reduction is necessary to approach the $F_{0.1}$ reference point (Factor; ~70-75% of the current F value, depending on the year) from the current level of F. However, considering the high productivity in terms of incoming year classes, this stock has the potential to recover quickly if F is reduced towards $F_{0.1}$.

- Source of data and methods:

The data used in the analyses were from trawl surveys (time series of MEDITS and GRUND surveys from 1994 to 2009 and from 1994 to 2006 respectively) and from fisheries. A check of the hauls allocation between GSA 09 and 10 is needed before the calculation of indices from the JRC MEDITS database.
The analyses on the population were conducted using SURBA, ALADYM and VIT models in a complementary way. Two growth scenarios were tested: Set 1) 'slow' growth: L_∞=96 cm, K=0.13, t_0= -0.73; for sex combined. Set 2) 'fast' growth: L_∞=104 cm, K=0.2, t_0= -0.01; length-weight relationship for both scenarios: a=0.00435, b=3.155 for sex combined. Natural mortality vector for the two scenarios were obtained applying the Prodbiom method. Size at first maturity was varying around 33 cm (maturity range about 4 cm). Estimates of total mortality from SURBA were used to feed ALADYM in the hindcasting approach. Recruitment estimates from SURBA were rescaled for getting a guess estimate of the absolute recruitment. In addition, estimates of the initial number from VIT were used to approximately set the order of magnitude of the recruitment.
ALADYM routines re-estimated the total and fishing mortality using the whole information on the population parameters and a simulated exploitation pattern from the fishery. The fleet fishing selectivity was simulated using an ogive model with the following parameters: L_c=12cm; selection range (SR) 1 cm. This was coupled with a deselection ogive with 50% deselection size at 40 cm and a deselection range of 1 cm, to account for possible avoidance/reduced availability of older fish. Also the coefficient of monthly activity of the fleet was considered in the simulation, accounting for the current fishing ban in the summer season (fishing coefficient=0.2 in August, 0.9 in September and October and 1 in all the other months). The proportion of offspring per month was set according to the observations carried out in the area. For the use of VIT model length frequency distributions of the landings were age sliced using the fast growth parameters and LFDA routine.

Outlook and management advice

SGMED recommends the relevant fleet's effort to be reduced until fishing mortality is below or at $F_{0.1}$ in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan taking into account mixed-fisheries effects.

Short and medium term scenarios:
Short and medium term scenarios are provided in section 6 of this report.

Fisheries

Hake is one of the most important species in the Geographical Sub Area 18 representing more than 20% of landings from trawlers. Demersal species catches are landed on the western side (Italian coast) and the eastern side (Albanian and Montenegro coasts), with an approximate percentage of 97% and 3%, respectively. Trawling is the most important fishery activity on the whole area and effort by trawlers is about 70% of the total effort.
Landings by demersal trawlers dominate. The Mediterranean 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). Long-line landings account for about 10-12% of the total production.
Fishing grounds are located on the soft bottoms of continental shelves and the upper part of continental slope. 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*.

Annual landings (t) by fishing technique, 2004-2009.

Sum of LW					YEAR					
COUNTR	AREA	SPECIE	FT_LV	FT_LVL5	2004	2005	2006	2007	2008	2009
ITA	18	HKE				1	1	0		
			GNS	Demersal species	19	38	30	19	15	8
				Small and large pelagic fish					0	0
			GTR	Demersal species	21	18	26	18	42	20
			LLD	Large pelagic fish			0		0	
			LLS	Demersal fish	233	452	836	620	551	534
			OTB	Deep water species					3	8
				Demersal species	195	55	1113	923	3330	3086
				Mixed demersal and deep water species	2737	3221	3500	2575	311	451
			PTM	Small pelagic fish	0					
		HKE Total			3204	3785	5507	4155	4251	4106

Limit and precautionary management reference points

Table of limit and precautionary management reference points **proposed by SGMED**

$F_{0.1}$ (equilibrium)	≤0.22
F_{max} (age range)	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Table of limit and precautionary management reference points **agreed by fisheries managers**

$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Comments on the assessment

The detailed assessment of hake in GSA 18 can be found in section 7.7 of this report.

4.7. Red mullet in GSA 09

Species common name:	Red mullet
Species scientific name:	*Mullus barbatus*
Geographical Sub-area(s) GSA(s):	GSA9

Most recent state of the stock

State of the adult abundance and biomass:

- The index of stock abundance derived from MEDITS surveys suggest an increasing trend up to 2002 followed by a relatively steady status up to 2009. SGMED is unable to fully evaluate the status of the stock size as no precautionary reference point is defined.

- State of the juvenile (recruits): index of abundance of juveniles shows a high variability, with higher values in years 2000-2003 and with recent levels similar to those of 1994-95.

- State of exploitation: SGMED propses $F_{MSY} \leq 0.62$ as limit reference point consistent with high long term yields. LPUEs increased along the study period in the main fisheries of the area. The stock status as regards the agreed precautionary and target reference points $F_{0.1}$, F_{max} and F_{MSY} can be defined as overfished even though in the recent years the ratio F/F_{MSY} is decreased.

- Source of data and methods: Data used derive from trawl surveys, with supply data on size composition and abundance indices, on commercial landings by size/age, data on catches and fishing effort directed to the species in question proceeding from commercial catch assessement surveys. A dynamic Biomass Production model (ASPIC) using both a time series from 1994 and 2009 of catch and effort of commercial vessels proceeding from two of the main ports (Viareggio and Porto Santo Stefano) and an abundance index derived from trawl surveys for the same time interval were used to estimate F_{MSY}, q for each fishery, B_{MSY}, f_{MSY}, and a value of F for each year along the time series. A cohort analysis with VIT using commercial landings demographic structure for the years 2006-2009 was also used for deriving F estimates by year, the value of the $F_{0.1}$, numbers at age and other features.

The main parameters used
L_{inf}=29, K=0.6, t_0=-0.1 L/W relationship a=0.00053 b=3.12
An M vector (age1=1.30, age2=0.79, age 3=0.62, age 4+=0.54) and a weighted mean value of M of 0.8.

Outlook and management advice

SGMED recommends to reduce fishing mortality towards the proposed reference point F_{MSY} by means of effort reduction of the relevant fleets. Catch forecasts consistent with the effort reductions shall be estimated. As red mullet is mainly caught in mixed fisheries, the effort reductions require multi-annual management plans being developed and fully implemented.

Fisheries

The species is mainly exploited by bottom trawlers, being the catches derived from artisanal fisheries negligible. *Mullus barbatus* catch rates are much higher in late summer-autumn. About 200 trawlers and a relatively small but variable number of artisanal vessels exploit the species in the GSA9. Annual landings, mostly proceeding from trawling, ranged from 500 to 1100 tons in the last years.

The species is caught as a part of a species mix that constitutes the target of the trawlers operating near shore. The main species caught in GSA9 are *Squilla mantis, Sepia officinalis, Trigla lucerna, Merluccius merluccius, Mullus barbatus, Gobius niger*. The species is mainly caught in late summer-beginnings of autumn, when juveniles are highly concentrated near shore. Age of first capture is of about 7 cm. Catch is mainly composed by age 0+ individuals while the older age classes are poorly represented in the catch. Catch rates increased along the analysed period and considering that no dramatic changes occurred on effort allocation nor on other aspects of fishing behaviour in the analysed years, this increase has to be attributed to an enhancement in biomass. Even if catch within the coastal 3 miles stripe is forbidden, illegal fishing do occur considering the high value that small-sized individuals have in the area.

Total catches of *Mullus barbatus* by gear

	2004	2005	2006	2007	2008	2009
Nets	60.0	24.0	16.0	9.0	11.0	21.0
trawlers	521.0	684.0	1033.0	1087.0	716.0	707.0
Longlines					0.0	
Miscelaneous	2.3		0.5			
Seines	0.0	0.1				
TOTAL	583.3	708.1	1049.5	1096.0	727.0	728.0

- <u>Short, medium and long term scenarios</u>

Determinstic short and medium term forecasts are presented in section 6 of this report.

Limit and precautionary management reference points

Table of limit and precautionary management reference points **proposed by SGMED**

$F_{0.1}$ (average for all age classes)	
F_{max} (average value for all ages)=	
F_{msy} (all exploited ages)	≤0.613
F_{pa} (F_{lim}) (age range)	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)	

Table of limit and precautionary management reference points **agreed by fisheries managers**

$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Comments on the assessment

The detailed assessment of red mullet in GSA 9 can be found in section 7.8 of this report.

4.8. Red mullet in GSA 10

Species common name:	Red mullet
Species scientific name:	*Mullus barbatus*
Geographical Sub-area(s) GSA(s):	GSA 10

Most recent state of the stock

- State of the adult abundance and biomass:

In the absence of proposed and agreed precautionary management reference points SGMED-10-03 is unable to fully evaluate the state of the SSB. However, survey indices indicate a variable pattern of biomass with the recent values amongst the lowest observed, except for 2007.

- State of the juvenile (recruits):

In 2007 and 2009 the MEDITS surveys indicated abundant recruits.

- State of exploitation:

SGMED proposes $F_{0.1} \leq 0.42$ as limit management reference point consistent with high long term yields. Thus, given the results of the present analysis (F 2006=1.11, F 2007=0.78, F 2008=0.9; F 2009=0.57), the stock appeared to have been subject to overfishing during 2006-2009. A reduction of F of about 40% would be thus necessary in order to avoid future loss in stock productivity and landings.

- Source of data and methods:

The data used in the analyses were from trawl surveys (time series of MEDITS and GRUND surveys from 1994 to 2009 and from 1994 to 2006 respectively) and from fisheries. The stock is assessed by a VPA (VIT) using the pseudocohort approach for each year (2006, 2007, 2008, 2009). A sex combined analysis was carried out. Regarding growth parameters the set L_∞=26 cm k=0.42 t_0= -0.4 was re-parameterized to the following equivalent set: L_∞=28 cm k=0.4 t_0= -0.4, given the presence of individuals with length higher than 26 cm. The length-weight relationship parameters were: a=0.0103; b=3.0246. A constant natural mortality M (Alagaraja) = 0.61 was adopted, because this value was close to 0.70, an estimate reported for a very slightly exploited area in the Castellammare Gulf (northern Sicily coasts) within the GSA. The setting of the proportion of mature females was 0.16 at age 0, 0.92 at age 1 and 1 at age 2. Management reference points were estimated by an YPR analysis.

Outlook and management advice

SGMED recommends the relevant fleet's effort to be reduced until fishing mortality is below or at $F_{0.1}$ in order to avoid future loss in stock productivity and landings. This should be achieved by effort reductions of the relevant fleets by means of a multi-annual management plan taking into account mixed-fisheries effects. Catch forecasts consistent with the effort reductions shall be estimated.

Short and medium term scenarios:

Forecasts of yield and biomass under various management scenarios are presented in section 6 of this report.

Fisheries

Red mullet is an important species in the area, targeted by trawlers and small scale fisheries using mainly gillnet and trammel nets. Fishing grounds are located along the coasts of the whole GSA within the continental shelves. Available landing data collected under the DCF framework range from 524 tons of 2004 to 278 tons in 2009, the latter being the lowest value registered. Most part of the landings of red mullet were from trawlers up to 2006, while since 2007 the level of catches of trawlers is similar to that of the other métier grouped together, to which the maximum contribution is given by gillnet (GNS) and trammel net (GTR). In 2009 the catches of both métier are decreasing.

Annual landings by major fishing techniques in tons for red mullet in the GSA10 (2004-2009).

Sum of LW				YEAR					
AREA	SPECIES	FT_LVL4	FT_LVL5	2004	2005	2006	2007	2008	2009
10	MUT			9.80	39.31	0.55		0.09	
		GND	Small pelagic fish		0.02			0.04	
		GNS	Demersal species	15.77	24.87	34.51	24.43	7.19	7.08
		GTR	Demersal species	96.05	102.20	68.25	212.21	125.37	97.73
		LLS	Demersal fish	0.58					
		OTB	Deep water species			1.35	0.26	0.23	0.23
			Demersal species	183.87		19.38	42.62	145.60	122.28
			Mixed demersal and deep water species	216.50	254.98	268.98	222.36	36.44	51.20
		PS	Small pelagic fish	0.04					
		SB-SV	Demersal species	1.77					
	MUT Total			524.38	421.38	393.02	501.88	314.96	278.52

Limit and precautionary management reference points

Table of limit and precautionary management reference points **proposed by SGMED**

$F_{0.1}$ (age range) =	≤0.42
F_{max} (age range) =	
F_{msy} (age range) =	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Table of limit and precautionary management reference points **agreed by fisheries managers**

$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Comments on the assessment

The detailed assessment of red mullet in GSA 10 can be found in section 7.9 of this report.

4.9. Red mullet in GSA 11

Species common name:	Red mullet
Species scientific name:	*Mullus barbatus*
Geographical Sub-area(s) GSA(s):	GSA 11

Most recent state of the stock

- State of the adult abundance and biomass:

SGMED could not estimate the absolute levels of stock abundance. MEDITS abundance (n/km²) and biomass (kg/km²) indices do not reveal any significant trends since 1994. In the last period both the indices since appear high but are subject to high level of uncertainty. The relative SSB estimated by SURBA show two peaks in 1999 and 2007 but with no particular trend. In the absence of precautionary reference points SGMED is unable to fully evaluate the state of the stock size.

- State of the juvenile (recruits):

SGMED is unable to provide any scientific advice given the preliminary status of the data and analyses.

- State of exploitation:

SGMED proposes $F_{0.1}$≤0.47 of ages 1-3 as limit management reference point consistent with high long term yields. Taking into account the results from VIT the stock of red mullet in GSA 11 is considered overexploited during the time series available. A reduction of F of almost 70% would be thus necessary in order to avoid future loss in stock productivity and landings.

- Source of data and methods:

The present assessment was derived by both indirect and direct data. By using VIT and SURBA the status stock was assessed considering the same set of parameters reported below. Vectors of natural mortality calculated from ProdBiom was used. Finally the Yield per Recruit (Y/R) Analysis was performed by means of the Yield software.

VBGF	L_∞=29.1 cm, K=0.41, t_0= -0.39
M vector	Age_0=1.30, Age_1=0.41, Age_2=0.27, Age_3=0.24
Catchability (q)	q_{1-3} = 1
Length at maturity (L50)	13 cm (sex combined)
Age at maturity	1
Age at first capture	0.7

Outlook and management advice

SGMED recommends the relevant fleets' effort to be reduced until fishing mortality is below or at the proposed level $F_{0.1}$, in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan. Catches consistent with the effort reductions should be estimated. The enforcement of the minimum landing size (fixed at 11 cm TL since 1995) and the recent (June 2010) enforcement of EC Council Regulation No 1967/2006 that changed the gear selectivity might have positive impact on the productivity of the stock in the near future. Finally an appropriate effort in achieving realistic indirect fishing effort information as well as the necessary control policy to avoid misapplication of EC regulation should be included in the management plan.

Short and medium term scenarios:

Short and medium term predictions of yield and biomass under different management options are provided in section 6 of this report.

Fisheries

Red mullet is exploited in all trawlable areas around Sardinia and is one of the most important target species showing the highest landings on shelf bottoms, together with the cephalopod *Octopus vulgaris*. According to the scientist's knowledge of the GSA11 landings of red mullet comes both from bottom trawl vessels and small artisanal fishery. Commonly small mullets are caught at around 50 m of depth where show high dense patches, whereas adults are caught at greater depths where are less concentrate. Both small and adults catches coming from a mixed fishery, then in the GSA there is not a specific fishery target on red mullet. At the end of 2006 the trawl fleet of GSA11 accounted for 157 vessels (11.7% of the overall Sardinian fishery fleet). The main trawl fleets of GSA11 are present in the following harbours: Cagliari, Alghero, Porto Torres, La Caletta, Sant'antioco, Oristano, Alghero and Arbatax. The fishing capacity of the GSA trawl fleet has shown in these last 15 years remarkable changes. From 1994 to 2004 a general increase in the number of vessels and by the replacement of the old, low tonnage wooden boats by larger steel boats. In the latest years the effort shows a peak in 2005, then continuously decrease and a drop in 2008 and 2009. Since 2004 the annual landings varied between 222 and 346 t, with a consistent drop (-22% of the 6 years mean) in the last year (2009). The landings were mainly from demersal otter trawls (catches from other gears are less than 5% of the total).

Limit and precautionary management reference points

Table of limit and precautionary management reference points **proposed by SGMED**

$F_{0.1}$ (from VIT, average for all age classes)	$\leq$0.47
F_{max} (from VIT, average for all age classes)	=0.68
F_{msy}	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Table of limit and precautionary management reference points **agreed by fisheries managers**

$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Comments on the assessment

Because the biology of the species, direct information which refer to autumn period (GRUND survey) should be standardized and used in the assessment to more precisely estimate the recruits.

The detailed assessment of red mullet in GSA 11 can be found in section 7.10 of this report.

4.10. Red mullet in GSA 16

Species common name:	Red mullet
Species scientific name:	*Mullus barbatus*
Geographical Sub-area(s) GSA(s):	GSA 16

Most recent state of the stock

- State of the adult abundance and biomass: According to VIT analysis, absolute estimations of SSB (combined sex) in the 2006-2009 was 1070 t in 2006, 1307 t in 2007, 1046 t in 2008 and 905 t in 2009. Nevertheless, biomass indices derived from scientific surveys in spring-summer (MEDITS), show a clear increasing trend of SSB. In the absence of precautionary biomass reference points SGMED is unable to fully evaluate the status of the stock size.

- State of the juvenile (recruits): The estimates of absolute recruitment in millions of individuals (age class 0) from VIT analysis in 2006-2009 were 39.2 in 2006, 34.3 in 2007, 28.8 in 2008 and 15.8 in 2009. The time series of recruitment indices from trawl surveys in autumn (GRUND surveys) carried out in GSA 16 (individuals smaller than 11 mm CL) showed a peak in 2004 and in 2005. Considering the overall time series, an increasing trend of recruitment seem to have occurred.

- State of exploitation: The stock of red mullet in the Northern sector of the Strait of Sicily is overfished since the current fishing mortality is estimated to exceed both $F_{0.1}$ and F_{max}.

- Source of data and methods:
  Four complete years (2006, 2007, 2008 and 2009) of length frequency distributions from GSA 16 commercial landings data (fished in GSA 15 as well as GSA 16) were available, so an approach under steady state (pseudocohort) assumptions was used. Cohort (VPA equation) and Y/R analysis as implemented in the package VIT4win were thus used (Lleonart and Salat, 2000). Data were derived from the DCF data call for GSA 16. In addition, fishery independent information regarding the state of the red mullet in GSA 16 was derived from the international survey MEDITS and the Italian survey GRUND. Trends in abundance and biomass indices as well as length frequency distributions were plotted.

Outlook and management advice

Considering the Sicilian fleet operating in GSAs 15-16, for which both commercial data were available at SGMED 10-03, a reduction of about 50% of the fishing mortality is needed to reach $F_{0.1}$, and a reduction between 10 and 30% is needed to reach F_{max}. However no sign of decrease of SSB and recruitment indices from trawl surveys in the area were detected. This could be correlated with the reduction of illegal trawling in the coastal areas within the 50 m depth, where the recruitment of the species occurs in late summer-early autumn.

The working group was informed that the Italian government is adopting a management plan in which a reduction of fishing mortality of 25% is planned within 2013. SGMED recommends the adoption of a management plan to continuously reduce current F through consistent effort reductions, and an improvement in current exploitation patterns.

- Short and medium term scenarios: SGMED-03-10 performed short term projections of stock status (See section 6 of this report).

Fisheries

Red mullet (*M. barbatus*) is one of the main demersal resources of the coastal areas in the Mediterranean, fished by otter trawl and trammel and gill-net, together with other several species (Voliani, 1999). Red

Mullet is caught together with other important species such as *Mullus surmuletus, Merluccius merluccius, Pagellus sp., Uranoscopus scaber, Raja sp., Trachinus sp., Octopus vulgaris, Sepia officinalis, Eledone sp.* and *Lophius sp*. In GSA 15 and 16 red mullet is caught almost exclusively by inshore trawlers operating on shelf fishing-groundsof GSA 16 and 15. According to Andreoli *et al*., (1995), the estimated yield of *Mullus* sp. between April 1985 and March 1986 was about 1100 tons; the next year it amounted 630 tons. Considering that overall yield was about 9670 tons in the first year and 8050 tons in the second one, *Mullus* sp. landings represented about 8-11% of total yield in the area. This landing is sold and recorded on coastal production markets, unlike the fish caught by distant water trawlers. More recent data (IREPA) give a yield of 5116 tons of *Mullus* spp. in 2003. In 2006 yield decreased to 3050 tons, of which 1626 tons were due to *M. barbatus*. Annual landings decreased from 1626 t in 2004 to 800 t in 2009. Demersal otter trawlers dominate the landings by far.

Annual landings (t) by fishing technique as reported to SGMED-10-03 through the DCR data call.

Species	Area	Country	FT_LVL4	2002	2003	2004	2005	2006	2007	2008	2009
MUT	16	ITA	GTR			58	29	39	37	20	13
MUT	16	ITA	OTB			1568	1377	1084	1343	1158	787
MUT	16	ITA	Total			1627	1406	1124	1380	1177	800

Limit and precautionary management reference points

Table of limit and precautionary management reference points **proposed by SGMED**

$F_{0.1}$	≤ 0.31
F_{max} =	
Fmsy (age range)= not available	
Fpa (Flim) (age range)= not available	
Bmsy (spawning stock)= not available	

Table of limit and precautionary management reference points **agreed by fisheries managers**

F0.1 (age range)=	
Fmax (age range)=	
Fmsy (age range)=	
Fpa (Flim) (age range)=	
Bmsy (spawning stock)=	
Bpa (Blim, spawning stock)=	

Comments on the assessment

The detailed assessment of red mullet in GSA 16 can be found in section 7.11 of this report.

4.11. Pink shrimp in GSA 09

Species common name:	Deepwater pink shrimp
Species scientific name:	*Parapenaeus longirostris*
Geographical Sub-area(s) GSA(s):	GSA 09

Most recent state of the stock

- State of the adult abundance and biomass:

Stock assessment has been updated performing Length Cohort Analysis (VIT software) using DCF data of 2009. SGMED was unable to estimate the absolute stock size. Since 1998, SSB shows an increasing, although fluctuating, trend with the highest value in 2009 (Medits data). As no precautionary level for the stock of deep-sea pink shrimp in GSA 09 is proposed or agreed, SGMED cannot evaluate the stock status in relation to the precautionary approach.

- State of the juveniles (recruits):

MEDITS data showed that recruitment is increasing since 1994 with highest values in 2008-2009.

- State of exploitation:

SGMED proposed $F \leq 0.7$ as limit management reference point (basis $F_{0.1}$, FMSY proxy). SGMED's advice relies on the VIT analysis and considers the stock being harvested sustainably, as F_{1-3} was estimated to range among 0.4-0.6 for the period 2006-2009.

- Source of data and methods:

Time series of survey data were used (MEDITS: 1994-2009; GRUND: 1994-2007) to investigate trends in abundance and F with SURBA. Length cohort analysis was used on 2006, 2007, 2008, 2009 DCF data. The following parameters were used both for SURBA and VIT analyses:
MEDITS survey data were available from 1994. A check of hauls allocation between GSA 9 and 10 needs to be done before calculation of indices from JRC MEDITS database

• **Growth**
L∞ = 43.5 mm carapace length
K = 0.6
to = 0
• **Length-Weight relationhips**
a = 0.00686
b = 2.24
• **Natural mortality**
Mvector = 1.0 (age 1), 0.78 (age 2), 0.69 (age 3), 0.65 (age 4)
• **Length-at-maturity (L50)**
L50 = 24 mm
Lc100 = 20 mm

Outlook and management advice

Given the current uncertainty in F estimates, SGMED recommends the fleet effort to not be increased, in order to avoid future low stock productivity and landings. Any management measure should consider the mixed nature of the fisheries exploiting the stock.

Short and medium term scenarios:
See section 6 of this report.

Fisheries

The species is exploited by trawl fleet mostly on muddy bottoms from 150 to 500 m depth. Annual trawl landings increased from 160 tons in 2002 to 450 tons in 2006, decreasing to 220 tons in 2007, 254 tons in 2008 and 220 tons in 2009.

Annual landings (t) by fishing technique in GSA 09.

SPECIES	COUNTRY	FT_LV4	2002	2003	2004	2005	2006	2007	2008	2009
DPS	ITA	DTS	133	308	367	430	462	215	253	219
DPS	ITA	PGP		3	8	1		2	1	
DPS	ITA	PMP	19	12	•					
DPS	ITA	PTS	9		1					
SUM	ITA		161	323	376	431	462	217	254	219

A total of 9 tons of discards, composed by individuals smaller than 20 mm carapace length, was estimated in 2006 (approx. 2% of total landings). Proportion of juveniles (0+) increased in 2007 landing. The total trawl fleet of GSA 09 at the end of 2009 accounted for about 350 vessels. Deep sea pink shrimp is mostly exploited in the southern part of the GSA9 (fleets of Porto Santo Stefano Porto Ercole, Fiumicino, Terracina and Gaeta. The fishing capacity of the GSA 09 has shown in the last 20 years a progressive decrease. From 1996 to 2006 the number of bottom trawlers of GSA 09 decreased of about 30%. Also fishing effort decreased, even though in a lesser extent, in this period.

Trends in annual fishing effort (kW*days) by fishing technique deployed in GSA 09, 2004-2009.

AREA	COUNTRY	FT_LVL4	2004	2005	2006	2007	2008	2009
9	ITA	DRB	271337	290683	222614	232521	355036	273697
10	ITA	FPO			1687		25059	9484
11	ITA	GND	7686	2640	59526			4429
12	ITA	GNS	2828257	3887852	3192557	3730816	2897517	3165163
13	ITA	GTR	2930802	3825650	3758552	2840462	2330668	2819133
14	ITA	LHP-LHM	40544					
15	ITA	LLD	435343	795954	872471	485306	576643	326821
16	ITA	LLS	356268	482620	356556	112415	31134	29423
17	ITA	LTL			7086	2476		2603
18	ITA	OTB	13997398	14737375	12427695	13044590	10602617	11927325
19	ITA	PS	385988	455763	1128366	1117009	976131	1311059
20	ITA	PTM			4690			
21	ITA	SB-SV	750263	902510	614857	550613	349487	355366

Limit and precautionary management reference points

Table of limit and precautionary management reference points **proposed by SGMED**

$F_{0.1}$ (1-3) ≤ 0.7	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Table of limit and precautionary management reference points **agreed by fisheries managers**

$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Comments on the assessment

The detailed assessment of pink shrimp in GSA 09 can be found in section 7.12 of this report.

4.12. Pink shrimp in GSA 10

Species common name:	Deepwater pink shrimp
Species scientific name:	*Parapenaeus longirostris*
Geographical Sub-area(s) GSA(s):	GSA 10

Most recent state of the stock

- State of the adult abundance and biomass:

In the absence of proposed and agreed precautionary management references, SGMED-10-03 is unable to fully evaluate the status of SSB. Survey indices indicate a variable pattern of abundance (n/h) and biomass (kg/h) without a clear trend. MEDITS indices indicate a sharp decrease from 2006 to 2007 and then a slight increase. GRUND data showed a recent decrease of abundance and biomass from 2005 to 2006 after a rising phase.

- State of the juveniles (recruits):

Recruitment estimates from MEDITS surveys showed a sharp decrease from 2005 to 2009.

- State of exploitation:

SGMED-10-03 proposes $F \leq 0.58$ as limit management reference point (basis $F_{0.1}$) of exploitation consistent with high long term yield (F_{MSY} proxy). Given the results of the present analysis (F current on average about 1.33), the stock is considered subject to overfishing during the period 2006-2009.

- Source of data and methods:

The analyses were conducted using VIT and YIELD software. The following growth parameters were used to split the LFD for the VIT age-class analyses; females: $CL_\infty = 4.6$ cm, K= 0.575, t_0= -0.2; males: $CL_\infty = 4$ cm, K= 0.68, t_0= -0.25. Since YIELD software uses only specimens total lengths data for the analyses, growth parameters and length-weight relationship coefficients were converted to the following equation: $TL_\infty = 20.77$ cm, K= 0.575, t_0= -0.23, a= 0.0178, b= 2.5423. Constant natural mortality M (mean natural mortality over all the age classes) = 0.89 and a constant recruitment of 383 million individuals were assumed (average recruitment estimated by VIT during 2006-2009) to parameterize YIELD software. Management reference points were estimated by an YPR analysis.

Outlook and management advice

SGMED recommends the relevant fleets' effort to be reduced to reach the proposed level $F_{0.1}$, in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan taking into account mixed fisheries effects.

Short and medium term scenarios:

Projections of yield and biomasse under different management scenarios are presented in section 6 of this report.

Fisheries

The pink shrimp is only targeted by trawlers and fishing grounds are located on the soft bottoms of continental shelves and the continental slope along the coasts of the whole GSA. The pink shrimp occurs mainly with *M. merluccius*, *M. barbatus*, *Eledone cirrhosa*, *Illex coindetii* and *Todaropsis eblanae, N. norvegicus*, *P. blennoides*, depending on depth and area.

The catches of the species raised from 2004 to 2006 when 1,089 tons were recorded and then declined to 379 tons in 2009, a value lower than in 2004 (552 tons).

Annual landings (t) by gear type, 2004-2009.

Species	Area	Country	FT_LVL4	2004	2005	2006	2007	2008	2009
DPS	10	ITA		2	1				
			GNS	3	6			0	0
			GTR	3	0				
			LLS		26				
			OTB	544	743	1088	534	400	379
			PS			1			
			Total	552	776	1089	534	400	379

Limit and precautionary management reference points

Table of limit and precautionary management reference points **proposed by SGMED**

$F_{0.1}$ (age range)=	≤0.58
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Table of limit and precautionary management reference points **agreed by fisheries managers**

$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Comments on the assessment

The detailed assessment of pink shrimp GSA 10 can be found in section 7.13 of this report.

4.13. Pink shrimp in GSAs 12-16

Species common name:	Deep water pink shrimp
Species scientific name:	*Parapenaeus longirostris* (Lucas, 1846)
Geographical Sub-area(s) GSA(s):	GSAs 12-16

Most recent state of the stock

- State of the adult abundance and biomass: According to the VIT analyses, absolute estimations of SSB in the period 2007-2009 were 5,679 t, 4,673 t and 4,630 t, respectively. Relative indices derived from scientific surveys in the Strait of Sicily (GSA 15 and 16) indicate a recent recovery of the stock size after a period of low biomass and abundance indices from 2005 to 2007. In the absence of precautionary reference points SGMED is unable to fully evaluate the state of the SSB.

- State of the juvenile (recruits): The index of recruitment derived by trawl surveys in GSA 16 showed a peak in recruitment in 2004 (MEDITS series – 1800 n/km^2) and in 2005 (GRUND series – 1300 R/km^2). The MEDITS indices of more recent years (300 n/km^2 in 2008 and 200 n/km^2 in 2009) were lower than the median of the series in MEDITS (340 R/km^2). The index from GRUND series in 2008 (535 n/km^2), the more recent year, is higher than the median (200 n/km^2).

State of exploitation: SGMED proposes $F_{0.1} \leq 0.9$ as limit reference point consistent with high long term yields. The stock of deep water pink shrimp in the Northern sector of the Strait of Sicily is subject to overfishing since the current fishing mortality is higher than $F_{0.1}$.

-

- Data quality and availability:

In terms of data quality and availability, SGMED noted that commercial data from Tunisia, Malta and Sicily was for the first time available for a joint assessment. The proportion of landings which can be attributed to Italy, Tunisia and Malta reflects the number of vessels targeting this species in the Central Mediterranean; 82.6% of the catches were landed by the Sicilian fleet, 17.2% by Tunisian fishermen, and 0.2% by the Maltese trawlers. In order to obtain an accurate estimation of stock status it is thus clearly crucial that data from Tunisia is considered in future assessments of pink shrimp in this area.

The assessment was performed using length cohort analysis (LCA) as implemented in VIT4Win (Lleonart and Salat 1992, 1997). Landings data as well as length frequency distributions from Tunisia, Malta and Sicily for the years 2007, 2008 and 2009 were used. Length frequency distributions from Malta were only available for 2009. The parameters used were an average of growth parameters and length-weight relationships from SAMED (2002) and Ben Meriem (unpublished). Females: $L\infty = 42.705$, $k = 0.67$, $t0 = -0.208$, $a = 0.0029$, $b = 2.48185$. Male: $L\infty = 33.56$, $k = 0.73$, $t0 = -0.13$, $a = 0.00345$, $b = 2.4096$. Combined sex: $L\infty = 44.59$, $k = 0.6$, $t0 = -0.118$, $a = 0.0033$, $b = 2.4572$.

Analyses were performed separately on length frequency distributions of males and females and by keeping fleet segments separate. Current mean F and exploitation pattern were assessed using the steady state LCA by length on LFD of 2007, 2008 and 2009 raised to the total landings. LCA and Y/R values by sex and year were combined to obtain a single value for both the sexes by using an average, weighed by sex ratios.

Outlook and management advice

SGMED recommends the relevant fleet's effort to be reduced until fishing mortality is at $F_{0.1}$ in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan taking into account mixed-fisheries effects. Based on the biological reference points calculated using the VIT method, current fishing mortality should be reduced by 20-30% to reach the target level $F_{0.1}$.

- Short and medium term scenarios: SGMED-10-03 performed short term projections of stock status. These are presented in section 6 of this report.

Fisheries

Trawling for pink shrimp *Parapenaeus longirostris* is carried out on the continental shelf of the Central Mediterranean throughout the year, and catches often include Norway lobster (*Nephrops norvegicus*), giant red shrimp (*Aristaeomorpha foliacea*), hake (*Merluccius merluccius*), violet shrimp (*Aristeus antennatus*), scorpionfish (*Helicolenus dactylopterus*), grater forkbeard (*Phycis blennoides*), red Pandora (*Pagellus bogaraveo),* common Pandora (*Pagellus erythrinus*) and monkfish (*Lophius piscatorius*). Scientific data available indicates that exploitation by the fishing fleets of Tunisia, Malta, Libya and Italy is targeting a single shared stock of pink shrimp (MedSudMed 2007).
Sicilian trawlers between 12 and 24 m vessel length targeting deep water pink shrimp are based in seven harbours along the southern coasts of Sicily. These trawlers operate mainly on a short-distance trawl fishery basis, with trips from 1 to 2 days at sea, and fishing taking place on the outer shelf and upper slope of GSA 15 and 16. With 250 registered vessels, this is the largest fleet component targeting pink shrimp in 2009. Sicilian trawlers which measure over 24 m vessel length are employed longer fishing trips, which may have a duration of up to 4 weeks. These vessels operate offshore, in both Italian and international waters of the Strait of Sicily. In 2009 140 such vessels were active. In the Maltese Islands small vessels measuring 12 to 24 m in length target pink shrimp at depths of about 600 m. Fishing grounds are located to the north and north-west of Gozo, as well as to the west and south-west of Malta. Catches are primarily destined for the local market. The number of trawlers targeting pink shrimp increased from 7 in 2005 to 12 in 2009.Tunisian trawl vessels which target pink shrimp measure over 24 m in length, and operate primarily in Northern Tunisia where 90% of the country's total *P. longirostris* catches originate. The great majority of these catches are landed in the town of Bizerte. The number of Tunisian trawlers targeting pink shrimp has increased from 40 in 1996 to around 70 in 2009.

Limit and precautionary management reference points

Table of limit and precautionary management reference points **proposed by SGMED**

$F_{0.1}$	≤ 0.9
F_{max} = NA	(no clear peak in the YPR curve)
Fmsy (age range)= not available	
Fpa (Flim) (age range)= not available	
Bmsy (spawning stock)= not available	

Table of limit and precautionary management reference points **agreed by fisheries managers**

F0.1 (age range)=	
Fmax (age range)=	
Fmsy (age range)=	
Fpa (Flim) (age range)=	
Bmsy (spawning stock)=	
Bpa (Blim, spawning stock)=	

Comments on the assessment

The detailed assessment of pink shrimp GSAs 12-16 can be found in section 7.14 of this report.

4.14. Giant red shrimp in GSAs 15 and 16

Species common name:	Giant red shrimp
Species scientific name:	*Aristaeomorpha foliacea*
Geographical Sub-area(s) GSA(s):	GSAs 15 and 16

Most recent state of the stock

- State of the adult abundance and biomass:
  SGMED estimated the absolute levels of stock abundance in 2006, 2007, 2008 and 2009 by VIT approach on length structure of Sicilian trawlers which catch about 98% of the total yield in the area. Mean biomass at sea ranges between 1721 (2008) and 2229 (2009) t, SSB ranges between 70 and 75% of the biomass at the sea.
  Survey indices (MEDITS) in the GSA 16 (1994-2009) show that SSB has an apparent cyclic pattern with the last peak in 2000 and a new increasing phase seems to be occurring since 2007. In the absence of precautionary reference points SGMED is unable to fully evaluate the state of the stock size.
- State of the juvenile (recruits):
  Absolute estimate of recruitment (18-22 mm CL) from VIT ranged between 83 (2008) and 118 (2009) millions of recruits. A low variability in recruitment indices derived from Surba was observed, with the exception of sudden fall in recruit density observed in 2006.
- State of exploitation:
  SGMED proposes $F_{0.1} \leq 0.3$, consistently esimtated by the both the VIT and YIELD methods, as limit reference points consistent with high long term yields.
  Thus, the giant red shrimp in the Northern sector of the Strait of Sicily is considered overfished since the current fishing mortality exceeds both F_{max} and $F_{0.1}$.

- Data quality and availability:
  In terms of data quality and availability, SGMED 03-09 noted that both data from GSA 15 and 2009 commercial data from GSA 16 were now available for assessment.

Source of data and methods:
Data was derived both from indirect (fisheries monitoring) and direct (scientific surveys) sources. Stock status was assessed by using Y and SSB per recruit analyses with the packages VIT and Yield on females, which reach a larger size and represent more than 60% of overall landings in weight. Current F was assessed with steady state VPA with VIT by length and by age on LFD of 2006, 2007, 2008 and 2009 landings. Further estimations of F, SSB and recruitment indices derived from the SURBA software program were used to analyse the MEDITS time series. The analysis was based on MEDITS data from GSA 16 since a much longer time series is available for GSA 16 (1994-2009) than GSA 15 (2002-2009).Biological parameters used were: K=0.61; L_{inf} = 68.9 cm; t_0 = -0.2. M-at-age vector (PROBIOM sheet): 0.62; 0.30; 0.23; 0.19; 0.17; 0.16. q vector = estimate: q(Age0) = 0.4; q(Age1+) = 1.0; q(Age2+) = 1.0; q(Age3+);tq(Age4+) = 1.0. BRP (F_{max} and $F_{0.1}$) was estimated by VIT, with vector M by size (PROBIOM sheet) and Yield package (2000 runs) with scalar M=0 .42.

Outlook and management advice

All the stock assessments performed during the SGMED suggest quite similar diagnosis in terms of exploitation state in long term. Considering $F_{0.1}$ as limit reference points, a reduction ranging between 50 and 60 % of the current F is needed to achieve sustainable fishery exploitation. To reach F_{max}, a reduction of current F ranging between 30 and 40% is necessary. SGMED was informed that the Italian government is adopting a management plan in which a reduction of trawling capacity of 25% is planned within 2013. SGMED recommends the adoption of a multi-annual management plan to continuously reduce current F through consistent effort reductions considering mixed fisheries effects. Catches consistent with effort reductions shall be estimated.

- Short and medium term scenarios: SGMED-10-03 performed short term projections of stock status (see section 6 of this report).

Fisheries

The giant red shrimps is a relevant target species of the Sicilian and Maltese trawlers and is caught on the slope ground throughout the year, although peaks in landings are observed in summer. *A.foliacea* is fished exclusively by otter trawl, mainly in the central – eastern side of the Strait of Sicily, whereas in the western side it is substituted by the violet shrimp, *Aristeus antennatus***.** Due to reduction of catch rate since 2004 some distant trawlers based in Mazara del Vallo, which is the main fleet in the area, recently moved to the eastern Mediterranean (Aegean and Levant Sea) to fish red shrimps (Garofalo et al., 2007). In Maltese waters, trawlers targeting the giant red shrimp *A. foliacea* within the 25nm fisheries management zone trawl either to the north / north-west of the Island of Gozo, or to the west / south-west of Malta, at depths of about 600m. Detailed maps of the trawling grounds for Maltese Fisheries Management Zone (FMZ), including a wide part of GSA 15 are available (Camilleri *et al*., 2008). Giant red shrimps are frequently caught together with Norway lobster (*Nephrops norvegicus*), large sized deep water pink shrimp (*Parapenaeus longirostris*), the more rare violet shrimp (*Aristeus antennatus*) as well as large hake (*Merluccius merluccius*).

Yield of both the Italian and Maltese trawlers in 2009 reach the highest values of the last years, being 1620 t and 42 t respectively.

Table XX. Landings (t) by year and major gear types, 2004-2009 as reported through DCR, OTB = bottom otter trawls.

Species	Area	Country	Fleet	2004	2005	2006	2007	2008	2009
ARS	15	Malta	OTB		18	26	34	27	42
ARS	16	Italy	OTB	786	1270	1424	1541	1260	1620
ARS	15&b 16	Italy&Malta	OTB	786	1288	1450	1575	1287	1662

Limit and precautionary management reference points

Table of limit and precautionary management reference points **proposed by SGMED**

$F_{0.1}$ (0-7+)	≤ 0.3
F_{max} (0-7+)	
Z_{MBP} (1-3)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Table of limit and precautionary management reference points **agreed by fisheries managers**

$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Comments on the assessment

The detailed assessment of giant red shrimp GSAs 15 and 16 can be found in section 7.15 of this report.

4.15. Anchovy in GSA 16

Species common name:	Anchovy
Species scientific name:	*Engraulis encrasicolus*
Geographical Sub-area(s) GSA(s):	GSA 16 – South of Sicily

Most recent state of the stock

- State of the adult abundance and biomass:

Biomass estimates of total population obtained by hydro-acoustic surveys for anchovy in GSA 16 show a decreasing trend over the last decade, despite the occurrence of quite large inter-annual fluctuations, from a maximum of about 22,900 t in 2001 to a minimum of 3,100 t in 2008. Latest biomass estimates (2006-2009 surveys) are the lowest of the series and their average represents less than one-quarter of the maximum recorded value. However, in the absence of proposed or agreed precautionary management reference points, SGMED-10-03 is unable to fully evaluate the state of the stock and provide any scientific advice in relation to them.

- State of the juvenile (recruits):

No recruitment data were provided by this assessment.

- State of exploitation:

SGMED 10-03 recommends the exploitation rate E≤0.4 as target management reference point. The high and increasing yearly harvest rates, as estimated by the ratio between total landings and stock sizes, indicate high fishing mortality levels. Actually, as long as this estimate of harvest rate can be considered a proxy for F estimate obtained from the fitting of standard stock assessment models (assuming survey biomass estimate as a proxy of mean stock size), this index can also be used to assess the corresponding exploitation rate E=F/Z, provided that an estimate of natural mortality is given. The current (2009) harvest rate is 0.88, whereas the estimated average value over the years 2006-2009 is 0.79. The exploitation rate corresponding to F=0.79 is E=0.54 with M=0.66 estimated with Pauly (1980) empirical equation, and E=0.59 with M=0.56 estimated with Beverton & Holt's Invariants method (Jensen, 1996). As exploitation rates estimates are higher than the suggested reference point, thus the stock is considered to be overexploited.

- Source of data and methods:

Census data for catch and effort data were obtained from census information (on deck interviews) in Sciacca port, the most important base port for the landings of small pelagic fish species along the southern Sicilian coast (GSA16), accounting for about 2/3 of total landings in GSA 16. Acoustic data were used for fish biomass evaluations. Von-Bertalanffy growth parameters, necessary for the calculation of natural mortality, were estimated by FISAT with DCF data collected in GSA16 over the period 2007-2009. For BHI method, the equation $M = \beta * k$ was applied, with β set to 1.8 and k = 0.31.

To the aim of exploring the possibility to produce short term predictions, the regression approach proposed Rätz & Cheilari (2009) during the SGMED-09-03 meeting was applied. Specifically, the relationship between the series of acoustic survey biomass estimates (1998-2008) and landings the consecutive years (1999-2009) was analyzed, so using updated information (2008 for survey data and 2009 for landings data) compared to what presented during the SGMED-09-03 meeting.

Outlook and management advice

Based on available information and assuming status quo exploitation in 2010, SGMED-10-03 recommends that exploitation should be reduced towards E= 0.4 in order to promote stock recovery and avoid future loss in stock productivity and landings. Catches consistent with the reductions in exploitation rate should be estimated. SGMED notes that mere effort management of fisheries targeting stocks of small pelagics implies a high risk due to their schooling behavior and the multi-species character of their fisheries (changing target species as available and appropriate). SGMED rather recommends the consideration of landing restrictions as a more effective management tool for small pelagics. SGMED recommends a multi-annual management plan being implemented taking into account mixed-fisheries effects, in particular the technical relation with sardine fisheries.

Taking into account that fishing effort was relatively stable in last decade, whereas CPUE trend was even increasing, results would suggest that also environmental factors are important to explain the variability on yearly recruitment success. However, the stock biomass did not recover from the 2006 "collapse" in biomass (-69% from July 2005 to June 2006), and even further decreased (-53%) in 2008. This fact, along with the quite high and increasing level of harvest rates experienced over the last years, also suggests questioning about the sustainability of current fishing. In addition, possible negative effects on the stock could result from pressure of other fishing gears on larval stages (locally known as "bianchetto" or "neonata"). This fishing activity is allowed in GSA16 for two months during the winter (February-March), so it essentially affects sardine but it may also be relevant for anchovy if seasonal restrictions are not properly enforced. However, more data and investigation are needed in order to estimate the possible impact of this fishing activity on the exploited populations.

<u>Short and medium term scenarios:</u>
SGMED-10-03 notes that there is no data available to formulate any model to predict stock size and landings and discards in short term (2010-2011).

Fisheries
In Sciacca port, the most important base port for the landings of small pelagic fish species along the southern Sicilian coast (GSA16), accounting for about 2/3 of total landings in GSA 16, two operational units (OU) are presently active, purse seiners and pelagic pair trawlers. The fleet in GSA16 is composed by about 50 units (17 purse seiners and 30 pelagic pair trawlers were counted up in a census carried out in December 2006). In both OUs, anchovy represents the main target species due to the higher market price.

Average anchovy landings over the period 1997-2009 were about 1,700 metric tons (Sciacca port only), with large inter-annual fluctuations. Total effort was slightly increasing over the same period.

Limit and precautionary management reference points

Table of limit and precautionary management reference points **proposed by SGMED**

E_{msy} (F/Z, F age range 0-3)=	≤0.4
$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Table of limit and precautionary management reference points **agreed by fisheries managers**

$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Comments on the assessment

The detailed assessment of anchovy in GSA 16 can be found in section 7.16 of this report.

4.16. Sardine in GSA 16

Species common name:	Sardine
Species scientific name:	*Sardina pilchardus*
Geographical Sub-area(s) GSA(s):	GSA 16 – South of Sicily

Most recent state of the stock

- State of the adult abundance and biomass:

Biomass estimates of the total population obtained by hydro-acoustic surveys for sardine in GSA 16 show that the recent stock level is well below the average value over the last decade until 2009. However, in the absence of proposed or agreed references, SGMED-10-03 is unable to fully evaluate the state of the stock and provide any scientific advice in relation to them.

- State of the juvenile (recruits):

Data not available.

- State of exploitation:

SGMED recommends the application of the proposed exploitation rate $E \leq 0.4$ as management target for stocks of anchovy and sardine in the Mediterranean Sea. This value might be revised in the future when more information becomes available. Annual harvest rates, as estimated by the ratio between total landings and stock sizes, indicate relatively low fishing mortality during the last decade. Actually, as long as this estimate of harvest rate can be considered as a proxy of F estimate obtained from the fitting of standard stock assessment models (assuming survey biomass estimate as a proxy of mean stock size), this index can also be used to assess the corresponding exploitation rate $E=F/Z$, provided that an estimate of natural mortality is given. However, sardine biomass estimates are based on acoustic surveys carried out during the summer and, as in general they would include the effect of the annual recruitment of the population, they are possibly higher than the average annual stock sizes. This in turn could determine in an underestimation of the harvest rates and of the corresponding exploitation rates. The current (year 2009) harvest rate is 0.23, whereas the estimated average value over the years 2006-2009 is 0.19. The exploitation rate corresponding to $F=0.19$ is $E=0.20$, if $M=0.77$, estimated with Pauly (1980) empirical equation, is assumed, and $E=0.21$ if $M=0.72$, estimated with Beverton & Holt's Invariants method (BHI; Jensen, 1996), is used instead. In relation to the above considerations on the possible overestimation of mean stock size in harvest rate calculation, it is worth noting that, even if the harvest rates were twice the estimated values, the exploitation rates would continue to be lower than the target reference point.

Using the exploitation rate as a target reference point, the stock of sardine in GSA 16 is considered as being sustainably exploited.

- Source of data and methods:

Census data for catch and effort data were obtained from census information (on deck interviews) in Sciacca port, the most important base port for the landings of small pelagic fish species along the southern Sicilian coast (GSA16), accounting for about 2/3 of total landings in GSA 16. Acoustic data were used for fish biomass evaluations. Von-Bertalanffy growth parameters, necessary for the calculation of natural mortality, were estimated by FISAT with DCF data collected in GSA16 over the period 2007-2008. For BHI method, the equation $M = \beta * k$ was applied, with β set to 1.8 and $k = 0.40$.
To the aim of exploring the possibility to produce short term predictions, a regression approach suggested at the SGMED-09-03 meeting was applied (Rätz & Cheilari, 2009). Specifically, the relationship between the series of acoustic survey biomass estimates (1998-2008) and landings the consecutive years (1999-2009) was analyzed, so using updated information (2008 for survey data and 2009 for landings data) compared to what presented during the SGMED-09-03 meeting.

Outlook and management advice

Based on available information and assuming status quo exploitation in 2010, SGMED-10-03 recommends the relevant fleet effort should not be allowed to increase in order to avoid future loss in stock productivity and landings. SGMED notes that mere effort management of fisheries targeting stocks of small pelagics implies a high risk due to their schooling behavior and the multi-species character of their fisheries (changing target species as available and appropriate). SGMED rather recommends the consideration of landing restrictions as a more effective management tool for small pelagics. SGMED recommends a multi-annual management plan being implemented taking into account mixed-fisheries effects, in particular the technical relation with anchovy fisheries. In addition, due to the low level of the anchovy stock, measures should be taken to prevent a shift of effort from anchovy to sardine.

Taking into account that fishing effort was relatively stable in the last decade results would suggest that also environmental factors are important to explain the variability on yearly recruitment success. However, the stock did not recover from the 2006 "collapse" in biomass (-52% from July 2005 to June 2006), and this fact, along with the general decreasing trend in landings over the last decade (last biomass estimate represents the second lowest value of the series), also suggests questioning about the sustainability of current levels of fishing effort. In addition, possible negative effects on these populations could results from pressure of other fishing gears on larval stages. A warning on the fishing of larval stages (locally named *bianchetto* or *neonata*) is relevant, taking into account that in the past years derogation of the fishing ban was normally operated in wintertime, i.e. during the sardine spawning season, even though more data and investigation are needed in order to estimate the possible impact of this fishing activity on the exploited populations.

- <u>Short, medium and long term scenarios</u>

In the absence of updated information on sardine stock acoustic biomass (echosurvey) in 2010, SGMED was unable to accomplish short term predictions of catch and stock biomass for 2011. However, the application of the regression approach suggested at SGMED-09-03 meeting (Rätz & Cheilari, 2009), aiming at exploring the relationship between the series of acoustic biomass at year (t) and landings at year (t+1), already performed for short term predictions of sardine stock in GSA16 for 2009 and 2010 (see SGMED-09-03 Report), was firstly checked and then revisited including in the regression analysis updated (2009) total catch information that was not previously used as not yet available at that time.

Actually, in SGMED-09-03 the regression analysis had covered the periods 1998-2007 (biomass estimates) and 1999-2008 (landing data), whereas in the present run available data of the following year (2008 for biomass and 2009 for landings) were also included in the analysis. Firstly, the output of the model fitted last year for year 2009 (estimated sardine landings = 1,988 t) was compared with total landings (1,874 t) estimated from Sciacca port census data, showing an overestimation of about 6%. Secondly, the regression model was refitted with the new available data. The results of this model updating are summarized below, together with the results of the previous regression model (see also SGMED-09-03 Report), reported for comparisons purposes:

Model	SGMED	Intercept	slope	F	p	r	r^2
1	09-03	1667.63	0.026372	4.09	0.08	0.58	0.34
2	10-03	1647.72	0.026930	4.89	0.05	0.59	0.35

The resulting estimated landings are listed below.

Year	Estimated landings [tons] in SGMED-09-03 (model 1 of Tab. above)	Estimated landings [tons] in SGMED-10-03 (model 2 of Tab. above)
2009	1,988	1,975
2010	1,879	1,864

Fisheries

In Sciacca port, the most important base port for the landings of small pelagic fish species along the southern Sicilian coast (GSA 16), accounting for about 2/3 of total landings in GSA 16, two operational units (OU) are presently active, purse seiners and pelagic pair trawlers. The fleet in GSA 16 is composed by about 50 units (17 purse seiners and 30 pelagic pair trawlers were counted up in a census carried out in December 2006). In both OUs, anchovy represents the main target species due to the higher market price.

Average sardine landings over the last decade (1997-2009) were about 1,400 metric tons, with a general decreasing trend. Total effort was slightly increasing over the same period.

Limit and precautionary management reference points

Table of limit and precautionary management reference points **proposed by SGMED**

E_{msy} (F/Z, F age range)=	≤ 0.4
$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Table of limit and precautionary management reference points **agreed by fisheries managers**

$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Comments on the assessment

The detailed assessment of sardine in GSA 16 can be found in section 7.17 of this report.

4.17. Norway lobster in GSA 09

Species common name:	Norway lobster
Species scientific name:	*Nephrops norvegicus* (L., 1758)
Geographical Sub-area(s) GSA(s):	GSA 09

Most recent state of the stock

- State of the adult abundance and biomass:

Stock assessment has been updated performing Length Cohort Analysis (VIT software) using DCF data of 2009. Relative spawning stock biomass (SSB) indices derived from MEDITS (1994-2009) and GRUND (1994-2006) showed a fluctuating but slightly increasing trend in the spawning stock biomass (SSB). In the absence of precautionary reference points SGMED is unable to fully evaluate the state of the stock size.

- State of the juveniles (recruits):

Juveniles (0+ group) are not completely recruited by the trawl gear during MEDITS and they are also scarce in the commercial catches

- State of exploitation:

The reference points ($F_{0.1}$ and F_{max}) estimated for this species using the Yield software were 0.21 and 0.36 (median values), respectively. Recent values of F_{3-7} obtained on commercial data with LCA (VIT) were: 0.32 (2006), 0.30 (2007), 0.36 (2008), 0.45 (2009).
Similar F_{3-7} values were obtained from MEDITS data using SURBA (0.36 in 2006 and 0.33 in 2007); a similarly higher F (0.61) value was observed in 2008 using survey data.
SGMED-10-03 proposes the $F \leq 0.21$ as target management reference point for sustainable exploitation consistent with high long term yield (basis $F_{0.1}$,F_{MSY} proxy). The values of $F_{3-7,}$ obtained on commercial data with LCA (VIT) and on experimental survey data using SURBA, indicate that the stock is currently overexploited.

- Source of data and methods:

Data coming from MEDITS (1994-2008) and GRUND (1994-2006) trawl surveys were used to estimate relative SSB and F with SURBA. DCF data (size distribution of trawl landings 2006-2009) were used to estimate F at age, absolute abundance at age with VIT (LCA analysis). Medits survey data were available from 1994.

The following parameters were used both for SURBA and VIT analyses:

Growth parameters (Von Bertalanffy)
$L\infty$ = 74 (mm, carapace length); k = 0.17; $t_{0=}$ 0
L*W: a = 0.0005; b=3.04
M = vectorial of 3-7 age classes (from ProdBiom)
q = 1
Length at maturity (L_{50}) = 29 mm total length (sex combined)

Outlook and management advice

SGMED recommends the fleet effort to be reduced until fishing mortality is below or at the proposed $F_{0.1}$ level, in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan taking into account mixed-fisheries effects. Catches consistent with the effort reductions should be estimated.

Short and medium term scenarios:
See chapter 6 of this report.

Fisheries

Norway lobster is one of the most important commercial species in the GSA as total annual landing value. All the landing is due to bottom trawl vessels exploiting slope muddy bottoms mainly between 300 and 500 m depth. Catch of vessels targeting Norway lobster is composed of a mix of both commercial (hake, deep-sea pink shrimp, horned octopus (*Eledone cirrhosa*), squids (*Todaropsis eblanae*)), and non-commercial species. The trawl fleet of GSA 09 at the end of 2007 accounted for 360 trawlers. To date about 80-100 trawlers are involved in this fishery. In the last five years the total landings of Norway lobster of GSA 09 fluctuated between 248 (2005) to 228 tons (2008).

Landings (t) by year and major gear types, 2004-2009 as reported through DCF.

SPECIES	AREA	COUNTRY	FT_LVL4	2004	2005	2006	2007	2008	2009
NEP	9	ITA		5,3	1,6	0,6			
NEP	9	ITA	FPO					0,1	
NEP	9	ITA	GNS	0,1	0,4	0,1		0,1	
NEP	9	ITA	GTR		0,5				0,0
NEP	9	ITA	OTB	268,6	287,6	247,4	260,5	227,7	250,2
NEP	9	ITA	PS	0,0					
TOTAL LANDINGS				274,0	290,1	248,1	260,5	227,8	250,3

Trend in fishing effort (kW*days) by major gear types, 2004-2009.

AREA	COUNTRY	FT_LVL4	2004	2005	2006	2007	2008	2009
9	ITA	DRB	271337	290683	222614	232521	355036	273697
10	ITA	FPO			1687		25059	9484
11	ITA	GND	7686	2640	59526			4429
12	ITA	GNS	2828257	3887852	3192557	3730816	2897517	3165163
13	ITA	GTR	2930802	3825650	3758552	2840462	2330668	2819133
14	ITA	LHP-LHM	40544					
15	ITA	LLD	435343	795954	872471	485306	576643	326821
16	ITA	LLS	356268	482620	356556	112415	31134	29423
17	ITA	LTL			7086	2476		2603
18	ITA	OTB	13997398	14737375	12427695	13044590	10602617	11927325
19	ITA	PS	385988	455763	1128366	1117009	976131	1311059
20	ITA	PTM			4690			
21	ITA	SB-SV	750263	902510	614857	550613	349487	355366

The catch is mainly composed by adult individuals over the size-at-maturity and discarding of specimens under MLS (20 mm CL) is negligible.

Limit and precautionary management reference points

Table of limit and precautionary management reference points **proposed by SGMED**

$F_{0.1}$ (age 2-7) F_{MSY} proxy of limit	≤ 0.21
F_{max} (age 2-7) ≤ 0.36	
F_{msy} (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Table of limit and precautionary management reference points **agreed by fisheries managers**

$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Comments on assessment

GRUND data prior to 1994 should be standardised and used within this assessment. MEDITS survey data does not allow the calculation of length-at-maturity because the survey period (late spring-early summer) does not cover the spawning season (autumn-winter). Recent increase in SSB and recruitment seems poorly correlated with fishing mortality. This may suggest that other factors can be affecting the stock dynamics during recent years.
The detailed assessment of Norway lobster in GSA 9 can be found in section 7.18 of this report.

5. Reviews of stocks assessed under other scientific frameworks (ToR c)

5.1. Anchovy (Engraulis encrasicolus) in GSA 17

During the SGMED-10-03 meeting the stock assessments of anchovy in GSA 17 presented at GFCM-SAC-SCSA meeting (Mazara del Vallo, 1-6 November 2010) was reviewed. Significant improvements in the new assessments in relation to previous assessments were noted and acknowledged by SGMED. However, detailed information on assessment diagnostics are missing in the report. SGMED notes that the important catch input data used in the most recent assessement largely differ from the DCF data called from Member States. The DCF data indicated significantly higher annual landings in the period 2004-2007, the differences ranging from 10% to 40%.

While SGMED agrees with the proposed reference point of an exploitation rate E≤0.4, SGMED expresses uncertainty regarding the estimated recent exploitation rates and resulting stock sizes. SGMED does not endorse the conclusion that the stock is exploited sustainably and recommends the catch data being reviewed and the stock being re-assessed accordingly. In the absence of a biomass reference point, SGMED is unable to fully evaluate the state of the stock size.

SGMED advises that the short term prediction of catch and stock biomass of the stock of anchovy in GSA 17 and the specific management advice as given in section 6.22 of this report is conditional of the fact that the observed inconsistencies in the catch data can be resolved and a re-assessment does not indicate significant changes in the resulting parameters of the stock assessment.

5.2. Sardine (*Sardina pilchardus*) in GSA 17

During the SGMED-10-03 meeting the stock assessments of sardine in GSA 17 presented at GFCM-SAC-SCSA meeting (Mazara del Vallo, 1-6 November 2010) was reviewed. Significant improvements in the new assessments in relation to previous assessments were noted and acknowledged by SGMED. However, detailed information on assessment diagnostics are missing in the report. Furthermore SGMED notes that the important catch input data indicate a drastic change in selction at age with a significant underrepresentation of age groups 1 and 2 towards older fish for the most recent years (2005-2009). SGMED notes that such recently changed selectivition has a major impact on the estimated exploitation rates and stock numbers at age.

While SGMED agrees with the proposed reference point of an exploitation rate E≤0.4, SGMED expresses uncertainty regarding the estimated recent exploitation rates and resulting stock sizes. SGMED does not endorse the conclusion that the stock is exploited sustainably and recommends the catch data being reviewed and the stock being re-assessed accordingly. In the absence of a biomass reference point, SGMED is unable to fully evaluate the state of the stock size.

SGMED advises that the short term prediction of catch and stock biomass of the stock of sardine in GSA 17 and the specific management advice as given in section 6.27 of this report is conditional of the fact that the observed changes in the recent selection can be resolved and a re-assessment does not indicate significant changes in the resulting parameters of the stock assessment.

5.3. Pink shrimp (*Parapenaeus longirostris*) in GSAs 12-16

The assessment of pink shrimp stock status in GSAs 12-16 was initially carried out under the auspices of the MedSudMed project, and finalised at the 2010 GFCM SCSA meeting in Istanbul, 18th-23rd October 2010.

At the GFCM SCSA meeting, VIT analyses were carried out using average catch data by fleet segment for 2007-2009, females and males combined. This was done to take into account the fact that VIT is a pseudocohort analysis. Additional analyses done at GFCM SCSA were VIT analyses keeping sexes separate, LCA using ANALEN and Y/R analysis using the YIELD programmes. At SGMED 10-03, the VIT analyses carried out at the GFCM SCSA based on average catches were complemented by separate annual analyses for 2007, 2008 and 2009 in order to ensure the equilibrium (steady state) assumption made by the VIT model were met. The variation in the estimated stock parameters was low and overall median results similar to the results obtained at the GFCM SCSA. In addition, survey data trends from GSA 15 and GSA 16 were presented to SGMED 10-03, which were not considered by the GFCM SCSA working group.

The detailed SGMED 10-03 assessment is presented in section 7.14 while section 4.13 provides the stock summary sheet and section 6.33 provides the deterministic short term prediction of catch and biomass along with specific scientific advice.

6. SHORT AND MEDIUM TERM PREDICTIONS OF STOCK BIOMASS AND CATCHES (TOR F)

6.1. European hake (*Merluccius merluccius*) in GSA 5

6.1.1. *Short term prediction 2010-2012*

6.1.1.1. Method and justification

A deterministic short term prediction for 2010 to 2012 was performed using the EXCEL workbook provided by JRC IPSC (H.-J. Rätz), which take into account the catch and landings in numbers and weight and the discards, and based on the results of the Extended Survivor Analyses (XSA, Darby and Flatman, 1994) presented at the SGMED-10-02 (Heraklion, Crete, Greece, 31 May – 4 June 2010)

6.1.1.2. Input parameters

The following data have been used to derive the input data for the short term projection of the hake stock in GSA 5:

Maturity and M vectors

PERIOD	Age	0	1	2	3	4	5+
2006-2009	Prop. Matures	0.00	0.05	0.56	0.89	0.98	1.00

PERIOD	Age	0	1	2	3	4	5+	Mean 0-4
2006-2009	M	1.00	0.70	0.50	0.40	0.40	0.40	0.60

F vector

F	0	1	2	3	4	5+
2009	0.01	0.99	1.08	1.20	0.89	0.89

Several scenarios with different harvest strategy were run, with F_{stq} (F_{bar} ages 0-4) calculated as the average ages 0 to 4 in 2009 was used and defined F_{stq} (F_{stq} = 0.84). These short term predictions were done without taking into account the change in the mesh as adopted by Council Regulation (EC) No 1967/2006 of 21 December 2006.

Weight-at-age in the stock

Mean weight in stock (kg)	0	1	2	3	4	5+
2006-2009	0.018	0.069	0.198	0.441	0.763	1.391

Weight-at-age in the catch

Mean weight in catch (kg)	0	1	2	3	4	5+
2006-2009	0.018	0.069	0.198	0.441	0.763	1.391

Number at age in the catch

Catch at age in numbers (thousands)	0	1	2	3	4	5+
2009	12	591	110	20	5	5

Number at age in the stock

Stock at age in numbers (thousands)	0	1	2	3	4	5+
2010	3265	482	245	55	7	5

Stock recruitment

Recruitment (class 0+) has been estimated as the geometric mean of the class 0+ estimated from 1992 to 2009.

6.1.1.3. Results

Short-term implications

A short term projection (Table 6.1.1.3.1), assuming an F_{stq} of 0.84 in 2010 and a recruitment of 3265 (thousand) individuals, shows that:

- Fishing at the F_{stq} (0.84) generates a decrease of the catch of 11% from 2009 to 2011 along with a decrease of the spawning stock biomass of 4% from 2011 to 2012.
- Fishing at $F_{0.1}$ (0.22) for the same time frame (2009-2012) generates a decrease of the catch for 68% in 2011 and a spawning stock biomass increase by 118% from 2011 to 2012.
- SGMED recommends that catch in 2011 should not exceed 24 tons, corresponding to $F_{0.1} = 0.22$.

Outlook until 2012

Table 6.1.1.3.1. Short term forecast in different F scenarios computed for hake in GSA 5.

Basis: F(2010) = mean (F_{bar} 1-4 2009); Catch (2010): 61t; R(2010) = GM (2006–2009) = 3265 (thousands); F (2010) = 0.84; SSB (2011) = 58 t

Rationale	F scenario	F factor	Catch 2011	Catch 2012	SSB 2012	Change SSB 2011-2012 (%)	Change Catch 2009-2011 (%)
zero catch	0.00	0.00	0	0	123	179.5	-100.0
High long-term yield ($F_{0.1}$)	0.22	0.26	24	39	96	118.2	-68.0
Status quo	0.84	1.00	67	73	46	4.5	-10.7
Different scenarios	0.08	0.10	10	18	112	154.5	-86.7
	0.17	0.20	19	34	101	129.5	-74.7
	0.25	0.30	27	44	92	109.1	-64.0
	0.33	0.40	35	52	82	86.4	-53.3
	0.42	0.50	41	59	74	68.2	-45.3
	0.50	0.60	47	63	69	56.8	-37.3
	0.58	0.70	53	67	61	38.6	-29.3
	0.67	0.80	58	70	56	27.3	-22.7
	0.75	0.90	62	71	51	15.9	-17.3
	0.92	1.10	71	74	43	-2.3	-5.3
	1.00	1.20	75	73	39	-11.4	0.0
	1.09	1.30	78	74	35	-20.5	4.0
	1.17	1.40	81	75	33	-25.0	8.0
	1.25	1.50	84	75	31	-29.5	12.0

Weights in t.

Another deterministic short term prediction was performed using the same methodology and data input, but taking into account the change in the mesh as adopted by Council Regulation (EC) No 1967/2006 of 21 December 2006 as fully implemented in 2010. Thus, a change from 40 mm diamond to 40 mm square mesh was considered taking into account using the selectivity curves obtained in the Balearic Islands by Guijarro and Massutí (2006) and obtaining the following F vector:

F vector

F	0	1	2	3	4	5+
2009	0.006	0.97	1.08	1.20	0.89	0.89

A comparison between both projections shows that:

- Fishing at the F_{stq} generates a slightly lower change in the decrease of catch from 2009 to 2011 along with a slightly higher change in SSB from 2011 to 2012.
- Fishing at $F_{0.1}$ for the same time frame (2009-2012) shows no differences in the change of catches from 2009 to 2011 and a slightly higher change in SSB from 2011 to 2012.

Rationale	Mesh	F scenario	F factor	Catch 2011	Catch 2012	SSB 2012	Change SSB 2011-2012 (%)	Change Catch 2009-2011 (%)
High long-term yield ($F_{0.1}$)	40 DI	0.22	0.26	24	39	96	118.2	-68.0
	40 SQ	0.22	0.27	25	40	97	120.5	-66.7
Status quo	40 DI	0.84	1.00	67	73	46	4.5	-10.7
	40 SQ	0.83	1.00	67	73	47	6.8	-10.7

These low differences are related to the pattern of exploitation of hake in GSA 5 in which individuals under 15 cm TL are scarce in the catches, while that part of the population would be the more potentially benefitted from a change of mesh shape (Fig. 6.1.1.3.1).

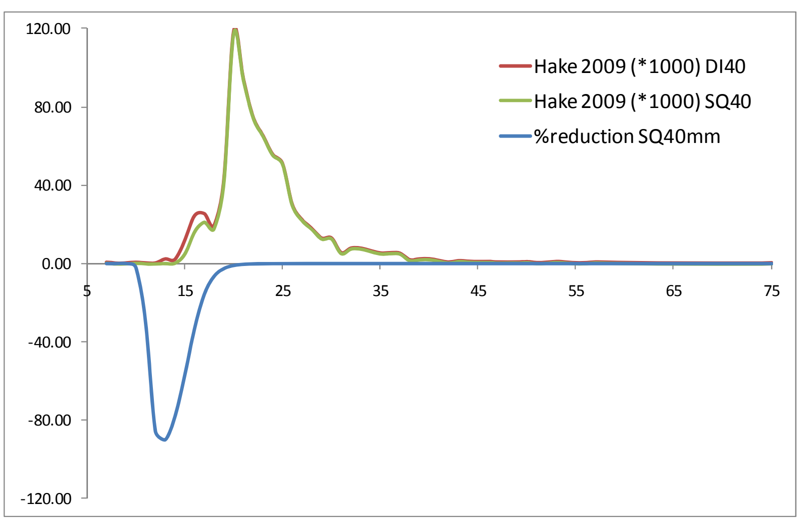


Fig. 6.1.1.3.1. Length frequency distribution of landings in GSA 5 for 2009, estimated length frequency distribution of landings in GSA 5 for 2010 considering the selectivity curves computed by Guijarro and Massutí (2006) and percentage of catches reduction by length by a change of mesh shape, from 40 mm diamond to 40 mm square mesh codend.

The following table summarizes the results of the short term predictions computed during SGMED-09-03 for landings in 2009 in comparison with real values, showing high consistency.

	Landings (t)	Recruits (thousands)	F
2009 predictions (SGMED-09-03)	69	1916	1.08
2009 real data	75	1329	0.84

6.1.2. *Medium term prediction*

6.1.2.1. Method and justification

Medium term prediction from 2010 to 2020 was implemented in R (www.r-project.org) using the FLR libraries and based on the results of the Extended Survivor Analyses (XSA, Darby and Flatman, 1994) that was applied for hake stock in GSA 5 in the framework of the SGMED-10-03 using the VPA Lowestoft software suite. Four different assumptions were used in the Medium term projections (10 years): (i) F_{stq}; (ii) a decrease from F_{stq} to $F_{0.1}$ in 2011; (ii) a progressive decrease from F_{stq} to $F_{0.1}$ in 2015 and (iv) a progressive decrease from F_{stq} to $F_{0.1}$ in 2020. The stock-recruitment relationship used geometric mean recruitment over the observed SSB range from 1992 to 2009. These short term predictions were done without taking into account the change in the mesh as adopted by Council Regulation (EC) No 1967/2006 of 21 December 2006.

6.1.2.2. Input parameters

The maturity ogive, the natural mortality, the numbers of individuals and weight-at-age for the stock and for the catch were the same used in the short term forecast.
These medium term predictions were done without taking in to account the mesh shape changed (40 mm square mesh) as adopted by Council Regulation (EC) No 1967/2006 of 21 December 2006.

6.1.2.3. Results

Output of the medium term forecast showed a large increase in SSB for all the simulations using a reduction towards $F_{0.1}$. In the case of the catches, there is a clear decreasing trend in the same year in which F is reduced to $F_{0.1}$, followed by an increase to values higher than for F_{stq}.

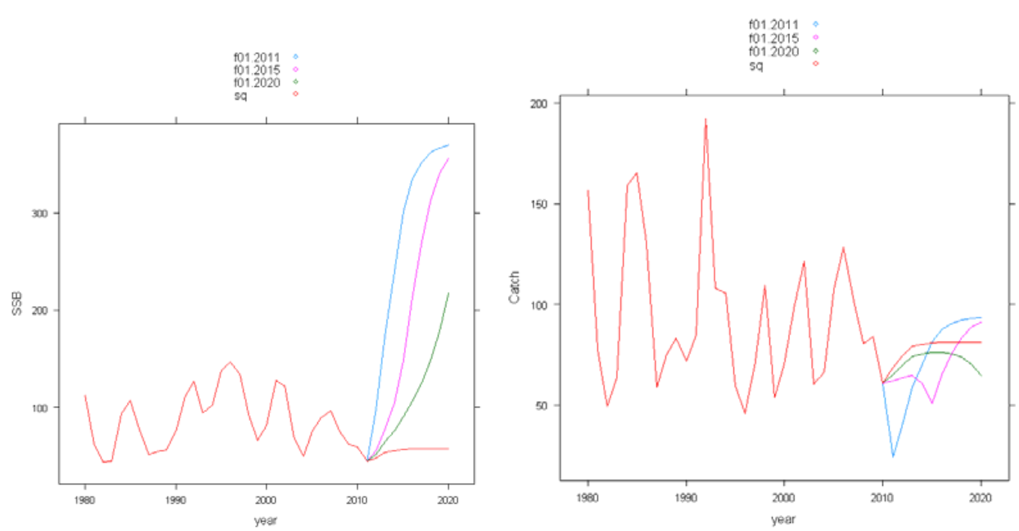


Fig. 6.1.2.3.1 Outputs of the medium term forecast computed for the hake in GSA 5.

6.2. European hake (*Merluccius merluccius*) in GSA 6

6.2.1. *Short term prediction 2010-2012*

6.2.1.1. Method and justification

A deterministic short term prediction for 2010 to 2012 was performed using the EXCEL workbook provided by JRC IPSC (H.-J. Rätz) which takes into account the catch and landings in numbers and weight and the discards, and based on the results of the Extended Survivor Analyses (XSA, Darby and Flatman, 1994) stock assessment performed during SGMED-10-02.

6.2.1.2. Input parameters

The following data have been used to derive the input data for the short term projection of the hake stock in GSA 6:

Maturity and M vectors

PERIOD	Age	0	1	2	3	4	5	6	7+
2009	Prop. Matures	0.00	0.00	0.14	0.77	0.96	0.99	1.00	1.00

PERIOD	Age	0	1	2	3	4	5	6	7+	Mean 0-4
2009	M	1.36	0.57	0.37	0.30	0.27	0.25	0.24	0.22	0.57

F vector

F	0	1	2	3	4	5	6	7+
2009	0.79	1.31	0.87	0.76	0.72	1.48	1.04	1.04

Several scenarios with different harvest strategy were run, with F_{stq} (F_{bar} ages 0-2) calculated as the average of the last 3 years (F_{sq} = 0.99). These short term predictions were done without taking into account the change in the mesh as adopted by Council Regulation (EC) No 1967/2006 of 21 December 2006.

Weight-at-age in the stock

Mean weight in stock (kg)	0	1	2	3	4	5	6	7+
2009	0.01	0.04	0.18	0.43	0.71	1.10	1.34	2.25

Weight-at-age in the catch

Mean weight in catch (kg)	0	1	2	3	4	5	6	7+
2009	0.01	0.04	0.18	0.43	0.71	1.10	1.34	2.25

Number at age in the catch

Catch at age in numbers (thousands)	0	1	2	3	4	5	6	7+
2009	61789	34073	3532	666	217	80	21	0

Number at age in the stock

Numbers at age in the stock (thousands)	0	1	2	3	4	5	6	7+
2010	359642	26127	9408	2116	505	179	21	10

Stock recruitment

Recruitment (class 0+) has been estimated as the geometric mean from 2002 to 2009 (from XSA done in SGMED-10-02; this assessment regards bottom trawl exclusively).

6.2.1.3. Results

Short-term implications

A short term projection (Table 6.2.1.3.1), assuming an F_{stq} of 0.99 in 2010 and a recruitment of 359642 (thousand) individuals, shows that:

- Fishing at the F_{stq} (0.99) from 2009 to 2011 would generate no change of the catches in 2011, while the spawning stock biomass would decrease by 12% between 2011 to 2012.
- Fishing at $F_{0.1}$ (0.14) from 2009 to 2011 generates a decrease of the catches of 80% in 2011 and a spawning stock biomass increase by 87% from 2011 to 2012.
- SGMED recommends that catch in 2011 should not exceed 741 tons, corresponding to $F_{0.1}$ = 0.14.

Outlook until 2011

Table 6.2.1.3.1 – Short term forecast for different F scenarios computed for hake in GSA 6.

Basis: F(2010) = mean (Fbar 0-2, 2007-2009); R(2010) = GM (2002-2009) = 359642 (thousands); F (2010) = 0.99; SSB (2010) = 1481 t; landings(2010)= 3446

Rationale	F scenario	F factor	Catch 2011	Catch 2012	SSB 2012	Change SSB 2011-2012 (%)	Change Catch 2009-2011 (%)
zero catch	0.00	0.00	0	0	3756	112.9	-100.0
High long-term yield ($F_{0.1}$)	0.14	0.14	741	1376	3306	87.4	-80.3
Status quo	0.99	1.00	3772	3812	1547	-12.3	0.5
Different scenarios	0.10	0.10	535	1026	3432	94.6	-85.7
	0.20	0.20	1024	1812	3132	77.6	-72.7
	0.30	0.30	1472	2408	2863	62.3	-60.8
	0.40	0.40	1886	2858	2623	48.7	-49.8
	0.50	0.50	2267	3190	2398	35.9	-39.6
	0.59	0.60	2617	3427	2193	24.3	-30.3
	0.69	0.70	2941	3595	2013	14.1	-21.7
	0.79	0.80	3240	3707	1845	4.6	-13.7
	0.89	0.90	3514	3778	1689	-4.3	-6.4
	1.09	1.10	4007	3826	1421	-19.4	6.7
	1.19	1.20	4226	3824	1306	-26.0	12.6
	1.29	1.30	4431	3802	1197	-32.1	18.0
	1.39	1.40	4621	3776	1101	-37.6	23.1
	1.49	1.50	4795	3744	1011	-42.7	27.7

Weights in t.

Comparison between the short- term forecast delivered in SGMED09-3 for hake in GSA06 in 2009

For 2009 the short- term forecast, was (status quo scenario):
R(2009) = GM(1995-2008) = 346360 (thousands)
landings(2009)= 8195 t.

The observed values in 2009 were the following:
R(2009) = 223760 (thousands)
landings(2009)= 3754 t

R calculated as the geometric mean over 1995-2008 provided an over-optimistic value given that the recruitment of hake displays a decreasing trend that started in 2000.

The landings foreseen for 2010 based on data from the DCF provide a value quite similar to the landings observed in the last years.

Another deterministic short term prediction was performed using the same methodology and data input, but taking into account the change in the mesh as adopted by Council Regulation (EC) No 1967/2006 of 21 December 2006 as fully implemented in 2010. Thus, a change from 40 mm diamond to 40 mm square mesh was considered taking into account using the selectivity curves obtained in the Balearic Islands by Guijarro and Massutí (2006) and obtaining the following F vector:

F vector

F	0	1	2	3	4	5	6	7+
2009	0.42	0.04	0.87	0.76	0.72	1.48	1.10	1.10

A comparison between both projections shows that:

- Fishing at the F_{stq} with the 40 mm square mesh generates a 15% decrease in catches from 2009 to 2001, while no change is found with the 40 mm diamond mesh along with a 58% increase in SSB with the 40 mm square mesh and a 12% decrease with the 40 mm diamond mesh.
- Fishing at the $F_{0.1}$ with the 40 mm square mesh generates a 67% decrease in catches from 2009 to 2001, and 80% with the 40 mm diamond mesh along with a 150% increase in SSB with the 40 mm square mesh and an 87% increase with the 40 mm diamond mesh.

Rationale	**Mesh**	**F scenario**	**F factor**	**Catch 2011**	**Catch 2012**	**SSB 2012**	**Change SSB 2011-2012 (%)**	**Change Catch 2009-2011 (%)**
High long-term yield ($F_{0.1}$)	40 DI	0.14	0.14	741	1376	3306	87.4	-80.3
	40 SQ	0.14	0.32	1241	2592	5070	150.4	-66.9
Status quo	40 DI	0.99	1.00	3772	3812	1547	-12.3	0.5
	40 SQ	0.44	1.00	3192	5326	3209	58.5	-15.0

These big differences are related to the pattern of exploitation of hake in GSA 6 in which individuals under 20 cm TL are abundant in the catches (Fig. 6.2.1.3.1).

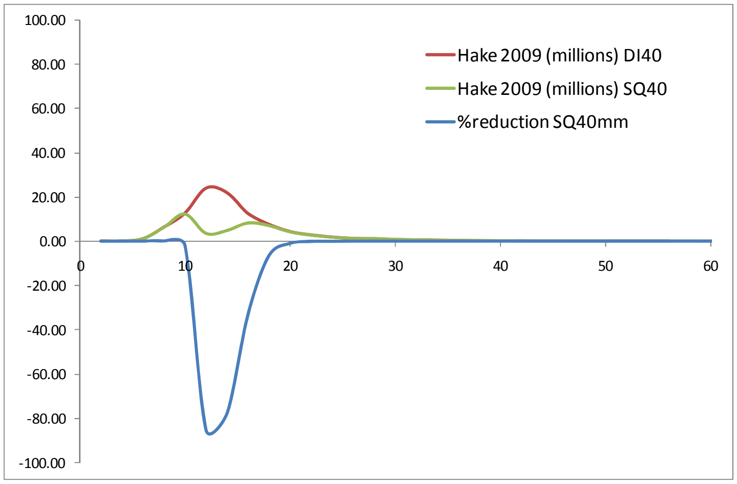


Fig. 6.2.1.3.1. Length frequency distribution of landings in GSA 6 for 2009, estimated length frequency distribution of landings in GSA 6 for 2010 considering the selectivity curves computed by Guijarro and Massutí (2006) and percentage of catches reduction by length by a change of mesh shape, from 40 mm diamond to 40 mm square mesh codend.

6.2.2. *Medium term prediction*

6.2.2.1. Method and justification

Medium term prediction from 2010 to 2020 was implemented in R (www.r-project.org) using the FLR libraries and based on the results of the Extended Survivor Analyses (XSA, Darby and Flatman, 1994) applied for hake stock in GSA 6 in the framework of the SGMED-10-03. The assumption of F_{stq} was used. We used geometric mean recruitment over the observed SSB range from 2007 to 2009. These medium term predictions were done considering both the mesh shape unchanged (40 mm diamond mesh) and changed (40 mm square mesh) as adopted by Council Regulation (EC) No 1967/2006 of 21 December 2006.

6.2.2.2. Input parameters

The maturity ogives, the natural mortality, the numbers of individuals and weight-at-age for the stock and for the catch were the same used in the short term forecast.

6.2.2.3. Results

Outputs of the medium term forecast showed a very important increasing trend in SSB when the mesh shape is changed from 40 mm diamond to 40 mm square. Similarly, catches show a clear increasing trend with the 40 mm square mesh codend.

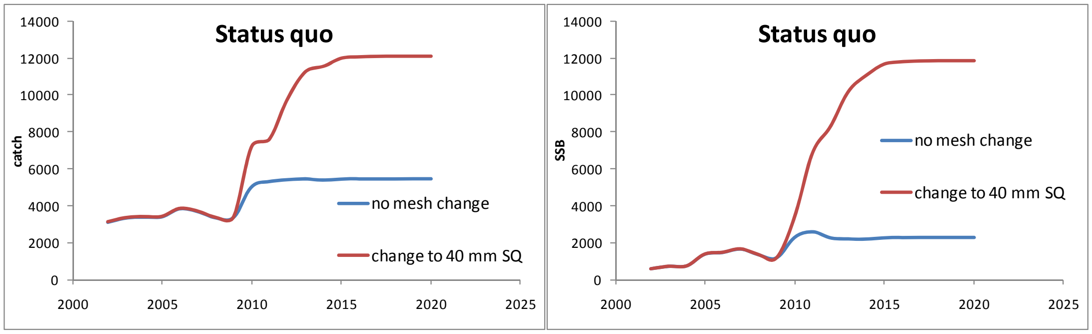


Fig. 6.2.2.3.1 Outputs of the medium term forecast computed for the hake in GSA6.

Data consistency

To assess stocks which are simultaneously exploited by different fishing gears and fleets all relevant data should be available to SGMED. For hake in GSA06 only bottom trawl data were available (no data from longline and gillnet were available). Also, no discards data were available.

Results should be taken with caution because only bottom trawl data have been considered (in GSA06, hake is fished also with gillnet and longline, which target the larger individuals of the population). Even not taking into account in the forecast that at least part of SSB is fished by the artisanal fleet, SSB decreases along with the increase in trawl effort.

Next year it is expected the assessment and short- term forecast will be delivered including data from the artisanal fishery, at least from long-line.

6.3. European hake (*Merluccius merluccius*) in GSA 7

6.3.1. *Short term prediction 2010-2012*

6.3.1.1. Method and justification

A deterministic short term prediction for 2010 to 2012 was performed using the EXCEL workbook provided by JRC IPSC (H.-J. Rätz) which takes into account the catch and landings in numbers and weight and the discards, and based on the results of the Extended Survivor Analyses (XSA, Darby and Flatman, 1994) presented at the SGMED-10-02 (Heraklion). We considered total landings (all gears combined) and fleet specific landings.

6.3.1.2. Input parameters

The following data have been used to derive the input data for the short term projection of the hake stock in GSA 7:

Maturity and M vectors

PERIOD	Age	0	1	2	3	4	5	6	7	8+
1998-2008	Prop. Matures	0	0	0.45	0.975	1	1	1	1	1

PERIOD	Age	0	1	2	3	4	5	6	7	8+
1998-2008	M	0.68	0.47	0.30	0.22	0.19	0.17	0.16	0.15	0.14

F vector

F	0	1	2	3	4	5	6	7	8+
2009	0.08	0.56	1.31	1.73	0.57	0.19	0.24	0.04	0.04

Several scenarios with different harvest strategy were run, with F_{stq} (F_{bar} ages 0-3 F_{stq} = 0.92). These short term predictions were done without taking into account the change in the mesh as adopted by Council Regulation (EC) No 1967/2006 of 21 December 2006.

Weight-at-age in the stock

Mean weight in stock (kg)	0	1	2	3	4	5	6	7	8+
2006-2008	0.03	0.12	0.41	0.90	1.43	2.05	2.54	3.16	3.62

Weight-at-age in the catch

Mean weight in catch (kg)	0	1	2	3	4	5	6	7	8+
2006-2008	0.03	0.12	0.41	0.90	1.43	2.05	2.54	3.16	3.62

Number at age in the catch

Catch at age in numbers (thousands)	0	1	2	3	4	5	6	7	8+
2006	2866	4302	1534	472	153	31	8	3	2
2007	3287	6037	1758	418	109	30	13	4	2
2008	12023	17832	1529	284	56	17	6	2	1
2009	3038	7465	2552	710	88	13	8	1	1

Number at age in the stock

Stock at age in numbers (thousands)	0	1	2	3	4	5	6	7	8+
2006	28813	9995	2682	775	283	61	44	23	13
2007	61944	12557	2846	666	199	94	22	30	14
2008	60512	29042	3076	595	160	65	52	7	5
2009	54758	22099	4054	963	223	81	39	38	38
2010	49725	25579	7910	806	137	105	57	26	64

Recruitment

Recruitment (class 0) has been estimated with the regression between MEDITS indices (n/h) and XSA results (numbers of age 0): estimated value was 49,725 (thousands) individuals described in the Table 6.3.1.2.1 and Figure 6.3.1.2.1 below.

Table 6.3.1.2.1 Projection of Recruitment (Age 0+) based on the relationship between the MEDITS survey index the results of XSA (Age 0+)

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
MEDITS abundance index (n/h)	549	167	425	383	675	75	330	152	193	210	975	348	265
XSA - Age 0 (n*1000)	71580	43961	52338	74782	76712	34609	35688	32451	32226	70286	65966	62760	**49725**

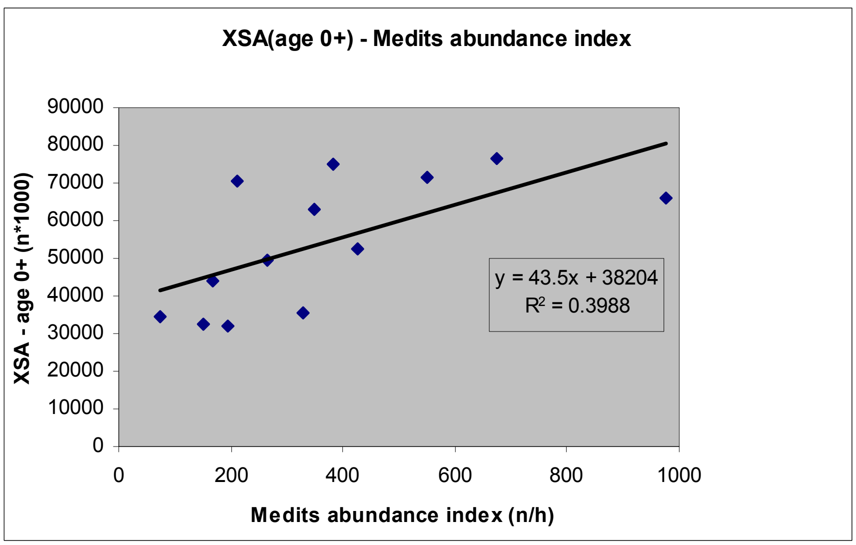


Figure 6.3.1.2.1. Projection of recruitment (Age 0) based on the relationship between the MEDITS index and the results of XSA (Age 0).

6.3.1.3. Results

Short-term implications

A short term projection (Table 6.3.1.3.1), assuming an F_{stq} of 0.92 in 2009 (mean 0-3 ages) and a recruitment of 49,725 (thousand) individuals, shows that:

- Fishing at the F_{stq} (0.92) generates an increase of the catch of 105 % from 2009 to 2011 along with an increase of the spawning stock biomass of 4 % from 2011 to 2012.

- Fishing at F=0.25 generates a decrease of the catch of 21 % from 2009 to 2011 and a spawning stock biomass increase by 116 % from 2011 to 2012.

- SGMED recommends that catch in 2011 should not exceed 734 tons, corresponding to $F_{0.1}$ = 0.09.

Outlook until 2011, all fleets combined (Spanish and French bottom trawl, Spanish longline, French gillnet).

Table 6.3.1.3.1 Short term forecast in different F scenarios computed for hake in GSA 7. (All fleets combined: Spanish and French bottom trawl, Spanish longline, French gillnet).

Basis: F (2009) = mean (F_{bar} 0-3 2009); R (2009) = regression MEDITS indices 2010 = 49725 (thousands); F (2009) = 0.92; SSB (2011) = 3753 t; Catch (2010)= 3836 t.

Rationale	F scenario	F factor	Catch 2011	Catch 2012	SSB 2012	Change SSB 2011-2012 (%)	Change Catch 2009-2011 (%)
zero catch	0.00	0.00	0	0	10891	190	-100
High long-term yield ($F_{0.1}$)	0.09	0.10	734	1571	9735	159	-68
Different scenarios	0.25	0.27	1782	3243	8108	116	-21
	0.28	0.30	1965	3467	7827	108	-13
	0.37	0.40	2479	3996	7037	87	10
	0.46	0.50	2940	4348	6340	69	30
	0.55	0.60	3356	4557	5728	52	48
	0.64	0.70	3725	4669	5180	38	65
	0.74	0.80	4063	4714	4701	25	80
	0.83	0.90	4363	4704	4274	14	93
	0.92	1.00	4635	4660	3892	4	105
	1.01	1.10	4879	4589	3552	-5	116
	1.10	1.20	5106	4508	3251	-13	126
	1.20	1.30	5311	4412	2976	-21	135
	1.29	1.40	5499	4310	2738	-27	143
	1.38	1.50	5669	4208	2520	-33	151

Weights in t.

Outlook until 2011 Fleet specific (fleet 1: bottom trawl, and fleet 2:longline+gillnet)

1. Bottom trawl targets mainly juveniles while gillnet and longline target the adult population.
2. Input data for the estimation of F by fleet are catch-at-age by fleet and mean weight-at-age by fleet.
3. The increase of longline and gillnet landings (spawners) is predicted for 2011 when the strong year classes 2007 and 2008 become fully available to these fleets.

Table 6.3.1.3.2. Basis for the short term forecast for hake in GSA 07 for 2009, considering trawls and gillnet – longline separately.

2010					Trawlers	Gillnet & longline
F-factor	Reference F	Stock biomass (t)	SSB (t)	Landings (t)	landings (t)	landings (t)
1.00	0.92	8907	2963	3917	3323	594

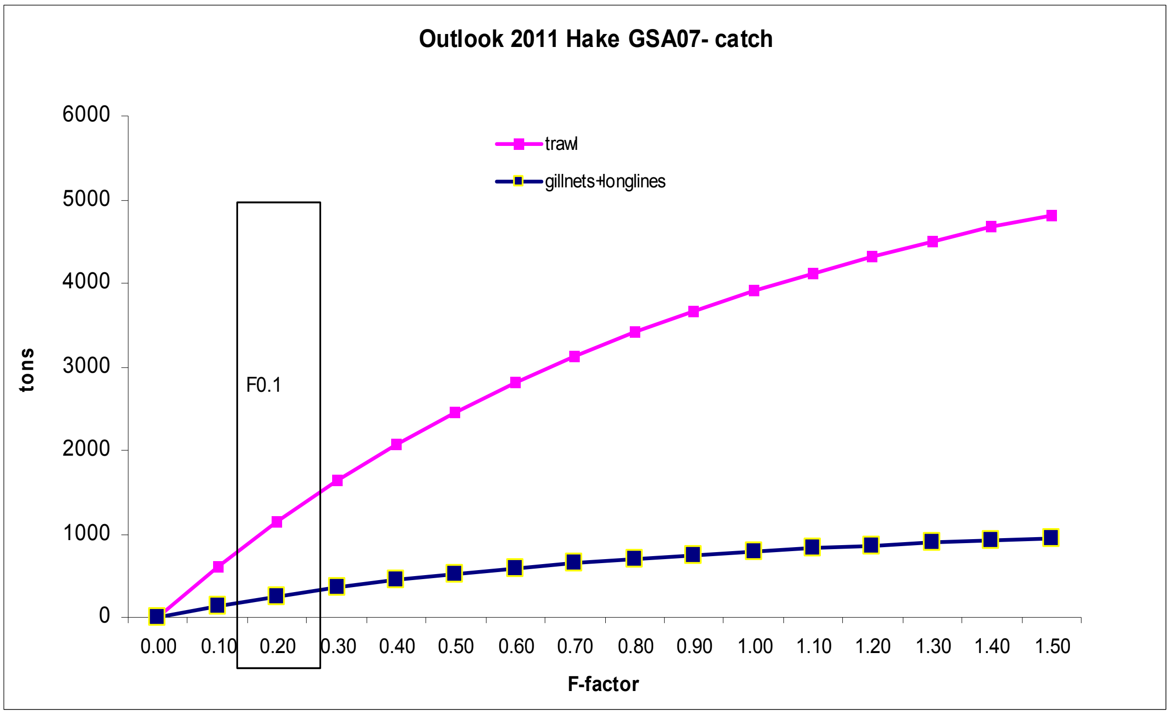


Fig. 6.3.1.3.1 Projected landings in 2011 of hake in GSA 7 by fleet as fishing mortality increases.

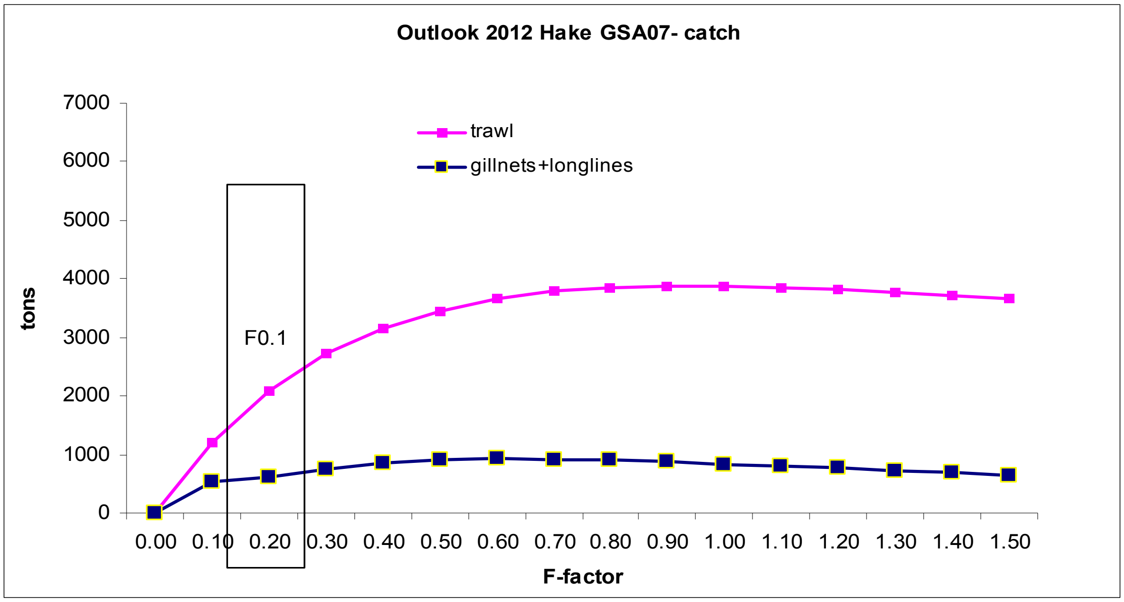


Fig. 6.3.1.3.2. Projected landings in 2012 of hake in GSA 7 by fleet as fishing mortality increases.

Table 6.3.1.3.2. Outlook for 2011-2012 for hake in GSA 7, by fleet.

		2011		2012		2012	
F Factor	**F scenario**	Trawlers landings (t)	Gill nets & longlines landings (t)	Trawlers landings (t)	Gill nets & longlines landings (t)	Total Biomass (t)	SSB (t)
0.0	0	0	0	0	0	18686	10990
0.1	0.09	603	134	1207	527	17295	9822
0.2	0.18	1149	246	2082	604	16054	8793
0.3	0.28	1632	350	2713	761	14957	7896
0.4	0.37	2063	443	3153	857	13970	7099
0.5	0.46	2454	518	3456	903	13087	6395
0.6	0.55	2807	587	3659	925	12298	5777
0.7	0.64	3124	649	3785	919	11587	5227
0.8	0.74	3413	701	3856	901	10949	4742
0.9	0.83	3669	747	3884	871	10372	4310
1.0	0.92	3907	790	3882	836	9849	3924
1.1	1.01	4121	831	3857	803	9377	3582
1.2	1.10	4315	863	3824	763	8948	3279
1.3	1.20	4497	892	3774	725	8554	3003
1.4	1.29	4664	918	3718	686	8198	2761
1.5	1.38	4815	942	3659	650	7871	2541

6.3.2. *Medium term prediction*

6.3.2.1. Method and justification

Medium term predictions for a 10 years period were implemented in R (www.r-project.org) using the FLR libraries and based on the results of the Extended Survivor Analyses (XSA, Darby and Flatman, 1994) presented at the SGMED-10-02 (Heraklion). Four predictions were conducted, (1) first one assuming the same F_{sq} (0.92) on the whole period 2010-2020, (2) assuming a decrease of F towards the $F_{0.1}$ (0.25) in 2011, (3) in 2015 and (4) in 2020.

6.3.2.2. Input parameters

The input parameters were exactly the same as the ones used in the short term forecast.
These medium term predictions were done without taking in to account the mesh shape changed (40 mm square mesh) as adopted by Council Regulation (EC) No 1967/2006 of 21 December 2006.

6.3.2.3. Method and justification

In Figure 6.3.2.3.1-3 are represented respectively the fishing mortality decreasing (described above) and the results of the 4 predictions for Catch and SSB.

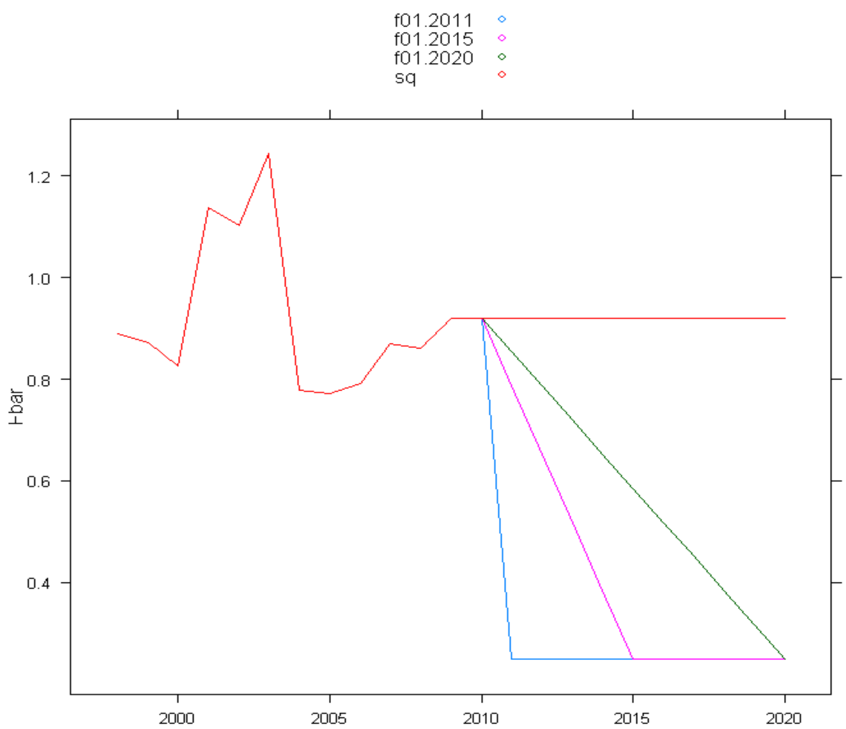


Figure 6.3.2.3.1. Fishing mortality used in the medium term prediction.

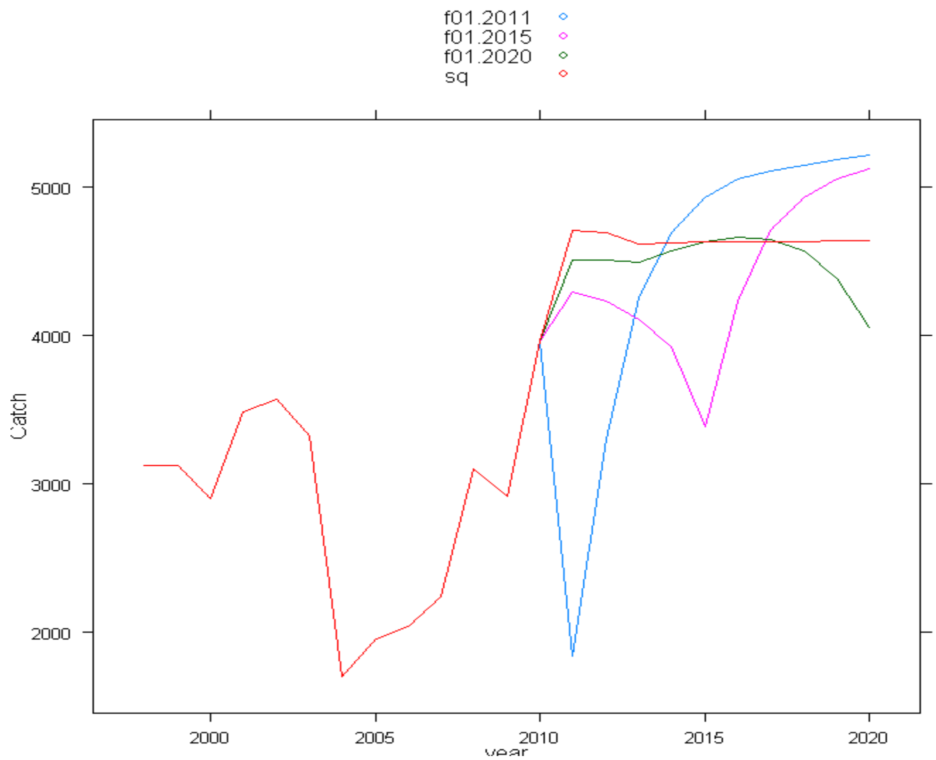


Figure 6.3.2.3.2. Medium term Catch forecast estimated for hake in GSA 07.

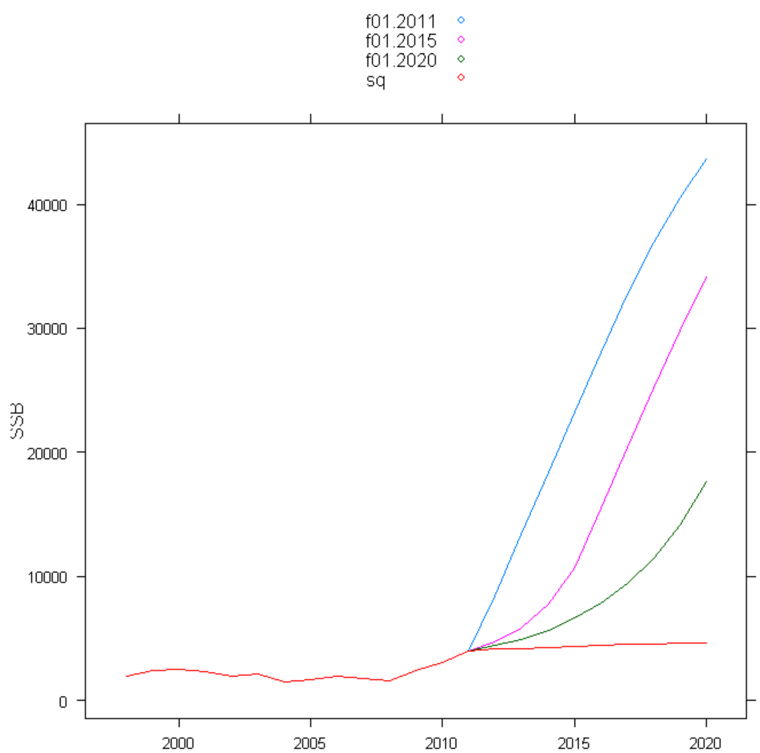


Figure 6.3.2.3.3. SSB outputs of the medium term forecast computed for hake in GSA 07.

The decrease in fishing mortality to the $F_{0.1}$ from 2010 to 2011 determines a considerable increase of the SSB, which is more than 10 times the one of 2010. The stock recovery was achieved along a decrease in catches until 2011, and then with a rapid increase of the catches with F approaching $F_{0.1}$. However, there are here two elements that should be taken into account. First, the very strong year classes 2007 and 2008 (Age 0 and 1) become fully mature at age 3 (0.975 %), which can explain the high values of the SSB when F is reduced and also the rapid increase of the catches in the medium term in the case of $F_{0.1}$ in 2011. The second is the reduction of the F_{sq} of 73 % in 1 year to reach the $F_{0.1}$. The predictions showed a positive impact of the reduction of the F_{sq} to $F_{0.1}$ on the SSB due to a good recruitment in previous years. It is important to notice that this stock is highly dependant of recruitment since 90% of catches are ages 0 and 1.

SGMED recognizes that the stock of hake in GSA 7 has a high recovery potential in the short and medium term (next 10 years) due to the projected continuous high recruitment and reduction of the fishing mortality to achieve a sustainable level in 2011, 2015 and 2020. SGMED recommends that appropriate management measures being implemented to materialize the potential recovery given by the presence of large years classes in the stock. SGMED notes also that the hake is mainly caught in a mixed fisheries which implies a management plan being designed and implemented which takes into account both multi-species landings and fishing efforts constraints. SGMED assessed the individuals of the stock of hake in GSA 7 to be poorly conditioned on average in recent years. SGMED is neither able to explain this effect, nor to project it. However, such poor condition implies reduced stock productivity in terms of future individual growth and expected recruitment to the stock. This shall be taken into account when assessing management reference points and designing multi-annual plans.

6.4. European hake (*Merluccius merluccius*) in GSA 9

Short term prediction 2010-2012

6.4.1.1. Method and justification

Short term prediction for 2010 to 2012 was implemented in R (www.r-project.org) using the FLR libraries and based on the results of the XSA carried out on catch data collected under DCR from 2005 to 2009.

6.4.1.2. Input parameters

The following data have been used to derive the input data for the short term projection of hake in GSA 9:

Maturity and M vectors

PERIOD	Age	0	1	2	3	4	5
2005-2009	Prop. Matures	0.00	0.21	0.90	1.0	1.0	1.0

Maturity was estimated as the mean of the last 3 years.

PERIOD	Age	0	1	2	3	4	5
2005-2009	M	1.30	0.60	0.46	0.41	0.30	0.20

M was calculated using the ProBiom method,

F vector

F	0	1	2	3	4	5
2005	1.15	1.89	1.24	0.52	0.63	0.63
2006	1.62	1.97	1.34	2.23	1.75	1.75
2007	0.93	1.78	1.24	0.28	0.51	0.51
2008	0.50	2.82	1.51	1.15	0.79	0.79
2009	0.43	2.49	1.75	0.96	1.83	1.83

F vector used is that estimated in 2009.
Several scenarios with different harvest strategies were run. These short term predictions were done without taking into account the change in the mesh as adopted by Council Regulation (EC) No 1967/2006 of 21 December 2006.

Weight-at-age in the stock

Mean weight in stock (kg)	0	1	2	3	4	5
2005	0.01	0.10	0.43	1.34	2.32	3.20
2006	0.01	0.14	0.61	1.37	2.30	3.31
2007	0.01	0.13	0.60	1.36	2.28	3.28
2008	0.01	0.12	0.60	1.35	2.29	3.29
2009	0.01	0.10	0.45	1.36	2.44	3.20

Weight-at-age in the catch

Mean weight in catch (kg)	0	1	2	3	4	5
2005	0.01	0.10	0.43	1.34	2.32	3.20
2006	0.01	0.14	0.61	1.37	2.30	3.31
2007	0.01	0.13	0.60	1.36	2.28	3.28
2008	0.01	0.12	0.60	1.35	2.29	3.29

2009	0.01	0.10	0.45	1.36	2.45	3.20

Number at age in the catch

Catch at age in numbers	0	1	2	3	4	5
2005	56407	7940	509	48	10	9
2006	85166	8709	618	120	41	14
2007	72515	6740	593	34	4	1
2008	18677	17238	626	106	41	15
2009	14276	10114	529	71	29	13

Stock numbers at age	0	1	2	3	4	5
2006	158194	12634	902	146	25	22
2007	203287	13666	1052	165	58	19
2008	229670	10942	1048	173	12	3
2009	90408	24736	1012	191	87	31
2010	117000	16027	1126	111	49	10

6.4.1.3. Results

Short-term implications

A short term projection (Table 5.4.1.3.1), assuming an F_{stq} of 1.56 (F_{1-3}) in 2009 and a recruitment of 117 (millions) individuals, shows that:

- Fishing at the F_{stq} (1.56) will generate an increase of the catches of 53% from 2009 to 2011 and of the spawning stock biomass of 14% from 2011 to 2012.

- Fishing at $F_{0.1}$ (0.22), which corresponds to an 86% reduction of the current F, is expected to generate a decrease of the catch in the short term (about 58% in 2011) and a spawning stock biomass increase of 433% from the year 2011 to 2012.

- SGMED recommends that fishing mortality in 2011 should not exceed the value of $F_{0.1}$ = 0.22, which corresponds to a catch of 671 tons.

Outlook until 2011

Table 5.4.1.3.1 – Short term forecast for different F scenarios computed for hake in GSA 9.

Basis: F_{1-4} (2009) = Catch stq (2010) = 1875 t; R (2009) = GM (2007–2009) = 117 (millions); F_{1-4} (2009) = 1.56; SSB (2010) = 901 t

Rationale	F scenario	F factor	Catch 2011	Catch 2012	SSB 2012	Change SSB 2011-2012 (%)	Change in catch 2009-2011 (%)
zero catch	0.00	0.00	0	0	7130	621	-100
High long-term yield ($F_{0.1}$)	0.22	0.14	671	1686	5270	433	-58
Status quo	1.56	1.00	2443	2551	1125	14	53
Different scenarios	0.16	0.10	494	1315	5749	481	-69
	0.31	0.20	899	2090	4660	371	-44
	0.47	0.30	1231	2523	3799	284	-23
	0.62	0.40	1506	2741	3117	215	-6
	0.78	0.50	1735	2825	2576	160	8
	0.94	0.60	1926	2829	2145	117	20
	1.09	0.70	2087	2786	1801	82	30
	1.25	0.80	2224	2718	1526	54	39
	1.40	0.90	2342	2637	1304	32	46
	1.71	1.10	2530	2465	980	-1	58
	1.87	1.20	2607	2382	861	-13	63
	2.03	1.30	2675	2303	764	-23	67
	2.18	1.40	2735	2228	683	-31	71
	2.34	1.50	2789	2158	616	-38	74
	2.49	1.60	2838	2093	559	-44	77
	2.65	1.70	2882	2031	511	-48	80
	2.81	1.80	2923	1974	470	-52	83
	2.96	1.90	2960	1920	435	-56	85
	3.12	2.00	2994	1869	404	-59	87

The catch forecast for 2009, estimated last year (1,520 tons) was very close to the 2009 landing (1,600 tons).

6.5. Hake (Merluccius merluccius) in GSA 10

6.5.1. *Short term prediction for 2010-2012*

6.5.1.1. Method and justification

Short term prediction for 2011 and 2012 was implemented in R (www.r-project.org) using the FLR libraries and based on the results of the stock assessment performed using VIT (Lleonart and Salat, 1997) that was conducted in the framework of the SGMED-10-03 using the VPA Lowestoft routines.

6.5.1.2. Input parameters

The following data have been used to derive the input data for the short term projection of the hake in the GSA 10:

Maturity and M vectors

PERIOD	Age	0	1	2	3	4	5	6	7	8
2007-2009	Prop. Matures	0.0	0.19	0.86	1.0	1.0	1.0	1.0	1.0	1.0

PERIOD	Age	0	1	2	3	4	5	6	7	8	Mean 0-4
2007-2009	M	1.16	0.53	0.40	0.35	0.32	0.30	0.30	0.30	0.30	0.46

F vector

F	0	1	2	3	4	5	6	7	8
2007	0.45	1.64	0.86	1.03	0.95	0.58	0.32		
2008	0.31	1.28	0.67	0.61	1.10	1.05	0.32		
2009	0.29	1.59	0.81	0.43	0.53	0.32	0.29	0.36	0.32

Several scenarios with different harvest strategy were run, with F_{stq} (F_{bar} ages 0-6) calculated as the average of the last 3 years, but rescaled to the F of 2009 (F_{stq} =0.61). These short term predictions were done without taking into account the change in the mesh as adopted by Council Regulation (EC) No 1967/2006 of 21 December 2006.

Weight-at-age in the stock

Mean weight in stock	0	1	2	3	4	5	6	7	8
kg	0.01	0.11	0.48	1.11	1.88	2.77	3.67	4.53	5.34

Weight-at-age in the catch

Mean weight in catch	0	1	2	3	4	5	6	7	8
kg	0.010	0.11	0.48	1.11	1.88	2.77	3.67	4.53	5.34

Number at age in the catch

Catch at age in numbers (thousands)	0	1	2	3	4	5	6	7	8
2009	5027	5180	446	85	46	13	7	4	2

Number at age in the stock

Stock at age in numbers (thousands)	0	1	2	3	4	5	6	7	8
2009	33276	7850	948	281	129	55	30	17	9
2010	35774	7826	1339	332	112	46	24	17	14

Stock recruitment

The recruitment used for the short term projection was estimated as the geometric mean from 2007-2009.

6.5.1.3. Results

A short term projection (Table below), assuming an F_{stq} of 0.61 in 2010 and a recruitment of 35774 (thousand) individuals, shows that:

- Fishing at the F_{stq} (0.61) from 2009 to 2011 generates an increase of the catch for 13 % and an increase of the spawning stock biomass of 8% from 2011 to 2012.

- Fishing at F_{01} (0.19) from 2009 to 2011 generates a decrease of the catch of 55% and a spawning stock biomass increase of 86% from 2011 to 2012.

- A 30% reduction of the F_{stq} (F=0.43) generates a decrease of catch for 13% in 2011 and an increase of spawning stock biomass of about 36% from 2011 to 2012, indicating that this level of reduction could generate a slight decrease of catches but a significant increase of the spawning stock biomass.

- SGMED recommends that fishing mortality in 2011 should not exceed $F_{0.1}$.= 0.19, corresponding to catches of 491 tons.

Outlook until 2012

Basis: F (2010) = F (2009) rescaled (F_{bar} 0-6); R (2010) = GM (2007–2009) = 35774 (thousands); F (2010) = 0.61; SSB (2011) = 1836; Catch (2010) = 1125 t

Rationale	F scenario	F factor	Catch 2011	Catch 2012	SSB 2012	Change SSB 2011-2012 (%)	Change Catch 2009-2011 (%)
zero catch	0	0	0	0	4477	143.8	-100.0
High long-term yield ($F_{0.1}$)	0.19	0.3	491	796	3424	86.5	-54.9
Status quo	0.61	1.0	1227	1295	1980	7.8	12.6
Different scenarios	0.06	0.1	171	320	4103	123.4	-84.3
	0.12	0.2	329	574	3765	105.0	-69.8
	0.18	0.3	474	774	3460	88.4	-56.5
	0.24	0.4	608	931	3183	73.3	-44.2
	0.30	0.5	732	1050	2932	59.6	-32.8
	0.36	0.6	847	1140	2704	47.2	-22.3
	0.43	0.7	953	1205	2497	35.9	-12.6
	0.49	0.8	1051	1250	2308	25.7	-3.6
	0.55	0.9	1142	1279	2137	16.3	4.8
	0.67	1.1	1306	1300	1837	0.1	19.8
	0.73	1.2	1380	1297	1707	-7.1	26.6
	0.79	1.3	1449	1287	1587	-13.6	32.9
	0.85	1.4	1513	1272	1478	-19.5	38.8
	0.91	1.5	1573	1253	1377	-25.0	44.3
	0.97	1.6	1629	1230	1285	-30.0	49.4
	1.03	1.7	1681	1205	1200	-34.6	54.2
	1.09	1.8	1731	1179	1122	-38.9	58.8
	1.16	1.9	1777	1151	1051	-42.8	63.0
	1.22	2.0	1821	1123	984	-46.4	67.0

Weights in t

6.5.2. *Medium term prediction*

6.5.2.1. Method and justification

Medium term prediction from 2010 to 2030 was implemented in R (www.r-project.org) using the FLR libraries and based on the results of stock assessment obtained using VIT (Lleonart and Salat, 1997) and the VPA Lowestoft routines. The medium term projections (20 years) were run assuming a progressive decreasing trend of F toward $F_{0.1}$ in 10 years (2020) and in 5 years (2015). The stock-recruitment relationship used geometric mean recruitment over the observed SSB range from 2007 to 2009. Runs were made with 500 simulations per run. To simulate a stochastic process the recruitment was multiplied by log-normally distributed noise with mean 1 and standard deviation 0.3.

6.5.2.2. Input parameters

The maturity ogives, the natural mortality, the numbers of individuals and weight-at-age for the stock and for the catch were the same used in the short term forecast.

These medium term predictions were done without taking in to account the mesh shape changed (40 mm square mesh) as adopted by Council Regulation (EC) No 1967/2006 of 21 December 2006.

6.5.2.3. Results

In Fig. 6.5.2.3.1 (left panel), the 5th, 25th, 50th, 75th and 95th percentile are shown for the SSB, recruitment and catches in t from 2009 to 2030, considering a constant reduction of the F_{stq} of around 21% each year from 2010 to 2015.

In Fig. 6.5.2.3.1 (right panel), the 5th, 25th, 50th, 75th and 95th percentile are showed for the SSB, recruitment and catches in t from 2009 to 2030, considering a constant reduction of the F_{stq} of around 11% each year from 2010 to 2020.

Landing of hake from 2004 to 2009 in the GSA10 are reported in the table xxxx and shows a decreasing pattern. In both the scenarios of the medium-term forecasts the decreasing of fishing mortality results in a clear increase of the SSB, while the amount of the catches also increased in the medium term.

Table 6.5.2.3.1. Landings of hake in the GSA 10.

year	2004	2005	2006	2007	2008	2009
DCF landings	1339	1485	1544	1269	1123	1091

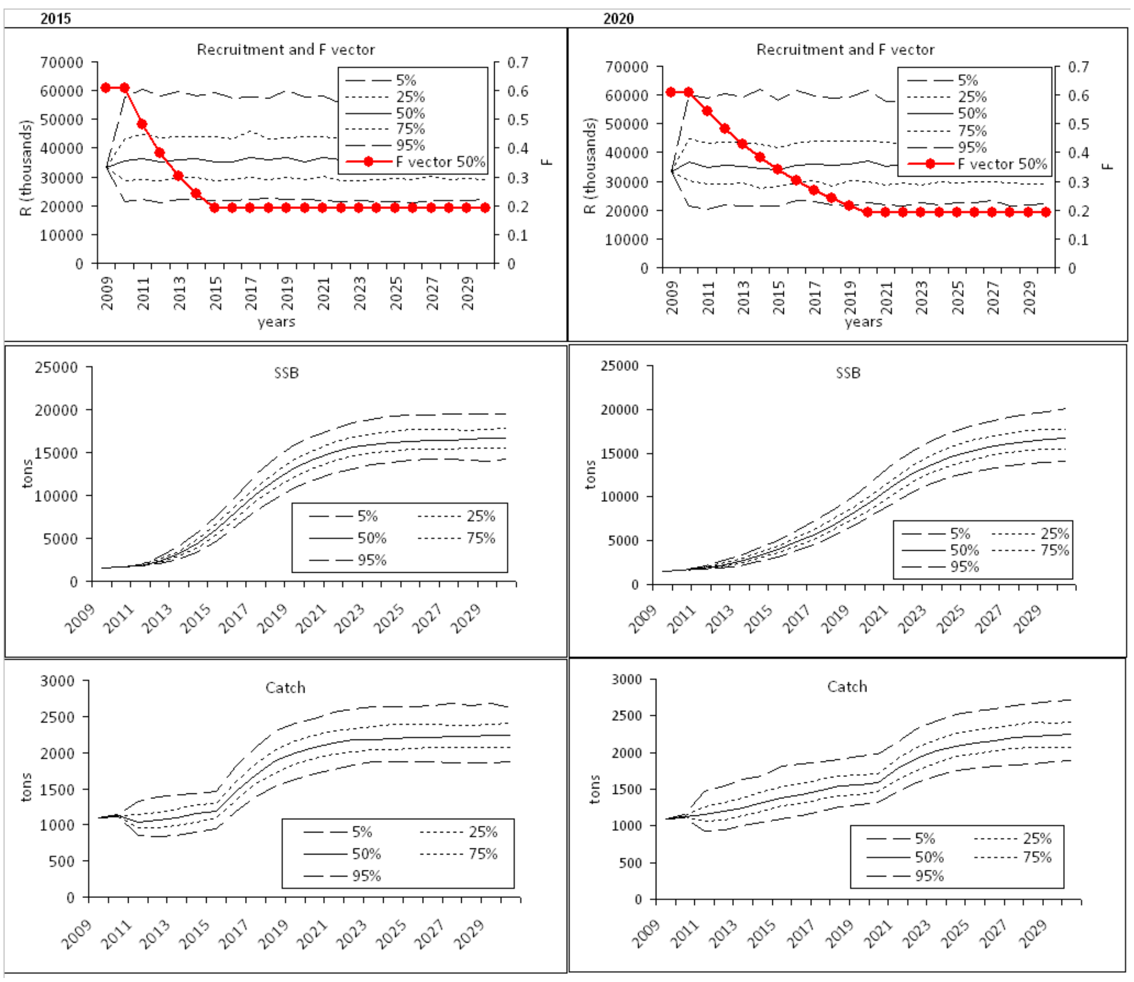


Fig. 6.5.2.3.1 Output of the medium term forecast computed for the hake in the GSA 10 reaching the $F_{0.1}$ in 2015 (left) and 2020 (right).

6.6. Hake (Merluccius merluccius) in GSA 11

6.6.1. *Short term prediction for 2010-2012*

6.6.1.1. Method and justification

Short term predictions for 2010 and 2011 were based on the results of the stock assessment that was carried out for European hake stock in GSA 11 during the SGMED-10-03 using the VIT software (Lleonart and Salat, 1992).

6.6.1.2. Input parameters

The following data have been used to derive the input data for the short term projection of the European hake in GSA 11:

Maturity and M vectors

PERIOD	Age	0	1	2	3	4
2009	Prop. Matures	0.01	0.19	0.88	1.00	1.00

PERIOD	Age	0	1	2	3	4
2009	M	1.10	0.51	0.39	0.33	0.31

Maturity. weight-at-age in the stock, weight-at-age in the catch, F and M before spawning were considered the same as the one considered in the VPA for 2009.

F vector

PERIOD	Age	0	1	2	3	4
2009	F	0.40	1.59	0.87	0.79	0.30

For the projections, the mean F (F_{bar} ages 0-4) calculated as the average of the last 4 years for each age class, and rescaled to the level of 2009 was defined as F status quo (F_{stq} = 0.86). Several scenarios of constant harvest strategy were run. These short term predictions were done without taking into account the change in the mesh as adopted by Council Regulation (EC) No 1967/2006 of 21 December 2006.

Weight-at-age in the stock

Mean weight in stock	0	1	2	3	4
Kg	0.011	0.166	0.668	1.409	2.309

Weight-at-age in the catch

Mean weight in stock	0	1	2	3	4
Kg	0.011	0.166	0.668	1.409	2.309

Number at age in the catch

Catch at age in numbers (thousands)	0	1	2	3	4
	732	527	48	13	2

Number at age in the stock

Stock at age in numbers (thousands)	0	1	2	3	4
	7919	1770	216	61	10

Stock recruitment

The recruitment (age 0+) used for the short term projection derived from the results of the stock numbers provided by the VIT.

6.6.1.3. Results

A short term projection (Table below), assuming an F_{stq} of 0.86 and a recruitment of 10.2 (millions) individuals, shows that:

- Fishing at the F_{stq} (0.86) in the time frame from the year 2009 to 2011 generates an increase of the catch for 22,3 % in 2010 and a slight increase of the spawning stock biomass for 9 % from the year 2011 to 2012.

- Fishing at $F_{0.1}$ (0.38) for the same time frame (2009-2011) generates a decrease of the catch of 30 % in 2011 and an increase of the spawning stock biomass for 73.7 % from the year 2011 to 2012.

- A 20% reduction of the F_{stq} (F from 0.86 to 0.68) generates a minimum increase of catch for 6 % in 2011 and a greater spawning stock biomass increase of 28 from the year 2011 to 2012.

- A 30% reduction of the F_{stq} (F from 0.86 to 0.60) generates a negligible decrease of catch for -3.3 % in 2011 and a significant spawning stock biomass increase of 38% from the year 2011 to 2012.

The last point clearly indicates that the 30% reduction of F does not generate a reduction in the catch in the year 2011 in comparison with 2010, meanwhile it predicts a high increase (39%) in the SSB from the year 2011 to 2012.

SGMED recommends the catch in 2011 should not exceed the catch of 234 tons that corresponds to $F_{0.1}$.

Outlook until 2012

Basis: F (2010) = mean (2006–2009) scaled to 2009; R (2010) = GM (2006–2009) = 10.2 (millions); F (2010) = 0.86; SSB (2011) = 726 t; Catch (2010) = 341 t

Rationale	F scenario	F factor	Catch 2011	Catch 2012	SSB 2012	Change SSB 2011-2012 (%)	Change Catch 2009-2011 (%)
zero catch	0.00	0.00	0	0	1962	163.7	-100.0
High long-term yield ($F_{0.1}$)	0.38	0.45	234	382	1292	73.7	-30.4
Status quo	0.86	1.00	411	438	810	8.9	22.3
Different scenarios	0.09	0.10	65	137	1780	139.2	-80.7
	0.17	0.20	120	237	1617	117.3	-64.3
	0.26	0.30	172	312	1470	97.6	-48.8
	0.34	0.40	217	363	1343	80.5	-35.4
	0.43	0.50	259	398	1226	64.8	-22.9
	0.51	0.60	294	423	1126	51.3	-12.5
	0.60	0.70	325	437	1034	39.0	-3.3
	0.68	0.80	358	442	953	28.1	6.5
	0.77	0.90	384	440	875	17.6	14.3
	0.94	1.10	432	433	753	1.2	28.6
	1.03	1.20	454	423	696	-6.5	35.1
	1.11	1.30	472	414	649	-12.8	40.5
	1.20	1.40	487	399	601	-19.2	44.9
	1.28	1.50	506	390	562	-24.5	50.6

Potential changes in selectivity due to the implementation of the 40mm square / 50mm diamond mesh size on Sardinian trawlers based on Council Regulation (EC) No 1967/2006 of 21 December 2006were not taken into account in the predictions made above.

6.6.2. *Medium term prediction*

6.6.2.1. Methods and justification

Medium term prediction from 2010 to 2030 was implemented in R (www.r-project.org) using the FLR libraries and based on the results of the stock assessment that was applied for European hake stock in GSA 11 during the SGMED-10-03 using the VIT software (Lleonart and Salat, 1992). For the prediction, a progressive declining trend of the F_{stq} toward $F_{0.1}$ in 10 years (2020) was assuming.
The stock-recruitment relationship used geometric mean recruitment over the observed SSB range from 2006 to 2009.

These medium term predictions were done without taking in to account the mesh shape changed (40 mm square mesh) as adopted by Council Regulation (EC) No 1967/2006 of 21 December 2006.

6.6.2.2. Input parameters

The maturity ogives, the natural mortality, the numbers of individuals and weight-at-age for the stock and for the catch were the same used in the short term forecast.

6.6.2.3. Results

Assuming each year from 2010 to 2020 a constant reduction of the F_{stq} of about 5%, the SSB, recruitment and catches in t from 2009 to 2030 are showed below.
The decreasing of fishing mortality outcome as an increase of the SSB and consequently also an increase of the catches in the medium term.

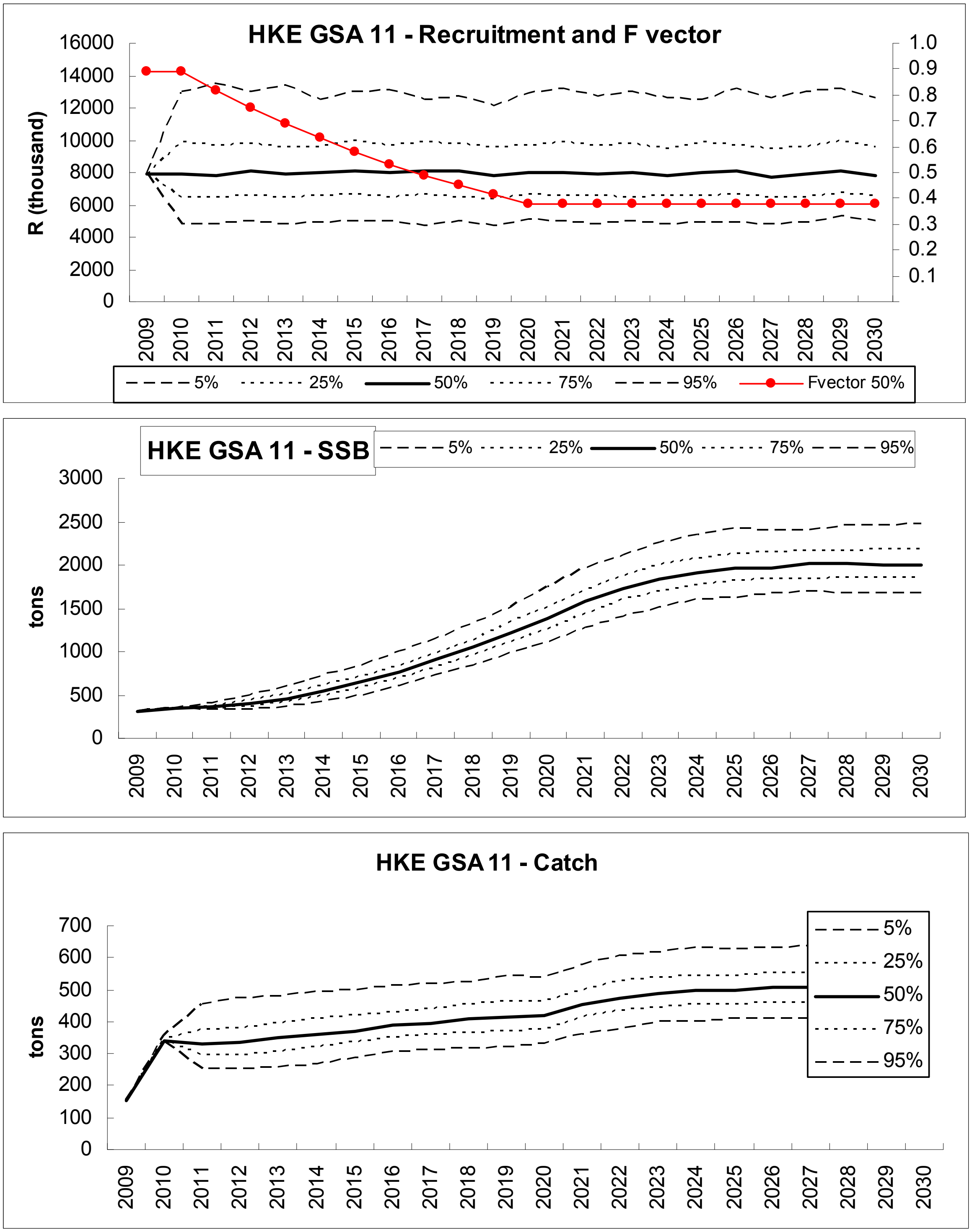


Fig. 6.6.2.3.1 Medium term forecast computed for the hake in the GSA 11 reaching the $F_{0.1}$ in 2020.

6.7. Hake (*Merluccius merluccius*) in GSA 15 and 16

6.7.1. *Short term prediction 2010-2012*

6.7.1.1. Method and justification

Short term prediction for 2011 and 2012 was implemented in R (www.r-project.org) using the FLR libraries and based on the results of the Length Cohort and Yield per Recruit Analysis as implemented in the programme VIT4win (Lleonart and Salat, 2000). The underlying stock assessment for hake in GSA 15 and 16 carried out by SGMED 02/2010 was updated with 2009 data which was not available at the previous meeting.

6.7.1.2. Input parameters

The following data have been used to derive the input data for the short term projection of the hake in GSA 15 and 16:

Maturity and M vectors

PERIOD	Age	0	1	2	3	4	5	6	7	8+
2006-2009	Prop. Mature	0.04	0.15	0.36	0.56	0.86	0.98	1.00	1.00	1.00

PERIOD	Age	0	1	2	3	4	5	6	7	8+
2006-2009	M	0.68	0.30	0.22	0.19	0.17	0.16	0.15	0.14	0.14

F vector

F	0	1	2	3	4	5	6	7	8+
2006	0.18	1.62	1.17	0.78	0.44	0.46	0.33	0.19	0.21
2007	0.18	1.66	1.13	0.65	0.39	0.50	0.26	0.25	0.21
2008	0.15	1.51	1.21	1.08	0.65	0.42	0.26	0.33	0.21
2009	0.21	1.60	1.08	0.64	0.51	0.52	0.55	0.21	0.21
Mean 06-09 scaled to 09	0.18	1.61	1.16	0.79	0.50	0.48	0.35	0.25	0.21

Several scenarios with different harvest strategy were run, with F_{stq} (F_{bar} ages 0-8) calculated as the average of the last 4 years, but rescaled to the F of 2009 ($F_{stq} = 0.61$).

Potential changes in selectivity due to the implementation of the 40mm square / 50mm diamond mesh size on Italian and Maltese trawlers based on EC 1967/2006 were not taken into account in the predictions made above.

Weight-at-age in the stock

Mean weight in stock	0	1	2	3	4	5	6	7	8+
kg	0.01	0.06	0.19	0.41	0.65	0.98	1.40	1.83	2.24

Weight-at-age in the catch

Mean weight in catch	0	1	2	3	4	5	6	7	8+
kg	0.01	0.06	0.19	0.41	0.65	0.98	1.40	1.83	2.24

Number at age in the catch (thousands)

Catch at age	0	1	2	3	4	5	6	7	8+

in numbers									
2006	5640	13979	1809	357	89	50	21	8	6
2007	5501	14271	1703	313	93	65	19	13	7
2008	3720	11432	1741	394	81	25	10	8	3
2009	6241	12998	1649	323	119	62	33	7	5

Number at age in the stock (thousands)

Stock at age in numbers	0	1	2	3	4	5	6	7	8+
2006	46238	19423	2865	714	271	148	80	49	35
2007	46358	19579	2751	714	310	177	92	61	41
2008	37624	16399	2702	644	182	80	45	30	19
2009	44519	18150	2726	740	322	163	83	41	29
2010	43530	18360	2891	737	264	125	67	39	26

Stock recruitment

The recruitment used for the short term projection was estimated as the geometric mean from 2006-2009.

6.7.1.3. Results

A short term projection (Table below), assuming an F_{stq} of 0.61 in 2010 and a recruitment of 43,530 (thousand) individuals, shows that:

- Fishing at the F_{stq} (0.61) from the year 2010 to 2011 generates an increase of the catch of 0.5% and an increase of the spawning stock biomass of 0.6% from the year 2011 to 2012.
- Fishing at $F_{0.1}$ (0.15) for the same time frame (2010-2011) generates a decrease of the catch of 64% and a spawning stock biomass increase of 83% from the year 2011 to 2012.
- •SGMED recommends a decrease of F_{stq} by 76% in order to reach the target point $F_{0.1}$. According to the short term simulation the catch of hake in the Central Mediterranean (GSA 15 and 16) in 2011 corresponding to F0.1 is 563 t

Basis: F (2010) = mean (2006–2009) scaled to 2009; R (2010) = GM (2006–2009) = 43530 thousands; F(2010) = 0.61; SSB(2011) = 1193 t; Catch (2010) = 1577 t

Rationale	F scenario	F factor	Catch 2011	Catch 2012	SSB 2012	Change SSB 2011-2012 (%)	Change Catch 2009-2011 (%)
zero catch	0.00	0.00	0	0	2746	130	-100
High long-term yield ($F_{0.1}$)	0.15	0.24	563	977	2183	83	-64
Status quo	0.61	1.00	1563	1557	1200	1	1
Different scenarios	0.06	0.10	251	496	2494	109	-84
	0.12	0.20	473	854	2272	91	-70
	0.18	0.30	670	1109	2076	74	-57
	0.25	0.40	844	1287	1903	60	-46
	0.31	0.50	1000	1407	1750	47	-36
	0.37	0.60	1138	1485	1613	35	-27
	0.43	0.70	1262	1532	1492	25	-19
	0.49	0.80	1373	1555	1384	16	-12
	0.55	0.90	1473	1562	1287	8	-5
	0.68	1.10	1644	1544	1122	-6	6
	0.74	1.20	1718	1525	1051	-12	10
	0.80	1.30	1785	1502	988	-17	15
	0.86	1.40	1846	1477	930	-22	19
	0.92	1.50	1901	1450	878	-27	22
	0.98	1.60	1952	1424	830	-30	26
	1.05	1.70	1999	1397	786	-34	29
	1.11	1.80	2043	1370	746	-37	31
	1.17	1.90	2083	1344	710	-40	34
	1.23	2.00	2120	1319	676	-43	36

Weights in t

6.8. Hake (Merluccius merluccius) in GSA 18

6.8.1. *Short term prediction 2010-2012*

6.8.1.1. Method and justification

Short term prediction for 2010 -2012 was implemented in R (www.r-project.org) using the FLR libraries and based on the results of the stock assessment performed using VIT (Lleonart and Salat, 1997) that was conducted in the framework of the SGMED-10-03 using the VPA Lowestoft routines.

6.8.1.2. Input parameters

The following data have been used to derive the input data for the short term projection of the hake in the GSA 18:

Maturity and M vectors

PERIOD	Age	0	1	2	3	4+
2007-2009	Prop. Matures	0.01	0.12	0.92	1.00	1.00

PERIOD	Age	0	1	2	3	4+	Mean 0-4
2007-2009	M	1.16	0.52	0.40	0.34	0.31	0.55

F vector

F	0	1	2	3	4+
2007	0.48	2.28	0.91	0.26	0.32
2008	0.22	2.40	0.60	0.55	0.32
2009	0.27	2.37	0.86	0.29	0.32

Several scenarios with different harvest strategy were run, with F_{stq} (F_{bar} ages 0-3) calculated as the average of the last 3 years, but rescaled to the F of 2009 (F_{stq} =0.95).
Potential changes in selectivity due to the implementation of the 40mm square / 50mm diamond mesh size on trawlers based on EC 1967/2006 were not taken into account in the predictions presented below.

Weight-at-age in the stock

Mean weight in stock	0	1	2	3	4+
kg	0.01	0.10	0.49	1.12	2.87

Weight-at-age in the catch

Mean weight in catch	0	1	2	3	4+
kg	0.01	0.10	0.49	1.12	2.87

Number at age in the catch

Catch at age in numbers (thousands)	0	1	2	3	4+
2009	21760	28278	994	124	156

Number at age in the stock

Stock at age in numbers	0	1	2	3	4+

(thousands)					
2009	152080	36517	2032	576	306
2010	159101	34661	2127	623	448

Stock recruitment

The recruitment used for the short term projection was estimated as the geometric mean from 2007-2009.

6.8.1.3. Results

A short term projection (Table below), assuming an F_{stq} of 0.95 in 2010 and a recruitment of 159,101 (thousands) individuals, shows that:

- Fishing at the F_{stq} (0.95) from 2010 to 2011 generates an increase of the catch for 1 % and an increasing of the spawning stock biomass of 5% from 2011 to 2012.

- Fishing at $F_{0.1}$ (0.21) for the same time (2010-2011) generates a decrease of the catch of 63% and a spawning stock biomass increase of 172% from 2011 to 2012.

- A 30% reduction of the F_{stq} (F=0.67) generates a decrease of catch for 18% and an increase of spawning stock biomass of about 43% from 2011 to 2012, indicating that this level of reduction could generate a decrease of catches but a significant increase of the spawning stock biomass.

- SGMED recommends that fishing mortality in 2011 should not exceed $F_{0.1}$= 0.21, corresponding to catches of 1,501 t.

Outlook until 2012

Basis: F (2010) = F (2009) rescaled (F_{bar} 0-3); R (2010) = GM (2007–2009) = 159101 (thousands); F (2010) =0.95; SSB (2011) = 3661; Catch (2010) = 3871 t

Rationale	F scenario	F factor	Catch 2011	Catch 2012	SSB 2012	Change SSB 2011-2012 (%)	Change Catch 2009-2011 (%)
zero catch	0.00	0	0	0	14313	290.98	-100.00
High long-term yield ($F_{0.1}$)	0.21	0.222	1501	2612	9947	171.7	-63.5
Status quo	0.95	1	4047	4104	3859	5.4	-1.4
Different scenarios	0.09	0.1	750	1450	12086	230.2	-81.7
	0.19	0.2	1378	2444	10289	181.1	-66.4
	0.28	0.3	1909	3114	8832	141.3	-53.5
	0.38	0.4	2360	3556	7648	108.9	-42.5
	0.47	0.5	2746	3837	6682	82.5	-33.1
	0.57	0.6	3080	4005	5889	60.9	-25.0
	0.66	0.7	3369	4095	5235	43.0	-17.7
	0.76	0.8	3623	4131	4693	28.2	-11.8
	0.85	0.9	3848	4130	4240	15.8	-6.3
	1.04	1.1	4226	4061	3537	-3.4	2.9
	1.14	1.2	4388	4007	3262	-10.9	6.8
	1.23	1.3	4535	3947	3025	-17.4	10.4
	1.33	1.4	4669	3881	2819	-23.0	13.7
	1.42	1.5	4793	3814	2639	-27.9	16.7
	1.52	1.6	4908	3745	2480	-32.2	19.5
	1.61	1.7	5014	3676	2339	-36.1	22.1
	1.70	1.8	5113	3607	2212	-39.6	24.5
	1.80	1.9	5207	3539	2098	-42.7	26.8
	1.89	2.0	5294	3472	1993	-45.5	28.9

Weights in t

6.8.2. *Medium term prediction*

6.8.2.1. Method and justification

Medium term prediction from 2010 to 2030 was implemented in R (www.r-project.org) using the FLR libraries and based on the results of stock assessment obtained using VIT (Lleonart and Salat, 1997) and the VPA Lowestoft routines. Medium term projections (20 years) were assuming a progressive decreasing trend of F toward $F_{0.1}$ in 10 years (2020) and in 5 years (2015). The stock-recruitment relationship used geometric mean recruitment over the observed SSB range from 2007 to 2009. Runs were made with 500 simulations per run. To simulate a stochastic process the recruitment was multiplied by log-normally distributed noise with mean 1 and standard deviation 0.3.

6.8.2.2. Input parameters

The maturity ogive, the natural mortality, the numbers of individuals and weight-at-age for the stock and for the catch were the same used in the short term forecast. Potential changes in selectivity due to the implementation of the 40mm square / 50mm diamond mesh size on trawlers based on EC 1967/2006 were not taken into account in the predictions made below.

6.8.2.3. Results

In Fig. 6.8.2.3.1, the 5th, 25th, 50th, 75th and 95th percentile are showed for the SSB, recruitment and catches in t from 2009 to 2020, considering a constant reduction of F of around 26% each year from 2010 to 2015.
In Fig. 6.8.2.3.1, the 5th, 25th, 50th, 75th and 95th percentile are showed for the SSB, recruitment and catches in t from 2009 to 2020, considering a constant reduction of F of around 14% each year from 2010 to 2020.

Landing data of hake from 2004 to 2009 in the GSA18 are reported in the table xxxx and show a rather stable pattern in the last three years after the decreasing following the peak of 5507 tons in 2006. In both the scenarios of the medium-term forecasts the decreasing of fishing mortality results in a clear increase of the SSB, and a significant increase of the catches in the medium term.

Table 6.8.2.3.1. Landings of hake in the GSA 18.

year	2004	2005	2006	2007	2008	2009
DCF landings	3204	3785	5507	4155	4251	4106

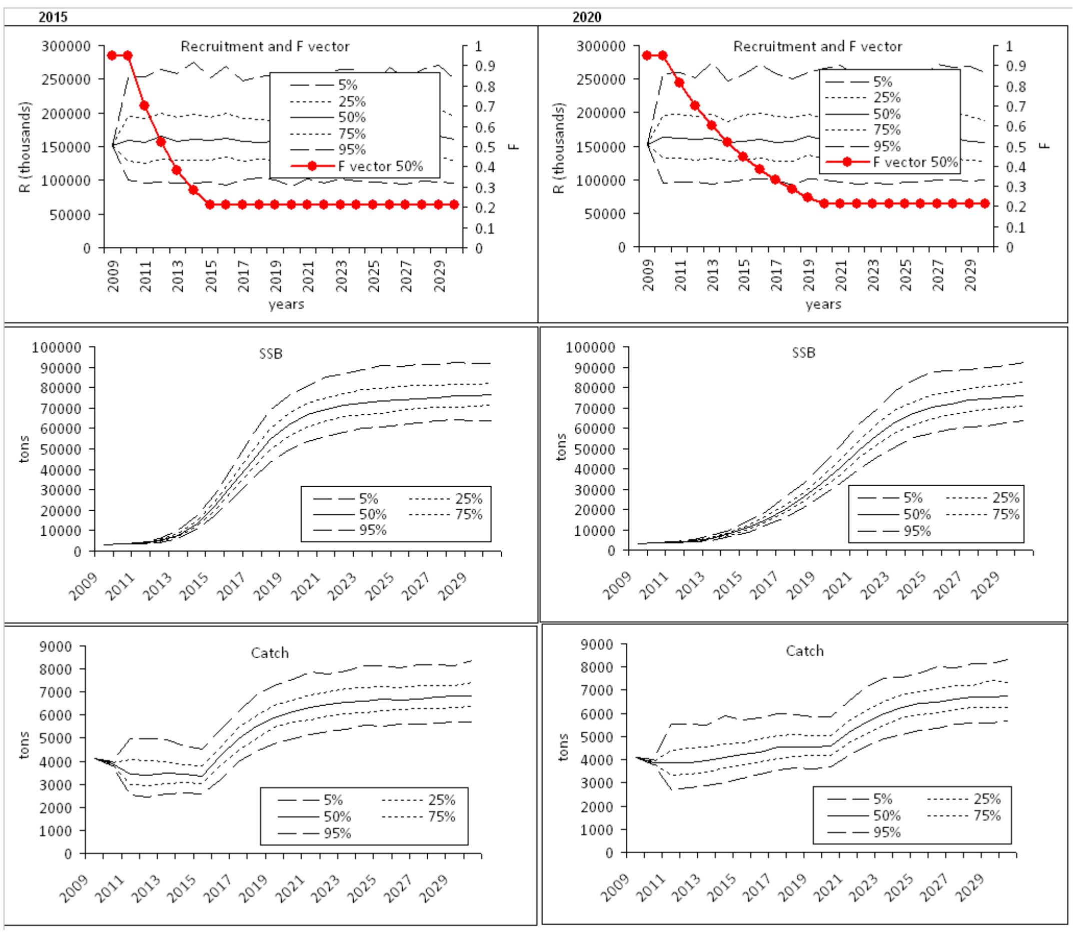


Fig. 6.8.2.3.1. Output of the medium term forecast computed for the hake in the GSA 18 reaching $F_{0.1}$ in 2015 (left) and 2020 (right).

6.8.3. *Potential effects of changes of selectivity*

ALADYM model was applied to forecast the possible effects of the newly enforced mesh size regulation (from 40 mm to 50 mm diamond mesh opening in the cod-end) on stock biomass, catches and other relevant population indicators in the long-term. The results of the simulations under the new mesh size scenario were compared to the results under the *status quo* scenario in the long-term. The model assumptions are a full compliance to the mesh size regulations and full survival of the fish escaped by the cod-end.

6.8.3.1. Input parameters

The same parameters as in 6.8.3.1.1. In addition the new selection pattern in the long-term was mimicked using the following selectivity parameters since 2011 to 2020: $L_{50\%}$=16 cm; SR=1cm. Selectivity parameters were derived from studies conducted in the area (Adriamed website; Leonori et al., 2005). The recruitment for the forecast scenarios was set equal to the geometric mean of the last three years as well as the total mortality.

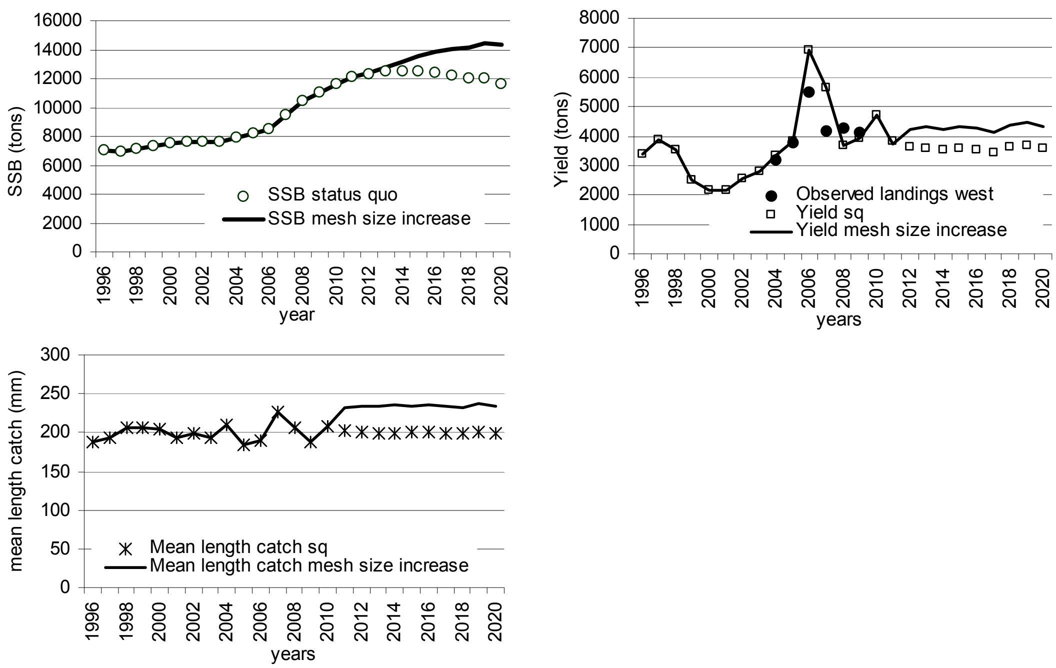


Fig. 6.8.3.1.1 Forecasts from ALADYM simulations regarding the following model based indicators: SSB, Yield and mean length of the catches.

6.8.3.2. Results

The forecast evidenced poor losses for the catches in the short-term, after a slight decline in the first year, and a stable situation in the future when the present levels of catches will be maintained. According to the model predictions in the medium term the catches might be higher than the current one of about 10% (3939 in 2009 vs. 4340 tons in 2020). In addition, the average size of catches would increase of about 20% resulting in more valuable yields (19 in 2009 vs. 23 cm TL in 2020). The stock sustainability would improve as the level of SSB would increase of about 30% (11000 in 2009 vs. 14300 tons in 2020). The new enforced mesh size would allow in the medium term a higher average size of catches (increasing of about 20% compared to the current level) resulting in more valuable yields that would compensate the loss of catches occurring in the short-term. However, given the uncertainty of the effectiveness of mesh size regulation, regarding fish survival and compliance to the regulation, management measures based on spatial and temporal fishing reduction should complement such technical measure.

6.9. Hake (Merluccius merluccius) in GSA 22

6.9.1. *Medium term prediction*

6.9.1.1. Method and justification

Based on the results of the non-equilibriun surplus production model assessment conducted during the SGMED 10-02 meeting, stochastic stock biomass and catch predictions up to the year 2020 were implemented. Three different management scenarios were evaluated: (a) the status quo, i.e fishing mortality (F) remains at the level estimated at the last assessment year, for the whole projection period, (b) F equals to the F_{msy} and (c) F equals to the $F_{0.1}$ value that was obtained from the Y/R analysis. Each projection scenario was simulated 100 times assuming normally distributed errors for the parameters r and k of the surplus production model. Future biomass and catch levels were estimated through the commonly used Shaefer equation:

$$B_t = B_{t-1} + rB_{t-1}(1-B_{t-1}/k)-FB_{t-1}$$

Runs were made under the R language environment.

Input parameters
r = 0.66 (sd = 0.09)
k = 25187 (sd = 3180)
$B_{2006} = 12954$
$F_{2006} = 0.39$
$F_{msy} = 0.33$
$F_{0.1} = 0.20$

6.9.1.1. Results

The table below indicates stock biomass and catch predictions under the different scenarios (status quo, F_{msy} and $F_{0.1}$). Predictions together with the assessment estimates are shown in Figure 6.9.1.1.1.

Short term implications
Under the current F, stock biomass will decrease and by 2015 will be about 16% lower than the current level, which is around the B_{msy} value. An analogous reduction is expected for the catches. Fishing at F_{msy} will bring stock biomass and up to the optimum levels by 2015. Similarly catch will be stabilized to MSY levels by the same year. Under the $F_{0.1}$ scenario stock biomass will reach optimum levels within the next 2-3 years and catches will be stabilized at levels about 18% lower than MSY.

Outlook until 2020
Under the current F, stock biomass will decrease being in 2020 about 20% lower than the current level. An analogous reduction is expected for the catches. As expected, fishing at F_{msy} will keep stock biomass and catches to MSY levels reached in 2015. Under the $F_{0.1}$ scenario stock biomass will be in 2020 about 30% higher than B_{msy} and catch levels 20% lower than MSY. Thus, SGMED recommends the reduction of fishing mortality to the F_{msy} levels in order to achieve stock rebuilding in the short term, corresponding to catches around 4150 tonnes in 2011. Although the officially reported Greek catches in FAO (Fishstat database) are not detailed by GSA and considering the existing fishery exploitation pattern, it is estimated that the 2007 and 2008 catches are within the predicted limits for the given years, under the “status quo” scenario

Data consistency
Due to data limitations, the analysis is based on a production modeling approach which considers the population as a whole without taking into account that it is composed by a sum of age groups that undergo different levels of fishing pressure by the various fleet components. Such an assumption which implies

constant fishing mortality over age is endogenous in production models and may severely bias results, especially if the exploitation pattern changes over time; hence prediction estimates should be faced with caution. Additionally, given that the available time series of survey CPUE data was short with low contrast between years, strong assumptions had to be made regarding the initial harvest rate in order to achieve convergence in the surplus production model that has been previously applied for the assessment of the stock. However, the mean fishing mortality estimate (F = 0.32) obtained from a cohort analysis based on the 2004 catch at age data (Table 1) is identical to that estimated from the surplus production model for the same year (SGMED 10-02), confirming the consistency of the surplus model estimates.

Status quo

Year	Biomass (mt)	Biomass CI (95% upper limit)	Biomass CI (95% lower limit)	Catch (mt)	Catch (95% upper limit)	Catch (95% lower limit)	F
2007	12100	13648	10553	4770	5380	4160	0.39
2008	11485	13926	9043	4527	5490	3565	0.39
2009	11073	14115	8031	4365	5564	3166	0.39
2010	10782	14259	7305	4250	5621	2879	0.39
2011	10568	14374	6761	4166	5666	2665	0.39
2012	10406	14471	6342	4102	5704	2500	0.39
2013	10282	14553	6012	4053	5737	2370	0.39
2014	10185	14624	5746	4015	5765	2265	0.39
2015	10108	14687	5529	3985	5790	2179	0.39
2016	10046	14743	5349	3960	5812	2109	0.39
2017	9996	14793	5199	3941	5832	2049	0.39
2018	9955	14838	5072	3924	5849	1999	0.39
2019	9921	14878	4964	3911	5865	1957	0.39
2020	9893	14915	4872	3900	5879	1920	0.39

$F = F_{msy}$

Year	Biomass (mt)	Biomass CI (95% upper limit)	Biomass CI (95% lower limit)	Catch (mt)	Catch (95% upper limit)	Catch (95% lower limit)	F
2007	12158	13737	10578	3905	4412	3398	0.32
2008	12469	15050	9889	4005	4834	3176	0.32
2009	12692	15984	9399	4077	5134	3019	0.32
2010	12840	16616	9063	4124	5337	2911	0.32
2011	12934	17031	8836	4154	5470	2838	0.32
2012	12992	17300	8683	4173	5557	2789	0.32
2013	13026	17476	8577	4184	5613	2755	0.32
2014	13046	17591	8502	4191	5650	2731	0.32
2015	13058	17668	8448	4194	5675	2713	0.32
2016	13064	17721	8407	4196	5692	2700	0.32
2017	13067	17757	8377	4197	5704	2691	0.32
2018	13068	17783	8354	4198	5712	2683	0.32
2019	13068	17801	8336	4198	5718	2677	0.32
2020	13068	17815	8321	4197	5722	2673	0.32

$F = F_{0.1}$

Year	Biomass (mt)	Biomass CI (95% upper limit)	Biomass CI (95% lower limit)	Catch (mt)	Catch (95% upper limit)	Catch (95% lower limit)	F
2007	12079	13442	10716	2416	2688	2143	0.20
2008	13802	16227	11377	2760	3245	2275	0.20
2009	15176	18483	11868	3035	3697	2374	0.20
2010	16164	20087	12240	3233	4017	2448	0.20
2011	16821	21124	12519	3364	4225	2504	0.20
2012	17237	21752	12723	3447	4350	2545	0.20
2013	17494	22118	12870	3499	4424	2574	0.20
2014	17650	22327	12973	3530	4465	2595	0.20
2015	17746	22446	13045	3549	4489	2609	0.20
2016	17804	22513	13094	3561	4503	2619	0.20
2017	17840	22551	13128	3568	4510	2626	0.20
2018	17862	22573	13151	3572	4515	2630	0.20
2019	17876	22585	13167	3575	4517	2633	0.20
2020	17885	22592	13177	3577	4518	2635	0.20

Table 6.9.1.1.1: Hake fishing mortality estimates derived from cohort analysis on 2004 catch-at-age data.

Age	Catch (N)	F
1	26591	0.15
2	42622	0.38
3	21510	0.34
4	14862	0.42
5	8154	0.43
6	4153	0.41
7	1926	0.34
8	788	0.23
9+	1413	0.20
	Mean F:	**0.32**

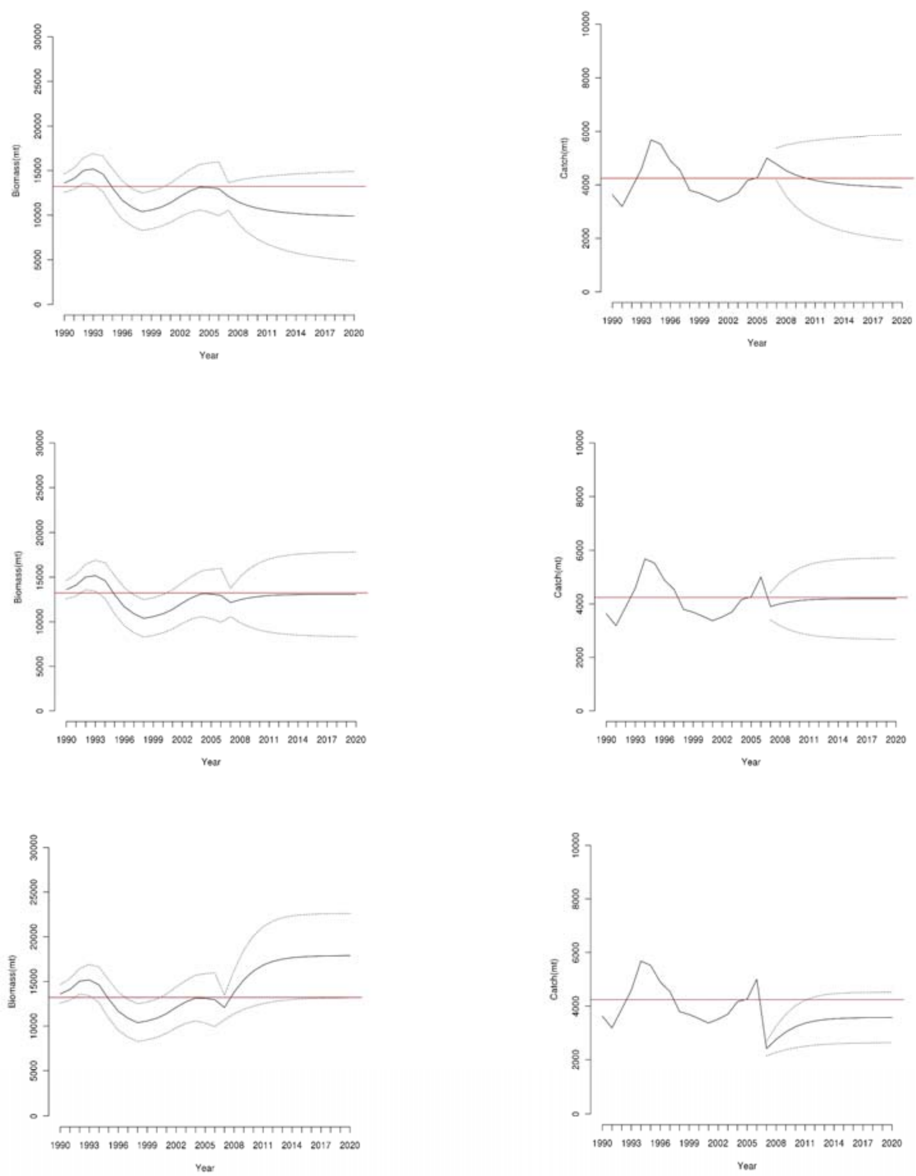


Figure 6.9.1.1.1. Stock biomass and catch predictions under different exploitation scenarios. From top to bottom: Status quo, F = F_{msy}, F = $F_{0.1}$. Horizontal lines indicate the corresponding MSY levels and dotted lines the 95% confidence intervals of the estimates.

6.10. Red mullet (*Mullus barbatus*) in GSA 5

6.10.1. *Short term prediction 2010-2012*

6.10.1.1. Method and justification

A deterministic short term prediction for 2010 to 2012 was performed using the EXCEL workbook provided by JRC IPSC (H.-J. Rätz), which takes into account the catch and landings in numbers and weight and the discards, and based on the results of the Extended Survivor Analyses (XSA, Darby and Flatman, 1994) performed during the SGMED 10-02 meeting.

6.10.1.2. Input parameters

The following data have been used to derive the input data for the short term projection of the red mullet stock in GSA 5:

Maturity

Period	Age	0	1	2	3	4	5
2000-2009	Prop. Matures	0.30	0.57	0.80	0.92	0.97	0.99

M vector

Period	Age	0	1	2	3	4	5
2000-2009	M	1.00	0.70	0.50	0.40	0.40	0.40

F vector

F	0	1	2	3	4	5
2009	0.01	0.53	1.41	1.49	1.08	0.95

Several scenarios with different harvest strategy were run, with F_{stq} (F_{bar} ages 1-4) estimated as the F vector in 2009 (F_{stq} = 1.13).
Potential changes in selectivity due to the implementation of the 40mm square / 50mm diamond mesh size on trawlers based on EC 1967/2006 were not taken into account in the predictions.

Weight-at-age in the stock

Mean weight (kg)	0	1	2	3	4	5
2007-2009	0.011	0.033	0.053	0.085	0.111	0.148

Weight-at-age in the catch

Mean weight (kg)	0	1	2	3	4	5
2007-2009	0.011	0.033	0.053	0.085	0.111	0.148

Number at age in the stock

N (thousands)	0	1	2	3	4	5
2010	749	339	112	39	9	3

Stock recruitment

Due to the decreasing trend in recruitment during the entire time series, recruitment (class 0+) has been estimated as the geometric mean of the class 0+ of the last two years (2008-2009).

6.10.1.3. Results

Short-term implications

A short term projection (Table below), assuming an F_{stq} of 1.13 in 2010 and a recruitment of 749 (thousands) individuals, shows that:

- Fishing at the F_{stq} (1.13) generates a decrease of the catch of 25% from 2009 to 2011 along with a decrease of the spawning stock biomass of 6% from 2011 to 2012.

- Fishing at $F_{0.1}$ (0.31) for the same time frame (2009-2012) generates a decrease of the catch of 67% from 2009 to 2011 and a spawning stock biomass increase of 38% from 2011 to 2012.

- SGMED reccomends that catches in 2011 should not exceed 4 tons, corresponding to F = $F_{0.1}$.

Outlook until 2012

Short term forecast for different F scenarios computed for red mullet in GSA 5.

Basis: F (2010) = mean (F_{bar}1-4 2009); Catch (2010): 11 t; R (2010) = GM (2008–2009) = 749 (thousands); F (2010) = 1.13; SSB(2011) = 16 t

Rationale	F scenario	F factor	Catch 2011	Catch 2012	SSB 2012	Change SSB 2011-2012 (%)	Change Catch 2009-2011 (%)
zero catch	0.00	0.0	0	0	27	68.8	-100.0
High long-term yield ($F_{0.1}$)	0.31	0.2781	4	6	22	37.5	-66.7
Status quo	1.13	1.0	9	9	15	-6.3	-25.0
Different scenarios	0.11	0.1	1	2	24	50.0	-91.7
	0.23	0.2	4	6	22	37.5	-66.7
	0.34	0.3	4	6	22	37.5	-66.7
	0.45	0.4	5	7	20	25.0	-58.3
	0.56	0.5	6	8	19	18.8	-50.0
	0.68	0.6	6	8	18	12.5	-50.0
	0.79	0.7	8	9	18	12.5	-33.3
	0.90	0.8	8	9	16	0.0	-33.3
	1.01	0.9	8	8	15	-6.3	-33.3
	1.24	1.1	10	9	14	-12.5	-16.7
	1.35	1.2	11	9	14	-12.5	-8.3
	1.46	1.3	11	9	13	-18.8	-8.3
	1.58	1.4	12	10	13	-18.8	0.0
	1.69	1.5	12	10	13	-18.8	0.0

Weights are in tons.

6.11. Red mullet (*Mullus barbatus*) in GSA 6

6.11.1. *Short term prediction 2010-2012*

6.11.1.1. Method and justification

A deterministic short term prediction for 2010 to 2012 was performed using the EXCEL workbook provided by JRC IPSC (H.-J. Rätz) which takes into account the catch and landings in numbers and weight and the discards, and based on the results of the Extended Survivor Analyses (XSA, Darby and Flatman, 1994) performed during SGMED-10-02. The effect of changes in the selectivity due to the application of the recent Mediterranean regulation was not considered.

6.11.1.2. Input parameters

The following data have been used to derive the input data for the short term projection of the red mullet stock in GSA 7:

Maturity and M vectors

PERIOD	Age	0	1	2	3	4+	
2009	Prop. Matures	0	1	1	1	1	

PERIOD	Age	0	1	2	3	4+		Mean 0-4+
2009	M	1.36	0.77	0.66	0.61	0.54		0.79

F vector

F	0	1	2	3	4+	
2009	0.17	0.89	1.50	0.84	0.84	

Several scenarios with different harvest strategy were run, with F_{stq} (F_{bar} ages 1-3) calculated as the average of the last 3 years, but scaled to the F of 2009 in order to account for the recent decreasing trend in the fishing mortality pattern.

Potential changes in selectivity due to the implementation of the 40mm square / 50mm diamond mesh size on trawlers based on EC 1967/2006 were not taken into account in the predictions.

Weight-at-age in the stock

Mean weight in stock (kg)	0	1	2	3	4	
2009	0.017	0.037	0.063	0.091	0.185	

Weight-at-age in the catch

Mean weight in catch (kg)	0	1	2	3	4	
2009	0.017	0.037	0.063	0.091	0.185	

Number at age in the catch

Catch at age in numbers (thousands)	0	1	2	3	4+	
2009	7231	8564	752	32	13	

Number at age in the stock

Stock at age in numbers (thousands)	0	1	2	3	4+	

2010	149660	22030	4111	161	27	

Stock recruitment

Recruitment (class 0+) has been estimated as the geometric mean from 2002 to 2009 (from XSA done in SGMED-10-02; this assessment consider catches from bottom trawl exclusively).

6.11.1.3. Results

A short term projection (Table below), assuming an F_{stq} of 1.08 in 2009 and a recruitment of 91200 (thousands) individuals, shows that:

- Fishing at the F_{stq} (1.08) from 2009 to 2011 would generate an increase of the catches of 35% in 2011, while the spawning stock biomass would increase by 11% between 2011 to 2012.
- Fishing at $F_{0.1}$ (0.74) from 2009 to 2011 generates a decrease of the catches of 7.3% in 2011 and a spawning stock biomass increase by 26% from 2011 to 2012.
- SGMED recommends that landings in 2011 should not exceed 689 t, corresponding to $F_{0.1}$= 0.74.

Outlook until 2012

Short term forecast for different F scenarios computed for red mullet in GSA 6.

Basis: F(2010) = mean(F_{bar}1-3 2009); R (2010) = GM (2002-2009) = 149660 (thousands); F (2010) = 1.08; SSB (2010) = 1002 t; landings (2010)= 702 t.

Rationale	F scenario	F factor	Catch 2011	Catch 2012	SSB 2012	Change SSB 2011-2012 (%)	Change Catch 2009-2011 (%)
zero catch	0.00	0.00	0	0	2588	74.5	-100.0
High long-term yield ($F_{0.1}$)	0.74	0.69	689	862	1862	25.6	-7.3
Status quo	1.08	1.00	909	1007	1645	10.9	35.5
Different scenarios	0.01	0.10	12	22	2575	73.6	-98.4
	0.22	0.20	236	378	2334	57.4	-68.2
	0.32	0.30	342	516	2222	49.8	-54.0
	0.43	0.40	439	631	2118	42.8	-40.9
	0.54	0.50	532	725	2024	36.5	-28.4
	0.65	0.60	617	803	1935	30.5	-17.0
	0.76	0.70	697	868	1855	25.1	-6.2
	0.86	0.80	773	922	1779	20.0	4.0
	0.97	0.90	844	969	1711	15.4	13.6
	1.19	1.10	972	1041	1586	6.9	30.8
	1.29	1.20	1030	1070	1528	3.0	38.6
	1.40	1.30	1088	1094	1476	-0.5	46.4
	1.51	1.40	1141	1117	1425	-3.9	53.6
	1.62	1.50	1191	1137	1379	-7.0	60.3

Data consistency

Fisheries dependent data refer only to bottom trawling although a small part of the total red mullet landings are obtained using trammel nets. No discards data were available.

6.12. Red mullet (*Mullus barbatus*) in GSA 7

6.12.1. Short term prediction 2010-2012

6.12.1.1. Method and justification

A deterministic short term prediction for 2010 to 2012 was performed using the EXCEL workbook provided by JRC IPSC (H.-J. Rätz) which takes into account the catch and landings in numbers and weight (no discards observed) and based on the results of pseudo-cohort 2009 stock assessment (LCA and Y/R; VIT software) presented at the Working group of SGMED 10-02.

6.12.1.1. Input parameters

The following data have been used to derive the input data for the short term projection of the red mullet stock in GSA 7:

Maturity and M vectors

PERIOD	Age	0	1	2	3	4+
2004-2009	Prop. Matures	0.00	0.17	0.61	0.89	0.98

PERIOD	Age	0	1	2	3	4+
2004-2009	M	0.64	0.43	0.27	0.18	0.14

F vector

F	0	1	2	3	4+
2009	0.16	0.69	0.88	0.85	0.53

Several scenarios with different harvest strategy were run, with F_{stq} (F_{bar} ages 0-4) equal to the F vector in 2009 (F_{stq} = 0.62). Potential changes in selectivity due to the implementation of the 40mm square / 50mm diamond mesh size on trawlers based on EC 1967/2006 were not taken into account in the predictions.

Weight-at-age in the stock

Mean weight in stock (kg)	0	1	2	3	4+
2009	0.0053	0.0279	0.0629	0.0988	0.1296

Weight-at-age in the catch

Mean weight in catch (kg)	0	1	2	3	4+
2009	0.0053	0.0279	0.0629	0.0988	0.1296

Number at age in the catch

Catch at age in numbers (thousands)	0	1	2	3	4+
2009	1149	1950	808	261	67

Number at age in the stock

Stock at age in numbers (thousands)	0	1	2	3	4+
2009	7230	2846	921	307	128
2010	11157	4722	1549	492	176

Stock recruitment

Recruitment (class 0+) has been estimated from the population results from the annual VIT (geometric mean of age 0+ of the 3 last years) and it corresponds to 11157 (thousands) individuals.

6.12.1.1. Results

A short term projection (Table below), assuming a F_{stq} of 0.62 in 2010 and a recruitment of 11157 (thousands) individuals, shows that:

- Fishing at the F_{stq} (0.62) generates an increase of the catch of 3% from 2009 to 2011 along with a slight increase of 3 % of the spawning stock biomass from 2011 to 2012.

- Fishing at $F_{0.1}$ (0.33) generates a decrease of the catch of 35 % from 2009 to 2011 and an increase of the spawning stock biomass of 30 % from 2011 to 2012.

- SGMED recommends that landings in 2011 should not exceed 95 t, corresponding to $F_{0.1}$= 0.33.

Outlook until 2012

Short term forecast for different F scenarios computed for red mullet in GSA 7.

Basis: F (2010) = mean (F_{bar}0-4 ; 2009); R (2010) = initial number from geometric mean of the last 3 years VIT; R = 11157 (thousands); F (2010) = 0.62 ; SSB(2011) = 368 t, Catch (2010)= 146 t

Rationale	F scenario	F factor	Catch 2011	Catch 2012	SSB 2012	Change SSB 2011-2012 (%)	Change Catch 2009-2011 (%)
zero catch	0.00	0.00	0	0	309	52	-100
High long-term yield ($F_{0.1}$)	0.33	0.54	95	122	211	30	-35
Status quo	0.62	1.00	150	153	152	3	3
Different scenarios	0.19	0.30	56	84	250	41	-62
	0.33	0.54	95	122	211	30	-35
	0.31	0.50	88	117	216	31	-40
	0.38	0.62	104	130	198	25	-29
	0.43	0.70	116	138	188	21	-21
	0.50	0.80	127	144	176	16	-13
	0.56	0.90	139	149	163	9	-5
	0.62	1.00	150	153	152	3	3
	0.68	1.10	159	156	143	-3	9
	0.74	1.20	170	158	133	-11	16
	0.80	1.30	178	157	124	-19	22
	0.87	1.40	186	157	116	-28	27
	0.93	1.50	194	157	110	-35	33

6.13. Red mullet (*Mullus barbatus*) in GSA 9

6.13.1. Short and medium term prediction applying a surplus production model

A short and medium term projections were performed with ASPIC-P.

6.13.1.1. Method and justification

ASPIC-P was used for producing Biomass and Relative Yield forecasts for 10 years forward assuming two alternative scenarios, namely the status-quo current F (0.73) and a reduction of F of about 14% in order to drive mortality rate to the F_{msy} value (0.64) . Data used as input are the results of the bootstrapped version of ASPIC non-equilibrium production model.

6.13.1.2. Input parameters

MODEL PARAMETER ESTIMATES

Parameter		Estimate	User/pgm guess	2nd guess	Estimated	User guess
B1/K	Starting relative biomass (in 1994)	1.198E-01	4.000E-01	5.604E-01	1	1
MSY	Maximum sustainable yield	2.553E+05	3.500E+05	3.200E+05	1	1
K	Maximum population size	7.960E+05	2.500E+06	8.654E+05	1	1
phi	Shape of production curve (Bmsy/K)	0.5000	0.5000	----	0	1

MANAGEMENT and DERIVED PARAMETER ESTIMATES

Parameter		Estimate	Logistic formula	General formula
MSY	Maximum sustainable yield	2.553E+05	----	----
Bmsy	Stock biomass giving MSY	3.980E+05	K/2	K*n**(1/(1-n))
Fmsy	Fishing mortality rate at MSY	6.413E-01	MSY/Bmsy	MSY/Bmsy
n	Exponent in production function	2.0000	----	----
g	Fletcher's gamma	4.000E+00	----	[n**(n/(n-1))]/[n-1]
B./Bmsy	Ratio: B(2010)/Bmsy	6.394E-01	----	----
F./Fmsy	Ratio: F(2009)/Fmsy	1.138E+00	----	----
Fmsy/F.	Ratio: Fmsy/F(2009)	8.687E-01	----	----

6.13.1.3. Results

While in the first case, (status quo situation) a further increase in B is expected, such increase will not reach the value of B_{msy}. With the 14 % reduction of F, the level of B_{msy} will be reached in about 6 years. Relative yields derived from a reduction in F will be still lower in the first years in the projection while will be higher in the last portion of the projected time interval.

Results from ASPICP.EXE, version 3.19
Short and medium forecast assuming a F kept at the current level. (F=0.73)

USER CONTROL INFORMATION (FROM INPUT FILE)

Control (CTL) file read was:	proj con current f.ctl
Biomass (BIO) file read was:	mba 2 fisheries 2009.bot.bio
Output file (this file) written was:	proj con current f.prj
Production-model type:	Logistic
Number of years of projections:	10
Type of confidence intervals:	Bias-corrected percentile
Confidence interval smoothing:	ON

Year	Input data	User data type

2010	1.000E+00	F/F(2009)
2011	1.000E+00	F/F(2009)
2012	1.000E+00	F/F(2009)
2013	1.000E+00	F/F(2009)
2014	1.000E+00	F/F(2009)
2015	1.000E+00	F/F(2009)
2016	1.000E+00	F/F(2009)
2017	1.000E+00	F/F(2009)
2018	1.000E+00	F/F(2009)
2019	1.000E+00	F/F(2009)

TRAJECTORY OF RELATIVE BIOMASS B/Bmsy (BOOTSTRAPPED)

Year	Point estimate	Estimated bias	Relative bias	Approx 80% lower CL	Approx 80% upper CL	Approx 50% lower CL	Approx 50% upper CL	Inter-quartile range	Relative IQ range
1994	2.396E-01	5.734E-03	2.39%	2.354E-01	2.452E-01	2.380E-01	2.402E-01	2.142E-03	0.009
1995	2.346E-01	5.204E-03	2.22%	2.309E-01	2.432E-01	2.335E-01	2.359E-01	2.368E-03	0.010
1996	2.691E-01	6.559E-03	2.44%	2.645E-01	2.823E-01	2.677E-01	2.707E-01	3.041E-03	0.011
1997	3.182E-01	9.161E-03	2.88%	3.132E-01	3.376E-01	3.165E-01	3.207E-01	4.148E-03	0.013
1998	3.913E-01	1.388E-02	3.55%	3.825E-01	4.088E-01	3.887E-01	3.937E-01	5.028E-03	0.013
1999	4.972E-01	2.056E-02	4.13%	4.846E-01	5.142E-01	4.929E-01	4.991E-01	6.170E-03	0.012
2000	5.554E-01	2.364E-02	4.26%	5.408E-01	5.760E-01	5.501E-01	5.575E-01	7.416E-03	0.013
2001	5.699E-01	2.355E-02	4.13%	5.538E-01	5.915E-01	5.648E-01	5.722E-01	7.368E-03	0.013
2002	5.303E-01	2.098E-02	3.96%	5.168E-01	5.480E-01	5.251E-01	5.320E-01	6.848E-03	0.013
2003	5.091E-01	2.006E-02	3.94%	4.962E-01	5.236E-01	5.041E-01	5.110E-01	6.941E-03	0.014
2004	5.080E-01	2.056E-02	4.05%	4.950E-01	5.225E-01	5.024E-01	5.103E-01	7.954E-03	0.016
2005	5.258E-01	2.213E-02	4.21%	5.131E-01	5.462E-01	5.188E-01	5.305E-01	1.166E-02	0.022
2006	5.306E-01	2.311E-02	4.36%	5.145E-01	5.508E-01	5.207E-01	5.363E-01	1.558E-02	0.029
2007	5.470E-01	2.470E-02	4.52%	5.222E-01	5.771E-01	5.325E-01	5.578E-01	2.530E-02	0.046
2008	5.149E-01	2.413E-02	4.69%	4.683E-01	5.571E-01	4.887E-01	5.287E-01	3.999E-02	0.078
2009	5.371E-01	2.540E-02	4.73%	4.467E-01	6.065E-01	4.869E-01	5.612E-01	7.422E-02	0.138
2010	6.394E-01	2.444E-02	3.82%	4.740E-01	7.479E-01	5.561E-01	6.806E-01	1.245E-01	0.195
2011	7.181E-01	2.052E-02	2.86%	5.005E-01	8.513E-01	6.152E-01	7.763E-01	1.611E-01	0.224
2012	7.729E-01	1.529E-02	1.98%	5.186E-01	9.216E-01	6.540E-01	8.387E-01	1.846E-01	0.239
2013	8.084E-01	1.055E-02	1.31%	5.322E-01	9.566E-01	6.809E-01	8.719E-01	1.910E-01	0.236
2014	8.303E-01	6.994E-03	0.84%	5.415E-01	9.792E-01	7.019E-01	8.948E-01	1.929E-01	0.232
2015	8.434E-01	4.596E-03	0.54%	5.480E-01	9.849E-01	7.107E-01	9.059E-01	1.952E-01	0.231
2016	8.512E-01	3.086E-03	0.36%	5.526E-01	9.915E-01	7.183E-01	9.128E-01	1.945E-01	0.228
2017	8.557E-01	2.176E-03	0.25%	5.545E-01	9.936E-01	7.232E-01	9.165E-01	1.933E-01	0.226
2018	8.583E-01	1.645E-03	0.19%	5.568E-01	9.934E-01	7.257E-01	9.165E-01	1.908E-01	0.222
2019	8.599E-01	1.344E-03	0.16%	5.584E-01	9.945E-01	7.276E-01	9.178E-01	1.901E-01	0.221
2020	8.607E-01	1.176E-03	0.14%	5.595E-01	9.950E-01	7.288E-01	9.185E-01	1.897E-01	0.220

NOTE: Confidence intervals are approximate.

Results from ASPICP.EXE, version 3.19
TRAJECTORY OF RELATIVE FISHING MORTALITY RATE F/Fmsy (BOOTSTRAPPED)

Year	Point estimate	Estimated bias	Relative bias	Approx 80% lower CL	Approx 80% upper CL	Approx 50% lower CL	Approx 50% upper CL	Inter-quartile range	Relative IQ range
1994	1.796E+00	-4.488E-03	-0.25%	1.772E+00	1.804E+00	1.790E+00	1.798E+00	7.554E-03	0.004
1995	1.535E+00	-4.027E-03	-0.26%	1.512E+00	1.550E+00	1.528E+00	1.541E+00	1.223E-02	0.008
1996	1.445E+00	-7.044E-03	-0.49%	1.416E+00	1.461E+00	1.437E+00	1.451E+00	1.373E-02	0.010
1997	1.323E+00	-1.144E-02	-0.87%	1.292E+00	1.337E+00	1.316E+00	1.328E+00	1.193E-02	0.009
1998	1.182E+00	-1.548E-02	-1.31%	1.154E+00	1.191E+00	1.178E+00	1.185E+00	7.053E-03	0.006
1999	1.300E+00	-2.012E-02	-1.55%	1.283E+00	1.312E+00	1.298E+00	1.305E+00	6.178E-03	0.005
2000	1.397E+00	-2.180E-02	-1.56%	1.383E+00	1.413E+00	1.395E+00	1.403E+00	8.307E-03	0.006
2001	1.564E+00	-2.279E-02	-1.46%	1.546E+00	1.580E+00	1.561E+00	1.570E+00	8.926E-03	0.006
2002	1.544E+00	-2.175E-02	-1.41%	1.529E+00	1.558E+00	1.542E+00	1.551E+00	8.814E-03	0.006
2003	1.495E+00	-2.166E-02	-1.45%	1.471E+00	1.507E+00	1.490E+00	1.502E+00	1.206E-02	0.008
2004	1.429E+00	-2.225E-02	-1.56%	1.404E+00	1.445E+00	1.422E+00	1.439E+00	1.682E-02	0.012
2005	1.458E+00	-2.428E-02	-1.67%	1.424E+00	1.486E+00	1.446E+00	1.472E+00	2.650E-02	0.018
2006	1.413E+00	-2.502E-02	-1.77%	1.371E+00	1.462E+00	1.399E+00	1.442E+00	4.252E-02	0.030
2007	1.564E+00	-2.743E-02	-1.75%	1.485E+00	1.672E+00	1.536E+00	1.623E+00	8.734E-02	0.056
2008	1.408E+00	-1.861E-02	-1.32%	1.293E+00	1.610E+00	1.361E+00	1.510E+00	1.489E-01	0.106
2009	1.138E+00	2.153E-02	1.89%	1.007E+00	1.438E+00	1.081E+00	1.269E+00	1.885E-01	0.166
2010	1.138E+00	2.153E-02	1.89%	1.007E+00	1.438E+00	1.081E+00	1.269E+00	1.885E-01	0.166
2011	1.138E+00	2.153E-02	1.89%	1.007E+00	1.438E+00	1.081E+00	1.269E+00	1.885E-01	0.166
2012	1.138E+00	2.153E-02	1.89%	1.007E+00	1.438E+00	1.081E+00	1.269E+00	1.885E-01	0.166
2013	1.138E+00	2.153E-02	1.89%	1.007E+00	1.438E+00	1.081E+00	1.269E+00	1.885E-01	0.166
2014	1.138E+00	2.153E-02	1.89%	1.007E+00	1.438E+00	1.081E+00	1.269E+00	1.885E-01	0.166
2015	1.138E+00	2.153E-02	1.89%	1.007E+00	1.438E+00	1.081E+00	1.269E+00	1.885E-01	0.166

2016	1.138E+00	2.153E-02	1.89%	1.007E+00	1.438E+00	1.081E+00	1.269E+00	1.885E-01	0.166
2017	1.138E+00	2.153E-02	1.89%	1.007E+00	1.438E+00	1.081E+00	1.269E+00	1.885E-01	0.166
2018	1.138E+00	2.153E-02	1.89%	1.007E+00	1.438E+00	1.081E+00	1.269E+00	1.885E-01	0.166
2019	1.138E+00	2.153E-02	1.89%	1.007E+00	1.438E+00	1.081E+00	1.269E+00	1.885E-01	0.166

TABLE OF PROJECTED YIELDS

2010	1.978E+05	-2.848E+03	-1.44%	1.875E+05	2.038E+05	1.935E+05	2.013E+05	7.847E+03	0.040
2011	2.171E+05	-5.302E+03	-2.44%	1.987E+05	2.258E+05	2.100E+05	2.227E+05	1.264E+04	0.058
2012	2.301E+05	-7.347E+03	-3.19%	2.081E+05	2.394E+05	2.230E+05	2.367E+05	1.371E+04	0.060
2013	2.383E+05	-8.836E+03	-3.71%	2.131E+05	2.471E+05	2.301E+05	2.445E+05	1.437E+04	0.060
2014	2.433E+05	-9.823E+03	-4.04%	2.180E+05	2.513E+05	2.352E+05	2.495E+05	1.425E+04	0.059
2015	2.462E+05	-1.044E+04	-4.24%	2.225E+05	2.543E+05	2.386E+05	2.520E+05	1.338E+04	0.054
2016	2.480E+05	-1.080E+04	-4.36%	2.246E+05	2.562E+05	2.407E+05	2.533E+05	1.265E+04	0.051
2017	2.490E+05	-1.101E+04	-4.42%	2.275E+05	2.573E+05	2.424E+05	2.542E+05	1.183E+04	0.048
2018	2.496E+05	-1.113E+04	-4.46%	2.308E+05	2.579E+05	2.433E+05	2.546E+05	1.129E+04	0.045
2019	2.499E+05	-1.120E+04	-4.48%	2.310E+05	2.582E+05	2.437E+05	2.548E+05	1.108E+04	0.044

NOTE: Confidence intervals are approximate.

TRAJECTORY OF ABSOLUTE BIOMASS (BOOTSTRAPPED)

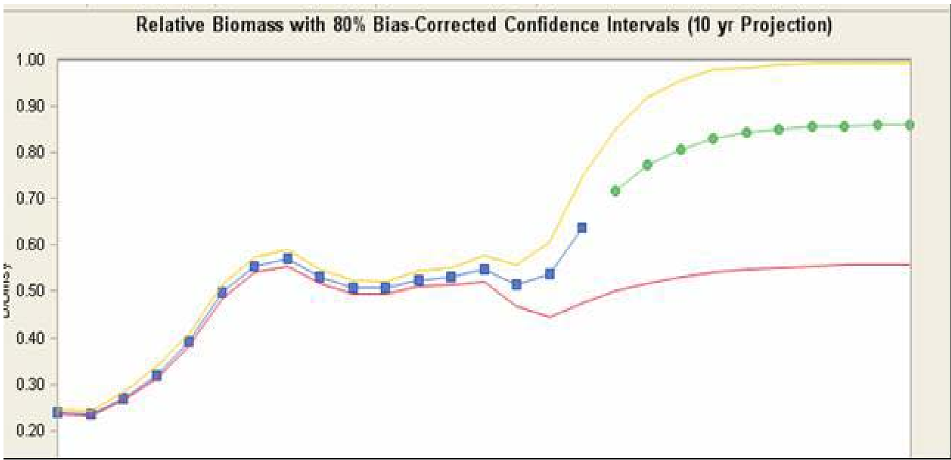
Year	Point estimate	Estimated bias	Relative bias	Approx 80% lower CL	Approx 80% upper CL	Approx 50% lower CL	Approx 50% upper CL	Inter-quartile range	Relative IQ range
1994	9.538E+04	-1.591E+03	-1.67%	9.164E+04	1.022E+05	9.467E+04	9.813E+04	3.453E+03	0.036
1995	9.339E+04	-1.649E+03	-1.77%	8.918E+04	1.009E+05	9.251E+04	9.639E+04	3.878E+03	0.042
1996	1.071E+05	-1.714E+03	-1.60%	1.021E+05	1.158E+05	1.059E+05	1.111E+05	5.261E+03	0.049
1997	1.267E+05	-1.632E+03	-1.29%	1.205E+05	1.370E+05	1.250E+05	1.309E+05	5.860E+03	0.046
1998	1.557E+05	-1.299E+03	-0.83%	1.486E+05	1.687E+05	1.538E+05	1.606E+05	6.764E+03	0.043
1999	1.979E+05	-8.904E+02	-0.45%	1.899E+05	2.113E+05	1.956E+05	2.030E+05	7.381E+03	0.037
2000	2.210E+05	-8.269E+02	-0.37%	2.128E+05	2.341E+05	2.185E+05	2.259E+05	7.409E+03	0.034
2001	2.268E+05	-1.048E+03	-0.46%	2.190E+05	2.401E+05	2.245E+05	2.318E+05	7.363E+03	0.032
2002	2.111E+05	-1.211E+03	-0.57%	2.031E+05	2.239E+05	2.087E+05	2.158E+05	7.123E+03	0.034
2003	2.026E+05	-1.154E+03	-0.57%	1.951E+05	2.156E+05	2.004E+05	2.078E+05	7.412E+03	0.037
2004	2.022E+05	-9.663E+02	-0.48%	1.948E+05	2.161E+05	2.000E+05	2.078E+05	7.791E+03	0.039
2005	2.093E+05	-7.199E+02	-0.34%	2.008E+05	2.233E+05	2.066E+05	2.152E+05	8.649E+03	0.041
2006	2.112E+05	-4.212E+02	-0.20%	2.011E+05	2.264E+05	2.075E+05	2.178E+05	1.030E+04	0.049
2007	2.177E+05	-6.886E+01	-0.03%	2.045E+05	2.355E+05	2.127E+05	2.259E+05	1.326E+04	0.061
2008	2.049E+05	4.223E+02	0.21%	1.847E+05	2.274E+05	1.959E+05	2.144E+05	1.853E+04	0.090
2009	2.138E+05	6.742E+02	0.32%	1.809E+05	2.464E+05	1.965E+05	2.282E+05	3.172E+04	0.148
2010	2.545E+05	-1.115E+03	-0.44%	2.011E+05	3.047E+05	2.297E+05	2.783E+05	4.856E+04	0.191
2011	2.858E+05	-3.501E+03	-1.22%	2.174E+05	3.486E+05	2.523E+05	3.139E+05	6.168E+04	0.216
2012	3.076E+05	-6.002E+03	-1.95%	2.306E+05	3.798E+05	2.726E+05	3.419E+05	6.930E+04	0.225
2013	3.217E+05	-8.086E+03	-2.51%	2.411E+05	3.970E+05	2.866E+05	3.594E+05	7.285E+04	0.226
2014	3.305E+05	-9.591E+03	-2.90%	2.486E+05	4.064E+05	2.957E+05	3.694E+05	7.371E+04	0.223
2015	3.357E+05	-1.058E+04	-3.15%	2.560E+05	4.153E+05	3.038E+05	3.795E+05	7.570E+04	0.226
2016	3.388E+05	-1.120E+04	-3.31%	2.589E+05	4.192E+05	3.070E+05	3.826E+05	7.563E+04	0.223
2017	3.406E+05	-1.156E+04	-3.40%	2.605E+05	4.214E+05	3.075E+05	3.832E+05	7.564E+04	0.222
2018	3.416E+05	-1.178E+04	-3.45%	2.616E+05	4.228E+05	3.087E+05	3.841E+05	7.542E+04	0.221
2019	3.422E+05	-1.190E+04	-3.48%	2.617E+05	4.235E+05	3.094E+05	3.846E+05	7.524E+04	0.220
2020	3.426E+05	-1.196E+04	-3.49%	2.623E+05	4.240E+05	3.100E+05	3.862E+05	7.621E+04	0.222

NOTE: Confidence intervals are approximate.

TRAJECTORY OF ABSOLUTE FISHING MORTALITY RATE (BOOTSTRAPPED)

Year	Point estimate	Estimated bias	Relative bias	Approx 80% lower CL	Approx 80% upper CL	Approx 50% lower CL	Approx 50% upper CL	Inter-quartile range	Relative IQ range
1994	1.152E+00	2.776E-02	2.41%	1.070E+00	1.203E+00	1.118E+00	1.162E+00	4.400E-02	0.038
1995	9.843E-01	2.393E-02	2.43%	9.093E-01	1.031E+00	9.518E-01	9.938E-01	4.192E-02	0.043
1996	9.265E-01	2.017E-02	2.18%	8.564E-01	9.711E-01	8.938E-01	9.359E-01	4.214E-02	0.045
1997	8.483E-01	1.465E-02	1.73%	7.835E-01	8.911E-01	8.231E-01	8.597E-01	3.660E-02	0.043
1998	7.580E-01	8.792E-03	1.16%	7.063E-01	7.914E-01	7.374E-01	7.677E-01	3.026E-02	0.040
1999	8.339E-01	6.987E-03	0.84%	7.855E-01	8.678E-01	8.154E-01	8.446E-01	2.918E-02	0.035
2000	8.957E-01	7.182E-03	0.80%	8.452E-01	9.288E-01	8.765E-01	9.054E-01	2.886E-02	0.032
2001	1.003E+00	9.306E-03	0.93%	9.469E-01	1.041E+00	9.819E-01	1.016E+00	3.427E-02	0.034
2002	9.905E-01	9.930E-03	1.00%	9.320E-01	1.029E+00	9.676E-01	1.001E+00	3.380E-02	0.034
2003	9.587E-01	9.279E-03	0.97%	8.932E-01	9.949E-01	9.325E-01	9.687E-01	3.620E-02	0.038
2004	9.165E-01	7.768E-03	0.85%	8.583E-01	9.523E-01	8.914E-01	9.285E-01	3.704E-02	0.040
2005	9.348E-01	6.830E-03	0.73%	8.753E-01	9.789E-01	9.089E-01	9.502E-01	4.133E-02	0.044
2006	9.063E-01	5.635E-03	0.62%	8.383E-01	9.579E-01	8.755E-01	9.246E-01	4.910E-02	0.054

2007	1.003E+00	6.812E-03	0.68%	9.140E-01	1.088E+00	9.656E-01	1.040E+00	7.409E-02	0.074
2008	9.029E-01	1.072E-02	1.19%	8.027E-01	1.033E+00	8.552E-01	9.677E-01	1.125E-01	0.125
2009	7.299E-01	3.335E-02	4.57%	6.212E-01	9.026E-01	6.757E-01	8.066E-01	1.309E-01	0.179
2010	7.299E-01	3.335E-02	4.57%	6.212E-01	9.026E-01	6.757E-01	8.066E-01	1.309E-01	0.179
2011	7.299E-01	3.335E-02	4.57%	6.212E-01	9.026E-01	6.757E-01	8.066E-01	1.309E-01	0.179
2012	7.299E-01	3.335E-02	4.57%	6.212E-01	9.026E-01	6.757E-01	8.066E-01	1.309E-01	0.179
2013	7.299E-01	3.335E-02	4.57%	6.212E-01	9.026E-01	6.757E-01	8.066E-01	1.309E-01	0.179
2014	7.299E-01	3.335E-02	4.57%	6.212E-01	9.026E-01	6.757E-01	8.066E-01	1.309E-01	0.179
2015	7.299E-01	3.335E-02	4.57%	6.212E-01	9.026E-01	6.757E-01	8.066E-01	1.309E-01	0.179
2016	7.299E-01	3.335E-02	4.57%	6.212E-01	9.026E-01	6.757E-01	8.066E-01	1.309E-01	0.179
2017	7.299E-01	3.335E-02	4.57%	6.212E-01	9.026E-01	6.757E-01	8.066E-01	1.309E-01	0.179
2018	7.299E-01	3.335E-02	4.57%	6.212E-01	9.026E-01	6.757E-01	8.066E-01	1.309E-01	0.179
2019	7.299E-01	3.335E-02	4.57%	6.212E-01	9.026E-01	6.757E-01	8.066E-01	1.309E-01	0.179



Time Plot of B/Bmsy with Bias-Corrected (BC) 80% Confidence Interval (Dashed reference line is 1.0)

Results from ASPICP.EXE, version 3.19

Short and medium forecast assuming a reduction of F at the levels of F corresponding to MSY F_{msy}=0.64

USER CONTROL INFORMATION (FROM INPUT FILE)

Control (CTL) file read was:	proj con fmsy.ctl
Biomass (BIO) file read was:	mba 2 fisheries 2009.bot.bio
Output file (this file) written was:	proj con fmsy.prj
Production-model type:	Logistic
Number of years of projections:	10
Type of confidence intervals:	Bias-corrected percentile
Confidence interval smoothing:	ON

Year	Input data	User data type
2010	8.700E-01	F/F(2009)
2011	8.700E-01	F/F(2009)
2012	8.700E-01	F/F(2009)
2013	8.700E-01	F/F(2009)
2014	8.700E-01	F/F(2009)
2015	8.700E-01	F/F(2009)
2016	8.700E-01	F/F(2009)
2017	8.700E-01	F/F(2009)
2018	8.700E-01	F/F(2009)
2019	8.700E-01	F/F(2009)

TRAJECTORY OF RELATIVE BIOMASS B/Bmsy (BOOTSTRAPPED)

Year	Point estimate	Estimated bias	Relative bias	Approx 80% lower CL	Approx 80% upper CL	Approx 50% lower CL	Approx 50% upper CL	Inter-quartile range	Relative IQ range

1994	2.396E-01	5.734E-03	2.39%	2.354E-01	2.452E-01	2.380E-01	2.402E-01	2.142E-03	0.009
1995	2.346E-01	5.204E-03	2.22%	2.309E-01	2.432E-01	2.335E-01	2.359E-01	2.368E-03	0.010
1996	2.691E-01	6.559E-03	2.44%	2.645E-01	2.823E-01	2.677E-01	2.707E-01	3.041E-03	0.011
1997	3.182E-01	9.161E-03	2.88%	3.132E-01	3.376E-01	3.165E-01	3.207E-01	4.148E-03	0.013
1998	3.913E-01	1.388E-02	3.55%	3.825E-01	4.088E-01	3.887E-01	3.937E-01	5.028E-03	0.013
1999	4.972E-01	2.056E-02	4.13%	4.846E-01	5.142E-01	4.929E-01	4.991E-01	6.170E-03	0.012
2000	5.554E-01	2.364E-02	4.26%	5.408E-01	5.760E-01	5.501E-01	5.575E-01	7.416E-03	0.013
2001	5.699E-01	2.355E-02	4.13%	5.538E-01	5.915E-01	5.648E-01	5.722E-01	7.368E-03	0.013
2002	5.303E-01	2.098E-02	3.96%	5.168E-01	5.480E-01	5.251E-01	5.320E-01	6.848E-03	0.013
2003	5.091E-01	2.006E-02	3.94%	4.962E-01	5.236E-01	5.041E-01	5.110E-01	6.941E-03	0.014
2004	5.080E-01	2.056E-02	4.05%	4.950E-01	5.225E-01	5.024E-01	5.103E-01	7.954E-03	0.016
2005	5.258E-01	2.213E-02	4.21%	5.131E-01	5.462E-01	5.188E-01	5.305E-01	1.166E-02	0.022
2006	5.306E-01	2.311E-02	4.36%	5.145E-01	5.508E-01	5.207E-01	5.363E-01	1.558E-02	0.029
2007	5.470E-01	2.470E-02	4.52%	5.222E-01	5.771E-01	5.325E-01	5.578E-01	2.530E-02	0.046
2008	5.149E-01	2.413E-02	4.69%	4.683E-01	5.571E-01	4.887E-01	5.287E-01	3.999E-02	0.078
2009	5.371E-01	2.540E-02	4.73%	4.467E-01	6.065E-01	4.869E-01	5.612E-01	7.422E-02	0.138
2010	6.394E-01	2.444E-02	3.82%	4.740E-01	7.479E-01	5.561E-01	6.806E-01	1.245E-01	0.195
2011	7.749E-01	2.106E-02	2.72%	5.518E-01	9.043E-01	6.658E-01	8.287E-01	1.630E-01	0.210
2012	8.716E-01	1.430E-02	1.64%	6.142E-01	1.010E+00	7.539E-01	9.319E-01	1.779E-01	0.204
2013	9.325E-01	8.168E-03	0.88%	6.615E-01	1.075E+00	8.119E-01	9.951E-01	1.832E-01	0.196
2014	9.678E-01	4.049E-03	0.42%	6.937E-01	1.106E+00	8.509E-01	1.028E+00	1.774E-01	0.183
2015	9.874E-01	1.699E-03	0.17%	7.138E-01	1.119E+00	8.699E-01	1.045E+00	1.746E-01	0.177
2016	9.980E-01	5.008E-04	0.05%	7.276E-01	1.121E+00	8.795E-01	1.052E+00	1.727E-01	0.173
2017	1.004E+00	-5.049E-05	-0.01%	7.350E-01	1.124E+00	8.864E-01	1.057E+00	1.703E-01	0.170
2018	1.007E+00	-2.714E-04	-0.03%	7.403E-01	1.124E+00	8.905E-01	1.057E+00	1.668E-01	0.166
2019	1.008E+00	-3.373E-04	-0.03%	7.436E-01	1.125E+00	8.928E-01	1.059E+00	1.657E-01	0.164
2020	1.009E+00	-3.377E-04	-0.03%	7.457E-01	1.126E+00	8.941E-01	1.059E+00	1.651E-01	0.164

NOTE: Confidence intervals are approximate.
At least 500 to 1000 trials are recommended when estimating confidence intervals.

TRAJECTORY OF RELATIVE FISHING MORTALITY RATE F/Fmsy (BOOTSTRAPPED)

Year	Point estimate	Estimated bias	Relative bias	Approx 80% lower CL	Approx 80% upper CL	Approx 50% lower CL	Approx 50% upper CL	quartile range	Relative IQ range
1994	1.796E+00	-4.488E-03	-0.25%	1.772E+00	1.804E+00	1.790E+00	1.798E+00	7.554E-03	0.004
1995	1.535E+00	-4.027E-03	-0.26%	1.512E+00	1.550E+00	1.528E+00	1.541E+00	1.223E-02	0.008
1996	1.445E+00	-7.044E-03	-0.49%	1.416E+00	1.461E+00	1.437E+00	1.451E+00	1.373E-02	0.010
1997	1.323E+00	-1.144E-02	-0.87%	1.292E+00	1.337E+00	1.316E+00	1.328E+00	1.193E-02	0.009
1998	1.182E+00	-1.548E-02	-1.31%	1.154E+00	1.191E+00	1.178E+00	1.185E+00	7.053E-03	0.006
1999	1.300E+00	-2.012E-02	-1.55%	1.283E+00	1.312E+00	1.298E+00	1.305E+00	6.178E-03	0.005
2000	1.397E+00	-2.180E-02	-1.56%	1.383E+00	1.413E+00	1.395E+00	1.403E+00	8.307E-03	0.006
2001	1.564E+00	-2.279E-02	-1.46%	1.546E+00	1.580E+00	1.561E+00	1.570E+00	8.926E-03	0.006
2002	1.544E+00	-2.175E-02	-1.41%	1.529E+00	1.558E+00	1.542E+00	1.551E+00	8.814E-03	0.006
2003	1.495E+00	-2.166E-02	-1.45%	1.471E+00	1.507E+00	1.490E+00	1.502E+00	1.206E-02	0.008
2004	1.429E+00	-2.225E-02	-1.56%	1.404E+00	1.445E+00	1.422E+00	1.439E+00	1.682E-02	0.012
2005	1.458E+00	-2.428E-02	-1.67%	1.424E+00	1.486E+00	1.446E+00	1.472E+00	2.650E-02	0.018
2006	1.413E+00	-2.502E-02	-1.77%	1.371E+00	1.462E+00	1.399E+00	1.442E+00	4.252E-02	0.030
2007	1.564E+00	-2.743E-02	-1.75%	1.485E+00	1.672E+00	1.536E+00	1.623E+00	8.734E-02	0.056
2008	1.408E+00	-1.861E-02	-1.32%	1.293E+00	1.610E+00	1.361E+00	1.510E+00	1.489E-01	0.106
2009	1.138E+00	2.153E-02	1.89%	1.007E+00	1.438E+00	1.081E+00	1.269E+00	1.885E-01	0.166
2010	1.0001E-00	1.873E-02	1.89%	8.758E-01	1.251E+00	9.401E-01	1.104E+00	1.640E-01	0.166
2011	1.000E-00	1.873E-02	1.89%	8.758E-01	1.251E+00	9.401E-01	1.104E+00	1.640E-01	0.166
2012	1.000E-00	1.873E-02	1.89%	8.758E-01	1.251E+00	9.401E-01	1.104E+00	1.640E-01	0.166
2013	1.000E-00	1.873E-02	1.89%	8.758E-01	1.251E+00	9.401E-01	1.104E+00	1.640E-01	0.166
2014	1.000E-00	1.873E-02	1.89%	8.758E-01	1.251E+00	9.401E-01	1.104E+00	1.640E-01	0.166
2015	1.000E-00	1.873E-02	1.89%	8.758E-01	1.251E+00	9.401E-01	1.104E+00	1.640E-01	0.166
2016	1.000E-00	1.873E-02	1.89%	8.758E-01	1.251E+00	9.401E-01	1.104E+00	1.640E-01	0.166
2017	1.000E-00	1.873E-02	1.89%	8.758E-01	1.251E+00	9.401E-01	1.104E+00	1.640E-01	0.166
2018	1.000E-00	1.873E-02	1.89%	8.758E-01	1.251E+00	9.401E-01	1.104E+00	1.640E-01	0.166
2019	1.000E-00	1.873E-02	1.89%	8.758E-01	1.251E+00	9.401E-01	1.104E+00	1.640E-01	0.166

TABLE OF PROJECTED YIELDS

2010	1.795E+05	-2.515E+03	-1.40%	1.719E+05	1.837E+05	1.769E+05	1.823E+05	5.460E+03	0.030
2011	2.089E+05	-5.025E+03	-2.41%	1.987E+05	2.141E+05	2.059E+05	2.124E+05	6.464E+03	0.031
2012	2.286E+05	-7.199E+03	-3.15%	2.206E+05	2.338E+05	2.263E+05	2.312E+05	4.897E+03	0.021

2013	2.406E+05	-8.653E+03	-3.60%	2.368E+05	2.478E+05	2.402E+05	2.445E+05	4.320E+03	0.018
2014	2.473E+05	-9.470E+03	-3.83%	2.456E+05	2.580E+05	2.475E+05	2.523E+05	4.805E+03	0.019
2015	2.510E+05	-9.873E+03	-3.93%	2.502E+05	2.632E+05	2.514E+05	2.624E+05	1.098E+04	0.044
2016	2.530E+05	-1.005E+04	-3.97%	2.523E+05	2.673E+05	2.534E+05	2.648E+05	1.132E+04	0.045
2017	2.541E+05	-1.011E+04	-3.98%	2.535E+05	2.698E+05	2.547E+05	2.668E+05	1.207E+04	0.048
2018	2.546E+05	-1.012E+04	-3.97%	2.541E+05	2.713E+05	2.552E+05	2.675E+05	1.229E+04	0.048
2019	2.549E+05	-1.011E+04	-3.96%	2.544E+05	2.722E+05	2.556E+05	2.679E+05	1.235E+04	0.048

NOTE: Confidence intervals are approximate.
At least 500 to 1000 trials are recommended when estimating confidence intervals.

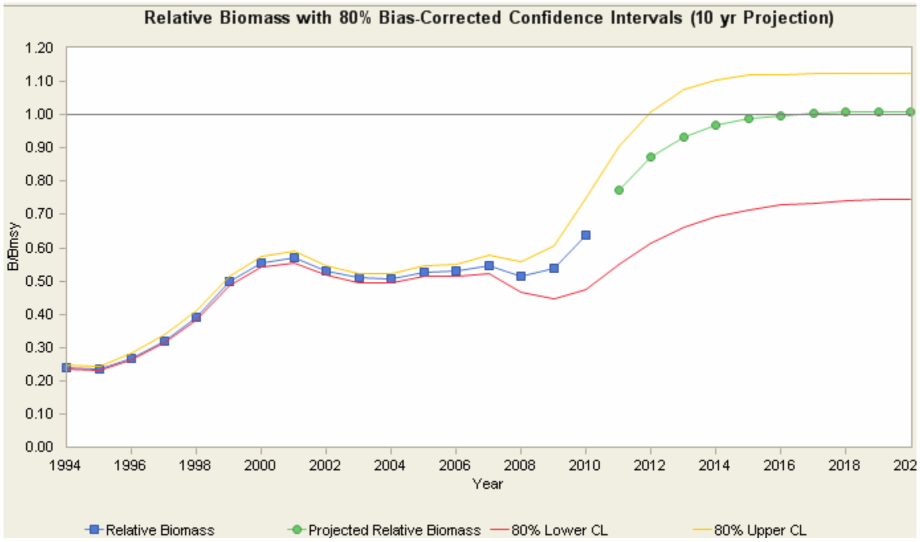
TRAJECTORY OF ABSOLUTE BIOMASS (BOOTSTRAPPED)

Year	Point estimate	Estimated bias	Relative bias	Approx 80% ower CL	Approx 80% upper CL	Approx 50% lower CL	Approx 50% upper CL	Inter-quartile range	Relative IQ range
1994	9.538E+04	-1.591E+03	-1.67%	9.164E+04	1.022E+05	9.467E+04	9.813E+04	3.453E+03	0.036
1995	9.339E+04	-1.649E+03	-1.77%	8.918E+04	1.009E+05	9.251E+04	9.639E+04	3.878E+03	0.042
1996	1.071E+05	-1.714E+03	-1.60%	1.021E+05	1.158E+05	1.059E+05	1.111E+05	5.261E+03	0.049
1997	1.267E+05	-1.632E+03	-1.29%	1.205E+05	1.370E+05	1.250E+05	1.309E+05	5.860E+03	0.046
1998	1.557E+05	-1.299E+03	-0.83%	1.486E+05	1.687E+05	1.538E+05	1.606E+05	6.764E+03	0.043
1999	1.979E+05	-8.904E+02	-0.45%	1.899E+05	2.113E+05	1.956E+05	2.030E+05	7.381E+03	0.037
2000	2.210E+05	-8.269E+02	-0.37%	2.128E+05	2.341E+05	2.185E+05	2.259E+05	7.409E+03	0.034
2001	2.268E+05	-1.048E+03	-0.46%	2.190E+05	2.401E+05	2.245E+05	2.318E+05	7.363E+03	0.032
2002	2.111E+05	-1.211E+03	-0.57%	2.031E+05	2.239E+05	2.087E+05	2.158E+05	7.123E+03	0.034
2003	2.026E+05	-1.154E+03	-0.57%	1.951E+05	2.156E+05	2.004E+05	2.078E+05	7.412E+03	0.037
2004	2.022E+05	-9.663E+02	-0.48%	1.948E+05	2.161E+05	2.000E+05	2.078E+05	7.791E+03	0.039
2005	2.093E+05	-7.199E+02	-0.34%	2.008E+05	2.233E+05	2.066E+05	2.152E+05	8.649E+03	0.041
2006	2.112E+05	-4.212E+02	-0.20%	2.011E+05	2.264E+05	2.075E+05	2.178E+05	1.030E+04	0.049
2007	2.177E+05	-6.886E+01	-0.03%	2.045E+05	2.355E+05	2.127E+05	2.259E+05	1.326E+04	0.061
2008	2.049E+05	4.223E+02	0.21%	1.847E+05	2.274E+05	1.959E+05	2.144E+05	1.853E+04	0.090
2009	2.138E+05	6.742E+02	0.32%	1.809E+05	2.464E+05	1.965E+05	2.282E+05	3.172E+04	0.148
2010	2.545E+05	-1.115E+03	-0.44%	2.011E+05	3.047E+05	2.297E+05	2.783E+05	4.856E+04	0.191
2011	3.084E+05	-4.225E+03	-1.37%	2.398E+05	3.731E+05	2.766E+05	3.374E+05	6.083E+04	0.197
2012	3.469E+05	-7.845E+03	-2.26%	2.725E+05	4.186E+05	3.151E+05	3.829E+05	6.787E+04	0.196
2013	3.711E+05	-1.072E+04	-2.89%	2.945E+05	4.464E+05	3.396E+05	4.114E+05	7.179E+04	0.193
2014	3.852E+05	-1.254E+04	-3.26%	3.073E+05	4.611E+05	3.534E+05	4.269E+05	7.351E+04	0.191
2015	3.930E+05	-1.356E+04	-3.45%	3.149E+05	4.661E+05	3.597E+05	4.330E+05	7.335E+04	0.187
2016	3.972E+05	-1.406E+04	-3.54%	3.218E+05	4.710E+05	3.652E+05	4.372E+05	7.200E+04	0.181
2017	3.994E+05	-1.430E+04	-3.58%	3.246E+05	4.735E+05	3.682E+05	4.404E+05	7.219E+04	0.181
2018	4.006E+05	-1.439E+04	-3.59%	3.278E+05	4.745E+05	3.699E+05	4.420E+05	7.211E+04	0.180
2019	4.013E+05	-1.441E+04	-3.59%	3.263E+05	4.750E+05	3.702E+05	4.420E+05	7.185E+04	0.179
2020	4.016E+05	-1.441E+04	-3.59%	3.265E+05	4.753E+05	3.706E+05	4.423E+05	7.173E+04	0.179

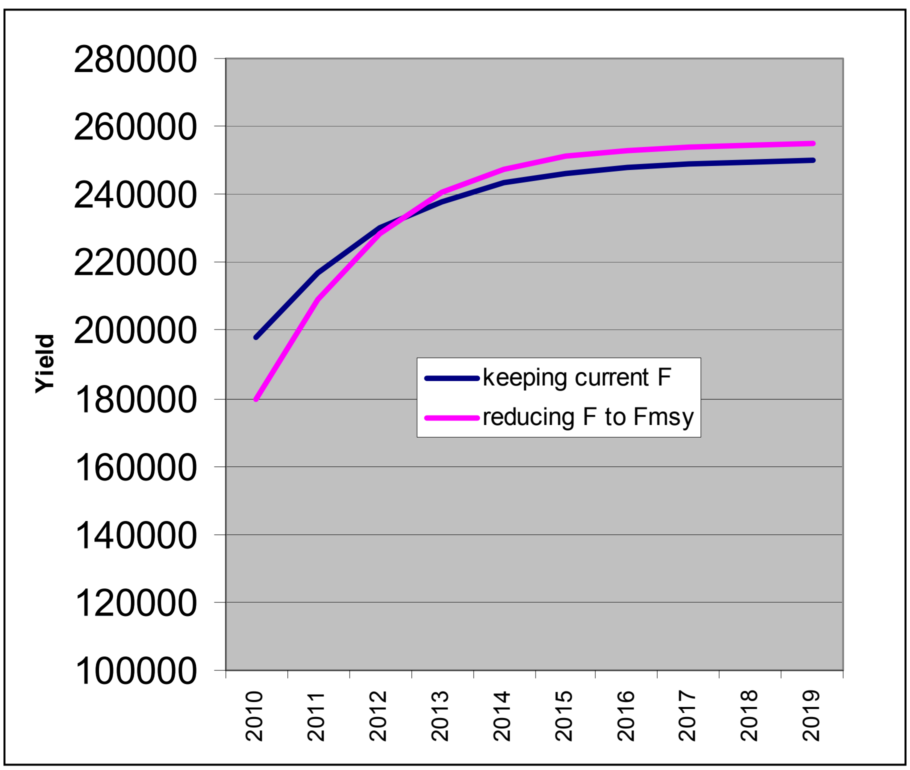
TRAJECTORY OF ABSOLUTE FISHING MORTALITY RATE (BOOTSTRAPPED)

Year	Point estimate	Estimated bias	Relative bias	Approx 80% lower CL	Approx 80% upper CL	Approx 50% lower CL	Approx 50% upper CL	Inter-quartile range	Relative IQ range
1994	1.152E+00	2.776E-02	2.41%	1.070E+00	1.203E+00	1.118E+00	1.162E+00	4.400E-02	0.038
1995	9.843E-01	2.393E-02	2.43%	9.093E-01	1.031E+00	9.518E-01	9.938E-01	4.192E-02	0.043
1996	9.265E-01	2.017E-02	2.18%	8.564E-01	9.711E-01	8.938E-01	9.359E-01	4.214E-02	0.045
1997	8.483E-01	1.465E-02	1.73%	7.835E-01	8.911E-01	8.231E-01	8.597E-01	3.660E-02	0.043
1998	7.580E-01	8.792E-03	1.16%	7.063E-01	7.914E-01	7.374E-01	7.677E-01	3.026E-02	0.040
1999	8.339E-01	6.987E-03	0.84%	7.855E-01	8.678E-01	8.154E-01	8.446E-01	2.918E-02	0.035
2000	8.957E-01	7.182E-03	0.80%	8.452E-01	9.288E-01	8.765E-01	9.054E-01	2.886E-02	0.032
2001	1.003E+00	9.306E-03	0.93%	9.469E-01	1.041E+00	9.819E-01	1.016E+00	3.427E-02	0.034
2002	9.905E-01	9.930E-03	1.00%	9.320E-01	1.029E+00	9.676E-01	1.001E+00	3.380E-02	0.034
2003	9.587E-01	9.279E-03	0.97%	8.932E-01	9.949E-01	9.325E-01	9.687E-01	3.620E-02	0.038
2004	9.165E-01	7.768E-03	0.85%	8.583E-01	9.523E-01	8.914E-01	9.285E-01	3.704E-02	0.040
2005	9.348E-01	6.830E-03	0.73%	8.753E-01	9.789E-01	9.089E-01	9.502E-01	4.133E-02	0.044
2006	9.063E-01	5.635E-03	0.62%	8.383E-01	9.579E-01	8.755E-01	9.246E-01	4.910E-02	0.054
2007	1.003E+00	6.812E-03	0.68%	9.140E-01	1.088E+00	9.656E-01	1.040E+00	7.409E-02	0.074
2008	9.029E-01	1.072E-02	1.19%	8.027E-01	1.033E+00	8.552E-01	9.677E-01	1.125E-01	0.125
2009	7.299E-01	3.335E-02	4.57%	6.212E-01	9.026E-01	6.757E-01	8.066E-01	1.309E-01	0.179
2010	6.300E-01	2.901E-02	4.57%	5.405E-01	7.852E-01	5.879E-01	7.018E-01	1.139E-01	0.179
2011	6.300E-01	2.901E-02	4.57%	5.405E-01	7.852E-01	5.879E-01	7.018E-01	1.139E-01	0.179
2012	6.300E-01	2.901E-02	4.57%	5.405E-01	7.852E-01	5.879E-01	7.018E-01	1.139E-01	0.179
2013	6.300E-01	2.901E-02	4.57%	5.405E-01	7.852E-01	5.879E-01	7.018E-01	1.139E-01	0.179
2014	6.300E-01	2.901E-02	4.57%	5.405E-01	7.852E-01	5.879E-01	7.018E-01	1.139E-01	0.179
2015	6.300E-01	2.901E-02	4.57%	5.405E-01	7.852E-01	5.879E-01	7.018E-01	1.139E-01	0.179
2016	6.300E-01	2.901E-02	4.57%	5.405E-01	7.852E-01	5.879E-01	7.018E-01	1.139E-01	0.179
2017	6.300E-01	2.901E-02	4.57%	5.405E-01	7.852E-01	5.879E-01	7.018E-01	1.139E-01	0.179

2018	6.300E-01	2.901E-02	4.57%	5.405E-01	7.852E-01	5.879E-01	7.018E-01	1.139E-01	0.179
2019	6.300E-01	2.901E-02	4.57%	5.405E-01	7.852E-01	5.879E-01	7.018E-01	1.139E-01	0.179



Time Plot of B/Bmsy with Bias-Corrected (BC) 80% Confidence Interval (Dashed reference line is 1.0)



Expected relative yields (in kg) obtained by keeping F at the current level or by reducing F of 14 % in order to reach the F_{msy} value

6.13.2. Short term prediction 2010-2012

6.13.2.1. Method and justification

Short term prediction for 2009 and 2010 were implemented in R (www.r-project.org) using the FLR libraries and based on the results of Length Cohort Analysis (LCA) carried out on 2009 catch data collected under DCR.

6.13.2.2. Input parameters

The following data have been used to derive the input data for the short term projection of red mullet in GSA 9:

Maturity and M vectors

PERIOD	Age	0	1	2	3	4
2006-2008	Prop. Matures	0.0	1.0	1.0	1.0	1.0

PERIOD	Age	0	1	2	3	4
2006-2008	M	1.30	0.79	0.62	0.54	0.40

F vector

F	0	1	2	3	4
2006	0.08	1.00	0.68	0.26	0.10
2007	0.15	2.14	1.40	0.23	0.10
2008	0.27	1.67	0.22	0.11	0.10
2009	0.13	1.41	0.66	0.24	0.10

Potential changes in selectivity due to the implementation of the 40mm square / 50mm diamond mesh size on trawlers based on EC 1967/2006 were not taken into account in the predictions.

Weight-at-age in the stock

Mean weight in stock (kg)	0	1	2	3	4
2006	0.004	0.041	0.095	0.134	0.188
2007	0.004	0.037	0.092	0.134	0.188
2008	0.004	0.038	0.096	0.134	0.188
2009	0.004	0.039	0.095	0.134	0.188

Weight-at-age in the catch

Mean weight in catch (kg)	0	1	2	3	4
2006	0.004	0.041	0.095	0.134	0.156
2007	0.004	0.037	0.092	0.134	0.156
2008	0.004	0.038	0.096	0.134	0.156
2009	0.004	0.039	0.095	0.134	0.156

Number at age in the catch

Catch at age in numbers	0	1	2	3	4
2006	5902406	18364587	3033915	465905	101230
2007	7084978	15913524	927790	40940	10220
2008	15935120	16979930	452647	126034	68859
2009	4775584	10430274	944309	143356	33525

Number at age in the stock

Stock numbers	0	1	2	3	4

at age					
2006	1.42E+08	40191521	7657180	2492521	1289336
2007	94825943	25022118	1536341	244191	130168
2008	1.24E+08	29003043	2837482	1462319	877034
2009	71420054	19155589	2439737	812103	426999

Maturity was estimated as the mean of the last 3 years. M was calculated using the ProBiom method, weight at age is the average of the last three years, F vector and number at age are those estimated in 2009.

6.13.2.3. Results

A short term projection (Table below), assuming an F_{stq} of 0.51 ($F_{1\text{-}5}$) in 2010 and a recruitment of 94 millions individuals, shows that:

- Fishing at the F_{stq} from year 2009 to 2011 generates an increase in catch of 11.5% and an increase in SSB of 3.9%.
- Fishing at $F_{0.1}$ (0.40) generates a reduction of catch of 3.9% from 2009 to 2011 and an increasing of spawning stock biomass of 13.6% between 2011 and 2012.

SGMED reccomends that catches in 2011 should not exceed 521 tons, corresponding to $F_{0.1}$.

Outlook until 2012

Short term forecast for different F scenarios computed for red mullet in GSA 9.

Basis: F (2009) = mean (F_{bar}2007–2009); R (2009) = GM (2007–2009) = 94 (millions); F (2009) = 0.51; SSB (2011) = 1247 t; Catch (2010) = 495 t

Rationale	**F scenario**	**F factor**	**Catch 2011**	**Catch 2012**	**SSB 2012**	**Change SSB 2011-2012 (%)**	**Change Catch 2009-2011 (%)**
Zero catch	0.00	0.00	0.0	0.0	2234	79.0	-100.0
High long term yield ($F_{0.1}$)	0.40	0.79	521.5	577	1417	13.6	-3.9
Status quo	0.51	1.00	605.1	625	1296	3.9	11.5
Different scenarios	0.05	0.10	92.4	135	2083	67.0	-83.0
	0.10	0.20	175.3	244	1950	56.3	-67.7
	0.15	0.30	249.8	333	1832	46.8	-54.0
	0.20	0.40	316.9	405	1727	38.4	-41.6
	0.25	0.50	377.4	464	1634	31.0	-30.5
	0.30	0.60	432.1	511	1551	24.3	-20.4
	0.36	0.70	481.7	550	1476	18.3	-11.3
	0.41	0.80	526.7	580	1410	13.0	-3.0
	0.46	0.90	568	605	1350	8.2	4.6
	0.56	1.10	639	641	1248	0.0	17.8
	0.61	1.20	671	653	1203	-3.5	23.6
	0.66	1.30	699	663	1163	-6.7	28.9
	0.71	1.40	726	670	1127	-9.7	33.8
	0.76	1.50	751	675	1093	-12.4	38.3
	0.81	1.60	773	679	1062	-14.8	42.5

	0.86	1.70	795	682	1034	-17.1	46.4
	0.91	1.80	814	684	1008	-19.2	50.0
	0.96	1.90	833	685	983	-21.2	53.4
	1.02	2.00	850	685	961	-23.0	56.6

The catch forecast for 2009 was 2070 tons whereas a total catch of 542 tons was obtained. Such difference might be explained with a too optimistic recruitment figure used for the forecast (164 millions against 71 million estimated by LCA in 2009). There were no special problems regarding the data quality and availability.

6.13.3. Final comments on the consistency of both approaches

The perception of the exploitation status and the need of a relatively modest reduction of fishing mortality to drive F to F_{msy} (13.8 and 21% for the biomass dynamic model and LCA, respectively) are very close. The absolute values of F are different, but this difference is related to the F on which we are dealing with in the two models. While for ASPIC-P F is a mean weighted fishing mortality, the F value derived from VIT and used in the computations is the simple average F for all the age classes, including those very lightly exploited and $F_{0.1}$ is estimated as a fraction of this value. From VIT is also possible to estimate weighted averages based on the catches by age, or means for the more represented ages in the catch. In these cases much higher values of F_{curr}, and consequently for $F_{0.1}$, are obtained, which are similar to those obtained with ASPIC.

6.14. Red mullet (*Mullus barbatus*) in GSA 10

6.14.1. *Short term prediction 2010-2012*

6.14.1.1. Method and justification

Short term prediction for 2010-2012 was implemented in R (www.r-project.org) using the FLR libraries and based on the results of the stock assessment performed using VIT (Lleonart and Salat, 1997) that was conducted in the framework of the SGMED-10-03 using the VPA Lowestoft routines.

6.14.1.2. Input parameters

The following data have been used to derive the input data for the short term projection of the red mullet in the GSA 10:

Maturity and M vectors

PERIOD	Age	0	1	2	3	4	5	6
2007-2009	Prop. Matures	0.16	0.92	1.00	1.00	1.00	1.00	1.00

PERIOD	Age	Mean
2007-2009	M	0.61

F vector

F	0	1	2	3	4	5	6
2006	0.27	0.68	1.18	1.46	1.71	0.56	0.70
2007	0.15	0.81	1.29	0.71	0.52	0.57	0.70
2008	0.26	0.73	0.85	0.74	1.01	1.18	0.70
2009	0.51	0.67	0.81	0.61	0.38	0.36	0.70

Several scenarios of constant harvest strategy with with F_{stq} (F_{bar} ages 1-5) calculated as the average of the last 3 years, but rescaled to the F of 2009 (Fstq =0.57). Potential changes in selectivity due to the implementation of the 40mm square / 50mm diamond mesh size on trawlers based on EC 1967/2006 were not taken into account in the predictions.

Weight-at-age in the stock

Mean weight in stock	0	1	2	3	4	5	6
kg	0.0062	0.0331	0.0736	0.1159	0.1521	0.1797	0.1994

Weight-at-age in the catch

Mean weight in catch	0	1	2	3	4	5	6
kg	0.0062	0.0331	0.0736	0.1159	0.1521	0.1797	0.1994

Number at age in the catch

Catch at age in numbers (thousands)	0	1	2	3	4	5	6
2009	8492	3391	1080	214	43	15	10

Number at age in the stock

Stock at age in numbers (thousands)	0	1	2	3	4	5	6
2009	27581	8979	2498	604	178	66	25
2010	30474	12248	2996	677	181	52	31

Stock recruitment

The recruitment used for the short term projection was estimated as the geometric mean from 2006-2009.

6.14.1.3. Results

A short term projection (Table below), assuming an F_{stq} of 0.57 in 2010 and a recruitment of 30474 (thousands) individuals, shows that:

- Fishing at the F_{stq} (0.57) from 2010 to 2011 generates an increase of the catch for 16 % and an increasing of the spawning stock biomass of 8% from 2011 to 2012.

- Fishing at $F_{0.1}$ (0.43) for the same time (2009-2011) generates a decrease of the catch of 9% and a spawning stock biomass increase of 20% from 2011 to 2012.

- A 30% reduction of the F_{stq} (F=0.397) generates a decrease of catch of 13% and an increase of spawning stock biomass of about 24% from 2011 to 2012, indicating that this level of reduction could generate a decrease of catches but an increase of the spawning stock biomass, that however was only slightly higher (22%) than at $F_{0.1}$ (0.42).

- SGMED recommends that fishing mortality in 2011 should not exceed $F_{0.1}$ = 0.42, corresponding to catches of 253 tons.

Outlook for 2011-2012

Basis: F (2010) = F (2009) rescaled (F_{bar}1-5); R (2010)=GM (2006–2009) = 30474 (thousands); F (2010) =0.57; SSB (2011) = 881; Catch (2010)=272 t

Rationale	F scenario	F factor	Catch 2011	Catch 2012	SSB 2012	Change SSB 2011-2012 (%)	Change Catch 2009-2011 (%)
zero catch	0	0	0	0	1427	61.89	-100.00
High long-term yield ($F_{0.1}$)	0.420	0.74	253	303	1056	19.79	-9.28
Status quo	0.568	1.0	322	349	955	8.30	15.56
Different scenarios	0.057	0.1	40	62	1369	55.25	-85.70
	0.114	0.2	78	116	1313	48.93	-72.11
	0.170	0.3	114	163	1260	42.93	-59.18
	0.227	0.4	148	203	1210	37.22	-46.87
	0.284	0.5	181	238	1162	31.78	-35.16
	0.341	0.6	212	268	1116	26.61	-24.01
	0.397	0.7	242	294	1073	21.69	-13.39
	0.454	0.8	270	315	1031	17.01	-3.27
	0.511	0.9	297	334	992	12.55	6.37
	0.624	1.1	347	362	919	4.25	24.33
	0.681	1.2	370	372	885	0.39	32.69
	0.738	1.3	392	380	852	-3.30	40.68
	0.795	1.4	414	387	822	-6.81	48.29
	0.851	1.5	434	392	792	-10.16	55.57
	0.908	1.6	453	395	764	-13.35	62.52
	0.965	1.7	472	398	737	-16.41	69.16
	1.022	1.8	490	399	711	-19.32	75.51
	1.078	1.9	507	400	687	-22.11	81.58
	1.135	2.0	523	399	663	-24.77	87.38

Weights in t

6.14.2. *Medium term prediction*

6.14.2.1. Method and justification

Medium term prediction from 2010 to 2030 was implemented in R (www.r-project.org) using the FLR libraries and based on the results of stock assessment obtained using VIT (Lleonart and Salat, 1997) and the VPA Lowestoft routines Medium term projections (20 years) were run assuming a progressive decreasing trend of F toward the $F_{0.1}$ in 10 years (2020) and in 5 years (2015). The stock-recruitment relationship used geometric mean recruitment over the observed SSB range from 2007 to 2009. Runs were made with 500 simulations per run. To simulate a stochastic process the recruitment was multiplied by log-normally distributed noise with mean 1 and standard deviation 0.3.

6.14.2.2. Input parameters

The maturity ogive, the natural mortality, the numbers of individuals and weight-at-age for the stock and for the catch were the same used in the short term forecast.

6.14.2.3. Results

In Fig. 6.14.2.3.1 (left panel), the 5th, 25th, 50th, 75th and 95th percentile are shown for the SSB, recruitment and catches in t from 2010 to 2030, considering a constant reduction of F of around 6% each year from 2010 to 2015.

In Fig. 6.14.2.3.1 (right panel), the 5th, 25th, 50th, 75th and 95th percentile are showed for the SSB, recruitment and catches in t from 2010 to 2030, considering a constant reduction of the F_{stq} of around 3% each year from 2010 to 2020.

Landing data of red mullet from 2004 to 2009 in the GSA10 are reported in the Table 6.14.2.3.1 and show a decreasing pattern except in 2007. In 2009 the lowest value of 279 t was observed. In both the scenarios of the medium-term forecasts the decreasing of fishing mortality results in an increase of the SSB and an increase of the catches in the medium term.

Table 6.14.2.3.1. Landings of red mullet in the GSA 10.

Year	2004	2005	2006	2007	2008	2009
DCF landings	524	421	393	502	315	279

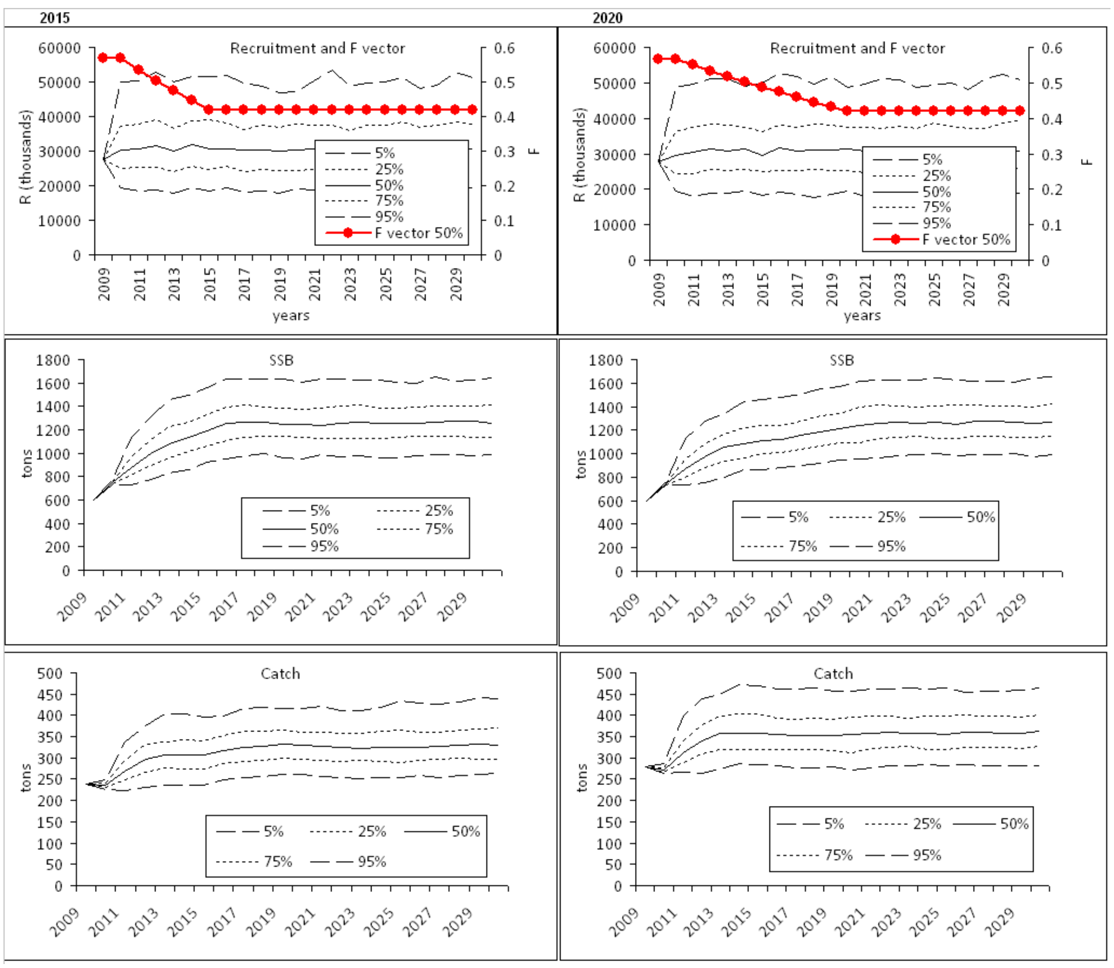


Fig. 6.14.2.3.1 Output of the medium term forecast computed for the red mullet in the GSA 10 reaching $F_{0.1}$ in 2015 (left) and 2020 (right).

6.15. Red mullet (*Mullus barbatus*) in GSA 11

6.15.1. *Short term prediction 2010-2012*

6.15.1.1. Method and justification

Taking into account the output of the assessment done for red mullet stock in GSA 11 during the SGMED-10-03 using the VIT software (Lleonart and Salat, 1992), short term predictions for 2010 to 2012 were elaborated using the EXCEL workbook provided by JRC IPSC (H.-J. Rätz).

6.15.1.1. Input parameters

The following data have been used to derive the input data for the short term projection of the red mullet in GSA 11:

Maturity and M vectors

PERIOD	Age	0	1	2	3
2009	Prop. Matures	0	1	1	1

PERIOD	Age	0	1	2	3
2009	M	1.30	0.41	0.27	0.23

F vector

PERIOD	Age	0	1	2	3
2009	F	0.02	1.49	1.92	0.60

For the projections, the mean F (F_{bar} ages 0-3) calculated as the average of the last 4 years for each age class was used and defined as F status quo (F_{stq} = 1.34). Several scenarios of constant harvest strategy were run. Potential changes in selectivity due to the implementation of the 40mm square / 50mm diamond mesh size on trawlers based on EC 1967/2006 were not taken into account in the predictions.

Weight-at-age in the stock

Mean weight in stock	0	1	2	3
Kg	0.010	0.044	0.091	0.135

Weight-at-age in the catch

Mean weight in stock	0	1	2	3
Kg	0.010	0.044	0.091	0.135

Number at age in the catch

Catch at age in numbers (thousands)	0	1	2	3
	118	1670	291	17

Number at age in the stock

Stock at age in numbers (thousands) in 2010	0	1	2	3
	30591	7458	1114	125

Maturity, weight-at-age in the stock, weight-at-age in the catch, F and M before spawning were considered the same as the one considered in the VPA.

Stock recruitment

The recruitment (age 0+) used for the short term projection derived from the results of the stock numbers provided by the VIT.

6.15.1.1. Results

A short term projection (Table below), assuming an F_{stq} of 1.34 and a recruitment of 39.1 (millions) individuals, shows that:

- Fishing at the F_{stq} (1.34) in the time frame from the year 2009 to 2011 generates an increase of the catch for 80 % in 2010 and a least increase of the spawning stock biomass for 5 % from the year 2011 to 2012.

- Fishing at $F_{0.1}$ (0.47) for the same time frame (2009-2011) generates a small decrease of the catch for 6 % in 2011 and an increase of the spawning stock biomass of 53 % from the year 2011 to 2012.

- A 20% reduction of the F_{stq} (F from 1.34 to 1.07) generates an increase of catch for 60.9 % in 2011 and of spawning stock biomass for 15.0 % from the year 2011 to 2012.

The last bullet point clearly indicates that the 20% reduction of F generates a small increase (16%) in the SSB from the year 2011 to 2012. To obtain a greater increase of SSB as well as an increase of the catch for the 2011 the reduction of F should range from 30 % to 50%.

SGMED recommends the catch in 2011 should not exceed the catch of 211 tons, that corresponds to $F_{0.1}$.

Outlook until 2012

Basis: F (2010) = mean F (F_{bar} ages 1-3); R (2010) = mean (2006–2009) = 39.1 (millions); F(2010) = 1.34; SSB (2011) = 477 t; Catch (2010) = 331 t

Rationale	F scenario	F factor	Catch 2011	Catch 2012	SSB 2012	Change SSB 2011-2012 (%)	Change Catch 2009-2011 (%)
zero catch	0.00	0.00	0	0	1224	108.5	-100.0
High long-term yield ($F_{0.1}$)	0.47	0.36	211	336	900	53.3	-6.2
Status quo	1.34	1.00	404	429	619	5.5	79.6
Different scenarios	0.13	0.10	70	141	1114	89.8	-68.9
	0.27	0.20	132	242	1019	73.6	-41.3
	0.40	0.30	184	307	940	60.1	-18.2
	0.53	0.40	230	354	870	48.2	2.2
	0.67	0.50	270	383	811	38.2	20.0
	0.80	0.60	305	403	760	29.5	35.6
	0.94	0.70	334	415	717	22.1	48.4
	1.07	0.80	362	423	679	15.7	60.9
	1.20	0.90	383	427	647	10.2	70.2
	1.47	1.10	421	429	595	1.4	87.1
	1.60	1.20	437	428	575	-2.0	94.2
	1.74	1.30	450	428	557	-5.1	100.0
	1.87	1.40	463	426	542	-7.7	105.8
	2.01	1.50	473	426	528	-10.1	110.2

6.15.2. *Medium term prediction*

6.15.2.1. Method and justification

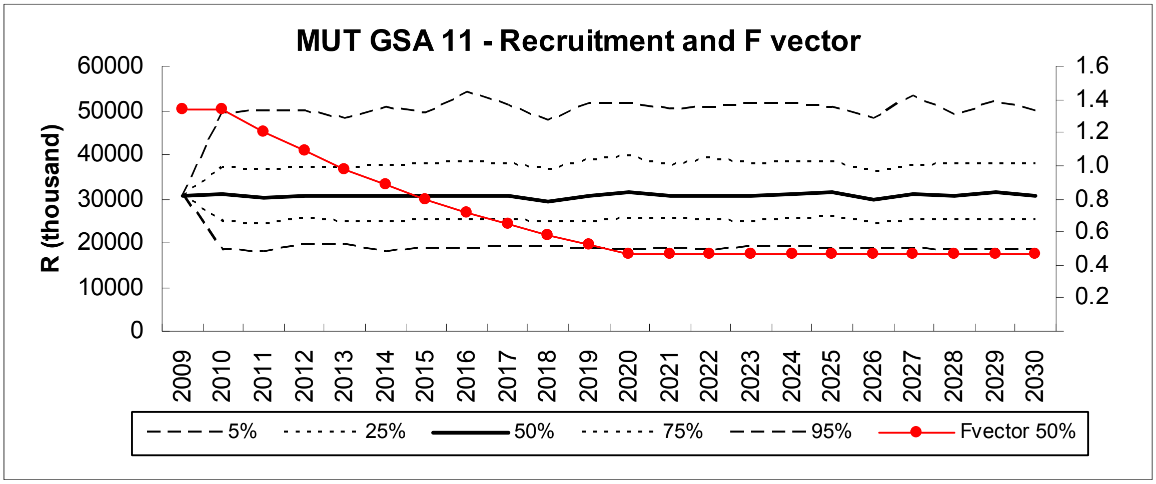
Medium term prediction from 2010 to 2030 was implemented in R (www.r-project.org) using the FLR libraries and based on the results of the stock assessment that was applied for red mullet stock in GSA 11 during the SGMED-10-03 using the VIT software (Lleonart and Salat, 1992). For the prediction, a progressive declining trend of the F_{stq} toward $F_{0.1}$ in 10 years (2020) was assumed. The stock-recruitment relationship used geometric mean recruitment over the observed SSB range from 2006 to 2009. These medium term predictions were done without taking in to account the mesh shape changed (40 mm square mesh) as adopted by Council Regulation (EC) No 1967/2006 of 21 December 2006.

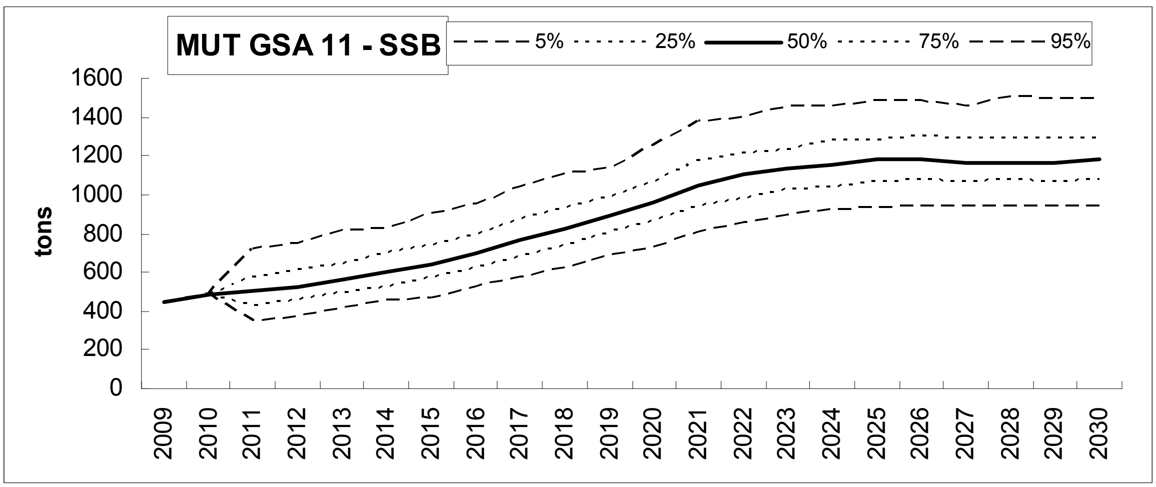
6.15.2.2. Input parameters

The maturity ogives, the natural mortality, the numbers of individuals and weight-at-age for the stock and for the catch were the same used in the short term forecast.

6.15.2.3. Results

Assuming each year from 2010 to 2020 a constant reduction of F of about 9% per year, the SSB, recruitment and catches in t from 2009 to 2030 are showed below. The analysis shows that the decreasing of fishing mortality is accompanied by an increase of the SSB and consequently also an increase of the catches in the medium term.





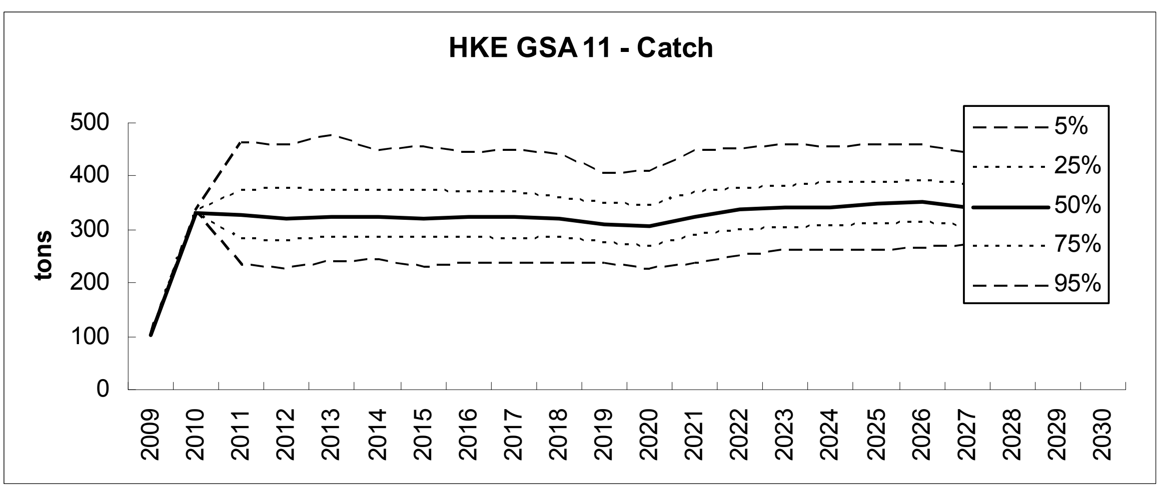


Fig. 6.15.2.3.1Medium term forecast computed for red mullet

6.16. Red mullet (*Mullus barbatus*) in GSA 16

6.16.1. *Short term prediction 2010-2012*

6.16.1.1. Method and justification

Short term prediction for 2011 and 2012 was implemented in R (www.r-project.org) using the FLR libraries and based on the results of the Length Cohort and Yield / Recruit Analysis as implemented in the programme VIT4win (Lleonart and Salat, 2000). The underlying stock assessment for red mullet in GSA 16 carried out by SGMED 10-03 for the first time.

6.16.1.2. Input parameters

The following data have been used to derive the input data for the short term projection of red mullet in GSA 16:

Maturity and M vectors

PERIOD	Age	0	1	2	3	4	5	6	7+
2006-2009	Prop. Mature	0.32	0.76	0.96	0.99	1.00	1.00	1.00	1.00

PERIOD	Age	0	1	2	3	4	5	6	7+
2006-2009	M	0.54	0.27	0.21	0.19	0.17	0.17	0.16	0.16

F vector

F	0	1	2	3	4	5	6	7
2006	0.07	0.61	1.08	1.18	1.30	0.52	/	/
2007	0.08	0.43	1.00	1.15	1.01	0.50	0.65	0.63
2008	0.06	0.45	1.11	1.13	0.82	0.50	0.65	0.63
2009	0.09	0.30	0.74	0.97	0.77	0.50	0.65	0.63
Mean 06-09 scaled to 09	0.07	0.38	0.84	0.94	0.83	0.43	0.56	0.54

Several scenarios of constant harvest strategy were run with F (F_{bar} ages 0-7) calculated as the average of the last 4 years for each age class and rescaled to the level of 2009 (F_{stq} = 0.57).
Potential changes in selectivity due to the implementation of the 40mm square / 50mm diamond mesh size on Italian and Maltese trawlers based on EC 1967/2006 were not taken into account in the predictions made above.

Weight-at-age in the stock

Mean weight in stock	0	1	2	3	4	5	6	7+
kg	0.01	0.04	0.06	0.08	0.09	0.10	0.11	0.11

Weight-at-age in the catch

Mean weight in catch	0	1	2	3	4	5	6	7+
kg	0.01	0.04	0.06	0.08	0.09	0.10	0.11	0.11

Number at age in the catch (thousands)

Catch at age in numbers	0	1	2	3	4	5	6	7

2006	2300583	10104211	6425426	1955500	544994	70568	0	0
2007	2043108	28684097	13674536	3469020	937873	358416	9308	3915
2008	1374002	10996904	9986294	2752727	620969	166414	13253	5574
2009	1108048	5448399	6125167	2905496	809544	236554	11487	4831

Number at age in the stock (thousands)

Catch at age in numbers	0	1	2	3	4	5	6	7
2006	39262143	24961654	10549757	3015221	792642	185793		
2007	34305840	42349756	19911073	6076339	1618087	506446	21127	9106
2008	28800952	35394893	16289054	4363781	1188114	449056	30083	12966
2009	15797413	24435292	12946572	5032509	1610100	639188	26074	11238

Stock recruitment

The recruitment used for the short term projection was estimated as the geometric mean from 2006-2009.

6.16.1.3. Results

A short term projection (Table below), assuming an F_{stq} of 0.57 in 2010 and a recruitment of 27979 (thousand) individuals, shows that:

- Fishing at the F_{stq} (0.57) in the time frame from the year 2010 to 2011 generates a decrease of the catch of 34.4% and a decrease of the spawning stock biomass for 1.7% from the year 2011 to 2012.

- Fishing at $F_{0.1}$ (0.31) for the same time frame (2010-2011) generates a decrease of the catch for 56.8% and a spawning stock biomass increase of 17.2% from the year 2011 to 2012.

- In order to reach the target point $F_{0.1}$, a decrease of F_{stq} by 45% is needed. Thus SGMED recommends that, catches in GSA 16 should not exceed 399 t in 2011, corresponding to $F=F_{01}$.

Outlook for 2011 to 2012

Basis: F (2010) = mean (2006–2009) scaled to 2009; R (2010) = GM (2006–2009) = ; F (2010) = 0.57; SSB (2011) = 1419 t; Catch (2010) = 830 t

Rationale	**F scenario**	**F factor**	**Catch 2011**	**Catch 2012**	**SSB 2012**	**Change SSB 2011-2012 (%)**	**Change Catch 2009-2011 (%)**
zero catch	0.00	0.00	0	0	2121	49.4	-100.0
High long-term yield ($F_{0.1}$)	0.31	0.55	399	471	1664	17.2	-56.8
Status quo	0.57	1.00	633	613	1395	-1.7	-31.4
Different scenarios	0.06	0.10	85	125	2024	42.6	-90.8
	0.11	0.20	164	230	1933	36.2	-82.3
	0.17	0.30	237	316	1849	30.3	-74.3
	0.23	0.40	306	388	1771	24.7	-66.9
	0.29	0.50	370	447	1697	19.6	-59.9
	0.34	0.60	430	496	1628	14.7	-53.5
	0.40	0.70	486	535	1564	10.2	-47.4
	0.46	0.80	538	567	1504	6.0	-41.7
	0.52	0.90	587	593	1448	2.0	-36.4
	0.63	1.10	677	629	1346	-5.2	-26.7
	0.69	1.20	717	641	1299	-8.5	-22.4
	0.75	1.30	755	650	1256	-11.5	-18.2
	0.80	1.40	791	656	1215	-14.4	-14.4
	0.86	1.50	825	661	1176	-17.1	-10.7
	0.92	1.60	856	663	1140	-19.7	-7.3
	0.98	1.70	886	664	1105	-22.1	-4.0
	1.03	1.80	914	663	1073	-24.4	-1.0
	1.09	1.90	941	662	1043	-26.5	1.9
	1.15	2.00	966	660	1014	-28.6	4.6

Weights in t

6.17. Red mullet (*Mullus barbatus*) in GSA 22

6.17.1. *Medium term prediction*

6.17.1.1. Method and justification

Based on the results of the non-equilibriun surplus production model assessment conducted during the SGMED 2010-02 meeting, stochastic stock biomass and catch predictions up to the year 2020 were carried out. Three different management scenarios were evaluated: (a) the status quo, i.e fishing mortality (F) remains at the level estimated at the last assessment year, for the whole projection period, (b) F equals to the F_{msy} and (c) F equals to the $F_{0.1}$ value that was obtained from the Y/R analysis.

Each projection scenario was simulated 100 times assuming normally distributed errors for the parameters r and k of the surplus production model. Future biomass and catch levels were estimated through the commonly used Shaefer equation:

$B_t = B_{t-1} + rB_{t-1}(1-B_{t-1}/k)-FB_{t-1}$

Runs were made under the R language environment.

6.17.1.2. Input parameters

r = 0.79 (sd = 0.04)
k = 26744 (sd = 1148)
$B_{2006} = 12528$
$F_{2006} = 0.402$
$F_{msy} = 0.395$
$F_{0.1} = 0.28$

6.17.1.3. Results

The table below shows stock biomass and catch predictions under the different scenarios (status quo, F_{msy} and $F_{0.1}$). Predictions together with the assessment estimates are shown in Figure 1.

Short and medium term implications
Given that the current stock biomass is very closed to B_{msy} and current F is just 2% higher than F_{msy}, the status quo and the F_{msy} scenario provide nearly identical results. In both cases stock biomass and catches remain closed to the corresponding MSY values all over the examined period. Under the $F_{0.1}$ scenario stock biomass will be by 2020 about 30% higher than B_{msy} and while catches will be about 20% lower than MSY.

Based on the above SGMED recommends that fishing mortality should not exceed the estimated F_{msy} value (0.39) which is identical to the current (2006) fishing mortality levels, corresponding to catches around 5,290 tonnes in 2011. Although the officially reported Greek catches in FAO (Fishstat database) are not detailed by GSA, considering the existing fishery exploitation pattern, it is estimated that the 2007 and 2008 catches are within the predicted limits for the given years, under the "status quo" scenario"

Data consistency
Due to data limitations, the analysis is based on a production modeling approach which in fact considers the population as a whole without taking into account that it is composed by a sum of age groups that undergo different levels of fishing pressure by the various fleet components. Such an assumption which also implies constant fishing mortality over age is endogenous in production models and may severely bias results, especially if the exploitation pattern changes over time; hence prediction estimates should be faced with caution. Additionally, given that the available time series of CPUE survey data was short with low contrast

between years, strong assumptions had to be made regarding the initial harvest rate in order to achieve convergence in the surplus production model that has been previously applied for the assessment of the stock.

Status quo

Year	Biomass (mt)	Biomass CI (95% upper limit)	Biomass CI (95% lower limit)	Catch (mt)	Catch (95% upper limit)	Catch (95% lower limit)	F
2007	13252	13935	12569	5330	5605	5055	0.402
2008	13188	14324	12052	5304	5761	4847	0.402
2009	13149	14564	11734	5289	5858	4720	0.402
2010	13123	14710	11537	5278	5917	4640	0.402
2011	13106	14800	11412	5272	5953	4590	0.402
2012	13094	14856	11333	5267	5975	4558	0.402
2013	13086	14890	11282	5263	5989	4538	0.402
2014	13081	14911	11250	5261	5998	4525	0.402
2015	13077	14925	11228	5260	6003	4516	0.402
2016	13074	14933	11215	5259	6006	4511	0.402
2017	13072	14939	11205	5258	6009	4507	0.402
2018	13071	14942	11199	5257	6010	4505	0.402
2019	13070	14945	11195	5257	6011	4503	0.402
2020	13069	14946	11193	5257	6012	4502	0.402

$F = F_{msy}$

Year	Biomass (mt)	Biomass CI (95% upper limit)	Biomass CI (95% lower limit)	Catch (mt)	Catch (95% upper limit)	Catch (95% lower limit)	F
2007	13291	14006	12575	5250	5532	4967	0.395
2008	13343	14526	12159	5270	5738	4803	0.395
2009	13373	14839	11906	5282	5861	4703	0.395
2010	13389	15024	11753	5288	5935	4642	0.395
2011	13396	15133	11659	5291	5977	4605	0.395
2012	13399	15197	11601	5293	6003	4582	0.395
2013	13400	15235	11565	5293	6018	4568	0.395
2014	13400	15258	11542	5293	6027	4559	0.395
2015	13399	15271	11527	5293	6032	4553	0.395
2016	13399	15280	11518	5293	6035	4550	0.395
2017	13398	15285	11512	5292	6038	4547	0.395
2018	13398	15288	11508	5292	6039	4546	0.395
2019	13398	15290	11505	5292	6040	4545	0.395
2020	13397	15291	11503	5292	6040	4544	0.395

$F = F_{0.1}$

Year	Biomass (mt)	Biomass CI (95% upper limit)	Biomass CI (95% lower limit)	Catch (mt)	Catch (95% upper limit)	Catch (95% lower limit)	F
2007	13258	13952	12564	3712	3907	3518	0.280
2008	14816	16049	13582	4148	4494	3803	0.280
2009	15873	17450	14296	4444	4886	4003	0.280
2010	16508	18251	14765	4622	5110	4134	0.280
2011	16858	18662	15054	4720	5225	4215	0.280
2012	17043	18860	15225	4772	5281	4263	0.280
2013	17137	18953	15322	4798	5307	4290	0.280
2014	17185	18995	15375	4812	5319	4305	0.280
2015	17210	19014	15405	4819	5324	4313	0.280
2016	17222	19023	15421	4822	5326	4318	0.280
2017	17229	19027	15430	4824	5328	4320	0.280
2018	17232	19029	15435	4825	5328	4322	0.280
2019	17234	19029	15438	4825	5328	4323	0.280
2020	17234	19030	15439	4826	5328	4323	0.280

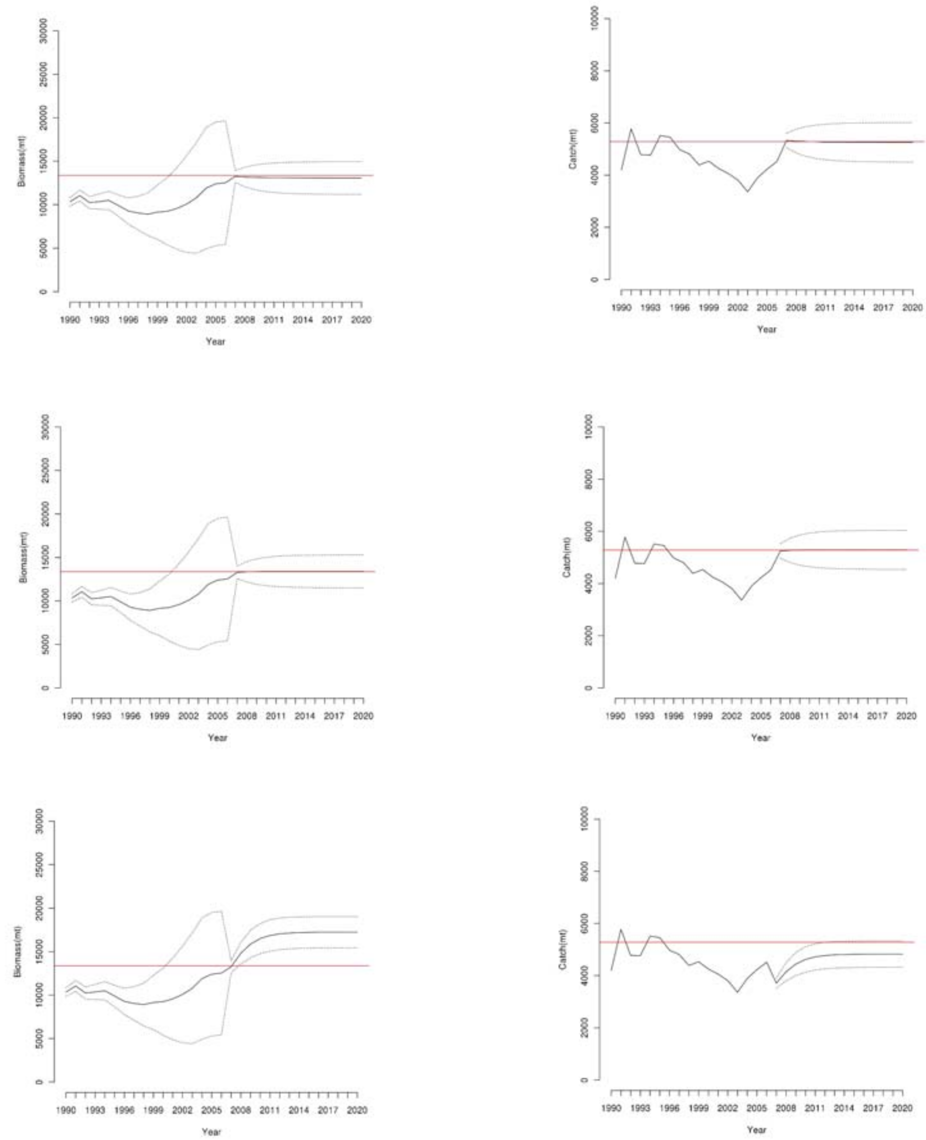


Figure 6.17.1.3.1. Stock biomass and catch predictions under different exploitation scenarios. From top to bottom: Status quo, $F = F_{msy}$, $F = F_{0.1}$. Horizontal lines indicate the corresponding MSY levels and dotted lines indicate the 95% confidence intervals of the estimates.

6.18. Striped red mullet (*Mullus surmuletus*) in GSA 5

6.18.1. *Short term prediction 2010-2012*

6.18.1.1. Method and justification

A deterministic short term prediction for 2010 to 2012 was performed using the EXCEL workbook provided by JRC IPSC (H.-J. Rätz), which takes into account the catch and landings in numbers and weight and the discards, and based on the results of the Extended Survivor Analyses (XSA, Darby and Flatman, 1994) stock assessment performed during the SGMED 10-02 meeting.

6.18.1.2. Input parameters

The following data have been used to derive the input data for the short term projection of the striped red mullet stock in GSA 5:

Maturity

Period	Age	0	1	2	3	4	5
2000-2009	Prop. Matures	0.15	0.39	0.79	0.95	1.00	1.00

M vector

Period	Age	0	1	2	3	4	5
2000-2009	M	1.0	0.6	0.4	0.3	0.3	0.3

F vector

F	0	1	2	3	4	5
2009	0.0777	0.61	0.89	0.89	0.73	0.67

Several scenarios with different harvest strategy were run, with F_{stq} (F_{bar} ages 1-5) equal to the F vector in 2009 (F_{stq} = 0.76). Potential changes in selectivity due to the implementation of the 40mm square / 50mm diamond mesh size on trawlers based on EC 1967/2006 were not taken into account in the predictions.

Weight-at-age in the stock

Mean weight (kg)	0	1	2	3	4	5
2007-2009	0.029	0.058	0.100	0.152	0.209	0.296

Weight-at-age in the catch

Mean weight (kg)	0	1	2	3	4	5
2007-2009	0.029	0.058	0.100	0.152	0.209	0.296

Number at age in the stock

N (thousands)	0	1	2	3	4	5
2010	6034	2342	520	196	55	19

Stock recruitment

Due to the decreasing trend in recruitment during the entire time series, recruitment (class 0+) has been estimated as the geometric mean of the class 0+ of the last three years (2007 to 2009).

6.18.1.3. Results

Short-term implications

A short term projection (Table below), assuming an F_{stq} of 0.76 in 2010 and a recruitment of 6034 (thousand) individuals, shows that:

- Fishing at the F_{stq} (0.76) generates an increase of the catch of 15% from 2009 to 2011 along with a decrease of the spawning stock biomass of 2% from 2011 to 2012.

- Fishing at $F_{0.1}$ (0.29) for the same time frame (2009-2012) generates a decrease of the catch of 47% from 2009 to 2011 and a spawning stock biomass increase of 32% from 2011 to 2012.

Thus, SGMED recommends that catches in 2011 should not exceed 48 t, corresponding to F = F_{01}.

Outlook until 2012

Short term forecast for different F scenarios computed for red mullet in GSA 5.

Basis: F (2010) = mean (F_{bar}1-5 2009); Catch (2010): 107 t; R (2010) = GM (2007–2009) = 6034 (thousands); F (2010) = 0.76; SSB(2011) = 167 t

Rationale	F scenario	F factor	Catch 2011	Catch 2012	SSB 2012	Change SSB 2011-2012 (%)	Change Catch 2009-2011 (%)
zero catch	0.00	0.0	0	0	268	60.5	-100.0
High long-term yield ($F_{0.1}$)	0.29	0.38	48	61	220	31.7	-47.3
Status quo	0.76	1.0	105	103	164	-1.8	15.4
Different scenarios	0.08	0.1	14	22	241	44.3	-70.3
	0.15	0.2	27	39	228	36.5	-57.1
	0.23	0.3	39	53	218	30.5	-45.1
	0.30	0.4	50	63	206	23.4	-34.1
	0.38	0.5	60	74	197	18.0	-22.0
	0.46	0.6	71	82	188	12.6	-12.1
	0.53	0.7	80	90	179	7.2	-2.2
	0.61	0.8	89	96	172	3.0	7.7
	0.68	0.9	98	101	241	-1.8	15.4
	0.83	1.1	112	107	183	-6.0	23.1
	0.92	1.2	119	109	176	-9.6	30.8
	0.99	1.3	126	112	169	-13.2	38.5
	1.06	1.4	132	114	163	-16.8	45.1
	1.14	1.5	137	113	158	-19.2	50.5

Weights are in tons.

6.19. Striped red mullet (*Mullus surmuletus*) in GSA 22

6.19.1. *Medium term prediction*

6.19.1.1. Method and justification

Based on the results of the non-equilibriun surplus production model assessment conducted during the SGMED 10-02 meeting, stochastic stock biomass and catch predictions up to the year 2020 were carried out. Three different management scenarios were evaluated: (a) the status quo, i.e fishing mortality (F) remains at the level estimated at the last assessment year, for the whole projection period, (b) F equals to the F_{msy} and (c) F equals to the $F_{0.1}$ value that was obtained from the Y/R analysis.

Each projection scenario was simulated 100 times assuming normally distributed errors for the parameters r and k of the surplus production model. Future biomass and catch levels were estimated through the commonly used Shaefer equation:

$B_t = B_{t-1} + rB_{t-1}(1-B_{t-1}/k)-FB_{t-1}$

Runs were made under the R language environment.

6.19.1.2. Input parameters

r = 0.75 (sd = 0.04)
k = 16144 (sd = 829)
$B_{2006} = 8490$
$F_{2006} = 0.32$
$F_{msy} = 0.37$
$F_{0.1} = 0.33$

6.19.1.3. Results

The table below indicates stock biomass and catch predictions under the different scenarios (status quo, F_{msy} and $F_{0.1}$). Predictions together with the assessment estimates are shown in Figure 1.

Short and medium term implications
Given that the current stock biomass level is higher than B_{msy} and current F is close to $F_{0.1}$ and slightly lower than F_{msy}, differences among scenarios are negligible. In all cases, catches will be around MSY for the whole projection period, while stock biomass will be slightly higher or equal to the B_{msy} value. Based on the above analysis, SGMED recommends that cathes in 2011 should not exceed 3,000 tonnes, corresponding to F= F_{msy}.

Data consistency
Due to data limitations, the analysis is based on a production modeling approach which considers the population as a whole without taking into account that it is composed by a sum of age groups that undergo different levels of fishing pressure by the various fleet components. Such an assumption, which implies constant fishing mortality over age, is endogenous in production models and may severely bias results, especially if the exploitation pattern changes over time. Hence, results should be taken with caution. Additionally, given that the available time series of CPUE survey data was short with low contrast between years, strong assumptions had to be made regarding the initial harvest rate in order to achieve convergence in the surplus production model used for the assessment of the stock. Regarding the used CPUE data it should be also noted that they are coming from the MEDITS trawl survey which does not cover essential habitats of striped mullet such as rocky bottoms. Hence MEDITS indicators may not fully represent the population abundance.

Status quo

Year	Biomass (mt)	Biomass CI (95% upper limit)	Biomass CI (95% lower limit)	Catch (mt)	Catch (95% upper limit)	Catch (95% lower limit)	F
2007	9044	9506	8583	2862	3008	2716	0.32
2008	9209	9979	8440	2915	3158	2671	0.32
2009	9308	10262	8354	2946	3248	2644	0.32
2010	9365	10425	8305	2964	3299	2628	0.32
2011	9397	10517	8278	2974	3328	2620	0.32
2012	9415	10569	8262	2980	3345	2615	0.32
2013	9425	10597	8253	2983	3354	2612	0.32
2014	9431	10614	8249	2985	3359	2610	0.32
2015	9434	10623	8246	2986	3362	2610	0.32
2016	9436	10628	8244	2986	3363	2609	0.32
2017	9437	10631	8243	2987	3364	2609	0.32
2018	9437	10632	8243	2987	3365	2609	0.32
2019	9438	10633	8242	2987	3365	2609	0.32
2020	9438	10634	8242	2987	3365	2608	0.32

$F = F_{msy}$

Year	Biomass (mt)	Biomass CI (95% upper limit)	Biomass CI (95% lower limit)	Catch (mt)	Catch (95% upper limit)	Catch (95% lower limit)	F
2007	8973	9460	8486	3341	3522	3159	0.37
2008	8588	9369	7808	3197	3488	2907	0.37
2009	8371	9320	7423	3117	3470	2763	0.37
2010	8242	9295	7189	3068	3461	2676	0.37
2011	8162	9284	7040	3039	3456	2621	0.37
2012	8112	9279	6944	3020	3455	2585	0.37
2013	8079	9278	6881	3008	3454	2562	0.37
2014	8059	9279	6839	3000	3454	2546	0.37
2015	8045	9280	6810	2995	3455	2536	0.37
2016	8036	9281	6791	2992	3455	2528	0.37
2017	8031	9283	6779	2990	3456	2524	0.37
2018	8027	9284	6770	2988	3456	2520	0.37
2019	8024	9285	6764	2987	3457	2518	0.37
2020	8023	9285	6760	2987	3457	2517	0.37

$F = F_{0.1}$

Year	Biomass (mt)	Biomass CI (95% upper limit)	Biomass CI (95% lower limit)	Catch (mt)	Catch (95% upper limit)	Catch (95% lower limit)	F
2007	8986	9409	8563	2965	3105	2826	0.33
2008	8989	9684	8293	2966	3196	2737	0.33
2009	8991	9847	8135	2967	3249	2685	0.33
2010	8992	9942	8042	2967	3281	2654	0.33
2011	8992	9997	7987	2967	3299	2636	0.33
2012	8991	10029	7953	2967	3309	2625	0.33
2013	8990	10047	7933	2967	3316	2618	0.33
2014	8990	10058	7921	2967	3319	2614	0.33
2015	8989	10065	7914	2966	3321	2612	0.33
2016	8989	10069	7909	2966	3323	2610	0.33
2017	8989	10071	7907	2966	3323	2609	0.33
2018	8989	10072	7905	2966	3324	2609	0.33
2019	8988	10073	7904	2966	3324	2608	0.33
2020	8988	10074	7903	2966	3324	2608	0.33

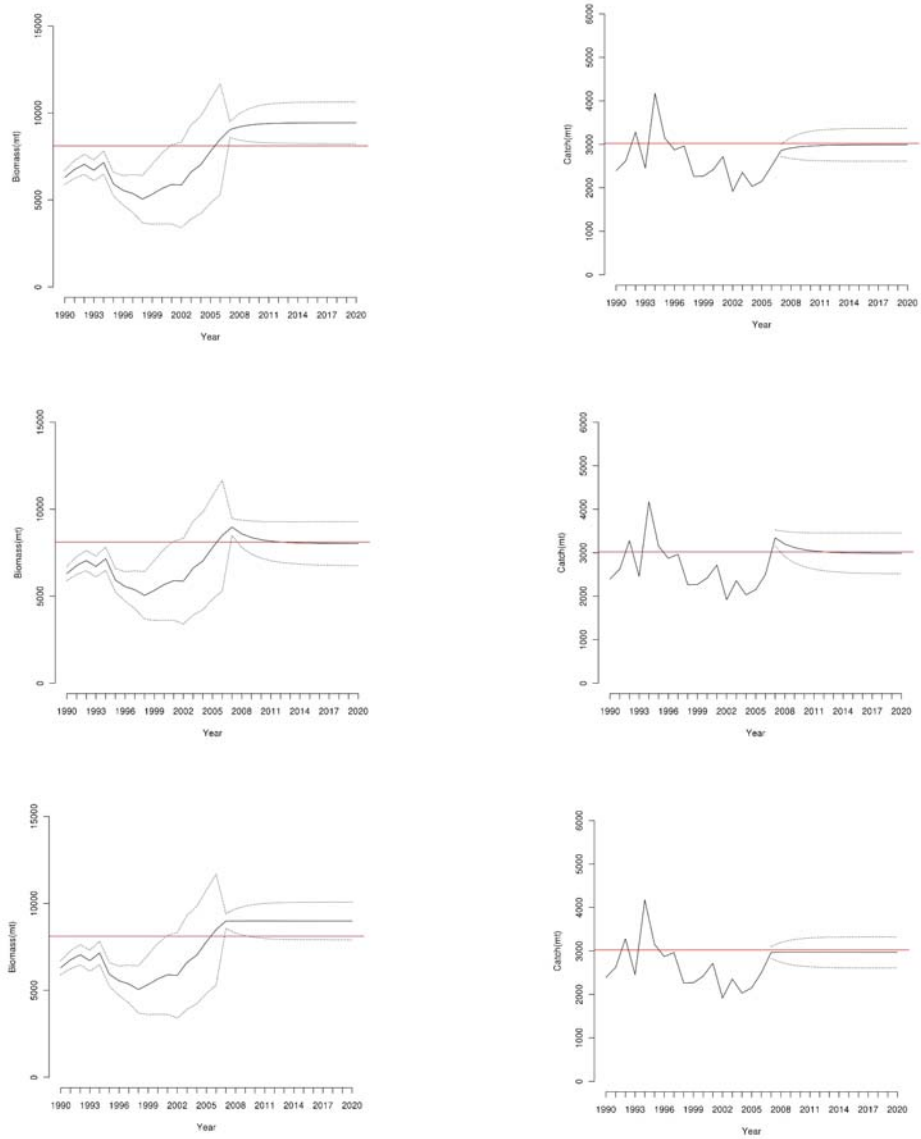


Figure 6.19.3.1. Stock biomass and catch predictions under different exploitation scenarios. From top to bottom: Status quo, $F = F_{msy}$, $F = F_{0.1}$. Horizontal lines indicate the corresponding MSY levels and dotted lines the 95% intervals of the estimates.

6.20. Common sole (*Solea solea*) in GSA 17

6.20.1. *Short term prediction 2010-2012*

6.20.1.1. Method and justification

Short term prediction for 2011 and 2012 was implemented in R (www.r-project.org) using the FLR libraries and based on the results of the Extended Survivor Analyses (XSA, Darby and Flatman, 1994) that was conducted in the framework of the SGMED-09-02 using the VPA Lowestoft software suite.

6.20.1.2. Input parameters

The following data have been used to derive the input data for the short term projection of the common sole in GSA 17:

Maturity and M vectors

PERIOD	Age	0	1	2	3	4	5+
2005-2009	Prop. Matures	0.00	0.16	0.76	0.96	0.99	1.00

PERIOD	Age	0	1	2	3	4	5+	Mean 0-4
2005-2009	M	0.70	0.35	0.28	0.25	0.23	0.22	0.40

F vector

F	0	1	2	3	4	5+
2005	0.07	1.76	2.44	1.57	1.46	1.46
2006	0.10	1.84	1.78	1.20	1.22	1.22
2007	0.11	1.56	1.86	1.31	1.21	1.21
2008	0.17	1.71	1.87	1.28	1.27	1.27
2009	0.16	1.88	2.04	1.36	1.37	1.37

Several scenarios of constant harvest strategy were run, with variation of the mean F (F_{bar} ages 0-4) calculated as the average of the last 3 years. Potential changes in selectivity due to the implementation of the 40mm square / 50mm diamond mesh size on trawlers based on EC 1967/2006 were not taken into account in the predictions.

Weight-at-age in the stock

Mean weight in stock	0	1	2	3	4	5+
Kg	0.024	0.104	0.207	0.304	0.38	0.522

Weight-at-age in the catch

Mean weight in catch	0	1	2	3	4	5+
Kg	0.024	0.104	0.207	0.304	0.38	0.522

Number at age in the catch

Catch at age in numbers (thousands)	0	1	2	3	4	5+
2005	2190	12910	3120	138	11	8
2006	2629	15151	1637	159	20	10
2007	3813	11205	1768	186	38	14
2008	5779	15675	1830	181	39	14
2009	4957	15195	2191	190	41	21

Number at age in the stock

Stock at age in numbers (thousands)	0	1	2	3	4	5+
2005	46340	18593	3930	197	16	11
2006	37720	21468	2265	258	32	15
2007	51294	16878	2410	289	61	22
2008	51211	22785	2488	284	61	21
2009	48974	21358	2898	289	62	31
2010	46340	18593	3930	197	16	11

Maturity, weight-at-age in the stock and weight-at-age in the catch were estimated as the mean of the last 3 years.

Stock recruitment

The recruitment used for the short term projection was estimated as the geometric mean from 2007-2009.

6.20.1.3. Results

A short term projection (Table below), assuming an F_{stq} of 1.28 in 2010 and a recruitment of 50481 (thousand) individuals, shows that:

- Fishing at the F_{stq} (1.28) from 2010 to 2011 generates an increase of the catch of 0.5 % and an increase of the spawning stock biomass of 2.8% from 2011 to 2012.

- Fishing at F_{01} (0.26) for the same time frame (2009-2011) generates a decrease of the catch for 66% and a spawning stock biomass increase of 192% from the year 2011 to 2012.

- A 30% reduction of the F_{stq} (F = 0.89) generates a decrease of catch for 16% and an increase of spawning stock biomass of 47% from the year 2011 to 2012.

- The last point indicates that the 30% reduction of F generates minimal reduction in the catch in the year 2011 in comparison with 2010, however it predicts a high increase (40%) in the SSB from the year 2011 to 2012.

- In order to reach the target point $F_{0.1}$, a decrease of F_{stq} by 80% is needed. Keeping with the present analysis based on F_{stq}, and the use of F_{01} as a target reference point, SGMED reccomends that catch for sole in the Northern Adriatic Sea (GSA 17) should not exceed 770 t in 2011, corresponding to $F = F_{0.1}$.

Outlook until 2012
Basis: F_{stq} = mean (F_{bar}2007–2009); R (2010) = GM (2007–2009) = 50481; F (2010) = 1.28; SSB (2011) = 879 t; Catch (2010) = 2140 t

Rationale	F scenario	F factor	Catch 2011	Catch 2012	SSB 2012	Change SSB 2011-2012 (%)	Change Catch 2009-2011 (%)
zero catch	0	0	0	0	3503	298.4	-100.0
High long-term yield ($F_{0.1}$)	0.26	0.2	770	1399	2569	192.2	-65.6
Status quo	1.28	1.0	2249	2271	904	2.8	0.5
Different scenarios	0.13	0.1	409	829	3003	241.6	-81.7
	0.26	0.2	759	1383	2583	193.8	-66.1
	0.38	0.3	1057	1748	2229	153.5	-52.8
	0.51	0.4	1312	1983	1931	119.7	-41.4
	0.64	0.5	1531	2129	1680	91.1	-31.6
	0.77	0.6	1719	2215	1469	67.1	-23.2
	0.89	0.7	1881	2261	1290	46.7	-15.9
	1.02	0.8	2021	2280	1139	29.6	-9.6
	1.15	0.9	2143	2281	1012	15.1	-4.2
	1.41	1.1	2341	2254	812	-7.6	4.6
	1.53	1.2	2422	2234	734	-16.5	8.3
	1.66	1.3	2493	2212	668	-24.0	11.4
	1.79	1.4	2556	2188	612	-30.4	14.2
	1.92	1.5	2612	2165	564	-35.8	16.7
	2.04	1.6	2661	2142	523	-40.5	19.0
	2.17	1.7	2706	2121	488	-44.5	21.0
	2.30	1.8	2746	2100	457	-48.0	22.7
	2.43	1.9	2782	2079	431	-51.0	24.4
	2.56	2.0	2815	2060	408	-53.6	25.8

Weights in t

Potential changes in selectivity due to the implementation of the 40mm square / 50mm diamond mesh size on Italian and Slovenian trawlers based on EC 1967/2006 were not taken into account in the predictions made above.

The actual landings recorded in 2009 (2135 t for the Italian, Slovenian and Croatian fleet combined) are higher compared to the landings projected for 2009 by SGMED 09-03 (1472t). Such discrepancy, is related to the value of fishing mortality estimated for 2009 (1.36) higher than the F_{stq} considered in the SGMED 09-03 (1.28) and to different matrixes of stock-weight at age and catch-weight at age used in the assessment performed during SGMED 10-02.

6.20.2. *Medium term prediction*

6.20.2.1. Method and justification

Medium term prediction from 2009 to 2020 was implemented in R (www.r-project.org) using the FLR libraries and based on the results of the Extended Survivor Analyses (XSA, Darby and Flatman, 1994) that was applied for common sole stock in GSA 17 in the framework of the SGMED-09-02 using the VPA Lowestoft software suite. The program used in the Medium term projections (10 years) were assuming a progressive decreasing trend of the F_{stq} toward the $F_{0.1}$ in 10 years and in 5 years. The stock-recruitment relationship used was the geometric mean recruitment over the observed SSB range from 2007 to 2009. Runs were made with 500 simulations per run to try projecting with stochastic recruitment, multiplying the recruitment by log-normally distributed noise with a mean of 1 and a standard deviation of 0.3.

6.20.2.2. Input parameters

The maturity ogive, the natural mortality, the numbers of individuals and weight-at-age for the stock and for the catch were the same used in the short term forecast.

6.20.2.3. Results

In fig. 6.19.2.3.1a, the 5th, 25th, 50th, 75th and 95th percentiles are shown for the trends in SSB, recruitment and catches in t from 2005 to 2020, considering a constant reduction of the F of around 14% each year from 2010 to 2020.

In fig. 6.19.2.3.1b, the 5th, 25th, 50th, 75th and 95th percentiles are shown for trends in SSB, recruitment and catches in t from 2005 to 2020, considering a constant reduction of the F of around 14% each year from 2010 to 2015.

It is interesting that the decreasing fishing mortality determine in both cases a clear increase of the SSB but did not affect the amount of the catches in a medium term. This stressed the fact that currently the fishing activity is conducted in a not rationale sense, considering that the catches could be rather constant in the medium term but with a large decrease of the fishing mortality.

Data used in the present assessment (XSA) and in the short and medium term forecast have been compared with the official data collected by Italy in the framework of the Data Collection Regulation. The sampling regarding the age structures of the landings did not provide useful data for 2007 and 2008, when the selectivity patterns seemed very different from 2006 and 2009. Moreover only 4 age classes (0-3) were provided, that, considering the longevity of the species, do not describe the real demography of the stock. As regarding the total landings (Table 6.20.2.3.1), there is a high level of similarity comparing the official DCR data and the data collected in the framework of other projects used in the present assessment. The most important difference (753 t) has been observed only in the last year (2008), likely due to the underestimation of the "rapido" trawl fishing activity in the DCR data.

A "pilot" age based assessment using the Italian DCF data together with the DCF Slovenian data of 2010 and Croatian data was performed. A separable VPA, a process which is independent of the survey tuning data, provided residual patters indicating incongruence in the catch data (Fig. 6.20.2.3.2). Anyway, also in this case the F value for 2009 (0.95) was higher than the reference points agreed by the sub-group.

The Slovenian data were not available for the assessment period, however, considering the relatively low amount, they should not change the results of the assessment. Moreover a considerable difference was noted between the data submitted in 2009 and 2010 from this MS. At present, data on sole are not available from the Croatian part; because sole is considered under the "mixed flatfish" category in the Croatian fishery statistics. However, landings of around 200 t of *S. solea* per year have been suggested, mainly caught by small scale fisheries. Therefore this value of Croatian landings was included in the present assessment. As for age structure of *S. solea* in the eastern part of Adriatic Sea, the data collected during the SoleMon survey carried out in the area close to the Croatian coast, were used.

Table 6.20.2.3.1 – Landings of common sole from GSA 17.

	2005	2006	2007	2008	2009
DCR Italian landings	1662	1891	1492	1231	1708
SGMED landings*	1867	1808	1473	1984	1985
DCR Slovenian landings submitted in 2009	6.4	5.6	8.3	6.2	-
DCR Slovenian landings submitted in 2010	13	11	17	14	21
Croatian landings*	200	200	200	200	150

*used in the present assessment

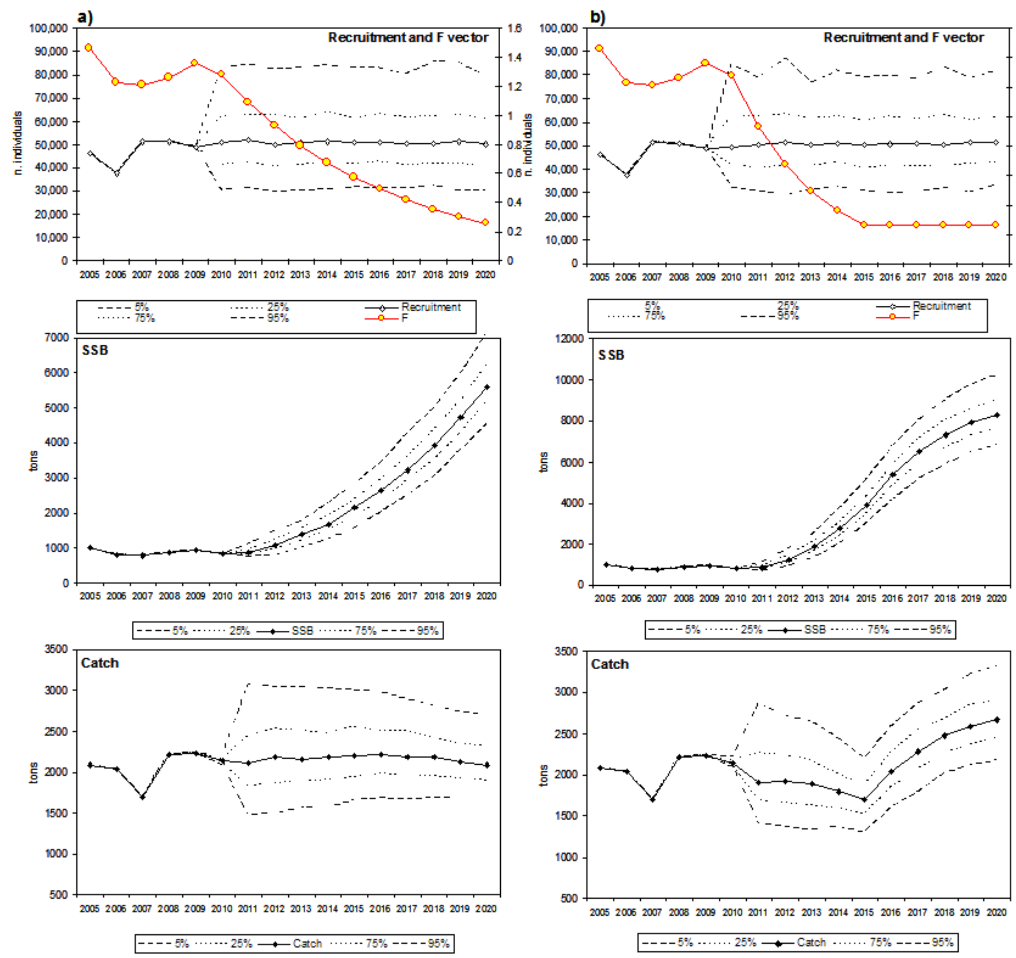


Fig. 6.20.2.3.1– Output of the medium term forecast computed for the common sole in GSA 17 reaching $F_{0.1}$ in 2020 (a) and 2015 (b).

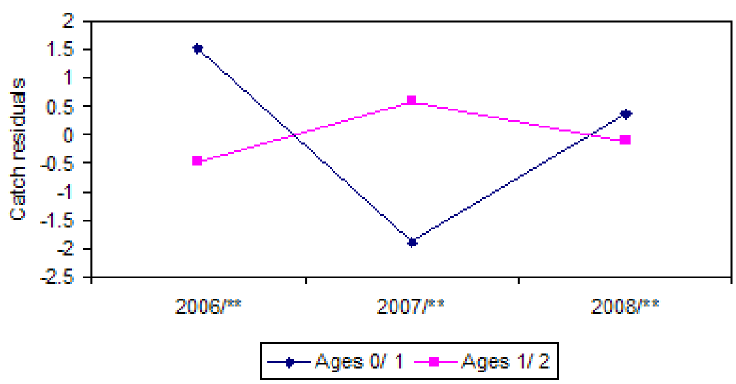


Fig. 6.20.2.3.2 - Residuals of log catchabilities calculated with a separable VPA using Italian and Slovenian DCF data together with Croatian catch estimations.

6.21. Anchovy (Engraulis encrasicolus) in GSA 1

6.21.1. *Short term prediction 2010-2012*

6.21.1.1. Method and justification

The use of yield-per-recruit analysis for estimating targets for long-term management of pelagic fisheries has been discouraged (Patterson, 1992) because 1) the exploitation rate is very sensitive to M values and 2) in many cases, yield-per-recruit gives rise to flat-topped curves. As an alternative, the threshold F/Z = 0.4 has been adopted as biological reference point for small pelagics (Patterson, 1992) and this was also adopted by SGMED.

Consequently, instead of using the F_{ref} obtained with the yield-per-recruit analysis, an alternative F_{ref} was calculated from the following formula: $F_{ref}=E \cdot M/(1-E)$, where E is the exploitation rate and M is the natural mortality. Along with E=0.4, we used a mean M to calculate this new F_{ref}.

Although a deterministic short term prediction could not be used based on the F_{ref} obtained with a yield-per-recruit analysis, the new F_{ref} were used for predictions using the EXCEL spreadsheet provided by JRC IPSC (H.-J. Rätz), which takes into account the catch and landings in numbers and weight, and the discards. The projection is based on the results of the Extended Survivor Analyses (XSA, Darby and Flatman, 1994) stock assessment performed during the SGMED 10-02 meeting.

6.21.1.2. Input parameters

The following input data have been used for the short term projection of the anchovy stock in GSA 1:

Maturity

Period	Age	0	1	2	3
2002-2009	Prop. Matures	0.50	0.89	1	1

M vector

Period	Age	0	1	2	3
2002-2009	M	1.17	0.43	0.32	0.27

F vector

F	0	1	2	3
2009	0.701	1.388	1.064	1.064

The new F_{ref} was obtained using the mean M=0.64 and E=0.4, which gives an F_{ref}=0.43.

Weight-at-age in the stock

Mean weight (kg)	0	1	2	3
2007-2009	0.01	0.014	0.021	0.027

Weight-at-age in the catch

Mean weight (kg)	0	1	2	3
2007-2009	0.01	0.014	0.021	0.027

Number at age in the stock

N (thousands)	0	1	2	3
2010	89225	23969	907	115

Stock recruitment

Recruitment (class 0+) has been estimated as the geometric mean of the class 0+ estimated from 2002 to 2009. This estimate has been used in all years of the projection (2010-2012).

6.21.1.3. Results

Short-term implications

A short term projection (Table below), consistent with F_{ref}=0.43 (corresponding to the proposed management reference point E=0.4) for 2011 and assuming a recruitment of 116806 (thousand) individuals, shows that:

- Fishing at the F_{stq} (1.05) generates an increase of the catch of 99% from 2009 to 2011 along with a decrease of the spawning stock biomass of 0.1% from 2011 to 2012.

- Fishing at F_{ref} (0.43) for the same time frame (2009-2012) generates an increase of the catch of 26% from 2009 to 2011 and a spawning stock biomass increase of 24% from 2011 to 2012.

Consequently, SGMED recommends that the catch level of 292 t should not be exceeded, corresponding to F_{ref} = 0.43.

Outlook until 2012

Short term forecast for different F scenarios computed for anchovy in GSA 1.

Basis: F (2010) = mean (F_{bar} 0-2 2009); Catch (2010): 598 t; R (2010) = GM (2000–2009) = 116806 (thousands); F_{stq} (2010) = 1.05; SSB(2011) = 895 t

Rationale	F scenario	F factor	E	Catch 2011	Catch 2012	SSB 2012	Change SSB 2011-2012 (%)	Change Catch 2009-2011 (%)
Zero catch	0.00	0.00	0.00	0	0	1358	51.6	-100
High long-term yield (E)	0.43	0.406	0.40	292	368	1114	24.3	26.0
Status quo	1.05	1.0	0.62	582	581	895	-0.1	99.0
Different scenarios	0.11	0.1	0.14	82	122	1288	43.8	-58.2
	0.21	0.2	0.25	155	220	1225	36.7	-24.7
	0.32	0.3	0.33	224	300	1167	30.2	2.7
	0.42	0.4	0.40	289	365	1116	24.6	25.0
	0.53	0.5	0.45	346	419	1070	19.4	43.5
	0.63	0.6	0.50	402	465	1028	14.7	59.2
	0.74	0.7	0.54	452	502	990	10.5	71.9
	0.84	0.8	0.57	498	533	956	6.7	82.5
	0.95	0.9	0.60	541	559	923	3.0	91.4
	1.16	1.1	0.64	620	601	870	-2.9	105.8
	1.26	1.2	0.67	655	620	846	-5.6	112.3
	1.37	1.3	0.68	688	635	825	-7.9	117.5
	1.47	1.4	0.70	718	648	805	-10.2	121.9
	1.58	1.5	0.71	747	661	788	-12.1	126.4

Weights are in tons.

6.22. Anchovy (Engraulis encrasicolus) in GSA 6

6.22.1. *Short term prediction 2010-2012*

6.22.1.1. Method and justification

The use of yield-per-recruit analysis for estimating targets for long-term management of pelagic fisheries has been discouraged (Patterson, 1992) because 1) the exploitation rate is very sensitive to M values and 2) in many cases, yield-per-recruit gives rise to flat-topped curves. As an alternative, the threshold F/Z = 0.4 has been adopted as biological reference point for small pelagics (Patterson, 1992) and this was also adopted by SGMED.

Consequently, instead of using the F_{ref} obtained with the yield-per-recruit analysis, an alternative F_{ref} was calculated from the following formula: F_{ref}=E·M/(1-E), where E is the exploitation rate and M is the natural mortality. Along with E=0.4, we used a mean M to calculate this new Fref.

Although a deterministic short term prediction could not be used based on the F_{ref} obtained with a yield-per-recruit analysis, the new F_{ref} were used for predictions using the EXCEL spreadsheet provided by JRC IPSC (H.-J. Rätz), which takes into account the catch and landings in numbers and weight and the discards. The projection is based on the results of the Extended Survivor Analyses (XSA, Darby and Flatman, 1994) stock assessment performed during the SGMED 10-02 meeting.

6.22.1.2. Input parameters

The following input data have been used for the short term projection of the anchovy stock in GSA 6:

Maturity

Period	Age	0	1	2	3
2002-2009	Prop. Matures	0.50	0.89	1	1

M vector

Period	Age	0	1	2	3
2002-2009	M	1.17	0.43	0.32	0.27

F vector

F	0	1	2	3
2009	0.19	0.61	1.88	0.90

The new F_{ref} was obtained using the mean M=0.64 and E=0.4, which gives an F_{ref}=0.43.

Weight-at-age in the stock

Mean weight (kg)	0	1	2	3
2007-2009	0.015	0.019	0.024	0.028

Weight-at-age in the catch

Mean weight (kg)	0	1	2	3
2007-2009	0.015	0.019	0.024	0.028

Number at age in the stock

N (thousands)	0	1	2	3
2010	1213205	356315	208617	21888

Stock recruitment

Recruitment (class 0+) has been estimated as the geometric mean of the class 0+ estimated from 2002 to 2009. This estimate has been used in all years of the projection (2010-2012).

6.22.1.3. Results

Short-term implications

A short term projection (Table below), consistent with F_{ref}=0.43 (corresponding to the proposed management reference point E=0.4) for 2011 and assuming a recruitment of 1213205 (thousand) individuals, shows that:

- Fishing at the F_{stq} (0.89) generates a decrease of the catch of 34% from 2009 to 2011 along with a decrease of the spawning stock biomass of 5% from 2011 to 2012.
- Fishing at F_{ref} (0.43) for the same time frame (2009-2012) generates a decrease of the catch of 55% from 2009 to 2011 and a spawning stock biomass increase of 8% from 2011 to 2012.

Consequently, SGMED recommends that the catch level of 3594 t should not be exceeded in 2011, corresponding to F_{ref} = 0.43.

Outlook until 2012

Short term forecast for different F scenarios computed for anchovy in GSA 6.

Basis: F(2010) = mean (F_{bar} 0-2 2009); Catch (2010): 8573 t; R (2010) = GM (2002–2009) = 1213205 (thousands); F_{ref} (2010) = 0.89; SSB (2011) = 18314 t

Rationale	F scenario	F factor	E	Catch 2011	Catch 2012	SSB 2012	Change SSB 2011-2012 (%)	Change Catch 2009-2011 (%)
Zero catch	0.00	0.0	0.000	0	0	22706	24.0	-100
High long-term yield (E)	0.4267	0.4794	0.400	3594	4364	19739	7.8	-55.5
Status quo	0.8900	1.0	0.582	6788	6502	17324	-5.4	-33.7
Different scenarios	0.0890	0.1	0.122	980	1436	21875	19.4	-85.4
	0.1780	0.2	0.218	1868	2571	21136	15.4	-73.8
	0.2670	0.3	0.294	2672	3472	20478	11.8	-64.6
	0.3560	0.4	0.357	3408	4195	19888	8.6	-57.3
	0.4451	0.5	0.410	4083	4779	19355	5.7	-51.3
	0.5340	0.6	0.455	4705	5258	18872	3.0	-46.4
	0.6230	0.7	0.493	5283	5653	18434	0.7	-42.4
	0.7120	0.8	0.527	5819	5983	18032	-1.5	-39.0
	0.8011	0.9	0.556	6320	1436	17664	-3.5	-36.2
	0.9790	1.1	0.605	7229	6711	17009	-7.1	-31.6
	1.0681	1.2	0.625	7646	6893	16717	-8.7	-29.8
	1.1571	1.3	0.644	8039	7054	16443	-10.2	-28.1
	1.2460	1.4	0.661	8412	7200	16188	-11.6	-26.6
	1.3351	1.5	0.676	8768	7333	15948	-12.9	-25.3

Weights are in tons.

6.23. Anchovy (Engraulis encrasicolus) in GSA 17

6.23.1. *Short term prediction 2010-2012*

6.23.1.1. Method and justification

Short term predictions for 2010 and 2012 were implemented in R (www.r-project.org) using the FLR libraries and based on the results of the Laurec-Shepherd tuned VPA that was applied for anchovy stock in GSA 17 in the framework of the GFCM-WG on small pelagic of 2010 (www.gfcm.org).

6.23.1.2. Input parameters

The input parameters for projection of catch biomass were adopted from the most recent GFCM SAC assessment of anchovy in GSA 17. The interpretation of the results shall consider the specific SGMED-10-03 comments given in section 5.1 of this report.
The following data have been used to derive the input data for the short term projection of the anchovy stock in GSA 17:

Maturity and M vectors

PERIOD	Age	0	1	2	3	4
2004-2009	Prop. Matures	0.50	0.75	1.00	1.00	1.00

PERIOD	Age	0	1	2	3	4	Mean M ages 1-3
2004-2009	M	1.02	0.82	0.67	0.57	0.54	0.69

F vector

F	0	1	2	3	4
2004	0.05	0.34	0.55	0.36	0.36
2005	0.05	0.25	0.54	0.36	0.36
2006	0.05	0.16	0.36	0.39	0.39
2007	0.01	0.15	0.58	0.38	0.38
2008	0.01	0.1	0.69	0.29	0.29
2009	0.02	0.12	0.31	0.48	0.48

Several scenarios of constant harvest strategy were run, with variation of the mean F (F_{bar} ages 1-3) calculated as the average of the last 3 years.

Weight-at-age in the catch and in the stock

Kg	0	1	2	3	4
2004	0.007	0.009	0.009	0.009	0.008
2005	0.010	0.012	0.012	0.012	0.011
2006	0.015	0.016	0.017	0.016	0.014
2007	0.018	0.02	0.022	0.019	0.018
2008	0.023	0.023	0.024	0.026	0.022
2009	0.007	0.009	0.009	0.009	0.008

Number at age in the catch

Catch at age in numbers (thousands)	0	1	2	3	4
2004	937742	1566232	414941	82271	7881

2005	1270095	1534611	754955	90644	9803
2006	840354	1442839	784111	181755	84980
2007	348001	918557	1708298	303673	28836
2008	402565	1060100	1324708	290665	40427
2009	414062	1478567	1317734	268714	31303

Number at age in the stock

Stock at age in numbers (thousands)	0	1	2	3	4
2004	29497390	7744050	1308360	351040	33200
2005	40507050	10099450	2422760	386760	41300
2006	27180480	13879060	3473970	725000	334710
2007	46256720	9319710	5191730	1237960	116070
2008	54109780	16479940	3517970	1494310	205170
2009	36349670	19280350	6578570	904250	104030
2010	37880910	12847961	7531441	2469010	316431

Maturity, weight-at-age in the stock and weight-at-age in the catch were estimated as the mean of the last 3 years.

Stock recruitment

The recruitment used for the short term projection was estimated as the geometric mean from 2004-2009.

6.23.1.3. Results

SGMED advises that the short term prediction of catch and stock biomass of the stock of anchovy in GSA 17 and the specific management advice is conditional of the fact that the observed inconsistencies in the catch data (see section 5.1) can be resolved and and a re-assessment does not indicate significant changes in the resulting parameters of the stock assessment.
A short term projection (Table below), assuming an F_{stq} of 0.30 in 2010 and a constant recruitment of 37880909 (thousands) individuals, shows that:

- Fishing at the F_{stq} (0.30) from 2009 to 2011 generates an increase in the catches of 15% and a spawning stock biomass decrease of 1.4% from 2011 to 2012.
- Fishing with a 50% reduction of F_{stq} (F = 0.17) generates a decrease in the catches of 38% from 2009 to 2011 and a spawning stock biomass increase of 3.4 % from 2011 to 2012.
- The precautionary reference point of E (0.4) as suggested by Patterson (1998) and endorsed by SGMED-10-02 was used in order to comment the short terms implications of the different exploitation scenarios. Taking into consideration age groups from 1 to 3, such value of exploitation pattern corresponds to a fishing mortality of 0.46, considering an average value of natural mortality of 0.69.
- Based on these results the SGMED-10-03 suggests that catch in 2011 should not exceed 75,000 t, that correspond to E (0.4).

Outlook until 2012

Short term forecast for different F scenarios computed for anchovy in GSA 17.

Basis: F (2010) = mean (F2007–2009) = 0.30; R (2010) = GM (2004–2009) = 37880909 (thousands); Catch (2010) = 53653 t and F_{stq} (2010) = 0.30; SSB (2011) = 430302 t

Rationale	F scenario	F factor	Catch 2011	Catch 2012	SSB 2012	Change SSB 2011-2012 (%)	Change Catch 2009-2011 (%)
zero catch	0	0	0	0	456641	9.1	-100
Exploitation pattern of 0.4	0.46	1.5	74629	65702	395337	-5.6	62.6
Status quo	0.30	1.0	53058	51005	412639	-1.4	15.6
Different scenarios	0.03	0.1	6013	6989	451564	7.9	-86.9
	0.06	0.2	11852	13460	446654	6.7	-74.2
	0.09	0.3	17525	19456	441904	5.6	-61.8
	0.12	0.4	23037	25015	437308	4.5	-49.8
	0.15	0.5	28395	30174	432859	3.4	-38.1
	0.18	0.6	33604	34964	428553	2.4	-26.8
	0.21	0.7	38669	39416	424383	1.4	-15.8
	0.24	0.8	43597	43557	420344	0.4	-5
	0.27	0.9	48392	47412	416431	-0.5	5.4
	0.33	1.1	57602	54355	408963	-2.3	25.5
	0.36	1.2	62026	57483	405400	-3.2	35.1
	0.39	1.3	66336	60406	401943	-4	44.5
	0.42	1.4	70536	63141	398591	-4.8	53.7
	0.49	1.6	78619	68104	392179	-6.3	71.3
	0.52	1.7	82511	70358	389114	-7	79.8
	0.55	1.8	86306	72476	386137	-7.8	88
	0.58	1.9	90010	74469	383245	-8.4	96.1
	0.61	2.0	93625	76347	380435	-9.1	104
	0.64	2.1	97154	78119	377704	-9.8	111.7

Weights in ‘t.

6.23.2. *Medium term prediction*

6.23.2.1. Method and justification

Medium term predictions for a 10 and 5 years periods were implemented in R (www.r-project.org) using the FLR libraries and based on the results of the previous assessment using the FLXSA- FLR library. The predictions were conducted assuming a progressive increase in F in 2020 and 2015 towards the reference point E(0.4) suggested by Patterson (1998) and endorsed by SGMED-10-02. The stock-recruitment relationship used was based on the Ricker model for the estimated SSB from 2004 to 2009. Runs were made with 500 simulations, using a log-normally distributed recruitment noise with a mean of 1 and a standard deviation of 0.3.

6.23.2.2. Input parameters

The input parameters were the same as the ones used in the short term forecast.

6.23.2.3. Results

In Figure 6.23.2.3.1, 5^{th}, 25^{th}, 50^{th}, 75^{th} and 95^{th} percentile are showed for the SSB, recruitment and catches from 2010 to 2020, considering an increase of the F_{stq} in order to obtain an E 0.4 (F = 0.46) in 2020.

In Figure 6.23.2.3.2, 5^{th}, 25^{th}, 50^{th}, 75^{th} and 95^{th} percentile are showed for the SSB, recruitment and catches from 2010 to 2020, considering an increase of the F_{stq} in order to obtain an E 0.4 (F = 0.46) in 2015.

Under the aforementioned assumptions, the model predicts a constant trend for the SSB, recruitment and catch.

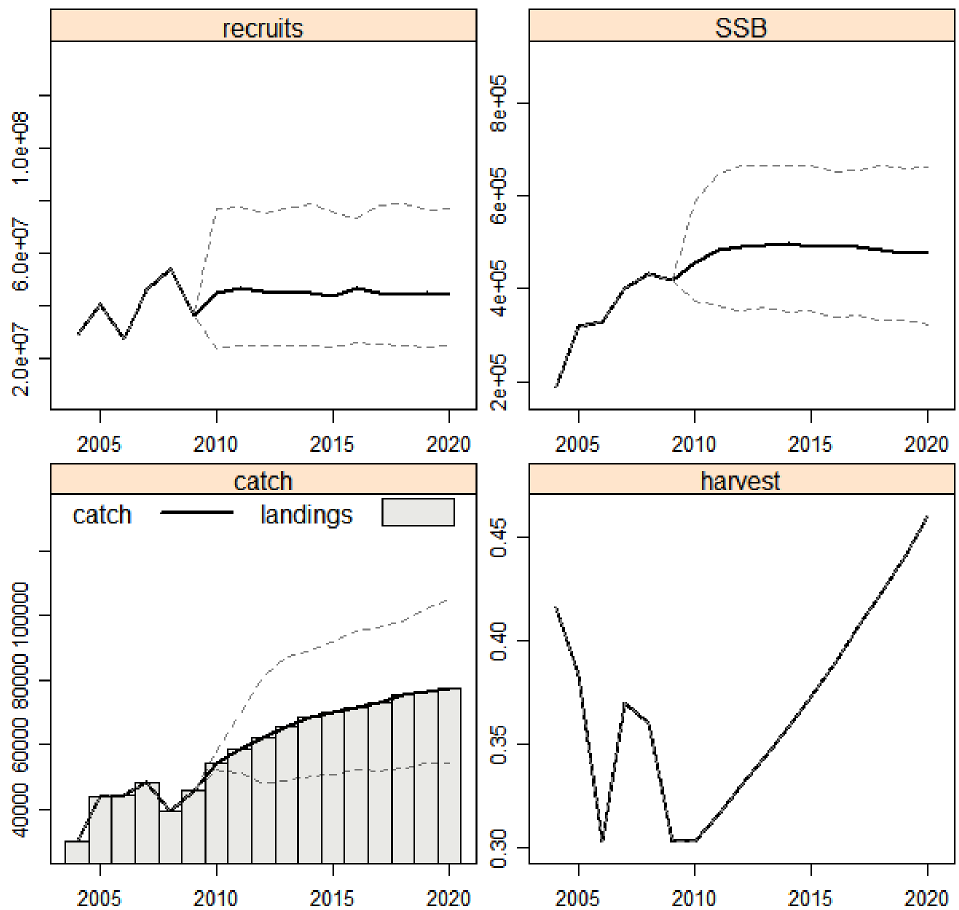


Fig. 6.23.2.3.1 – Output of the medium term forecast computed for sardine in GSA 17 based on a scenario for the reduction of F towards the E (0.4) progressively up to 2020.

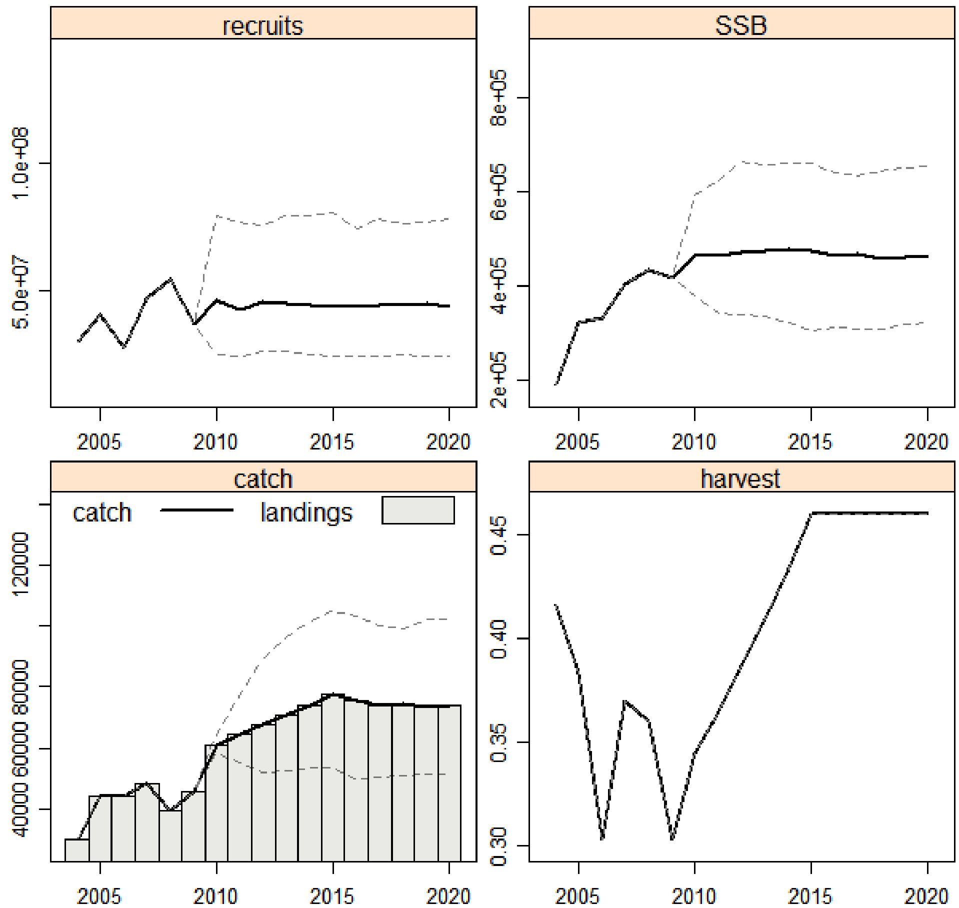


Fig. 6.23.2.3.2 – Output of the medium term forecast computed for sardine in GSA 17 based on a scenario for the reduction of F towards the E(0.4) progressively up to 2015.

Data consistency

In the period 2004-2007, total catch data used in the assessment and in the forecasts were lower than the official data collected by Italy and Slovenia in the framework of the Data Collection Regulation coupled with the Croatian statistics.
The same comparison considering the catch at age data was impossible as the combined data set (i.e. all countries together) was available only.

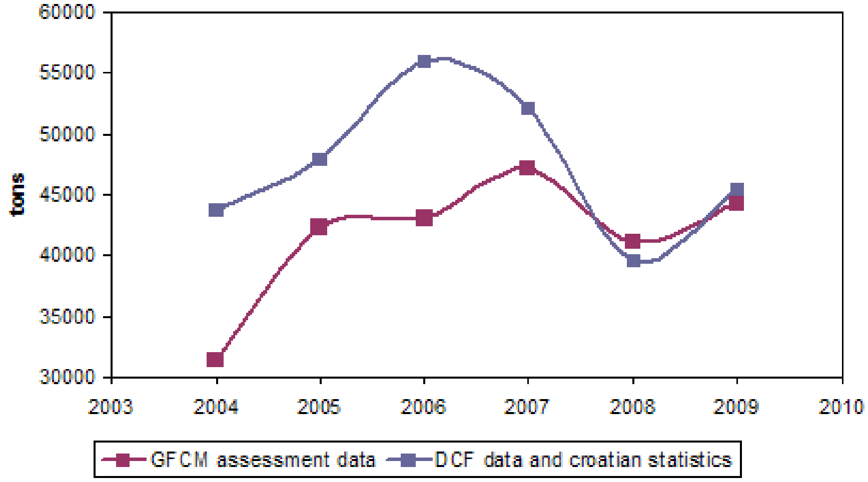


Fig. 6.23.2.3.3 Anchovy data in GSA 17.

6.24. Anchovy (Engraulis encrasicolus) in GSA 20

6.24.1. *Short term prediction 2009-2011*

6.24.1.1. Method and justification

Short term predictions for 2009 and 2010 were implemented in R (www.r-project.org) using the FLR libraries and based on the results of the Extended Survivors Analysis (XSA) (Shepherd, 1992) that was applied for anchovy stock in GSA 20 in the framework of the SGMED-10-02 using the FLXSA FLR library.

6.24.1.2. Input parameters

Due to a lack of data SGMED was unable to provide an update of the prediction of catch and biomass for the period 2010-2012. Using available data, SGMED provides the short term prediction for the period 2009-2011.

The following data have been used to derive the input data for the short term projection of the anchovy stock in GSA 20:

Maturity

PERIOD	Age	0	1	2	3	4
2000-2008	Prop. Matures	0.00	0.4	0.98	1.0	1.0

M vectors

PERIOD	Age	0	1	2	3	4
2000-2008	M	1.50	1.00	0.74	0.66	0.62

F vector

F	0	1	2	3	4
2000	0.001	0.001	0.001	0.001	0.001
2001	0.187	0.141	0.116	0.194	0.194
2002	1.149	0.743	0.614	1.021	1.023
2003	1.502	0.270	0.222	0.370	0.371
2004	0.836	0.297	0.245	0.408	0.409
2005	0.836	0.297	0.245	0.408	0.409
2006	0.001	0.001	0.000	0.001	0.001
2007	0.187	0.141	0.116	0.194	0.194
2008	1.149	0.743	0.614	1.021	1.023

Weight-at-age in the stock

Mean weight in stock	0	1	2	3	4
kg	0.0085	0.0141	0.0169	0.0207	0.0269

Weight-at-age in the catch

Mean weight in catch	0	1	2	3	4
kg	0.0085	0.0141	0.0169	0.0207	0.0269

Number at age in the catch

Catch at age in numbers	0	1	2	3	4

(thousands)					
2000	606	22401	31507	2789	308
2001	103	8425	15844	2210	420
2002	68	8310	15117	1862	319
2003	93	41266	71228	6856	864
2004	1196	6264	3271	222	11
2005	2060	35348	33465	2893	368
2006	1400	24016	22736	1965	250
2007	185	7185	10602	1234	237
2008	720	27946	41237	4801	924

Number at age in the stock

Stock at age in numbers (thousands)	0	1	2	3	4
2000	557790	138010	57945	6794	750
2001	1140500	124200	38036	7874	1496
2002	484750	254430	40832	7962	1364
2003	700840	108130	88783	9692	1221
2004	770850	156340	17302	1567	78
2005	634510	171480	53887	6087	774
2006	965640	140690	43138	5105	649.47
2007	672950	214860	38124	6262	1203
2008	635180	150080	74880	11236	2162

Maturity, weight-at-age in the stock and weight-at-age in the catch were estimated as the mean of the last 3 years. F and M before spawning were considered the same as the one considered in the XSA. Several scenarios with different harvest strategy were run, with F_{stq} (F_{bar} ages 1-3) calculated as the average of the last 3 years, but rescaled to the F of 2008 in order to account for the recent decreasing trend in the fishing mortality pattern.

Stock recruitment

The recruitment used for the short term projection was estimated as the geometric mean from 2000-2008.

6.24.1.3. Results

A short term projection (Table below), assuming an F_{stq} of 0.813 in 2009 and a recruitment of 706099 (thousand) individuals, shows that:

- Fishing at the F_{stq} (0.813) between 2008 to 2011 generates a decrease in the catch of 32.4% in 2011 maintaining the spawning stock biomass at the same level (0.01% increase) from the year 2010 to 2011.
- Reducing F at 30% of the F_{stq} (0.57) that corresponds to the E (0.4) results into a 49% decrease of the catches in 2010 and a 44% decrease in 2011 associated with an increase in spawning stock biomass of 8.5% from the year 2010 to 2011.

Based on these short term predictions results, SGMED suggests that catch in 2011 should not exceed 733 t, corresponding to E (0.4).

Outlook until 2011

Short term forecast in different F scenarios computed for anchovy in GSA 20.

Basis: F(2009) = mean (F2006–2008) scaled to 2008 = 0.814; R (2009) = GM (2000–2008) = 706099 (thousands); Landings (2009) = 885 ton and F_{stq} (2009) = 0.814; SSB (2011) = 850 t

Rationale	F scenario	F factor	Catch 2010	Catch 2011	E 2010	SSB 2011	Change SSB 2010-2011 (%)	Change Catch 2009-2010 (%)	Change Catch 2009-2011 (%)
zero catch	0.00	0	0	0	0.00	1608	41	-100	-100
Status quo	0.81	1	869	884	0.48	850	0	-34	-32
Different scenarios	0.00	0	0	0	0.00	1608	41	-100	-100
	0.08	0.1	115	158	0.10	1492	35	-91	-88
	0.16	0.2	223	293	0.17	1387	30	-83	-78
	0.24	0.3	323	408	0.24	1294	25	-75	-69
	0.33	0.4	416	508	0.29	1210	20	-68	-61
	0.41	0.5	504	594	0.33	1134	16	-62	-55
	0.49	0.6	586	668	0.37	1065	12	-55	-49
	0.57	0.7	663	733	0.40	1003	9	-49	-44
	0.65	0.8	736	790	0.43	947	5	-44	-40
	0.73	0.9	804	840	0.46	896	3	-39	-36
	0.81	1	869	884	0.48	850	0	-34	-32
	0.89	1.1	930	924	0.50	808	-2	-29	-29
	0.98	1.2	988	959	0.52	769	-4	-24	-27
	1.06	1.3	1044	991	0.54	734	-6	-20	-24
	1.14	1.4	1096	1020	0.55	701	-8	-16	-22
	1.22	1.5	1146	1047	0.57	672	-10	-12	-20
	1.30	1.6	1194	1071	0.58	644	-11	-9	-18
	1.38	1.7	1239	1094	0.60	619	-12	-5	-16
	1.46	1.8	1283	1114	0.61	596	-13	-2	-15
	1.55	1.9	1325	1134	0.62	574	-14	1	-13
	1.63	2	1365	1152	0.63	554	-15	4	-12

Weights in tonnes.

1) SSB 2011 relative to SSB 2010. SSB estimates refer to the middle of the year.

2) Landings in 2010 relative to landings in 2009.

6.24.2. *Medium term prediction*

6.24.2.1.Method and justification

Medium term predictions for a 10 years period were implemented in R (www.r-project.org) using the FLR libraries and based on the results the Extended Survivors Analysis (XSA) for stock assessment (Shepherd, 1992) that was applied for anchovy stock in GSA 20 in the framework of the SGMED-10-02 using the FLXSA FLR library. The predictions were conducted assuming a progressive decrease in F towards the F corresponding to E 0.4 in 2015 or 2020. The stock-recruitment relationship used was based on the Ricker model using data from 2000 to 2008. Runs were made with 500 simulations, using a log-normally distributed recruitment noise with a mean of 1 and a standard deviation of 0.3.

6.24.2.2. Input parameters

The input parameters were the same as the ones used in the short term forecast.

6.24.2.3. Results

In Figure 6.24.2.3.1, 5th, 25th, 50th, 75th and 95th percentile are showed for SSB, recruitment and catches from 2000 to 2020, considering a progressive decrease of F towards F that corresponds to E(0.4) in 2015 and remaining at this level for the projected period. Under these assumptions the model predicts an increase in SSB, whereas recruitment remains rather stable. The SSB remains around 1100 t after 2015, associated with catches being approximately at the level of 800 t.

Similarly, in Figure 6.24.2.3.2 5th, 25th, 50th, 75th and 95th percentile are showed for SSB, recruitment and catches from 2000 to 2020, considering a progressive decrease of F towards F that corresponds to E(0.4) in 2020. Under this scenario the model predicts a smaller increase in SSB, remaining around 1000 t from 2010 to 2020 associated with catches being approximately at the level of 850 t.

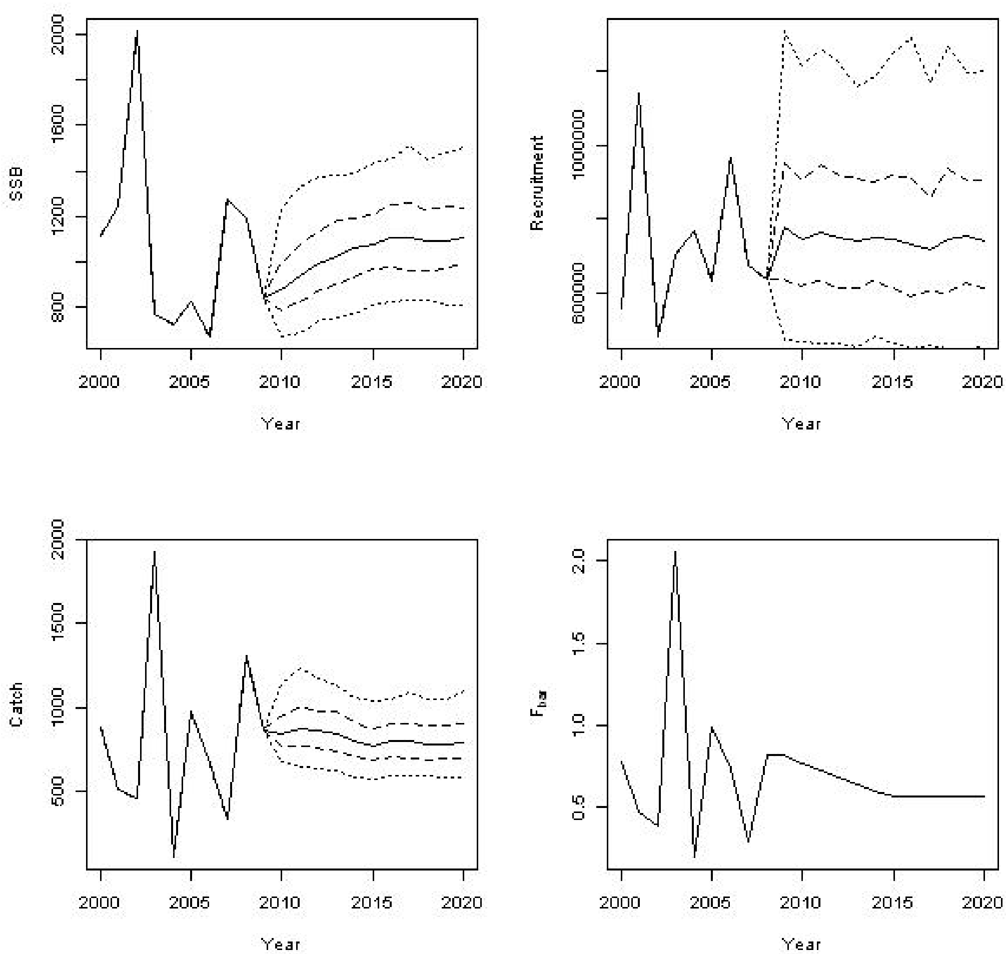


Fig. 6.24.2.3.1 Output of the medium term forecast computed for anchovy in GSA 20 based on a scenario with a progressive reduction of F towards E(0.4) in 2015 and remaining at this level up to 2020.

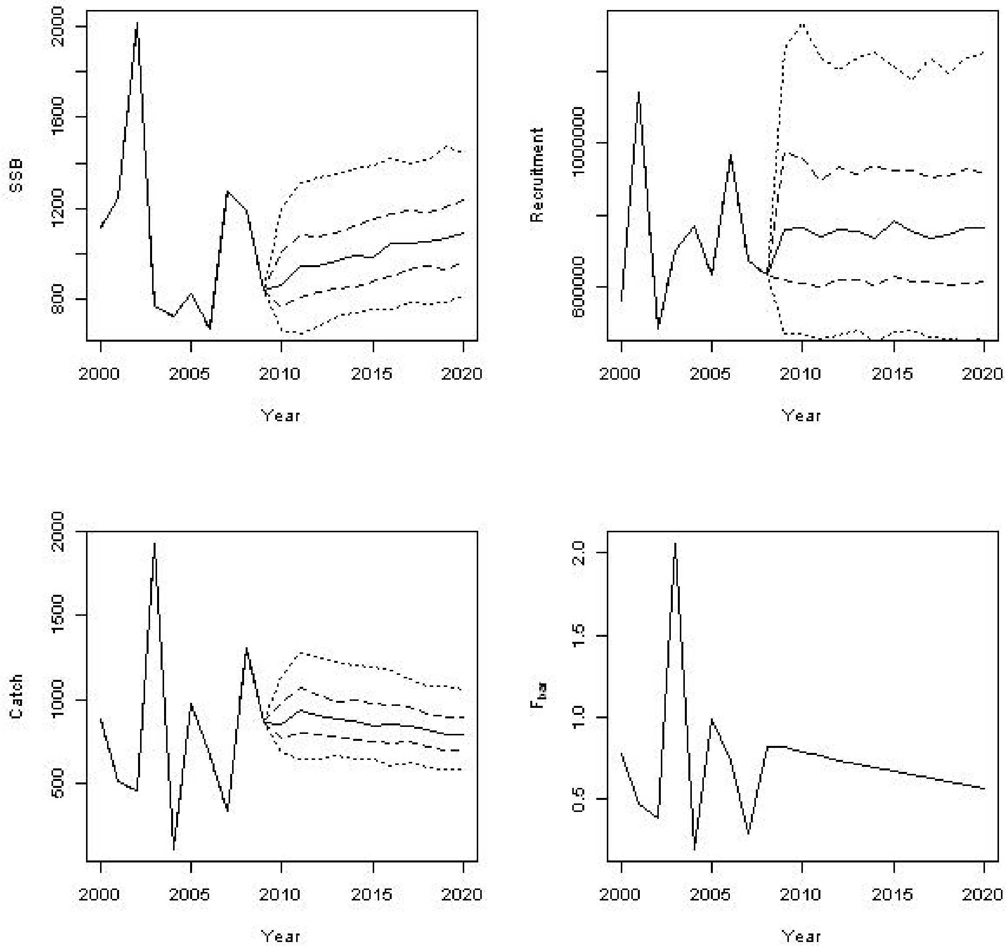


Fig. 6.24.2.3.2 Output of the medium term forecast computed for anchovy in GSA 20 based on a scenario with a progressive reduction of F towards E(0.4) in 2020.

6.25. Sardine (*Sardina pilchardus*) in GSA 1

6.25.1. *Short term prediction 2010-2012*

6.25.1.1. Method and justification

The use of yield-per-recruit analysis for estimating targets for long-term management of pelagic fisheries has been discouraged (Patterson, 1992) because 1) the exploitation rate is very sensitive to M values and 2) in many cases, yield-per-recruit gives rise to flat-topped curves. As an alternative, the threshold F/Z = 0.4 has been adopted as biological reference point for small pelagics (Patterson, 1992) and this was also adopted by SGMED.

Consequently, instead of using the F_{ref} obtained with the yield-per-recruit analysis, an alternative F_{ref} was calculated from the following formula: $F_{ref}=E\cdot M/(1-E)$, where E is the exploitation rate and M is the natural mortality. Along with E=0.4, we used a mean M to calculate this new F_{ref}.

Although a deterministic short term prediction could not be used based on the F_{ref} obtained with yield-per-recruit analysis, the new F_{ref} were used for predictions using the EXCEL spreadsheet provided by JRC IPSC (H.-J. Rätz), which takes into account the catch and landings in numbers and weight and the discards. The projection is based on the results of the Extended Survivor Analyses (XSA, Darby and Flatman, 1994) performed during the SGMED 10-02 meeting.

6.25.1.2. Input parameters

The following data have been used to derive the input data for the short term projection of the sardine stock in GSA 1:

Maturity

Period	Age	0	1	2	3	4	5
2000-2009	Prop. Matures	0.34	0.9	0.99	1.00	1.00	1.00

M vector

Period	Age	0	1	2	3	4	5
2000-2009	M	1.17	0.44	0.32	0.27	0.25	0.24

F vector

F	0	1	2	3	4	5
2009	0.0945	0.1335	0.0983	0.2287	0.1265	0.1265

Weight-at-age in the stock

Mean weight (kg)	0	1	2	3	4	5
2007-2009	0.019	0.034	0.051	0.064	0.073	0.083

Weight-at-age in the catch

Mean weight (kg)	0	1	2	3	4	5
2007-2009	0.019	0.034	0.051	0.064	0.073	0.083

Number at age in the stock

N (thousands)	0	1	2	3	4	5
2010	1338897	355762	167338	82426	86456	66042

Stock recruitment

Recruitment (class 0+) has been estimated as the geometric mean of the class 0+ estimated from 2000 to 2009. This estimate has been used in all years 2010-2012.

6.25.1.3. Results

Short-term implications

A short term projection (Table below), consistent with F_{ref}=0.23 (equals the proposed management reference point E=0.4) for 2011 and assuming a recruitment of 1338897 (thousand) individuals, shows that:

- Fishing at the F_{stq} (0.15) generates a decrease of the catch of 0.8% from 2009 to 2011 along with an increase of the spawning stock biomass of 2.6% from 2011 to 2012.

- Fishing at F_{ref} (0.23) for the same time frame (2009-2012) generates an increase of the catch of 36% from 2009 to 2011 and a spawning stock biomass decrease of 2% from 2011 to 2012.

SGMED recommends that the catch level in 2011 should not exceed 8128 t, corresponding to E = 0.4

Outlook until 2012

Short term forecast for different F scenarios computed for sardine in GSA 1.

Basis: F (2010) = mean (F_{bar}1-3 2009); Catch (2010): 5475 t; R (2010) = GM (2000–2009) = 1338897 (thousands); F_{ref} (2010) = 0.15; SSB(2011) = 45968 t

Rationale	F scenario	F factor	E	Catch 2011	Catch 2012	SSB 2012	Change SSB 2011-2012 (%)	Change Catch 2009-2011 (%)
zero catch	0.00	0.0	0.000	0	0	52351	13.9	-100
High long-term yield (E)	0.2267	1.4767	0.400	8128	8067	44922	-2.3	36.1
Status quo	0.1535	1.0	0.311	5667	5881	47155	2.6	-0.8
Different scenarios	0.0154	0.1	0.043	601	681	51796	12.7	-88.5
	0.0307	0.2	0.083	1192	1337	51251	11.5	-77.4
	0.0461	0.3	0.119	1779	1973	50713	10.3	-66.7
	0.0614	0.4	0.153	2355	2588	50183	9.2	-56.3
	0.0768	0.5	0.400	2929	3185	49658	8.0	-46.3
	0.0921	0.6	0.213	3487	3760	49146	6.9	-36.6
	0.1075	0.7	0.213	4045	4319	48636	5.8	-27.1
	0.1228	0.8	0.265	4592	4856	48136	4.7	-18.1
	0.1382	0.9	0.289	5134	5378	47640	3.6	-9.2
	0.1689	1.1	0.332	6196	6369	46674	1.5	7.5
	0.1842	1.2	0.351	6718	6839	46201	0.5	15.4
	0.1996	1.3	0.370	7232	7295	45733	-0.5	23.1
	0.2149	1.4	0.387	7741	7737	45274	-1.5	30.6
	0.2303	1.5	0.404	8244	8165	44818	-2.5	37.8

Weights are in tons.

6.26. Sardine (*Sardina pilchardus*) in GSA 6

6.26.1. *Short term prediction 2010-2012*

6.26.1.1. Method and justification

The use of yield-per-recruit analysis for estimating targets for long-term management of pelagic fisheries has been discouraged (Patterson, 1992) because 1) the exploitation rate is very sensitive to M values and 2) in many cases, yield-per-recruit gives rise to flat-topped curves. As an alternative, the threshold F/Z = 0.4 has been adopted as biological reference point for small pelagics (Patterson, 1992) and this was also adopted by SGMED.

Consequently, instead of using the F_{ref} obtained with the yield-per-recruit analysis, an alternative F_{ref} was calculated from the following formula: $F_{ref} = E \cdot M/(1-E)$, where E is the exploitation rate and M is the natural mortality. Along with E=0.4, we used a mean M to calculate this new F_{ref}.

Although a deterministic short term prediction could not be used based on the F_{ref} obtained with yield-per-recruit analysis, the new F_{ref} were used for predictions using the EXCEL spreadsheet provided by JRC IPSC (H.-J. Rätz), which takes into account the catch and landings in numbers and weight and the discards. The projection is based on the results of the Extended Survivor Analyses (XSA, Darby and Flatman, 1994) performed during the SGMED 10-02 meeting.

6.26.1.2. Input parameters

The following data have been used to derive the input data for the short term projection of the sardine stock in GSA 6:

Maturity

Period	Age	0	1	2	3	4	5
2000-2009	Prop. Matures	0.38	0.85	0.99	1.00	1.00	1.00

M vector

Period	Age	0	1	2	3	4	5
2000-2009	M	1.20	0.46	0.34	0.29	0.26	0.25

F vector

F	0	1	2	3	4	5
2009	0.1249	0.68	1.40	1.52	0.94	0.94

Weight-at-age in the stock

Mean weight (kg)	0	1	2	3	4	5
2007-2009	0.022	0.029	0.038	0.048	0.059	0.069

Weight-at-age in the catch

Mean weight (kg)	0	1	2	3	4	5
2007-2009	0.022	0.029	0.038	0.048	0.059	0.069

Number at age in the stock

N (thousands)	0	1	2	3	4	5
2010	2097509	611190	99428	8595	906	2249

The new F_{ref} was obtained using a mean M=0.36 and E=0.4, which gives rise to F_{ref} =0.24.

Stock recruitment

Recruitment (class 0+) has been estimated as the geometric mean of the class 0+ estimated from 2000 to 2009. This estimate has been used in all years 2010-2012.

6.26.1.3. Results

Short-term implications

A short term projection (Table below), consistent with F_{ref} =0.24 (equals to the proposed management reference point E=0.4) for 2011 and assuming a recruitment of 2097509 (thousand) individuals, shows that:

- Fishing at the F_{stq} (1.12) generates an increase of the catch of 167% from 2009 to 2011 along with a decrease of the spawning stock biomass of 0.7% from 2011 to 2012.

- Fishing at F_{ref} (0.24) for the same time frame (2009-2012) generates an increase of the catch of 8% from 2009 to 2011 and a spawning stock biomass increase of 28% from 2011 to 2012.

The projected catch of sardine in GSA 6 for 2011 amounts to 4188 tons. Consequently, SGMED recommends that the catch level in 2011 should not exceed 4188 t, corresponding to E = 0.4.

Outlook until 2012

Short term forecast for different F scenarios computed for sardine in GSA 6.

Basis: F (2010) = mean (F_{bar}1-3 2009); Catch (2010): 15852 t; R (2010) = GM (2000–2009) = 2097509 (thousands); F_{ref}(2010) = 0.13; SSB (2011) = 37388 t

Rationale	F scenario	F factor	E	Catch 2011	Catch 2012	SSB 2012	Change SSB 2011-2012 (%)	Change Catch 2009-2011 (%)
zero catch	0.00	0.0	0.000	0	0	53913	38.3	-100
High long-term yield (E)	0.24	0.2	0.400	4188	6383	49829	27.8	7.7
Status quo	1.12	1.0	0.769	15623	15811	39251	0.7	166.8
Different scenarios	0.12	0.1	0.1199	2181	3563	51773	32.8	-39.9
	0.24	0.2	0.2398	4185	6379	49831	27.8	7.6
	0.36	0.3	0.3597	6026	8613	48065	23.3	45.3
	0.48	0.4	0.4796	7725	10394	46452	19.1	75.4
	0.60	0.5	0.5995	9295	11819	44980	15.3	99.4
	0.72	0.6	0.7194	10749	12969	43634	11.9	118.8
	0.84	0.7	0.8393	12100	13902	42399	8.7	134.6
	0.96	0.8	0.9592	13355	14661	41263	5.8	147.4
	1.08	0.9	1.0791	14528	15290	40217	3.1	158.0
	1.32	1.1	0.1199	16652	16249	38359	-1.6	174.2
	1.44	1.2	0.2398	17616	16623	37531	-3.8	180.5
	1.56	1.3	0.3597	18522	16942	36764	-5.7	185.9
	1.68	1.4	0.4796	19377	17220	36049	-7.6	190.6
	1.80	1.5	0.5995	20186	17465	35383	-9.3	194.7

Weights are in tons.

6.27. Sardine (*Sardina pilchardus*) in GSA 16

The absence of updated information on sardine stock acoustic biomass (echosurvey) in 2010 did not allow SGMED to accomplish short term predictions of catch and stock biomass for 2011. However, the application of the regression approach suggested at SGMED-09-03 meeting (Rätz & Cheilari, 2009), aiming at exploring the relationship between the series of acoustic biomass at year (t) and landings at year (t+1), already performed for short term predictions of sardine stock in GSA16 for 2009 and 2010 (see SGMED-09-03 Report), was firstly checked and then revisited including in the regression analysis updated (2009) total catch information that was not previously used as not yet available at that time. Actually, in SGMED-09-03 the regression analysis covered the periods 1998-2007 (biomass estimates) and 1999-2008 (landing data), whereas in the present run available data for the following years (2008 for biomass and 2009 for landings) were also included in the analysis.

Firstly, the output of the model fitted last year for year 2009 (estimated sardine landings = 1,988 t) was compared with total landings (1,874 t) estimated from Sciacca port census data, showing an overestimation of about 6%. The results of the updating of the regression model are summarized below, together with the results of the previous regression model (see also SGMED-09-03 Report), reported for comparisons purposes:

Table 6.27.1.

Model	SGMED	n	Intercept	slope	F	p	r	r^2
1	09-03	10	1667.63	0.026372	4.09	0.08	0.58	0.34
2	10-03	11	1647.72	0.026930	4.89	0.05	0.59	0.35

The resulting estimated landings are listed in Table 6.26.2.

Table 6.26.2.

Year	Estimated landings [tons] in SGMED-09-03 (model 1 of Tab. 6.26.1)	Estimated landings [tons] in SGMED-10-03 (model 2 of Tab. 6.26.1)
2009	1,988	1,975
2010	1,879	1,864

6.28. Sardine (*Sardina pilchardus*) in GSA 17

6.28.1. *Short term prediction 2010-2012*

6.28.1.1. Method and justification

Short term predictions for 2010 and 2012 were implemented in R (www.r-project.org) using the FLR libraries and based on the results of the Laurec-Shepherd tuned VPA that was applied for sardine stock in GSA 17 in the framework of the GFCM-WG on small pelagic of 2010 (www.gfcm.org).

6.28.1.2. Input parameters

The input parameters for projection of catch biomass were adopted from the most recent GFCM SAC assessment of anchovy in GSA 17. Such interpretation of the results shall consider the specific SGMED-10-03 comments given in section 5.2 of this report.
The following data have been used to derive the input data for the short term projection of the sardine stock in GSA 17:

Maturity and M vectors

PERIOD	Age	1	2	3	4	5	6
2004-2009	Prop. Matures	1.0	1.0	1.0	1.0	1.0	1.0

PERIOD	Age	1	2	3	4	5	6	Mean M ages 2-5
2004-2009	M	1.10	0.76	0.62	0.56	0.52	0.50	0.62

F vector

F	1	2	3	4	5	6
2004	0.05	0.27	0.50	0.23	0.47	0.47
2005	0.01	0.19	0.32	0.50	0.53	0.53
2006	0.01	0.10	0.45	0.36	0.52	0.52
2007	0.01	0.11	0.25	0.42	0.44	0.44
2008	0.03	0.11	0.21	0.39	0.39	0.39
2009	0.02	0.18	0.37	0.45	0.53	0.53

Weight-at-age in the catch and in the stock

Kg	1	2	3	4	5	6
2004	0.022	0.03	0.034	0.037	0.04	0.046
2005	0.024	0.029	0.034	0.038	0.041	0.045
2006	0.025	0.03	0.034	0.039	0.042	0.046
2007	0.023	0.029	0.032	0.038	0.041	0.048
2008	0.024	0.029	0.034	0.037	0.041	0.047
2009	0.023	0.028	0.033	0.035	0.039	0.048

Number at age in the catch

Catch at age in numbers (thousands)	1	2	3	4	5	6
2004	229349	437905	188641	12553	1724	1063
2005	79693	274008	196415	63490	11662	2621
2006	69530	193385	242056	86982	23361	551

2007	76402	228352	211308	80496	41446	1209
2008	182371	276715	195238	129803	29236	24779
2009	125601	413512	360053	165984	66248	30043

Number at age in the stock

Stock at age in numbers (thousands)	1	2	3	4	5	6
2004	7191420	2639900	631060	78300	5750	3510
2005	8947650	2268540	947010	206690	35460	7900
2006	9722680	2934730	880100	369950	71770	1680
2007	11220160	3198270	1244140	302650	147500	4270
2008	11201200	3692970	1344270	518720	113970	95770
2009	10756900	3628690	1543610	583750	201180	90480
2010	9724712	3509759	1417467	573569	212613	70400

Maturity, weight-at-age in the stock and weight-at-age in the catch were estimated as the mean of the last 3 years. Several scenarios of constant harvest strategy were run, with variation of the mean F (F_{bar} ages 2-5) calculated as the average of the last 3 years.

Stock recruitment

The recruitment used for the short term projection was estimated as the geometric mean from 2004-2009.

6.28.1.3. Results

SGMED advises that the short term prediction of catch and stock biomass of the stock of sardine in GSA 17 and the specific management advice is conditional of the fact that the observed changes in the recent selection (see section 5.2) can be resolved and and a re-assessment does not indicate significant changes in the resulting parameters of the stock assessment.

A short term projection (Table below), assuming an F_{stq} of 0.33 in 2010 and a constant recruitment of 9 724711(thousands) individuals, shows that:

- Fishing at the F_{stq} (0.33) from 2010 to 2011 generates a decrease in the catches of 6% and a spawning stock biomass decrease of 1.4% from 2011 to 2012.
- Fishing with a 50% reduction of F_{stq} (F = 0.17) generates a decrease in the catches of 49% from 2009 to 2011 and a spawning stock biomass increase of 1.7 % from 2011 to 2012.
- The precautionary reference point of E(0.4) as suggested by Patterson (1998) and endorsed by SGMED-10-02 was used in order to comment the short terms implications of the different exploitation scenarios. Taking into consideration age groups from 2 to 5, such value of exploitation pattern corresponds to a fishing mortality of 0.37, considering an average value of natural mortality of 0.62.
- Based on these results, SGMED suggests that catch in 2011 shall not exceed 37,000 t, which corresponds to E (0.4).

Outlook until 2012

Short term forecast for different F scenarios computed for sardine in GSA 17.

Basis: F (2010) = mean (F2007–2009) = 0.33; R (2010) = GM (2004–20059) = 9 724711 (thousands); Catch (2010) = 35847 t and F_{stq} (2010) = 0.33; SSB (2011) = 396144 t

Rationale	F scenario	F factor	Catch 2011	Catch 2012	SSB 2012	Change SSB 2011-2012 (%)	Change Catch 2009-2011 (%)
zero catch	0	0	0	0	416983	5.3	-100
Exploitation pattern of 0.4	0.37	1.1	36864	34716	388354	-2.0	1.9
Status quo	0.33	1.0	33957	32558	390562	-1.4	-6.2
Different scenarios	0.03	0.1	3847	4438	413936	4.5	-89.4
	0.07	0.2	7584	8553	410989	3.7	-79.0
	0.10	0.3	11215	12370	408138	3.0	-69.0
	0.13	0.4	14743	15914	405378	2.3	-59.3
	0.17	0.5	18172	19207	402707	1.7	-49.8
	0.20	0.6	21506	22270	400121	1.0	-40.6
	0.23	0.7	24748	25119	397616	0.4	-31.6
	0.27	0.8	27902	27774	395190	-0.2	-22.9
	0.30	0.9	30971	30249	392840	-0.8	-14.4
	0.37	1.1	36864	34716	388354	-2.0	1.9
	0.40	1.2	39694	36733	386214	-2.5	9.7
	0.43	1.3	42450	38621	384138	-3.0	17.3
	0.47	1.4	45135	40390	382125	-3.5	24.7
	0.50	1.5	47752	42049	380171	-4.0	32.0
	0.53	1.6	50302	43606	378276	-4.5	39.0
	0.57	1.7	52788	45071	376436	-5.0	45.9
	0.60	1.8	55212	46449	374650	-5.4	52.6
	0.63	1.9	57576	47748	372916	-5.9	59.1
	0.67	2.0	59882	48973	371231	-6.3	65.5

Weights in ‘t.

6.28.2. *Medium term prediction*

6.28.2.1. Method and justification

Medium term predictions for a 10 and 5 years periods were implemented in R (www.r-project.org) using the FLR libraries and based on the results of the previous assessment using the FLXSA- FLR library. The predictions were conducted assuming a progressive increase in F in 2020 and 2015 towards the reference point E(0.4) suggested by Patterson (1998) and endorsed by SGMED-10-02. The stock-recruitment relationship used was based on the Ricker model for the estimated SSB from 2004 to 2009. Runs were made with 500 simulations, using a log-normally distributed recruitment noise with a mean of 1 and a standard deviation of 0.3.

6.28.2.2. Input parameters

The input parameters were the same as the ones used in the short term forecast.

6.28.2.3. Results

In Figure 6.28.2.3.1a, 5^{th}, 25^{th}, 50^{th}, 75^{th} and 95^{th} percentile are showed for the SSB, recruitment and catches from 2010 to 2020, considering an increase of the F_{stq} in order to obtain an E 0.4 (F = 0.37) in 2020.

In Figure 6.28.2.3.1b, 5^{th}, 25^{th}, 50^{th}, 75^{th} and 95^{th} percentile are showed for the SSB, recruitment and catches from 2010 to 2020, considering an increase of the F_{stq} in order to obtain an E 0.4 (F = 0.37) in 2015.

Under the aforementioned assumptions, the model predicts a constant trend for the SSB, recruitment and catch.

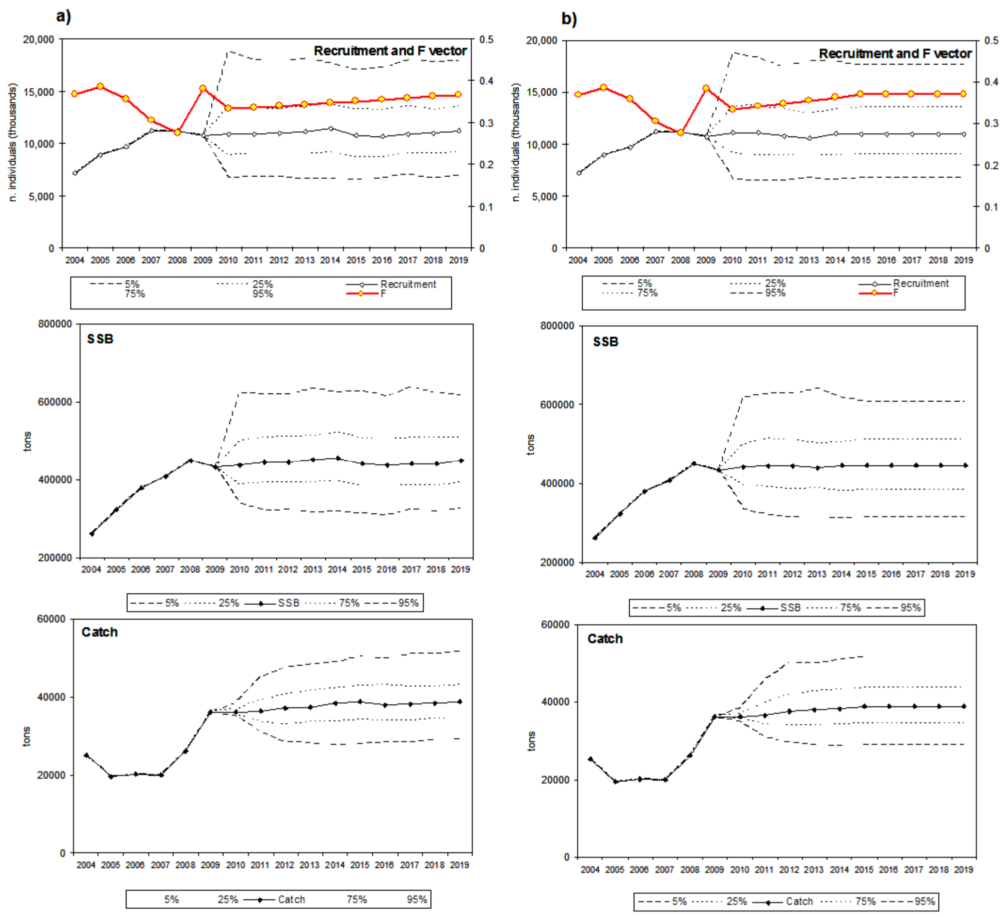


Fig. 6.28.2.3.1 – Output of the medium term forecast computed for sardine in GSA 17 based on a scenario for the reduction of F towards the E(0.4) progressively up to 2020 (a) and 2015 (b).

Data consistency

Total catch data used in the assessment and in the forecasts showed a good agreement with the official data collected by Italy and Slovenia in the framework of the Data Collection Regulation, combined with the national Croatian catch data. The same comparison considering the catch at age data was impossible as the combined data set (i.e. all countries together) was available only. However, SGMED noted incongruence in the selection pattern between the assessed period (2004-2009) and the previous years, when the age group 1 was well represented in the catches. Moreover the GFCM assessment did not consider the 0+ age group, which represents more than 20% in numbers of the stock in the Italian and Slovenian DCF data, nor data from sardine fry fisheries.

6.29. Sardine (*Sardina pilchardus*) in GSA 20

6.29.1. *Short term prediction 2009-2011*

6.29.1.1. Method and justification

Short-term predictions for 2009 and 2010 were implemented in R (www.r-project.org) using the FLR libraries and based on the results of the Extended Survivors Analysis (XSA) (Shepherd, 1992) that was applied for sardine stock in GSA 20 in the framework of the SGMED-10-02 using the FLXSA FLR library.

6.29.1.2. Input parameters

Due to a lack of data SGMED was unable to provide an update of the prediction of catch and biomass for the period 2010-2012. Using available data, SGMED provides the short term prediction for the period 2009-2011.

The following data have been used to derive the input data for the short term projection of the sardine stock in GSA 20:

Maturity

PERIOD	Age	0	1	2	3	4
2000-2008	Prop. Matures	0.0	0.4	1.0	1.0	1.0

M vectors

PERIOD	Age	0	1	2	3	4
2000-2008	M	1.50	0.96	0.69	0.61	0.57

F vector

F	0	1	2	3	4
2000	0.059	0.748	0.729	0.739	0.739
2001	0.024	0.696	0.643	0.669	0.669
2002	0.018	0.479	0.711	0.595	0.595
2003	0.028	0.942	0.863	0.903	0.903
2004	0.030	0.383	0.582	0.481	0.481
2005	0.079	0.814	1.105	0.923	0.923
2006	0.004	0.671	0.728	0.664	0.664
2007	0.001	0.133	0.296	0.264	0.264
2008	0.027	0.560	0.738	0.649	0.649

Weight-at-age in the stock

Mean weight in stock	0	1	2	3	4
kg	0.0134	0.0201	0.0239	0.0290	0.0424

Weight-at-age in the catch

Mean weight in catch	0	1	2	3	4
kg	0.0134	0.0201	0.0239	0.0290	0.0424

Number at age in the catch

Catch at age in numbers (thousands)	0	1	2	3	4

2000	10838	29650	5827	1376	1006
2001	6085	25971	5317	1368	1008
2002	5320	27057	5579	1366	1007
2003	8615	52229	11066	1671	1010
2004	14333	27159	6086	1565	1023
2005	27347	76349	17269	2448	1037
2006	2192	47190	13234	2099	1029
2007	1304	19115	5250	1449	1013
2008	14252	118828	31000	3842	1094

Number at age in the stock

Stock at age in numbers (thousands)	0	1	2	3	4
2000	363087	82655	14967	3393	2481
2001	489024	76379	14972.9	3622	2669
2002	565639	106502	14582	3949	2911
2003	594141	123924	25251	3591	2171
2004	925885	128872	18491	5341	3491
2005	691248	200440	33643	5184	21962
2006	1059530	142567	34015	5589	2740
2007	1851480	235469	27896	8238	5759
2008	1036855	412559	78892	10407	2963

Maturity, weight-at-age in the stock and weight-at-age in the catch was estimated as the mean of the last 3 years. F and M before spawning were considered the same as used in XSA.

Several scenarios with different harvest strategy were run, with F_{stq} (F_{bar} ages 1-3) calculated as the average of the last 3 years, but scaled to the F of 2008 in order to account for the recent decreasing trend in the fishing mortality pattern.

Stock recruitment

The recruitment used for the short term projection was estimated as the geometric mean from 2000-2008.

6.29.1.3. Results

A short term projection, assuming an F_{stq} of 0.65 in 2009 and a constant recruitment of 752838 (thousands) individuals, shows that:

- Fishing at F_{stq} (0.65) from 2008 to 2011 generates a decrease in the catches of 37% in 2010 and of 43% in 2011 and a spawning stock biomass decrease of 13% from 2010 to 2011.
- Fishing with a 20% reduction of F_{stq} (F=0.5) from 2008 to 2011, that corresponds to E(0.4), generates a decrease in the catches of 47% in 2010 and 49% in 2011 and a spawning stock biomass decrease of 6% from 2010 to 2011.

Based on these results, SGMED suggests that catch in 2011 should not exceed 1500 t, corresponding to E(0.4).

Outlook until 2011

Short term forecast in different F scenarios computed for sardine in GSA 20.

Basis: F (2009) = mean (F2006–2008) scaled to 2008 = 0.65; R (2009) = GM (2000–2008) = 706099 (thousands); Landings (2009) = 2567 t and F_{stq} (2009) = 0.65; SSB (2011) = 1780 t

Rationale	F scenario	F factor	Catch 2010	Catch 2011	E 2010	SSB 2011	Change SSB 2010-2011 (%)	Change Catch 2009-2010 (%)	Change Catch 2009-2011 (%)
zero catch	0.00	0	0	0	0.00	3433	30	-100	-100.00
Status quo	0.65	1	1942	1756	0.47	1780	-13	-37	-49
Different scenarios	0.00	0	0	0	0.00	3433	30	-100	-100
	0.06	0.1	241	285	0.08	3201	24	-92	-91
	0.13	0.2	470	537	0.15	2987	19	-85	-82
	0.19	0.3	687	759	0.21	2790	14	-78	-75
	0.26	0.4	894	957	0.26	2608	10	-71	-69
	0.32	0.5	1091	1131	0.31	2441	5	-64	-63
	0.39	0.6	1278	1287	0.35	2287	1	-58	-58
	0.45	0.7	1456	1425	0.38	2145	-3	-52	-53
	0.52	0.8	1626	1548	0.41	2013	-6	-47	-49
	0.58	0.9	1788	1658	0.44	1892	-10	-42	-46
	0.65	1	1942	1756	0.47	1780	-13	-37	-42
	0.71	1.1	2089	1844	0.49	1676	-16	-32	-40
	0.78	1.2	2230	1923	0.51	1580	-19	-27	-37
	0.84	1.3	2364	1994	0.53	1492	-21	-23	-35
	0.91	1.4	2492	2059	0.55	1409	-24	-19	-33
	0.97	1.5	2615	2117	0.57	1333	-26	-15	-31
	1.04	1.6	2732	2170	0.58	1262	-28	-11	-29
	1.10	1.7	2844	2219	0.60	1196	-30	-7	-28
	1.17	1.8	2952	2263	0.61	1135	-32	-4	-26
	1.23	1.9	3054	2304	0.62	1078	-34	0	-25

Weights in ‘000t.

1) SSB 2011 relative to SSB 2010. SSB is estimated at the middle of the year.

2) Landings 2010 relative to Landing 2009.

6.29.2. *Medium term prediction*

6.29.2.1. Method and justification

Medium term predictions for a 10 years period were implemented in R (www.r-project.org) using the FLR libraries and based on the results of the Extended Survivors Analysis (XSA) for stock assessment (Shepherd, 1992) using the FLXSA- FLR library. The predictions were conducted assuming a progressive decrease in F towards the F corresponding to E 0.4 in 2015 or 2020. The stock-recruitment relationship used was based on the Ricker model using data from 2000 to 2008. Runs were made with 500 simulations, using a log-normally distributed recruitment noise with a mean of 1 and a standard deviation of 0.3.

6.29.2.2. Input parameters

The input parameters were the same as the ones used in the short term forecast.

6.29.2.3. Results

In Figure 6.29.2.3.1, 5th, 25th, 50th, 75th and 95th percentile are showed for SSB, recruitment and catches from 2000 to 2020, considering a progressive decrease of F towards F that corresponds to E(0.4) in 2015 and remaining at this level for the rest of the projected period.

Under the aforementioned assumptions, the model predicts an increase for SSB and a slight increase in recruitment. The SSB increases from 2800 to 3500 t, associated with catches being approximately at the level of 2550 t.

Similarly, in Figure 6.29.2.3.2 5th, 25th, 50th, 75th and 95th percentile are showed for SSB, recruitment and catches from 2000 to 2020, considering a progressive decrease of F towards F that corresponds to E(0.4) in 2020. Under this scenario, the model predicts an increase in SSB from t from 2600 to 3400 t from 2010 to 2020 associated with catches being approximately at the level of 2650 t.

Moreover a stock-recruitment relationship used based on the Beverton-Holt model as well as the geometric mean of the entire time series were also applied. Results obtained were similar in terms of absolute values and trends.

This analysis results are largely based on a good recruitment scenario for sardine stock in GSA 20. However, it is important to stress that successful recruitment of sardine is largely dependent on environmental conditions and their abundance can highly fluctuate annually. SGMED notes that there are no data available on recruitment for recent 2009 and 2010, and thus medium term predictions are based on year classes up to 2007. .

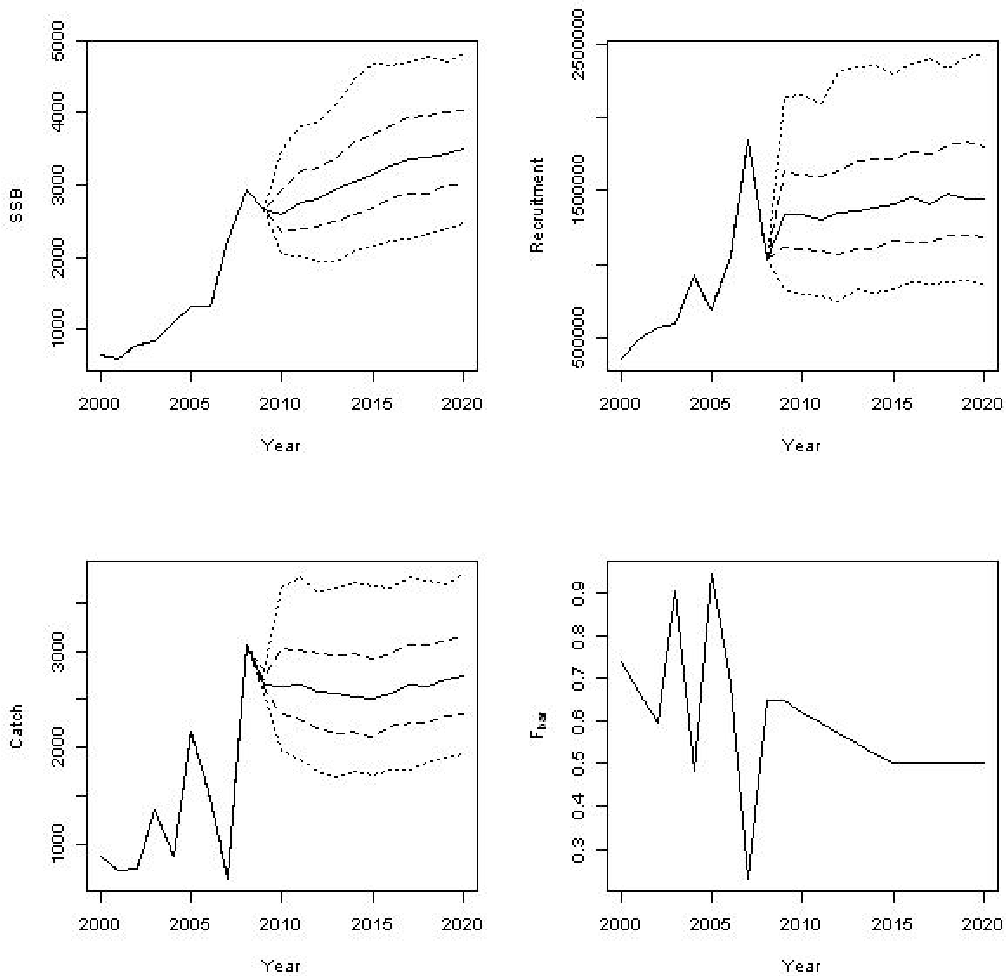


Fig. 6.29.2.3.1 Output of the medium term forecast computed for sardine in GSA 20 based on a scenario with a progressive reduction of F towards E(0.4) in 2015 and remaining at this level up to 2020.

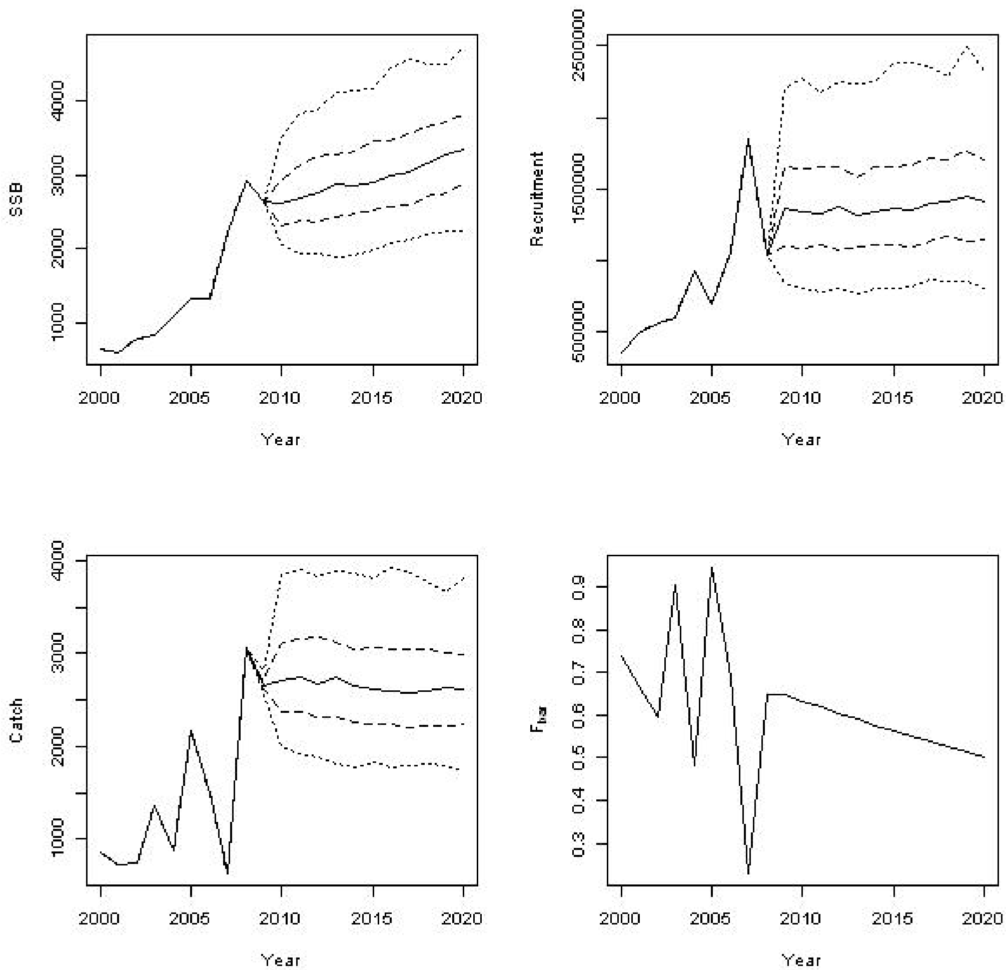


Fig. 6.29.2.3.2 Output of the medium term forecast computed for sardine in GSA 20 based on a scenario with a progressive reduction of F towards E(0.4) up to 2020.

6.30. Pink shrimp (*Parapenaeus longirostris*) in GSA 5

6.30.1. *Short term prediction 2010-2012*

6.30.1.1. Method and justification

Short term prediction for 2010 to 2012 was implemented in R (www.r-project.org) using the FLR libraries and based on the results of the Extended Survivor Analyses (XSA, Darby and Flatman, 1994) that was conducted in the framework of the SGMED-10-03 using the VPA Lowestoft software suite.

6.30.1.2. Input parameters

The following data have been used to derive the input data for the short term projection of the pink shrimp stock in GSA 5:

Maturity and M vectors

PERIOD	Age	0	1	2	3+
2009	Prop. Matures	0.22	0.83	1.00	1.00

PERIOD	Age	0	1	2	3+
2009	M	0.85	0.45	0.28	0.17

F vector

F	0	1	2	3+
2009	0.6256	1.45	1.25	1.09

Several scenarios with different harvest strategy were run, with F_{stq} (F_{bar} ages 0-3) estimated as the F vector in 2009 (F_{stq} = 1.10). These short term predictions were done without taking into account the change in the mesh as adopted by Council Regulation (EC) No 1967/2006 of 21 December 2006.

Weight-at-age in the stock

Mean weight in stock (kg)	0	1	2	3+
2006-2009	0.010	0.017	0.023	0.026

Weight-at-age in the catch

Mean weight in catch (kg)	0	1	2	3+
2006-2009	0.010	0.017	0.023	0.026

Number at age in the catch

Catch at age in numbers (thousands)	0	1	2	3+
2009	231.3	178	12.1	2.6

Number at age in the stock

Stock at age in numbers (thousands)	0	1	2	3+
2010	855	174	44	4

Stock recruitment

Recruitment (class 0+) has been estimated as the geometric mean of the class 0+ estimated from 2008 to 2009. These years were chosen following the trends found during MEDITS survey in 2010.

6.30.1.3. Results

Short-term implications

A short term projection (Table below), assuming an F_{stq} of 1.10 in 2010 and a recruitment of 855 (thousand) individuals, shows that:

- Fishing at the F_{stq} (1.10) generates a decrease of the catch of 6% from 2009 to 2011 along with an increase of the spawning stock biomass of less than 1% from 2011 to 2012.
- Fishing at $F_{0.1}$ (0.31) for the same time frame (2009-2012) generates a decrease of the catch of 65% in 2011 and a spawning stock biomass increase by 57% from 2011 to 2012.
- SGMED recommends that catches in 2011 should not exceed 2 tonnes, corresponding to F = $F_{0.1}$.

Outlook until 2012

Short term forecast in different F scenarios computed for pink shrimp in GSA 5.

Basis: F (2010) = mean (F_{bar} 0-3 2009); Catch (2010): 5 t; R (2010) = GM (2008–2009) = 855 (thousands); F (2010) = 1.1; SSB (2011) = 5 t

Rationale	F scenario	F factor	Catch 2011	Catch 2012	SSB 2012	Change SSB 2011-2012 (%)	Change Catch 2009-2011 (%)
zero catch	0.00	0.00	0.0	0.0	10.4	94.1	-100.0
High long-term yield ($F_{0.1}$)	0.31	0.28	2.0	2.9	8.4	57.3	-64.6
Status quo	1.10	1.00	5.3	5.3	5.4	0.3	-6.1
Different scenarios	0.11	0.10	0.8	1.3	9.6	79.7	-86.3
	0.22	0.20	1.5	2.3	9.0	66.8	-73.9
	0.33	0.30	2.1	3.0	8.3	55.2	-62.6
	0.44	0.40	2.7	3.6	7.8	44.8	-52.3
	0.55	0.50	3.2	4.1	7.3	35.4	-42.8
	0.66	0.60	3.7	4.5	6.8	26.9	-34.2
	0.77	0.70	4.2	4.8	6.4	19.2	-26.3
	0.88	0.80	4.6	5.0	6.0	12.3	-19.0
	0.99	0.90	5.0	5.2	5.7	6.0	-12.3
	1.21	1.10	5.7	5.5	5.1	-4.9	-0.4
	1.32	1.20	6.0	5.5	4.8	-9.6	4.9
	1.43	1.30	6.2	5.6	4.6	-13.9	9.8
	1.54	1.40	6.5	5.7	4.4	-17.9	14.4
	1.65	1.50	6.7	5.7	4.2	-21.5	18.6

Weights in t.

Another deterministic short term prediction was performed using the same methodology and data input, but taking into account the change in the mesh as adopted by Council Regulation (EC) No 1967/2006 of 21 December 2006 as fully implemented in 2010. Thus, a change from 40 mm diamond to 40 mm square mesh was considered taking into account using the selectivity curves obtained in the Balearic Islands by Guijarro and Massutí (2006) and obtaining the following F vector:

F vector

F	0	1	2	3+
2009	0.61	1.80	1.25	1.09

A comparison between both projections shows that:

- Fishing at the F_{stq} generates a similar decrease of catch from 2009 to 2011 along with a similar increase in SSB from 2011 to 2012.
- Fishing at $F_{0.1}$ for the same time frame (2009-2012) shows no differences in the change of catches and SSB from 2009 to 2011.

Rationale	Mesh	F scenario	F factor	Catch 2011	Catch 2012	SSB 2012	Change SSB 2011-2012 (%)	Change Catch 2009-2011 (%)
High long-term yield ($F_{0.1}$)	40 DI	0.31	0.28	2.0	2.9	8.4	57.3	-64.6
	40 SQ	0.31	0.28	2.0	2.9	8.5	56.8	-64.6
Status quo	40 DI	1.10	1.00	5.3	5.3	5.4	0.3	-6.1
	40 SQ	1.10	1.00	5.3	5.3	5.4	0.4	-6.3

These low differences are related to the pattern of exploitation of pink shrimp in GSA 5 in which the part of the population would be the more potentially benefitted from a change of mesh shape is already scarce in the catches (Fig. 6.30.1.3.1).

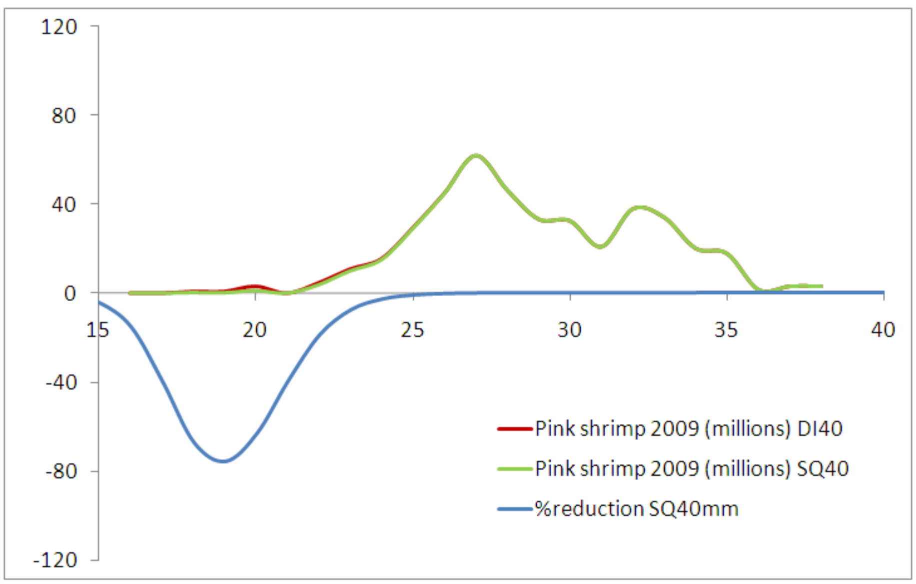


Fig. 6.30.1.3.1. Length frequency distribution of landings for pink shirmp in GSA 5 for 2009, estimated length frequency distribution of landings in GSA 5 for 2010 considering the selectivity curves computed by Guijarro and Massutí (2006) and percentage of catches reduction by length by a change of mesh shape, from 40 mm diamond to 40 mm square mesh codend.

6.30.2. *Medium term prediction*

6.30.2.1. Method and justification

Medium term prediction from 2010 to 2020 was implemented in R (www.r-project.org) using the FLR libraries and based on the results of the Extended Survivor Analyses (XSA, Darby and Flatman, 1994) stock assessment that was applied for pink shrimp stock in GSA 5 in the framework of the SGMED-10-03 using the VPA Lowestoft software suite. Four different assumptions were used in the Medium term projections (10 years): (i) F_{stq}; (ii) a decrease from F_{stq} to $F_{0.1}$ in 2011; (ii) a progressive decrease from F_{stq} to $F_{0.1}$ in 2015 and

(iv) a progressive decrease from F_{stq} to $F_{0.1}$ in 2020. The stock-recruitment relationship used geometric mean recruitment over the observed SSB range from 2008 to 2009. These medium term predictions were done without taking into account the change in the mesh as adopted by Council Regulation (EC) No 1967/2006 of 21 December 2006.

6.30.2.2. Input parameters

The maturity ogives, the natural mortality, the numbers of individuals and weight-at-age for the stock and for the catch were the same used in the short term forecast.

6.30.2.3. Results

Output of the medium term forecast showed an increasing trend in SSB for all the simulations using a reduction towards $F_{0.1}$, while catches remain stable.

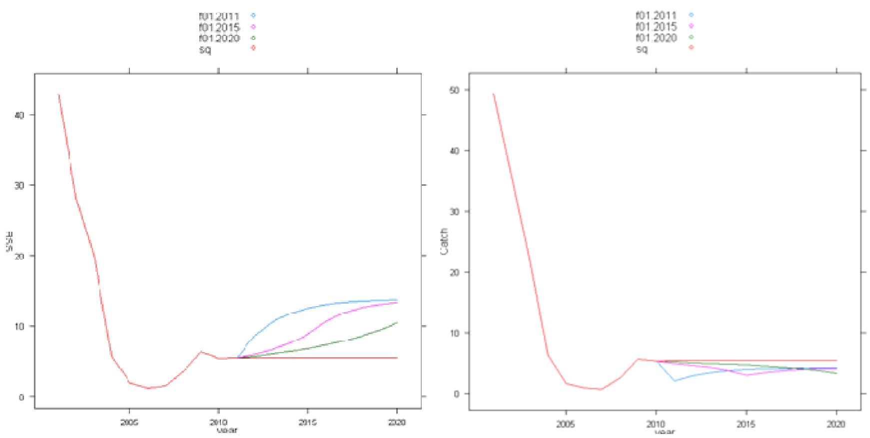


Fig. 6.30.2.3.1. Output of the medium term forecast computed for the pink shrimp in GSA 5.

6.31. Pink shrimp (***Parapenaeus longirostris***) in GSA 9

6.31.1. *Short term prediction 2010-2012*

6.31.1.1. Method and justification

Short term predictions for 2011 and 2012 were implemented in R (www.r-project.org) using the FLR libraries and based on the results of Length Cohort Analysis (LCA) carried out on 2006, 2007, 2008, 2009 catch data collected under DCF

6.31.1.2. Input parameters

The following data have been used to derive the input data for the short term projection of the pink shrimp stock in GSA9:

Maturity and M vectors

PERIOD	Age	0	1	2	3	4
2006-2009	Prop. Matures	0.3	0.8	1.0	1.0	1.0

PERIOD	Age	0	1	2	3	4
2006-2009	M	1.20	0.78	0.76	0.65	0.50

F vector

F	0	1	2	3	4
2006	0.002	0.17	0.38	0.16	0.21
2007	0.011	0.43	0.79	0.43	0.33
2008	0.019	0.26	0.30	0.13	0.18
2009	0.052	0.50	0.69	0.57	0.51

These short term predictions were done without taking into account the change in the mesh as adopted by Council Regulation (EC) No 1967/2006 of 21 December 2006.

Weight-at-age in the stock

Mean weight in stock (kg)	0	1	2	3	4
2006	0.0015	0.0092	0.0175	0.0236	0.0296
2007	0.0015	0.0091	0.0174	0.0234	0.0304
2008	0.0015	0.0091	0.0174	0.0234	0.0296
2009	0.0014	0.0089	0.0173	0.0234	0.0272

Weight-at-age in the catch

Mean weight in catch (kg)	0	1	2	3	4
2006	0.0015	0.0092	0.0175	0.0236	0.0296
2007	0.0015	0.0090	0.0173	0.0235	0.0296
2008	0.0015	0.0092	0.0176	0.0236	0.0296
2009	0.0015	0.0090	0.0174	0.0234	0.0272

Number at age in the catch

Catch at age in numbers (thousands)	0	1	2	3	4

2006	394	15458	12364	2063	467
2007	835	10825	5211	792	333
2008	2430	11852	5072	912	952
2009	4359	11439	3788	787	220

Number at age in the stock

Stock numbers at age	0	1	2	3	4
2006	395097	145110	54336	19016	15575
2007	126665	46091	13310	3095	1781
2008	214616	77479	26609	10016	8514
2009	157186	44951	11278	2528	745
2010	162000	44950	12500	2646	746

Maturity was estimated as the mean of the last 3 years. M was calculated using the ProBiom method.

6.31.1.3. Results

A short term projection (Table below), assuming an F_{stq} of 0.46 in 2010 and a recruitment of 162 millions individuals, shows that:

- Fishing at the F_{stq} from 2009 to 2012 generates an increases in catch of 5.9 % and an increase in SSB of 4.2%.

- Fishing at $F_{0.1}$ (0.7) for the same time frame (2009-2012) generates an icrease in the catches of 47.4% and a decrease of spawning stock biomass of 6.8% from 2010 to 2012.

SGMED's advice considers the stock being harvested sustainably, as $F_{1\text{-}3}$ was estimated to range among 0.4-0.6 for the period 2006-2009. SGMED recommends that in 2011 fishing mortality should not exceed the value of $F_{0.1}$ = 0.70, which corresponds to a catch of 292 tons.

Outlook until 2012

Short term forecast in different F scenarios computed for pink shrimp in GSA 9.

Basis: F(2010) = mean(F_{bar} 2006–2009); R(2010) = GM(2006–2009) = 162 (millions); F (2010) = 0.46; SSB(2011) = 770 t; Catch (2010) = 191 t.

Rationale	F scenario	F factor	Catch 2011	Catch 2012	SSB 2012	Change SSB 2012 - 2010 (%)	Change Catch 2011 -2009 (%)
Zero catch	0.00	0.00	0	0	1026	33.4	-100.0
High long term yield (F_{01})	0.70	1.53	292	270	717	-6.8	47.4
Status quo	0.46	1.00	210	219	802	4.2	5.9
Different scenarios	0.05	0.10	25	33	999	29.8	-87.4
	0.09	0.20	49	63	973	26.5	-75.3
	0.14	0.30	72	90	948	23.2	-63.7
	0.18	0.40	94	114	925	20.2	-52.5
	0.23	0.50	115	136	902	17.2	-41.8
	0.27	0.60	136	156	880	14.4	-31.5
	0.32	0.70	155	174	859	11.7	-21.6
	0.37	0.80	174	191	839	9.1	-12.0
	0.41	0.90	192	205	820	6.6	-2.9
	0.50	1.10	227	231	785	2.0	14.4
	0.55	1.20	243	242	768	-0.2	22.6
	0.59	1.30	258	251	752	-2.3	30.4
	0.64	1.40	273	260	736	-4.3	38.0
	0.69	1.50	288	268	722	-6.2	45.2
	0.73	1.60	302	275	708	-8.1	52.3
	0.78	1.70	315	282	694	-9.8	59.0
	0.82	1.80	328	287	681	-11.5	65.5
	0.87	1.90	340	293	668	-13.1	71.8
	0.91	2.00	352	297	657	-14.7	77.8

6.32. Pink shrimp (*Parapaeneus longirostris*) in GSA 10

6.32.1. *Short term prediction for 2010 and 2011*

6.32.1.1. Method and justification

Short term prediction for 2011 and 2012 was implemented in R (www.r-project.org) using the FLR libraries and based on the results of the stock assessment performed using VIT (Lleonart and Salat, 1997) that was conducted in the framework of the SGMED-10-03 using the VPA Lowestoft routines.

6.32.1.2. Input parameters

The following data have been used to derive the input data for the short term projection of pink shrimp in the GSA 10:

Maturity and M vectors

PERIOD	Age	0	1	2+
2007-2009	Prop. Matures	0.47	0.98	1.00

PERIOD	Age	0	1	2	Mean 0-2+
2007-2009	M	1.41	0.81	0.70	0.97

F vector

F	0	1	2+
2007	0.32	2.75	1.00
2008	0.86	1.90	1.00
2009	0.59	2.97	1.00

Several scenarios with different harvest strategy were run, with F_{stq} (F_{bar} ages 0-2) calculated as the average of the last 3 years, but rescaled to the F of 2009 (F_{stq} = 1.20).
These short term predictions were done without taking into account the change in the mesh as adopted by Council Regulation (EC) No 1967/2006 of 21 December 2006.

Weight-at-age in the stock

Mean weight in stock	0	1	2+
g	2.01	10.05	22.33

Weight-at-age in the catch

Mean weight in catch	0	1	2+
g	2.01	10.05	22.33

Number at age in the catch

Catch at age in numbers (thousands)	0	1	2+
2009	36577	27978	1092

Number at age in the stock

Stock at age in numbers (thousands)	0	1	2+
2009	229017	39875	1856
2010	284695	32606	2437

Stock recruitment

The recruitment used for the short term projection was estimated as the geometric mean from 2007-2009.

6.32.1.3. Results

A short term projection (Table below), assuming an F_{stq} of 1.20 in 2010 and a recruitment of 284695 (thousand) individuals, shows that:

- Fishing at the F_{stq} (1.20) from 2010 to 2011 generates an increase of the catch of 16 % and an increase of the spawning stock biomass of 1% from 2011 to 2012.

- Fishing at $F_{0.1}$ (0.58) from 2009 to 2011 generates a decrease of the catch of 27% and a spawning stock biomass increase of 33% from 2011 to 2012.

- A 30% reduction of the F_{stq} (F=0.84) generates a decrease of catch of 6% in 2011 and an increase of spawning stock biomass of about 17 % from 2011 to 2012, indicating that this level of reduction could generate a slight decrease of catches but a significant increase of the spawning stock biomass.

- SGMED recommends that fishing mortality in 2011 should not exceed $F_{0.1}$ = 0.58, corresponding to catches of 278 t.

Outlook until 2012

Basis: F (2010) = F (2009) rescaled (F_{bar} 0-2+); R (2010) = GM (2007–2009) = 284695 (thousands); F (2010) = 1.20; SSB (2011) = 714; Catch (2010) = 379 t

Rationale	F scenario	F factor	Catch 2011	Catch 2012	SSB 2012	Change SSB 2011-2012 (%)	Change Catch 2009-2011 (%)
zero catch	0	0	0	0	1376	92.7	-100.0
High long-term yield ($F_{0.1}$)	0.58	0.48	278	369	951	33.1	-26.5
Status quo	1.20	1.00	438	442	722	1.1	15.6
Different scenarios	0.12	0.10	74	127	1,260	76.4	-80.5
	0.24	0.20	138	220	1,162	62.7	-63.6
	0.36	0.30	194	288	1,077	50.8	-48.9
	0.48	0.40	242	338	1,004	40.6	-36.1
	0.60	0.50	285	374	941	31.9	-24.8
	0.72	0.60	323	399	886	24.1	-14.9
	0.84	0.70	356	417	837	17.3	-6.0
	0.96	0.80	386	429	794	11.2	2.0
	1.08	0.90	414	437	756	5.9	9.1
	1.32	1.10	461	445	691	-3.2	21.5
	1.44	1.20	481	446	663	-7.1	27.0
	1.56	1.30	500	445	638	-10.6	32.0
	1.68	1.40	518	445	615	-13.9	36.6
	1.80	1.50	534	443	594	-16.9	40.8
	1.92	1.60	549	441	574	-19.6	44.8
	2.04	1.70	563	439	556	-22.1	48.5
	2.16	1.80	576	437	539	-24.5	52.0
	2.28	1.90	589	435	524	-26.7	55.3
	2.40	2.00	600	432	509	-28.7	58.4

(weights in t)

6.32.2. *Medium term prediction*

6.32.2.1. Method and justification

Medium term prediction from 2010 to 2030 was implemented in R (www.r-project.org) using the FLR libraries and based on the results of stock assessment obtained using VIT (Lleonart and Salat, 1997) and the VPA Lowestoft routines. Medium term projections (10 years) were run assuming a progressive decreasing trend of F toward $F_{0.1}$ in 10 years (2020) and in 5 years (2015). The stock-recruitment relationship used geometric mean recruitment over the observed SSB range from 2007 to 2009. Runs were made with 500 simulations per run. To simulate a stochastic process the recruitment was multiplied by log-normally distributed noise with mean 1 and standard deviation 0.3. These medium term predictions were done without taking into account the change in the mesh as adopted by Council Regulation (EC) No 1967/2006 of 21 December 2006.

6.32.2.2. Input parameters

The maturity ogive, the natural mortality, the numbers of individuals and weight-at-age for the stock and for the catch were the same used in the short term forecast.

6.32.2.3. Results

In Fig. 6.31.2.3.1a, the 5th, 25th, 50th, 75th and 95th percentile are showed for the SSB, recruitment and catches in t from 2010 to 2030, considering a constant reduction of the F_{stq} of around 10% each year from 2010 to 2015 and then an F constant until 2030.

In Fig. 6.31.2.3.1b, the 5th, 25th, 50th, 75th and 95th percentile are showed for the SSB, recruitment and catches in t from 2010 to 2030, considering a constant reduction of the F_{stq} of around 5% each year from 2010 to 2020 and then an F constant until 2030.

Landing data of pink shrimp from 2004 to 2009 in the GSA10 are reported in the table 6.31.2.3.1 and show an increasing pattern until 2006 and then a decreasing pattern, where the production in 2009 is third of that in 2006. In both the scenarios of the medium-term forecasts the decreasing of fishing mortality results in a clear increase of the SSB, while the catches in a medium term remain fairly constant but larger than the level observed in the last 2 years.

Table 6.31.2.3.1. Landings of pink shrimp in the GSA 10.

year	2004	2005	2006	2007	2008	2009
DCF landings	552	776	1089	534	400	379

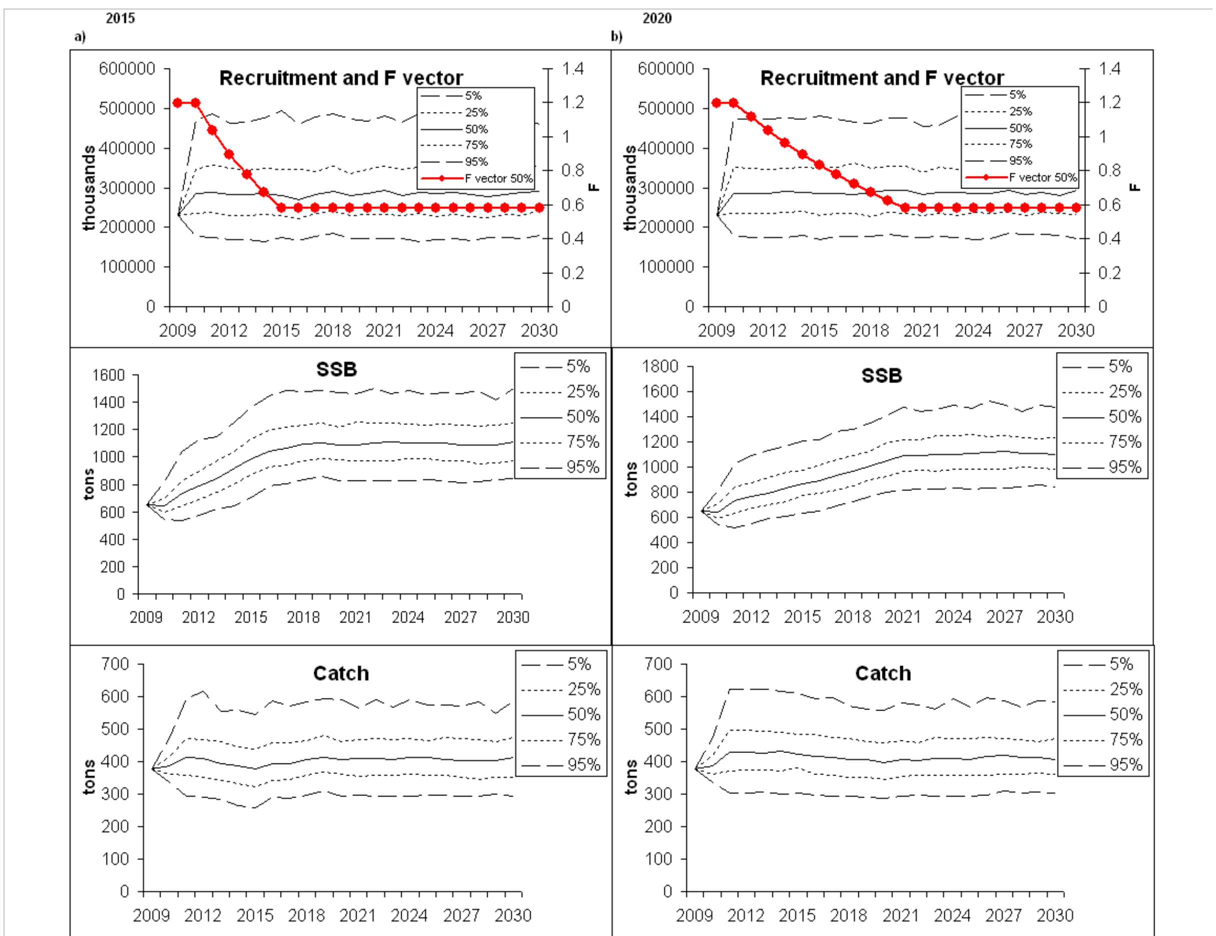


Fig. 6.31.2.3.1 Output of the medium term forecast computed for the pink shrimp in the GSA 10 reaching the $F_{0.1}$ in 2015 (left) and 2020 (right).

6.33. Pink shrimp (*Parapenaeus longirostris*) in GSA 12-16

6.33.1. *Short term prediction 2010-2012*

6.33.1.1. Method and justification

Short term prediction for 2011 and 2012 was implemented in R (www.r-project.org) using the FLR libraries and based on the results of the Length Cohort and Yield / Recruit Analysis as implemented in the programme VIT4win (Lleonart and Salat, 2000). The stock assessment was conducted under the framework of the MedSudMed project, finalised at the GFCM demersal working group meeting held on 17th to 24th October 2010 in Istanbul, and accepted by the GFCM SAC on 29th November to 2nd December 2010 in Malta. The assessment including input parameters was presented to SGMED-10-03 under TOR 3, and accepted by the group.

6.33.1.2. Input parameters

The following data have been used to derive the input data for the short term projection of the pink shrimp in GSA 12-16:

Maturity and M vectors

PERIOD	Age	0	1	2	3	4	5+
2007-2009	Prop. Mature	0.12	0.86	0.98	1.00	1.00	1.00

PERIOD	Age	0	1	2	3	4	5+
2007-2009	M	1.25	0.56	0.41	0.36	0.30	0.30

F vector

F	0	1	2	3	4	5+
2007	0.23	1.00	1.56	1.50	1.43	1.40
2008	0.14	1.42	1.34	1.09	1.02	1.00
2009	0.13	2.13	2.27	1.62	1.47	1.40
Mean 07-09 scaled to 2009	0.21	1.85	2.11	1.71	1.60	1.55

Weight-at-age in the stock

Mean weight in stock	0	1	2	3	4	5+
kg	0.00242	0.00951	0.01545	0.01822	0.01830	0.01919

Weight-at-age in the catch

Mean weight in catch	0	1	2	3	4	5+
kg	0.00242	0.00951	0.01545	0.01822	0.01830	0.01919

Number at age in the catch (thousands)

Catch at age in numbers	0	1	2	3	4	5+
2007	485006	464410	58008	4489	1342	978
2008	420113	578575	32146	5397	1004	232
2009	458960	782553	28676	1581	356	46

Number at age in the stock (thousands)

Stock at age	0	1	2	3	4	5+

in numbers						
2007	2899792	582590	87216	18055	8850	2977
2008	2415345	371267	53890	10487	4334	1435
2009	2983713	360177	24421	2982	1310	359
2010	2754447	360177	24420	2981	1310	358

Several scenarios with different harvest strategy were run, with F_{stq} (F_{bar} ages 0-5) calculated as the average of the last 3 years, but scaled to the F of 2009 (F_{stq} = 1.5).

Stock recruitment

The recruitment used for the short term projection was estimated as the geometric mean from 2007-2009.

6.33.1.3. Results

A short term projection (Table below), assuming an F_{stq} of 1.5 in 2010 and a recruitment of 2,754,447 (thousand) individuals, shows that:

- Fishing at the F_{stq} (1.5) from 2010 to 2011 generates a decrease of the catch of 36% and a decrease of the spawning stock biomass of 0.5% from 2011 to 2012.

- Fishing at $F_{0.1}$ (0.9) for the same time frame (2010-2011) generates a decrease of the catch by 52% and a spawning stock biomass increase of 21% from 2011 to 2012.

- Although the present analysis shows that in order to reach $F_{0.1}$, a decrease of F_{stq} by 40% is needed, it has to be taken into account that catches in 2009 were particularly high. In other words, F_{stq} is representative only of the last year, not of the situation over the last 3 years. If an average of 2007-2009 is used instead to calculate $F_{stq,}$ a reduction of about 25% would be needed to reach $F_{0.1}$.

- SGMED recommends that fishing mortality in 2011 should not exceed $F_{0.1}$ = 0.9, corresponding to catches of 4,363 t.

Outlook until 2012

Basis: F(2010) = mean (2007–2009) scaled to 2009; R (2010) = GM (2007–2009) = 2 754447; F (2010) = 1.5; SSB (2011) = 7032 t; Catch (2010) = 5770 t

Rationale	F scenario	F factor	Catch 2011	Catch 2012	SSB 2012	Change SSB 2011-2012 (%)	Change Catch 2009-2011 (%)
zero catch	0.00	0.00	0	0	13578	93	-100
High long-term yield ($F_{0.1}$)	0.90	0.60	4363	5301	8546	22	-52
Status quo	1.50	1.00	5777	5752	7005	-0.4	-36
Different scenarios	0.15	0.10	1035	1865	12357	76	-89
	0.30	0.20	1919	3143	11327	61	-79
	0.45	0.30	2675	4019	10454	49	-70
	0.60	0.40	3325	4618	9713	38	-63
	0.75	0.50	3885	5027	9080	29	-57
	0.90	0.60	4371	5305	8537	21	-52
	1.05	0.70	4794	5492	8070	15	-47
	1.20	0.80	5164	5618	7665	9	-43
	1.35	0.90	5489	5700	7313	4	-39
	1.65	1.10	6033	5784	6732	-4	-33
	1.81	1.20	6261	5800	6491	-8	-31
	1.96	1.30	6467	5807	6275	-11	-28
	2.11	1.40	6652	5806	6081	-14	-26
	2.26	1.50	6822	5801	5905	-16	-24
	2.41	1.60	6976	5791	5744	-18	-23
	2.56	1.70	7119	5779	5596	-20	-21
	2.71	1.80	7250	5766	5459	-22	-20
	2.86	1.90	7373	5751	5332	-24	-18
	3.01	2.00	7487	5734	5213	-26	-17

Weights in t

The actual landings recorded in 2009 (8806 t for the Tunisian, Maltese and Italian fleet combined) are higher compared to the landings projected by SGMED 03/09 for 2009 (7662 t). However, the SGMED 03/09 were based only on a regression between the MEDITS survey biomass indices in 2001-2007 and landings in the consecutive years 2002-2008 for GSA 16 and not on an age-structured production model for GSAs 12-16, as is the case above.

Potential changes in selectivity due to the implementation of the 40mm square/50mm diamond mesh size on Italian and Maltese trawlers based on EC 1967/2006 were not taken into account in the predictions made above.

6.34. Pink shrimp (*Parapenaeus longirostris*) in GSA 22

6.34.1. *Medium term prediction*

6.34.1.1. Method and justification

Based on the results of the non-equilibriun surplus production model assessment conducted during the SGMED 2010-02 meeting, stochastic stock biomass and catch predictions up to the year 2020 were carried out. Three different management scenarios were evaluated: (a) the status quo, i.e fishing mortality (F) remains at the level estimated at the last assessment year, for the whole projection period, (b) F equals to the F_{msy} and (c) F equals to the $F_{0.1}$ value that was obtained from the Y/R analysis.

Each projection scenario was simulated 100 times assuming normally distributed errors for the parameters r and k of the surplus production model. Future biomass and catch levels were estimated through the commonly used Shaefer equation:

$B_t = B_{t-1} + rB_{t-1}(1-B_{t-1}/k)-FB_{t-1}$

Runs were made under the R language environment.

6.34.1.2. Input parameters

$r = 0.72$ (sd = 0.05)
$k = 12688$ (sd = 810)
$B_{2006} = 3852$
$F_{2006} = 0.68$
$F_{msy} = 0.36$
$F_{0.1} = 0.34$

6.34.1.3. Results

The table below shows stock biomass and catch predictions under the different scenarios (status quo, F_{msy} and $F_{0.1}$). Predictions together with the assessment estimates are shown in Figure 6.34.1.3.1.

Short term implications
Under the current F, stock biomass is decreasing and by 2015 will be about 50% lower than the current level, which is up to 60% of the B_{msy} value. An analogous reduction is expected for the catches. Fishing at F_{msy} will allow the stock to rebuild and will bring stock biomass closely to the B_{msy} level by 2015. Similarly catches will increase up to the MSY level. Under the $F_{0.1}$ scenario stock rebuilding will be achieved by 2013 and catches at that time will reach up to 90% of the MSY.

Outlook until 2020
Under the current status stock biomass will be reduced being up to 35% of the current level. A corresponding reduction is expected for the catches. Given that $F_{0.1}$, is closed to F_{msy}, fishing at either level will keep stock biomass and catches at the MSY levels reached by 2015. Based on the above, SGMED recommends a reduction of fishing mortality to the F_{msy} level on order to achieve stock rebuilding to the optimum levels by 2015, corresponding to catches around 1920 tonnes in 2011.

Data consistency
Due to data limitations, the analysis is based on a production modeling approach which considers the population as a whole without taking into account that it is composed by a sum of age groups that undergo different levels of fishing pressure by the various fleet components. Such an assumption, which also implies constant fishing mortality over age, is endogenous in production models and may severely bias results,

especially if the exploitation pattern changes over time; hence prediction estimates should be faced with caution. Additionally, given that the available time series of CPUE survey data was short with low contrast between years, strong assumptions had to be made regarding the initial harvest rate in order to achieve convergence in the surplus production model that has been previously applied for the assessment of the stock.

Status quo

Year	Biomass (mt)	Biomass CI (95% upper limit)	Biomass CI (95% lower limit)	Catch (mt)	Catch (95% upper limit)	Catch (95% lower limit)	F
2007	3431	3714	3147	2322	2514	2130	0.68
2008	2923	3370	2477	1979	2281	1676	0.68
2009	2578	3127	2029	1745	2116	1373	0.68
2010	2326	2948	1704	1574	1995	1153	0.68
2011	2133	2811	1455	1443	1902	985	0.68
2012	1980	2703	1257	1340	1829	851	0.68
2013	1857	2617	1096	1256	1771	742	0.68
2014	1754	2547	961	1187	1724	650	0.68
2015	1668	2490	847	1129	1685	573	0.68
2016	1595	2443	748	1080	1653	506	0.68
2017	1533	2403	662	1037	1626	448	0.68
2018	1478	2370	587	1000	1604	397	0.68
2019	1430	2341	520	968	1585	352	0.68
2020	1388	2317	459	940	1568	311	0.68

$F = F_{msy}$

Year	Biomass (mt)	Biomass CI (95% upper limit)	Biomass CI (95% lower limit)	Catch (mt)	Catch (95% upper limit)	Catch (95% lower limit)	F
2007	3411	3703	3118	1228	1333	1123	0.36
2008	3972	4521	3422	1430	1628	1232	0.36
2009	4499	5292	3706	1620	1905	1334	0.36
2010	4960	5951	3968	1785	2142	1429	0.36
2011	5335	6465	4205	1921	2327	1514	0.36
2012	5624	6835	4412	2025	2461	1588	0.36
2013	5835	7086	4584	2101	2551	1650	0.36
2014	5985	7249	4721	2154	2609	1699	0.36
2015	6088	7350	4827	2192	2646	1738	0.36
2016	6159	7411	4907	2217	2668	1766	0.36
2017	6207	7447	4966	2234	2681	1788	0.36
2018	6239	7468	5010	2246	2689	1804	0.36
2019	6261	7479	5042	2254	2693	1815	0.36
2020	6275	7485	5065	2259	2695	1824	0.36

$F = F_{0.1}$

Year	Biomass (mt)	Biomass CI (95% upper limit)	Biomass CI (95% lower limit)	Catch (mt)	Catch (95% upper limit)	Catch (95% lower limit)	F
2007	3426	3690	3162	1165	1255	1075	0.34
2008	4071	4573	3568	1384	1555	1213	0.34
2009	4685	5421	3948	1593	1843	1342	0.34
2010	5223	6154	4292	1776	2092	1459	0.34
2011	5658	6724	4592	1924	2286	1561	0.34
2012	5985	7127	4843	2035	2423	1647	0.34
2013	6217	7391	5043	2114	2513	1715	0.34
2014	6374	7553	5196	2167	2568	1767	0.34
2015	6479	7649	5309	2203	2601	1805	0.34
2016	6546	7703	5390	2226	2619	1832	0.34
2017	6590	7733	5447	2241	2629	1852	0.34
2018	6618	7749	5487	2250	2635	1865	0.34
2019	6636	7758	5514	2256	2638	1875	0.34
2020	6648	7762	5533	2260	2639	1881	0.34

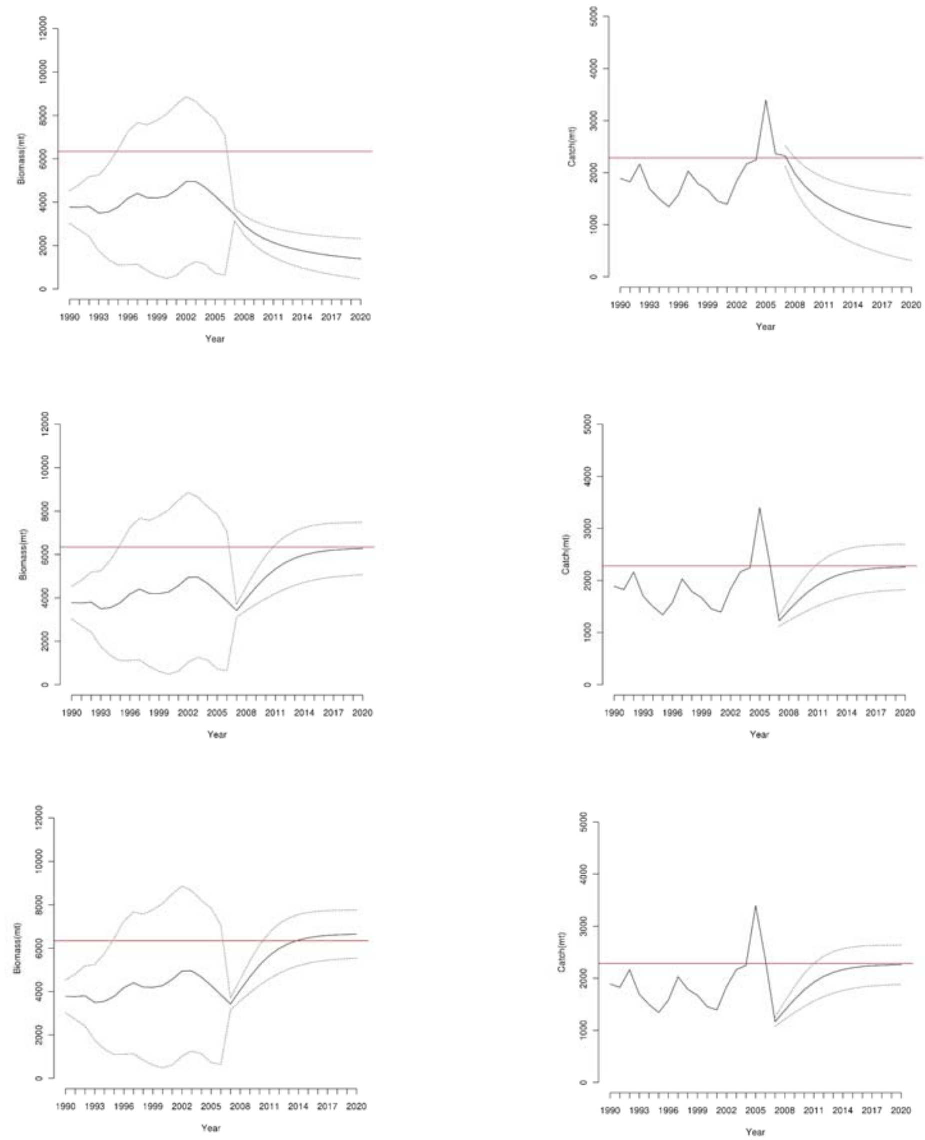


Figure 6.34.1.3.1. Stock biomass and catch predictions under different exploitation scenarios. From top to bottom: Status quo, $F = F_{msy}$, $F = F_{0.1}$. Horizontal lines indicate the corresponding MSY levels and dotted lines the 95% confidence intervals.

6.35. Giant red shrimp (*Aristaeomorpha foliacea*) in GSA 15 and 16

6.35.1. *Short term prediction 2010-2012*

6.35.1.1. Method and justification

SGMED emphasises that this analyses covers only the female part of the stock representing (75% of catch). Short term prediction for 2011 and 2012 was implemented in R (www.r-project.org) using the FLR libraries and based on the results of the Length Cohort and Yield per Recruit Analysis as implemented in the programme VIT4win (Lleonart and Salat, 2000). The underlying stock assessment for red shrimp in GSA 15 and 16 was carried out by SGMED 02/2009, and updated with 2009 data by SGMED 03/2009.

6.35.1.2. Input parameters

The following data have been used to derive the input data for the short term projection of giant red shrimp in GSA 15 and 16:

Maturity and M vectors

PERIOD	Age	0	1	2	3	4	5	6+
2007-2009	Prop. Mature	0.03	0.81	1.00	1.00	1.00	1.00	1.00

PERIOD	Age	0	1	2	3	4	5	6+
2007-2009	M	0.62	0.30	0.23	0.19	0.17	0.16	0.15

F vector

F	0	1	2	3	4	5	6+
2007	0.21	0.65	1.59	0.96	1.10	0.36	0.30
2008	0.03	0.79	0.73	1.11	1.59	0.36	0.30
2009	0.08	1.00	1.05	0.73	0.45	0.36	0.30
Mean 07-09 scaled to 09	0.09	0.69	0.95	0.79	0.89	0.31	0.25

Changes in selectivity due to the implementation of the 40mm square / 50mm diamond mesh size on Italian and Maltese trawlers based on EC 1967/2006 were not taken into account in the predictions

Weight-at-age in the stock

Mean weight in stock	0	1	2	3	4	5	6+
kg	0.006	0.027	0.050	0.068	0.078	0.084	0.088

Weight-at-age in the catch

Mean weight in catch	0	1	2	3	4	5	6+
kg	0.006	0.027	0.050	0.068	0.078	0.084	0.088

Number at age in the catch (thousands)

Catch at age in numbers	0	1	2	3	4	5	6+

2007	16369	20711	14133	1786	616	79	40
2008	1574	20960	6834	3500	1144	74	38
2009	6951	32904	9421	2126	594	268	136

Number at age in the stock (thousands)

Stock at age in numbers	0	1	2	3	4	5	6+
2007	114037	49657	19308	3130	991	280	166
2008	83051	43542	14630	5628	1530	263	156
2009	118357	58673	15933	4443	1766	949	563
2010	103879	58131	21823	4886	1665	613	971

Several scenarios of constant harvest strategy were run with reduction of the mean F (F_{bar} ages 0-6+) calculated as the average of the last 3 years for each age class and rescaled to the level of 2009 (F_{stq} = 0.57).

Stock recruitment

The recruitment used for the short term projection was estimated as the geometric mean from 2007-2009.

6.35.1.3. Results

A short term projection (Table below), assuming an F_{stq} of 0.57 in 2010 and a recruitment of 103879 (thousand) individuals, shows that:

- Fishing at the F_{stq} (0.57) in the time frame from the year 2010 to 2011 generates a decrease of the catch for 2.3% and a decrease of the spawning stock biomass for 2.6% from the year 2011 to 2012.

- Fishing at $F_{0.1}$ (0.27) for the same time frame (2010-2011) generates a decrease of the catch for 44% and a spawning stock biomass increase of 28% from the year 2011 to 2012.

In order to reach the target point $F_{0.1}$, a decrease of F_{stq} by 50% is needed. Keeping with the present analysis based on F_{stq} scaled to 2009, and the use of $F_{0.1}$ as a target reference point, SGMED 10 03 recommends that catches of red shrimp in the Central Mediterranean (GSA 15 and 16) in 2011 should not exceed 900 t. SGMED emphasises that this analyses covers only the female part of the stock representing (75% of catch). Considering that this catch recomendation covers only females, which correspond at about 75% of catch in weight, the overall yield (combined sex) amounts to 1,125 t in 2011.

Outlook until 2012

Basis: F(2010) = mean (2007–2009) scaled to 2009; R (2010) = GM (2007–2009) = ; F (2010) = 0.57; SSB (2011) = 2947 t; Catch (2010) = 1599 t

Rationale	**F scenario**	**F factor**	**Catch 2011**	**Catch 2012**	**SSB 2012**	**Change SSB 2011-2012 (%)**	**Change Catch 2009-2011 (%)**
zero catch	0	0	0	0	4977	68.85	-100
High long-term yield ($F_{0.1}$)	0.27	0.5	900	1146	3775	28.08	-44.38
Status quo	0.57	1	1580	1534	2870	-2.63	-2.32
Different scenarios	0.06	0.1	217	344	4686	59	-86.58
	0.11	0.2	418	624	4418	49.89	-74.16
	0.17	0.3	604	850	4169	41.46	-62.65
	0.23	0.4	777	1032	3939	33.64	-51.98
	0.28	0.5	937	1177	3726	26.4	-42.09
	0.34	0.6	1085	1291	3528	19.69	-32.92
	0.4	0.7	1223	1380	3344	13.47	-24.4
	0.45	0.8	1351	1448	3174	7.7	-16.49
	0.51	0.9	1469	1498	3016	2.34	-9.15
	0.62	1.1	1682	1558	2734	-7.25	4.03
	0.68	1.2	1778	1573	2607	-11.55	9.93
	0.74	1.3	1867	1581	2489	-15.54	15.43
	0.79	1.4	1950	1582	2380	-19.26	20.55
	0.85	1.5	2027	1578	2278	-22.72	25.33
	0.91	1.6	2099	1571	2183	-25.94	29.78
	0.96	1.7	2166	1560	2094	-28.95	33.93
	1.02	1.8	2229	1547	2012	-31.75	37.81
	1.08	1.9	2288	1532	1935	-34.37	41.44
	1.13	2	2342	1516	1863	-36.81	44.82

Weights in t

Potential changes in selectivity due to the implementation of the 40mm square / 50mm diamond mesh size on Italian and Maltese trawlers based on EC 1967/2006 were not taken into account in the predictions made above.

The actual landings recorded in 2009 (1662 t for the Maltese and Italian fleet combined) are higher than the landings projected for 2009 by SGMED 09 03 (1116 t based on Aladym projections).

6.36. Norway lobster (*Nephrops norvegicus*) in GSA 5

6.36.1. *Short term prediction 2010-2012*

6.36.1.1. Method and justification

A deterministic short term prediction for 2010 to 2012 was performed using the EXCEL workbook provided by JRC IPSC (H.-J. Rätz), which takes into account the catch and landings in numbers and weight and the discards, and based on the results of the LCA stock assessment performed using VIT program (Lleonart and Salat, 1992) at the SGMED-10-02 (Heraklion, Crete, Greece, 31 May – 4 June 2010).

6.36.1.2. Input parameters

The following data have been used to derive the input data for the short term projection of the Norway lobster stock in GSA 5:

Maturity and M vectors

PERIOD	Age	1	2	3	4	5	6	7	8	9+
2009	Prop. Matures	0.2	0.5	0.9	1	1	1	1	1	1

PERIOD	Age	1	2	3	4	5	6	7	8	9+
2009	M	0.6	0.4	0.3	0.2	0.2	0.2	0.2	0.2	0.2

F vector

F	1	2	3	4	5	6	7	8	9+
2009	0.02	0.12	0.66	0.74	0.50	0.40	0.35	0.47	0.61

Several scenarios with different harvest strategy were run, with F_{stq} (F_{bar} ages 2-5) equal to the F vector in 2009 (F_{stq} = 0.50). These short term predictions were done without taking into account the change in the mesh as adopted by Council Regulation (EC) No 1967/2006 of 21 December 2006.

Weight-at-age in the stock

Mean weight in stock (kg)	1	2	3	4	5	6	7	8	9+
2006-2009	0.002	0.009	0.020	0.035	0.052	0.071	0.090	0.109	0.126

Weight-at-age in the catch

Mean weight in catch (kg)	1	2	3	4	5	6	7	8	9+
2006-2009	0.002	0.009	0.020	0.035	0.052	0.071	0.090	0.109	0.126

Number at age in the catch

Catch at age in numbers (thousands)	1	2	3	4	5	6	7	8	9+
2009	14.6	57.5	155.9	68.5	19.5	8.2	4.1	3.1	2

Number at age in the stock

Stock at age in numbers (thousands)	1	2	3	4	5	6	7	8	9+
2010	995.1	607.7	365.8	144.1	54.7	27.2	15.1	9.0	4.7

Stock recruitment

As there is no recruitment (class 0+) in the landings, the analysis have been carried out from class 1, estimated as the geometric mean of the class 1 from 2005 to 2009.

6.36.1.3. Results

Short-term implications

A short term projection (Table below), assuming an F_{stq} of 0.50 in 2010 and a recruitment of 995 (thousand) individuals, shows that:

- Fishing at the F_{stq} (0.50) generates a decrease of the catch of 19% from 2009 to 2011 along with a decrease of the spawning stock biomass of 4% from 2011 to 2012.
- Fishing at $F_{0.1}$ (0.84) for the same time frame (2009-2012) generates a decrease of the catch for 30% in 2011 and no change in the spawning stock biomass from 2011 to 2012.
- Thus, SGMED recommends that catches in 2011 should not exceed 6 tonnes, that corresponds to F = $F_{0.1}$.

Outlook until 2012

Short term forecast in different F scenarios computed for Norway lobster in GSA 5.

Basis: F (2010) = mean (F_{bar} 2-5 2009); Catch (2010): 8 t; R (2010) = GM (2005,2009) = 995 (thousands); F (2010) = 0.50; SSB (2011) = 22 t

Rationale	F scenario	F factor	Catch 2011	Catch 2012	SSB 2012	Change SSB 2011-2012 (%)	Change Catch 2009-2011 (%)
zero catch	0.00	0.00	0	0	33	50.0	-100.0
High long-term yield ($F_{0.1}$)	0.42	0.84	6	6	22	0.0	-30.2
Status quo	0.50	1.00	7	7	21	-4.5	-18.6
Different scenarios	0.05	0.10	0	1	32	45.5	-100.0
	0.10	0.20	2	2	30	36.4	-76.7
	0.15	0.30	2	3	29	31.8	-76.7
	0.20	0.40	2	4	27	22.7	-76.7
	0.25	0.50	4	5	26	18.2	-53.5
	0.30	0.60	5	5	25	13.6	-41.9
	0.35	0.70	5	5	24	9.1	-41.9
	0.40	0.80	6	5	22	0.0	-30.2
	0.45	0.90	6	7	21	-4.5	-30.2
	0.55	1.10	9	8	21	-4.5	4.7
	0.60	1.20	10	8	19	-13.6	16.3
	0.65	1.30	10	8	19	-13.6	16.3
	0.70	1.40	10	8	19	-13.6	16.3
	0.75	1.50	11	8	18	-18.2	27.9

Weights in t.

6.37. Norway lobster (Nephrops norvegicus) in GSA 9

6.37.1. *Short term prediction 2010-2012*

6.37.1.1. Method and justification

Short term predictions for 2011 and 2012 were implemented in R (www.r-project.org) using the FLR libraries and based on the results of Length Cohort Analysis (LCA) carried out on 2006, 2007, 2008, 2009 catch data collected under DCF.

6.37.1.2. Input parameters

The following data have been used to derive the input data for the short term projection of Norway lobster in the GSA 9:

Maturity and M vectors

PERIOD	Age	0	1	2	3	4	5	6	7	8	9
2006-2009	Prop. Matures	0.0	0.2	0.5	0.9	1.0	1.0	1.0	1.0	1.0	1.0

PERIOD	Age	0	1	2	3	4	5	6	7	8	9
2006-2009	M	1.0	0.6	0.4	0.23	0.2	0.2	0.2	0.2	0.2	0.2

F vector

F	0	1	2	3	4	5	6	7	8	9
2006	0.001	0.10	0.44	0.27	0.23	0.35	0.24	0.10	0.13	0.11
2007	0.01	0.10	0.24	0.23	0.23	0.49	1.02	1.10	0.22	0.21
2008	0.01	0.12	0.31	0.42	0.38	0.28	0.76	0.52	0.61	0.22
2009	0.003	0.14	0.28	0.37	0.26	0.23	0.19	0.21	0.08	0.09

These short term predictions were done without taking into account the change in the mesh as adopted by Council Regulation (EC) No 1967/2006 of 21 December 2006.

Weight-at-age in the stock

Mean weight in stock (kg)	0	1	2	3	4	5	6	7	8	9
2006	0.0026	0.0094	0.0202	0.0351	0.0520	0.0697	0.0879	0.1055	0.1219	0.1370
2007	0.0026	0.0094	0.0205	0.0351	0.0520	0.0695	0.0868	0.1042	0.1218	0.1560
2008	0.0027	0.0098	0.0219	0.0380	0.0570	0.0775	0.0973	0.1178	0.1367	0.1770
2009	0.0026	0.0093	0.0204	0.0349	0.0519	0.0699	0.0880	0.1054	0.1220	0.1493

Weight-at-age in the catch

Mean weight in catch (kg)	0	1	2	3	4	5	6	7	8	9
2006	0.0026	0.0094	0.0202	0.0351	0.0520	0.0697	0.0879	0.1055	0.1219	0.1600
2007	0.0009	0.0055	0.0148	0.0281	0.0442	0.0618	0.0799	0.0977	0.1146	0.1500
2008	0.0027	0.0098	0.0219	0.0380	0.0570	0.0775	0.0973	0.1178	0.1367	0.1770
2009	0.0026	0.0093	0.0204	0.0349	0.0519	0.0699	0.0879	0.1053	0.1219	0.1500

Number at age in the catch

Catch at age in numbers (thousands)	0	1	2	3	4	5	6	7	8	9

2006	45	1959	4634	1326	588	457	156	38	29	14
2007	174	1820	2421	1250	654	664	457	116	8	10
2008	181	1688	2493	1571	644	225	254	60	27	11
2009	92	2806	3108	2000	699	324	144	89	19	13

Number at age in the stock

Stock numbers at age (thousands)	0	1	2	3	4	5	6	7	8	9
2006	38559	25810	15713	6818	3502	1873	888	469	284	167
2007	33996	22646	13705	7233	3840	2046	840	204	46	44
2008	28195	18752	11203	5503	2429	1111	564	176	70	44
2009	40171	26852	15702	7981	3712	1916	1019	565	306	190
2010	33700	14735	12812	7955	4380	2343	1246	690	375	231

Maturity was estimated as the mean of the last 3 years. An vectorial M value (0.4) coming from prodbiom estimation was used.

6.37.1.3. Results

A short term prediction (Table below), assuming an F_{stq} of 0.45 (F_{3-7}) in 2010 and a recruitment of 33.7 million individuals shows that:

- Fishing at the F_{stq} (0.45) from 2009 to 2011 is expected to produce both a decrease of the catches of 7.2% in 2011 and the spawning stock biomass of 4.4 % from 2011 to 2012.

- Fishing at $F_{0.1}$ (0.21) generates a short term decrease of the catches of 50.9% in 2011 and a spawning stock biomass increase of 23.5% from 2011 to 2012.

- SGMED's advice considers the stock overexploited being the current F (0.45) higher than the candidate reference point ($F_{0.1}$) of 0.21.

- SGMED recommends that in 2011 fishing mortality should not exceed the value of $F_{0.1}$ = 0.21, which corresponds to a catch of 119 tons.

Outlook until 2012

Short term forecast in different F scenarios computed for Norway lobster in GSA 9.

Basis: F (2009) = mean (Fbar2006–2008); R (2009) = GM (2005–2008) = 33.7 (millions) individuals; F (2010) = 0.45; SSB (2011) = 377 t; Catch (2010) = 236 t

Rationale	F scenario	F factor	Catch 2011	Catch 2012	SSB 2012	Change SSB 2011-2012 (%)	Change Catch 2009-2011 (%)
zero catch	0.00	0.00	0.00	0.00	587	55.5	-100.0
High long-tem yield ($F_{0.1}$)	0.21	0.46	119	143	467	23.5	-50.9
Status quo	0.45	1.00	226	215	361	-4.4	-7.2
Different scenarios	0.05	0.10	28	40	559	47.9	-88.4
	0.09	0.20	55	74	531	40.7	-77.4
	0.14	0.30	80	104	506	33.9	-67.0
	0.18	0.40	105	129	481	27.4	-57.1
	0.23	0.50	127	150	459	21.4	-47.6
	0.27	0.60	149	168	437	15.6	-38.7
	0.32	0.70	170	183	416	10.2	-30.2
	0.36	0.80	190	196	397	5.1	-22.2
	0.41	0.90	208	207	379	0.2	-14.5
	0.50	1.10	243	222	345	-8.7	-0.3
	0.54	1.20	259	228	329	-12.8	6.3
	0.59	1.30	274	232	315	-16.7	12.6
	0.63	1.40	289	235	301	-20.4	18.6
	0.68	1.50	303	237	288	-23.9	24.3
	0.72	1.60	316	239	275	-27.2	29.7
	0.77	1.70	328	239	263	-30.3	34.9
	0.81	1.80	340	239	252	-33.3	39.8
	0.86	1.90	352	239	241	-36.1	44.5
	0.90	2.00	363	238	231	-38.8	49.0

Weights in t

The catch forecast for 2009 (220 tons) was very consistent with the observed catch in 2009 (250 tons).

7. DETAILED STOCK ASSESSMENTS (TOR A, B, D AND E)

7.1. Introductory notes

SGMED-10-03 presents the following stock assessment approaches in an agreed and consistent format in order to allow scientists and fisheries managers a thorough review of all information provided, the methods used and the assessment results. The assessment results are consistently summarized in the summary sheets provided in the previous section 5 of this report. Such summary sheets replace or supplement those given in report of SGMED-10-02.

Constrained by data availability and the fact, that the framework of SGMED has just been created in 2008, not all the assessments presented are considered final. SGMED will continue to improve and update the assessments in the future, especially where data or scientific advice with respect to precautionary and limit references of stock size and exploitaiton is lacking.

In some assessments, SGMED applied a number of different approaches in order to verify the assessment results. The assessment tools applied are CPUE analyses from surveys, hydro-acoustic surveys, daily egg productions, virtual population analyses (XSA or ICA) calibrated with survey or commercial data on stock abundance, pseudo-cohort analyses (VIT) and various dynamic production models under equilibrium (YpR) or non-equilibrium conditions (ALADYM, ASPIC). Different software was identified and used for the analyses conducted.

Where applicable, the assessments are largely based on data obtained through the DCR (until 2008) and DCF (since 2009) and the official call issued in 2010 for fisheries and scientific survey data (published on the STECF homepage https://datacollection.jrc.ec.europa.eu/), also covering data collected during national programmes or projects co-funded by the EU-Commission. SGMED was often unable to verify the origin or quality of the data used in the assessment but will continue its effort to validate the data through expert knowledge and transparent presentation of the data.

In accordance with the ToRs, this SGMED-10-03 report deals with the assessment of historic and recent trends in stock parameters (stock size, recruitment and exploitation) and relevant scientific fisheries management advice. SGMED-10-03 represents 16 detailed stock assessment approaches with relevant data for European hake (*Merluccius merluccius*, 5 stocks), red mullet (*Mullus barbatus*, 4 stocks), pink shrimp (*Parapenaeus longirostris*, 3 stocks), giant red shrimp (*Aristaeomorpha foliacea*, 1 stock), Norway lobster (*Nephrops norvegicus*, 1 stock), anchovy (*Engraulis encrasicolus*, 1 stock) and sardine (*Sardina pilchardus*,1 stock). Such stock assessments are considered updates and supplements of the SGMED-10-02 report due to lack of data and/or working time. The stock assessment of hake in GSA 17 was not undertaken due to severe shortfalls in data and data quality as outlined in section 7.6.

Where exploitation rates or coefficients of exploitation rates (fishing mortality) could be analytically assessed, fisheries management advice consistent with high long term yields is formulated conditional of proposed limit reference points (F_{MSY} or $F_{0.1}$).

Deterministic short and medium term predictions of stock size and catches (landings) under various management options as well as relevant scientific advice are also provided in the preceding section 6.

7.2. Stock assessment of hake in GSA 09

7.2.1. *Stock identification and biological features*

7.2.1.1. Stock Identification

Due to a lack of information about the structure of hake population in the western Mediterranean, this stock was assumed to be confined within the GSA 09 boundaries. Hake is distributed in the whole area between 10 and 800 m depth (Biagi et al., 2002; Colloca et al., 2003). Recruits peak in abundance between 150 and 250 m depth over the continental shelf-break and appear to move slightly deeper when they reach 10 cm total length. Crinoid (*Leptometra phalangium*) bottoms over the shelf-break are the main settlement habitat for hake in the area (Colloca *et al*., 2004, 2006; Reale *et al*., 2005). Migration from nurseries takes place when juveniles attained a critical size between 13 and 15.5 cm TL (Bartolino *et al.*, 2008a). Maturing hakes (15-35 cm TL) persist on the continental shelf with a preference for water of 70-100 m depth, while larger hakes can be found in a larger depth range from the shelf to the upper slope. Juveniles show a patchy distribution with some main density hot spots (i.e. nurseries areas) showing a high spatio-temporal persistence (Abella *et al*., 2005; Colloca *et al*., 2006; 2009; Jona Lasinio *et al*., 2007) (Fig. 5.7.1.1.1) in areas with frontal systems and other oceanographic structures that can enhance larval retention (Abella *et al*., 2008).

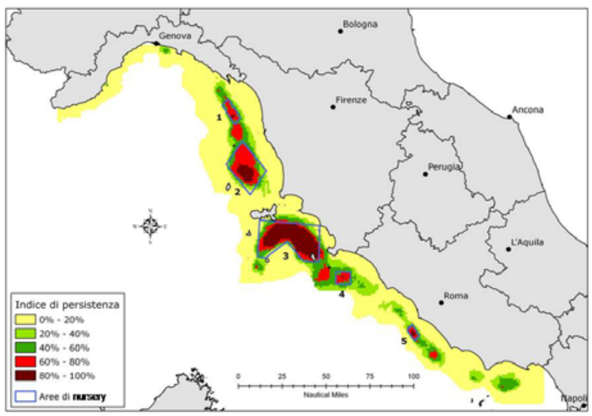
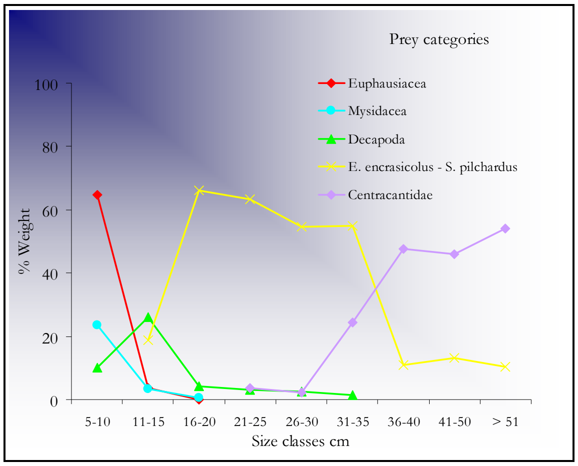
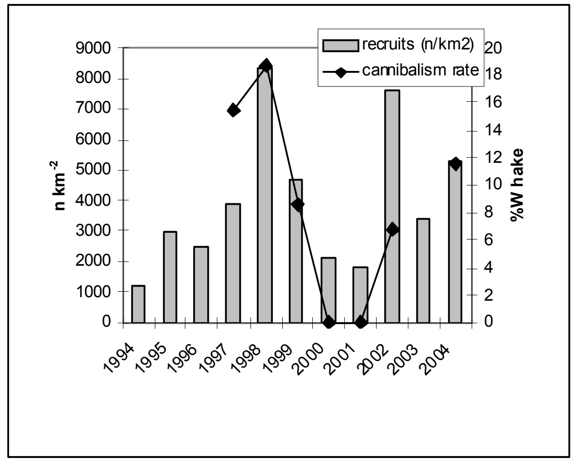


Fig 7.2.1.1.1 Temporal persistence of hake nurseries calculated from MEDITS and GRUND time-series density maps (1994-2005) of juveniles.

Although hakes are demersal fish feeding typically upon fast-moving pelagic preys while ambushed in the water column (Alheit and Pitcher, 1995), there is evidence that hakes feed in mid-water or at the surface during night-time, undertaking daily vertical migrations (Orsi-Relini *et al*., 1989, Carpentieri *et al*., 2008) which are more intense for juveniles. In GSA 09 many different studies are available on hake diet. Results from stomach data collected in the 1996-2001 period can be found in Sartor et al. (2003a) and Carpentieri et al. (2005). Hake diet shifts from euphausids and mysiids consumed by smaller hake (<16 cm TL), to fishes consumed by larger hake.

Before the transition to the complete ichthyophagous phase (TL> 36 cm) hake shows more generalized feeding habits where decapods, benthic (Gobiidae, *Callionymus* spp.,) and necktonic fish (*S. pilchardus, E. encrasicolus*) dominated the diet, whereas cephalopods had a lower incidence (Fig. 7.2.1.1.2).





A) B)

Fig. 7.2.1.1.2 A) Hake diet composition in GSA 09 by size class (from Carpentieri *et al*., 2005). B) Relationships between recruitment and cannibalism rate (proportion by weight, %W, of hake in hake stomachs).

Estimation of cannibalism rate has been provided for the southern part of the GSA (Latium, EU Because project). Cannibalism increased with size and can be considered significant for hakes between 30 and 40 cm TL (up to 20% by weight in diet) and seems to relate closely to hake recruitment density and level of spatial overlapping.

Consumption rate has been estimated for juveniles and piscivorous hakes. Daily consumption of juveniles, calculated in proportion of body weight (%BW), varied between 5 (July) and 5.9 % BW (Carpentieri et al., 2008). The estimated relative daily consumption for hake between 14 and 40 cm TL, using a bioenergetic approach (EU Because project), was between 2.9 and 2.3 BW%.

7.2.1.2. Growth

Juvenile growth rate was estimated to be about 1.5 cm.month^{-1} using daily growth increments on otoliths (Belcari et al., 2006). According to this growth rate, hake reaches an average length of about 18 cm TL at the end of the first year. According to these observations, the growth of hake in the GSA 09 seems to follow the pattern estimated in the NW Mediterranean (Garcia-Rodriguez and Esteban, 2002) adopting the hypothesis that two rings are laid down on otoliths each year. This new interpretation of otolith ring patterns returns a growth rate (L_∞ = 103.9, K/year = 0.212, t_0 =0.031) almost double than that assumed in the past.

As showed in the Fig. 7.2.1.2.1, cohorts obtained through age slicing of LFDS MEDITS data according to fast growth parameters, can be consistently followed during time, while a less reliable pattern was obtained using parameters conform to the slow growth hypothesis.

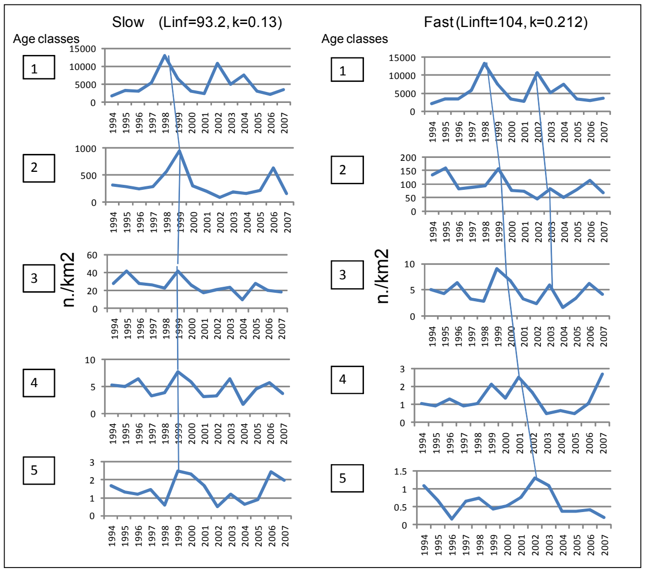


Fig. 7.2.1.2.1 Trends in abundance of age classes obtained using age slicing according to two different sets of growth parameters on MEDITS data.

7.2.1.3. Maturity

The catchability of hake spawners to the Mediterranean trawl nets is rather limited. The distribution of adults which are more abundant on deeper or untrawable grounds, or the ability of larger fish to avoid capture have been claimed as causes of the observed extremely reduced catch of adult hake by trawlers in the Mediterranean (Abella *et al.*, 1997). Also during trawl surveys (MEDITS and GRUND) the catch rate of mature specimens was very low, reducing the possibility of use trawl survey data to explore patterns in gonad development as well as the relationships between growth rate and maturation processes.

Large size hake are targets of a specifically targeted gillnet fishery carried out by several vessels working in the southern part (northern and central Tyrrhenian Sea) of the GSA 09 (Sartor *et al*., 2001a).

Reproductive biology and fecundity of hake have been studied in northern Tyrrhenian Sea (Biagi *et al*., 1995; Nannini *et al*., 2001; Recasens *et al*., 2008) by monthly samplings of adults caught by trawling and gillnets.

Females in advanced maturity stages, spawning and partial post-spawning are present all year round, but reproductive activity is concentrated from January to May, with two peaks of spawning in February and May. The presence of hake spawners seems to be more concentrated in the southern part of GSA 09.

Female length at first maturity was estimated at 35 cm TL in northern Tyrrhenian Sea (Recasens *et al*., 2008). This value is consistent with the observations obtained from trawl surveys over the Latium (Colloca, pers. comm.) reporting first maturity from 31 to 37 cm TL for females and from 21 to 25 cm TL for males.

Batch fecundity was about 200 eggs per gonad-free female gram, with asynchronous oocyte development (Recasens *et al*., 2008).

7.2.2. *Fisheries*

7.2.2.1. General description of fisheries

Hake is among the most important component of bottom trawlers targeting a species complex and is the demersal species providing the highest landings and incomes for the GSA 09. The analysis of available information suggests that about 80% of landings of hake are obtained by bottom trawl vessels; the remaining fraction is provided by artisanal vessels using set nets, in particular gillnets.

The trawl fleet of GSA 09 at the end of 2006 accounted for 361 vessels (Tab. 7.2.2.1.1).

The main trawl fleets of GSA 09 are present in the following continental harbours: Viareggio, Livorno, Porto Santo Stefano (Tuscany), Fiumicino, Terracina, Gaeta (Latium).

Tab. 7.2.2.1.1 Technical characteristics of the trawl fleet of GSA 09.

N. of boats	361
GT	13.191
kW	75.514
Mean GT	36.5
Mean kW	209.2

As concerns fishing activity, the majority of bottom trawlers of GSA 09 operate daily fishing trips with only some vessels staying out for two-three days and especially in summer.

Hake fishing grounds comprise all the soft bottoms of continental shelves and the upper part of continental slope. Fishing pressure shows some geographical differences inside the GSA 09 according to the consistency of the fleets and the characteristics of the bottoms.

The artisanal fleets, according to the last official data (end of 2006), accounted for 1,309 vessels that operate in several harbours along the continental and insular coasts. Of these, about 50 vessels, mainly located in some harbors of the GSA 09 (e.g. Marina di Campo, Ponza, Porto Santo Stefano), utilize gillnets and target medium and large-sized hakes (larger than 25 cm TL) especially from winter to summer.

7.2.2.2. Management regulations applicable in 2009 and 2010

- Fishing closure for trawling: 45 days in late summer (not every year have been enforced)
- Minimum landing sizes: EC regulation 1967/2006: 20 cm TL for hake.
- Cod end mesh size of trawl nets: 40 mm (stretched, diamond meshes) till 30/05/2010. From 1/6/2010 the existing nets will be replaced with a cod end with 40 mm (stretched) square meshes or a cod end with 50 mm (stretched) diamond meshes.
- Towed gears are not allowed within three nautical miles from the coast or at depths less than 50 m when this depth is reached at a distance less than 3 miles from the coast.
- Two small No Take Zones (“Zone di Tutela Biologica”, ZTB) are present inside the GSA 09; one off the Giglio Island (50 km^2, northern Tyrrhenian Sea) another off Gaeta, (125 km^2, central Tyrrhenian Sea). Bottom fishing was not allowed in the two ZTB. A recent regulation of the Italian Ministry of Agricultural, Food and Forestry Policies has established that fishing activity can be carried out in these two areas from July 1st to December 31st.

7.2.2.3. Catches

7.2.2.3.1. Landings

In the last six years the total landings of hake of GSA 09 fluctuated between 1195 to about 2300 tons (Fig. 7.2.2.3.1.1).

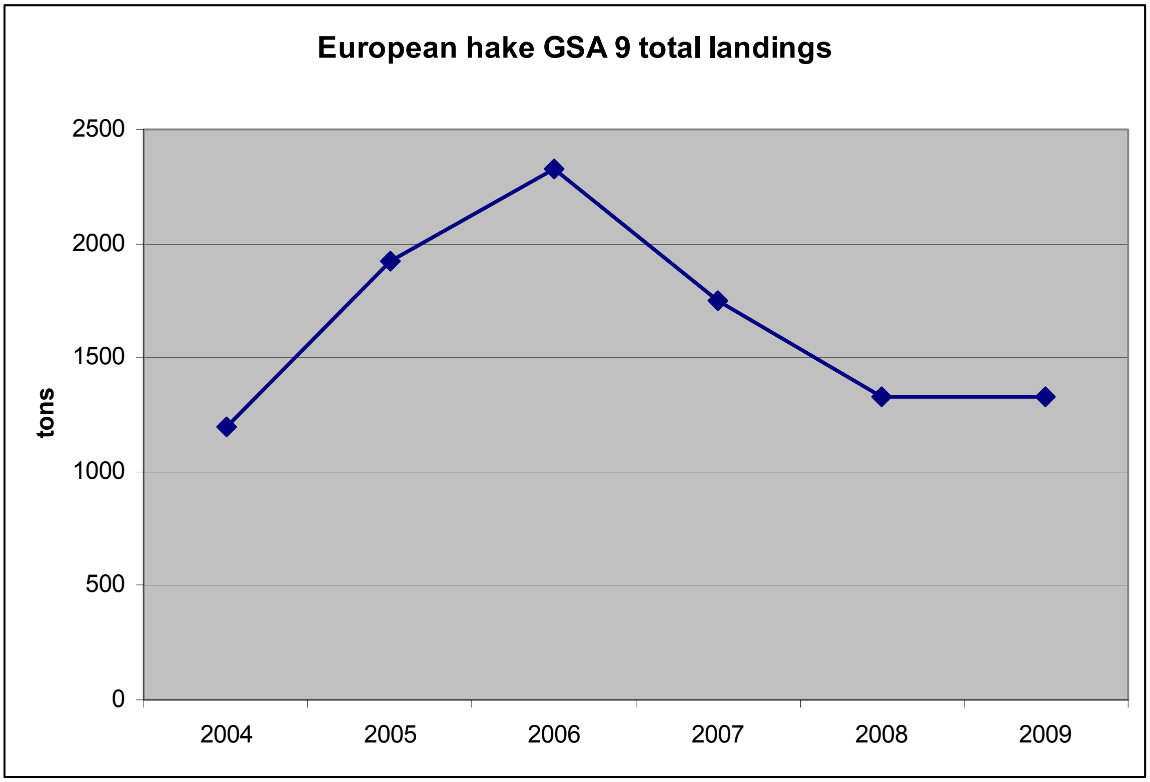


Fig. 7.2.2.3.1.1 Landings of hake (all gears) in the GSA 09, from 2004 to 2009 (DCF official data).

Due to huge concentration of hake juveniles in GSA 09, trawl catches are traditionally dominated by small sized specimens; they are basically composed by 0+ and 1+ age class individuals. Gillnet fishery lands mostly 2+ and 3+ years old fishes, as shown, as an example, by the two following histograms (Fig. 7.2.2.3.1.2).

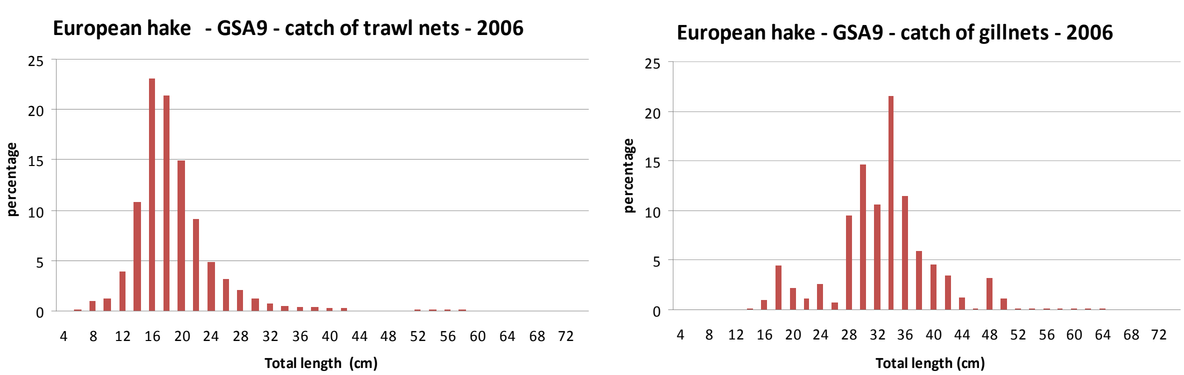


Fig. 7.2.2.3.1.2 Example of size structure of the catches of hake in GSA 9 provided in 2006 by otter trawling and by set nets in the GSA 09 (DCR official data).

The Table 7.2.2.3.1.1 lists the landings data of Hake in GSA 09 coming from the Data Collection Regulation, by major gear types.

According to the STECF-SGMED-10-03 scientist's knowledge, DCR landing data for GSA 09 probably give an overstimation of the amount derived from the set nets (GNS in particular). This aspect underlines both the need of some improvements of the data collection, paying particular attention to the sampling design and the importance of a routinely check made by experts of the official data.

Table 7.2.2.3.1.1 Landings (t) by year and major gear types, 2004-2009 as reported through DCF. No data for 2002 and 2003 were submitted.

SPECIES	AREA	COUNTRY	FT_LVL4	2004	2005	2006	2007	2008	2009
HKE	9	ITA		39,9	25,9	3,9			
HKE	9	ITA	GND			4,8			
HKE	9	ITA	GNS	249,5	551,0	592,9	580,2	348,9	409,2
HKE	9	ITA	GTR	346,4	284,4	404,0	131,9	61,1	54,0
HKE	9	ITA	LLD	1,1		56,8	0,2	2,2	4,4
HKE	9	ITA	LLS	3,3	5,2	85,1	15,6	2,9	2,0
HKE	9	ITA	OTB	552,9	1053,9	1180,0	1025,0	914,8	853,2
HKE	9	ITA	PS	0,0		2,8			6,2
HKE	9	ITA	SB-SV	1,5		0,1			
TOTAL LANDINGS				1194,6	1920,3	2330,3	1752,8	1329,8	1329,0

7.2.2.3.2. Discards

Several EU and national projects carried out in GSA 09 highlighted the problem of discard of hake by trawl fisheries. High quantities of small sized hakes are routinely discarded, especially in summer and on the fishing grounds located near the main nursery areas of the species (Fig. 7.2.2.3.2.1).

Due to the introduction of the EU Regulations on MLS, a progressive increase of the size at which 50% of the specimens caught was discarded has been observed in these last years: from about 11 cm TL in 1995 (Sartor *et al*., 2001b), to about 17 cm TL in 2006 (De Ranieri, 2007). In the last years this size is even increasing (Sartor, pers. obs.) This phenomenon might be also explained with the reduction of the fishing pressure on the nursery areas of this species.

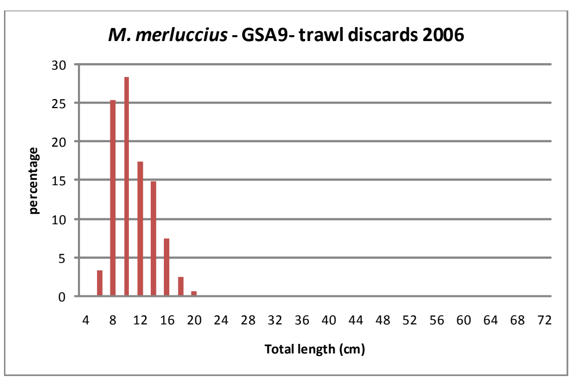


Fig. 7.2.2.3.2.1 Size structure of the hake discarded by the trawl fleets operating in the GSA 09 in 2006 (DCR official data).

Reported discards through the DCR data call to SGMED-09-02 amount 467 t in 2006 for trawlers.

7.2.2.3.3. Fishing effort

The fishing capacity of the GSA 09 has shown in these last 10 years a progressive decrease; from 1996 to 2007.

Fishing effort (kw*fishing days) performed by the GSA 09 trawlers decreased from about 14,000,000 in 2004 to about 12,000,000; that of set nets (GNS and GTR) remained substantially stable in the period considered.

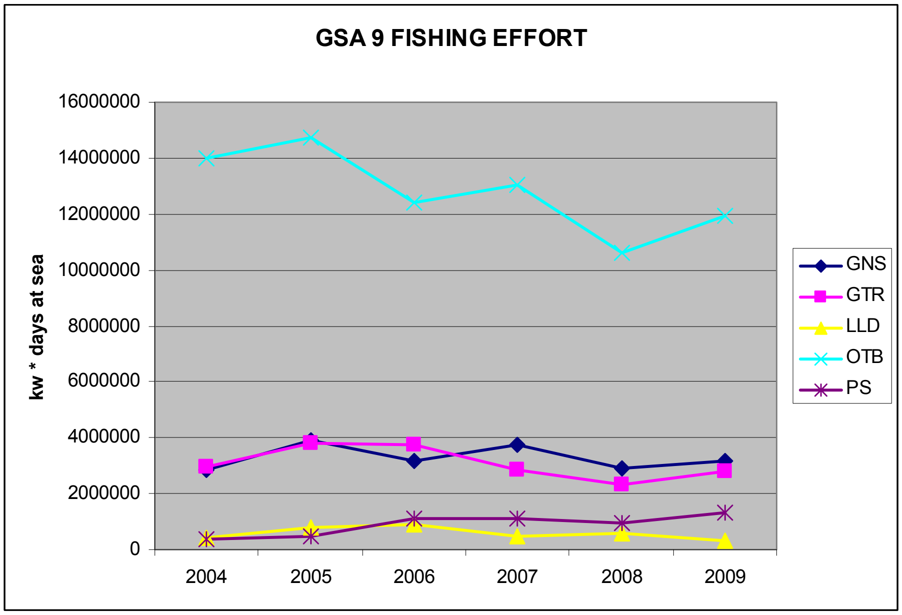


Fig. 7.2.2.3.3.1 Effort trends (days and kW*days) by major fleets, 2004-2007.

Tab. 7.2.2.3.3.1 Effort trends (kW*days) by major fleets as reported through DCF (2004-2009).

AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	VESSEL_LENGTH	2004	2005	2006	2007	2008	2009
9	ITA				VL0006			17656	17264	18783	83933
9	ITA				VL0612	472199	644679	294865	73209	117265	164688
9	ITA				VL1218	3700			2547		
9	ITA				VL1824	17372					
9	ITA	DRB	Molluscs		VL1218	271337	290683	222614	232521	355036	273697
9	ITA	FPO	nersal species		VL0006			1687			
9	ITA	FPO	nersal species		VL0612					2569	
9	ITA	FPO	nersal species		VL1218					22490	9484
9	ITA	GND	iall pelagic fish		VL0612	7686	2640	47550			4429
9	ITA	GND	iall pelagic fish		VL1218			11976			
9	ITA	GNS	nersal species		VL0006			241006	187684	119389	159810
9	ITA	GNS	nersal species		VL0612	2671807	3040551	2043295	2876900	1943304	2084677
9	ITA	GNS	nersal species		VL1218	143130	731268	892800	588214	780959	860279
9	ITA	GNS	nersal species		VL1824	1616					
9	ITA	GNS	id large pelagic fish		VL0006				5402	2776	
9	ITA	GNS	id large pelagic fish		VL0612	11704	63837	15456	4132	20976	38386
9	ITA	GNS	id large pelagic fish		VL1218		52196		68484	30113	22011
		TOTAL GNS				**2828257**	**3887852**	**3192557**	**3730816**	**2897517**	**3165163**
9	ITA	GTR	nersal species		VL0006			51327	45484	31192	89981
9	ITA	GTR	nersal species		VL0612	2907871	3430873	3354500	2549277	2158965	2581318
9	ITA	GTR	nersal species		VL1218	22931	394777	352725	245701	140511	147834
		TOTAL GTR				**2930802**	**3825650**	**3758552**	**2840462**	**2330668**	**2819133**
9	ITA	LHP-LHM	Finfish		VL0612	40544					
9	ITA	LLD	ge pelagic fish		VL0612	428218	782673	709249	295671	439382	184624
9	ITA	LLD	ge pelagic fish		VL1218	7125	13281	163222	189635	137261	142197
9	ITA	LLD	ge pelagic fish		VL1824						0
		TOTAL LLD				**435343**	**795954**	**872471**	**485306**	**576643**	**326821**
9	ITA	LLS	emersal fish		VL0006			1186	21025	925	
9	ITA	LLS	emersal fish		VL0612	354518	458614	355370	91390	30209	27155
9	ITA	LLS	emersal fish		VL1218	1750	24006				2268
9	ITA	LTL	ge pelagic fish		VL0006			7086	2476		2603
9	ITA	OTB	p water species		VL1218					145852	320102
9	ITA	OTB	p water species		VL1824	10206				75837	165696
9	ITA	OTB	nersal species		VL0006					108	
9	ITA	OTB	nersal species		VL0612	202730	189101	226836	251665	174990	171451
9	ITA	OTB	nersal species		VL1218	1645868	1504133	1250063	2496441	2314631	2229315
9	ITA	OTB	nersal species		VL1824	2669494	314808	1266539	1540497	5460490	6053329
9	ITA	OTB	nersal species		VL2440	1492529					968737
9	ITA	OTB	al and deep water spec		VL1218	2119148	2664115	2362684	2519541	1177098	583020
9	ITA	OTB	al and deep water spec		VL1824	5857423	10065218	7321573	6236446	1253611	1372778
9	ITA	OTB	al and deep water spec		VL2440						62897
		TOTAL OTB				**13997398**	**14737375**	**12427695**	**13044590**	**10602617**	**11927325**
9	ITA	PS	ge pelagic fish		VL1218					4160	30424
9	ITA	PS	ge pelagic fish		VL1824	7275	3880		1299	59472	
9	ITA	PS	ge pelagic fish		VL2440						14965
9	ITA	PS	iall pelagic fish		VL0006				11193		
9	ITA	PS	iall pelagic fish		VL0612	27674	148646	44847		32718	42881
9	ITA	PS	iall pelagic fish		VL1218	269016	145756	569851	475217	525772	419772
9	ITA	PS	iall pelagic fish		VL1824	82023	157481	513668	629300	354009	240111
9	ITA	PS	iall pelagic fish		VL2440						562906
		TOTAL PS				**385988**	**455763**	**1128366**	**1117009**	**976131**	**1311059**
9	ITA	PTM	iall pelagic fish		VL0006			3148			
9	ITA	PTM	iall pelagic fish		VL0612			1542			
9	ITA	SB-SV	nersal species		VL0006			8996	25084	16683	7458
9	ITA	SB-SV	nersal species		VL0612	683331	856943	556372	499729	314844	327792
9	ITA	SB-SV	nersal species		VL1218	66124	45567	49489	25800	17960	20116
9	ITA	SB-SV	nersal species		VL1824	808					

7.2.3. *Scientific surveys*

7.2.3.1. MEDITS

7.2.3.1.1. Methods

Based on the DCF data call, abundance and biomass indices were recalculated. In GSA 09 the following number of hauls were reported per depth stratum (s. Tab. 5.7.3.1.1.1).

Tab. 7.2.3.1.1.1. Number of hauls per year and depth stratum in GSA 09, 1994-2009.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GSA09_010-050	19	18	18	18	19	18	18	18	13	13	13	14	13	13	13	14
GSA09_050-100	19	20	18	19	18	19	20	20	15	15	15	14	16	16	13	14
GSA09_100-200	35	35	36	35	35	35	34	34	26	27	26	27	25	26	28	27
GSA09_200-500	32	33	33	36	32	36	37	35	27	27	27	28	29	33	30	28
GSA09_500-800	31	30	31	28	30	28	27	29	24	22	21	20	20	17	18	20

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

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

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

Where:

A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA. Given the sheer number of plots generated, these distributions are not presented in this report.

7.2.3.1.2. Geographical distribution patterns

According to recent studies (Orsi Relini *et al*., 2002), the density of hake recruits concentrations in nursery areas in GSA 09 is by far higher than that of the other GSAs of the western Mediterranean and, probably, also of the other Mediterranean GSAs (Fig. 7.2.3.1.2.1).

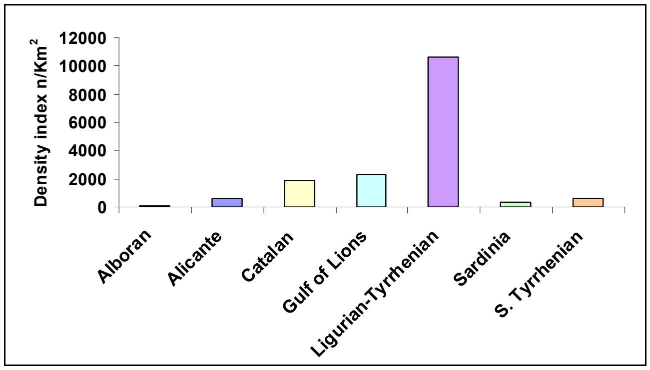


Fig. 7.2.3.1.2.1 MEDITS density indices of the hake recruits (<12 cm TL) obtained in different Mediterranean GSAs (from Orsi-Relini *et al*., 2002, modified).

Generalized additive models were developed to investigate hake recruitment dynamics in the Tyrrhenian Sea in relation to spawner abundance and selected key oceanographic variables. Thermal anomalies in summer, characterized by high peaks in water temperature, revealed a negative effect on the abundance of recruits in autumn, probably due to a reduction in hake egg and larval survival rate. Recruitment was reduced when elevated sea-surface temperatures were coupled with lower levels of water circulation. Enhanced spring primary production, related to late winter low temperatures could affect water mass productivity in the following months, thus influencing spring recruitment. In the central Tyrrhenian a dome-shaped relationship between wind mixing in early spring and recruitment could be interpreted as an "optimal environmental window" in which intermediate water mixing level played a positive role in phytoplankton displacement, larval feeding rate and appropriate larval drift (Bartolino *et al*., 2008b) (Fig. 7.2.3.1.2.2).

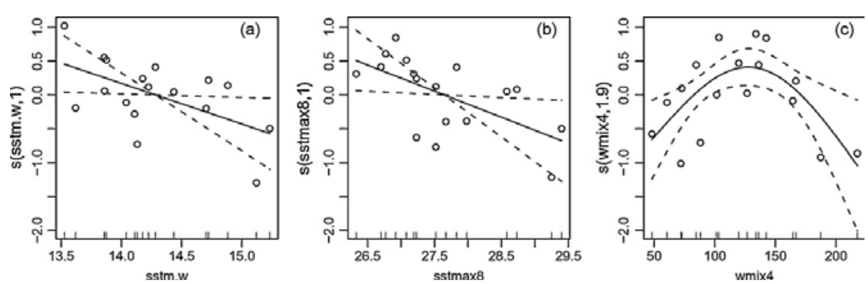


Fig. 7.2.3.1.2.2 Effects of: (a) sstm.w, (b) sstmax8 and (c) wmix4 on hake recruitment in the central Tyrrhenian (from Bartolino et al., 2008b).

The temporal trend in spatial distribution of hake > 26 cm TL showed a clear reduction of distribution area, particularly in the Tyrrhenian part of the GSA (GRUND data, Fig. 7.2.3.1.2.3).

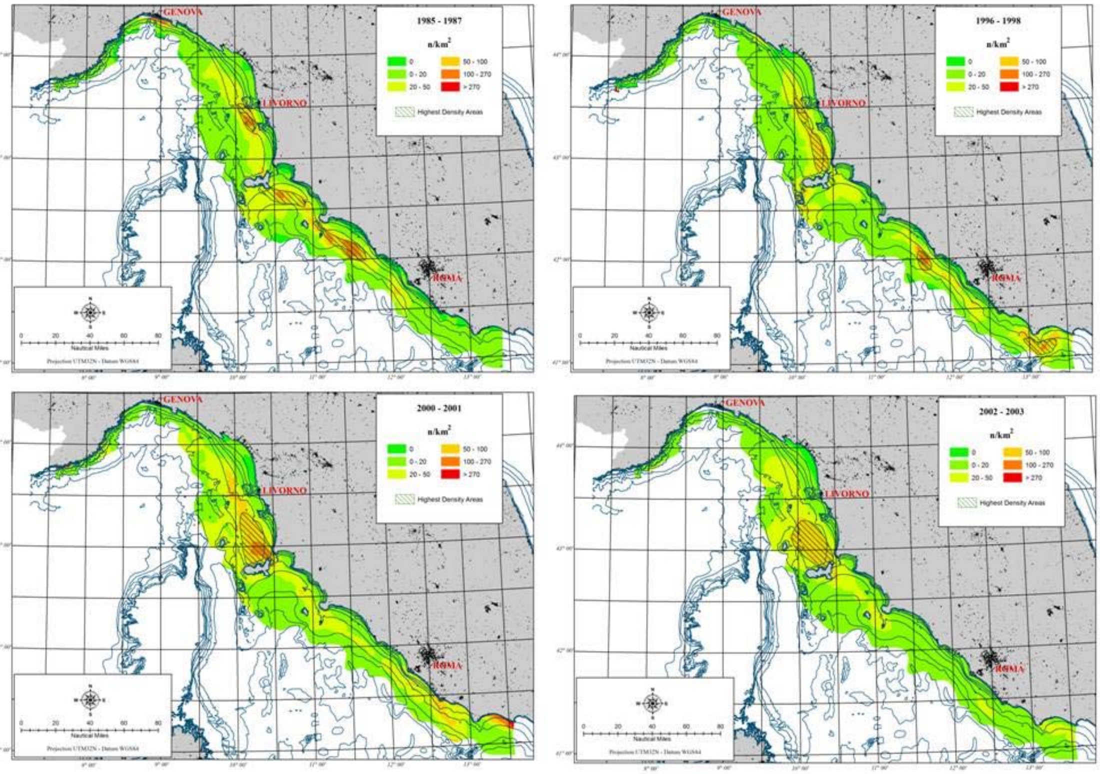
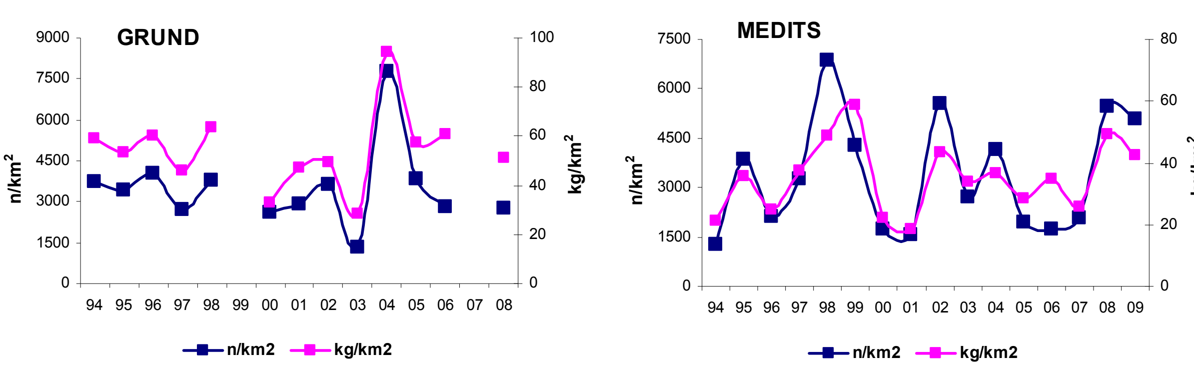


Fig. 7.2.3.1.2.3 Distribution of hakes larger than 26 cm TL in 1985-87, 1996-98, 2000-01, 2002-03.

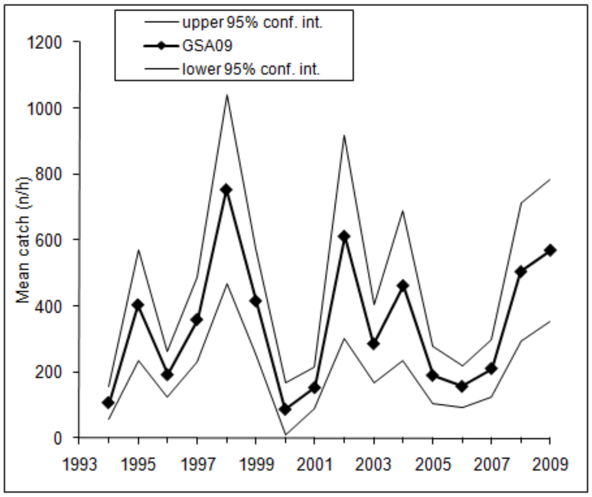
7.2.3.1.3. Trends in abundance and biomass

The national GRUND trawl survey (Relini, 1998) has been performed out along the Italian coasts in addition to MEDITS. It has been carried out since 1985, with some years lacking (1988, 1989 and 1999, 2007). Sampling is random stratified, except in the period 1990-93 where a different sampling design, based on transects, was applied. Locations of stations were selected randomly within each stratum in the period 1985-87, while starting from 1996, the same stations were sampled the following years. Therefore from 1994 in Italy two trawl surveys are regularly carried out each year: MEDITS, in spring, and GRUND, in autumn. The two surveys provide integrate pictures on different seasons, allowing to monitor the most important biological events (recruitment, spawning) for the majority of the demersal species.
Figure 7.2.3.1.3.1 shows the density and biomass indices of hake obtained from 1994 to 2009; no evident trends are present.



7.2.3.1.3.1 Density and biomass indices of hake according to the GRUND and MEDITS surveys.

Figure 7.2.3.1.3.2 displays the re-estimated trend in hake abundance and biomass in GSA 09 (kg/h) based on the MEDITS DCR data call. Both MEDITS trends presented are similar without any long term trend.



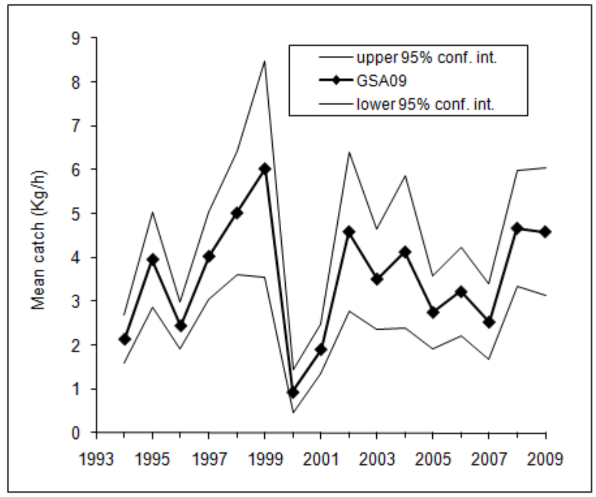


Fig. 7.2.3.1.3.2 Abundance and biomass indices of hake in GSA 09.

7.2.3.1.4. Trends in abundance by length or age

The following Fig. 7.2.3.1.4.1 and 2 display the stratified abundance indices of GSA 09 in 1994-2001 and 2002-2009.

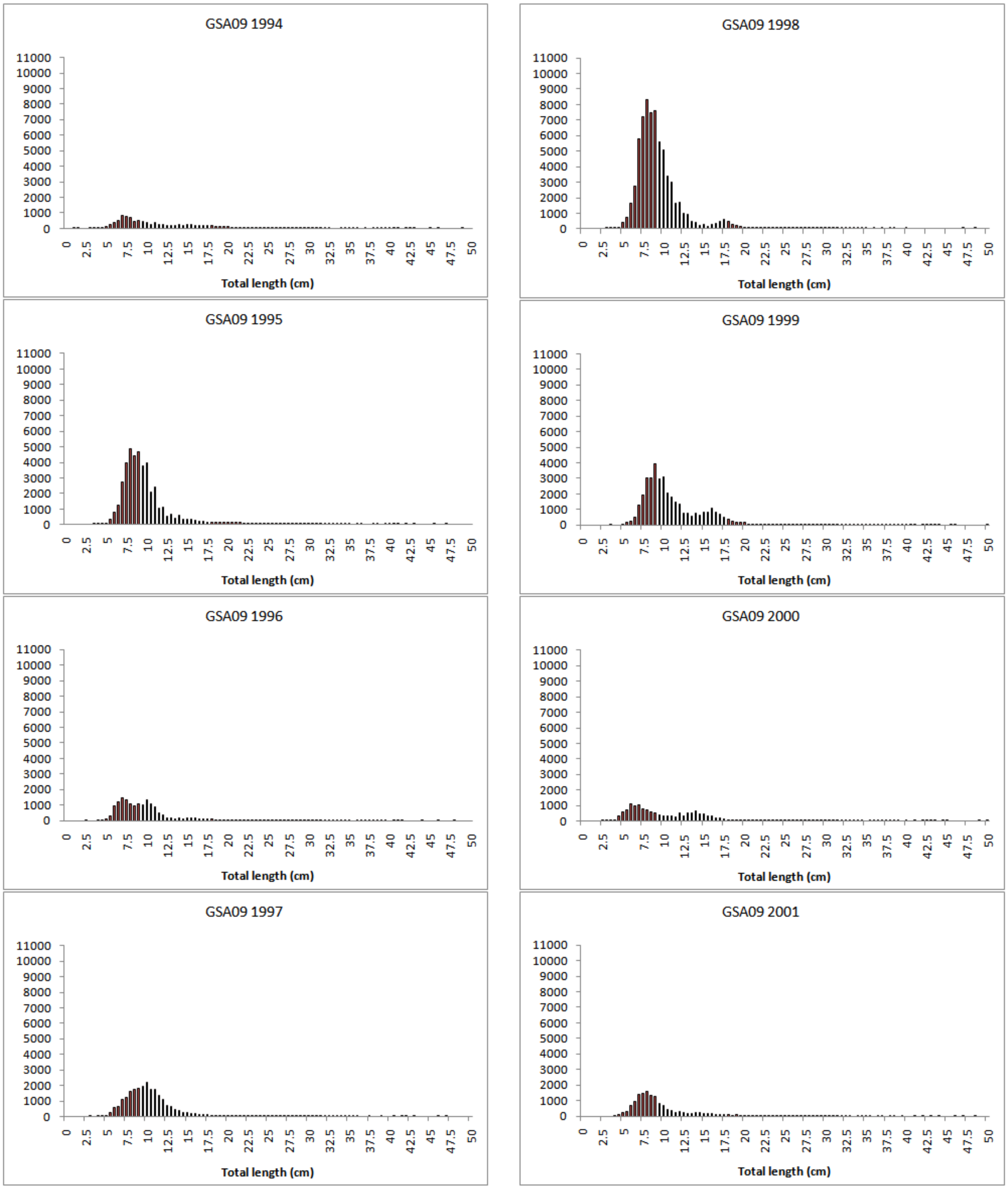


Fig. 7.2.3.1.4.1 Stratified abundance indices by size, 1994-2001.

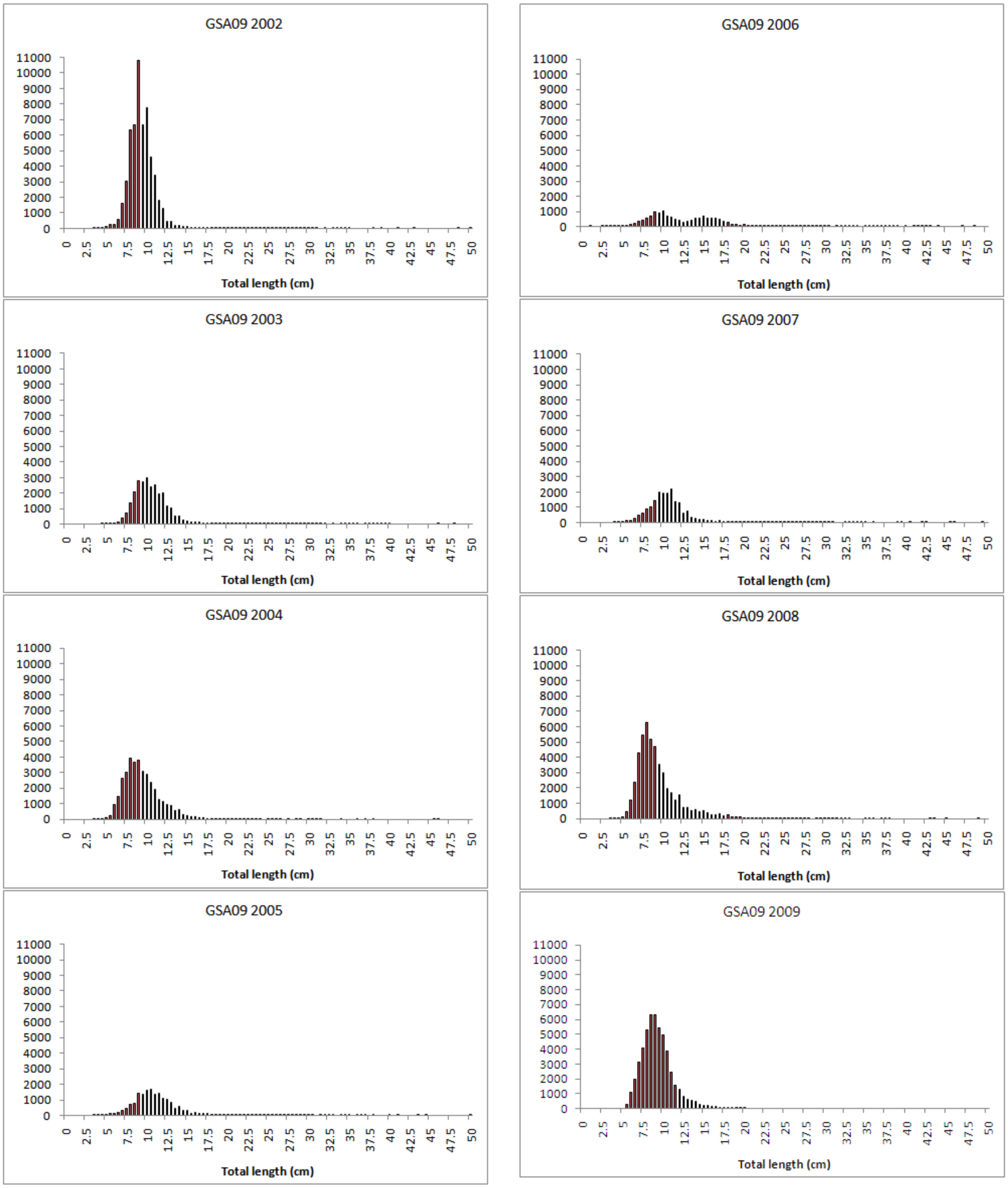

GSA09 2002
GSA09 2003
GSA09 2004
GSA09 2005
GSA09 2006
GSA09 2007
GSA09 2008
GSA09 2009
Total length (cm)

Fig. 7.2.3.1.4.2 Stratified abundance indices by size, 2002-2009.

7.2.3.1.5. Trends in growth

No analyses were conducted.

7.2.3.1.6. Trends in maturity

No analyses were conducted.

7.2.4. *Assessment of historic stock parameters*

Due to its importance as demersal resource, hake has been object of several assessments in the GSA 09 (Reale *et al*., 1995; Fiorentino et al., 1996; Ardizzone et al., 1998; Abella *et al.*, 1999; 2007; Colloca *et al*., 2000). These results are published and regularly updated in the GFCM SAC sheets. The assessments, often performed with different approaches in different periods or in different subareas of the GSA 09, showed substantially convergent results.

The hake in the GSA 09 seems to be in a "chronic" overexploitation, as shown by the results of the analytical models (reference points as F_{max}, $F_{0.1}$ and SSB_{curr}/SSB_0). Also the production models based on total mortality provided total mortality estimates greater than the mortality corresponding to the maximum biological production (ZMBP).

A growth overfishing situation was detected, with excessive fishing mortality on 0+ and 1+ age classes. The values of the SSB_{curr}/SSB_0 ratio are always lower than 0.1.

Two new assessments based on DCF landing data and survey data (MEDITS and GRUND) were produced using Length Cohort Analysis (LCA) and SURBA respectively during STECF-SGMED-09-02. SURBA assessment was updated including 2009 MEDITS data in the time series during STECF-SGMED-10-02. The lack of 2009 landings data for GSA 9 during the meeting makes it impossible to perform a new LCA assessment for this stock.

7.2.4.1. Method 1: Trends in LPUE

As concerns the Landings per Unit of Effort, quite long time series are available for some important fleets operating in this GSA 09.

7.2.4.1.1. Justification

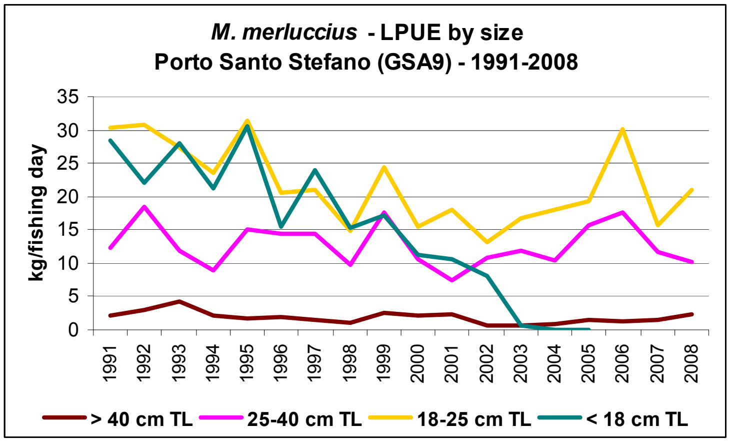
Trends in LPUE may provide insight into trends in stock size. SGMED-10-02 recommends that technological creep should be considered when trends in LPUE are interpreted.

7.2.4.1.2. Input parameters

These data come from independent monitoring activities performed by the research institutes working in the GSA.

7.2.4.1.3. Results

As an example, the LPUE evolution in the period 1991-2008 is reported in Fig. 7.2.4.1.3.1. LPUE showed a continuous decreasing trend till 2004 while LPUE remained substantially stable in the last four years. The decrease in LPUE is mainly due to a change in fishing pattern experienced by the local fleets: the progressive disappearance of the smallest specimens from the landings is the effect of the introduction of the EU Regulations (1626/94 and 1967/06) concerning MLS (20 cm TL for hake). Also a progressive reduction of fishing pressure on the nursery areas is occurring in the last years, especially on the northern fishing grounds of GSA 09.



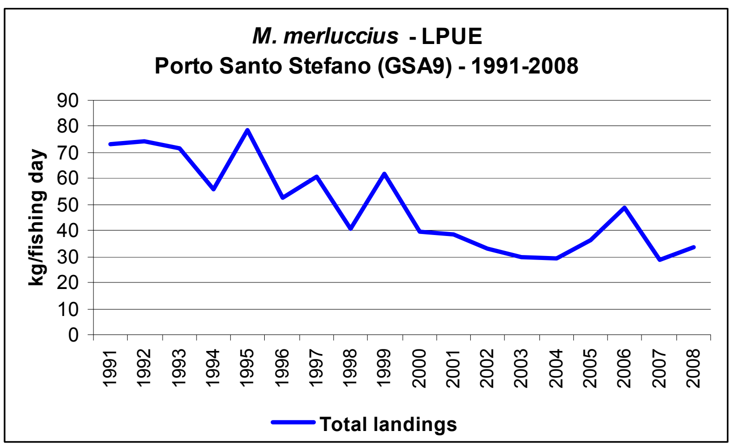


Fig. 7.2.4.1.3.1 Hake LPUE of the Porto Santo Stefano trawl fleet (1991-2008); above: LPUE by size class; below: total LPUE

7.2.4.2. Method 2: SURBA

7.2.4.2.1. Justification

The relatively long time series of data available from the GRUND and MEDITS surveys provided the most useful data sets for analysis. The survey-based stock assessment approach SURBA (Needle, 2003) was used both on MEDITS (1994-2009) and GRUND (1994-2004) data of the hake of GSA 09.

7.2.4.2.2. Input parameters

The following set of parameters was adopted:

Growth parameters (Von Bertalanffy)
$L\infty$ = 104 (mm, length)
K = 0.2
t_0 = - 0.03
L*W
a = 0.006657
b = 3.028
Natural mortality
M vector Age_1=1.3 , Age_2=0.6, Age_3=0.46, Age_4=0.41, Age_5=0.3
Catchability (q)
q(age 0+) = 0.8, q(age 1+) = 1.0, q(age 2+)=0.7, q(age3+)=0.7, q(age 4+)=0.7
Length at maturity (L50)
L50 = 30 cm
Length of first capture (Lc)
Lc = 12 cm

Tab. 7.2.4.2.2.1 Input parameters used for the SURBA model.

MEDITS						GRUND				
Mean abundance										
	Age					Age				
Year	0	1	2	3	4+	0	1	2	3	4+
1994	2062.6	132.4	5	1.1	1.1	4079.4	111.5	6.5	0.1	0.3
1995	3446.2	159.5	4.3	0.9	0.7	3586.1	132.0	3.2	0.6	0.3
1996	3366.3	80.9	6.3	1.3	0.2	3930.0	157.9	4.5	1.1	0.6
1997	5753.5	86.4	3.3	0.9	0.7	2729.1	119.9	4.0	0.9	0.7
1998	13371	94.8	2.9	1	0.7	3894.3	122.9	4.4	0.7	0.3
1999	7441.3	156.7	9	2.2	0.4	3265.3	103.9	5.0	0.6	0.5
2000	3371	75.3	6.8	1.4	0.5	2636.3	84.9	5.6	0.6	0.7
2001	2663.1	73.8	3.3	2.5	0.7	3254.5	126.2	4.0	0.8	0.4
2002	10864	44.7	2.3	1.7	1.3	3901.0	107.8	3.9	0.8	0.5
2003	5153	82	6	0.5	1.1	1243.5	102.7	4.4	0.7	0.7
2004	7590.5	51.1	1.6	0.6	0.4	7859.5	110.5	3.3	0.9	0.6
2005	3278.9	79.3	3.4	0.5	0.4					
2006	2865	114	6.2	1.1	0.4					
2007	3559.8	69.1	4.2	2.7	0.2					
2008	8529	94.8	3.6	1	1					
2009	5121.2	60.855	1.905	0.357	0.1					
Proportion mature										
	Age									
Year	0	1	2	3	4+	0	1	2	3	4+
1994	0	0.012	0.96	1	1	0	0	0.012	0.96	1
1995	0	0.012	0.92	1	1	0	0.012	0.92	1	1
1996	0	0.029	0.9	1	1	0	0.029	0.9	1	1
1997	0	0.02	0.94	1	1	0	0.02	0.94	1	1
1998	0	0.017	0.89	1	1	0	0.017	0.89	1	1
1999	0	0.015	0.92	1	1	0	0.015	0.92	1	1
2000	0	0.026	0.92	1	1	0	0.026	0.92	1	1
2001	0	0.018	0.96	1	1	0	0.018	0.96	1	1
2002	0	0.028	0.97	1	1	0	0.028	0.97	1	1
2003	0	0.025	0.93	1	1	0	0.025	0.93	1	1
2004	0	0.012	0.9	1	1	0	0.012	0.9	1	1
2005	0	0.027	0.92	1	1					
2006	0	0.021	0.93	1	1					
2007	0	0.019	0.96	1	1					
2008	0	0.019	0.96	1	1					
2009	0	0.02	0.94	1	1					
Mean weights										
	Age									
Year	0	1	2	3	4+	0	1	2	3	4+
1994	0.008	0.086	0.498	1.244	3.261	0.013	0.113	0.461	0.875	1.794
1995	0.006	0.091	0.491	1.205	3.031	0.013	0.112	0.488	0.912	2.885
1996	0.006	0.103	0.452	1.455	2.122	0.012	0.108	0.454	1.051	1.834
1997	0.007	0.097	0.519	1.340	2.918	0.013	0.114	0.420	1.095	1.954
1998	0.005	0.091	0.489	1.509	2.630	0.015	0.105	0.438	1.021	1.952
1999	0.009	0.090	0.451	1.292	2.036	0.012	0.110	0.449	1.026	1.919
2000	0.008	0.105	0.475	1.153	2.136	0.009	0.116	0.458	1.032	1.904
2001	0.006	0.094	0.580	1.180	2.839	0.012	0.112	0.438	1.108	2.359
2002	0.005	0.114	0.513	1.335	2.522	0.011	0.111	0.445	1.060	2.118
2003	0.007	0.100	0.509	1.269	2.509	0.015	0.117	0.420	0.986	1.596
2004	0.006	0.087	0.491	1.345	2.233	0.011	0.112	0.447	1.113	2.245
2005	0.009	0.101	0.448	1.052	3.447					
2006	0.013	0.088	0.505	1.286	3.307					
2007	0.007	0.096	0.505	1.286	3.307					
2008	0.007	0.096	0.559	1.220	2.000					
2009	0.0074	0.0964	0.5593	1.225	1.8109					

7.2.4.2.3. Results

Fitted year effect, that is the model proxy for the combination of fishing effort and mean natural mortality in the underlying population, shows peaks in 1999, 2003 and 2009 following recruitment peaks with a time lag of one year. Fitted age effect shows a decreasing from age 0 to age 2, while fitted cohort effects (Figure 7.2.4.2.3.1) show large fluctuations.

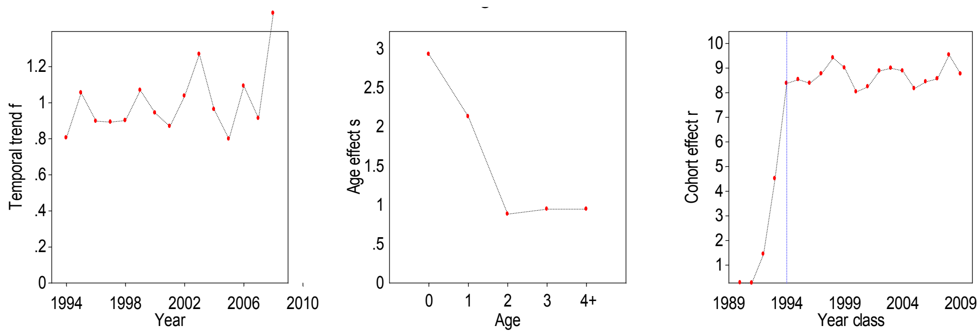


Fig. 7.2.4.2.3.1 MEDITS survey. Fitted year, age and cohort effects estimated by SURBA.

The two surveys gave a similar picture for F_{1-3} which shows a clear increasing trend (MEDITS, $p<0.01$) from 0.8 (1994) to 2.4 (2009). Relative SSB decreased significantly (MEDITS, $p<0.01$). Recruitment fluctuated from year to year without a clear temporal pattern during MEDITS. The largest year classes were observed in 1998 and 2008. GRUND showed a more constant pattern in recruitment with the lowest value in 2003 and a high peak in 2004 (Fig. 7.2.4.2.3.2).

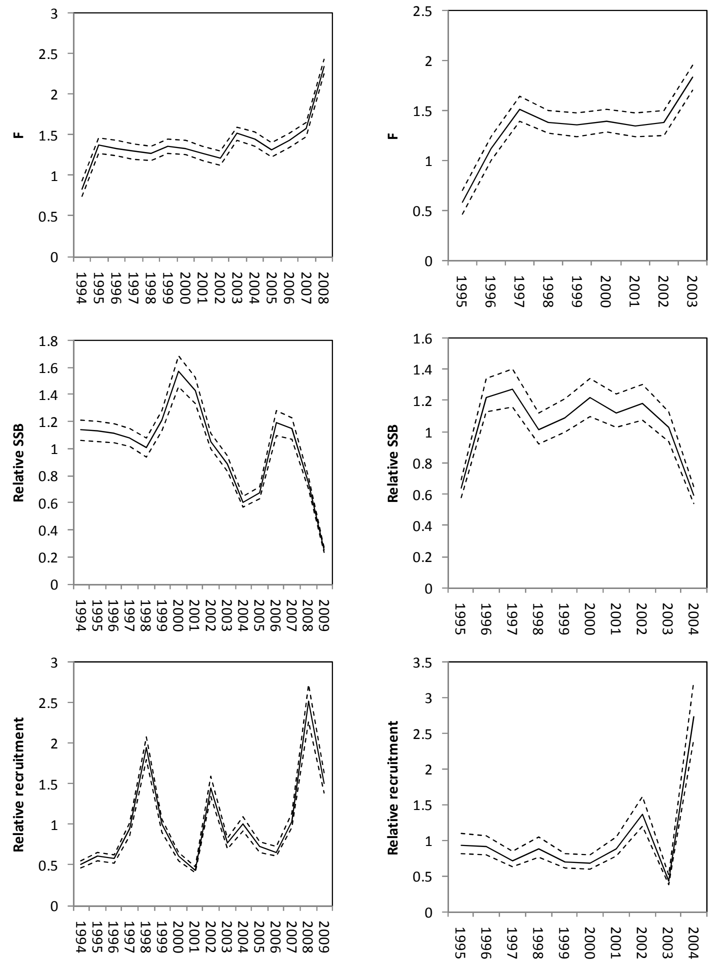


Fig. 7.2.4.2.3.2 MEDITS and GRUND surveys. Estimated trend in F, relative SSB and recruitment using SURBA. 50th percentile of bootstrapped runs (solid line) and 5% and 95% percentiles of bootsrapped runs (dashed lines).

Model diagnostics are shown in the following Fig. 7.2.4.2.3.3 and Fig. 7.2.4.2.3.4.

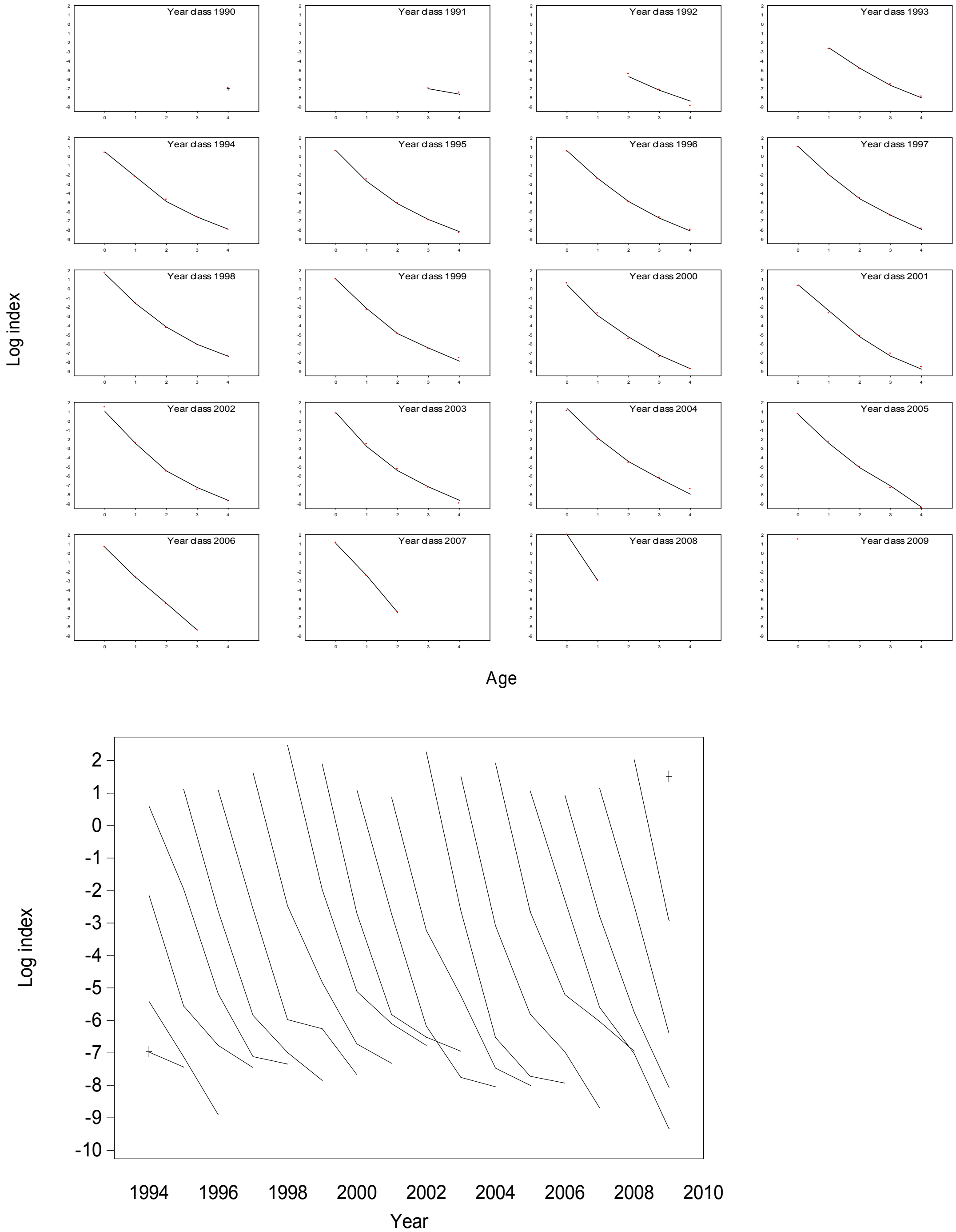


Fig. 7.2.4.2.3.3 Model diagnostic for SURBA model in the GSA 09 (MEDITS data). A) Comparison between observed (points) and fitted (lines) survey abundance indices, for each year. B) Log survey abundance indices by cohort. Each line represents the log index abundance of a particular cohort throughout its life.

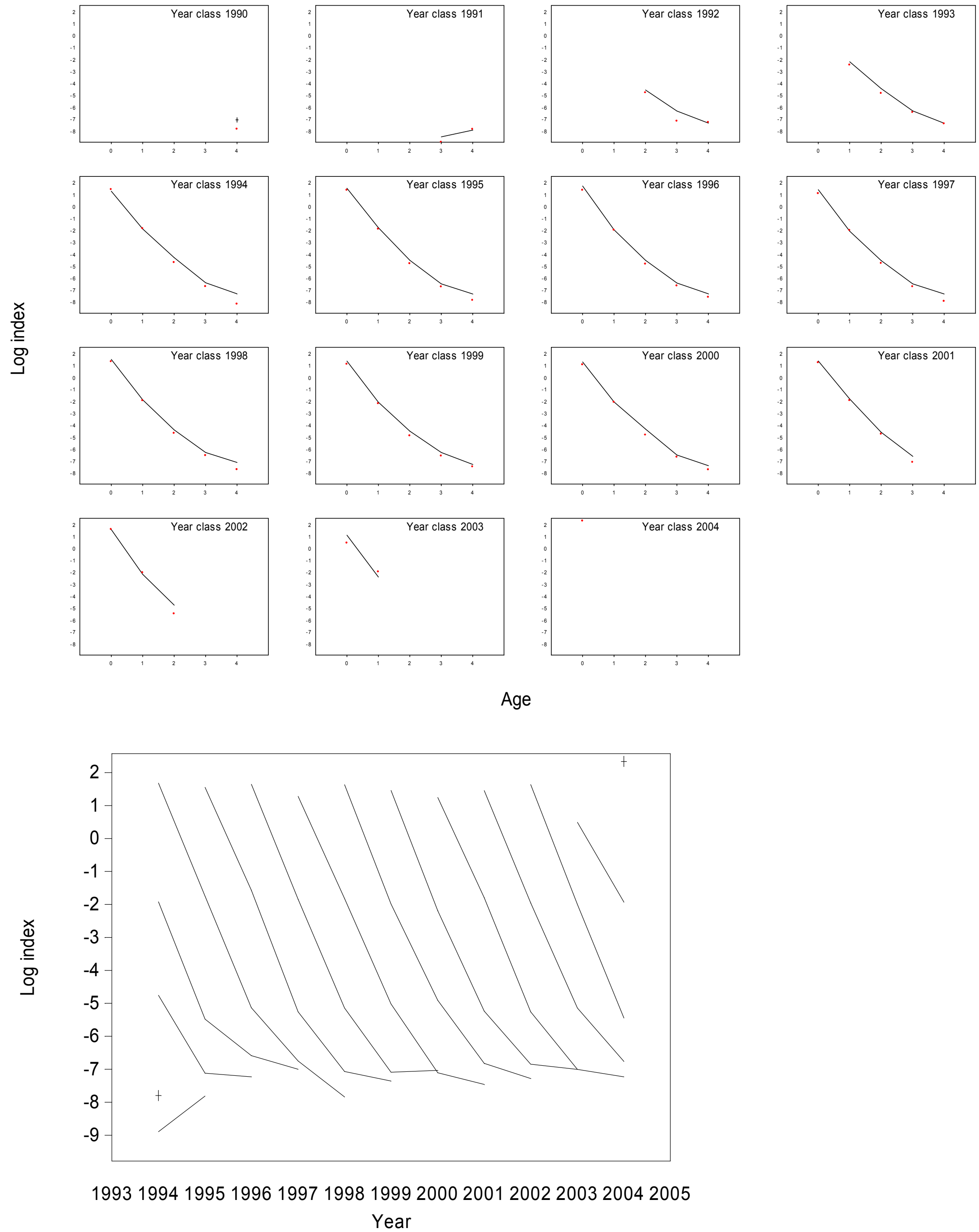


Fig. 7.2.4.2.3.4 Model diagnostic for Surba SURBA model in the GSA 09 (Grund GRUND data). A) Comparison between observed (points) and fitted (lines) of survey abundance indices, for each year. B) Log survey abundance indices by cohort. Each line represents the log index abundance of a particular cohort throughout its life.

7.2.4.3. Method 3: XSA

7.2.4.3.1. Justification

An XSA war performed using DCF data from 2005 to 2009 calibrated with fishery independent survey abundance indices (MEDITS)

7.2.4.3.2. Input parameters

The following Tab. 7.2.4.2.2.1 lists the input parameters to the XSA, i.e. catch at age, weight at age, matutity at age, natural mortality at age. The tuning series at age (MEDITS) are shown in Tab. 7.2.4.2.2.1.

Tab. 7.2.4.2.2.1 The input parameters to the XSA, i.e. catch at age, weight at age, matutity at age, natural mortality at age.

Maturity and M vectors

PERIOD	Age	0	1	2	3	4	5
2005-2009	Prop. Matures	0.0	0.21	0.9	1.0	1.0	1.0

PERIOD	Age	0	1	2	3	4	5
2005-2009	M	1.3	0.60	0.46	0.41	0.30	0.20

Weight-at-age in the catch

Mean weight in catch (kg)	0	1	2	3	4	5
2005	0.01	0.10	0.43	1.34	2.32	3.20
2006	0.01	0.14	0.61	1.37	2.30	3.31
2007	0.01	0.13	0.60	1.36	2.28	3.28
2008	0.01	0.12	0.60	1.35	2.29	3.29
2009	0.01	0.10	0.45	1.36	2.45	3.20

Number at age in the catch (thousands)

Catch at age in numbers	0	1	2	3	4	5
2005	56407	7940	509	48	10	9
2006	85166	8709	618	120	41	14
2007	72515	6740	593	34	4	1
2008	18677	17238	626	106	41	15
2009	14276	10114	529	71	29	13

According to the STECF-SGMED-10-02 scientist's knowledge, DCR landing data for GSA 09 have been adjusted concerning the contribution of artisanal fishery to the total catch. DCF data gave a proportion of about 60% for trawling and about 40% for set nets. An overestimation of the set nets was supposed, so the percentage contribution of set nets was reduced to a more realistic value of 20%, taking into account the expert's knowledge of the GSA 09 fisheries. This aspect underlines both the need of some improvements of the data collection, paying particular attention to the sampling design and the importance of a routinely check made by experts of the official data.

7.2.4.3.3. Results

Fig. 7.2.4.3.3.1 shows results from XSA. During 2005-2009 SSB oscillated between 948 and 1734 t (2008). In 2009 SSB is estimated to be around 1100 t. Recruitment estimates ranged between about 230x10^6 in 2007 and 77 x10^6 recruits in 2009. Fishing exploitation is basically focused on young age classes, mainly 0+ and 1+, reflecting a growth overfishing state. Mean F_{1-5} ranged between 1.32- 1.65 from 2005 to 2009 (Fig. 7.2.4.3.3.1).

Fig. 7.2.4.3.3.1. XSA estimates of hake SSB, number of recruits and fishing mortality from 2005 to 2009 in the GSA 9.

7.2.5.*Long term prediction*

7.2.5.1. Justification

Equilibrium YPR reference points for the stock estimated through the Yield software (Hoggarth *et al*., 2006) were assessed. Further YPR analyses were conducted based on the VIT (pseudocohort) results.

7.2.5.2. Input parameters

Equilibrium YPR reference points for the stock were estimated through the Yield software (Hoggarth *et al.*, 2006) assuming recruitment fluctuating randomly around a constant value and 20% uncertainty in input parameters. The second YPR analyses used the results of VIT (pseudocohort) as inputs. The used parameters were the same of the SURBA and LCA analyses given above.

7.2.5.3. Results

Yield software quantified uncertainty by repeatedly selecting a set of biological and fishery parameters by sampling from the probability distributions for uncertain parameters set by the user, and then calculating the quantities of interest. In this sampling, it is assumed that each of the uncertain parameters are independently distributed, even though for some biological parameters, this assumption is almost certainly incorrect (Hoggarth *et al*., 2006). F_{max} and F_{ref} , this latter corresponding to F at SSB/initial SSB = 0.30, were assumed as limiting reference points. $F_{0.1}$ was assumed as target reference point. The probability distributions of the three RPs showed a considerable variations (Fig. 7.2.5.3.1). The following mean values were obtained: F_{max} = 0.35; $F_{0.1}$= 0.22 and F_{ref} = 0.28. The maximum predicted values were respectively 0.59 (F_{max}), 0.36 (F_{01}) and 0.41 (F_{ref}). RPs suggest an overfishing situation for the stock considering current F about six times higher than the limit and target RPs F.

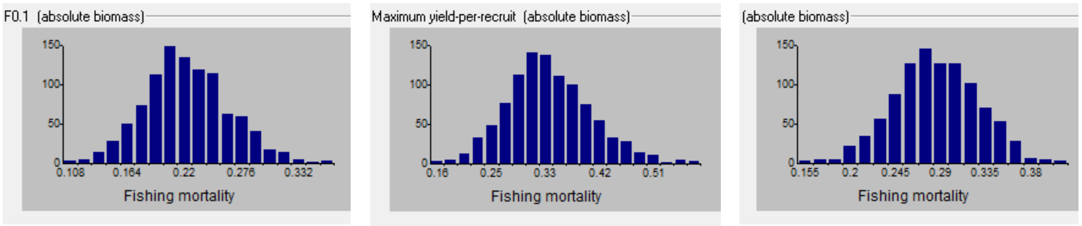


Fig. 7.2.5.3.1 Probability distribution of hake RPs in the GSA 09 obtained using the Yield software (age groups 1-5).

7.2.6. *Data quality*

MEDITS survey data were available from 1994. A check of hauls allocation between GSA 09 and 10 needs to be done before calculation of indices from MEDITS database.

7.2.7. *Scientific advice*

7.2.7.1. Short term considerations

7.2.7.1.1. State of the spawning stock size

The size of spawning size resulted very low in recent years (about 1000 tons in 2009). Fishing at $F_{0.1}$ (0.22), which corresponds to an 86% reduction of the current F, is expected to generate a spawning stock biomass increase of 433% from the year 2011 to 2012. In the absence of precautionary reference points SGMED is unable to fully evaluate the state of the stock size.

7.2.7.1.2. State of recruitment

In recent years recruitment has varied without a clear trend between 229 millions in 2007 and 77 millions in 2009 (the lowest value since 2005).

7.2.7.1.3. State of exploitation

The stock appeared heavily overexploited in 2009 and F needs a consistent reduction from the current F towards the candidate reference points for long term sustainability based on F around $F_{0.1}$ (0.2). SGMED proposes $F_{0.1} \leq 0.2$ as limit reference point consistent with high longterm yields (F_{MSY} proxy).

Considering the high productivity in terms of incoming year classes, this stock has the potential to recover quickly if F is reduced towards F_{msy}. The continued lack of older fish in the surveyed population indicates exploitation rates far beyond those considered consistent with high yields and low risk. An improvement of the estimates of catchability of adults is needed to better estimate the stock dynamics and to assess the likely impact of fishing activity on this stock.

7.3. Stock assessment of hake in GSA 10

7.3.1. *Stock identification and biological features*

7.3.1.1. Stock Identification

The stock of European hake was assumed in the boundaries of the whole GSA 10, lacking specific information on stock identification. *M. merluccius* is with red mullet and deep-water pink shrimp a key species of fishing assemblages in the central-southern Tyrrhenian Sea (GSA 10). It 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.

7.3.1.2. Growth

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_∞=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 83 cm for females and 58 cm for males both registered in the landings (bottom long-lines). 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 (Fig. 7.3.1.2.1)

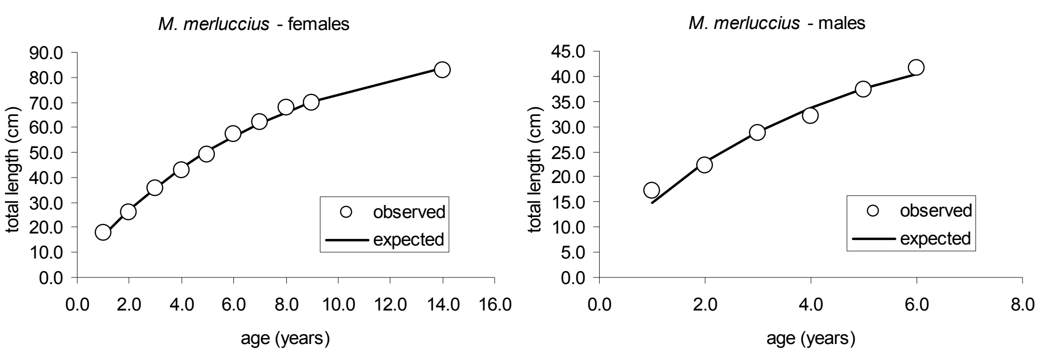


Fig. 7.3.1.2.1 V. Bertalanffy growth functions for female and male of hake in the GSA 10.

7.3.1.3. Maturity

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 the period 2006-2008 is reported in the table below together with the estimated maturity ogive which indicates a $L_{m50\%}$ of about 33 cm (±0.27 cm) (Fig. 7.3.1.3.1). These estimates are similar to those of 2003-2005 (Lm50%=32.9±0.8; MR=6.4±0.9).

Proportion of mature females			
TL (cm)	p	TL (cm)	p
20	0.023	29	0.243
21	0.021	30	0.403
22	0.011	31	0.37
23	0.012	32	0.483
24	0.06	33	0.563
25	0.091	34	0.667
26	0.114	35	0.722
27	0.063	36	0.903
28	0.164	37	0.735

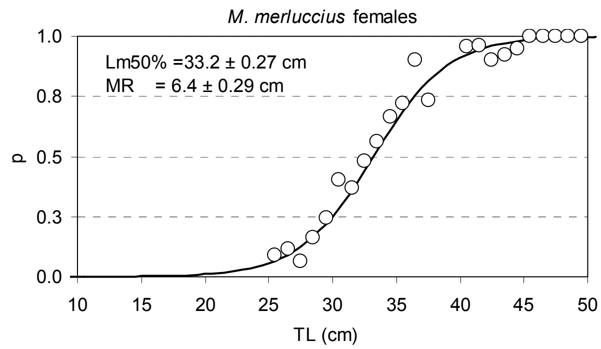


Fig. 7.3.1.3.1 Maturity ogive and proportions of mature female of hake in the GSA 10 (MR indicates the difference $Lm_{75\%}$-$Lm_{25\%}$).

The sex ratio is about 1:1 up to the size of 35 cm, after females are prevailing (Fig. 7.3.1.3.2).

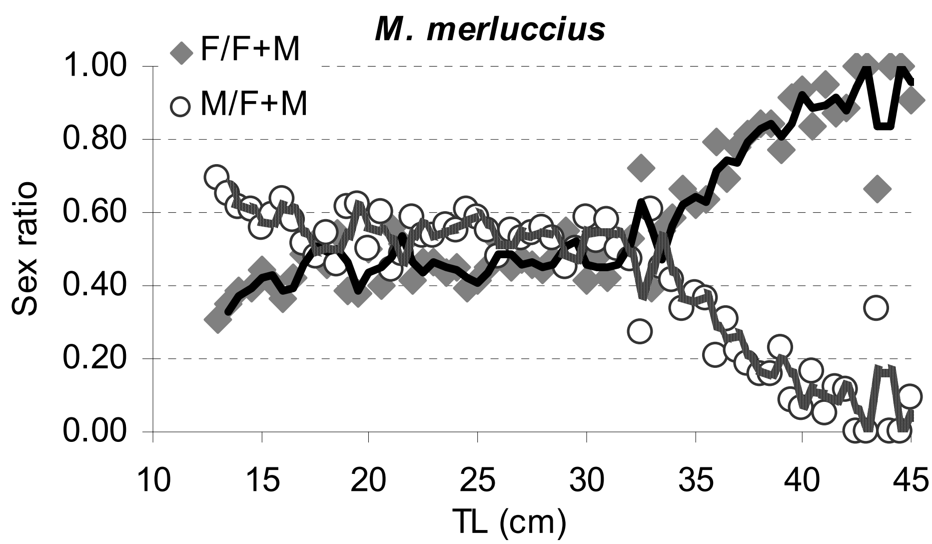


Fig. 7.3.1.3.2 Sex ratio for females and males by length.

7.3.2. *Fisheries*

7.3.2.1. General description of the fisheries

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*.

7.3.2.2. Management regulations applicable in 2010

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 is 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 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 licences.

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.

7.3.2.3. Catches

7.3.2.3.1. Landings

Available landing data are from DCF regulations. SGMED-10-03 received Italian landings data for GSA10 by fishing gears which are listed in Tab. 7.3.2.3.1.1.

Since 2004, landings of hake increased from 1,338 t to 1,544 t in 2006 and decreased to about 1,091 t in 2009. Most part of the landings of hake is from trawlers and nets (GNS and GTR), but the catches of the demersal long-line fishery are also important.

Tab. 7.3.2.3.1.1. Annual landings (t) by major gear type, 2004-2009.

Sum di LW					YEAR					
COUNTR	AREA	SPECIE	FT_LVL	FT_LVL5	2004	2005	2006	2007	2008	2009
ITA	10	HKE			198	186	8			
			GND	Small pelagic fish	7		12	11	8	9
			GNS	Demersal species	177	294	323	213	311	282
				Small and large pelagic fish				7	0	2
			GTR	Demersal species	202	124	152	157	68	107
			LLD	Large pelagic fish					2	3
			LLS	Demersal fish	266	269	288	240	232	247
			OTB	Deep water species			14	4	3	8
				Demersal species	186		97	173	351	277
				Mixed demersal and deep water species	300	612	649	464	147	156
			PS	Small pelagic fish	1		2			
			SB-SV	Demersal species	1				1	
Total					1339	1485	1544	1269	1123	1091

7.3.2.3.2. Discards

The discards of hake in the GSA 10 are reported for 2006 and 2009 being about 16 and 48 tons respectively.

7.3.2.3.3. Fishing effort

The trends in fishing effort by year and major gear type is listed in Tab. 7.3.2.3.3.1. The total fishing effort in kWdays from 2004 to 2009 is decreasing.

Tab. 5.8.2.3.3.1 Trend in fishing effort (kW*days) for the GSA 10 by fleet level, 2004-2009.

Sum of KWDAYS				YEAR					
COUNTRY	AREA	FT_LVL	FT_LVL5	2004	2005	2006	2007	2008	2009
ITA	10			3519197	4007554	3100388	2443896	1814941	1806725
		DRB	Molluscs	86367	320173	310045	148014	231605	183186
		FPO	Demersal species		314276	147983			
		GND	Small pelagic fish	233350	167135	562722	453447	442960	438783
		GNS	Demersal species	3733486	4991450	2920088	2044527	2430099	2574024
			Small and large pelagic fish	1549			84412	1910	30418
		GTR	Demersal species	3151368	1739872	4199352	3897405	3005134	2498246
		LHP-LHM	Cephalopods	619019	437364	397018	341953	773830	1076201
			Finfish	268	3849	1709	14405		
		LLD	Large pelagic fish	480149	1085372	606942	411540	307955	1140807
		LLS	Demersal fish	2486099	2006238	1462244	1320208	1259852	816877
		LTL	Large pelagic fish						
		OTB	Deep water species			240741	131937	140964	295269
			Demersal species	4055773	75241	1540349	1595569	3808424	3483512
			Mixed demersal and deep water species		8416369	5992696	5934631	2752751	3076559
		PS	Large pelagic fish	1372121	800937	103190	157860	231965	506989
			Small pelagic fish	2258283	1946520	1902659	1782940	952413	1713744
		PTM	Small pelagic fish	6204					
		SB-SV	Demersal species	619495	205264	111798	32984	107412	20545
Total				22622728	26517614	23599924	20795728	18262215	19661885

7.3.3. *Scientific surveys*

7.3.3.1. Medits

7.3.3.1.1. Methods

According to the MEDITS protocol (Bertrand *et al*., 2002), trawl surveys were yearly (May-July) carried out, applying a random stratified sampling by depth (5 strata with depth limits at: 50, 100, 200, 500 and 800 m; each haul position randomly selected in small sub-areas and maintained fixed throughout the time). Haul allocation was proportional to the stratum area. The same gear (GOC 73, by P.Y. Dremière, IFREMER-Sète), with a 20 mm stretched mesh size in the cod-end, was employed throughout the years. Detailed data on the gear characteristics, operational parameters and performance are reported in Dremière and Fiorentini (1996). Considering the small mesh size a complete retention was assumed. All the abundance data (number of fish per surface unit) were standardized to square kilometer, using the swept area method.

Based on the DCF data call, abundance and biomass indices were recalculated. In GSA 10 the following number of hauls was reported per depth stratum (Tab. 7.3.3.1.1.1).

Tab. 7.3.3.1.1.1. Number of hauls per year and depth stratum in GSA 10, 1994-2009.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GSA10_010-050	7	8	8	8	8	8	8	8	6	7	7	7	7	7	7	7
GSA10_050-100	10	10	10	10	10	10	10	10	9	8	8	8	8	8	8	8
GSA10_100-200	17	17	17	17	17	17	17	17	14	14	14	14	14	14	14	14
GSA10_200-500	22	22	22	22	22	22	22	24	18	18	18	18	18	18	19	18
GSA10_500-800	28	28	28	28	28	27	28	26	23	23	23	23	23	23	22	23

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in the GSA:

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

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

Where:

A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien *et al*. 2004).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA. Given the sheer number of plots generated, these distributions are not presented in this report.

7.3.3.1.2. Geographical distribution patterns

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 analysed (Lembo *et al*., 1998b, 2000). The higher concentration of recruits in the GSA 10 were localised 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 localised 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 (SGMED 09-02).

7.3.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the hake in GSA 10 was derived from the international survey MEDITS. Figure 7.3.3.1.3.1 displays the estimated trend of hake abundance and biomass indices standardized to the surface unit in the GSA10. Indices from MEDITS trawl-surveys show an increasing pattern in the last years, although variability is high (Fig. 8.8.3.1.3.1).

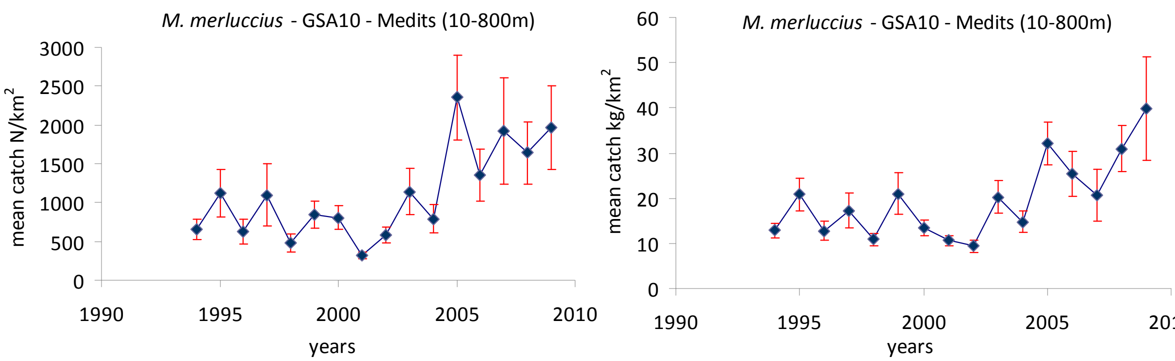


Fig. 7.3.3.1.3.1 Trends in survey abundance and biomass derived from MEDITS (bars indicate standard deviation).

The re-estimated abundance and biomass indices (Figure 7.3.3.1.3.2) also reveal increasing trends since 2002. However, the recent high abundance and biomass indices are subject to high uncertainty.

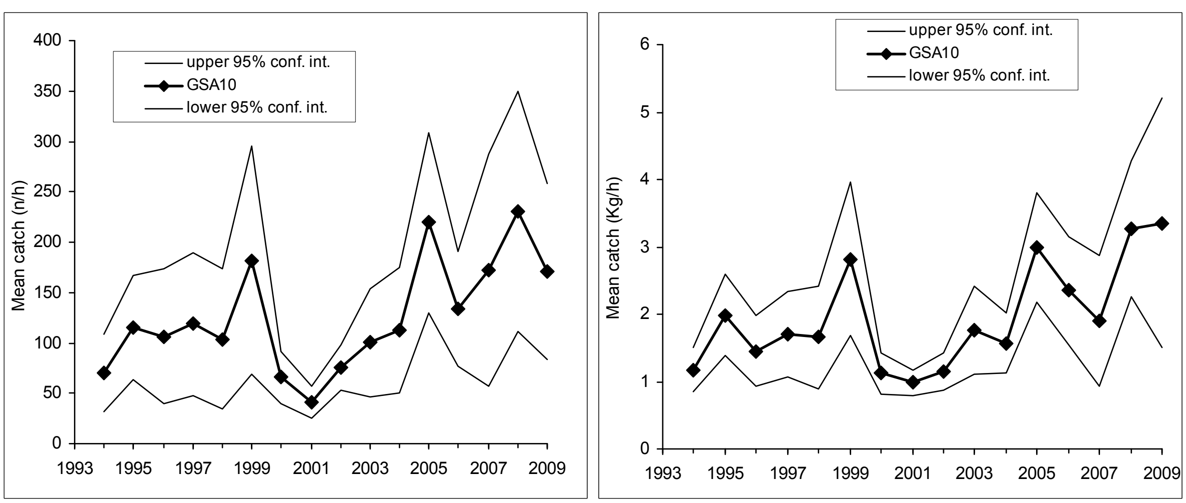


Fig. 7.3.3.1.3.2 Abundance and biomass indices of hake in GSA 10.

7.3.3.2. Grund

7.3.3.2.1. Methods

Since 2003 Grund surveys (Relini, 2000) was conducted using the same vessel and gear in the whole GSA. Sampling scheme, stratification and protocols were similar as in MEDITS. All the abundance data (number of fish and weight per surface unit) were standardised to square kilometer, using the swept area method.

7.3.3.2.2. Geographical distribution patterns

Mapping of the hake recruits obtained applying the indicator kriging technique with contouring that represents probability (in percentage) is reported in the STECF_SGMED 02 2009 report.

Trends derived from the GRUND surveys are shown in Fig. 7.3.3.2.2.1. Abundance indices increased significantly ($p<0.05$ on ln-transformed data), as well as recruitment indices, while biomass indices were almost stationary.

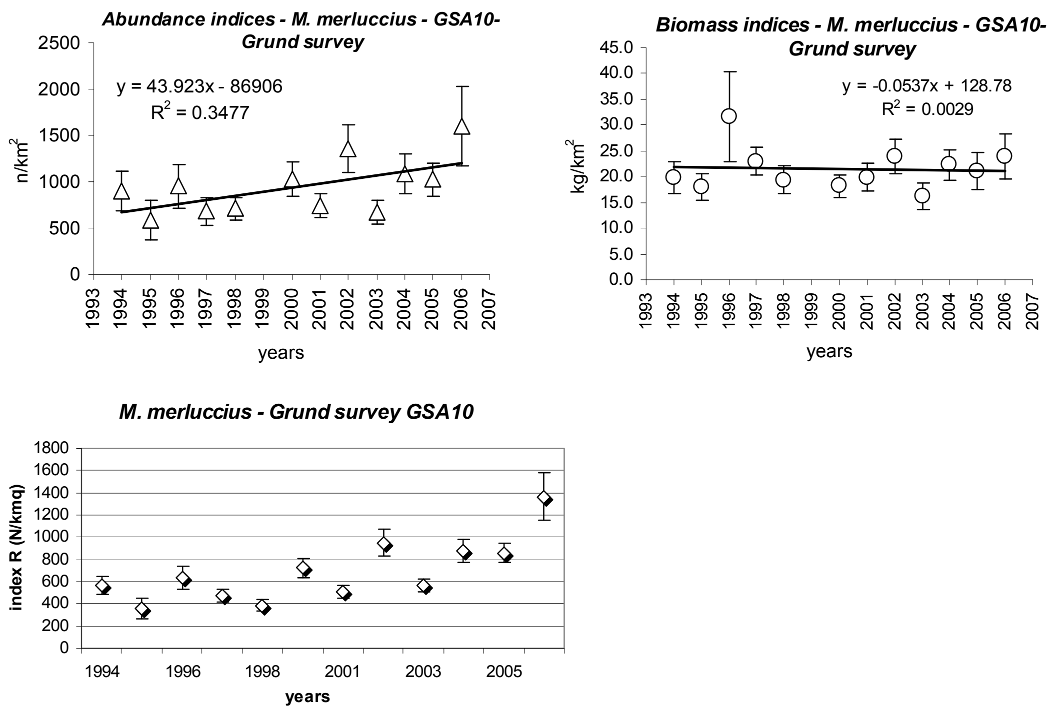


Fig. 7.3.3.2.2.1. Abundance and biomass indices of hake in GSA10 derived from GRUND surveys. Recruitment indices (N/km^2) with standard deviation are also reported.

7.3.3.2.3. Trends in abundance by length or age

No trend in the mean length was observed in MEDITS survey (Fig. 7.3.3.2.3.1), nor at the third quantile lengths, as obtained from the length structures of GRUND time series from 1994 to 2006 (Fig. 7.3.3.2.3.2). However the mean length of older fish is reduced along the time.

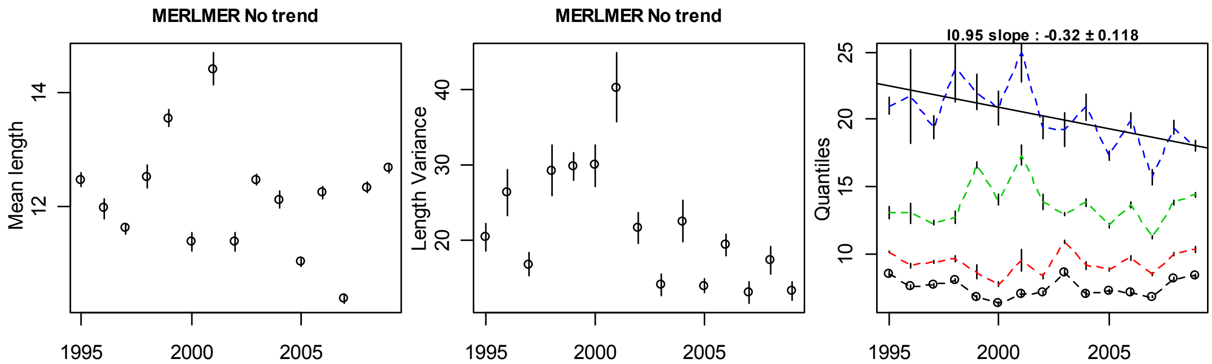


Fig. 7.3.3.2.3.1 Mean length, variance and quantiles derived from the MEDITS length compositions.

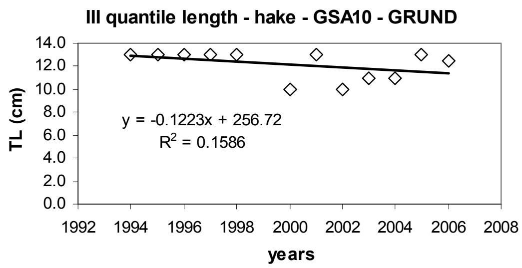


Fig. 7.3.3.2.3.2 III Quantile derived from the GRUND length structures in 1994-2006.

The following Fig. 7.3.3.2.3.3 and 4 display the stratified abundance indices of GSA 10 in 1994-2001 and 2002-2009.

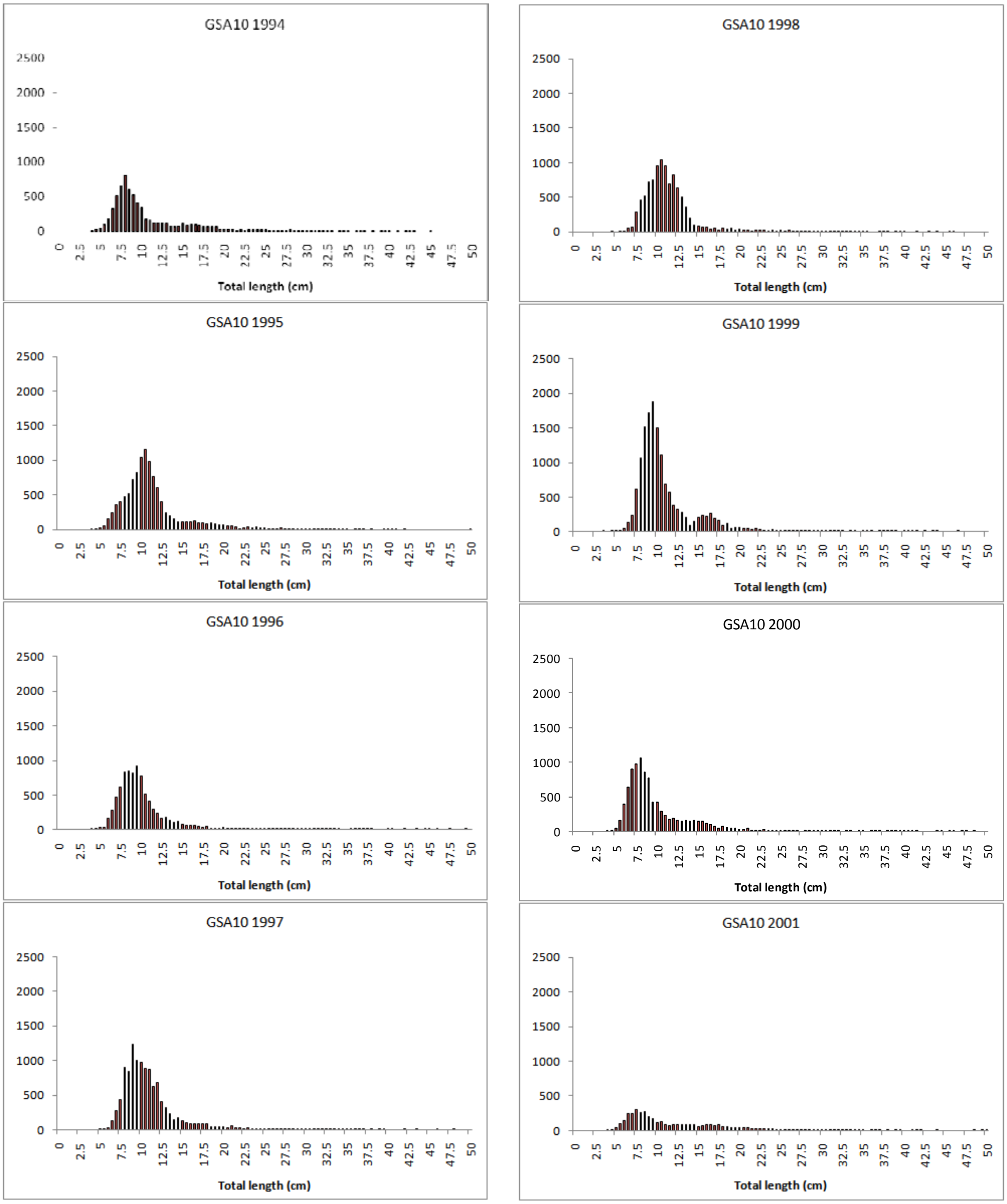


Fig. 7.3.3.2.3.3 Stratified abundance indices by size, 1994-2001.

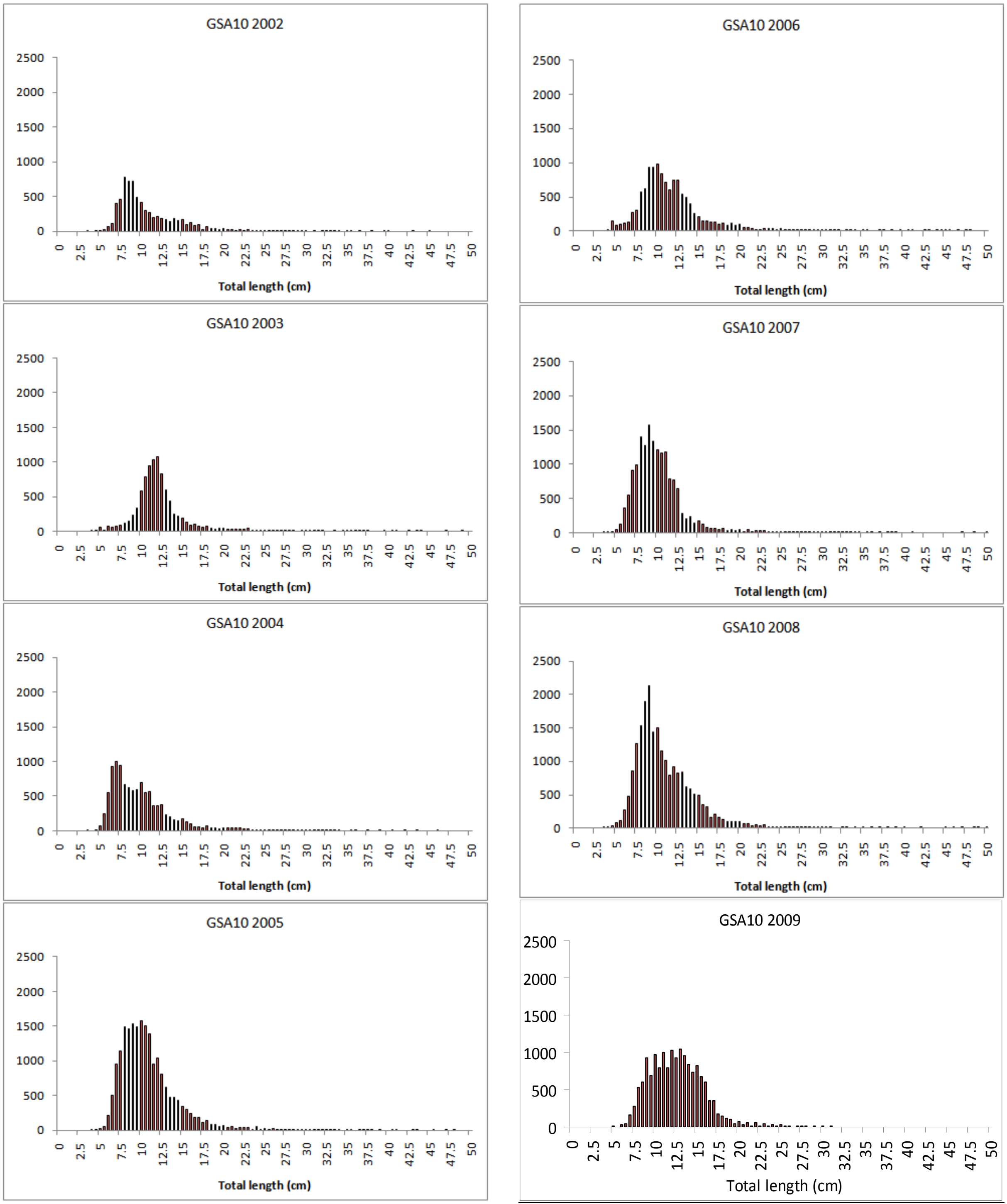


Fig. 7.3.3.2.3.4 Stratified abundance indices by size, 2002-2009.

7.3.3.2.4. Trends in growth

No analyses were conducted.

7.3.3.2.5. Trends in maturity

No analyses were conducted.

7.3.4. *Assessment of historic stock parameters*

7.3.4.1. Method 1: Surba

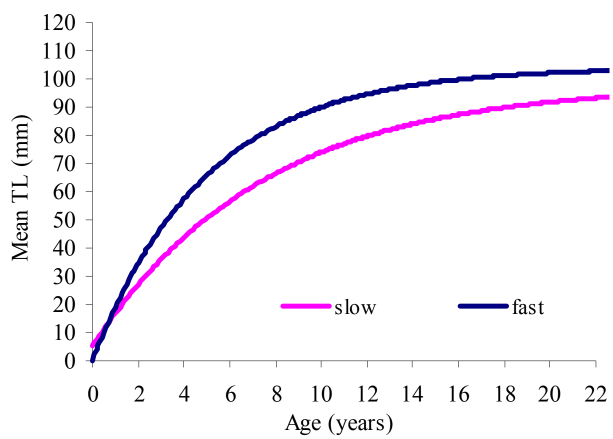
7.3.4.1.1. Justification

SURBA software was applied using MEDITS abundance estimates by length. Two scenarios based on a different growth pattern were used to account for uncertainty in the growth of the species.

7.3.4.1.2. Input parameters

Two sets of growth parameters were used in the analyses to split the LFDs after that these were raised to the square km and averaged over the area for the SURBA analyses.

Set 1) 'slow' growth
L_∞=97.9 cm, K=0.135, t_0= -0.4; males: L_∞=50.8 cm, K=0.25, t_0= -0.4; length-weight relationship: a=0.00355, b=3.22 for sex combined.
Set 2) 'fast' growth
L_∞=104 cm, K=0.2, t_0= -0.01; length-weight relationship: a=0.00355, b=3.22 for sex combined. Length at age and graphs of the growth curves according to the two sets are reported in the figure and table below.



growth	slow	fast
age (years)	mean length (cm)	mean length (cm)
0	5.03	0.21
1	16.77	19.02
2	27.03	34.43
3	35.99	47.04
4	43.82	57.36
5	50.66	65.82
6	56.64	72.74
7	61.86	78.41
8	66.43	83.04
9	70.41	86.84
10	73.90	89.95

Fig. 7.3.4.1.2.1 Growth scenarios used in the assessment

The age groups derived from the age slicing performed using the LFDA software are reported in the tables below. Age slicing was conducted on separate sex in the case of 'slow' parameter set and numbers were afterward combined. A 5+ group and a 4+ group were respectively used for the two data sets.

Tab. 7.3.4.1.2.1 Age groups obtained after the age slicing procedure and used as input in SURBA

	'Slow' age groups						'fast' age groups				
Year	0	1	2	3	4	5+	0	1	2	3	4+
1994	539.4	91.35	15.92	4.52	0.7	0.73	600.1	48.7	3.411	0.2	0.2
1995	916.6	173.2	24.19	3.01	0.9	0.87	1018	97.56	2.465	0.14	0.24
1996	527.6	82	14.37	3.66	1.78	0.48	578.1	48.42	3.008	0.42	0
1997	962.6	117.3	13.63	2.77	0.5	0.24	1037	57.45	1.96	0.24	0
1998	392.9	64.03	17.94	2.49	1.11	0.47	421.6	54.7	2.517	0	0.15
1999	522.4	291.6	20.93	5.31	0.96	0.86	743.9	94.89	3.225	0.12	0
2000	671.7	113.2	13.96	4.15	1.49	0.39	746	54.43	3.809	0.603	0.038
2001	210.1	93.95	15.61	2.12	1.1	0.61	259.1	61.23	2.563	0.47	0.11
2002	481.2	89.02	9.68	1.65	0.77	0.17	544.6	36.29	1.4	0	0
2003	1002	118.5	16.97	3.84	0.86	0.28	1075	63.39	3.141	0.399	0
2004	667.9	107.9	12.52	2.9	0.27	0.58	732.7	57.54	1.306	0	0.41
2005	2109	216.8	26.04	2.58	1.09	0.81	2267	86.38	2.209	0.607	0.23
2006	1134	188.9	25.69	2.82	1.3	0.17	1250	100.1	2.323	0.51	0
2007	1812	92.19	14.81	1.41	0.76	0.83	1869	50.69	1.188	0.973	0.28
2008	1378	239.1	18.84	3.81	1.33	1.46	1544	93.24	2.936	1.498	0.39
2009	1560	388.5	20.14	1.2	0.17	0.67	1891	78.38	0.38	0.32	0.32

The other settings of the model, regarding natural mortality, catchability, maturity and weight at age, are reported in the table below. Natural mortality vector for the two scenarios were obtained applying the Prodbiom method (Abella et al., 1997) and calculation sheet provided by the author.

Tab. 7.3.4.1.2.2 SURBA settings related to the natural mortality (M), the catchability coefficient q, the proportion of mature and the weight at age in the slow and fast growth scenarios.

Age	0	1	2	3	4	5+
M (slow)	0.85	0.46	0.37	0.33	0.31	0.29
M (fast)	1.16	0.53	0.40	0.35	0.32	
q (slow)	0.90	1.00	1.00	0.75	0.50	0.5
q (fast)	0.90	1.00	1.00	0.75	0.50	
Proportion mature (slow)	0.01	0.31	0.97	1.00	1.00	1.00
Proportion mature (fast)	0.01	0.25	0.89	1.00	1.00	
Weight (kg) (slow)	0.01	0.07	0.20	0.41	0.67	1.81
Weight (kg) (fast)	0.01	0.15	0.56	1.23	3.50	

7.3.4.1.3. Results

Estimates of total mortality from SURBA, for sex combined and for slow and fast growth, are presented in Tab. 7.3.4.1.3.1:

Tab. 7.3.4.1.3.1 Relative estimates of total mortality Z and spawning stock biomass SSB from Surba, for sex combined and for slow and fast growth scenarios.

	Slow growth pattern - Results				Fast growth pattern - Results			
	Original		Smoothed		Original		Smoothed	
Year	SSB	Z	SSB	Z	SSB	Z	SSB	Z
1994	0.896	1.536	0.929	1.506	0.896	1.536	0.929	1.506
1995	1.221	1.634	1.055	1.549	1.221	1.634	1.055	1.549
1996	0.836	1.81	0.935	1.588	0.836	1.81	0.935	1.588
1997	0.731	1.497	0.845	1.389	0.731	1.497	0.845	1.389
1998	0.769	1.096	0.998	1.427	0.769	1.096	0.998	1.427
1999	1.519	1.976	1.111	1.531	1.519	1.976	1.111	1.531
2000	0.882	1.731	0.959	1.692	0.882	1.731	0.959	1.692
2001	0.8	1.844	0.805	1.628	0.8	1.844	0.805	1.628
2002	0.547	1.078	0.646	1.372	0.547	1.078	0.646	1.372
2003	0.877	2.223	0.775	1.46	0.877	2.223	0.775	1.46
2004	0.74	1.327	0.907	1.573	0.74	1.327	0.907	1.573
2005	1.341	1.68	1.022	1.482	1.341	1.68	1.022	1.482
2006	1.175	2.253	1.201	1.665	1.175	2.253	1.201	1.665
2007	0.77	1.001	1.108	1.854	0.77	1.001	1.108	1.854
2008	1.435	2.779	1.188	2.367	1.435	2.779	1.188	2.367
2009	1.46	NA	1.515	NA	1.46	NA	1.515	NA

In the slow growth hypothesis, the temporal trend of f and the mean F estimates in the age range 1-3 years showed an increasing pattern and a high variability as well as the estimates of SSB index. The retrospective analysis showed a sharp increase of recruitment. Residuals varied without any trend.

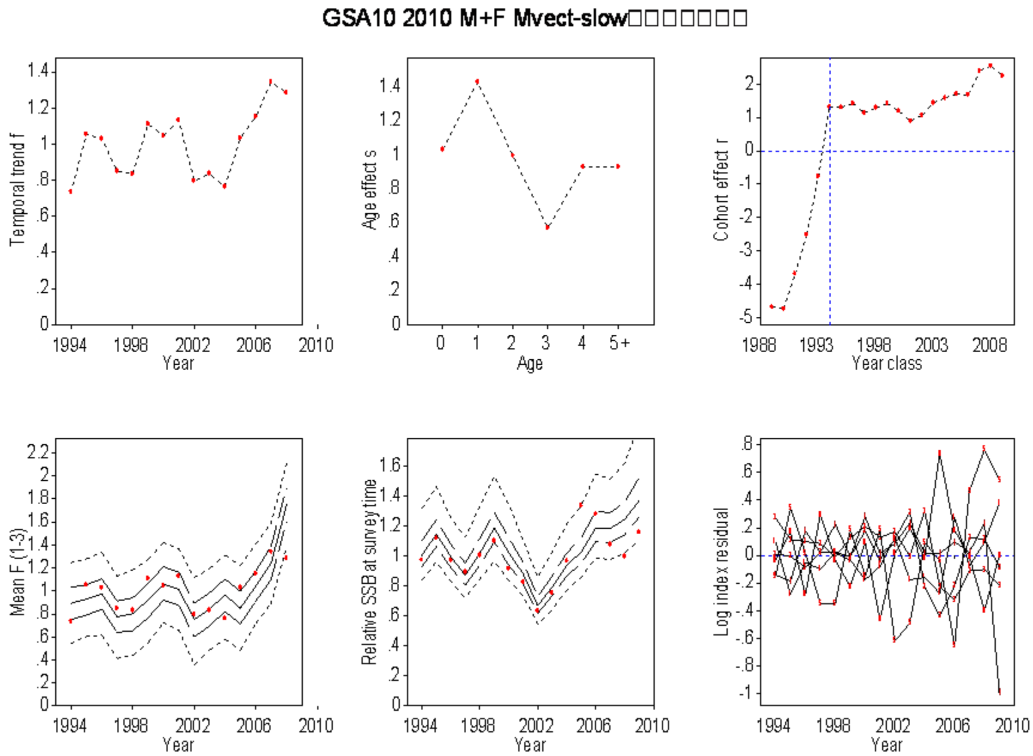


Fig. 7.3.4.1.3.1 Trends in various stock parameters from SURBA, hake GSA10, slow growth pattern.

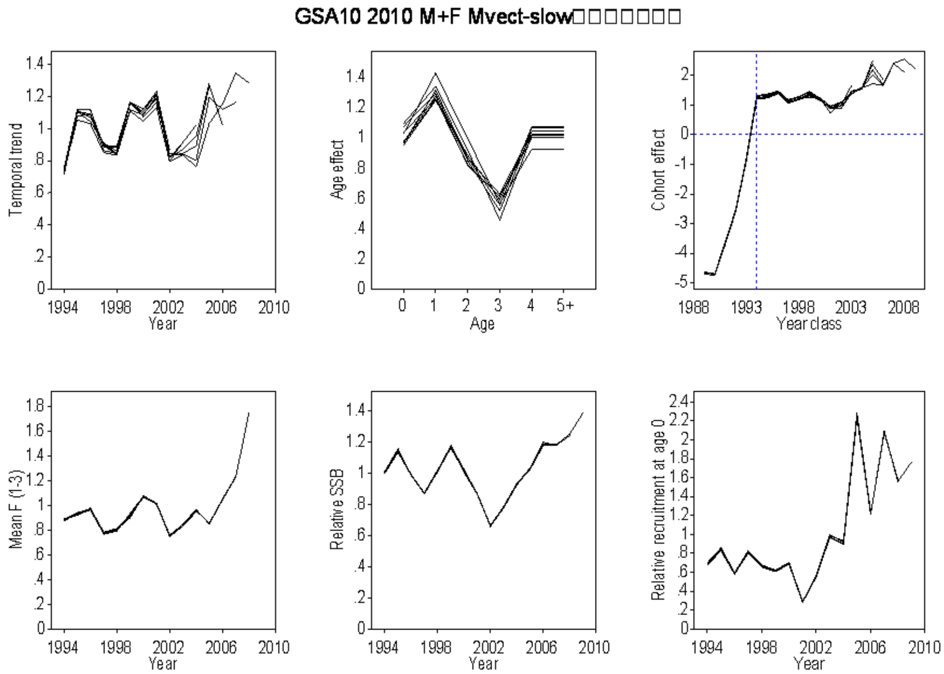


Fig. 7.3.4.1.3.2 Retrospective analysis from SURBA, hake GSA10, slow growth pattern.

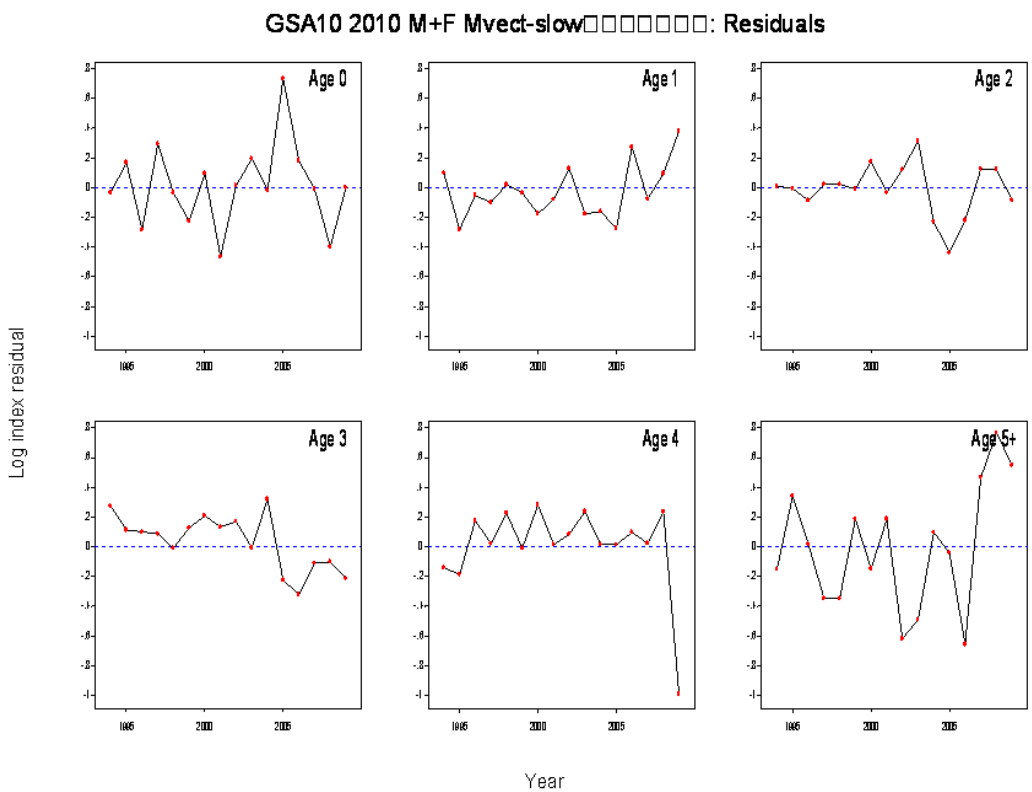


Fig. 7.3.4.1.3.3 Residuals from SURBA, hake GSA10, slow growth pattern.

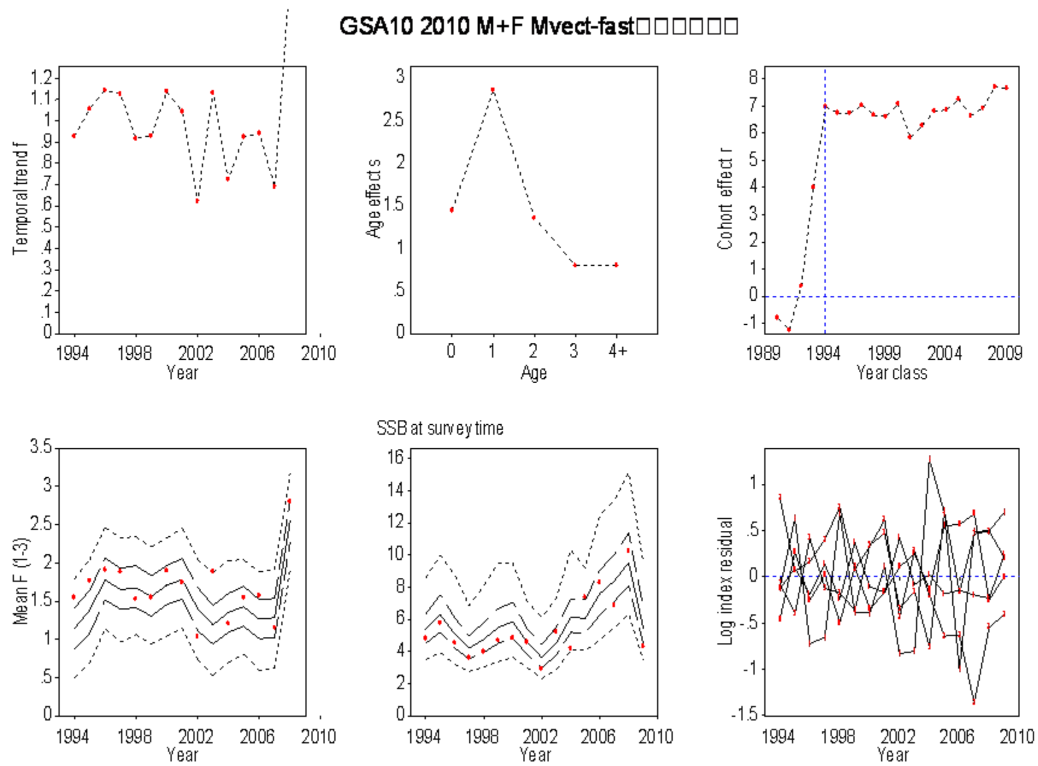


Fig. 7.3.4.1.3.4 Trends in various stock parameters from SURBA, hake GSA10, fast growth pattern.

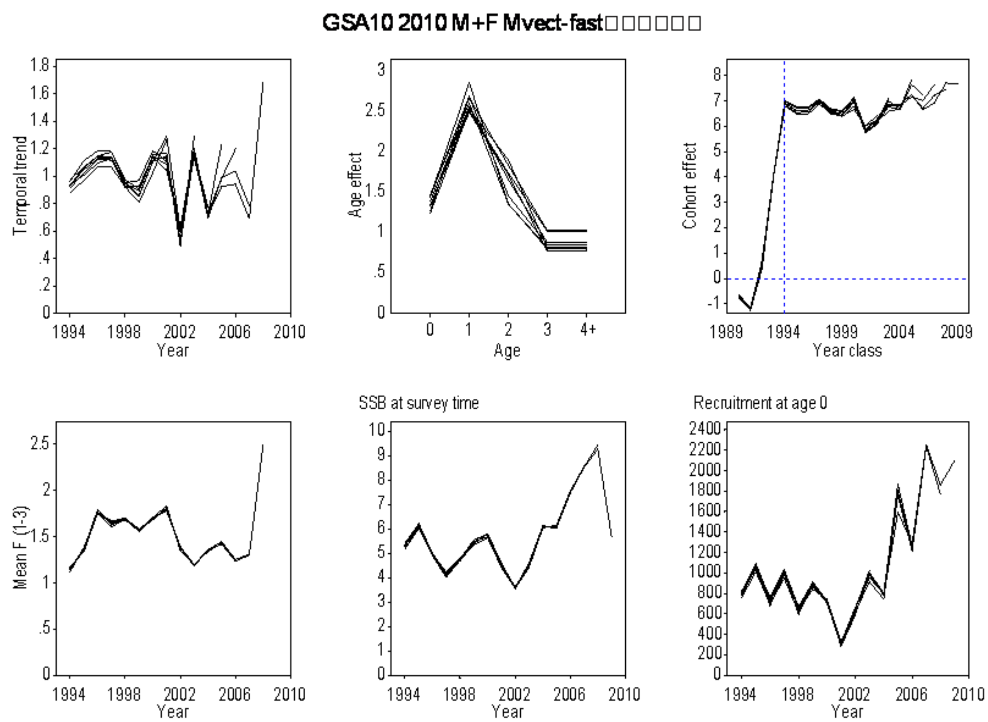


Fig. 7.3.4.1.3.5 Retrospective analysis from SURBA, hake GSA10, fast growth pattern.

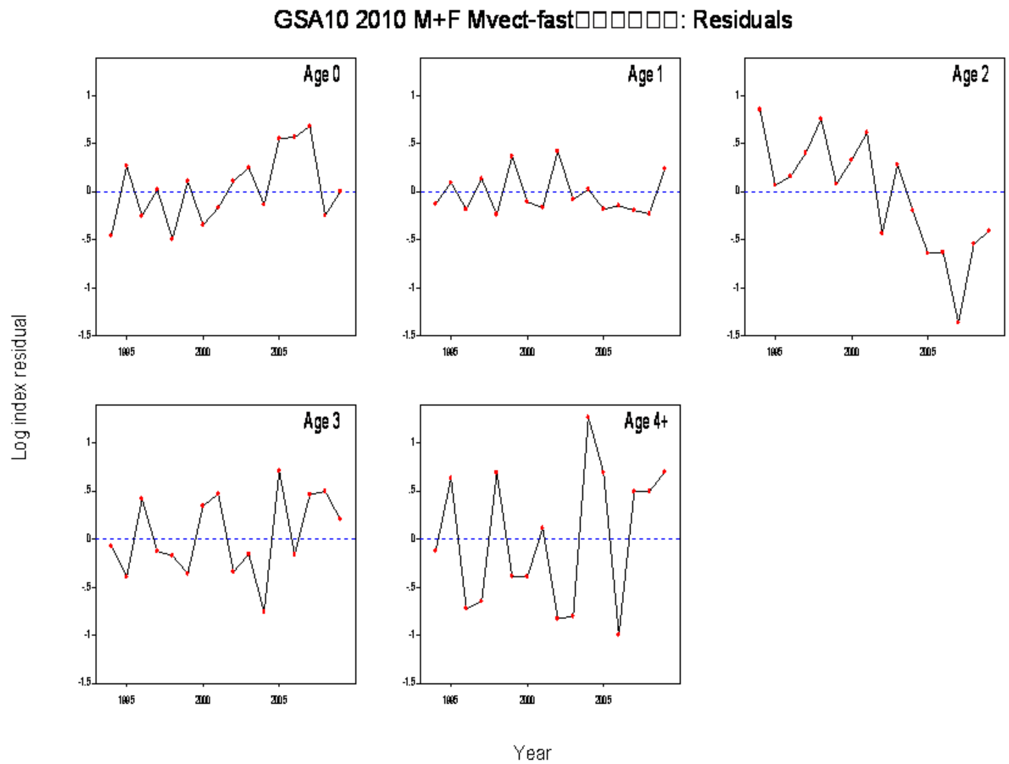


Fig. 7.3.4.1.3.6 Residuals from SURBA, hake GSA10, fast growth pattern.

In the fast growth hypothesis, the temporal trend of F and the mean F estimates in the age range 1-3 showed a remarkable increasing pattern and a high variability as well as the SSB index estimates that showed a decreasing since 2006. The analysis showed also a sharp increase of recruitment. Residuals varied without any trend, except for age 2.

The overall (for the whole life span) fishing mortality rate has been calculated as geometric mean for the slow and fast growth pattern and is reported in the Fig. 7.3.4.1.3.7. In 2006 average F was 1.2 for both the scenarios. In 2007 it was 0.767 and 0.889 for the slow and fast growth scenario respectively, while in 2008 it was 1.33 and 2.16, respectively.

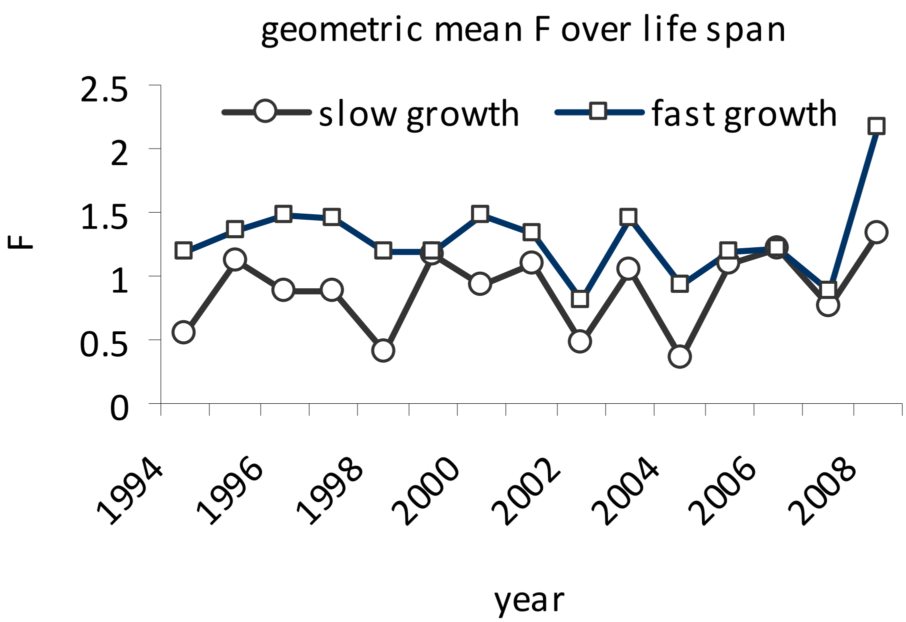


Fig. 7.3.4.1.3.7 Geometric mean of F from SURBA calculated over the life span for the fast and slow growth pattern of hake in the GSA10.

7.3.4.2. Method 2: VIT

7.3.4.2.1. Justification

The cohort analysis and the Y/R approach as implemented in the VIT software under equilibrium conditions were used, as the time series of landings is short. The fast growth scenario was retained for the VIT analysis.

7.3.4.2.2. Input parameters

The input parameters regarding age, maturity, natural mortality and length-weight relationship were those already reported for the SURBA inputs. The landing structures (in length and age) of 2006, 2007, 2008, and 2009 were from the SGMED 10-03 data call. Length frequency distributions of the landings were age sliced using the fast growth parameters and LFDA routine. The terminal fishing mortality F_{term} was set in the model equal to 0.32.

		2006			2007			2008			2009	
Age	OTB	LLS	NETS	OTB	LLS	NETS	OTB	LLS	NETS	OTB	LLS	NETS
0	6124829	0	114059	8022653	0	11668	4450313	3773	1940	4393823	0	53693
1	4212240	71947	1789996	3163018	0	1814732	2660604	193499	806614	2920353	162712	1071948
2	112225	126105	278806	185626	52817	188722	143600	81650	187336	70746	93267	157322
3	17707	89341	15743	4663	120089	23642	26023	47930	60913	5623	35995	20637
4	5502	40335	4121	4663	18962	11668	11381	33039	33153	0	24371	9253
5	7968	8809	0	0	7332	0	0	10625	7727	0	3870	5276
6				0	1880	0	0	2033	0	0	3507	1299
7										0	3417	0
8										0	1596	0

7.3.4.2.3. Results

VIT results regarding the pattern of catch reconstruction by age, year and fishing level 4, and the total and fishing mortality by age and fishing level 4, are showed in the Fig. 7.3.4.2.3.1 and 7.3.4.2.3.2. The total catch is mainly based on the fish aged 1, as result of the trawling targeting features, however age 1 and 2 are also important components of the catches of the set nets, like trammel net and gillnet. Age older than 2 are instead the major target of long-lines. The mortality acting on the age groups mirrors the pattern of the catches. The results for the fast growth scenario show a current fishing mortality changing from 0.83 in 2007 to 0.61 in 2009. The Yield per Recruit analyses indicate a current level of F that is on average, between the four years analyzed, of about 0.72. The limit reference point F_{max} is on average about 0.26 and the target reference point $F_{0.1}$ is about 0.20.

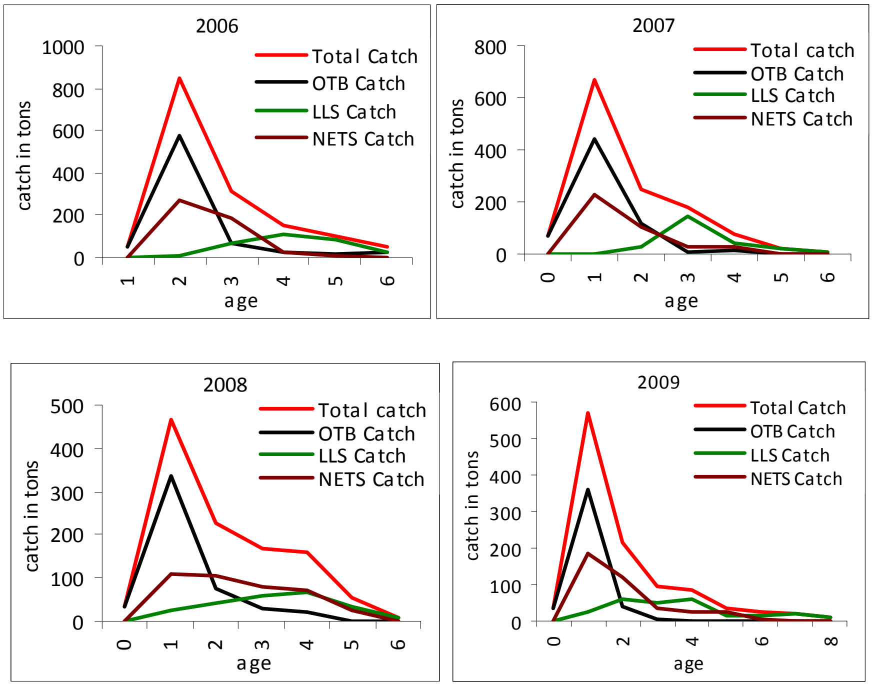


Fig. 7.3.4.2.3.1 Catch at age by year and fishing gear. Fast growth scenario.

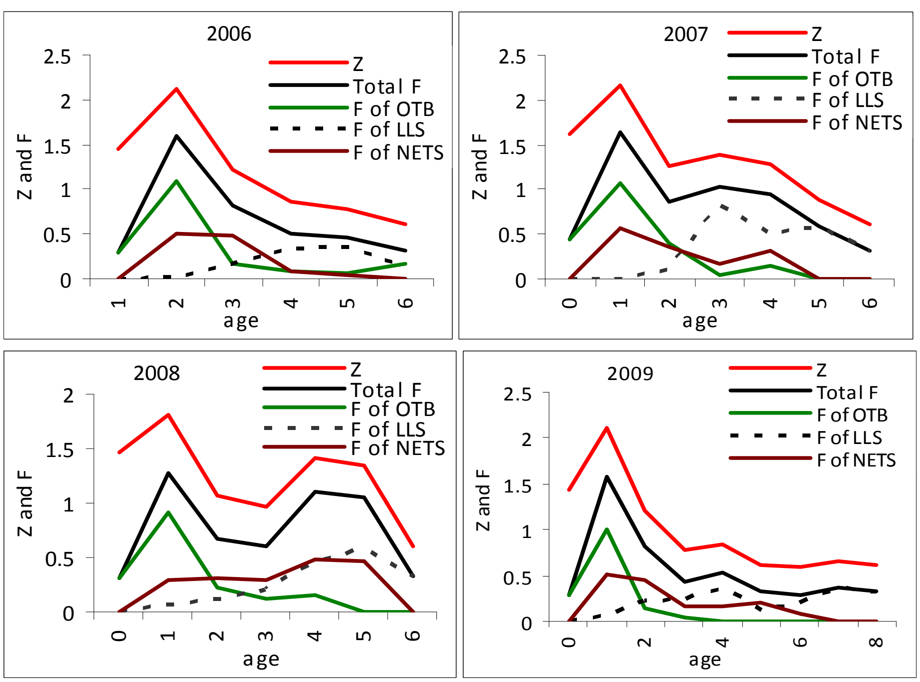
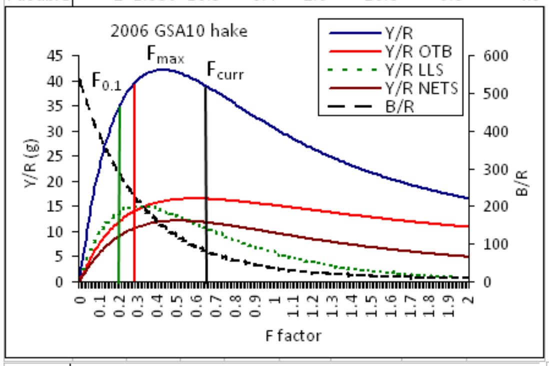
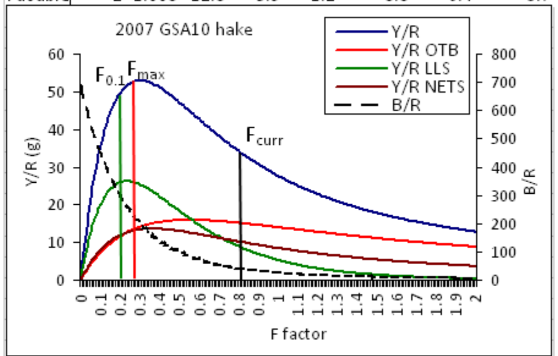


Fig. 7.3.4.2.3.2 – Total and fishing mortality by age as estimated by the cohort analysis using VIT for each year. Fast growth scenario.

2006	Factor F		Y/R	B/R	SSB	Y/R OTB	Y/R LLS	Y/R NETS
F(0)	0	0	0	533.8	490.7	0	0	0
F(0.1)	0.33	0.219	41.1	197.5	169.8	14.9	14.9	11.3
Fmax	0.44	0.293	42.1	148.6	124.1	16.0	14.1	12.0
Fcurr	1.01	0.665	30.6	36.1	22.8	15.2	5.8	9.7
Fdouble	2	1.330	16.5	8.4	2.0	10.8	0.8	4.9

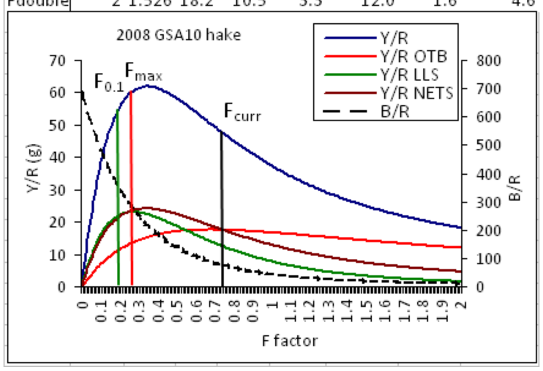
2007	Factor F		Y/R	B/R	SSB	Y/R OTB	Y/R LLS	Y/R NETS
F(0)	0	0	0	685.6	642.5	0	0	0
F(0.1)	0.23	0.192	51.5	264.9	234.6	12.6	26.3	12.6
Fmax	0.31	0.259	53.0	202.4	175.1	14.2	25.4	13.4
Fcurr	1.01	0.834	27.6	25.3	13.9	14.0	5.3	8.4
Fdouble	2	1.668	12.8	5.9	1.2	8.8	0.4	3.7





2008	Factor F		Y/R	B/R	SSB	Y/R OTB	Y/R LLS	Y/R NETS
F(0)	0	0	0	685.6	642.5	0	0	0
F(0.1)	0.26	0.198	60.1	284.7	252.9	13.5	23.1	23.5
Fmax	0.35	0.267	61.9	222.5	193.4	15.3	22.5	24.2
Fcurr	1.01	0.763	37.4	43.8	28.7	16.7	7.8	13.0
Fdouble	2	1.526	18.2	10.5	3.3	12.0	1.6	4.6

2009	Factor F		Y/R	B/R	SSB	Y/R OTB	Y/R LLS	Y/R NETS
F(0)	0.00	0	0	943.4	900.3	0	0	0
F(0.1)	0.28	0.170	50.6	350.3	320.6	9.3	23.3	18.0
Fmax	0.37	0.225	51.8	267.7	240.9	10.6	22.5	18.7
Fcurr	1.01	0.608	32.8	42.4	28.9	13.2	7.5	12.0
Fdouble	2.00	1.217	16.9	8.7	2.2	10.3	1.2	5.3



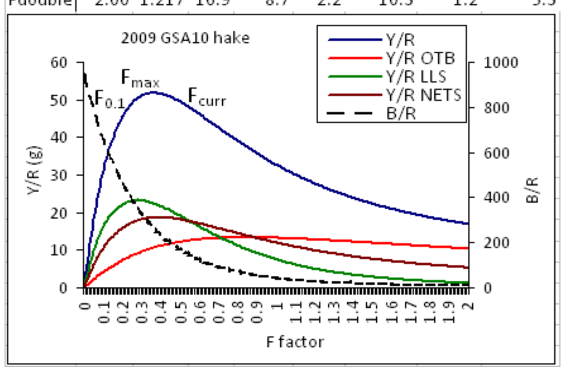


Fig. 7.3.4.2.3.3 Y/R curves by gear and year from VIT analysis. For each year the overall estimates regarding F-factor, F (F_0, $F_{0.1}$, F_{max}, F_{curr}, F_{double}), overall and by gear Y/R, B/R and SSB are reported. Fast growth scenario. B/R by year and F-factor is also showed.

7.3.5. *Data quality and availability*

Some discrepancies were identified from the cross-checking between estimates related to total landings (transversal variables) and raised catch structures by metier (biological metier related variable). This can be a consequence of the different classification of the fishing activity (fishing segments and metier) that can rise when the fleet is characterised by an opportunistic behaviour, i.e. frequent change, during the year, of gear (for example, from gillnets to long-line) or of fishing ground (for example, from demersal to mixed fishery, as in the OTB fishing segment). In these cases, the ratios among the landings of the different métier along the time were used to correct the raised age structures of the catches before the model parameterization. Data on maturity and growth from DCF have also been used. Information from GRUND surveys and from nurseries studies in the GSA have also been included.

7.3.6. *Scientific advice*

7.3.6.1.1. State of the spawning stock size

Survey indices indicate a variable pattern of abundance (n/h) and biomass (kg/h) without a clear trend. However, recent values are among the highest observed since 1994. The hind casting approach using Aladym model in SGMED 09-02 showed instead that the SSB was continuously decreasing (Fig. 7.3.6.1.1.1).

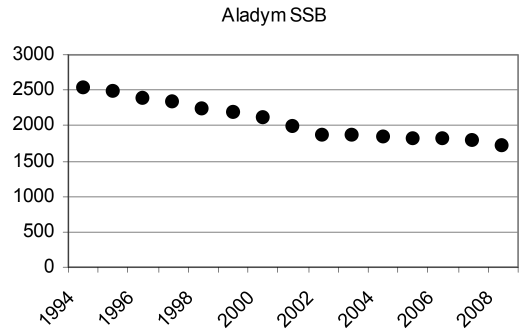


Fig. 7.3.6.1.1.1– Pattern of the spawning stock biomass as obtained through Aladym simulation in SGMED 02 2009.

No biomass reference points have been proposed for this stock. As a result, SGMED is unable to evaluate the status of the stock with respect to biomass.

7.3.6.1.2. State of recruitment

Recent recruitment since 2005 appears to be above average, as derived directly from the trawl survey estimates considering as recruits the age 0 group (Fig. 7.3.6.1.2.1) and from the SURBA model analysis.

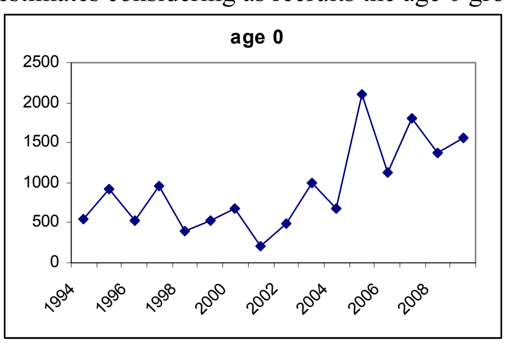


Fig. 7.3.6.1.2.1 – Recruitment pattern from survey data.

7.3.6.1.3. State of exploitation

Analyses performed applying different approaches gave consistent results, indicating that the fishing mortality is far in excess of sustainable levels, and that the stock of *Merluccius merluccius* in the GSA10 appears to be subject to overfishing. Regardless of the growth pattern, a considerable reduction, of about 60-70%, would be necessary to approach the $F_{0.1}$ reference point that is estimated on average about 0.20. SGMED proposes $F_{0.1} \leq 0.2$ as limit management reference point. This value is interpreted as proxy of F_{msy}. SGMED recommends the relevant fleet's effort to be reduced until fishing mortality is below or at $F_{0.1}$ in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan taking into account mixed-fisheries effects.

7.4. Stock assessment of hake in GSA 11

7.4.1. *Stock identification and biological features*

7.4.1.1. Stock Identification

This stock is assumed to be confined within the GSA 11 boundaries, where it is distributed between 30 and 650 m of depth, with a peak in abundance (due to high number of recruits) over the continental shelf-break (between 150 and 250 m depth). The stock is mainly exploited by the local fishing fleet, although seasonally and occasionally some other Italian fleet use to fish in some areas of the GSA 11. Spawning is taking place almost all year round, with a peak during winter –spring.

Juveniles showed a patchy distribution with some main density hot spots (nurseries) showing a high spatio-temporal persistence (Murenu *et al*., 2007) in western areas.

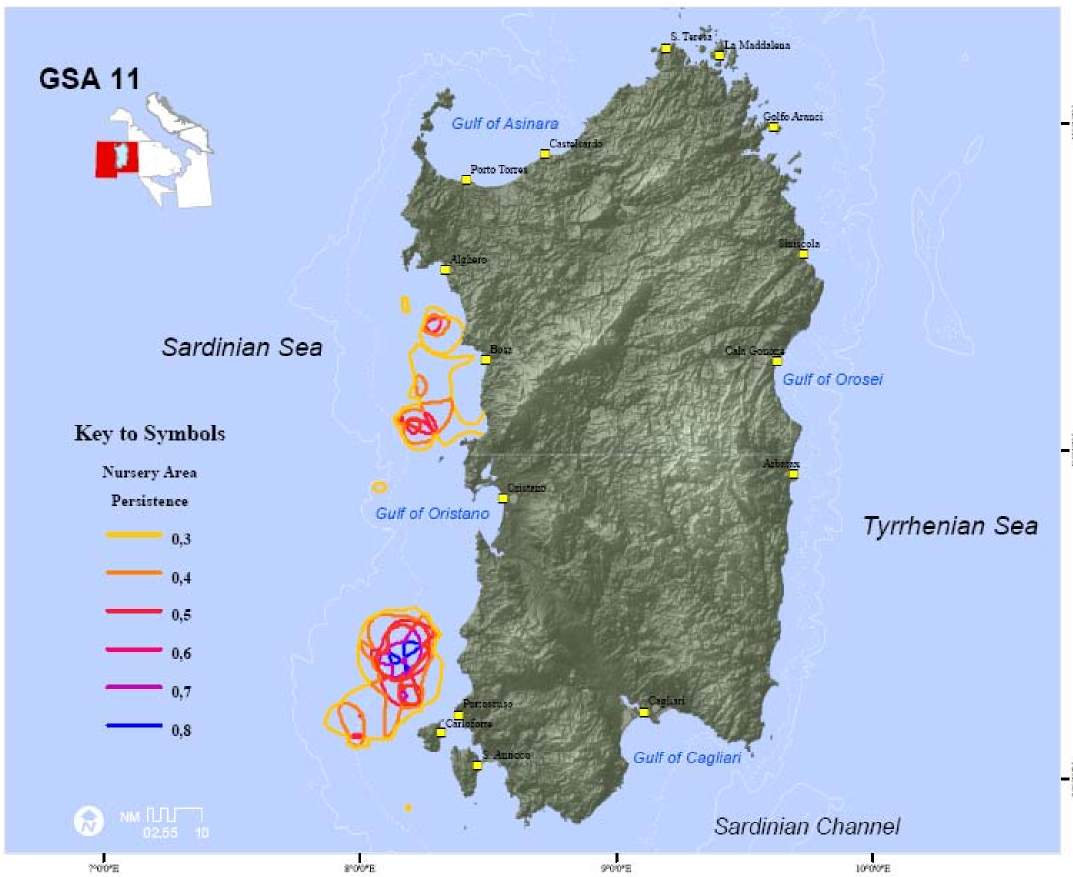


Fig. 7.4.1.1.1 Temporal persistence of hake nurseries calculated from data survey time-series density maps (1994-2006) of juveniles.

7.4.1.2. Growth

Analysis of LFDA of hake in GSA 11 showed a slow growth pattern both in male and female (SAMED, 2002). A slower growth pattern for the GSA 11 hake population comes also from otolith readings. New Von Bertalanffy Growth Function parameters have been calculated and used in this assessment. This is in line with recent evidences that suggest a fast growing pattern hypothesis for hake either in the Western Mediterranean (Garcia-Rodriguez and Esteban, 2002; Jadaud *et al*., 2006; Piñeiro *et al*., 2007) or in the Bay of Biscay (De Pontual *et al*., 2003).

7.4.1.3. Maturity

Due to the low catchability of large hake in trawl, the catch rate of mature specimens during the MEDITS trawl survey is usually very low, influencing the identification of gonad development and growth rate for large individuals. Female length at first maturity is estimated at around 36 cm. Although spawning around Sardinian coasts (GSA 11) occurs nearly all over the year (January to September), a maturity peak is usually observed in winter and spring (February-May).

7.4.2.*Fisheries*

7.4.2.1. General description of fisheries

Hake is one of the most important commercial species in the Sardinian seas. In this area, the biology and population dynamics have been studied intensively in the past fifteen years. Although hake is not a target of a specific fishery, such as for example red shrimp, it is the third species in terms of biomass landed in GSA 11 (Murenu M., pers. com.). In the GSA 11 hake is caught exclusively by a mixed bottom trawl fishery at depth between 50 and 600 m. No gillnet or longline fleets target this species. Although different nets are used in shallow, mid and deep water (“terra” mainly targeting *Mullus* spp., “mezzo fondo” targeting fish and “fondale” net targeting deep shrimp) the main trawl used is an “Italian trawl net” type with a low vertical opening (max up to 1.5 m). The dimensions of the trawl change in relation to the trawlers engine power. Important by catch species are horned octopus, squids, poor cod, shortnose greeneye, greater forkbeard and pink shrimp.

Detailed maps of the fishing-grounds are reported in Murenu *et al*. (2006). Most of the effort is concentrated within a relative short distance around the major fishing ports (Cagliari, Alghero, Porto Torres, La Caletta, Sant’antioco, Oristano, Alghero). Moreover, some large trawlers move seasonally in different fishing grounds far from the usual ports.

From 1994 to 2004, the trawl fleet showed remarkable changes in GSA 11. Those mostly consisted of a general increase in the number of vessels and by the replacement of the old, low tonnage wooden boats by larger steel boats. For the entire GSA an increase of 85% for boats >70 tons class occurred. A decrease of 20% for the smaller boats (<30 GRT) was also observed.

7.4.2.2. Management regulations applicable in 2009 and 2010

As in other areas of the Mediterranean, the management of this stock is based on the control of fishing capacity (licenses), fishing effort (fishing activity), technical measures (mesh size and area closures), and minimum landing sizes (EC 1967/06). Two small closed areas were also established along the mainland (west and east coast respectively) although these are defined to mainly protect Norway lobster. Since 1991, a fishing closure for 45 trawling days has been enforced (month and year are reported on the following figure) almost every year.

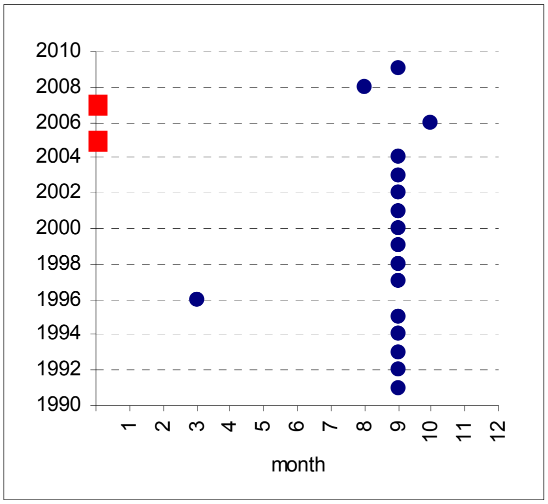


Fig. 7.4.2.2.1 Month and year of the fishing closure. Red points show the years when no closing measure was adopted.

Towed gears are not allowed within the three nautical miles from the coast or at depths less than 50 m when this depth is reached at a distance less than 3 miles from the coast.

7.4.2.3. Catches

7.4.2.3.1. Landings

Landings data from 2009 were not submitted by the Italian authorities. Landings available for GSA 11 by major fishing gears are listed in Tab. 5.9.2.3.1.1. Since 2004, landings decreased to 336 t in 2009 (Fig. 7.4.2.3.1.1). Landings of hake are mostly taken by the demersal trawl fisheries (DTS, OTB and partially PMP). According to SGMED scientist's knowledge, official DCF data for GSA 11 is likely overestimating the contribution of the landings derived from LLS, GNS and GTR. A cross-check of the official data and the update of 2009 landings information is needed to improve and allow the assessment of hake in next SGMED meetings.

Tab. 7.4.2.3.1.1 Landings (t) by year and major gear types, 2004-2009 as reported through DCF in 2010.

FT_LVL4	2004	2005	2006	2007	2008	2009
GNS	32,1	59,8	7,93	36,6	21,9	26,1
GTR	80,6	101	206	63,3	28,6	39,5
LLD			3,02	0,19		2,99
LLS	1,12	2,22	13,4	8,08	10	7,02
OTB	597	765	594	442	279	261
total landings (all gears)	711	928	824	550	339	336

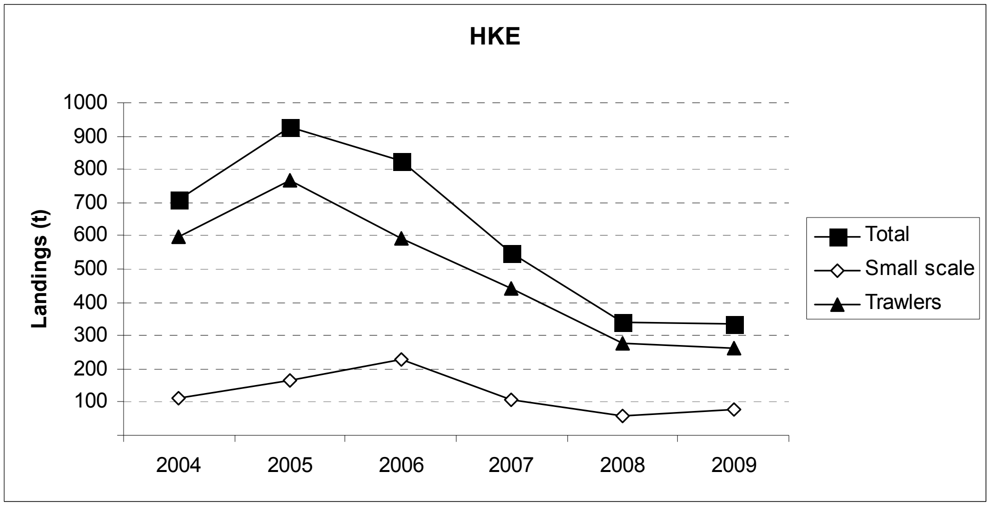


Fig. 7.4.2.3.1.1 Landings (t) by year and major gear types, 2002-2009 as reported through DCF.

7.4.2.3.2. Discards

Discards were reported to SGMED-10-02, as noted in SGMED-09-02, for 2005 and 2006 only. Total discard for hake was 15 t in 2005 for long-lines and 63 t in 2006 for trawlers.

7.4.2.3.3. Fishing effort

Using data reported in SGMED-10-03, the trends in fishing effort by year and major gear type is listed in Tab. 7.4.2.3.3.1 and shown in Fig. 7.4.2.3.3.1 in terms of kW*days. Similar to the trend in total fishing effort, the trend in fishing effort by trawler showed a decrease in 2008.

Tab. 7.4.9.2.3.3.1 Trend in fishing effort (kW*days) for Italy in GSA 11 for the major gear types in 2004-2009.

FT_LVL4	2004	2005	2006	2007	2008	2009
				15720		
FPO	41196	79505	967791	1487078	900543	1011209
FYK				1155	0	0
GNS	1010930	1039342	204277	773799	435020	951187
GTR	5118454	7262485	7201973	4830951	3677886	4127035
LHP-LHM	18192	773	64100	121765	62982	44015
LLD	3608	277773	463381	1187584	746975	459397
LLS	805007	924018	1322417	1107356	645248	671985
LTL			6647	1742	588	566
OTB	7008771	7714815	6073729	6258161	4411130	4371051
PS	1369					
total	14007527	17298711	16304315	15785311	10880372	11636445

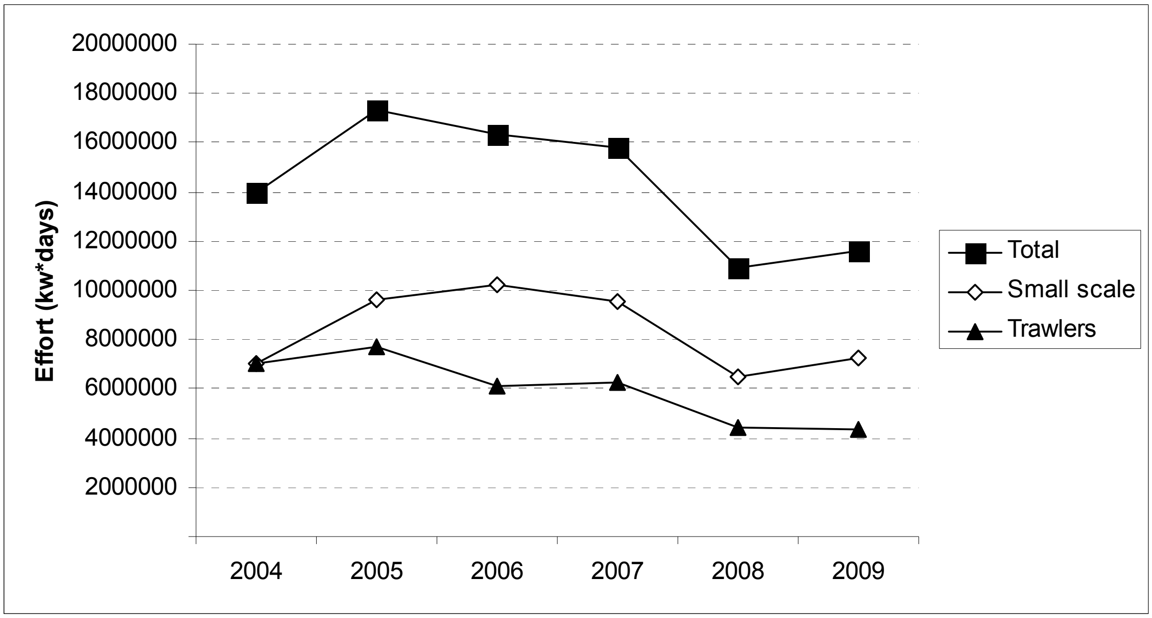


Fig. 7.4.2.3.3.1 Trend in fishing effort (kW*days) for the Italian fleet in GSA 11 for the major gear types in 2004-2009.

Tab. 7.4.2.3.3.2 Trend in fishing effort (kW*days) for Italy in GSA 11 for the major gear types in 2004-2009, as reported through the DCF in 2010.

AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	VESSEL_LENGTH	2004	2005	2006	2007	2008	2009
11	ITA				VL1218				15720		
11	ITA	FPO	Demersal species		VL0006				78503	17179	24215
11	ITA	FPO	Demersal species		VL0612	41196	23012	814366	1280047	827583	828017
11	ITA	FPO	Demersal species		VL1218		56493	153425	128528	55781	158977
11	ITA	FYK	Demersal species		VL0006				723	0	0
11	ITA	FYK	Demersal species		VL0612				432		
11	ITA	GNS	Demersal species		VL0006			2553	74890	19315	33167
11	ITA	GNS	Demersal species		VL0612	1002998	695840	139310	629250	318463	674666
11	ITA	GNS	Demersal species		VL1218	7932	343502	62414	69659	97242	243354
11	ITA	GTR	Demersal species		VL0006			173809	116139	83038	75866
11	ITA	GTR	Demersal species		VL0612	5057167	5513005	5786113	3778300	2768964	3256884
11	ITA	GTR	Demersal species		VL1218	61287	1749480	1242051	936512	825884	794285
11	ITA	LHP-LHM	Cephalopods		VL0006				21043	2463	
11	ITA	LHP-LHM	Cephalopods		VL0612	18192	773	19435	61145	14044	4273
11	ITA	LHP-LHM	Cephalopods		VL1218			38550	39577	21711	910
11	ITA	LHP-LHM	Finfish		VL0612			918		24764	38832
11	ITA	LHP-LHM	Finfish		VL1218			5197			
11	ITA	LLD	Large pelagic fish		VL0612			113740		6484	6161
11	ITA	LLD	Large pelagic fish		VL1218	3608	277773	209763	1172955	740491	453236
11	ITA	LLD	Large pelagic fish		VL2440			139878	14629		
11	ITA	LLS	Demersal fish		VL0006			11563	17871	2898	3231
11	ITA	LLS	Demersal fish		VL0612	795811	695883	924521	769091	414061	449671
11	ITA	LLS	Demersal fish		VL1218	9196	228135	289938	296777	228289	219083
11	ITA	LLS	Demersal fish		VL1824			10135			
11	ITA	LLS	Demersal fish		VL2440			86260	23617		
11	ITA	LTL	Large pelagic fish		VL0612			6647	1742	588	566
11	ITA	OTB	Deep water species		VL2440					139344	199254
11	ITA	OTB	Demersal species		VL0612				1064		153616
11	ITA	OTB	Demersal species		VL1218	1425360	1331798	1607505	151584	1321796	1316636
11	ITA	OTB	Demersal species		VL1824	45888				855033	699312
11	ITA	OTB	Demersal species		VL2440				20124	257107	217971
11	ITA	OTB	Mixed demersal and deep water species		VL1218				1551232	82379	
11	ITA	OTB	Mixed demersal and deep water species		VL1824	2134561	2982686	1912624	2058755	392755	543997
11	ITA	OTB	Mixed demersal and deep water species		VL2440	3402962	3400331	2553600	2475402	1362716	1240265
11	ITA	PS	Small pelagic fish		VL1218	1369					

7.4.3. *Scientific surveys*

7.4.3.1. MEDITS

7.4.3.1.1. Methods

Since 1994 the MEDITS trawl surveys have been yearly carried out between May and July (except in 2007). According to the MEDITS protocol (Relini, 2000; Bertand *et al.*, 2002) a stratified random sampling design with allocation of hauls proportional to depth strata extension (depth strata: 10–50 m, 51–100 m, 101–200 m, 201–500 m, 501–800 m) was adopted. A specific gear (GOC 73, with a 20 mm stretched mesh size in the cod-end) was always used following the instruction stated and reported in Dremière and Fiorentini (1996). Based on the DCR data call, abundance and biomass indices were recalculated. In GSA 11 the following number of hauls was reported per depth stratum (s. Tab. 7.4.3.1.1.1).

Tab. 7.4.3.1.1.1. Number of hauls per year and depth stratum in GSA 11, 1994-2009.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GSA11_010-050	16	18	21	21	21	20	19	17	20	18	17	17	19	19	17	18
GSA11_050-100	25	21	22	22	20	22	22	24	19	19	18	21	18	20	19	20
GSA11_100-200	20	23	30	31	31	30	29	30	24	24	24	24	24	24	22	24
GSA11_200-500	33	29	29	26	25	27	24	25	20	24	21	20	20	20	21	19
GSA11_500-800	23	16	21	25	25	24	27	26	16	14	15	14	16	17	16	16

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

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

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

Where:

- A=total survey area
- Ai=area of the i-th stratum
- si=standard deviation of the i-th stratum
- ni=number of valid hauls of the i-th stratum
- n=number of hauls in the GSA
- Yi=mean of the i-th stratum
- Yst=stratified mean abundance
- V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA. Given the sheer number of plots generated, these distributions are not presented in this report.

7.4.3.1.2. Geographical distribution patterns

The spatial distribution of European hake has been described by modelling the spatial correlation structure of the abundance indices using geostatistical techniques (i.e. kriging). In different studies either total abundance index or abundances of recruits and adults were analysed (Murenu *et al*., 2007).

On average, considering the analyzed yearly distributions (1994-2005), the recruits were considered individuals smaller than 12.3 cm (±1.41). These individual are belonging to the age 0 group. Persistence of the nursery areas along the years was studied by applying indicator kriging technique (Journel 1983, Goovaerts, 1997) to abundance estimations of recruits (Murenu *et al*., 2008). Main results and maps are reported in the "nursery section" of SGMED-09-02 report.

7.4.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the hake in GSA 11 was derived from the international survey MEDITS. Figure 5.9.3.1.3.1 displays the estimated trend in hake abundance and biomass in GSA 11.

The estimated abundance and biomass indices since 2000 show high variation without any trend.

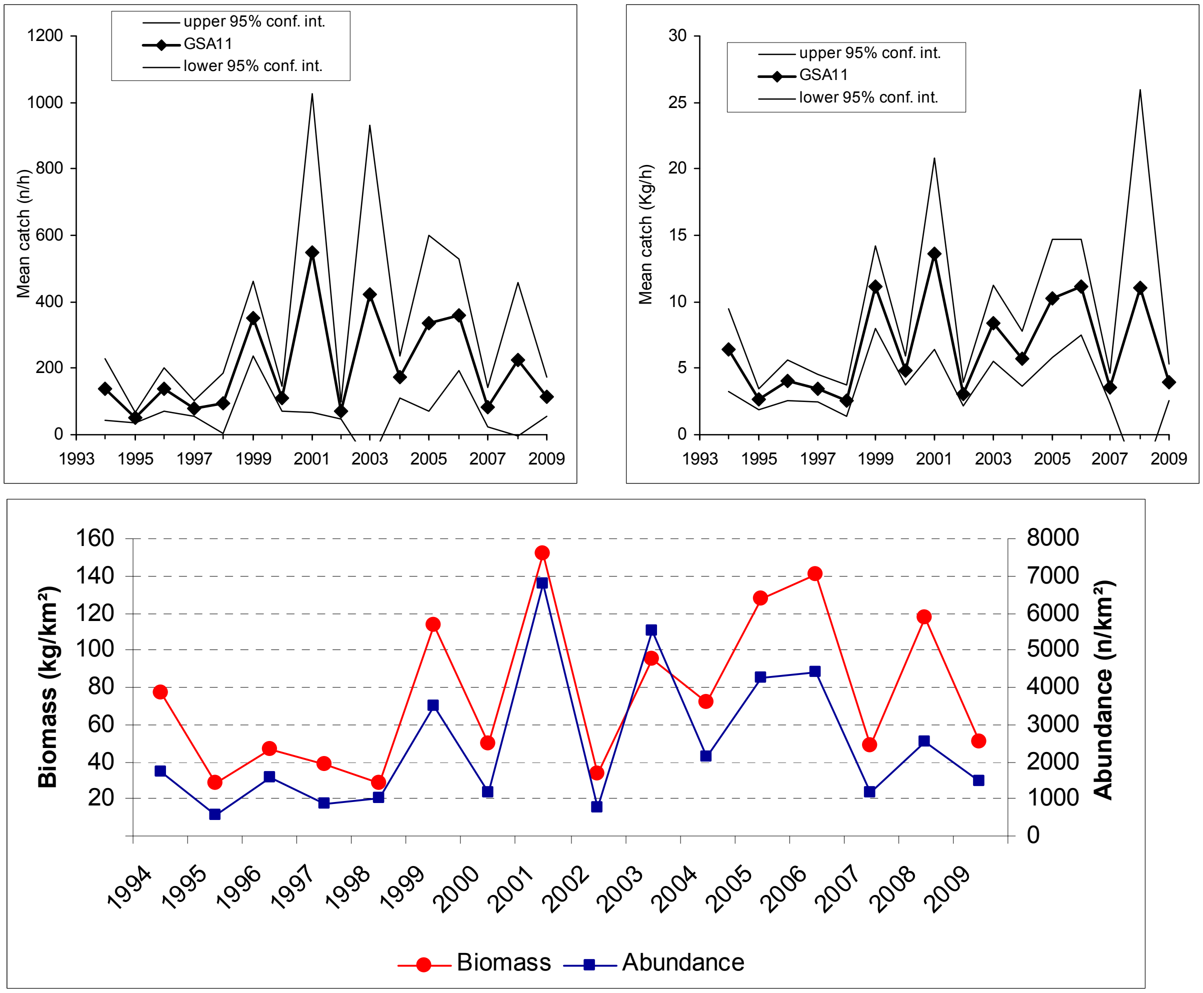


Fig. 7.4.3.1.3.1 Abundance and biomass indices of hake in GSA 11.

7.4.3.1.4. Trends in abundance by length or age

The following Fig. 7.4.3.1.4.1 and 2 display the stratified abundance indices of GSA 11 in 1994-2001 and 2002-2009 respectively.

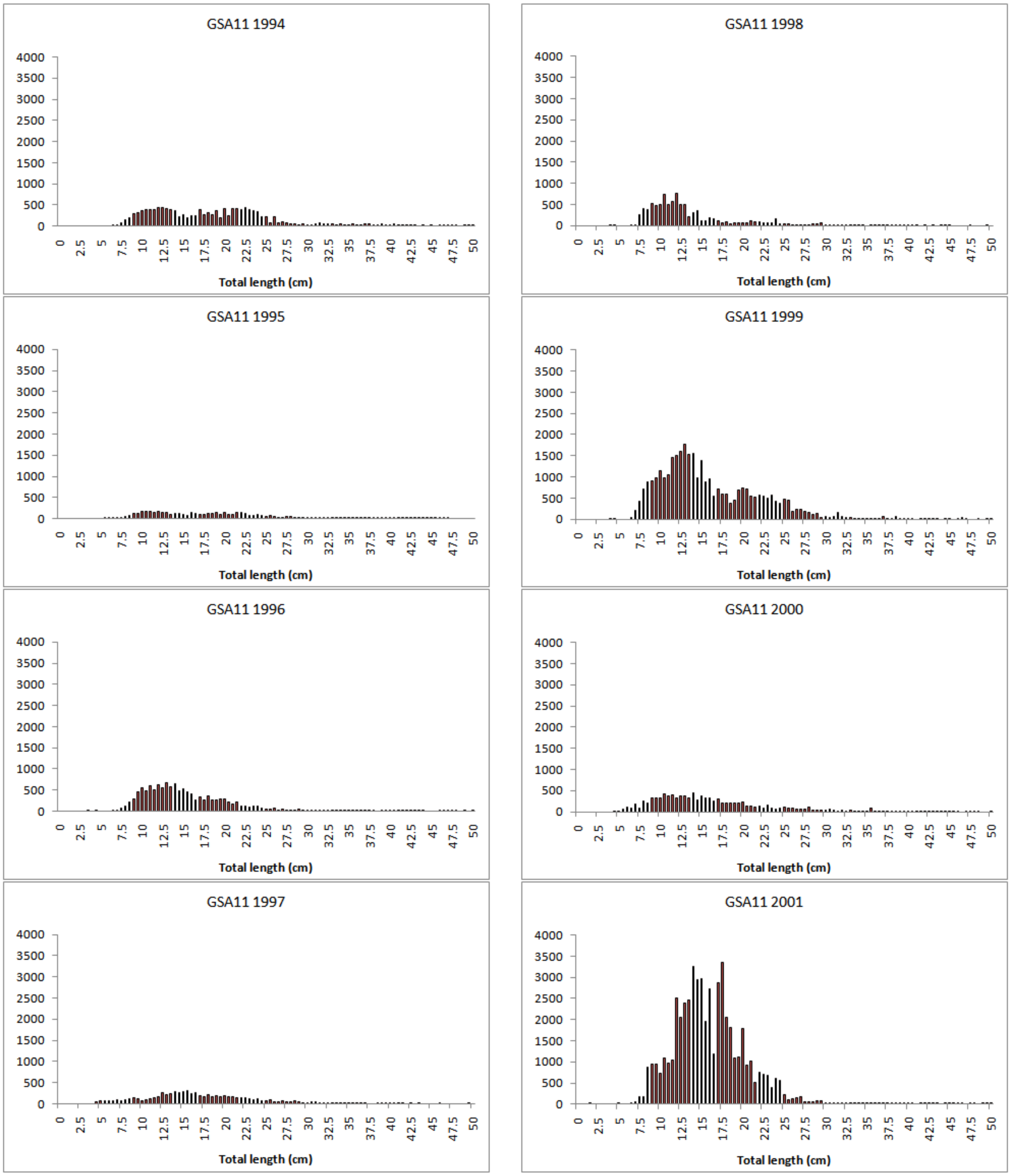


Fig. 7.4.3.1.4.1 Stratified abundance indices by size, 1994-2001.

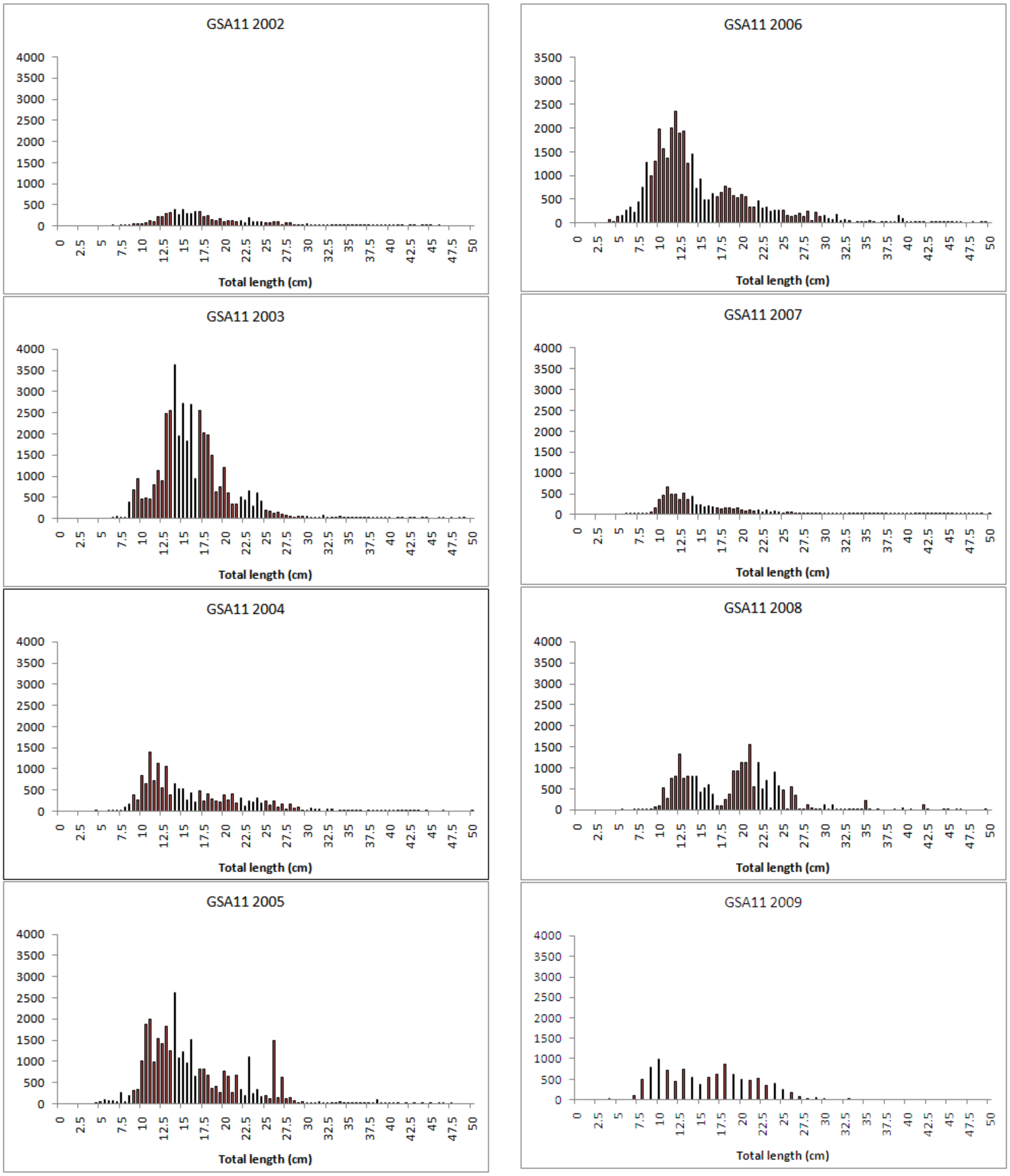


Fig. 7.4.3.1.4.2 Stratified abundance indices by size, 2002-2009.

7.4.3.1.5. Trends in growth

No analyses were conducted.

7.4.3.1.6. Trends in maturity

No analyses were conducted.

7.4.4. *Assessment of historic stock parameters*

7.4.4.1. Method 1: SURBA

7.4.4.1.1. Justification

The SURBA analyses was applied to the MEDITS survey estimates.

7.4.4.1.2. Input parameters

Data from trawl surveys (time series of MEDITS from 1994 to 2009) and effort and landings data from DCR have been used for the analysis. The SURBA software package (Needle, 2003) use trawl surveys data available from MEDITS to estimate fishing mortality rates of hake in the GSA 11. First, the LFDs were converted in numbers at age using the subroutine "age slicing" as implemented in the R routine by SGMED. The VBGF parameters used to split the LFD has been changed from L_∞=97.15 cm, K=0.165, t_0= 0.03 used in SGMED-09-02 to a faster growth set as L_∞=100 cm, K=0.248, t_0= -0.01. According to the Prodbiom approach developed by Caddy and Abella (1999), a vectorial natural mortality at age was estimated (Tab. 7.4.4.1.2.1). Guess-estimates of catchability by age are given in Tab. 7.4.4.1.2.1.

Tab. 7.4.4.1.2.1 Input parameters used in the SURBA analysis (sex combined) in GSA11.

VBGF	L_∞=100 cm, K=0.248, t_0= -0.01
M vector	Age_1=1.11 , Age_2=0.51, Age_3=0.40, Age_4=0.35, Age_5=0.33
Catchability (q)	q_1 = 0.8, q_{2-3} = 1.0, q_4=0.75, q_5=0.6
Length at maturity (L_{50})	36 cm (sex combined)

7.4.4.1.3. Results

Estimates of total mortality for sex combined from Surba were as follows: SURBA results show that the mean F for ages 1-3 was high and stable until 2005, then increasing up to 3.1 in 2008.

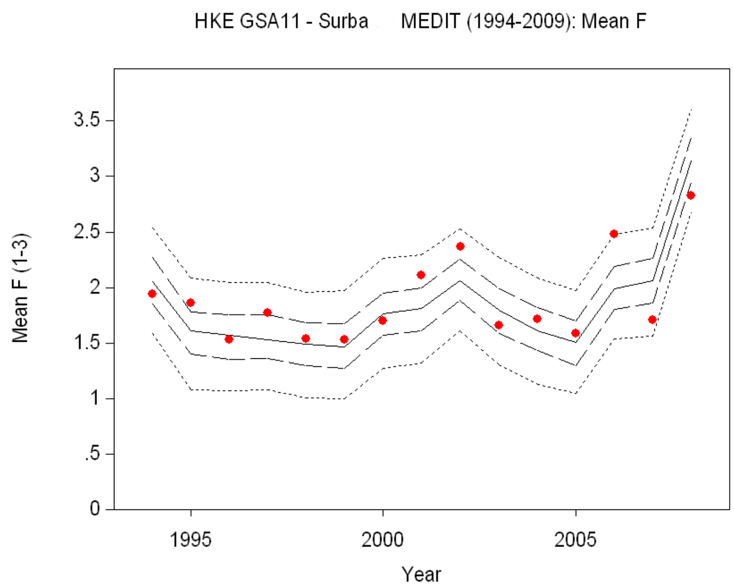


Fig. 7.4.4.1.3.1 Fishing mortalities of hake in GSA 11 estimated by SURBA using trawl surveys age composition (MEDITS).

SSB peaks were detected in 1994, 2000 and 2006, with a clear drop in the last years. Relative indices estimated by SURBA indicated very high fluctuations of recruitment in the period 1994-2009, with large recruitment observed in 2001, 2003 and 2005.

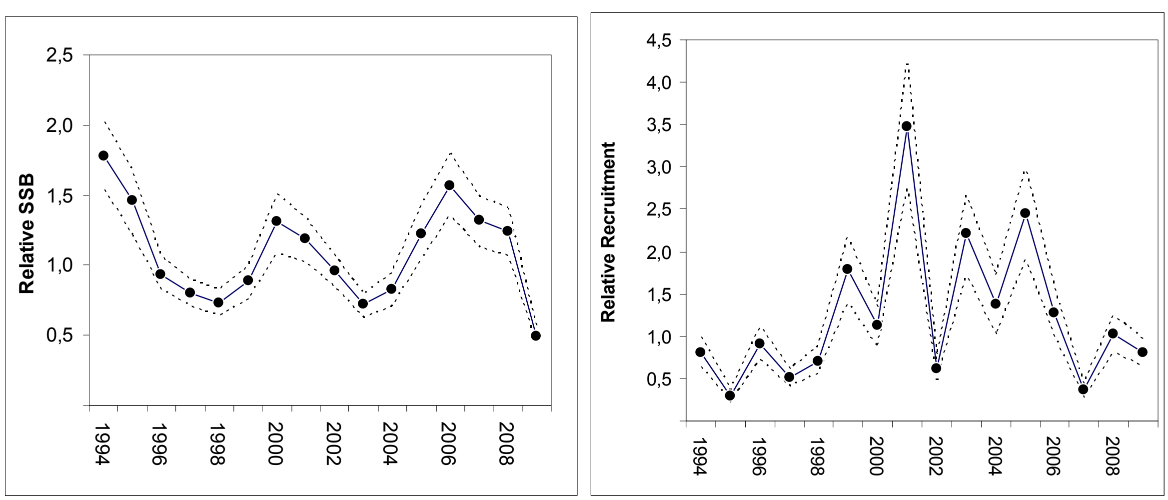
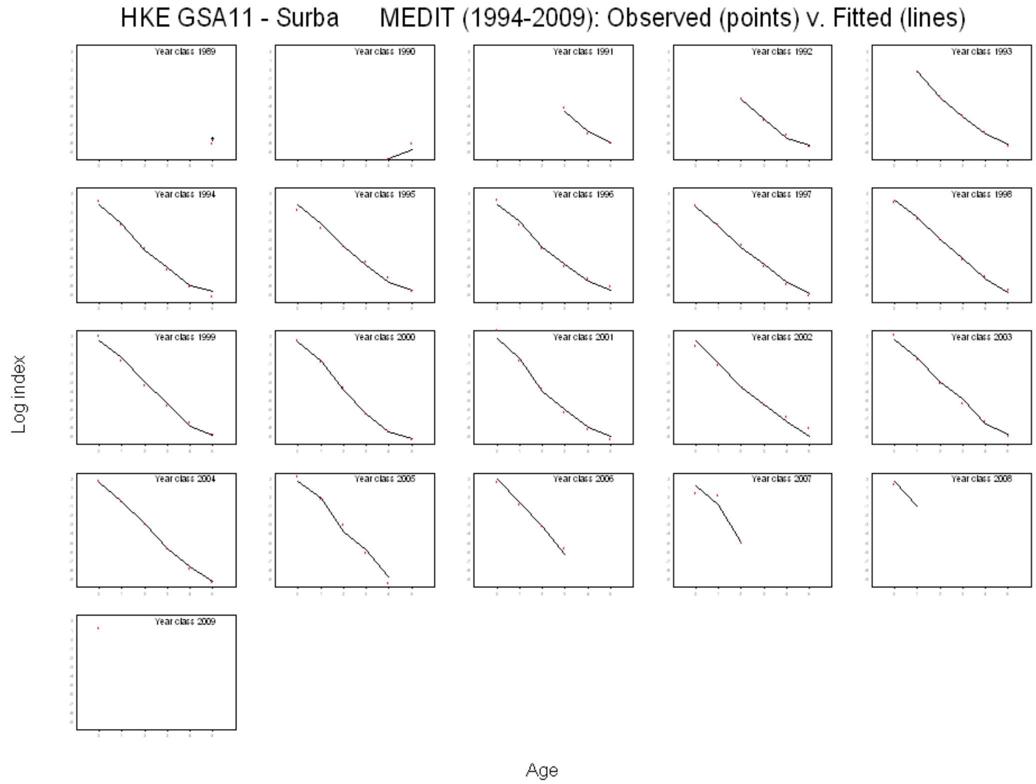


Fig. 7.4.4.1.3.2 Trend of SSB and recruitment of hake in GSA 11 estimated by SURBA using trawl surveys data (MEDITS).

Model diagnostics are shown in the Fig. 7.4.4.1.3.3. Observed and fitted MEDITS survey indices of abundance for each year were reasonably in agreement (A) while catch curve reconstruction from log survey abundance indices showed some deviation from the expected curve (B). Log index residuals over time, plotted by age class (C) varied without any trend.


HKE GSA11 - Surba MEDIT (1994-2009): Observed (points) v. Fitted (lines)
Year class 1989
Year class 1990
Year class 1991
Year class 1992
Year class 1993
Year class 1994
Year class 1995
Year class 1996
Year class 1997
Year class 1998
Year class 1999
Year class 2000
Year class 2001
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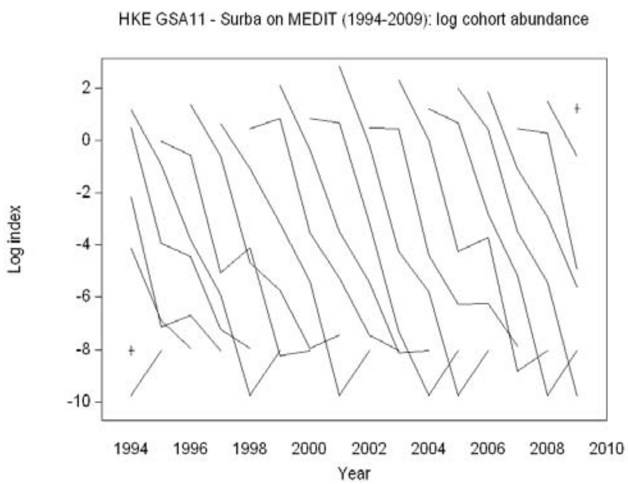
Year class 2004
Year class 2005
Year class 2006
Year class 2007
Year class 2008
Year class 2009
Log index
Age

A


HKE GSA11 - Surba on MEDIT (1994-2009): log cohort abundance
Log index
2
0
-2
-4
-6
-8
-10
1994
1996
1998
2000
2002
2004
2006
2008
2010
Year

B

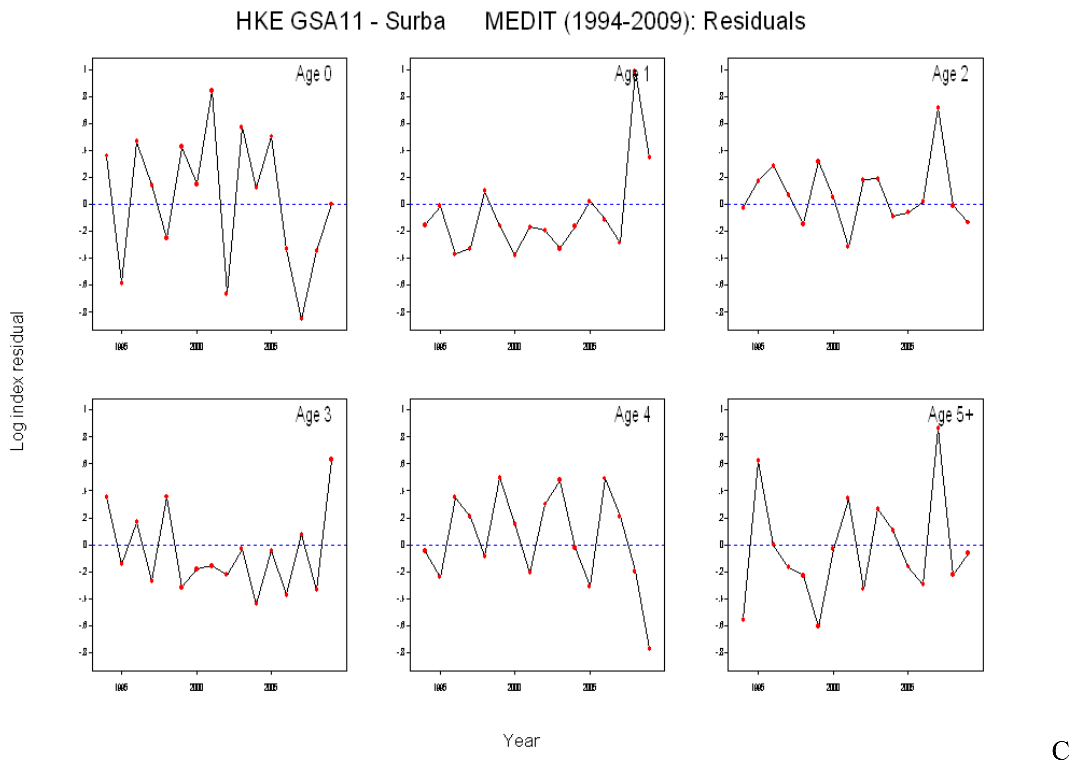


Fig. 7.4.4.1.3.3 Model diagnostic for SURBA model in the GSA 11 (MEDITS survey). A) Comparison between observed (points) and fitted (lines) survey abundance indices, for each year. B) Log survey abundance indices by cohort. Each line represents the log index abundance of a particular cohort throughout its life. C) Log index residuals over time, plotted by age class.

7.4.4.2. Method 2: VIT LCA

7.4.4.2.1. Justification

An approach under steady state (pseudocohort) assumption was applied due to the shortness of landing by length and age (2006-2009 , DCR) data. Pseudocohort, LCA and Y/R analyses as been carried out with VIT software for trawl fishery only. No discard data were included.

7.4.4.2.2. Input parameters

According to the Prodbiom approach by Caddy and Abella (1999), a vectorial natural mortality at age was computed for the stock analysis (Tab. 7.4.4.2.2.1). Terminal F was fixed to 0.3.

Tab. 7.4.4.2.2.1 Input parameters used of the analysis (sex combined) in the GSA11.

Growth parameters (Von Bertalanffy)
$L\infty = 104$ (cm, total length); $k = 0.2$; $t_{0=}$ - 0.03
L*W: a = 0.006657; b=3.028
M vector Age_1=1.3, Age_2=0.6, Age_3=0.46, Age_4=0.41, Age_5=0.3 (ProdBiom)
Length at maturity (L_{50}) = 30 cm total length (sex combined)

Tab. 7.4.4.2.2.2 Catch numbers at age in 2006-2009.

AGE	2006	2007	2008	2009
0	1217	1792	3742	732
1	2385	1537	1684	527
2	620	112	238	48
3	78	0	70	13
4	22	6	14	2

7.4.4.2.3. Results including sensitivity analyses

Results obtained by year do not showed interannual variation of the exploitation pattern.

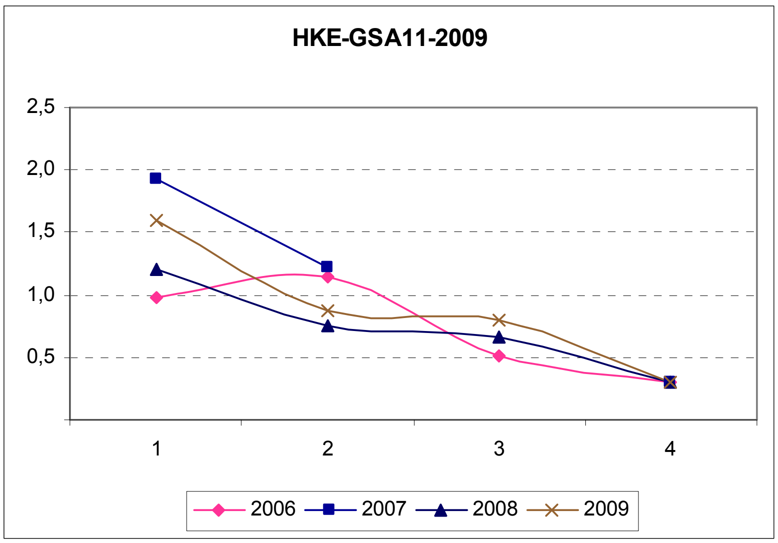


Figure 7.4.4.2.3.1 Fishing (F) by age and year of hake in GSA11 (age groups 1-4).

$F_{(1-4)}$ is almost stable and around a mean value of 0.8 for the period 2006-2009.

Table 7.4.4.2.3.1 Estimated fishing mortaliy in 2006-2009 as well as the mean of all years.

year	2006	2007	2008	2009	mean 06-09
$F_{(1-4)}$	**0.73**	**0.86**	**0.73**	**0.89**	**0.80**

7.4.5. *Long term prediction*

7.4.5.1. Justification

State of the stock in relation to reference points was estimated using Yield software (Hoggarth *et al*., 2006).

7.4.5.2. Input parameters

The parameters used were those adopted from the SURBA analysis presented above.

7.4.5.3. Results

$F_{0.1}$ was assumed as target reference point. F_{max} and F_{ref} were considered as limit reference points. F_{ref} is the F where the ratio SSB/initial SSB is equal to 0.30. The following mean values were obtained: F_{max} = 0.4; $F_{0.1}$= 0.3 and F_{ref} = 0.8.

7.4.6. *Data quality*

MEDITS survey data were not available for 2010.

7.4.7. *Scientific advice*

7.4.7.1. Short term considerations

7.4.7.1.1. State of the spawning stock size

Due to the lack of validated landings information, SGMED-10-03 was not in the position to estimate the absolute levels of stock abundance. Survey abundance (n/km²) and biomass (kg/km²) indices do not indicate a significant trend. The stock SSB is more variable over the last decade. No biomass reference points have been proposed for this stock. As a result, SGMED is unable to evaluate the status of the stock with respect to biomass.

7.4.7.1.2. State of recruitment

SGMED-10-03 was not in the position to estimate the absolute levels of recruitment. Relative indices estimated by SURBA indicated very high fluctuations of recruitment in the period 1994-2009, with a clear decreasing trend in the last five years.

7.4.7.1.3. State of exploitation

Trends in the average fishing mortality over ages 1 to 3 derived from MEDITS surveys ranged from 1.5 to 3.1, with the highest value observed in the last year.

SGMED proposes $F_{0.1}$=0.3 of ages 1-3 as limit management reference point consistent with high long term yields. This value is interpreted as proxy of F_{msy}. Taking into account the results from VIT the stock of hake in GSA 11 SGMED notes that the current F is far in excess of the proposed target reference point $F_{0.1}$. Assuming a similar selection patters of the survey and the commercial fishery, SGMED concludes that the hake stock in GSA 11 is overfished until 2009.

7.5. Stock assessment of hake in GSAs 15 and 16

7.5.1. *Stock identification and biological features*

7.5.1.1. Stock Identification

The stock structure of hake in the Strait of Sicily has to date not been defined. Levi *et al*. (1994) compared the growth of *M. merluccius* in Mediterranean and found quite a similar pattern in individuals from the Northern side of the Strait of Sicily (GSAs 15 and 16) and those caught in the Gulf of Gabes (GSA 14). Lo Brutto *et al*. (1998) have also found no evident of genetic subdivisions or significant differences in allelic frequencies, between samples near Sicily and those from the mid-line. More recently Levi *et al*. (2004) applied electrophoretic, morphometric and growth analyses to test the hypothesis of the existence of a unique stock of hake in the Sicily channel, which includes part of the North African continental shelf off the Tunisian coast and the shelf off the southern Sicilian coast. Although the level of genetic variation detected at five selected sampling sites was very low, morphometric analyses and otolith readings revealed some significant differences at phenotypic level, mainly in females. On the basis of the spatial distribution of spawning and nursery areas compared with the current patterns in the Strait of Sicily, Camilleri *et al*. (2008) believed the existence of genetic exchange between hake sub-populations inhabiting GSAs 15 and 16. In the northern sector of the Strait of Sicily (GSA 15 and 16), although some inter-annual variability in the nurseries distribution was evident, Abella et al. (2008) identified two stable nursery areas, which are related with prevailing meso-scale oceanographical processes. These nurseries are located on the eastern side of the Adventure and Malta banks, between 100 and 200 m depth (Fig. 7.5.1.1.1).

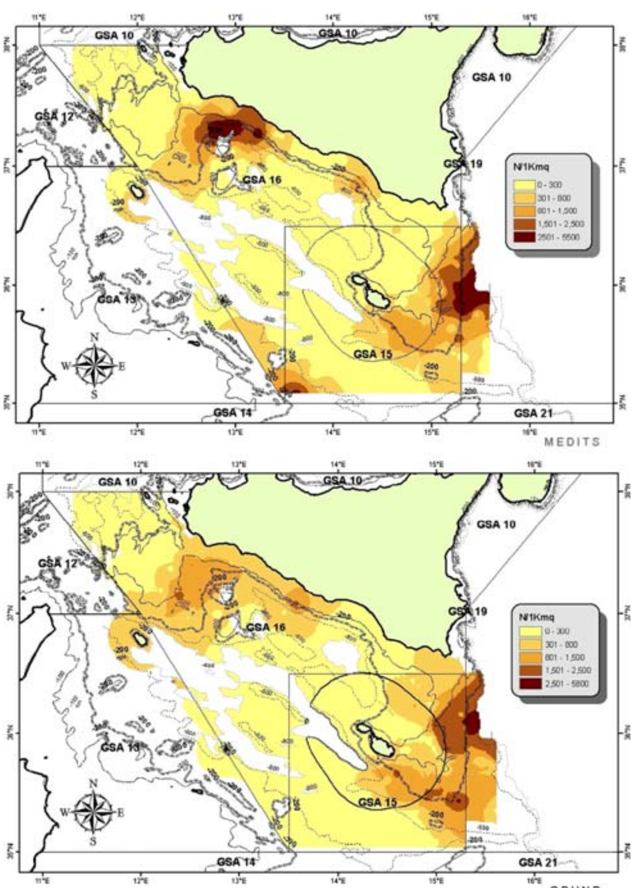


Fig. 7.5.1.1.1. Mean pattern of highest concentration of YOY's in the Strait of Sicily in spring (MEDITS surveys) and autumn (GRUND surveys; Abella et al. 2008).

On the basis of trawl landings (GSA 15 & 16) sex ratio is around 0.5 between 24 and 32 cm TL, while females prevail on males mainly at larger sizes (SR≥0.90 after 40 cm TL). In GSA 16 sex ratios from trawl surveys shows a significant decrease (r_s=-0.657) with time, showing a reduction of females in the population since 1994 (Figure XX).

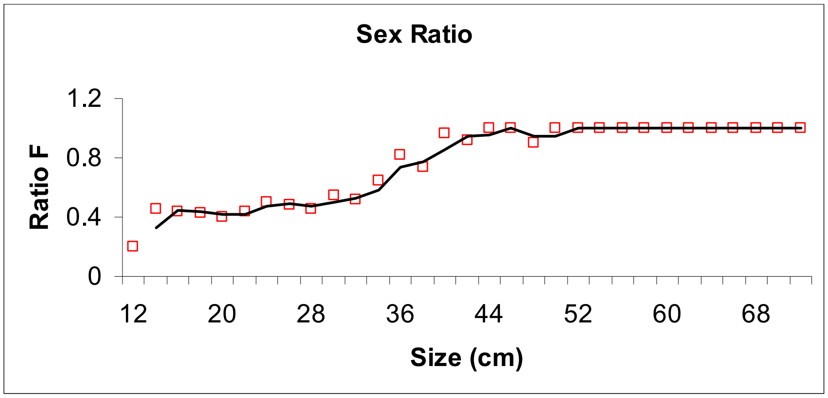


Fig. 7.5.1.1.2. Ratio of female *M. merluccius* in the Strait of Sicily based on landings data; black line represents moving average.

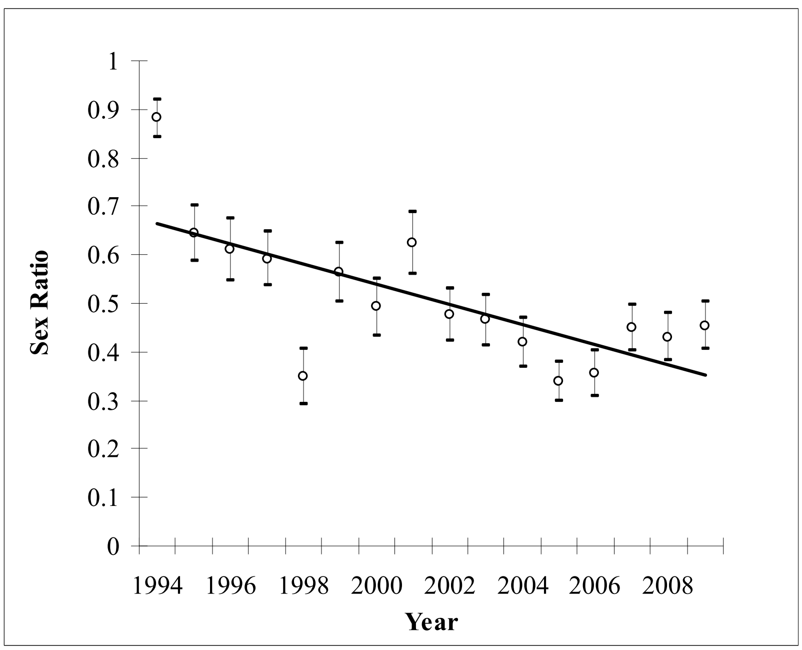


Fig. 7.5.1.1.3. Hake sex ratio in the Straight of Sicily based on MEDITS survey data from 1994-2009.

A study by Andaloro *et al*., (1985) in the Strait of Sicily found that hake's diet varied according to size. Smallest fish of 4.5-12 cm TL feed mainly on Euphausiacea. Decapods are the main preys of hake between 13 and 24 cm TL, while fish is the preferred food of individuals larger than 25 cm TL. Similar feeding behaviour that varied with size has also been observed for other areas in the Mediterranean (see Colloca, 1999). Parameters of the length-weight relationship are listed in Table 7.5.1.1.1.

Tab. 7.5.1.1.1. Parameters of length-weight relationships of hake in the GSAs 15 and 16.

Author	GSA	Sex	a	b
Andaloro *et al*., 1985	16	F+M+I	0.0060	3.1190
Cannizzaro *et al*., 1991	15 & 16	F	0.0069	3.0248
		M	0.0068	3.0222
		F+M+I	0.0066	3.0370
IRMA-CNR, 1999	15 & 16	F+M+I	0.0056	3.0831
CNR-IAMC, 2006	16	F	0.0041	3.1669
		M	0.0051	3.0916
		F+M+I	0.0046	3.1341
CNR-IAMC, 2007	16	F	0.0043	3.1525
		M	0.0049	3.1028

7.5.1.2. Growth

Considering the northern sector of the Strait of Sicily (GSA 15 and 16) the observed maximum length is 88 cm TL in females (Fiorentino *et al*., 2003a) and 53 cm TL in males (Sinacori G., pers. com.). According to Fiorentino *et al*. (2003a), the maximum estimated age in years in the exploited standing stock, resulted to be 15 years. This was established by thin section otolith lectures of largest females collected in trawl surveys for over 15 years.

The Von Bertalanffy Growth Function parameters by sex available for GSAs 15 and 16 are reported in Table 7.5.1.2.1.

Tab. 7.5.1.2.1. Von Bertalanffy growth function parameters in the strait of Sicily and adjacent seas.

Author	GSA	***Females***			**Males**			Remarks
		$L\infty$	K	t_0	$L\infty$	K	t_0	
Andaloro *et al*. (1985)	16	69.40	0.14	-0.35	57.1	0.16	-0.39	Otolith readings
IRMA-CNR, 1999	15&16	70.54	0.18	-0.1	49.37	0.29	-0.01	LFD analysis
SAMED, 2002	15&16	76.4	0.16	-0.2	44.9	0.28	-0.2	LFD analysis
Gangitano *et al*., 2007	16	82.60	0.12	-0.91	52.2	0.22	-0.83	Otolith reading
CNR_IAMC; 2007	16	81.54	0.15	-0.08	53.58	0.22	-0.13	Otolith readings and LFDA

With the exception of Andaloro *et al*. (1985), hake showed similar growth patterns in populations inhabiting the Strait of Sicily and the adjacent seas. Excluding the values given by Andaloro *et al*. (1985), the mean growth rates per month during the first two years range between 0.92 and 1.1 cm in females and 0.86 and 1.0 cm in males. These rates are compatible with those reported for juvenile hake in the Mediterranean by Fiorentino *et al*. (2000).

Recently, results given by otolith reading were considered as underestimating growth due to the presence of several checks, which can be confused with year rings. However the mean growth rates obtained for the first two years are consistent with those given by de Pontual *et al*. (2003), based on tagging experiments in the Bay of Biscay (0.84-0.99 cm per month in a size range of 21-40 cm TL).

7.5.1.3. Maturity

Although spawning off Tunisia (GSA 12) occurs year around, Bouhlel (1973) reported three maturity peaks, in summer, winter and spring depending to the size of females. The largest females (LT> 40 cm) spawn mainly in spring, while the smallest (29<TL<39 cm) have two main spawning peaks one in summer and another one in winter. Bouaziz *et al*. (1998), studied samples from Bou-Ismail (GSA 4), reported that the spawning season runs throughout the whole year, even if a peak in summer is evident. According to Levi (1991), mature specimens were collected both in autumn (November) and winter (February) in GSA 15 and 16. Information from the northern sector of the Strait of Sicily (GSA 16) revealed that outer shelf on the western side of Adventure Bank might be a relevant spawning area (Fiorentino *et al*., 2006b). According to literature spawning should occur in the outer shelf-upper slope. For instance, aggregation of mature adults was reported between 100 and 200 m in the Gulf of Tunis (Bouhlel, 1973). Available estimates of length at first maturity for the Strait of Sicily are reported in Table 7.5.1.3.1.

Tab. 7.5.1.3.1 Length at first maturity, as $L_{50\%}$ of maturity ogive, for hake in the Strait of Sicily and adjacent seas.

Author	**GSA**	**Females**		**Males**	
		L50%	**g**	**L50%**	**g**
Bouhlel, 1973	12 & 13	30.5	n.a.	28	n.a.
Mugahid & Hashem, 1982	21	24.5 (30)	n.a.	21	n.a.
Bouaziz *et al*., 1998	4	30.6	n.a.	21.5	n.a.
SAMED, 2002	15 & 16	33.5	n.a.	n.a.	n.a.
Gangitano *et al*., 2007	16	37.6	0.288	27.8	0.329
CNR_IAMC, 2007	15 & 16	35.6	0.29	24.6	0.23

7.5.2. *Fisheries*

7.5.2.1. General description of fisheries

Although hake is not a target of a specific fishery such as deep water pink shrimp and striped mullet, it is the third species in terms of biomass of Italian yield in GSA 16. Hake is caught by trawlers in a wide depth range (50-500m) together with other important species such as *Nephrops norvegicus*, *Parapenaeus longirostris*, *Eledone* spp., *Illex coindetii, Todaropsis eblanae*, *Lophius* spp., *Mullus* spp., *Pagellus* spp., *Zeus faber, Raja* spp. among others. In 2004-2009, 97% of declared catches were caught by demersal otter board trawlers, which is the fleet segment the current assessment is based on. 1% of catches were obtained using longlines, and 2% using trammel nets.

A rough delimitation of the most important commercial macro-areas for a large part of the Strait of Sicily is reported in Andaloro (1996). The main fishing-grounds, species caught, fishing periods and other relevant information regarding the Mazara distant trawl fleet fishing for hake in the Strait of Sicily are reported in Fiorentino *et al*. (2008). Detailed maps of the trawling grounds inside the Maltese Fisheries Management Zone (FMZ), which includes a substantial part of GSA 15, are available in Camilleri *et al*. (2008).

Trawlers operating in the Strait of Sicily use the same typology of trawl net called “Italian trawl net”. Although some differences in material between the net used in shallow waters (“banco” net, mainly targeted to shelf fish and cephalopods) and that employed in deeper ones (‘fondale’ net, mainly targeting deep water crustaceans) exist, the Italian trawl net is generally characterized by a low vertical opening (up to 1.5 m). However dimensions change with engine power (Fiorentino *et al*., 2003a).

7.5.2.2. Management regulations applicable

As in other areas of the Mediterranean, stock management measures are based on the control of fishing capacity (licenses), fishing effort (fishing activity), technical measures (mesh size and area closures), and minimum landing sizes (EC 1967/06).

In order to limit the over-capacity of fishing fleets, Italian fishing licenses have been fixed since the late 1980s. Moreover, after 2000, in agreement with the European Common Policy of Fisheries, a gradual decrease of fleet capacity was put into place. From 1987 to 2005 a 30-45 days stopping of fishing activities was enforced each year, in order to reduce fishing effort. Furthermore, as SGMED-08-04 was informed, a medium term management plan (2008-2013) was agreed for Italian trawlers, in part fulfilment of regulation EC 1967/2006.

In Malta the trawling fleet was stable with 16 licensed trawlers from 2000-2008. In 2008, due to a reduction in capacity of other fleets, 8 new trawl licenses were issued, thus increasing the trawl capacity for Malta by 50%. The Maltese Islands are surrounded by a 25 nautical miles (nm) fisheries management zone, where fishing effort and capacity are being managed by limiting vessel sizes, as well as total vessel engine powers (EC 813/04; EC 1967/06). Trawling is allowed within this designated conservation area, however only by vessels not exceeding an overall length of 24m and only within designated areas. Such vessels fishing in the management zone hold a special fishing permit in accordance with Article 7 of Regulation (EC) No 1627/94, and are included in a list containing their external marking and vessel's Community fleet register number (CFR) to be provided to the Commission annually by the Member States concerned. Moreover, the overall capacity of the trawlers allowed to fish in the 25nm zone can not exceed 4 800 kW, and the total fishing effort of all vessels is not allowed to exceed an overall engine power and tonnage of 83 000 kW and 4 035 GT respectively. The fishing capacity of any single vessel with a license to operate at less than 200m depth can not exceed 185 kW. In addition, the use of all trawl nets within 1.5nm of the coast is prohibited according to EC regulation 1967 / 2006, although again a transitional derogation is at present in place until 2010. There are no closed seasons in Maltese waters.

In terms of technical measures, the new regulation EC 1967 of 21 December 2006 fixed a minimum mesh size of 40 mm for bottom trawling of EU fishing vessels (Italian and Maltese trawlers). Minimum mesh sizes have to be modified to square 40 mm or diamond 50 mm by June 2009; hereafter no further derogations are possible. The minimum landing size for *M. merluccius* is at present 20 cm (Annex III, EC 1967/2006).

In addition to these management measures, the protection of spawning grounds has been suggested to be one of the most effective management approaches to enhance recruitment whilst maintaining the reproductive potential of populations. Similarly, reducing fishing effort on juveniles is vital if populations are to be harvested at maximum sustainable yield, in particular when juveniles are vulnerable to unselective fishing gears. The location of nursery areas of *M. merluccius* in the Strait of Sicily have been identified using data from MEDITS and GRUND trawl surveys carried out in GSA 16 (Abella *et al.* 2008). However, the location of hake nurseries were found to be located at discrete off-shore areas on the outer shelf (100-200 m) in international waters, making the possibility of protecting the nursery areas a difficult task especially with respect to enforcement (see Fig.XX). Nevertheless, both Malta and Italy suggested setting up a Fishing Restricted Area (FRA) on Malta Bank in their national fisheries management plans submitted to the European Commission (as required by Article 18 of EC 1967/2006).

7.5.2.3. Catches

7.5.2.3.1. Landings

The most recent Italian and Maltese data were collected within the EU Data Collection Framework (DCF). Andreoli *et al*. (1995) estimated yield of hake landed by trawling with 1-2 day trip of commercial fisheries of southern coasts of Sicily (GSA 15 and 16) in the middle eighties: in April 1985 - March 1986 landings of about 1440 tons were recorded; the next year it amounted to 1238 tons. Considering that the overall yield of trawling was about 15337 tons in 2007 and 13249 tons in 2008, hake landings represent about 10% of total demersal trawl yields in the area (see Table 7.5.2.3.1.1). On the basis of 2007 data, 93% of the combined Sicilian and Maltese landings are due to trawling. In 2008 as well as 2009, this percentage increased to 98%.

Tab. 7.5.2.3.1.1. Landings (t) of hake by fishing technique by the Sicilian and Maltese fleets as recorded under the EU DCF.

		Year				
GSA	**Fleet**	**2005**	**2006**	**2007**	**2008**	**2009**
15	GTR	1	1	0	0	0
	LLS	2	1	2	1	1
	OTB	4	5	6	1	10
16	GTR	46	6	83	16	24
	LLS	23	22	36	12	10
	OTB	1720	1598	1599	1367	1546
	OTM	0	0	0	0.1	1
15 & 16	**Overall**	**1796**	**1633**	**1726**	**1397**	**1592**

In 2004-2008, hake landings decreased for demersal trawlers measuring >24m in length, but remained stable for trawlers measuring 12-24m in length.

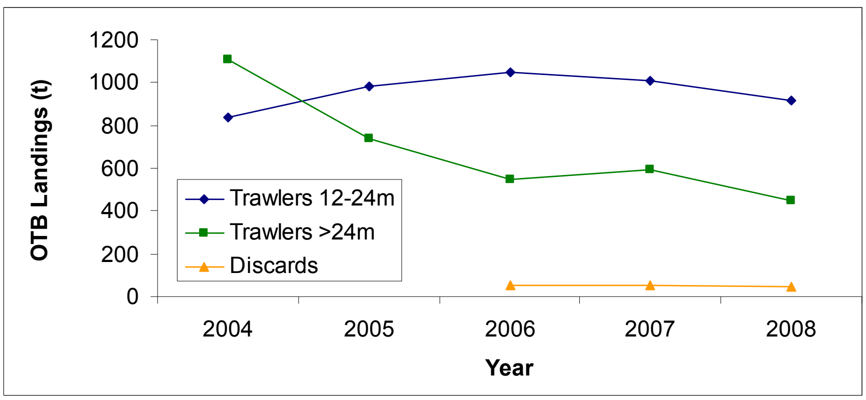


Fig. 7.5.2.3.1.2. Sicilian hake yield, fished in GSA 15 and 16, by fleet segment. Discards are shown for both fleets combined. Data from 2009 was not available by fleet level in the database.

Length compositions of landings for Sicilian vessels reveal that trawlers measuring 12-24 m fish a higher percentage of small individuals compared to trawlers measuring over 24 m in length.

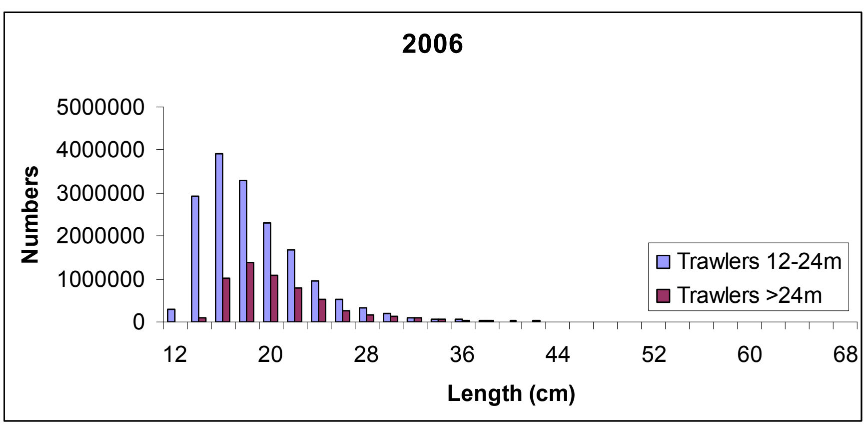


Fig. 7.5.2.3.1.1 2006 length structures of hake landings by Sicilian trawlers in absolute numbers.

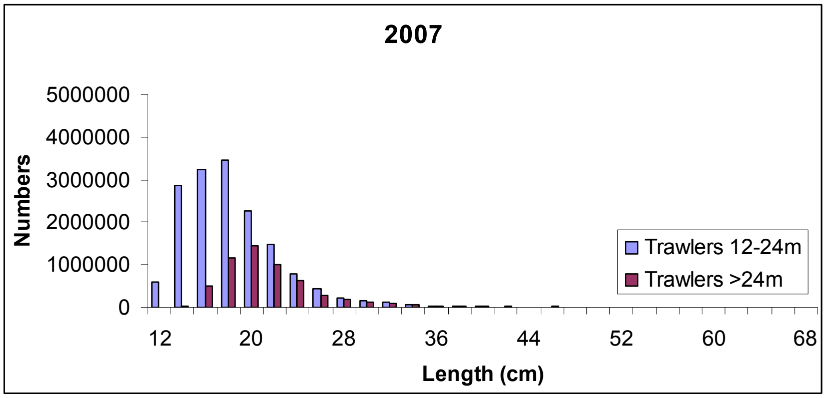


Fig. 7.5.2.3.1.2 2007 length structures of hake landings by Sicilian trawlers in absolute numbers.

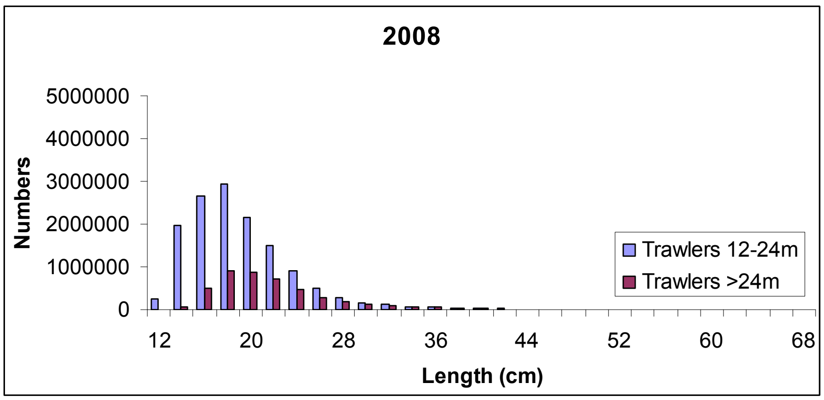


Fig. 7.5.2.3.1.3 2008 length structures of hake landings by Sicilian trawlers in absolute numbers. Data from 2009 was not available by fleet level in the database.

7.5.2.3.2. Discards

In the late nineties Sicilian trawlers fishing off-shore (15 – 25 days of trip) had higher discard rates of hake (86% in number and 31% in weight of the total catch) than the inshore trawlers (1-2 days trips) (32% in number and 9% in weight) (Anon., 2000). For distant fisheries the first modal group (10-12 cm) in the catches was totally discarded. This primarily due to the limited amount of freezer space available on vessels, which fishermen preferentially use to store more highly priced crustaceans. Conversely trawlers operating in coastal waters tend to reduce the discarded fraction to only the smallest specimens of the first age group present in catches.

More recent data, collected within the framework of DCR, showed that the discarded fraction of undersized hakes by Sicilian trawlers was stable in 2006-2008, but increased sharply in 2009. In 2006, 54 tons of discards were recorded, which represented 13% in number and 3% in weight of total catch. In 2008, 46 tons of discards were reported, which again represented only 3% in weight of total catch. In 2009 however 185 tons of discards were reported by otter-board trawlers based in GSA 16, 12% in weight of the total catch. In Malta, 1 tonne of discards was recorded, equivalent to 10% in weight of the total catch.

The mean size of the discarded hakes in varies according to the season. During 2006 the length at 50% discard of the Sicilian trawlers ranged between 12.9 (summer and autumn) and 15.0 (spring) cm TL, being 13.5 cm TL the yearly value (Gancitano V., pers. comm.).

7.5.2.3.3. *Fishing effort*

The trends in fishing effort by year and major gear type is listed in Table 7.5.2.3.3.1, and shown in Figure 7.5.2.3.1.1 in terms of kW*days for the Maltese and Italian bottom otter trawl fleets.

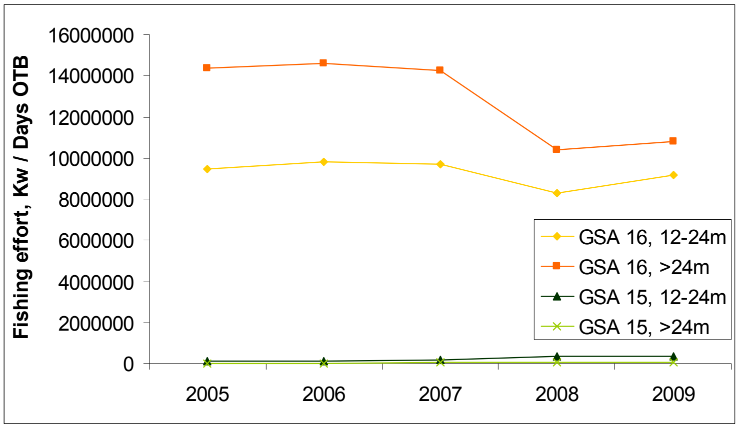


Fig. 7.5.2.3.1.1 Trend in annual effort (kW*days) of Italian and Maltese otter trawlers operating in GSAs 15 and 16, 2005-2009.

Tab. 7.5.2.3.3.1 Trend in annual effort (kW*days) by country, gears and vessel length in GSAs 15 and 16, 2005-2009. Only fleets with relevance to hake exploitation are represented.

COUNTRY	AREA	FT_LVL4	VESSEL_LENGTH	2005	2006	2007	2008	2009
ITA	16	GTR	VL0006	0	219584	162478	137523	244783
		LLS	VL0006	0	77109	57980	49633	43112
			VL0612	827572	454738	410856	296031	396728
			VL1218	24862	229105	262549	140076	110425
			VL1824	164	1005	13015	0	32031
		OTB	VL0612	11001	0	0	0	183954
			VL1218	3307141	3442496	3722837	3523709	3705588
			VL1824	6156064	6374977	5947067	4792117	5294526
			VL2440	14355019	14603903	14257032	10376157	10830753
		OTM	VL1824	3949	219664	441228	403011	418415
			VL2440	107017	21257	0	0	0
MAL	15	GTR	VL0006	0	0	0	0	1222
			VL0012	8364	6899	19700	14197	0
			VL0612	0	0	0	0	2952
			VL1224	5316	1492	1024	164	0
			VL2440	209	0	0	0	0
		LLS	VL0006	0	0	0	0	5242
			VL0012	47773	82092	81472	141656	0
			VL0612	0	0	0	0	101973
			VL1218	0	0	0	0	40027
			VL1224	79870	73824	79442	68490	0
			VL1824	0	0	0	0	8556
			VL2440	13204	3775	0	0	634
		OTB	VL1224	128047	133167	201767	352184	0
			VL1824	0	0	0	0	340113
			VL2440	1790	10742	39090	30358	59792

7.5.3. *Scientific surveys*

7.5.3.1. Medits

7.5.3.1.1. Methods

Based on the DCR data call, abundance and biomass indices were recalculated and presented in section 11 of this report.

In order to collect fisheries independent data, which is a requirement of the EU DCF (Council Regulation 199/2008, Commission Regulation 665/2008, Commission Decision EC 949/2008 and Commission Decision 93/2010), the MEDITS international trawl survey is carried out in GSAs 15 and 16 on an annual basis. The following number of hauls was reported per depth stratum in 1994-2009 (GSA 16) and 2002-2009 (GSA 15):

Tab. 7.5.3.1.1.1. Number of hauls per year and depth stratum in GSA 16, 1994-2009.

Depth (m)	1994	1995	1996	1997	1998	1999	2000	2001
10-50	4	4	4	4	4	4	4	4
50-100	8	8	8	8	8	8	7	8
100-200	4	4	4	4	5	5	6	5
200-500	10	11	11	12	11	11	11	11
500-800	10	14	14	13	14	14	14	14
Depth (m)	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
10-50	7	7	7	10	10	11	11	11
50-100	11	12	12	20	22	23	23	23
100-200	10	8	9	18	19	21	21	21
200-500	19	18	19	28	31	27	27	27
500-800	19	20	19	32	33	38	38	38

Tab. 7.5.3.1.1.2. Number of hauls per year and depth stratum in GSA 15, 2002-2009.

Depth (m)	2002	2003	2004	2005	2006	2007	2008	2009
10-50	1	1	2	1	1	0	0	0
50-100	5	5	4	5	5	12	6	6
100-200	13	13	13	13	13	12	13	14
200-500	10	10	10	9	10	4	9	10
500-800	16	16	15	17	16	17	17	15

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). A limited number of obvious data errors were corrected and catches by haul were standardized to 60 minutes haul duration. Only hauls noted as valid were used, including stations with no catches of hake, red mullet or pink shrimp (i.e. zero catches were included).

The abundance and biomass indices were subsequently calculated by stratified means (Cochran, 1953; Saville, 1977). This implies weighing average values of the individual standardized catches as well as the variation of each stratum by the respective stratum area:

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

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

Where:
- A = total survey area
- Ai = area of the i-th stratum
- si = standard deviation of the i-th stratum
- ni = number of valid hauls of the i-th stratum
- n = number of hauls in the GSA
- Yi = mean of the i-th stratum
- Yst = stratified mean abundance
- V(Yst) = variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t (student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions about the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien *et al.* 2004).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA. Given the sheer number of plots generated, these distributions are not presented in this report.

7.5.3.1.2. Geographical distribution patterns

No analyses were conducted during SGMED-03-10.

7.5.3.1.3. Trends in abundance and biomass

In addition to information on the trends in hake abundance in early summer collected through the MEDITS survey, fisheries independent information was also collected in GSA 16 through the GRUND survey, which is conducted in autumn (Figure 7.5.3.1.3.1). The biomass indices of both surveys show very similar patterns, with a stable period from 2000-2003, followed by a sharp increase in biomass in 2004-2006 and a decline to intermediate levels in 2007-2009.

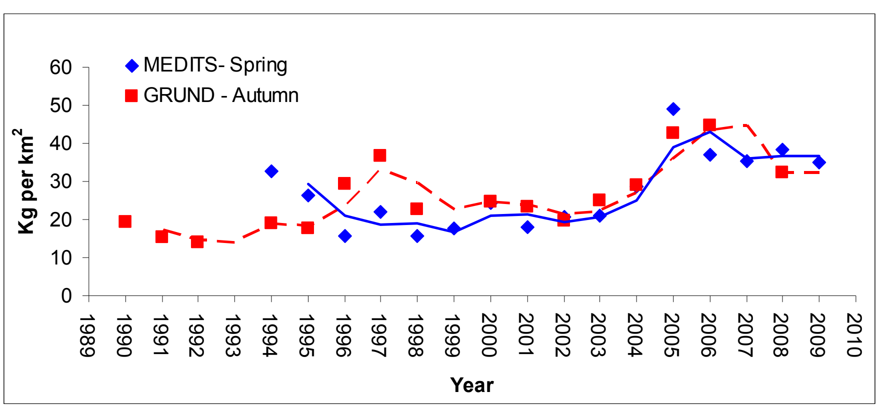


Fig. 7.5.3.1.3.1 Biomass indices (BI as kg per km^2) obtained during the MEDITS and GRUND surveys in GSA 16.

The trend in abundance and biomass, including upper and lower 95% confidence intervals as re-estimated by SGMED-10-02 are shown in Figure 7.5.3.1.3.2 for GSA 16.

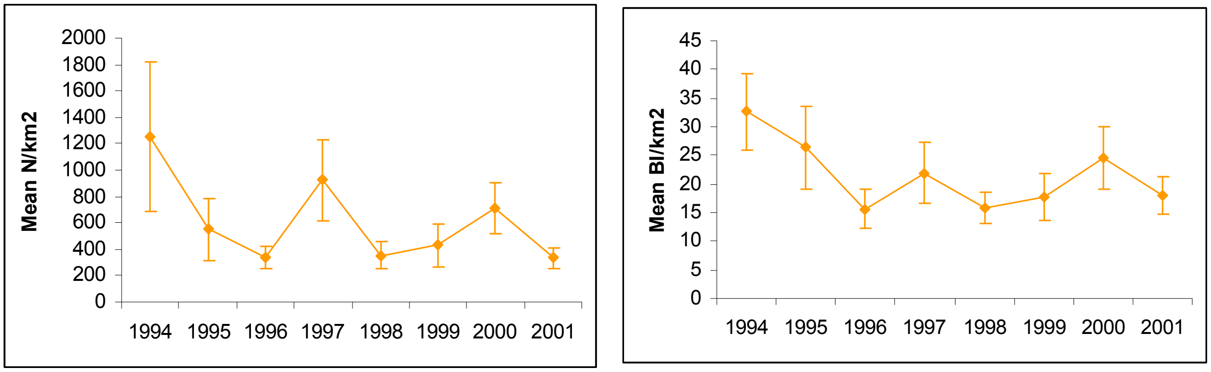


Fig. 7.5.3.1.3.2. Abundance and biomass indices of hake in GSA 16, 1994-2001

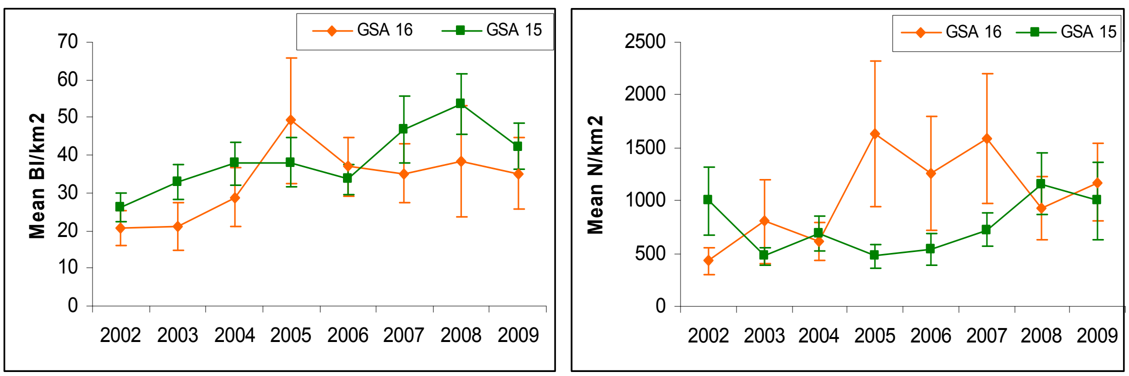


Fig. 7.5.3.1.3.3. Abundance and biomass indices of hake in GSA 15 & 16, 2002-2009

7.5.3.1.4. Trends in abundance by length or age

Figures 7.5.3.1.4.1 and 7.5.3.1.4.2 show abundance indices of hake per 100 km^2 GSA 16 in 1994-2001 and in GSA 15 / 16 in 2002-2009 respectively.

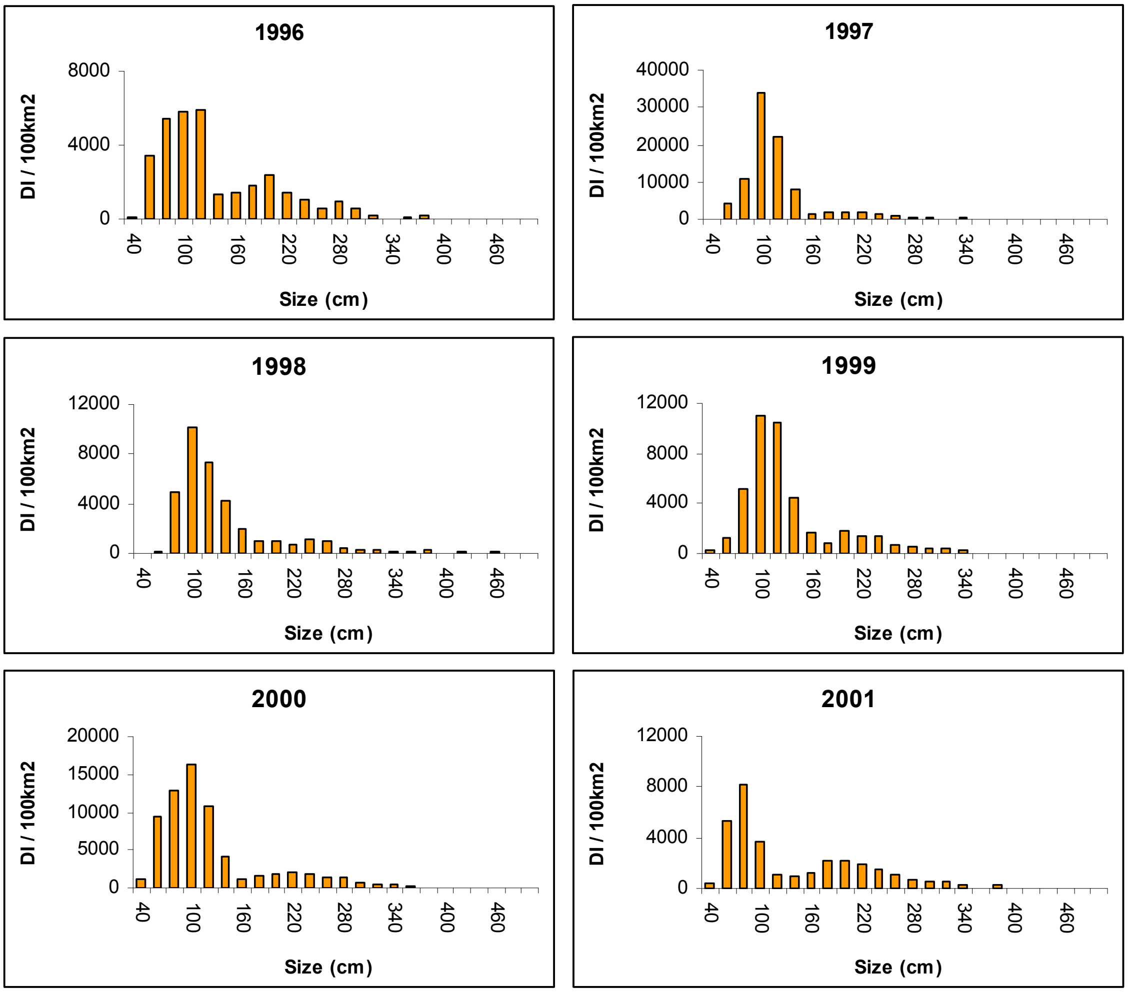


Fig. 7.5.3.1.4.1. Hake abundance indices in GSA 16.

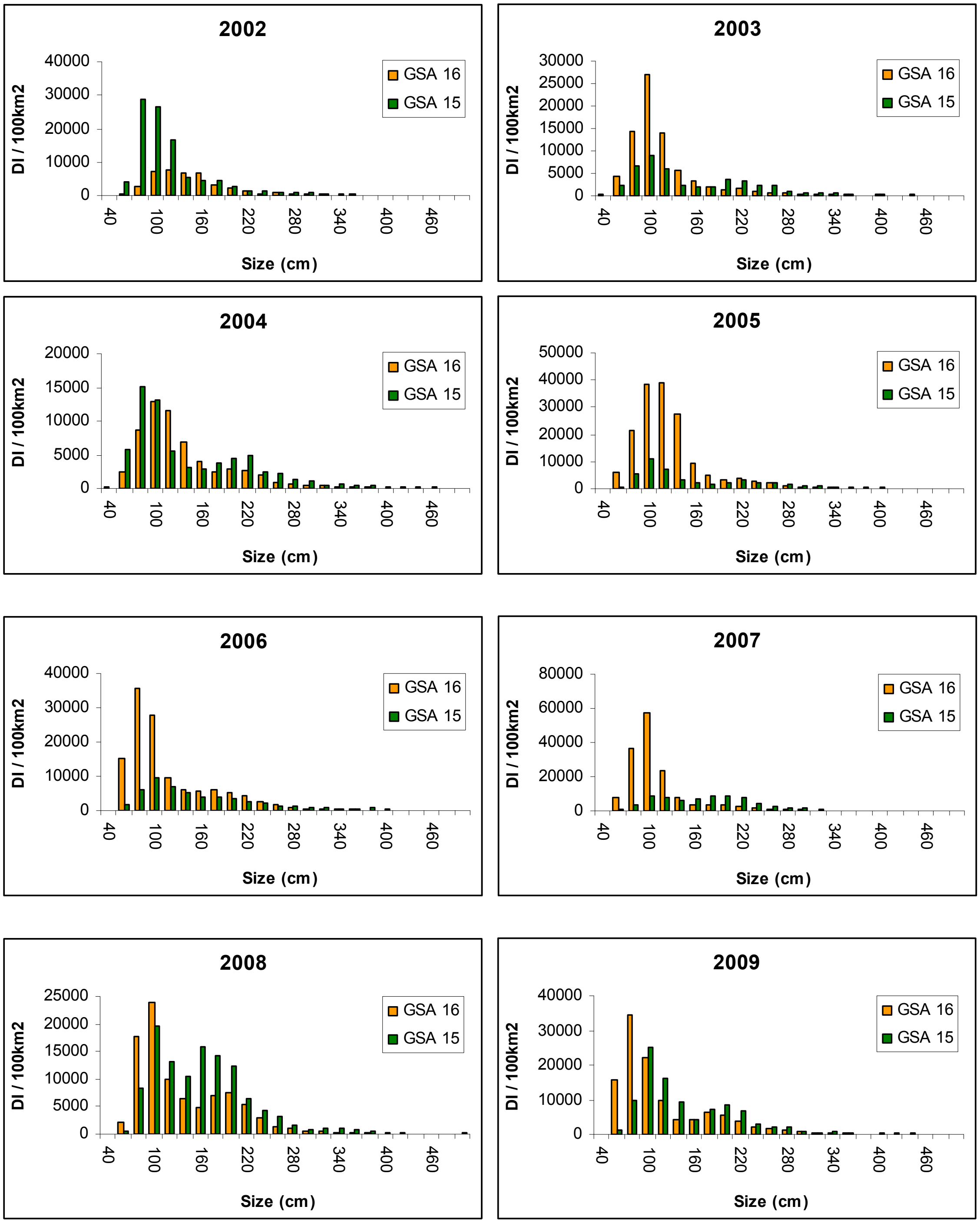


Fig. 7.5.3.1.4.2. Hake abundance indices in GSA 15 and 16.

7.5.3.1.5. Trends in growth

No analyses were conducted during SGMED-10-03.

7.5.3.1.6. Trends in maturity

No analyses were conducted during SGMED-10-03.

7.5.4. *Assessment of historic stock parameters*

7.5.4.1. Method 1: SURBA

7.5.4.1.1. Justification

SGMED 03/2010 performed an assessment combining survey data (MEDITS) from GSA 15 and GSA 16 using SURBA; however the model fit was very poor. The poor model fit was almost certainly due to the short time series of survey data available from both GSA 15 and GSA 16 (2002-2009), compared to the long time series of survey data available from GSA 16 (1994-2009). However, the availability of a long time series of length frequency distributions (LFD) did allow for the reconstruction of the evolution of hake fishing mortality rates in GSA 16 by using the SURBA software package. Firstly the LFD by sex from the MEDITS trawl surveys was corrected by including the data for the individuals with unidentified sexes. This was based on the sex ratio per size class. The corrected LFDs by sex for each GSA were then converted in numbers by age group using the subroutine "age slicing" as implemented in the software package LFDA (Kirkwood *et al*., 2001). Secondly we estimated the mean weight at age using the VBGF, and a vectorial natural mortality at age (Caddy and Abella, 1999) for the SURBA software to run the analysis.

7.5.4.1.2. Input parameters

The von Bertalanffy growth function (VBGF) parameters used for age slicing of the *M. merluccius* LFD were calculated by taking averages of male and female parameters (obtained from CNR_IAMC (2007) for GSA 16), which were subsequently weighed by the sex ratio. The combined stock parameters were: L_{inf}= 100cm; k= 0.116; t_0= -0.643; a= 0.0043; b= 3.1525.

Tab. 7.5.4.1.2.1. GSA 16 MEDITS hake LFD, values shown are standardized to N/km^2.

Size (cm)	1994	1995	1996	1997	1998	1999	2000	2001
≤12	87372	33715	20655	71141	22735	27983	50687	18550
14	12349	5609	1336	7985	4232	4507	4203	939
16	5744	2565	1436	1418	1968	1692	1110	1286
18	3694	2389	1775	1764	978	803	1512	2205
20	2674	2489	2340	1995	969	1846	1812	2191
22	2090	1315	1452	1815	699	1440	2130	1950
24	2098	1076	1045	1295	1120	1416	1948	1502
26	780	1461	549	726	951	738	1380	1156
28	791	706	929	647	355	493	1344	635
30	777	484	609	545	311	350	628	495
32	626	457	233	172	258	382	478	534
34	494	465	0	288	191	247	513	297
36	473	347	109	229	113	64	282	0
38	361	276	149	43	234	65	82	224
40	191	160	0	125	43	0	60	44
42	121	64	45	23	134	67	0	0
44	91	56	0	65	0	0	0	45
46	89	44	23	0	98	44	0	45
48	28	42	0	0	0	0	21	44
50	0	56	0	0	21	0	0	0

52	62	0	23	0	0	22	48	22
54	0	0	46	0	0	46	0	22
56	29	21	26	0	0	0	22	0
58	62	0	22	0	28	0	60	46
60	0	0	0	0	0	0	0	0
62	0	21	0	0	0	0	0	0
64	0	0	0	0	0	23	0	0
66	0	22	0	0	0	22	0	0

Size (cm)	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
≤12	17816	59964	35774	105245	88004	126111	53449	81661
14	6577	5684	6935	27417	6153	7444	6453	4328
16	6873	3313	4074	9312	5439	3412	4926	4165
18	3120	1875	2525	4746	6163	3907	7056	6329
20	2140	1453	2797	3360	5337	3857	7609	5739
22	1334	1576	2667	4112	4264	2857	5427	3750
24	592	905	1949	2947	2770	2159	3076	1983
26	792	775	976	2043	1860	971	1445	1508
28	541	526	604	1088	873	637	1097	1099
30	384	444	480	760	545	457	519	742
32	351	186	336	529	403	293	616	558
34	221	223	255	326	317	270	301	495
36	305	195	229	264	230	208	310	292
38	50	136	138	157	143	135	171	154
40	29	174	105	265	153	110	93	92
42	44	66	93	138	54	162	130	120
44	147	15	87	167	53	107	41	80
46	62	29	81	75	55	66	50	110
48	78	14	28	71	0	67	32	51
50	16	51	62	38	45	45	36	47
52	14	0	56	0	19	16	16	24
54	67	29	29	48	19	8	24	33
56	15	0	0	27	17	41	37	20
58	14	0	0	41	9	25	27	0
60	0	15	14	0	28	18	16	0
62	0	0	14	38	8	0	16	0
64	0	0	30	0	17	8	36	0
66	0	0	59	28	27	8	0	0

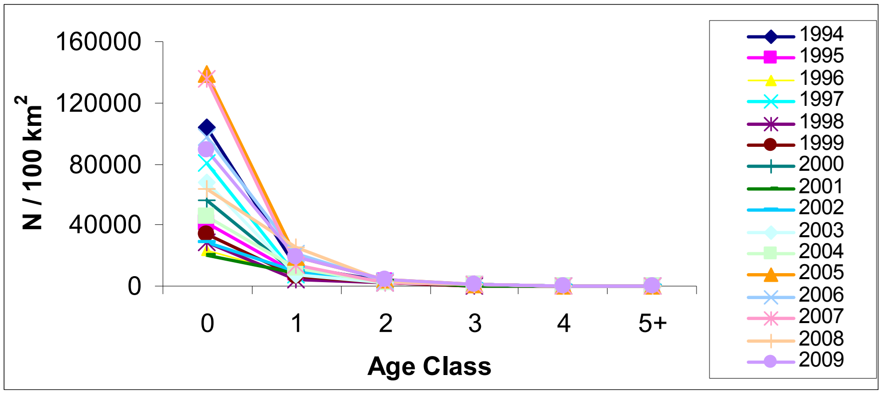


Fig. 7.5.4.1.2.1. GSA 16 hake age frequency distributions for 1994-2007, obtained from age slicing using combined sex parameters.

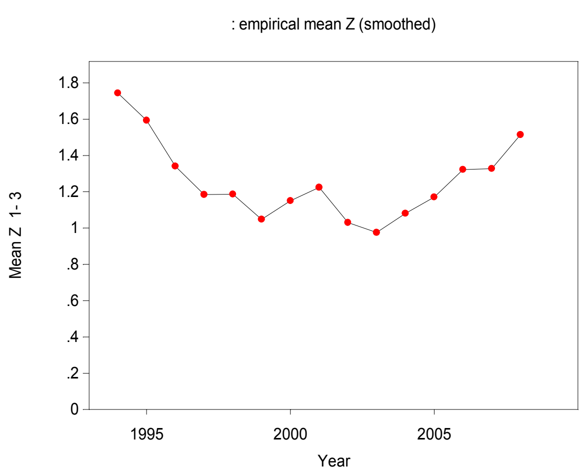
Natural mortality rates by age group but constant for all years were calculated based on ProdBiom (Abella *et al.*, 1997), as recommended by SGMED 09-01. Guess estimates of catchability by age were used.

Tab. 7.5.4.1.2.2. Vectors of natural mortality, maturity, weight and catchability for hake (sex combined) in the Strait of Sicily (GSA 16).

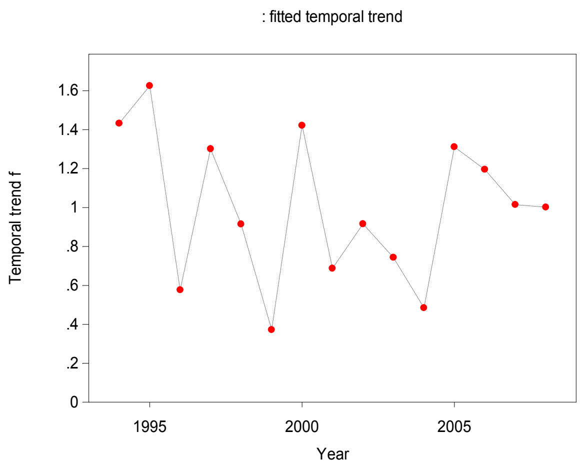
	Age					
	0.5	**1.5**	**2.5**	**3.5**	**4.5**	**5.5**
Mortality	0.68	0.30	0.22	0.19	0.17	0.16
Weight	12.08	73.40	206.35	415.86	696.04	1035.30
Catchability	0.8	1	1	1	0.75	0.5

7.5.4.1.3. Results

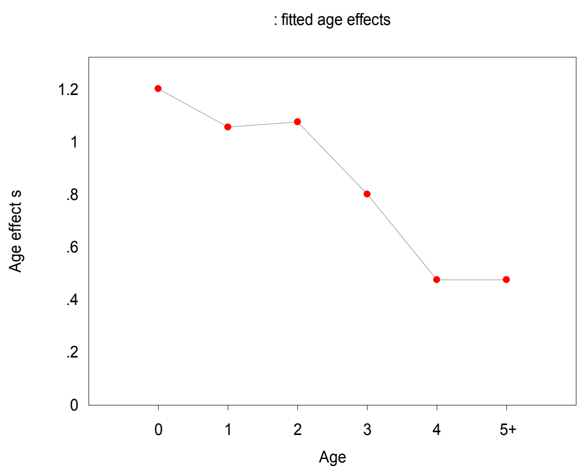
SURBA outputs show that in 2005-2008 mean F for the age groups 1-3 years decreased from 1.28 to 0.98. Relative SSB has remained at an approximately stable level since 2006.



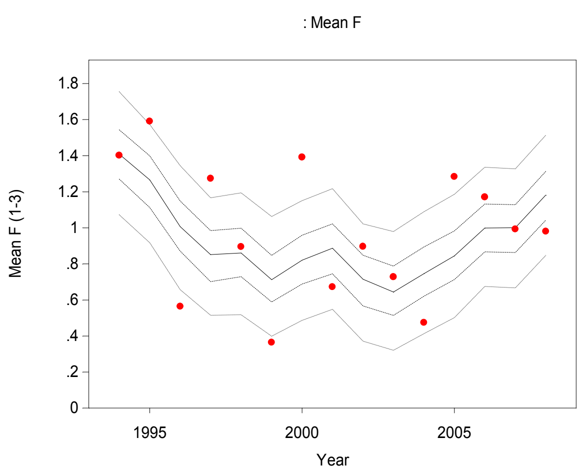
A)


: fitted temporal trend
Temporal trend f
1.6
1.4
1.2
1
.8
.6
.4
.2
0
1995
2000
2005
Year

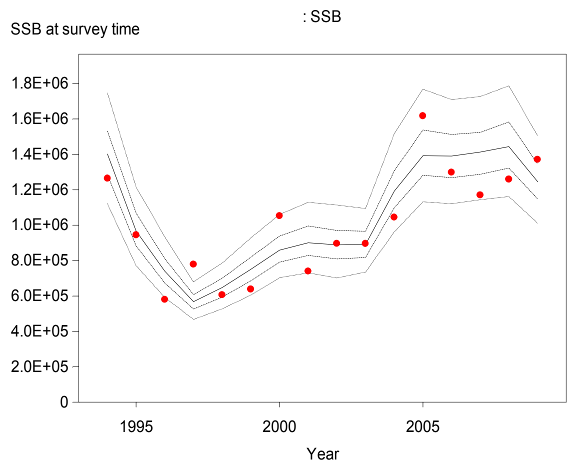
B)


: fitted age effects
Age effect s
1.2
1
.8
.6
.4
.2
0
0
1
2
3
4
5+
Age

C)


: Mean F
Mean F (1-3)
1.8
1.6
1.4
1.2
1
.8
.6
.4
.2
0
1995
2000
2005
Year

D)



E)

Fig. 7.5.4.1.3.1. Results of SURBA analysis based on 1994-2009 MEDITS hake survey data from GSA 16. A) Smoothed empirical mean Z, ages 1-3; B) Fitted temporal trend in F; C) Fitted age effect in F; D) Mean F; E) SSB at survey time. 50th percentile of bootstrapped runs (solid line) and 5% and 95% percentiles of bootsrapped runs (dashed lines) are shown for D) and E).

The recruitment indices obtained during MEDITS surveys (Fig 7.5.4.1.3.2) ranged between 85 and 577 Recruits per km^2. After a period of low recruit abundance from 1995 to 2002, a phase of increasing recruitment is occurring.

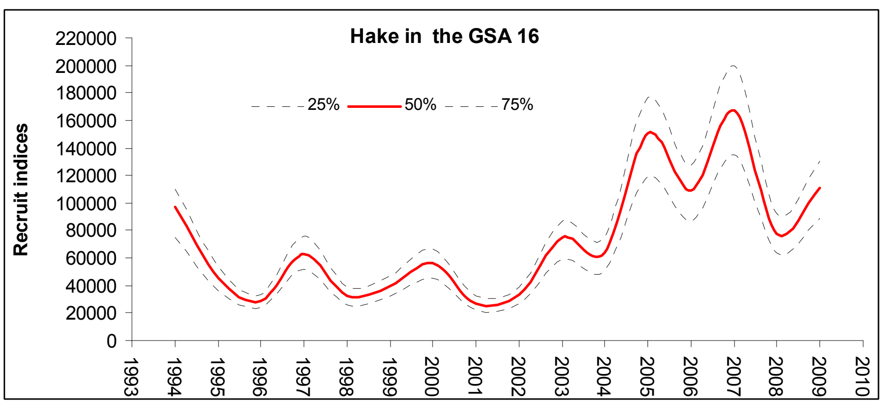
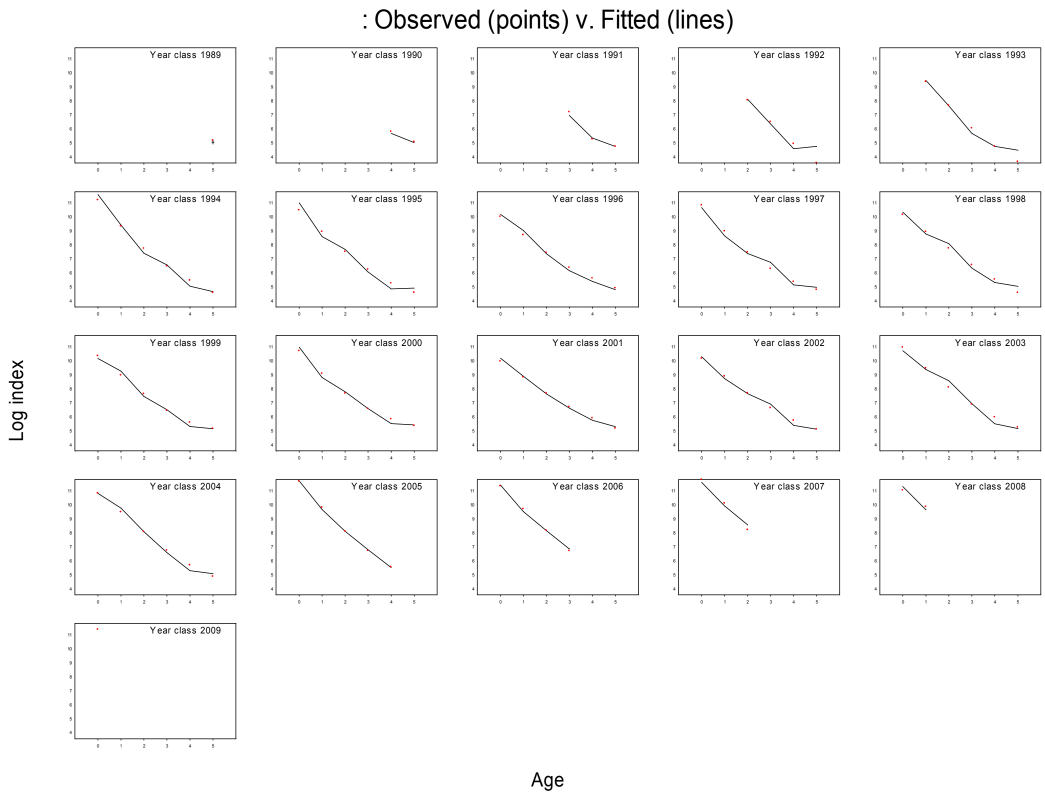
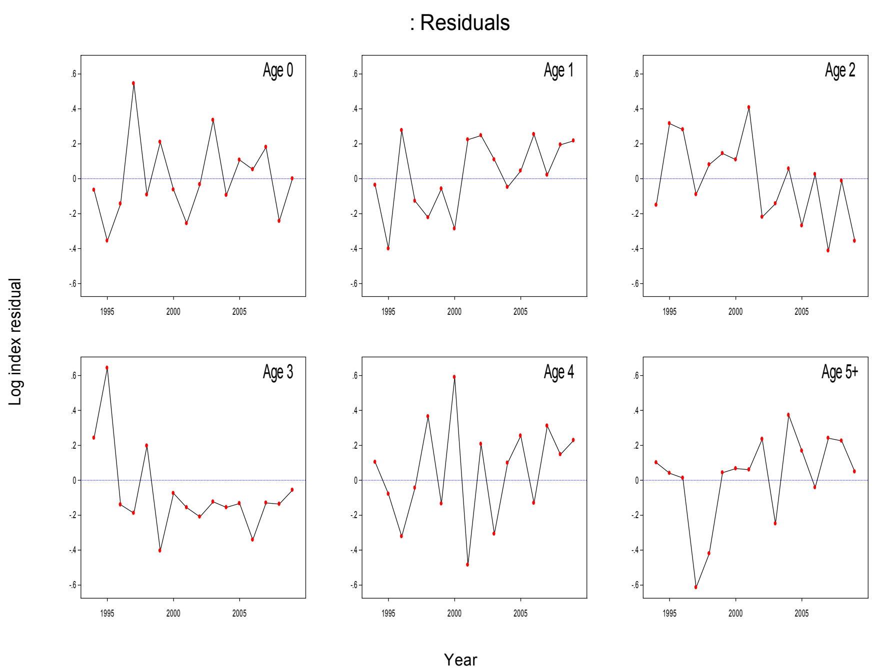


Fig. Fig 7.5.4.1.3.2 Recruitment indices (MEDITS surveys) in GSA 16 from Surba; 25th, 50th and 75th percentiles of bootstrapped runs are reported.

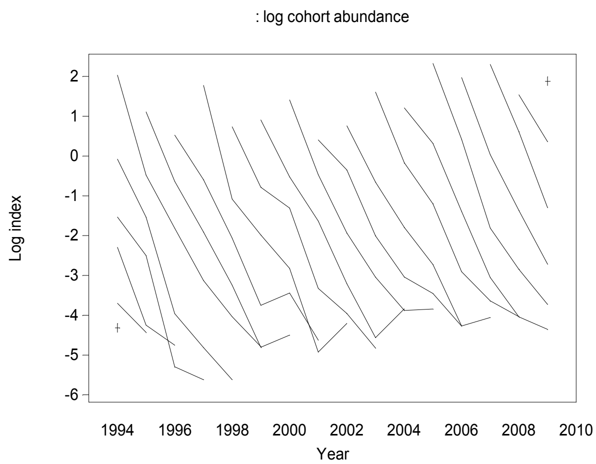
Model diagnostics are shown below.


: Observed (points) v. Fitted (lines)
Year class 1989
Year class 1990
Year class 1991
Year class 1992
Year class 1993
Year class 1994
Year class 1995
Year class 1996
Year class 1997
Year class 1998
Year class 1999
Year class 2000
Year class 2001
Year class 2002
Year class 2003
Year class 2004
Year class 2005
Year class 2006
Year class 2007
Year class 2008
Year class 2009
Log index
Age

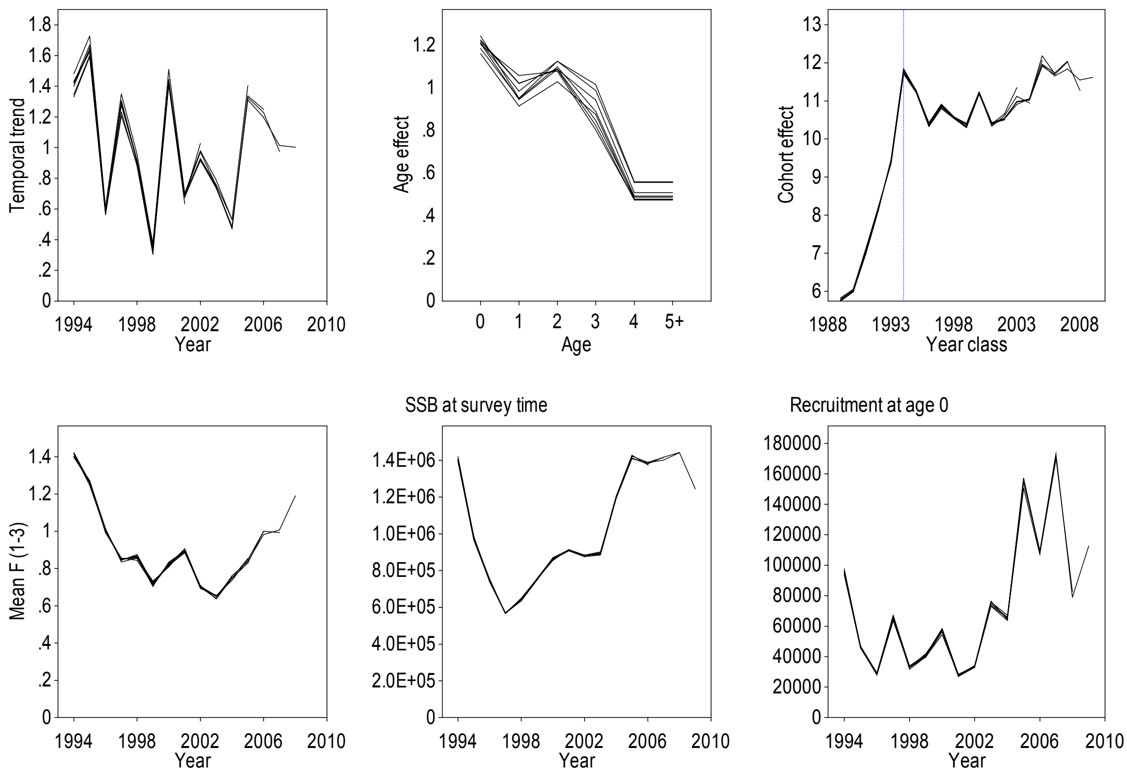
A)


: Residuals
Age 0
Age 1
Age 2
Age 3
Age 4
Age 5+
Log index residual
Year

B)



C)



D)

Fig. Fig 7.5.4.1.3.3 Model diagnostic for SURBA analysis based on 1994-2009 MEDITS hake survey data from GSA 16. A) Comparison between observed (points) and fitted (lines) of MEDITS survey abundance indices, for each year; B) Log index residuals over time, plotted by age class; C) Log survey abundance indices by cohort, where each line represents the log index abundance of a particular cohort throughout its life; D) Retrospective SURBA model outputs.

7.5.4.2. Method 2: VIT

7.5.4.2.1. Justification

Four complete years (2006, 2007, 2008 and 2009) of length frequency distributions from GSA 16 commercial landings data (fished in GSA 15 as well as GSA 16) were available, so an approach under steady state (pseudocohort) assumptions was used. Cohort (VPA equation) and Y/R analysis as implemented in the package VIT4win were thus used (Lleonart and Salat, 2000). Data were derived from the DCF data call for GSA 15 and 16.

7.5.4.2.2. Input parameters

LFD from commercial landings were converted into numbers at age using combined sex stock parameters calculated as described for MEDITS input parameters above. The combined stock parameters thus calculated were: L_{inf} = 100cm; k = 0.116; t_0 = -0.643; a = 0.0043; b = 3.1525. The maturity and natural mortality vector by size are reported in table 7.5.4.2.2.1. Terminal F was fixed as 0.20. Discard data was not included in the analysis.

Table 7.5.4.2.2.1. Maturity and natural mortality vector by size (combined sex)

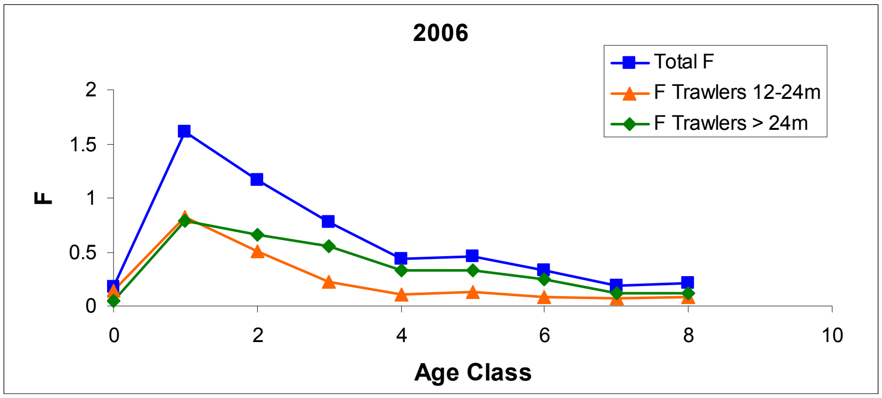
TL (cm)	% of mature	M	TL (cm)	% of mature	M
12	0.02	1.93	44	0.86	0.22
14	0.02	1.37	46	0.92	0.22
16	0.04	0.96	48	0.96	0.20
18	0.06	0.74	50	0.97	0.20
20	0.09	0.61	52	0.98	0.19
22	0.13	0.52	54	0.99	0.19
24	0.16	0.45	56	1.00	0.18
26	0.23	0.40	58	1.00	0.18
28	0.31	0.36	60	1.00	0.17
30	0.35	0.33	62	1.00	0.15
32	0.44	0.30	64	1.00	0.15
34	0.46	0.28	66	1.00	0.14
36	0.48	0.26	68	1.00	0.14
38	0.63	0.25	70	1.00	0.13
40	0.68	0.24	72	1.00	0.13
42	0.80	0.23	74	1.00	0.12

Tab. 7.5.4.2.2.2 LFD of commercial hake landings data from GSA 16 by fleet segment, used as input data for age splicing and subsequently VIT analysis.

	Trawlers 12- 24m				Trawlers > 24m			
Length (cm)	**2006**	**2007**	**2008**	**2009**	**2006**	**2007**	**2008**	**2009**
12	288894	606773	235866	411751	818	0	1051	1749
14	2938474	2850866	1960737	2713077	104585	21131	77341	16652
16	3929216	3254704	2663705	3980222	1006712	517323	514682	170769
18	3301003	3462604	2930002	3705013	1396832	1178380	917213	838339
20	2307962	2250072	2170930	2639173	1071935	1433477	885288	982224
22	1672636	1482702	1486808	1743209	795064	1009861	710617	623812
24	969605	798260	899731	1178148	538323	622539	470202	490643
26	519955	450890	507442	639145	262833	293750	279173	305613
28	341680	231243	281328	365605	163372	177918	181226	124535
30	191177	152939	150609	244949	137456	131570	132351	66322
32	99707	129260	113993	144871	98089	104978	95220	66859
34	73973	71932	75438	106435	61857	50854	61606	55503
36	57725	47007	61857	69920	44070	37176	63671	41704
38	18836	25915	31445	49106	41075	25656	37993	35392
40	8768	26689	26888	29368	26465	34543	24181	42885
42	15842	6622	20369	28376	19974	17675	10254	71181
44	5168	6081	11656	18337	10955	12436	6969	7590
46	6466	5072	12333	11610	5183	15896	6303	7819
48	8653	8915	7569	7488	7028	10052	5600	6499
50	6500	5735	540	7412	3982	15602	3500	29547
52	4000	6595	1882	5853	13287	9698	3000	44552
54	2450	6901	1258	3706	879	2393	1094	26781
56	3161	2523	634	2780	5840	2500	2442	9401
58	2259	1080	1191	1853	2800	2000	2442	5148
60	2000	5230	1498	1996	900	1800	876	1589
62	1000	3069	1584	1763	835	1600	1624	0
64	3161	2000	1669	765	1860	1000	0	0
66	0	1540	864	1730	0	0	0	794
68	0	1080	0	765	0	0	0	0

7.5.4.2.3. Results

Fishing mortality rates (F) for combined sexes by age class, fleet segment and year are shown in Fig. 7.5.4.2.3.1 below.



A)

B)

C)

D)

Fig. 7.5.4.2.3.1. Fishing mortalities rates (F) by age and fleet segment for combined sexes of hake in GSA 16. A) 2006; B) 2007; C) 2008; D) 2009.

The reconstructed yields obtained by the VIT package for 2006, 2007 and 2008 (1597.53, 1599.29, 1367.86 t) were virtually equal to the observed yields (1598, 1599 and 1367 t). The other main results of the VIT analysis, including the current mortality rates, are listed in table 7.5.4.2.3.1.

Table 7.5.4.2.3.1. The main results of VIT analysis.

Variables	2006	2007	2008	2009
Observed Yield (tons)	1598	1599	1367	1546
Reconstructed Yield (tons)	1597.53	1599.29	1367.86	1547.62
Mean F	0.60	0.58	0.65	0.62
Mean Z (ages 1-3)	1.42	1.38	1.50	1.34
Mean F (ages 1-3)	1.19	1.15	1.26	1.12
Catch mean length (cm)	19.54	19.54	20.22	19.24
Stock mean length (cm)	14.85	14.89	14.90	14.91

7.5.5. *Long term prediction*

7.5.5.1. Method 1: Y, B and SSB per recruit according to the VIT package

7.5.5.1.1. Justification

The VIT approach to Biomass and Yield per recruit analysis has been applied in order to analyse the stock production with increasing exploitation under equilibrium conditions.

7.5.5.1.2. Input parameters

The input parameters have been already reported in section 7.5.4.3.2.

7.5.5.1.3. Results

The results of estimating spawning stock biomass as well as biomass and yield per recruit, by varying current fishing mortality (Fc) through a multiplicative factor for 2006, 2007, 2008 and 2009 catches, are reported in Fig. 7.5.5.1.3.1 A) - D).

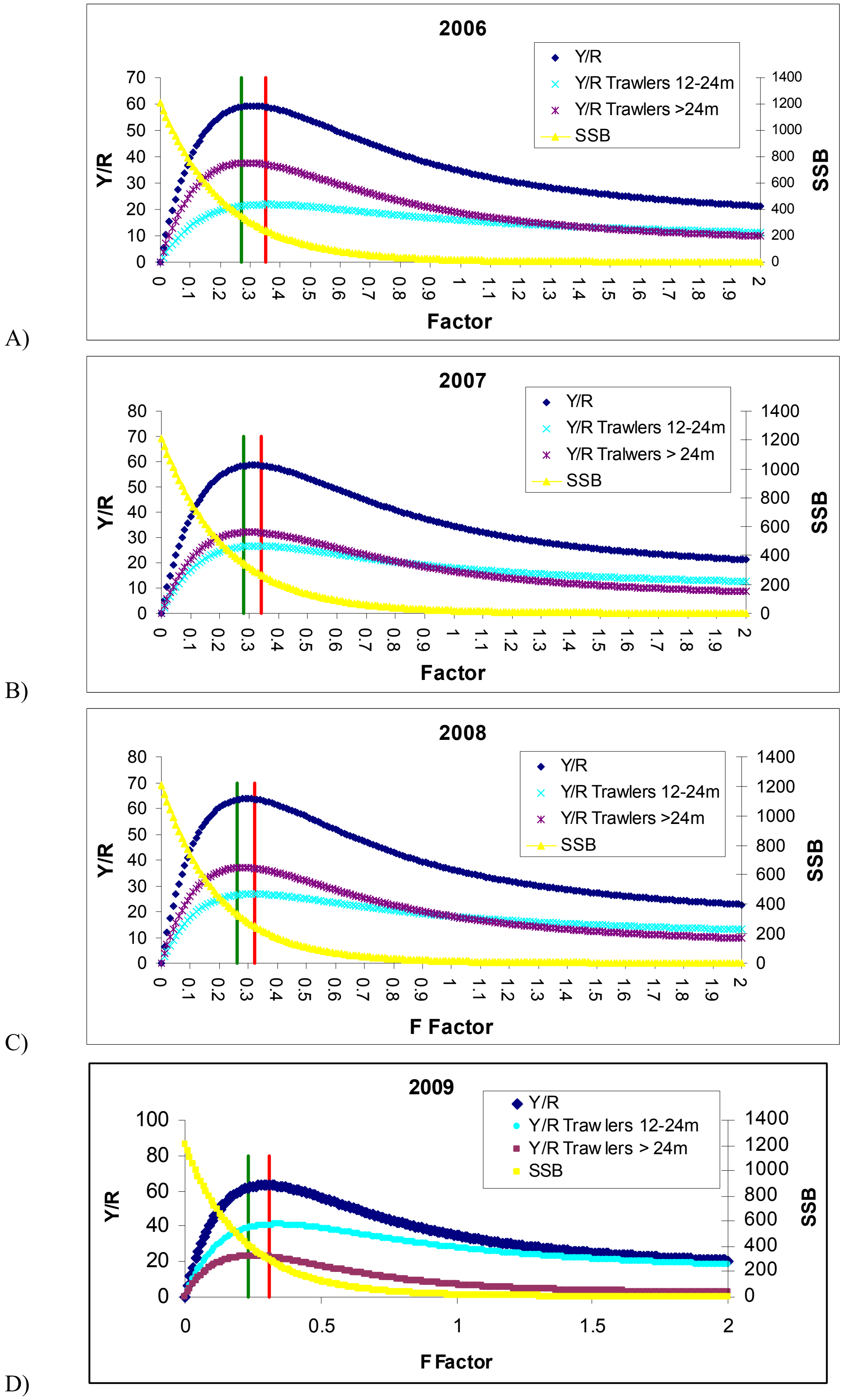


Fig. 7.5.5.1.3.1 Spawning Stock Biomass and Yield per recruit under varying current fishing mortality (Fc) according to the VIT package. Green lines indicate $F_{0.1}$, red lines F_{max}. A) 2006; B) 2007; C) 2008, D) 2009.

Assuming no variation in the exploitation pattern, the main results of Y/R analysis are reported in Tab. 7.5.5.1.3.1.

Tab. 7.5.5.1.3.1 Estimation of yield (Y in g), biomass (B in g) and spawning stock biomass (SSB in g) per recruit (R) varying current fishing mortality by a multiplicative factor.

	Variable	Factor	Y/R	B/R	SSB
2006	F(Virgin)	0.00	0.00	1365.68	1209.06
	F(0.1)	0.27	58.53	440.26	358.47
	F(max)	0.35	59.02	331.43	261.33
	F(Current)	1.01	34.55	40.46	16.56
	F(Double)	2.00	21.22	13.25	1.49
2007	F(Virgin)	0.00	0.00	1365.68	1209.06
	F(0.1)	0.28	57.76	447.16	365.71
	F(max)	0.34	58.58	356.96	284.99
	F(Current)	1.01	34.50	42.25	18.40
	F(Double)	2.00	21.18	13.21	1.52
2008	F(Virgin)	0.00	0.00	1365.68	1209.06
	F(0.1)	0.26	62.70	440.63	355.58
	F(max)	0.32	63.65	345.84	270.61
	F(Current)	1.01	36.36	39.34	13.98
	F(Double)	2.00	22.73	14.55	1.65
2009	F(Virgin)	0.00	0.00	1365.68	1209.06
	F(0.1)	0.23	61.678	506.046	416.383
	F(max)	0.31	63.291	380.084	303.335
	F(Current)	1.01	34.763	41.204	17.205
	F(Double)	2	20.585	12.842	1.503

According to the VIT steady state VPA, a state of overfishing for all three years was clearly detected. Maintaining the current (2009) fishing pattern, an average reduction of current effort of 77% and 69% is advisable to reach $F_{0.1}$ and F_{max} respectively.

7.5.5.2. Method 2: Non equilibrium Surplus Production model

7.5.5.2.1. Justification

When commercial information is limited, but a long time-series of Z and U from trawl surveys are available, a variant of a non-equilibrium surplus production model can be fitted (Abella, 2007).

The classical model requiring time series of index of abundance and effort is:

$$B_{t+1} = B_t + rB_t(1-(B_t / k)) - qfB_t$$

Since $qfBt = Y$, catch in weight (Yt) can be substituted by the classic Baranov catch equation:

$$Y=(F/Z)\ B(1-exp(-Z_t)$$

and the model can now be written as:

$$B_{t+1} = B_t + rB_t(1-(B_t / k)) - (F/Z)\ B_t(1-exp(-Z_t)\ )$$

Z can be estimated by analysing the size structure of the surveys catches, and F computed by subtraction if an estimate of M is available.

7.5.5.2.2. *Input parameters*

Data input is time series of biomass indices and total mortality rates derived from MEDITS trawl surveys in GSA 16 (1994-2009). A scalar value of M=0.34 was used to estimate Z_{MBP} from F_{MBP}.

Tab. 7.5.5.2.2.1 Non equilibrium surplus production model data inputs. BI are overall means in kg/km^2 and total mortality rates are SURBA estimates.

Year	Z	BI	Year	Z	BI
1994	1.74	32.63	**2002**	1.03	20.59
1995	1.59	26.36	**2003**	0.98	21.06
1996	1.34	15.61	**2004**	1.08	28.83
1997	1.18	21.89	**2005**	1.17	49.13
1998	1.19	15.82	**2006**	1.32	37.05
1999	1.05	17.77	**2007**	1.33	35.19
2000	1.15	24.46	**2008**	1.51	38.43
2001	1.22	18.01	**2009**	n/a	35.04

7.5.5.2.3. Results

Main model parameters are reported in Table 7.5.5.2.3.1.

Tab. 7.5.5.2.3.1 Main parameters of the surplus production model of hake in GSA 16.

Population growth rate (r)	0.82
K	68.3
F_{MBP} (r/2)	0.41
Z_{MBP} (F_{MBP}+M)	0.75

Observed and predicted values of biomass indices (kg per km^2) were in agreement (Fig. 7.5.5.2.3.1), and the distribution of residuals was satisfying. The surplus production model in terms of Biological production is shown in Fig. 7.5.5.2.3.3.

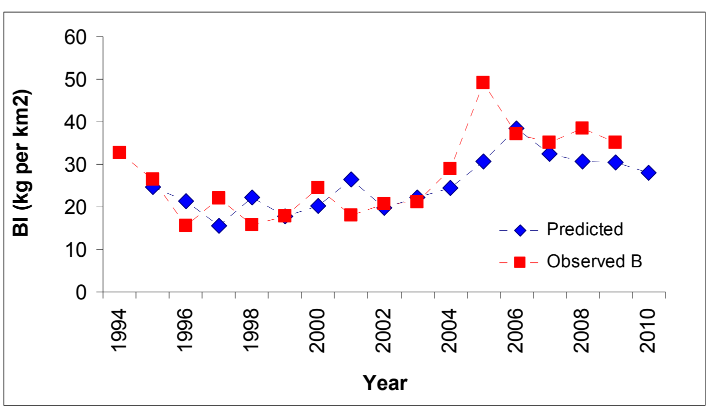


Fig. 7.5.5.2.3.1. Observed and predicted values of biomass indices (kg / km^2) according to the Surplus production model based on hake trawl survey data from GSA 16.

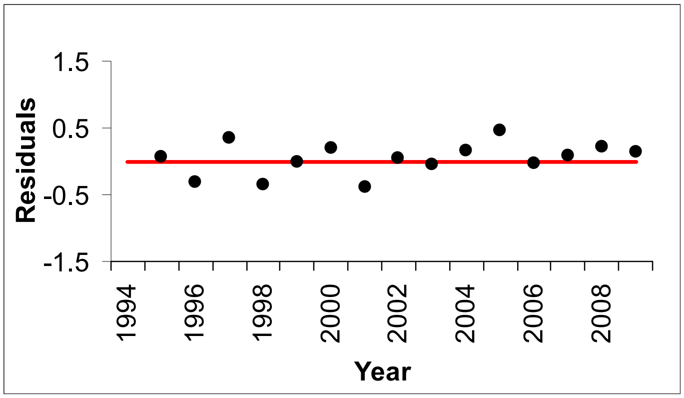


Fig. 7.5.5.2.3.2 Residuals of fitted non-equilibrium surplus production model.

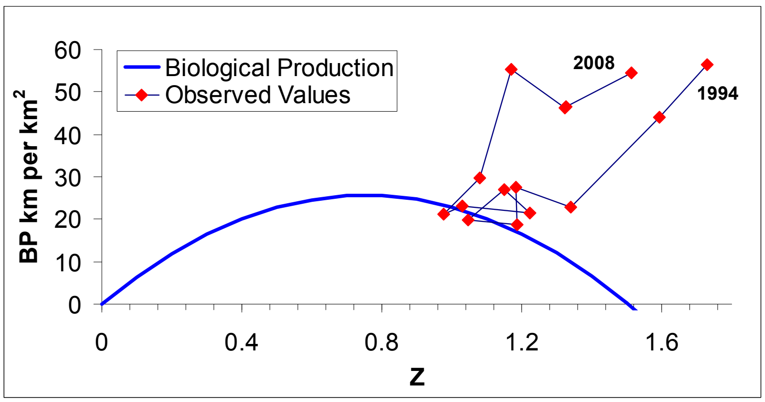


Fig. 7.5.5.2.3.3. Biological production (BP) vs. total mortality rates (Z) for hake in GSA 16 under the non-equilibrium state assumption.

The ratio of the mean Z of 2007 and 2008 obtained by SURBA (Z= 1.421) and the optimal one (Z_{MBP}= 0.752) suggested an overfishing state ($Z_{curr.}/Z_{opt.}$=1.89). If an estimation of current F is obtained as Z-M, with M=0.34, the ratio between current F (1.081) and the optimal one (F_{MBP}=0.412) suggested a reduction of fishing mortality of 62% to improve the status of the stock.

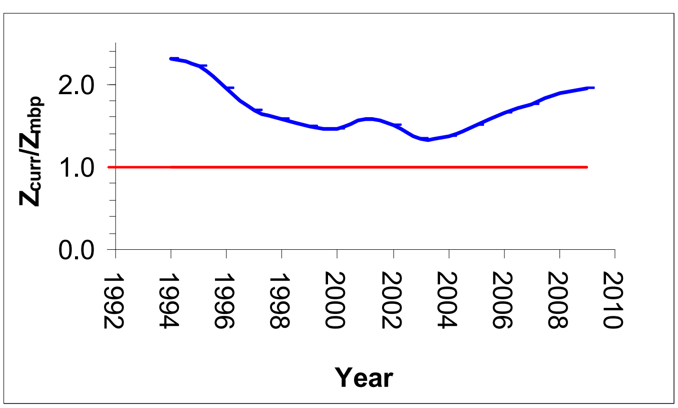


Fig. 7.5.5.2.3.4 Ratio of current total mortality rates (Z_{curr}) over total mortality rates which would sustain maximum biological production (Z_{mbp}).

7.5.6. *Data Quality and Availability*

In terms of data quality and availability, SGMED 03-09 noted that both data from GSA 15 and 2009 commercial data from GSA 16 were now available for assessment. However the lack of this data at SGMED 02/2010 greatly increased the work of the scientists since assessments performed at SGMED 02/2010 had to be run again by SGMED 03/2010.

7.5.7. *Scientific advice*

7.5.7.1. Short term considerations

7.5.7.1.1. *State of the spawning stock size*

Spawning stock biomass (SSB) calculated using the SURBA approach increased from 1998 to 2005, and has remained stable since. No biomass reference point is proposed due to data constraints. Thus, SGMED is unable to evaluate the state of the stock size against such reference.

7.5.7.1.2. *State of recruitment*

MEDITS results indicate that levels of recruitment in the past decade peaked in 2005-2007, followed by a decline in 2008 and 2009.

7.5.7.1.3. *State of exploitation*

SGMED proposes $F_{0.1}$=0.15 as target reference point consistent with high long term yields. This value is interpreted as proxy of F_{msy}. Results of analyses performed on fisheries dependent as well as fisheries independent data using different modelling approaches gave consistent results. All approaches indicated that fishing mortality is far in excess of sustainable levels, and that *Merluccius merluccius* in GSA 15/16 is clearly subject to overfishing. The continued low abundance of adult fish in the surveyed population as well as commercial catches similarly indicate very high exploitation patterns far in excess of fishing mortalities consistent with sustainable high yields and a precautionary approach to fisheries management.

Tab. 7.5.7.1.3.1. Summary table of assessment outcomes for combined sex analysis of hake in GSA 15 and 16.

Method	**Year**	**2006**	**2007**	**2008**	**2009**
VIT	Factor for $F_{0.1}$	0.27	0.28	0.26	0.23
VIT	Factor For F_{max}	0.35	0.34	0.32	0.31
VIT	Mean F	0.6	0.58	0.65	0.62
VIT	Mean F 1-3	1.19	1.15	1.26	1.12
SURBA	Mean F 1-3	1.01	1	1.16	n/a
Surplus Production Model	Z MBP / FMBP	0.752 / 0.412			
VIT	Mean Z 1-3	1.42	1.38	1.5	1.34
SURBA	Mean Z	1.32	1.33	1.51	n/a

7.6. Stock assessment of hake in GSA 17

7.6.1. *Data quality*

The SGMED 10-03 analysed the submitted hake data from GSA17. The inconsistency in the data observed during the previous SGMED 10-02 was evidenced also during the present meeting, thus the group decided to reject the previous assessment, for the following reasons:

- the Von Bertalanffy growth parameters (slow growth) used for the VIT analyses were not in agreement with the growth characteristic observed for the same species in other GSAs and the population structure present in the catch data. Moreover the parameters used determined an underestimation of the stock and catch weight at age.
- the lack of discard data, well reported in scientific papers (see SGMED 10-02) for the GSA 17, lead to an underestimation of the catches of age 0 and 1.
- the lack of specimens bigger than 40 cm of total length in the catches is totally inconsistent with the length structures observed in the Medits survey data, as shown in Fig. 7.6.1.1.
- the lack of data from the Croatian fishery could bias the analyses.

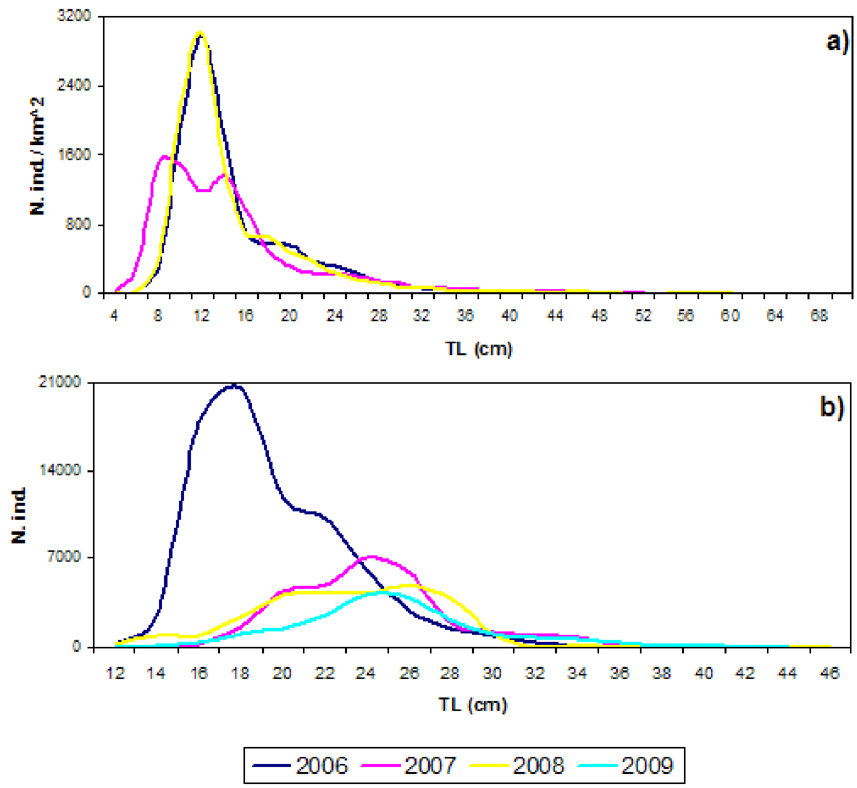


Fig. 7.6.1.1 – Length frequency distributions of hake in GSA 17 from Medits survey (a) and DCF (b).

7.7. Stock assessment of hake in GSA 18

7.7.1. *Stock identification and biological features*

7.7.1.1. Stock Identification

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). However the species 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).

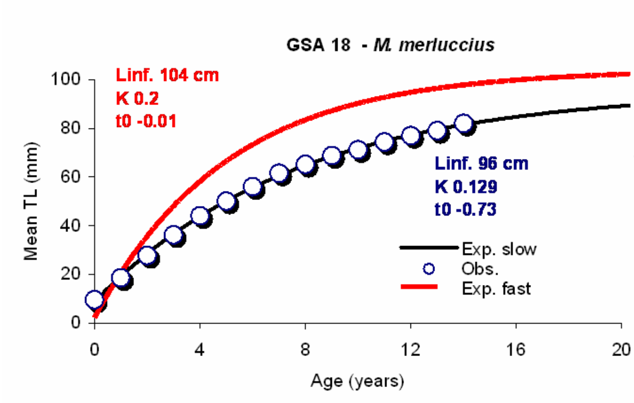
M. merluccius spawns throughout the year, but with different intensities. The spawning peaks are in the summer and winter periods (Zupanovic, 1968; Ungaro *et al*., 1993; Donnaloia, 2009). Recent estimates of the batch fecundity (Donnaloia, 2009) reported higher values in comparison to the fecundity 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).

The geographical distribution pattern of European hake has been studied in the area using trawl-survey data and the geostatistical methods. In the GSA18 nursery areas have been localised off Gargano promontory along the west side (100-200 m depth) and in the southern part of Albanian coasts (Frattini and Paolini, 1995; Lembo *et al*., 2000; Carlucci *et al*., 2009).

Kirinčić and Lepetić (1955) and De Zio *et al.* (1998) investigated the catch size structure from the bottom long-line fishery in the Southern Adriatic. The average total length of the European hake was 58.6 cm (Kirinčić and Lepetić, 1955), while De Zio *et al.* (1998) found a median total length of 70 cm. The average catch rate was 5.6 specimens per 100 hooks.

7.7.1.2. Growth

Estimates of growth parameters were achieved during the SAMED project (SAMED, 2002) by the analysis of length frequency distributions. The following von Bertalanffy parameters were estimated by sex: females L_∞=83.4 cm; K=0.15; t_0= -0.11; males: L_∞=58.2cm; K=0.23; t_0= -0.06.
The observed maximum lengths of European hake were 93.5 cm for females and 66.5 cm for males both registered during Medits samplings. In the commercial sampling also a female of 93.5 cm length was observed in 2009. In the DCF framework the growth has been studied ageing fish by otolith readings using the whole sagitta and thin sections for older individuals. Length frequency distributions were also analyzed using techniques as Batthacharya for separation of modal components. The estimates of von Bertalanffy growth parameters were obtained for sex combined from average length at age using an iterative non-liner procedure that minimizes the sum of the square differences between observed and expected values.
Two scenarios of growth rate were tested for sex combined in the following assessment sections: the slow pattern using the parameters L_∞=96 cm, K=0.129, t0= -0.73 and the fast growth: L_∞=104 cm, K=0.2, t0= -0.01 setting, to account for uncertainty in life history profile of European hake (Fig. 7.7.1.2.1). Parameters of the length-weight relationship were a=0.0043, b=3.155 for length expressed in cm and weight in grams.

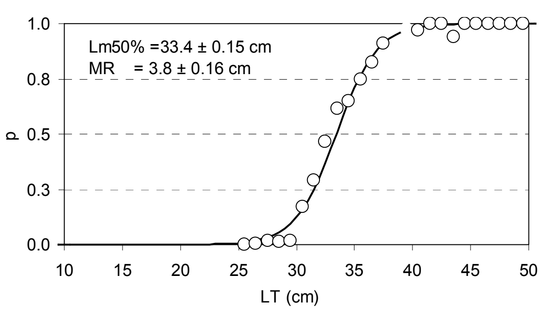


age	slow	fast
1	19.2	20.5
2	28.5	35.7
3	36.6	48.1
4	43.8	58.2
5	50.1	66.5

Fig7.7.1.2.1 V. Bertalanffy growth functions for female of hake in the GSA 18. Slow and fast growth scenarios are represented.

7.7.1.3. Maturity

Mature females were found all year round with peaks in early winter and late spring. A proxy of size at first maturity as estimated in the SAMED project (SAMED, 2002) using the average length at stage 2 (females with gonads at developing stage) indicated an average length of about 29 cm. According to the data obtained in 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. 7.7.1.3.1).



Proportion of mature females			
TL (cm)	p	TL (cm)	P
20	0.000	29	0.018
21	0.005	30	0.170
22	0.002	31	0.290
23	0.008	32	0.467
24	0.010	33	0.614
25	0.000	34	0.649
26	0.006	35	0.750
27	0.018	36	0.825
28	0.015	37	0.911

Fig. 7.7.1.3.1 Maturity ogive and proportions of mature female of hake in the GSA 18 (MR indicates the difference $Lm_{75\%}$-$Lm_{25\%}$).

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 is in accordance with data reported for other areas along the Italian seas and western Mediterranean.

The sex ratio is about 1:1 up to the size of 27 cm, after females are prevailing (Fig. 7.7.1.3.2).

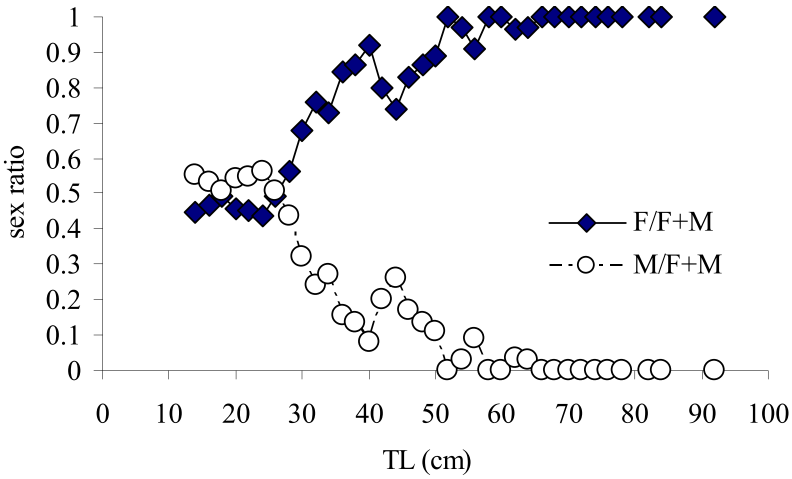


Fig. 7.7.1.3.2 Sex ratio for females and males by length.

7.7.2. *Fisheries*

7.7.2.1. General description of fisheries

STECF (Consolidated Advice on Stocks of Interest to the European Community, 2009) noted that *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. Demersal species catches are landed on the western side (Italian coast) and the eastern side (Albanian coast), with an approximate percentage of 97% and 3%, respectively. Trawling is the most important fishery activity on the whole area (about 900 boats, 60% of total number of fishing vessels; 85% of gross tonnage). The Mediterranean 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). 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*.

7.7.2.2. Management regulations applicable in 2009 and 2010

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. 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 30, 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.

7.7.2.3. Catches

7.7.2.3.1. Landings

SGMED-10-03 received the following information about hake landings in GSA 18 through the official DCF data call (Tab. 7.7.2.3.1.1). Landings by demersal trawlers dominate by far. Long-line landings account for about 10-12% of the total production.

Tab. 7.7.2.3.1.1 Hake landings in GSA 18 by fishing technique, 2004-2009.

Sum of LW					YEAR					
COUNTRY	AREA	SPECIES	FT_LVL4	FT_LVL5	2004	2005	2006	2007	2008	2009
ITA	18	HKE				1	1	0		
			GNS	Demersal species	19	38	30	19	15	8
				Small and large pelagic fish					0	0
			GTR	Demersal species	21	18	26	18	42	20
			LLD	Large pelagic fish			0		0	
			LLS	Demersal fish	233	452	836	620	551	534
			OTB	Deep water species					3	8
				Demersal species	195	55	1113	923	3330	3086
				Mixed demersal and deep water species	2737	3221	3500	2575	311	451
			PTM	Small pelagic fish	0					
		HKE Total			3204	3785	5507	4155	4251	4106

7.7.2.3.2. Discards

Discards information documented during SGMED-10-03 were 116 tons from the metier OTB demersal species and 8.8 tons from the metier OTB Mixed demersal and deep water species.

7.7.2.3.3. Fishing effort

SGMED-10-03 received the following information about fishing effort in the GSA 18 through the official DCF data call (Tab. 7.7.2.3.3.1). Effort by trawlers is about 70% of the total effort.

Tab. 7.7.2.3.3.1 Fishing effort in d KW*DAYS by fishing technique deployed in GSA 18, 2004-2009 as reported to SGMED-10-03 through the DCR data call.

Sum of KWDAYS				YEAR					
COUNTRY	AREA	FT_LVL	FT_LVL5	2004	2005	2006	2007	2008	2009
ITA	18				4212	41841	2069	15987	
		DRB	Molluscs	373845	574482	765092	841605	502535	741326
		GNS	Demersal species	1449382	2019788	1783617	1266356	873598	904502
			Small and large pelagic fish					16441	17782
		GTR	Demersal species	381498	509124	67875	321930	978111	539955
		LHP-LHM	Cephalopods	576				5833	
		LLD	Large pelagic fish		94423	44025	22636	11184	23155
		LLS	Demersal fish	483101	808140	771723	577673	830102	821755
		OTB	Deep water species					127982	112771
			Demersal species	760510	494395	4126011	2874734	10577639	12395745
			Mixed demersal and deep water species	12622303	13271688	11089761	10252061	902621	1388461
		PS	Small pelagic fish	336730	441752	565883	715979	339925	325545
		PTM	Small pelagic fish	1197362	1218263	1468173	1968559	1956060	1847443
	18 Total			17605307	19436267	20724001	18843602	17138018	19118440

7.7.3. *Scientific surveys*

7.7.3.1. Medits

7.7.3.1.1. Methods

Based on the DCR data call, abundance and biomass indices were recalculated. In GSA 18 the following number of hauls was reported per depth stratum (s. Tab. 7.7.3.1.1.1).

Tab. 7.7.3.1.1.1. Number of hauls per year and depth stratum in GSA 18, 1994-2009.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GSA18_010-050	14	14	18	17	17	17	17	18	12	12	11	10	11	10	13	12
GSA18_050-100	14	15	24	25	25	26	25	24	20	19	21	20	21	22	21	20
GSA18_100-200	24	23	33	33	33	32	33	33	31	32	31	33	31	31	33	30
GSA18_200-500	10	10	18	18	18	19	18	18	13	13	13	13	13	13	12	14
GSA18_500-800	10	10	19	19	19	18	19	19	14	14	14	14	14	14	11	14

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

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

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

Where:

A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum

Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA. Given the sheer number of plots generated, these distributions are not presented in this report.

7.7.3.1.2. Geographical distribution patterns

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 (Fig. 7.7.3.1.2.1).

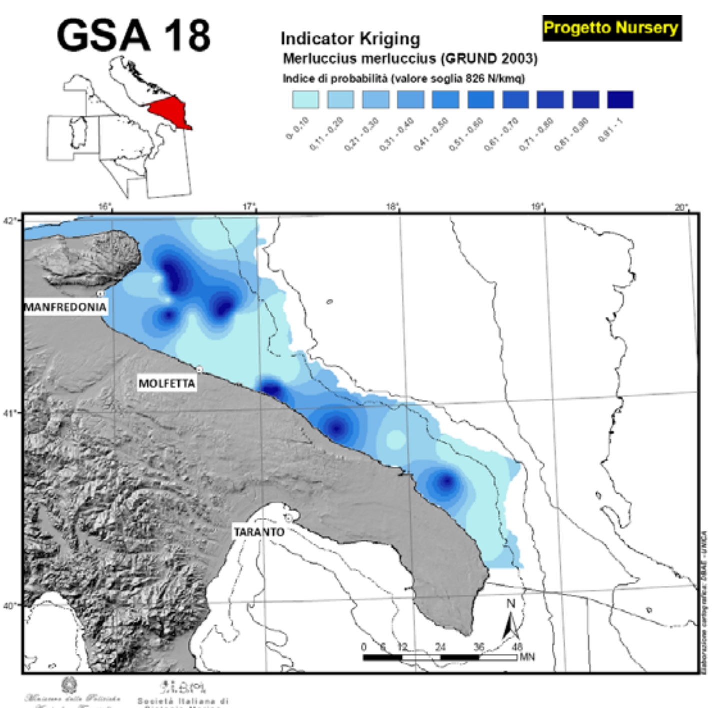


Fig. 7.7.3.1.2.1 Nursery areas of hake in the GSA 18.

7.7.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the hake in GSA 18 was derived from the international survey Medits. Figure 7.7.3.1.3.1 displays the estimated trend in hake abundance and biomass in GSA 18.

The estimated abundance indices do not reveal any significant trends since 1995 until 2003, increased to the highest values in 2005 and dropped sharply to an average level of the time series thereafter. A similar pattern shows the biomass index that is however increasing since 2007 to 2009.

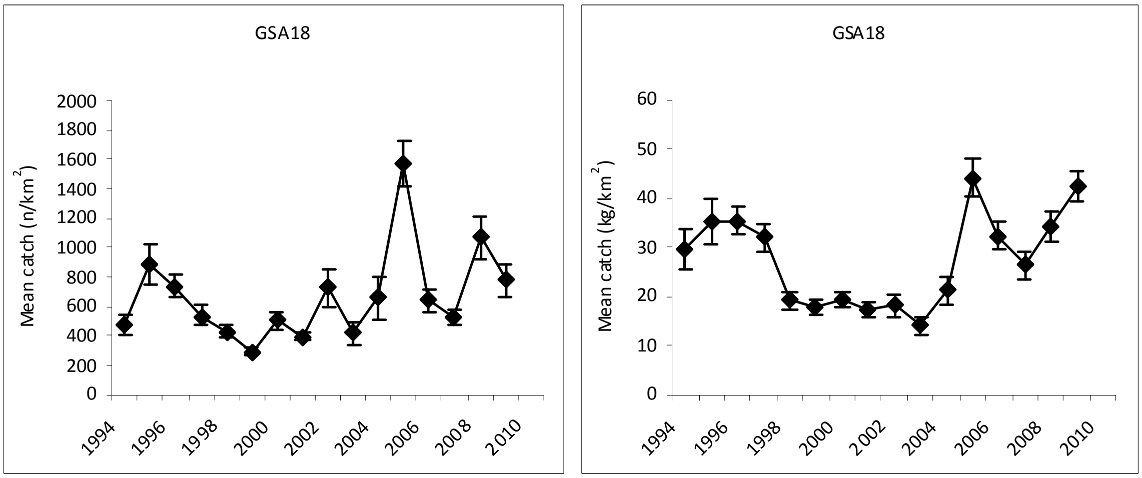


Fig. 7.7.3.1.3.1 Abundance and biomass indices of hake in GSA 18.

7.7.3.1.4. Trends in abundance by length or age

The following Fig. 7.7.3.1.4.1 and 2 display the stratified abundance indices of GSA 18 in 1996-2003 and 2004-2009.

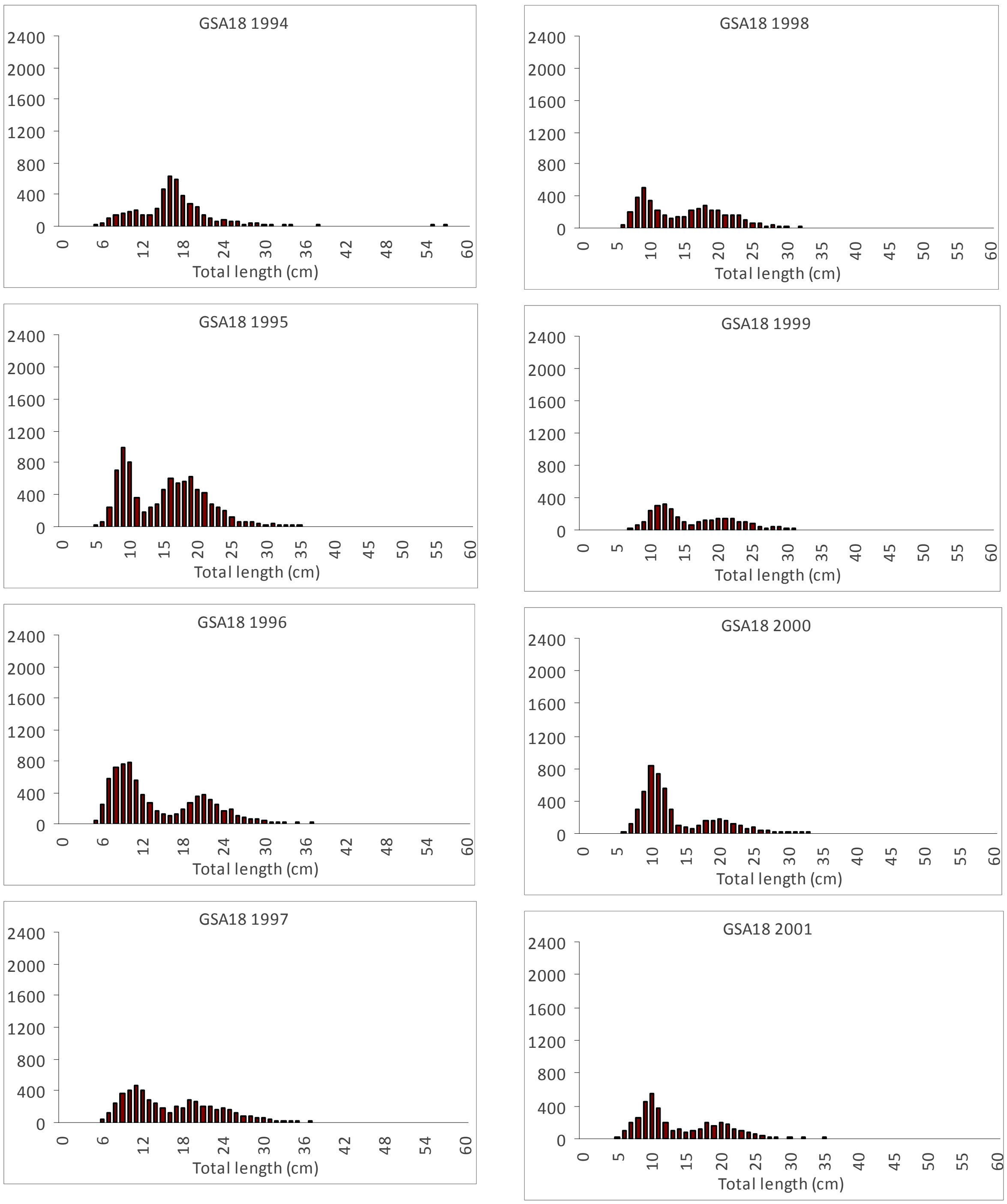


Fig. 7.7.3.1.4.1 Stratified abundance indices by size, 1994-2001.

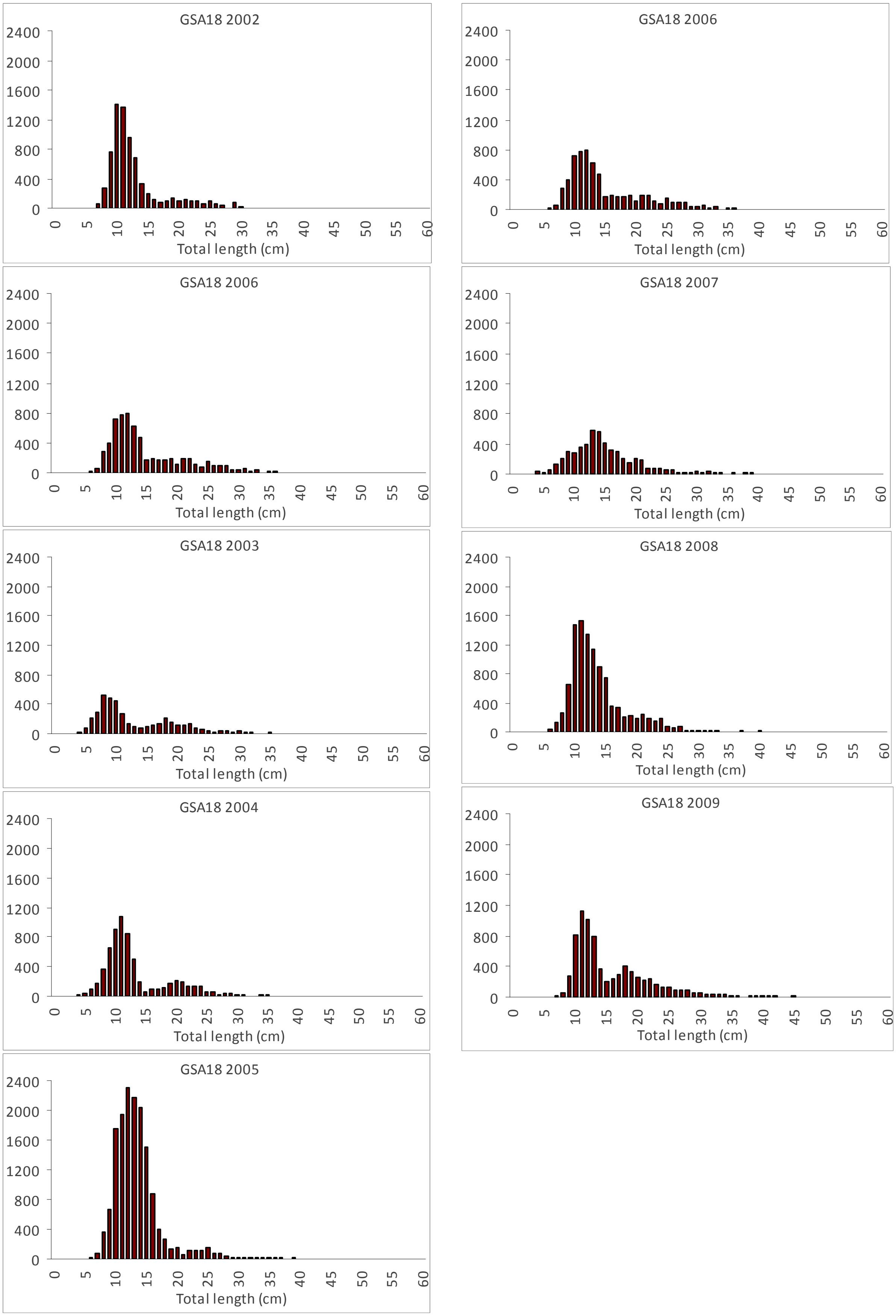


Fig. 7.7.3.1.4.2 Stratified abundance indices by size, 2004-2009.

No trend in the mean length was observed in MEDITS survey (Fig. 7.7.3.1.4.3), nor at the third quantile lengths.

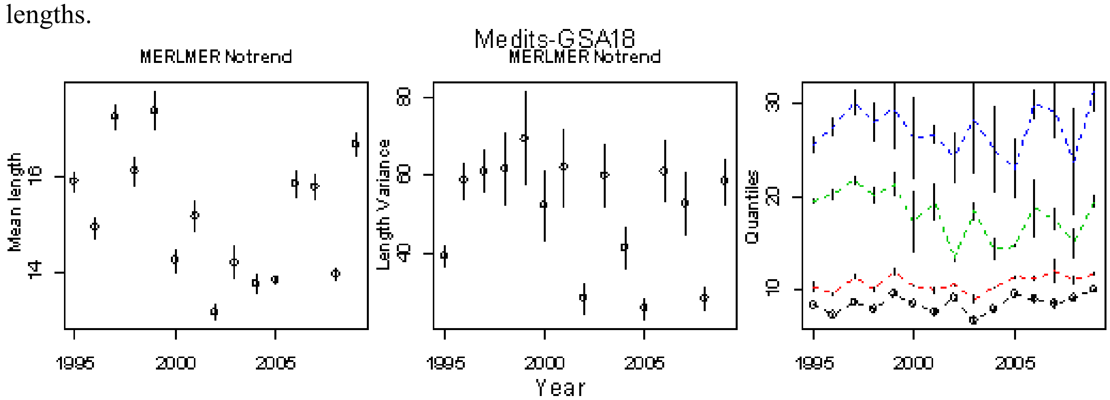


Fig. 7.7.3.1.4.3 Mean length, variance and quantiles derived from the MEDITS length compositions.

7.7.3.1.5. Trends in growth

No analyses were conducted during SGMED-10-03.

7.7.3.1.6. Trends in maturity

No analyses were conducted during SGMED-10-03.

7.7.4. *Assessment of historic stock parameters*

7.7.4.1. Method 1: SURBA

SURBA software was applied using MEDITS abundance estimates by length. Two scenarios based on a different growth pattern were used to account for uncertainty in the growth of the species and results were compared. Outputs from SURBA were thereafter used to feed ALADYM model.

7.7.4.1.1. Input parameters

For the SURBA analyses two sets of growth parameters were used to split the LFDs after that these were raised to the square km and averaged over the area.

<u>Set 1) ‘slow’ growth</u>

Sex combined: L_∞=96 cm, K=0.13, t_0= -0.73; length-weight relationship: a=0.0043, b=3.155.

<u>Set 2) ‘fast’ growth</u>

Sex combined: L_∞=104 cm, K=0.2, t_0= -0.01; length-weight relationship: a=0.0043, b=3.155.

The age groups derived from the age slicing using the LFDA software are reported in the tables below. A 5+ group and a 4+group were respectively used for the two data sets.

Tab. 7.7.4.1.1.1 Age groups obtained after the age slicing procedure and used as input in SURBA

'Slow' age groups							'fast' age groups				
Year	0	1	2	3	4	5+	0	1	2	3	4+
1996	504.51	205.30	23.33	3.90	0.83	2.03	499.74	230.48	7.03	1.43	1.22
1997	331.83	166.81	27.93	4.37	1.26	1.57	326.85	196.74	8.20	1.30	0.66
1998	303.55	111.19	11.84	2.05	0.70	1.63	299.70	124.99	4.34	0.69	1.24
1999	187.43	89.93	10.53	1.61	0.85	2.08	185.38	101.26	3.59	0.77	1.43
2000	392.52	92.80	10.30	2.01	0.46	1.58	389.66	105.11	3.20	0.81	0.90
2001	290.27	93.46	8.50	1.81	1.03	1.15	287.28	103.43	3.96	0.56	1.00
2002	633.66	76.32	12.58	1.47	0.70	0.52	631.05	90.11	3.43	0.14	0.52
2003	318.79	76.35	15.18	2.25	0.61	1.11	315.85	92.61	4.71	0.83	0.28
2004	526.87	107.74	13.96	1.49	0.75	1.54	523.90	122.25	3.84	1.88	0.38
2005	1439.33	97.53	17.76	6.35	2.01	2.24	1436.77	114.30	11.05	1.32	1.67
2006	486.98	119.64	25.51	3.46	1.84	2.82	483.60	145.32	7.97	1.43	1.92
2007	418.61	86.32	16.79	5.12	1.09	2.64	416.07	103.38	7.70	1.97	1.56
2008	928.17	133.66	12.66	3.35	2.43	1.32	924.15	149.38	5.54	1.98	0.54
2009	568.87	164.34	33.61	8.14	3.30	2.28	562.89	198.60	15.63	2.05	1.36

The other settings of the model, regarding natural mortality, catchability coefficient, maturity and weight at age, are reported in the table below. Natural mortality vector for the two scenarios were obtained applying the Prodbiom method (Abella et al., 1997) through a calculation sheet provided by the author. Natural mortality was assumed varying by age and constant through the time, and likewise maturity and weight at age.

Tab. 7.7.4.1.1.2 SURBA settings related to the natural mortality (M), the catchability coefficient q, the proportion of mature and the weight at age in the slow and fast growth scenarios.

Age	0	1	2	3	4	5+
M (slow)	0.76	0.42	0.30	0.25	0.21	0.20
M (fast)	1.16	0.53	0.40	0.35	0.32	
q (slow)	0.90	1.00	1.00	1.00	0.75	0.75
q (fast)	0.90	1.00	1.00	0.75	0.75	
Proportion mature (slow)	0.000	0.005	0.325	0.670	1.000	1.000
Proportion mature (fast)	0.008	0.248	0.887	1.000	1.000	
Weight (kg) (slow)	0.01	0.04	0.15	0.35	0.66	1.77
Weight (kg) (fast)	0.01	0.14	0.53	1.15	2.35	

7.7.4.1.2. Results

Estimates of total mortality from SURBA, for sex combined and for slow and fast growth, are presented in Tab. 7.7.4.1.2.1:

Tab. 7.7.4.1.2.1 – Relative estimates of total mortality Z and spawning stock biomass SSB from SURBA, for sex combined and for slow and fast growth scenarios.

Slow growth pattern - Results					Fast growth pattern - Results			
	Original		Smoothed		Original		Smoothed	
Year	SSB	Z	SSB	Z	SSB	Z	SSB	Z
1996	1.09	1.573	1.137	1.601	1.251	2.079	0.988	2.12
1997	1.032	1.923	1.118	1.519	1.198	2.313	1.059	1.964
1998	1.113	1.525	1.465	1.459	0.724	1.972	0.837	1.851
1999	0.923	1.305	0.88	1.41	0.706	1.823	0.716	1.713
2000	0.843	1.545	0.724	1.421	0.615	1.899	0.622	1.768
2001	0.579	1.519	0.595	1.389	0.773	2.027	0.732	1.728
2002	0.705	1.404	0.705	1.335	0.683	1.968	0.722	1.789
2003	0.605	1.545	0.622	1.261	0.769	1.671	0.848	1.639
2004	0.778	0.925	0.82	1.18	0.913	1.773	0.924	1.666
2005	1.235	1.668	1.053	1.44	1.33	2.449	1.219	1.885
2006	1.504	1.614	1.416	1.461	1.196	1.944	1.302	1.887
2007	1.358	1.527	1.309	1.236	1.132	1.752	1.204	1.561
2008	0.724	0.77	0.94	1.314	1.086	1.622	1.271	1.868
2009	1.511	NA	1.218	NA	1.626	NA	1.556	NA

In the slow growth hypothesis, the temporal trend of F and the mean F estimates showed a decreasing pattern until 2004 and than an increasing up to 2006 with a new decrease to 2008. SSB index was declining from 1998 to 2002 and than rising to 2007 (Fig. 7.7.4.1.2.1). The analysis showed a sharp increase of recruitment in 2005 and thereafter a level similar or higher than the past years (Fig. 7.7.12.4.1.2.2). Residuals by age class varied without any trend (Fig. 7.7.4.1.2.3). Total mortality also showed a decreasing trend to 2004 and than an increasing in 2005 and 2006, thereafter the level was similar to the beginning of the time series (Fig. 7.7.4.1.2.4). The log survey abundance indices by cohort showed an expected pattern of decline (Fig. 7.7.4.1.2.4).

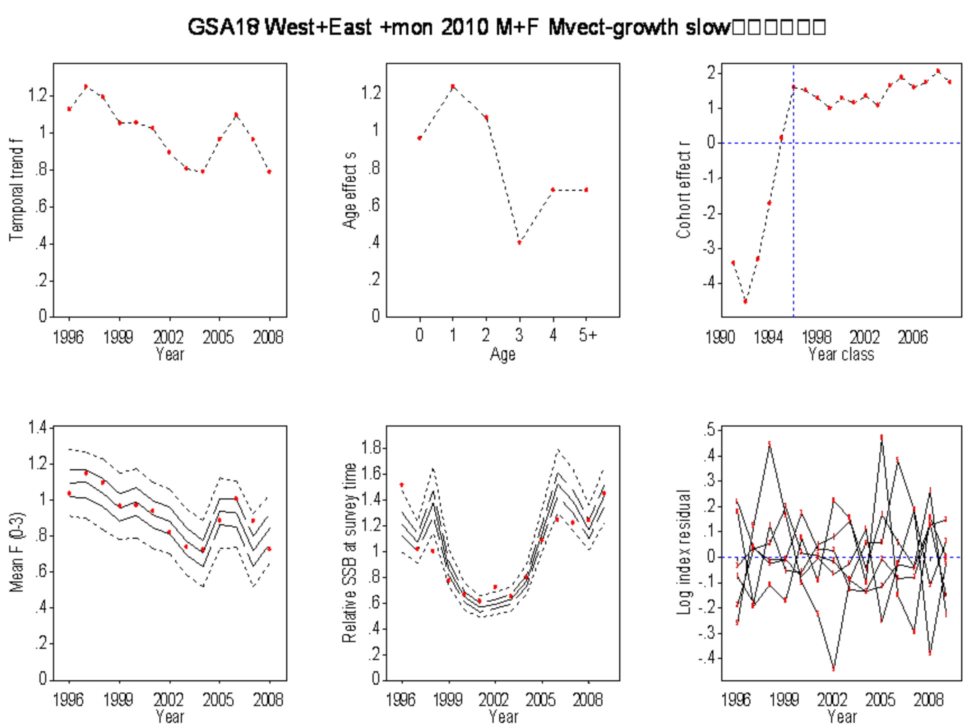


Fig. 7.7.4.1.2.1 Trends in various stock parameters from SURBA, hake GSA18, slow growth pattern.

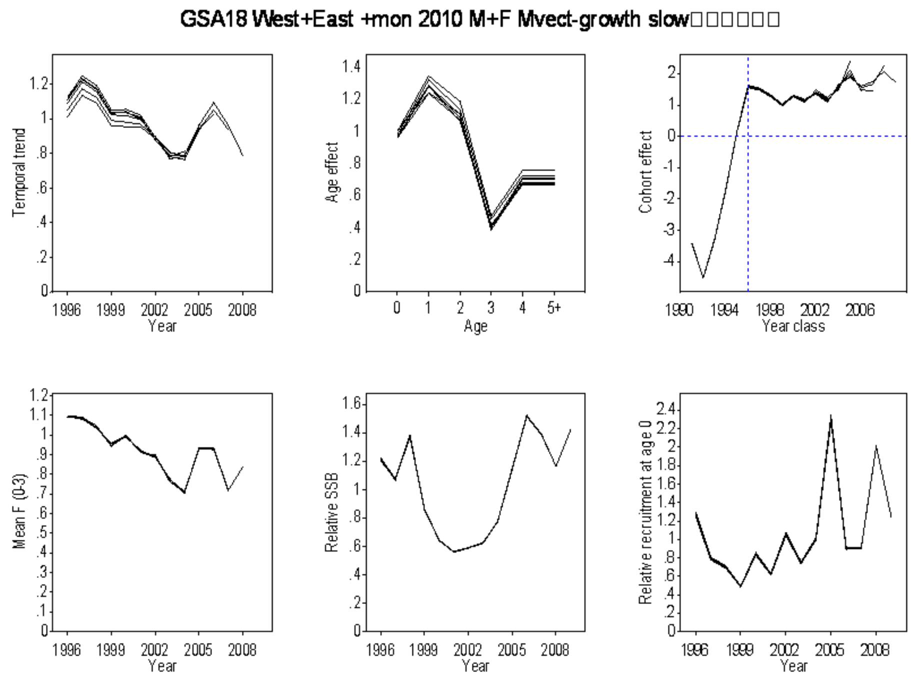


Fig. 7.7.4.1.2.2 Retrospective analysis from SURBA, hake GSA18, slow growth pattern.

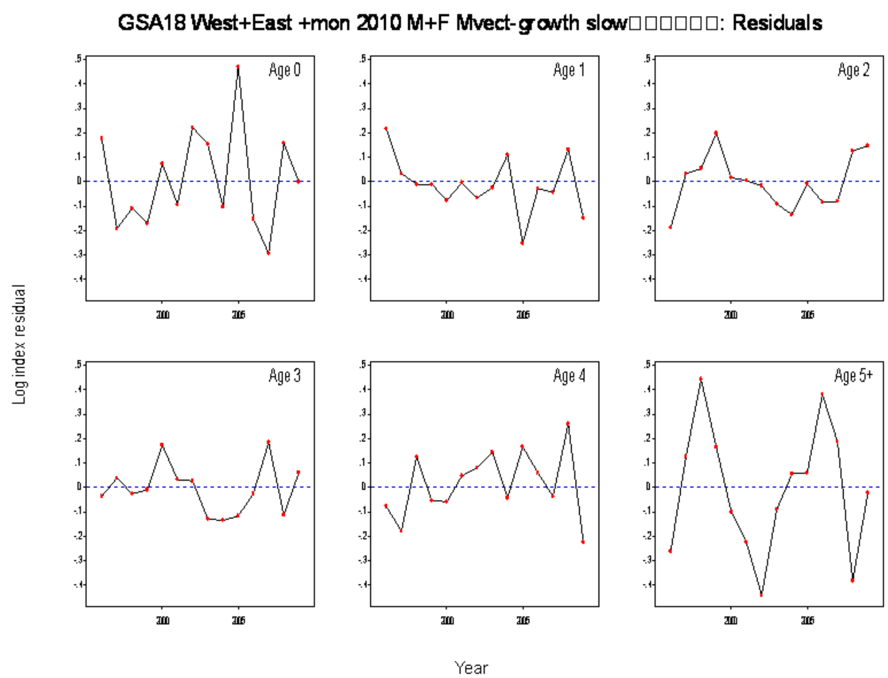


Fig. 7.7.4.1.2.3 Residuals from SURBA, hake GSA18, slow growth pattern.

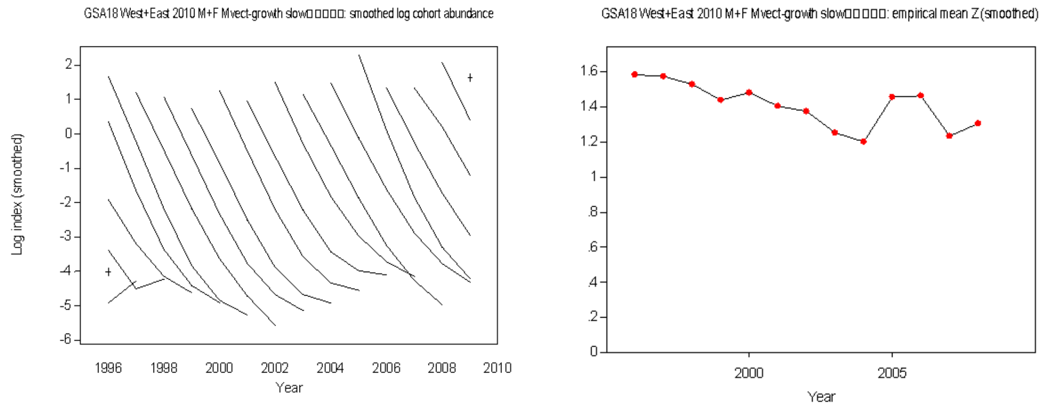


Fig. 7.7.4.1.2.4 Log survey abundance indices by cohort (left; each line represents the log abundance index of a given cohort throughout its life) and total mortality (right); hake GSA18, slow growth pattern.

Under the fast growth hypothesis, the temporal trend of F and the mean F estimates showed an irregular but decreasing pattern to 2004 and then an increase up to 2007. The estimates of SSB index at survey time showed a decrease up to 2001 and a continuous increasing afterwards (Fig. 7.7.4.1.2.5). As in the slow growth scenario the analysis showed also a sharp increase of recruitment in 2005. Residuals by age class varied without any trend, except for age 2. Total mortality also showed a decreasing trend to 2004 and than an increasing in 2005 (Fig. 7.7.4.1.2.8). The pattern of the log survey abundance indices by cohort was comparable to that of the slow growth scenario.

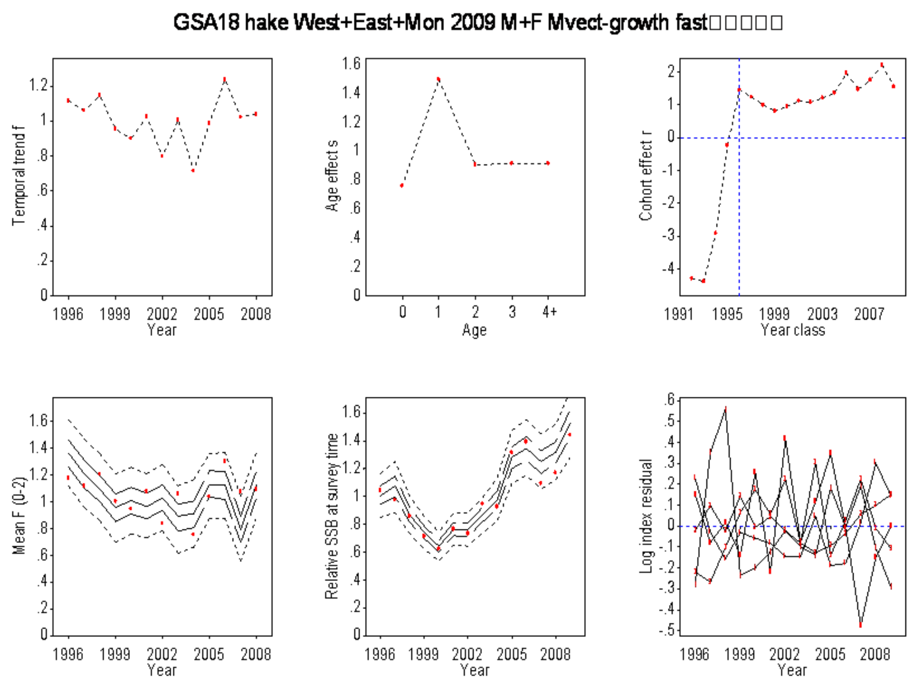


Fig. 7.7.4.1.2.5 Trends in various stock parameters from SURBA, hake GSA18, fast growth pattern.

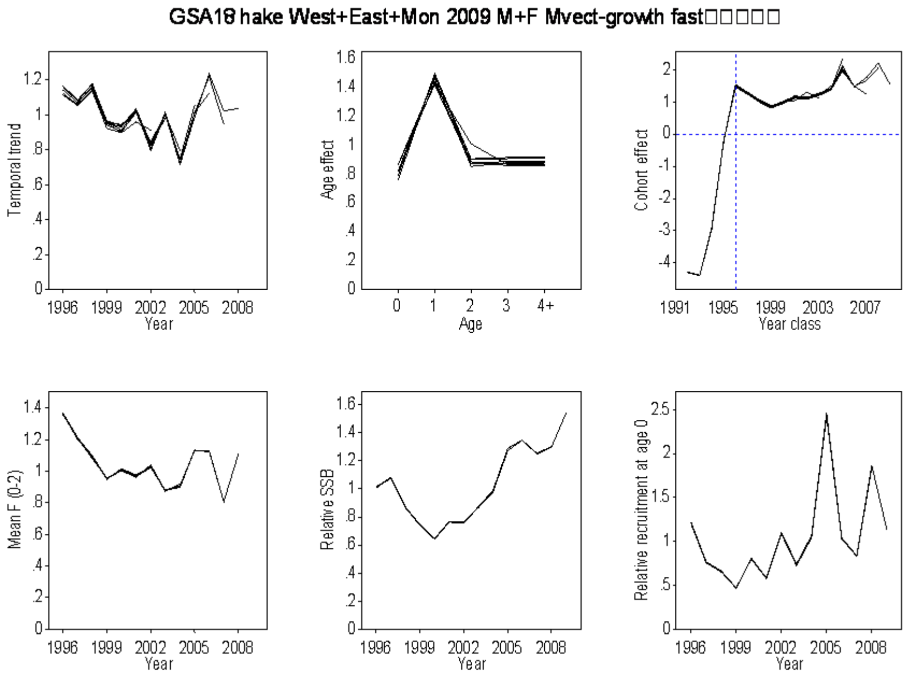


Fig. 7.7.4.1.2.6 Retrospective analysis from SURBA, hake GSA18, fast growth pattern.

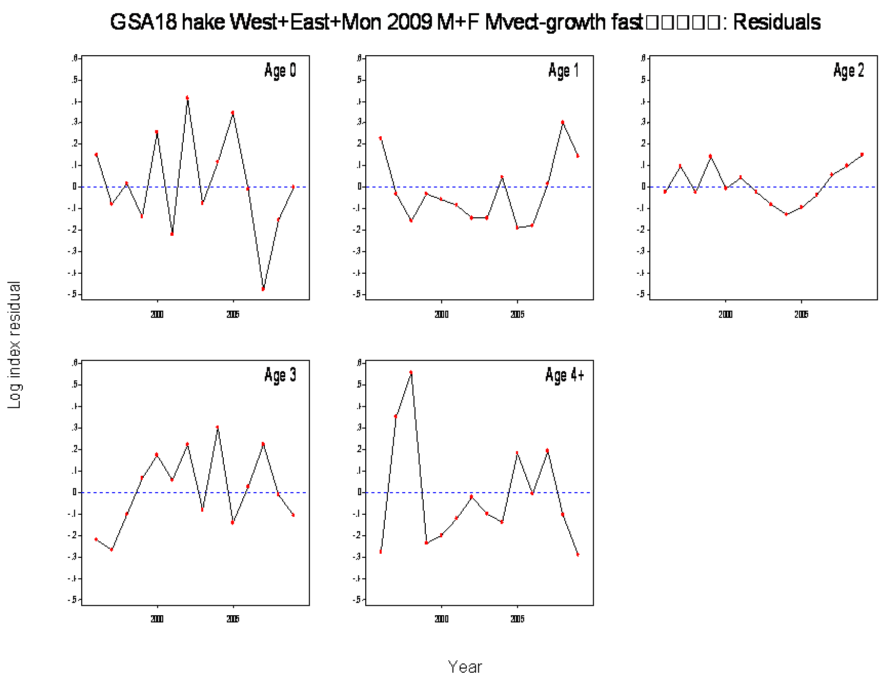


Fig. 7.7.4.1.2.7 Residuals from SURBA, hake GSA18, fast growth pattern.

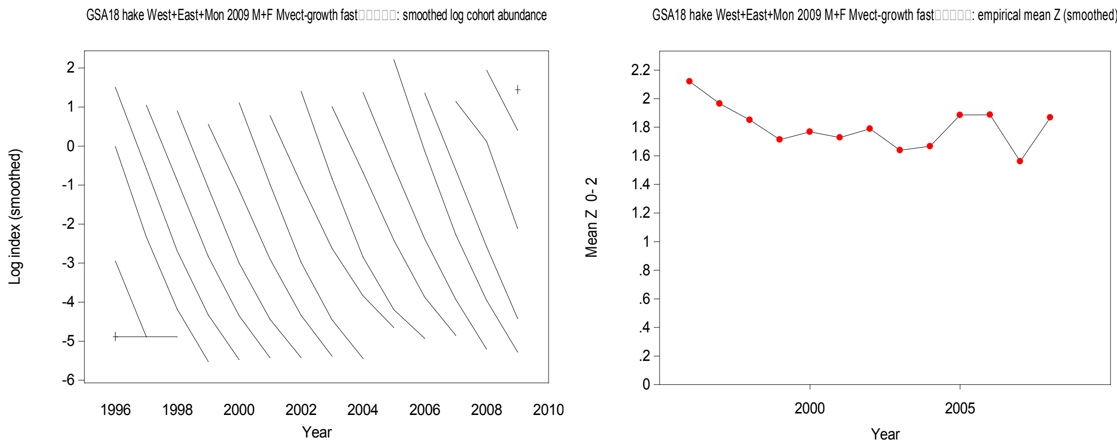


Fig. 7.7.4.1.2.8 Log survey abundance indices by cohort (left; each line represents the log abundance index of a given cohort throughout its life) and total mortality (right); hake GSA18, fast growth pattern.

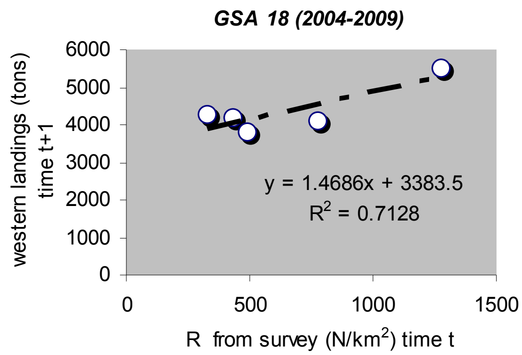
On the overall, results from SURBA highlight a level of Z from 1.2 to 1.6 under the slow growth and a range of 1.6-2.1 under the fast growth scenario, while F is respectively 0.7-1.2 and 0.8-1.4.

7.7.4.2. Method 2: ALADYM

ALADYM model (Lembo *et al*., 2009) was used to perform simulations using both hindcasting and forecasting approaches (Spedicato *et al*., 2010). The former allowed the reconstruction of the model-based population indicators evaluating the effects of the fishing pressure on the SSB and on production indicators as the yield and the mean fish size in the catches. The latter was used to predict the effects of management measures, as the change of mesh size in the long-term and to make comparison with the *status quo* situation. The model was applied to the slow and fast growth scenarios, however as the results are similar, only those from the fast growth scenario are reported here.

7.7.4.2.1. Input parameters

Estimates of total mortality from SURBA were used to feed ALADYM in the hindcasting approach, in the last year (2009) the total mortality was set as a geometric mean of the last three years, as not available in the SURBA outputs. Recruitment estimates from SURBA were rescaled for getting a guess estimate of the absolute recruitment. This was done taking into account the information on the significant relationships between recruitment at time *t* and production at time *t+1* (Cheilari and Rätz, 2008) (Fig. 7.7.4.2.1.1). In addition, estimates of the initial number from VIT were used to approximately set the order of magnitude of the recruitment. The shape of recruitment along the time was set from SURBA outputs based on MEDITS survey indices. In the table 7.7.4.2.1.1 the recruitment vector used as input in ALADYM is reported.



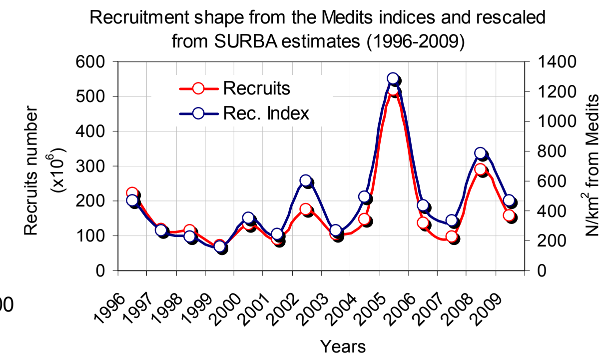


Fig. 7.7.4.2.1.1 Relationship between the index of recruitment from the MEDITS survey at the time *t* and the landings of hake at time *t+1* in the western side of the GSA18 (left) and recruitment pattern used to parameterize ALADYM model (right).

Tab. 7.7.4.2.1.1 Recruitment vector used as input in ALADYM

year	Z	Offspring
seed	1.99	143,062,020
1996	2.122	219,741,193
1997	1.984	118,274,091
1998	1.861	112,660,576
1999	1.703	70,667,615
2000	1.767	131,764,814
2001	1.742	90,467,367
2002	1.798	174,449,090
2003	1.629	101,961,763
2004	1.667	147,237,691
2005	1.927	518,220,406
2006	1.984	135,683,680
2007	1.615	95,199,116
2008	1.858	290,686,024
2009	1.812	155,427,631

ALADYM routines re-estimated the total and fishing mortality using the whole information on the population parameters (the same life history parameters reported in the section 7.7.4.1) and a simulated exploitation pattern from the fishery. The fleet fishing selectivity was simulated using an ogive model with the following parameters: L_c=12cm; selection range (SR) 1 cm. This was coupled with a deselection ogive with 50% deselection size at 40 cm and a deselection range of 1 cm, to account for possible avoidance/reduced availability of older fish (Abella and Serena, 1998). Also the coefficient of monthly activity of the fleet was considered in the simulation, accounting for the current fishing ban in the summer season (fishing coefficient=0.2 in August, 0.9 in September and October and 1 in all the other months). The proportion of offspring per month was set according to the observations carried out in the area (Tab. 7.7.4.2.1.2).

Tab. 7.7.4.2.1.2 Proportion of offspring per month as input in ALADYM

Proportion of offspring/month					
January	February	March	April	May	June
0.25	0.15	0.05	0.05	0.05	0.05
July	August	September	October	November	December
0.15	0.05	0.15	0.15	0.05	0.25

7.7.4.2.2. Results

Outcomes from ALADYM converged with the Z estimates from SURBA and catches simulated using ALADYM rather well approximated the observed ones (Fig. 7.7.4.2.2.1). Regardless of the method used a slightly decreasing trend of total mortality were observed from 1996 to 2005 and an increasing mortality value was recorded thereafter. Mean length of the simulated catches was rather stable around 18-20 cm (average 20 cm; Fig. 5.12.4.2.2.1), that is in agreement with the mean lengths estimated from the observed landings that were 18 cm in 2007 and 20 cm in 2008 and 2009.

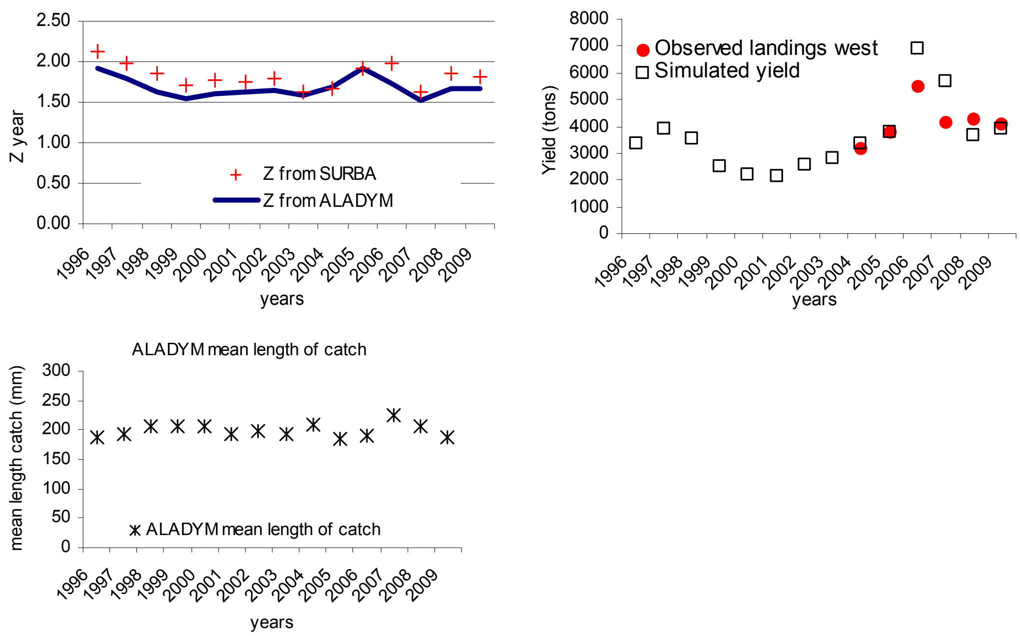


Fig. 7.7.4.2.2.1 Results from ALADYM model regarding the total mortality rate, the simulated yield and the mean length of the catches.

Regarding the spawning stock, the SSB is slightly increasing in the last years and the Spawning Potential Ratio (SPR) as well, probably as result of the decreasing trend in total mortality. However the level of SPR that is the ratio between the unexploited (F=0) and the exploited SSB is very low (7-8%) compared with the suggested reference levels for other fish stocks (about 20-30%).

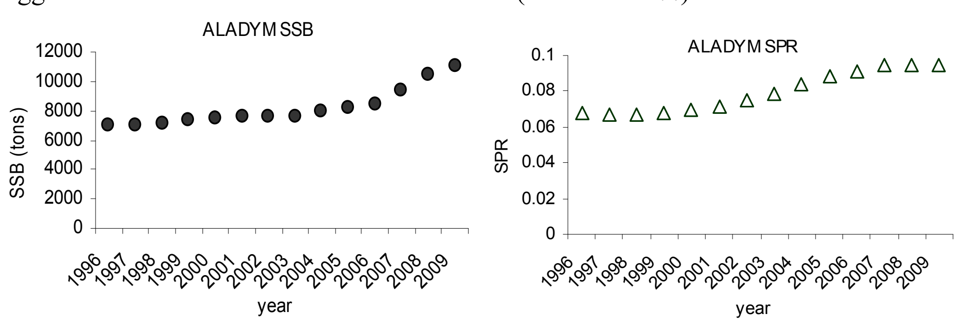


Fig. 7.7.4.2.2.2 Results from ALADYM model regarding the SSB level and the Spawning Potential Ratio (SPR).

7.7.4.3. Method 3: VIT

Given the short time series of length structure of landings, VIT model based on the pseudocohort approach was applied to get an estimate of the overall fishing mortality and of the fishing mortality by fishing gear and age. In addition, VIT model results were used to appraise the order of magnitude of the recruitment, that was useful information for validation purposes between the different models applied. VIT model was also used to get an indicative estimate of the reference points ($F_{0.1}$ and F_{max}). The VIT model was applied to the fast growth scenario.

7.7.4.3.1. Input parameters

The life history parameters used for VIT were the same as in the section 7.7.4.1. Length frequency distributions of the landings were age sliced using the fast growth parameters and LFDA routine.

		2007		2008		2009	
Age	OTB	LLS	OTB	LLS	OTB	LLS	NETS
0	37089700	0	18625620	0	18717657	0	0
1	23118193	186356	30052020	38467	24152779	38342	11035
2	792949	183934	726804	67644	705204	166984	1627
3	49295	62546	107632	169494	42376	83828	0
4+	0	174079	41706	117428	21655	145357	0

7.7.4.3.2. Results

VIT results regarding the pattern of catch reconstruction by age, year and fishing level 4, and the total and fishing mortality by age and fishing level 4, are showed in the Fig. 7.7.4.3.2.1. The catch is mostly based on the fish aged 1 and, in turn, also the mortality acting on this group is the highest. Globally the catches and the mortality are dominated by the trawl fishing system.

The Yield per Recruit analyses indicate a current level of F that is on average, between the three years analyzed, of about 0.95. The limit reference point F_{max} is on average about 0.27-0.28 and the target reference point $F_{0.1}$ is about 0.21-0.22.

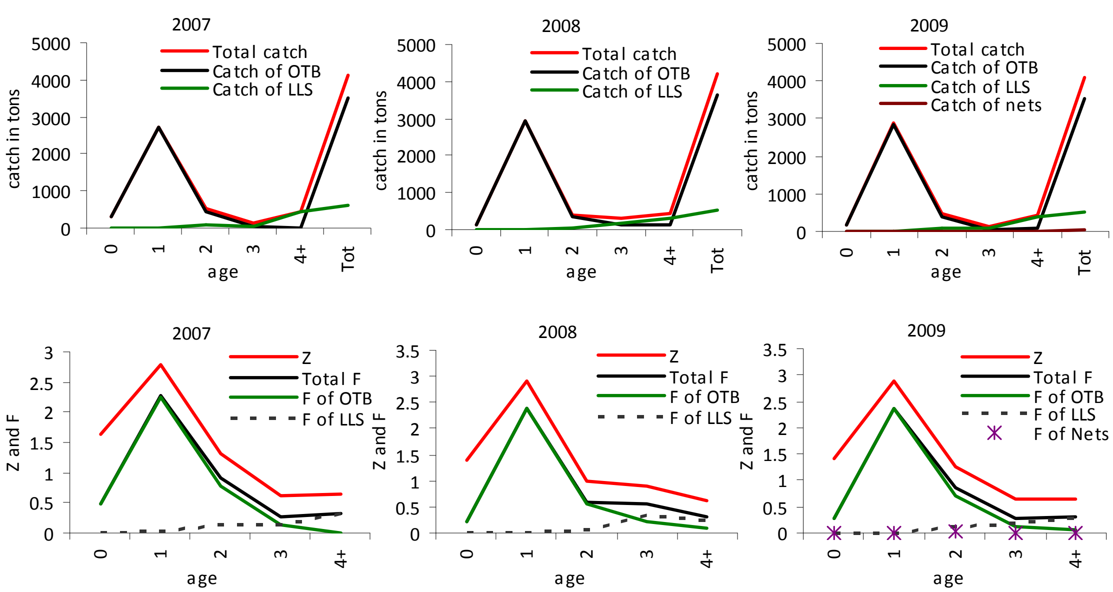
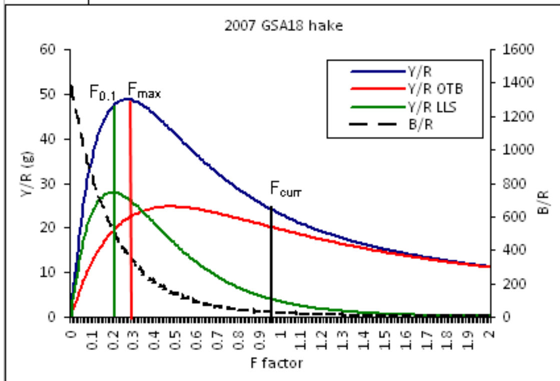
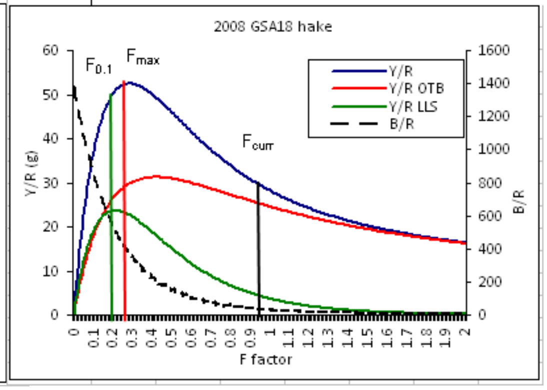


Fig. 7.7.4.3.2.1 VIT results. Pattern of catch reconstruction by age, year and fishing level 4 (up), total and fishing mortality by age and fishing level 4 (down).

2007	Factor	F	Y/R	B/R	SSB	Y/R OTB	Y/R LLS
F(0)	0	0	0	1381.0	1339.3	0	0
F(0.1)	0.21	0.206	47.7	496.9	468.3	19.8	27.9
Fmax	0.28	0.275	48.8	376.9	351.0	22.1	26.6
Fcurr	1.01	0.983	23.1	24.0	14.4	19.6	3.5
Fdouble	2	1.965	11.3	4.6	0.5	11.1	0.2



2008	Factor	F	Y/R	B/R	SSB	Y/R OTE	Y/R LLS
F(0)	0	0	0	1381.0	1339.3	0	0
F(0.1)	0.23	0.217	51.7	472.5	443.6	28.0	23.7
Fmax	0.29	0.274	52.5	379.5	352.6	29.7	22.8
Fcurr	1.01	0.943	28.2	29.6	17.9	24.6	3.7
Fdouble	2	1.887	16.3	6.9	0.8	16.2	0.2



2009	Factor	F	Y/R	B/R	SSB	Y/R OTB	Y/R LLS	Y/R NETS
F(0)	0	0	0	1381.0	1339.3	0	0	0
F(0.1)	0.23	0.218	50.2	467.9	439.2	25.2	24.8	0.268
Fmax	0.29	0.275	51.0	374.8	348.2	26.9	23.7	0.286
Fcurr	1.01	0.948	27.0	28.0	16.7	23.3	3.5	0.189
Fdouble	2	1.895	15.3	6.4	0.7	15.1	0.2	0.084

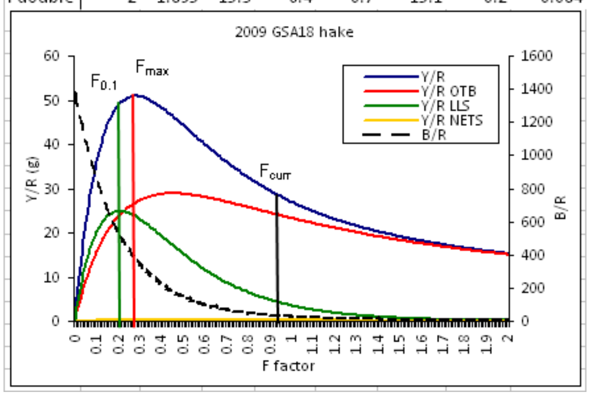


Fig. 7.7.4.3.2.2 Y/R curves by gear and year from VIT analysis. For each year the overall estimates regarding F-factor, F (F_0, $F_{0.1}$, F_{max}, F_{curr}, F_{double}), overall and by gear Y/R, B/R and SSB are reported. Fast growth scenario. B/R by year and F-factor is also showed.

7.7.5. *Long term prediction*

7.7.5.1. Justification

ALADYM model was applied to forecast the possible effects of the newly enforced mesh size regulation (from 40 mm to 50 mm diamond mesh opening in the cod-end) on stock biomass, catches and other relevant population indicators in the long-term. The model was applied to the fast growth scenario. The results of the simulations under the new mesh size scenario were compared to the results under the *status quo* scenario in the long-term. The model assumptions are a full compliance to the mesh size regulations and full survival of the fish escaped by the cod-end.

7.7.5.2. Input parameters

The same parameters as in 7.7.4.2.1. were used that are below reported.
Estimates of total mortality from SURBA were used to feed ALADYM in the hindcasting approach, in the last year (2009) the total mortality was set as a geometric mean of the last three years, as not available in the SURBA outputs.

Tab. 7.7.4.2.1.1 Recruitment vector used as input in ALADYM

year	Z	Offspring
seed	1.99	143,062,020
1996	2.122	219,741,193
1997	1.984	118,274,091
1998	1.861	112,660,576
1999	1.703	70,667,615
2000	1.767	131,764,814
2001	1.742	90,467,367
2002	1.798	174,449,090
2003	1.629	101,961,763
2004	1.667	147,237,691
2005	1.927	518,220,406
2006	1.984	135,683,680
2007	1.615	95,199,116
2008	1.858	290,686,024
2009	1.812	155,427,631

ALADYM routines re-estimated the total and fishing mortality using the whole information on the population parameters (the same life history parameters reported in the section 7.7.4.1; Sex combined: L_{∞}=104 cm, K=0.2, t_0= -0.01; length-weight relationship: a=0.0043, b=3.155).
Also the coefficient of monthly activity of the fleet was considered in the simulation, accounting for the current fishing ban in the summer season (fishing coefficient=0.2 in August, 0.9 in September and October and 1 in all the other months). The proportion of offspring per month was set according to the observations carried out in the area (Tab. 7.7.4.2.1.2).

Tab. 7.7.4.2.1.2 Proportion of offspring per month as input in ALADYM

Proportion of offspring/month					
January	February	March	April	May	June
0.25	0.15	0.05	0.05	0.05	0.05
July	August	September	October	November	December
0.15	0.05	0.15	0.15	0.05	0.25

In addition the new selection pattern in the long-term was mimicked using the following selectivity parameters since 2011 to 2020: $L_{50\%}$ =16 cm; SR=1cm. Selectivity parameters were derived from studies conducted in the area along the time (Adriamed website; Leonori *et al*., 2005). This was coupled with a deselection ogive with 50% deselection size at 40 cm and a deselection range of 1 cm, to account for possible avoidance/reduced availability of older fish (Abella and Serena, 1998).The recruitment for the forecast scenarios was set equal to the geometric mean of the last three years, as well as the total mortality.

7.7.5.3. Results

The forecasts from ALADYM simulations are reported in the Fig. 7.7.5.3.1 that shows the effects of the application of the 50 mm mesh size opening (diamond mesh) in the cod-end. The forecast evidenced poor losses for the catches in the short-term, after a slight decline in the first year, and a stable situation in the future when the present levels of catches could be maintained. According to the model predictions in the medium term the catches might be higher than the current one of about 10% (3939 in 2009 vs. 4340 tons in 2020). In addition, the average size of catches would increase of about 20% resulting in more valuable yields (19 in 2002 vs. 23 cm TL in 2020). The stock sustainability would improve as the level of SSB would increase of about 30% (11000 in 2009 vs. 14300 tons in 2020). However, the effectiveness of mesh size regulation is uncertain, as far as compliance and fish survival after escapement from the cod-end.

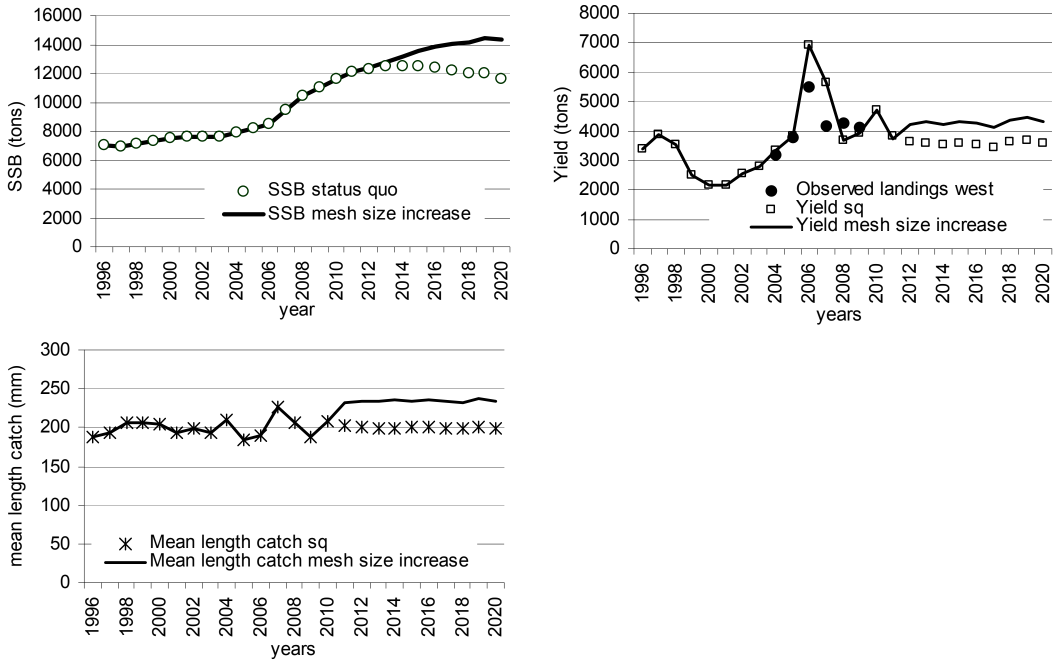


Fig. 7.7.5.3.1 Forecasts from ALADYM simulations regarding the following model based indicators: SSB, Yield and mean length of the catches.

7.7.6. *Data quality and availability*

Minor discrepancies were identified from the cross-checking between estimates related to total landings (transversal variables) and raised catch structures by metier (biological metier related variable). Data on maturity and growth from DCF have also been used. Information from GRUND surveys and from nurseries studies in the GSA have also been included.

7.7.7. *Scientific advice*

7.7.7.1. Short term considerations

7.7.7.1.1. State of the spawning stock size

SGMED-10-03 is unable to provide any scientific advice of the state of the spawning stock in relation to proposed precautionary level as those have not been defined. However, the simulations using ALADYM model indicate low levels of the ratio between fished and unfished (F=0) spawning population.

7.7.7.1.2. State of recruitment

After the exceptional peak of recruitment observed in 2005 MEDITS data, the recruit abundance reached similar levels as in the years before 2005.

7.7.7.1.3. State of exploitation

SGMED proposes $F_{0.1}$ = 0.22 as limit reference point consistent with high long term yield. This value is interpreted as proxy of F_{msy}.

Analyses performed applying different approaches gave consistent results, indicating that the fishing mortality is far in excess of sustainable levels, and that the stock of *Merluccius merluccius* in the GSA18 appears to be subject to overfishing. Regardless of the growth pattern a considerable reduction, of about 70-75%, would be necessary to approach the $F_{0.1}$ reference point that can be considered included in the range 0.21-0.22. SGMED recommends the relevant fleet's effort to be reduced until fishing mortality is below or at $F_{0.1}$ in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan taking into account mixed-fisheries effects.

7.8. Stock assessment of red mullet in GSA 09

7.8.1. *Stock identification and biological features*

7.8.1.1. Stock Identification

Red mullet is distributed along the shelf of all the Mediterranean countries. The species can be found at depths over 200m, but is mainly concentrated in the depth range 0-100m. All the year classes and nursery and spawning areas are well distributed along the narrow Mediterranean shelves. There is not any available definition of unit stocks neither based on genetics, bio-chemistry, fishery-based nor on any alternative method based on somatic features. Under a management point of view, in the frame of GFCM, it has been decided, when the lack of any evidence does not allow suggesting an alternative hypothesis, that inside each one of the GSAs boundaries inhabits a single, homogeneous red mullet stock that behaves as a single well-mixed and self-perpetuating population. The GSA boundaries are however arbitrary and certaintly do not take under consideration neither the existence of any local biological feature nor of any difference in the spatial allocation in fishing pressure within it. The hypothesis of a single stock of red mullet in GSA9, which includes waters belonging to 2 seas (Ligurian and Tyrrhenian) separated by the Elba Island and fleets that does not show any spatial overlapping is almost unlikely. The inability to account for spatial structure reduces flexibility and can lead to uncertainty in the definition of the status of the stocks, due to the possibility of local depletions and to a worse utilization of the potential productivity of the resources.

7.8.1.2. Growth

The species is fast growing, and reaches half of its total size when is one year old. Some light differences in growth speed has been observed within different zones within the GSA9. In zones where the species is less exploited, where individuals are more densely concentrated or available food is lower, the mean size of 6 months old individuals is from 1 to 1.5 cm lower than in other areas of the same GSA were the species is more highly exploited and hence less abundant. In any case, the parameters reported as follows may be considered suitable for the description of an average growth performance valid for the whole GSA9.

Table 7.8.1.2.1. Common growth parameters considered representative for *M. barbatus* in the GSA9 utilized in the successive analyses.

Linf=29, K=0.6, to=-0.1   L/W relationship a=0.00053   b=3.12

An M vector (age1=1.30, age2 0.79, age 3 0.62, age 4= 0.54) and a weighted mean value of M of 0.8 was used.

7.8.1.3. Maturity

The species reaches massively the sexual maturity at one year old. Observations of proportion of mature individuals by size and analysis with the standard procedure have produced the following sizes at age maturity by sex.

L_m	12.5 cm TL (females) 10 cm TL (males	Sanchez *et al*. 1995

The classical approach for the definition of Lm, as expected, produces a light underestimation of this size. In fact, the bulk of the females spawn at a size of about 14 cm. In GSA9 there have been performed studies on fecundity. The following relationship of fecundity at size (in cm) was defined in the area:

Fec= 0.7599*TL^3.336

The generation time G corresponding to the weighted mean age of spawners in a not exploited population (Goodyear 1995) was estimated to be 2.75 years assuming a mean *M*=0.8

7.8.2. *Fisheries*

7.8.2.1. General description of fisheries

STECF (second stock review in 2007) notes that *Mullus barbatus* is among the most commercially valuable species in the area and is an important component of a species assemblage that is the target of the bottom trawling fleets operating near shore. It becomes a first order target of part of the fleet in some particular periods when the juveniles of the species are densely concentrated near the coast. The species in GSA9 is mainly caught with three different variants of the Italian bottom trawl net (tartana, volantina and francese). The small mesh size of the cod end in all cases defines a very precocious size/age of first capture.

L_c	7.4 cm TL (males + females)	De Ranieri *et al.* , 2000

Set nets used by artisanal fleets catch modest quantitatives of relatively large individuals, in general over 12 cm TL. The exerted fishing pressure on this species on different zones of GSA9 is quite variable because conditioned by the structural composition of the fractions of the fleets that operate close to their respective ports, by the characteristics of the grounds potentially exploitable close to the ports and also by differences in the fisheries' target among fleets and zones. *Mullus barbatus* catch rates are higher during the post-recruitment period (from September to November). About 200 of the 350 trawlers and a small number of artisanal vessels exploit the species in the GSA9. Annual landings, mostly proceeding from trawling, ranged from 500 to 1100 tons in the last years. Discards of undersized individuals is in general limited (was about 10% in weight in 2006), mainly due to the fact that immediately after recruitment, small sized individuals, even though potentially vulnerable to the gear, are mostly concentrated inside the 3 miles where trawling practices are forbidden. Illegal catches of juveniles within this stripe, may occur, but can be considered of limited importance.

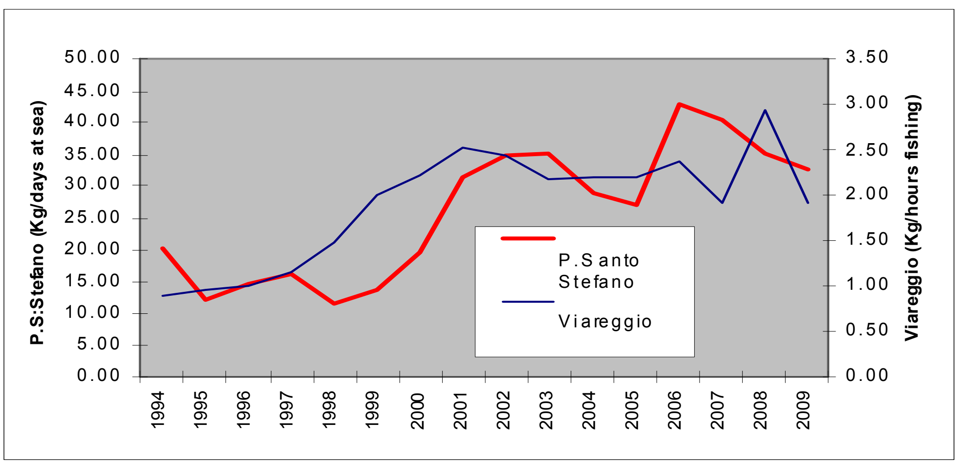


Fig. 7.8.2.1.1 Landings per unit of effort by year in two of the more important ports of the area.

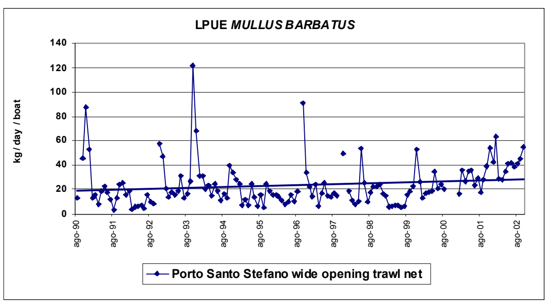
7.8.2.2. Management regulations applicable in 2009 and changes in 2010

Fishing closure for trawling: a 45 days trawling ban was enforced in GSA9 in late summer. The measure was mos of the years not compulsory and hence adhesion did not covered all the fleets of the GSA. Only in 2008 it was compulsory for all the trawlers in the area and is expected this measure with the same characteristics will be repeated this year. Minimum landing sizes: EC regulation 1967/2006 defined 12 cm TL as minimum legal landed size for red mullet. Cod end mesh size of trawl nets: the 40 mm (stretched, diamond meshes) will continue to be utilized up to 30/05/2010. Since 1/6/2010, such cod end will be replaced by a 40 mm cod end with square mesh geometry or alternatively by a net with a cod end of 50 mm stretched diamond meshes. It is not expected a noticeable increase in the size of entering to the fishery with the introduced changes because this size is only partially defined by the gear selectivity but also by reduced availability of juveniles due to their spatial distribution. Trawling is not allowed within three nautical miles from the coast or at depths less than 50 m when this depth is reached at a distance less than 3 miles from the coast.

7.8.2.3. Catches

7.8.2.3.1. Landings

Landings data were reported to SGMED-08-04 through the Data collection regulation and are listed in Table A3.2 of Appendix 3. Since 2002 annual landings varied between 620 and 1100 (Tab. 7.8.2.3.1.1). Demersal bottom trawlers dominate the landings by far. Landings size show a very high seasonal variability, with peaks at the end of summer (september) determined by the increase in availability/vulnerability after the massive recruitment on the coastal area.



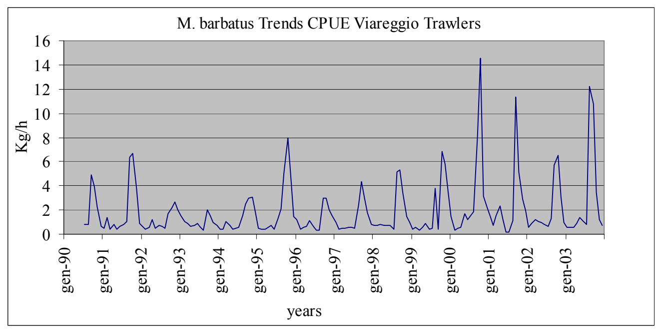


Fig. 7.8.2.3.1.1 Monthly catches with regular seasonal fluctuations in red mullet landings in two of the main ports of GSA9.

Table 7.8.2.3.1.1 Annual landings (t) by fishing technique as reported to SGMED-09-06 through the DCR data call.

	2004	2005	2006	2007	2008	2009
Nets	60.0	24.0	16.0	9.0	11.0	21.0
trawlers	521.0	684.0	1033.0	1087.0	716.0	707.0
Longlines					0.0	
Miscelaneous	2.3		0.5			
Seines	0.0	0.1				
TOTAL	583.3	708.1	1049.5	1096.0	727.0	728.0

Fig. 7.8.2.3.1.2 Composition of the commercial catches in numbers (Official data).

Catch in Numbers 2006

Class	Total catch	trawlers	nets
1	5902406.36	5691343	211063
2	18364586.7	17761197	603390
3	3033915.26	2831822	202094
4	465904.71	396632	69273
5	101230.5	93631	7599
Total	27868043.5	26774625	1093419
Mean Age	1.321	1	2
Mean Leng	13.813	14	15

Catch in Numbers 2008

Class	Total catch	trawlers	nets
1	15935120	15899316	35804
2	16979930	16327104	652827
3	452647	355093	97554
4	126034	118096	7938
5	68859	66765	2095
Total	33562590	32766373	796217
Mean Age	0.906	0.893	1.447
Mean Leng	10.497	10.384	15.161

Catch in Numbers 2007

Class	Total catch	trawlers	nets
1	7084978	7071286	13692
2	15913524	15265519	648006
3	927790	838686	89104
4	40940	23931	17009
5	10220	6731	3489
Total	23977452	23206152	771300
Mean Age	1.07	1.06	1.46
Mean Leng	12.18	12.07	15.30

Catch in Numbers 2009

Class	Total catch	trawlers	nets
1	15935120	15899316	35804
2	16979930	16327104	652827
3	452647	355093	97554
4	126034	118096	7938
5	68859	66765	2095
Total	33562590	32766373	796217
Mean Age	0.906	0.893	1.447
Mean Leng	10.497	10.384	15.161

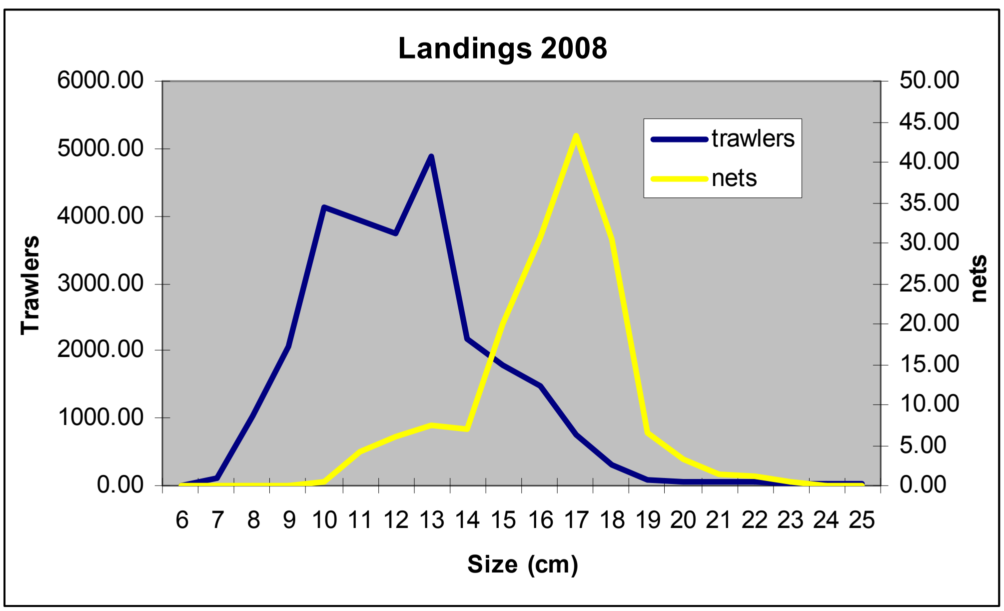


Fig. 7.8.2.3.1.2. Age structure of landings for trawlers and artisanal fleet for years 2006-2009.

7.8.2.3.2. Discards

158 t of discards in 2006 were reported to SGMED-08-04.

7.8.2.3.3. *Fishing effort*

The effort by fishing technique deployed in GSA 09 is reported to SGMED-08-03 through the DCR data call. A minor decrease is observed for the main gear demersal otter trawl and changes in the importance of the effort from the different gears and segments can be observed. It is however difficult to extract from these figures the real number of vessels that target red mullet. In the last 15 years, a general decrease in the size of the fishing fleets operating in the GSA9 targeting demersal species was observed. The number of vessels targeting the species in question and the changes (reduction) in number along the time interval 1990-2009 is only known for some ports of the GSA. The reduction of number of vessels has been particularly important in Porto Santo Stefano fleet (about 50% of reduction) in the South and in Viareggio (about 30%) in the North. It is likely that this general reduction in numbers of vessels also apply for the fraction of the fleet that exerts its fishing effort on *M. barbatus* over all the other GSA9 fleets.

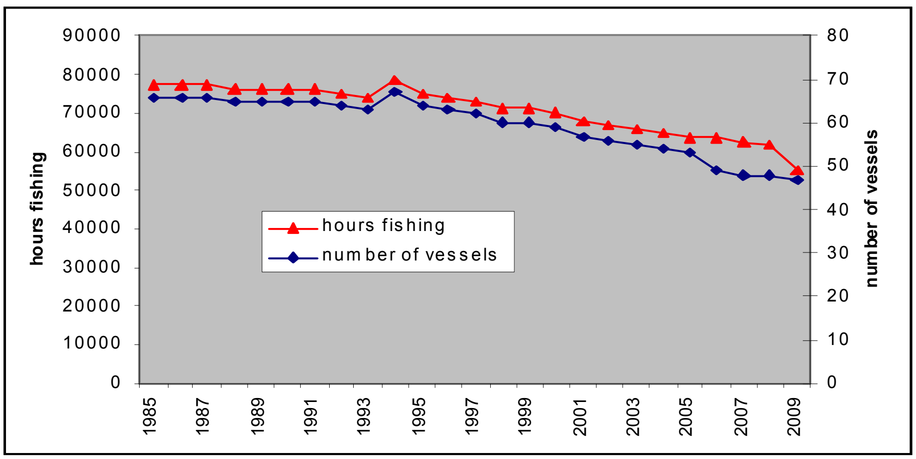


Fig. 7.8.2.3.3.1 Number of vessels and fishing activity in the port of Viareggio (1990-2009)

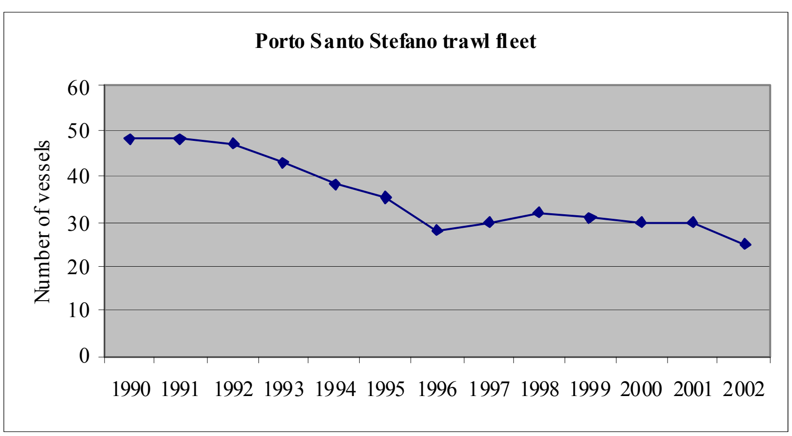


Fig. 7.8.2.3.3.2 Number of vessels in the port of Porto Santo Stefano (1990-2002).

7.8.3. *Scientific surveys*

7.8.3.1. Medits

7.8.3.1.1. Methods

Based on the DCR data call, abundance indices were recalculated and presented in this report. In GSA 09 the following number of hauls were reported per depth stratum (s. Tab. 7.8.4.1.1.1).

Tab. 7.8.4.1.1.1. Number of hauls per year and depth stratum in GSA 09, 1994-2009.

	YEAR															
STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
10-50	19	18	18	18	19	18	18	18	13	13	13	14	13	13	17	16
50-100	19	19	18	19	18	19	20	20	15	15	15	14	16	16	19	19
100-200	35	35	36	35	35	35	34	34	26	27	26	27	25	26	26	26
200-500	32	33	33	36	32	36	37	35	27	27	27	28	29	33	34	34
500-800	31	30	32	28	30	28	27	29	24	22	21	20	20	17	24	23

Data were assigned to bathymetric strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes trawling duration. Only hauls considered valid were used in the computations. Valid hauls include the cases of null catches of the species. The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

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

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

Where:

A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (sub-samples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA. Given the sheer number of plots generated, these distributions are not presented in this report.

7.8.3.1.2. Geographical distribution patterns

The species is distributed all along the continental shelf of the GSA9, with major abundance in the depth range 0-100m. The species is highly concentrated along the coastal stripe 0-30m when in late summer-beginnings of autumn juveniles massively settle to the bottom. The major nursery areas are allocated in the northern portion of the GSA9, Northwards the Elba Island (yellow areas in Fig. 7.8.4.1.2.1). Also mature individuals are more abundant in the Northern portion of the GSA9.

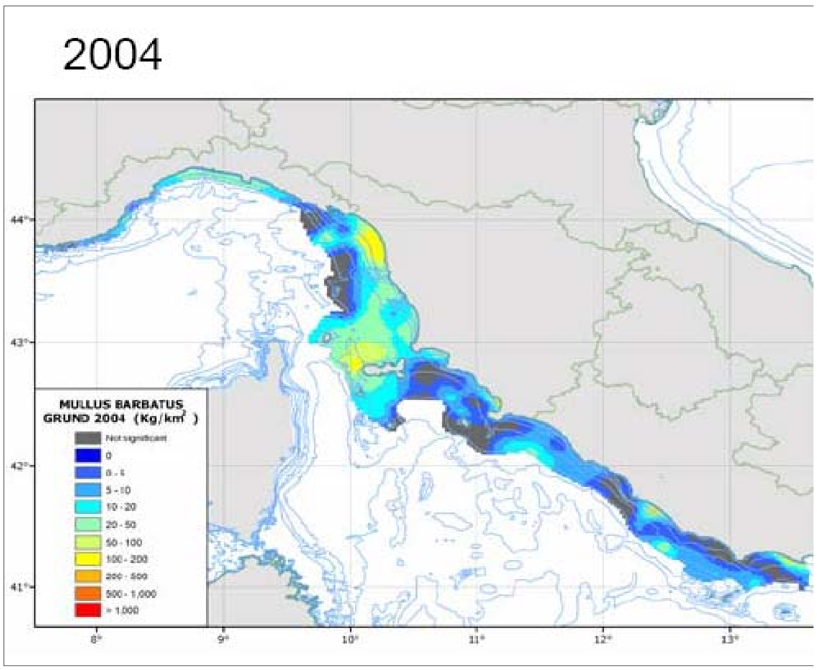


Fig. 7.8.4.1.2.1 Distribution of juveniles of red mullet in autumn 2004 (GRUND survey) in kg/km^2

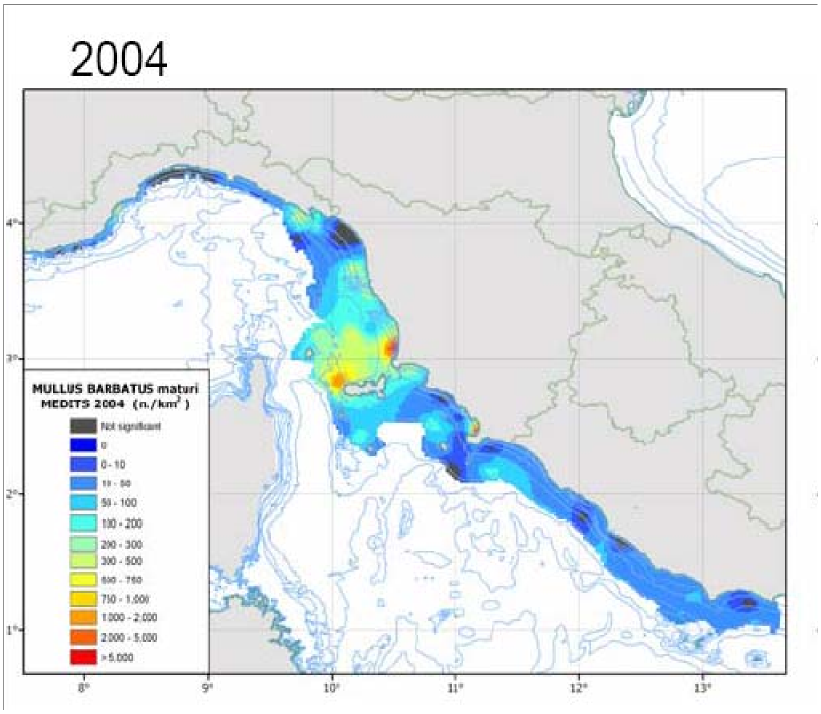


Fig. 7.8.4.1.2.2 Distribution of mature adults of red mullet in spring 2004 (MEDITS survey) in numbers/km^2

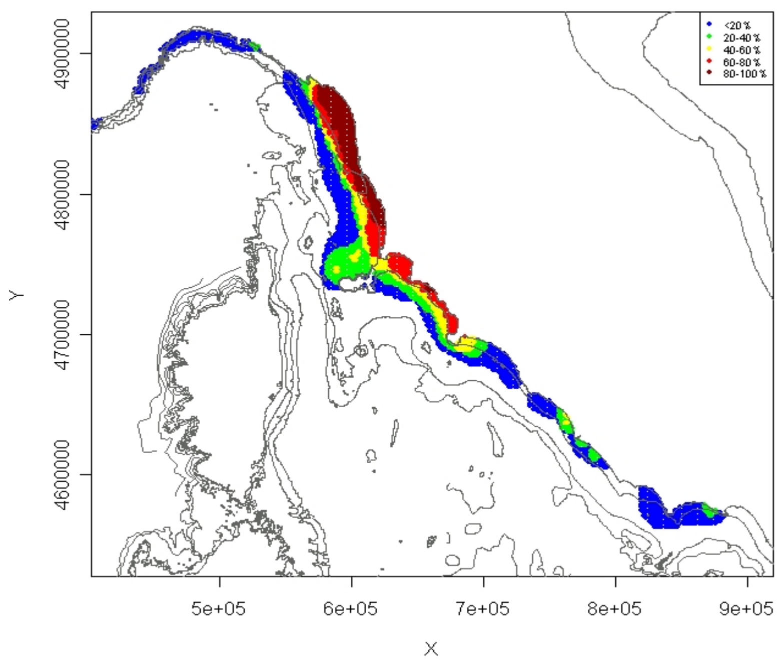


Figure 7.8.4.1.2.3. Stability analysis of the nursery areas of red mulle.t

The nursery concentrations show a marked spatial stability. Fig. 7.8.4.1.2.3 shows the areas where a major stability along time has been observed (in dark brown)

7.8.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the red mullet in GSA 09 was derived from the international survey MEDITS. Figure 7.8.4.1.3.1 displays the estimated trends in abundance and biomass.

The estimated abundance and biomass indices do not reveal any significant trend since 1994 with a mean abundance index of about 40 kg/km^2. The more recent estimated abundance indices since 2001 appear to be almost stable, even though it is characterized by a high variation (uncertainty).

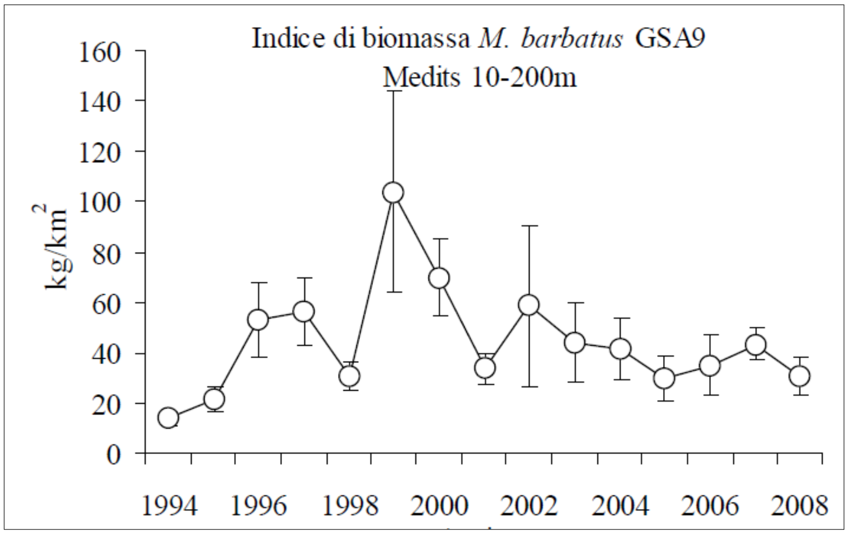


Fig. 7.8.4.1.3.1 Abundance indices of red mullet in GSA 09.

7.8.3.1.4. Trends in abundance by length or age

The following Fig. 7.8.4.1.4.1 displays the size distribution of red mullet in GSA 09 in 2006-2008.

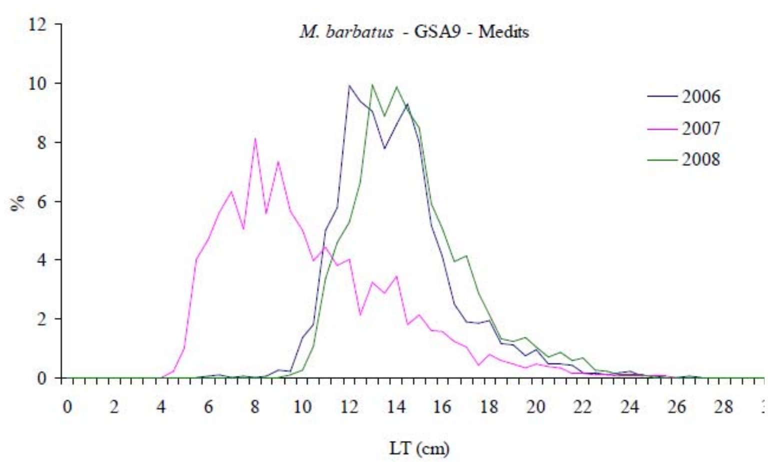


Fig. 7.8.4.1.4.1 displays the size distribution of red mullet in GSA 09 in 2006-2008.

7.8.3.1.5. Trends in growth

No analyses were conducted during SGMED-10-03.

7.8.3.1.6. Trends in maturity

No analyses were conducted during SGMED-10-03.

7.8.4. *Assessment of historic stock parameters*

7.8.4.1. Method 1: Length cohort analysis LCA

7.8.4.1.1. Justification

A LCA was performed aimed at the estimation of a vector of *F* at size, using data on total annual catches by size, including discard. Considering the short time series available, it was not possible to perform a formal VPA. An average size distribution of the catch for the years 2007-2009 was used in order to approach an equilibrium status.

7.8.4.1.2. Input parameters

Catch of red mullet proceeds from two fisheries (bottom trawlers targeting a coastal demersal assemblage and artisanal fisheries using trammel nets. The catch of trammel nets is quite modest (<2% in numbers). A reasonable hypothesis of a declining rate of M with age derived from ProdBiom was used in the computations (mean values for age 0 =1.30, age 1 = 0.79, age 2 = 0.62, age 3+ = 0.54).

7.8.4.1.3. Results

The analysis suggest a mean *F* (ages 0-3) of about 0.51. The values of *F* for the bigger ages (y>3) may be handled with care due to the limited number of individuals included in the analysis, especially for big sized individuals that live at deeper waters and are seldom caught. The performed simulations departing from the F vector derived from the LCA suggest that the current spawning stock biomass in the area is reduced to about 18% of the pristine SSB. The estimated value for $F_{0.1}$ (always a mean value including ages 0 to 3) was of 0.4.

Maturity and M vectors

PERIOD	Age	0	1	2	3	4
2006-2008	Prop. Matures	0.0	1.0	1.0	1.0	1.0

PERIOD	Age	0	1	2	3	4
2006-2008	M	1.30	0.79	0.62	0.54	0.40

F vector

F	0	1	2	3	4
2006	0.08	1.00	0.68	0.26	0.10
2007	0.15	2.14	1.40	0.23	0.10
2008	0.27	1.67	0.22	0.11	0.10
2009	0.13	1.41	0.66	0.24	0.10

Weight-at-age in the stock

Mean weight in stock (kg)	0	1	2	3	4
2006	0.004	0.041	0.095	0.134	0.188
2007	0.004	0.037	0.092	0.134	0.188
2008	0.004	0.038	0.096	0.134	0.188
2009	0.004	0.039	0.095	0.134	0.188

Weight-at-age in the catch

Mean weight in catch (kg)	0	1	2	3	4
2006	0.004	0.041	0.095	0.134	0.156
2007	0.004	0.037	0.092	0.134	0.156
2008	0.004	0.038	0.096	0.134	0.156
2009	0.004	0.039	0.095	0.134	0.156

Number at age in the catch

Catch at age in numbers	0	1	2	3	4
2006	5902406	18364587	3033915	465905	101230
2007	7084978	15913524	927790	40940	10220
2008	15935120	16979930	452647	126034	68859
2009	4775584	10430274	944309	143356	33525

Number at age in the stock

Stock numbers at age	0	1	2	3	4
2006	1.42E+08	40191521	7657180	2492521	1289336
2007	94825943	25022118	1536341	244191	130168
2008	1.24E+08	29003043	2837482	1462319	877034
2009	71420054	19155589	2439737	812103	426999

7.8.4.2. Method 2: Stock-Production model

7.8.4.2.1. Justification

The analysis was performed using the ASPIC.5 software (A Stock-Production model Incorporating Covariates) (Prager, 1994, 2005) assuming a Schaefer (1954) model. This program implements a non-equilibrium, continuous-time, observation-error estimator for the dynamic production model (Schnute, 1977; Prager, 1994). The model was used to estimate *r* (the intrinsic rate of population growth), *MSY*, the ratios of both current biomass or *F* to the biomass or F at which *MSY* can be attained, and *q* (the catchability coefficient, the proportion of total stock removed by one unit of fishing effort).

7.8.4.2.2. Input parameters

Input data consist in 2 sets of time series of total landings (in kg) and fishing effort expressed as kg/hour and kg/day for two of the main ports of the GSA9 (Viareggio and Porto Santo Stefano) which are considered representative for the area and a time series of an index of abundance (kg/km2) for the whole GSA9 derived from MEDITS surveys. The possibility of using at the same time several data sets and combinations of catch and effort and abundance indices is a new extension incorporated in ASPIC new versions.

Table 7.8.4.2.2.1 Aspic input parameters.

```
BOT                  ## Run type (FIT, BOT, or IRF)
"None Selected"
LOGISTIC YLD SSE   ## Model type, conditioning type, objective function
102                  ## Verbosity
500                 ## Number of bootstrap trials, <= 1000
1 50000              ## 0=no MC search, 1=search, 2=repeated srch; N trials
1.00000d-08          ## Convergence crit. for simplex
3.00000d-08   6      ## Convergence crit. for restarts, N restarts
1.00000d-04   0      ## Convergence crit. for estimating effort; N steps/yr
8.00000d00               ## Maximum F allowed in estimating effort
0d0          ## Weighting for B1 > K as residual (usually 0 or 1)
3                ## Number of fisheries (data series)
1.00000d00  1.00000d00  1.00000d00          ## Statistical weights for data series
4.00000d-01          ## B1/K (starting guess, usually 0 to 1)
3.50000d05           ## MSY (starting guess)
2.50000d06           ## K (carrying capacity) (starting guess)
5.00000d-04  8.00000d-04  4.00000d-04          ## q (starting guesses -- 1 per data series)
1 1 1 1 1 1          ## Estimate flags (0 or 1) (B1/K,MSY,K,q1...qn)
1.50000d05  1.00000d06         ## Min and max constraints -- MSY
4.00000d05  1.00000d07         ## Min and max constraints -- K
657438223            ## Random number seed
      16             ## Number of years of data in each series

      Series 1" Porto Santo Stefano
CE
  1994   1.92800d03   3.90290d04
  1995   2.25000d03   2.73570d04
  1996   2.32000d03   3.36430d04
  1997   2.13700d03   3.47150d04
  1998   2.62600d03   3.00910d04
  1999   2.45400d03   3.31610d04
  2000   2.35400d03   4.60630d04
  2001   1.53200d03   4.80690d04
  2002   1.17400d03   4.09930d04
  2003   1.44800d03   5.10270d04
  2004   1.59100d03   4.60480d04
  2005   1.47500d03   5.19490d04
  2006   1.62900d03   5.75110d04
  2007   1.55000d03   6.09360d04
  2008   1.42300d03   5.34110d04
  2009   1.44900d03   5.03960d04

"Series 2" Viareggio
CE
  1994   7.83750d04   6.96500d04
  1995   7.52400d04   7.13260d04
  1996   7.41950d04   7.46630d04
  1997   7.41500d04   8.51100d04
  1998   7.10600d04   1.04051d05
  1999   7.10600d04   1.41873d05
  2000   7.00150d04   1.54654d05
  2001   6.79250d04   1.70953d05
  2002   6.68800d04   1.63647d05
  2003   6.58350d04   1.43018d05
  2004   6.47900d04   1.42679d05
  2005   6.37450d04   1.44629d05
  2006   6.35560d04   1.37005d05
  2007   6.26320d04   1.50682d05
  2008   6.17260d04   1.35800d05
  2009   5.54030d04   1.20991d05

"Series 3" MEDITS trawl surveys
I1
```

1994 7.45060d00
1995 1.10108d01
1996 1.29917d01
1997 1.45988d01
1998 1.76335d01
1999 1.92935d01
2000 1.98471d01
2001 2.25128d01
2002 2.42151d01
2003 2.30405d01
2004 1.79391d01
2005 1.64171d01
2006 1.88141d01
2007 1.77500d01
2008 1.66300d01
2009 1.54800d01

7.8.4.2.3. Results

```
ASPIC -- A Surplus-Production Model Including Covariates (Ver. 5.16)
                                                        FIT program mode
Author:   Michael H. Prager; NOAA Center for Coastal Fisheries and Habitat Research        LOGISTIC model mode
          101 Pivers Island Road; Beaufort, North Carolina  28516  USA                     YLD conditioning
          Mike.Prager@noaa.gov                                                              SSE optimization

Reference:  Prager, M. H. 1994. A suite of extensions to a nonequilibrium          ASPIC User's Manual is available
          surplus-production model.  Fishery Bulletin 92: 374-389.                  gratis from the author.

CONTROL PARAMETERS (FROM INPUT FILE)                 Input file: c:\abella\aspic5\mbar09proveconoriginale.inp
-----------------------------------------------------------------------------------------------------------------
Operation of ASPIC:  Fit logistic (Schaefer) model by direct optimization.
Number of years analyzed:                16         Number of bootstrap trials:            0
Number of data series:                    3         Bounds on MSY (min, max):      1.500E+05    1.000E+06
Objective function:               Least squares       Bounds on K (min, max):      4.000E+05    1.000E+07
Relative conv. criterion (simplex):    1.000E-08       Monte Carlo search mode, trials:     1     50000
Relative conv. criterion (restart):    3.000E-08      Random number seed:                  657438223
Relative conv. criterion (effort):     1.000E-04      Identical convergences required in fitting:     6
Maximum F allowed in fitting:              8.000


PROGRAM STATUS INFORMATION (NON-BOOTSTRAPPED ANALYSIS)                                  ------------------------
-----------------------------------------------------------------------------------
Normal convergence
Number of restarts required for convergence:    590


CORRELATION AMONG INPUT SERIES EXPRESSED AS CPUE (NUMBER OF PAIRWISE OBSERVATIONS BELOW)
-----------------------------------------------------------------------------------------------------------------
                              |
 1  Series 1                  |  1.000
                              |     16
                              |
 2  Series 2                  |  0.772    1.000
                              |     16       16
                              |
 3  Series 3                  |  0.448    0.812    1.000
                              |     16       16       16
                              --------------------------------------------------
                                     1        2        3


GOODNESS-OF-FIT AND WEIGHTING (NON-BOOTSTRAPPED ANALYSIS)
-----------------------------------------------------------------------------------------------------------------
                                  Weighted         Weighted      Current      Inv. var.      R-squared
Loss component number and title     SSE        N       MSE       weight        weight        in CPUE
```

Loss(-1)	SSE in yield	0.000E+00					
Loss(0)	Penalty for B1 > K	0.000E+00	1	N/A	0.000E+00	N/A	
Loss(1)	Series 1	1.935E+00	16	1.382E-01	1.000E+00	1.906E-01	0.396
Loss(2)	Series 2	1.941E-01	16	1.386E-02	1.000E+00	1.900E+00	0.868
Loss(3)	Series 3	4.056E-01	16	2.897E-02	1.000E+00	9.091E-01	0.567

....

TOTAL OBJECTIVE FUNCTION, MSE, RMSE: 2.53476886E+00 6.035E-02 2.457E-01

MODEL PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	User/pgm guess	2nd guess	Estimated	User guess
B1/K	Starting relative biomass (in 1994)	1.198E-01	4.000E-01	5.604E-01	1	1
MSY	Maximum sustainable yield	2.553E+05	3.500E+05	3.200E+05	1	1
K	Maximum population size	7.960E+05	2.500E+06	8.654E+05	1	1
phi	Shape of production curve (Bmsy/K)	0.5000	0.5000	----	0	1

MANAGEMENT and DERIVED PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	Logistic formula	General formula
MSY	Maximum sustainable yield	2.553E+05	----	----
Bmsy	Stock biomass giving MSY	3.980E+05	K/2	K*n**(1/(1-n))
Fmsy	Fishing mortality rate at MSY	6.413E-01	MSY/Bmsy	MSY/Bmsy
n	Exponent in production function	2.0000	----	----
g	Fletcher's gamma	4.000E+00	----	[n**(n/(n-1))]/[n-1]
B./Bmsy	Ratio: B(2010)/Bmsy	6.394E-01	----	----
F./Fmsy	Ratio: F(2009)/Fmsy	1.138E+00	----	----
Fmsy/F.	Ratio: Fmsy/F(2009)	8.787E-01	----	----
Y.(Fmsy)	Approx. yield available at Fmsy in 2010	1.632E+05	MSY*B./Bmsy	MSY*B./Bmsy
	...as proportion of MSY	6.394E-01	----	----
Ye.	Equilibrium yield available in 2010	2.221E+05	4*MSY*(B/K-(B/K)**2)	g*MSY*(B/K-(B/K)**n)
	...as proportion of MSY	8.700E-01	----	----

--------- Fishing effort rate at MSY in units of each CE or CC series ---------

fmsy(1)	Series 1	4.779E+03	Fmsy/q(1)	Fmsy/q(1)
fmsy(2)	Series 2	6.440E+04	Fmsy/q(2)	Fmsy/q(2)

ESTIMATED POPULATION TRAJECTORY (NON-BOOTSTRAPPED)

Obs	Year or ID	Estimated total F mort	Estimated starting biomass	Estimated average biomass	Observed total yield	Model total yield	Estimated surplus production	Ratio of F mort to Fmsy	Ratio of biomass to Bmsy
1	1994	1.152	9.538E+04	9.436E+04	1.087E+05	1.087E+05	1.067E+05	1.796E+00	2.396E-01
2	1995	0.984	9.339E+04	1.003E+05	9.868E+04	9.868E+04	1.124E+05	1.535E+00	2.346E-01
3	1996	0.926	1.071E+05	1.169E+05	1.083E+05	1.083E+05	1.279E+05	1.445E+00	2.691E-01
4	1997	0.848	1.267E+05	1.412E+05	1.198E+05	1.198E+05	1.489E+05	1.323E+00	3.182E-01
5	1998	0.758	1.557E+05	1.770E+05	1.341E+05	1.341E+05	1.763E+05	1.182E+00	3.913E-01
6	1999	0.834	1.979E+05	2.099E+05	1.750E+05	1.750E+05	1.982E+05	1.300E+00	4.972E-01
7	2000	0.896	2.210E+05	2.241E+05	2.007E+05	2.007E+05	2.065E+05	1.397E+00	5.554E-01
8	2001	1.003	2.268E+05	2.184E+05	2.190E+05	2.190E+05	2.032E+05	1.564E+00	5.699E-01
9	2002	0.991	2.111E+05	2.066E+05	2.046E+05	2.046E+05	1.962E+05	1.544E+00	5.303E-01
10	2003	0.959	2.026E+05	2.024E+05	1.940E+05	1.940E+05	1.936E+05	1.495E+00	5.091E-01
11	2004	0.916	2.022E+05	2.059E+05	1.887E+05	1.887E+05	1.958E+05	1.429E+00	5.080E-01
12	2005	0.935	2.093E+05	2.103E+05	1.966E+05	1.966E+05	1.985E+05	1.458E+00	5.258E-01
13	2006	0.906	2.112E+05	2.146E+05	1.945E+05	1.945E+05	2.011E+05	1.413E+00	5.306E-01
14	2007	1.003	2.177E+05	2.109E+05	2.116E+05	2.116E+05	1.988E+05	1.564E+00	5.470E-01
15	2008	0.903	2.049E+05	2.096E+05	1.892E+05	1.892E+05	1.980E+05	1.408E+00	5.149E-01
16	2009	0.730	2.138E+05	2.348E+05	1.714E+05	1.714E+05	2.121E+05	1.138E+00	5.371E-01
17	2010		2.545E+05				6.394E-01		

Data type CE: Effort-catch series Series weight: 1.000

Obs	Year	Observed CPUE	Estimated CPUE	Estim F	Observed yield	Model yield	Resid in log scale	Statist weight
1	1994	2.024E+01	1.266E+01	0.4136	3.903E+04	3.903E+04	-0.46908	1.000E+00
2	1995	1.216E+01	1.346E+01	0.2729	2.736E+04	2.736E+04	0.10136	1.000E+00
3	1996	1.450E+01	1.569E+01	0.2878	3.364E+04	3.364E+04	0.07872	1.000E+00
4	1997	1.624E+01	1.896E+01	0.2458	3.472E+04	3.472E+04	0.15436	1.000E+00
5	1998	1.146E+01	2.375E+01	0.1700	3.009E+04	3.009E+04	0.72888	1.000E+00
6	1999	1.351E+01	2.817E+01	0.1580	3.316E+04	3.316E+04	0.73460	1.000E+00
7	2000	1.957E+01	3.007E+01	0.2056	4.606E+04	4.606E+04	0.42978	1.000E+00
8	2001	3.138E+01	2.931E+01	0.2201	4.807E+04	4.807E+04	-0.06811	1.000E+00
9	2002	3.492E+01	2.773E+01	0.1984	4.099E+04	4.099E+04	-0.23062	1.000E+00
10	2003	3.524E+01	2.717E+01	0.2521	5.103E+04	5.103E+04	-0.26024	1.000E+00
11	2004	2.894E+01	2.764E+01	0.2236	4.605E+04	4.605E+04	-0.04621	1.000E+00
12	2005	3.522E+01	2.822E+01	0.2470	5.195E+04	5.195E+04	-0.22154	1.000E+00
13	2006	3.530E+01	2.880E+01	0.2680	5.751E+04	5.751E+04	-0.20350	1.000E+00
14	2007	3.931E+01	2.831E+01	0.2889	6.094E+04	6.094E+04	-0.32852	1.000E+00
15	2008	3.753E+01	2.813E+01	0.2549	5.341E+04	5.341E+04	-0.28858	1.000E+00
16	2009	3.478E+01	3.151E+01	0.2146	5.040E+04	5.040E+04	-0.09865	1.000E+00

RESULTS FOR DATA SERIES # 2 (NON-BOOTSTRAPPED) Series 2

Data type CE: Effort-catch series Series weight: 1.000

Obs	Year	Observed CPUE	Estimated CPUE	Estim F	Observed yield	Model yield	Resid in log scale	Statist weight
1	1994	8.887E-01	9.397E-01	0.7381	6.965E+04	6.965E+04	0.05586	1.000E+00
2	1995	9.480E-01	9.985E-01	0.7114	7.133E+04	7.133E+04	0.05192	1.000E+00
3	1996	1.006E+00	1.164E+00	0.6387	7.466E+04	7.466E+04	0.14577	1.000E+00
4	1997	1.163E+00	1.407E+00	0.6026	8.511E+04	8.511E+04	0.18979	1.000E+00
5	1998	1.464E+00	1.763E+00	0.5879	1.041E+05	1.041E+05	0.18539	1.000E+00
6	1999	1.997E+00	2.090E+00	0.6759	1.419E+05	1.419E+05	0.04595	1.000E+00
7	2000	2.209E+00	2.232E+00	0.6901	1.547E+05	1.547E+05	0.01030	1.000E+00
8	2001	2.517E+00	2.175E+00	0.7827	1.710E+05	1.710E+05	-0.14593	1.000E+00
9	2002	2.447E+00	2.057E+00	0.7921	1.636E+05	1.636E+05	-0.17335	1.000E+00
10	2003	2.172E+00	2.016E+00	0.7066	1.430E+05	1.430E+05	-0.07479	1.000E+00
11	2004	2.202E+00	2.051E+00	0.6929	1.427E+05	1.427E+05	-0.07123	1.000E+00
12	2005	2.269E+00	2.094E+00	0.6878	1.446E+05	1.446E+05	-0.08012	1.000E+00
13	2006	2.156E+00	2.137E+00	0.6383	1.370E+05	1.370E+05	-0.00849	1.000E+00
14	2007	2.406E+00	2.100E+00	0.7144	1.507E+05	1.507E+05	-0.13574	1.000E+00
15	2008	2.200E+00	2.087E+00	0.6480	1.358E+05	1.358E+05	-0.05271	1.000E+00
16	2009	2.184E+00	2.338E+00	0.5153	1.210E+05	1.210E+05	0.06841	1.000E+00

F_{msy}	Fishing mortality rate at MSY	0.613
B/B_{msy}	Ratio: $B(2010)/B_{msy}$	0.639
F/F_{msy}	Ratio: $F(2009)/F_{msy}$	1.138

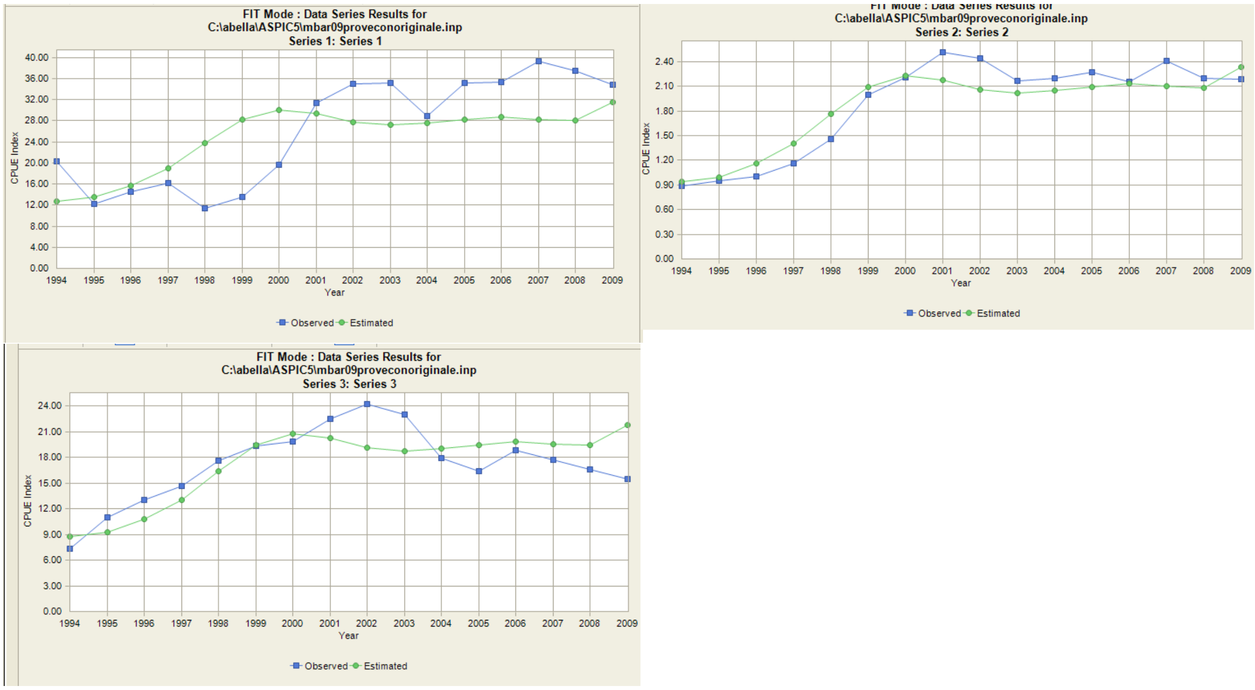


Fig. 7.8.4.2.3.1 Estimated trends in stock parameters.

7.8.5. *Scientific advice*

7.8.5.1. Short term considerations

7.8.5.1.1. State of the spawning stock size

The index of stock abundance from GRUND survey shows high variability throughout the time series, but no trend is observed. The index of abundance from MEDITS surveys, that approximates a spawning stock biomass index (almost completely represented by mature fish), suggests a positive trend from 1994 to 2008. Wide fluctuations are observed from 2002 to 2009. SGMED is unable to fully evaluate the stock size as no precautionary management reference point is defined.

7.8.5.1.2. State of recruitment

Recruitment shows a slight increasing trend, especially in the most recent years.

7.8.5.1.3. State of exploitation

SGMED proposed F_{MSY}=0.62 as limit reference point consistent with high long term yield.
The species is considered overexploited, with quite consistent estimates of the current exploitation status obtained with the 2 used approaches (F_{2009} = 0.73 with ASPIC, $F_{2007\text{-}2009}$=0.51 with LCA) are higher than the values considered limit reference points (F_{MSY}=0.62 and $F_{0.1}$ =0.40 respectively). The size of first capture is too low (growth overfishing) and an increase in yield can be expected in the case a reduction of fishing effort do occur and/or more selective gears are used. It is advised to avoid the fishing within the 3 miles distance from the shore as well as the landing of undersized individuals in order to discourage fishing pressure on juveniles.

7.8.5.2. Medium term considerations

SGMED-10-03 concludes that the red mullet stock in GSA 09 has no significant recovery potential under the current fishing strategy. Under the status quo F, an increase in biomass is expected but it is likely will not reach the B_{MSY} level. According to the results from the Stock production Model and ASPIC, a reduction of about 14% of *F* is likely to drive the stock biomass close to the B_{MSY} level. A lightly major reduction (of about 20%) should be necessary based on the results of the cohort analysis using VIT. The perception of the exploitation status as well as the need of a relatively modest reduction of fishing mortality needed to drive F to F_{MSY} (respectively about 14 and 20% for the biomass dynamic model and LCA) are very similar. The absolute values of F are different, but this difference is related to the F on which we are referring to in the two models. While for ASPIC-P the estimated value of F is a sort of mean weighted fishing mortality, the F value derived from VIT, and used in the computations, is the simple average for all the age classes up to age 3 and $F_{0.1}$ is estimated as a fraction (relative) of this value. From VIT is also possible to estimate weighted averages based on the catches by age, or means for the more represented ages in the catch. In these cases higher values of F_{stq}, and consequently for $F_{0.1}$, similar to those derived from ASPIC, can be obtained.

7.9. Stock assessment of red mullet in GSA 10

7.9.1. *Stock identification and biological features*

7.9.1.1. Stock Identification

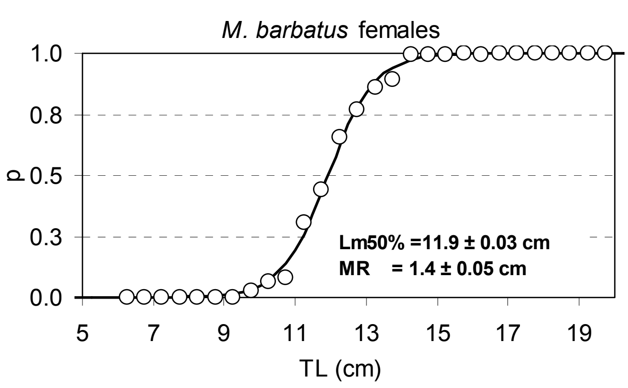
Red mullet stock was assumed in the boundaries of the whole GSA 10, lacking specific information on stock identification. *M. barbatus* is with European hake and deep-water rose shrimp a key species of the fishing assemblages in the central-southern Tyrrhenian Sea (GSA 10). The species is almost exclusively distributed on the continental shelf and is a rather small-sized, fast-growing and characterized by a relatively short lifespan. It spawns in late spring-early summer with a peak in June-July. In late summer, recently settled juveniles are highly concentrated nearshore and this concentration is still present until October. Aggregation of juveniles and subsequent movements towards more offshore grounds have been reported and indicated as a source of increased vulnerability of this population component to harvest (Voliani *et al*., 1998). During late summer-early autumn (September-October), the species is intensely fished. About three-four months after settlement, red mullet has spread up to depths of about 100 m.

7.9.1.2. Growth

The growth of red mullet has been studied in the GSA 10 using two different approaches that allowed the validation of the aging: 1) whole otolith readings and 2) the analysis of length-frequency distributions using techniques as Batthacharya for separation of modal components. The estimates of the von Bertalanffy growth parameters by sex for the period 2006-2009were: females L_∞=27 cm k=0.363 t_0= -0.6; males: L_∞=21 cm k=0.534 t_0= -0.5; sex combined L_∞=26 cm k=0.42 t_0= -0.4. Parameters of the length-weight relationship were a=0.0105; b=3.0207 for females, a=0.0103; b=3.0231 for males and a=0.0103; b=3.0246 for sex combined.

7.9.1.3. Maturity

According to the data obtained in the DCF, 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 the period 2006-2008 is reported in the table below together with the estimated maturity ogives which indicates a $L_{m50\%}$ of about 12 cm (±0.03 cm) (Fig. 7.9.1.3.1).



TL (cm)	Proportion of mature females
9	0.017
10	0.075
11	0.38
12	0.71
13	0.88
14	0.99
15	0.99
16	0.99
17	1
18	1
19	1
20	1

Fig. 7.9.1.3.1 Maturity ogives and proportions of mature female of red mullet in the GSA 10 (MR indicates the difference $Lm_{75\%}$-$Lm_{25\%}$).

The sex ratio was in favour of males up to the size of about 11 cm and females start to prevail for large individuals (Fig. 7.9.1.3.2).

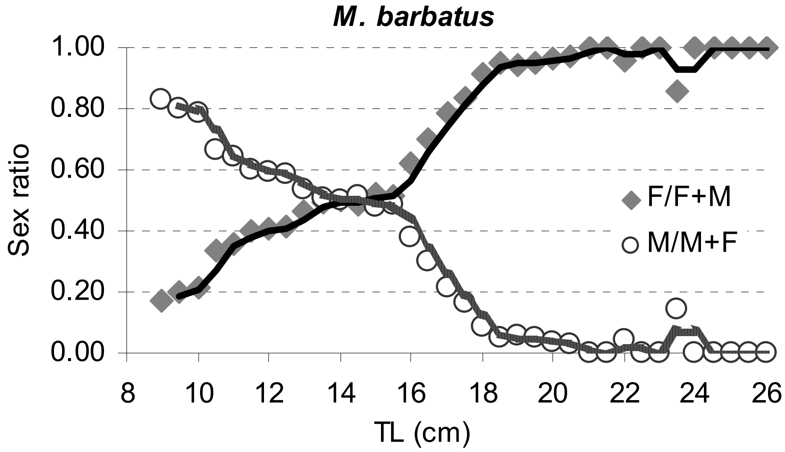


Fig. 7.9.1.3.2 Sex ratio for females and males by length.

7.9.2. *Fisheries*

7.9.2.1. General description of fisheries

Red mullet is an important species in the area, targeted by trawlers and small scale fisheries using mainly gillnet and trammel nets. Fishing grounds are located along the coasts of the whole GSA within the continental shelves.

7.9.2.2. Management regulations applicable in 2009 and 2010

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 is 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 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 licences.
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.

7.9.2.3. Catches

7.9.2.3.1. Landings

Available landing data collected under the DCF framework ranged from 524 tons in 2004 to 278 tons in 2009, the latter being the lowest value registered (Tab. 7.9.2.3.1.1). Most part of the landings of red mullet were from trawlers up to 2006 (Fig. 7.9.2.3.1.1), while since 2007 the level of catches of trawlers is similar to that of the other métier grouped together, to which the maximum contribution is given by gillnet (GNS) and trammel net (GTR). Since 2008 the catches of both métier are decreasing.

Tab. 7.9.2.3.1.1 Annual landings by major fishing techniques in tons for red mullet in the GSA 10 (2004-2009).

Sum of LW				YEAR					
AREA	SPECIES	FT_L	FT_LVL5	2004	2005	2006	2007	2008	2009
10	MUT			9.80	39.31	0.55		0.09	
		GND	Small pelagic fish		0.02			0.04	
		GNS	Demersal species	15.77	24.87	34.51	24.43	7.19	7.08
		GTR	Demersal species	96.05	102.20	68.25	212.21	125.37	97.73
		LLS	Demersal fish	0.58					
		OTB	Deep water species			1.35	0.26	0.23	0.23
			Demersal species	183.87		19.38	42.62	145.60	122.28
			Mixed demersal and deep water species	216.50	254.98	268.98	222.36	36.44	51.20
		PS	Small pelagic fish	0.04					
		SB-SV	Demersal species	1.77					
	MUT Total			524.38	421.38	393.02	501.88	314.96	278.52

7.9.2.3.2. Discards

The proportion of the discards of red mullet in the GSA 10 was generally low and concentrated in the third and fourth quarter, when recruitment is occurring. In 2006 the estimate of discard proportion compared to the total landings in the GSA was about 2% in weight. Despite this value was lower than the prescription of reg UE 1639/2001 (10% in weight or 20% in number), the composition in length and age was estimated, showing the dominance of the age 0 group with an the average length of 8.7 cm. In 2006, 8 t of discards were reported. In 2009 the reported biomass of discard was 3.4 tons.

7.9.2.3.3. Fishing effort

The trends in fishing effort by year and major gear type in terms of kWdays are listed in Tab. 7.9.2.3.3.1.

Tab. 7.9.2.3.3.1 Trend in fishing effort (kW*days) for GSA 10 by gear type, 2004-2009 as reported through the DCF official data call.

Sum of KWDAYS				YEAR					
COUNTRY	AREA	FT_LVL	FT_LVL5	2004	2005	2006	2007	2008	2009
ITA	10			3519197	4007554	3100388	2443896	1814941	1806725
		DRB	Molluscs	86367	320173	310045	148014	231605	183186
		FPO	Demersal species		314276	147983			
		GND	Small pelagic fish	233350	167135	562722	453447	442960	438783
		GNS	Demersal species	3733486	4991450	2920088	2044527	2430099	2574024
			Small and large pelagic fish	1549			84412	1910	30418
		GTR	Demersal species	3151368	1739872	4199352	3897405	3005134	2498246
		LHP-LHM	Cephalopods	619019	437364	397018	341953	773830	1076201
			Finfish	268	3849	1709	14405		
		LLD	Large pelagic fish	480149	1085372	606942	411540	307955	1140807
		LLS	Demersal fish	2486099	2006238	1462244	1320208	1259852	816877
		LTL	Large pelagic fish						
		OTB	Deep water species			240741	131937	140964	295269
			Demersal species	4055773	75241	1540349	1595569	3808424	3483512
			Mixed demersal and deep water species		8416369	5992696	5934631	2752751	3076559
		PS	Large pelagic fish	1372121	800937	103190	157860	231965	506989
			Small pelagic fish	2258283	1946520	1902659	1782940	952413	1713744
		PTM	Small pelagic fish	6204					
		SB-SV	Demersal species	619495	205264	111798	32984	107412	20545
Total				22622728	26517614	23599924	20795728	18262215	19661885

7.9.3. *Scientific surveys*

7.9.3.1. Medits

7.9.3.1.1. Methods

According to the MEDITS protocol (Bertrand et al., 2002), trawl surveys were carried out yearly (May-July), applying a random stratified sampling by depth (5 strata with depth limits at: 50, 100, 200, 500 and 800 m; each haul position randomly selected in small sub-areas and maintained fixed throughout the time). Haul allocation was proportional to the stratum area. The same gear (GOC 73, by P.Y. Dremière, IFREMER-Sète), with a 20 mm stretched mesh size in the cod-end, was employed throughout the years. Detailed data on the gear characteristics, operational parameters and performance are reported in Dremière and Fiorentini (1996). Considering the small mesh size a complete retention was assumed. Abundance data (number of fish per surface unit) were standardised to square kilometre, using the swept area method.

Based on the DCR data call, abundance and biomass indices were recalculated. In GSA 10 the following number of hauls were reported per depth stratum (Tab. 7.9.3.1.1.1).

Tab. 7.9.3.1.1.1. Number of hauls per year and depth stratum in GSA 10, 1994-2009.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GSA10_010-050	7	8	8	8	8	8	8	8	6	7	7	7	7	7	7	7
GSA10_050-100	10	10	10	10	10	10	10	10	9	8	8	8	8	8	8	8
GSA10_100-200	17	17	17	17	17	17	17	17	14	14	14	14	14	14	14	14
GSA10_200-500	22	22	22	22	22	22	22	24	18	18	18	18	18	18	19	18
GSA10_500-800	28	28	28	28	28	27	28	26	23	23	23	23	23	23	22	23

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

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

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

Where:

- A=total survey area
- Ai=area of the i-th stratum
- si=standard deviation of the i-th stratum
- ni=number of valid hauls of the i-th stratum
- n=number of hauls in the GSA
- Yi=mean of the i-th stratum
- Yst=stratified mean abundance
- V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien *et al*. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA.

7.9.3.1.2. Geographical distribution patterns

Map of the bubble plot of the survey indices indicates a higher abundance of the population in the southernmost part of the area, along the mainland and the north Sicily coasts. The approach based on spatial indicators (Woillez *et al*., 2007) to characterise the spatial dynamics of red mullet life stages has been applied to the GSA 10 (Spedicato *et al*., 2007), with the objectives of identifying areas where red mullet recruits are more concentrated (Fig. 7.9.3.1.2.1), establishing relationships with the adult distribution and detecting the ability of spatial indicators to capture the stability of the spatial occupation of preferential sites across the years. The spatial indices mainly studied were the centre of gravity (CG), the inertia (I) and the global index of collocation (GIC). Gravity centres (xcg-longitude; ycg-latitude; graph below) by age groups across years and life-stages highlighted a less changing spatial location of the younger age (A1) compared to the older ones (A2 and A3) that were more dispersed. The approach of the spatial indicators enabled the location of the geographical zone (along the Calabrian coast, southwards in the study area) where recruits (age 0 fish) of red mullet are mainly distributed and to verify that these locations are rather stable across years.

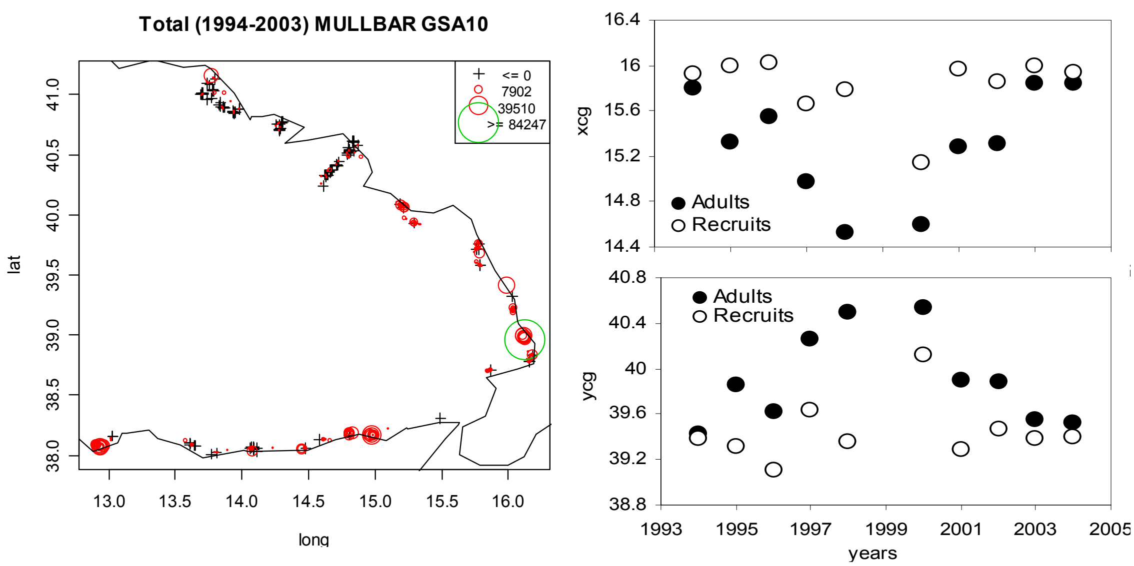


Fig. 7.9.3.1.2.1 Scaled survey catches of red mullet in GSA 10 and centre of gravity (CG) of recruits and adults.

7.9.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the red mullet in GSA 10 was derived from the international survey MEDITS. Figure 7.9.3.1.3.1 displays the estimated trend in red mullet abundance and biomass in GSA 10. Abundance indices from MEDITS trawl-survey show a very variable pattern also due to the presence of recruits in some years. However, an increasing pattern was observed from 1999 to 2002, a decreasing pattern from 2000 to 2006 and again an increasing in 2007, followed by a sharp reduction in 2008 and a new remarkable rising in 2009. Biomass indices followed a similar pattern except for the last value that was low (Fig. 7.9.3.1.3.1).

The re-estimated abundance and biomass indices do reveal identical trends (Figure 7.9.3.1.3.2) to those shown above. However, the recent abundance and biomass indices in 2007 appear high but are subject to high uncertainty.

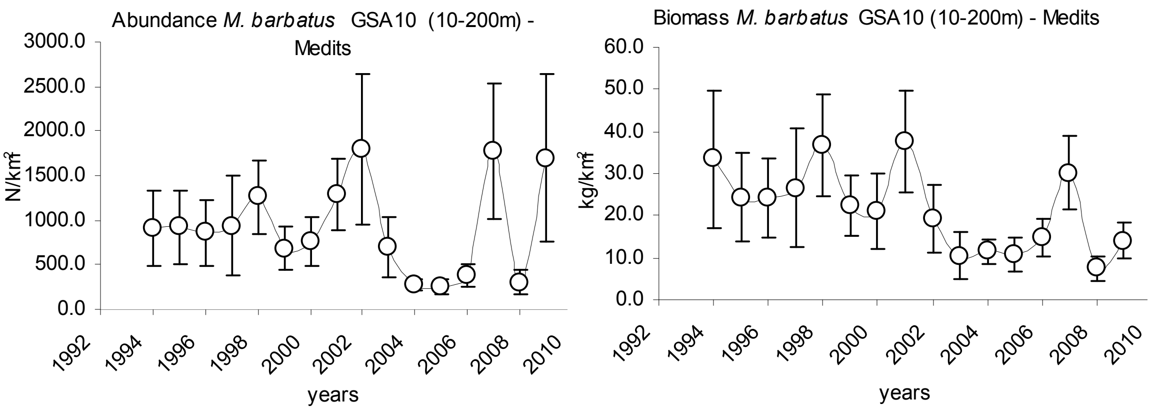


Fig. 7.9.3.1.3.1 Trends in survey abundance and biomass derived from MEDITS.

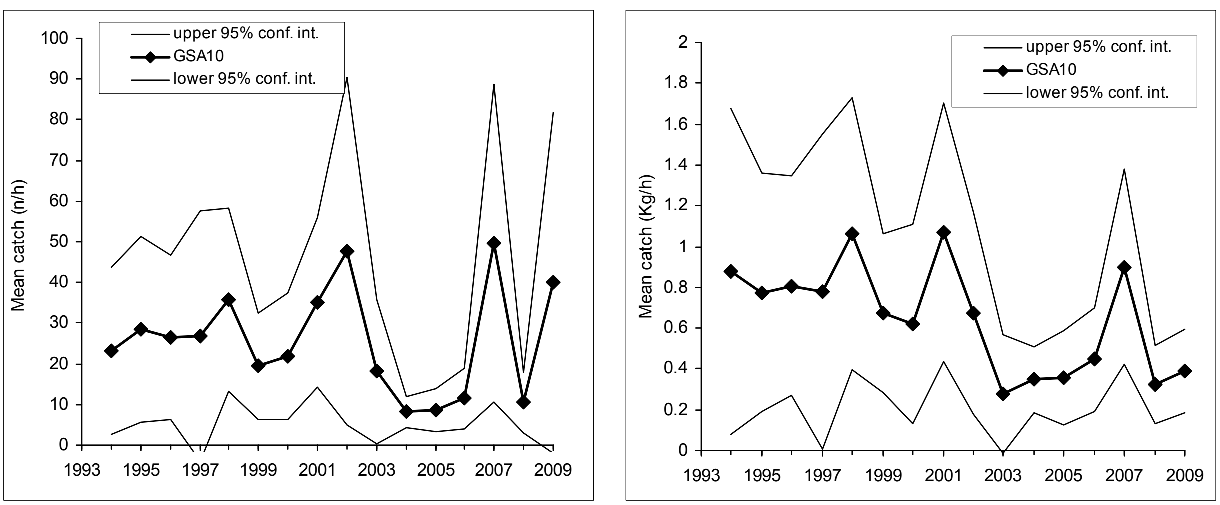


Fig. 7.9.3.1.3.2 Abundance and biomass indices of red mullet in GSA 10 derived from MEDITS.

7.9.3.1.4. Trends in abundance by length or age

No trend in the mean length was observed in MEDITS survey.

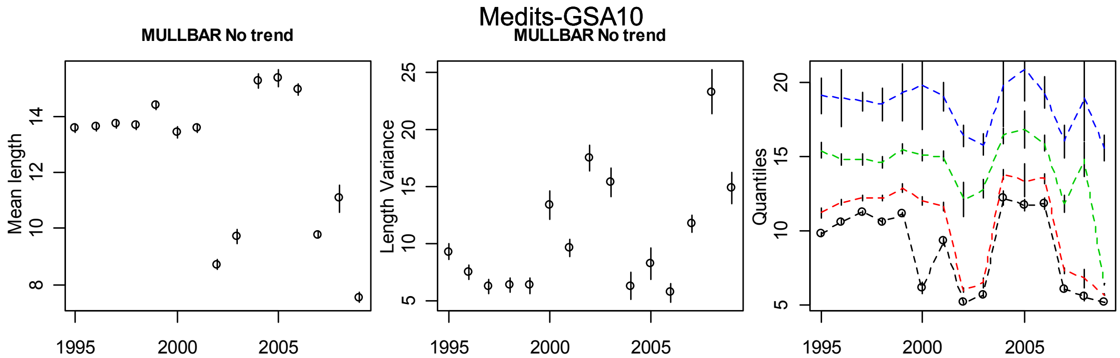


Fig. 7.9.3.1.4.1 Mean length, variance and quantiles derived from the MEDITS length compositions.
Fig. 7.9.3.1.4.2 and 3 display the stratified abundance indices by length of red mullet in the GSA 10 in 1994-2001 and 2002-2009.

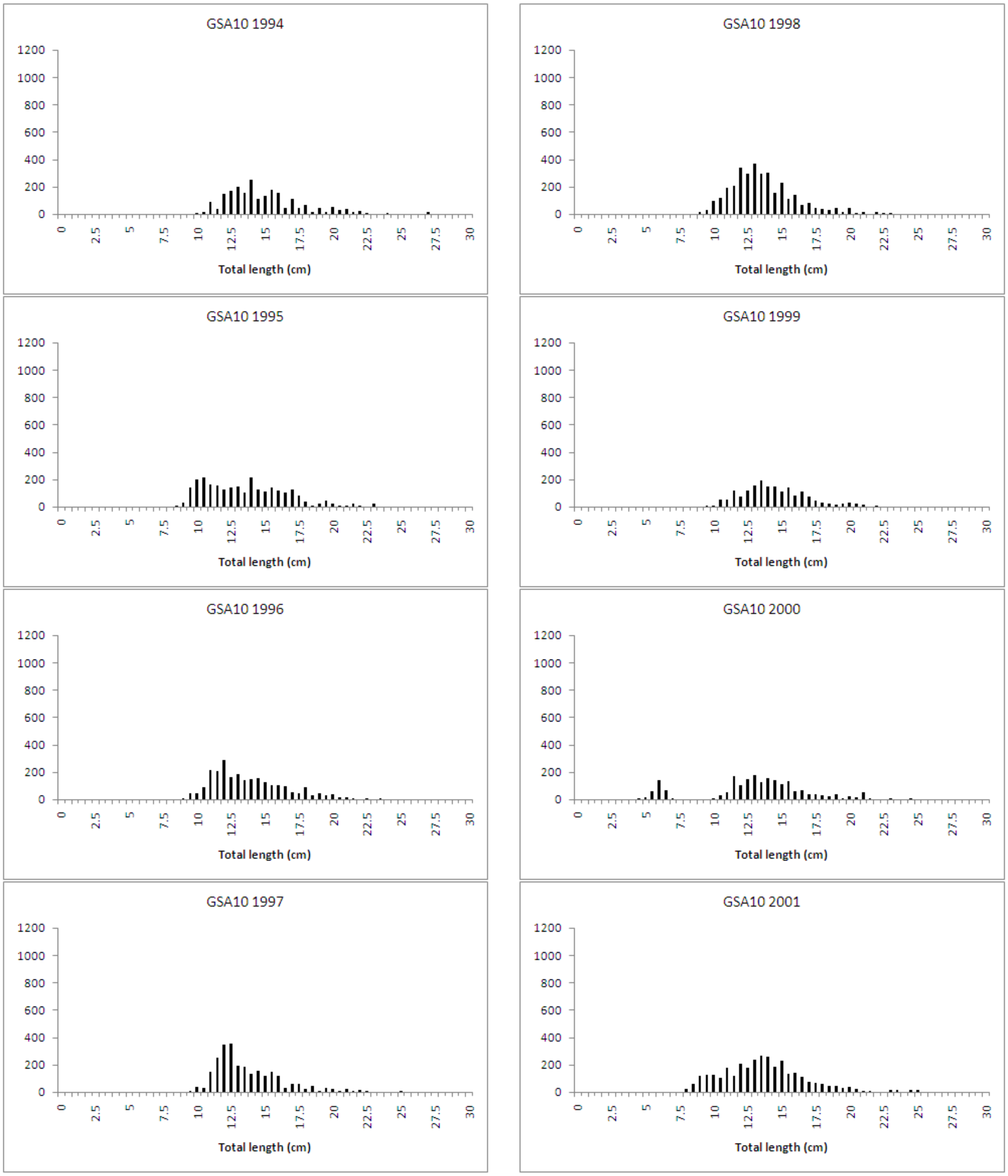


Fig. 7.9.3.1.4.2 Stratified abundance indices by size, 1994-2001.

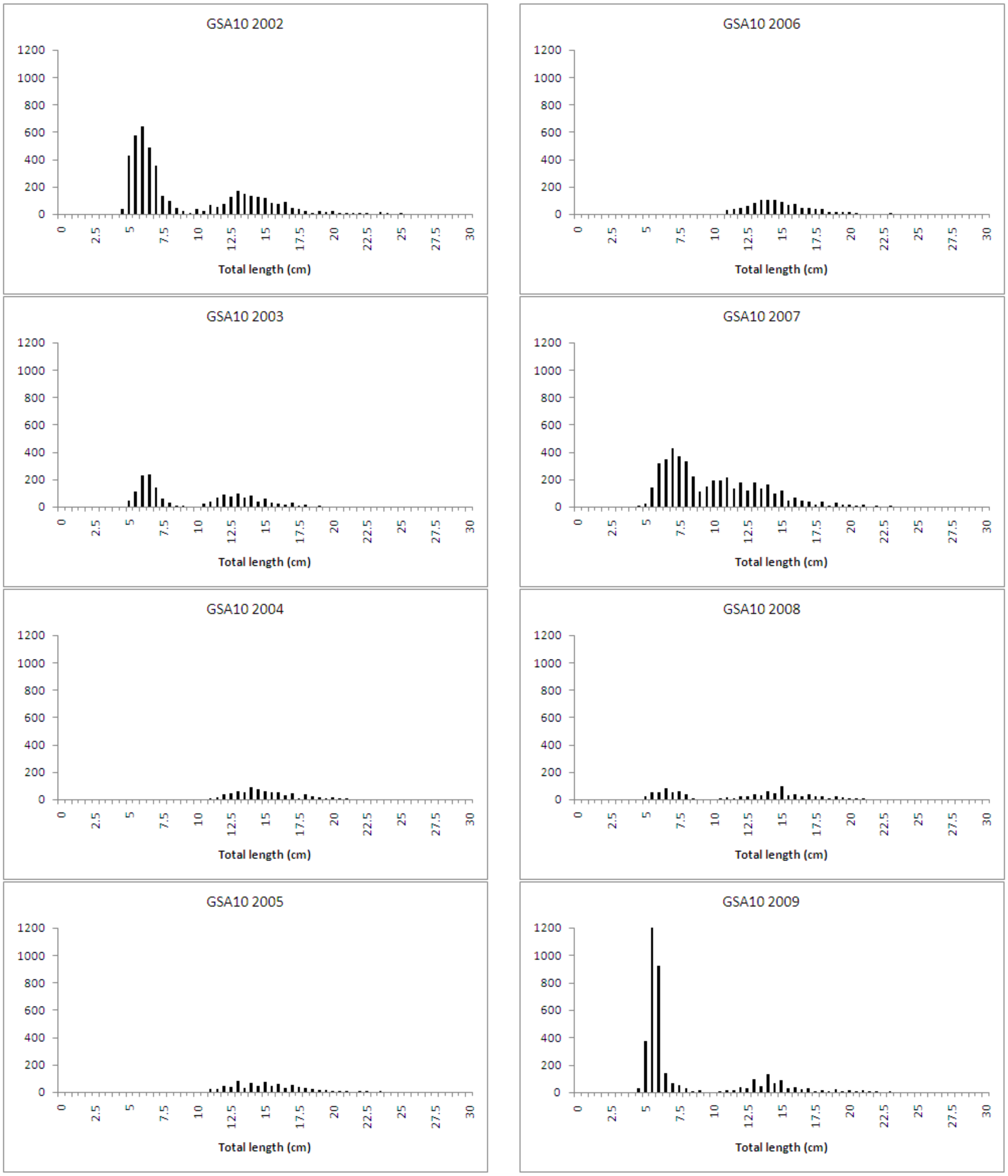


Fig. 7.9.3.1.4.3 Stratified abundance indices by size, 2002-2009.

7.9.3.2. GRUND

7.9.3.2.1. Methods

Since 2003 GRUND surveys (Relini, 2000) was conducted using the same sampler (vessel and gear) in the whole GSA. Sampling scheme, stratification and protocols were similar as in MEDITS. All the abundance data (number of fish and weight per surface unit) were standardised to km^2 using the swept area method.

7.9.3.2.2. Geographical distribution patterns

Map of abundance of recruits (n·km^{-2}) as estimated using GRUND data and the ordinary kriging shows that the sub-zones where the recruits are mainly concentrated along the nearshore grounds of the southernmost part of the GSA, except a nucleus located in the northernmost side (Fig. 7.9.3.2.2.1). The higher values were around 25000 recruits·km^{-2}. On average, considering the analyzed distributions (years 1994-2005), the recruits are individual smaller than 11.5 cm (±1.08). These individual are mostly belonging to the age 0+ group.

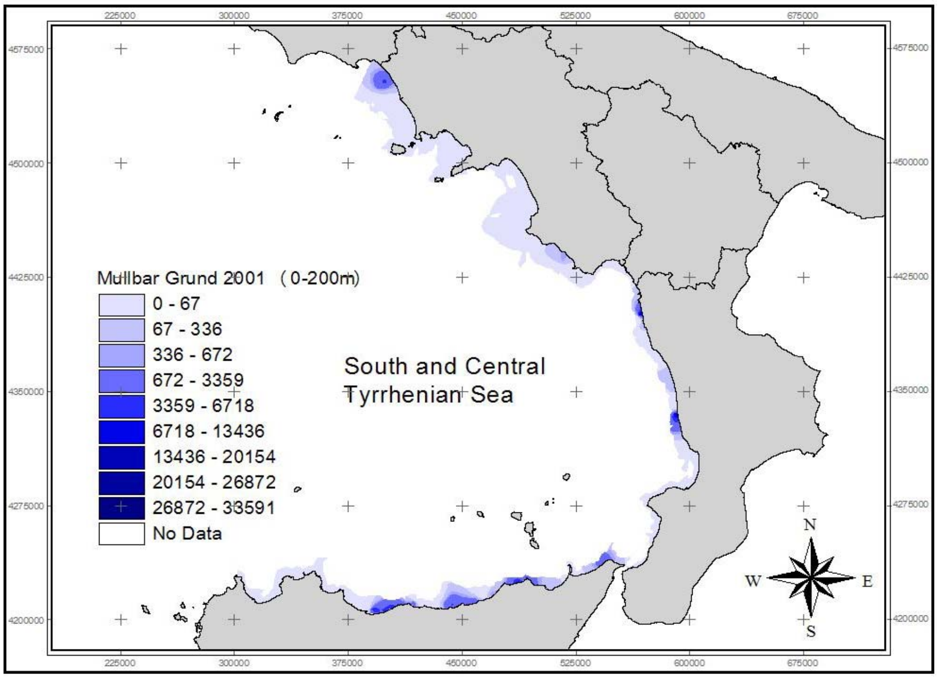


Fig. 7.9.3.2.2.1 Map of abundance of recruits (n·km^{-2}) as estimated using GRUND data and the ordinary kriging.

7.9.3.2.3. Trends in abundance and biomass

Similar to MEDITS trends are derived from the GRUND survey and shown in Fig. 7.9.3.2.3.1. Biomass and abundance indices were both decreasing, while the recruitment indices were highly variable but without any significant trend. Low levels were however observed in the periods 1994-1996 and 2003-2008.

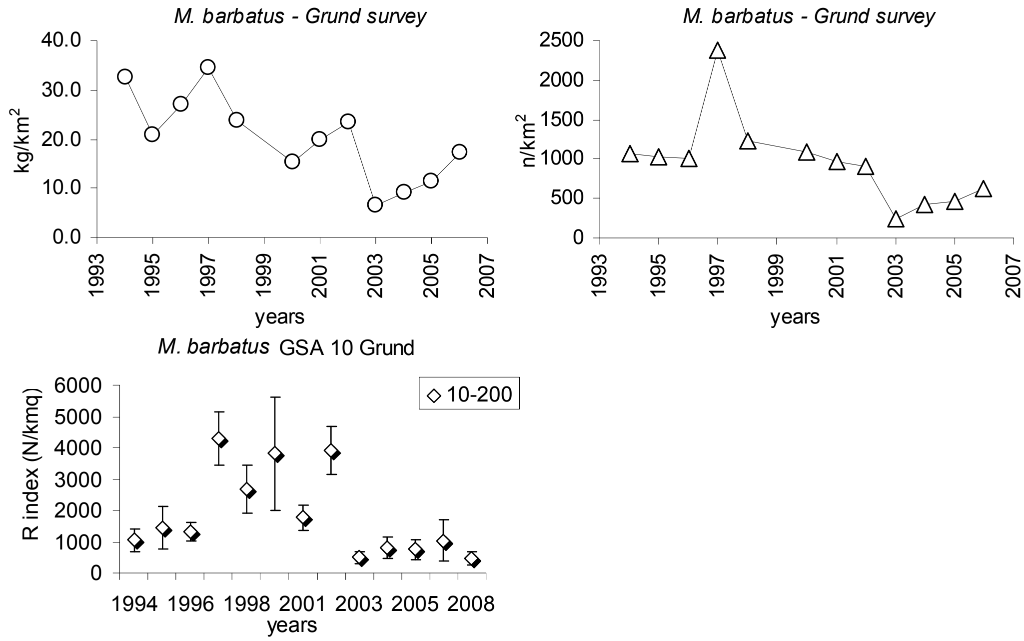


Fig. 7.9.3.2.3.1. Abundance and biomass indices of red mullet in GSA 10 derived from GRUND survey. Also recruitment indices ($n \cdot km^{-2}$) with standard deviation are reported.

7.9.3.2.4. Trends in abundance by length or age

No analyses presented during SGMED-10-03.

7.9.3.2.5. Trends in growth

The occurrence of growth change along time was not fully explored during SGMED-10-02.

7.9.3.2.6. Trends in maturity

No analyses were conducted during SGMED-10-03.

7.9.4. *Assessment of historic stock parameters*

7.9.4.1. Method 1: VIT

7.9.4.1.1. Justification

Four complete years (2006-2009) of length frequency distributions of the landings were available, thus only an approach under steady state (pseudocohort) assumption was applicable to the data. Cohort (VPA equation) and Y/R analyses as implemented in the package VIT4win were used (Lleonart and Salat, 1997). Data of number at age were derived from DCF official data in the GSA 10.

7.9.4.1.2. Input parameters

A sex combined analysis was carried out. Regarding growth parameters the set L_∞=26 cm k=0.42 t_0= -0.4 was re-parameterized to the following equivalent set: L_∞=28 cm k=0.4 t_0= -0.4, given the presence of individuals with length higher than 26 cm. The length-weight relationship parameters were: a=0.0103; b=3.0246. A constant natural mortality M = 0.61 (Alagaraja, 1984) was adopted. This value was close to 0.7 an estimate reported for a very slightly exploited area in the Castellammare Gulf (northern Sicily coasts). The terminal fishing mortality was thus set at: F_{term}= 0.7. In 2007 a plus group (6+) have been introduced. The setting of the proportion of mature females was 0.16 at age 0, 0.92 at age 1 and 1 at age 2. These values were derived from the proportion at length and the VBGF.

		2006		2007		2008		2009
Age	OTB	NETS	OTB	NETS	OTB	NETS	OTB	NETS
0	5003994	602178	805789	3494216	2519934	2025658	2504690	3853305
1	3925223	1050253	3819521	4475418	3435757	884473	2234788	872911
2	1434474	510025	2129294	636888	586445	680003	1025517	108655
3	220832	140452	135683	137453	46447	220801	210563	17345
4	30914	18450	18419	38257	9401	75144	40626	4497
5	1744	673	12542	7828	3682	14732	9375	4308
6+	919	0	2020	7418	2174	0	4959	3281

7.9.4.1.3. Results

The Figures 7.9.4.1.3.1 shows the pattern of catch at age by year and fishing gear. The pattern of the reconstructed age class catch in weight is rather variable among the years, however the age 2 and 3 are the more abundant. Total mortality rate Z, total fishing mortality F, fishing mortality by fishing gear (OTB and Nets), as estimated by LCA using VIT are reported in the Fig. 7.9.4.1.3.2. Also the pattern of the fishing mortality by fishing fleet is rather variable among years and fishing mortality rates from the set nets is high on the older age classes in 2006 and 2008 compared with 2007 and 2009.
The results for the cohort analysis show a current fishing mortality changing from 1.12 in 2006 to 0.57 in 2009, on average around 0.84. In the last year a lower fishing mortality has been estimated.

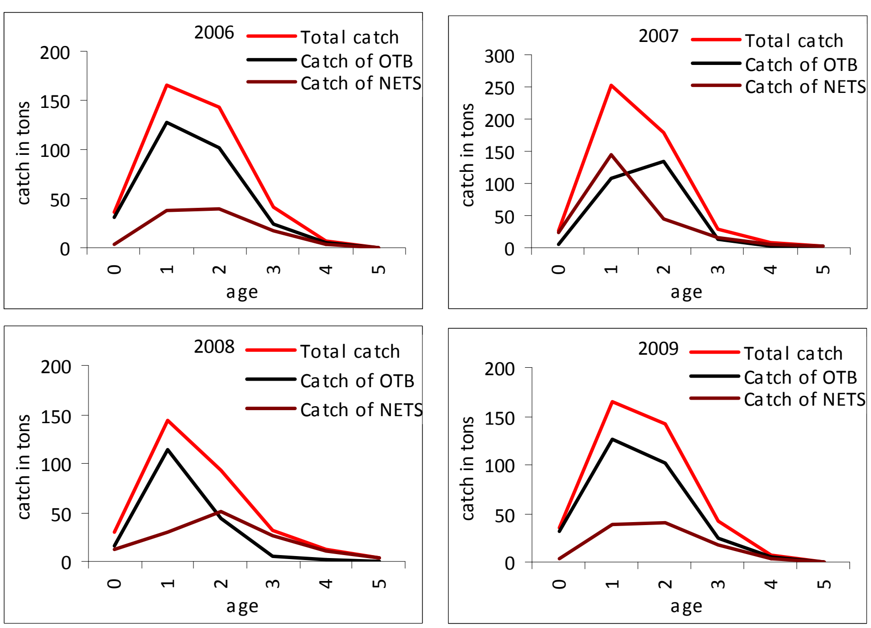


Fig. 7.9.4.1.3.1 Pattern of catch at age per year and fishing gear as estimated by the cohort analysis.

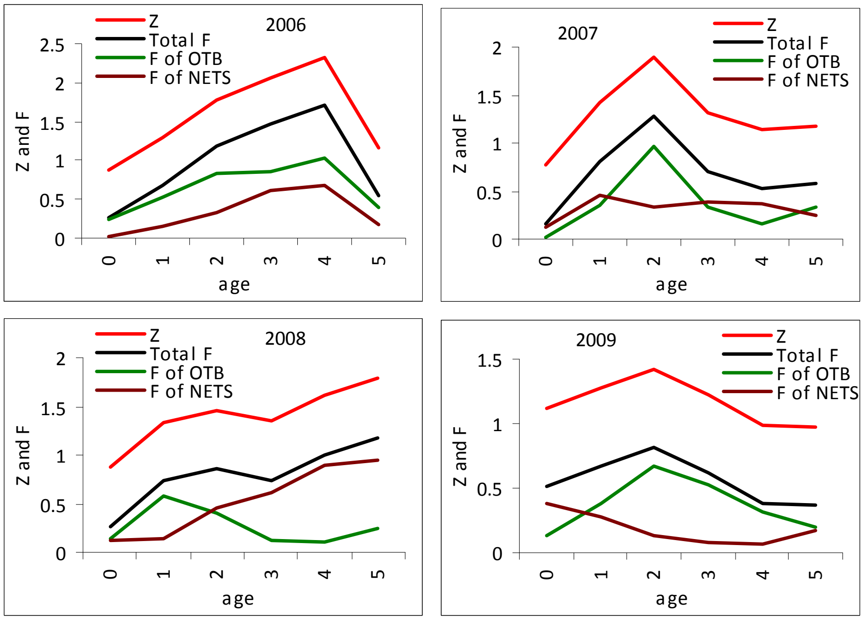


Fig. 7.9.5.3.2 Total and fishing mortality by age and gear as estimated by the cohort analysis.

7.9.5.*Long term prediction*

7.9.5.1. Justification

Yield per recruit analysis has been conducted by means of the VIT4win program.

7.9.5.2. Input parameters

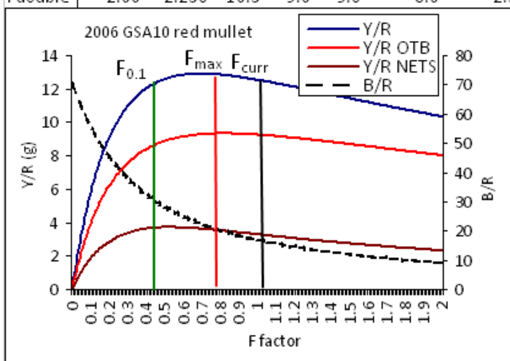
Yield per recruit (Y/R) analysis was performed for each year. Input parameters are the same as used in the VIT programRegarding growth parameters the set L_{∞}=26 cm k=0.42 t_0= -0.4 was re-parameterized to the following equivalent set: L_{∞}=28 cm k=0.4 t_0= -0.4, given the presence of individuals with length higher than 26 cm. The length-weight relationship parameters were: a=0.0103; b=3.0246. A constant natural mortality M = 0.61 (Alagaraja, 1984) was adopted. This value was close to 0.7 an estimate reported for a very slightly exploited area in the Castellammare Gulf (northern Sicily coasts). The terminal fishing mortality was thus set at: F_{term}= 0.7 that was close to the natural mortality. In 2007 a plus group (6+) have been introduced. The setting of the proportion of mature females was 0.16 at age 0, 0.92 at age 1 and 1 at age 2. These values were derived from the proportion at length and the VBGF.
Input cach at age used in VIT are below reported.

		2006		2007		2008		2009
Age	OTB	NETS	OTB	NETS	OTB	NETS	OTB	NETS
0	5003994	602178	805789	3494216	2519934	2025658	2504690	3853305
1	3925223	1050253	3819521	4475418	3435757	884473	2234788	872911
2	1434474	510025	2129294	636888	586445	680003	1025517	108655
3	220832	140452	135683	137453	46447	220801	210563	17345
4	30914	18450	18419	38257	9401	75144	40626	4497
5	1744	673	12542	7828	3682	14732	9375	4308
6+	919	0	2020	7418	2174	0	4959	3281

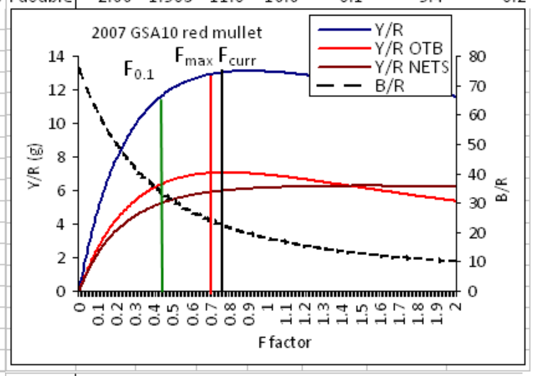
7.9.5.3. Results

The yield curves were slightly dome-shaped, in particular in 2007. The value of $F_{0.1}$ ranged between 0.32 in 2009 to 0.47 in 2008, and was on average 0.42. Average mortality was computed on ages 1-5.

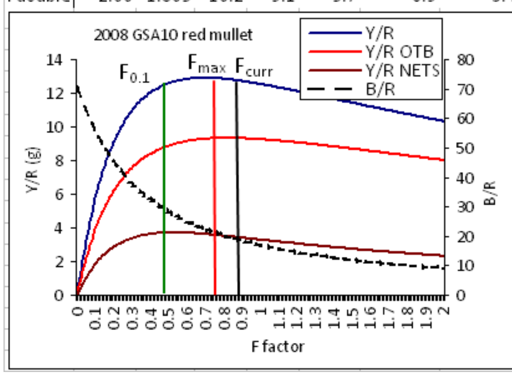
2006	Factor	F	Y/R	B/R	SSB	Y/R OTB	Y/R NETS
F(0)	0.00	0	0	70.6	65.2	0	0
F(0.1)	0.42	0.469	12.2	31.6	26.7	8.5	3.7
Fmax	0.70	0.782	12.9	22.6	18.1	9.3	3.6
Fcurr	1.01	1.118	12.5	16.9	12.7	9.3	3.3
Fdouble	2.00	2.236	10.3	9.0	5.6	8.0	2.3



2007	Factor	F	Y/R	B/R	SSB	Y/R OTB	Y/R NETS
F(0)	0.00	0	0	75.7	70.3	0	0
F(0.1)	0.55	0.430	12.4	28.8	23.9	6.8	5.6
Fmax	0.91	0.711	13.1	19.7	15.1	7.0	6.1
Fcurr	1.01	0.781	13.1	18.0	13.5	6.9	6.2
Fdouble	2.00	1.563	11.6	10.0	6.1	5.4	6.2



2008	Factor	F	Y/R	B/R	SSB	Y/R OTB	Y/R NETS
F(0)	0.00	0	0	70.6	65.2	0	0
F(0.1)	0.52	0.469	11.5	30.6	25.9	5.7	5.8
Fmax	0.84	0.758	12.2	21.5	17.1	6.7	5.4
Fcurr	1.01	0.903	12.1	18.3	14.1	7.0	5.1
Fdouble	2.00	1.805	10.2	9.1	5.7	6.9	3.4



2009	Factor	F	Y/R	B/R	SSB	Y/R OTB	Y/R NETS
F(0)	0.00	0	0	70.6	65.2	0	0
F(0.1)	0.56	0.318	9.9	27.7	23.4	6.6	3.3
Fmax	0.80	0.454	10.3	20.3	16.4	6.7	3.6
Fcurr	1.01	0.568	10.1	15.7	12.2	6.3	3.8
Fdouble	2.00	1.135	7.8	6.3	3.9	4.1	3.8

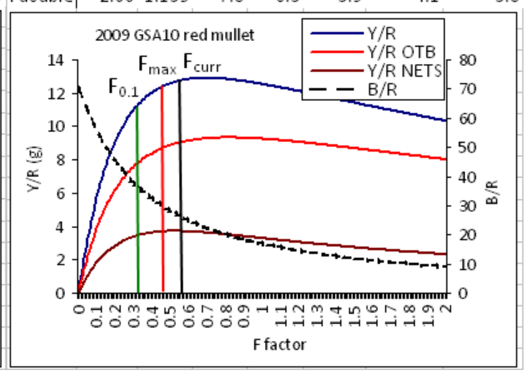


Fig. 7.9.5.3.2 Y/R curves by gear and year from VIT analysis. For each year the overall estimates regarding F-factor, F (F_0, $F_{0.1}$, F_{max}, F_{curr}, F_{double}), overall and by gear Y/R, B/R and SSB are reported.

7.9.6. *Data quality and availability*

Some discrepancies were identified from the cross-checking between estimates related to total landings (transversal variables) and raised catch structures by metier (biological metier related variable). This can be a consequence of the different classification of the fishing activity (fishing segments and metier) that can rise when the fleet is characterised by an opportunistic behaviour, i.e. frequent change, during the year, of gear (for example, from gillnets to long-line) or of fishing ground (for example, from demersal to mixed fishery, as in the OTB fishing segment). In these cases, the ratios among the landings of the different métier along the time were used to correct the raised age structures of the catches before the model parameterization. Data on maturity and growth from DCF have also been used. Information from GRUND surveys and from nurseries studies in the GSA have also been included.

7.9.7. *Scientific advice*

7.9.7.1. Short term considerations

7.9.7.1.1. State of the spawning stock size

SGMED is unable to fully evaluate the state of the spawning stock due to the absence of proposed or agreed management reference points. However, survey indices indicate a variable pattern of abundance indices with the recent values amongst the lowest observed, except for 2007.

7.9.7.1.2. State of recruitment

In 2007 and 2009 the MEDITS surveys indicated high indices of recruit abundance.

7.9.7.1.3. State of exploitation

SGMED proposes $F_{0.1} \leq 0.42$ as limit management reference point consistent with high long term yields. Thus, given the results of the present analysis (F 2006=1.11, F 2007=0.78, F 2008=0.9; F 2009=0.57), the stock appeared to have been subject to overfishing during 2006-2009. A reduction of F of about 40% would be thus necessary in order to avoid future loss in stock productivity and landings.

7.10. Stock assessment of red mullet in GSA 11

7.10.1. *Stock identification and biological features*

7.10.1.1. Stock Identification

Under a management point of view, in the frame of GFCM, it has been decided, when the lack of any evidence does not allow suggesting an alternative hypothesis, that inside each one of the GSAs boundaries inhabits a single, homogeneous stock that behaves as a single well-mixed and self-perpetuating population. Thus, red mullet (*Mullus barbatus*) in GSA 11 was assumed to be confined within the GSA 11 boundaries. In the GSA 11 red mullet is distributed between 0 and 300 m of depth, even though is generally found on shelf bottoms (within 200 m of depths) with the bulk of abundance and biomass up to 100 m. The stock is mainly exploited by the local fishing fleet, using trawl and net gears. Juveniles showed a patchy distribution with some main density hot spots (nurseries) and a high spatio-temporal persistence in western and southern areas.

7.10.1.2. Growth

Analysis of LFDA of red mullet in GSA 11 showed a slow growth pattern both in male and female (SAMED, 2002). For the GSA 11, data from otolith readings (DCR, 2008) show instead a faster growth pattern (sex combined). SGMED-10-03 used the same fast growing parameters adopted in SGMED-09-03. Since the species reaches 50% of its total size at 1.5 year, it has been treated as fast growing.

Table 7.10.1.2.1 Growth parameters for *M. barbatus* in the GSA 11 used in the analyses.

L_∞	29.1
K	0.41
to	-0.39
L/W a	0.01
L/W b	3.02

7.10.1.3. Maturity

The species reaches massively the sexual maturity at the age of one year. Observations of proportion of mature individuals by size and analysis with the standard procedure show that the bulk of the females spawn at a size of about 10 cm. Data on spawning (DCR 2006 and 2007) confirm that is taking place on spring (April-June), with a peak during late spring (May).

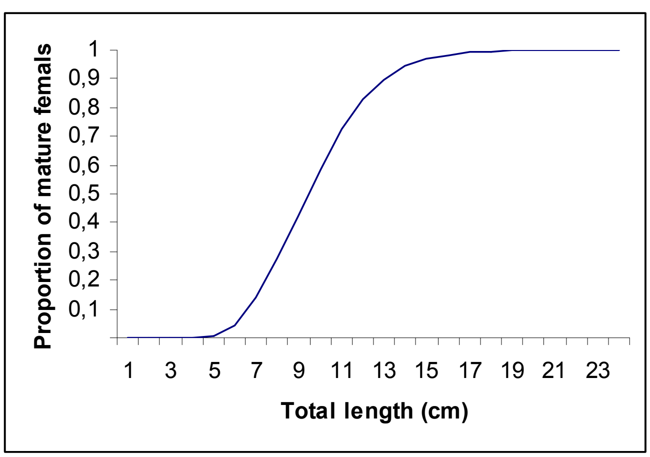


Fig. 7.10.1.3.1 Maturity ogive for females *M. barbatus* in the GSA 11.

7.10.2. *Fisheries*

7.10.2.1. General description of fisheries

Red mullet (*Mullus barbatus*) is among the most commercially important species in the area and forms part of an assemblage that is the target of the bottom trawling and small scale fleets, which operate near shore. Particularly, during the bulk of post-recruitment (September-October), small trawlers target this species on shallower waters, near the coasts. From 1994 to 2004, in GSA 11, the trawling-fleet has remarkably changed, with a general increase of the number of vessels and the replacement of the old, low tonnage wooden boats by larger steel boats. For the entire GSA a decrease of 20% for the smaller boats (<30 GRT), which principally exploit this species, was also observed.

7.10.2.2. Management regulations applicable in 2009 and 2010

As in other areas of the Mediterranean, the management of this stock is based on control of fishing capacity (licenses), fishing effort (fishing activity), technical measures (mesh size and area closures), and minimum landing sizes (EC 1967/06). Two small closed areas were also established along the mainland (west and east coast respectively), although these are finalised to protect lobsters mainly. Since 1991, a fishing ban for trawling 45 day was have been almost every year enforced in different periods for the small scale fishery (March, TSL<=15) and for the big trawlers (September, TSL<15). In the following figure, differences in the closure regime are shown; a red point means that no fishing ban measure has been adopted for that particular year.

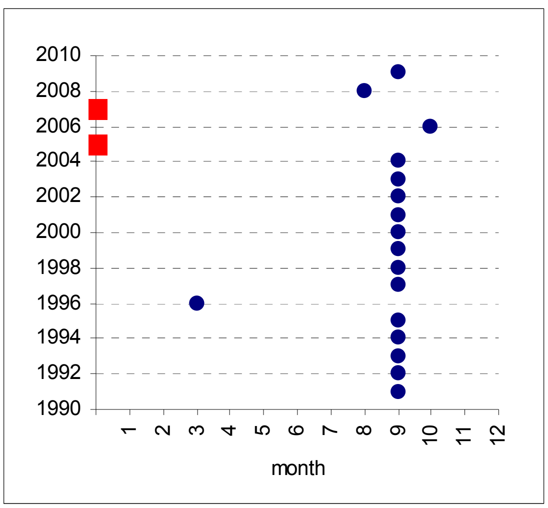


Fig. 7.10.2.2.1 Differences in the closure regime are shown; a red point means that no fishing ban measure has been adopted for that particular year.

Furthermore, recently (2006) the closure was differentiate also considering different coast (west and east mainly) with a shift of 15 days of the fishing ban period. Towed gears are not allowed within three nautical miles from the coast or at depths less than 50 m when this depth is reached at a distance less than 3 miles from the coast.

7.10.2.3. Catches

7.10.2.3.1. Landings

Landings for GSA 11 by major fishing gears are listed in Tab. 7.10.2.3.1.1. Since 2002, landings increased from 346 t in 2002 to 225 t in 2009 (Fig. 7.10.2.3.1.1). Landings are dominated by demersal trawl fisheries (DTS, OTB and partially PMP). According to the STECF-SGMED scientist's knowledge, DCF data for GSA 11 seems to underestimate landings derived from LLS, GNS and GTR. Both a check made by experts of the official data and an update of information are needed to improve and facilitate the work in next SGMED meetings.

Tab. 7.10.2.3.1.1 lists landings by fishing technique. Since 2004 the annual landings varied between 222 and 346 t. The landings were mainly from demersal otter trawls (catches from other gears are less than 5% of the total).

Tab. 7.103.2.3.1.1 Annual landings (t) by fishing technique in GSA 11, 2002-2009 as reported through DCF.

FT_LVL4	2004	2005	2006	2007	2008	2009
FPO				3	1	2
FYK				5	1	1
GNS	3					0
GTR	11	13	13	0	1	
OTB	333	253	249	346	263	222
total	346	265	262	354	266	225

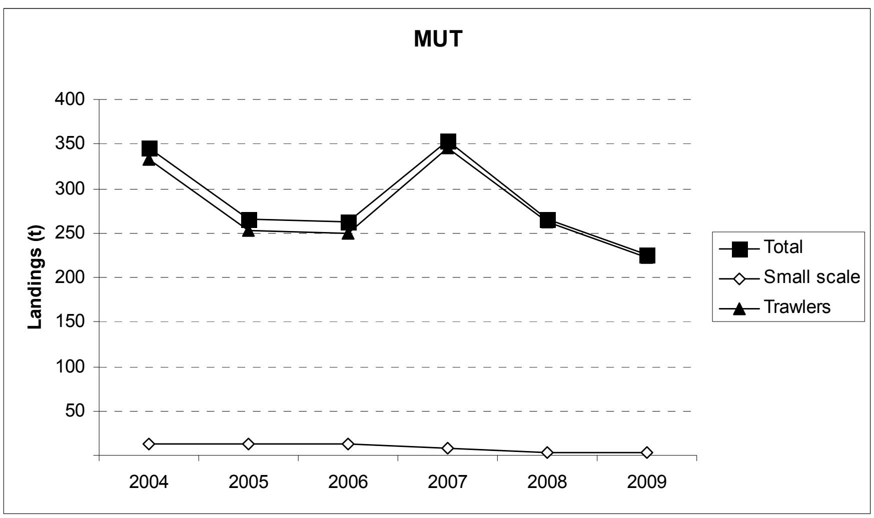


Fig. 7.10.2.3.1.1 Landings (t) by year and major gear types, 2002-2009 as reported through DCR.

7.10.2.3.2. Discards

Low discards quantities (7 t) were reported through DCR and for 2006 only.

7.10.2.3.3. Fishing effort

The trends in fishing effort by fishing technique are the same reported to SGMED-10-03 and are listed in Tab. 7.10.2.3.3.1. The effort of the major trawler fleet has decrease in 2008 and stayed at the low level thereafter.

Tab. 7.10.2.3.3.1 Trends in annual fishing effort by fishing technique deployed in GSA 11, 2004-2009.

FT_LVL4	2004	2005	2006	2007	2008	2009
				15720		
FPO	41196	79505	967791	1487078	900543	1011209
FYK				1155	0	0
GNS	1010930	1039342	204277	773799	435020	951187
GTR	5118454	7262485	7201973	4830951	3677886	4127035
LHP-LHM	18192	773	64100	121765	62982	44015
LLD	3608	277773	463381	1187584	746975	459397
LLS	805007	924018	1322417	1107356	645248	671985
LTL			6647	1742	588	566
OTB	7008771	7714815	6073729	6258161	4411130	4371051
PS	1369					
total	14007527	17298711	16304315	15785311	10880372	11636445

Tab. 7.10.2.3.3.2 Trends in annual fishing effort by fishing technique deployed in GSA 11, 2004-2009, as reported through the official DCF data call in 2010.

AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	VESSEL_LENGTH	2004	2005	2006	2007	2008	2009
11	ITA				VL1218				15720		
11	ITA	FPO	Demersal species		VL0006				78503	17179	24215
11	ITA	FPO	Demersal species		VL0612	41196	23012	814366	1280047	827583	828017
11	ITA	FPO	Demersal species		VL1218		56493	153425	128528	55781	158977
11	ITA	FYK	Demersal species		VL0006				723	0	0
11	ITA	FYK	Demersal species		VL0612				432		
11	ITA	GNS	Demersal species		VL0006			2553	74890	19315	33167
11	ITA	GNS	Demersal species		VL0612	1002998	695840	139310	629250	318463	674666
11	ITA	GNS	Demersal species		VL1218	7932	343502	62414	69659	97242	243354
11	ITA	GTR	Demersal species		VL0006			173809	116139	83038	75866
11	ITA	GTR	Demersal species		VL0612	5057167	5513005	5786113	3778300	2768964	3256884
11	ITA	GTR	Demersal species		VL1218	61287	1749480	1242051	936512	825884	794285
11	ITA	LHP-LHM	Cephalopods		VL0006				21043	2463	
11	ITA	LHP-LHM	Cephalopods		VL0612	18192	773	19435	61145	14044	4273
11	ITA	LHP-LHM	Cephalopods		VL1218			38550	39577	21711	910
11	ITA	LHP-LHM	Finfish		VL0612			918		24764	38832
11	ITA	LHP-LHM	Finfish		VL1218			5197			
11	ITA	LLD	Large pelagic fish		VL0612			113740		6484	6161
11	ITA	LLD	Large pelagic fish		VL1218	3608	277773	209763	1172955	740491	453236
11	ITA	LLD	Large pelagic fish		VL2440			139878	14629		
11	ITA	LLS	Demersal fish		VL0006			11563	17871	2898	3231
11	ITA	LLS	Demersal fish		VL0612	795811	695883	924521	769091	414061	449671
11	ITA	LLS	Demersal fish		VL1218	9196	228135	289938	296777	228289	219083
11	ITA	LLS	Demersal fish		VL1824			10135			
11	ITA	LLS	Demersal fish		VL2440			86260	23617		
11	ITA	LTL	Large pelagic fish		VL0612			6647	1742	588	566
11	ITA	OTB	Deep water species		VL2440					139344	199254
11	ITA	OTB	Demersal species		VL0612				1064		153616
11	ITA	OTB	Demersal species		VL1218	1425360	1331798	1607505	151584	1321796	1316636
11	ITA	OTB	Demersal species		VL1824	45888				855033	699312
11	ITA	OTB	Demersal species		VL2440				20124	257107	217971
11	ITA	OTB	Mixed demersal and deep water species		VL1218				1551232	82379	
11	ITA	OTB	Mixed demersal and deep water species		VL1824	2134561	2982686	1912624	2058755	392755	543997
11	ITA	OTB	Mixed demersal and deep water species		VL2440	3402962	3400331	2553600	2475402	1362716	1240265
11	ITA	PS	Small pelagic fish		VL1218	1369					

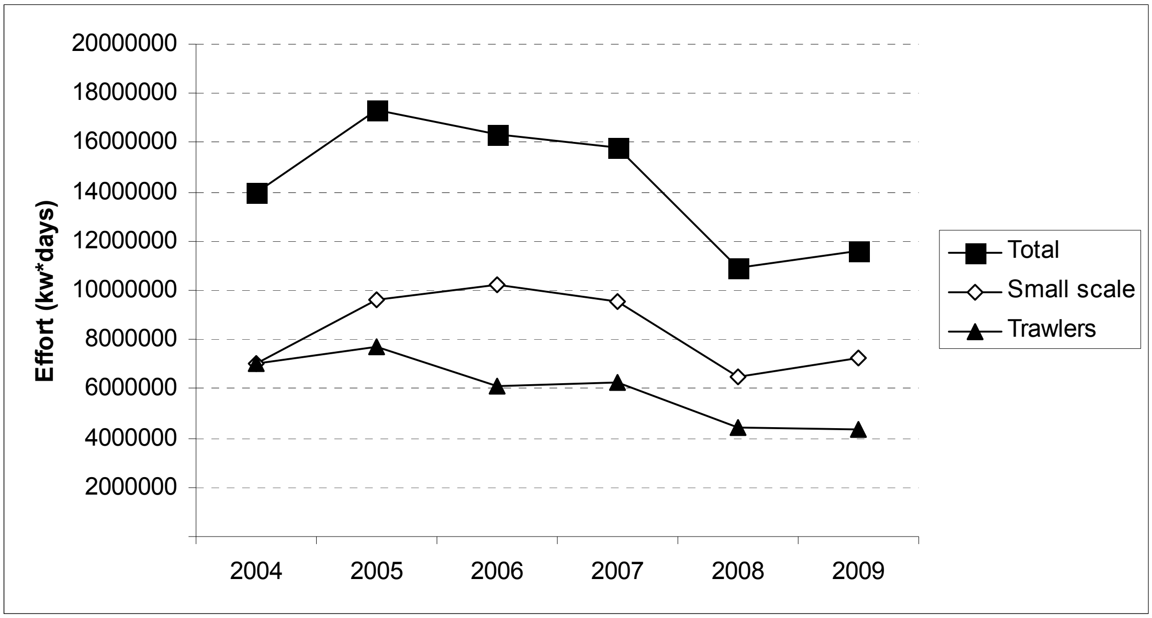


Fig. 7.10.2.3.3.1 Trend in fishing effort (kW·days) for GSA 11 by major gear types, 2004-2009.

7.10.3. *Scientific surveys*

7.10.3.1. MEDITS

7.10.3.1.1. Methods

Based on the DCR data call, abundance and biomass indices were recalculated and presented in this report. In GSA 11 the following number of hauls on shelf bottoms was reported per depth stratum (s. Tab. 7.10.3.1.1.1).

Tab. 7.10.3.1.1.1. Number of hauls per year and depth stratum in GSA 11, 1994-2009.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GSA11_010-050	16	18	21	21	21	20	19	17	20	18	17	17	19	19	17	18
GSA11_050-100	25	21	22	22	20	22	22	24	19	19	18	21	18	20	19	20
GSA11_100-200	20	23	30	31	31	30	29	30	24	24	24	24	24	24	22	24
GSA11_200-500	33	29	29	26	25	27	24	25	20	24	21	20	20	20	21	19
GSA11_500-800	23	16	21	25	25	24	27	26	16	14	15	14	16	17	16	16

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Only hauls noted as valid were used, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

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

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

Where:

- A=total survey area
- Ai=area of the i-th stratum
- si=standard deviation of the i-th stratum
- ni=number of valid hauls of the i-th stratum
- n=number of hauls in the GSA
- Yi=mean of the i-th stratum
- Yst=stratified mean abundance
- V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA.

7.10.3.1.2. Geographical distribution patterns

The spatial structure of red mullet have been achieved by modelling the spatial correlation structure of the abundance indices through geostatistical techniques, showing clear areas of persistence in the south (Gulf of Cagliari) and western coasts (Carloforte and coast between Bosa Marina and Capo Mannu). Main results and maps are reported in the "nursery section" of SGMED-09-02 report.

7.10.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the red mullet in GSA 11 was derived from the international survey MEDITS. Figure 7.10.3.1.3.1 displays the estimated trend in red mullet abundance and biomass in GSA 11. The estimated abundance and biomass indices do not reveal any significant trends. However, the recent abundance and biomass indices since 2005 appear high but are subject to high uncertainty.

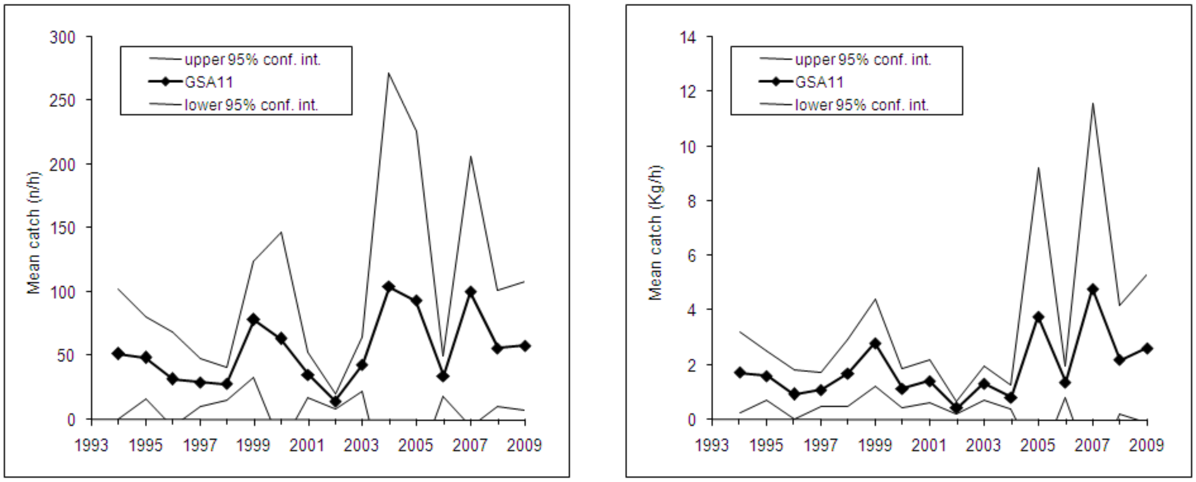


Fig. 7.10.3.1.3.1 Abundance and biomass indices of red mullet in GSA 11.

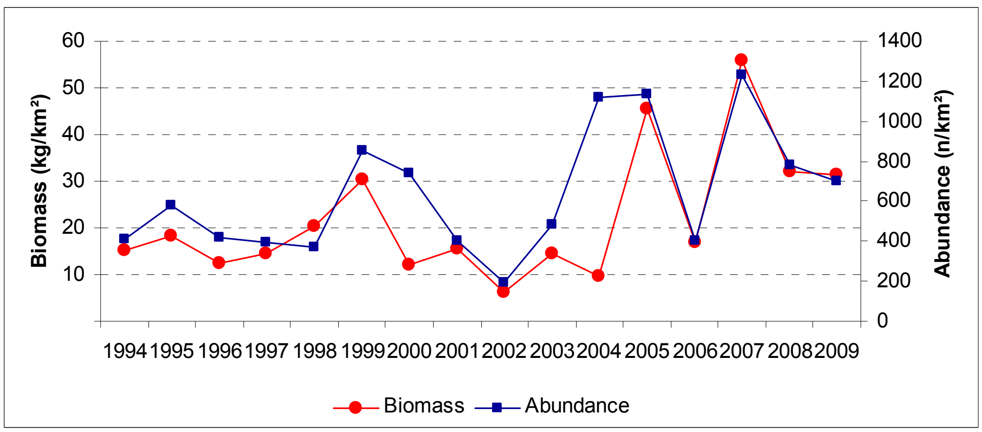


Fig. 7.10.3.1.3.2 Abundance and biomass indices of red mullet in GSA 11.

7.10.3.1.4. Trends in abundance by length or age

The following Fig. 7.10.3.1.4.1 and 2 display the stratified abundance indices of GSA 11 in 1994-2001 and 2002-2009.

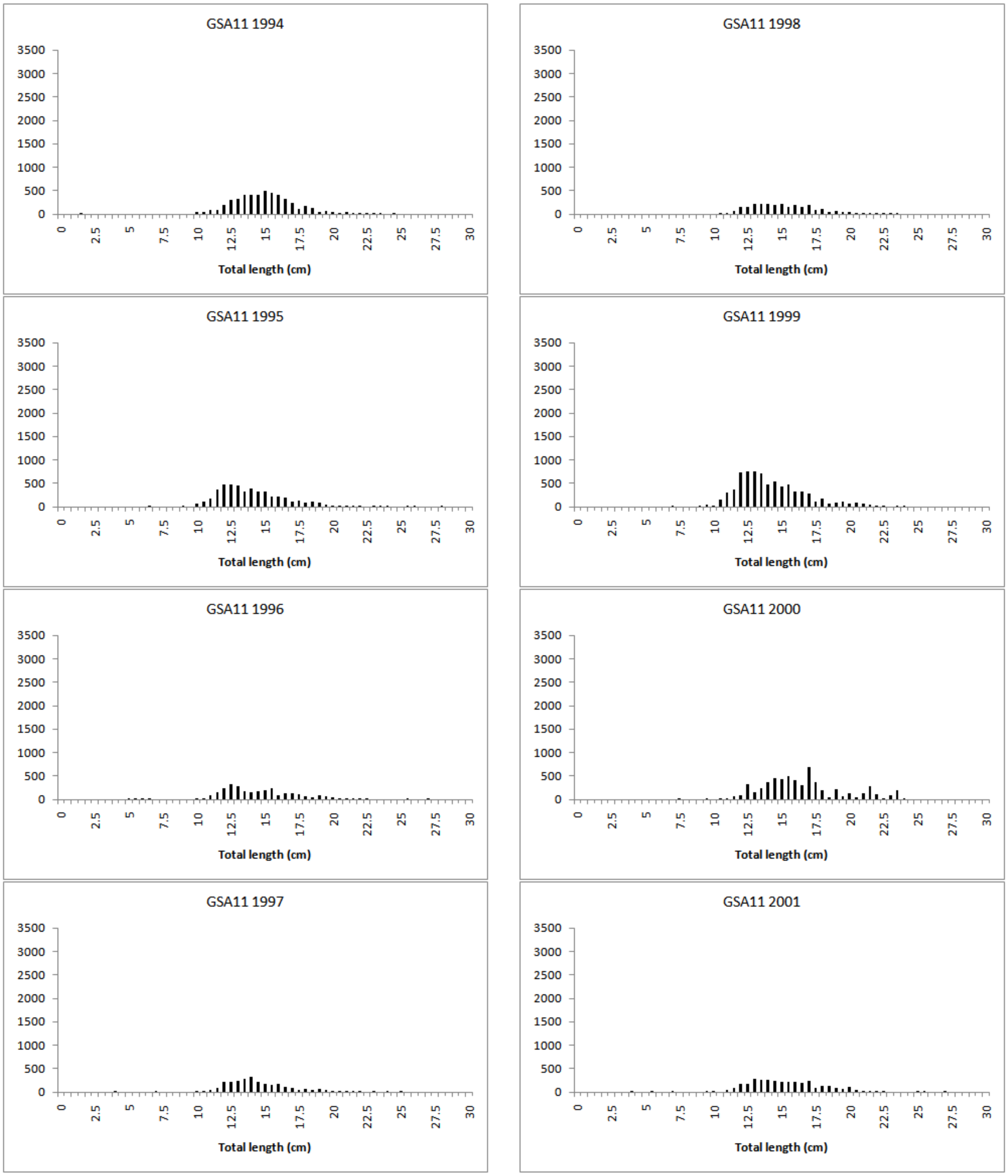


Fig. 7.10.3.1.4.1 Stratified abundance indices by size, 1994-2001.

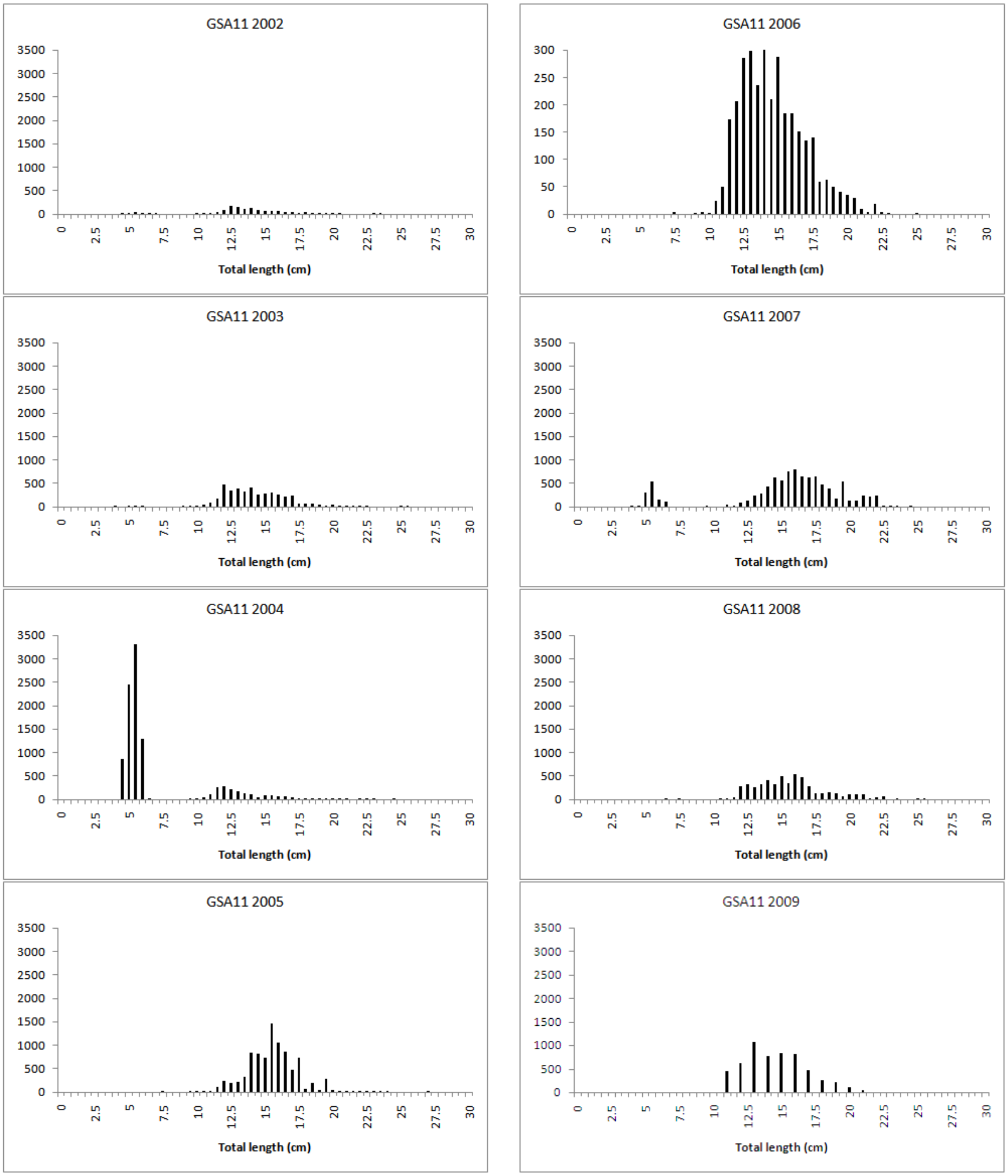


Fig. 7.10.3.1.4.2 Stratified abundance indices by size, 2002-2009.

7.10.3.1.5. Trends in growth

No analyses were conducted.

7.10.3.1.6. Trends in maturity

No analyses were conducted.

7.10.4. *Assessment of historic stock parameters*

7.10.4.1. Method 1: SURBA

7.10.4.1.1. Justification

The SURBA was applied to the MEDITS survey estimates.

7.10.4.1.2. Input parameters

Data from trawl surveys (time series of MEDITS from 1994 to 2009) and landings data from DCR have been used for the analysis. The SURBA software package (Needle, 2003) use trawl surveys data time series available from the MEDITS to estimate fishing mortality rates of red mullet in the GSA 11. First, the LFDs were converted in numbers at age group using the subroutine "age slicing" as implemented in the R routine by SGMED. The VBGF parameters used to split the LFD was the same used for the LCA approach used here and in SGMED-09-03. According to the Prodbiom approach (Caddy and Abella 1999), a vectorial natural mortality at age was estimated (Tab. 7.10.4.1.2.1). Guess estimates of catchability at age are given in Tab. 7.10.4.1.2.1.

Tab. 7.10.4.1.2.1. Input parameters used in the SURBA analysis (sex combined) in the GSA 11.

VBGF M vector	L_∞=29.1 cm, K=0.41, t_0= -0.39 Age_1=0.41, Age_2=0.27, Age_3=0.24, Age_4=0.21
Catchability (q)	$q_{1\text{-}4}$ = 1
Length at maturity (L50)	13 cm (sex combined)

7.10.4.1.3. Results

SURBA output show that the mean F for ages 1-3 was varying until 2001 with a clear decreasing trend thereafter and an increase in 2009 (Fig. 7.10.4.1.3.1).

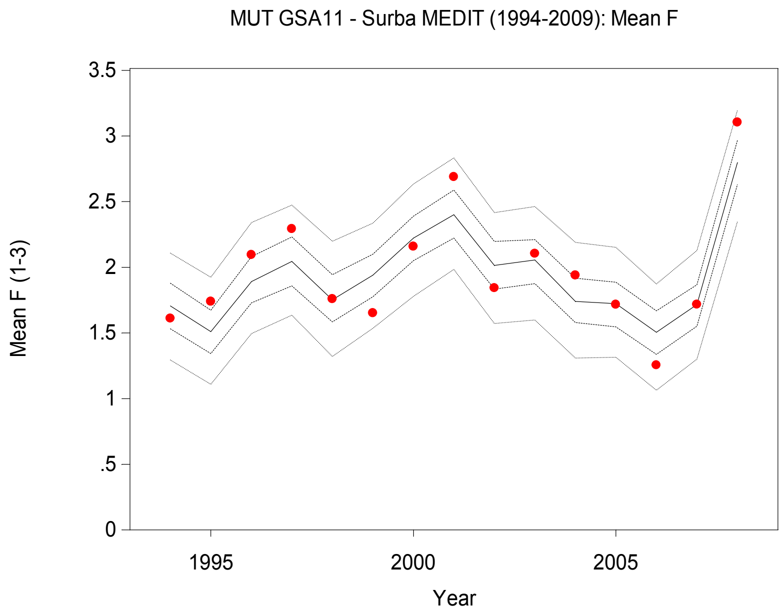


Fig. 7.10.4.1.3.1 Fishing mortalities estimated by SURBA using trawl surveys age composition (MEDITS).

Peaks in relative SSB has been detected in 1999 and 2007, as show below in Fig. 5.23.4.1.3.2.

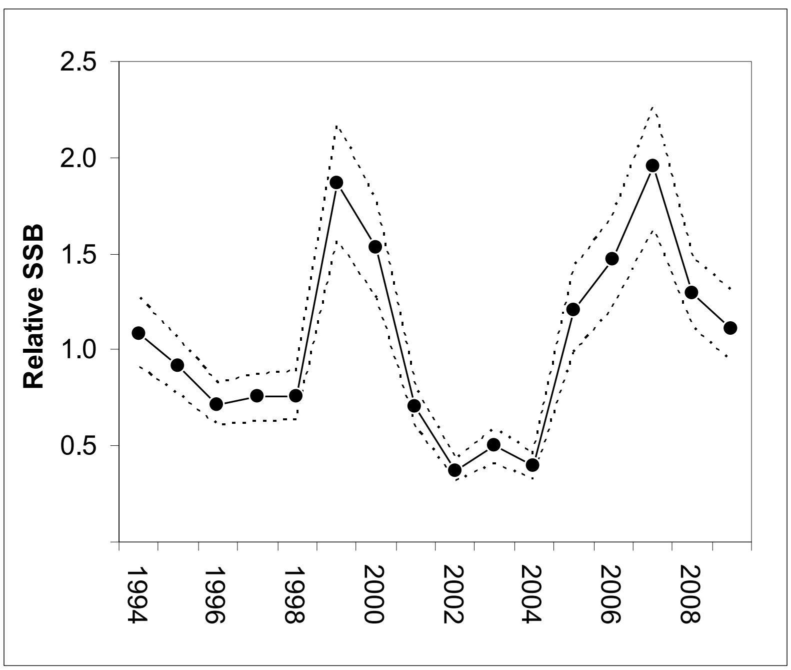
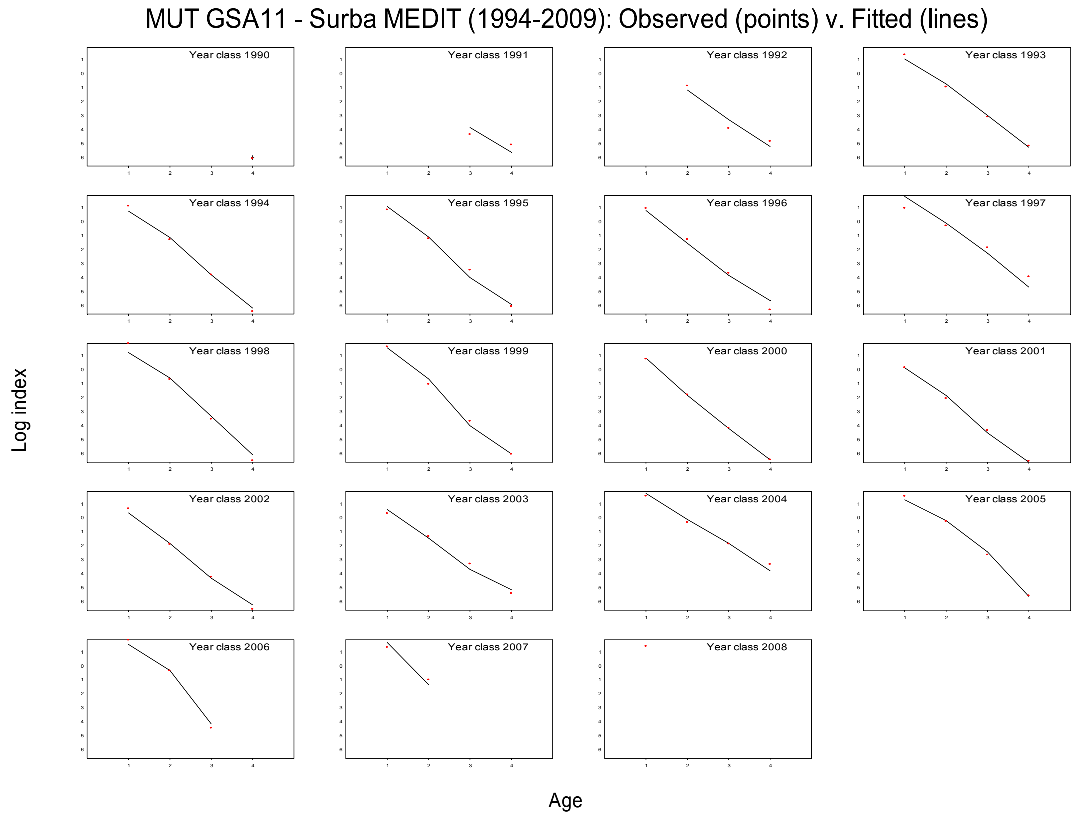
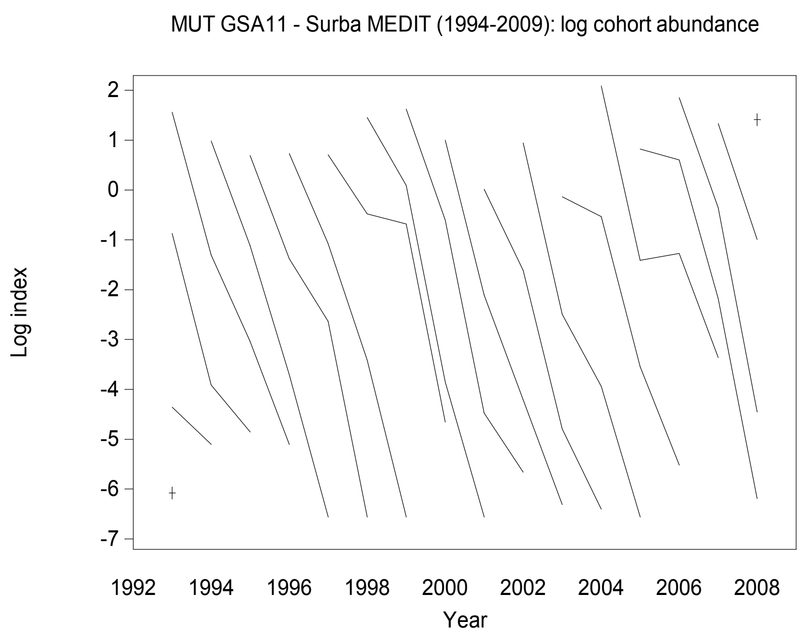


Fig. 7.10.4.1.3.2 Trend of SSB estimated by SURBA using trawl surveys age composition (MEDITS).

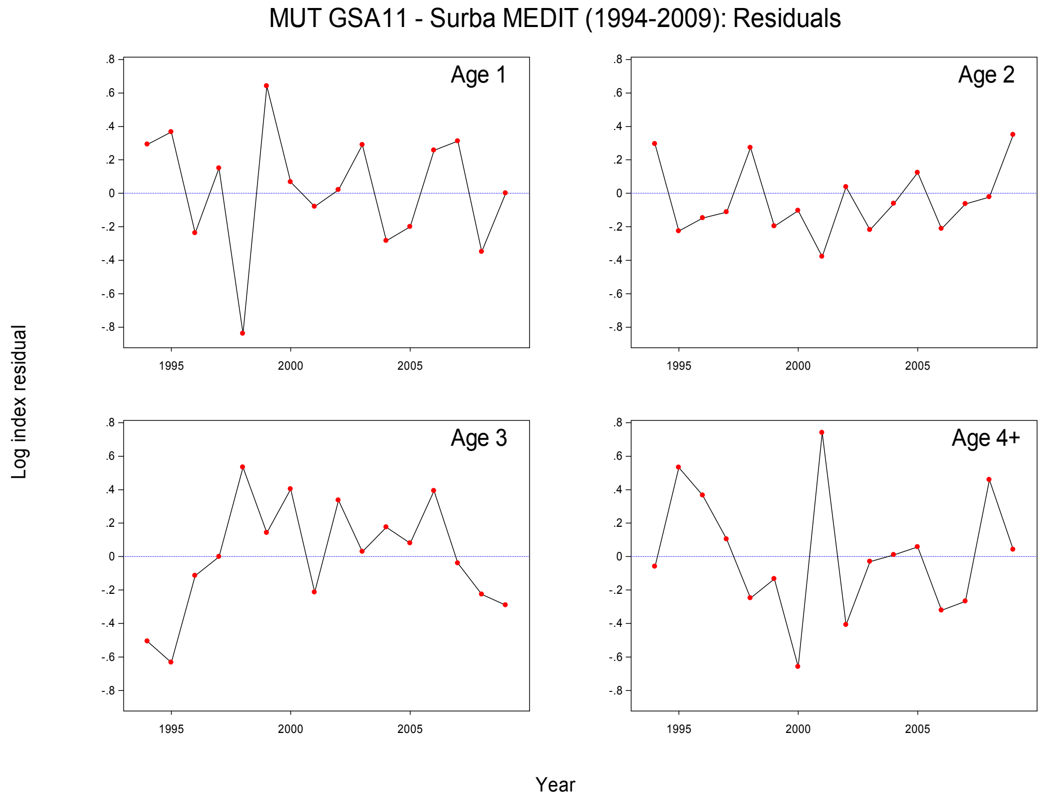
Since the survey period is close to the spawing period, the relative recruitment indices were not shown. Model diagnostics are presented in Fig. 7.10.4.1.3.3. Observed and fitted MEDITS survey indices of abundance for each year were reasonably in agreement (A) while catch curve reconstruction from log survey abundance indices showed some deviation from the expected curve (B). Log index residuals over time, plotted by age class (C) varied without any trend.


MUT GSA11 - Surba MEDIT (1994-2009): Observed (points) v. Fitted (lines)
Year class 1990
Year class 1991
Year class 1992
Year class 1993
Year class 1994
Year class 1995
Year class 1996
Year class 1997
Year class 1998
Year class 1999
Year class 2000
Year class 2001
Year class 2002
Year class 2003
Year class 2004
Year class 2005
Year class 2006
Year class 2007
Year class 2008
Log index
Age

A


MUT GSA11 - Surba MEDIT (1994-2009): log cohort abundance
Log index
2
1
0
-1
-2
-3
-4
-5
-6
-7
1992
1994
1996
1998
2000
2002
2004
2006
2008
Year

B



C

Fig. 7.10.4.1.3.3 Model diagnostic for SURBA model in the GSA 11 (MEDITS survey). A) Comparison between observed (points) and fitted (lines) survey abundance indices, for each year. B) Log survey abundance indices by cohort. Each line represents the log index abundance of a particular cohort throughout its life. C) Log index residuals over time by age class.

7.10.4.2. Method 2: VIT LCA

7.10.4.2.1. Justification

An approach under steady state (pseudocohort) assumption was applied due to the shortness of landing by length and age (2006-2009 , DCR) data. Pseudocohort, LCA and Y/R analyses as been carried out with VIT software for trawl fishery only. No discard data were included and a plus group has been used.

7.10.4.2.2. Input parameters

According to the Prodbiom approach by Caddy and Abella (1999), a vectorial natural mortality at age was computed for the stock analysis (Tab. 7.10.4.2.2.1). Terminal F was fixed to 0.6.

Tab. 7.10.4.2.2.1 Input parameters used of the analysis (sex combined) in the GSA11.

VBGF M vector	L_∞=29.1 cm, K=0.41, t_0= -0.39 Age_0=1.3, Age_1=0.41, Age_2=0.27, Age_3=0.24, Age_4=0.21
Length at maturity (L50)	13 cm (sex combined)

Tab. 5.23.4.2.2.2 Catch numbers at length and at age in 2006-2009 (The VBGF parameters used to split catch at length)

.

length	age	2006	2007	2008	2009
11	0	508	1080	2881	118
12	1	784	847	2747	235
13	1	1408	2089	2680	350
14	1	1026	1073	2613	314
15	1	762	1244	2010	258
16	1	761	1355	1139	284
17	1	455	810	268	229
18	2	269	379	268	127
19	2	324	486	0	85
20	2	52	94	0	59
21	2	5	35	16	20
22	3	10	12	16	3
23	3	10	23	16	7
24	3	10		0	7

Age/Year	2006	2007	2008	2009
0	508	1080	2881	118
1	5196	7418	11457	1670
2	650	994	284	291
3	30	35	32	17
4	0	0	0	0

7.10.4.2.3. Results including sensitivity analyses

Results obtained by year highligth a different pattern in 2007 probably related to the data quality of landings. However results did not show a great interannual variation of the exploitation pattern.

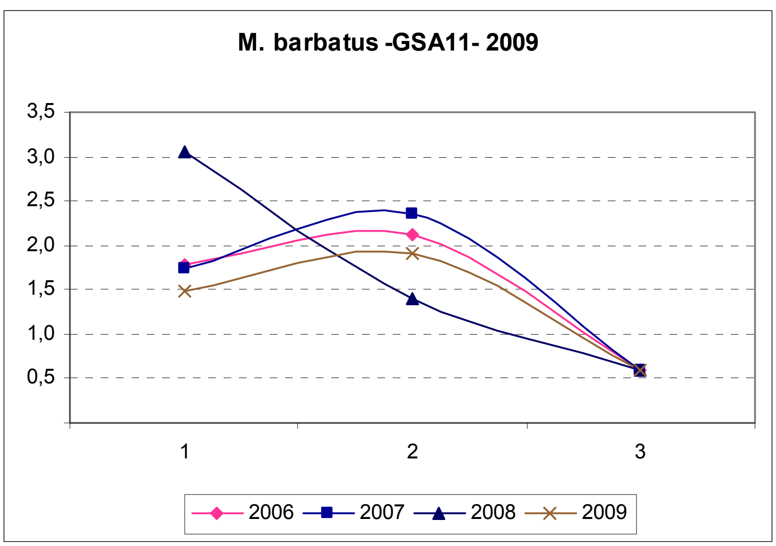


Figure 7.10.4.2.3.1 Fishing (F) rates by age class and year in GSA11 (age groups 1-3).

Table 7.10.4.2.3.1 Estimated fishing mortaliy in 2006-2009 as well as the mean of all years.

year	2006	2007	2008	2009	mean 06-09
$F_{(1-3)}$	**1.50**	**1.57**	**1.69**	**1.34**	**1.52**

7.10.5. *Long term prediction*

7.10.5.1. Justification

Equilibrium YPR reference points for the stock were estimated through the Yield software (Hoggarth *et al*., 2006).

7.10.5.2. Input parameters

The growth and L/W parameters previously defined in the biological features section (Table 7.10.1.2.1) were used, while a weighted mean value of M of 0.6 was used instead of an M-at-size vector. Age at maturity was set as 1 and age at first capture was 0.7.

7.10.5.3. Results

Reference fishing mortality (F_{ref}) and the referent points $F_{0.1}$ and the F_{max} are listed below (ages 1-3).

$F_{0.1}$	0,47
F_{max}	0,68
F_{ref}	1,52

7.10.6. *Data quality and availability*

MEDITS data for 2010 were not submitted by the Italian authorities, however quality of previous years was appropriate. Due to the fact that the survey has been generally carried out in late spring and did sample the bulk of the recruitment of the species, the assessment of the recruits from the SURBA analysis is not presented. The use of other survey results (GRUND) should help further to update the information and should be encouraged.

7.10.7. *Scientific advice*

7.10.7.1. Short term considerations

7.10.7.1.1. State of the spawning stock size

SGMED could not estimate the absolute levels of stock abundance. MEDITS survey abundance (n/km²) and biomass (kg/km²) indices which should be considered as a proxy of the spawning stock biomass, show high variability throughout the time series. Two peaks of SSB are detected in 1999 and 2007. SGMED is unable to fully evaluate the status of the SSB in the absence of precautionary management reference points.

7.10.7.1.2. State of recruitment

SGMED is unable to provide any scientific advice of the state of recruitment given the preliminary state of the data and analyses.

7.10.7.1.3. State of exploitation

SGMED proposes $F_{0.1} \leq 0.47$ of ages 1-3 as limit management reference point consistent with high long term yields. Taking into account the results from VIT the stock of red mullet in GSA 11 is considered overexploited along the time series.

7.11. Stock assessment of red mullet in GSA 16

7.11.1. *Stock identification and biological features*

7.11.1.1. Stock Identification

Levi *et al*., (1992), comparing growth curve of *M. barbatus* in the Mediterranean, found significant differences between red mullet growth in Sicilian side of Strait of Sicily (GSA 15 and 16) and Gulf of Gabes (GSA 14). Other evidences supporting the existence of separate stocks of red mullets in Central Mediterranean comes from parasitological observations. A large infestation by a trematode of the genus *Stephanostomum* seriously affected the red mullet fishery in the Tunisian waters for several months in 1990. No such occurrence was noted in the fish landed at the Sicilian base-ports of the strait of Sicily (Levi *et al.*, 1993). Other hypothesis on separation of stocks units in the strait of Sicily was proposed by Levi *et al.* (1995), on the basis of independence of water masses and circulation system in the Sicilian and African border of the Strait of Sicily. Since the red mullet is a typical coastal resource, the peculiarity of the Strait of Sicily (two shelfs - the European and the African ones-separated by narrow deep bottoms) supports the hypothesis of the existence of different subpopulations in the area. It is worth to note that studies on genetic structures of *M. barbatus* along the Adriatic (Garoia *et al.*, 2004) and the Sicilian coasts (Arculeo *et al*., 2005) have proved subtle, but significant genetic differentiation, indicating that red mullet may group in local, genetically isolated populations.

7.11.1.2. Growth

The Von Bertalanffy Growth Function parameters by sex available for different areas of the Strait of Sicily are reported in Table 7.11.1.2.1.

Table 7.11.1.2.1. Von Bertalanffy growth function parameters of *M. barbatus* in the Strait of Sicily (n.a. – not available).

Author	Area	Females			Males			Combined sexes			Remarks
		L_∞	K	t_0	L_∞	K	t_0	L_∞	K	t_0	
Gharbi & Ktari 1981	14	20.46	0.50	-0.04	18.09	0.50	-0.18	-	-	-	Scales readings
Andaloro & Prestipino G., 1985	16	24.55	0.23	-2.01	23.29	0.16	-2.84	-	-	-	Otoliths readings
Levi et al., 1992	15 & 16	-	-	-	-	-	-	27.62	0.15	-2.68	Otoliths readings
Djabali et al., 1990	4	-	-	-	-	-	-	29.65	0.21	n.a.	n.a.
Ben Meriem et al., 1995	n.a.	-	-	-	-	-	-	26.70	0.51	n.a.	n.a.
IRMA-CNR, 1999	15 & 16	23.20	0.64	-0.55	19.91	0.67	-0.66	-	-	-	LFD analysis
SAMED, 2002	15 & 16	26.00	0.62	-0.20	20.20	0.64	-0.20	-	-	-	Otoliths readings
CNR-IAMC, 2007	16	26.50	0.26	-1.24	20.67	0.49	-0.62	-	-	-	Otoliths readings

7.11.1.3. Maturity

Red mullet reproduction in the GSA 13 occurs near the coast, from May to June-July (Gharbi & Ktari, 1981; Cherif *et al*., 2007). According to Levi (1991) spawning in GSA 15 and 16 takes place in May. The estimation of length at first maturity for the Strait of Sicily (Tab. 7.11.1.3.1) resulted fairly close to what is found in the available literature on the Central Mediterranean (Voliani, 1999).

Table 7.11.1.3.1. Length at 50% maturity ($L_{50\%}$) and curvature parameters of ogive at maturity by sex of *M. barbatus* in the Strait of Sicily (n.a.–not available).

Author	GSA	Females		Males	
		L50%	g	L50%	g
Gharbi & Ktari, 1981	13	15-16	n.a.	14	n.a.
SAMED, 2002	15&16	15.5	n.a.	n.a.	n.a.
Gangitano S. (pers. comm.)	15&16	14.9	1.18	n.a.	n.a.
Cherif *et al.*, 2007	12	13.9	n.a.	13.9	n.a.

7.11.2. *Fisheries*

7.11.2.1. General description of fisheries

Red mullet (*M. barbatus*) is one of the main demersal resources of the coastal areas in the Mediterranean, fished by otter trawl and trammel and gill-net, together with other several species (Voliani, 1999). Red Mullet is caught together with other important species such as *Mullus surmuletus, Merluccius merluccius, Pagellus sp., Uranoscopus scaber, Raja sp., Trachinus sp., Octopus vulgaris, Sepia officinalis, Eledone sp.* and *Lophius sp*. In GSA 15 and 16 red mullet is caught almost exclusively by inshore trawlers operating on shelf fishing-grounds of GSA 16 and 15.

7.11.2.2. Management regulations applicable in 2010 and 2011

At present there are no formal management objectives for red mullet fisheries in the Strait of Sicily. As in other areas of the Mediterranean, the stock management is based on control of fishing capacity (licenses), fishing effort (fishing activity), technical measures (mesh size and area closures) and fish size limits. Since 1989 no new fishing licenses were assigned in Italy and a progressive reduction of fleet capacity is occurring.The adoption of the fishing closure of 30-45 days per year since late eighties should have contributed to reduce the fishing effort on demersal resources. However this measure had low efficacy in Sicily because the period of stopping trawling was not chosen to reduce fishing mortality on juveniles. Coupling the trawling ban in autumn, when the young red mullets move deeper, with the existing prohibition of trawling within three nautical miles from the coast, where the fish recruit in summer (Voliani, 1999), has proved to produce a remarkable increase of the stock size (Relini *et al*., 1996; Pipitone *et al*., 2000). Since 2001 the legal minimum mesh for Sicilian trawlers should be 40 mm opening in the cod-end, due to the end of the UE derogation, allowing a minimum size of 28 mm for Sicily and Greece. However up to now this measure was not implemented. The new regulation CE 1967 of 21 December 2006 fixed in 40 mm the minimum size for bottom trawling for UE fishing boats (Italian and Maltese trawlers). The mesh has been modified in square 40 mm or 50 mm rhomboidal after July 2008, although derogations were considered up to 2010. The regulation CE 27 June 1994 n°1626 of the European Union fixed the minimum marketable size of *Mullus* sp. at 11 cm total length. This minimum length, confirmed by the new regulation CE 1967 of 21 December 2006, is valid for both Italian and Maltese fishing boats operating in the area. It must be to outline the existence in the Strait of Sicily of the Maltese Management Fishing Zone (MMFZ) extending up to 25 nautical miles from baselines around the Maltese islands, in which fisheries are specifically managed on the basis of the control of the fleet capacity. The access of Community vessels to the waters and resources in the MMFZ is regulated as follows:

(a) fishing within the management zone is limited to fishing vessels smaller than 12 metres overall length using other than towed gears and ;

(b) the total fishing effort of those vessels, expressed in terms of the overall fishing capacity, does not exceed the average level observed in 2000-2001 that corresponds to 1950 vessels with an overall engine power and tonnage of 83000 kW and 4035 GT respectively.

Trawlers not exceeding an overall length of 24 metres are authorised to fish in certain areas within the management zone. The overall fishing capacity of the trawlers allowed to operate in the management zone must not exceed the ceiling of 4800 kW and the fishing capacity of any trawler authorised to operate at a depth of less than 200 metres must not exceed 185 kW. Trawlers fishing in the management zone hold a special fishing permit in accordance with Article 7 of Regulation (EC) No 1627/94 and are included in a list containing their external marking and vessel's Community fleet register number (CFR) to be provided to the Commission annually by the Member States concerned.

7.11.2.3. Catches

7.11.2.3.1. Landings

According to Andreoli et al., (1995), the estimated yield of *Mullus* sp. between April 1985 and March 1986 was about 1100 tons; the next year it amounted 630 tons. Considering that overall yield was about 9670 tons in the first year and 8050 tons in the second one, *Mullus* sp. landings represented about 8-11% of total yield in the area. This landing is sold and recorded on coastal production markets, unlike the fish caught by distant water trawlers. More recent data (IREPA) give a yield of 5116 tons of *Mullus* sp. in 2003. In 2006 yield decreased to 3050 tons, of which 1626 tons were due to *M. barbatus*. Landings data were reported to SGMED-10-02 through the Data Collection Framework. Annual landings decreased from 1626 t in 2004 to 800 t in 2009 (Tab. 7.11.2.3.1.1). Demersal otter trawlers dominate the landings by far.

Table 7.11.2.3.1.1 Annual landings (t) by fishing technique as reported to SGMED-10-03 through the DCR data call.

Species	Area	Country	FT_LVL4	2002	2003	2004	2005	2006	2007	2008	2009
MUT	16	ITA	GTR			58	29	39	37	20	13
MUT	16	ITA	OTB			1568	1377	1084	1343	1158	787
MUT	16	ITA	Total			1627	1406	1124	1380	1177	800

7.11.2.3.2. Discards

During the eighties, the estimates of landings evidenced a fishing cycle with a catch peak in summer which was due to trawlers of southern coast of Sicily (only trawlers carrying out 1 day-trips between Spring 1985 and Winter 1987 were considered) (Fiorentino, 1999). The Sicilian peak occurred earlier respect to the other Italian areas where the main catches are observed in autumn. This pattern was attributed to the wide diffusion in late eighties of illegal fishery in protected nurseries within the three miles zone on recently recruited small fish. The discarded fraction of red mullet varies with season and typology of fisheries. Considering the Sicilian fleet, trawlers fishing near coast have the lower fraction of discard, as they land all catches. In summer the smallest landed *M. barbatus* may be 7-8 cm total length. The biggest trawlers, carrying out 15 – 25 day-trips and fishing far from the coast, discard red mullet smaller than about 12 cm TL. This discard may be important during the summer and autumn. The high discard rate is due to the necessity to use the space in the cold cellar almost exclusively for high prised crustaceans. In this situation the first modal group (9-10 cm) in the catches is totally discarded (Anon., 2000) (Tab. 7.11.2.3.2.1).

Tab. 7.11.2.3.2.1. Yearly modal length in cm of discarded fraction and landings of red mullet in typical inshore (Porto Palo- South eastern Sicily) and distant (Mazara del Vallo - South western Sicily) Sicilian trawling fisheries (from Anon., 2000).

	Modal length (cm)	
	discards	landings
Inshore fisheries	No discard	16
Distant fisheries	9 and 15	18-19

Recent studies on the discarded fraction of trawlers in GSA 16 during 2006 given a length at 50% discard ranging between 11.3 (autumn) and 12.0 (spring) cm TL (Gancitano V., pers. comm.). Discards data, collected within the DCF, were reported for 2006 to 2008.

Tab. 7.11.2.3.2.2 Discards data by fishing technique in GSA 16.

SPECIES	AREA	COUNTRY	FT_LVL4	2002	2003	2004	2005	2006	2007	2008
MUT	16	ITA	OTB					94	117	101

7.11.2.3.3. Fishing effort

Tab. 5.24.2.3.3.1 lists the effort by fishing technique deployed in GSA 16 as reported to SGMED-10-02 through the DCR data call. The main gear demersal otter trawl does not reveal any significant trend in effort deployed.

Tab. 5.24.2.3.3.1 Effort (kW*days) trends by fishing technique in GSA 16, 2004-2008.

AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	VESSEL_LENGTH	2003	2004	2005	2006	2007	2008	2009
16	ITA				VL0612			3886			417	
16	ITA	GTR	DEMSP		VL0006				8548	9979	12285	
16	ITA	GTR	DEMSP		VL0612		164944	178522	76073	103953	103352	
16	ITA	GTR	DEMSP		VL1218		25926	7720	23894	18868	8189	
16	ITA	GTR	DEMSP		VL1824			1420				
16	ITA	LHP-LHM	CEP		VL0006				525	1162		
16	ITA	LHP-LHM	FINF		VL0612		16931	16553	14973	15019	21934	
16	ITA	LHP-LHM	FINF		VL1218		641					
16	ITA	LLD	LPF		VL1218		12401	3900	2924	3435	16936	
16	ITA	LLD	LPF		VL1824		36304	5756	1029	78320	12919	
16	ITA	LLS	DEMF		VL0006				1022	3942	1394	
16	ITA	LLS	DEMF		VL0612		26733	58661	12698	57631	9512	
16	ITA	LLS	DEMF		VL1218		21984	1640	3115	62773	18439	
16	ITA	LLS	DEMF		VL1824		1870					
16	ITA	OTB	DEMSP		VL1218		210042	238629	272220		263191	
16	ITA	OTB	DEMSP		VL1824		54367	13425			397440	
16	ITA	OTB	DEMSP		VL2440						693213	
16	ITA	OTB	DWSP		VL1824						15246	
16	ITA	OTB	DWSP		VL2440						41113	
16	ITA	OTB	MDDWSP		VL1218					285378	4336	
16	ITA	OTB	MDDWSP		VL1824		377936	418914	434834	549867	93949	
16	ITA	OTB	MDDWSP		VL2440		1116269	1161841	442196	1484331	225904	
16	ITA	OTM	MDPSP		VL1824				21611	26555	41792	
16	ITA	OTM	MDPSP		VL2440		5306		9096			
16	ITA	PS	LPF		VL1824						9763	
16	ITA	PS	SPF		VL0006						397	
16	ITA	PS	SPF		VL0612			8471		670	3127	
16	ITA	PS	SPF		VL1218		1772	1997	1355		2354	
16	ITA	PS	SPF		VL1824		17339	12429	7349	39307	11625	
16	ITA	PTM	SPF		VL1824			19612	72116	107330	38857	

7.11.3. *Scientific surveys*

7.11.3.1. Medits

7.11.3.1.1. Methods

Based on the DCF data call, abundance and biomass indices were recalculated. In GSA 16 the following number of hauls was reported per depth stratum (s. Tab. 7.11.3.1.1.1).

Tab. 7.11.3.1.1.1. Number of hauls per year and depth stratum in GSA 16, 1994-2009.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GSA16_010-050	4	4	4	4	4	4	4	4	7	7	7	10	10	11	11	11
GSA16_050-100	9	8	8	8	8	8	7	8	11	12	12	20	22	23	23	23
GSA16_100-200	4	4	4	4	5	5	6	5	11	10	11	20	19	21	21	21
GSA16_200-500	10	11	11	12	11	11	11	11	19	18	26	37	31	27	27	27
GSA16_500-800	10	14	14	13	14	14	14	14	20	20	21	33	33	38	38	38

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

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

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

Where:

A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA. Given the sheer number of plots generated, these distributions are not presented in this report.

7.11.3.1.2. Geographical distribution patterns

As indicated by Garofalo et al. (2004), two major and clearly separate spawning areas exist in the Northern side of the Strait of Sicily (GSA 15 and 16). They are located over the Adventure Bank, off the South–Western coast of Sicily (GSA 16) and over the Malta Bank, between Sicily and the Maltese Island (GSA 15), respectively, in the outer shelf (100-150m) (Fig. 7.11.3.1.2.1). Recent researches on the Marine Protected Area of Castellammare del Golfo (north-western coasts of Sicily – GSA 10), where trawling has been forbidden since 1990, have shown that the oldest spawners prefer deeper bottom (100<p<200m), while the young ones are found in shallower areas (p<50m) (Fiorentino et al., 2006).

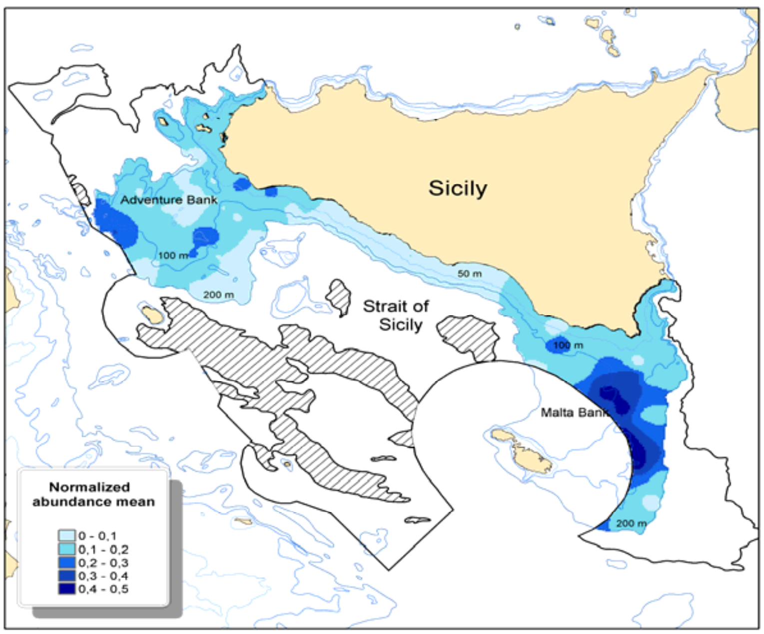


Fig. 7.11.3.1.2.1. Map of the average distribution pattern of *M. barbatus* spawners. The contour of the overall study area and the water depth of more than 800 m (black shaded) are also shown (GSA 15 and 16) (from Garofalo et al., 2004).

7.11.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the red mullet in GSA 16 was derived from the international survey Medits. Figure 7.11..3.1.3.1 displays the estimated trend in red mullet abundance and biomass in GSA 16. The estimated abundance and biomass indices reveal a significant increasing trend since 1999.

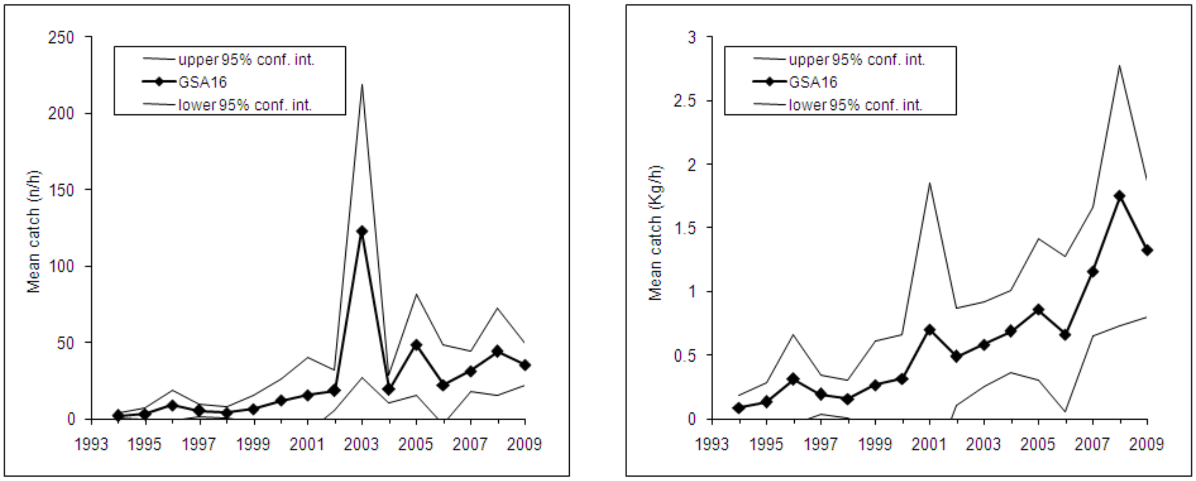


Fig. 7.11.3.1.3.1 Abundance and biomass indices of red mullet in GSA 16.

7.11.3.1.4. Trends in abundance by length or age

The following Fig. 7.11.3.1.4.1 and 2 display the stratified abundance indices by size of GSA 16 in 1994-2001 and 2002-2009.

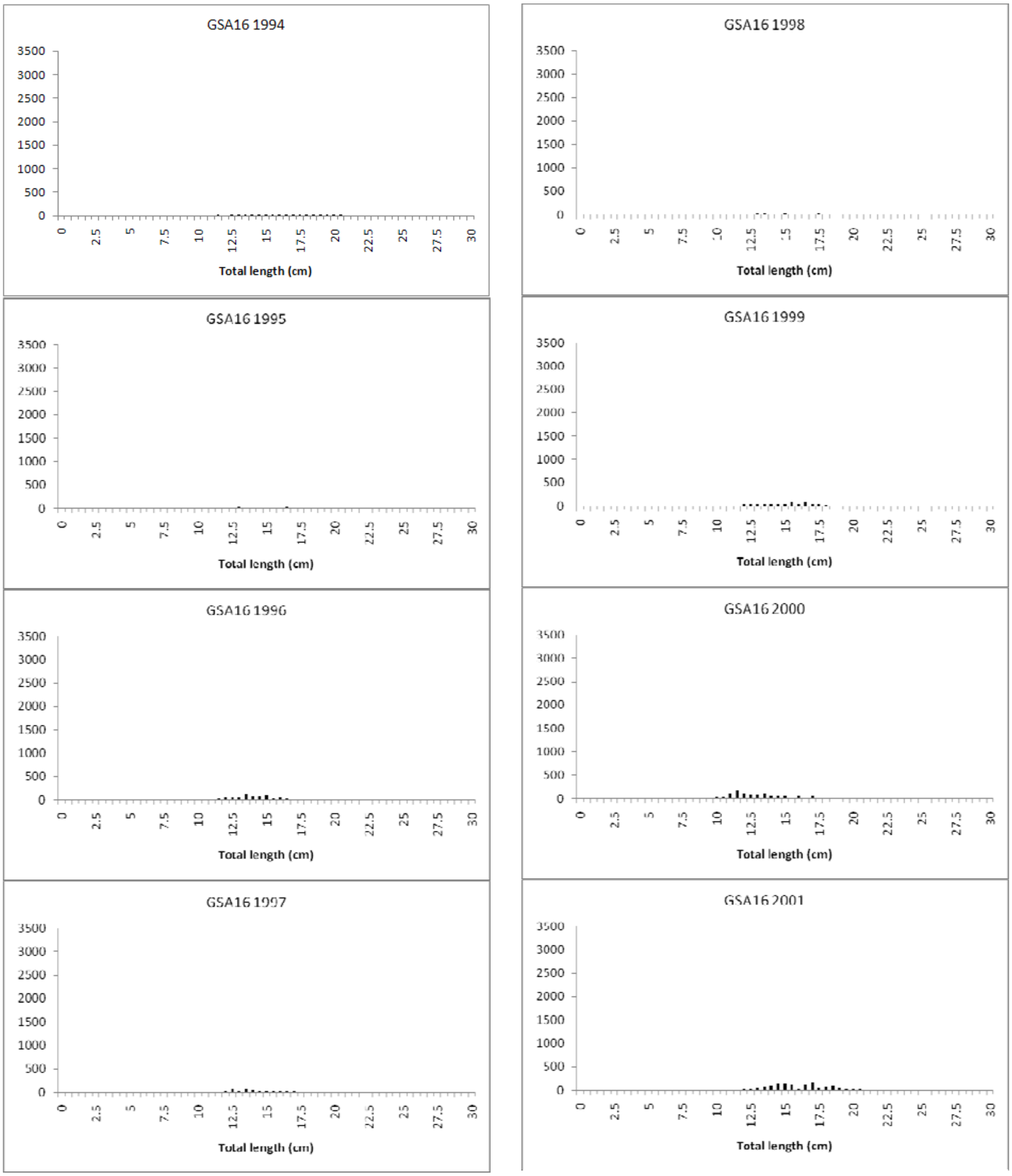


Fig. 7.11.3.1.4.1 Stratified abundance indices by size, 1994-2001.

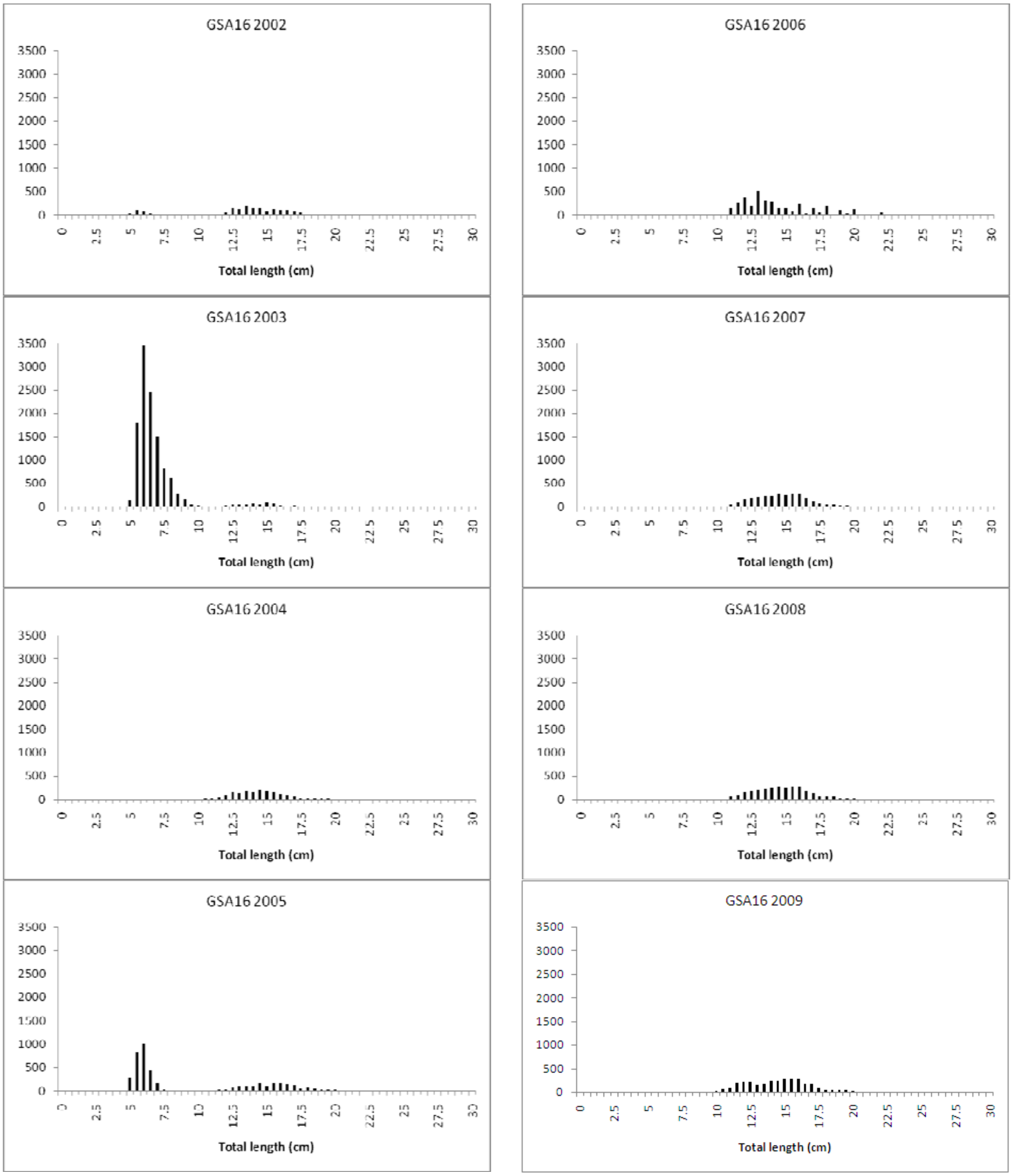


Fig. 7.11.3.1.4.2 Stratified abundance indices by size, 2002-2009.

7.11.3.1.5. Trends in growth

No analyses were conducted during SGMED-10-03.

7.11.3.1.6. Trends in maturity

No analyses were conducted during SGMED-10-03.

7.11.4. *Assessment of historic stock parameters*

Levi *et al*. (1993) assessed exploitation state of *M. barbatus* of Sicilian side of Strait of Sicily (GSA 15 & 16), by using analytical model based on trawl surveys data. According to the Beverton and Holt relative yield per recruit model, the exploitation rate (E=F/Z) in 1985/87, ranging between 0.66 and 0.73, was higher than E_{max} (=0.59) (Fig. 7.11.4.1). The stock simulation according to a Thompson and Bell model, with fishing mortality (F) from 0.5 to 2 times the current value and keeping gear selectivity constant, showed that the long term yield does not change significantly varying fishing effort (Fig. 7.11.4.2). However the picture is different in terms of economic gain since the potential income doubled if fishing mortality was reduced to a 40% of current value. Further increase of yield and economic value in long-term scenario could derive by changing from 32 to 40 mm.

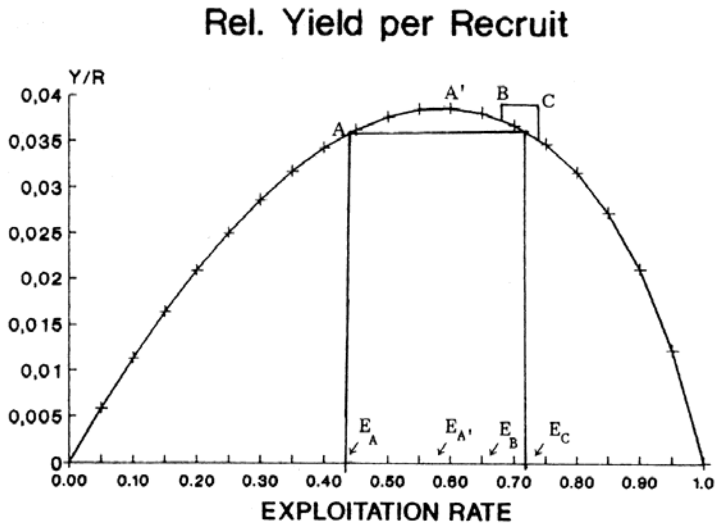


Fig. 7.11.4.1. Beverton and Holt relative yield per recruit. *Mullus barbatus.* $L\infty$ = 27.62 cm; M/K= 1.61. B-C 1985/86 situation; A' is the maximum yield per recruit; Optima: $E_{max.}$= 0.59; $E_{0.1}$= 0.56; $E_{0.5}$=0.31 (from Levi *et al*., 1993).

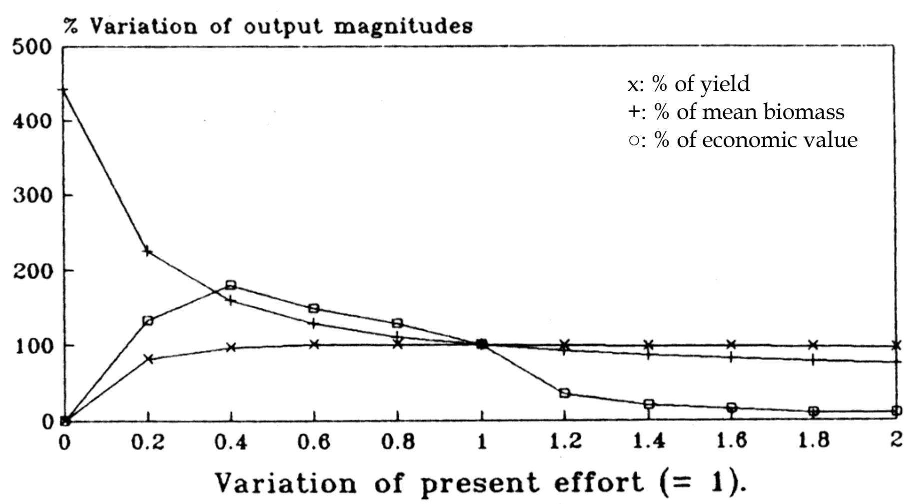


Fig. 7.11.4.2. Thompson and Bell analysis for 1985/86 fishing pattern. *Y*, %variation of output magnitudes; *X*, variations of present effort (=1) (from Levi *et al*., 1993).

Comparable results were obtained by stock assessments carried out in the framework of the GRUND (Italian group on evaluation of demersal resources) trawl surveys in the late nineties (tab. 4) (IRMA-CNR, 1999).

Table 7.11.4.1. Simulation of long - term variation in yield per recruit (Y/R) and income per recruit (£/R) of Red Mullet in GSA 15 and 16 changing current mesh size from 30 to 40 mm opening according to Thompson and Bell model (from IRMA-CNR, 1999).

Fishing mortality (F)	Y/R(g) "30"	Y/R(g) "40"	Δ%	£/R "30"	£/R "40"	Δ%
0.5	5.8	5.9	+1.9	29	31	+5.5

In more recent literature, the exploitation rate (E) on the hake of GSA 15 and 16, estimated by demographic structure of the stock derived from trawl surveys (1994-1999), was about 0.56 in both sexes, suggesting a state of light overexploitation (SAMED, 2002). According to Ben Mariem et al. (1995) and Gharbi et al. (2004), red mullet is fully exploited in the GSA 12 and 13, while the stock is overfished in the GSA 14. The scientists recommend to decrease the current fishing effort. On the basis of the yield per recruit analysis changing the mesh size from 38 to 50 mm an increase of yield should be obtained. Levi *et al*. (2003) investigated the stock-recruitment relationship for Red mullet in the Strait of Sicily including environmental information in terms of sea surface temperature (SST) anomaly as a proxy for oceanographic processes affecting recruitment. The study showed that, for a given level of spawning stock, higher level of recruitment corresponded to SST warmer than average during the early life stages (fig. 7.11.4.3).

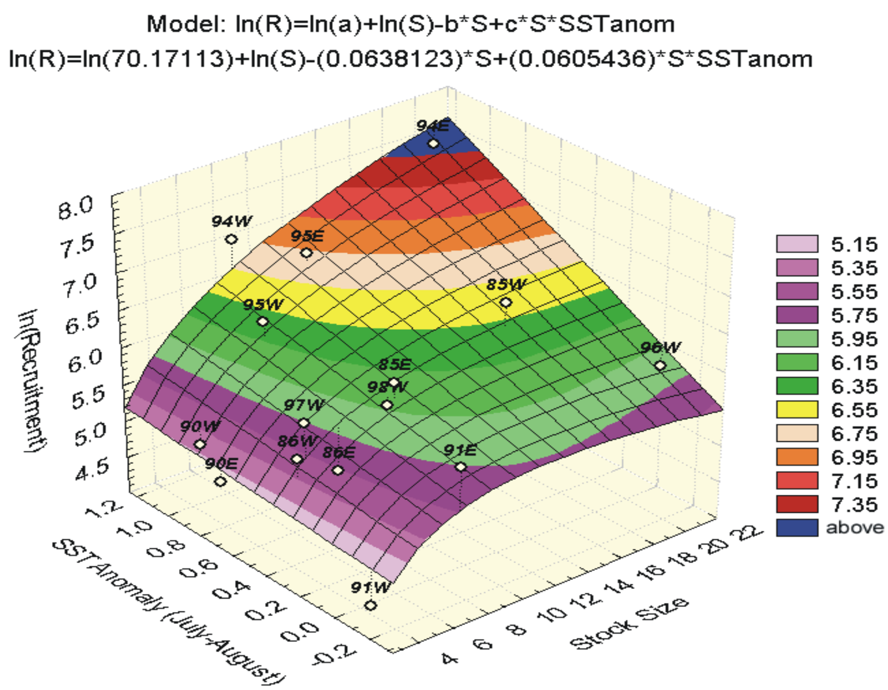


Fig. 7.11.4.3. Stock-recruitment relationship including sea surface temperature anomalies of *M. barbatus* in the Strait of Sicily (GSA 16 and 15, excluding the MMFZ) (from Levi *et al*., 2003).

7.11.4.1. Method 1: VIT LCA

7.11.4.1.1. Justification

Four complete years (2006, 2007, 2008 and 2009) of length frequency distributions from GSA 16 commercial landings data (fished in GSA 15 as well as GSA 16) were available, so an approach under steady state (pseudocohort) assumptions was used. Cohort (VPA equation) and Y/R analysis as implemented in the package VIT4win were thus used (Lleonart and Salat, 2000). Data were derived from the DCF data call for GSA 16.

7.11.4.1.2. Input parameters

The used v. Bertalanffy parameters were reported in table 7.11.4.1.2.1.

Table 7.11.4.1.2.1 v. Bertalanffy parameters

Sex	L_{inf}	k	t_0	a	b
F	23.61	0.45	-0.80	0.0134	2.9419
M	20.16	0.57	-0.80	0.0176	2.8226

The maturity and natural mortality vector by size are reported in table Table 7.11.4.1.2.2. Terminal F was fixed as 0.15. Discard data was not included in the analysis.

Table 7.11.4.1.2.2 Maturity and M as over length as used in the assessment model.

Size	Maturity		Natural mortality	
	F	M	F	M
10	0.02	0.51	0.45	0.64
11	0.04	0.68	0.37	0.51
12	0.09	0.81	0.32	0.39
13	0.18	0.90	0.28	0.35
14	0.32	0.95	0.25	0.31
15	0.51	0.97	0.22	0.29
16	0.70	0.99	0.20	0.26
17	0.84	0.99	0.19	0.24
18	0.92	1.00	0.18	0.21
19	0.96	1.00	0.17	0.19
20	0.98	1.00	0.16	0.19
21	0.99	1.00	0.15	0.19
22	1.00	1.00	0.15	0.19
23	1.00	1.00	0.15	0.19
24	1.00	1.00	0.15	0.19
25	1.00	1.00	0.15	0.19

Tab. 7.11.4.1.2.3 FLD (thousands) of commercial *Mullus barbatus* landings (females) data from GSA 16 by fleet segment used as input data for age splicing and subsequently VIT analysis.

Females	**Trawlers 12- 24m**				**Trawlers > 24m**			
Length (cm)	**2006**	**2007**	**2008**	**2009**	**2006**	**2007**	**2008**	**2009**
10		21950	32747	79620	71962	24445	5966	1281
11	73341	89675	136931	143983	241602	376985	152354	10612
12	184470	181043	172645	296180	155302	892669	643161	107211
13	373439	325228	252081	460328	256052	580200	1034058	139698
14	622821	550340	329227	755167	657378	932302	1542678	160870
15	800097	781254	603387	1030449	1179859	1589075	1856986	250943
16	767174	789684	722298	1196814	1035983	1583551	1221041	237170
17	713698	754678	672504	1378089	866067	1238896	668492	121120
18	709470	470496	570019	1173900	837793	560965	351724	30066
19	545685	439610	391815	846310	222484	374064	128776	10877
20	282737	274003	275346	509094	534828	60277	55419	2170
21	206654	141389	125502	259338	71962	24445	5966	1281
22	5279587	4819350	4284502	8129272	241602	376985	152354	10612
total	5279587	4819350	4284502	8129272	6059310	8213428	7660655	1072016

Tab. 7.11.4.1.2.4 LFD (thousands) of commercial *Mullus barbatus* landings (males) data from GSA 16 by fleet segment used as input data for age splicing and subsequently VIT analysis.

Males	**Trawlers 12- 24m**				**Trawlers > 24m**			
Length (cm)	**2006**	**2007**	**2008**	**2009**	**2006**	**2007**	**2008**	**2009**
10		77077	27190	103607	229939	71051	59764	3290
11	246326	317378	185855	338306	206814	831442	949656	32602
12	563238	693704	340439	640562	364672	1851494	2483065	133996
13	541355	976438	837523	979729	574918	1930867	2248945	353068
14	470376	827749	990914	1192637	1490228	2802320	2121474	449364
15	492132	660035	746295	1093111	1390963	2753708	1924233	172362
16	480422	567854	699611	1154709	582357	929144	766105	31773
17	220040	235269	368133	800175	144404	162348	122590	5056
18	24759	36936	138709	288982	56343	29063	18393	830
19	93688	18447	66091	59933	229939	71051	59764	3290
total	3132336	4410888	4400758	6651750	5040636	11361437	10694225	1182341

7.11.4.1.3. Results

Fishing mortality rates (F) for combined sexes by age class, fleet segment and year are shown in Fig. 7.11.4.1.3.1 below.

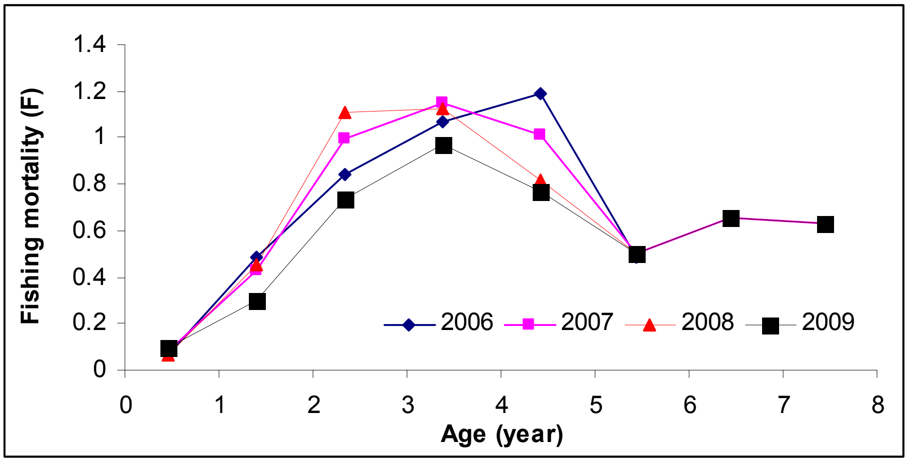


Fig. 7.11.4.1.3.1. Fishing mortalities rates (F) by age and fleet segment for combined sexes of M. barbatus in GSA 16.

The other main results of the VIT analysis, including the current mortality rates, are listed in table 7.11.4.1.3.1.

Table 7.11.4.1.3.1 The main results of VIT analysis.

Variables	**2006**	**2007**	**2008**	**2009**
Observed Yield (tons)	1124	1380	1177	800
Recruitment (ml)	39.2	34.3	28.8	15.8
Mean F all ages	0.69	0.60	0.67	0.57

7.11.5. *Long term prediction*

7.11.5.1. Justification

A Yield per Recruit analysis was done using the VIT program.

7.11.5.2. Input parameters

See in the chapter 7.11.4.1.2.

7.11.5.3. Results

The results of the Y/R analysis are presented below.

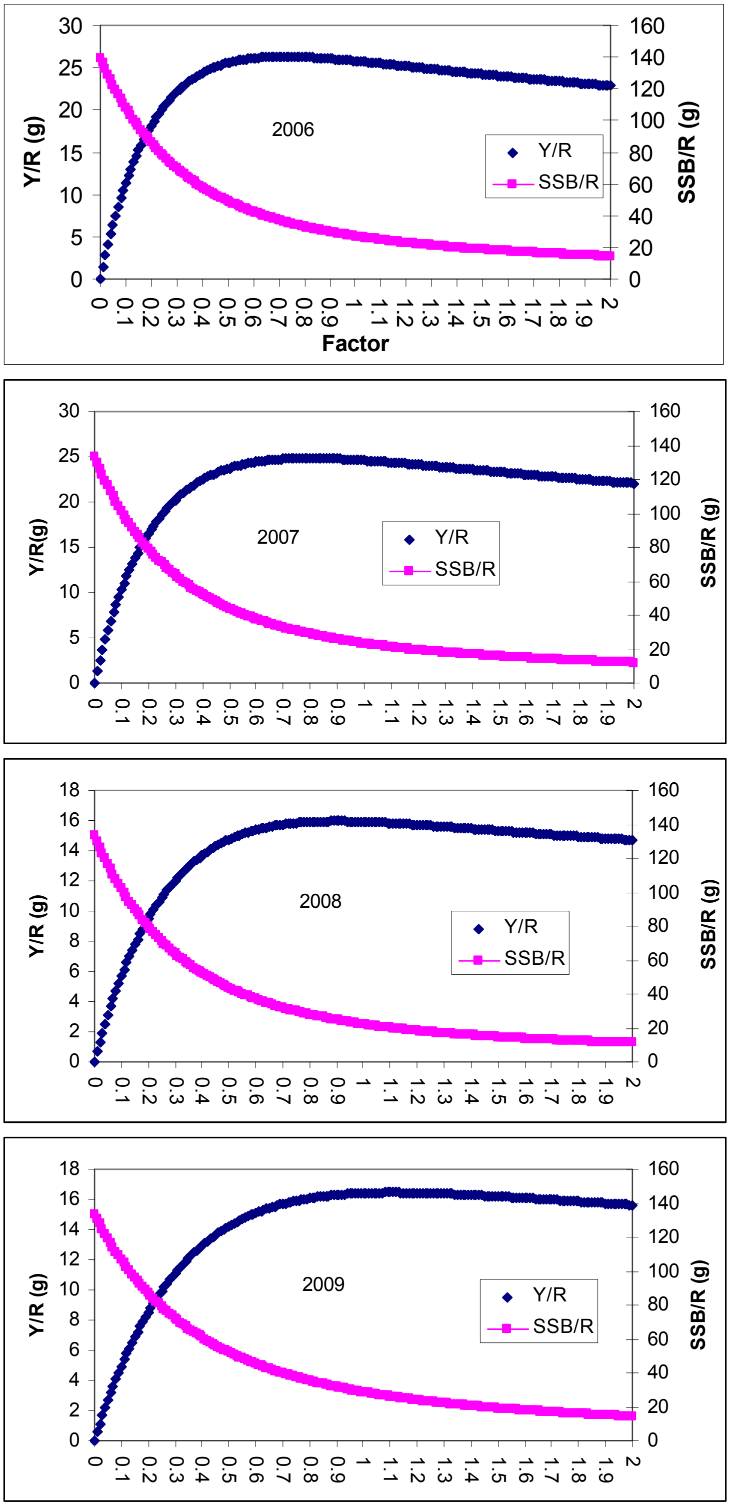


Fig. 7.11.5.3.1. Yield and Spawning Stock Biomass per recruit under varying current fishing mortality (F_{stq}) according to the VIT package (combined sex), 2006-2009.

Tab. 7.11.5.3.1. Estimation of yield (Y in g), biomass (B in g) and spawning stock biomass (SSB in g) per recruit (R), varying current fishing mortality by a multiplicative factor. The factor corresponding to $F_{0.1}$ is marked in bold (combined sex).

Year	Factor	F	Y/R	B/R	SSB
	0.00	0.00	0	157.276	139.5955
	0.43	**0.29**	**24.83**	**70.181**	**55.0405**
	0.73	0.50	26.294	50.318	36.2525
2006	1.00	0.69	25.7755	40.1675	26.934
	0.00	0.00	0	152.243	133.742
	0.45	**0.30**	**23.542**	**62.621**	**47.554**
	0.76	0.51	24.8975	43.7385	29.962
2007	1.00	0.68	24.599	36.4595	23.3085
	0.00	0.00	0	152.243	133.742
	0.46	**0.31**	**23.138**	**60.912**	**46.1**
	0.79	0.53	24.467	41.599	28.1485
2008	1.00	0.67	24.235	35.0575	22.181
	0.00	0.00	0	152.243	133.742
	0.53	**0.30**	**23.4585**	**64.424**	**49.306**
	0.91	0.52	24.854	44.629	30.8535
2009	1.00	0.57	24.7615	42.383	28.6075

7.11.6. *Scientific advice*

7.11.6.1.1. State of the spawning stock size

According to VIT analysis, absolute estimations of SSB (combined sex) in the 2006-2009 was 1,070 t in 2006, 1307 t in 2007, 1046 t in 2008 and 905 t in 2009. Nevertheless, biomass indices derived from scientific surveys in spring-summer (MEDITS), which is representative of SSB, show a clear increasing trend of spawners' abundance. In the absence of a precautionary management reference point SGMED is unable to fully evaluate the state of the SSB.

7.11.6.1.2. State of recruitment

The estimates of absolute recruitment in millions of individuals (age class 0) from VIT analysis in 2006-2009 were 39.2 in 2006, 34.3 in 2007, 28.8 in 2008 and 15.8 in 2009. The time series of recruitment indices from trawl surveys in autumn (GRUND surveys) carried out in GSA 16 (individuals smaller than 11 mm CL) showed a peak in 2004 and in 2005. Considering the overall time series an increasing trend of recruitment seem to occur.

7.11.6.1.3. State of exploitation

The stock of red mullet in the Northern sector of the Strait of Sicily is overfished since the current fishing mortality is higher than $F_{0.1}$ and F_{max}.

7.11.6.2. Medium term considerations

Considering he Sicilian fleet operating in GSAs 15-16, for which both commercial data were available at SGMED 10-03, a reduction of about 50% of the fishing mortality is needed to reach the $F_{0.1}$ and between 10 and 30% to reach F_{max}. However, recent survey indices of SSB and recruitment increased despite the obvious overfishing. As SGMED is unable to fully evaluate the state of the stock size due to a lack of reference points, SGMED suggests that the recent increase could be related to the reduction of illegal trawling in the coastal areas within the 50 m depth where the recruitment of the species occurs in late summer-early autumn.

The working group was informed that the Italian government is adopting a management plan in which a reduction of fishing mortality of 25% is planned within 2013. SGMED recommends the adoption of a management plan to continuously reduce current F through consistent effort reductions, and an improvement in current exploitation patterns.

7.12. Stock assessment of pink shrimp in GSA 09

7.12.1. *Stock identification and biological features*

7.12.1.1. Stock Identification

Due to a lack of information about the structure of pink shrimp population in the western Mediterranean, this stock was assumed to be confined within the GSA 09 boundaries.

The species shows a wide bathymetric distribution in the GSA 09, being present from 50 to 650 m depth with greatest abundance between 150 and 400 m depth over muddy or sandy-muddy bottoms (Ardizzone and Corsi, 1997; Biagi *et al.*, 2002).

The highest abundances have been found in the Tyrrhenian part of the GSA (south Tuscany and Latium).

Recruits (CL ≤ 15 mm) occur all year round with a main peak from July to October (De Ranieri *et al*., 1997). The main nurseries revealed a high spatio-temporal persistency (Fig. 7.12.1.1.1) between 60 and 220 m depth. The core of nursery areas overlap with crinoid beds (*Leptometra phalangium*) areas over the shelf-break (Colloca *et al*., 2004, 2006a; Reale *et al*., 2005). This is a peculiar habitat in the GSA 09 which is also an essential fish habitat for other commercially important species as the European hake, *Merluccius merluccius*. A positive size-depth distribution was found with an increased abundance of larger females with depth (Ardizzone *et al*., 1990).

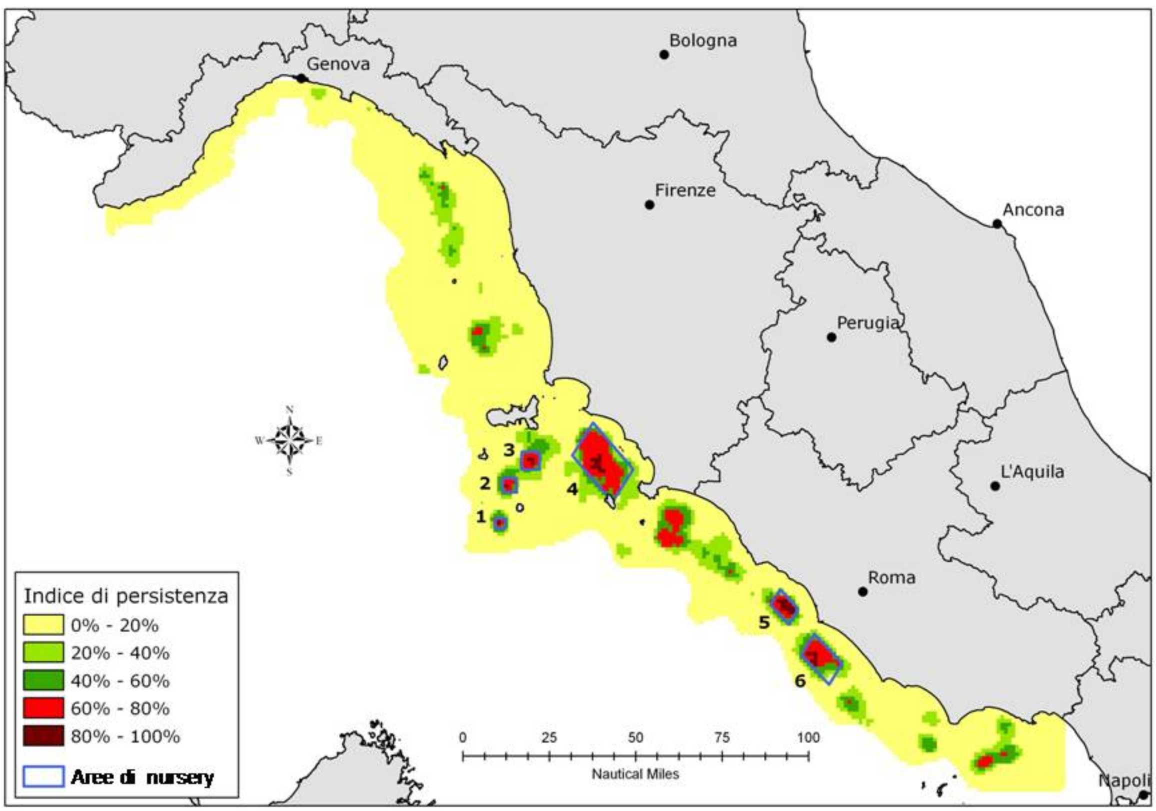


Fig. 7.12.1.1.1 Temporal persistence of *P. longirostris* nurseries in the GSA 09.

7.12.1.2. Growth

The growth of *P. longirostris* has been studied in the southern part of the GSA 09 (central Tyrrhenian Sea) using modal progression analysis (Ardizzone *et al*., 1990). The following sets of Von Bertalanffy growth parameters were estimated: Females: $L\infty = 43.5$, $K=0.74$, $t_0=-0.13$; Males: $L\infty = 33.1$, $K=0.93$, $t_0=-0.05$. The life cycle is of 3-4 years. Females grow faster than males attaining larger size-at-age.

P. longirostris diet is composed of a great variety of organisms; the prey items consisted mostly of external skeletons of bottom organisms, always crushed and often in an advanced state of deterioration. Crustaceans dominated the diet both qualitatively and quantitatively; they were characterized by a high abundance of peracarids, mainly represented by mysids (*Lophogaster typicus*) and amphipods (Lysianassidae). Molluscs (juvenile bivalves and gastropods), cephalopods (Sepiolids), small echinoderms, annelids, small fishes, foraminiferans, (Globigerinidae) and organic detritus are other important food item in the diet of the species (Mori *et al.*, 2000b).

7.12.1.3. Maturity

In the northern Tyrrhenian Sea, the reproduction area of *P. longirostris* is located from 150 to 350 m; mature females are present all year round, even though the species shows two peaks in reproductive activity, one in spring and another at the beginning of autumn (Mori *et al*., 2000a). In the central Tyrrhenian Sea, the southern part of GSA 09, a main winter spawning was hypothesized (Ardizzone *et al*., 1990). The size at onset of sexual maturity estimated for different years in northern Tyrrhenian Sea is about 24 mm CL (Mori *et al*., 2000a).

The number of oocytes in the ovary was related to the size of the females and ranged from 23,000 oocytes at 26 mm CL to 204,000 at 43 mm CL. An exponential relationship was observed between fecundity and carapace length: Fecundity = 0.0569 CL4.0177 (r = 0.829) (Mori *et al*., 2000a).

7.12.2. *Fisheries*

7.12.2.1. General description of fisheries

In the GSA 09 the deep water pink shrimp is one of the most important target species of the fishery carried out on the shelf break and upper part of continental slope. The species is exclusively exploited with otter bottom trawling.

The fishing grounds are located in the southern part of the GSA 09, to the south of Elba Island (northern and central Tyrrhenian Seas); they are mainly exploited by several trawlers of Porto Santo Stefano, Porto Ercole, Fiumicino, Terracina and Gaeta. *P. longirostris* belongs to a fishing assemblage distributed from 150 to 350 m depth, where the main target species are hake, *Merluccius merluccius*, horned octopus, *Eledone cirrhosa* and Norway lobster, *Nephrops norvegicus*, at greater depths (Biagi *et al.*, 2002; Colloca *et al*., 2003; Sartor *et al*., 2003; Sbrana *et al*., 2006).

The majority of bottom trawlers of GSA 09 operate daily fishing trips with some vessels (especially those of Porto Santo Stefano) staying out for two-three days and mainly in the summer. The mean number of fishing days/year per vessel carried out by the GSA 09 trawlers varied from 187 in 2004 to 177 in 2006. Due to the distance of the fishing grounds to the main harbours, fishing activity targeting *P. longirostris* shows some seasonal variations, with maxima from mid spring to mid autumn.

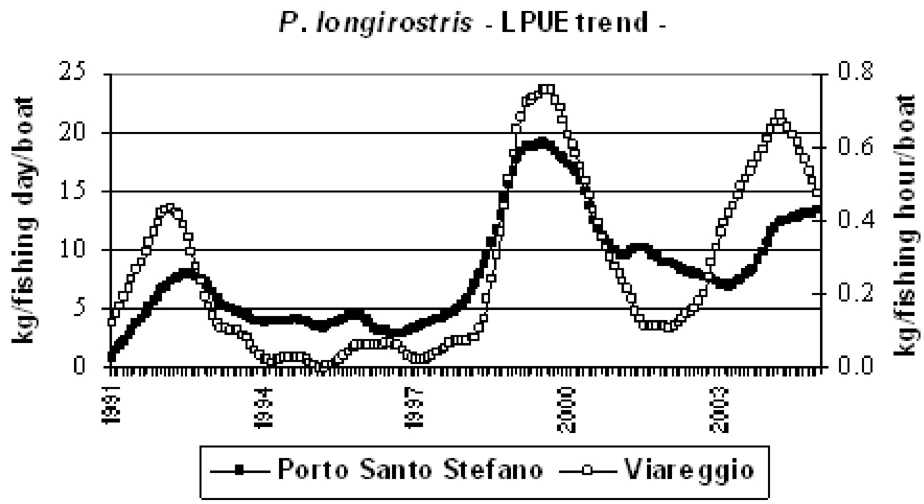


Fig. 7.12.2.1.1 *P. longirostris* LPUE of P. S. Stefano and Viareggio from 1991 to 2005.

The size structure of the landings, according to the DCR data, shows that the most exploited sizes ranged from 24 to35 mm CL (Fig. 7.12.2.1.2); the presence of specimens under the MLS (20 mm CL) is negligible. According to the growth pattern of the species, fishing exploits mainly 1^+ - 3^+ age classes.

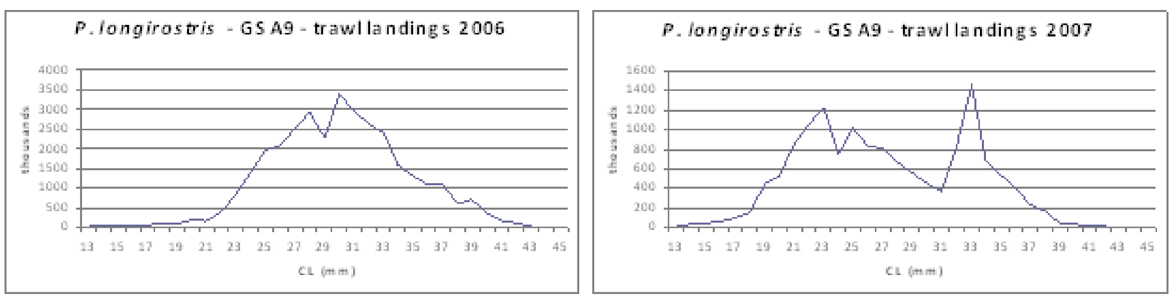


Fig. 7.12.2.1.2 Length frequency distribution of *P. longirostris* landed in the GSA 09 in 2006 and 2007.

7.12.2.2. Management regulations applicable in 2009 and 2010

The minimum legal landing size is 20 mm Carapace Length (EC regulation 1967/2006). The other management regulations are the same described for hake in the GSA 09.

7.12.2.3. Catches

7.12.2.3.1. Landings

Total landings of deep water rose shrimps fluctuated from 161 tons in 2002 to 219 tons in 2009, showing a peak in 2006 corresponding to 462 tons (Fig. 7.12.2.3.1.1; Tab. 7.12.2.3.1.1). The landings are almost entirely taken by demersal otter trawlers. The fluctuating trend is a proper characteristic of the landings of this species, as shown by the LPUE produced by the fleets of Porto Santo Stefano and Viareggio in the period 2001-2005 (Sartor *et al*., 2005) (Fig. 7.12.2.1.1). The values of the two fleets showed the same temporal pattern with maxima in 1992, 1999 and 2004.

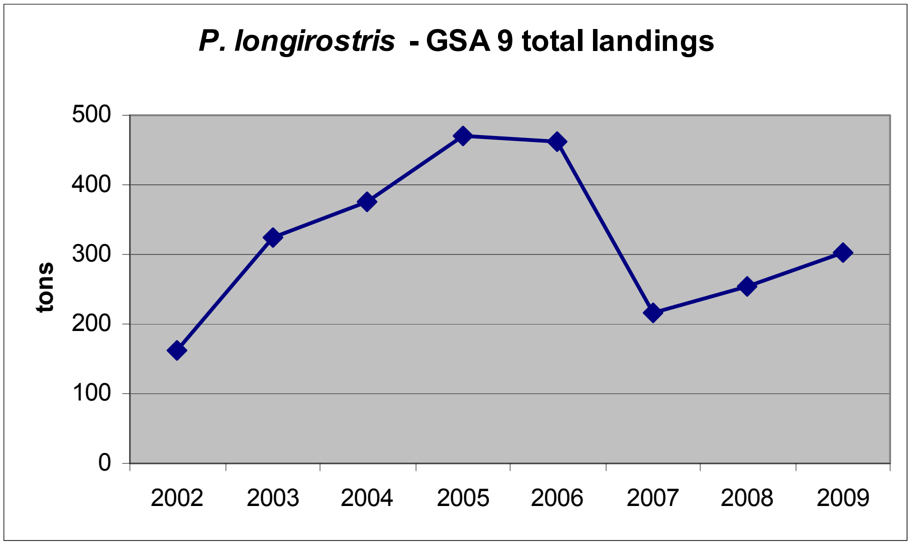


Fig. 7.12.2.3.1.1 Total landings in GSA 09.

Tab. 7.12.2.3.1.1 Annual landings (t) by fishing technique in GSA 09 as provided through the official DCF data call 2010.

SPECIES	AREA	COUNTRY	FT_LVL4	2004	2005	2006	2007	2008	2009
DPS	9	ITA		0,0					
DPS	9	ITA	GNS	3,6			2,3	0,5	
DPS	9	ITA	GTR	4,2	0,5				
DPS	9	ITA	OTB	367,4	430,4	462,4	215,2	253,5	303,1
TOTAL LANDINGS				375,3	430,9	462,4	217,4	254,0	303,1

7.12.2.3.2. Discards

Discards of *P. longirostris* are scarce; according to Sbrana *et al*. (2006) they ranged from 0.35 to 1.24% of the total catch of the species. Discards occurred mainly on the fishing grounds located at depths of less than 200 m, where juvenile specimens are more abundant.

About 9 t of discards were reported to SGMED-09-02 for 2006.

7.12.2.3.3. Fishing effort

The trends in fishing effort by fishing technique reported to SGMED-10-02 are listed in Tab. 7.12.2.3.3.1. After 2006, the effort of the major demersal trawler fleet decreased slightly.

Tab. 7.12.2.3.3.1 Trends in annual fishing effort (kW*days) by fishing technique deployed in GSA 09, 2004-2009.

AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	VESSEL_LENGTH	2004	2005	2006	2007	2008	2009
9	ITA				VL0006			17656	17264	18783	83933
9	ITA				VL0612	472199	644679	294865	73209	117265	164688
9	ITA				VL1218	3700			2547		
9	ITA				VL1824	17372					
9	ITA	DRB	Molluscs		VL1218	271337	290683	222614	232521	355036	273697
9	ITA	FPO	nersal species		VL0006			1687			
9	ITA	FPO	nersal species		VL0612					2569	
9	ITA	FPO	nersal species		VL1218					22490	9484
9	ITA	GND	iall pelagic fish		VL0612	7686	2640	47550			4429
9	ITA	GND	iall pelagic fish		VL1218			11976			
9	ITA	GNS	nersal species		VL0006			241006	187684	119389	159810
9	ITA	GNS	nersal species		VL0612	2671807	3040551	2043295	2876900	1943304	2084677
9	ITA	GNS	nersal species		VL1218	143130	731268	892800	588214	780959	860279
9	ITA	GNS	nersal species		VL1824	1616					
9	ITA	GNS	nd large pelagic fish		VL0006				5402	2776	
9	ITA	GNS	nd large pelagic fish		VL0612	11704	63837	15456	4132	20976	38386
9	ITA	GNS	nd large pelagic fish		VL1218		52196		68484	30113	22011
		TOTAL GNS				**2828257**	**3887852**	**3192557**	**3730816**	**2897517**	**3165163**
9	ITA	GTR	nersal species		VL0006			51327	45484	31192	89981
9	ITA	GTR	nersal species		VL0612	2907871	3430873	3354500	2549277	2158965	2581318
9	ITA	GTR	nersal species		VL1218	22931	394777	352725	245701	140511	147834
		TOTAL GTR				**2930802**	**3825650**	**3758552**	**2840462**	**2330668**	**2819133**
9	ITA	LHP-LHM	Finfish		VL0612	40544					
9	ITA	LLD	ge pelagic fish		VL0612	428218	782673	709249	295671	439382	184624
9	ITA	LLD	ge pelagic fish		VL1218	7125	13281	163222	189635	137261	142197
9	ITA	LLD	ge pelagic fish		VL1824						0
		TOTAL LLD				**435343**	**795954**	**872471**	**485306**	**576643**	**326821**
9	ITA	LLS	emersal fish		VL0006			1186	21025	925	
9	ITA	LLS	emersal fish		VL0612	354518	458614	355370	91390	30209	27155
9	ITA	LLS	emersal fish		VL1218	1750	24006				2268
9	ITA	LTL	ge pelagic fish		VL0006			7086	2476		2603
9	ITA	OTB	p water species		VL1218					145852	320102
9	ITA	OTB	p water species		VL1824	10206				75837	165696
9	ITA	OTB	nersal species		VL0006					108	
9	ITA	OTB	nersal species		VL0612	202730	189101	226836	251665	174990	171451
9	ITA	OTB	nersal species		VL1218	1645868	1504133	1250063	2496441	2314631	2229315
9	ITA	OTB	nersal species		VL1824	2669494	314808	1266539	1540497	5460490	6053329
9	ITA	OTB	nersal species		VL2440	1492529					968737
9	ITA	OTB	al and deep water spec		VL1218	2119148	2664115	2362684	2519541	1177098	583020
9	ITA	OTB	al and deep water spec		VL1824	5857423	10065218	7321573	6236446	1253611	1372778
9	ITA	OTB	al and deep water spec		VL2440						62897
		TOTAL OTB				**13997398**	**14737375**	**12427695**	**13044590**	**10602617**	**11927325**
9	ITA	PS	ge pelagic fish		VL1218					4160	30424
9	ITA	PS	ge pelagic fish		VL1824	7275	3880		1299	59472	
9	ITA	PS	ge pelagic fish		VL2440						14965
9	ITA	PS	iall pelagic fish		VL0006				11193		
9	ITA	PS	iall pelagic fish		VL0612	27674	148646	44847		32718	42881
9	ITA	PS	iall pelagic fish		VL1218	269016	145756	569851	475217	525772	419772
9	ITA	PS	iall pelagic fish		VL1824	82023	157481	513668	629300	354009	240111
9	ITA	PS	iall pelagic fish		VL2440						562906
		TOTAL PS				**385988**	**455763**	**1128366**	**1117009**	**976131**	**1311059**
9	ITA	PTM	iall pelagic fish		VL0006			3148			
9	ITA	PTM	iall pelagic fish		VL0612			1542			
9	ITA	SB-SV	nersal species		VL0006			8996	25084	16683	7458
9	ITA	SB-SV	nersal species		VL0612	683331	856943	556372	499729	314844	327792
9	ITA	SB-SV	nersal species		VL1218	66124	45567	49489	25800	17960	20116
9	ITA	SB-SV	nersal species		VL1824	808					

7.12.3. *Scientific surveys*

7.12.3.1. MEDITS

7.12.3.1.1. Methods

From 1994 two trawl surveys are regularly carried out each year: MEDITS, in spring, and GRUND, in autumn. The two surveys gave a similar temporal increasing trend in density and biomass of deep water pink shrimp, even though large fluctuations are present from year to year (Fig. 7.12.3.1.1.1). A similar increasing trend in abundance has been observed also in other Italian geographic subareas and could be related to the warming trend in water temperature. *P. longirostris* is a thermophile species that could benefit by the ongoing climatic change in the Mediterranean region. The relationship between environmental variability and deep-sea pink shrimp population dynamic has not been investigated yet.

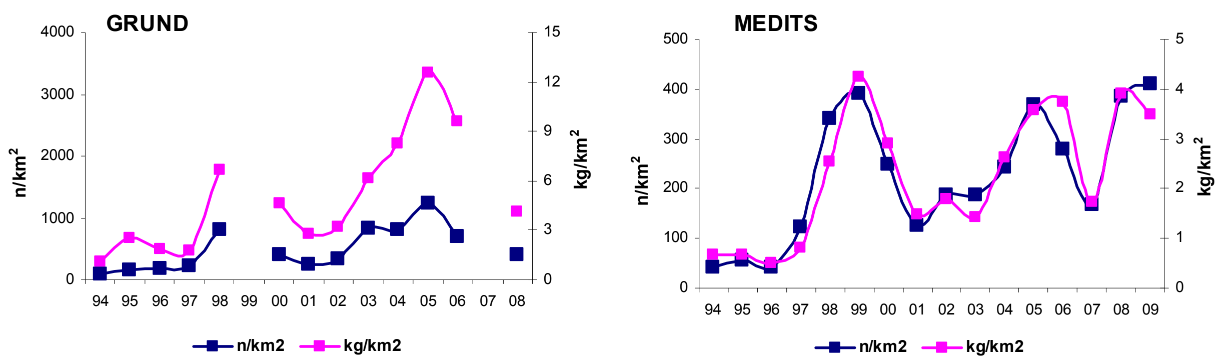


Fig. 7.12.3.1.1.1 *P. longirostris*: GRUND and MEDITS trends in density and biomass from 1994 to 2009 in GSA 09.

Based on the DCR data call, abundance and biomass indices were recalculated. In GSA 09 the following number of hauls was reported per depth stratum (s. Tab. 7.12.3.1.1.1).

Tab. 7.12.3.1.1.1. Number of hauls per year and depth stratum in GSA 09, 1994-2009.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GSA09_010-050	19	18	18	18	19	18	18	18	13	13	13	14	13	13	13	14
GSA09_050-100	19	20	18	19	18	19	20	20	15	15	15	14	16	16	13	14
GSA09_100-200	35	35	36	35	35	35	34	34	26	27	26	27	25	26	28	27
GSA09_200-500	32	33	33	36	32	36	37	35	27	27	27	28	29	33	30	28
GSA09_500-800	31	30	31	28	30	28	27	29	24	22	21	20	20	17	18	20

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

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

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

Where:

A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA.

7.12.3.1.2. Geographical distribution patterns

The stock is more abundant in the southern part of the GSA (Tyrrhenian Sea) as showed in Figure 7.12.3.1.2.1.

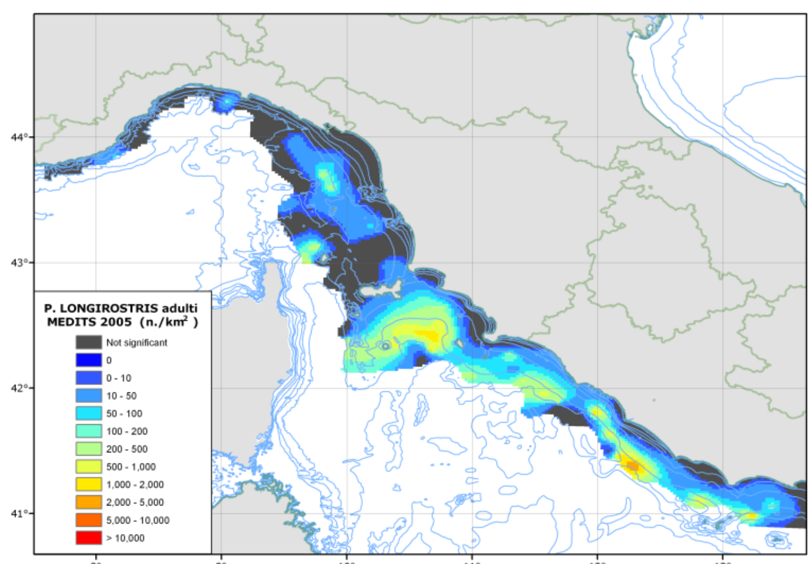


Fig. 7.12.3.1.2.1 *P. longirostris*: Adult specimens density, MEDITS 2005, GSA 09.

7.12.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the pink shrimp in GSA 09 was derived from the international survey MEDITS. Figure 7.12.3.1.3.1 displays the estimated trend in pink shrimp abundance and biomass in GSA 09.

The estimated abundance and biomass indices do not reveal a clear trend but appear to be above average recently.

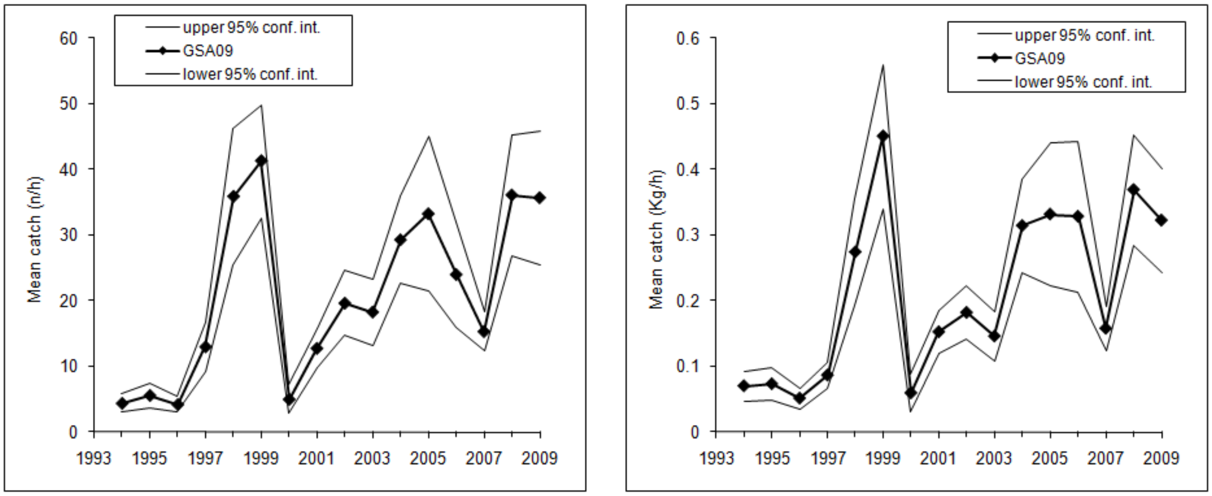


Fig. 7.12.3.1.3.1 Abundance and biomass indices of pink shrimp in GSA 09.

7.12.3.1.4. Trends in abundance by length or age

The following Fig. 7.12.3.1.4.1 and 2 display the stratified abundance indices of GSA 09 in 1994-2001 and 2002-2009.

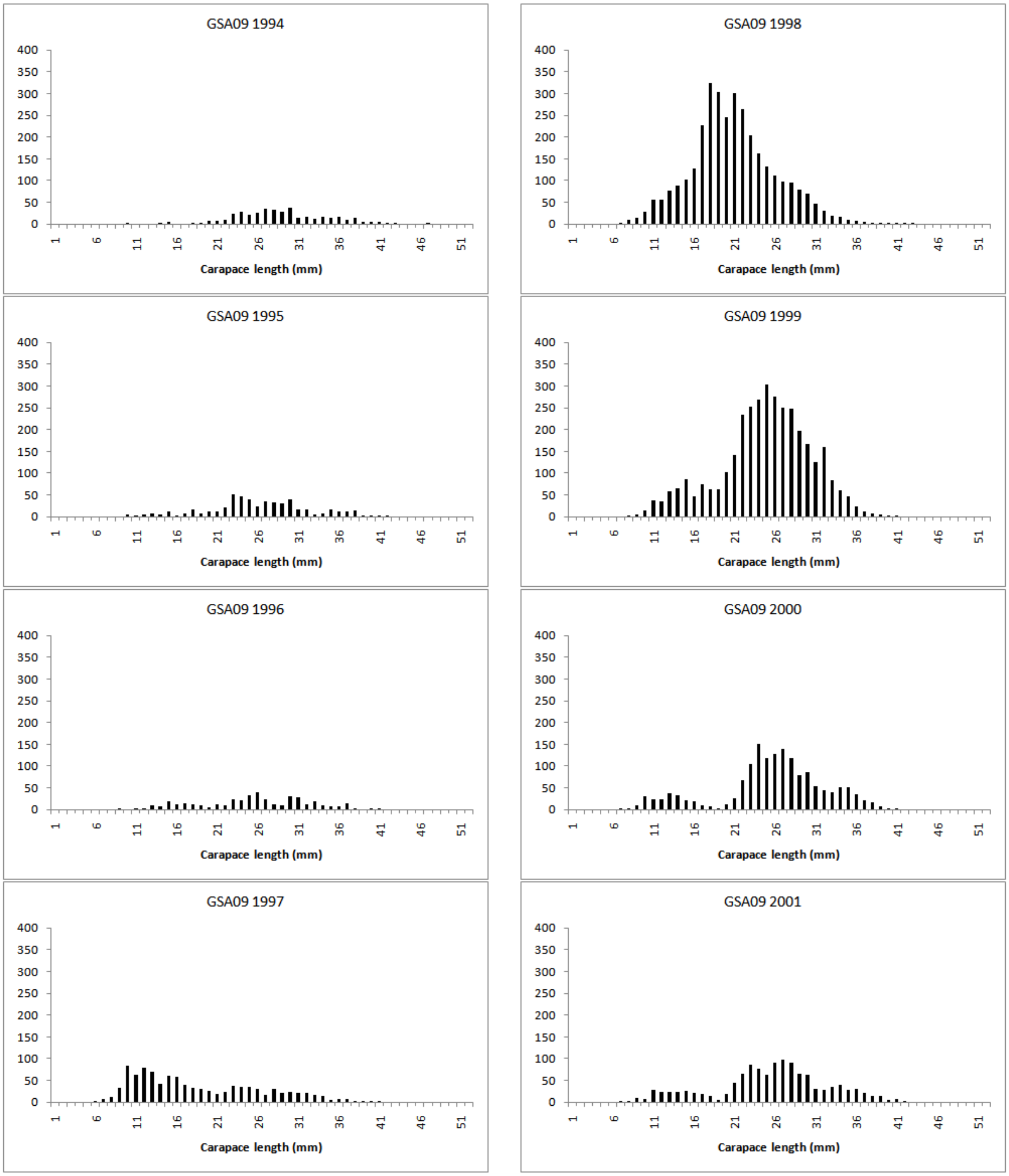


Fig. 7.12.3.1.4.1 Stratified abundance indices by size, 1994-2001.

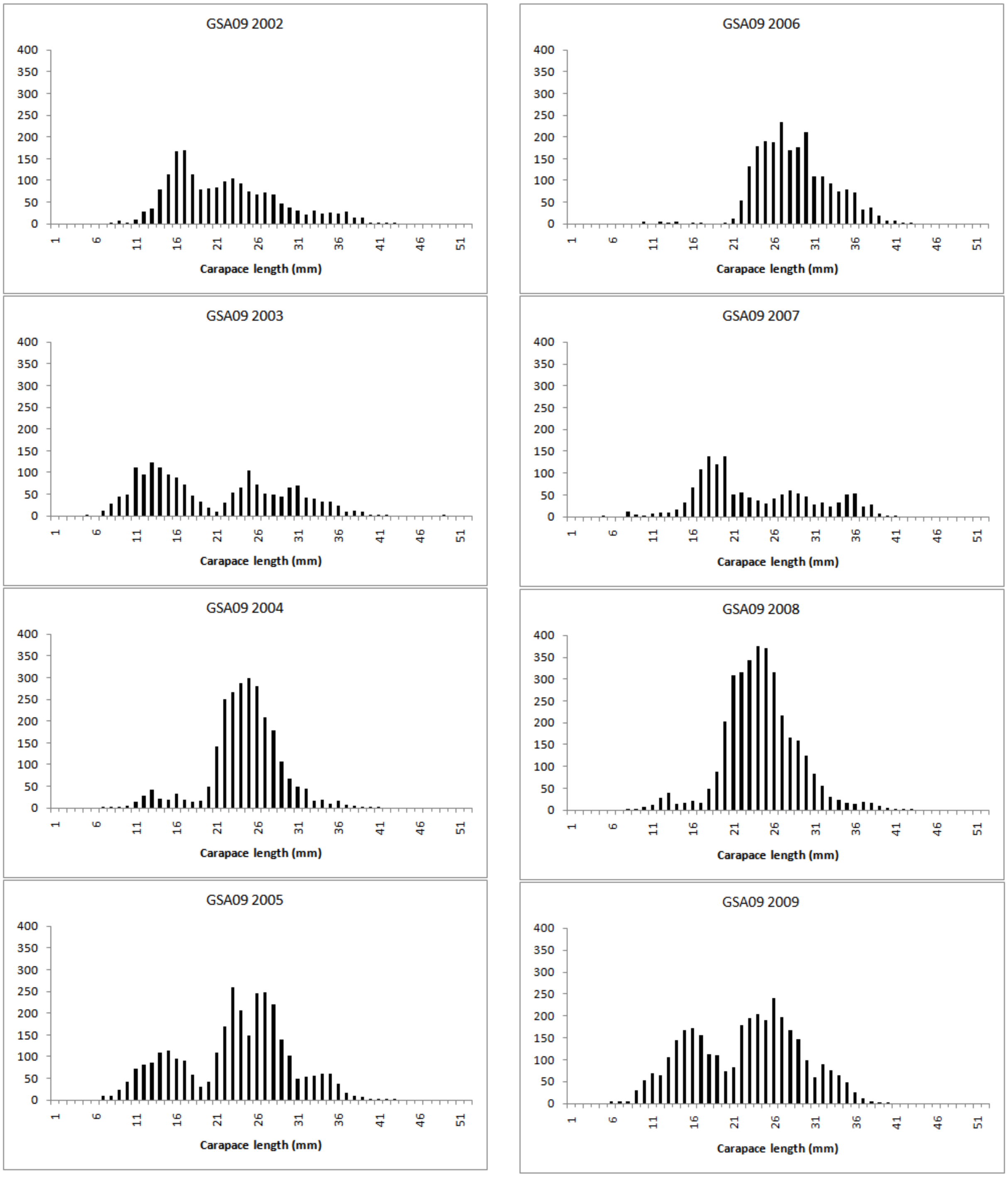


Fig. 7.12.3.1.4.2 Stratified abundance indices by size, 2002-2009.

7.12.3.1.5. Trends in growth

No analyses were conducted during SGMED-10-03.

7.12.3.1.6. Trends in maturity

No analyses were conducted during SGMED-10-03.

7.12.4. *Assessment of historic stock parameters*

7.12.4.1. Method 1: SURBA

7.12.4.1.1. Justification

The MEDITS survey provided the longer standardized time-series data on abundance and population structure of *P. longirostris* in the GSA 09.

7.12.4.1.2. Input parameters

The survey-based stock assessment model SURBA (Needle, 2003) was used to reconstruct trend in population structure and fishing mortality.

The following set of input data and parameters were used (Tab. 7.12.4.1.2.1 and 2).

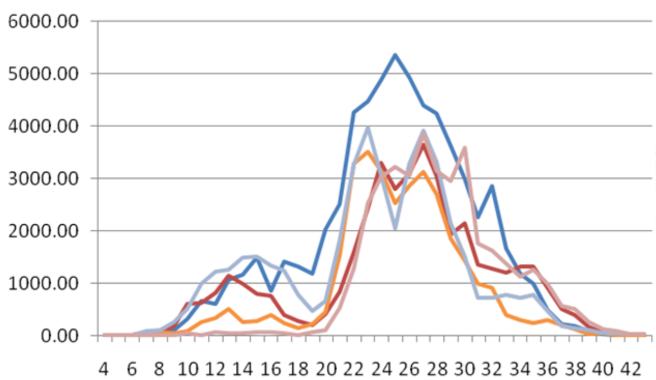
Tab. 7.12.4.1.2.1 Input data used in the SURBA model.

MEDITS					GRUND			
Mean abundance								
	Age				Age			
Year	0	1	2	3+	0	1	2	3+
1994		26.0	9.7	3.0	35.3	14.6	4.7	0.8
1995		33.8	7.1	2.5	80.6	23.6	4.4	0.4
1996		22.6	7.1	1.6	93.8	16.2	3.0	0.4
1997		33.2	7.8	1.0	74.2	18.2	2.0	0.1
1998		132.8	9.4	0.9	444.4	33.2	2.6	0.2
1999		253.7	45.7	1.9	339.5	53.1	5.6	0.2
2000		155.6	39.6	3.7	234.7	73.0	8.6	0.2
2001		73.2	18.8	3.9	141.9	40.7	6.7	0.3
2002		70.1	17.4	4.0	176.3	28.1	3.9	0.6
2003		58.1	17.3	2.5	235.8	63.8	6.3	0.7
2004		186.9	16.5	1.4	509.8	93.4	23.4	26.8
2005		216.3	29.7	2.4	567.0	177.4	16.9	1.0
2006		209.5	53.6	7.7	470.9	187.0	14.6	1.2
2007		57.9	26.0	4.0	363.2	101.6	8.2	0.6
2008		260.7	16.4	3.7				
2009		278.7	64.5	3.6				
Proportion mature								
	Age							
Year	0	1	2	3+	0	1	2	3+
1994		0.8	1	1	0.4	0.8	1	1
1995		0.8	1	1	0.4	0.8	1	1
1996		0.8	1	1	0.4	0.8	1	1
1997		0.8	1	1	0.4	0.8	1	1
1998		0.8	1	1	0.4	0.8	1	1
1999		0.8	1	1	0.4	0.8	1	1
2000		0.8	1	1	0.4	0.8	1	1
2001		0.8	1	1	0.4	0.8	1	1
2002		0.8	1	1	0.4	0.8	1	1
2003		0.8	1	1	0.4	0.8	1	1
2004		0.8	1	1	0.4	0.8	1	1
2005		0.8	1	1	0.4	0.8	1	1
2006		0.8	1	1	0.4	0.8	1	1
2007		0.8	1	1	0.4	0.8	1	1
2008		0.8	1	1				
2009		0.8	1	1				
Mean weights								
	Age							
Year	0	1	2	3+	0	1	2	3+
1994		15.5	18.1	25.1	4.5	16.5	18.1	25.0
1995		15.1	18.0	24.7	5.0	13.8	17.4	24.6
1996		16.5	18.1	25.0	3.9	15.8	17.1	24.9
1997		13.8	17.4	24.6	5.2	15.9	17.2	24.0
1998		15.8	17.1	24.9	4.9	14.7	18.0	23.8
1999		15.9	17.2	24.0	5.0	14.7	18.2	24.6
2000		14.7	18.0	23.8	4.5	16.0	18.0	24.2
2001		14.7	18.2	24.6	5.2	14.9	17.6	24.3
2002		16.0	18.0	24.2	5.1	14.7	17.1	23.8
2003		14.9	17.6	24.3	5.0	14.9	18.0	24.7
2004		14.7	17.1	23.8	4.3	16.5	17.8	24.4
2005		14.9	18.0	24.7	4.7	5.0	17.2	18.5
2006		16.5	17.8	24.4	5.1	17.2	18.5	23.8
2007		17.2	18.5	23.8	4.9	17.2	18.5	23.8
2008		17.2	18.5	23.8				
2009		16.5	17.8	24.4				

Tab. 7.12.4.1.2.2 Input parameters used in the SURBA model.

• **Growth**
L∞ = 43.5 mm carapace length
K = 0.6
to = 0
• **Length-Weight relationhips**
a = 0.00686
b = 2.24
• **Natural mortality**
M = 1..0 (age 0), 0.78 (age 1), 0.69 (age 2), 0.65 (age 3) (ProdBiom)
• **Length-at-maturity (L50)**
L50 = 24 mm
Lc100 = 20 mm

Standardized time series of MEDITS length-frequency-distributions were sliced into different age-groups using the same growth parameters for the whole time series (Fig. 7.12.4.1.2.1). The resulting age structures showed a very high internal consistency, thus showing the reliability of the growth parameters used (Fig. 7.12.4.1.2.1).



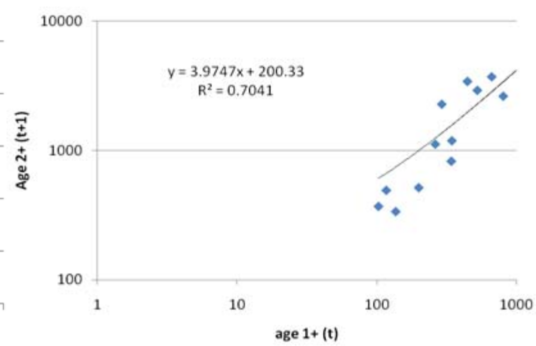


Fig. 7.12.4.1.2.1 Length frequency distributions of *P. longirostris* for 2000 to 2005 (left). Relationship between the estimated shrimp abundance at age 1 (time t) and age 2 (time t+1) (right).

A preliminary attempt to use SURBA was made excluding 0+ (CL < 20mm) specimens from the dataset due to their low catchability with the MEDITS trawl net. A fixed M mortality value (M=1.0) obtained from literature was used.

7.12.4.1.3. Results

Fitted year effect shows strong fluctuations from year to year with a decrease since 2006, while the age effect shows a flat-topped selection pattern for stock mortality with an increase from age 3 to age 6. Fitted cohort effects (Figure 7.12.4.1.3.1) are high in recent years.

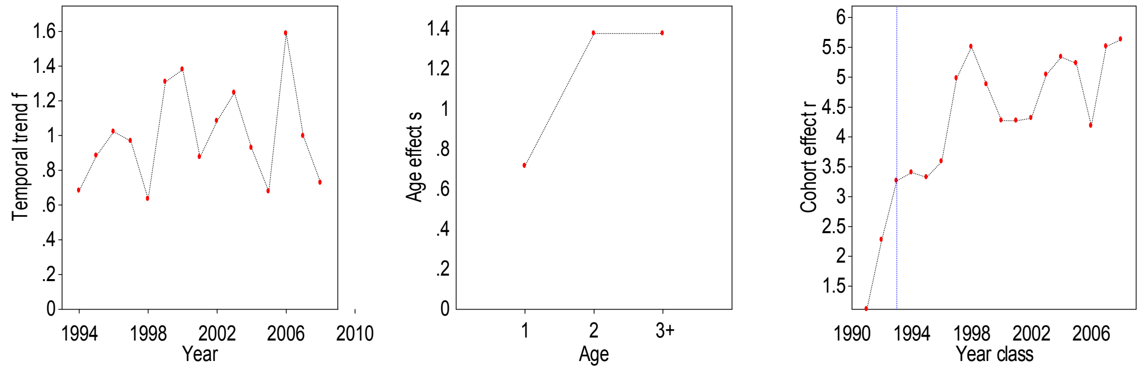


Fig. 7.12.4.1.3.1 MEDITS survey. Fitted year, age and cohort effects estimated by SURBA.

Average mortality (F_{1-3}) estimated from MEDITS ranged between 0.63 and 1.80 (0.76 in 2008). GRUND gives higher F_{1-3} values with some outliers in 2002-03. Relative indices derived from MEDITS survey for the period 1994-2008 indicated an increasing trend of the spawning stock biomass with highest values in 1999, 2006 and 2009. In 2009 the SSB was the highest observed since 1994. GRUND data showed a very similar temporal trend in SSB (Fig. 7.12.4.1.3.2). Young of the year (0+) are poorly sampled by the MEDITS survey. GRUND survey showed a clear increase of 0+ specimens since 1994 (Fig. 7.12.4.1.3.2).

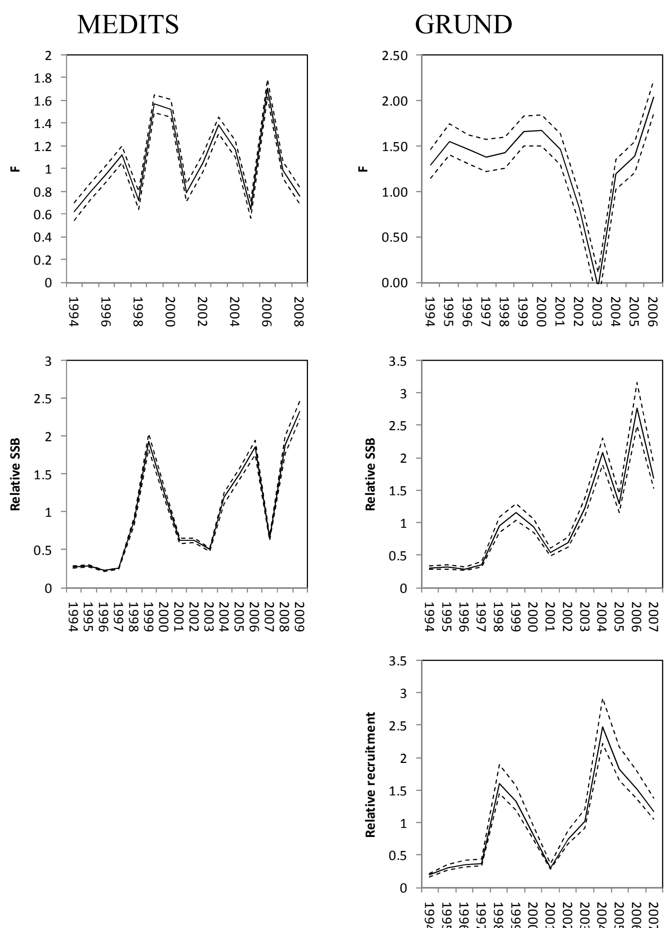


Fig. 7.12.4.1.3.2 Estimated trend in F_{1-3}, relative SSB and recruitment index at age 1+ of *P. longirostris* in the GSA 09, dotted lines are 2.5% and 97.5% confidence intervals.

Model diagnostics

The SURBA model for *P. longirostris* fits very well on survey data as showed in Fig. 7.12.4.1.3.3.

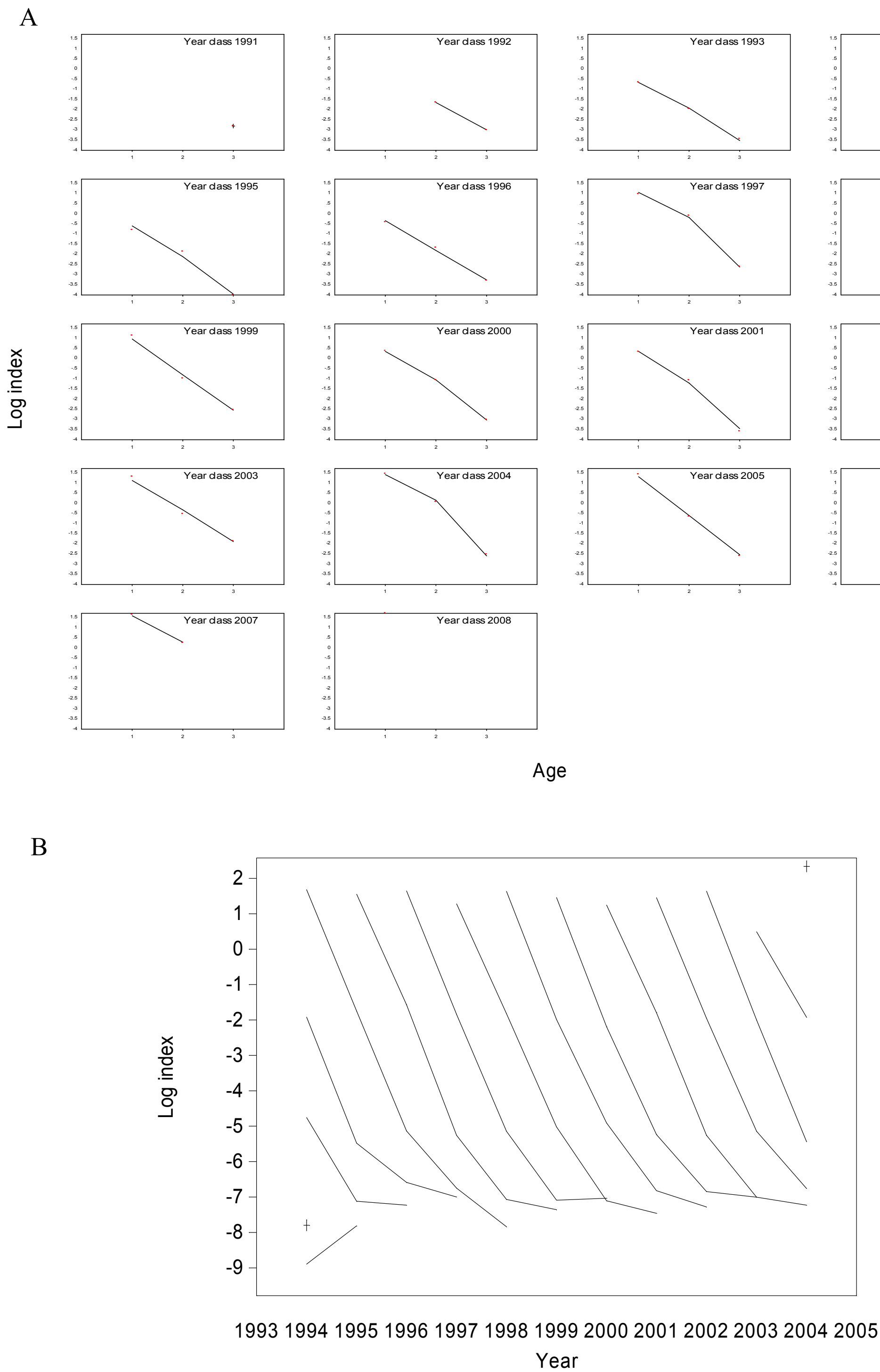


Fig. 7.12.4.1.3.3. Model diagnostic for SURBA model of in the GSA 9. A) Comparison between observed (points) and fitted (lines) MEDITS survey abundance indices, for each year. B) Log survey abundance indices by cohort. Each line represents the log index abundance of a particular cohort throughout its life.

7.12.4.2. Method 2: LCA

7.12.4.2.1. Justification

The pseudo-cohort analysis VIT was applied using data from 2006 to 2009.

7.12.4.2.2. Input parameters

Data coming from DCF provided at SGMED-10-03 contained information on deep water pink shrimp landings and discards and the respective size structure for 2006-2009 (Fig. 7.12.4.2.2.1). VIT software was used to run an LCA analysis for each year separately, using data in Tab. 7.12.4.2.2.1 and biological parameters listed in Tab. 7.12.4.1.2.2. The same M-vector used for SURBA (ProdBiom estimation) was used (age 1: 1; age 2: 0.78; age 3: 0.69; age 4: 0.65; age 5. 0.5).

Tab. 7.12.4.2.2.1. Input data for LCA of deep water pink shrimp in GSA 09.

	Catch (thousands)			
CL (mm)	2006	2007	2008	2009
13	18.16432	11.07079	61.50741	18.53493
14	27.24648	32.13541	73.85361	170.4239
15	65.92655	40.18933	132.9235	348.3502
16	55.81803	51.95908	323.9451	906.7234
17	67.40918	101.9767	419.8965	961.8374
18	120.833	146.9725	584.1598	1248.982
19	91.57851	447.3504	626.3145	1478.078
20	181.9051	520.8375	585.6067	1638.427
21	164.4702	843.671	650.5895	1253.395
22	396.3106	1059.506	770.9663	1442.096
23	850.9383	1223.911	703.7378	2026.029
24	1409.767	745.9678	742.4034	1980.551
25	1938.533	1017.44	687.0492	1534.539
26	2088.326	827.0652	532.2859	1251.946
27	2508.965	804.4397	628.9242	1082.998
28	2907.608	667.7498	718.2855	885.1118
29	2257.037	557.4856	633.8025	755.8328
30	3385.704	446.5953	593.5333	917.0832
31	2949.607	374.8371	638.4429	966.865
32	2627.644	832.3745	696.6365	1304.792
33	2373.102	1460.373	550.3642	1230.67
34	1579.829	678.0591	446.6311	847.4497
35	1298.287	531.8717	361	592.7765
36	1074.175	397.6136	333.439	608.7266
37	1072.87	232.8181	214	219.2185
38	596.2829	165.8361	212.4401	182.0989
39	689.9982	46.67985	139.66	351.6544
40	363.0406	29.09057	95.58767	110.1728
41	170.7018	12.61705	36.78293	49.72664
42	109.9197	6.639298	24.50597	13.95267
43	16.14419	3.695749	60.9532	7.575631

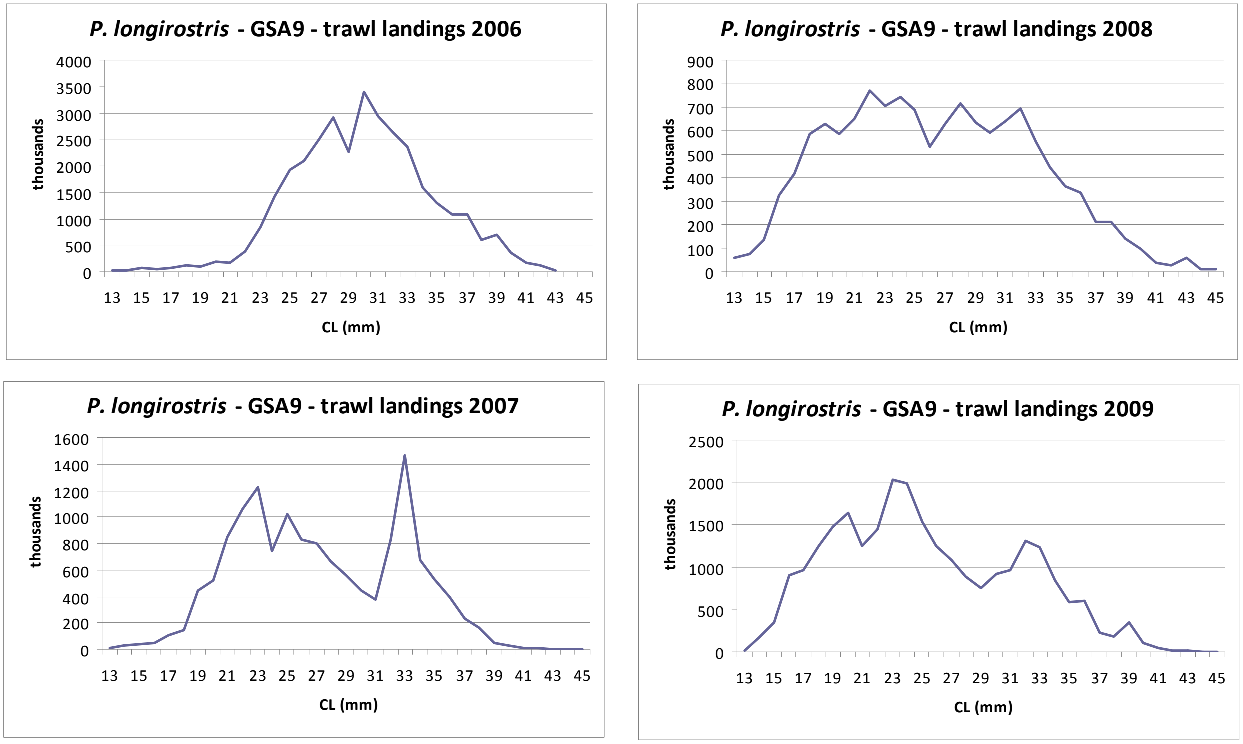


Fig. 7.12.4.2.2.1. Length frequency distributions of the *P. longirostris* catch from 2006 to 2009 in GSA 09.

7.12.4.2.3. Results

Deep water pink shrimp landings are concentrated on adults of age classes 2-4. High landings were observed in 2006. Fishing mortality peaked for specimens of age classes 2 and 3 (Fig. 7.12.4.2.3.1). F_{1-3} (obtained averaging the estimated F values of age classes 2, 3 and 4) was 0.24, 0.55, 0.23 and 0.59 in 2006, 2007, 2008 and 2009, respectively.

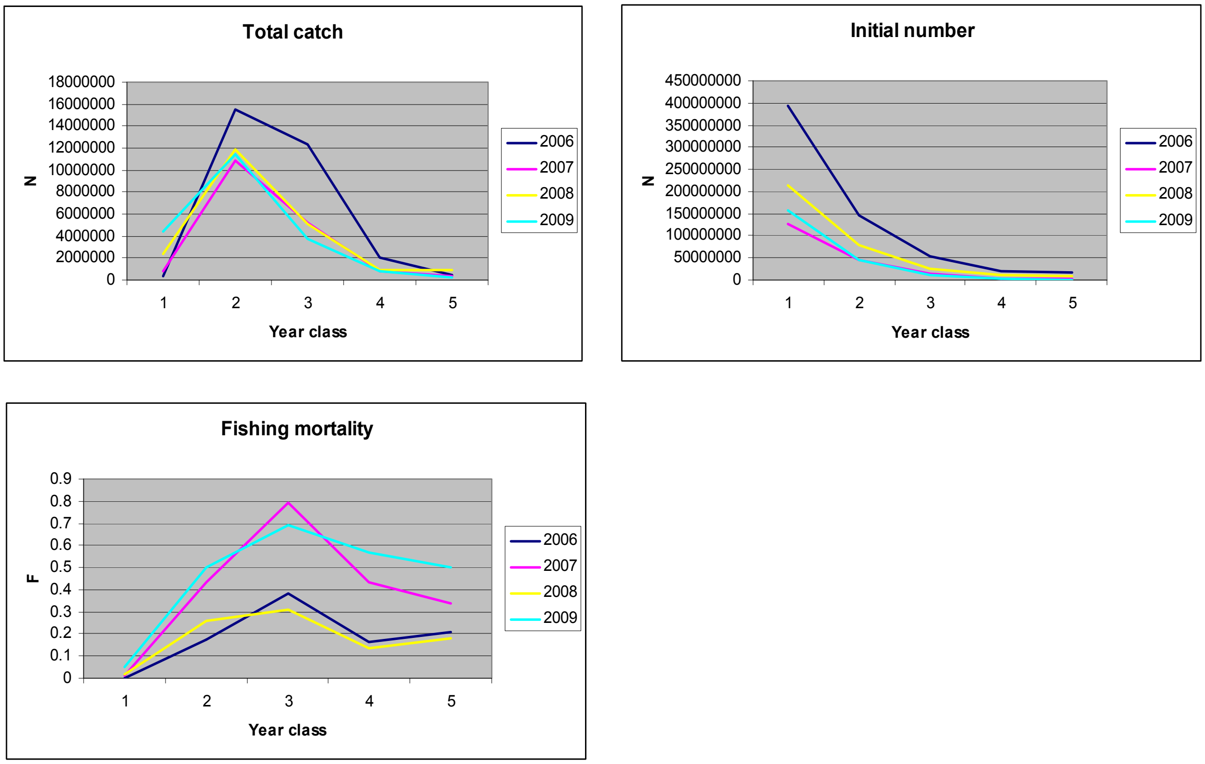


Fig. 7.12.4.2.3.1 LCA outputs: catch numbers, numbers-at-age and fishing mortality at age of *P. longirostris* in the GSA 09.

7.12.5. *Long term prediction*

7.12.5.1. Justification

The Yield software (Hoggarth *et al*., 2006) was used to estimate $F_{0.1}$ as target equilibrium YPR reference point for the stock assuming a 20% uncertainty in parameters estimations.

7.12.5.2. Input parameters

The following parameters were used to estimate $F_{0.1}$ through Yield software.

Tab. 7.12.5.2.1 Input to long term forecast.

L∞ = 43.5 mm carapace length
K = 0.6
t_0 = 0
a = 0.00686
b = 2.24
M = 1.2 CV=0.1
L_{50} = 24 mm, CV=0.05
Lc100 = 20 mm, CV=0.05
Spawning season: March-August
Fishing season: January-December

7.12.5.3. Results

Fig. 7.12.5.3.1 shows the probability distribution of $F_{0.1}$ (1,000 simulations). Uncertainty in model parameters produced considerable variations in $F_{0.1}$ which ranged between 0.5 and 1.1 (mean = 0.7) with an increased probability for values between 0.7 and 0.8.

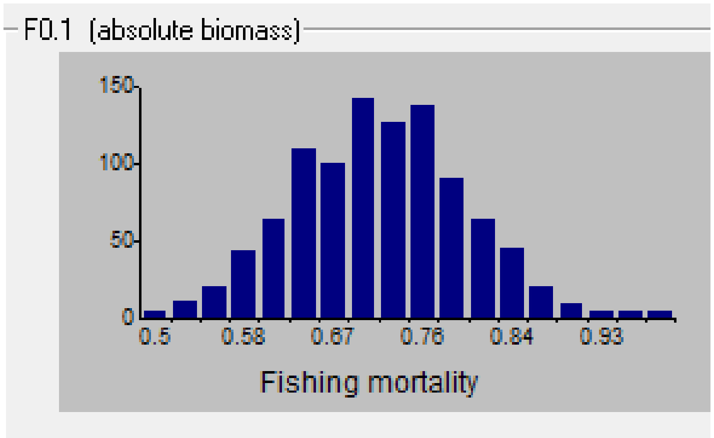


Fig. 7.12.5.3.1 Probability distribution of $F_{0.1}$ obtained using the Yield software.

According to these $F_{0.1}$ estimates, Fcurr was in most of the year above the average and maximum estimated $F_{0.1}$ values.

7.12.6. *Data quality*

Medits survey data were available from 1994. A check of hauls allocation between GSA 9 and 10 needs to be done before calculation of indices from JRC MEDITS database.

7.12.7. *Scientific advice*

7.12.7.1. Short term considerations

7.12.7.1.1. State of the spawning stock size

SSB showed an increasing trend during the last 13 years with the highest value in the last year. In the absence of precautionary reference points SGMED is unable to fully evaluate the state of the stock size.

7.12.7.1.2. State of recruitment

Relative indices for age 1+ from survey data indicated a general increasing trend since 1994 with three main recruitment peaks in 1999, 2005 and 2009. In 2007 recruitment estimated by GRUND survey (age 0) was 61% of the short term average (2004-06). In 2009 recruitment at age 1 (MEDITS) was 180% of the short term average (2005-07). VIT estimates for 2006-2009 showed a reduced recruitment in 2007.

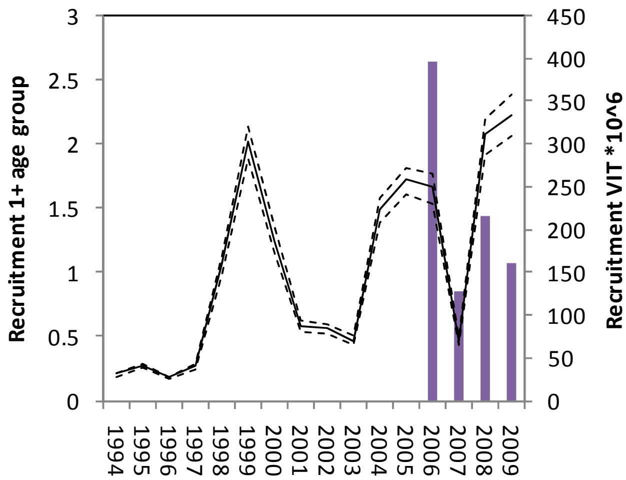


Fig. 7.12.7.1.2.1 Estimated trend in relative recruitment of *P. longirostris* in the GSA 09. Lines are SURBA indices at age 1+, dotted lines are 2.5% and 97.5% confidence intervals. Bars are annual VIT recruitments estimates.

7.12.7.1.3. State of exploitation

SGMED proposes $F_{0.1} \leq 0.70$ as limit management reference point consistent with high long term yields (F_{MSY} proxy).

According to the F estimates obtained using trawl surveys indices (GRUND and MEDITS) with SURBA, F_{curr} was in most of the years above the average and maximum estimated $F_{0.1}$ values. In this case, the stock would not appear to be able to sustain the current level of fishing effort in the GSA 09 and thus the stock is considered overexploited using survey data estimates.

A different picture comes from the F estimates through LCA on the last four years of landing data. $F_{1\text{-}3}$ was between 0.2 and 0.6 for the period 2006-2009, below the estimated reference value of $F_{0.1}$=0.7.

SGMED advice relies on the LCA and considers the stock has been harvested sustainably consistent with high long term yields in 2006-2009. It is important to consider that this stock could be strongly driven by environmental and ecological factors (e.g. water temperature, predatory release effect) that can make difficult to evaluate the effect of fishing on the stock.

7.13. Stock assessment of pink shrimp in GSA 10

7.13.1. *Stock identification and biological features*

7.13.1.1. Stock Identification

The stock of pink shrimp was assumed in the boundaries of the whole GSA10, lacking specific information on the stock identification. The pink shrimp is an epibenthic species and inhabits the muddy or sandy-muddy bottoms of the continental shelf. A gradient of size increasing with depth has been observed in GSA 10 as in other areas, being the smallest specimens fished more frequently in the upper part of the continental shelf (100-200 m), while the largest ones are mainly distributed along the slope at depths greater than 200 m (Spedicato *et al*., 1996). Aggregations with higher abundance were localised between 100 and 200 m depth, with some intrusions in the deeper waters in three sub-areas. Two most important patches were located in the Gulf of Naples and along the Calabrian coasts in correspondence with Cape Bonifati, while a third one in the Gulf of Salerno (Lembo *et al*., 1999). These are the areas where also the main nurseries are localised (Lembo *et al*., 2000a). In the Central-Southern Tyrrhenian Sea the occurrence of mature females was observed in spring (May), summer (July-August) and autumn (October), with a higher relative frequency in spring-summer seasons (Spedicato et al., 1996). Thus, a continuous recruitment pattern is shown which, however, exhibits a main pulse in the autumn season. At 16 mm carapace length the pink shrimp is considered recruited to the grounds (SAMED, 2002). The overall sex ratio is about 0.5. The structure of the sizes of *P. longirostris* is characterised by differences in growth between the sexes, the larger individuals being females. The pink shrimp is a short-living crustaceans with a life span of about 4 years (Carbonara *et al*., 1998).

The deep-water rose shrimp with hake and red mullet is a key species of fishing assemblages in the central-southern Tyrrhenian Sea. In the last decade it is generally also ranked among the species with higher abundance indices (number of individuals) in the trawl surveys (e.g. Spedicato *et al*. 2003) as observed for different Mediterranean areas (Abella *et al*., 2002). The pink shrimp is caught on the same fishing grounds as European hake and the production of this shrimp is steadily growing in the last decade in the southern basin and it reached in 2006 about 10% of the demersal landings.

7.13.1.2. Growth

Past estimates of the growth pattern of the pink shrimp females were obtained using different methods based on the LFD analysis (modal progression analysis-MPA, Elefan, Multifan) applied to GRUND data from 1990 to 1995. Parameters of VBGF were as follows: L_∞=45.9; K=0.673 t_0= -0.251 (Carbonara *et al.*, 1998). VBGF parameters were also re-estimated during the Samed project (SAMED, 2002) using the MEDITS time series from 1994 to 1999, that gave the following values: females: CL_∞=45.0 mm, K=0.7, t_0= -0.15; males: CL_∞=40.0 mm; K=0.78; t_0= -0.2. Maximum carapace lengths (CL) observed for females and males were respectively 42.3 mm and 39 mm. The growth parameters from DCF (2006-2008) are as follows: females CL_∞=46 mm, K=0.575, t_0= -0.2; males CL_∞=40 mm, K=0.68, t_0= -0.25. They also describe a fast growing pattern albeit slightly lower than that previously observed. The length weight relationships by sex and for sex combined are as follows: females: a=0.935, b=2.452; males a=0.974; b=2.335 sex combined a=0.920; b= 2.445.

7.13.1.3. Maturity

The maturity ogive Fig. 7.13.1.3.1 was obtained from a maximum likelihood procedure applied grouping as mature individuals belonging to the maturity stage 2b-2e (according to the Medits maturity scale). The fitting of the curve was fairly good, however the estimates of the size at first maturity $L_{m50\%}$ (18.7 cm ±0.06 cm) and of the maturity range (0.31 cm ±0.009 cm), reported in the figure below, seem underestimated if compared with literature values (average of the smallest females 24 mm CL; in Relini et al., 1999).

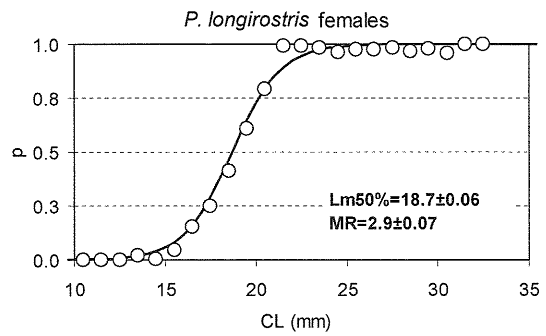


Fig. 7.13.1.3.1 Maturity ogive of pink shrimp in the GSA10 (MR indicates the difference $Lm_{75\%}$-$Lm_{25\%}$).

The sex ratio from DCF (2006-2008 data) evidenced the prevalence of males between 1.4 and 2.0 cm, while from 2.4 cm onwards the proportion of females was dominant (Fig. 7.13.1.3.2).

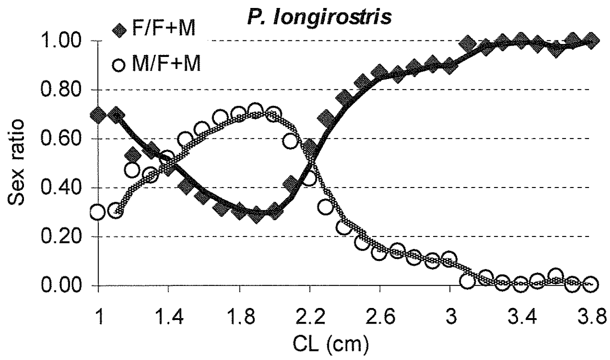


Fig. 7.13.1.3.2 Sex ratio over lenght of pink shrimp in the GSA10.

7.13.2. *Fisheries*

7.13.2.1. General description of fisheries

The pink shrimp is only targeted by trawlers and fishing grounds are located on the soft bottoms of continental shelves and the continental slope along the coasts of the whole GSA. The pink shrimp occurs mainly with *M. merluccius*, *M. barbatus*, *Eledone cirrhosa*, *Illex coindetii* and *Todaropsis eblanae, N. norvegicus*, *P. blennoides*, depending on depth and area.

7.13.2.2. Management regulations applicable in 2009 and 2010

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 is 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 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 licences.
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.

7.13.2.3. Catches

7.13.2.3.1. Landings

Available landing data are from DCF regulations. SGMED-10-03 received Italian landings data for GSA 10 by fishing gears which are listed in Tab. 7.13.2.3.1.1. Almost all landings are from trawlers. Nevertheless, a gradual slight decrease in the production in the last 3 years was noticed, from 534 tons in 2007 to 379 tons in 2009.

Tab. 7.13.2.3.1.1. Annual landings (t) by gear type, 2004-2009.

Species	Area	Country	FT_LVL4	2004	2005	2006	2007	2008	2009
DPS	10	ITA		2	1				
			GNS	3	6			0	0
			GTR	3	0				
			LLS		26				
			OTB	544	743	1088	534	400	379
			PS			1			
			Total	552	776	1089	534	400	379

The catches of the species raised from 2004 to 2006 when 1089 tons were recorded and then declined to 379 tons in 2009.

7.13.2.3.2. Discards

2 t of discards in 2006 and 2 t in 2009 was reported to SGMED-10-03 through the DCR data call.

7.13.2.3.3. Fishing effort

Trend in fishing effort (kW*days) for GSA 10 by gear type, for 2004 to 2009 as reported through the DCF official data call is in the Tab. 7.13.2.3.3.1.

Tab. 7.13.2.3.3.1 Trend in fishing effort (kW*days) for GSA10 by major gear types, 2004-2009. Data submitted through the DCF data call in 2010.

Sum of KWDAYS				YEAR					
COUNTRY	AREA	FT_LVL	FT_LVL5	2004	2005	2006	2007	2008	2009
ITA	10			3519197	4007554	3100388	2443896	1814941	1806725
		DRB	Molluscs	86367	320173	310045	148014	231605	183186
		FPO	Demersal species		314276	147983			
		GND	Small pelagic fish	233350	167135	562722	453447	442960	438783
		GNS	Demersal species	3733486	4991450	2920088	2044527	2430099	2574024
			Small and large pelagic fish	1549			84412	1910	30418
		GTR	Demersal species	3151368	1739872	4199352	3897405	3005134	2498246
		LHP-LHM	Cephalopods	619019	437364	397018	341953	773830	1076201
			Finfish	268	3849	1709	14405		
		LLD	Large pelagic fish	480149	1085372	606942	411540	307955	1140807
		LLS	Demersal fish	2486099	2006238	1462244	1320208	1259852	816877
		LTL	Large pelagic fish						
		OTB	Deep water species			240741	131937	140964	295269
			Demersal species	4055773	75241	1540349	1595569	3808424	3483512
			Mixed demersal and deep water species		8416369	5992696	5934631	2752751	3076559
		PS	Large pelagic fish	1372121	800937	103190	157860	231965	506989
			Small pelagic fish	2258283	1946520	1902659	1782940	952413	1713744
		PTM	Small pelagic fish	6204					
		SB-SV	Demersal species	619495	205264	111798	32984	107412	20545
Total				22622728	26517614	23599924	20795728	18262215	19661885

7.13.3. *Scientific surveys*

7.13.3.1. MEDITS

7.13.3.1.1. Methods

According to the MEDITS protocol (Bertrand et al., 2002), trawl surveys were yearly (May-July) carried out, applying a random stratified sampling by depth (5 strata with depth limits at: 50, 100, 200, 500 and 800 m; each haul position randomly selected in small sub-areas and maintained fixed throughout the time). Haul allocation was proportional to the stratum area. The same gear (GOC 73, by P.Y. Dremière, IFREMER-Sète), with a 20 mm stretched mesh size in the cod-end, was employed throughout the years. Detailed data on the gear characteristics, operational parameters and performance are reported in Dremière and Fiorentini (1996). Considering the small mesh size a complete retention was assumed. All the abundance data (number of fish and weight per surface unit) were standardised to square kilometre, using the swept area method.

Based on the DCR data call, abundance and biomass indices were recalculated. In GSA 10 the following number of hauls was reported per depth stratum (Tab. 7.13.3.1.1.1).

Tab. 7.13.3.1.1.1. Number of hauls per year and depth stratum in GSA 10, 1994-2009.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GSA10_010-050	7	8	8	8	8	8	8	8	6	7	7	7	7	7	7	7
GSA10_050-100	10	10	10	10	10	10	10	10	9	8	8	8	8	8	8	8
GSA10_100-200	17	17	17	17	17	17	17	17	14	14	14	14	14	14	14	14
GSA10_200-500	22	22	22	22	22	22	22	24	18	18	18	18	18	18	19	18
GSA10_500-800	28	28	28	28	28	27	28	26	23	23	23	23	23	23	22	23

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. 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). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

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

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

Where:

A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

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

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA.

7.13.3.1.2. Geographical distribution patterns

Data on the the geographical distribution pattern of pink shrimp come from studies conducted in the area using trawl-survey data, length frequency distribution analyses and geostatistical methods (Lembo *et al.*, 2000a). The indicator kriging approach combined with a persistence analysis showed that the nurseries of the pink shrimp were localised with higher level of probability offshore Cape Bonifati (Calabria coasts) Napoli and Salerno Gulfs between 100 and 200 m depth (Fig. 7.13.3.1.2.1).

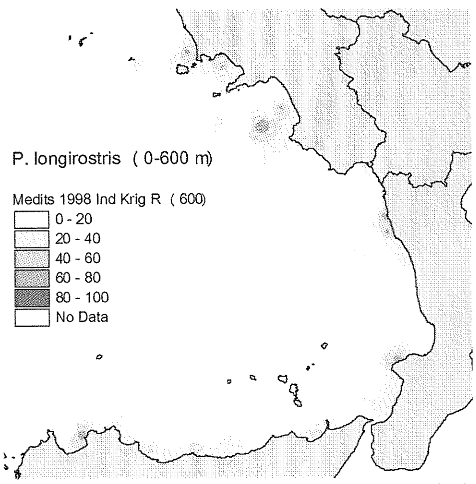


Fig. 7.13.3.1.2.1 Map of nursery area of pink shrimp.

7.13.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of pink shrimp in GSA 10 was derived from the international survey MEDITS. Figure 7.13.3.1.3.1 displays the estimated trend of *P. longirostris* abundance and biomass standardized to the surface unit in GSA 10. Indices from MEDITS trawl-surveys show two peaks in 1999 and 2005, but without any trend. From 2005 onwards the indices are decreasing and commercial catches follow a similar pattern.

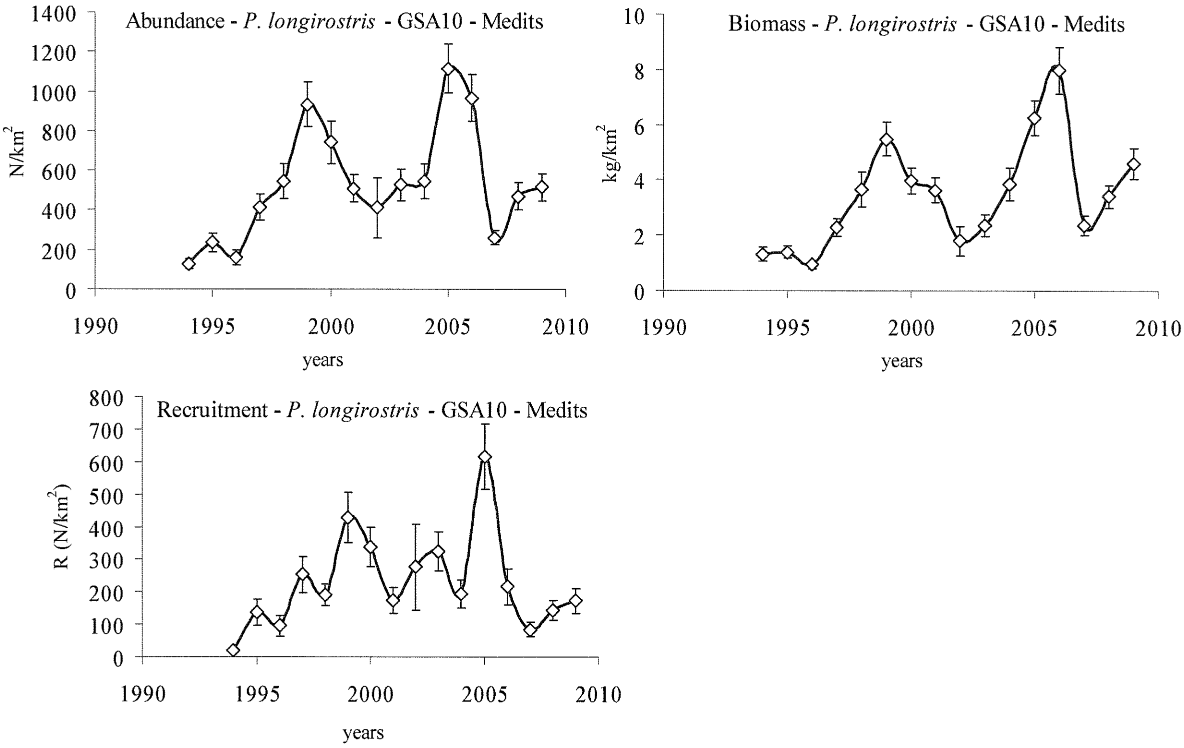


Fig. 7.13.3.1.3.1 Trends in survey abundance and biomass indices standardized to the surface unit and derived from MEDITS (bars indicate standard deviations). Abundance of recruits is also reported.

The re-estimated abundance indices (Figure 7.13.3.1.3.2) show the same temporal pattern.

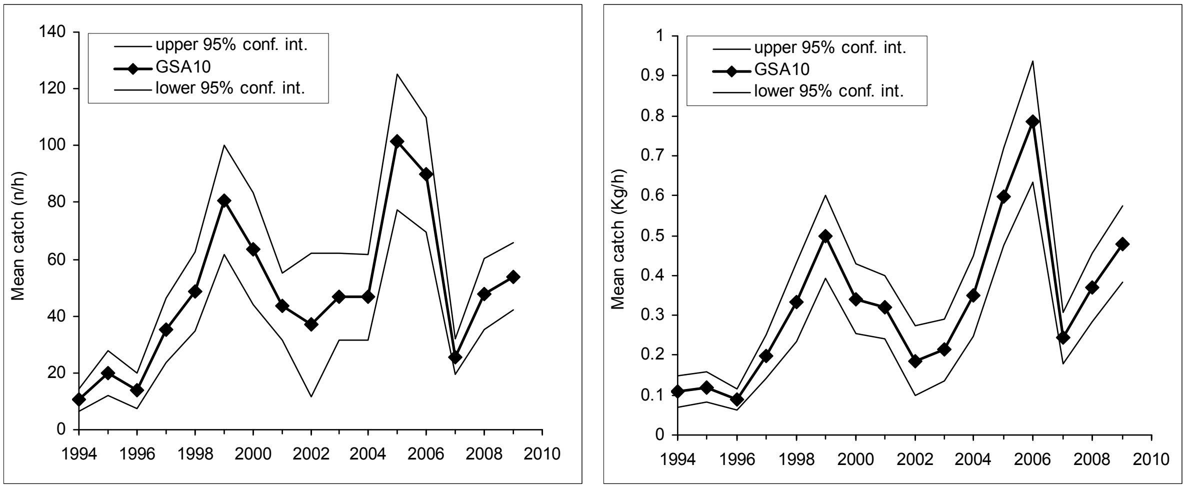


Fig. 7.13.3.1.3.2 Trends in survey abundance and biomass indices (MEDITS) of pink shrimp in GSA 10.

7.13.3.1.4. Trends in abundance by length or age

The following Fig. 7.13.3.1.4.1 and 2 display the stratified abundance indices of GSA 10 in 1994-2001 and 2002-2009. These size compositions are considered preliminary.

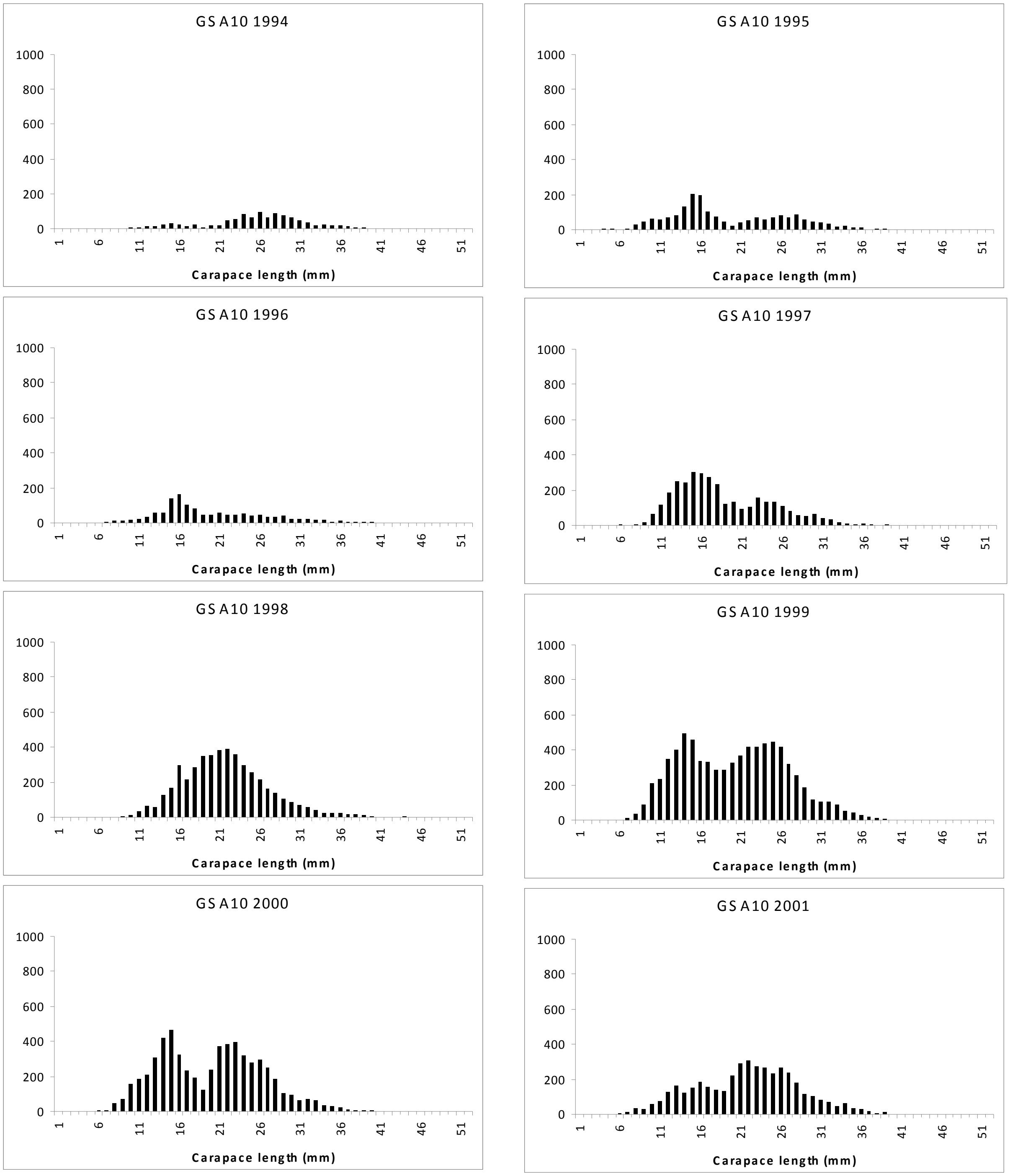
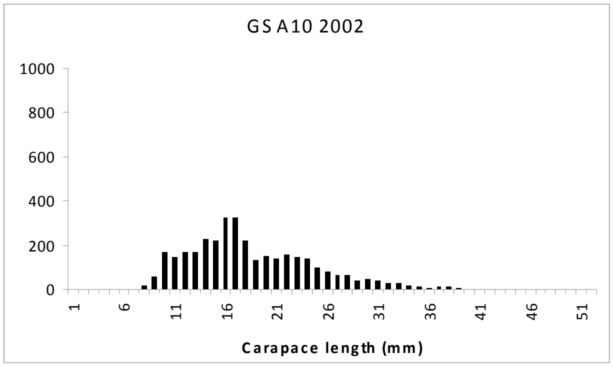
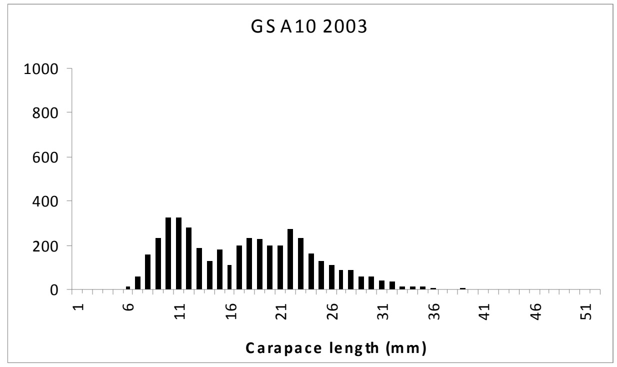
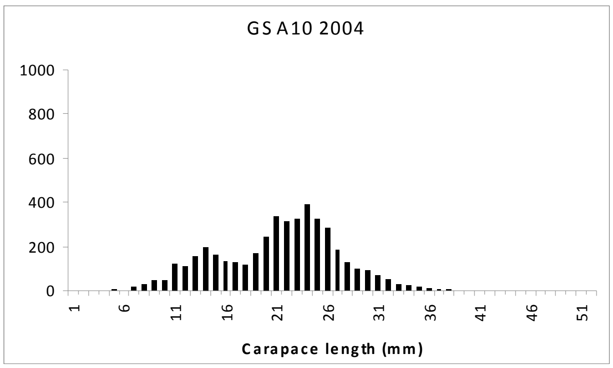
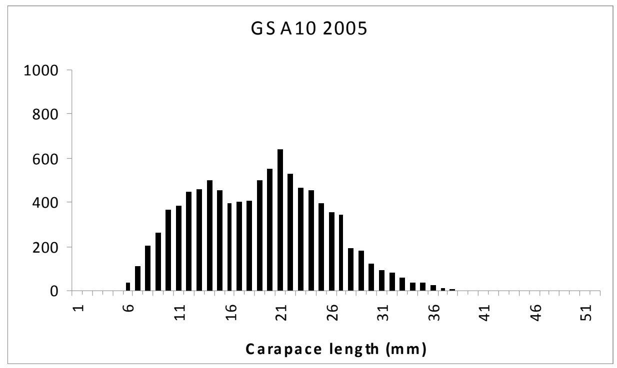


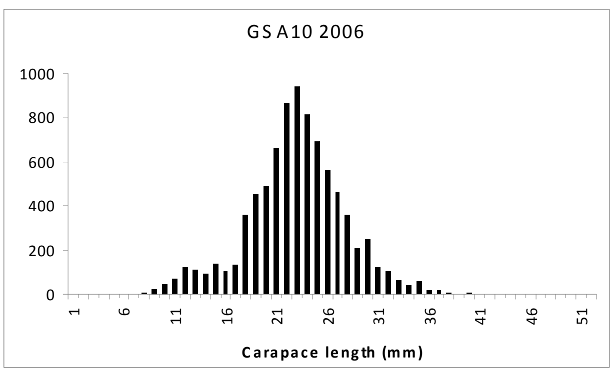
Fig. 7.13.3.1.4.1 Stratified abundance indices by size, 1994-2001.

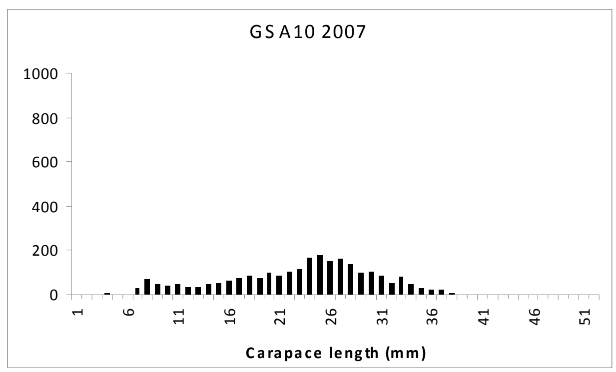

GSA10 2002
1000
800
600
400
200
0
1 6 11 16 21 26 31 36 41 46 51
Carapace length (mm)

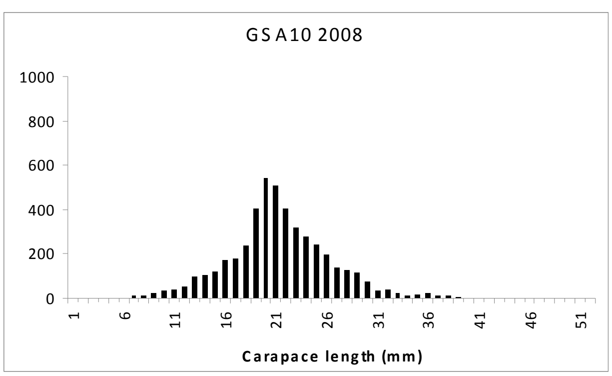

GSA10 2003
1000
800
600
400
200
0
1 6 11 16 21 26 31 36 41 46 51
Carapace length (mm)


GSA10 2004
1000
800
600
400
200
0
1 6 11 16 21 26 31 36 41 46 51
Carapace length (mm)


GSA10 2005
1000
800
600
400
200
0
1 6 11 16 21 26 31 36 41 46 51
Carapace length (mm)


GSA10 2006
1000
800
600
400
200
0
1 6 11 16 21 26 31 36 41 46 51
Carapace length (mm)


GSA10 2007
1000
800
600
400
200
0
1 6 11 16 21 26 31 36 41 46 51
Carapace length (mm)


GSA10 2008
1000
800
600
400
200
0
1 6 11 16 21 26 31 36 41 46 51
Carapace length (mm)

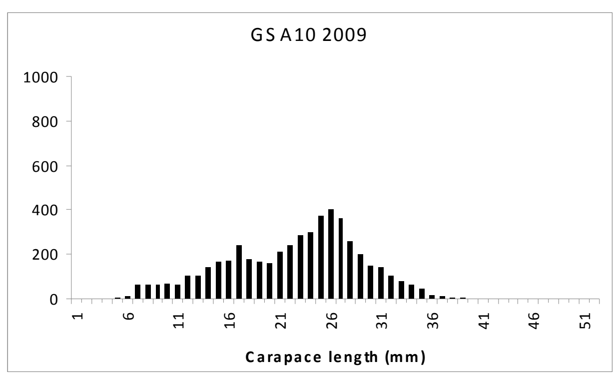

GSA10 2009
1000
800
600
400
200
0
1 6 11 16 21 26 31 36 41 46 51
Carapace length (mm)

Fig. 7.13.3.1.4.2 Stratified abundance indices by size, 2002-2009.

No trend in the mean length was observed in MEDITS survey (Fig. 7.13.3.1.4.3), neither in any other length indicators.

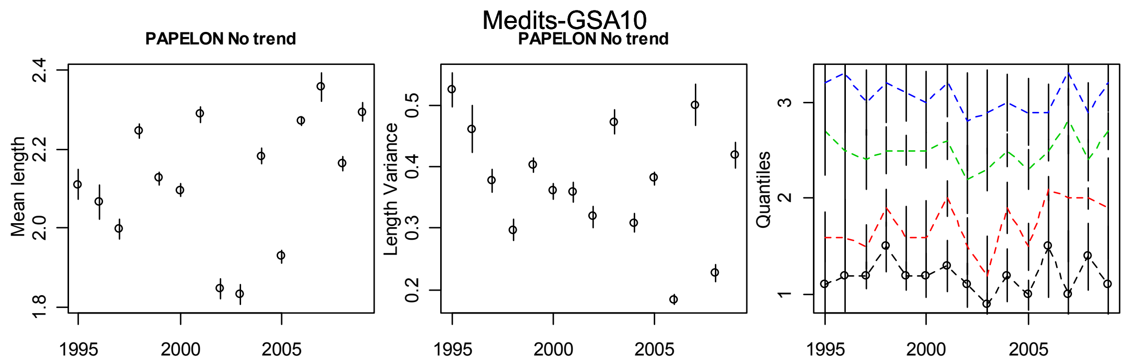


Fig. 7.13.3.1.4.3 Mean length, variance and quantiles derived from the MEDITS length compositions.

7.13.3.2. GRUND

7.13.3.2.1. Methods

GRUND survey trends were estimated and are shown in the following sections.

7.13.3.2.2. Geographical distribution patterns

No analyses were conducted during SGMED-10-03.

7.13.3.2.3. Trends in abundance by length or age

Trends derived from the GRUND surveys are shown in Fig. 7.13.3.2.3.1. Abundance and biomass indices as well as recruitment indices, show an increasing trend up to 2005 and a decreasing since 2006 (Fig. 7.13.3.2.3.1). In 1999 the survey was not performed.

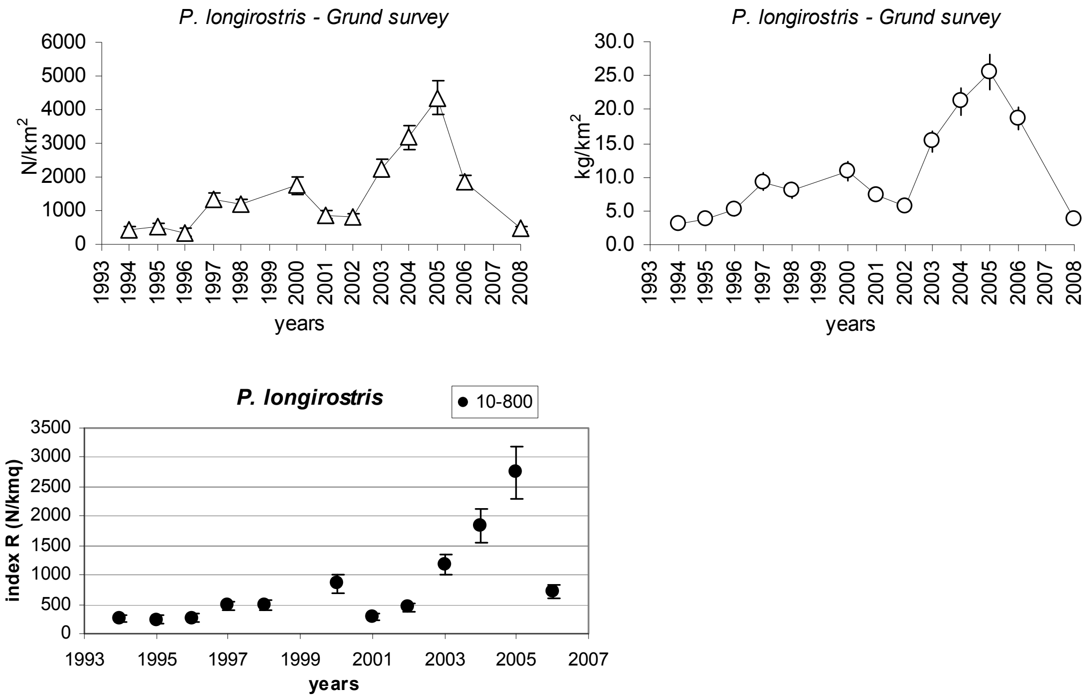


Fig. 7.13.3.2.3.1 Abundance and biomass indices of the pink shrimp in GSA 10 (bars indicate standard deviations) derived from GRUND surveys. Recruitment indices (N/km^2) computed in the total depth range with standard deviation is also reported.

7.13.3.2.4. Trends in abundance by length or age

Also time series of length structures of GRUND from 1994 to 2006 (Fig. 7.13.3.2.4.1) did not show any trend.

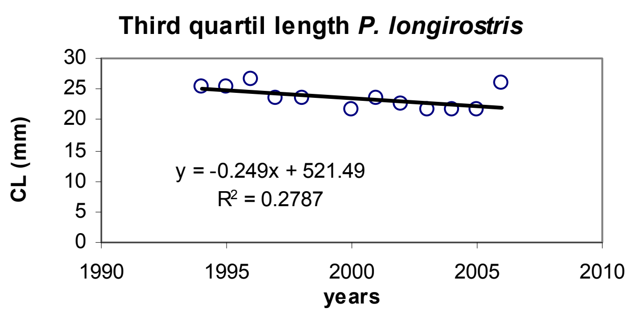


Fig. 7.13.3.2.4.1 III Quantile derived from the GRUND length structures in 1994-2006.

7.13.3.2.5. Trends in growth

No analyses were conducted during SGMED-10-03.

7.13.3.2.6. Trends in maturity

No analyses were conducted during SGMED-10-03.

7.13.4. *Assessment of historic stock parameters*

SGMED-10-03 applied the VIT model to commercial landings.

7.13.4.1. Method 1: VIT

7.13.4.1.1. Justification

VIT software was applied using landings data of 2006-2009. Four analyses were performed (one for each year) in order to overcome the limitation of equilibrium condition hypothesis in VPA technique.

7.13.4.1.2. Input parameters

A sex combined analysis was carried out using females growth parameters:
CL_∞ = 4.6 cm, K= 0.575, t_0= -0.2; length-weight relationship: a = 0.935, b = 2.4523.
The vector of natural mortality M was estimated using Prodbiom (Abella *et al.*, 1998) and terminal fishing mortality F_{term}= 1 were assumed.

Table 7.13.4.1.2.1 Natural mortality and maturity vectors used in 2006-2009.

Age	M vector
0	1.21
1	0.55
2+	0.42

Age	Maturity
0	0.4670451
1	0.9775925
2+	0.9974531

Table 7.13.4.1.2.2 Landings in numbers at age (thousands) in 2006, 2007, 2008 and 2009.

	Year			
Age	**2006**	**2007**	**2008**	**2009**
0	74,627,920	32,219,580	42,475,320	13,117,840
1	64,486,140	6,399,047	17,380,509	10,033,949
2+	1,173,539	380,391	303,668	391,640

7.13.4.1.3. Results

Estimates of total and fishing mortality at age for sex combined by VIT are plotted in the Fig. 7.13.4.1.3.1.
The mortality acting on the age groups show values changing from 1.2 in 2009 to 1.52 in 2007, with an average over the four years of 1.33.

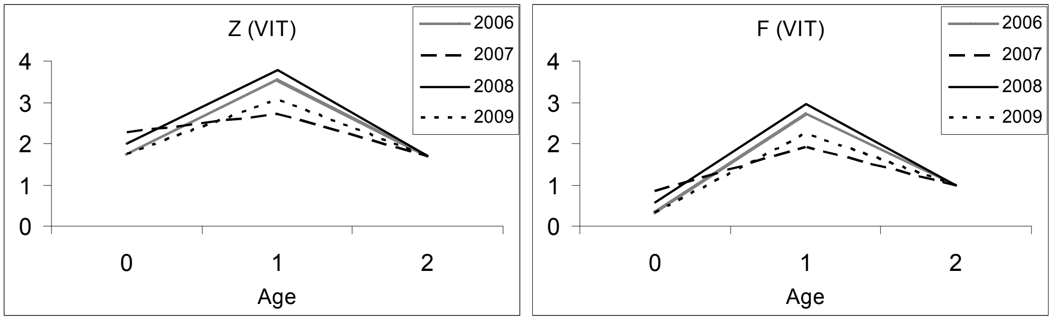


Fig. 7.13.4.1.3.1. Total and fishing mortality by age as estimated by the cohort analysis using VIT, by year (2006-2009).

7.13.5. *Long term prediction*

Two assessment approaches were applied for long term predictions, the VIT and secondly the YIELD software.

7.13.5.1. Method 1: VIT

7.13.5.1.1. Justification

The cohort analysis and the Y/R approach as implemented in the VIT software under equilibrium conditions were used, as the time series of landings is short, then VIT and YIELD results were compared.

7.13.5.1.2. Input parameters

Input parameters are given in section 7.13.4.1.2 on the VIT assessment above.

7.13.5.1.3. Results

Results of the YPR analysis from the VIT are shown in the table 7.13.5.1.3.1 and in the figure 7.13.5.1.3.1. The Yield per Recruit analyses indicate that the limit reference point F_{max} is on average about 1 and the target reference point $F_{0.1}$ is about 0.58. The YPR curve of 2006 is slightly dome-shaped.

Tab. 7.13.5.1.3.1 Overall results of Y/R analysis for 2006-2009.

2006	Factor	F	Y/R	B/R	SSB
F(0)	0	0	0	4.794	4.124
F(0.1)	0.59	0.80122	1.603	2.038	1.466
Fmax	0.89	1.20862	1.662	1.601	1.066
Fcurr	1.01	1.358	1.657	1.481	0.959
Fdouble	2	2.716	1.496	0.972	0.546
2007	Factor	F	Y/R	B/R	SSB
F(0)	0	0	0	7.235	6.558
F(0.1)	0.43	0.539937	1.398	2.552	2.033
Fmax	0.65	0.816183	1.454	1.804	1.342
Fcurr	1.01	1.255667	1.386	1.154	0.772
Fdouble	2	2.511333	1.098	0.531	0.294
2008	Factor	F	Y/R	B/R	SSB
F(0)	0	0	0	7.235	6.558
F(0.1)	0.4	0.607867	1.533	2.483	1.922
Fmax	0.63	0.95739	1.599	1.759	1.246
Fcurr	1.01	1.519667	1.529	1.199	0.755
Fdouble	2	3.039333	1.27	0.686	0.37
2009	Factor	F	Y/R	B/R	SSB
F(0)	0	0	0	7.235	6.558
F(0.1)	0.5	0.599167	1.58	2.623	2.038
Fmax	0.85	1.018583	1.664	1.813	1.275
Fcurr	1.01	1.198333	1.655	1.601	1.082
Fdouble	2	2.396667	1.486	0.994	0.574

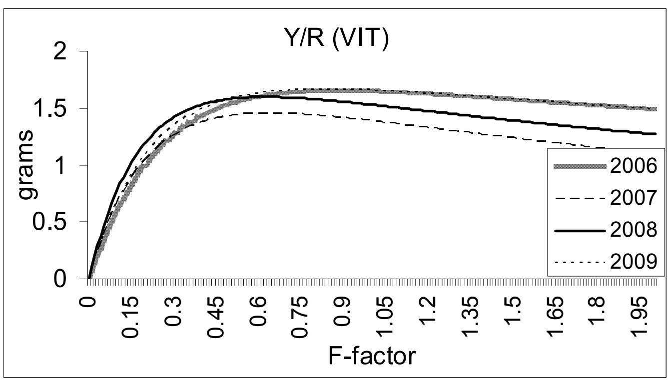


Fig. 7.13.5.1.3.1 Y/R curves for 2006-2009.

7.13.5.2. Method 2: YIELD

7.13.5.2.1. Justification

A yield per recruit analyses was conducted also using the Yield software, in order to obtain a point estimate with the associated variability for the reference point to be used in the advice and for comparison with the VIT analysis.

7.13.5.2.2. Input parameters

The same growth and natural mortality parameters used in VIT were also the input to Yield. The parameters were however converted in TL (growth parameters and length-weight relationship coefficients) in order to parameterize the YIELD software: TL_∞ = 20.77 cm, K= 0.575, t_0= -0.23, a= 0.0178, b= 2.5423. The conversion from CL to TL was obtained by the following relationship: TL=2.98+4.47*CL, from Crosnier *et al*., 1970.

Both total length at first maturity of 8.13 cm (normally distributed, coefficient of variation (CV)= 0.01), according to the maturity ogive derived in the area and a total length at first capture of 6.57 cm (normally distributed, CV=0.01) were entered in YIELD software. Finally, it was fixed a constant recruitment of 383 million individuals (CV=0.2) that was derived averaging the 2006-2009 age 0 classes computed by VIT.

7.13.5.2.3. Results

The results from Yield analysis are reported in Tab. 7.13.5.2.3.1.

Tab. 7.13.5.2.3.1. Results of Y/R analysis from YIELD.

$F_{0.1}$	Y/R kg	Fmax	Y/R kg
0.66	0.002	1.3	0.002

7.13.6. *Data quality and availability*

Few discrepancies were identified from the cross-checking between estimates related to total landings (transversal variables) and raised catch structures by metier (biological metier related variable). This can be a consequence of the different classification of the fishing activity (fishing segments and metier) that can rise when the fleet is characterised by an opportunistic behaviour, i.e. frequent change, during the year, of fishing ground (for example, from demersal to mixed fishery, or deep water fishery as in the OTB fishing segment). Data on maturity and growth from DCF have also been used. Information from GRUND surveys and from nurseries studies in the GSA have also been included.

7.13.7. *Scientific advice*

7.13.7.1. Short term considerations

7.13.7.1.1. State of the spawning stock size

In the absence of proposed and agreed precautionary management references, SGMED-10-03 is unable to fully evaluate the status of SSB. Survey indices indicate a variable pattern of abundance (n/h) and biomass (kg/h) without a clear trend. MEDITS indices indicate a sharp decrease from 2006 to 2007 and then a slight increase. GRUND data showed a recent decrease of abundance and biomass from 2005 to 2006 after a rising phase.

7.13.7.1.2. State of recruitment

Recruitment estimates from GRUND surveys showed a decrease in abundance from 2005 to 2006 after a rising phase from 2002 to 2005.

7.13.7.1.3. State of exploitation

SGMED-10-03 proposes $F \leq 0.58$ as limit management reference point (basis $F_{0.1}$) of exploitation consistent with high long term yield. Given the results of the present analysis (F current on average about 1.33), the stock is considered subject to overfishing during the period 2006-2009. SGMED recommends the relevant fleets' effort to be reduced to reach the proposed level $F_{0.1}$, in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan.

7.14. Stock assessment of pink shrimp in GSAs 12-16 (Strait of Sicily)

7.14.1. *Stock identification and biological features*

7.14.1.1. Stock identification

The stock structure of deep water pink shrimp (*Parapenaeus longirostris*) in the Strait of Sicily has yet to be defined. Levi et al. (1995) hypothesised that there is a flux of eggs, larvae and juvenile *P. longirostris* from east to west due to an intermediate water current present in the region. More recently, the existence of at least two sub-populations in the northern side of the area (GSA 15 and 16) were reported by Fortibuoni et al. (2010). This idea is based on the occurrence of local spawning and nursery areas, which are connected by the Atlantic Ionian Stream flow (0-150 m depth). It is hypothesised that the development of larval and juveniles phases occurs in this Atlantic Ionian Stream. These local sub-populations, one on the Adventure Bank and one on the Malta Bank, are separated by a wide area, where the species abundance is somewhat lower (Fig. 7.14.1.1.1).

The maximum observed lengths in GSA 15 and 16 recorded during trawl surveys over the last 14 years were 46 and 41 mm CL for females and males respectively (Sinacori G., pers. com.). Although very small specimens were caught in trawl surveys samples, with a recorded minimum sample size of 5 mm CL (Sinacori G., pers. com.), full recruitment to the benthos occurs at 17 mm and 18 mm for females and males respectively (Samed, 2002).

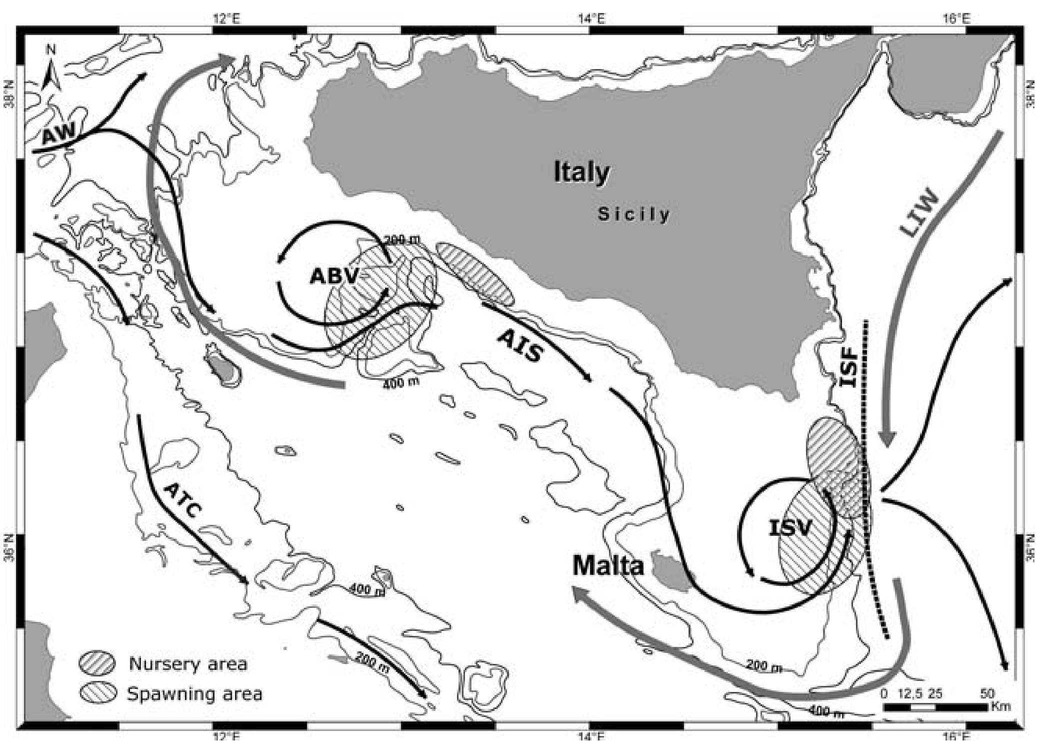


Fig. 7.14.1.1.1 Schematic model of the spawning strategy of *Parapenaeus longirostris* in the northern sector of the Strait of Sicily. The location of stable nursery and spawning areas is shown, as well as the main hydrological characteristics of the area. ABV: Adventure Bank Vortex; ATC: Atlantic Tunisian Current; AIS: Atlantic Ionian Stream; ISV: Ionian Shelf-break Vortex; ISF: Ionian Slope Front; LIW: Levantine Intermediate Water; AW: Atlantic Water (from Fortibuoni et al., 2010).

On the basis of trawl surveys carried out in the northern side of the Strait in GSA 16, sex ratios have remained stable and close to 0.5 (Fiorentino et al., 2005). The sex ratio in weight from commercial landings (2006-2007) as F / (M+F) is 0.66.

In GSA 16, a significant increase in the sex ratio with shrimp size can be observed, with the number of males prevailing in the sampled population from 16 to 22 mm CL, whereas females were more abundant at carapace lengths exceeding 24 mm (SAMED, 2002).

7.14.1.2. Growth, maturity and natural mortality

The parameters used were an average of growth parameters and length-weight relationships from SAMED (2002) and Ben Meriem (unpublished). Females: $L\infty = 42.705$, $k = 0.67$, $t0 = -0.208$, $a = 0.0029$, $b = 2.48185$. Male: $L\infty = 33.56$, $k = 0.73$, $t0 = -0.13$, $a = 0.00345$, $b = 2.4096$. Combined sex: $L\infty = 44.59$, $k = 0.6$, $t0 = -0.118$, $a = 0.0033$, $b = 2.4572$. The M range was estimated between 1.05 (Females) and 1.20 (Males).

According to Levi et al., (1995) mature females are found in GSA 15 and 16 throughout the year, with a maturity peak extended from November to February, and another maturity peak in April. The lowest percentage of mature females appeared in June-July, but continuous spawning seems to occur. Ben Mariem et al. (2001) reported that *P. longirostris* off the Tunisian coasts (GSA 12) reproduces all year along, with a peak in June-July and a minimum in winter.

The most recent maturity oogive parameters are: $L_{50\%}$ of 22.1 mm CL, and a corresponding slope value of 0.45 in females, $L_{50\%}$ of 14.3 mm CL, and a corresponding slope value of 1.5 in males (CNR_IAMC, 2007). The vector of percentage of mature for combined sex (values by sex averaged by sex ratio weighting) is reported in Fig. 7.14.1.2.1.

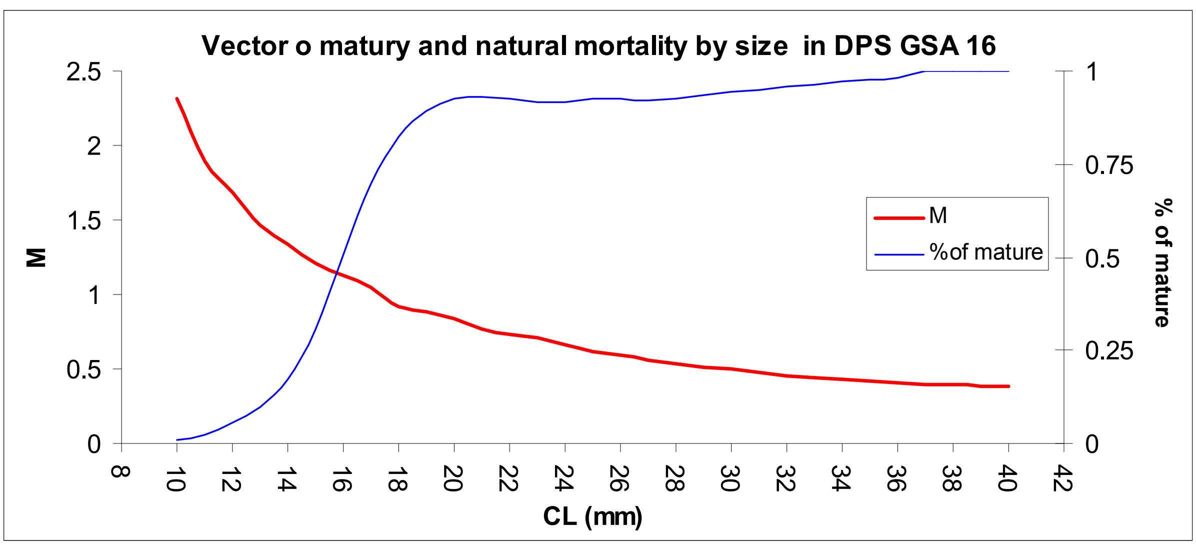


Fig. 7.14.1.2.1. Natural mortality vector (estimated according to Caddy and Abella 1999), and maturity oogive (CNR_IAMC, 2007).

7.14.2. *Fisheries*

7.14.2.1. General description of fisheries

Trawling for pink shrimp *Parapenaeus longirostris* is carried out on the continental shelf of the Central Mediterranean throughout the year, and catches often include Norway lobster (*Nephrops norvegicus*), giant red shrimp (*Aristaeomorpha foliacea*), violet shrimp hake (*Merluccius merluccius*), violet shrimp (*Aristeus antennatus*), scorpionfish (*Helicolenus dactylopterus*), grater forkbeard (*Phicys blennioides*), red Pandora (*Pagellus bogaraveo),* common Pandora (*Pagellus erythrinus*) and monkfish (*Lophius piscatorius*). Scientific data available indicates that exploitation by the fishing fleets of Tunisia, Malta, Libya and Italy is targeting a single shared stock of pink shrimp (MedSudMed 2007).

Sicilian trawlers between 12 and 24 m vessel length targeting deep water pink shrimp are based in seven harbours along the southern coasts of Sicily. These trawlers operate mainly on a short-distance trawl fishery basis, with trips from 1 to 2 days at sea, and fishing taking place on the outer shelf and upper slope. With 250 registered vessels, this is the largest fleet component targeting pink shrimp in 2009. Sicilian trawlers which measure over 24 m vessel length are employed longer fishing trips, which may have a duration of up to 4 weeks. These vessels operate offshore, in both Italian and international waters of the Strait of Sicily (Fig. 7.14.2.1.1). In 2009 140 such vessels were active.

In the Maltese Islands small vessels measuring 12 to 24 m in length target pink shrimp at depths of about 600 m. Fishing grounds are located to the north and north-west of Gozo, as well as to the west and south-west of Malta. Catches are primarily destined for the local market. The number of trawlers targeting pink shrimp increased from 7 in 2005 to 12 in 2009.

Tunisian trawl vessels which target pink shrimp measure over 24 m in length, and operate primarily in Northern Tunisia where 90% of the country's total *P. longirostris* catches originate. The great majority of these catches are landed in the town of Bizerte. The number of Tunisian trawlers targeting pink shrimp has increased from 40 in 1996 to around 70 in 2009.

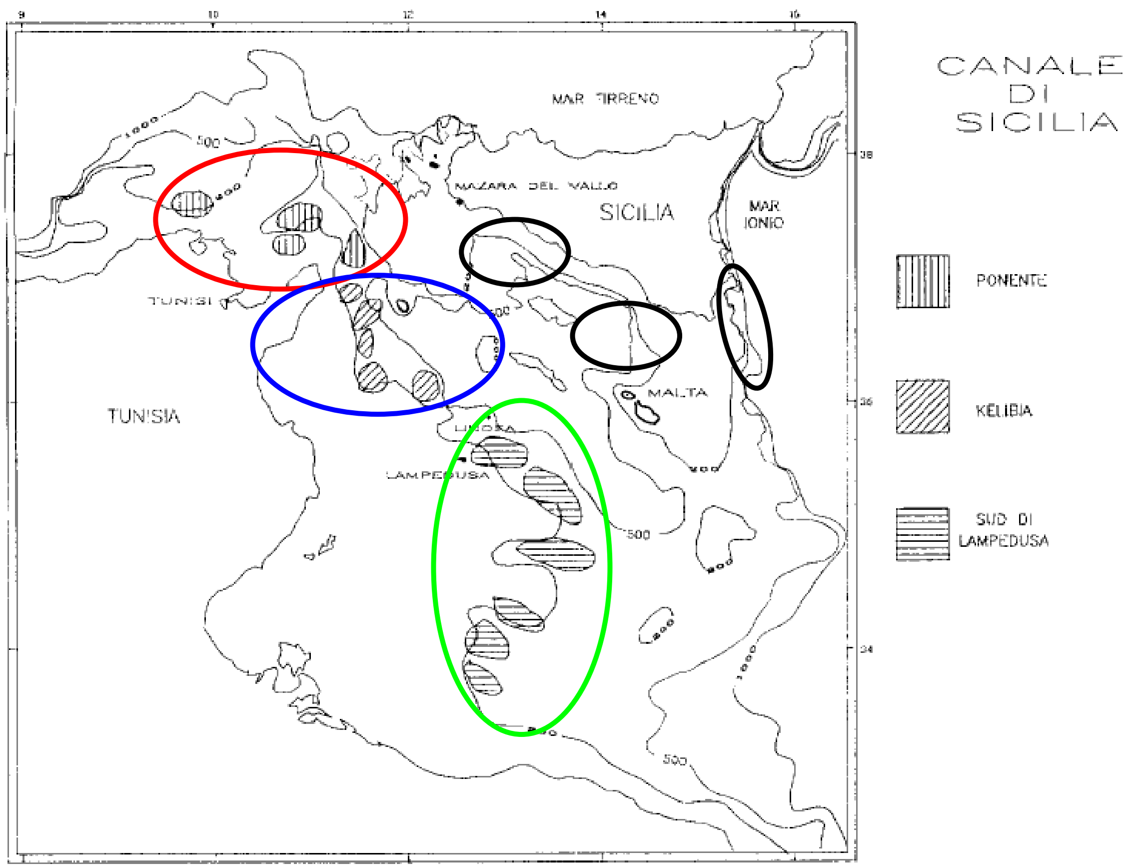


Fig. 7.14.2.1.1. The main fishing areas of *P. longirostris* for distant (coloured) and coastal (black) Sicilian trawlers in the Strait of Sicily (modified from Levi et al. 1995).

7.14.2.2. Management regulations applicable in 2010 and 2011

A medium term management plan for 2008-2013 has been agreed for Italian trawlers targetting pink shrimp in the Strait of Sicily. This Italian Management Fishery Plans (IFMP) is based on :

- a fleet reduction of 25% of the current capacity obtained in two steps. The first (12.5%) from 2008 to 2010, and the second (12.5%) from 2011 to 2013
- a trawling ban of 45 days per year between January and March

In addition, the new regulation EC 1967 of 21 December 2006 fixed a minimum harvest size of 20 mm and a minimum mesh size of 40 mm square or 50 mm diamond for EU bottom trawling vessels (i.e. Italian and Maltese trawlers). According to the regulation, mesh size had to be modified in July 2008, and derogations are no longer possible since June 2010.

In order to limit the over-capacity of fishing fleet, Maltese fishing licenses had been fixed at a total of 16 trawlers since 2000. Eight new licences were however issued in 2008, a move made possible under EU law by the reduction of the capacities of other Maltese fishing fleets. However, the Maltese Islands are surrounded by a 25 nautical miles (nm) fisheries management zone, where fishing effort and capacity are being managed by limiting vessel sizes, as well as total vessel engine powers (EC 813/04; EC 1967/06). Trawling is allowed within this designated conservation area, however only by vessels not exceeding an overall length of 24m and only within designated areas. Such vessels fishing in the management zone hold a special fishing permit in accordance with Article 7 of Regulation (EC) No 1627/94, and are included in a list containing their external marking and vessel's Community fleet register number (CFR) to be provided to the Commission annually by the Member States concerned. Moreover, the overall capacity of the trawlers allowed to fish in the 25nm zone can not exceed 4 800 kW, and the total fishing effort of all vessels is not allowed to exceed an overall engine power and tonnage of 83 000 kW and 4 035 GT respectively. The fishing capacity of any single vessel with a license to operate at less than 200m depth can not exceed 185 kW.

In Tunisia, no regulations targeted specifically at the pink shrimp fishery are currently in place. However, trawling is not permitted within 3 nautical miles of the coast and at less than 50m depth in GSAa 12-14. Moreover, in GSA 14 a closed season where trawling is prohibited extending from July-September is in place in order to protect recruits of a large number of species. Although minimum landing sizes exist for a number of crustacean species harvested by the Tunisian fleets, there is no minimum landing size for *P. longirostris*. The minimum legal mesh size used by benthic trawlers in Tunisian waters is 20mm.

7.14.2.3. Catches

7.14.2.3.1. Landings

The estimation of yearly overall landings from Sicilian trawlers which perform fishing trips with a 1-2 day duration ranged between 1290 and 1640 tons (Andreoli *et al*., 1995) in the mid 1980s. The estimation of yearly overall yields of the Mazara distant fleet in late 1980s and in the early 1990s ranged between 2360 and 5180 tons (Levi *et al*., 1995). In 2009 the total landings of the Sicilian fleet recorded under the DCF were 7273 tons. The combined landings or pink shrimp in the Strait of Sicily by Italian, Tunisian and Maltese vessels was 8806 tons.

Absolute catches in numbers, harvested by Italian trawlers in the Strait of Sicily in 2006-2008 for the two operational units ($LOA_{12\text{-}24}$ and $LOA_{>24}$) are distinguished under the EU DCF. Total landings data was thus separated according to vessel lengths.

Table 7.14.2.3.1.1. Landings (t) of pink shrimp by small fleet segment for Malta, Italy and Tunisia.

	Malta 12-24 m	Italy 12-24 m	Italy >24 m	Tunisia > 24m
2007	8	3248	2097	1030
2008	22	3734	2207	992
2009	18	5496	1777	1515

Considering that the overall trawl yield (all species combined) of the Maltese and Italian fleets combined was 15411 tons in 2007, 13313 tons in 2008 and 13670 tons in 2009, *P. longirostris* pink shrimp landings represent an average of 45% of the Maltese and Italian fleet's total yield by catch weight. It is important to note that landings of deep water pink shrimp in Sicilian and Maltese ports do not derive solely from GSAs 15 and 16, but may also originate in other GSAs in the Strait of Sicily.

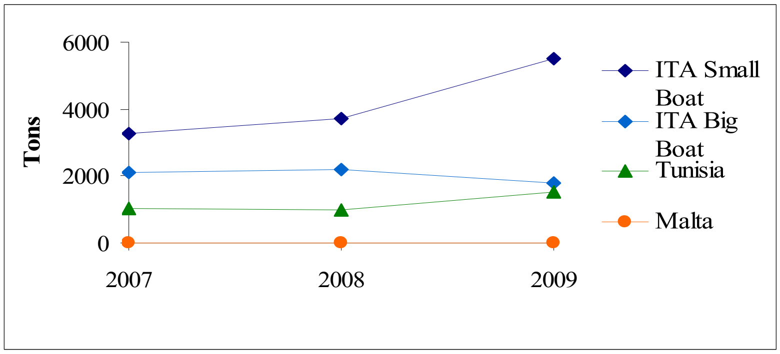
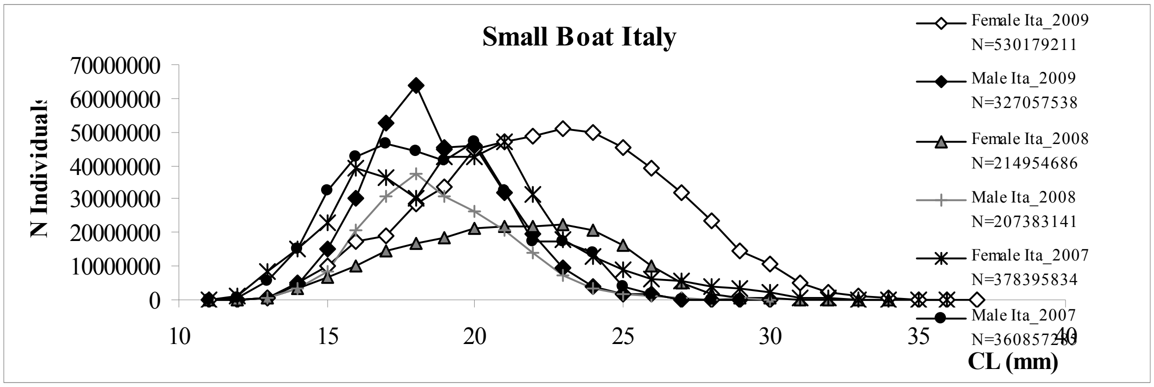
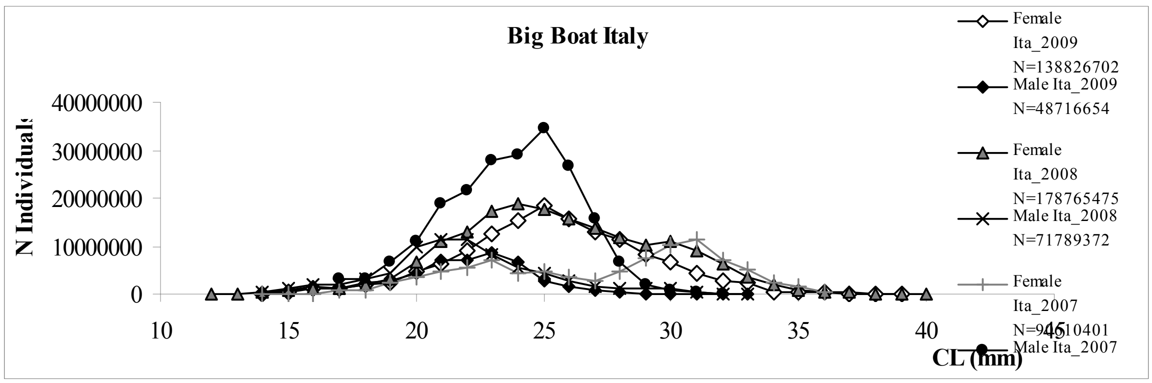


Fig. 7.14.2.3.1.1. Yield of Italian, Tunisian and Maltese trawlers operating in GSAs 12-16.

Data on the length compositions of landing can be considered representative since the 3rd quarter of 2005, when a sampling scheme allowing a realistic raising of the sampled catches to the total ones was adopted (SIBM, 2005).



A)



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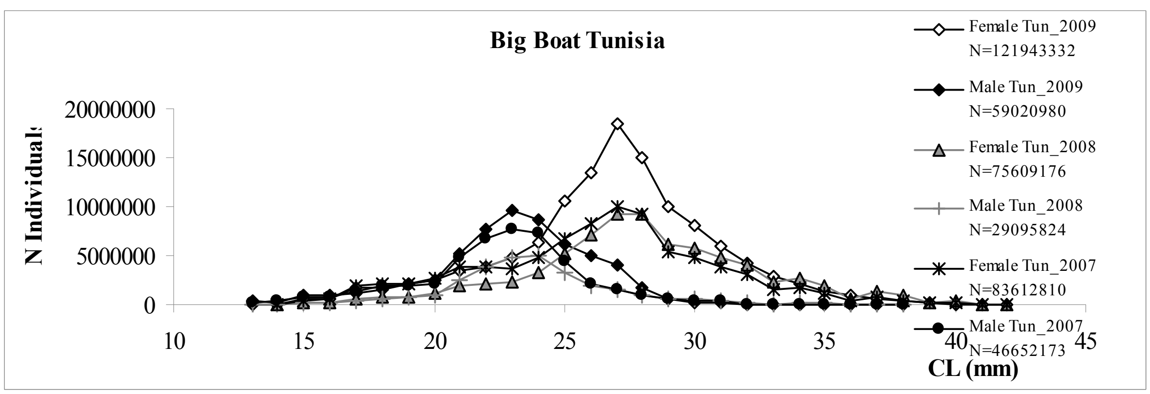


C)

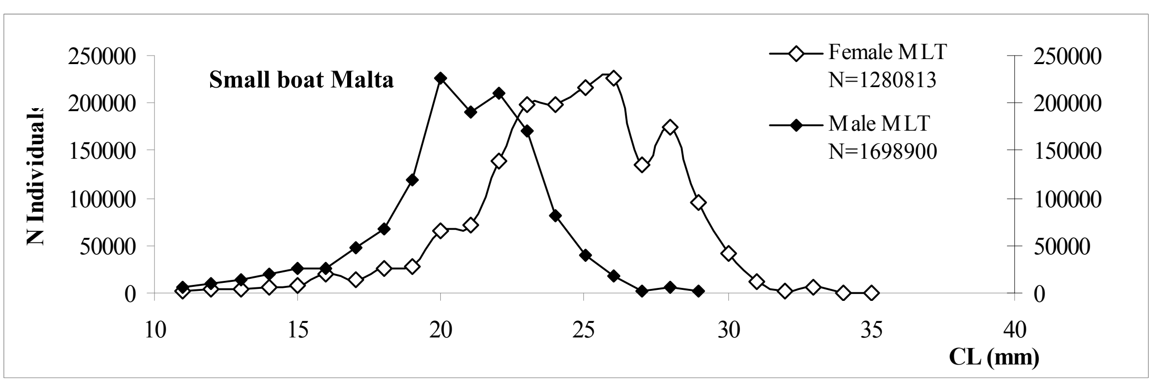


Fig. 7.14.2.3.1.2. Catches in numbers of Italian, Tunisian and Maltese trawlers operating in the Strait of Sicily, 2007, 2008 and 2009. Catches of the two operational units ($LOA_{12\text{-}24}$ and $LOA_{>24}$) are distinguished. For Maltese vessels only 2009 data is available under the DCF.

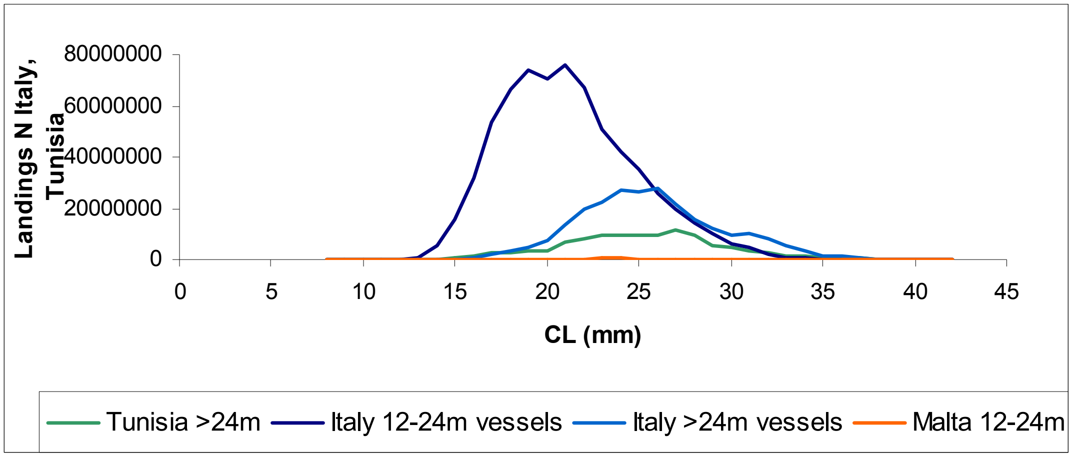


Fig. 7.14.2.3.1.3. Overview of average landings (2007-2009) by the four fleet segments exploiting pink shrimp in the Central Mediterranean.

7.14.2.3.2. Discards

According to Levi et al. (1995), the length at 50% capture of 32 mm mesh size trawling, as estimated by using a catch curve was 16.1 mm CL (Selection Factor=0.5). More recently experiments of selectivity for the same mesh size gave a L50%= 13.0±0.1 (mm) (Selection Range=5.2 and SF=0.42) (Ragonese & Bianchini, 2006). Studies on the discarded fraction of trawlers in GSA 16 during 2006 however recorded a length at 50% discard ranging between 14.6 and 17.0 mm CL (Gancitano V., pers. comm.).

The modal size of the catch and discarded fraction of *P. longirostris* of Sicilian trawlers is very variable, changing both with regards to the fishing season and fishing deep ranges (Tab. 7.14.2.3.1.1). The amount of discards are also variable, with higher discards recorded in autumn-winter, as well as from catches harvested between 150 and 300 m (Anon., 2000).

Table 7.14.2.3.1.1.1. Yearly modal length (LC in mm) of discarded fraction and landings of *P. longirostris* in typical inshore (Porto Palo- South eastern Sicily) and distant (Mazara del Vallo - South Western Sicily) Sicilian trawling fisheries (from Anon., 2000).

	Modal length (mm)	
	discards	landings
Inshore fisheries	12	16 and 19
Distant fisheries	19	25-26

In recent years the discarded fraction of pink shrimp recorded by the Sicilian fleet ranged from 18-25 tons (2006-2008), but increased dramatically to 455 tons in 2009. The Maltese fleet recorded 1 ton of discards in 2009.

7.14.2.3.3. Fishing capacity and effort

With 250 registered vessels, the largest fleet component targeting pink shrimp in 2009 was the small Sicilian trawlers of 12-24 m length. In addition in 2009 140 Sicilian vessels larger than 24m length were active. The number of Maltese trawlers targeting pink shrimp increased from 7 in 2005 to 12 in 2009, and the number of Tunisian trawlers targeting pink shrimp has increased from 40 in 1996 to around 70 in 2009.

No information on the specific effort of trawling on pink shrimp is available. The trends in fishing effort by year and major gear type is listed in Table 7.14.2.3.3.1, and shown in Figure 7.14.2.3.3.1 in terms of kW*days for the Maltese and Italian bottom otter trawl fleets. Data on fishing effort from Tunisia is not available.

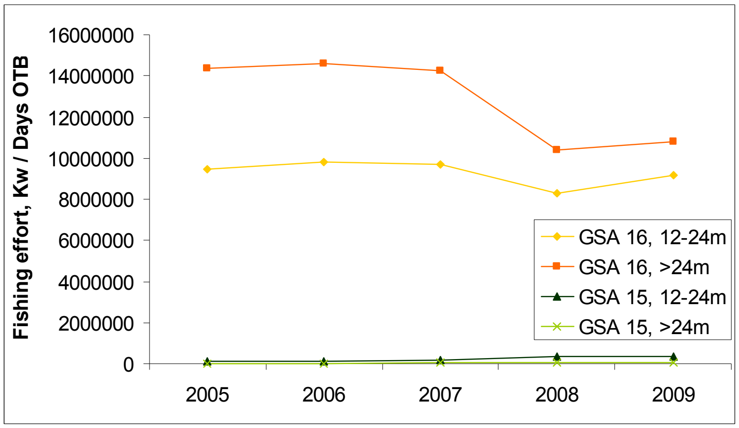


Fig. 7.14.2.3.3.1. Trend in annual effort (kW*days) of Italian and Maltese otter trawlers operating in GSAs 15 and 16, 2005-2009.

Tab. 7.14.2.3.3.1 Trend in annual effort (kW*days) by country, gears and vessel length in GSAs 15 and 16, 2005-2009.

COUNTRY	GSA	FT_LVL4	VESSEL_LENGTH	2005	2006	2007	2008	2009
ITA	16	OTB	VL0612	11001	0	0	0	183954
			VL1218	3307141	3442496	3722837	3523709	3705588
			VL1824	6156064	6374977	5947067	4792117	5294526
			VL2440	14355019	14603903	14257032	10376157	10830753
MAL	15	OTB	VL1224	128047	133167	201767	352184	0
			VL1824	0	0	0	0	340113
			VL2440	1790	10742	39090	30358	59792

7.14.3. *Scientific surveys*

7.14.3.1. Medits

7.14.3.1.1. Methods

Based on the DCR data call, abundance and biomass indices were recalculated and presented in section 11 of this report.

In order to collect fisheries independent data, which is a requirement of the EU DCF (Council Regulation 199/2008, Commission Regulation 665/2008, Commission Decision EC 949/2008 and Commission Decision 93/2010), the MEDITS international trawl survey is carried out in GSAs 15 and 16 on an annual basis. The following number of hauls was reported per depth stratum in 1994-2009 (GSA 16) and 2002-2009 (GSA 15):

Tab. 7.14.3.1.1.1. Number of hauls per year and depth stratum in GSA 16, 1994-2009.

Depth (m)	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
10-50	4	4	4	4	4	4	4	4
50-100	8	8	8	8	8	8	7	8
100-200	4	4	4	4	5	5	6	5
200-500	10	11	11	12	11	11	11	11
500-800	10	14	14	13	14	14	14	14
Depth (m)	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
10-50	7	7	7	10	10	11	11	11
50-100	11	12	12	20	22	23	23	23
100-200	10	8	9	18	19	21	21	21
200-500	19	18	19	28	31	27	27	27
500-800	19	20	19	32	33	38	38	38

Tab. . 7.14.3.1.1.2. Number of hauls per year and depth stratum in GSA 15, 2002-2009.

Depth (m)	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
10-50	1	1	2	1	1	0	0	0
50-100	5	5	4	5	5	12	6	6
100-200	13	13	13	13	13	12	13	14
200-500	10	10	10	9	10	4	9	10
500-800	16	16	15	17	16	17	17	15

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). A limited number of obvious data errors were corrected and catches by haul were standardized to 60 minutes haul duration. Only hauls noted as valid were used, including stations with no catches of hake, red mullet or pink shrimp (i.e. zero catches were included).

The abundance and biomass indices were subsequently calculated by stratified means (Cochran, 1953; Saville, 1977). This implies weighing average values of the individual standardized catches as well as the variation of each stratum by the respective stratum area:

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

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

Where:

A = total survey area
Ai = area of the i-th stratum
si = standard deviation of the i-th stratum
ni = number of valid hauls of the i-th stratum
n = number of hauls in the GSA
Yi = mean of the i-th stratum
Yst = stratified mean abundance
V(Yst) = variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t (student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions about the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien *et al.* 2004).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA. Given the sheer number of plots generated, these distributions are not presented in this report.

Scientific survey data from Tunisia was not available to SGMED 03-2010.

7.14.3.1.2. Geographical distribution patterns

No analyses were conducted during SGMED-10-03.

7.14.3.1.3. Trends in abundance and biomass

Relative indices derived from scientific surveys in the Central Mediterranean indicate a recent recovery of the stock size after a period of low biomass and abundance indices from 2005 to 2007.

A) B)

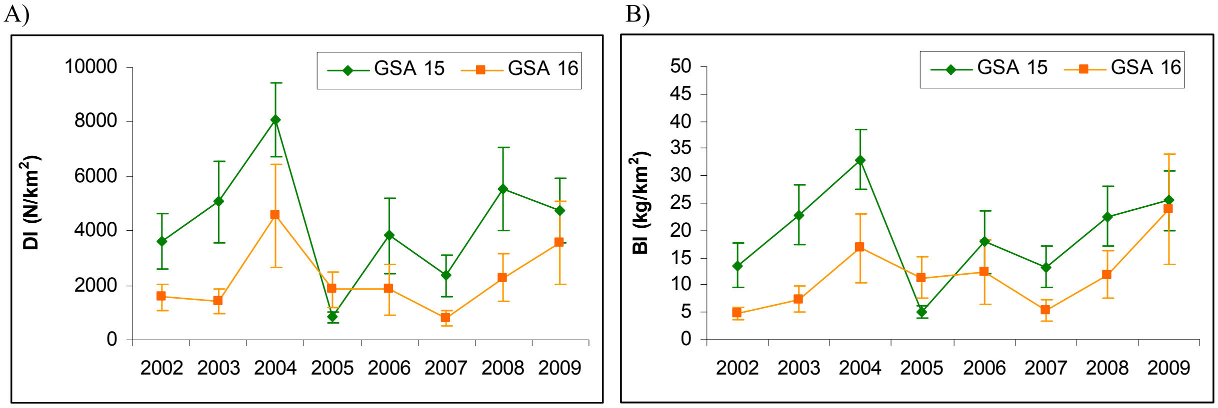


Fig. 7.14.3.1.3.1 A) Density; and B) Biomass indices obtained during 2002-2009 MEDITS surveys in GSAs 15 /16

In addition to information on the trends in *P. longirostris* abundance in early summer collected through the MEDITS survey, fisheries independent information was also collected in GSA 16 through the GRUND programme, which is conducted in autumn. Figure XX and Figure XX display the estimated trend in deep water pink shrimp density and biomass in GSA 16 respectively. The GSA 16 GRUND time series extends back to 1990.

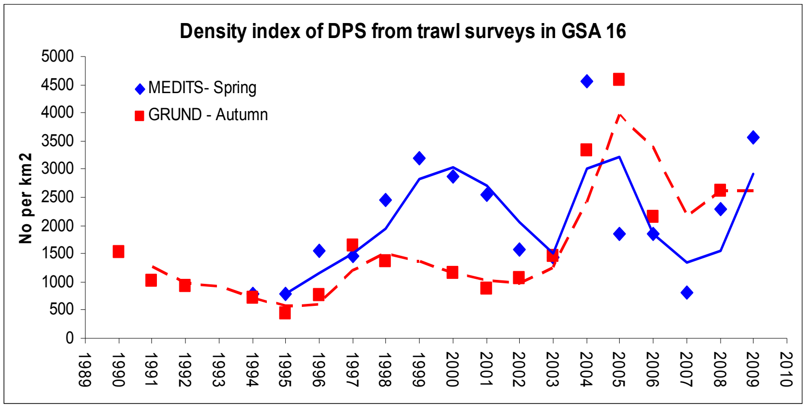


Fig. 7.14.3.1.3.2 Density indices (N per km^2) obtained during the MEDITS and GRUND surveys in GSA 16.

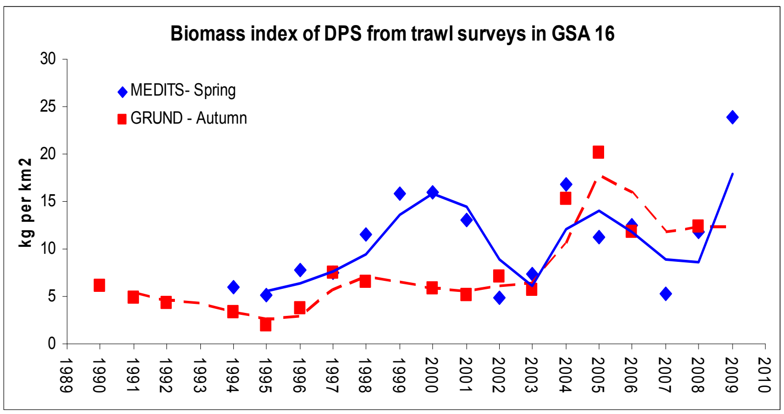


Fig. 7.14.3.1.3.3 Biomass indices (kg per km^2) obtained during the MEDITS and GRUND surveys in GSA 16.

Density indices (DI) of recruits (individuals less than 16 mm CL) derived from MEDITS and GRUND trawl surveys were used to describe variation recruitment strength in the Central Mediterranean. The mean value (± sd) of DI from 1999 to 2009 was 341 ± 463 individuals per km^2 in the Spring (MEDITS) and 258 ± 306 in the Autumn (GRUND).

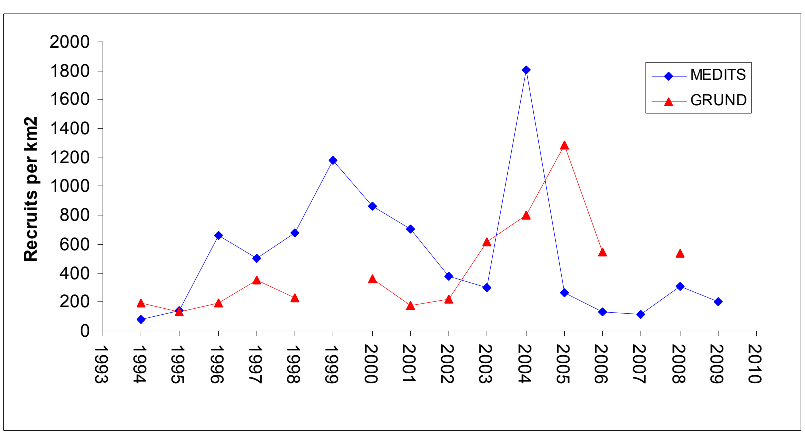


Fig 7.14.3.1.3.4 Index of *P. longirostris* recruits (individuals < 16mm CL) in number per km^2, GSA 16.

The trends in abundance and biomass as re-estimated for GSA 16 by SGMED-10-02 are shown in Figure 7.14.3.1.3.5.

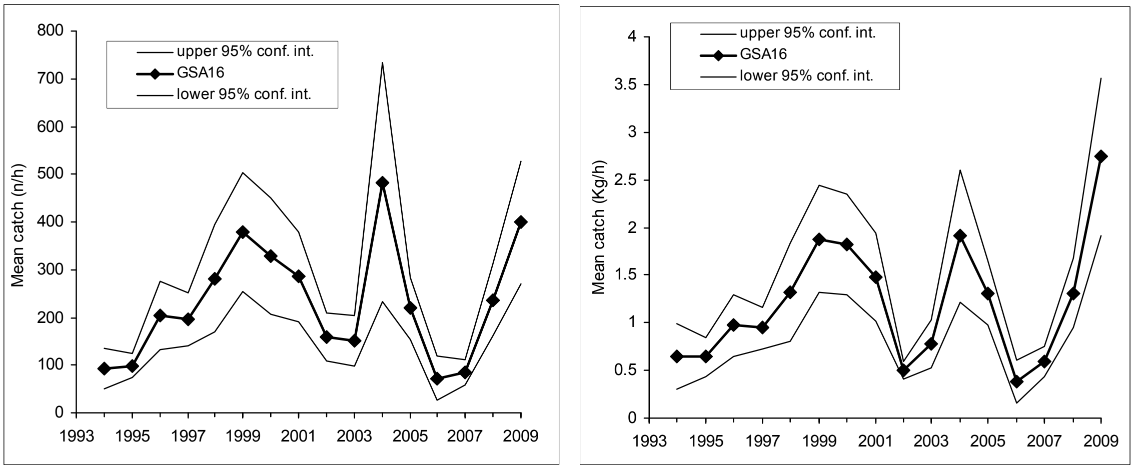


Fig. 7.14.3.1.3.5 Abundance and biomass indices of DPS in GSA 16.

7.14.3.1.4. Trends in abundance by length or age

The Figures 7.14.3.1.4.1 and 2 display the stratified abundance indices of GSA 16 in 1994-2001 and GSAs 15-16 in 2002-2009.

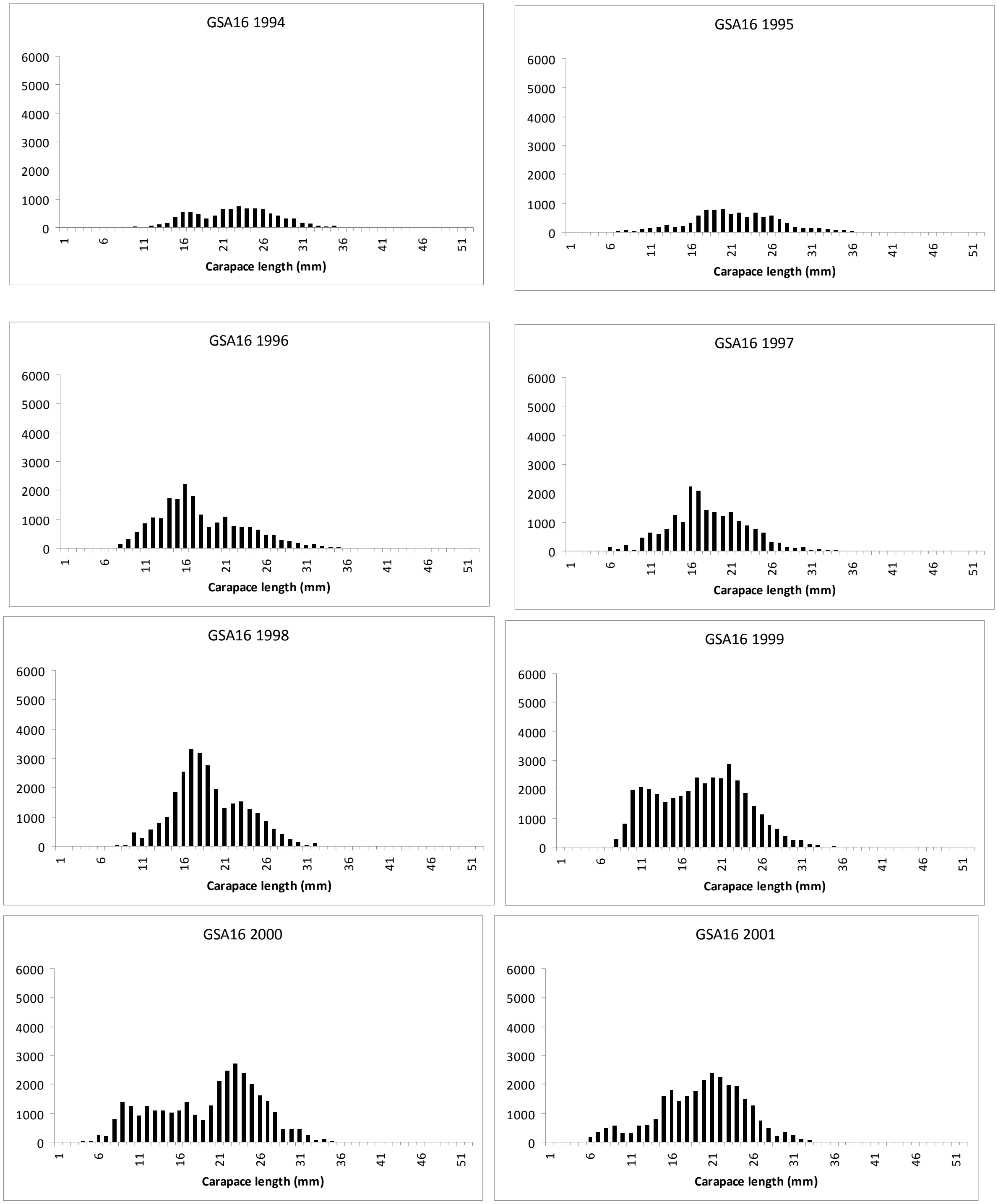


Fig. 7.14.3.1.4.1 Stratified abundance indices by size in GSA 16, 1994-2001.

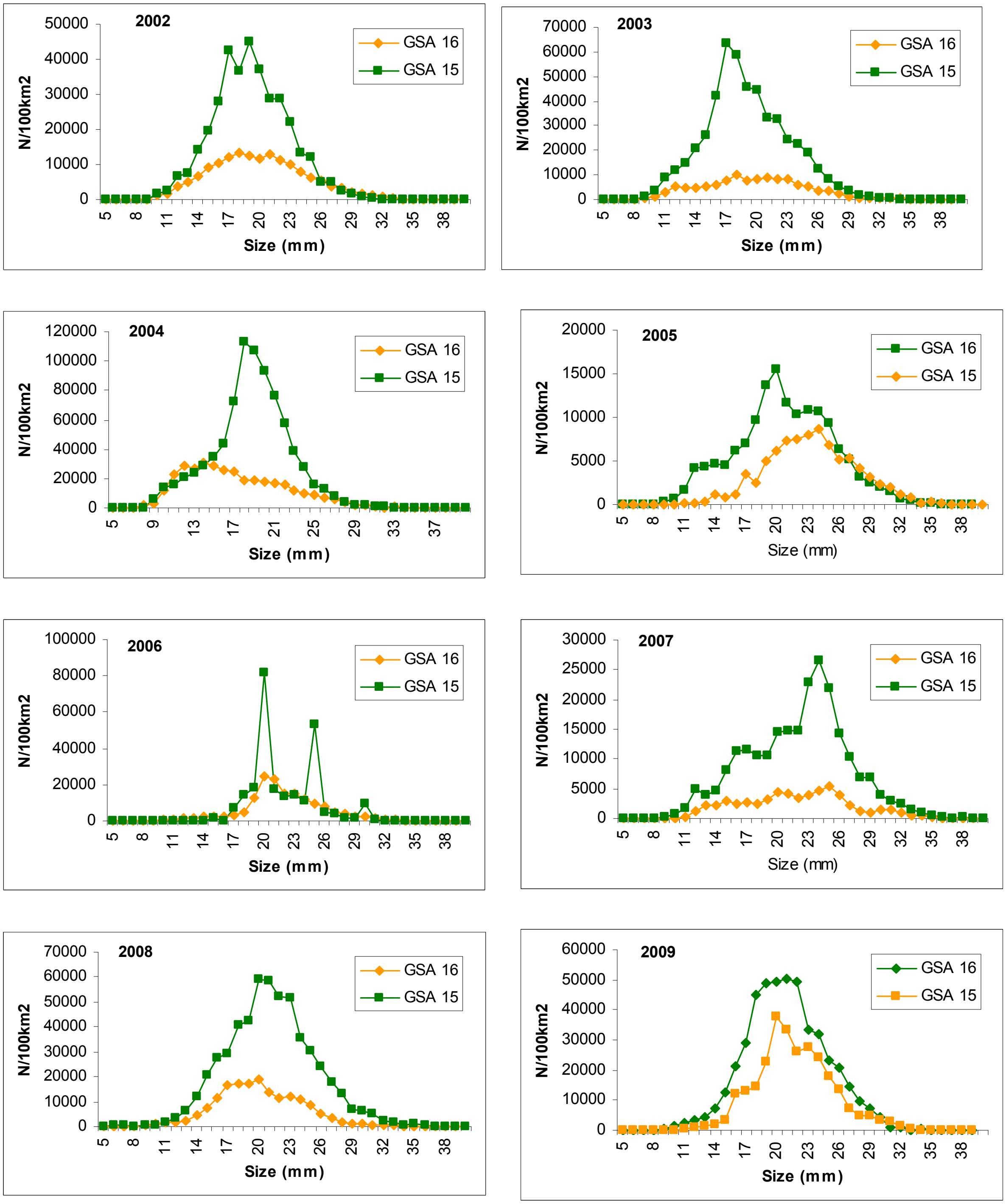


Fig. 7.14.3.1.4.2 Stratified abundance indices by size in GSAs 15 and 16, 2002-2009.

7.14.3.1.5. Trends in growth

No analyses were conducted during SGMED-10-03.

7.14.3.1.6. Trends in maturity

No analyses were conducted during SGMED-10-03.

7.14.4. *Assessment of historic stock parameters*

7.14.4.1. Method 1: Trends in LPUE

7.14.4.1.1. Justification

Trends in LPUE may provide insight into trends in stock size. SGMED-10-03 recommends that technological creep should be considered when trends in LPUE are interpreted.

7.14.4.1.2. Input parameters

Landings and effort for the Sicilian trawler fleet operating in GSA 16 were used.

7.14.4.1.3. Results

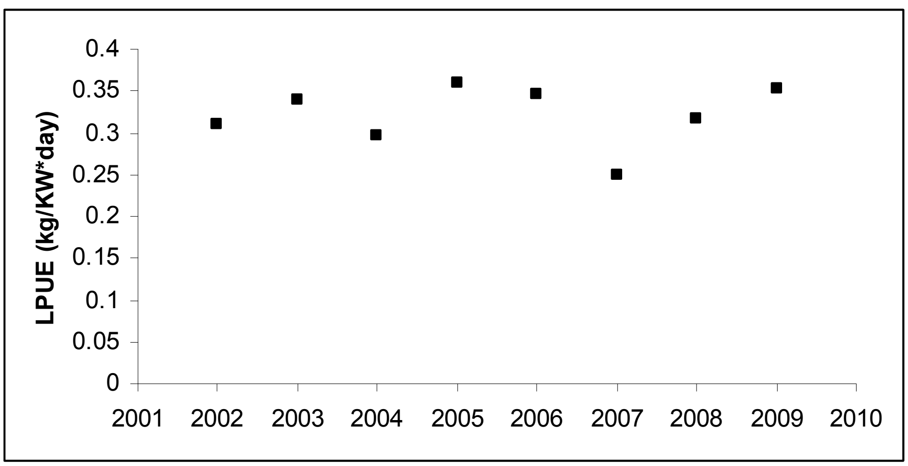


Fig. 7.14.4.1.3.1 Landings per unit effort of commercial trawling by the Sicilian fleet operating in the Strait of Sicily.

According to commercial data, an increasing phase of shrimp landings per unit effort is thus occurring after the minimum of 2007 (Fig. 7.14.4.1.3.1 above). This pattern is coherent with the trend of biomass from trawl surveys.

7.14.4.2. Method 2: VIT

7.14.4.2.1. Justification

Data used in this assessment derived from indirect (fisheries monitoring) sources. Landings data as well as length frequency distributions from Tunisia, Malta and Sicily for the years 2007, 2008 and 2009 were used. Length frequency distributions from Malta were only available for 2009. The assessment was performed using length cohort analysis (LCA) as implemented in VIT4Win (Lleonart and Salat 1992, 1997). Analyses were performed separately on length frequency distributions of males and females and by keeping fleet segments separate. Current mean F and exploitation pattern were assessed using the steady state LCA by length on LFD of 2007, 2008 and 2009 raised to the total landings. The F values by size and year for combined sex were obtained as ratio of the sum of the catch of males and females out the sum of mean number at sea of males and females. The Y/R values by sex and year were combined to obtain a single value for both the sexes by using an average, weighed by sex ratios (0.57 females and 0.43 males).

7.14.4.2.2. Input parameters

The parameters used in the analysis are reported in Table 7.14.4.2.2.1. VIT analyses were run for 2007, 2008 and 2009 separately as well as combined using the average 2007-2009 catches.

Table 7.14.4.2.2.1. Parameters used for stock assessment trough the VIT approach (from Ben Mariem *et al*., 2010).

		Sex		
	Units	Female	Male	Comb.
L∞	mm	42.71	33.56	44.59
K		0.67	0.73	0.60
t0	year	-0.21	-0.13	-0.12
a		0.001	0.001	0.001
b		2.48	2.41	2.46
M		1.05	1.20	1.12

Table 7.14.4.2.2.1. Absolute numbers by length class of landings by year for the Maltese 12-24 m fleet.

	2009	
LC (mm)	**Female**	**Male**
8	138	414
9	71	213
10	702	2105
11	1786	5359
12	3615	10846
13	4495	13485
14	6880	20640
15	7186	25152
16	19869	24836
17	14150	46695
18	26338	68039
19	28577	120024
20	64785	225589
21	71146	190541
22	139098	211012
23	198863	170454
24	198647	81473
25	216657	38752
26	226603	17566
27	135460	2419

28	175075	5404
29	96105	2529
30	41251	0
31	12256	0
32	1830	0
33	6423	0
34	879	0
35	927	0

Table 7.14.4.2.2.3. Absolute numbers by length class of landings by year for the Italian 12-24 m fleet.

	2007		**2008**		**2009**	
LC (mm)	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**
11	11134	174932	108020	0		134844
12	915067	491389	197475	0	196036	0
13	8478919	5321790	793744	723444	689325	772598
14	14942327	14864909	3405838	3176333	4228111	5152947
15	22708064	32229241	6637083	8521668	15264807	9850795
16	39137772	42515472	10350692	20813723	30301436	17150102
17	36275604	46208607	14428260	30691359	52872716	18782243
18	30322650	44161422	16915257	37293873	63745500	28802119
19	42371451	41542071	18558406	30974464	45268580	33428213
20	42720314	47106079	21325921	26427205	45696504	44526242
21	46912626	32546273	22109408	20878315	32124357	47051764
22	31415123	17283146	22068288	13946160	19674494	48864893
23	17921125	17135189	22468774	7316439	9480845	51238256
24	13053034	13771849	20873452	3392939	3892223	50009258
25	9035917	3865262	16126276	1442202	1630169	45517385
26	6147974	1419521	9969758	935824	1587025	38920430
27	5762245	180109	4900844	286536	107387	31967001
28	4060601	20012	1936488	175267	179647	23659571
29	3186788	20012	836303	281962	59188	14794257
30	1973553	0	449341	105430	59188	10657027
31	371581	0	262230	0	0	4798261
32	287639	0	110738	0	0	2506732
33	123860	0	77402	0	0	887977
34	123860	0	44689	0	0	654335
35	0	0	0	0	0	51961
36	136606	0	0	0	0	

Table 7.14.4.2.2.4. Absolute numbers by length class of landings by year for the Italian > 24 m fleet.

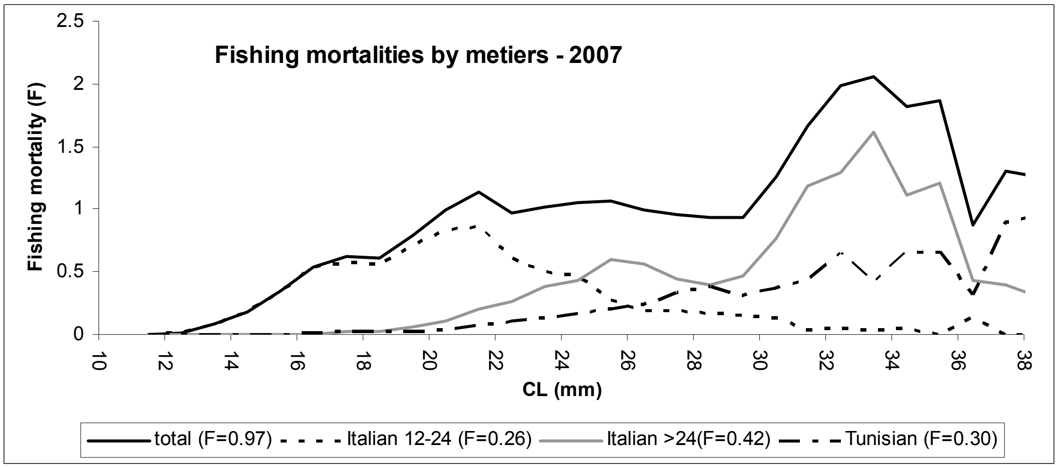
	2007		2008		2009	
LC (mm)	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**
12	0	0	88112	0	0	0
13	0	0	110140	0	0	0
14	30030	0	198253	279321	172448	100553
15	47930	0	628340	1007374	612228	347481
16	189548	0	1165425	2117070	1411602	1071013
17	848603	3101046	1364220	1905376	1316796	1224907
18	806923	2949290	2138656	3327612	2419064	2143497
19	2535763	6558908	3098108	4128937	2805642	2240142
20	3708557	10917774	6697499	9901077	4503450	4687522
21	4900987	18914374	11123662	11445010	7019773	6104840
22	5480091	21394399	13084955	11434830	7253768	9153675
23	6895414	27788357	17320761	8335216	8493146	12459466
24	4428865	29195397	18913195	5642141	6485632	15458039
25	4729978	34454833	17801469	4241551	2920133	18396795
26	3366790	26496574	15694226	2610788	1574239	1566341
27	2828533	15846019	13533979	1373466	773450	13060865
28	4726328	6797040	11848576	1185004	339655	11320011
29	7270096	1849539	10389603	1172324	191887	8074446
30	10079262	839485	10991883	1156997	120561	6483043
31	11344156	248943	8915794	412816	134442	4179552
32	7105018	89044	6326830	95019	115021	2912215
33	4969229	0	3344830	17443	53716	2179104
34	2303741	0	2049782	0	0	562845
35	1623312	0	938260	0	0	564185
36	391248	0	317319	0	0	309515
37	0	0	367448	0	0	68406
38	0	0	174725	0	0	55986
39	0	0	91996	0	0	3278
40	0	0	47429	0	0	0

Table 7.14.4.2.2.5. Absolute numbers by length class of landings by year for the Tunisian >24m fleet (from Ben Mariem et al., 2010).

	2007		**2008**		**2009**	
LC (mm)	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**
13	0	209937	0	32229	315181	0
14	71782	316024	13539	59080	242810	28976
15	467970	723282	102104	158292	895185	579011
16	643901	808234	165279	206753	922257	657247
17	1935826	1316956	576372	392183	1214829	1679044
18	2171524	1951594	743755	670329	1608853	1702674
19	2194416	1876868	851756	732128	2082198	2209146
20	2731006	2096669	1201689	934897	2533561	2489102
21	3902133	4870681	1938704	2450185	5247474	3532375
22	3891020	6781613	2174724	3834471	7611339	3777551
23	3692403	7662421	2310672	4811789	9684318	4744672
24	4739873	7264852	3345677	5049991	8631458	6414211
25	6738531	4389338	5261212	3353001	6064241	10498072
26	8198575	2176294	7046935	1836768	4914788	13397034
27	9943781	1564246	9286607	1455446	4103427	18502461
28	9142788	967025	9292125	980260	1657172	14906879
29	5477265	536046	6065119	588049	607951	9965501
30	4829296	407947	5772593	483425	250486	8125125
31	3770060	359436	4841750	459546	229055	5993883
32	2983106	77375	4119508	107035	31242	4286823
33	1591602	61491	2384787	91824	23805	2930329
34	1674692	94461	2708749	152502	85125	2168105
35	1104991	87561	1917187	150546	43300	1289194
36	348614	0	653147	0	0	968687
37	692826	25911	1367247	50859	10462	502771
38	434480	25911	911835	54235	462	324867
39	98828	0	222464	0	0	123815
40	136393	0	319216	0	0	79747
41	0	0	0	0	0	60190
42	5126	0	14425	0	0	5843

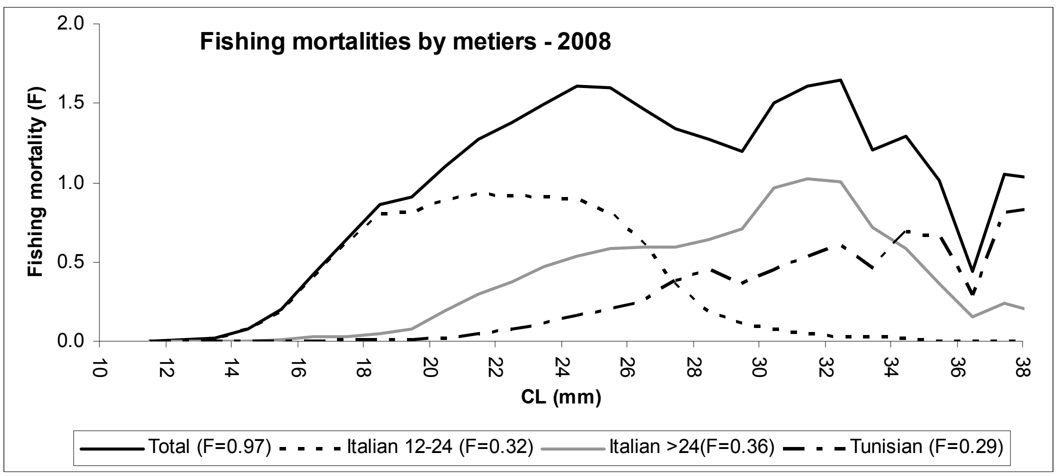
7.14.4.2.3. Results

Fishing mortality rates (F) of pink shrimp catches in GSA 12-16 are shown in Fig. 7.14.4.2.3.1 by size, fleet segments and year for combined sexes as well as for average catches in 2007-2009.



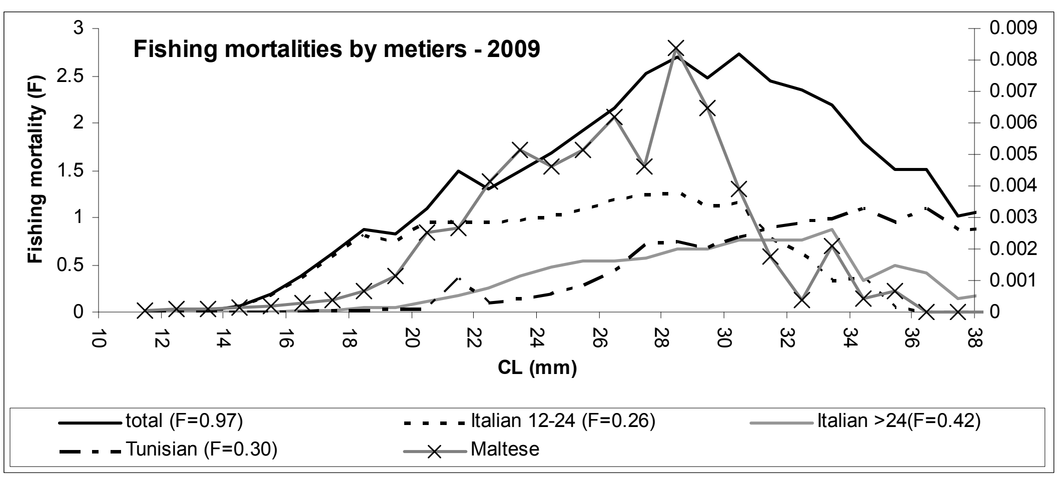
Fishing mortalities by metiers - 2007
Fishing mortality (F)
CL (mm)
total (F=0.97)
Italian 12-24 (F=0.26)
Italian >24(F=0.42)
Tunisian (F=0.30)

A)



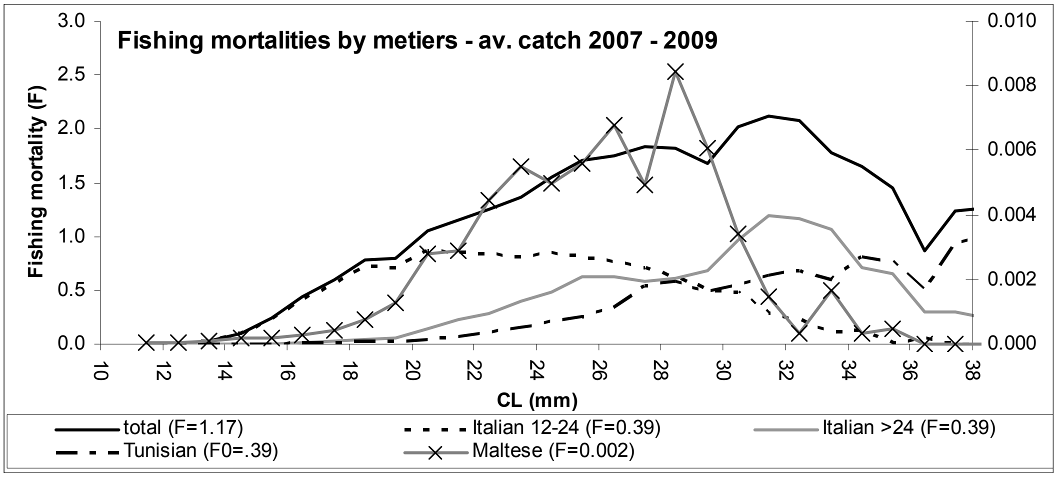
Fishing mortalities by metiers - 2008
Fishing mortality (F)
CL (mm)
Total (F=0.97)
Italian 12-24 (F=0.32)
Italian >24(F=0.36)
Tunisian (F=0.29)

B)



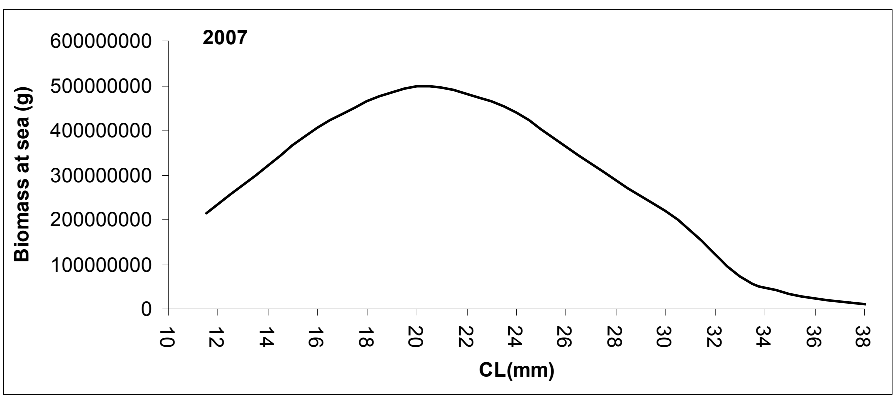
Fishing mortalities by metiers - 2009
Fishing mortality (F)
CL (mm)
total (F=0.97)
Italian 12-24 (F=0.26)
Italian >24(F=0.42)
Tunisian (F=0.30)
Maltese

C)

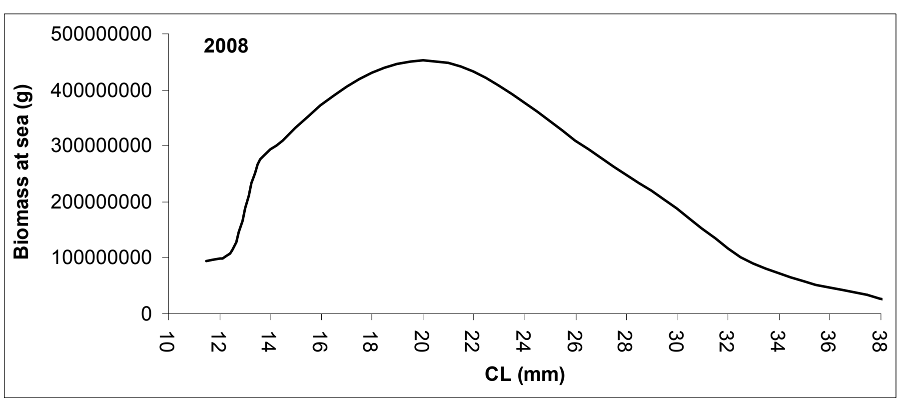


D)

Fig. 7.14.4.2.3.1 A)-C) Annual fishing mortality rates (F) for *P. longirostris* harvested by bottom otter trawling in GSAs 12-16. Mortality rates are shown by fleet segment and as total values. D) Fishing mortality rates (F) by size and fleet segments of deep water pink shrimps for the average 2007-2009 catches in GSA 12-16. The population at sea in terms of biomass in 2007, 2008 and 2009 are shown below.



A)



B)

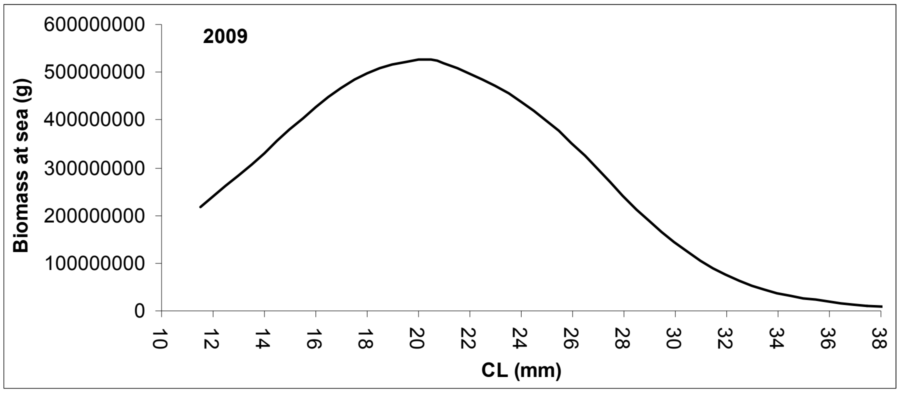
C) 

Fig. 7.14.4.2.3.2. Biomass at sea of pink shrimp for combined sexes as reconstructed with the VIT analysis for 2007, 2008 and 2009.

The reconstructed yields obtained by applying the VIT package are virtually equal to the observed ones. Absolute recruitment estimation and other main results of VIT, including the current mortality rates, are listed below.

Table 7.14.4.2.3.1. The main results of the VIT analysis (LCA).

Variables	2007	2008	2009	2007-2009
Observed Yield (tons)	6383	6955	8806	7381
Reconstructed Yield (tons)	6375	6933	8806	7383
Recruits at 11 mm CL (millions)	3167	2731	3374	3064
Mean F	1.00	1.02	1.38	1.16
Current critical length (mm)	18.3	18.3	18.7	18.3
Virgin critical length (mm)	22.0	22.0	22.0	22.0

7.14.5. *Long term prediction*

7.14.5.1. Method 1: Y, B and SSB per recruit according to the VIT package

7.14.5.1.1. Justification

The VIT approach to biomass and yield per recruit analysis has been applied in order to analyse the stock production with increasing exploitation under equilibrium conditions. To obtain an estimate of equilibrium conditions, average catch data from 2007-2009 was used for males and females.

7.14.5.1.2. Input parameters

Table 7.14.5.1.2.1 Absolute numbers by length class of landings by year for the Maltese 12-24 m fleet.

	2009	
LC (mm)	**Female**	**Male**
8	138	414
9	71	213
10	702	2105
11	1786	5359
12	3615	10846
13	4495	13485
14	6880	20640
15	7186	25152
16	19869	24836
17	14150	46695
18	26338	68039
19	28577	120024
20	64785	225589
21	71146	190541
22	139098	211012
23	198863	170454
24	198647	81473
25	216657	38752
26	226603	17566
27	135460	2419
28	175075	5404
29	96105	2529
30	41251	0

31	12256	0
32	1830	0
33	6423	0
34	879	0
35	927	0

Table 7.14.5.1.2.2 Absolute numbers by length class of landings by year for the Italian 12-24 m fleet.

	2007		**2008**		**2009**	
LC (mm)	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**
11	11134	174932	108020	0		134844
12	915067	491389	197475	0	196036	0
13	8478919	5321790	793744	723444	689325	772598
14	14942327	14864909	3405838	3176333	4228111	5152947
15	22708064	32229241	6637083	8521668	15264807	9850795
16	39137772	42515472	10350692	20813723	30301436	17150102
17	36275604	46208607	14428260	30691359	52872716	18782243
18	30322650	44161422	16915257	37293873	63745500	28802119
19	42371451	41542071	18558406	30974464	45268580	33428213
20	42720314	47106079	21325921	26427205	45696504	44526242
21	46912626	32546273	22109408	20878315	32124357	47051764
22	31415123	17283146	22068288	13946160	19674494	48864893
23	17921125	17135189	22468774	7316439	9480845	51238256
24	13053034	13771849	20873452	3392939	3892223	50009258
25	9035917	3865262	16126276	1442202	1630169	45517385
26	6147974	1419521	9969758	935824	1587025	38920430
27	5762245	180109	4900844	286536	107387	31967001
28	4060601	20012	1936488	175267	179647	23659571
29	3186788	20012	836303	281962	59188	14794257
30	1973553	0	449341	105430	59188	10657027
31	371581	0	262230	0	0	4798261
32	287639	0	110738	0	0	2506732
33	123860	0	77402	0	0	887977
34	123860	0	44689	0	0	654335
35	0	0	0	0	0	51961
36	136606	0	0	0	0	

Table 7.14.5.1.2.3 Absolute numbers by length class of landings by year for the Italian > 24 m fleet.

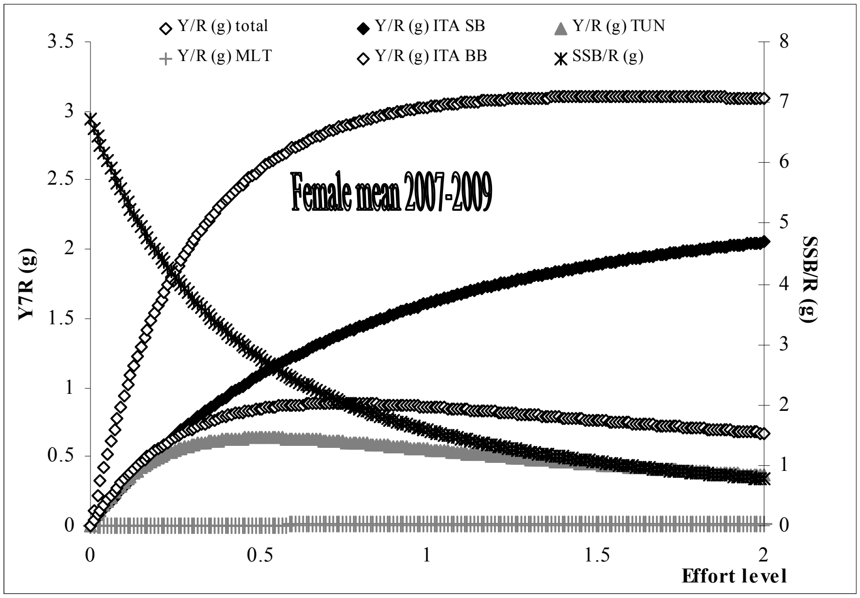
	2007		**2008**		**2009**	
LC (mm)	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**
12	0	0	88112	0	0	0
13	0	0	110140	0	0	0
14	30030	0	198253	279321	172448	100553
15	47930	0	628340	1007374	612228	347481
16	189548	0	1165425	2117070	1411602	1071013
17	848603	3101046	1364220	1905376	1316796	1224907
18	806923	2949290	2138656	3327612	2419064	2143497
19	2535763	6558908	3098108	4128937	2805642	2240142
20	3708557	10917774	6697499	9901077	4503450	4687522
21	4900987	18914374	11123662	11445010	7019773	6104840
22	5480091	21394399	13084955	11434830	7253768	9153675
23	6895414	27788357	17320761	8335216	8493146	12459466
24	4428865	29195397	18913195	5642141	6485632	15458039
25	4729978	34454833	17801469	4241551	2920133	18396795
26	3366790	26496574	15694226	2610788	1574239	1566341
27	2828533	15846019	13533979	1373466	773450	13060865
28	4726328	6797040	11848576	1185004	339655	11320011
29	7270096	1849539	10389603	1172324	191887	8074446
30	10079262	839485	10991883	1156997	120561	6483043
31	11344156	248943	8915794	412816	134442	4179552
32	7105018	89044	6326830	95019	115021	2912215
33	4969229	0	3344830	17443	53716	2179104
34	2303741	0	2049782	0	0	562845
35	1623312	0	938260	0	0	564185
36	391248	0	317319	0	0	309515
37	0	0	367448	0	0	68406
38	0	0	174725	0	0	55986
39	0	0	91996	0	0	3278
40	0	0	47429	0	0	0

Table 7.14.5.1.2.4 Absolute numbers by length class of landings by year for the Tunisian >24m fleet (from Ben Mariem et al., 2010).

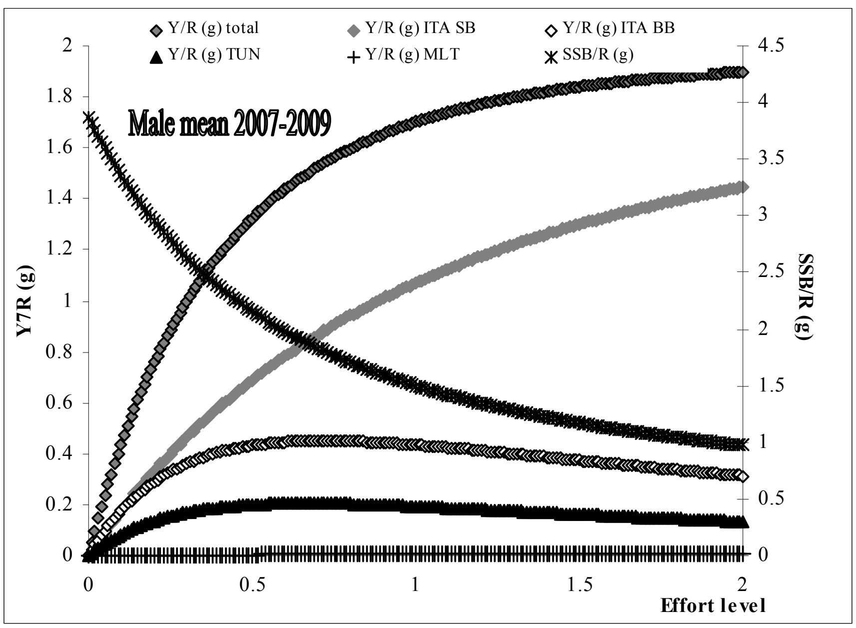
	2007		**2008**		**2009**	
LC (mm)	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**
13	0	209937	0	32229	315181	0
14	71782	316024	13539	59080	242810	28976
15	467970	723282	102104	158292	895185	579011
16	643901	808234	165279	206753	922257	657247
17	1935826	1316956	576372	392183	1214829	1679044
18	2171524	1951594	743755	670329	1608853	1702674
19	2194416	1876868	851756	732128	2082198	2209146
20	2731006	2096669	1201689	934897	2533561	2489102
21	3902133	4870681	1938704	2450185	5247474	3532375
22	3891020	6781613	2174724	3834471	7611339	3777551
23	3692403	7662421	2310672	4811789	9684318	4744672
24	4739873	7264852	3345677	5049991	8631458	6414211
25	6738531	4389338	5261212	3353001	6064241	10498072
26	8198575	2176294	7046935	1836768	4914788	13397034
27	9943781	1564246	9286607	1455446	4103427	18502461
28	9142788	967025	9292125	980260	1657172	14906879
29	5477265	536046	6065119	588049	607951	9965501
30	4829296	407947	5772593	483425	250486	8125125
31	3770060	359436	4841750	459546	229055	5993883
32	2983106	77375	4119508	107035	31242	4286823
33	1591602	61491	2384787	91824	23805	2930329
34	1674692	94461	2708749	152502	85125	2168105
35	1104991	87561	1917187	150546	43300	1289194
36	348614	0	653147	0	0	968687
37	692826	25911	1367247	50859	10462	502771
38	434480	25911	911835	54235	462	324867
39	98828	0	222464	0	0	123815
40	136393	0	319216	0	0	79747
41	0	0	0	0	0	60190
42	5126	0	14425	0	0	5843

7.14.5.1.3. Results

The results of estimating spawning stock biomass as well as biomass and yield per recruit, by varying current fishing mortality (F_{stq}) through a multiplicative factor for average catches recorded in the Strait of Sicily for 2007-2009, are illustrated in Fig. 7.14.5.1.3.1.



A)



B)

Fig. 7.14.5.1.3.1 Spawning Stock Biomass (SSB) and Yield (Y) per recruit varying current fishing mortality (F_{stq}) for male and female pink shrimp by a multiplicative factor according to the VIT package.

Assuming no variation in the exploitation pattern, the main results of Y/R analysis are reported in Tab. 7.14.5.1.3.1 below.

Table 7.14.5.1.3.1. Estimation of yield (g), biomass (g) and spawning stock biomass (SSB) (g) per recruit (R), varying current fishing mortality by a multiplicative factor. The factor corresponding to $F_{0.1}$ is marked in bold. Results for males and females are combined using a sex ratio weighted average (0.57 females and 0.43 males).

Year	Factor	F	Y/R	B/R	SSB
2007	0.00	0.00	0.00	6.46	5.50
	0.79	**0.76**	**2.12**	**3.03**	**2.17**
	1.00	1.00	2.25	2.55	1.74
2008	0.00	0.00	0.00	6.68	5.77
	0.94	**0.95**	**2.46**	**2.72**	**1.89**
	1.00	1.02	2.51	2.52	1.71
2009	0.00	0.00	0.00	6.46	5.50
	0.73	**0.98**	**2.41**	**2.76**	**1.85**
	1.00	1.35	2.57	2.24	1.37
MEAN	0.00	0.00	0.00	6.54	5.59
	0.82	**0.90**	**2.33**	**2.84**	**1.97**
	1.00	1.13	2.45	2.44	1.61
MEDIAN	0.00	0.00	0.00	6.46	5.50
	0.79	**0.95**	**2.41**	**2.76**	**1.89**
	1.00	1.02	2.51	2.52	1.71
2007-2009 MEAN CATCH	0.00	0.00	0.00	6.46	5.50
	0.77	**0.75**	**2.31**	**2.86**	**1.97**
	1.01	0.97	2.46	2.41	1.55

In order to investigate the robustness of the VIT analyses described above, a sensitivity analysis was done as implemented in the VIT4win programme. Results, displayed in Table 7.14.5.1.3.2 below, showed that changing M and k has a pronounced effect on Y/R when the variation is in the opposite direction, whilst biomass per recruit and spawning stock biomass per recruit are strongly affected when the change is in the same direction.

Table 7.14.5.1.3.21 Results of the sensitivity analysis performed for the most critical parameters (K and M) used in the VIT analysis. Variations of 10%, 20% and 40% were tested. The sign "minus (-) means a decrease and the sign "plus" (+) an increase. The "zero" means no variation in the parameters used for VIT. The parameters varied on the left is the "k" and that on the right is the "M". Only results of females were presented

	0.10			0.20			0.40		
Parameters	Y/R	Biomass	SSB	Y/R	Biomass	SSB	Y/R	Biomass	SSB
'0000000000'	2.36	2.44	1.66	2.36	2.44	1.66	2.36	2.44	1.66
'0-000-0000'	2.37	2.71	1.84	2.37	3.04	2.06	2.38	4.04	2.73
'0-000+0000'	1.77	2.48	1.67	1.17	2.48	1.63	0.23	2.19	1.29
'0+000-0000'	2.94	2.39	1.64	3.47	2.33	1.61	4.44	2.20	1.54
'0+000+0000'	2.36	2.23	1.52	2.36	2.05	1.40	2.35	1.76	1.21

Current values of F (mean over all size classes / calculated for average catches 2007-2009) are higher than F_{max} and $F_{0.1}$, suggesting a state of overexploitation for this stock. According to VIT analysis to reach $F_{0.1}$ a reduction of about 23% of the fishing mortality the Central Mediterranean pink shrimp stock was exposed to in 2007-2009 is advisable. If fishing mortality rates of 2009 are taken as a baseline, the necessary reduction to reach $F_{0.1}$ is 27%. The results of the assessment revealed that a reduction in fishing capacity should primarily target Italian artisanal trawlers, who harvest large numbers of juvenile pink shrimp.

7.14.6. *Data quality and availability*

In terms of data quality and availability, SGMED 03-09 noted that commercial data from Tunisia, Malta and Sicily was for the first time available for a joint assessment. The proportion of landings which can be attributed to Italy, Tunisia and Malta reflects the number of vessels targeting this species in the Central Mediterranean; 82.6 % of the catches were landed by the Sicilian fleet, 17.2% by Tunisian fishermen, and 0.2% by the Maltese trawlers. In order to obtain an accurate estimation of stock status it is thus clearly vital that data from Tunisia is considered in future assessments of pink shrimp in this area. Scientific survey data was only available from GSA 15 and 16. Intercalibration exercises should be held in the future in order to integrate data from scientific surveys carried out on an annual basis in Tunisia and the trawl surveys carried out according to MEDITS protocol in GSAs 15 and 16.

7.14.7. *Scientific advice*

7.14.7.1. Short term considerations

7.14.7.1.1. State of the spawning stock size

According to VIT analysis, absolute estimations of SSB (combined sex) in the 2007-2009 was 5679 t in 2007, 4673 t in 2008 and 4630 t in 2009. Relative indices derived from scientific surveys in the Central Mediterranean indicate a recent recovery of the stock size after a period of low biomass and abundance indices from 2005 to 2007. In the absence of precautionary management reference points SGMED is unable to fully evaluate the state of the SSB.

7.14.7.1.2. State of recruitment

The estimates of absolute recruitment in thousands of individuals (age class 0) from VIT analysis for GSAs 12-16 in 2007-2009 were 2899792 in 2007, 2415346 in 2008 and 2983713 in 2009. The time series of recruitment indices from trawl surveys carried out in GSA 16 (individuals smaller than 16 mm CL) showed a peak in 2004 (1802 recruits per km^2) in the spring trawl surveys, and in 2005 (1286 recruits per km^2) for the autumn surveys. The mean indices over the time series were 341 ± 463 in spring and 258 ± 306 in autumn. The spring indices in the last three years (2007-2009) were lower than the mean, whereas the only value available for the autumn series (2008) was higher than the corresponding mean.

7.14.7.1.3. State of exploitation

SGMED proposes $F_{0.1} \leq 0.9$ as limit reference point consistent with high long term yields. The stock of deep water pink shrimp in the Northern sector of the Strait of Sicily is subject to overfishing since the current fishing mortality is higher than $F_{0.1}$.

7.14.7.2. Medium term considerations

Considering GSAs 12-16, for which both commercial data were available at SGMED 10-03, all the stock assessments performed suggest a similar diagnosis in terms of the long term exploitation state. Maintaining the current exploitation pattern, characterized by high catches of undersized shrimps from small trawlers, and considering $F_{0.1}$ as limit reference point, a reduction of about 23% of the fishing mortality the Central

Mediterranean pink shrimp stock is necessary. If fishing mortality rates of 2009 are taken as a baseline, the necessary reduction to reach $F_{0.1}$ is 27%.

The working group was informed that the Italian government is adopting a management plan in which a reduction of fishing mortality of 25% is planned within 2013. SGMED recommends the adoption of a management plan to continuously reduce current F through consistent effort reductions, and an improvement in current exploitation patterns. Finally, a protection of key nursery areas in the Strait of Sicily is recommended in order to improve the status of this fishery. Stable nurseries of this species have been identified on the Adventure and Malta Banks in the Strait of Sicily (Fortibuoni *et al.*, 2010).

7.15. Stock assessment of giant red shrimp in GSAs 15 and 16

7.15.1. *Stock identification and biological features*

7.15.1.1. Stock Identification

No information is available to the WG on stock unity in the area.

7.15.1.2. Growth and natural mortality

Considering the northern sector of the Strait of Sicily (GSA 15 and 16) the observed maximum length was 70 mm. After age slicing with the parameters estimated by CNR-IAMC (2009; Table 7.15.1.2.1 below), the maximum estimated age in years in the exploited standing stock resulted to be 6 years. The growth parameters estimated in the past for the Strait of Sicily are reported in Table x for comparative purposes. During the SGMED 02 09 new parameters were estimated in order to allow a better performance of VIT approach. This new parameters, with a higher L_{inf} and lower k than the parameters given by the data call but showing a very similar growth performance (see Φ' column in table 7.15.1.2.1), were obtained by the Powel-Wetherall method (L_{inf}) and the ELEFAN "K scan" routine (K). Data used were the length frequency distributions collected in trawl surveys from 1994 to 2008. Parameters were estimated by the package FISAT II (Gayanilo et al., 2005).

Table 7.15.1.2.1. Von Bertalanffy growth function and the length-weight relationship parameters in the Strait of Sicily (GSA 15 and 16). L_{inf} as CL in mm

Reference	**Sex**	**Linf**	**K**	**t_0**	**Φ'**	**a**	**b**
Ragonese *et al.* (1994)	Females	65.5	0.67	0.28	3.459	/	/
	Males	41.5	0.96	0.28	3.218	/	/
Cau et al. (2002)	Females	65.5	0.67	/	3.459	/	/
AAVV (2008); Red's Project	Females	62.24	0.65	0.05	3.401	0.002	2.507
	Males	40.31	0.79	-0.44	3.108	0.002	2.618
Ragonese *et al.* (2004)	Females	65.8	0.52	-0.23	3.352	0.00176-0.00210	2.51-2.56
	Males	/	/	/	/	0.00116-0.00135	2.65-2.69
CNR-IAMC (2009)	Females	61,66	0,78	-0,22	3.472	0.0016	2.5884
	Males	41.95	0,70	-0,18	3.091	0.0010	2.7456
SGMED 02 09	Females	68.9	0.61	-0.2	3.462	0.0013	2.636

7.15.1.3. Maturity

Although spawning in *A. foliacea* occurs from spring till autum in the Strait of Sicily, maturity peaks in summer (Ragonese and Bianchini, 1995). According to Ragonese *et al*. (2004) the length at 50% of maturity was 42 mm CL in females and 30-33 mm CL in males. The most recent assessment of maturity ogive was given by CNR_IAMC (2009), being $L_{50\%}$=37.17 (se=0.108) mm CL and slope =0.541 (se=0.028) for females and $L_{50\%}$=27.41 (se=0.0.037) mm CL and slope=0.988 (se=0.031) for males.

7.15.2. *Fisheries*

7.15.2.1. General description of fisheries

The giant red shrimps is a relevant target species of the Sicilian and Maltese trawlers and is caught on the slope ground during all year round, but landing peaks are observed in summer. *A.foliacea* is fished exclusively by otter trawl, mainly in the central – eastern side of the Strait of Sicily, whereas in the western side it is substituted by the violet shrimp, ***Aristeus antennatus.***

Due to reduction of catch rate since 2004 some distant trawlers based in Mazara del Vallo, which is the main fleet in the area, recently moved to the eastern Mediterranean (Aegean and Levant Sea) to fish red shrimps Garofalo et al., 2007).

A rough delimitation of the most important fishing grounds of red shrimps in the Strait of Sicily of Sicilian trawlers, including GSA 12, 13, 14, 15 and 16, is reported in Ragonese (1995) (Fig. 7.15.2.1.1).

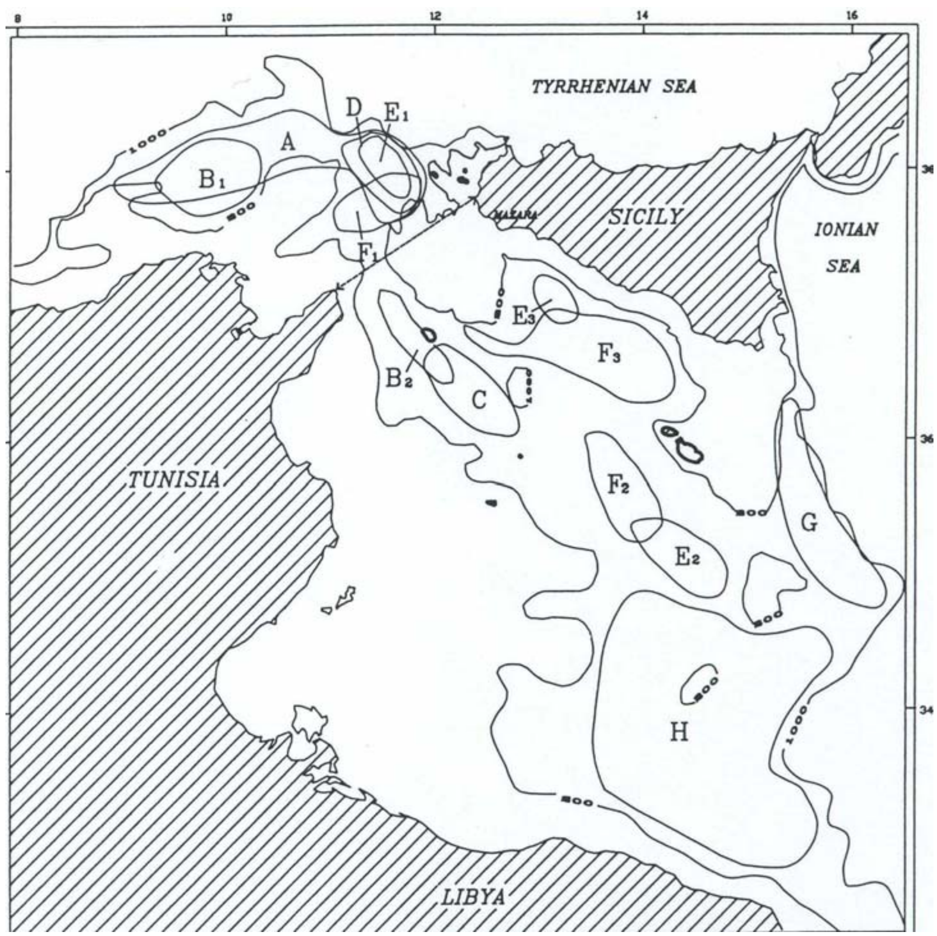


Fig 7.15.2.1.1. Main fishing grounds of red shrimps in the Strait of Sicily according to Ragonese (1995).

Due to reduction of catch rate since 2004 some distant trawlers based in Mazara del Vallo, which is the main fleet in the area, recently moved to the eastern Mediterranean (Aegean and Levant Sea) to fish red shrimps Garofalo *et al*., 2007).

In Maltese waters, trawlers targeting the giant red shrimp *A. foliacea* within the 25nm fisheries management zone trawl either to the north / north-west of the Island of Gozo, or to the west / south-west of Malta, at depths of about 600m. Detailed maps of the trawling grounds for Maltese Fisheries Management Zone (FMZ), including a wide part of GSA 15 are available (Camilleri *et al*., 2008). Giant red shrimps are frequently caught together with Norway lobster (*Nephrops norvegicus*), large sized deep water pink shrimp (*Parapenaeus longirostris*), the more rare violet shrimp (*Aristeus antennatus*) as well as large hake (*Merluccius merluccius*).

In terms of fishing gear, the Italian and Maltese trawlers operating in the Strait of Sicily use the same typology of trawl net called "Italian trawl net". Although some differences in material between the net used in shallow waters ("banco" net, mainly targeted to shelf fish and cephalopods) and that employed in deeper ones ("fondale" net, mainly targeted to deep water crustaceans) exist, the Italian trawl net is characterized by a low vertical opening (up to 1.5 m) with dimensions changing with engine power (Fiorentino *et al*., 2003).

7.15.2.2. Management regulations applicable in 2009 and 2010

At present there are no formal management objectives for giant red shrimp fisheries in the Strait of Sicily. As in other areas of the Mediterranean, the stock management is based on control of fishing capacity (licenses), fishing effort (fishing activity), technical measures (mesh size and area/season closures). No minimum landing sizes is established for this species (EC 1967/06). A compulsive fishing ban for 30 days was adopted by Sicilian Government (August –September).

In order to limit the over-capacity of fishing fleet, Maltese fishing licenses have been fixed at a total of 16 trawlers since 2000. Eight new licences were however issued in 2008, a move made possible under EU law by the reduction of the capacities of other Maltese fishing fleets.

In terms of technical measures, the new regulation EC 1967 of 21 December 2006 fixed a minimum mesh size of 40 mm for bottom trawling of EU fishing vessels (Italian and Maltese trawlers). Mesh size had to be modified to square 40 mm or diamond 50 mm in July 2008, however derogations are possible up to 2010. Moreover, the Maltese Islands are surrounded by a 25 nautical miles (nm) fisheries management zone, where fishing effort and capacity are being managed by limiting vessel sizes, as well as total vessel engine powers (EC 813/04; EC 1967/06). Trawling is allowed within this designated conservation area, however only by vessels not exceeding an overall length of 24m and only within designated areas. Such vessels fishing in the management zone hold a special fishing permit in accordance with Article 7 of Regulation (EC) No 1627/94, and are included in a list containing their external marking and vessel's Community fleet register number (CFR) to be provided to the Commission annually by the Member States concerned. Moreover, the overall capacity of the trawlers allowed to fish in the 25nm zone can not exceed 4 800 kW, and the total fishing effort of all vessels is not allowed to exceed an overall engine power and tonnage of 83 000 kW and 4 035 GT respectively. The fishing capacity of any single vessel with a license to operate at less than 200m depth can not exceed 185 kW. In addition, the use of all trawl nets within 1.5nm of the coast is prohibited according to EC regulation 1967 / 2006, although again a transitional derogation is at present in place until 2010.

7.15.2.3. Catches

7.15.2.3.1. Landings

Yield of both the Italian and Maltese trawlers in 2009 reach the highest values of the last years, being 1620 t and 42 t respectively.

Table 7.15.2.3.1.1 Landings (t) by year and major gear types, 2004-2009 as reported through DCR, OTB = bottom otter trawls.

Species	Area	Country	Fleet	2004	2005	2006	2007	2008	2009
ARS	15	Malta	OTB		18	26	34	27	42
ARS	16	Italy	OTB	786	1270	1424	1541	1260	1620
ARS	15&b 16	Italy&Malta	OTB	786	1288	1450	1575	1287	1662

The most recent Italian and Maltese data were collected within the framework of the DCR. Available information is considered feasible by the experts attending the working group, with the exception of 2004 yield data where a mistake in species identification could have led to an underestimation of yields (giant red shrimps erroneously classified as *Aristeus antennatus*).

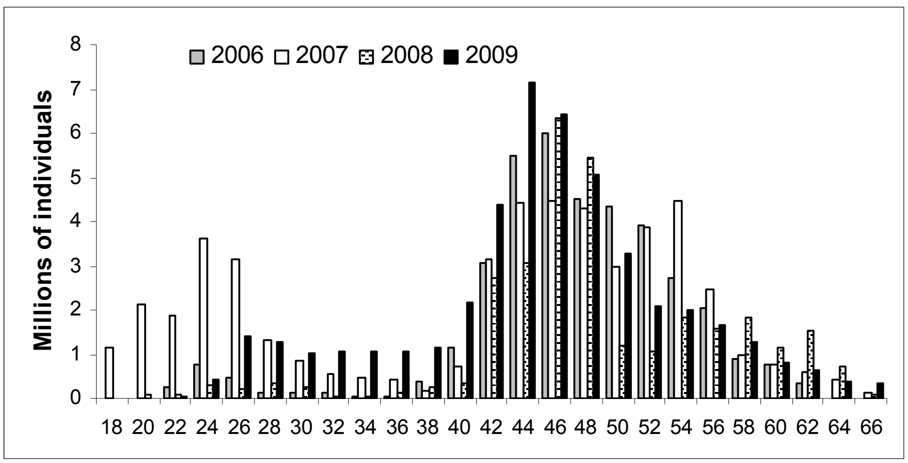


Figure 7.15.2.3.1.1 Yearly length structure of giant red shrimp landings in absolute numbers of Sicilian trawlers fishing in the Strait of Sicily (GSA 12, 13, 14, 15 and 16 see Fig. 7.15.2.1.1).

7.15.2.3.2. Discards

According to information available to the WG no catches of red shrimp were discarded by Italian trawlers. An assessment of the discards made by the Maltese fishing industry was carried out in 2005. Results showed that there is no discard practice amongst boats smaller than 10 m and that for larger boats the discard rate is negligible (average 4.7%). More detailed information on volume and species composition of the discards of vessels larger than 10 m by gear type and fleet segment is at present being compiled under the new Data Collection Framework. The bottom otter trawl fleet is being monitored monthly since January 2009 and results will be available shortly.

7.15.2.3.3. Fishing effort

The trends in fishing effort by year and major gear type is listed in Table XX and shown in Fig. 7.15.2.3.3.1 in terms of kw*day for the otter trawls. It worth noting that Italian effort is 98-99% of the total one.

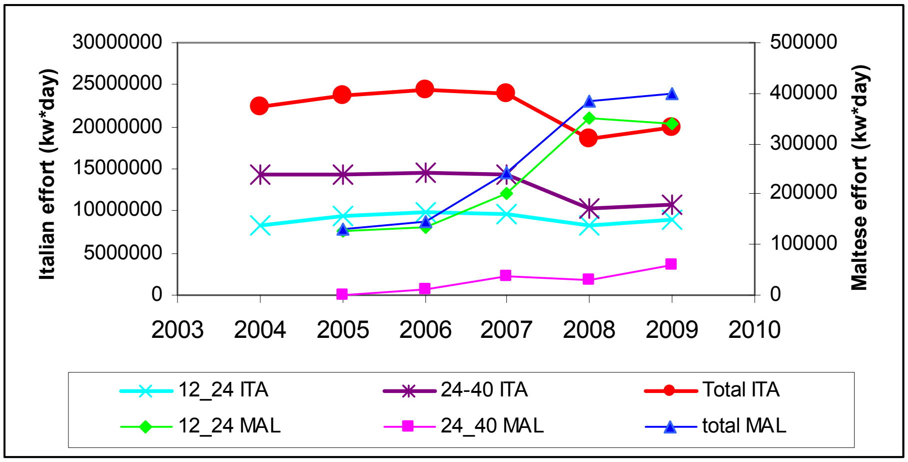


Fig. 7.15.2.3.3.1 Fishing effort in terms of kw*day of trawlers targeted to demersal species in GSA 15 and 16. Due to the different amount of fishing effort exerted by the Italian and Maltese fleets, two different axes were used.

Tab. 7.15.2.3.3.1 Trend in annual effort (kW*days) by country and length for the bottom otter trawl fleets operating in GSAs 15 and 16, 2005-2009.

COUNTRY	AREA	FT_LVL4	VESSEL_LENGTH	2005	2006	2007	2008	2009
ITA	16	OTB	VL0612	11001	0	0	0	183954
			VL1218	3307141	3442496	3722837	3523709	3705588
			VL1824	6156064	6374977	5947067	4792117	5294526
			VL2440	14355019	14603903	14257032	10376157	10830753
MAL	15	OTB	VL1224	128047	133167	201767	352184	0
			VL1824	0	0	0	0	340113
			VL2440	1790	10742	39090	30358	59792

7.15.3. *Scientific surveys*

7.15.3.1. Medits

7.15.3.1.1. Methods

In GSA 15 and 16 the following numbers of hauls were reported per depth stratum (Tab. XX).

Tab. 7.15.3.1.1.1. Number of hauls per year and depth stratum in GSA 16, 1994-2009.

Depth (m)	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
10-50	4	4	4	4	4	4	4	4
50-100	8	8	8	8	8	8	7	8
100-200	4	4	4	4	5	5	6	5
200-500	10	11	11	12	11	11	11	11
500-800	10	14	14	13	14	14	14	14
Depth (m)	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
10-50	7	7	7	10	10	11	11	11
50-100	11	12	12	20	22	23	23	23
100-200	10	8	9	18	19	21	21	21
200-500	19	18	19	28	31	27	27	27
500-800	19	20	19	32	33	38	38	38

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

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

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

Where:

A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA. Given the sheer number of plots generated, these distributions are not presented in this report.

7.15.3.1.2. Geographical distribution patterns

No analyses were conducted during SGMED-09-02. However some information on the ready to spawn female aggregate reported by Ragonese and Bianchini (1995) are shown in figure XX.

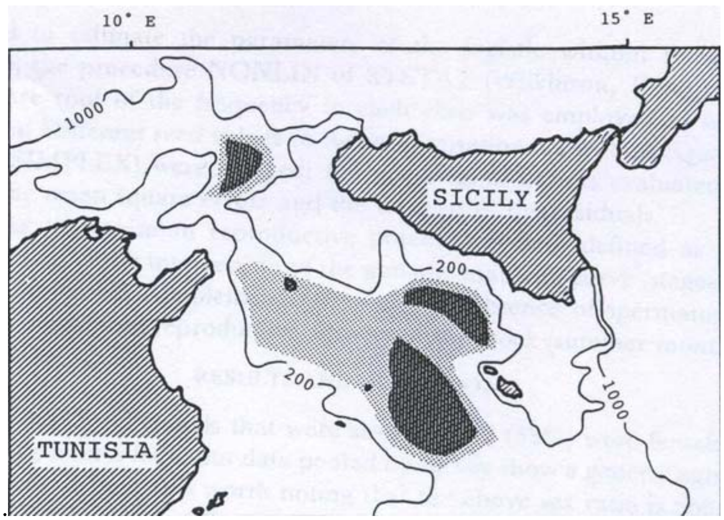


Fig. 7.15.3.1.2.1 Spawning areas of female according to Ragonese and Bianchini (1995).

7.15.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the giant red shrimp in GSAs 15 and 16 was derived from the international surveys MEDITS. Figures x and x indicate the stock to vary without an evident trend in the last year (2002-2008), although the abundance of giant red females in both GSAs reached its highest level in 2008 compared with the last 3 years.

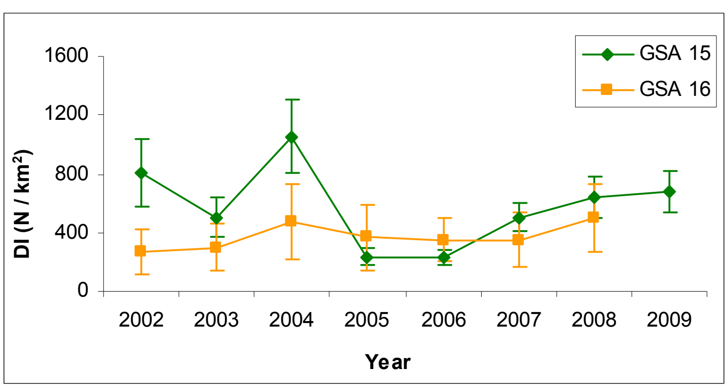


Fig. 7.15.3.1.3.1 Abundance in N/km^2 (MEDITS survey data) in GSA 15 and 16 for female *A. foliacea*. Only slope ground was considered (201-800m).

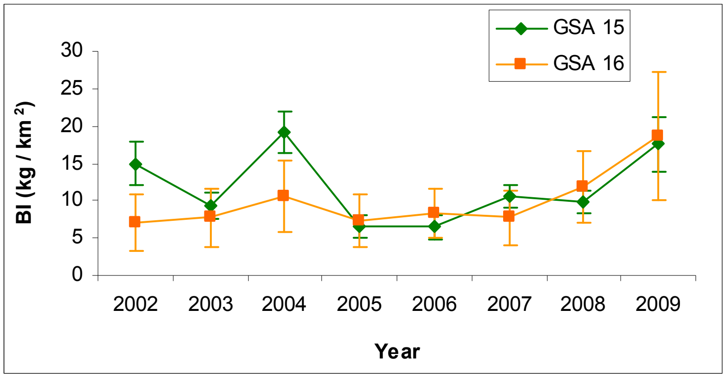
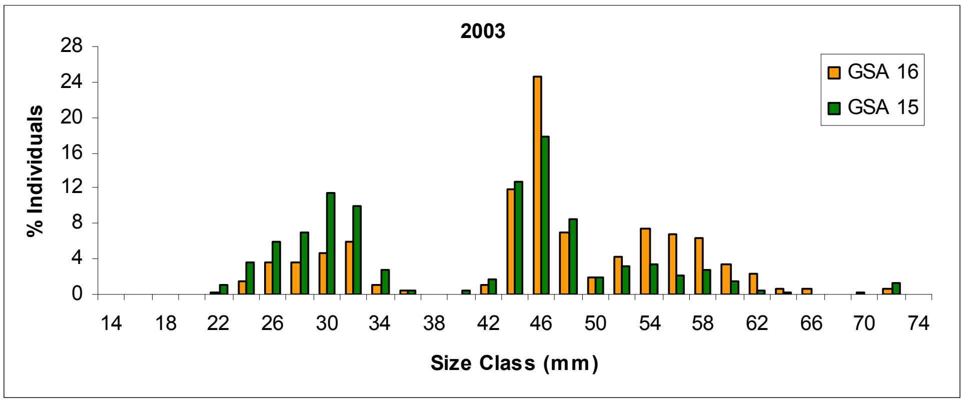


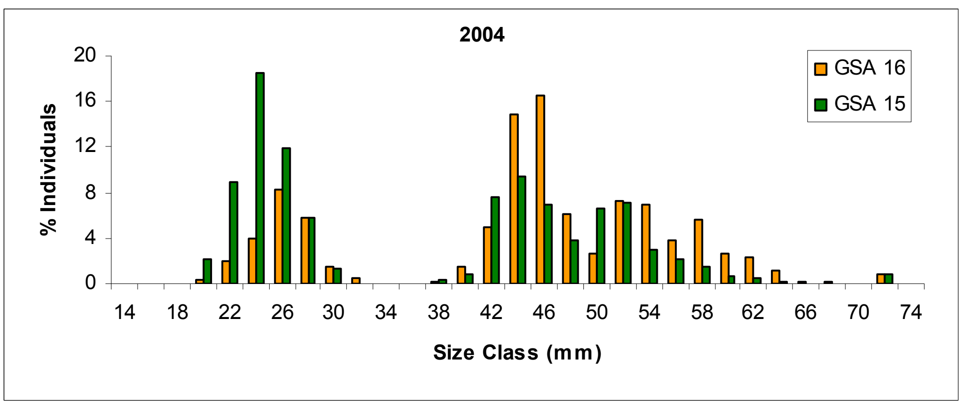
Fig. 7.15.3.1.3.2 Biomass in kg/km^2 (MEDITS survey data) in GSA 15 for female *A. foliacea*. Only slope ground was considered (201-800m).

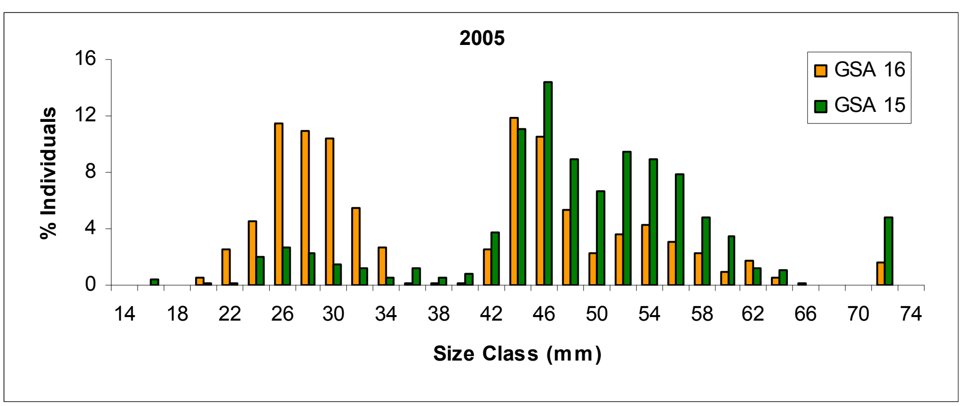
7.15.3.1.4. Trends in abundance by length or age

The following Fig. 7.15.3.1.4.1 displays the stratified abundance indices (strata d and e) of giant red shrimp in GSA 15 and GSA 16 in 2002-2008.


2002
% Individuals
20
16
12
8
4
0
14
18
22
26
30
34
38
42
46
50
54
58
62
66
70
74
Size Class (mm)
GSA 16
GSA 15


2003
% Individuals
28
24
20
16
12
8
4
0
14
18
22
26
30
34
38
42
46
50
54
58
62
66
70
74
Size Class (mm)
GSA 16
GSA 15


2004
% Individuals
20
16
12
8
4
0
14
18
22
26
30
34
38
42
46
50
54
58
62
66
70
74
Size Class (mm)
GSA 16
GSA 15


2005
% Individuals
16
12
8
4
0
14
18
22
26
30
34
38
42
46
50
54
58
62
66
70
74
Size Class (mm)
GSA 16
GSA 15

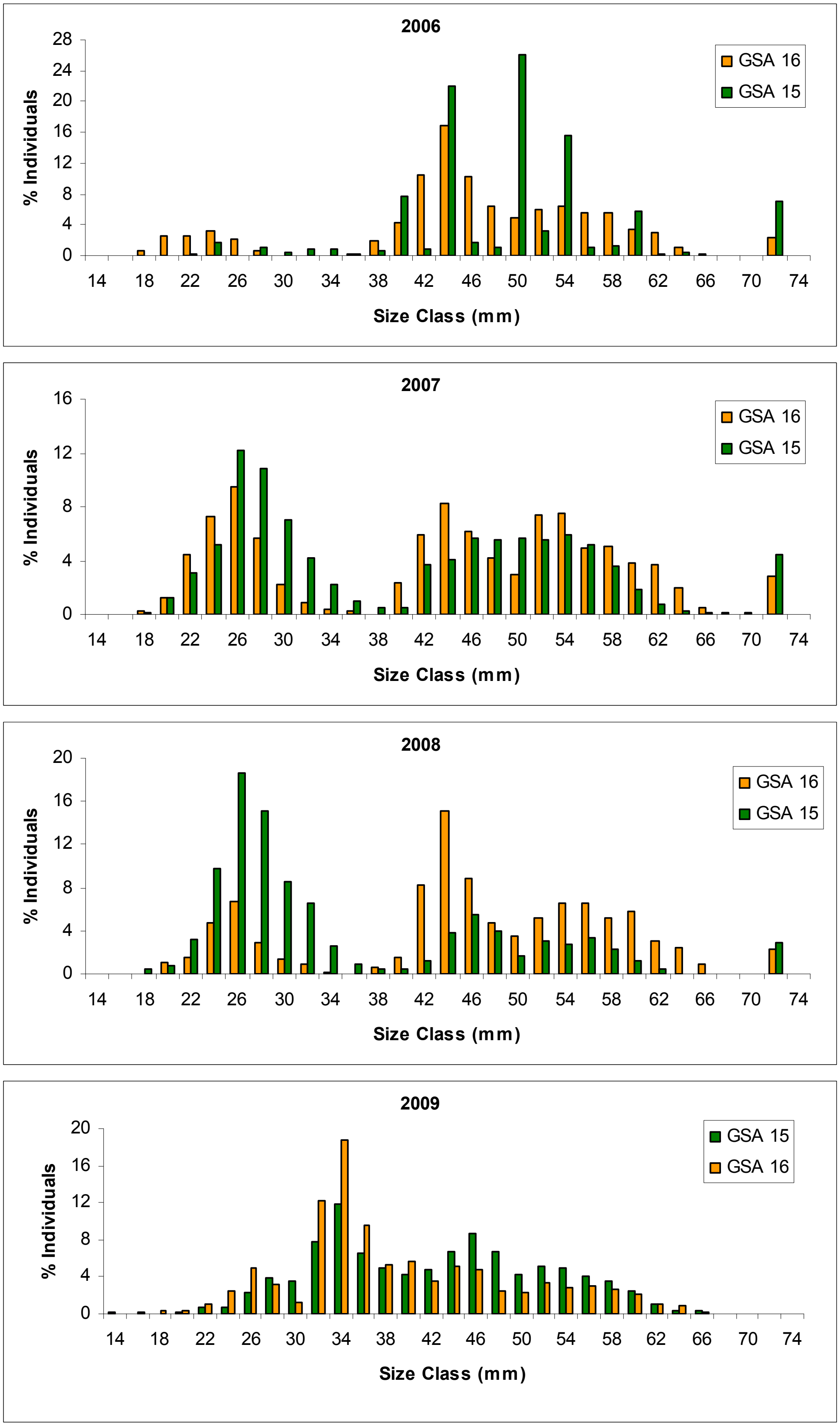
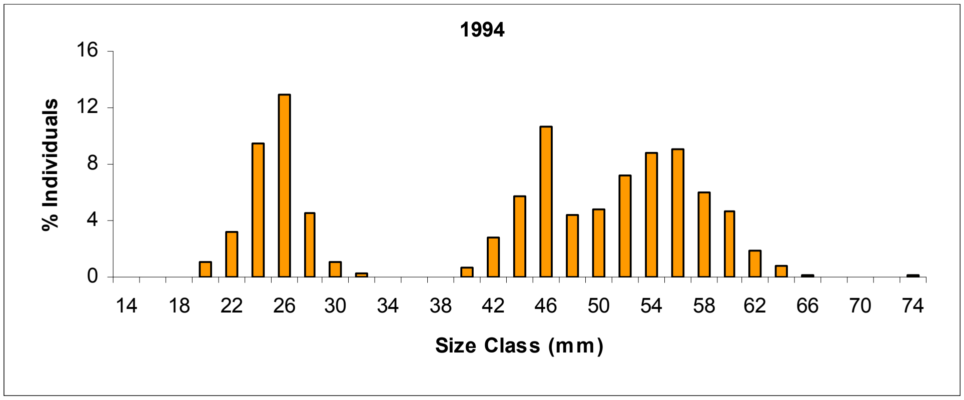
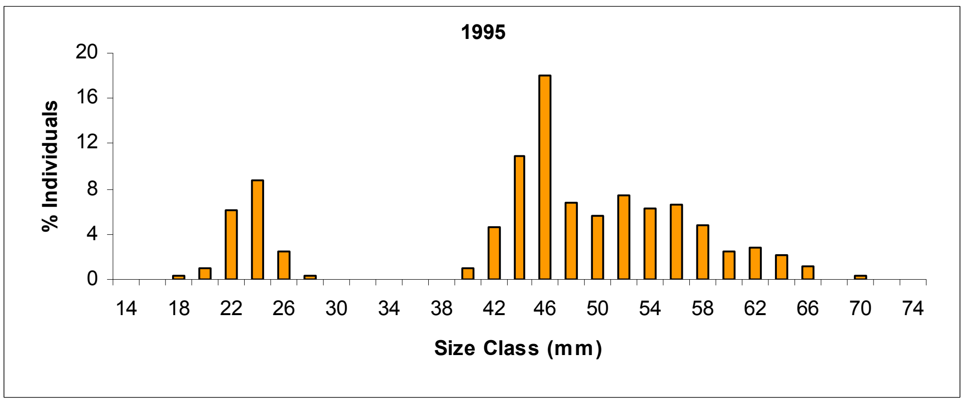
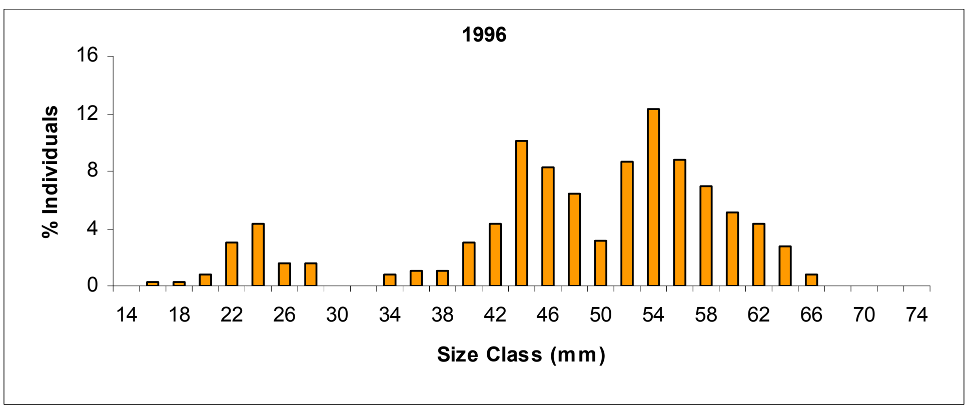


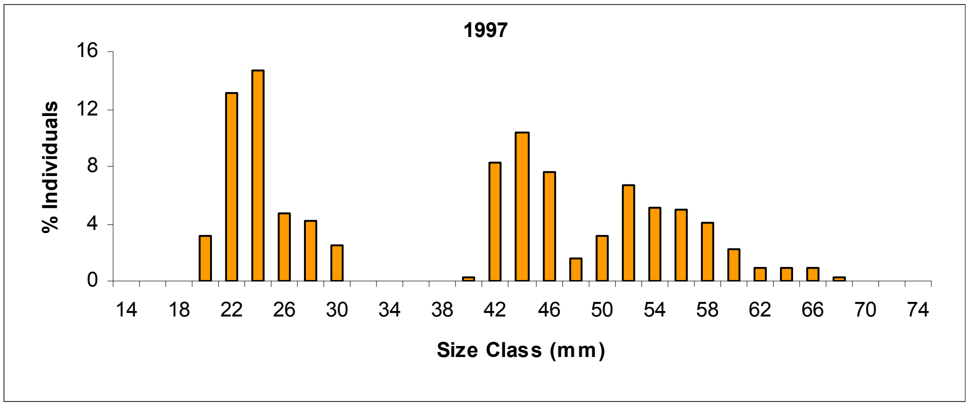
Fig. 7.15.3.1.4.1 Stratified abundance indices by size class in GSA 15 and 16, 2002-2009.

The Figure 7.15.3.1.4.2 displays the stratified abundance indices of giant red shrimp in GSA 16 in 1994-2001.








1997
% Individuals
0
4
8
12
16
14
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22
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38
42
46
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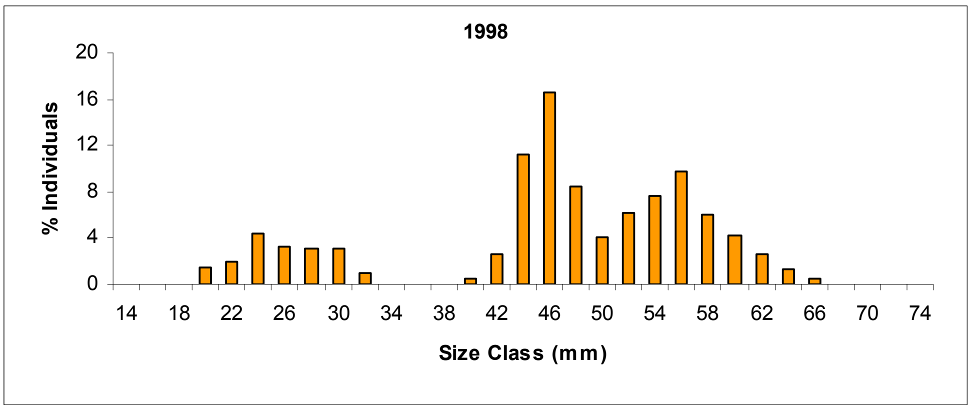
62
66
70
74
Size Class (mm)


1998
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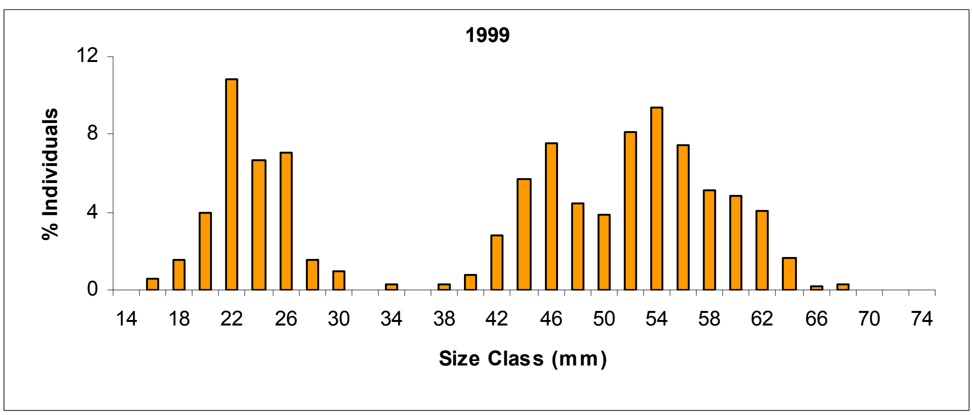
Size Class (mm)


1999
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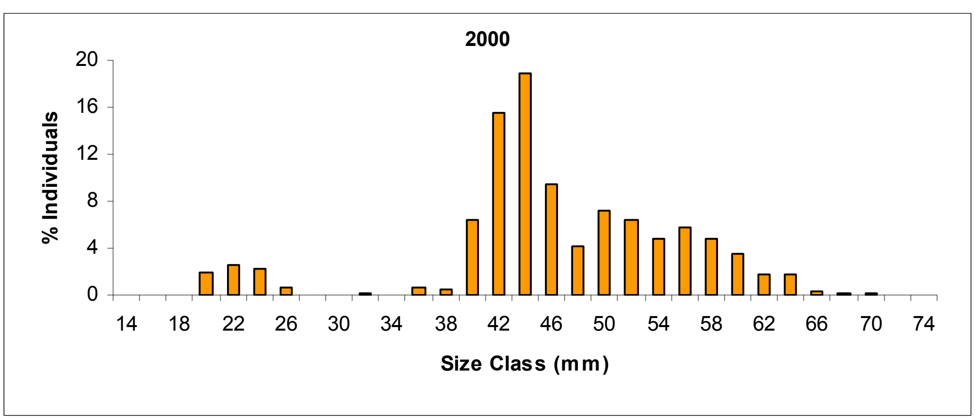
Size Class (mm)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Size Class (mm)

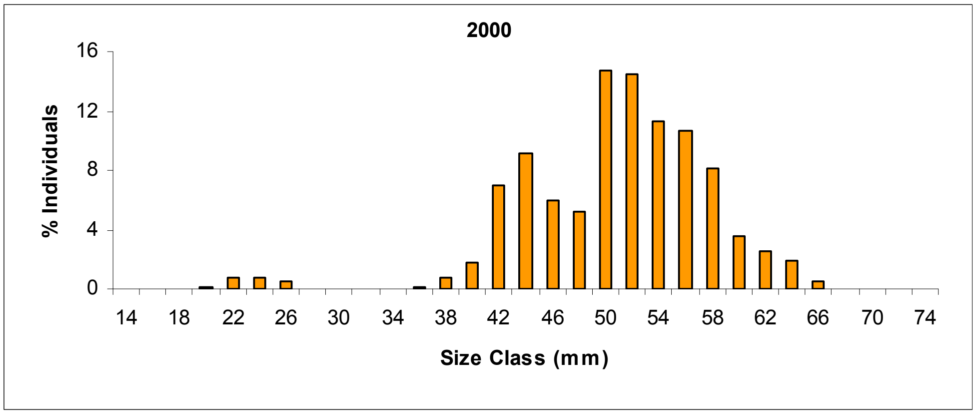

Fig. 7.15.3.1.4.2 Stratified abundance indices by size class in GSA 16, 1994-2001

7.15.3.1.5. Trends in growth

No analyses were conducted during SGMED-10-03.

7.15.3.1.6. Trends in maturity

No analyses were conducted during SGMED-10-03.

7.15.4. *Assessment of historic stock parameters*

7.15.4.1. Method 1: SURBA

7.15.4.1.1. Justification

The availability of time series (2002-2008 for GSA 15 and 1994-2008 for GSA 16) of length frequency distribution (LFD) from trawl surveys data allows reconstructing the evolution of main stock parameters (recruitment and spawning stock biomass indices and fishing mortality rates) of giant red shrimps in the GSA 15 and 16 by using the SURBA software package. Since females reach the largest size and they are more sensitive to fishery pressure, analysis was carried out only on the female's fraction, which represent about the 60 % of the commercial catch (mean of period 2006-2009).

Firstly the LFD by sex from the MEDITS trawl surveys was corrected by including the data for the individuals with unidentified sexes. This was based on the sex ratio per size class. The corrected LFDs by sex for each GSA were then converted in numbers by age group using the subroutine "age slicing" as implemented in the software package LFDA (Kirkwood *et al*., 2001). Secondly we estimated the mean weight and maturity at age using VBGF and a vectorial natural mortality at age (PRODBIOM excel sheet as implemented by Abella in SGMED 01 09) for the SURBA software to run the analysis. Then the numbers at age were used to estimate time series of fishing mortality rates, recruitment and SSB indices. Since the time series for GSA 15 is too short (from 2002 to 2009), SURBA analysis was done only considering the GSA 16 information (1994-2009).

7.15.4.1.2. Input parameters

The input parameters are reported in table 7.15.4.1.2.1.

Tab. 7.15.4.1.2.1 Biological parameters used for Surba analyses for giant red shrimp (females) in the Strait of Sicily (GSA 16).

growth			maturity		weight	
Linf	K	t0	Lm	g	a	b
68.9	0.61	-0.2	37.17	0.541	0.0016	2.5884

A declining value of M with age instead of a constant value was used based on the outcome of discussions held at SGMED 09 01, where the experts concluded such an approach is necessary considering the early age of first capture and the massive catch of juveniles characterised by higher M rates in most of the Mediterranean fisheries: natural mortality rates by age were calculated according to the ProdBiom model developed by Abella, Caddy and Serena (1997), based on Caddy (1991).

The value by age used in the analysis are given in Tab. 7.15.4.1.2.2. The age slicing produced only 6 age group (up age 5+).

Tab. 7.15.4.1.2.2 Values by age used for Surba analyses for giant red shrimp (females) in GSA 16.

Age	0	1	2	3	4	5+
Natural mortality at age	0.62	0.30	0.23	0.19	0.17	0.16
Maturità at age	0.03	0.80	1.00	1.00	1.00	1.00
Weight at age	5.79	26.70	50.28	67.62	78.22	84.23
Catchability coefficient	0.4	0.8	1.0	1.0	1.0	1.0

7.15.4.1.3. Results

State of adult / juvenile abundance:

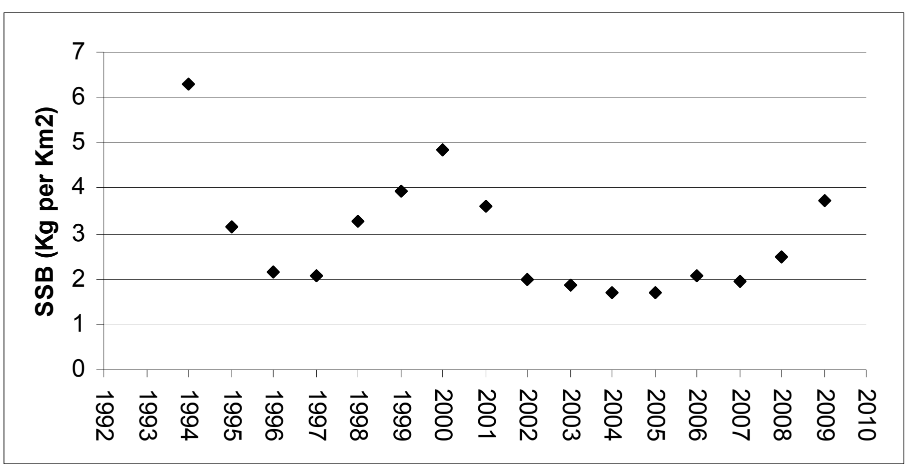

Fig. 7.15.4.1.3.1 SSB in kg/km^2 (MEDITS survey), as median of SURBA bootstrapped values, in GSA 16.

Survey indices in 2009 indicate the SSB seems to increase after a long period of low level (2002-2007).

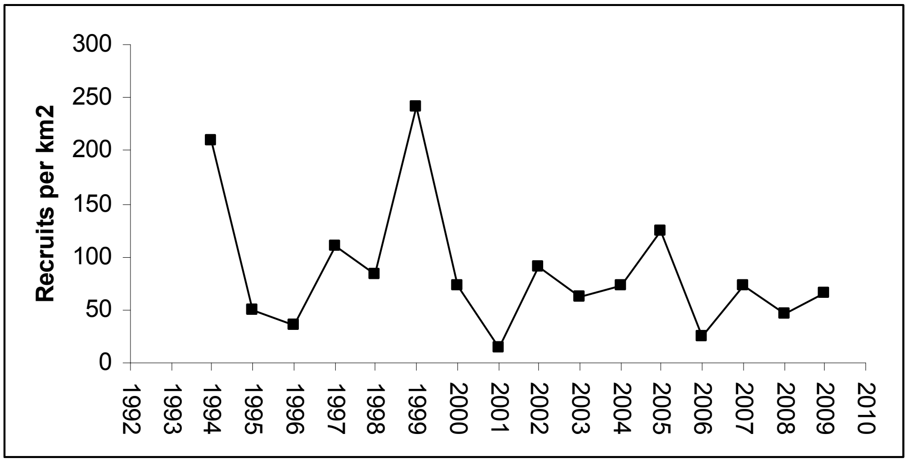

Fig. 7.15.4.1.3.2 Recruits n/km^2 (MEDITS survey), as median of SURBA bootstrapped values, in GSA 16.

From 1994 to 2001 recruitment indices fluctuate highly. From 2002 to 2009 recruits abundance vary without any clear trend.

The values of F (age 1-3; $F_{1\text{-}3}$) in GSA 16 from 2000 to 2005 remains high, with values around 1.0 (sd=0.11).

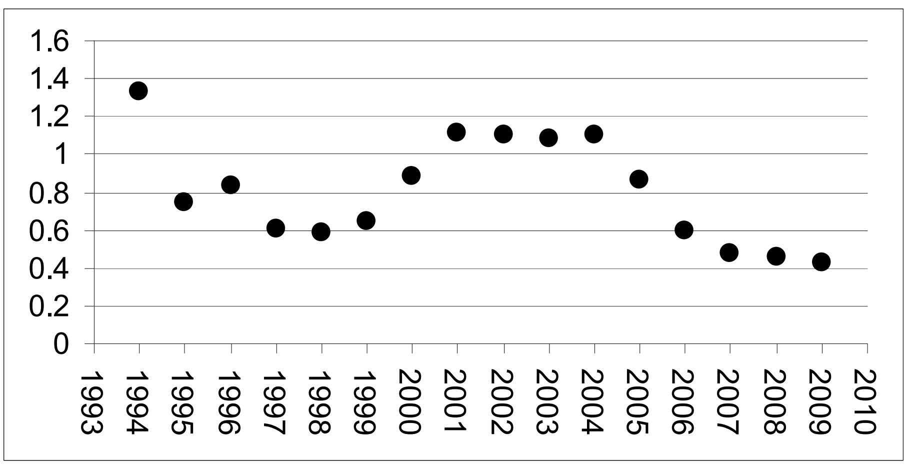

Fig. 7.15.4.1.3.3 Development of fishing mortality ($F_{1\text{-}3}$) (MEDITS survey), as median of SURBA bootstrapped values, in GSA 16.

7.15.4.2. Method 3: VIT

7.15.4.2.1. Justification

According to the SGMED 08 03 suggestions an approach under steady state (pseudocohort) was used keeping separate the available years (2006, 2007, 2008 and 2009) (fig……). Cohort (VPA equation) and Y/R analysis as implemented in the package VIT4win were used (Lleonart and Salat, 2000). Data were derived from DCR call for GSA 16.

7.15.4.2.2. Input parameters

The parameters used in the analysis are reported in table 7.15.4.2.2.1 and table 7.15.4.2.2.2. No discard data were included. Analysis were carried out on the landings of the Italian trawlers which contribute to more than 97% of the total yield in the GSA 15 and 16 (Table 7.15.2.3.1.1). Since females reach larger size than males and amount to more than 60% of landing in weight (mean 2006-2009), females catch structure and parameters were used to assess the stock exploitation. This choice was also due to the fact that stock VBGF parameters for males are not considered good enough (Ragonese at al., 2004)

Natural mortality and maturity by size are shown in Fig. 7.15.4.2.2.1.

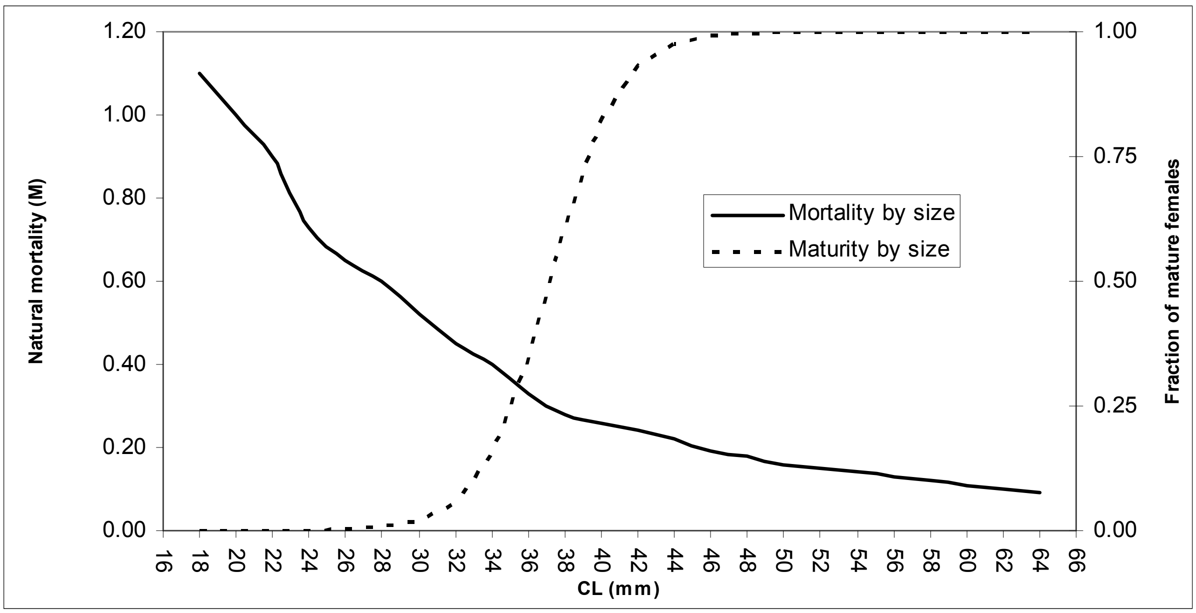

Fig. 7.15.4.2.2.1 Natural mortality (M) and maturity by length (CL) in females of giant red shrimp in the Strait of Sicily.

Table 7.15.4.2.2.1 Absolute number by length class (CL in mm) of females landed by year in the Strait of Sicily.

CL (mm)	2006	2007	2008	2009
18	0	1147718	0	0
20	0	2127058	100306.2	0
22	237775.4	1890491	100306.2	51574
24	772770.1	3623935	305042.5	412592
26	475550.8	3149727	215544.7	1388185
28	118887.7	1318576	341744.8	1267871
30	127265.8	842285.6	256317.1	1018950
32	127265.8	532422.2	58257.5	1055220
34	31831.27	470658.9	41612.88	1052649
36	31831.27	408893.2	145912.7	1047737
38	379236	181203.5	243618.9	1156809
40	1142386	711989.2	327243.4	2157004
42	3044008	3151277	2740826	4377946
44	5496558	4435267	3064312	7133900

46	6012676	4454301	6327786	6431671
48	4499250	4313914	5444355	5080945
50	4328759	2964016	1190867	3283812
52	3934095	3878326	1051074	2078437
54	2702964	4481193	1845097	2012452
56	2027310	2456743	1555172	1680363
58	904015.7	962710.1	1846294	1274067
60	760427.9	761040.8	1128505	809822
62	359591.3	574764.1	1515911	630901
64	0	446162	712458	389640
66	0	110052	101302.7	357679
total	37514455	49394723	30659868	46150230

7.15.4.2.3. Results

Fishing mortality rates (F) by size of female giant red shrimps caught by trawlers in GSA 15 and 16 are shown in Fig. 7.15.4.2.3.1.

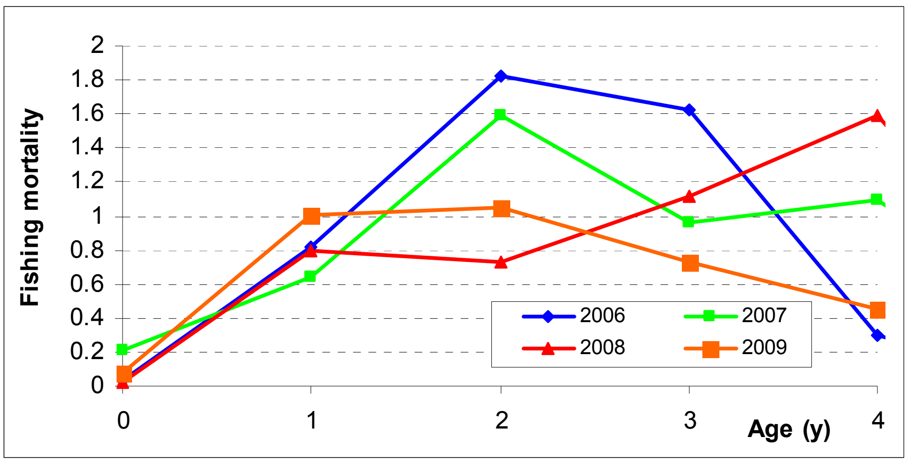

Fig. 7.15.4.2.3.1. Fishing mortality by age in giant red shrimp in the Strait of Sicily.

The reconstructed yields obtained by the VIT package are virtually equal to the observed ones. Absolute recruitment estimation and other main results of VIT, including the current mortality rates, are listed in table 7.15.4.2.3.1.

Table 7.15.4.2.3.1. The main results of VIT analysis.

Year	2006	2007	2008	2009	Median
Reconstructed yield (t)	1424	1540	1260	1620	1482
Recruitment (ml)	96.4	114.0	83.0	118.0	105.2
Mean Z over all age	1.22	1.00	0.96	0.83	0.98
Mean F over all age	0.92	0.74	0.70	0.57	0.72
Mean F (1-3 age groups)	1.42	1.06	0.88	0.93	0.995

7.15.5. *Long term prediction*

7.15.5.1. Method 1: Y, B and SSB per recruit according to the VIT package

7.15.5.1.1. Justification

The VIT approach to Biomass and Yield per recruit analysis has been applied in order to analyse the stock production with increasing exploitation under equilibrium conditions.

7.15.5.1.2. Input parameters

Table 7.15.5.1.2.1 Absolute number by length class (CL in mm) of females landed by year in the Strait of Sicily.

CL (mm)	2006	2007	2008	2009
18	0	1147718	0	0
20	0	2127058	100306.2	0
22	237775.4	1890491	100306.2	51574
24	772770.1	3623935	305042.5	412592
26	475550.8	3149727	215544.7	1388185
28	118887.7	1318576	341744.8	1267871
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34	31831.27	470658.9	41612.88	1052649
36	31831.27	408893.2	145912.7	1047737
38	379236	181203.5	243618.9	1156809
40	1142386	711989.2	327243.4	2157004
42	3044008	3151277	2740826	4377946
44	5496558	4435267	3064312	7133900
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48	4499250	4313914	5444355	5080945
50	4328759	2964016	1190867	3283812
52	3934095	3878326	1051074	2078437
54	2702964	4481193	1845097	2012452
56	2027310	2456743	1555172	1680363
58	904015.7	962710.1	1846294	1274067
60	760427.9	761040.8	1128505	809822
62	359591.3	574764.1	1515911	630901
64	0	446162	712458	389640
66	0	110052	101302.7	357679
total	37514455	49394723	30659868	46150230

7.15.5.1.3. Results

Estimation of Biomass and Yield per recruit varying current fishing mortality (F_c) by a multiplicative factor is reported in Fig. 7.15.5.1.3.1.

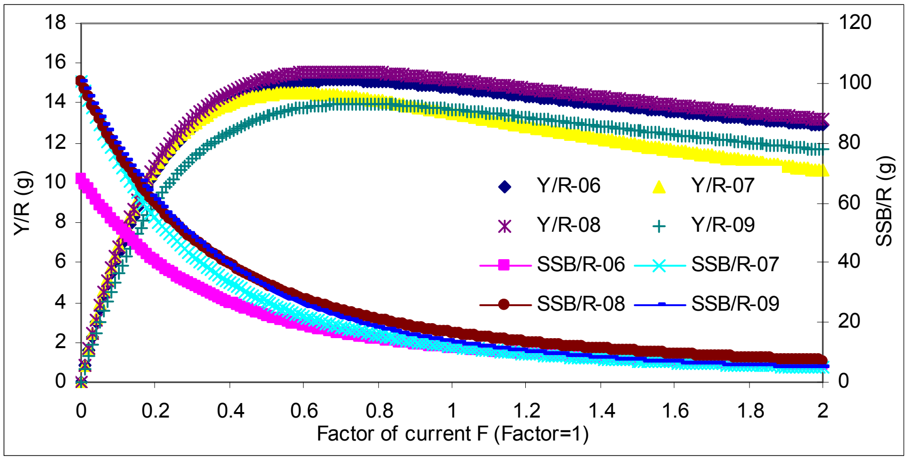


Fig. 7.15.5.1.3.1 Yield (Y/R) and Spawning stock biomass (SSB/R) per recruit varying current fishing mortality (Fc) by a multiplicative factor according to the VIT package. Analyses deal with pseudo-cohorts 2006, 2007, 2008 and 2009.

Assuming no variation in the exploitation pattern, the main result of Y/R analysis in terms of current F and optimal ones are reported in Tab. 7.15.5.1.3.1

Tab. 7.15.5.1.3.1 Estimation of current F, as F_{mean}, and optimal ones, as F max and F0.1, and corresponding Y, B and SSB per recruits analyses by pseudo cohorts according to VIT package.

	___	Factor	F	Y/R	B/R	SSB
2006	F(0)	0	0	0	74.97	68.11
	F(0.1)	0.44	0.4	14.41	31.03	24.68
	Fmax	0.71	0.65	15.15	22.45	16.35
	Fc	1	0.92	14.77	17.46	11.51
2007	F(0)	0	0	0	107.51	100.68
	F(0.1)	0.38	0.28	13.82	40.97	34.85
	Fmax	0.59	0.44	14.5	28.67	22.87
	Fc	1.01	0.74	13.5	17.21	12.01
2008	F(0)	0	0	0	107.51	100.68
	F(0.1)	0.42	0.21	14.72	44.35	37.98
	Fmax	0.7	0.49	15.59	30.5	24.39
	Fc	1.01	0.7	15.17	22.37	16.51
2009	F(0)	0.00	0.00	0.00	107.51	100.68
	F(0.1)	0.49	0.28	13.30	38.17	32.11
	Fmax	0.76	0.43	13.96	25.49	19.75
	Fc	1.01	0.57	13.69	18.84	13.36
median	F(0)	0.00	0.00	0.00	107.51	100.68
	F(0.1)	0.42	0.28	13.82	38.17	32.11
	Fmax	0.70	0.44	14.50	25.49	19.75
	Fc	1.01	0.70	13.69	17.46	12.01

Comparing current F with BRP according to the obtained by VIT steady state VPA an overfishing status was detected. The current F (median value 2006-2009 being 0.70) is higher than both F_{max} (median value 2006-2009 being 0.44) and $F_{0.1}$ (median value 2006-2009 being 0.28).

7.15.5.2. Method 2: Y, B and SSB per recruit according to the Yield package

7.15.5.2.1. Justification

Availability of biological parameter and length at first capture allows to quantify by simulation the likely changes in Y, B and SSB per recruit in function of fishing mortality (F) with the Yield package (Branch et al., 2001). The package was also used to estimate a probability estimation of BRP (Fmax and F0.1).

7.15.5.2.2. Input parameters

Due to the constraints of the package, all parameters were converted from Carapace Length (CL) in mm to Total Length (TL) by using the relation given by Gancitano (Pers. Com.):
LT (mm) = 2.678 CL (mm) + 28.564.
The new parameters were finally converted in terms of cm and g. A guess estimate of uncertainty in terms of coefficient of variation was added to each parameter (Table….). Due to the package constrains the natural mortality rate was assumed constant, being M=0.40 (Ragonese et al., 2004). Stock-recruitment relationship was not used. Recruitment was assumed constant with a random variability among years of (CV=0.4).

Table 7.15.5.2.2.1 Parameters used for stock assessment trough Yield approach. Length is in cm and weight in g. Only female's fraction of the fished stock was assessed.

L∞	21.6 (0.1)	Tm	1 (0.1)
K	0.61 (0.1)	Tc	1 (0.1)
t0	-0.2 (0.1)	M	0.40 (0.1)
a	0.0034	Recruitment	Constant with CV=0.4
b	3.3562		

7.15.5.2.3. Results

Estimation of Y and SSB per recruit according to Yield package is shown in Fig 7.15.5.2.3.1.

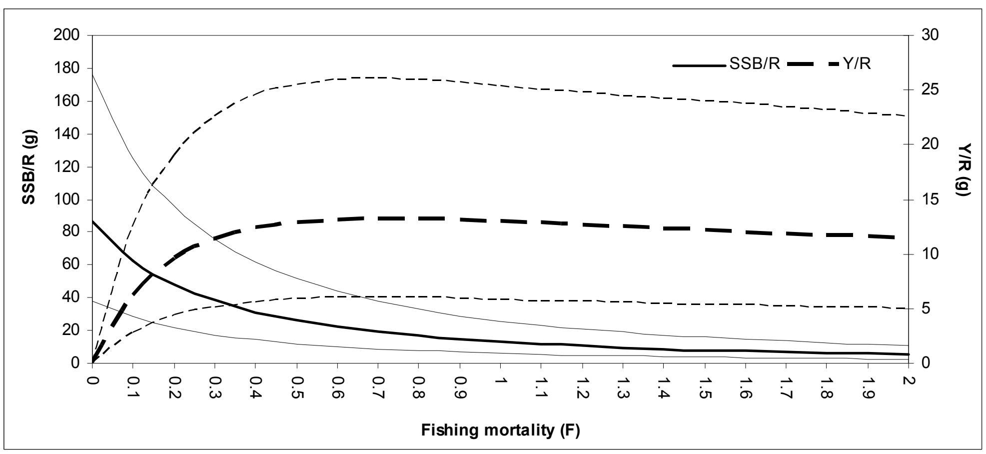


Fig. 7.15.5.2.3.1Median of yield and spawning stock biomass per recruit and corresponding uncertainty of female giant red shrimps in the GSA 15 and 16 according to the Yield Package.

Searching for biological reference points (BRP) through 2000 simulation produced the probability distribution of F_{max} and $F_{0.1}$ showed in Fig. 7.15.5.2.3.2. The median value of F_{max} = 0.75 should be considered as Limit Reference Points (LRP) whereas the median value of F0.1=0.4 should be considered as Target reference points (TRP).

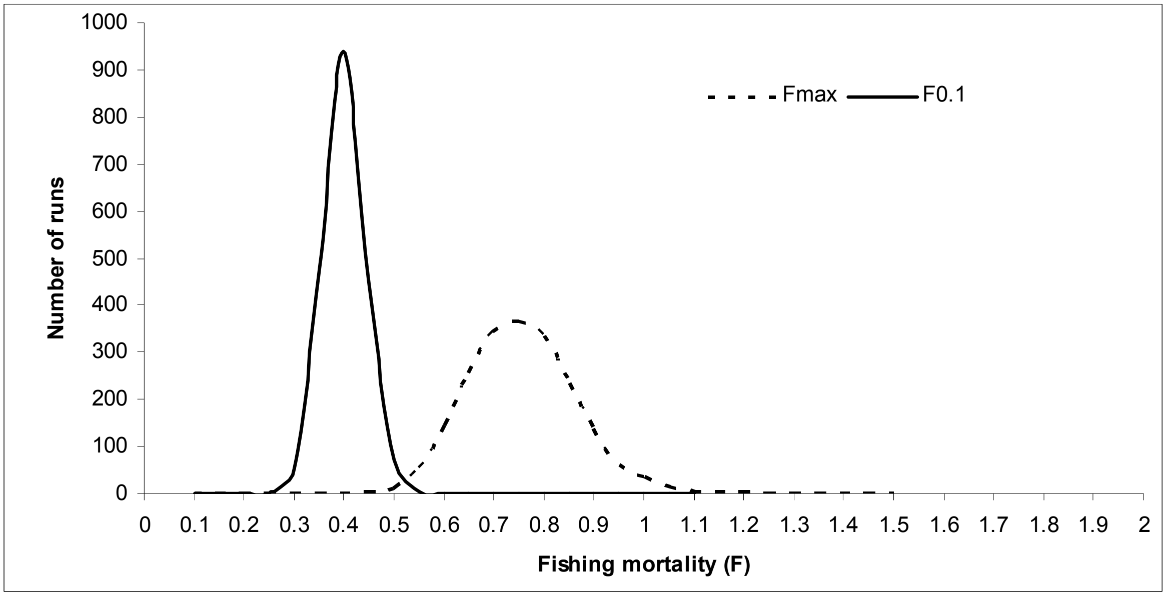


Fig. 7.15.5.2.3.2 Probability distribution of F_{max} and $F_{0.1}$ according to Yield package.

7.15.6. *Scientific advice*

7.15.6.1. Short term considerations

7.15.6.1.1. State of the spawning stock size

SGMED estimated the absolute levels of stock abundance in 2006, 2007, 2008 and 2009 by VIT approach on length structure of Sicilian trawlers which catch about 98% of the total yield in the area. Mean biomass at sea ranges between 1721 (2008) and 2229 (2009) t, SSB ranges between 70 and 75% of the biomass at the sea.
Survey indices (MEDITS) in the GSA 16 (1994-2009) show that SSB has an apparent cyclic pattern with the last peak in 2000 and a new increasing phase seems to be occurring since 2007. In the absence of precautionary reference points SGMED is unable to fully evaluate the state of the stock size.

7.15.6.1.2. State of recruitment

Absolute estimate of recruitment (18-22 mm CL) from VIT ranged between 83 (2008) and 118 (2009) millions of recruits. A low variability in recruitment indices derived from Surba was observed, with the exception of sudden fall in recruit density observed in 2006.

7.15.6.1.3. State of exploitation

SGMED proposes $F_{0.1} \leq 0.3$ as consistently esimtated by the both the VIT and YIELD methods as limit reference points consistent with high long term yields.
Thus, the giant red shrimp in the Northern sector of the Strait of Sicily is considered overfished since the current fishing mortality exceeds both F_{max} and $F_{0.1}$.
Fishing mortality shall be reduced to be reduced by 50 to 60 % of the current F.

7.16. Stock assessment of anchovy in GSA 16

7.16.1. *Stock identification and biological features*

7.16.1.1. Stock Identification

This assessment of the anchovy stock in GSA 16 is mainly based on information collected over the last decade on the fishery grounds off the southern Sicilian coast (GSA 16, South of Sicily), and specifically using biomass estimates obtained by hydro-acoustic surveys and catch/effort data from local small pelagic fisheries. The main distribution area of the anchovy stock in GSA 16 is the narrow continental shelf area between Mazara del Vallo and the southernmost tip of Sicily, Cape Passero (Patti *et al*., 2004). Daily Egg Production Method (DEPM) surveys were also carried out starting from 1998, giving also information on spawning areas distribution.

7.16.1.2. Growth

Growth parameters were only used for the estimation of natural mortality with the approches suggested by Pauly (1980) and the Beverton & Holt's Invariants method (Jensen, 1996). Von-Bertalanffy growth parameters were estimated by FISAT using DCF data collected in GSA16 over the period 2007-2009. The applied growth parameters are given below in the following table:

L_∞	k	t_0
19.83	0.31	-1.95

For BHI method, the equation $M = \beta * k$ was applied, with β set to 1.8.

7.16.1.3. Maturity

Maturity data were not used for this assessment.

7.16.2. *Fisheries*

7.16.2.1. General description of fisheries

In Sciacca port, the most important base port for the landings of small pelagic fish species along the southern Sicilian coast (GSA 16), accounting for about 2/3 of total landings in GSA 16, two operational units (OU) are presently active, purse seiners and pelagic pair trawlers. The fleet in GSA 16 is composed by about 50 units (17 purse seiners and 30 pelagic pair trawlers were counted up in a census carried out in December 2006). In both OUs, anchovy represents the main target species due to the higher market price.

7.16.2.2. Management regulations applicable in 2009 and 2010

Fisheries practices are affected by EU regulations through the Common Fisheries Policy (CFP), based on the following principles: protection of resources; adjustment of (structure) facilities to the available resources; market organization; and definition of relationships with other countries.

The main technical measures regulating fishing concern minimum landing size (9 cm for anchovy, 11 cm for sardine), mesh regulations (20 mm for pelagic pair trawlers, 14 mm for purse seiners) and restrictions on the use of fishing gear. Towed fishing gears are not allowed in the coastal area in less than 50 m depth, or within a distance of 3 nautical miles from the coastline. A seasonal closure for trawling, generally during summer-autumn, has been established since 1993. In GSA 16, two operational units fishing for small pelagic are based in Sciacca port: purse seiners (lampara vessels, locally known as “Ciancioli”) and midwaters pair trawlers (“Volanti a coppia”). Midwaters trawlers are based in Sciacca port only, and receive a special permission from Sicilian Authorities on an annual basis. Another fleet fishing on small pelagic fish species is based in some northern Sicilian ports and targets on pre-juvenile stages (mainly sardines). Also this fishery is allowed for a limited period (usually one or two months during the winter season) by a special Regional law renewed year by year.

7.16.2.3. Catches

7.16.2.3.1. Landings

Landings were obtained within the framework of the census data collection carried out by IAMC-CNR (Mazara del Vallo) in Sciacca port since 1998. Information collected in the framework of CA.SFO study project (Patti et al., 2007) showed that landings in Sciacca port account for about 2/3 of the total landings in GSA 16. Average anchovy landings in Sciacca port over the period 1997-2009 were about 1,700 metric tons, with large inter-annual fluctuations.

It is worth noting that, though trend in biomass is clearly decreasing over the last years (Fig. 7.16.2.3.1.1), landings levels over the same period were relatively high, indicating an increased vulnerability of the resource.

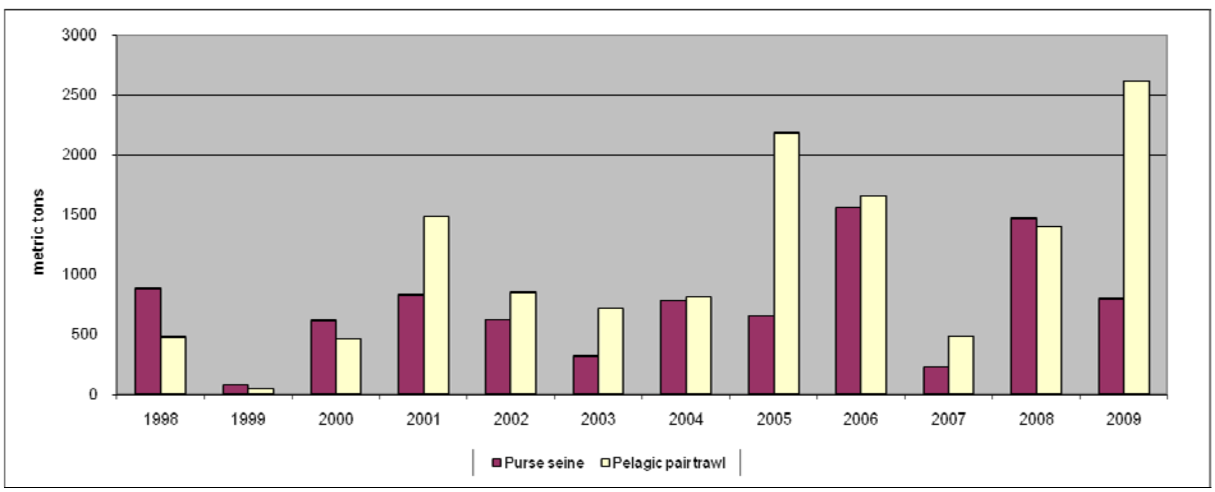


Fig. 7.16.2.3.1.1. Landings data regarding the purse seine and pelagic pair trawl fleets in Sciacca port (GSA 16), 1998-2009.

7.16.2.3.2. Discards

No discards data for anchovy were used for this assessment. However, discards are estimated to be less than 5% of total catch for both the pelagic pair trawl and the purse seine fisheries (Kallianiotis & Mazzola, 2002).

7.16.2.3.3. Fishing effort

Fishing effort data refer to census data collected in Sciacca port, the most important base port for the landings of small pelagic fish species along the southern Sicilian coast (GSA 16), accounting for about 2/3 of total landings in GSA 16.

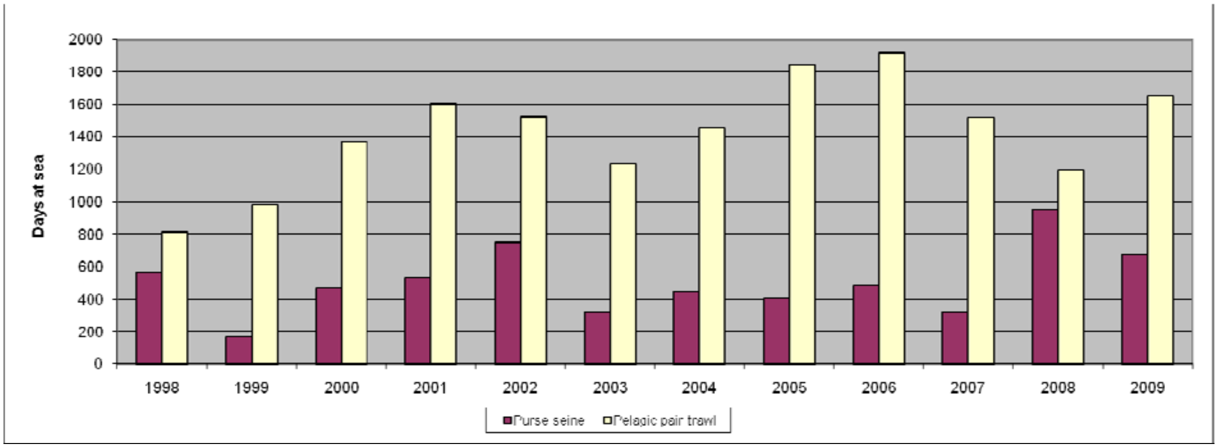


Fig. 7.16.2.3.3.1. Effort data regarding the purse seine and pelagic pair trawl fleets in Sciacca port (GSA 16), 1998-2009.

7.16.3. *Scientific surveys*

7.16.3.1. Acoustics

7.16.3.1.1. Methods

Acoustic surveys methodology

Steps for biomass estimation

- Collection of acoustic and biological data during surveys at sea;
- Extraction of $NASC_{Fish}$ (Fishes Nautical Area Scattering Coefficient [$m^2/n.mi^2$]) by means of Echoview (Sonar Data) post-processing software;
- Link of NASC values to control catches;
- Calculation of Fish density (ρ) from $NASC_{Fish}$ values and biological data;
- Production of ρ distribution maps for different fish species and size classes;
- Integration of density areas for biomass estimation.

Collection of acoustic and biological data

Since 1998 the IAMC-CNR has been collecting acoustic data for evaluating abundance and distribution pattern of small pelagic fish species (mainly anchovy and sardine) in the Strait of Sicily (GSA 16). The scientific echosounder Kongsberg Simrad EK500 was used for acquiring acoustic data until summer 2005; for the echosurvey in the period 2006-2009 the EK60 echosounder was used. In both cases the echosounder was equipped with three split beam transducers pulsing at 38, 120 and 200 kHz. During the period 1998-2008 acoustic data were collected continuously during day and night time; since the 2009 echosurvey acoustic data are collected during day time, according to the MEDIAS protocol.

Before or after acoustic data collection a standard procedure for calibrating the three transducers was carried out by adopting the standard sphere method (Johannesson & Mitson, 1983).

Biological data were collected by a pelagic trawl net with the following characteristics: total length 78 m, horizontal mouth opening 13-15 m, vertical mouth opening 6-8 m, mesh size in the cod-end 10 mm. The net was equipped with two doors with weight 340 kg. During each trawl the monitoring system SIMRAD ITI equipped with trawl-eye and temp-depth sensors was adopted.

Extraction of $NASC_{Fish}$ by means of Echoview (Sonar Data) post-processing software

The evaluation of the $NASC_{Fish}$ (Fishes Nautical Area Scattering Coeffcient [$m^2/n.mi^2$]) and the total NASC for each nautical mile of the survey track was performed by means of the SonarData Echoview software v3.50, taking into account the day and night collection periods.

Link of NASC values to control catches

For the echo trace classification the nearest haul method was applied, taking into account only representative fishing stations along transects.

Calculation of Fish density (ρ) from $NASC_{Fish}$ values and biological data

For each trawl haul the frequency distribution of the j-th species (ν_j) and for the k-th length class (f_{jk}) are estimated as

$$\nu_j = \frac{n_j}{N} \qquad \text{and} \qquad f_{jk} = \frac{n_{jk}}{n_j}$$

where n_j is the total number of specimens of the j-th species, n_{jk} is the total number of specimens of the k-th length class in the j-th species, and N is the total number of specimens in the sample.

For each nautical mile the densities for each size class and for each fish species are estimated as

$$\rho_{jk} = \frac{NASC_{FISH} * n_{jk}}{\sum_{j=1}^{n}\sum_{k=1}^{m} n_{jk} * \sigma_{jk}} \qquad \text{(number of fishes / n.mi}^2\text{)}$$

$$\rho_{jk} = \frac{NASC_{FISH} * W_{jk} * 10^{-6}}{\sum_{j=1}^{n}\sum_{k=1}^{m} n_{jk} * \sigma_{jk}} \qquad \text{(t / n.mi}^2\text{)}$$

where W_{jk} is the total weight of the k-th length class in the j-th species, and σ_{jk} is the scattering cross section of the k-th length class in the j-th species. σ_{jk} is given by

$$\sigma_{spjk} = 4\pi * 10^{\frac{TS_{jk}}{10}}$$

where the target strenght (TS) is

$$TS_{jk} = a_j Log_{10}(L_k) + b_j$$

L_k is the length of the k-th length class while the a_j and b_j coefficient are linked to the fish species.

For anchovy, sardine and trachurus we adopted respectively the following relationships:

$$TS = 20 \log L_k \, 76.1 \qquad [dB]$$
$$TS = 20 \log L_k \, 70.51 \qquad [dB]$$
$$TS = 20 \log L_k \, 72 \qquad [dB]$$

Integration of density areas for biomass estimation

The abundance of each species was estimated by integrating the density surfaces for each species.

7.16.3.1.2. Geographical distribution patterns

No analyses were conducted during SGMED-10-02.

7.16.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the anchovy stock in GSA 16 was derived from the acoustics. Figure 5.44.3.1.3.1 displays the estimated trend in anchovy total biomass (estimated by acoustics) for GSA 16. A decreasing trend was observed in biomass during the last years (Fig. 7.16.3.1.3.1).

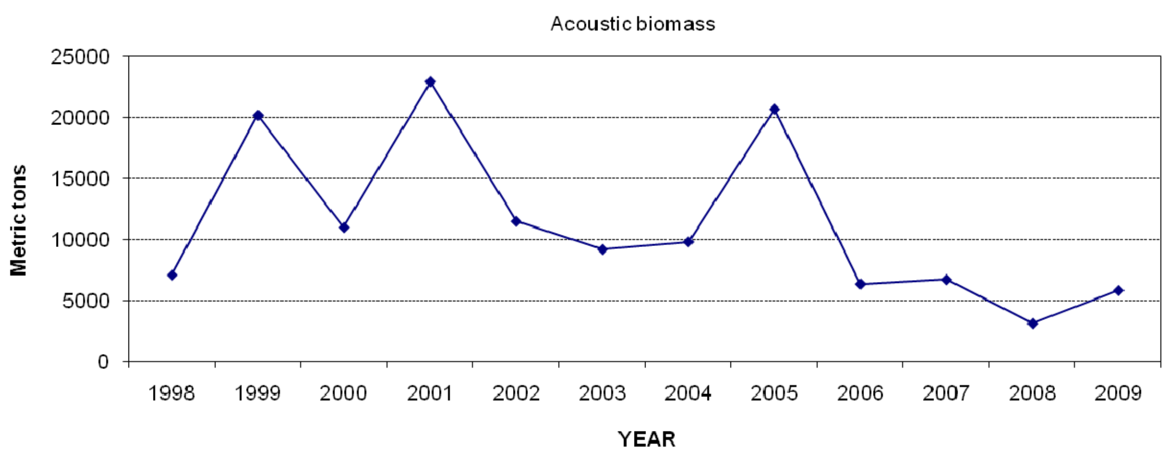


Fig. 7.16.3.1.3.1. Estimated anchovy biomass indices for GSA 16, years 1998-2009.

7.16.3.1.4. Trends in abundance by length or age

Length or age class data were not used for this assessment.

7.16.3.1.5. Trends in growth

Not applicable. Growth data were only used for the estimation of natural mortality with the approches suggested by Pauly (1980) and the Beverton & Holt's Invariants method (Jensen, 1996).

7.16.3.1.6. Trends in maturity

Maturity data were not used for this assessment.

7.16.4. *Assessment of historic stock parameters*

Not applicable. No stock assessment model was run for this assessment.

7.16.5. *Long term prediction*

Not applicable. No forecast analyses were conducted.

7.16.6. *Scientific advice*

7.16.6.1. Short term considerations

7.16.6.1.1. State of the spawning stock size

Biomass estimates of total population obtained by hydro-acoustic surveys for anchovy in GSA 16 show a decreasing trend over the last decade, despite the occurrence of quite large inter-annual fluctuations, from a maximum of about 22,900 t in 2001 to a minimum of 3,100 t in 2008. Latest biomass estimates (2006-2009 surveys) are the lowest of the series and their average represents less than one-quarter of the maximum recorded value. SGMED-10-03 notes that there is no data available to formulate any age-structured production model to predict stock size and landings and discards in short term (2010-2011). In addition, due to the unavailability of 2010 survey data, it was not possible to try and apply the approach used during SGMED-09-03 meeting for sardine in the same area (GSA 16), based on the exploration of the relationship between the series of acoustic survey biomass estimates (1998-2007) and landings the consecutive years (1999-2008) (Rätz & Cheilari, 2009). However, an attempt to replicate the approach was carried out, this time including in the regression analysis updated (2009) total catch information that was not previously used during SGMED 09-03. Again, as already observed last year when a shorter time series was used, the approach was not successful for anchovy stock, since the two series were found to be largely unrelated (r=0.06; $F_{1,9} = 0.03$, p=0.86). This was an expected result, as the acoustic surveys which biomass estimates are based on are carried out in June-July, so they do not include the effect of annual recruitment of the stock. In the absence of proposed or agreed references, SGMED-10-03 is unable to fully evaluate the state of the stock and provide any scientific advice in relation to them.

7.16.6.1.2. State of recruitment

No recruitment data were provided by this assessment.

7.16.6.1.3. State of exploitation

SGMED-10-03 proposes E=0.4 as limit management reference point consistent with high long term yields. The high and increasing yearly harvest rates, as estimated by the ratio between total landings and stock sizes, might indicate high fishing mortality levels. Actually, as long as this estimate of harvest rate can be considered as a proxy of F estimate obtained from the fitting of standard stock assessment models (assuming survey biomass estimate as a proxy of mean stock size), this index can be used to assess the corresponding exploitation rate E=F/Z, provided that an estimate of natural mortality is given. The current (2009) harvest rate is 0.88, whereas the estimated average value over the years 2006-2009 is 0.79. The exploitation rate corresponding to F=0.79 is E=0.54, if M=0.66, estimated with Pauly (1980) empirical equation, is assumed, and E=0.59 if M=0.56, estimated with Beverton & Holt's Invariants method (Jensen, 1996), is used instead. Using the exploitation rate as a reference point, this stock is considered as being overexploited. Given that biomass was low for period 2006-2009, fishing effort should be reduced by means of a multi-annual management plan until there is evidence for stock recovery. Consistent catch reductions along with effort reductions should be determined. The mixed fisheries effects, mainly the interaction with sardine, need to be taken into account when managing the anchovy fishery.

General considerations for the management of the anchovy fishery:

Taking into account that fishing effort was relatively stable in last decade, whereas CPUE trend was even increasing, results would suggest the importance of environmental factors variability on yearly recruitment success and/or a possible increase in the vulnerability of the resource. However, the high and increasing level of harvest rates experienced over the last years along with the low current biomass level also suggests questioning about the sustainability of current levels of fishing effort. In addition, negative effects on this population could result from pressure of other fishing gears on larval stages (locally known as *bianchetto* or *neonata*). This fishing activity is allowed for two months during the winter (February-March), so it essentially affects sardine but it may also be relevant for anchovy in case seasonal restrictions are not properly enforced. However, more data and investigation are needed in order to estimate the possible impact of this fishing activity on the exploited populations.

7.17. Stock assessment of sardine in GSA 16

7.17.1. *Stock identification and biological features*

7.17.1.1. Stock Identification

This assessment of the sardine stock in GSA 16 is mainly based on information collected over the last decade on fishery grounds off the southern Sicilian coast (GSA 16, South of Sicily), and specifically on biomass estimates obtained by hydroacoustic surveys and catch-effort data from local small pelagic fisheries. The main distribution area of the sardine stock in GSA 16 is the narrow continental shelf area between Mazara del Vallo and the southernmost tip of Sicily, Cape Passero (Patti *et al*., 2004).

7.17.1.2. Growth

Growth parameters were only used for the estimation of natural mortality with the approches suggested by Pauly (1980) and the Beverton & Holt's Invariants method (Jensen, 1996). Von-Bertalanffy growth parameters were estimated by FISAT using DCF data collected in GSA16 over the period 2007-2008. The applied growth parameters are given below in the following table:

L_∞	k	t_0
21.41	0.40	-1.83

For BHI method, the equation $M = \beta * k$ was applied, with β set to 1.8.

7.17.1.3. Maturity

Maturity data were not used for this assessment.

7.17.2. *Fisheries*

7.17.2.1. General description of fisheries

In Sciacca port, the most important base port for the landings of small pelagic fish species along the southern Sicilian coast (GSA 16), accounting for about 2/3 of total landings in GSA 16, two operational units (OU) are presently active, purse seiners and pelagic pair trawlers. The fleet in GSA 16 is composed by about 50 units (17 purse seiners and 30 pelagic pair trawlers were counted up in a census carried out in December 2006). In both OUs, anchovy represents the main target species due to the higher market price.

7.17.2.2. Management regulations applicable in 2009 and 2010

Fisheries practices are affected by EU regulations through the Common Fisheries Policy (CFP), based on the following principles: protection of resources; adjustment of (structure) facilities to the available resources; market organization and definition of relationships with other countries.

The main technical measures regulating fishing concern minimum landing size (9 cm for anchovy, 11 cm for sardine), mesh regulations (20 mm for pelagic pair trawlers, 14 mm for purse seiners) and restrictions on the use of fishing gear. Towed fishing gears are not allowed in the coastal area in less than 50 m depth, or within a distance of 3 nautical miles from the coastline. A seasonal closure for trawling, generally during summer-autumn, has been established since 1993. In GSA 16, the two operational units fishing for small pelagic are present, mainly based in Sciacca port: purse seiners (lampara vessels, locally known as "Ciancioli") and midwaters pair trawlers ("Volanti a coppia"). Midwaters trawlers are based in Sciacca port only, and receive a special permission from Sicilian Authorities on an annual basis. Another fleet fishing on small pelagic fish species is based in some northern Sicilian ports and targets on juvenile stages (mainly sardines). Also this fishery is allowed for a limited period (usually one or two months during the winter season) by a special Regional law renewed year by year.

7.17.2.3. Catches

7.17.2.3.1. Landings

Landings were obtained within the framework of the census data collection carried out by IAMC-CNR (Mazara del Vallo) in Sciacca port since 1998. Information collected in the framework of CA.SFO study project (Patti *et al*., 2007) showed that landings in Sciacca port account for about 2/3 of the total landings in GSA 16. Average sardine landings over the last decade (1997-2009) were about 1,400 metric tons, with a general decreasing trend.

It is worth noting that, though trend in biomass is clearly decreasing over the last years (Fig. 7.17.3.1.3.1.), landings levels over the same period were relatively high, indicating an increased vulnerability of the resource (Fig. 7.17.2.3.1.1).

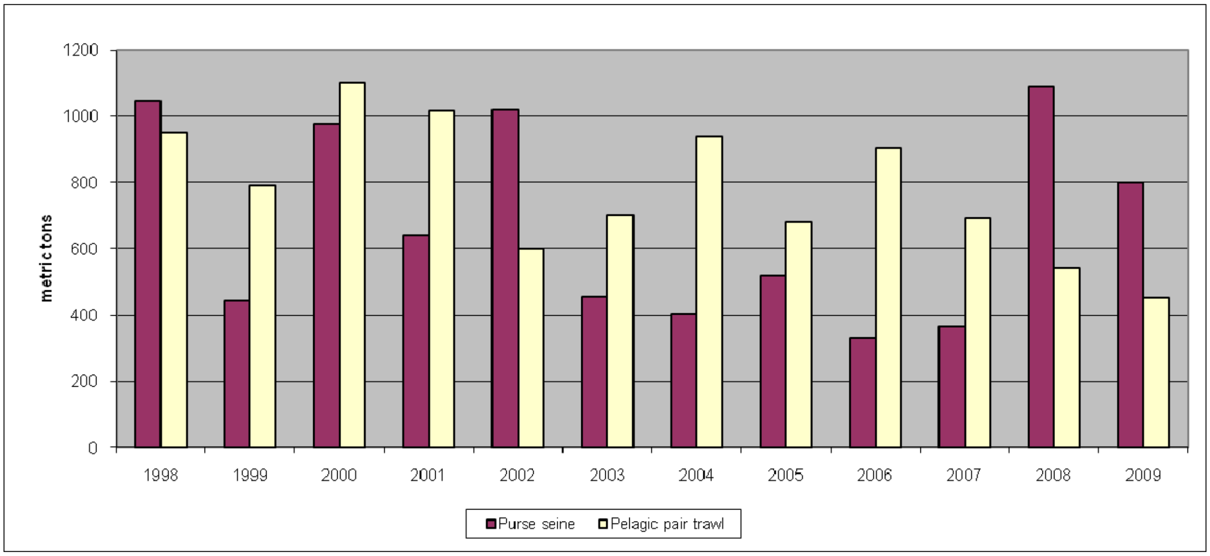


Fig. 7.17.2.3.1.1. Landings data regarding the purse seine and pelagic pair trawl fleets in Sciacca port (GSA 16), 1998-2009.

Tab. 7.17.2.3.1.1. Landings (t) as officially reported in 2010 through the DCF.

SPECIES	AREA	COUNTRY	FT_LVL4	FT_LVL5	2004	2005	2006	2007	2008	2009
PIL	16	ITA	OTB	DEMSP	1		0	1	3	7
PIL	16	ITA	OTB	MDDWSP		14	9	4		0
PIL	16	ITA	PS	LPF	18		174			
PIL	16	ITA	PS	SPF	872	904	1543	1559	1622	1301
PIL	16	ITA	PTM	SPF		332	500	610	442	342

7.17.2.3.2. Discards

No discards data for sardine were used for this assessment. However, discards are estimated to be less than 5% of total catch for both the pelagic pair trawl and the purse seine fisheries (Kallianiotis & Mazzola, 2002)

7.17.2.3.3. Fishing effort

Fishing effort data refer to census data collected in Sciacca port, the most important base port for the landings of small pelagic fish species along the southern Sicilian coast (GSA 16), accounting for about 2/3 of total landings in GSA 16.

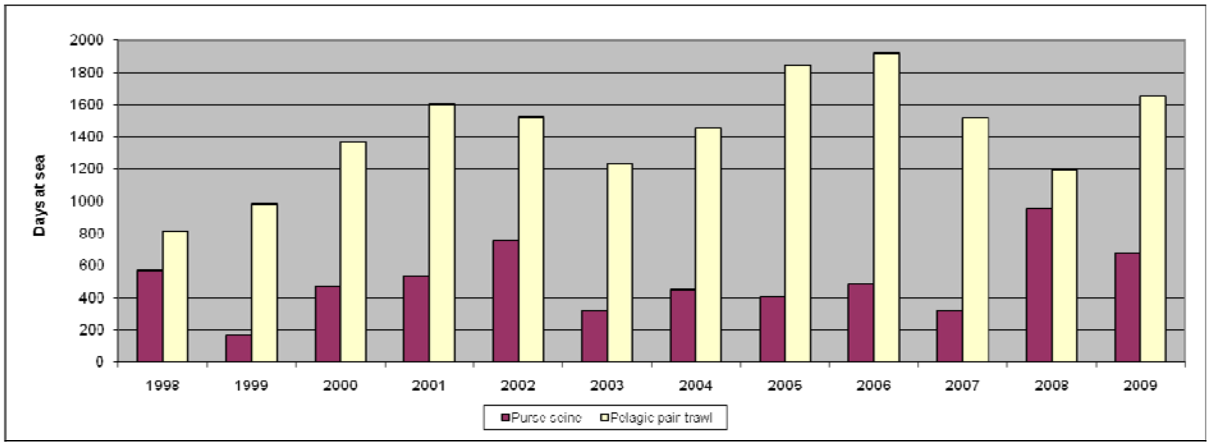


Fig. 7.17.2.3.3.1. Effort data regarding the purse seine and pelagic pair trawl fleets in Sciacca port (GSA 16), 1998-2009.

Tab. 7.17.2.3.3.1. Fishing effort (kW*days) as officially reported in 2010 through the DCF.

AREA	COUNTRY	FT_LVL4	FT_LVL5	2004	2005	2006	2007	2008	2009
16	ITA	OTB	DEMSP	1494345	742288	461219	7241	11424125	11956393
16	ITA	OTB	MDDWSP	20999175	23038080	23960157	23919695	3503392	3271710
16	ITA	PS	LPF	45715	212483	142104	114241	221944	172542
16	ITA	PS	SPF	73167	185546	798934	627965	522625	531086
16	ITA	PTM	SPF	0	29114	580922	883683	672151	657782

7.17.3. *Scientific surveys*

7.17.3.1. Acoustics

7.17.3.1.1. Methods

Acoustic surveys methodology

Steps for biomass estimation

- Collection of acoustic and biological data during surveys at sea;
- Extraction of $NASC_{Fish}$ (Fishes Nautical Area Scattering Coefficient [$m^2/n.mi^2$]) by means of Echoview (Sonar Data) post-processing software;
- Link of NASC values to control catches;
- Calculation of Fish density (ρ) from $NASC_{Fish}$ values and biological data;
- Production of ρ distribution maps for different fish species and size classes;
- Integration of density areas for biomass estimation.

Collection of acoustic and biological data

Since 1998 the IAMC-CNR has been collecting acoustic data for evaluating abundance and distribution pattern of small pelagic fish species (mainly anchovy and sardine) in the Strait of Sicily (GSA 16). The scientific echosounder Kongsberg Simrad EK500 was used for acquiring acoustic data until summer 2005; for the echosurvey in the period 2006-2009 the EK60 echosounder was used. In both cases the echosounder was equipped with three split beam transducers pulsing at 38, 120 and 200 kHz. During the period 1998-2008 acoustic data were collected continuously during day and night time; since the 2009 echosurvey acoustic data are collected during day time, according to the MEDIAS protocol.

Before or after acoustic data collection a standard procedure for calibrating the three transducers was carried out by adopting the standard sphere method (Johannesson & Mitson, 1983).

Biological data were collected by a pelagic trawl net with the following characteristics: total length 78 m, horizontal mouth opening 13-15 m, vertical mouth opening 6-8 m, mesh size in the cod-end 10 mm. The net was equipped with two doors with weight 340 kg. During each trawl the monitoring system SIMRAD ITI equipped with trawl-eye and temp-depth sensors was adopted.

Extraction of $NASC_{Fish}$ by means of Echoview (Sonar Data) post-processing software

The evaluation of the $NASC_{Fish}$ (Fishes Nautical Area Scattering Coeffcient [$m^2/n.mi^2$]) and the total NASC for each nautical mile of the survey track was performed by means of the SonarData Echoview software v3.50, taking into account the day and night collection periods.

Link of NASC values to control catches

For the echo trace classification the nearest haul method was applied, taking into account only representative fishing stations along transects.

Calculation of Fish density (ρ) from $NASC_{Fish}$ values and biological data

For each trawl haul the frequency distribution of the *j*-th species (ν_j) and for the *k*-th length class (f_{jk}) are estimated as

$$\nu_j = \frac{n_j}{N} \qquad \text{and} \qquad f_{jk} = \frac{n_{jk}}{n_j}$$

where n_j is the total number of specimens of the *j*-th species, n_{jk} is the total number of specimens of the *k*-th length class in the *j*-th species, and N is the total number of specimens in the sample.

For each nautical mile the densities for each size class and for each fish species are estimated as

$$\rho_{jk} = \frac{NASC_{FISH} * n_{jk}}{\sum_{j=1}^{n}\sum_{k=1}^{m} n_{jk} * \sigma_{jk}} \qquad \text{(number of fishes / n.mi}^2\text{)}$$

$$\rho_{jk} = \frac{NASC_{FISH} * W_{jk} * 10^{-6}}{\sum_{j=1}^{n}\sum_{k=1}^{m} n_{jk} * \sigma_{jk}} \qquad \text{(t / n.mi}^2\text{)}$$

where W_{jk} is the total weight of the *k*-th length class in the *j*-th species, and σ_{jk} is the scattering cross section of the *k*-th length class in the *j*-th species. σ_{jk} *is given by*

$$\sigma_{spjk} = 4\pi * 10^{\frac{TS_{jk}}{10}}$$

where the target strenght (TS) is

$$TS_{jk} = a_j Log_{10}(L_k) + b_j$$

L_k is the length of the k-th length class while the a_j and b_j coefficient are linked to the fish species.

For anchovy, sardine and trachurus we adopted respectively the following relationships:

$TS = 20 \log L_k\, 76.1 \quad [dB]$

$TS = 20 \log L_k\, 70.51 \quad [dB]$

$TS = 20 \log L_k\, 72 \quad [dB]$

Integration of density areas for biomass estimation

The abundance of each species was estimated by integrating the density surfaces for each species.

7.17.3.1.2. Geographical distribution patterns

No analyses were conducted during SGMED-10-03.

7.17.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the sardine stock in GSA 16 was derived from the acoustics. Figure 7.17.3.1.3.1 displays the estimated trend in sardine total biomass (estimated by acoustics) for GSA 16.

Values of the last four years are relatively low, well below the general average value over the last decade (about 16,000 t).

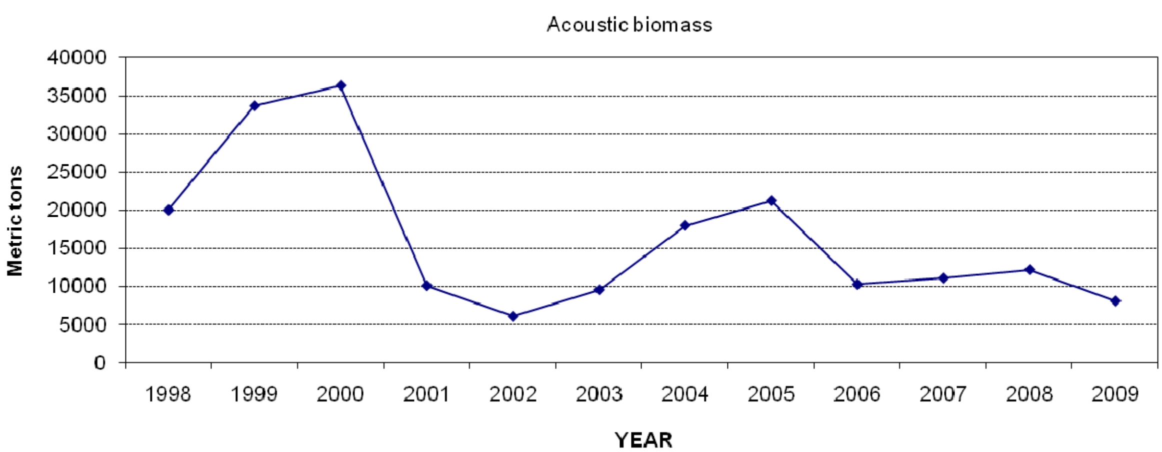


Fig. 7.13.3.1.3.1. Estimated sardine biomass indices for GSA 16, years 1998-2009.

7.17.3.1.4. Trends in abundance by length or age

Length or age class data were not used for this assessment.

7.17.3.1.5. *Trends in growth*

Not applicable. Growth data were only used for the estimation of natural mortality with the approches suggested by Pauly (1980) and the Beverton & Holt's Invariants method (Jensen, 1996).

7.17.3.1.6. *Trends in maturity*

Maturity data were not used for this assessment.

7.17.4. *Assessment of historic stock parameters*

Not applicable. No stock assessment model was run for this assessment.

7.17.5. *Long term prediction*

Not applicable. No forecast analyses were conducted.

7.17.6. *Scientific advice*

7.17.6.1. Short term considerations

7.17.6.1.1. *State of the spawning stock size*

Biomass estimates of the total population obtained by hydro-acoustic surveys for sardine in GSA 16 show that the recent stock level has been well below the average value over the last decade until 2009. In the absence of precautionary reference points SGMED is unable to fully evaluate the state of the stock size.

7.17.6.1.2. *State of recruitment*

No recruitment data were used for this assessment.

7.17.6.1.3. *State of exploitation*

SGMED recommends the application of the proposed exploitation rate $E \leq 0.4$ as management limit point for stocks of anchovy and sardine in the Mediterranean Sea consistent with high long term yield. This value might be revised in the future when more information becomes available. Annual harvest rates, as estimated by the ratio between total landings and stock sizes, indicate relatively low fishing mortality during the last decade. Actually, as long as this estimate of harvest rate can be considered as a proxy of F obtained from the fitting of standard stock assessment models (assuming survey biomass estimate as a proxy of mean stock size), this index can also be used to assess the corresponding exploitation rate $E=F/Z$, provided that an estimate of natural mortality is given. However, sardine biomass estimates are based on acoustic surveys carried out during the summer and, as in general they would include the effect of the annual recruitment of the population, they are possibly higher than the average annual stock sizes. This in turn could determine in an underestimation of the harvest rates and of the corresponding exploitation rates. The current (year 2009) harvest rate is 0.23, whereas the estimated average value over the years 2006-2009 is 0.19. The exploitation rate corresponding to F=0.19 is E=0.20, if M=0.77, estimated with Pauly (1980) empirical equation, is assumed, and E=0.21 if M=0.72, estimated with Beverton & Holt's Invariants method (Jensen, 1996), is used instead. In relation to the above considerations on the possible overestimation of mean stock size in harvest rate calculation, it is worth noting that, even if the harvest rates were twice the estimated values, the exploitation rates would continue to be lower than the target reference point. Thus, using the exploitation rate as a target reference point, the stock of sardine in GSA 16 is considered as being sustainably exploited.

Given that biomass was quite low for four consecutive years (2006-2009) and that the exploitation rate of sardine is moderate, fishing effort should not be increased beyond the current levels and consistent catches should be determined. However, as the small pelagic fishery is generally multispecies, any management of fishing effort targeting the anchovy stock (see above recommendations) would also have effects on sardine. In addition, due to the low level of the anchovy stock measures should be taken to prevent a shift of effort from anchovy to sardine.

General considerations

Taking into account that fishing effort was relatively stable in last decade, results would suggest that also the environmental factors are important to explain the variability on yearly recruitment success. However, the stock did not recover from the 2006 "collapse" in biomass (-52% from July 2005 to June 2006), and this fact, along with the general decreasing trend in landings over the last decade (last biomass estimate represents the second lowest value of the series), also suggests questioning about the sustainability of current levels of fishing effort. In addition, possible negative effects on these populations could results from pressure of other fishing gears on larval stages.

A warning on the fishing of larval stages (locally named *bianchetto* or *neonata*) is relevant, taking into account that in the past years derogation of the fishing ban was normally operated for about two months in wintertime, i.e. during the sardine spawning season, even though more data and investigation are needed in order to estimate the possible impact of this fishing activity on the exploited populations.

7.18. Stock assessment of Norway lobster in GSA 09

7.18.1. *Stock identification and biological features*

7.18.1.1. Stock identification

Due to a lack of information about the structure of Norway lobster (*Nephrops norwegicus*) population in the western Mediterranean, this stock was assumed to be confined within the GSA 09 boundaries. Adults tend to be territorial, with limited migration. However, transferal of larvae between areas may occur.

N. norvegicus is a mud-burrowing species that prefers sediments with mud mixed with silt and clay in variable proportions. The emergence from burrows of individuals may vary depending on biological features or environmental factors (moult or reproduction cycles, light intensity, etc).

The species lives on muddy substrates at depths between 150 and 800 m, but in the area is more commonly found between 250 and 800 m depth (Biagi *et al.*, 2002; Colloca *et al.*, 2003).

Recruits peak in abundance between 400 and 500 m depth over the upper slope and appear to move slightly deeper when they reach 30 mm carapace length (Fig. 7.18.1.1.1).

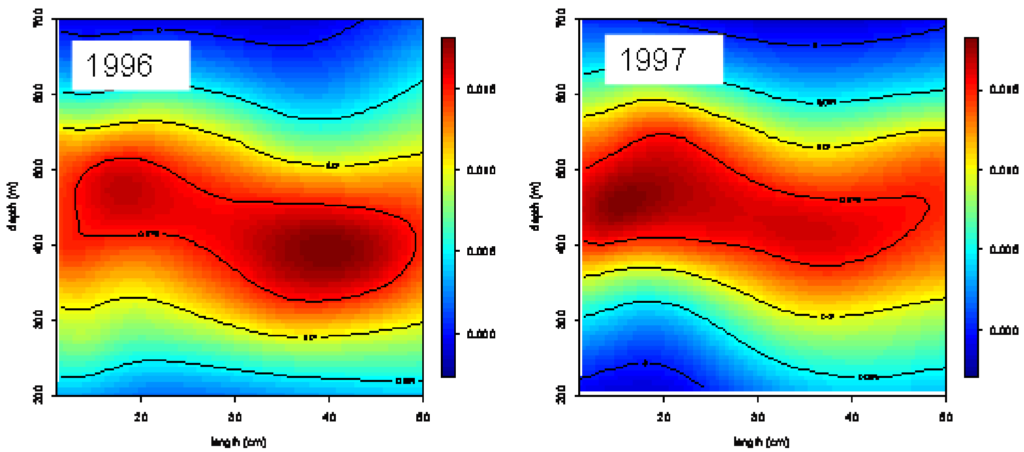


Fig. 7.18.1.1.1 Size-depth distribution of Norway lobster in the GSA 09 in 1996 and 1997 (GRUND survey).

7.18.1.2. Growth

The species shows a noticeable sexual dimorphism, with males that reach bigger sizes than females. Maximum observed size in the GSA 09 was 72 mm CL for males and 57 mm CL for females.
Growth parameters defined in the area were:
L_∞ =72.1 (males) 56 (females)
K = 0.169 (males) 0.214 (females)
Length-weight relationship for both sexes: a = 0.00040, b = 3.126

7.18.1.3. Maturity

Males reach maturity at 40 mm CL and females at 30.3 mm CL. Sex ratio is about 1:1 until 26 mm CL; in favour of females from 26 to 35 mm CL; in favour of males from 38 mm CL (De Ranieri *et al.*, 1996). Reproduction peak is between spring and summer, and females with external eggs are observed in autumn-winter.

7.18.2. *Fisheries*

7.18.2.1. General description of fisheries

Norway lobster is one of the most important components of bottom trawlers catch in the GSA 09, as total annual value of the landings.

The trawlers fleet of GSA 09 at the end of 2006 accounted for 361 vessels (Tab. 7.18.2.1.1). From those vessels, only a fraction targets *Nephrops norvegicus.*

The main trawl fleets of GSA 09 are present in the following continental harbours: Viareggio, Livorno, Porto Santo Stefano (Tuscany), Fiumicino, Terracina, Gaeta (Latium).

Tab. 7.18.2.1.1 Technical characteristics of the trawl fleet of GSA 09 (year 2007, DCR official data).

N. of boats	361
GT	13.191
kW	75.514
Mean GT	36.5
Mean kW	209.2

The majority of bottom trawlers of GSA 09 operates daily fishing trips with only some vessels able to stay out of the port for two-three days especially in summer.

Norway lobster fishing grounds include soft bottoms of upper slope, generally between 350 and 600 m depth. Fishing pressure shows some geographical differences inside the GSA 09 according to the consistency of the fleets, the availability of the resources and the morphology of the continental shelf and upper slope. The species by-catch is mainly represented by *Micromesistius poutassou, Phycis blennoides, Lepidorhombus bosci, Galeus melastomus, Parapenaeus longirostris, Eledone cirrhosa, Todaropsis eblane, Trachurus spp.*

7.18.2.2. Management regulations applicable in 2009 and 2010

- Fishing closure for trawling: 45 days in late summer (not every year have been enforced).
- Minimum landing sizes: EC regulation 1967/2006: 20 mm CL for Norway lobster.
- Cod end mesh size of trawl nets: 40 mm (stretched, diamond meshes) till 30/05/2010. From 01/06/2010 the existing nets will be replaced with a cod end with 40 mm (stretched) square meshes or a cod end with 50 mm (stretched) diamond meshes.
- Towed gears are not allowed within three nautical miles from the coast or at depths less than 50 m when this depth is reached at a distance less than 3 miles from the coast.

7.18.2.3. Catches

7.18.2.3.1. Landings

Landings of Norway lobster in GSA 09 are almost exclusively provided by trawling (Tab. 7.18.2.3.1.1). In the last six years the total landings varied between 228 and 289 tons (Fig. 7.18.2.3.1.1), showing a slightly decresing trend.

Tab. 7.18.2.3.1.1 Landings (t) of Norway lobster in GSA 09 by fishing technique as officially reported through the 2010 DCF data call. Total landings in 2009 accounted for 250 tons.

SPECIES	AREA	COUNTRY	FT_LVL4	2004	2005	2006	2007	2008	2009
NEP	9	ITA		5,3	1,6	0,6			
NEP	9	ITA	FPO					0,1	
NEP	9	ITA	GNS	0,1	0,4	0,1		0,1	
NEP	9	ITA	GTR		0,5				0,0
NEP	9	ITA	OTB	268,6	287,6	247,4	260,5	227,7	250,2
NEP	9	ITA	PS	0,0					
TOTAL LANDINGS				274,0	290,1	248,1	260,5	227,8	250,3

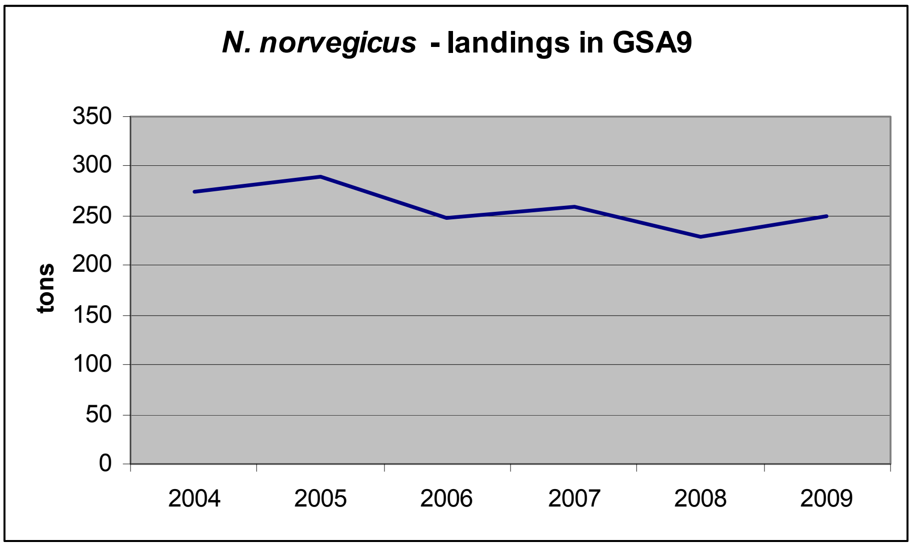


Fig. 7.18.2.3.1.1 Landings of Norway lobster in the GSA 09, from 2004 to 2009 (DCF official data).

Landings are mostly composed by specimens from 25 to 50 mm CL (Fig. 7.18.2.3.1.2) which correspond to individuals over 2+. Due to the sexual dimorphism of the species, the majority of the specimens greater than 40 mm CL are males.

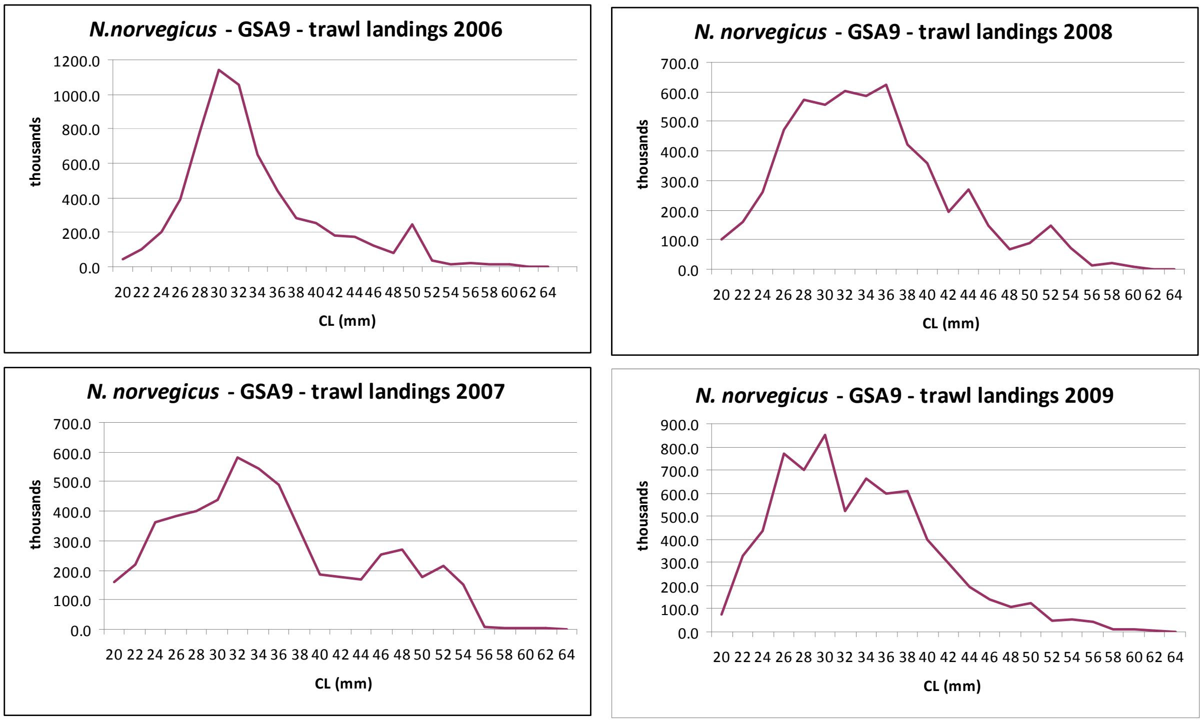


Fig. 7.18.2.3.1.2 Size structure of the landings of *N. norvegicus* in 2006-2009 caught by otter trawling in the GSA 09 (DCF official data).

7.18.2.3.2. Discards

Several EU and national projects carried out in GSA 09 highlighted that discard of Norway lobster in GSA 09 is negligible. At the same time, the presence of specimens under the MLS (20 mm CL) in the landings is very scarce. The same picture was obtained during the monitoring of discard performed in the 2006 DCR.

7.18.2.3.3. Fishing effort

The fishing capacity of the GSA 09 has shown in these last 10 years a progressive decrease. From 1996 to 2006 the number of bottom trawlers of GSA 09 decreased of about 30%.

Fishing effort, expressed as kw*days at sea, deployed by all trawlers in GSA 09 varied from about 14,000,000 to 12,000,000 (Fig. 7.18.2.3.3.1). Anyway, there is no information on the specific effort directed to *N. norvegicus* in GSA 09.

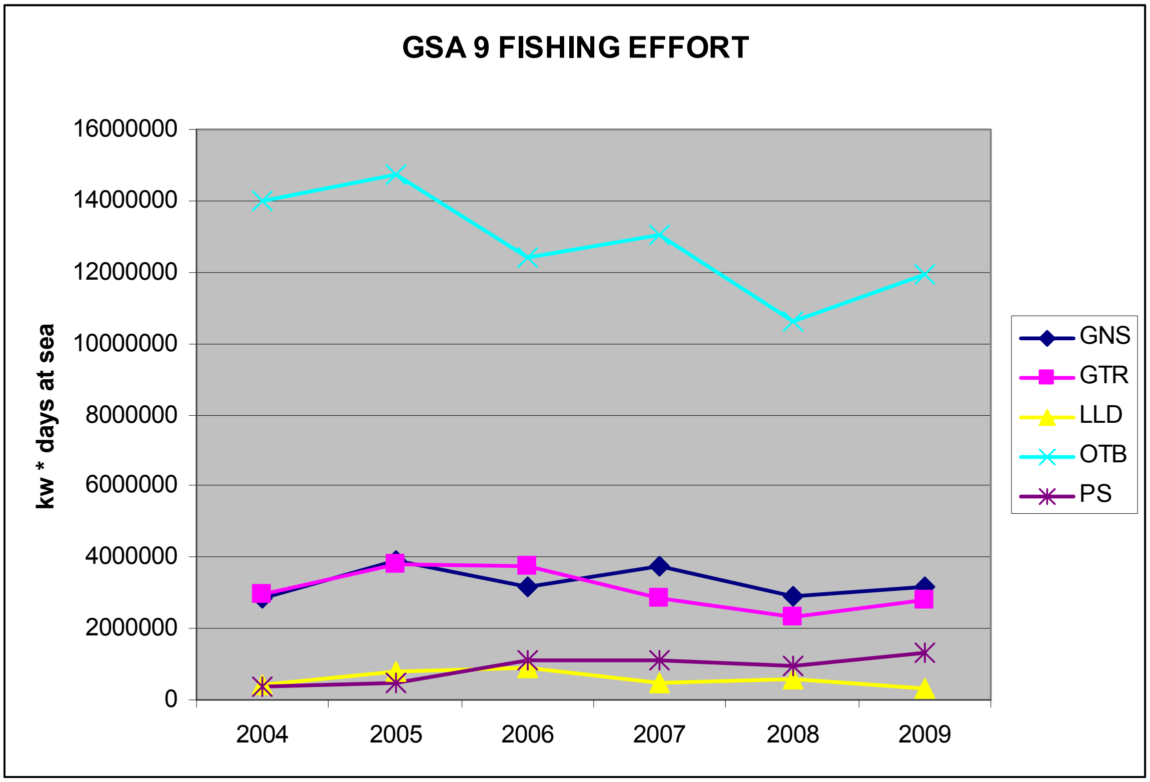


Fig. 7.18.2.3.3.1 Effort trends (kW*days) in 2004-2009 by the major fleets for GSA 09

Tab. 7.18.2.3.3.1 Effort trends (kW*days) in 2004-2009 by the major fleets for GSA 09.

AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	VESSEL_LENGTH	2004	2005	2006	2007	2008	2009
9	ITA				VL0006			17656	17264	18783	83933
9	ITA				VL0612	472199	644679	294865	73209	117265	164688
9	ITA				VL1218	3700			2547		
9	ITA				VL1824	17372					
9	ITA	DRB	Molluscs		VL1218	271337	290683	222614	232521	355036	273697
9	ITA	FPO	ıersal species		VL0006			1687			
9	ITA	FPO	ıersal species		VL0612					2569	
9	ITA	FPO	ıersal species		VL1218					22490	9484
9	ITA	GND	ıall pelagic fish		VL0612	7686	2640	47550			4429
9	ITA	GND	ıall pelagic fish		VL1218			11976			
9	ITA	GNS	ıersal species		VL0006			241006	187684	119389	159810
9	ITA	GNS	ıersal species		VL0612	2671807	3040551	2043295	2876900	1943304	2084677
9	ITA	GNS	ıersal species		VL1218	143130	731268	892800	588214	780959	860279
9	ITA	GNS	ıersal species		VL1824	1616					
9	ITA	GNS	ıd large pelagic fish		VL0006				5402	2776	
9	ITA	GNS	ıd large pelagic fish		VL0612	11704	63837	15456	4132	20976	38386
9	ITA	GNS	ıd large pelagic fish		VL1218		52196		68484	30113	22011
		TOTAL GNS				**2828257**	**3887852**	**3192557**	**3730816**	**2897517**	**3165163**
9	ITA	GTR	ıersal species		VL0006			51327	45484	31192	89981
9	ITA	GTR	ıersal species		VL0612	2907871	3430873	3354500	2549277	2158965	2581318
9	ITA	GTR	ıersal species		VL1218	22931	394777	352725	245701	140511	147834
		TOTAL GTR				**2930802**	**3825650**	**3758552**	**2840462**	**2330668**	**2819133**
9	ITA	LHP-LHM	Finfish		VL0612	40544					
9	ITA	LLD	'ge pelagic fish		VL0612	428218	782673	709249	295671	439382	184624
9	ITA	LLD	'ge pelagic fish		VL1218	7125	13281	163222	189635	137261	142197
9	ITA	LLD	'ge pelagic fish		VL1824						0
		TOTAL LLD				**435343**	**795954**	**872471**	**485306**	**576643**	**326821**
9	ITA	LLS	)emersal fish		VL0006			1186	21025	925	
9	ITA	LLS	)emersal fish		VL0612	354518	458614	355370	91390	30209	27155
9	ITA	LLS	)emersal fish		VL1218	1750	24006				2268
9	ITA	LTL	'ge pelagic fish		VL0006			7086	2476		2603
9	ITA	OTB	p water species		VL1218					145852	320102
9	ITA	OTB	p water species		VL1824	10206				75837	165696
9	ITA	OTB	ıersal species		VL0006					108	
9	ITA	OTB	ıersal species		VL0612	202730	189101	226836	251665	174990	171451
9	ITA	OTB	ıersal species		VL1218	1645868	1504133	1250063	2496441	2314631	2229315
9	ITA	OTB	ıersal species		VL1824	2669494	314808	1266539	1540497	5460490	6053329
9	ITA	OTB	ıersal species		VL2440	1492529					968737
9	ITA	OTB	al and deep water spec		VL1218	2119148	2664115	2362684	2519541	1177098	583020
9	ITA	OTB	al and deep water spec		VL1824	5857423	10065218	7321573	6236446	1253611	1372778
9	ITA	OTB	al and deep water spec		VL2440						62897
		TOTAL OTB				**13997398**	**14737375**	**12427695**	**13044590**	**10602617**	**11927325**
9	ITA	PS	'ge pelagic fish		VL1218					4160	30424
9	ITA	PS	'ge pelagic fish		VL1824	7275	3880		1299	59472	
9	ITA	PS	'ge pelagic fish		VL2440						14965
9	ITA	PS	ıall pelagic fish		VL0006				11193		
9	ITA	PS	ıall pelagic fish		VL0612	27674	148646	44847		32718	42881
9	ITA	PS	ıall pelagic fish		VL1218	269016	145756	569851	475217	525772	419772
9	ITA	PS	ıall pelagic fish		VL1824	82023	157481	513668	629300	354009	240111
9	ITA	PS	ıall pelagic fish		VL2440						562906
		TOTAL PS				**385988**	**455763**	**1128366**	**1117009**	**976131**	**1311059**
9	ITA	PTM	ıall pelagic fish		VL0006			3148			
9	ITA	PTM	ıall pelagic fish		VL0612			1542			
9	ITA	SB-SV	ıersal species		VL0006			8996	25084	16683	7458
9	ITA	SB-SV	ıersal species		VL0612	683331	856943	556372	499729	314844	327792
9	ITA	SB-SV	ıersal species		VL1218	66124	45567	49489	25800	17960	20116
9	ITA	SB-SV	ıersal species		VL1824	808					

7.18.3. *Scientific surveys*

7.18.3.1.MEDITS

7.18.3.1.1. Methods

Based on the DCR data call, abundance and biomass indices were recalculated. In GSA 09 the following number of hauls was reported per depth stratum (s. Tab. 7.18.3.1.1.1).

Tab. 7.18.3.1.1.1. MEDITS survey. Number of hauls per year and depth stratum in GSA 09, 1994-2009.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GSA09_010-050	19	18	18	18	19	18	18	18	13	13	13	14	13	13	13	14
GSA09_050-100	19	20	18	19	18	19	20	20	15	15	15	14	16	16	13	14
GSA09_100-200	35	35	36	35	35	35	34	34	26	27	26	27	25	26	28	27
GSA09_200-500	32	33	33	36	32	36	37	35	27	27	27	28	29	33	30	28
GSA09_500-800	31	30	31	28	30	28	27	29	24	22	21	20	20	17	18	20

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

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

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

Where:

- A=total survey area
- Ai=area of the i-th stratum
- si=standard deviation of the i-th stratum
- ni=number of valid hauls of the i-th stratum
- n=number of hauls in the GSA
- Yi=mean of the i-th stratum
- Yst=stratified mean abundance
- V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA. Given the sheer number of plots generated, these distributions are not presented in this report.

7.18.3.1.2. Geographical distribution patterns

Norway lobster is distributed in the whole GSA with the highest abundance in the south Ligurian Sea and northern Tyrrhenian Sea.

7.18.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the *N. norvegicus* in GSA 09 was derived from the international survey MEDITS. Figure 7.18.3.1.3.1 displays the re-estimated trend in *N. norvegicus* abundance and biomass in GSA 09 based on the DCR data call. While there appears no overall trend evident in the indices of biomass, 2009 represent the maximum since 1994. The index of abundance shows an increase over time with also a peak in 2009.

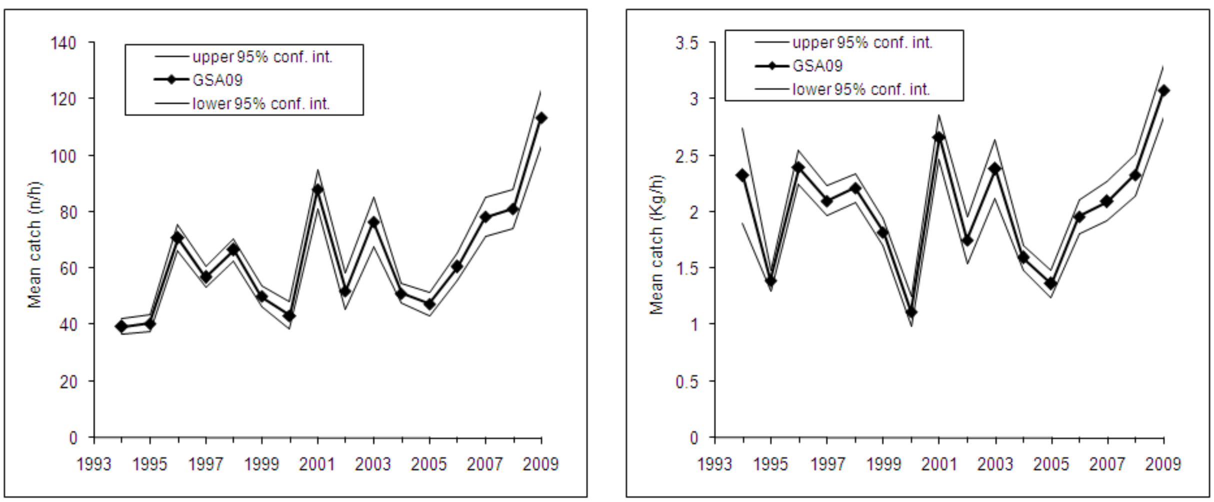


Fig. 7.18.3.1.3.1 Abundance and biomass indices of *Nephrops norvegicus* in GSA 09.

7.18.3.1.4. Trends in abundance by length or age

The following Fig. 7.18.3.1.4.1 and 2 display the stratified abundance indices of GSA 09 in 1994-2001 and 2002-2009.

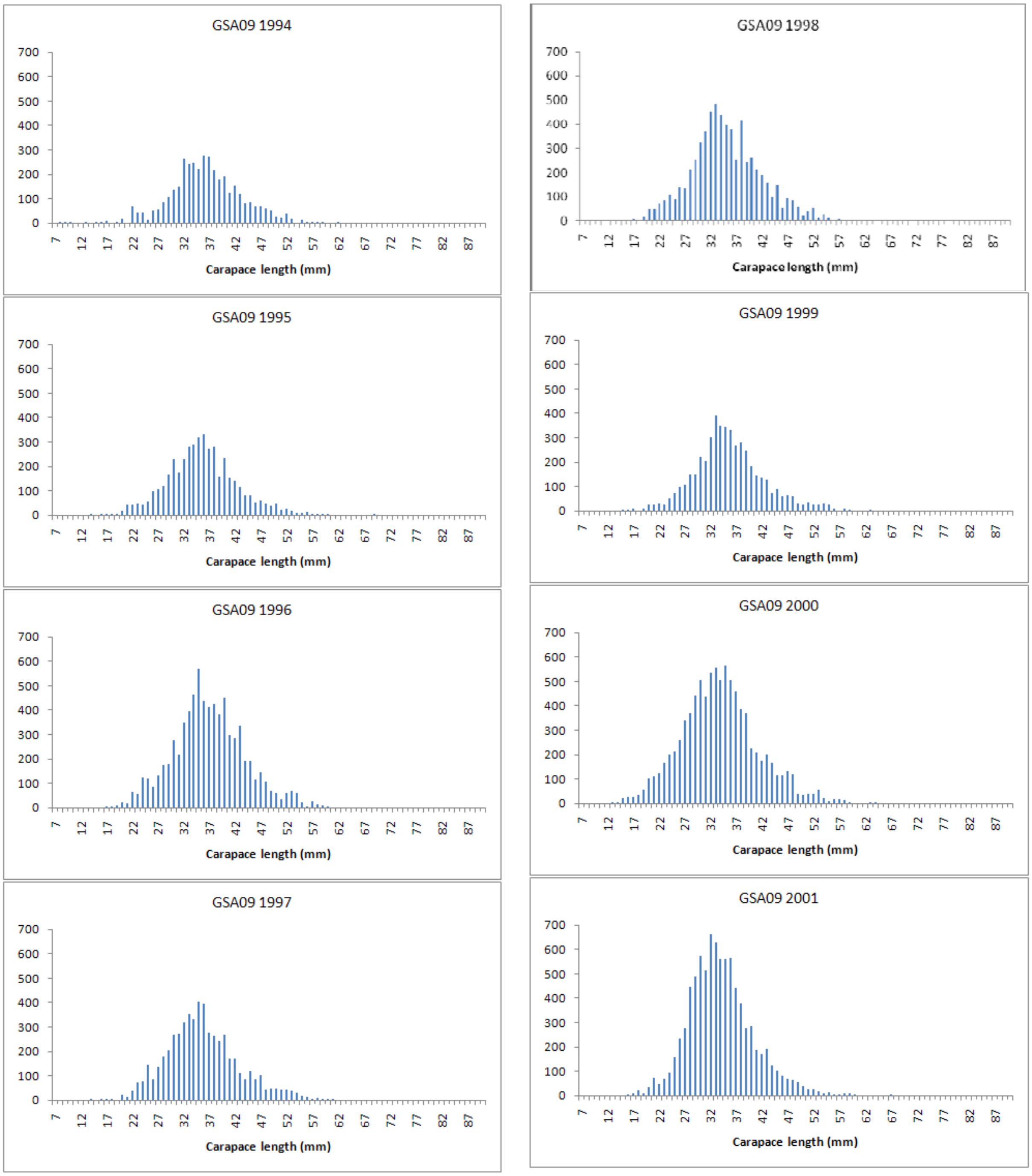
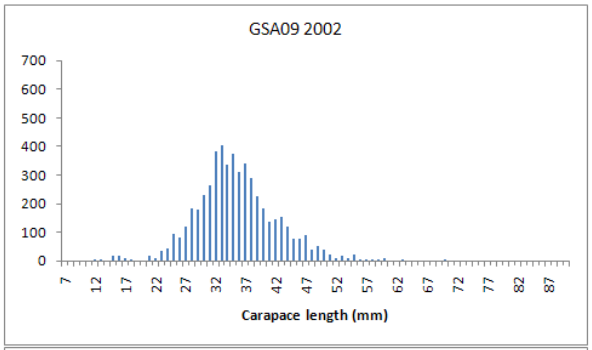
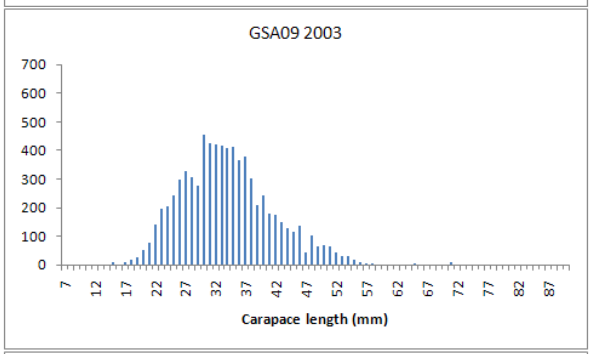
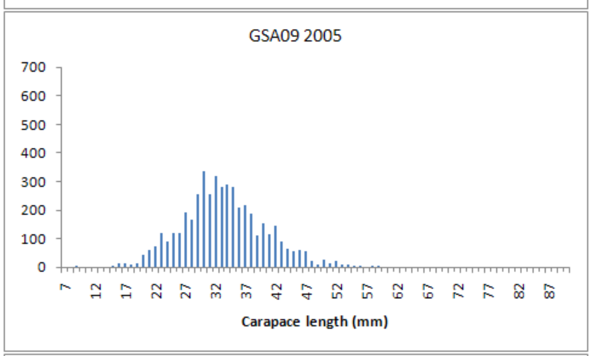
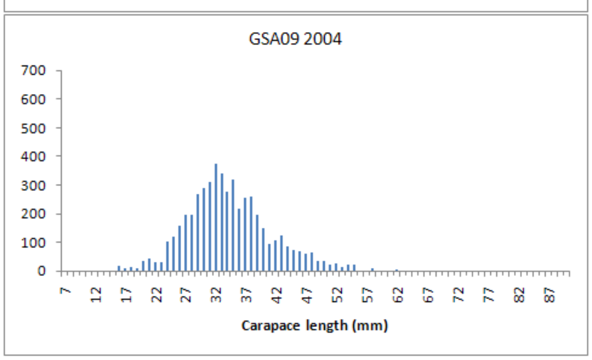


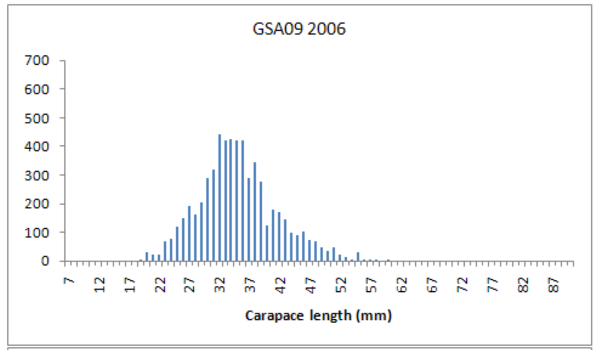
Fig. 7.18.3.1.4.1 Stratified abundance indices by size, 1994-2001.

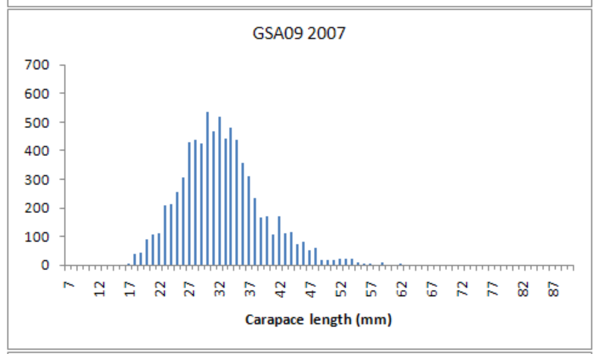

GSA09 2002
Carapace length (mm)

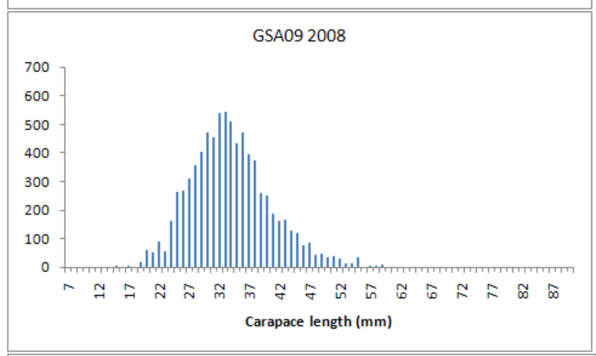

GSA09 2003
Carapace length (mm)


GSA09 2005
Carapace length (mm)


GSA09 2004
Carapace length (mm)


GSA09 2006
Carapace length (mm)


GSA09 2007
Carapace length (mm)


GSA09 2008
Carapace length (mm)

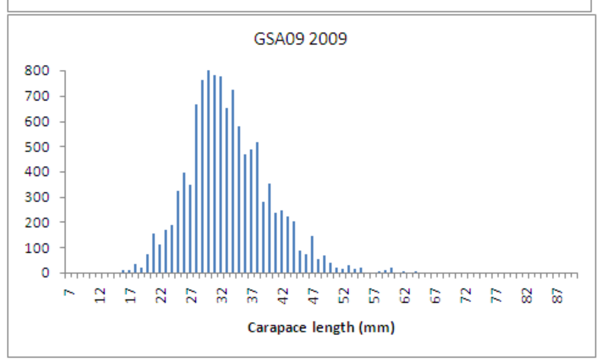

GSA09 2009
Carapace length (mm)

Fig. 7.18.3.1.4.2 Stratified abundance indices by size, 2002-2009.

An increasing trend was observed in MEDITS survey index (n km^{-2}) for age group 2^+ which is the first age group completely recruited by the gear (Fig. 7.18.3.1.4.3).

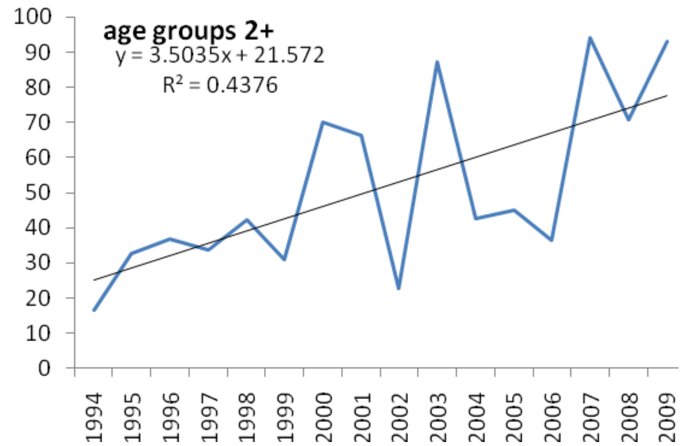


Fig. 7.18.3.1.4.3 MEDITS abundance indices of age groups 2+ (data pooled) of *N. norvegicus*.

7.18.3.2.GRUND

7.18.3.2.1. Methods

The national GRUND trawl survey (Relini, 1998) is regularly carried out along the Italian coasts in addition to MEDITS. It has been carried out since 1985, with some years lacking (1988, 1989 and 1999). Sampling is random stratified, except in the period 1990-93 where a different sampling design, based on transects, was applied. Locations of stations were selected randomly within each stratum in the period 1985-87, while since 1996, the same stations were sampled every year. Therefore from 1994 two trawl surveys are regularly carried out in Italy each year: MEDITS, in spring, and GRUND, in autumn. The two surveys provide integrate pictures on different seasons, allowing to monitor the most important biological events (recruitment, spawning) for the majority of the demersal species.

7.18.3.2.2. Geographical distribution patterns

Norway lobster is distributed in the whole GSA with the highest abundance in the south Ligurian Sea and northern Tyrrhenian Sea.

7.18.3.2.3. Trends in abundance and biomass

Fig. 7.18.3.2.3.1 shows the density and biomass indices of Norway lobster obtained from 1994 to 2009. The GRUND data series show a fluctuating trend with two peaks, in 1997 and in 2003-2005, while in 2008 values considerably lower than those of the previous years were recorded; MEDITS indices fluctuated without a clear trend until 2005, while in the last years they progressively increased.

The high values detected with the MEDITS survey (spring season) in the last years are essentially due to catches of specimens of the first age classes.

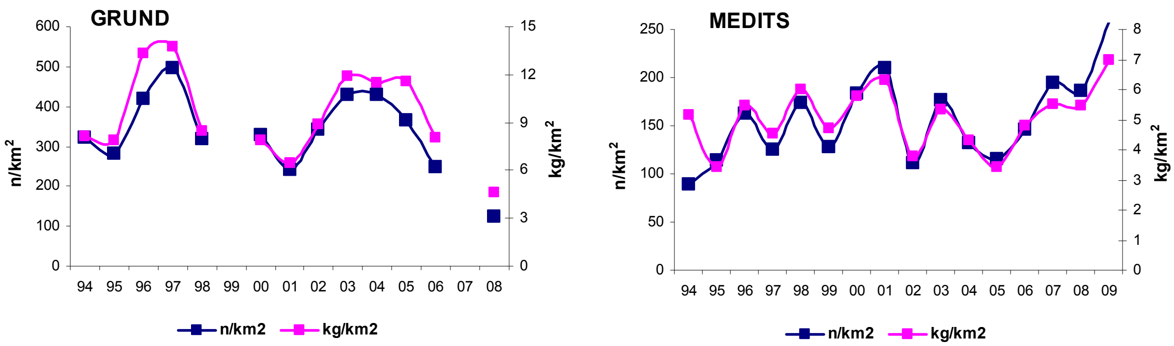


Fig. 7.18.3.2.3.1 Density and abundance indices of *N. norvegicus* according to the GRUND (left) and MEDITS (right) surveys.

7.18.3.2.4. Trends in abundance by length or age

Not presented to SGMED-10-03.

7.18.3.2.5. Trends in growth

No analyses were conducted during SGMED-10-03.

7.18.3.2.6. Trends in maturity

No analyses were conducted during SGMED-10-03.

7.18.4. *Assessment of historic stock parameters*

Due to its importance as demersal resource, *N. norvegicus* has been object of several assessments in the GSA 09 (Ardizzone *et al*., 1998; Abella & Righini, 1995; 1998; Abella *et al*., 1999; 2002; 2007; Biagi *et al*., 1990a; 1990b; 1990c; De Ranieri 1999; Mori *et al*., 1993; 1998; Sartor *et al*., 2003, Sbrana *et al*., 2003). These results are published and have been regularly updated in the GFCM SAC. The assessments performed with different approaches in different periods or in different subareas of the GSA 09 showed divergent results as *Nephrops* grounds within GSA 09 are not exploited with the same rate. It is likely that the current status (abundance and demographic structure) may depend mainly on the fishing pressure exerted in the different sub areas of the GSA. This fact does not exclude the possibility of drifting of eggs and larvae from one ground to others contributing to recruitments in grounds different from the parental ones.

The Norway lobster in the GSA 09 seems to be fully or in some cases underexploited, as shown by the results of the analytical models (reference points as F_{max}, $F_{0.1}$ and SSB_{curr}/SSB_0). The production models based on Z provided total mortality estimates for the whole GSA 09 greater than the mortality corresponding to the maximum biological production (Z_{MBP}).

A clear growth overfishing is not observed, considering that the smaller individuals, 0+ and 1+ age classes, even though present in the fishing grounds, show a limited vulnerability to the fishing gear. The values of the SSB/SSB_0 ratio are between 0.33 and 0.45.

7.18.4.1. Method 1: SURBA

7.18.4.1.1. Justification

The relatively long time series of data available from the GRUND and MEDITS surveys provided the most important data sets for analysis. The survey-based stock assessment approach SURBA (Needle, 2003) was used both on MEDITS (1994-2009) and GRUND (1994-2004) data of the Norway lobster of GSA 09.

7.18.4.1.2. Input parameters

The following set of parameters was adopted:

Tab. 7.18.4.1.2.1 Input parameters.

Growth parameters (Von Bertalanffy)
$L\infty$ = 74 mm, carapace length
K = 0.17
to = 0
L*W
a = 0.0005
b = 3.04
Natural mortality
M = 0.4
Catchability (q)
q = 1 for all the age classes
Length at maturity (L50)
L50 = 29 mm

Tab. 7.18.4.1.2.2 Input parameters used for the SURBA model.

Abundance indices						Mean weight					
	Age						Age				
Year	3	4	5	6	7 plus	Year	3	4	5	6	7 plus
1994	60.946	63.556	30.673	12.25	6.964	1994	50.8	72.5	95.2	117.8	139.5
1995	80.366	72.157	30.413	10.785	8.456	1995	50.8	72.5	95.2	117.8	139.5
1996	144.074	117.405	27.992	4.658	2.276	1996	50.8	72.5	95.2	117.8	139.5
1997	97.535	78.183	32.36	13.149	11.054	1997	50.8	72.5	95.2	117.8	139.5
1998	138.817	107.463	49.734	18.362	10.939	1998	50.8	72.5	95.2	117.8	139.5
1999	97.647	84.989	32.917	12.558	10.991	1999	50.8	72.5	95.2	117.8	139.5
2000	143.239	103.062	37.82	17.306	11.701	2000	50.8	72.5	95.2	117.8	139.5
2001	193.001	118.264	42.596	14.213	9.258	2001	50.8	72.5	95.2	117.8	139.5
2002	89.481	75.401	29.724	11.083	5.916	2002	50.8	72.5	95.2	117.8	139.5
2003	133.345	87.239	36.739	17.392	12.053	2003	50.8	72.5	95.2	117.8	139.5
2004	111.043	76.458	29.057	12.392	9.341	2004	50.8	72.5	95.2	117.8	139.5
2005	96.326	59.498	27.529	8.589	5.157	2005	50.8	72.5	95.2	117.8	139.5
2006	118.943	94.291	33.57	14.526	8.125	2006	50.8	72.5	95.2	117.8	139.5
2007	177.222	84.955	31.544	12.319	7.343	2007	50.8	72.5	95.2	117.8	139.5
2008	151.37	107.783	41.734	13.949	9.235	2008	50.8	72.5	95.2	117.8	139.5
2009	171.25	82.30	24.40	10.48	3.93	2009	50.8	72.5	95.2	117.8	139.5
Proportion of mature											
1994	1	1	1	1	1						
1995	1	1	1	1	1						
1996	1	1	1	1	1						
1997	1	1	1	1	1						
1998	1	1	1	1	1						
1999	1	1	1	1	1						
2000	1	1	1	1	1						
2001	1	1	1	1	1						
2002	1	1	1	1	1						
2003	1	1	1	1	1						
2004	1	1	1	1	1						
2005	1	1	1	1	1						
2006	1	1	1	1	1						
2007	1	1	1	1	1						
2008	1	1	1	1	1						
2009	1	1	1	1	1						

7.18.4.1.3. Results

Fitted year effect shows strong fluctuations from year to year with a high increases from 2007 to 2008, while the age effect shows a flat-topped selection pattern for stock mortality with an increase from age 3 to age 6. Fitted cohort effects are high in recent years.

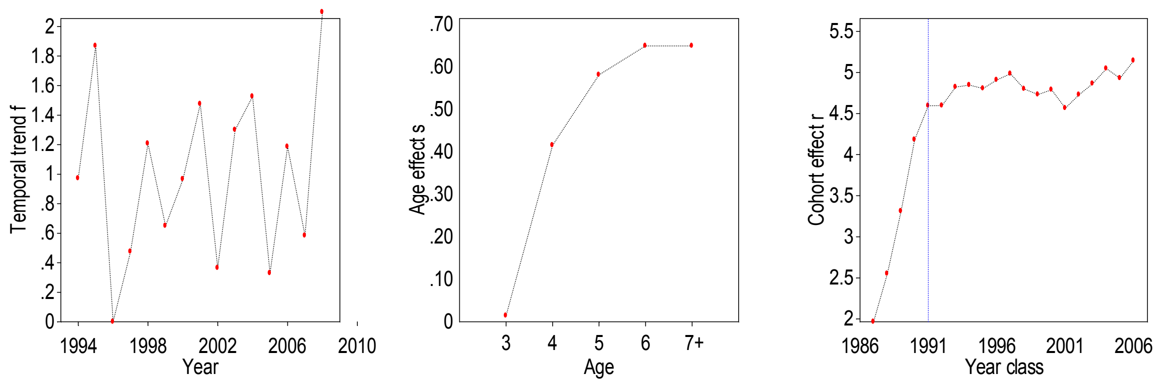


Fig. 7.18.4.1.3.1 MEDITS survey. Fitted year, age and cohort effects estimated by SURBA.

SURBA fishing mortality ($F_{3\text{-}6}$) estimated with MEDITS fluctuated between 0.17 in 1996 and 0.62 in 2008. Relative spawning stock biomass (SSB) indices showed a fluctuating trend with two main peaks in 2001 and 2008 (Fig. 7.18.4.1.3.2).

Young of the year are poorly captured by the commercial fleet and during surveys. Relative indices for ages 2+, obtained from MEDITS survey indicated an increasing trend (Fig. 7.18.4.1.3.2).

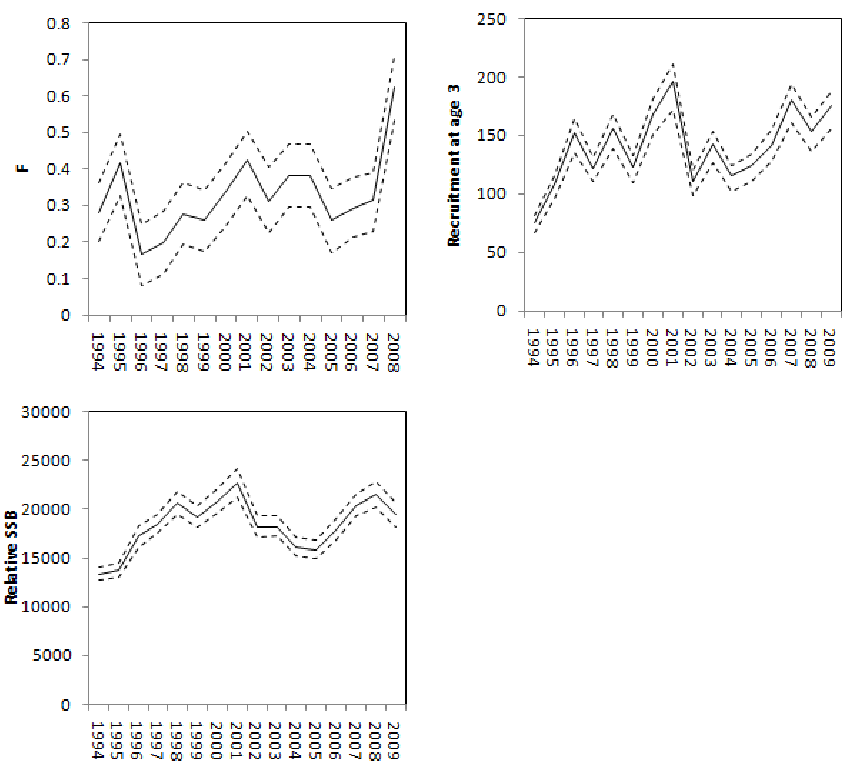
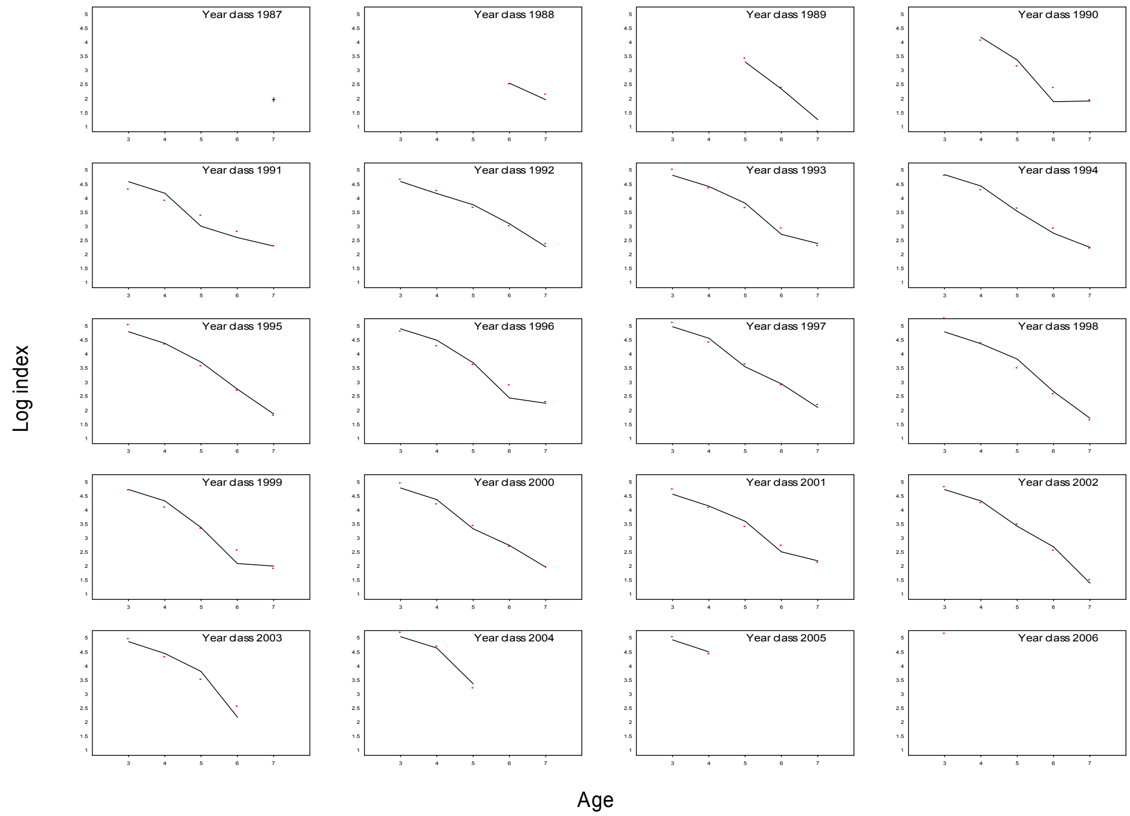


Fig. 7.18.4.1.3.2 MEDITS survey. SURBA estimates of mean $F_{3\text{-}6}$, SSB, and abundance at age 4

Model diagnostics are shown in the Fig. 7.18.4.1.3.3.



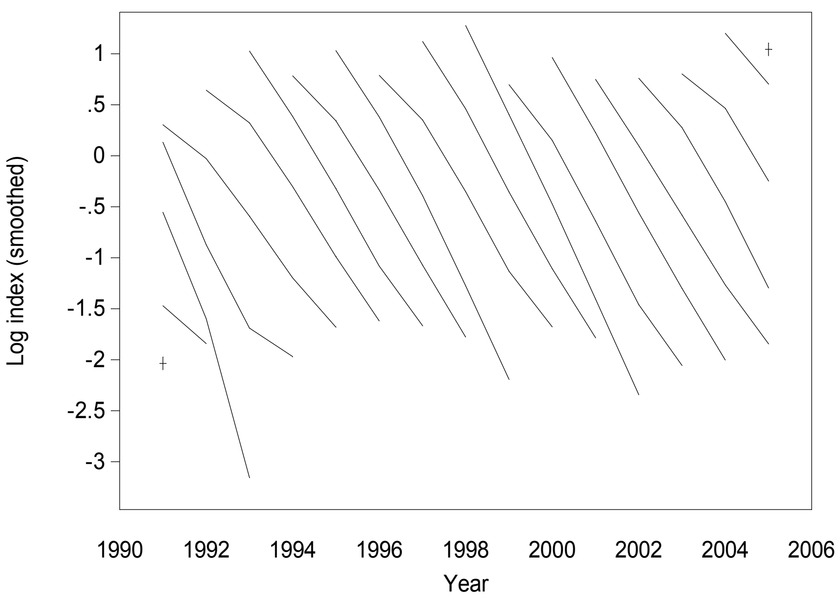


Fig. 7.18.4.1.3.3. Model diagnostic for Surba model in the GSA 09. a) Comparison between observed (points) and fitted (lines) of MEDITS survey abundance indices, for each year. b) Log survey abundance indices by cohort. Each line represents the fitted log index abundance of a particular cohort throughout its life.

7.18.4.2.Method 2: LCA on DCR data

7.18.4.2.1. Justification

Assessment was performed using an LCA (VIT software, Lleonart and Salat 1997) on an annual pseudocohort (2006-2009). During SGMED 10-03 a new LCA was performed usinf DCF data for 2009.

7.18.4.2.2. Input parameters

Data coming from DCR provided at SGMED-09-02 contained, for GSA 09, information on landings and the respective size/age structure for 2006-2009. The short data time series did not allow the application of VPA.

LCA was performed using VIT software on data of the years 2006, 2007, 2008, 2009. Tab. 7.18.4.2.2.1 shows the input data. The used parameters were the same of the SURBA analysis, including the M-vector and the maturity ogive.

Tab. 7.18.4.2.2.1. Input data for LCA of the Norway lobster in GSA 09.

Carapace length	2006	2007	2008	2009
14		2.5	3.7	
16	0.0	2.5	11.7	
18	0.0	16.0	63.9	16.9
20	45.3	160.7	103.2	75.5
22	99.3	221.2	159.9	330.9
24	203.2	363.4	260.8	438.2
26	388.2	384.0	473.2	772.3
28	790.4	401.4	572.2	703.0
30	1139.5	439.4	558.0	853.2
32	1055.9	581.5	603.3	521.7
34	650.3	543.6	587.2	663.2
36	444.0	490.6	622.7	597.4
38	279.5	331.6	423.3	608.3
40	252.8	187.5	357.8	400.7
42	177.3	178.5	192.3	294.1
44	173.5	167.7	271.7	195.5
46	120.5	253.8	147.1	140.7
48	82.3	269.7	66.2	105.5
50	249.3	175.9	89.5	122.3
52	34.4	213.8	148.8	50.3
54	14.8	151.6	70.5	52.8
56	18.5	10.1	14.3	41.2
58	16.4	4.2	19.7	10.9
60	12.2	5.0	8.8	11.4
62	0.0	2.9	1.9	3.7
64	0.0	0.4	0.5	0.9

7.18.4.2.3. Results

The general results of LCA (Fig. 7.18.4.2.3.1) show mean values of F (3-6) ranging from 0.34 to 0.58, very similar to those estimated with SURBA.

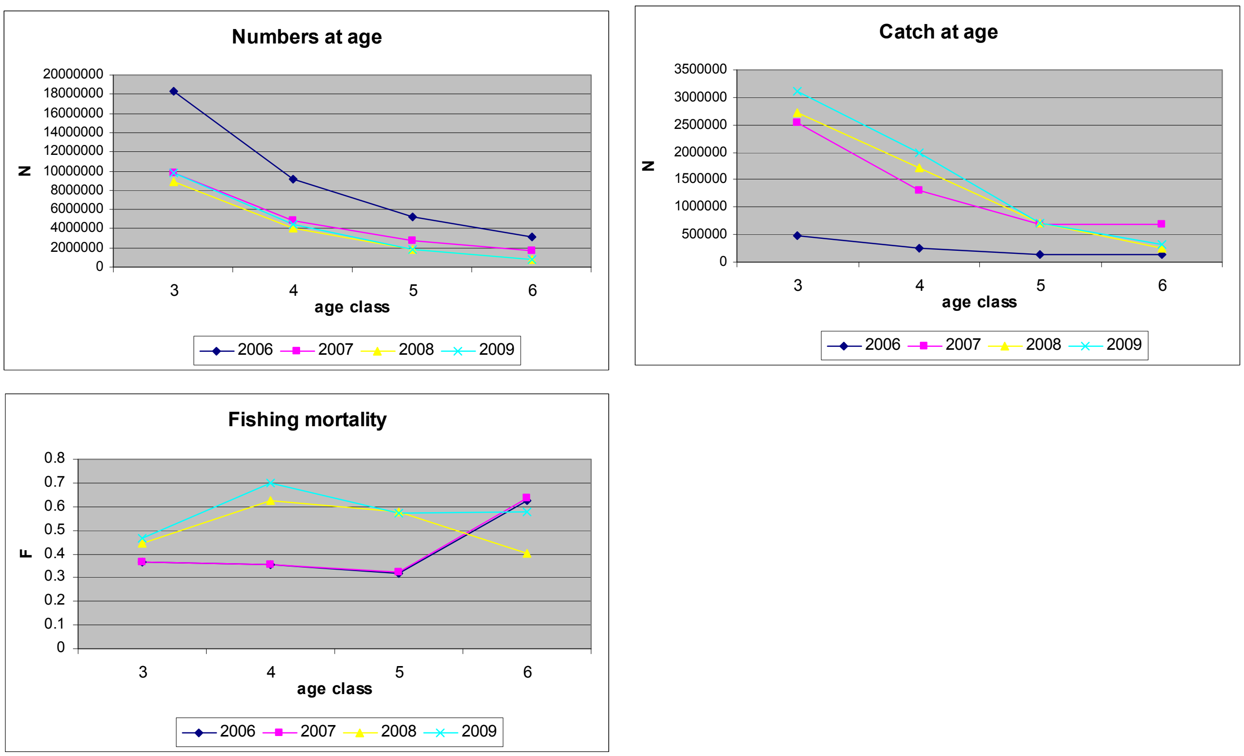


Fig. 7.18.4.2.3.1. LCA outputs: catch numbers, numbers-at-age and fishing mortality at age of *N. norvegicus* in GSA 09.

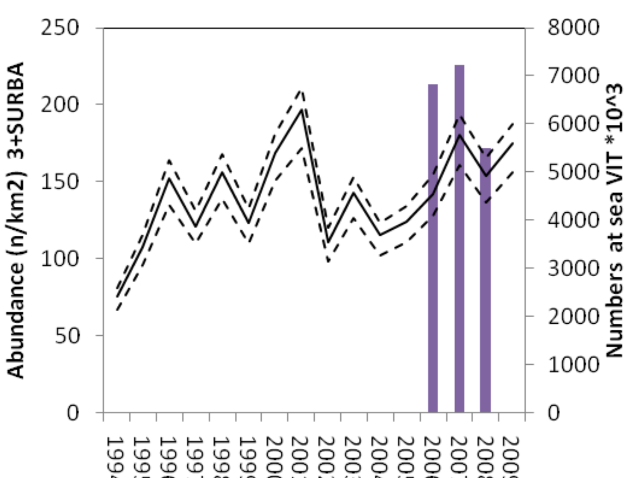


Fig. 7.18.5.2.3.2. Comparison between SURBA estimates of abundance-at-age 3 and numbers at sea for age 3 estimated from landing data for 2006-2008.

7.18.5. *Long term prediction*

7.18.5.1. Justification

Equilibrium YPR reference points for the stock estimated through the Yield software (Hoggarth *et al.*, 2006) which assumes recruitment fluctuating randomly around a constant value and 20% uncertainty in input parameters. Further YPR analyses were conducted based on the VIT (pseudocohort) results.

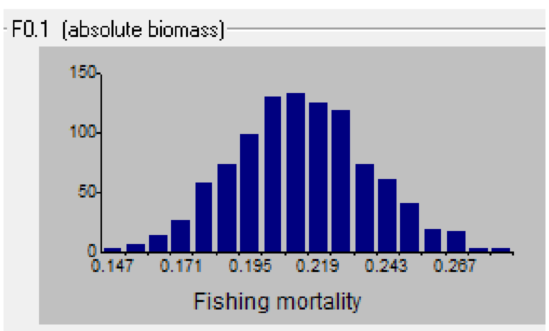
7.18.5.2. Input parameters

Parameters used were the same imputed for SURBA and LCA analyses.

7.18.5.3. Results

Yield software quantified uncertainty by repeatedly selecting a set of biological and fishery parameters by sampling from the probability distributions for uncertain parameters set by the user, and then calculating the quantities of interest. In this sampling, it is assumed that each of the uncertain parameters are independently distributed, even though for some biological parameters, this assumption is almost certainly incorrect (Hoggarth *et al.*, 2006). F_{max} and $F_{0.1}$ were assumed respectively as limiting and target reference points. Their probability distributions showed a considerable variation (Fig. 7.18.5.3.1). The following median values were obtained: F_{max} = 0.36; $F_{0.1}$= 0.21. The maximum predicted values were respectively 0.59 (F_{max}) and 0.30 (F_{01}).

Considering that the estimated current F was around 0.3 with a SURBA estimates of RPs suggest that the *N. norvegicus* stock is currently overexploited.



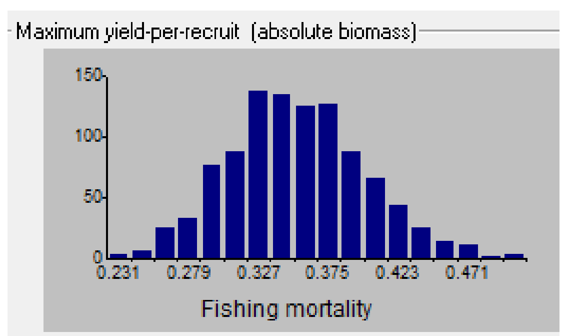


Fig. 7.18.5.3.1 Probability distribution of Norway lobster RPs in the GSA 09 obtained using the Yield software.

7.18.6. *Data quality and availability*

MEDITS survey data were available from 1994. A check of hauls allocation between GSA 09 and 10 needs to be done before calculation of indices from JRC MEDITS database.

7.18.7. *Scientific advice*

7.18.7.1. Short term considerations

7.18.7.1.1. State of the spawning stock size

Relative spawning stock biomass (SSB) indices derived from MEDITS (1994-2009) and GRUND (1994-2006) showed fluctuations without a particular trend in the spawning stock biomass (SSB). However, both indices of abundance and biomass in 2009 represent the maximum values since 1994.

SGMED-10-02 cannot fully evaluate the state of the SSB due to a lack of precautionary management reference points.

7.18.7.1.2. State of recruitment

Recruitment (age groups 1+ and 2+) showed a significant increasing trend since 1994.

7.18.7.1.3. State of exploitation

SGMED-10-03 proposes the estimated $F_{0.1}$ =0.21 as limit management reference point for sustainable exploitation consistent with high long term yield (F_{MSY} proxy).

Recent values of F_{3-6} obtained on commercial data with LCA (VIT) and using SURBA indicate that the stock is currently overexploited. SGMED-10-03 recommends a reduction of fishing effort to be achieved by means of a multiannual management plan towards the proposed management reference point in order to avoid long term losses in yield. Such management plan should consider the mixed fisheries implications for the *Nephrops* fisheries. SGMED-10-03 recommends the resulting catches consistent with the effort reductions be determined.

8. BIO-ECONOMIC MODEL REVIEWS AND FORECASTING TORS G AND H)

8.1. Review of existing bio-economic models for Mediterranean fisheries

SGMED-09-02 has reviewed the "Survey of existing bio-economic models" under Studies and Pilot Projects for carrying out the Common Fisheries Policy No FISH/2007/07 and highlighted that two bio-economic models, MEFISTO and BIRDMOD, among those described in that study are suitable to produce advice on biological and socio-economic impacts of a set of management measures for Mediterranean fisheries. However, both models have been developed to measure the effects of specific management measures rather than stock by stock harvesting strategies as defined by SGMED. Even though these models can be adapted to the approach followed by SGMED, other modelling approaches seem to be more appropriate.

The main problem encountered in the use of such models within the work of SGMED is represented by the level of integration between the biological and economic component. Both MEFISTO and BIRDMOD provide integrated bio-economic analysis using incorporated dynamic biological sub-models. These models can produce results in terms of stock biomass and yield different than those obtained by SGMED, which use alternative approaches. As a consequence, the economic outcomes would be associated to the biological assessment and forecasts coming from the biological sub-models of MEFISTO or BIRDMOD, and not from those provided by SGMED.

To overcome the problem, a different modelling approach based on the use of a non-integrated bio-economic model can be adopted. This approach consists of two steps:

1. the production of biological assessment and forecasts on stock biomass and yield based on a set of harvesting strategies (as done for many stocks and GSAs under point f),
2. an economic evaluation based on the catches by stock estimated in the first step.

A description of a potential non-integrated model, named HDA0.1, for the evaluation of economic consequences is provided in Appendix 4. Even though this seems to be the only approach compatible with the work structure developed until now within SGMED, it is strongly **recommended** to start as soon as possible to adopt an integrated approach for providing bio-economic evaluation of management options and/or harvesting strategies.

The difference between integrated and non-integrated bio-economic models can be deduced by comparing Figures 8.1.1 and 8.1.2. Fig. 8.1.1 shows the structure of a generic integrated bio-economic model where the economic outcomes can affect fishermen behaviour (Decision rules) changing the levels of capacity (number of vessels, GT or kW) and activity (days or hours at sea). Variations in fishermen behaviour would modify fishing effort and impact on stock biomass and yield in the subsequent period. On the contrary, fishermen behaviour is not included in a non-integrated model (Fig. 8.1.2) and the economic outcomes would not have any (direct or indirect) impact on stock biomass.

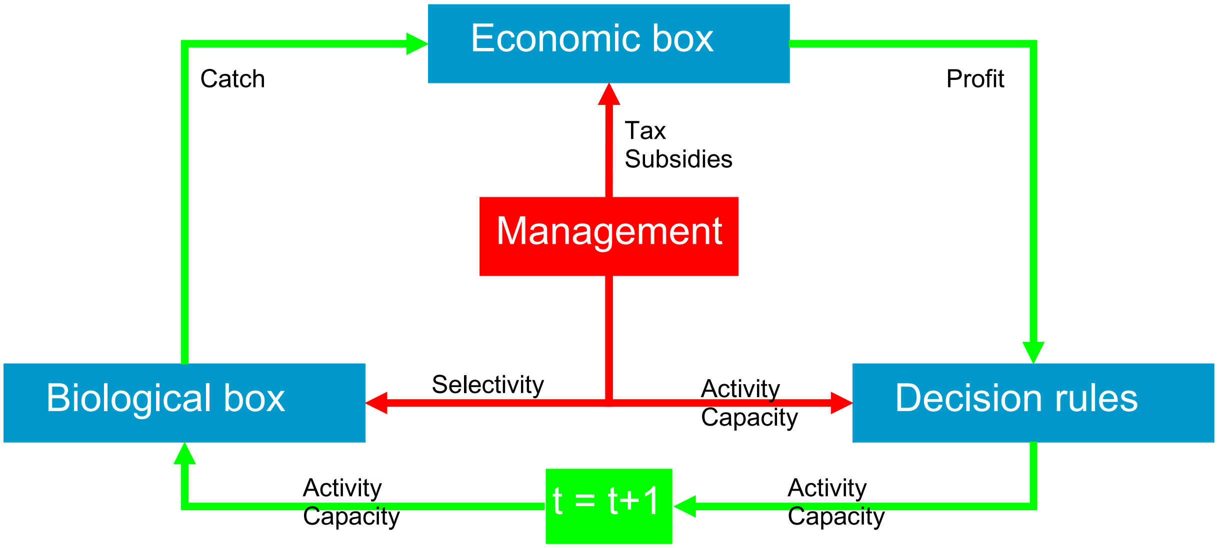


Fig. 8.1.1 - The structure of an integrated bio-economic simulation model

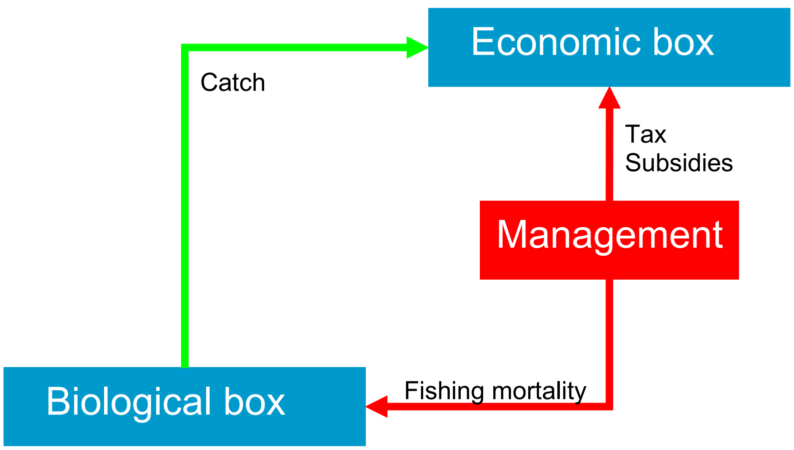


Fig. 8.1.2 - The structure of a non-integrated bio-economic simulation model

8.2. Use of MEY as a reference point and its estimation by bio-economic models

As the Maximum Sustainable Yield (MSY), also the Maximum Economic Yield (MEY) originates from logistic models, as the Gordon-Schaefer equilibrium model. The MEY is obtained at the level of fishing effort in which the maximum profit is achieved. In other words, it corresponds to the highest difference between revenues and total costs. Given the cost function as linear, the MEY value is positioned before and below the MSY (that is, left of the MSY, see Fig. 8.2.2). Since the effort that corresponds to the economic optimum is lower then that of the biological MSY, the adoption of the MEY as a RP will reduce the risk of overexploitation of resources. The level of effort associated with the MEY is likely to fluctuate as a consequence of the changes in the variables of the reference economic framework, such as the cost of fishing activities and the price of landings. When the price is a function of the catch quantity and, therefore, of the offer, low levels of catch may also correspond to higher profits. In these cases, the economic optimum will be positioned further left in the long-term equilibrium curve.

Both RPs (MSY and MEY) are based on models designed for single-species fisheries. Given the large biological and technical interactions within the Mediterranean Sea, a management system based on single species RPs would be totally unfeasible. Indeed, the same fishing effort will be directed to harvesting different species, to which different MSYs and levels of optimal effort might be applied. Figure 8.2.3 provides a clear example of this situation. Within this system fishery targets three species, each species has its own MSY. If we consider the aggregate catches by summing up the curves of sustainable production for each single species we may obtain a MSY corresponding to the optimal effort E_{msy} through which we may determine the impoverishment of the less productive stocks. In the case under discussion, species no. 3 is doomed to become extinct if we adopt the point equal to E_{msy} due to the level of long-term effort. As regards stocks preservation, from a precautionary viewpoint, the only feasible solution would be to define an RP which takes into consideration the species most vulnerable to fishery (in Fig. 8.2.3, species no. 3). This choice might prevent marine resources from being over-fished or even extinct, nevertheless it has large socio-economic costs in the short term although it might provide gains to fisheries industry and also to other stakeholders in the long term.

Within a multi-species context, the single-species economic approach (MEY) also follows different and much more complex guidelines. Compared to the MSY level, the level of effort corresponding to the MEY can no longer be considered as a prudential value. Indeed, since it depends on the ratios between the prices of the different species, it is likely to be positioned either on the left or on the right of the E_{msy} value. The latter case is expected to occur when consumers' choices determine a higher price of the most productive species. If species with higher E_{msy} also have a higher market value, the E_{mey} value will be positioned to the right of the E_{msy} value. Figure 8.2.4 illustrates this case: compared to species no. 2 and 3, species no. 1 shows a significantly higher price. This determines a MEY effort (E_{mey}) higher than the effort related to the MSY (E_{msy}). Conversely, when a higher price is associated with species whose intrinsic growth rate is lower, the MEY will be found on the left of the MSY. However, in this case the equivalent level of effort will not ensure the prevention of species belonging to the productive mix from being over-fished.

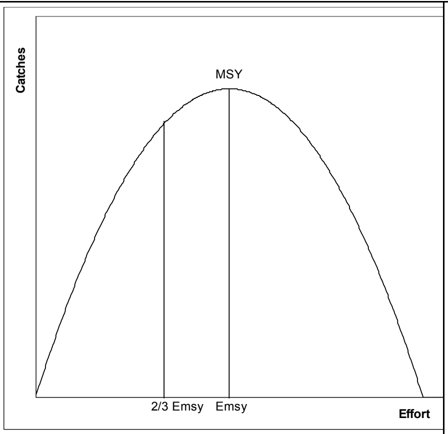


Fig. 8.2.1 - Gordon-Schaefer model. *Emsy* and *2/3Emsy*.

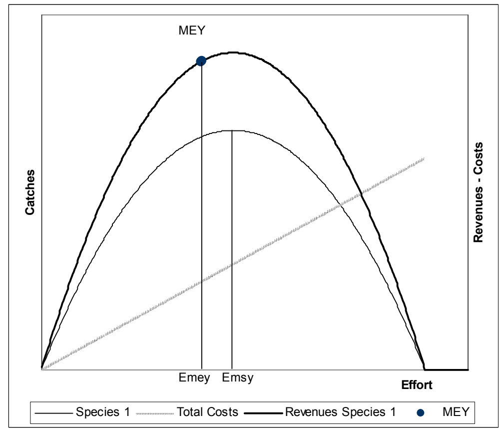


Fig 8.2.2 - Gordon-Schaefer model. Identification of *Emsy* and *Emey*.

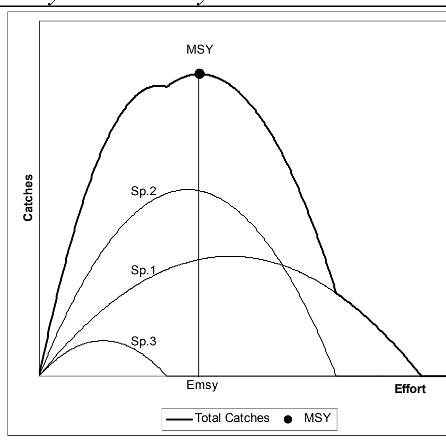


Fig. 8.2.3 - Gordon-Schaefer model in a multispecies fishery. Identification of E_{msy}.

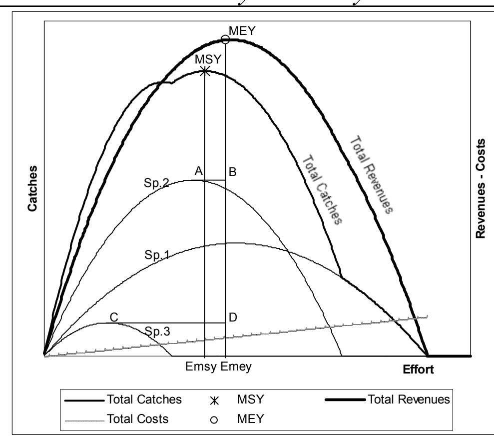


Fig. 8.2.4 – Gordon-Schaefer model in a multispecies fishery. Identification of E_{msy} and E_{mey}.

MEY or E_{mey} can be estimated by using bio-economic models. The most suitable approach for estimating optimal levels of fishing effort, such those corresponding to MSY or MEY, consists in using optimization bio-economic model. Indeed, these models are specifically developed to estimate optimal solutions. However, simulation bio-economic models, like MEFISTO or BIRDMOD, also can be used to identify optimal solutions. This is possible by simulating the effects of different levels of fishing effort and comparing long-term results of each simulation. An approximation of the optimal level of effort maximizing the economic yield in the long-run will be easily identified.

8.3. Appropriateness to dealing with Mediterranean bio-economic analyses under SGMED

As the European Community is expected to establish long-term management plans (LTMP) for relevant Mediterranean demersal and small pelagic fisheries, a bio-economic analysis of the harvesting strategies defined during the SGMED meetings represents a necessary contribution. However, some problems have been encountered in producing an integrated bio-economic analysis. The main problems are reported below:

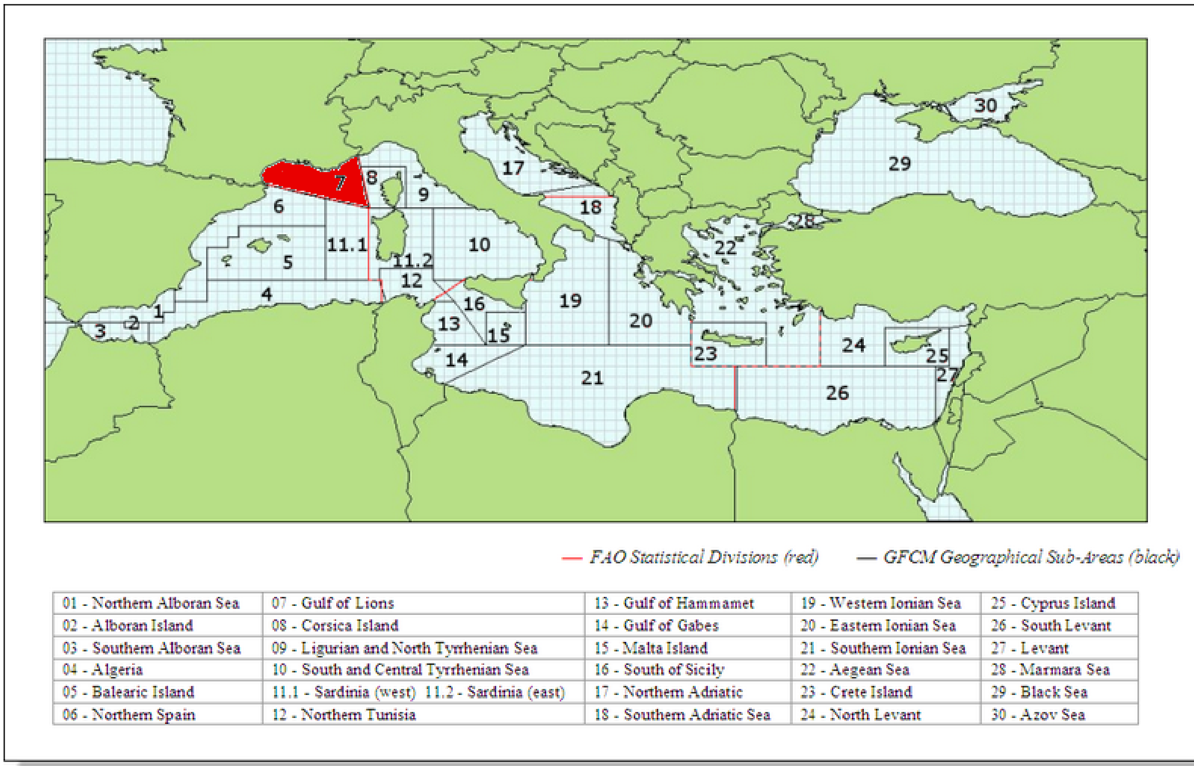
- Economic data have not been provided by GSA, but country. Given the stock biomass and yield assessment provided stock by stock at GSA level, the lack of economic data at the same level of aggregation does not allow SGMED to use bio-economic models and provide an economic evaluation of the harvesting strategies.
- Even in case economic data will be made available at GSA level, harvesting strategies simulated by single stock will not allow for an integrated bio-economic evaluation. Indeed, predicting economic consequences of harvesting strategies needs a simulation of each strategy on a sufficient number of

stocks to cover an acceptable proportion of total landings and total revenues for each of the fleet segments involved in that fishery.

- Use of integrated bio-economic models needs the collection of time series data and the estimation of a great number of biological and economic parameters. Therefore, a significant preliminary work is necessary to produce an acceptable bio-economic analysis. This work cannot reasonably be done during the meeting.
- Existing bio-economic models for the Mediterranean fisheries have been developed to answer specific questions. Changing the objectives of the bio-economic analysis and the requested outputs could require an adaptation of model structure and a further development of modelling methods.

Given the problems described above, undertaking such work under the umbrella of STECF SGECA does not seem to be a solution as SGECA will probably encounter the same problems highlighted above. Furthermore, experts participating in SGECA meetings, when interested in Mediterranean bio-economic analysis, are welcome to take part in SGMED meetings as well. Given the preparatory needs regarding complete stock and fisheries assessments it appears inappropriate to undertake bio-economic predictions during the ordinary SGMED stock and fisheries assessment expert meetings in 2011. SGMED notes that only hindcasting modeling of the economic fisheries performance shall be undertaken in parallel to its stock assessment sessions EWG 11-05, EWG 11-12 and EWG 11-20. Taking further into account that the economic data are usually available with a 2 years delay, SGMED recommends to dedicate a specific SGMED meeting with expertise in both stock and fisheries assessments as well as in fisheries economy attending to undertake bio-economic analyses and to provide respective integrated management advice. Such SGMED meeting shall be held in the first quarter in 2012, and the work shall be based on the results of the SGMED meetings in 2011 and the biological and economic data compiled at a consistent aggregation level through the 2011 SGMED data call..

8.4. Bioeconomic analysis of GSA07 (“Gulf of Lions”) hake and red mullet demersal fishery



The two main species, for which biological assessments are available and which constitute the main target species of the demersal fleets operating in the area, are: European hake (*Merluccius merluccius*), and red mullet (*Mullus barbatus*).

2009	Catch (t)
Merluccius merluccius	2261
Mullus barbatus	146

The four fleets considered in this bioeconomic simulation study are: two trawl fleets (one Spanish and one French, with 27 and 109 trawlers, respectively mean on the period 1998-2009), one Spanish longline fleet (with 15 longliners) and one French gillnetter fleet (with 72 gillnetters).

The biological parameters for the two stocks (growth parameters, abundance, fishing and natural mortality vectors, maturity) were obtained from recent stock assessments conducted by STECF-SGMED 10-02 group (Cardinale et al., 2010, pp. 196-211 and pp. 401-411). Economic parameters (costs and prices) were computed from the economic data set submitted by France to the SGMED 10-03 working group for the Mediterranean trawl and gillnet fleets, complemented with data from the STECF Annual Economic Report of the EU Fishing Fleet (STECF, 2010). Spain did not provide the corresponding economic data and this group has decided to use the French data for Mediterranean trawl and longline fleets. Without Spanish economic data, the following analysis was made on the assumption of technical similarity of characteristics between Spanish and French fleets, so results have to be considered with caution.

8.4.1. *Analytical tool:*

The forward bioeconomic projection of the GSA07 fishery was performed with the bioeconomic model MEFISTO ("Mediterranean FIsheries Simulation Tool", fully documented in Lleonart *et al*., 2003), freely available at www.mefisto.info. MEFISTO is a multi-species, multi-fleet model with technical interactions, with one or more fleets competing for a pool of fishery resources. The model comprises two interacting sub-models: one defining the population dynamics of the stock and the other defining the vessel dynamics. For the stock sub-model, MEFISTO follows the general formulation of a fully age-structured model, but it differs from other bioeconomic models in that MEFISTO follows a fully age-structured model for the biology of main species (for which assessment data is available, in this case: *M. merluccius* and *M. barbatus*) and treats the production of secondary (by-catch) species as an empirically estimated function of main species, because no biological parameters are available for these species, although they make a significant contribution to the total revenues of the vessels. In the case of GSA07 trawlers, the 2 species taken into account for the biological submodel account for 14% of the catch and 20% of the value.
The economic submodel applied here is a standard revenues minus costs submodel, with the endogenous effort-allocation dynamics of MEFISTO deactivated. The cost structure in the model includes trade costs, fuel costs, labour costs, fixed and depreciation costs, opportunity costs and financial costs. Note that in Mediterranean fisheries labour costs are a share of the revenues minus common costs (fuel and other daily costs are met by the owner and the crew). Hence, even maintaining the same fishing effort, when catches increase and revenues are higher, costs will also increase, because labour and trade costs increase.

8.4.2. *Biological data:*

The necessary input data required for year 0 (2009) of the simulation are shown in the following tables (taken from Cardinale *et al*., 2010):

allometric and vBGF coefficients

a	b	Linf	K	t0	Ncoh	nomstock
0.00690	3.03	86.75	0.2345	0	9	hake
0.0081	3.113	26	0.41	-0.4	5	redmullet

Stock number, vector of maturity, vector of natural mortality (M), vector of fishing mortality (F)

stockname	age	number	Mat	M
hake	0	54758000	0	1.25
hake	1	22099000	0	0.47
hake	2	4054000	0.45	0.30
hake	3	963000	0.98	0.22
hake	4	223000	1	0.19
hake	5	81000	1	0.17
hake	6	39000	1	0.16
hake	7	38000	1	0.15
hake	8	38000	1	0.14
redmullet	0	13000000	0	0.64
redmullet	1	6500000	0.17	0.43
redmullet	2	1900000	0.61	0.27
redmullet	3	500000	0.89	0.18
redmullet	4	10000	0.96	0.15

Recruitment (number of individuals) is assumed to follow a constant model (based on the geometric mean geometric mean of the whole period 1998-2009).

recruitment model

stockname	type	rec1
hake	0	49 725 000
redmullet	0	13 000 000

8.4.3. *Economic data:*

French economic data for 2008 were made available to the SGMED from the economic database submitted by each country; this data set has been complemented with economic data from Anderson and Guillen (2010). The economic analysis assumes that:

- The opportunity cost interest is set at 1.5%.
- It is estimated that the economic life of a vessel is 20 years. Thus, the depreciation of the vessel is established at a 5% annual rate.
- It is assumed that fish price is constant over time, and independent of the catch level/landings.

Economic official data cannot be transposed directly to the MEFISTO model and some assumptions have to be made to calculate the necessary parameters. For instance, the costs and revenues of a fleet are related to the entire set of species caught, not only to the 2 species modeled here. For this reason, an empirical relationship between catch of the main species and total catch was introduced (based on data in STECF 2010).

Economic and technical parameters:

	Spanish trawl	Spanish longline	French trawl	French gillnet
Number of fishing days per year	189	190	195	156
Commercial (or trade) cost	16%	16%	16%	16%
Fuel price	0.54 € / l	0.58 € / l	0.59 € / l	0.68 € / l
Opportunity cost	1.5%	1.5%	1.5%	1.5%
Financial cost	5%	5%	5%	5%
Capital	21 134 033 €	4 391 826 €	107 883 636 €	17 781 765 €
Gross tonnage	2401 GT	595 GT	10 996 GT	1175 GT
Fuel consumption	51 222 l / d	4 099 l / d	194 166 l / d	4 044 l / d
Crew size	105 FTE	51 FTE	468 FTE	126 FTE
Annual costs	4 855 475 €	1 102 609 €	21 812 364 €	1 466 941 €
Percentage of annual fixed costs	57.2%	54.5%	64.9%	68.5%
Percentage of annual depreciation costs	42.8%	45.5%	35.1%	31.5%
Unit price of hake	3.36 € / kg	3.71 € / kg	3.19 € / kg	4.90 € / kg
Unit price of red mullet	6.73 € / kg	*Not caught*	7.65 € /kg	*Not caught*

Additionally, constant capital is assumed throughout the simulation horizon. This assumption implies no internal investment in the fleet and no external investment (i.e., absence of national or Community subsidies).

8.4.4. *Simulation conditions:*

The simultaneous forward projections of the 2 stocks and 4 fleets were performed for the period 2010-2020 for each scenario (base year 2009). Two simulation scenarios were compared, one based on F_{ref} and the second one based on the F_{01} values recommended in Cardinale et al. (2010):

	F_{ref}	F_{01}
Hake	0.9207	0.267 (Fbar 0-3); 0.25 (Fbar 0-8+)
Red mullet	0.619	0.54 (Fbar 0-3); 0.500 (Fbar 0-4+)

Critical assumptions / limitations:
For the 2 species, future **recruitment** was the geometric mean for the last 3 years (2007-2009) for both stocks, (see table *Recruitment* above).

For hake the historical data series on recruitment runs from 1998 to 2009, while for red mullet only information for the period 2002-2009 is available (Figs. 8.4.4.1 and 2).

Fig. 8.4.4.1. Historical and projected series of recruitment (*Merluccius merluccius*) in GSA7 under the assumption of constant recruitment around the geometric mean of the years 1998-2009

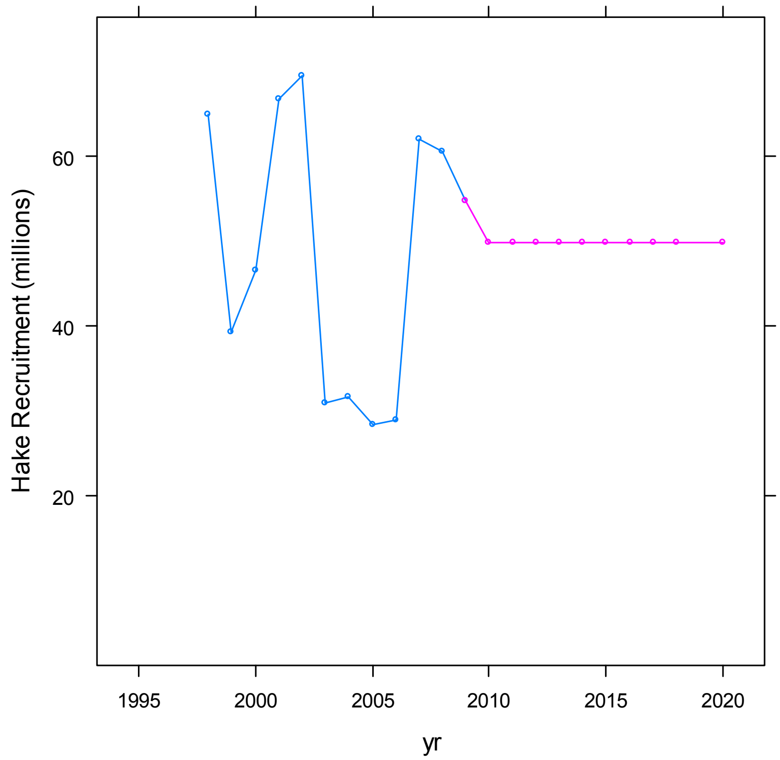
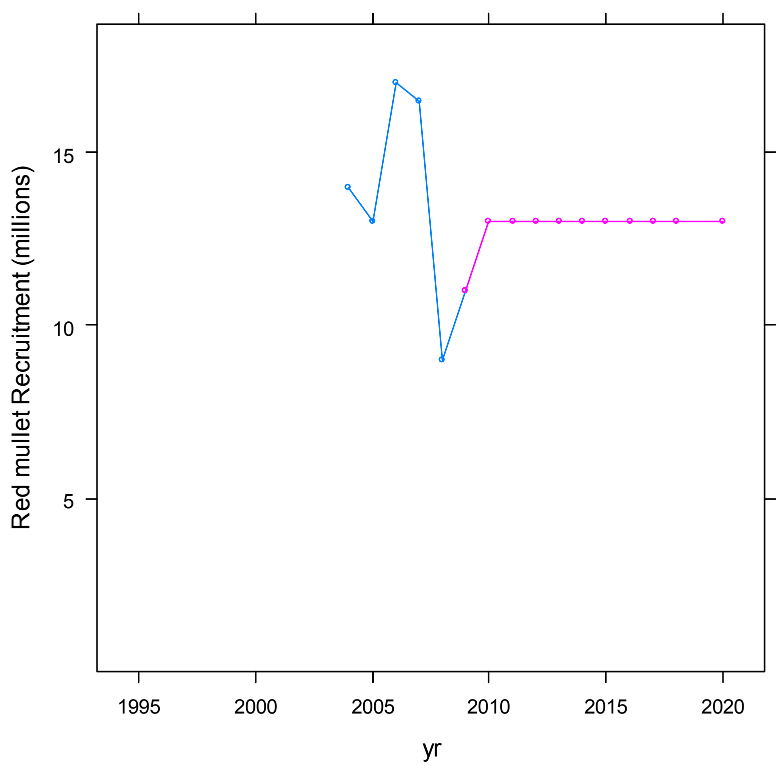


Fig. 8.4.4.2. Historical and projected series of recruitment (*Mullus barbatus*) in GSA7 under the assumption of constant recruitment around the geometric mean of the years 2002-2009



8.4.5. *Results*

Note that simulation results allow for **simultaneously analyzing the short, medium and long-term**. Summary statistics for the short-term are given in tables 1-2, while medium and long-term results can be inspected visually from the figures below.

Catches of hake in the years 2010-2012 are projected to be at the same level as in the historical series (Fig. 8.4.5.1), under current fishing levels (Fcurr corresponding to 2009). Implementing the F-reduction scenario, setting F to F_{01} , would produce the reduction of overall hake catches, particularly for the 2 trawl fleets. But note that this short term reduction in catches would be within historically observed values. In the mid and long-term (after 2015) catches would stabilize at around 3 times observed catch levels. Maintaining the status quo, i.e. continuing to fish at Fcurr, would allow maintaining catches at historically observed levels (this results depends strongly on the assumption of constant recruitment).

Catches of red mullet in the short term (2010-2012) would decrease under the F-reduction scenario (fishing at F_{01} level), below historically observed levels, but would grow to historically observed levels after 2013 (Fig. 8.4.5.2).

Fig. 8.4.5.1. Projected catches of hake (*Merluccius merluccius*) under different management scenarios. The reported catches of hake for the period 1998-2008 are shown also for comparison.

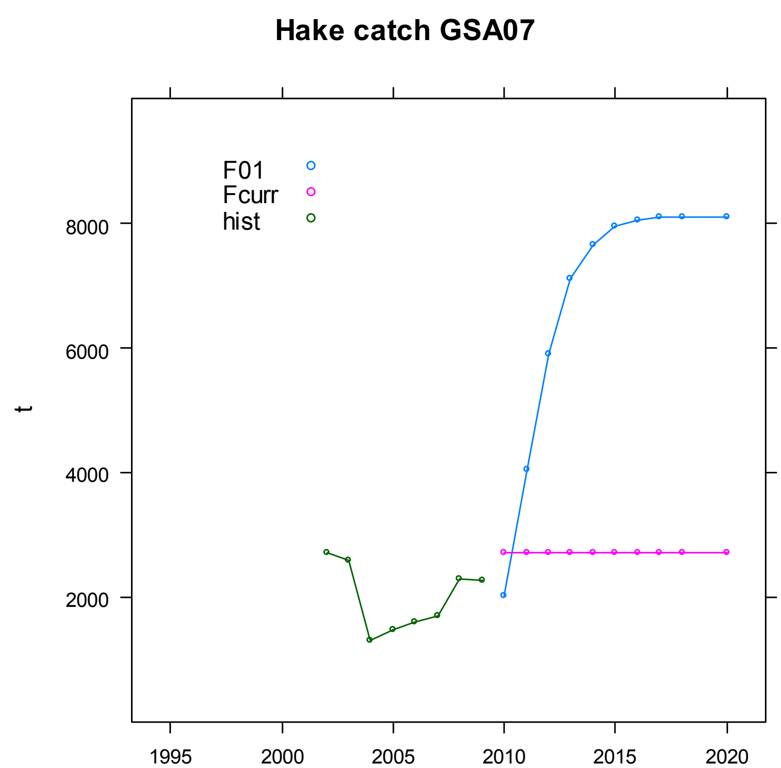
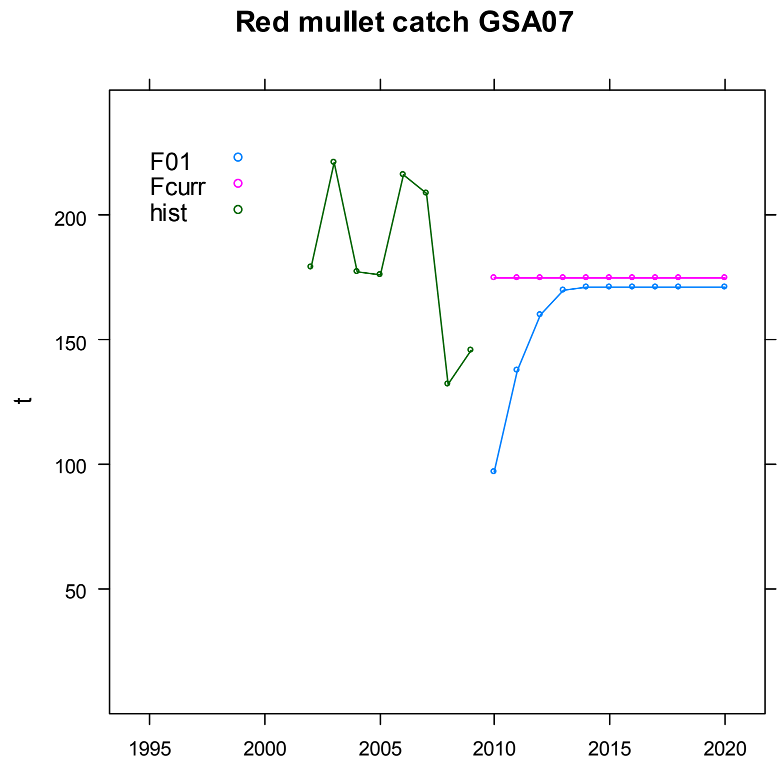


Fig. 8.4.5.2. Projected catches of red mullet (*Mullus barbatus*) under different management scenarios. The reported catches of red mullet for the period 2002-2008 are shown also for comparison.



Continuing the exploitation pattern of hake at current rates (Fcurr scenario) would imply reducing hake SSB to levels lower than observed historically (reduction of 35% of SSB, Fig. 8.4.5.3). In the F01 management scenario, SSB would grow rapidly to levels higher than 4 times of those observed historically.
In the case of red mullet, the projection of current exploitation rates would imply a strong reduction in SSB (more than 40%), while under the alternative management scenario would decrease in 2010 but grow afterwards (Fig. 8.4.5.4).

Fig. 8.4.5.3. Projected Spawning Stock Biomass of hake (*Merluccius merluccius*) under different management scenarios. The reported SSB of hake for the period 1998-2008 is shown also for comparison.

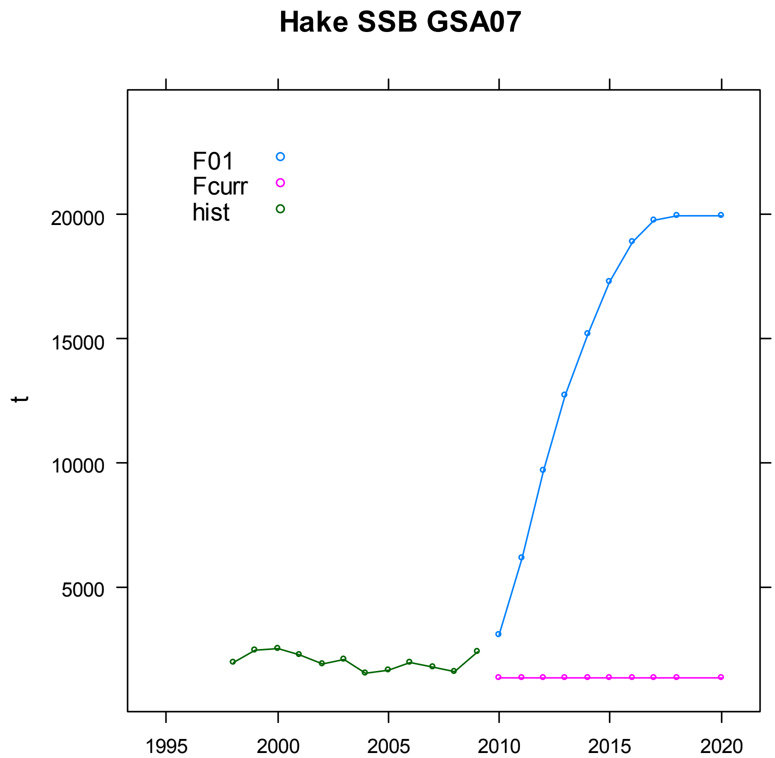
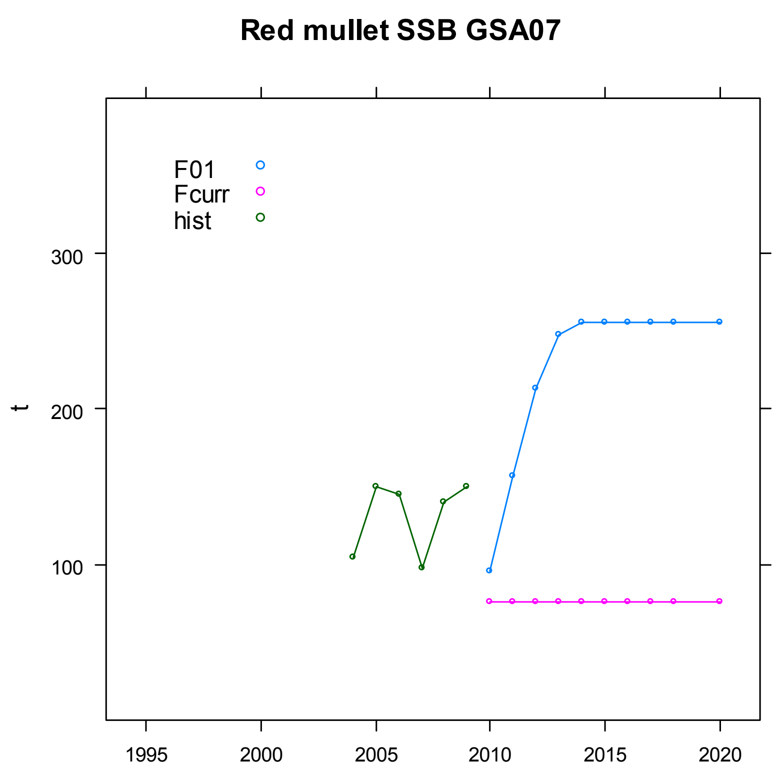


Fig. 8.4.5.4. Projected Spawning Stock Biomass of red mullet (*Mullus barbatus*) under different management scenarios. The reported SSB of red mullet for the period 2002-2008 is shown also for comparison.



8.4.6. *Economic indicators*

Two indicators were selected for analysis: Profits and Return on Investment, defined as:

RoI = (Profits / Capital) * 100

Profits of the 4 fleets are negative and likely to remain so during the projection period in the 2 simulation conditions, Fcurr and F01 (Figs 8.4.5.6.1-8).
Under the F01 scenario, both trawl fleets would suffer additional losses in the short term, due to lowered income from decreased catch of the main stocks and bycatch. In this scenario, the financial losses of French trawl fleet would decrease after 2011, but it would take until 2013 for the Spanish trawl fleet to have profits higher than in the Fcurr scenario.
In the case of the longline and gillnets fleets, continuing fishing at current levels Fcurr would make profits even more negative over time, due likely to technical competition for the resource with the trawl fleets. Conversely, the longline and gillnet fleets would not be adversely affected from the F01 management strategy in the short term, with profits essentially identical to the Fcurr scenario. In the mid and long term, profits would increase (while still negative) over the mid and long term.

These profits must be considered financial profits, in the sense that they account for the opportunity costs. The opportunity cost interest was estimated to be 1.5% in the simulation period. This is equivalent to the return of a risk-free investment. On the Return on Investment figures, it can be seen that the RoI is mostly around -0.3 - -0.6% for all fleets. This shows that maintaining the exploitation pattern of four fleets may not be fully economically rational.

Even with the negative economic profitability, this situation is stable over time. As already explained in the previous paragraph, the economic losses are lower than the opportunity cost. This means that the fishing fleets are covering their operational, fixed, financial and capital costs. So the fleets themselves are obtaining profits, but these are lower than the opportunity costs. The opportunity cost shows the return that a risk free investment can offer, so, it is expected that all economic activities, at least obtain the same return as the risk free investment. If the profits are lower tan the opportunity costs, then is more rational to invest this capital in another activity.

However, we should consider that the fishing activity has some sunk investment (the value of the vessels), that is very difficult to recover, by selling the vessels and investing it in some other activity. Moreover, it should be noted that in the fishing activity, fishermen and the captain receive a salary for their work. Often fishermen and captains are linked by blood ties or friendship to the vessel owners. Thus, the activity is giving more than just profits to the vessel owners and their community. This can explain the maintenance of these kind of "not so rational" investments from a theoretic economic point of view, but that are more than rational for the fishing communities.

The implementation of the alternative F01 scenario would allow increasing RoI towards 0 (that would be the economic equilibrium point).

Fig. 8.4.6.1. Projection of Spanish trawl fleet profits from 2010 to 2020 under different management scenarios.

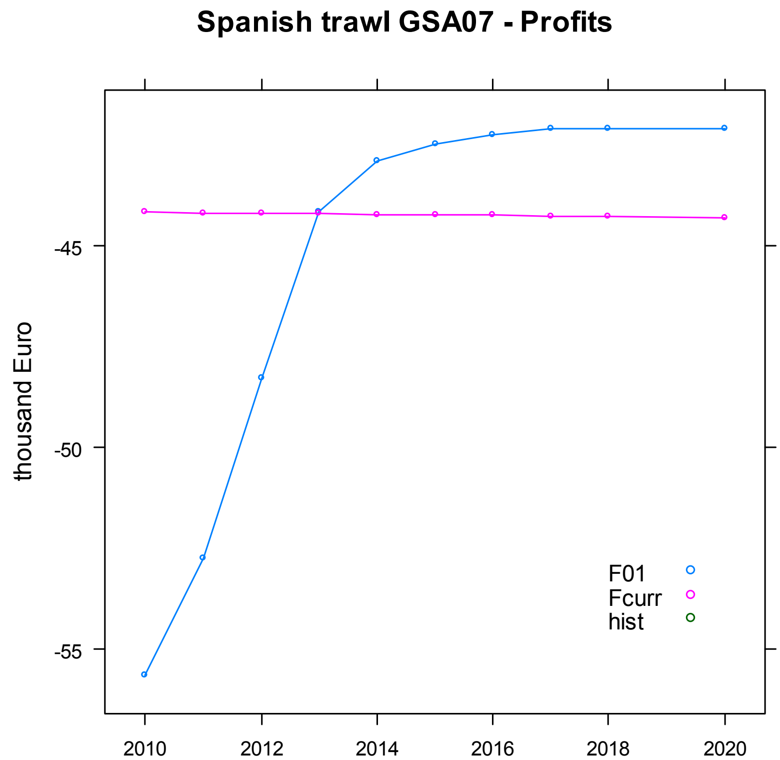


Fig. 8.4.6.2. Projection of Spanish trawl fleet Return on Investment from 2010 to 2020 under different management scenarios.

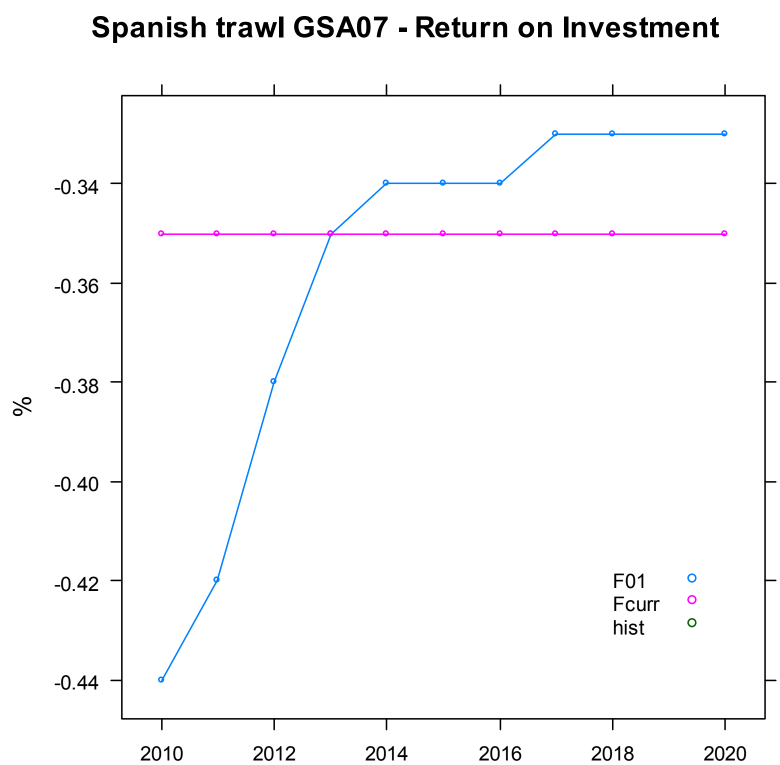


Fig. 8.4.6.3. Projection of Spanish longline fleet profits from 2010 to 2020 under different management scenarios.

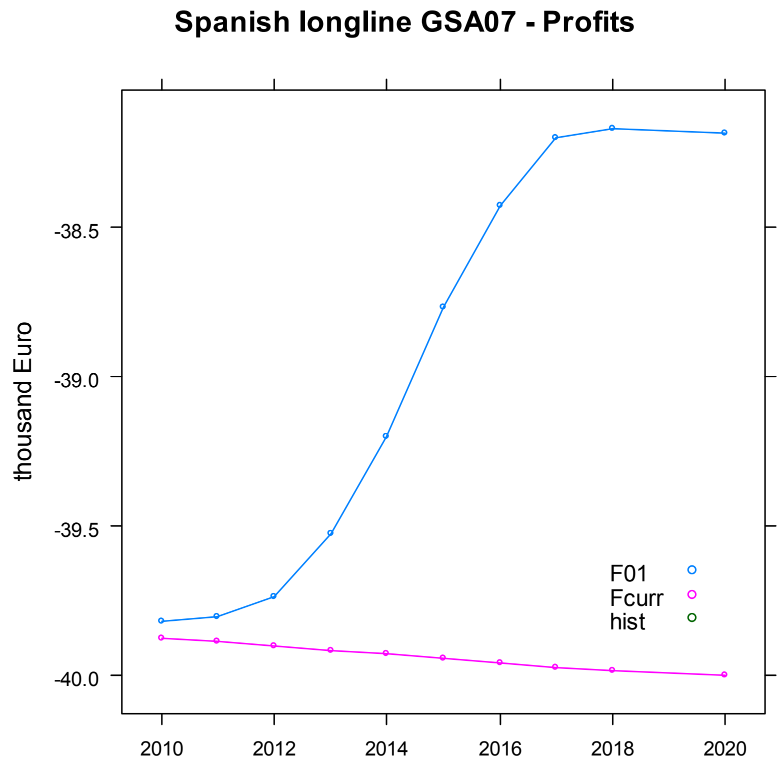


Fig. 8.4.6.4. Projection of Spanish longline fleet Return on Investment from 2020 to 2020 under different management scenarios.

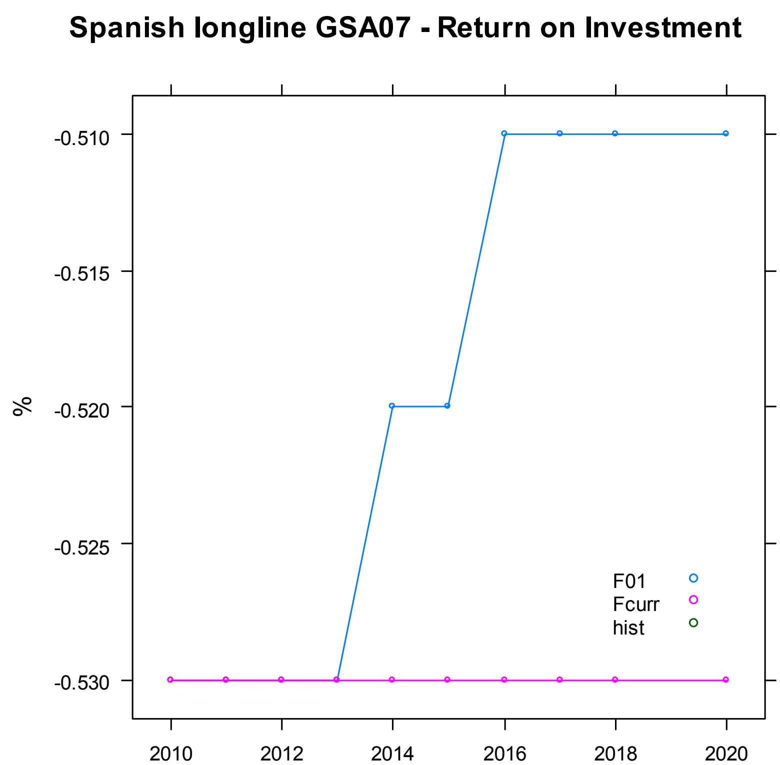


Fig. 8.4.6.5. Projection of French trawl fleet profits from 2010 to 2020 under different management scenarios.

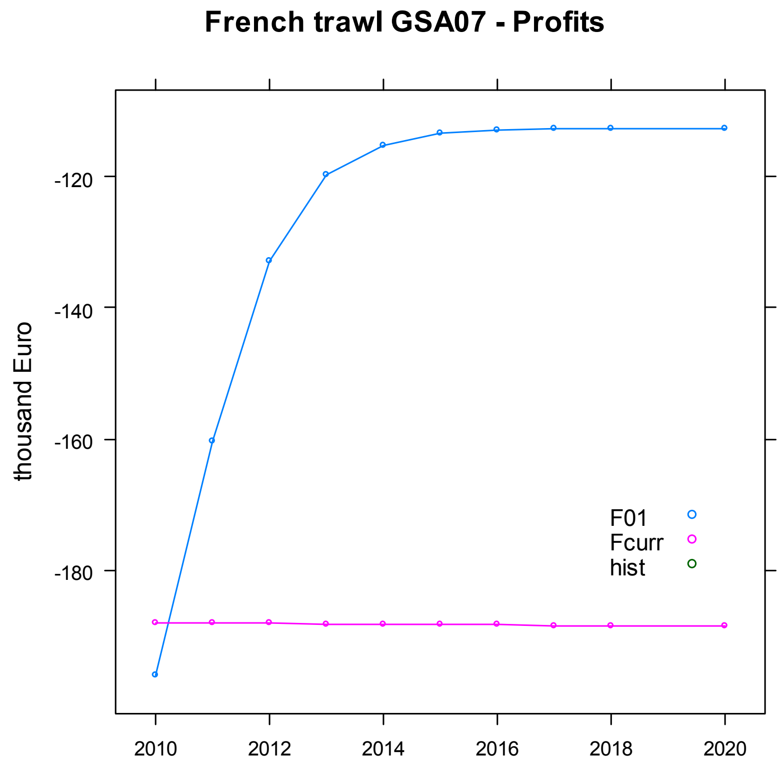


Fig. 8.4.6.6. Projection of French trawl fleet Return on Investment from 2010 to 2020 under different management scenarios.

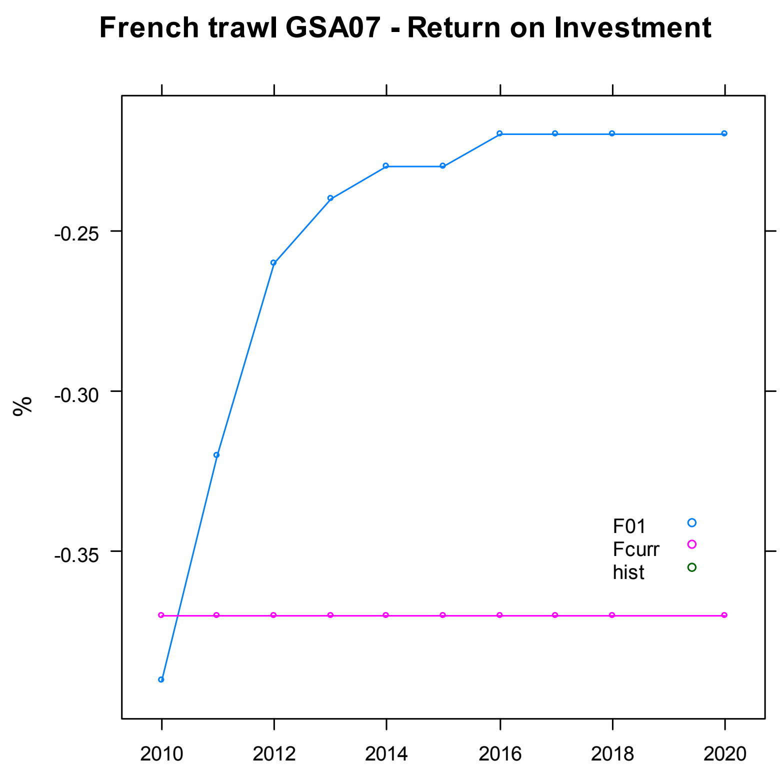


Fig. 8.4.6.7. Projection of French gillnet fleet profits from 2010 to 2020 under different management scenarios.

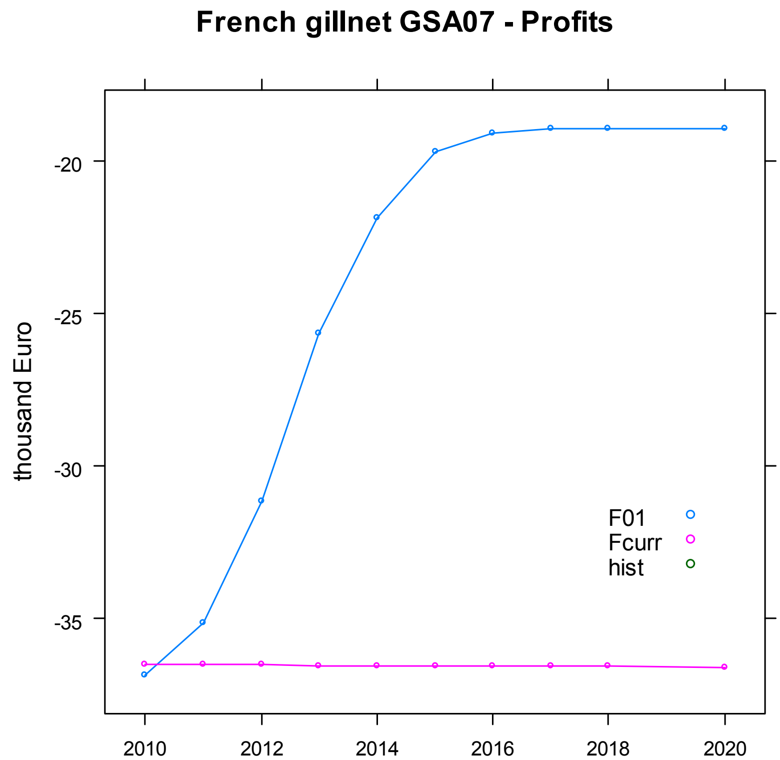
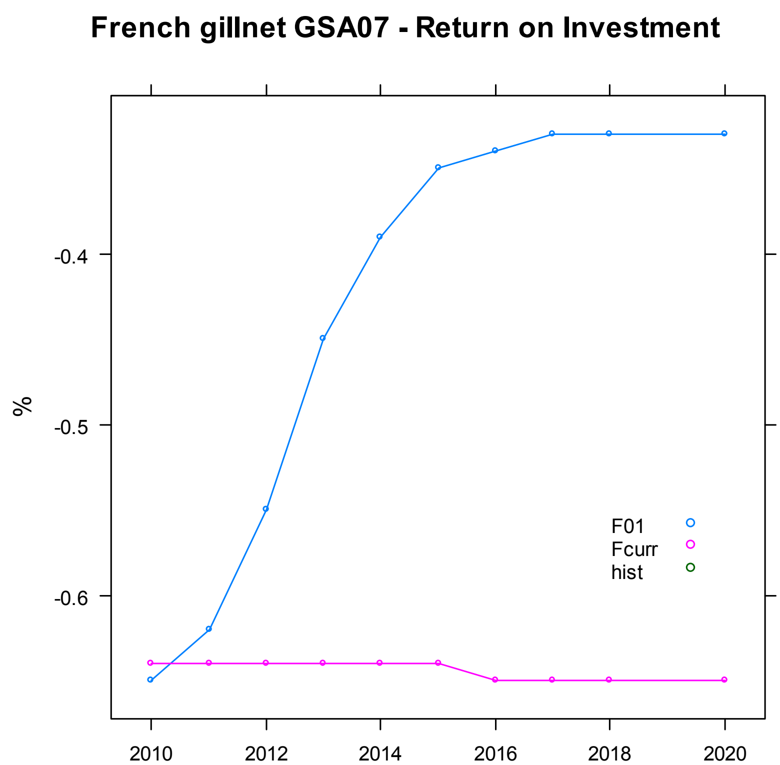


Fig. 8.4.6.8. Projection of fleet Return on Investment from 2010 to 2020 under different management scenarios.



Short-term implications

Table 8.4.6.1- *Merluccius merluccius* GSA07

Outlook for 2011

Basis:
F(2009): 0.9207 yr^{-1}
R(2009): 54.758 M ind
Landings (2009): 2261 t
Discards(2009): 0
SSB(2009): 2414 t

Rationale	Landings 2011	Basis	F total (2011)	Catch (2011)	SSB (2012)	%SSB change	%Landings change
Status quo	2724.7	Fcurr	0.92	2724.7	1328.0	55.01%	120.51%
	4055.9	F01	0.25	4055.9	9687.3	179.38%	401.30%

Weights in t.
1) SSB 2011 relative to SSB 2009
2) Landings 2011 relative to Landings 2009.

Short-term implications

Table 8.4.6.2 - *Mullus barbatus* GSA07

Outlook for 2011

Basis:
F(2009): 0.619 yr^{-1}
R(2009): 11 M ind
Landings(2009): 146 t
Discards(2009): 0
SSB(2009): 150 t

Rationale	Landings 2011	Basis	F total (2011)	Catch (2011)	SSB (2012)	%SSB change	%Landings change
Status quo	75.8	Fcurr	0.62	75.8	174.5	116.35%	51.92%
	213.3	F01	0.5	213.3	137.7	91.85%	146.10%

Weights in t.
1) SSB 2011 relative to SSB 2009
2) Landings 2010 relative to Landings 2009.

9. INDIVIDUAL FISH CONDITION FACTORS AS INDICATORS OF STOCK HEALTH OR STATUS TOR L)

9.1. Background

One of the objectives agreed in the SGMED 10-01 meeting (see section of the report "Development of methodologies for the estimation of empirical indicators of stock status in poor situations –TOR 3") is that condition factors can be used as indicators of stock health or status. Measuring the physiological condition of an organism (i.e. the amount of stored energy) is a useful mean of assessing the health of both the individual and the population. Condition is a particularly important attribute of fish and future population success because it has a large influence on growth, reproduction and survival. Although the causes that make condition vary over time and areas may be diverse and unclear (fishing pressure, environmental conditions, density dependent factors, prey availability, etc), the consequences of condition on the productivity of fish stocks have been well documented and it is evident that measuring the physiological condition of exploited fish may be useful to contribute to assess the status of a particular stock (reviewed in the SGMED 09-01 report). Despite this, the physiological evaluation of body condition of fishery species has been seldom monitored neither applied in the assessment of commercial fish stocks. In the Mediterranean, fish condition has never been taken into account for stock assessment and management. Morphometric condition factors, which assume that heavier fish of a given length are in better condition, are the simplest indicators of energy storage in many fish species. These morphometric condition factors are constructed with simple weight and length data. From all morphometric condition factors, the Le Cren relative condition index (Kn; Le Cren, 1951) is one of the best because, unlike other condition indices (e.g., Fulton's K), it does not assume isometric growth, and therefore remains independent of length (Bolger and Connolly, 1989; Froese, 2006). The relative condition index compares the actual weight to a standard length predicted by the weight-length relationship based on the population(s) from which the fish was sampled. Therefore, we used a single underlying weight-length relationship computed with all individuals of all populations.

The use of eviscerated weights instead of total weights is preferred, because the latter are not affected by the viscera and gonad weights. However, since eviscerated weights are only available for some few stocks and limited time periods, they are not used here. Similar to this, the hepatosomatic index, which is a better measure of fish stock condition – since in many demersal fish species the main energy reserve is stored in their livers, is not used here because currently data is scarce. However, efforts are being done to improve this situation (e.g. Spain is ES is collecting hake’s liver weights since 2008 on a regular basis during MEDITS).

Even though it is not easy to empirically relate fish condition with any biological variable used in standard stock assessment such as M (see SGMED report 09-01), any negative trend in condition, or poor condition values in the last year(s), i.e. $K_n<1.0$, should be considered when assessing stock status and using stock growth parameters and natural mortality for prediction of stock biomass.

9.2. Objective

The objective as outlined in ToR l) is to evaluate the appropriateness of individual fish condition factors as indicator of stock health or status, considering that morphometric condition factors might indicate changes in reproductive potential at both individual and population levels. In particular, this ToR aims to analyze the historic variation of condition based on weight and length data available in different GSAs, available from various SGMED experts and provided on a voluntary basis. The results are discussed regarding their impact on sustainable fisheries strategies. This ToR will also allow starting the construction of the first common data base on condition of Mediterranean fishery species, a task that can be continued with the update of data and new stocks and species.

9.3. Materials and methods

In order to compute condition factors, several experts have brought to the meeting the available individual length-weight data, collected in their area of expertise, for some stocks, on a voluntary basis (see table 9.3.2). Overall, 6 hake stocks, 3 sardine stocks, 2 anchovy stocks and 1 sole stock have been analyzed. The relative condition index K_n for each individual was calculated as K_n=100 (W/W_e), where W is the observed fish weight and W_e is the predicted length-specific weight (estimated from the weight-length relationship of all individuals in a given GSA). For sardine and anchovy GSA 17 stocks, the weights do not correspond to individuals but are mean weights of 0.5 length classes. When comparisons between GSAs are done, the full weight-length relationship taking into account all individuals of all GSA is used.

Individual total weight and lengths were available from trawl and pelagic surveys (e.g. MEDITS, GRUND, etc), and the different fisheries (trawling, purse seining and artisanal fishing). When individual weights were measured on board, the smallest individuals (< 10 cm) were not considered since the scales on board did not allow weighing in precision these individuals (e.g, some scales weigh up to 3000 g with a precision of 0.1 g). For GSA7 hake measured on board MEDITS FR, individuals measuring less than 15 cm have been eliminated because of the precision of the scale used (1 gram). The elimination of these smallest individuals (weights) avoids many of the anomalous values observed in an initial inspection of W-L data, as well as anomalous K_n values. This does not affect the final K_n values, since they are independent from fish lengths. In some cases, e.g. hake in GSA06, data are missing for a number of years, and therefore the historic data set must be completed in the future.
Files provided by the different experts were in different formats; therefore they been reorganised and a single format has been adopted. Errors have been eliminated and maturity scales have been standardized according to the guidelines given in Table 9.1.1.
The following approach was used: SGMED did not carry out a full scientific analysis (effect of gears, depth, month, sex, etc). Only the effect of year, area and sexual stage (juvenile-adult) on K_n has been considered. In the future, SGMED may conduct in the future more detailed analyses of K_n in relation to other variables (fishing gear, month, sex, etc) using GLM or GAM models. At least the effect of sexual stage must be taken into account to consider the effect of gonads weights (since total weights are used here to estimated K_n) and because the impact of condition on the productivity of fishes depends on their maturity stage: condition of juveniles usually impact on their growth and M whereas condition of adults usually impact on their reproductive potential. For some individuals, maturity data were not reported and in these cases individuals were classified as juveniles-adults according to their estimated size at maturity. Nevertheless, maturity data should be taken with caution because the methods used to estimate maturity (visual inspection of gonads, with or without the help of a binocular microscope) are not the best ones, particularly when fish is caught out of their spawning season. Therefore, the sexual stage (juvenile-adult) should be considered here as rough measure of the reproductive stage of individuals. The details of data input used in the current analysis are shown in table 9.3.2 (by species and GSA)

The data used here and set by stock is now stored under the STECF server. It will be necessary to complete and update the existent condition data set with data from new years, stocks and species to cover a broader range of exploited species, particularly those listed in SGMED-10-01 report under “data poor situations”.

It is important that any person willing to conduct further analyses must contact the stock coordinator to ask permission and to agree on the conditions (see table 9.3.2 for the name’s of the contact scientists).

Table 9.3.1 Conversion of maturity states.

MATURITY SCALE 1			**MATURITY SCALE 2 NIKOLSKY**	
Description	**Sexual stage**	**Value**	**Description**	**Sexual stage**
Immature	Juveniles	1	virgin	juveniles
maturing	Adults	2	virgin-developing inactive	juveniles
spawning	Adults	3	developing	adults
post spawning	Adults	4	mature	adults
		5	spawning (ripe)	adults
		6	post spawning (spent)	adults

Table 9.3.2. Details of the data used for the condition analysis, by species and stock. The total number of juveniles and adults is indicated, as well as the contact scientist(s), the time period (sampling years), the sampling months, the data source and the a-b parameters from the W-L relationships (computed from lengths in cm and total weights in grams). The place (on board, laboratory) where fish where weighted, and their status (fresh or frozen) is indicated under column "How". MEDITS, GRUND and MTW are bottom trawl surveys.

HAKE

Contact scientist(s)	Area	Juveniles	Adults	TOTAL	Time period	Months	Source	How	a	b
B. Guijarro	**GSA5***	3082	1280	4362	2001-2010	4,5,6,7,9,10	MEDITS	On board / Fresh	0.0046	3.1367
M.Garcia, L. Gil de Sola, J. Lloret	**GSA6***	1976	429	2405	1994-2009	5,6,10	MEDITS & landings	On board & lab / Fresh	0.0046	3.1442
A. Jadaud	**GSA7**	1616	3135	4751	2003-2009	1-12	MEDITS & landings	On board & lab / Fresh & frozen	0.0072	3.0249
M.T. Spedicato	**GSA10**	60940	3352	64292	1990-2008	1,5,6,7,8,9,10,11,12	GRUND	Lab / Frozen	0.0048	3.1282
L. Knittweis	**GSA15**	7211	698	7909	203-2010	6	MTW Survey	Lab / Frozen	0.0044	3.1507
G. Tserpes	**GSA22**	6255	3558	9813	2003-2008	1-12	Landings	Lab / fresh & frozen	0.0045	3.1440
	TOTAL	**81080**	**12452**	**93532**					0.0047	3.1348

* Incomplete (missing years)

ANCHOVY

Contact scientist(s)	Area	Juveniles	Adults	TOTAL	Time period	Months	Source	How	a	b
V. Ticina	**GSA17***	**	**	22886	2003-2010	9	Pelagic survey	On board / Fresh	0.0039	3.1773
M. Giannoulaki	**GSA22**	6602	26131	32733	2003-2008	2-12	Survey & landings	On board & lab / Fresh (landings) & frozen (survey	0.0023	3.4091
	TOTAL			**55619**						

* Mean weight of a 0.5 length class

** Sexual stage not determined

SARDINE

Contact scientist(s)	Area	Juveniles	Adults	TOTAL	Time period	Months	Source	How	a	b
V. Ticina	**GSA17***	**	**	8134	2003-2010	9	Pelagic survey	On board / Fresh	0.0044	3.2170
M. Giannoulaki	**GSA20**	6767	11363	18130	2003-2008	3-12	Survey & landings	On board & lab / Fresh (landings) & frozen (survey)	0.0034	3.3101
M. Giannoulaki	**GSA22**	5528	12597	18125	2003-2008	3-12	Survey & landings	On board & lab / Fresh (landings) & frozen (survey	0.0023	3.4703
	TOTAL			**44389**						

* Mean weight of a 0.5 length class
** Sexual stage not determined

SOLE

Contact scientist(s)	Area	Juveniles	Adults	TOTAL	Time period	Months	Source	How	a	b
G. Scarcella	**GSA17**	19079	1555	20634	1987-2006	1-12	Experimental catch & Landings	Lab / Fresh	0.007	3.0706

9.4. Results

Hake

With the exception of hake in GSA 15, the rest of stocks showed a significant difference in K_n between juveniles and adults (t-test, $p<0.01$). Figure 9.4.1 shows the interannual variability in K_n of hake stocks (disaggregated by sexual stage with the exception of GSA 15). A high interannual variability is observed. GSA7 and GSA 10 hake stocks show a decreasing trend in condition over the time period and attained the minimum values in recent years.

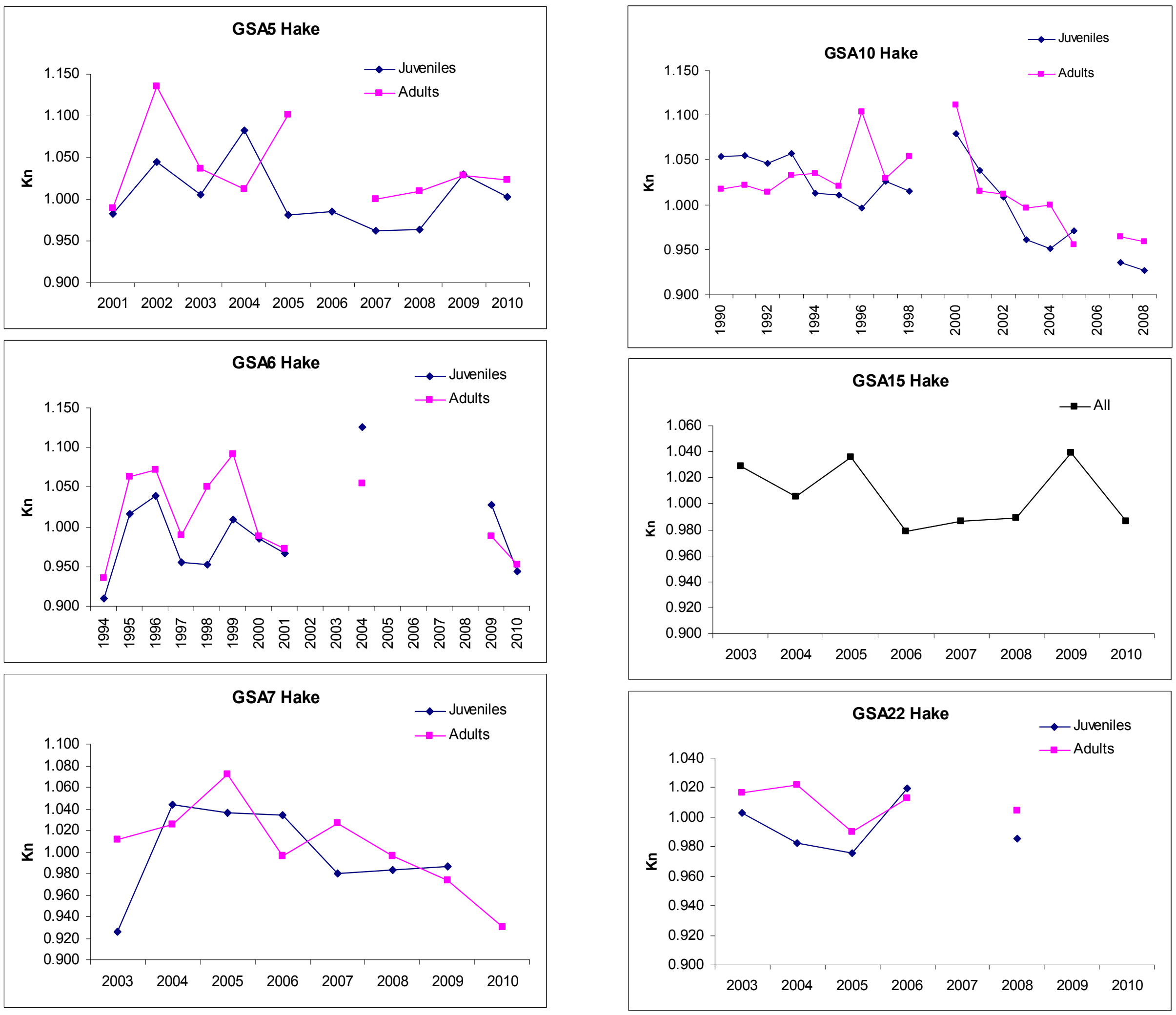


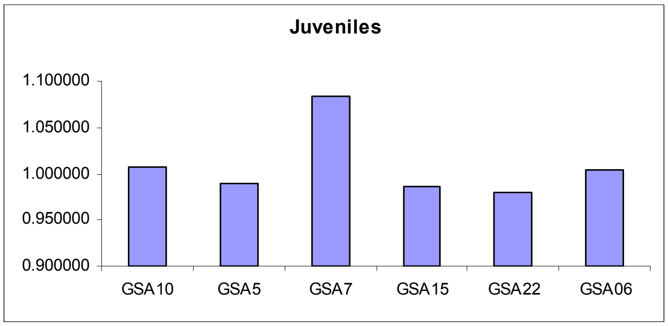
Fig. 9.4.1. Time series in condition (K_n) of several hake Mediterranean stocks.

Regarding the differences between stocks, these are statistically significant (ANOVA, post-hoc LSD test p-values, table 9.4.1). Overall (Fig 9.4.2), it is seen that hake in GSA07 (Gulf of Lions), despite the negative trend (see before), is overall the best conditioned stock from all the stocks analysed. In contrast, GSA05 (Balearic Islands) and GSA 22 (Greek waters) stocks are the poorest conditioned ones. This indicates that the Gulf of Lions hake stock is the likely the most productive one (this may be related to the favourable environmental conditions for productivity in these waters: strong wind mixing, high river runoff, relatively cold waters) whereas the Greek and Balearic stocks are the least productive ones (environmental conditions negatively affecting productivity: oligotrophic and relatively warm waters).

Table 9.4.1. LSD post-hoc test

LSD POST HOC TEST

		GSA10	GSA5	GSA7	GSA15	GSA22	GSA6
GSA10	{1}		0.000000	0.00	0.000000	0.000000	0.998642
GSA5	{2}	0.000000		0.00	0.054454	0.003284	0.000029
GSA7	{3}	0.000000	0.000000		0.000000	0.000000	0.000000
GSA15	{4}	0.000000	0.054454	0.00		0.254417	0.000000
GSA22	{5}	0.000000	0.003284	0.00	0.254417		0.000000
GSA06	{6}	0.998642	0.000029	0.00	0.000000	0.000000	



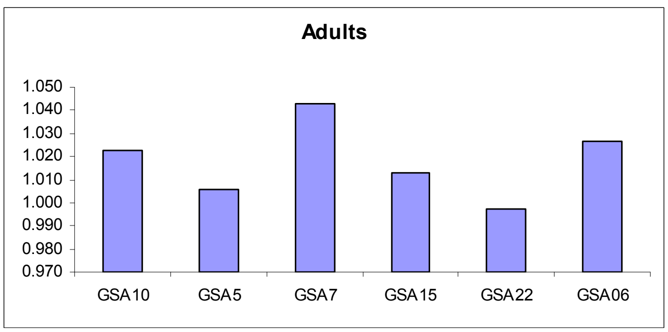
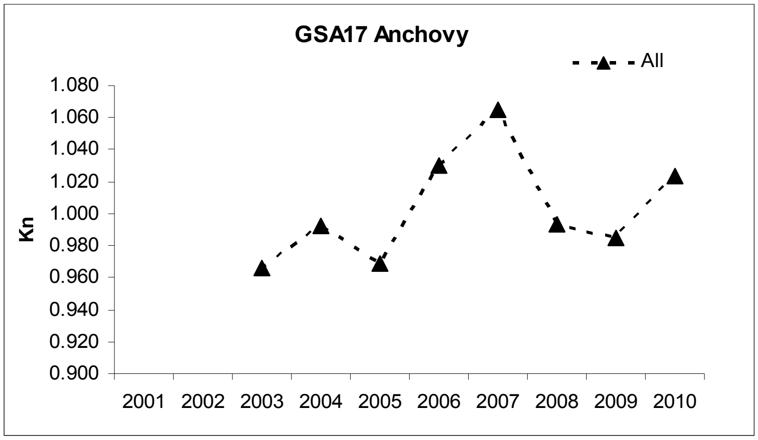


Fig. 9.4.2. Mean K_n (all years together) of several hake stocks

ANCHOVY

The mean condition of juveniles is statistically not different from the mean condition of adults (t-test, p>0.01) in GSA17 (therefore data have been pooled in this GSA); however the difference is statistically different in GSA22 (t-test, p<0.01). Fig. 9.4.3 shows an increasing trend in condition of anchovy in GSA17, indicating a relatively good productivity of this stock in recent years. GSA22 anchovy shows a decreasing trend, with the 2008 value being the lowest in the time series.



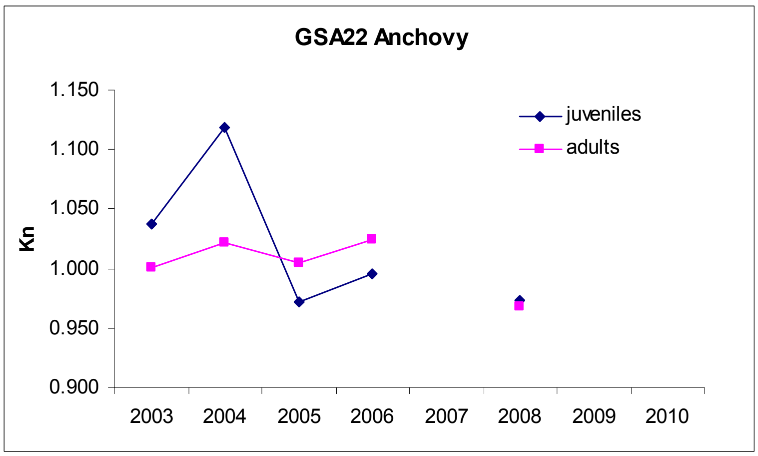


Fig 9.4.3. Time series in condition (K_n) of anchovy in GSA 17 and 22

SARDINE

Condition of juveniles are statistically not different from that of adults (t-test, p>0.01) in GSA17 (therefore data have been pooled in this GSA); however the difference is statistically different in GSA 20 and 22 (t-test, p<0.01). In GSA17, low condition values are observed in the two most recent years (Fig. 9.4.4), suggesting a poor productivity of this stock in recent years after good condition values recorded in 2005-2008. In GSA 20 and 22, there is a negative trend in condition of juveniles, suggesting a poor productivity of these stocks in recent years.

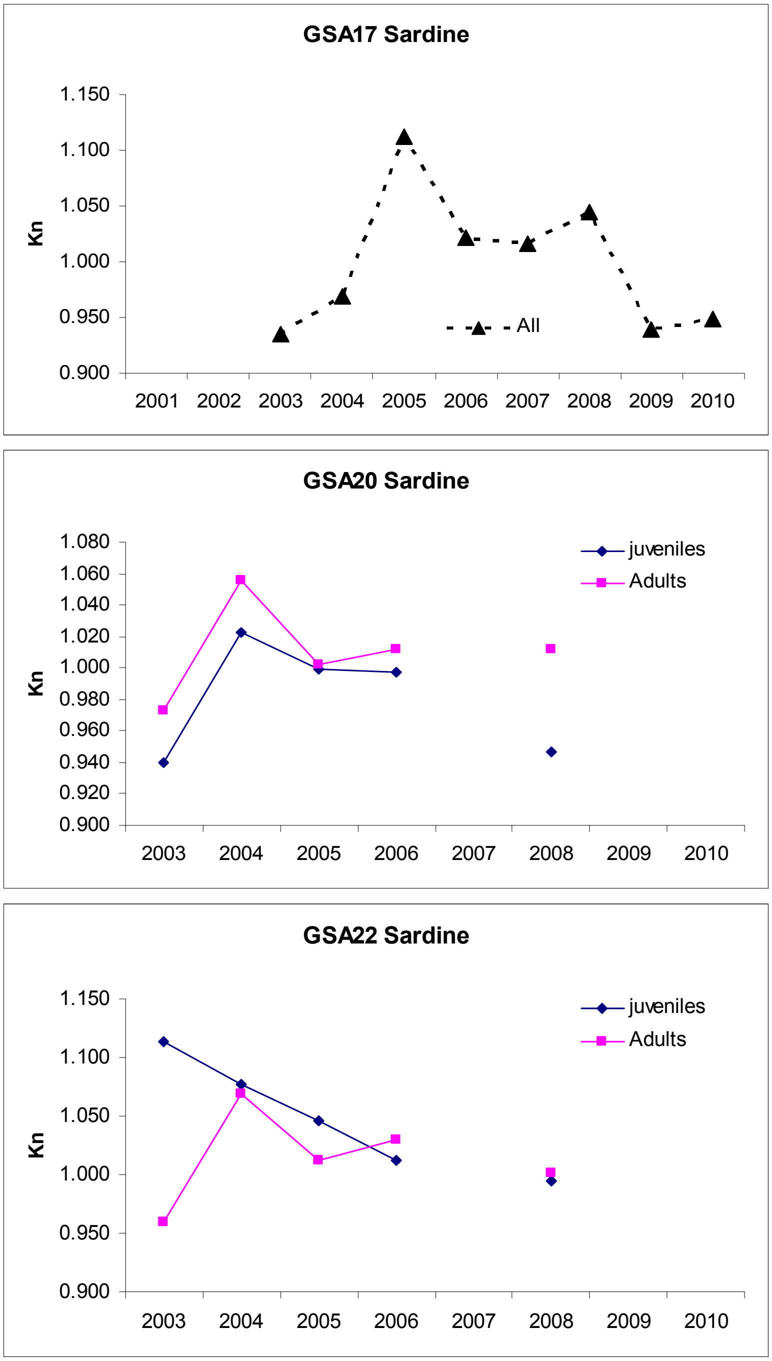


Fig 9.4.4. Time series in condition (K_n) of sardine in GSA 17, 20 and 22

SOLE

The mean condition of juveniles is statistically different from the mean condition of adults (t-test, p>0.01) and therefore data has been analysed by sex separately. From Fig. 9.4.5, a decreasing trend in condition of sole in GSA17 is observed in the 90s after the high values observed in the 80s, suggesting a decreasing productivity of this stock. The reduction in condition during the 90s coincides with the increase of rapido-trawling fishing effort. The 1994 extremely low value coincides with a huge algal bloom in the area that provoked severe anoxic conditions.

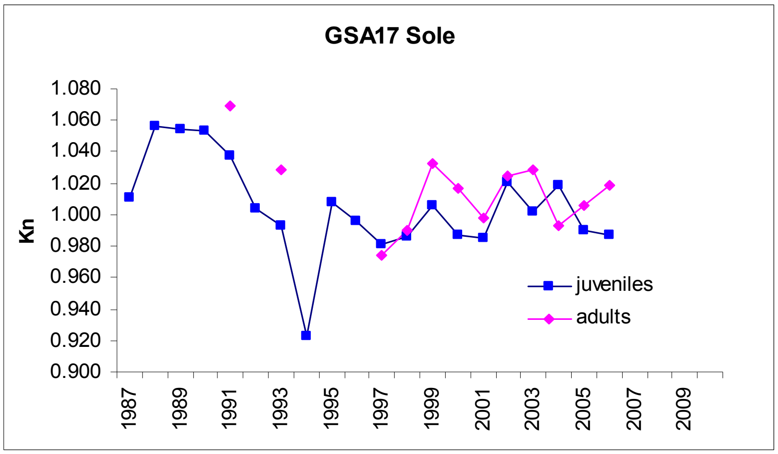


Fig 9.4.5. Time series in condition of GSA17 sole stock.

9.5. Conclusions

This first common analysis of morphometric condition data from several Mediterranean stocks has provided the first insight of the temporal and geographic variability in condition of these stocks. The relatively low condition values observed in recent years for hake in GSA 7 and 10, sardine in GSA 17, 20 and 22, anchovy in GSA 22 and sole in GSA 17, indicates a current poor condition of these stocks that may lead to a future decrease in growth, an increase of M or a reduction in the reproductive potential of adults and thus the likelihood of appearance of large year classes. The current analysis also showed that not all stocks have the same level of condition and hence productivity, a fact that should be taken into account in the long-term (better conditioned stocks should be also more productive and resistant to exploitation than the poorer conditioned ones). However, SGMED stressed that trends in K_n should in general be analysed in concert with the density of the population and possibly with that of their prey as a decline in condition might also due to high density level and/or the existence of density-dependent mechanisms.

This ToR has also allowed to start building up the first common data base on condition of Mediterranean fishery species, a data base that can be updated and enlarged in the future with the consideration of other stocks, particularly those listed in SGMED-10-01 report under “data poor situations”. This task will allow computing an indicator of stock’s status to be used as a complementary variable in standard assessments or in data poor situations.

10. TECHNOLOGICAL ASPECTS OF FISHING GEARS TOR M)

10.1. Background

This ToR was focused on the following issues:

- to provide a synoptic overview of the maximum, minimum and/or average dimensions (length, circumference) of both the cod-end and extension piece used in the Mediterranean bottom trawl nets fisheries of EU countries in particular.
- to provide the relative importance of the cod-end with respect to the entire length of the trawl net
- to provide the relative importance of the lifting bag with respect to the whole cod-end
- to identify what are the technical elements and attachments to a trawl net that allow to distinguish between the cod-end and the extension piece. Specific attention shall be given to the types, positions and numbers of chafers, strengthening bag, lifting strips, round strips etc.

The technical aspects of legislation on fishing gears are becoming an important issue in the Mediterranean Sea where several countries operate on shared stock and resources. The 21st of December 2006 the Council of the European Union has adopted the Regulation Nr. 1967/06 concerning management measures for the sustainable exploitation of fishery resources in the Mediterranean Sea. This Regulation contains definitions of technical parameters and defines new technical measures for fishing gears. Most of the technical changes, at least in Italy, became effective starting form June 2010.

The current document focus the attention to definitions and to technical measures affecting selectivity, in order to evidence eventual problems and possibly to suggest new technical details which can be inserted in the Regulation and give a clear and easier view of the Regulation.

Finally an overview of bottom trawl net designs and riggings was carried out in order to evidence technical development occurred during the last two decades.

Data collection was undertaken both through a critical review of the scientific and technical papers where the net drawings were available as well as through direct interviews of Mediterranean net makers and gear technologists. Spain, France, and Greece reacted providing useful data of the fishing gears currently used.

Anyway data presented during the STECF/SGMED-10-03 should be carefully considered and an exhaustive investigation should be conducted in order to collect more practical and reliable data.

10.2. Definitions (EC Reg. 1967/2006)

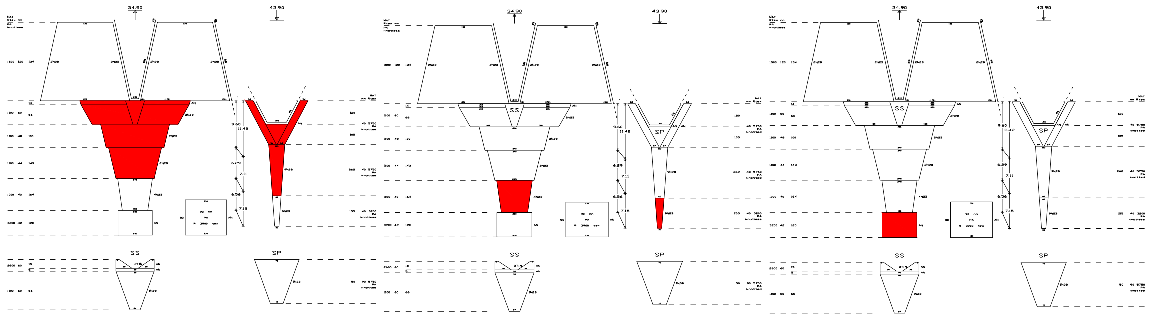
TOWED GEARS: Fishing gear, towed either by the engine power of the fishing vessel or hauled by means of winches with the fishing vessel either anchored or slowly under way, including in particular towed nets and dredges.

TECHNICAL CONDITIONS FOR ATTACHMENTS TO AND RIGGING OF TRAWL NETS.

TRAWL BODY: the tapered section in the front part of a trawl net.

EXTENSION PIECE: the untapered section, made of one or more panels, between the trawl body and the codend.

COD-END: the rearmost part of a trawl net, of net of the same mesh size, having either a cylindrical or a tapering shape, whose transversal cross-sections are nearly a circle of the same or decreasing radius respectively.



TRAWL BODY EXTENSION CODEND

RIGGING EQUIPMENTS

The circumference-perimeter of any cross section in a diamond-mesh netting of a trawl net shall be calculated as the number of meshes in that cross section multiplied by the stretched mesh size.

The circumference-perimeter of any cross section in a square-mesh netting of a trawl net shall be calculated as the number of meshes in that cross section multiplied by the mesh side length.

10.3. Technical measures affecting the selectivity process

Minimum mesh size (EC Reg. 1967/2006)
The use for fishing and the keeping on board of a towed net, a surrounding net or a gillnet shall be prohibited, unless the mesh size in that part of the net having the smallest meshes complies with paragraphs 3 to 6 of this Article. […] From 1 July 2008, the net referred to in point 1 shall be replaced by a square-meshed net of 40 mm at the cod-end or, at the duly justified request of the ship-owner, by a diamond meshed net of 50 mm (Transitional derogations Art. 14).

Twine thickness (EC Reg. 1967/2006)
The carrying on board or the use of any towed net constructed wholly or in part in the cod-end of single twine netting materials having a twine thickness of more than 3.0 millimetres shall be prohibited.
The carrying on board or the use of any towed net constructed wholly or in part in the cod-end of netting materials consisting of multiple twines shall be prohibited.
Netting materials having a twine thickness greater than 6 mm shall be prohibited in any part of a bottom trawl net.

Rigging equipments (EC Reg. 1967/2006)

1. A balloon cod-end shall be prohibited in trawl nets. Within any single cod-end the number of equal sized meshes around any circumference of the cod-end shall not increase from the front end to the rear end.
2. The circumference of the rearmost part of the trawl body (the tapered section) or of the extension piece (the untapered section) shall not be smaller than the circumference of the front end of the cod-end *sensu stricto*. In the case of a square mesh cod-end, in particular, the circumference of the rearmost part of the trawl body or of the extension piece shall be from two to four times the circumference of the front end of the cod-end *sensu stricto*.

Rigging equipments (EC Reg. 1967/2006)
[…] the mesh size of the strengthening bag shall not be less than 120 mm for bottom trawlers if the cod-end mesh is smaller than 60 mm.
The circumference of the strengthening bag, as defined in Article 6 of Regulation No 3440/84, shall not be less than 1.3 times that of the cod-end for bottom trawl nets.

Requirements relating to the characteristics of fishing gear (EC Reg. 1967/2006)
Technical specifications limiting the maximum dimension of floatline, groundrope, circumference or perimeter of trawl nets along with the maximum number of nets in multi-rig trawl nets shall be adopted, by October 2007, in accordance with the procedure laid down in Article 30 of this Regulation.

Strengthening bag (EC Reg. 1967/2006)
By way of modification of Article 6(4) of Regulation (EEC) No 3440/84 the mesh size of the strengthening bag shall not be less than 120 mm for bottom trawlers if the cod-end mesh is smaller than 60 mm, as in the case of Mediterranean trawl. The circumference of the strengthening bag, as defined in Article 6 of Regulation No 3440/84, shall not be less than 1,3 times that of the cod-end for bottom trawl nets.

Bottom-side chafer (EC REg. 3440/1984)
A bottom-side chafer may be formed of any piece of canvas, netting, or any other material. More than one bottom-side chafer may be used at the same time and they may overlap. Bottom-side chafers may be attached only to the outside of the trawl and only to the lower half of any part of the trawl. They may be fastened only at their front and side edges. If strengthening bags or chafing pieces are used, the bottom-side chafer may be attached only outside the strengthening bags or chafing pieces and in the manner specified above.

10.4. Review of trawl net design and rigging

Various types of bottom trawls are used by the different Mediterranean fleets. They are generally designed more according to the practice than to targeted species. However two main categories can be recognized Mediterranean and "Atlantic" shapes. The first ones have low vertical opening, essentially using sweeplines and sometimes small bridles. The second one has generally a larger vertical opening, sometimes due to the addition of lateral panel. In few cases larger lateral panel and fork rig are used to obtain higher vertical opening in order to catch pelagic fishes. Most of the Mediterranean trawls are made by the fishermen themselves using only basic rules of cutting and mounting, while Atlantic trawls are made following more advanced rules and drawing designs.

1. <u>Low vertical opening bottom trawls:</u>

    - Traditional two-faces trawl;

    - Entirely manufactured with Raschel knotless-PA netting;

    - Large amount of slack in the bottom panel, which is usual in Italian trawl design.

2. <u>High vertical opening bottom trawls</u>

    - Four-faces trawl with small or large lateral faces;

    - Large meshes or ropes in the wing section;

    - Manufactured with Raschel knotless-PA and knotted-PE netting.

    - The wings are built from two/three panels, which have bar cutting along the fishing and floatline and in the selvedge opposed to the one-panel wings in the traditional style Italian trawl. This change has been introduced to increase the bosom height as well as the horizontal opening of the trawl.

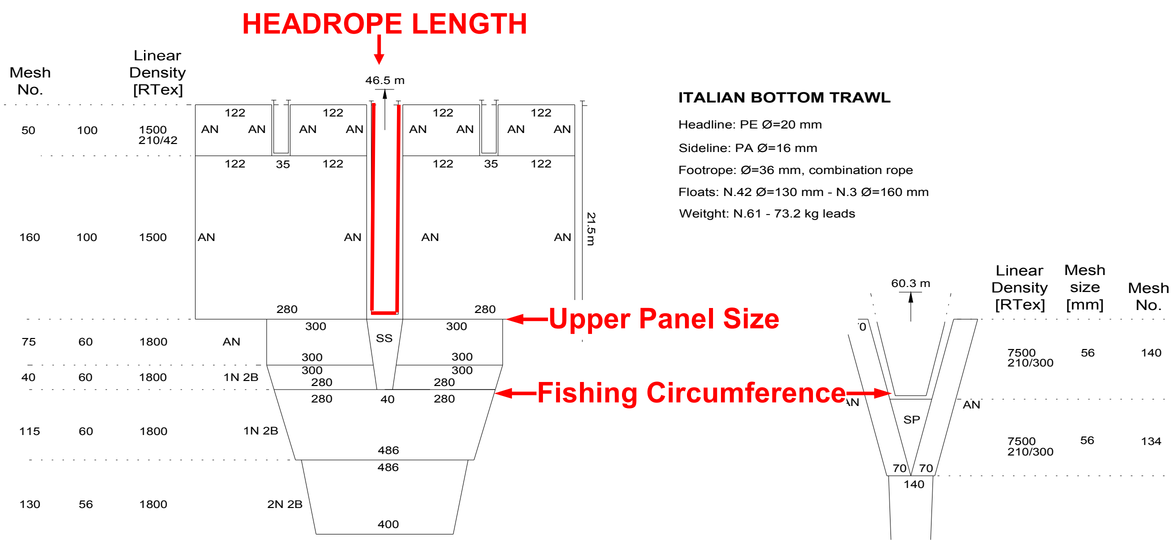
3. <u>Twin-trawls</u>

- Four-faces trawl with small or large lateral faces.

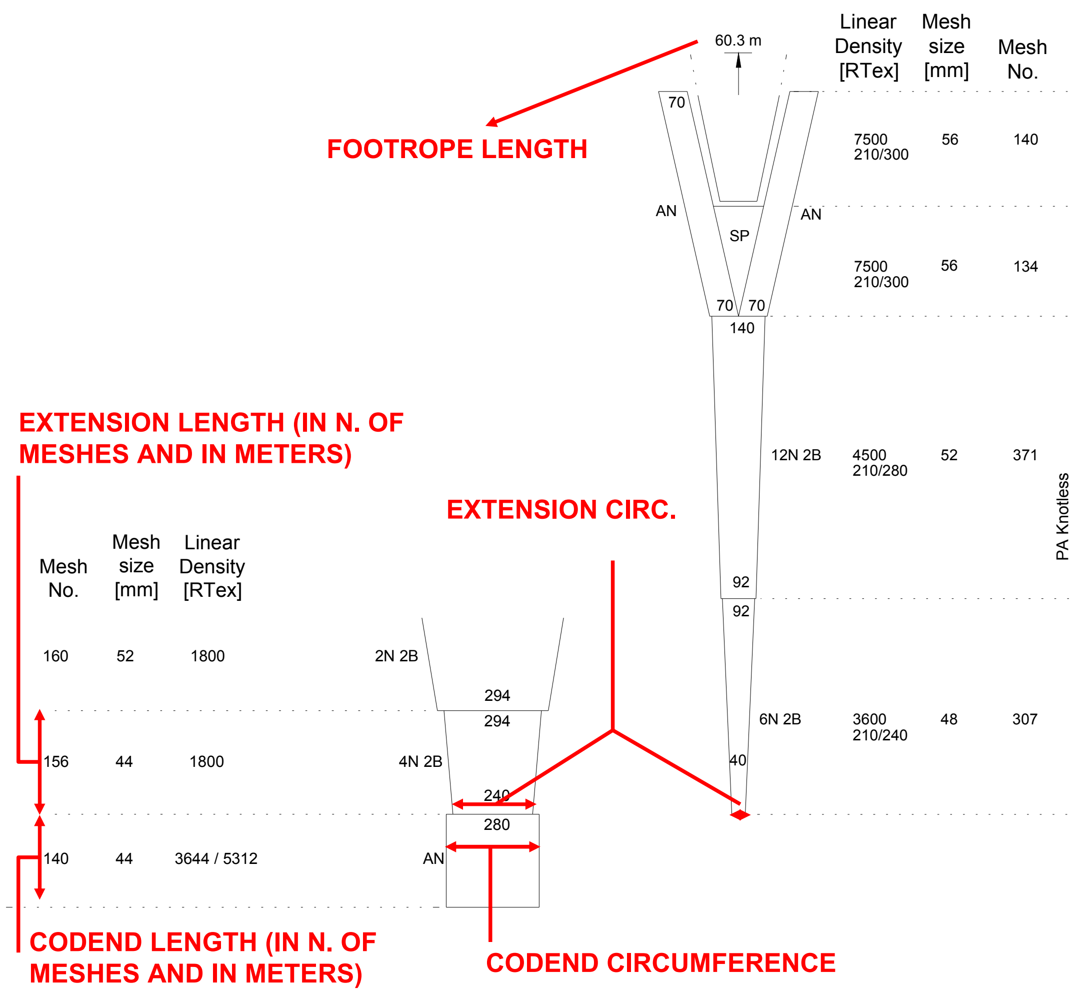
The critical review of technical net parameters was carried out, taking into account only the papers and technical reports where the net drawings were available. Moreover detailed interviews among some of the main net makers were carried out in order to know current situation. This kind of approach also allowed collecting information on the real engine power of fishing vessels, which might be difficult to obtain from official data (licenses). Obviously this was a preliminary exercise, therefore a more rigorous investigation should be done in order to obtain detailed and reliable information.

Data related to some technical parameters were summarized in order to homogenize the information collected and to obtain some useful conclusions.

For the net dimension the length of headrope and footrope, the upper panel size and the fishing circumference were reported or calculated.

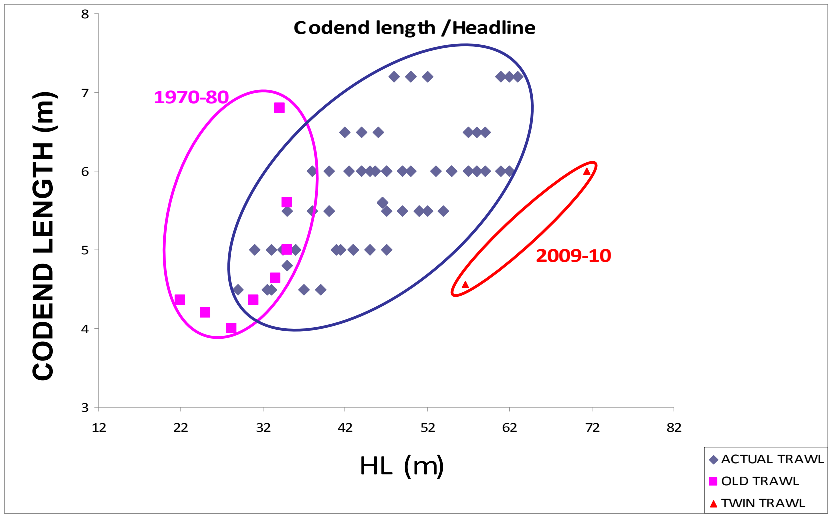


The length and the circumference of the codend and extension were analysed as number of meshes and meters, in order evaluate eventual correlation with the headrope length or fishing circumference.



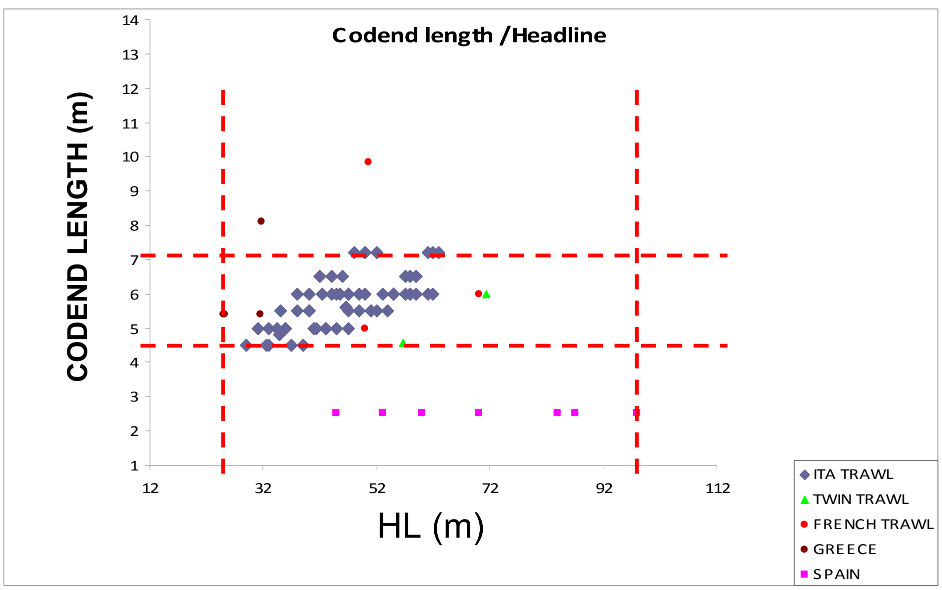
As it concerns Italian data, which were collected more in depth than the other, results show a strongly increase of the headrope length, net dimension and consequently swept area occurred in last 2 decades. Compared to the old situation it is possible to observe an increase in headrope length of more than 10 m. Moreover in the last 5 years some Italian bottom trawlers of the central-northern Adriatic, switched their activity from single- to twin-rig trawling (named by the Italian fishermen "*Americana trawl*"). The whole dimension of the headrope (the sum of the headrope of two nets) showed a considerable increase.

Preliminary surveys carried out by CNR-ISMAR of Ancona and Consorzio UNIMAR showed for this net an increase in the horizontal opening of bout 30% comparing to the traditional configuration, which caused a large increment in the swept area during fishing operations. Meanwhile it is possible to note that the codend length is not strictly correlated with the headrope length: the codend length of the former trawl nets is comparable with the recent nets. Nowadays the codend length ranges from 4.5 m to 7.2 m.

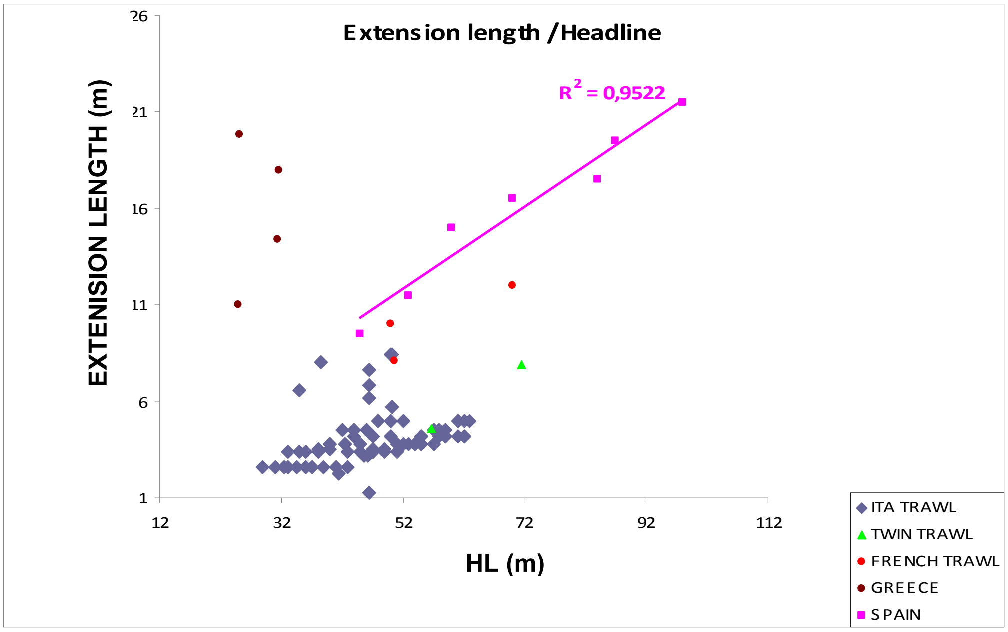


The headrope length, which can be used as index of trawl dimension, ranges from 25 to 98 m. Taking into account the information collected, it is possible to observe that the largest trawls are in Spain and the smallest in Greece.

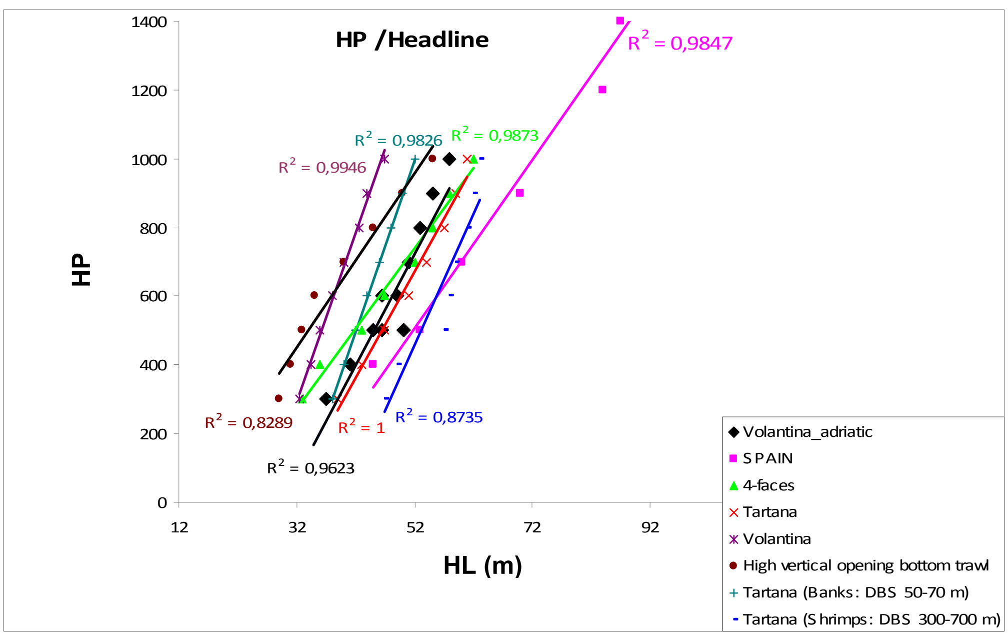
Furthermore, as observed in the Italian case only, the codend length seems to show a very poor correlation with the headrope length and most of the codends ranges from 4.5 to 7 m. While in Spain the codends are shorter varying around 2.5 m.

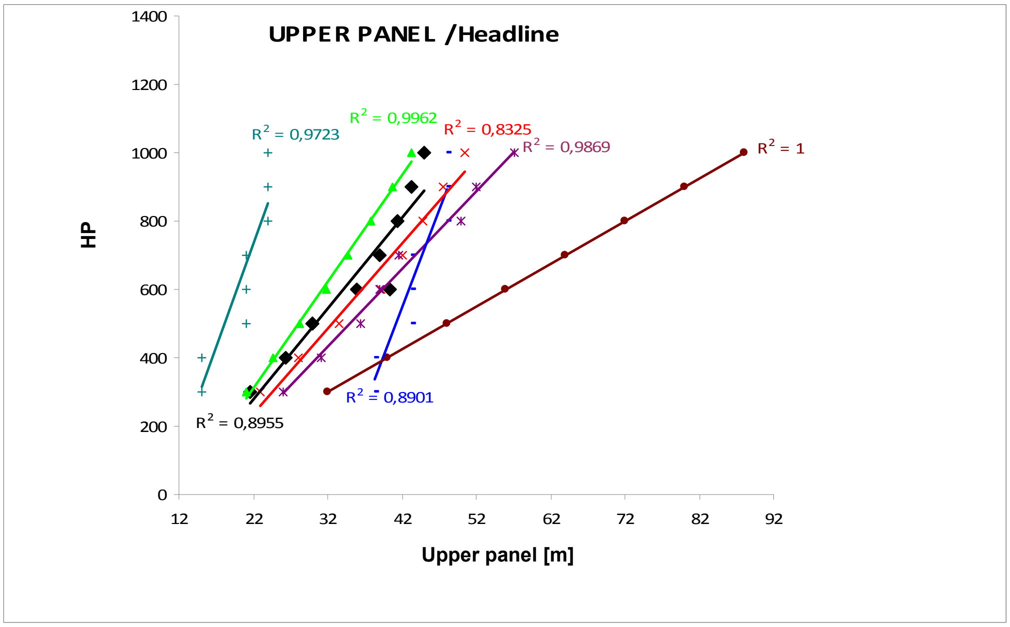


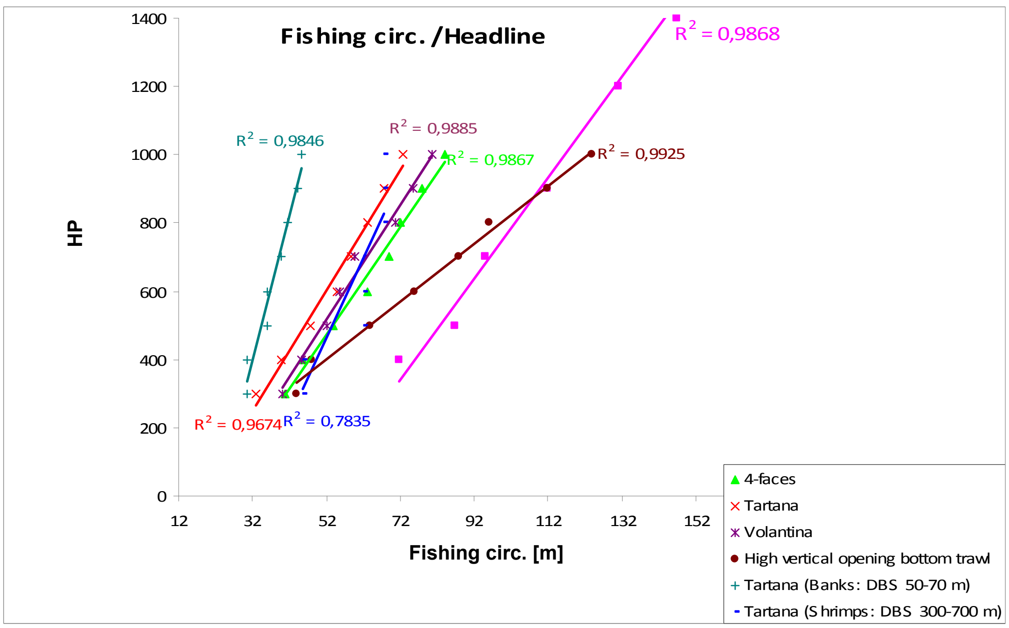
Apart Spain, also the extension piece seems not to be correlated with the headrope and trawl dimensions. Italian trawls show the smallest extension piece. The length of the extension strongly changes among different types of net design. Generally it is very difficult to obtain information on this parameter. On the basis of EC Reg. 1967/2006 the extension piece is the "untapered section, made of one or more panels, between the trawl body and the codend". However in some cases it is practically impossible to distinguish between the trawl body and the extension piece because this section is not a cylindrical netting panel.



The length of the headrope, the upper panel size and finally the fishing circumference seems to be strongly correlated with the type of net design (Spain, 4-faces, tartan, etc.). Notably also the net dimension (measured as headrope length) is significantly correlated to the engine power, as demonstrated by the high values of R^2. Also upper panel size and fishing circumference can be used as index of trawl dimension. They also allow obtaining a rough estimate of the real engine power of a fishing vessel.

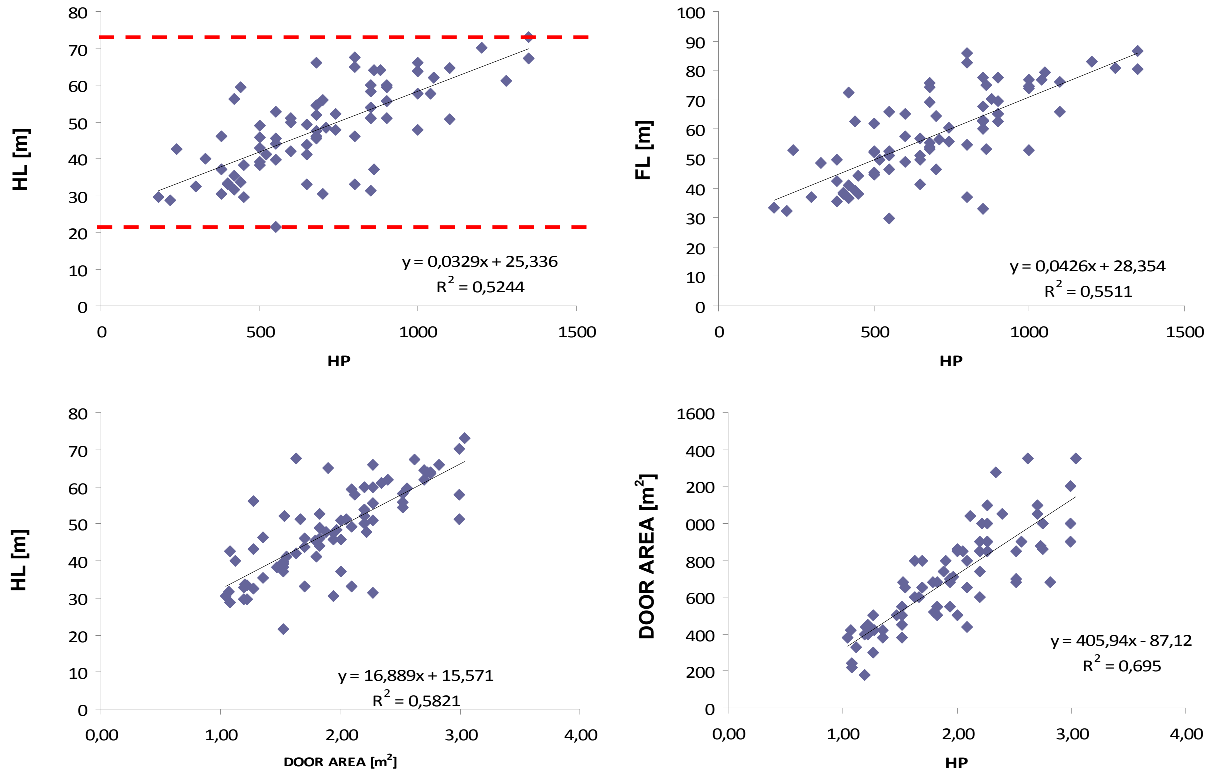




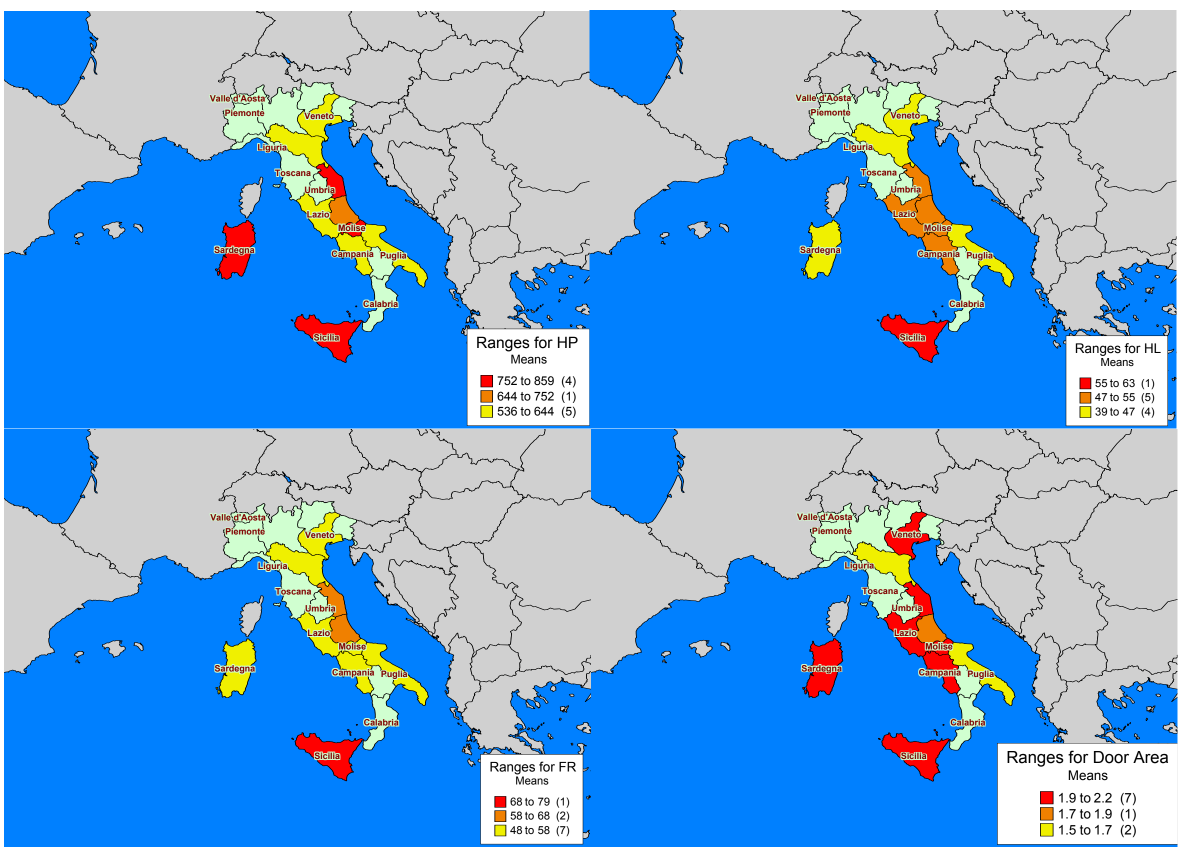


As it concerns the rigging of trawls a preliminary review was carried out for the Italian fisheries. Data of the main trawl characteristics in relation to the real engine power of fishing boats were provided by some net makers. This exercise allowed correlating different rigging parameters. Notably headrope length, which is an index of trawl dimension, is positively correlated with the engine power. Headrope length ranges between 20 m to 73 m. Also door characteristics enabled to correlate the door area with headrope length and HP.

The analysis was carried out considering the different Italian regions. The results obtained highlight the differences among the fisheries. Sicily has the largest boats in terms of engine power. Consequently Sicily has also the largest trawls in terms of headrope length, footrope length, and door dimension. Similar approach could be adopted in all the other Mediterranean countries.



HL [m]
HP
y = 0,0329x + 25,336
R^2 = 0,5244
FL [m]
HP
y = 0,0426x + 28,354
R^2 = 0,5511
HL [m]
DOOR AREA [m^2]
y = 16,889x + 15,571
R^2 = 0,5821
DOOR AREA [m^2]
HP
y = 405,94x - 87,12
R^2 = 0,695



Valle d'Aosta
Piemonte
Veneto
Liguria
Toscana
Umbria
Lazio
Molise
Campania
Puglia
Calabria
Sardegna
Sicilia
Ranges for HP
Means
752 to 859 (4)
644 to 752 (1)
536 to 644 (5)
Ranges for HL
Means
55 to 63 (1)
47 to 55 (5)
39 to 47 (4)
Ranges for FR
Means
68 to 79 (1)
58 to 68 (2)
48 to 58 (7)
Ranges for Door Area
Means
1.9 to 2.2 (7)
1.7 to 1.9 (1)
1.5 to 1.7 (2)

10.5. Considerations on technical measures

The EC Reg. 1967/06 implements some technical parameters which are very important for the selectivity such as the mesh configuration (square-mesh codend) and the twine diameter of towed net, net rigging etc. Nevertheless the misinterpretation of certain technical measures at a national level leaded to the inefficacy of some new rules.

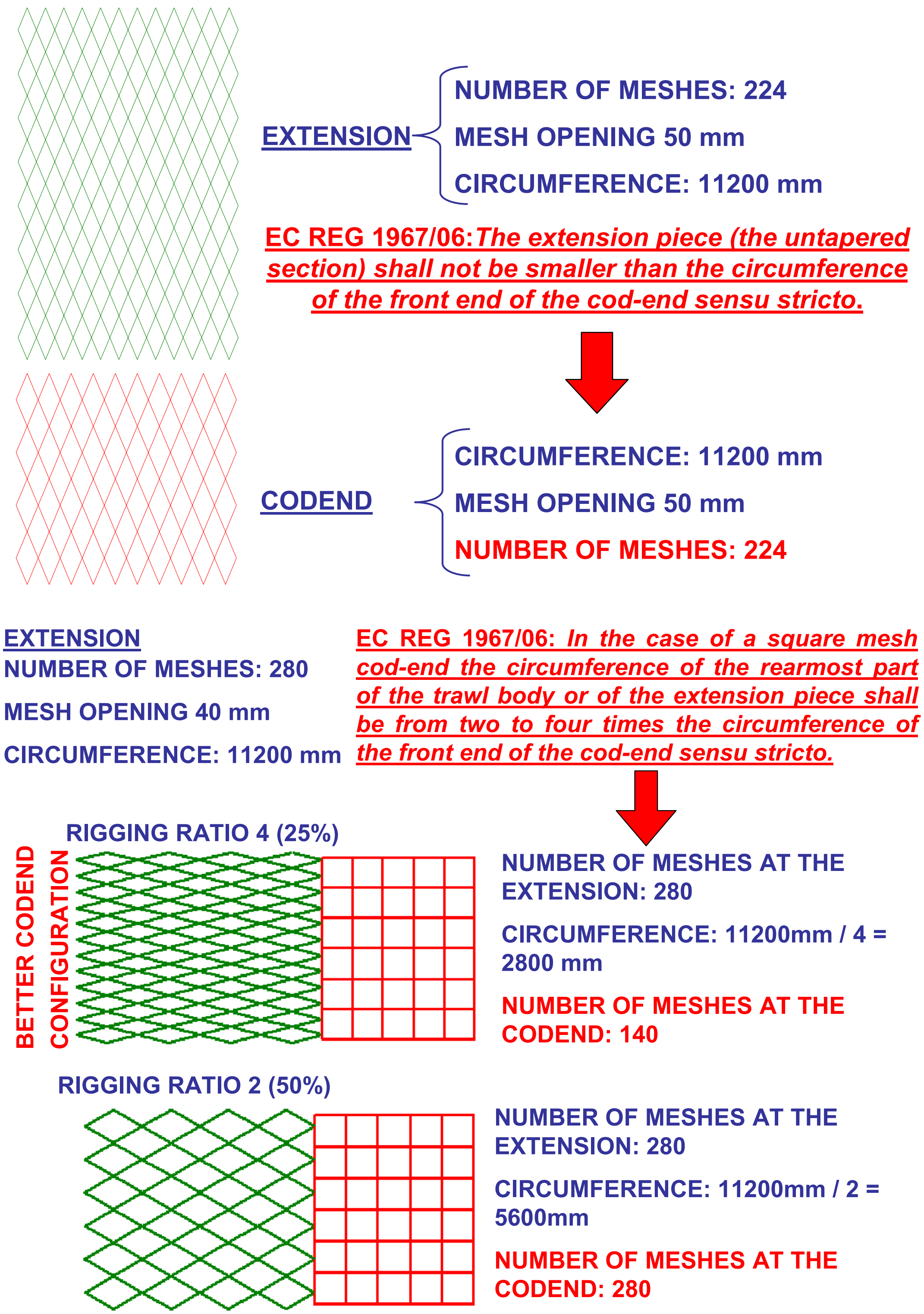
In the light of EC Reg. 1967/2006 and considering the present situation of bottom trawl in the Mediterranean it is possible to make the following considerations:

- As it concerns the use of square-mesh codend the Art. 9 reports: "*The use for fishing and the keeping on board of a towed net, a surrounding net or a gillnet shall be prohibited, unless the mesh size in that part of the net having the smallest meshes complies with paragraphs 3 to 6 of this Article. […] From 1 July 2008, the net referred to in point 1 shall be replaced by a square-meshed net of 40 mm at the cod-end or, at the duly justified request of the shipowner, by a diamond meshed net of 50 mm*". In the Regulation is clearly explained that the smallest meshes shall be at the codend. Thus, the correct interpretation of this Regulation is:
    a) in the case of 40 mm square-mesh codend the rest of the net should have a mesh opening more than 40 mm.
    b) in the case of 50 mm diamond mesh codend the rest of the net shall have a mesh opening more than 50 mm.

  The choice of 50 mm diamond-mesh should be scientifically motivated.

- Italian fishermen (fishing cooperatives) have sent a unitary and generic request for a diamond-meshed net of 50 mm at the codend. Subsequently to the adoption of the EC Reg. 1967/06, they are using a shorter netting panel (about 50-100 cm) at the final part of the codends with legal mesh size, leaving the rest of the net unchanged. This was because of a National Ministry Document (Circolare 7/5/2010) which stated: "*From 1 June 2010 […] the new meshes (40 mm square or 50 mm diamond) shall be adopted in the codend only. All the other netting panels will remain unchanged (>40mm diamond)*". Given that the length of the codend is not well defined, the fishermen have adopted such trick of using shorter codends to make practically inefficacy the new technical measures. The misinterpretation could be probably because in the EC Reg. 1967/06, among the prohibited fishing gears and practices, at the article 8 we read: "*panels of netting smaller than 40 mm mesh size opening for bottom trawlers*", therefore it seems to justify the use of netting panels with mesh size of less than 50 mm (and >40 mm). In the same way French and Spanish fishermen are using codends with only 20-30 meshes, in order to accomplish the requests of the EC Reg. 517/2008 laying down detailed rules for the determination of the mesh size and assessing the thickness of twine of fishing nets. This regulation stated that "*the mesh size of the net shall be determined as the mean value, displayed by the gauge, of the series of 20 selected meshes*". This means that French fishermen are actually using codend with legal mesh sizes of about 1-1.5 m in length.

- Concerning the codend circumference the EC Reg. 1967/06 says: "*In the case of a square mesh cod-end, in particular, the circumference of the rearmost part of the trawl body or of the extension piece shall be from two to four times the circumference of the front end of the cod-end sensu stricto*". The codend circumference in relation with the extension circumference is a crucial point to make the technical measurement effective. In fact, increasing the meshes at the codend circumference was a really common trick made by fishermen to decrease the codend selectivity. However in the Mediterranean Sea the effect of codend circumference on the selectivity properties is sometimes unclear because of the small catch sizes. We believe that the joining of codend with the extension needs a more precise description, in order to guarantee a right behaviour of the net during tow and to make safe the selectivity process. Following the recommendation of the EC Reg. 1967/06, below we provide some information:

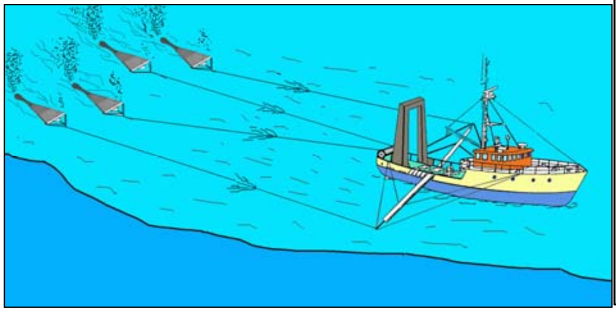


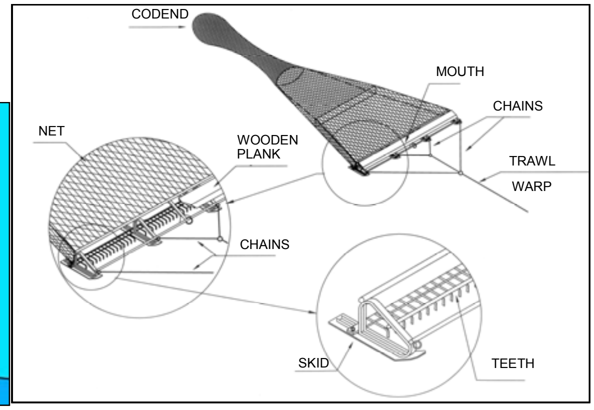
- The EC Reg. 1967/2006 also states: "*Technical specifications limiting the maximum dimension of floatline, groundrope, circumference or perimeter of trawl nets […] shall be adopted, by October 2007, in accordance with the procedure laid down in Article 30 of this Regulation*". However currently we are unable to find any national legislation in the Mediterranean Sea limiting neither the headrope dimension or the circumference or perimeter of trawl nets. Moreover no indications on the groundrope dimension or characteristics were provided except for Italy, Tyrrhenian side (DM 28/10/1993):

a. maximum diameter of groundrope: 40 mm
b. no bobbins or pieces of chains or chains as festoons.

In fact fishermen, especially over hard seabed, are used to rig their nets with footropes having a diameter more than 40 mm, with heavy chains not strictly joined to the footrope, with bobbins, rubber discs or other instruments which allow to fish over this kind of surfaces, avoiding ground damage form the contact with the stones whilst maintaining ground contact. Moreover, in order to enhance the gear efficiency, bottom trawls are yearly rigged with heavier tickler chains which imply a higher physical impact on the bottom. Tickler chains are usually shorter than the footrope and during towing operations they determine a considerable physical impact on the seabed.

- In Italy a growing number of fishermen started to shift their activity from traditional bottom trawl towards twin trawl since 2004. Actually there is not a complete survey of the situation but it is possible to assume with a reasonable certainty that around 20-30 % of the Adriatic trawling fleet is using such nets. The EC Reg. 1967/06 says: "*Technical specifications limiting the maximum dimension of floatline, groundrope, circumference or perimeter of trawl nets along with <u>the maximum number of nets in multi-rig trawl nets shall be adopted</u>, by October 2007"*. We believe it is important to test more precisely the use and the impact of these gears in the Mediterranean. As a precautionary approach Italian Ministry with the Decree 21/01/2009 obliged bottom trawlers using twin trawls to reduce their fishing activity of one day per week in respect to traditional bottom trawlers. Similar approach was not applied to rapido trawls in the Adriatic Sea. Rapido trawl is a sort of beam trawl commonly used in the Adriatic Sea for fishing flatfish in muddy inshore areas. The gear consists of a box dredge of 3-4 m wide and 170-250 kg weight, rigged with teeth of 5-7 cm long and a lower leading edge and net bag to collect the catch. An inclined wooden board is fitted to the front of the metallic frame to act as depressor, keep the gear in contact with seabed and, even more, press it on to the bottom to facilitate the penetration of the teeth in the sediment. The towing speed is about 5-7 knots and a single vessel may tow four rapido simultaneously. In this case, even if this fishing gear have a high impact, no national legislation was applied.





- The twine thickness has been widely demonstrated to strongly affect the selectivity performance of bottom trawl. The EC Reg. 1967/2006 states that twine thickness of more than 3.0 millimetres shall be prohibited in the codend. During present review several types of net showed a twine thickness at the codend more than 3 mm, measured in conformity with the EC Reg. 517/2008. This was mainly observed for Spanish and Sicilian bottom trawls, and for the rapido trawls in the Adriatic Sea. In these cases the twine diameter might be more than 4 mm.

- Strengthening bag should be considered as a cylindrical piece of netting completely surrounding the codend of a trawl. The mesh opening and the dimension of this netting panel can strongly influence the selectivity of the codend. However most of the papers and reports found did not provide useful information on this netting. The information available seems to indicate that the dimension of the strengthening bag is greater than that of the codend of about 15% in length and 11% in terms of circumference.

- As regards the chafer, nowadays, fishermen are using bottom-side chafer composed by piece of netting, old netting, rubber etc. They may use overlapped bottom-side chafers. They generally attach the chafer only to the outside part of the trawl and to the lower half part of the trawl. Therefore the real use of the chafer is for the reduction of the friction wear of the trawl.

- Due to the limited catch size, compared with other type of towed gears such as the pelagic net for small pelagics, lifting strips are not used in the Mediterranean bottom trawl.

SGMED conclusions and recommendations

The review carried out for the data collection of the net designs and properties should be considered as a preliminary attempt to give an overview of the situation in the Mediterranean, therefore the results should be considered with caution.

- Considering the strong increase of headrope length registered in the last two decades, in order to avoid an increment of the fishing effort in terms of swept area during towing operations, the maximum length of the headrope should be fixed. Headrope length should represent a good index of fishing effort exerted by a bottom trawl because it is strongly correlated with the net horizontal opening and also because it represents a parameter which is easy to control in fishery inspections. The definition of headrope length is also requested in the EC Reg. 1967/2006 ("*Technical specifications limiting the maximum dimension of floatline, groundrope, circumference or perimeter of trawl nets along with the maximum number of nets in multi-rig trawl nets shall be adopted, by October 2007*"; see Annex II, point 7). In our preliminary analysis maximum headrope of around 100 m was recorded in Spanish trawl fisheries even if most of the trawls have headropes less than 70 m.

- In order to make effective the measures stated in the EC Reg. 1967/06 concerning the codend meshes, the following explanation should be considered: in the case of 40 mm square-mesh codend, the rest of the net should have a mesh opening more than 40 mm. In the case of 50 mm diamond-mesh codend, the rest of the net shall have a mesh opening more than 50 mm. Thus in the case of 50 mm diamond mesh codend all trawl netting panels should be considered legal only if they have a mesh opening greater than 50 mm. On the other hand for the 40 mm square mesh codend the definitions of the EC Reg. 1967/06 did not provide any indication of the codend length and this could lead to make ineffective this technical measures. The review we have done showed that the codend length is generally comprised between 4.5 and 7 m. Therefore in order to avoid misinterpretation of the Regulation some more detailed information on technical measures, such as the codend length, should be provided. For example Italian fisherman use a shorter netting panel (about 50-100 cm) at the final part of the codends with legal mesh size, leaving the rest of the net unchanged and in practice making the normative highly ineffective to reduce mortality of juveniles fish.

- The dimension and the characteristics of the footrope (use of chains, type of joining, use of bobbins, use of tickler chains etc) should be fixed in relation with sea bottom characteristics, in order to avoid an increase in the physical bottom impact.

- The review of bottom trawl characteristics showed a strong increase in the net dimension in the last two decades, thus the CPUE recorded in the past should be compared with present data with caution, considering appropriate conversion factors. Information on the headrope length should be used as index of the swept area.

- Concerning the strengthening bags and chafers, most of the papers and reports collected, did not provide such information and the dimensions of the strengthening bad should be considered carefully. On the contrary the chafer is a question of minor concern because fishermen use chafer only for reducing the friction wear of the trawl.

- A detailed review of net designs and riggings in the Mediterranean should be done in order to obtain information useful for the reasonable management of fishing sector and for a better interpretation of the real fishing effort.

- In Italy a growing number of fishermen starting to change their activity from traditional bottom trawl towards twin trawl since 2004. Actually there is not a complete survey of the situation but it is possible to assume with reasonable certainty that around 20-30 % of the Adriatic trawling fleet is using such kind of nets. Some advices in this field could be useful to prevent an overgrowth of the fishing effort.

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12. APPENDIX 1. SGMED OVERALL TERMS OF REFERENCE

The European Community is expected to establish long-term management plans (LTMP) for relevant Mediterranean demersal and small pelagic fisheries based on precautionary approach and adaptive management in taking measures designed to protect and conserve living aquatic resources, to provide for their sustainable exploitation and to minimise the impact of fishing activities on marine eco-systems.

The plans shall include conservation reference points such as targets against which measuring the recovery to or the maintenance of stocks within safe biological limits for fisheries exploiting stocks at/or within safe biological limits (e.g. population size and/or long-term yields and/or fishing mortality rate and/or stability of catches). The management plans shall be drawn up on the basis of the precautionary approach to fisheries management and take account of limit reference points as identified by scientists. The quantitative scientific assessment should provide sufficiently precise and accurate biological and economic indicators and reference points to allow also for an adaptive management of fisheries.

Stating clearly how stocks and fisheries will be assessed and how decision will be taken is fundamental for proper and effective implementation of management plans as well as for transparency and consultations with stakeholders.

Demersal and small pelagic stocks and fisheries in the Mediterranean are evaluated both at national and GFCM level; however these evaluations are often not recurring, are spatially restricted to only some GFCM geographical sub-areas (see attached reference map), covering only partially the overall spatial range where Community fishing fleets and stocks are distributed, and address only few stocks out of several that may be exploited in the same fisheries. Limited attention is also given to technical interactions between different fishing gears exploiting the same stocks.

A limited, although fundamental, scientific contribution of EU fishery scientists to the GFCM assessment process is increasingly affecting the capacity of this regional fisheries management organization to identify harvesting strategies and control rules and to adopt precautionary and adaptive fisheries management measures based on scientific advice.

Anyhow, GFCM and most of the riparian countries consider that management measures to control the exploitation rate and fishing effort, complemented by technical measures, are the most adequate approach for multi-species and multiple-gears Mediterranean fisheries.

Nevertheless, provided that scientific advice underlines to do so, also output measures may be conceivable to manage fisheries particularly for both small pelagic and benthic fish stocks.

Coherence and certain level of harmonization between Community and multilateral framework measures are advisable for effective conservation measures and to enhance responsible management supported by all concerned Parties and stakeholders in the Mediterranean.

STECF can play an important role in focusing greater contributions of European scientists towards stocks and fisheries assessment, in identifying a common scientific framework regarding specific analyses to advise on Community plans and to be then channeled into or completed by the GFCM working groups[1].

STECF was requested at its November plenary session to set up an operational work-programme for 2008, beginning in the 1st quarter of 2008, with a view to update the status of the main demersal stocks and evaluate the exploitation levels with respect to their biological and economic production potentials and the sustainability of the stock by using both trawl surveys and commercial catch/landing data as collected through the Community Data Collection regulation N° 1543/2000 as well as other scientific information collected at national level.

Within this work-programme STECF is also requested to provide its advice on the status of the main small pelagic stocks and to evaluate the exploitation levels with respect to their biological and economic production potentials and the sustainability of the stock by using both echo and/or DEPM surveys and commercial

[1] STECF is requested to take into account the GFCM stock assessment forms as available at the web site http://www.gfcm.org/fishery/nems/36406/en

catch/landing data as collected through the Community Data Collection regulation N° 1543/2000 as well as other scientific information collected at national level.

STECF should take into consideration the data that Member States have been collecting on a regular basis both via monitoring fishing activities and carrying out direct surveys[2]. STECF, in replying at the following terms of reference, should also take into consideration chapter 7 of the 26th STECF Plenary session of 5-9 November 2007[3], as well as the report of the STECF working group on balance between fishing capacity and fishing opportunities[4].

STECF shall contribute to identify and setup an advisory framework regarding low risk adaptive management by identifying and using appropriate risk assessment methods in order to understand where we stand with respect to sustainable exploitation of ecologically and economically important stocks and what additional management actions need to be taken.

On the basis of the STECF advice the Commission will launch official data calls to EU Member States requesting submission of data collected under the Community Data Collection regulation N° 1543/2000.

STECF is requested in particular:

- to advice whether the data availability may allow the development of a precautionary conceptual framework within which develop specific harvesting strategies and decision control rules for an adaptive management of demersal and small pelagic fisheries in the Mediterranean;

- to set up a conceptual, methodological and operational assessment framework which will allow STECF to carry out in a standardized way both stocks assessment analyses and detailed reviews of assessments done by other scientific bodies in the Mediterranean. The selected assessment methods shall allow estimating indicators for measuring the current status of demersal and small pelagic fisheries and stocks, the sustainability of the exploitation and to measure progress towards higher fishing productivity (MSY or other proxy) with respect to precautionary technical/biological reference points relating to MSY or other yield-based reference points, to low risk of stock collapse and to maintaining the reproductive capacity of the stocks;

- to set up a conceptual, methodological and operational assessment framework which will allow STECF to identify economic indicators and reference points compatible with economic profitability of the main fisheries while ensuring sustainable exploitation of the stocks in the Mediterranean;

- to indicate whether age/length-based VPA or statistical catch-at –age/length methods are adequate modelling tools to estimate precautionary indicators and reference points measuring the current status and future development of multispecies/multigears Mediterranean fisheries. STECF shall also provide a conceptual and operational framework to use, if advisable, these methods for demersal and small pelagic Mediterranean fisheries;

- to identify adequate empirical modelling approaches that are adequate to estimate precautionary indicators and reference points measuring the current status and future development of multispecies/multigears Mediterranean fisheries. STECF shall also provide a conceptual and operational framework to use, if advisable, these methods for demersal and small pelagic Mediterranean fisheries;

- to identify the decision-making support modelling tools that are adequate for the Mediterranean fisheries and that will produce outputs that support sustainable use of fishery resources recognizing the need for a precautionary framework in the face of uncertainty and that may allow to provide projections of alternative scenarios for short-medium and long term management guidance;

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[2] Council Regulation (EC) No **1343/2007** of 13 November 2007 amending Regulation (EC) No 1543/2000 establishing a Community framework for the collection and management of the data needed to conduct the common fisheries policy

Commission Regulation (EC) No **1581/2004** of 27 August 2004 amending Regulation (EC) No 1639/2001 establishing the minimum and extended Community programmes for the collection of data in the fisheries sector and laying down detailed rules for the application of Council Regulation (EC) No 1543/2000

[3] http://stecf.jrc.ec.europa.eu/38

[4] Report of the STECF Working Group on The Balance between Capacity and Exploitation SGRST-SGECA-07-05 Working group convened in the margin of SGECA-SGRST-SGECA-07-02 (Review of Scientific advice II), 22-26th Oct 2007. Evaluated and endorsed at the November plenary session.

- to provide either a qualitative or quantitative understanding of the level of precision and accuracy attached to the estimation of indicators and reference points through the different modelling tools;

- to identify which decision-making support modelling tools may help in setting up stock-size dependent harvesting strategies and respective decision control rules;

- to provide information on the data and standardised format needed for each of the decision-making support modelling tool which will be used to launch official data calls under the DCR n° 1543/2000. STECF should also indicate criteria to ensure quality cross- checks of the data received upon the calls.

13. APPENDIX 2. SGMED-10-03 PARTICIPANTS LIST

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14. APPENDIX 3. PROPOSED AGGREGATION AND PARAMETERS FOR THE STECF SGMED AND SGBLACKSEA DCF DATA CALLS IN 2011.

14.1. Appendix 3.1 Fisheries catch data (including discards and biological parameters at age)

A Catch data for 2002-2010 fully aggregated (sum) by ID except for mean weight and length (arithmetic mean) in landings and discards at age. Missing values shall be indicated by "-1". Please ensure that data entries are fully consistent with coding given in Appendixes.

1. ID (this is a unique identifier; e.g. the combination of country, year, quarter, gear, mesh size range, fishery or metier, and area; this is free text with a maximum of 40 characters without space)
2. COUNTRY (this should be given according to the code list provided in Appendix 1)
3. YEAR (this should be given in four digits), like 2004
4. QUARTER (this should be given as one digit), like 1, 2, 3, or 4
5. VESSEL_LENGTH (vessel length should be given according to the code list provided in Appendix 2)
6. GEAR (gear should be given according to the code list provided in Appendix 3)
7. MESH_SIZE_RANGE (the mesh size range should be given according to the code list provided in Appendix 4)
8. FISHERY or métier (species complex, gear and vessel characteristics code is given in Appendix 5)
9. AREA (GFCM SA, e.g. SA 1, given in Appendix 6)
10. SPECON (any derogation granted, text string of maximum 10 characters, -1 if not appicable)
11. SPECIES (the species should be given according to the code list provided in Appendix 7 where applicable)
12. LANDINGS (estimated landings in tonnes should be given; if age based information is present, this quantity should correspond to the sum of products of numbers at age multiplied with weight at age)
13. DISCARDS (estimated discards in tonnes should be given; if age based information is present, this quantity should correspond to the sum of products of numbers at age multiplied with weight at age)
14. NO_SAMPLES_LANDINGS (the number of TRIPS should be given that relate to landings only; a number should be given only if it relates to this fishery only; otherwise "–1" should be given)
15. NO_LENGTH_MEASUREMENTS_LANDINGS (the number of length measurements should be given that relate to landings only; a number should be given only if it relates to this fishery only; otherwise "–1" should be given)
16. NO_AGE_MEASUREMENTS_LANDINGS (the number of age measurements should be given that relate to landings only; a number should be given only if it relates to this fishery only; otherwise "–1" should be given)
17. NO_SAMPLES_DISCARDS (the number of TRIPS should be given that relate to discards only; a number should be given only if it relates to this fishery only; otherwise "–1" should be given)
18. NO_LENGTH_MEASUREMENTS_DISCARDS (the number of length measurements should be given that relate to discards only; a number should be given only if it relates to this fishery only; otherwise "–1" should be given)
19. NO_AGE_MEASUREMENTS_DISCARDS (the number of age measurements should be given that relate to discards only; a number should be given only if it relates to this fishery only; otherwise "–1" should be given)
20. NO_SAMPLES_CATCH (the number of TRIPS should be given that relate to catches only; a number should be given only if it relates to this fishery only; otherwise "–1" should be given)
21. NO_LENGTH_MEASUREMENTS_CATCH (a number of length measurements should be given here if it relates to catch, i.e. landings and discards; a number should be given only if it relates to this fishery only; otherwise "–1" should be given)
22. NO_AGE_MEASUREMENTS_CATCH (a number of age measurements should be given here if it relates to catch, i.e. landings and discards; a number should be given only if it relates to this fishery only; otherwise "–1" should be given)
23. MIN_AGE (this is the minimum age in the data section; if minimum age and maximum age are both "–1", no age based data are given; otherwise age data must follow in the data section for each age in the age range MIN_AGE to MAX_AGE; minimum age and maximum age must either both be "-1" or both be not "-1")

24. MAX_AGE (this is the true maximum age in the data section (no plus group is allowed); if minimum age and maximum age are both "–1", no age based data are given; otherwise age data must follow in the data section for each age in the age range MIN_AGE to MAX_AGE; minimum age and maximum age must either both be "-1" or both be not "-1")
25. Age 0 (years)=0
26. Age 0 No. Landed (thousands)
27. Age 0 MEAN Weight Landed (kg, precision in gram=3 digits after the comma)
28. Age 0 MEAN Length Landed (cm, precision in mm=1 digits after the comma)
29. Age 0 No. Discard (thousands)
30. Age 0 MEAN Weight Discard (kg, precision in gram=3 digits after the comma)
31. Age 0 MEAN Length Discard (cm, precision in mm=1 digits after the comma)
32. Age 1 (years)=1
33. Age 1 No. Landed (thousands)
34. Age 1 MEAN Weight Landed (kg, precision in gram=3 digits after the comma)
35. Age 1 MEAN Length Landed (cm, precision in mm=1 digits after the comma)
36. Age 1 No. Discard (thousands)
37. Age 1 MEAN Weight Discard (kg, precision in gram=3 digits after the comma)
38. Age 1 MEAN Length Discard (cm, precision in mm=1 digits after the comma)
39. Age 2 (years)=2
40. Age 2 No. Landed (thousands)
41. Age 2 MEAN Weight Landed (kg, precision in gram=3 digits after the comma)
42. Age 2 MEAN Length Landed (cm, precision in mm=1 digits after the comma)
43. Age 2 No. Discard (thousands)
44. Age 2 MEAN Weight Discard (kg, precision in gram=3 digits after the comma)
45. Age 2 MEAN Length Discard (cm, precision in mm=1 digits after the comma)
46. Age 3 (years)=3
47. Age 3 No. Landed (thousands)
48. Age 3 MEAN Weight Landed (kg, precision in gram=3 digits after the comma)
49. Age 3 MEAN Length Landed (cm, precision in mm=1 digits after the comma)
50. Age 3 No. Discard (thousands)
51. Age 3 MEAN Weight Discard (kg, precision in gram=3 digits after the comma)
52. Age 3 MEAN Length Discard (cm, precision in mm=1 digits after the comma)
53. Age 4 (years)=4
54. Age 4 No. Landed (thousands)
55. Age 4 MEAN Weight Landed (kg, precision in gram=3 digits after the comma)
56. Age 4 MEAN Length Landed (cm, precision in mm=1 digits after the comma)
57. Age 4 No. Discard (thousands)
58. Age 4 MEAN Weight Discard (kg, precision in gram=3 digits after the comma)
59. Age 4 MEAN Length Discard (cm, precision in mm=1 digits after the comma)
60. Age 5 (years)=5
61. Age 5 No. Landed (thousands)
62. Age 5 MEAN Weight Landed (kg, precision in gram=3 digits after the comma)
63. Age 5 MEAN Length Landed (cm, precision in mm=1 digits after the comma)
64. Age 5 No. Discard (thousands)
65. Age 5 MEAN Weight Discard (kg, precision in gram=3 digits after the comma)
66. Age 5 MEAN Length Discard (cm, precision in mm=1 digits after the comma)
67. Age 6 (years)=6
68. Age 6 No. Landed (thousands)
69. Age 6 MEAN Weight Landed (kg, precision in gram=3 digits after the comma)
70. Age 6 MEAN Length Landed (cm, precision in mm=1 digits after the comma)
71. Age 6 No. Discard (thousands)
72. Age 6 MEAN Weight Discard (kg, precision in gram=3 digits after the comma)
73. Age 6 MEAN Length Discard (cm, precision in mm=1 digits after the comma)
74. Age 7 (years)=7
75. Age 7 No. Landed (thousands)
76. Age 7 MEAN Weight Landed (kg, precision in gram=3 digits after the comma)
77. Age 7 MEAN Length Landed (cm, precision in mm=1 digits after the comma)

78. Age 7 No. Discard (thousands)
79. Age 7 MEAN Weight Discard (kg, precision in gram=3 digits after the comma)
80. Age 7 MEAN Length Discard (cm, precision in mm=1 digits after the comma)
81. Age 8 (years)=8
82. Age 8 No. Landed (thousands)
83. Age 8 MEAN Weight Landed (kg, precision in gram=3 digits after the comma)
84. Age 8 MEAN Length Landed (cm, precision in mm=1 digits after the comma)
85. Age 8 No. Discard (thousands)
86. Age 8 MEAN Weight Discard (kg, precision in gram=3 digits after the comma)
87. Age 8 MEAN Length Discard (cm, precision in mm=1 digits after the comma)
88. Age 9 (years)=9
89. Age 9 No. Landed (thousands)
90. Age 9 MEAN Weight Landed (kg, precision in gram=3 digits after the comma)
91. Age 9 MEAN Length Landed (cm, precision in mm=1 digits after the comma)
92. Age 9 No. Discard (thousands)
93. Age 9 MEAN Weight Discard (kg, precision in gram=3 digits after the comma)
94. Age 9 MEAN Length Discard (cm, precision in mm=1 digits after the comma)
95. Age 10 (years)=10
96. Age 10 No. Landed (thousands)
97. Age 10 MEAN Weight Landed (kg, precision in gram=3 digits after the comma)
98. Age 10 MEAN Length Landed (cm, precision in mm=1 digits after the comma)
99. Age 10 No. Discard (thousands)
100. Age 10 MEAN Weight Discard (kg, precision in gram=3 digits after the comma)
101. Age 10 MEAN Length Discard (cm, precision in mm=1 digits after the comma)
102. Age 11 (years)=11
103. Age 11 No. Landed (thousands)
104. Age 11 MEAN Weight Landed (kg, precision in gram=3 digits after the comma)
105. Age 11 MEAN Length Landed (cm, precision in mm=1 digits after the comma)
106. Age 11 No. Discard (thousands)
107. Age 11 MEAN Weight Discard (kg, precision in gram=3 digits after the comma)
108. Age 11 MEAN Length Discard (cm, precision in mm=1 digits after the comma)
109. Age 12 (years)=12
110. Age 12 No. Landed (thousands)
111. Age 12 MEAN Weight Landed (kg, precision in gram=3 digits after the comma)
112. Age 12 MEAN Length Landed (cm, precision in mm=1 digits after the comma)
113. Age 12 No. Discard (thousands)
114. Age 12 MEAN Weight Discard (kg, precision in gram=3 digits after the comma)
115. Age 12 MEAN Length Discard (cm, precision in mm=1 digits after the comma)
116. Age 13 (years)=13
117. Age 13 No. Landed (thousands)
118. Age 13 MEAN Weight Landed (kg, precision in gram=3 digits after the comma)
119. Age 13 MEAN Length Landed (cm, precision in mm=1 digits after the comma)
120. Age 13 No. Discard (thousands)
121. Age 13 MEAN Weight Discard (kg, precision in gram=3 digits after the comma)
122. Age 13 MEAN Length Discard (cm, precision in mm=1 digits after the comma)
123. Age 14 (years)=14
124. Age 14 No. Landed (thousands)
125. Age 14 MEAN Weight Landed (kg, precision in gram=3 digits after the comma)
126. Age 14 MEAN Length Landed (cm, precision in mm=1 digits after the comma)
127. Age 14 No. Discard (thousands)
128. Age 14 MEAN Weight Discard (kg, precision in gram=3 digits after the comma)
129. Age 14 MEAN Length Discard (cm, precision in mm=1 digits after the comma)
130. Age 15 (years)=15
131. Age 15 No. Landed (thousands)
132. Age 15 MEAN Weight Landed (kg, precision in gram=3 digits after the comma)
133. Age 15 MEAN Length Landed (cm, precision in mm=1 digits after the comma)
134. Age 15 No. Discard (thousands)

135. Age 15 MEAN Weight Discard (kg, precision in gram=3 digits after the comma)
136. Age 15 MEAN Length Discard (cm, precision in mm=1 digits after the comma)
137. Age 16 (years)=16
138. Age 16 No. Landed (thousands)
139. Age 16 MEAN Weight Landed (kg, precision in gram=3 digits after the comma)
140. Age 16 MEAN Length Landed (cm, precision in mm=1 digits after the comma)
141. Age 16 No. Discard (thousands)
142. Age 16 MEAN Weight Discard (kg, precision in gram=3 digits after the comma)
143. Age 16 MEAN Length Discard (cm, precision in mm=1 digits after the comma)
144. Age 17 (years)=17
145. Age 17 No. Landed (thousands)
146. Age 17 MEAN Weight Landed (kg, precision in gram=3 digits after the comma)
147. Age 17 MEAN Length Landed (cm, precision in mm=1 digits after the comma)
148. Age 17 No. Discard (thousands)
149. Age 17 MEAN Weight Discard (kg, precision in gram=3 digits after the comma)
150. Age 17 MEAN Length Discard (cm, precision in mm=1 digits after the comma)
151. Age 18 (years)=18
152. Age 18 No. Landed (thousands)
153. Age 18 MEAN Weight Landed (kg, precision in gram=3 digits after the comma)
154. Age 18 MEAN Length Landed (cm, precision in mm=1 digits after the comma)
155. Age 18 No. Discard (thousands)
156. Age 18 MEAN Weight Discard (kg, precision in gram=3 digits after the comma)
157. Age 18 MEAN Length Discard (cm, precision in mm=1 digits after the comma)
158. Age 19 (years)=19
159. Age 19 No. Landed (thousands)
160. Age 19 MEAN Weight Landed (kg, precision in gram=3 digits after the comma)
161. Age 19 MEAN Length Landed (cm, precision in mm=1 digits after the comma)
162. Age 19 No. Discard (thousands)
163. Age 19 MEAN Weight Discard (kg, precision in gram=3 digits after the comma)
164. Age 19 MEAN Length Discard (cm, precision in mm=1 digits after the comma)
165. Age 20 (years)=20
166. Age 20 No. Landed (thousands)
167. Age 20 MEAN Weight Landed (kg, precision in gram=3 digits after the comma)
168. Age 20 MEAN Length Landed (cm, precision in mm=1 digits after the comma)
169. Age 20 No. Discard (thousands)
170. Age 20 MEAN Weight Discard (kg, precision in gram=3 digits after the comma)
171. Age 20 MEAN Length Discard (cm, precision in mm=1 digits after the comma)

14.2. Appendix 3.2 Fisheries' landings at length data

B Landings data for 2002-2010 fully aggregated (sum) by ID. Please ensure that data entries are fully consistent with coding given in Appendixes. Missing values shall be indicated by "-1".

1. ID (this is a unique identifier; e.g. the combination of country, year, quarter, gear, mesh size range, fishery or metier, and area; this is free text with a maximum of 40 characters without space)
2. COUNTRY (this should be given according to the code list provided in Appendix 1)
3. YEAR (this should be given in four digits), like 2004
4. QUARTER (this should be given as one digit), like 1, 2, 3, or 4
5. VESSEL_LENGTH (vessel length should be given according to the code list provided in Appendix 2)
6. GEAR (gear should be given according to the code list provided in Appendix 3)
7. MESH_SIZE_RANGE (the mesh size range should be given according to the code list provided in Appendix 4)
8. FISHERY or métier (species complex, gear and vessel characteristics code is given in Appendix 5)
9. AREA (GFCM SA, e.g. SA 1, given in Appendix 6)
10. SPECON (any derogation granted, text string of maximum 10 characters, -1 if not appicable)

11. SPECIES (the species should be given according to the code list provided in Appendix 7 where applicalbe)
12. LANDINGS (estimated landings in tonnes should be given; if length based information is present, this quantity should correspond to the sum of products of numbers at length multiplied with weight at length)
14 UNIT (unit of length classes, mm=millimetre, cm=centimetre)
15. LengthClass0 (numbers, precision in thousands=3 digits after the comma)
16. LengthClass1 (numbers, precision in thousands=3 digits after the comma)
17. LengthClass2 (numbers, precision in thousands=3 digits after the comma)
18. LengthClass3 (numbers, precision in thousands=3 digits after the comma)
19. LengthClass4 (numbers, precision in thousands=3 digits after the comma)
20. LengthClass5 (numbers, precision in thousands=3 digits after the comma)
21. LengthClass6 (numbers, precision in thousands=3 digits after the comma)
22. LengthClass7 (numbers, precision in thousands=3 digits after the comma)
23. LengthClass8 (numbers, precision in thousands=3 digits after the comma)
24. LengthClass9 (numbers, precision in thousands=3 digits after the comma)
25. LengthClass10 (numbers, precision in thousands=3 digits after the comma)
26. LengthClass11 (numbers, precision in thousands=3 digits after the comma)
27. LengthClass12 (numbers, precision in thousands=3 digits after the comma)
28. LengthClass13 (numbers, precision in thousands=3 digits after the comma)
29. LengthClass14 (numbers, precision in thousands=3 digits after the comma)
30. LengthClass15 (numbers, precision in thousands=3 digits after the comma)
31. LengthClass16 (numbers, precision in thousands=3 digits after the comma)
32. LengthClass17 (numbers, precision in thousands=3 digits after the comma)
33. LengthClass18 (numbers, precision in thousands=3 digits after the comma)
34. LengthClass19 (numbers, precision in thousands=3 digits after the comma)
35. LengthClass20 (numbers, precision in thousands=3 digits after the comma)
36. LengthClass21 (numbers, precision in thousands=3 digits after the comma)
37. LengthClass22 (numbers, precision in thousands=3 digits after the comma)
38. LengthClass23 (numbers, precision in thousands=3 digits after the comma)
39. LengthClass24 (numbers, precision in thousands=3 digits after the comma)
40. LengthClass25 (numbers, precision in thousands=3 digits after the comma)
41. LengthClass26 (numbers, precision in thousands=3 digits after the comma)
42. LengthClass27 (numbers, precision in thousands=3 digits after the comma)
43. LengthClass28 (numbers, precision in thousands=3 digits after the comma)
44. LengthClass29 (numbers, precision in thousands=3 digits after the comma)
45. LengthClass30 (numbers, precision in thousands=3 digits after the comma)
46. LengthClass31 (numbers, precision in thousands=3 digits after the comma)
47. LengthClass32 (numbers, precision in thousands=3 digits after the comma)
48. LengthClass33 (numbers, precision in thousands=3 digits after the comma)
49. LengthClass34 (numbers, precision in thousands=3 digits after the comma)
50. LengthClass35 (numbers, precision in thousands=3 digits after the comma)
51. LengthClass36 (numbers, precision in thousands=3 digits after the comma)
52. LengthClass37 (numbers, precision in thousands=3 digits after the comma)
53. LengthClass38 (numbers, precision in thousands=3 digits after the comma)
54. LengthClass39 (numbers, precision in thousands=3 digits after the comma)
55. LengthClass40 (numbers, precision in thousands=3 digits after the comma)
56. LengthClass41 (numbers, precision in thousands=3 digits after the comma)
57. LengthClass42 (numbers, precision in thousands=3 digits after the comma)
58. LengthClass 43 (numbers, precision in thousands=3 digits after the comma)
59. LengthClass44 (numbers, precision in thousands=3 digits after the comma)
60. LengthClass45 (numbers, precision in thousands=3 digits after the comma)
61. LengthClass46 (numbers, precision in thousands=3 digits after the comma)
62. LengthClass47 (numbers, precision in thousands=3 digits after the comma)
63. LengthClass48 (numbers, precision in thousands=3 digits after the comma)
64. LengthClass49 (numbers, precision in thousands=3 digits after the comma)
65. LengthClass50 (numbers, precision in thousands=3 digits after the comma)

66. LengthClass51 (numbers, precision in thousands=3 digits after the comma)
67. LengthClass52 (numbers, precision in thousands=3 digits after the comma)
68. LengthClass53 (numbers, precision in thousands=3 digits after the comma)
69. LengthClass54 (numbers, precision in thousands=3 digits after the comma)
70. LengthClass55 (numbers, precision in thousands=3 digits after the comma)
71. LengthClass56 (numbers, precision in thousands=3 digits after the comma)
72. LengthClass57 (numbers, precision in thousands=3 digits after the comma)
73. LengthClass58 (numbers, precision in thousands=3 digits after the comma)
74. LengthClass59 (numbers, precision in thousands=3 digits after the comma)
75. LengthClass60 (numbers, precision in thousands=3 digits after the comma)
76. LengthClass61 (numbers, precision in thousands=3 digits after the comma)
77. LengthClass62 (numbers, precision in thousands=3 digits after the comma)
78. LengthClass63 (numbers, precision in thousands=3 digits after the comma)
79. LengthClass64 (numbers, precision in thousands=3 digits after the comma)
80. LengthClass65 (numbers, precision in thousands=3 digits after the comma)
81. LengthClass66 (numbers, precision in thousands=3 digits after the comma)
82. LengthClass67 (numbers, precision in thousands=3 digits after the comma)
83. LengthClass68 (numbers, precision in thousands=3 digits after the comma)
84. LengthClass69 (numbers, precision in thousands=3 digits after the comma)
85. LengthClass70 (numbers, precision in thousands=3 digits after the comma)
86. LengthClass71 (numbers, precision in thousands=3 digits after the comma)
87. LengthClass72 (numbers, precision in thousands=3 digits after the comma)
88. LengthClass73 (numbers, precision in thousands=3 digits after the comma)
89. LengthClass74 (numbers, precision in thousands=3 digits after the comma)
90. LengthClass75 (numbers, precision in thousands=3 digits after the comma)
91. LengthClass76 (numbers, precision in thousands=3 digits after the comma)
92. LengthClass77 (numbers, precision in thousands=3 digits after the comma)
93. LengthClass78 (numbers, precision in thousands=3 digits after the comma)
94. LengthClass79 (numbers, precision in thousands=3 digits after the comma)
95. LengthClass80 (numbers, precision in thousands=3 digits after the comma)
96. LengthClass81 (numbers, precision in thousands=3 digits after the comma)
97. LengthClass82 (numbers, precision in thousands=3 digits after the comma)
98. LengthClass83 (numbers, precision in thousands=3 digits after the comma)
99. LengthClass84 (numbers, precision in thousands=3 digits after the comma)
100. LengthClass85 (numbers, precision in thousands=3 digits after the comma)
101. LengthClass86 (numbers, precision in thousands=3 digits after the comma)
102. LengthClass87 (numbers, precision in thousands=3 digits after the comma)
103. LengthClass88 (numbers, precision in thousands=3 digits after the comma)
104. LengthClass89 (numbers, precision in thousands=3 digits after the comma)
105. LengthClass90 (numbers, precision in thousands=3 digits after the comma)
106. LengthClass91 (numbers, precision in thousands=3 digits after the comma)
107. LengthClass92 (numbers, precision in thousands=3 digits after the comma)
108. LengthClass93 (numbers, precision in thousands=3 digits after the comma)
109. LengthClass94 (numbers, precision in thousands=3 digits after the comma)
110. LengthClass95 (numbers, precision in thousands=3 digits after the comma)
111. LengthClass96 (numbers, precision in thousands=3 digits after the comma)
112. LengthClass97 (numbers, precision in thousands=3 digits after the comma)
113. LengthClass98 (numbers, precision in thousands=3 digits after the comma)
114. LengthClass99 (numbers, precision in thousands=3 digits after the comma)
115. LengthClass100 (numbers, precision in thousands=3 digits after the comma)

14.3. Appendix 3.3 Fisheries' discards at length data

C Discards data for 2002-2010 fully aggregated (sum) by ID. Please ensure that data entries are fully consistent with coding given in Appendixes. Missing values shall be indicated by "-1".

1. ID (this is a unique identifier; e.g. the combination of country, year, quarter, gear, mesh size range, fishery or metier, and area; this is free text with a maximum of 40 characters without space)
2. COUNTRY (this should be given according to the code list provided in Appendix 1)
3. YEAR (this should be given in four digits), like 2004
4. QUARTER (this should be given as one digit), like 1, 2, 3, or 4
5. VESSEL_LENGTH (vessel length should be given according to the code list provided in Appendix 2)
6. GEAR (gear should be given according to the code list provided in Appendix 3)
7. MESH_SIZE_RANGE (the mesh size range should be given according to the code list provided in Appendix 4)
8. FISHERY or métier (species complex, gear and vessel characteristics code is given in Appendix 5)
9. AREA (GFCM SA, e.g. SA 1, given in Appendix 6)
10. SPECON (any derogation granted, text string of maximum 10 characters, -1 if not appicable)
11. SPECIES (the species should be given according to the code list provided in Appendix 7 where applicable)
12. DISCARDS (estimated discards in tonnes should be given; if length based information is present, this quantity should correspond to the sum of products of numbers at length multiplied with weight at length)

14 UNIT (unit of length classes, mm=millimetre, cm=centimetre)

15. LengthClass0 (numbers, precision in thousands=3 digits after the comma)
16. LengthClass1 (numbers, precision in thousands=3 digits after the comma)
17. LengthClass2 (numbers, precision in thousands=3 digits after the comma)
18. LengthClass3 (numbers, precision in thousands=3 digits after the comma)
19. LengthClass4 (numbers, precision in thousands=3 digits after the comma)
20. LengthClass5 (numbers, precision in thousands=3 digits after the comma)
21. LengthClass6 (numbers, precision in thousands=3 digits after the comma)
22. LengthClass7 (numbers, precision in thousands=3 digits after the comma)
23. LengthClass8 (numbers, precision in thousands=3 digits after the comma)
24. LengthClass9 (numbers, precision in thousands=3 digits after the comma)
25. LengthClass10 (numbers, precision in thousands=3 digits after the comma)
26. LengthClass11 (numbers, precision in thousands=3 digits after the comma)
27. LengthClass12 (numbers, precision in thousands=3 digits after the comma)
28. LengthClass13 (numbers, precision in thousands=3 digits after the comma)
29. LengthClass14 (numbers, precision in thousands=3 digits after the comma)
30. LengthClass15 (numbers, precision in thousands=3 digits after the comma)
31. LengthClass16 (numbers, precision in thousands=3 digits after the comma)
32. LengthClass17 (numbers, precision in thousands=3 digits after the comma)
33. LengthClass18 (numbers, precision in thousands=3 digits after the comma)
34. LengthClass19 (numbers, precision in thousands=3 digits after the comma)
35. LengthClass20 (numbers, precision in thousands=3 digits after the comma)
36. LengthClass21 (numbers, precision in thousands=3 digits after the comma)
37. LengthClass22 (numbers, precision in thousands=3 digits after the comma)
38. LengthClass23 (numbers, precision in thousands=3 digits after the comma)
39. LengthClass24 (numbers, precision in thousands=3 digits after the comma)
40. LengthClass25 (numbers, precision in thousands=3 digits after the comma)
41. LengthClass26 (numbers, precision in thousands=3 digits after the comma)
42. LengthClass27 (numbers, precision in thousands=3 digits after the comma)
43. LengthClass28 (numbers, precision in thousands=3 digits after the comma)
44. LengthClass29 (numbers, precision in thousands=3 digits after the comma)
45. LengthClass30 (numbers, precision in thousands=3 digits after the comma)
46. LengthClass31 (numbers, precision in thousands=3 digits after the comma)
47. LengthClass32 (numbers, precision in thousands=3 digits after the comma)
48. LengthClass33 (numbers, precision in thousands=3 digits after the comma)
49. LengthClass34 (numbers, precision in thousands=3 digits after the comma)
50. LengthClass35 (numbers, precision in thousands=3 digits after the comma)
51. LengthClass36 (numbers, precision in thousands=3 digits after the comma)
52. LengthClass37 (numbers, precision in thousands=3 digits after the comma)

53. LengthClass38 (numbers, precision in thousands=3 digits after the comma)
54. LengthClass39 (numbers, precision in thousands=3 digits after the comma)
55. LengthClass40 (numbers, precision in thousands=3 digits after the comma)
56. LengthClass41 (numbers, precision in thousands=3 digits after the comma)
57. LengthClass42 (numbers, precision in thousands=3 digits after the comma)
58. LengthClass43 (numbers, precision in thousands=3 digits after the comma)
59. LengthClass44 (numbers, precision in thousands=3 digits after the comma)
60. LengthClass45 (numbers, precision in thousands=3 digits after the comma)
61. LengthClass46 (numbers, precision in thousands=3 digits after the comma)
62. LengthClass47 (numbers, precision in thousands=3 digits after the comma)
63. LengthClass48 (numbers, precision in thousands=3 digits after the comma)
64. LengthClass49 (numbers, precision in thousands=3 digits after the comma)
65. LengthClass50 (numbers, precision in thousands=3 digits after the comma)
66. LengthClass51 (numbers, precision in thousands=3 digits after the comma)
67. LengthClass52 (numbers, precision in thousands=3 digits after the comma)
68. LengthClass53 (numbers, precision in thousands=3 digits after the comma)
69. LengthClass54 (numbers, precision in thousands=3 digits after the comma)
70. LengthClass55 (numbers, precision in thousands=3 digits after the comma)
71. LengthClass56 (numbers, precision in thousands=3 digits after the comma)
72. LengthClass57 (numbers, precision in thousands=3 digits after the comma)
73. LengthClass58 (numbers, precision in thousands=3 digits after the comma)
74. LengthClass59 (numbers, precision in thousands=3 digits after the comma)
75. LengthClass60 (numbers, precision in thousands=3 digits after the comma)
76. LengthClass61 (numbers, precision in thousands=3 digits after the comma)
77. LengthClass62 (numbers, precision in thousands=3 digits after the comma)
78. LengthClass63 (numbers, precision in thousands=3 digits after the comma)
79. LengthClass64 (numbers, precision in thousands=3 digits after the comma)
80. LengthClass65 (numbers, precision in thousands=3 digits after the comma)
81. LengthClass66 (numbers, precision in thousands=3 digits after the comma)
82. LengthClass67 (numbers, precision in thousands=3 digits after the comma)
83. LengthClass68 (numbers, precision in thousands=3 digits after the comma)
84. LengthClass69 (numbers, precision in thousands=3 digits after the comma)
85. LengthClass70 (numbers, precision in thousands=3 digits after the comma)
86. LengthClass71 (numbers, precision in thousands=3 digits after the comma)
87. LengthClass72 (numbers, precision in thousands=3 digits after the comma)
88. LengthClass73 (numbers, precision in thousands=3 digits after the comma)
89. LengthClass74 (numbers, precision in thousands=3 digits after the comma)
90. LengthClass75 (numbers, precision in thousands=3 digits after the comma)
91. LengthClass76 (numbers, precision in thousands=3 digits after the comma)
92. LengthClass77 (numbers, precision in thousands=3 digits after the comma)
93. LengthClass78 (numbers, precision in thousands=3 digits after the comma)
94. LengthClass79 (numbers, precision in thousands=3 digits after the comma)
95. LengthClass80 (numbers, precision in thousands=3 digits after the comma)
96. LengthClass81 (numbers, precision in thousands=3 digits after the comma)
97. LengthClass82 (numbers, precision in thousands=3 digits after the comma)
98. LengthClass83 (numbers, precision in thousands=3 digits after the comma)
99. LengthClass84 (numbers, precision in thousands=3 digits after the comma)
100. LengthClass85 (numbers, precision in thousands=3 digits after the comma)
101. LengthClass86 (numbers, precision in thousands=3 digits after the comma)
102. LengthClass87 (numbers, precision in thousands=3 digits after the comma)
103. LengthClass88 (numbers, precision in thousands=3 digits after the comma)
104. LengthClass89 (numbers, precision in thousands=3 digits after the comma)
105. LengthClass90 (numbers, precision in thousands=3 digits after the comma)
106. LengthClass91 (numbers, precision in thousands=3 digits after the comma)
107. LengthClass92 (numbers, precision in thousands=3 digits after the comma)
108. LengthClass93 (numbers, precision in thousands=3 digits after the comma)
109. LengthClass94 (numbers, precision in thousands=3 digits after the comma)

110. LengthClass95 (numbers, precision in thousands=3 digits after the comma)
111. LengthClass96 (numbers, precision in thousands=3 digits after the comma)
112. LengthClass97 (numbers, precision in thousands=3 digits after the comma)
113. LengthClass98 (numbers, precision in thousands=3 digits after the comma)
114. LengthClass99 (numbers, precision in thousands=3 digits after the comma)
115. LengthClass100 (numbers, precision in thousands=3 digits after the comma)

14.4. Appendix 3.4 Fisheries' effort data

D Fishing effort data for 2002-2010 fully aggregated (sum) by ID. Missing values shall be indicated by "-1".

1. ID (this is a unique identifier; e.g. the combination of country, year, quarter, gear, mesh size range, fishery or metier, and area; this is free text with a maximum of 40 characters without space)
2. COUNTRY (this should be given according to the code list provided in Appendix 1)
3. YEAR (this should be given in four digits after the comma), like 2004
4. QUARTER (this should be given as one digit), like 1, 2, 3, or 4
5. VESSEL_LENGTH (vessel length should be given according to the code list provided in Appendix 2)
6. GEAR (gear should be given according to the code list provided in Appendix 3)
7. MESH_SIZE_RANGE (the mesh size range should be given according to the code list provided in Appendix 4)
8. FISHERY or métier (species complex, gear and vessel characteristics code is given in Appendix 5)
9. AREA (GFCM SA, e.g. SA 1, given in Appendix 6)
10. SPECON (any derogation granted, text string of maximum 10 characters, -1 if not appicable)
11. NOMINAL_EFFORT (effort should be given in kWdays, i.e. engine power in kW times days at sea; if nominal effort is not available, "-1" should be given)
12. GT_DAYS_AT_SEA (effort should be given in gross tonnage * days at sea; if the number is not available, "-1" should be given)
13. NO_VESSELS (simple integer value of vessels, if the number is not available, "-1" should be given)

14.5. Appendix 3.5 Fisheries' economic data

E Economic data for 2002-2007 or 2008-2010 fully aggregated (sum). Missing values shall be indicated by "-1".

1. COUNTRY (this should be given according to the code list provided in Appendix 1)
2. YEAR (this should be given in four digits after the comma), like 2004
3. VESSEL_LENGTH (vessel length should be given according to the code list provided in Appendix 2)
4. GEAR (gear should be given according to the code list provided in Appendix 3)
5. AREA (GFCM SA, e.g. SA 1, given in Appendix 6)
6. SPECON (any derogation granted, text string of maximum 10 characters, -1 if not appicable)
7. TOTVES (total number of vessels in numbers for 2008-2010)
8. TOTDAYS (totol number of days at sea for 2008-2010)
9. AVGAGE (average age of fleet in years with, numeric with 2 digitis for 2008-2010)
10. AVGLOA (average length over all of the vessels in meters, numeric with 1 digit for 2008-2010)
11. AVGGT (average gross tonnage of the vessels, numeric for 2008-2010)
12. AVGKW (average kW of the vessels, numeric for 2008-2010. See Council Regulation (EC) No 2930/86 for more information)
13. NUMBER (total number of vessels in numbers, numeric for 2002-2007)
14. KW (maximum continuous engine power actually developed by the main engine, after derating if appropriate, expressed in kW as defined in Council Regulation (EC) No 2930/86. This is the TOTAL numeric value summed over all the vessels for 2002-2007)
15. GT (gross tonnage. This is the TOTAL numeric value summed over all the vessels for 2002-2007)

16. AGE (age of fleet. This is the nummeric average age of the vessels, numeric with 2 digits after the comma for 2002-2007)
17. TOTAL (number of employees, numeric for 2002-2007)
18. FULLTIME (number of crew employed full time, numeric for 2002-2007)
19. PARTTIME (number of crew employed part time, numeric for 2002-2007)
20. FTE (number of full time equivalents, numeric for 2002-2007)
21. TOTJOB (number of jobs on board of all vessels, equal to the average number of persons working for and paid by the individual vessel, numeric for 2008-2010)
22. INCOME (total income including subsidies, landings, renting vessel to tourists etc. Total value summed over all vessels and species, numberic in Euro for 2002-2007)
23. TOTLANDGINC (Value of landings in Euro of all fish species landed, numeric 2008-2010)
24. TOTDIRSUB (direct subsidies in Euro. Includes direct payments, e.g. compensation for stopping fishing, refunds of fuel duty or similar lump sum compensation payments. Excludes social benefit payments, indirect subsidies, e.g. reduced duty on inputs such as fuel, investment subsidies, numeric 2008-2010)
25. TOTOTHERINC (Other income in Euro. Includes other income from use of the vessel, e.g. recreational fishing, tourism, oil rig duty, etc. also insurance payments for damage/loss of gear/vessel, numeric 2008-2010)
26. CREWCOST (crew share (including social security, health insurance, retirements and other related taxes, in Euro. Total value summed over all vessels, numeric for 2002-2007)
27. FUELCOST (cost of fuel summed over all vessels in Euro, numeric for 2002-2007)
28. VARCOST (operational costs - sum of all costs (other than fuel and crew share) which are related to fishing effort in Euro. Does not include repair and maintenance that is counted separately. Total value summed over all vessels, numeric for 2002-2007)
29. CAPCOST (total costs related to invested capital (i.e. depreciation and interest). Depreciation and interest costs must be related to total invested capital, and not only to repayment of loans and/or interest payments. Every Member State can set their depreciation time and method and interest rate. Total value summed over all vessels in Euro, numeric for 2002-2007)
30. FIXEDCOST (sum of all costs which ARE NOT related to fishing effort. Does not include repair and maintenance or capital costs that are counted separately. Total value summed over all vessels in Euro, numeric for 2002-2007)
31. REPCOST (repair and maintenance. Total value summed over all vessels in Euro, numeric for 2002-2007)
32. TOTCREWWAGE (personnel costs: wages and salaries of crew. Including social security costs, in Euro numberic for 2008-2010)
33. TOTUNPAIDLAB (value of unpaid labour. Imputed value of unpaid labour. For example, the vessel owner's own labour. Chosen methodology should be explained by the Member State in their national programme, in Euro numberic for 2008-2010)
34. TOTENERCOST (energy costs. Costs derived from the energy consumption. Excluding lubrication oil. Broken down by type if possible (petrol, diesel, biofuel, etc., in Euro numberic for 2008-2010)
35. TOTREPCOST (gross costs of maintenance and repairs to vessel and gear., in Euro numberic for 2008-2010)
36. TOTVARCOST (variable costs. Includes all purchased inputs (goods and services) related to fishing effort and/or catch/landings, in Euro numberic for 2008-2010)
37. TOTNOVARCOST (non variable costs. Includes purchased inputs not related to effort and/or catch/landings (including leased equipment, in Euro numberic for 2008-2010)
38. TOTDEPCOST (annual depreciation. Estimated according to (the proposed PIM methodology in the capital valuation report of study No FISH/2005/03: 'IREPA Onlus Coordinator, 2006. Evaluation of the capital value, investments and capital costs in the fisheries sector Study No FISH/2005/03, 203 p.'. The data and estimation procedures should be explained in the national programme, in Euro numeric for 2008-2010)
39. BORROWING (ratio of borrowed capital to total capital, numeric with 2 digits after the comma for 2002-2007)
40. INVESTMENT (total investment in Euro. Assets, including the value of leased equipment. Sum over all vessels, numeric for 2002-2007)

41. TOTDEPREP (depreciated replacement value in Euro. Value of physical capital: depreciated replacement value. Value of the vessel, i.e. the hull, engine, all onboard equipment and the gear. Sum over all vessels, numeric for 2008-2010)
42. TOTINVEST (investments in physical capital in Euro. Improvements to existing vessel/gear during the given year, numeric for 2008-2010)
43. FINPOS (debt/asset ratio. % debt in relation to total capital value as defined above, numeric with 2 digits after the comma for 2008-2010)
44. TOTENERCONS (energy consumption. Amount of fuel used by each vessel over a specified time period - sum for whole fleet segment. Excluding lubrication oil, in litres numeric for 2008-2010)
45. TOTTRIPS (number of trips. Means sum of any voyage by a fishing vessel from a land location to a landing place, excluding non-fishing trips (a trip by a fishing vessel from a location to a land location during which it does not engage in fishing activities and during which any gear on board is securely lashed and stowed and not available for immediate use, numeric for 2008-2010)
46. TOTTRAPS (numbers of pots, traps. Sum of number of pots or traps deployed by vessels operating at a specified disaggregation level. For pot and trap vessels only, numeric for 2008-2010)
47. FUELCONS (consumption of fuel by fleet segment. Total value summed over all vessels in segment, in litres numeric for 2002-2007)

14.6. Appendix 3.6 Fisheries' economic data by species

F Economic data for 2002-2007 or 2008-2010 fully aggregated (sum). Missing values shall be indicated by "-1".

1. COUNTRY (this should be given according to the code list provided in Appendix 1)
2. YEAR (this should be given in four digits after the comma), like 2004
3. VESSEL_LENGTH (vessel length should be given according to the code list provided in Appendix 2)
4. GEAR (gear should be given according to the code list provided in Appendix 3)
5. AREA (GFCM SA, e.g. SA 1, given in Appendix 6)
6. SPECON (any derogation granted, text string of maximum 10 characters, -1 if not appicable)
t7. SPECIES (the species should be given according to the code list provided in Appendix 7 where applicable)
8. TOTWGHTLANDG (Live weight in tonnes declared on landing of all vessels, numeric for 2008-2010)
9. TOTVALLANDG (Value of landings total of all vessels in Euro, numeric for 2008-2010)
10. TOTPRICELANDG (Price per kg in Euro of species landed, numeric with 2 digits after the comma for 2008-2010)
11. LIVE (Average price per kg in Euro calculated on a live weight equivalent basis, numeric with 2 digits after the comma for 2008-2010)

14.7. Appendix 3.7 MEDITS haul data (Mediterranean only)

G MEDITS haul data Type A (in accordance with MEDITS instruction manual, Version 5 April 2007)

14.8. Appendix 3.8 MEDITS catch by haul data (Mediterranean only)

H MEDITS catch by haul data Type B, all species (in accordance with MEDITS instruction manual, Version 5 April 2007)

14.9. Appendix 3.9 MEDITS biological parameters by haul data (Mediterranean only)

I MEDITS biological parameters by haul data Type C, all species (in accordance with MEDITS instruction manual, Version 5 April 2007)

14.10. Appendix 3.10 MEDITS temperature data and codes for the temperature measuring systems by haul data (Mediterranean only)

K MEDITS temperature data and codes for the temperature measuring systems Type D (in accordance with MEDITS instruction manual, Version 5 April 2007)

14.11. Appendix 3.11 MEDITS list of hauls by stratum (Mediterranean only)

L MEDITS list of hauls by stratum Type T (in accordance with MEDITS instruction manual, Version 5 April 2007)

14.12. Appendix 3.12 Annual scientific survey ABUNDANCE by length (no MEDITS)

M Annual scientific survey ABUNDANCE by length and sex of pelagic and demersal species (ECOMED, PELMED, DEPM and all hydro-acoustic surveys, all bottom trawl surveys) in the Mediterranean and Black Sea

1. COUNTRY (this should be given according to the code list provided in Appendix 1)
2. YEAR (this should be given in four digits after the comma), like 2004
3. AREA(GFCM SA, e.g. SA 1, given in Appendix 6)
4. NAME_OF_SURVEY (free text string 10 characters, ECOMED, PELMED, DEPM, or any other)
5. SPECIES (the species should be given according to the code list provided in Appendix 7 where applicable)
6. SEX (female=F, male=M, unidentified=U, combinded=C)
7. UNIT (unit of length classes, mm=millimetre, cm=centimetre)
8. LengthClass0 (numbers, precision in thousands=3 digits after the comma)
9. LengthClass1 (numbers, precision in thousands=3 digits after the comma)
10. LengthClass2 (numbers, precision in thousands=3 digits after the comma)
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108. LengthClass100 (numbers, precision in thousands=3 digits after the comma)

14.13. Appendix 3.13 Annual scientific survey BIOMASS by length (no MEDITS)

N Annual scientific survey BIOMASS by length and sex of pelagic and demersal species (ECOMED, PELMED, DEPM and all hydro-acoustic surveys, all bottom trawl surveys) in the Mediterranean and Black Sea

1. COUNTRY (this should be given according to the code list provided in Appendix 1)
2. YEAR (this should be given in four digits after the comma), like 2004
3. AREA(GFCM SA, e.g. SA 1, given in Appendix 6)
4. NAME_OF_SURVEY (free text string 10 characters, ECOMED, PELMED, DEPM, or any other)
5. SPECIES (the species should be given according to the code list provided in Appendix 7 where applicable)
6. SEX (female=F, male=M, unidentified=U, combinded=C)
7. UNIT (unit of length classes, mm=millimetre, cm=centimetre)
8. LengthClass0 (numbers, precision in tons=3 digits after the comma)
9. LengthClass1 (numbers, precision in tons =3 digits after the comma)
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106. LengthClass98 (numbers, precision in tons=3 digits after the comma)
107. LengthClass99 (numbers, precision in tons=3 digits after the comma)
108. LengthClass100 (numbers, precision in tons=3 digits after the comma)

14.14. Appendix 3.14 Annual scientific survey ABUNDANCE and BIOMASS by age and sex of pelagic and demersal species (ECOMED, PELMED, DEPM and all hydro-acoustic surveys, all bottom trawl surveys) in the Mediterranean and Black Sea (no MEDITS)

O Annual scientific survey ABUNDANCE and BIOMASS by age and sex of pelagic and demersal species (ECOMED, PELMED, DEPM and all hydro-acoustic surveys, all bottom trawl surveys) in the Mediterranean and Black Sea

1. COUNTRY (this should be given according to the code list provided in Appendix 1)
2. YEAR (this should be given in four digits after the comma), like 2004
3. AREA(GFCM SA, e.g. SA 1, given in Appendix 6)
4. NAME_OF_SURVEY (free text string 10 characters, ECOMED, PELMED, DEPM, or any other)
5. SPECIES (the species should be given according to the code list provided in Appendix 7 where applicable)
6. SEX (female=F, male=M, unidentified=U, combinded=C)
7. AgeGroup0Abund (numbers, precision in thousands=3 digits after the comma)
8. AgeGroup0Biom (numbers, precision in tons=3 digits after the comma)
9. AgeGroup1Abund (numbers, precision in thousands=3 digits after the comma)
10. AgeGroup1Biom (numbers, precision in tons=3 digits after the comma)
11. AgeGroup2Abund (numbers, precision in thousands=3 digits after the comma)
12. AgeGroup2Biom (numbers, precision in tons=3 digits after the comma)
13. AgeGroup3Abund (numbers, precision in thousands=3 digits after the comma)
14. AgeGroup3Biom (numbers, precision in tons=3 digits after the comma)
15. AgeGroup4Abund (numbers, precision in thousands=3 digits after the comma)
16. AgeGroup4Biom (numbers, precision in tons=3 digits after the comma)
17. AgeGroup5Abund (numbers, precision in thousands=3 digits after the comma)
18. AgeGroup5Biom (numbers, precision in tons=3 digits after the comma)
19. AgeGroup6Abund (numbers, precision in thousands=3 digits after the comma)
20. AgeGroup6Biom (numbers, precision in tons=3 digits after the comma)
21. AgeGroup7Abund (numbers, precision in thousands=3 digits after the comma)
22. AgeGroup7Biom (numbers, precision in tons=3 digits after the comma)
23. AgeGroup8Abund (numbers, precision in thousands=3 digits after the comma)
24. AgeGroup8Biom (numbers, precision in tons=3 digits after the comma)
25. AgeGroup9Abund (numbers, precision in thousands=3 digits after the comma)
26. AgeGroup9Biom (numbers, precision in tons=3 digits after the comma)
27. AgeGroup10Abund (numbers, precision in thousands=3 digits after the comma)
28. AgeGroup10Biom (numbers, precision in tons=3 digits after the comma)
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37. AgeGroup15Abund (numbers, precision in thousands=3 digits after the comma)
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42. AgeGroup17Biom (numbers, precision in tons=3 digits after the comma)
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45. AgeGroup19Abund (numbers, precision in thousands=3 digits after the comma)
46. AgeGroup19Biom (numbers, precision in tons=3 digits after the comma)
47. AgeGroup20Abund (numbers, precision in thousands=3 digits after the comma)
48. AgeGroup20Biom (numbers, precision in tons=3 digits after the comma)

Appendix 1 Country coding

COUNTRY	CODE
Bulgaria	BUL
Cyprus	CYP
Greece	GRC
France	FRA
Italy	ITA
Malta	MLT
Romania	ROM
Slovenia	SVN
Spain	ESP

Appendix 2 Vessel length coding (1581/2004/EC, Appendix IV, Point 4: Mediterranean and Black Sea, 949/2008/EC)

VESSEL LENGTH CLASS	CODE
Vessel < 6m length	VL0006
Vessel < 12m length	VL0012
Vessel 6m – 12m length	VL0612
Vessel 12m – 18m length	VL1218
Vessel 12m – 24m length	VL1224
Vessel 18m – 24m length	VL1824
Vessel 24m – 40m length	VL2440
Vessel > 40m length	VL40XX
Not applicable/available	-1

Appendix 3 GEAR: FISHING TECHNIQUES

GEAR	CODE
Boat dredge	DRB
Stationary uncovered pound nets	FPN
Pots and Traps	FPO
Fyke nets	FYK
Driftnet	GND
Set gillnet	GNS
Trammel net	GTR
Lampara nets	LA
Glas eel fishing	GEF
Hand lines	LHM
Pole lines	LHP
Drifting longlines	LLD
Set longlines	LLS
Trolling lines	LTL
Bottom otter trawl	OTB
Midwater otter trawl	OTM
Midwater pair trawl	PTM
Multi-rig otter trawl	OTT
Purse seine	PS
Bottom pair trawl	PTB
Beach seine	SB
Boat seine	SV
Anchored seine	SDN
Pair seine	SPR
Fly shooting seine	SSC
Beam trawl	TBB
Not applicable/available	-1

Appendix 4 Mesh size coding

MESH TYPE AND SIZE	CODE
Diamond mesh < 14 mm	00D14
Diamond mesh >=14 mm and < 16 mm	14D16
Diamond mesh >=16 mm and < 20 mm	16D20
Diamond mesh >=20 mm and < 40 mm	20D40
Diamond mesh >=40 mm and < 50 mm	40D50
Diamond mesh >=50 mm and < 100 mm	50D100
Diamond mesh >=100 mm	100DXX
Square mesh < 40 mm	00S40
Square mesh >= 40 mm	40SXX
Not applicable/ available	-1

Appendix 5 FISHERY or métier

FISHERY	CODE
Only for these species Bluefin tuna Eels	BFTE
Catadromous species	CATSP
Cephalopods	CEP
Demersal fish	DEMF
Demersal species	DEMSP
Deep water species	DWSP
Finfish	FINF
Glass eel	GE
Non active vessels	INACTIVE
Large pelagic fish	LPF
Mixed demersal and deep water species	MDDWSP
Mixed demersal and pelagic species	MDPSP
Molluscs	MOL
Other activity than fishing	OATF
Small and large pelagic fish	SLPF
Small pelagic fish	SPF
Not applicable/ available	-1

Appendix 6 AREA

Codificated GFCM Subarea

SA 1
SA 2
SA 3
SA 4
SA 5
SA 6
SA 7
SA 8
SA 9
SA 10
SA 11
SA 12
SA 13
SA 14
SA 15
SA 16
SA 17
SA 18
SA 19
SA 20
SA 21
SA 22
SA 23
SA 24
SA 25
SA 26
SA 27
SA 28
SA 29
SA 30

Appendix 7 Species

SPECIES	CODE
Anchovy *Engraulis encrasicolus*	ANE
Anglerfish *Lophius piscatorius*	MON
Axillary seabream *Pagellus acarne*	SBA
Black-bellied angler *Lophius budegassa*	ANK
Blackspot seabream *Pagellus bogaraveo*	SBR
Blue and red shrimp *Aristeus antennatus*	ARA
Blue whiting *Micromesistius poutassou*	WHB
Bogue *Boops boops*	BOG
Caramote prawn *Penaeus kerathurus*	TGS
Common dolphinfish *Coryphaena hippurus*	DOL
Common Pandora *Pagellus erythrinus*	PAC
Common sole *Solea solea*	SOL
Deep water rose shrimp *Parapenaeus longirostris*	DPS
European hake *Merluccius merluccius*	HKE
Giant red shrimp *Aristaeomorpha foliacea*	ARS
Gilthead seabream *Sparus aurata*	SBG
Greater forkbeard *Phycis blennoides*	GFB
Grey gurnard *Eutrigla gurnardus*	GUG
Grey mullets (*Mugilidae*) *Mugilidae*	MUL
Horse mackerel *Trachurus trachurus*	HOM
Mackerel *Scomber spp.*	MAZ
Mediterranean horse mackerel *Trachurus mediterraneus*	HMM
Norway lobster *Nephrops norvegicus*	NEP
Picarel *Spicara smaris*	SPC
Piked dogfish *Squalus acanthias*	DGS
Poor cod *Trisopterus minutus*	POD
Rapa *Rapana venosa*	RPW
Red mullet *Mullus barbatus*	MUT
Sardine *Sardina pilchardus*	PIL
Sargo breams *Diplodus spp.*	SRG
Sea bass *Dicentrarchus labrax*	BSS
Spottail mantis squillids *Squilla mantis*	MTS
Sprat *Sprattus sprattus*	SPR
Striped red mullet *Mullus surmuletus*	MUR
Tub gurnard *Trigla lucerna* (= *Chelidonichthys lucerna*)	GUU
Turbot *Psetta maxima*	TUR
Whiting *Merlangius merlangus*	WHG

15. APPENDIX 4. HDA0.1: MODEL FOR EVALUATION OF THE ECONOMIC AND SOCIAL IMPACTS OF HARVESTING STRATEGIES

Introduction

The model HDA0.1 for evaluation of the social and economic impacts is a dynamic simulation model which evaluates changes deriving from implementation of the specific harvesting strategies based on fishing mortality variations.

This model is a stand-alone economic model not integrated with a specific biological component. This allows HDA0.1 to estimate economic consequences of any harvesting strategy preliminary defined by using biological model or stock assessment procedures.

The main inputs to the model are represented by projections on fishing mortality by stock and projections on catches by stock. By converting changes in fishing mortality into changes in fishing effort by fleet segment, and allocating changes in catches to the levels of landings by stock and fleet segment, HDA0.1 is able to produce an economic evaluation of the harvesting strategy in the short, medium and long term.

The main assumptions on which the model is based are the following:

- The landings of the main species are estimated on the basis of the percentage variations in catches simulated by biological model or procedure through the entire simulation period.
- The weighting of the main species on production and total income is assumed to be constant. The variations in landings and total income therefore follow the relative variations estimated for the main species.
- The production prices are a function of landings based on an estimated flexibility coefficient (ε).
- The variable costs are a linear function of the fishing effort, with the exception of commercial costs, which are directly correlated to income.
- The fixed costs are a linear function of the capacity employed expressed in terms of GT.

Equations

The main equations concern the dynamics of prices and costs.

Estimate of production and fishing effort

Simulated catches for one or more than one species for each reference scenario are produced by an unconnected biological model or procedure. Assuming the landings of each species represent a constant percentage of the relative catches, in other words assuming a constant percentage of discards at sea, the simulation of landings is obtained on the basis of the percentage variations in catches derived from the simulations of the biological model.

For the main generic species *j*, the relative annual landings $S_{j,t}$ are obtained by applying to the data recorded in year t-*1*, $S_{j,t-1}$, the percentage variation in the catches from time *t-1*, $C_{j,t-1}$, at time *t*, $C_{j,t}$, as simulated by the stand-alone biological model. This estimate may be expressed as follows:

$$S_{j,t}=S_{j,t-1}+\left(\frac{C_{j,t}-C_{j,t-1}}{C_{j,t-1}}*S_{j,t-1}\right)=S_{t-1}*\left(1+\frac{C_{j,t}-C_{j,t-1}}{C_{j,t-1}}\right)=S_{j,t-1}*\left(\frac{C_{j,t-1}+C_{j,t}-C_{j,t-1}}{C_{j,t-1}}\right)=S_{j,t-1}*\left(\frac{C_{j,t}}{C_{j,t-1}}\right) \qquad (13.1)$$

The equation (13.1) allows the total landings for each of the main species to be estimated. From the economic point of view, however, it is essential to know the production for each fleet segment, in other words the share of landings to be attributed to each fleet segments involved in the fishery under analysis.

In order to make a subdivision of production per species between two fleet segments, we must take into consideration both the production levels recorded in the years preceding the simulation period and the effects which the management measures proposed in the different scenarios could have on the fishing effort made by the two fleets.

When, for a particular species, it is recorded that in the past one of the two fleet segments has produced on average more than 99% of landings, the whole amount of the landings can be attributed to that fleet. If however the incidence of both fleet segments is not negligible, a sub-division is made by assuming that the ratio between the landings per unit of fishing effort (CPUE) of the two fleet segments is constant over time.

Let us consider the total production for a particular species *j*, $S_{j,t}$ as the sum of the production relating to the two fleet segments, $S'_{j,t}$ and $S''_{j,t}$:

$$S_{j,t} = S'_{j,t} + S''_{j,t}. \tag{13.2}$$

Multiplying and dividing the first term on the right-hand side of equation (13.2) by the level of effort of the first fleet segment and assuming that the ratio between the CPUEs of the two fleet segments is constant and equal to λ:

$$S_{j,t} = \frac{S'_{j,t}}{E'_t} E'_t + S''_{j,t}, \tag{13.3}$$

$$\lambda = \frac{S'_{j,t}}{E'_t} \Big/ \frac{S''_{j,t}}{E''_t}, \tag{13.4}$$

which is equivalent to the following equation:

$$\lambda = CPUE' / CPUE'', \tag{13.5}$$

giving:

$$\frac{S'_{j,t}}{E'_t} = \lambda \frac{S''_{j,t}}{E''_t}, \tag{13.6}$$

$$S_{j,t} = \lambda \frac{S''_{j,t}}{E''_t} E'_t + S''_{j,t}, \tag{13.7}$$

$$S''_{j,t} = \frac{E''_t}{E''_t + \lambda E'_t} S_{j,t}. \tag{13.8}$$

The equation (13.8) shows how the production of the second fleet segment is calculated on the basis of the effort of the two fleet segments, the total production and the ratio between the CPUE of the first segment and that of the second. The production of the first fleet segment may then be calculated by difference:

$$S'_{j,t} = S_{j,t} - S''_{j,t} \tag{13.9}$$

The equation (13.8) allows the shares of estimated total landings between the two fleet segments to be varied as the fishing effort varies. The fishing effort is given by the product between GT and average fishing days per vessel ($days_t / N_t$):

$$E_t = \frac{gg_t}{N_t} GT_t. \qquad [gg = days] \tag{13.10}$$

By doing this, it is possible to verify the variations in fishing effort and the sub-division of production between the fleet segments, as part of the simulations relating to both the permanent suspension scenario and the biological cessation scenario.

<u>Prices</u>
The prices are estimated for each individual main species and each fleet segment. The price dynamics are simulated on the assumption that the prices are a function of the quantity produced, in other words of the landings. The functional relationship between prices and landings was defined using a coefficient of flexibility (ε) for each species and fleet segment, representing the percentage variation in prices due to a unitary percentage variation in landings[4]. These relationships were estimated on the basis of a monthly temporal step.

The prices-quantity relationship is specified in the literature in various expressions. On the basis of the regressions estimated with the IREPA data, it was decided to assume as a standard function:

$$P_{j,t} = P_{j,0} * (S_{j,t}/S_{j,0})^{\varepsilon} \qquad (13.11)$$

where ε represents the coefficient of flexibility for a given species and a given fleet segment estimated on actual data for each area.

In equation 13.11, the annual price $P_{j,t}$ of the j-th main species is related to the relative average annual price ($P_{j,0}$), the estimated landings in year n ($S_{j,t}$) and the average annual landings for the base period ($S_{j,0}$).

<u>Revenue</u>
From the product of the annual average price and the landings of a particular species we obtain the relative revenue ($P_{j,t} * S_{j,t}$).

For each fleet segment, the total revenue should be obtained by summing the revenues calculated for each individual species. Normally, given the high number of species fished in the Mediterranean, it is not possible to obtain a reliable estimate of landings for each one. The total revenue relating to the main species therefore produces a partial value of the total revenues. Nevertheless, when this value represents a percentage of the total revenue which is sufficiently stable over time, it is possible to use this percentage to estimate the latter.

Assuming therefore a number *n* of main species and a percentage revenue of the secondary species with respect to the revenue for the main species of *rr*, the total annual revenue *RT* can be estimated using the following equation:

$$RT_t = (1+rr)\sum_{j=1}^{n} P_{j,t} S_{j,t} \qquad (13.12)$$

The parameter *rr* was calculated as the average value of the values obtained by comparing the revenue of the secondary species with the revenue of the main species for each fleet segment in the years preceding the simulation period.

<u>Costs and gross profit</u>
For each fleet segment, the costs were grouped into the following four categories:

- variable costs;
- fixed costs;
- cost of labour.

In general, the variable costs which include the costs of fuel and lubricants and the other variable costs are functionally associated with the level of fishing effort, while the commercial costs component is a function of the level of revenue.

The costs of fuel *Cc* are calculated as a function of the fishing effort *E* (given by the product of the gross

[4] In economic terms, the price coefficient of flexibility is the reciprocal of the coefficient of elasticity of demand, which considers the quantities produced as a function of prices. In statistical terms, on the other hand, in which the disturbance component is considered stochastic, this inverse relationship cannot be verified.

tonnage *GT* and the average day's activity per vessel) and of the price of fuel *Pc*. The latter value is assumed to be equal to the most recent fuel price recorded at the time of implementing the model.

$$Cc_t = \alpha_1 E_t Pc \tag{13.13}$$

The other variable costs *Acv* are also estimated as a direct function of the effort:

$$Acv_t = \alpha_2 E_t . \tag{13.14}$$

The commercial costs *Cco*, on the other hand, are defined as a function of the total revenue of the fleet segment:

$$Cco_t = \alpha_3 R_t . \tag{13.15}$$

For which the aggregate function of the variable costs *CV* will be:

$$CV_t = \alpha_1 E_t Pc + \alpha_2 E_t + \alpha_3 R_t = (\alpha_1 Pc + \alpha_2) E_t + \alpha_3 R_t . \tag{13.16}$$

The fixed costs are considered to be independent of the fishing effort. They depend essentially on the size of the fleet segment, for which it is assumed that they are a function of the gross tonnage *GT*:

$$CF_t = \beta\ GT_t \tag{13.17}$$

The cost of labour *CL* is estimated as a proportion of the revenue *R*:

$$CL_t = \delta(R_t) \tag{13.18}$$

Subtracting the cost of labour and the intermediate costs from revenue, in other words the total variable and fixed costs, we obtain the gross profit *PL*:

$$PL_t = R_t - (CV_t + CF_t + CL_t) \tag{13.19}$$

The added value is calculated as the difference between the total revenue less the variable costs and the fixed costs. So, on the basis of equation 13.19, it may also be obtained by summing the gross profit and the cost of labour.

$$VA_t = R_t - (CV_t + CF_t) = PL_t + CL_t . \tag{13.20}$$

For depreciation and interest, it is possible to provide a simplified estimate based on the gross profit *GT* for each fleet segment:

$$AM_t + I_t = \gamma\ GT_t . \tag{13.21}$$

Finally, depreciation and interest allow an estimate of net profit using the following equation:

$$PN_t = PL_t - AM_t - I_t . \tag{13.22}$$

Social and economic indicators

Tables 13.1 and 13.2 show respectively the economic and social indicators for the state of the sector. These represent only some of the indicators that the model can produce.

In order to estimate these indicators, it is necessary to predict the number of vessels and employees. Having assumed a constant average GT per vessel, the number of vessels will record percentage variations equal to those specified under specific scenarios for the GT. The number of employees will also present similar variations, being proportionally associated with the number of vessels according to an estimated coefficient as an average for the base period.

As regards evaluation of economic performance, the traditional indicators of average profitability per vessel, gross profit and added value were used.

Table 13.1: Economic indicators on fishing status and their description

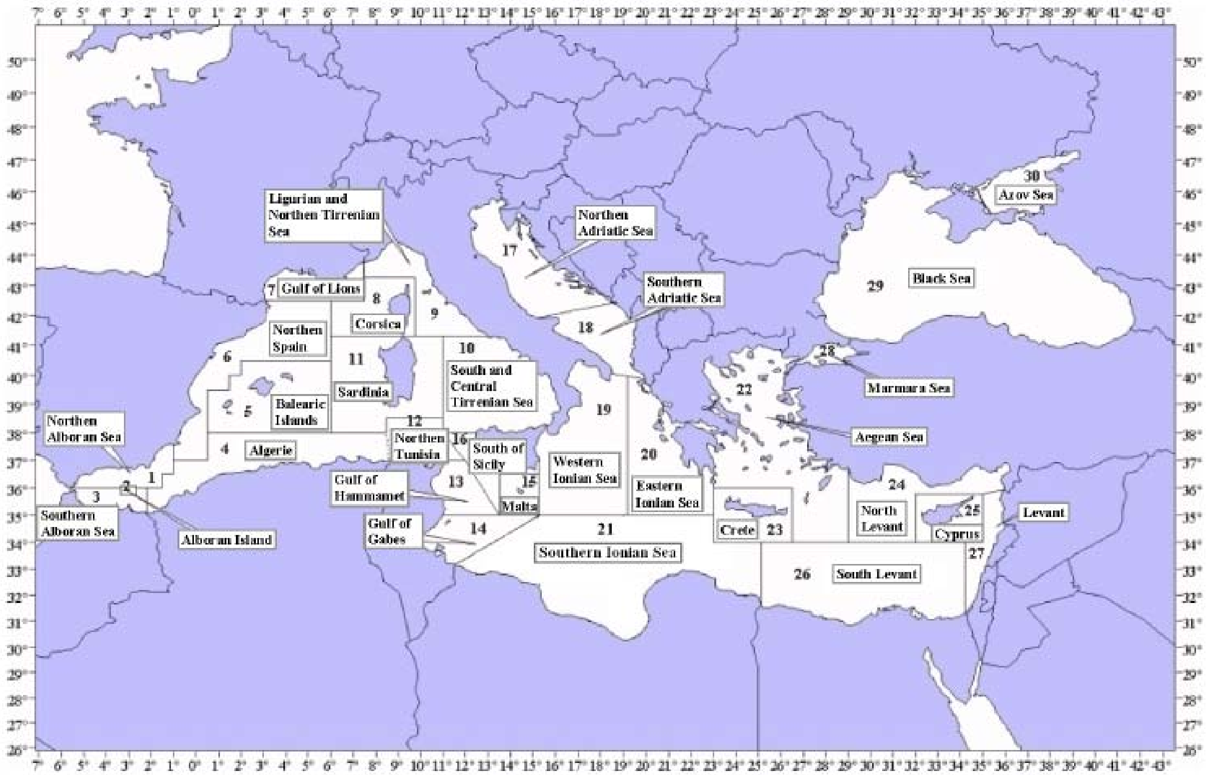
INDICATOR	DESCRIPTION
Gross profit/vessel (000 €)	Gross profit per vessel
Added value/vessel	Added value per vessel

From a social point of view, an indicator of profitability per employee and an indicator of the cost per employee were taken into consideration.

Table 13.2: Social indicators on fishing status and their description

INDICATOR	DESCRIPTION
Gross profit per employee (€)	Gross average profit per employee.
Cost of labour per employee (€)	Average cost of labour per employee.

16. APPENDIX 5. GFCM GSAS



17. ANNEX-EXPERT DECLARATIONS

Declarations of invited experts are published on the STECF web site on https://stecf.jrc.ec.europa.eu/home together with the final report.

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Abstract
SGMED-10-03 was held during 13 - 17 December 2010, Mazara del Vallo, Sicily (Italy). The report is a compilation of information on existing fisheries and stock data in order to update the status of the main demersal and small pelagic stocks. The report deals with assessment of historic and recent trends in stock parameters (stock size, recruitment and exploitation), short and medium term forecasts of stock size and catch under different management scenatios, as well as determination of limit and precautious reference points and relevant scientific advice. STECF reviewed the report during its Plenary meeting on 11-15 April 2011.

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