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Scientific, Technical and Economic Committee for Fisheries (STECF)

Report of the SGMED-10-01 Working Group on Preparation of assessment process

22-26 MARCH 2010, Barcelona, SPAIN

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The Scientific, Technical and Economic Committee for Fisheries (STECF) has been established by the European Commission. The STECF is being consulted at regular intervals on matters pertaining to the conservation and management of living aquatic resources, including biological, economic, environmental, social and technical considerations.

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STECF UNDERTOOK THE REVIEW DURING THE PLENARY MEETING

HELD IN NORWICH 26-30 APRIL 2010

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 living aquatic resources, to provide for their sustainable exploitation and to minimise the impact of fishing activities on marine ecosystems.

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 continued in 2009 with a dedicated workshop in Murcia, Spain, 2-6 March 2009, 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, the SGMED-09-02 part I meeting on the historic assessments and management advice regarding historic status of Mediterranean stocks and the SGMED-09-03 part II meeting on short term (2009-2011) and medium term predictions (2009-2018) of stock size and catches under various management options.

The first SGMED meeting in 2010 was held in Barcelona, Spain, 22-26 March, and was dedicated to the preparation of the stock assessment process to be implemented during 2010.

2. TERMS OF REFERENCE

Terms of reference for the STECF/SGMED-10-01 meeting (22-26/03/2010) were defined as follows:

1. Biological parameters and model set-up for analytical stock assessments
(implementation of recommendations by the workshop SGMED-09-01 in Murcia, 2-6 March 2009 and subsequent SGMED-09-02 and SGMED-09-03 in 2009).

It is acknowledged that SGMED made good progress in standardizing its work and reports. However, relevant information about the assessments and conclusions is still missing in the reports or not transparently presented. SGMED is therefore requested to

– provide synoptic tables of stock assessment parameters on a stock by stock basis as used in the 2009 assessments, such as natural mortality over length and age, maturity ogive over length and age, growth parameters k, t0 and Linf of v. Bertalanffy functions, parameters of length-weight relations, mean length and weight at age, maximum length, maximum weight and maximum age.

- review the parameters listed above, amend them as appropriate and recommend their use for future stock assessments.
- provide synoptic tables of parameters as defined above on a stock by stock basis for stocks not yet analytically assessed by SGMED. Species and stocks to be considered in future assessments should be selected in accordance with the recommendations by SGMED-09-03 (importance rankings).

2. Development and testing of trawl survey index standardization procedures with R

It is recognized that the use of the MEDITS data is yet not optimum for joint international stock assessment purposes. Therefore SGMED is requested to develop and test R scripts to select single and multiple species, area and time specific data (stock definition) from the MEDITS database in order to

2.1 age slicing to transform numbers at length in numbers at age on a station by station and species by species basis.

2.2 estimate annual trends in stock abundance and biomass indices (CPUE). In addition, such scripts should allow the use of GLM/GAM models to standardize the indices against theoretical or estimated statistical distribution patterns and provide diagnostics to assess best performing type of models, link function, family distribution and predictors.

2.3 estimate annual trends in stock abundance by length and age. In addition, such scripts should allow the use of GLM/GAM models to standardize the indices against theoretical or estimated statistical distribution patterns and provide diagnostics to assess best performing type of models, link function, family distribution and predictors.

2.4 transform the estimated indices of abundance by age into the input table formats of SURBA and XSA stock assessment programs.

3. Development of methodologies for the estimation of empirical indicators of stock status in data poor situations

Provide a critical overview of empirical indicators (i.e. calculated directly from a specific set of raw data or after statistical standardization) published for the different Mediterranean stocks in the various GSAs and currently used to assess the status of the stock in data poor situation. (*Data poor situations are defined as those stocks or species for which individual age information, also via LFD, are not collected and/or data on catches are highly uncertain or lacking*).

a) on the basis of the scientific literature and data availability, identify for each species or group of species, the most adequate empirical indicators of stocks and fisheries and appropriate management references that could be used in the assessments to be performed by SGMED working groups. The list of empirical indicators should include, as much as possible, both fishery independent (scientific surveys) and fishery dependent (commercial catches/landings) information. Possible indicators might be selected from those listed below:
    1) trends in mean age/length/weight of the stock
    2) trends in raw/standardized catch or catch per unit of effort;
    3) estimation of and changes of area distribution (stock or specific life-stages)
    4) proportion by weight of large fish in the stock
    5) trends in the average maximum length
    6) others (open list according to expert knowledge)

    Species and stocks to be considered in data poor assessments should be proposed as selected in accordance with the recommendations by SGMED-09-03 (importance rankings).

b) Review and recommend methodologies for the calculation of recommended empirical indicators.

c) On the basis of the recommended indicators and the methodologies to be applied, check if the format of the data calls defined in 2009 is adequate or, otherwise, establish the needed data formats to be included in the data call in 2010 in order to enable data poor assessments.

d) Develop a working plan and terms of reference for SGMED work in 2010 to cope with stock status in data poor situations with a view to estimate, under non-equilibrium conditions, the trend of the total mortality (Z) of selected stocks. The methodology used should refer to the mean length mortality estimator for application in non-equilibrium conditions. The estimation of the mean Z should be done on the basis of the agreed von Bertalanffy growth parameters (VBGF) and length at first capture (Lc) and the mean length above Lc as estimated either via the scientific surveys and/or commercial catches. The species or group of species should be selected in accordance to their importance as assigned by the ranking system developed by SGMED 09-03 and on the basis of the availability of VBGF parameters and information on length composition.

4. Plan of SGMED work in 2010

Develop a working plan and terms of reference for the 2nd and 3rd SGMED meetings to be held in 2010 (see also point 3d) above). Such detailed plan should propose the stocks, specific methods and parameters to be used in accordance with data availability for the assessment of historic and future (in short, medium and long term) trends in stock parameters. The tasks should cover the review and estimation of management references for exploitation and stock size consistent with high long term yield (MSY or proxies), against which the stock status should be evaluated. The detailed plan should identify stock coordinators responsible for the tasks.

3. STECF OBSERVATIONS

STECF acknowledges the recent progress achieved by the SGMED 10-01 WG in its tasks related to the assessment of Mediterranean living resources and fisheries exploiting them. STECF encourages further standardization its input data for assessments and methods used to accomplish the reoccurring tasks in order to increase efficiency and credibility. STECF notes that such standardizations are best achieved through the identification of individual stock coordinators from the experts attending SGMED WG meetings. The stock coordinators should be responsible for the data preparation, assessments and presentation of results as defined by the ToR. STECF recommends that individual stock coordinators be identified and that such experts regularly attend future meetings. Stock coordinators are invited to closely cooperate with other SGMED WG colleagues and to coordinate their tasks with the JRC experts attending SGMED working groups i.e. in advance of the working group meetings.

4. STECF COMMENTS AND CONCLUSIONS

STECF endorses the progress and findings as documented in the report of SGMED 10-01 in relation to its various ToR. STECF's comments regarding the specific tasks are given below.

ToR 1: STECF notes that SGMED 10-01 WG compiled synoptic tables of the requested biological parameters relevant for the assessments carried out by the WG and other scientific groups of the stocks of European hake (*Merluccius merluccius*), red mullet (*Mullus barbatus*), sardine (*Sardina pilchardus*), anchovy (*Engraulis encrasicolus*), common sole (*Solea solea*), blue and red shrimp (*Aristeus antennatus*), pink shrimp (*Parapenaeus longirostris*), giant red shrimp (*Aristaeomorpha foliacea*), and Norway lobster (*Nephrops norvegicus*) in the various areas (GSA) of the General Fisheries Commission of the Mediterranean (GFCM). STECF notes that this compilation does not include additional species not yet assessed. STECF notes that the SGMED WG was not in the position to explain certain major differences in the biological parameters and thus did not harmonise them among stocks in adjacent areas. In those GSAs where no biological information is available for assessments to be carried out, the SGMED 10-01 WG recommends to use the values of the parameters from adjacent GSAs to perform preliminary stock assessments. STECF recommends that all parameters used for assessments are documented in future reports.

STECF agrees with SGMED 10-01 recommendations regarding the ranking importance of additional species/stocks to be assessed in its future meetings. In addition to the important annual updates of the stocks assessed analytically in the past SGMED WG meetings, STECF recommends undertaking assessments of the species listed above in GSAs where they constitute significant landings, relevant data are available, participants' expertise is available and they are not yet assessed. Furthermore, STECF agrees with SGMED 10-01 that stocks and fisheries assessments in the Mediterranean Sea should be focused on stocks of striped mullet (*Mullus surmuletus*), anglerfish (*Lophius budegassa*), and picarel (*Spicara smaris*) in GSAs where the above-mentioned criteria are fulfilled.

ToR 2: STECF notes that SGMED 10-01 successfully tested the computer programs (R-script) provided by V. Bartolino, G.C. Osio, F. Scott and G. Pilling through a short term contract with DG Mare. The programs are designed to facilitate SGMED WG evaluations of the international MEDITS survey data as provided by Member States through the DCF program and data calls. While individual errors in the MEDITS survey data base were indentified through the testing procedures, the programs do not yet deliver all the results and features requested. While acknowledging the progress made so far, STECF recommends that the computer scripts and the respective user manuals be finalised and the various individual modules contained in the computer script should also be made applicable to other data sources of biological data than MEDITS. STECF recommends such remaining work, to be conducted during an additional short follow-up contract with the software experts in advance of the upcoming SGMED 10-02 meeting scheduled for 31 May-4 June 2010. This strategy would allow SGMED 10-02 to finalise the testing phase and to apply the software during its stock assessments planned for 2010. Alternatively, the computer experts could participate in the upcoming SGMED 10-02 meeting.

ToR 3: STECF notes that SGMED 10-01 provides in its report a comprehensive review of stock status indicators applicable in data poor situations. STECF recommends the various state and pressure indicators to be tested for stocks in data rich situations during upcoming the SGMED 10-02 meeting, before any conclusions regarding fisheries management advice on fisheries be drawn on the basis of such indicators. This recommendation explicitly applies to the elaboration of any state and pressure references points considered consistent with high long term yields.

STECF encourages SGMED WG experts to make individual length-weight data of the assessed stocks available on a voluntary basis to allow the computation and evaluation of condition factors.

SGMED-10-01 WORKING GROUP REPORT ON PREPARATION OF ASSESSMENT PROCESS

Barcelona, Spain, 22-26 March 2010

1. EXECUTIVE SUMMARY AND RECOMMENDATIONS

With the aim of establishing the scientific evidence required to support development of long-term management plans for selected fisheries 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-10-01 were extensive and are listed in section 2.1 below.

The meeting was dedicated to the preparation of the stock assessment process to be implemented during 2010. To this aim, biological parameters and model set-up for analytical assessments used in the previous SGMED meetings were revised (ToR 1); an R code that performs the functions described in ToR 2 was developed and tested using the MEDITS database; empirical indicators and methodologies for stock assessment in data poor situations were revised and a list of selected indicators was proposed, and the format of the data call was checked accordingly (ToR 3); finally, a working plan and terms of reference for the 2nd and 3rd SGMED meetings to be held in 2010 were developed (ToR 4). SGMED was able to answer to all ToRs, with the exception of ToRs 1.2 and 2.4.

The revision of the biological parameters used in previous assessments highlighted the differences among the parameters values for the different stocks of the same species, in particular regarding growth parameters, which explain the discrepancies in M vector by age and mean weight at age among the different stocks. SGMED could not agree on parameter values to recommend for future assessments due to time constraints. In any case, in the next SGMED-10-02 meeting, prior the start of the performance of the assessments, the experts tackling with different stocks of the same species will select parameter values which fall within agreed values ranges. In those GSAs where no biological information is available for assessments to be carried out, SGMED recommends to use the values of the parameters from adjacent GSAs to perform preliminary stock assessments.

SGMED agreed that, when assessing species with marked differences in growth between sexes, the size distributions of males and females will be transformed to ages using the corresponding growth parameters by sex. Input for the assessment will be the matrix of ages resulting from merging the males and females matrices. Similarly, M vector will be estimated for males and females separately, using the corresponding growth parameters. Input data for the assessment will be the combination of M vectors by sex, weighed by the sex-ratio. The input parameters a and b of the length- weight relationship will be those estimated for males+ females.

During 2008 and 2009 a number of stocks of the following species were assessed: *Merluccius merluccius* (6 stocks), *Mullus barbatus* (8), *Mullus surmuletus* (1), *Parapenaeus longirostris* (3), *Engraulis encrasicolus* (4), *Sardina pilchardus* (4) , *Solea solea* (1), *Aristeus antennatus* (2), *Aristaeomorpha foliacea* (2), and *Nephrops norvegicus* (2). SGMED recommends the stocks for which analytical assessments and short-term advice was provided in 2009 be updated accordingly in 2010. In addition, other stocks will be evaluated for the fist time.

The criteria SGMED followed for the recommendation on the priority for additional species and stocks to be assessed were two fold: first priority is to be given to those stocks of the species mentioned above in areas where they have never been assessed; secondly, in accordance with the recommendations by SGMED-09-03 (ranking list), other species and stocks are proposed, depending on their importance as fishing targets in the different GSAs. Furthermore, the tasks foreseen for SGMED to implement in 2010 include application of the recommended empirical indicators and methodologies, in addition to those stocks that will be assessed, to species and stocks in data poor situations.

SGMED selected a set of empirical indicators of stocks and fisheries considered as the most suitable for catching reliable signals of the status of the stocks, and recommended methodologies for their calculation (ToR 3). The use of indicators is related to the difficulty to expand to a significant number of stocks the assessment approaches used by SGMED for a small number of top-valued better-known species and fisheries, because of data poor situations.

SGMED recommends the use of the following empirical indicators of stock status in data poor situations:
- state indicators: mean length of the stock; average maximum length; population abundance; percentiles of the population length distribution; size at maturation of exploited fish species; mean weight of the stock; condition factors; frequency of occurrence; biomass index; recruit index; mean body length excluding recruits; positive area by life stage (recruits and adults); spreading area (recruits and adults).
- pressure indicators: Z; harvest ratio; exploitation rate; discard ratio; number of vessels; number of fishing days; landings per vessel; landings per day; catch rate.

SGMED recommends reference points for a number of the selected indicators. It is worth noting that in the Mediterranean, many stocks were in condition of overexploitation several years before the starting of a systematic data collection. In such conditions, direction of trends only suggest that the evolution of the stock is towards a better or worse situation, but nothing on whether such condition is still sustainable or not.

An R code developed for trawl survey index standardization procedures, as defined in TOR 2 (age slicing, trends in abundance and biomass indices, CPUE standardization with GLMs and GAMs) was tested during the meeting using the MEDITS data base.

The MEDITS DB available to SGMED scientists contains multitude of character, numeric and header row errors that have a serious impact on any attempt of using the DB and that need to be corrected by the Member States before the submission. The conclusion is that the current database contains fundamental structural problems and errors and when used it generates unpredictable errors that can propagate into assessments.

The age slicing function implemented in the R script was tested and compared with the LFDA software which is routinely used for age slicing and a third slicing function using mixed distributions. Results between the age slicing computed by the R routine and by LFDA were almost coincidental.

From the results of the working group during the meeting, SGMED agreed that no general conclusion should be drawn on the advantage of standardizing by fitting regression models compared to using indices derived from raw data. This is a very important matter as it should be understood whether standardization does or not actually change and improves the estimates of the yearly trends in CPUE of Number or Weight of the individuals or of the CPUE of the numbers at age. SGMED recommends an in depth assessment on the advantages/disadvantages of standardizing with regression models should be carried out along a cost benefit assessment. CPUE standardization through model fitting and model selection is a time consuming exercise as it needs to be carried out by each species and GSA and eventually even by age class.

Given time constraints and the errors in the MEDITS database very little time was spent in the standardization of the CPUE by Age classes. This task remains very important and SGMED recommends should be further tested.

SGMED proposed the terms of reference for the second (SGMED-10-02, 31 May- 4 June) and third (SGMED-10-03, 13-17 December) meetings to be held in 2010.

ToRs include: 1) updating of the assessments and short- term forecasts provided in 2009 and assessment of stocks not yet analytically assessed; 2) Stock assessment in data poor situation; 3) continue with the development and testing R code to standardize, estimate trends and perform age slicing with MEDITS data and for estimation of fisheries indicators out of MEDITS; 4) test differences in the assessment resulting from using a) age- slicing and age-length key, b) the growth parameters estimated from otolith on M vector; 5) Test the use of scorecard to assess the accuracy of data to be used for stock assessment.

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.

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 channelled into or completed by the GFCM working groups.

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.

To address the requests, the STECF Subgroup on the Mediterranean (SGMED-10-01) for demersal and small pelagic stocks met in Barcelona, Spain, from 22-26th March 2010. The meeting was opened at 14:00 on the 22nd, and closed at 17:00 on the 26th. The meeting built upon the work performed during SGMED meetings conducted during 2008 and 2009 to pursue the Commission's requests and was dedicated to the preparation of the stock assessment process to be implemented during 2010. To this aim, biological parameters and model set-up for analytical assessments used in the previous SGMED meetings were revised (ToR 1); an R code that performs the functions described in ToR 2 was developed and tested using the MEDITS database; empirical indicators and methodologies for stock assessment in data poor situations were revised and a list of selected indicators was proposed, and the format of the data call was checked accordingly (ToR 3); finally, a working plan and terms of reference for the 2nd and 3rd SDMED meetings to be held in 2010 were developed (ToR 4).

The present report is structured as follows: Experts' working documents and presentations related to the ToRs are summarized in section 3; results and recommendations for each ToR are presented in sections 4 (ToR 1), 5 (ToR 2), 6 (ToR 3) and 7 (ToR 4).

2.1. Terms of Reference for SGMED-10-01

The overall terms of reference for the SGMED meetings are listed in Appendix 1. Terms of reference for the STECF/SGMED-10-01 meeting (22-26/03/2010) were defined as follows:

1. Biological parameters and model set-up for analytical stock assessments
(implementation of recommendations by the workshop SGMED-09-01 in Murcia, 2-6 March 2009 and subsequent SGMED-09-02 and SGMED-09-03 in 2009).

It is acknowledged that SGMED made good progress in standardizing its work and reports. However, relevant information about the assessments and conclusions is still missing in the reports or not transparently presented. SGMED is therefore requested to

- provide synoptic tables of stock assessment parameters on a stock by stock basis as used in the 2009 assessments, such as natural mortality over length and age, maturity ogive over length and age, growth parameters k, t0 and Linf of v. Bertalanffy functions, parameters of length-weight relations, mean length and weight at age, maximum length, maximum weight and maximum age.
- review the parameters listed above, amend them as appropriate and recommend their use for future stock assessments.

– provide synoptic tables of parameters as defined above on a stock by stock basis for stocks not yet analytically assessed by SGMED. Species and stocks to be considered in future assessments should be selected in accordance with the recommendations by SGMED-09-03 (importance rankings).

2. Development and testing of trawl survey index standardization procedures with R

It is recognized that the use of the MEDITS data is yet not optimum for joint international stock assessment purposes. Therefore SGMED is requested to develop and test R scripts to select single and multiple species, area and time specific data (stock definition) from the MEDITS database in order to

2.1 age slicing to transform numbers at length in numbers at age on a station by station and species by species basis.

2.2 estimate annual trends in stock abundance and biomass indices (CPUE). In addition, such scripts should allow the use of GLM/GAM models to standardize the indices against theoretical or estimated statistical distribution patterns and provide diagnostics to assess best performing type of models, link function, family distribution and predictors.

2.3 estimate annual trends in stock abundance by length and age. In addition, such scripts should allow the use of GLM/GAM models to standardize the indices against theoretical or estimated statistical distribution patterns and provide diagnostics to assess best performing type of models, link function, family distribution and predictors.

2.4 transform the estimated indices of abundance by age into the input table formats of SURBA and XSA stock assessment programs.

3. Development of methodologies for the estimation of empirical indicators of <u>stock status in data poor situations</u>

Provide a critical overview of empirical indicators (i.e. calculated directly from a specific set of raw data or after statistical standardization) published for the different Mediterranean stocks in the various GSAs and currently used to assess the status of the stock in data poor situation. (*Data poor situations are defined as those stocks or species for which individual age information, also via LFD, are not collected and/or data on catches are highly uncertain or lacking*).

e) on the basis of the scientific literature and data availability, identify for each species or group of species, the most adequate empirical indicators of stocks and fisheries and appropriate management references that could be used in the assessments to be performed by SGMED working groups. The list of empirical indicators should include, as much as possible, both fishery independent (scientific surveys) and fishery dependent (commercial catches/landings) information. Possible indicators might be selected from those listed below:
   7) trends in mean age/length/weight of the stock
   8) trends in raw/standardized catch or catch per unit of effort;
   9) estimation of and changes of area distribution (stock or specific life-stages)
   10) proportion by weight of large fish in the stock
   11) trends in the average maximum length
   12) others (open list according to expert knowledge)

   Species and stocks to be considered in data poor assessments should be proposed as selected in accordance with the recommendations by SGMED-09-03 (importance rankings).

f) Review and recommend methodologies for the calculation of recommended empirical indicators.

g) On the basis of the recommended indicators and the methodologies to be applied, check if the format of the data calls defined in 2009 is adequate or, otherwise, establish the needed data formats to be included in the data call in 2010 in order to enable data poor assessments.

h) Develop a working plan and terms of reference for SGMED work in 2010 to cope with stock status in data poor situations with a view to estimate, under non-equilibrium conditions, the trend of the total mortality (Z) of selected stocks. The methodology used should refer to the mean length mortality estimator for application in non-equilibrium conditions. The estimation of the mean Z should be done on the basis of the agreed von Bertalanffy growth parameters (VBGF) and length at first capture (Lc) and the mean length above Lc as estimated either via the scientific surveys and/or commercial catches. The species or group of species should be selected in accordance to their importance as assigned by the ranking system developed by SGMED 09-03 and on the basis of the availability of VBGF parameters and information on length composition.

4. Plan of SGMED work in 2010

Develop a working plan and terms of reference for the 2nd and 3rd SGMED meetings to be held in 2010 (see also point 3d) above). Such detailed plan should propose the stocks, specific methods and parameters to be used in accordance with data availability for the assessment of historic and future (in short, medium and long term) trends in stock parameters. The tasks should cover the review and estimation of management references for exploitation and stock size consistent with high long term yield (MSY or proxies), against which the stock status should be evaluated. The detailed plan should identify stock coordinators responsible for the tasks.

5. Additional Term of Reference

Scorecard to assess the accuracy of data to be used for stock assessment

The scorecard summarizes the key findings and recommendations of the Workshop on Methods to evaluate and estimate the accuracy of fisheries data used for assessment [ICES WKACCU] held in Bergen, Norway, 27–30 October 2008. The workshop examined procedures and other factors that could cause bias in fisheries data used in stock assessments, and provided recommendations for improved procedures that could reduce such bias. Proposed by participants to the meeting, SGMED discussed on the utility of this scorecard in the assessment working groups of the EU Mediterranean (i.e. STECF-SGMED).

2.2. Participants

The full list of participants at SGMED-10-01 is presented in Appendix 2.

3. Abstracts of Presentations and Working documents (WD)

3.1. WD 1: Methods, Indicators and Software useful for stock assessment in situations of data shortage

By Alvaro Abella

The contribution discusses the utility of a selection of simple indicators and methods for the assessment of the status of exploitation of stocks in conditions of data shortage. Most of the described approaches and software are part of the NOAA Fisheries Toolbox (NFT), a suite of biological modelling freeware software programs useful in fisheries stock assessments. They have been seldom utilized in the Mediterranean, even though they can be very useful considering the characteristics of the fisheries and availability of data in the area. Some others are included in freeware packages FAO (Sparre & Venema, 1998; Hoggart et al, 2006), written in r or are spreadsheets implemented in MS Excel. The list of approaches is not exhaustive and includes some simple but robust indicators that can be considered useful for detecting changes in biomass or fishing pressure, in the proportion of stocks at or above targeted abundance or biomass, in age/size structure of species from surveys and/or landings, or changes in their spatial distributions. In the case of some software more or less frequently utilized in the SGMED, as SURBA, or standard assessment techniques used by ICES such as the Extended Survivors Analysis XSA (Darby and Flatman, 1994); the Integrated Catch-at-age Analysis ICA (Patterson and Melvin, 1996), forecasting routines, etc., their pro and cons have been already discussed and tested in the frame of the SG and hence description and comments on them were considered unnecessary.

The suitability of some indicators used in the frame of the MEDITS project for monitoring the stocks and community status likely to be useful for assessing the current status of exploitation and its evolution is briefly discussed. The need of the choice of robust indicators is stressed. There were illustrated some factors that may condition the value and in some cases the direction of the measured variables. Such factors may mask the signals and to drive to misleading conclusions on the real condition of the stocks and on the necessary measures to enforce.

A brief discussion on the utility of some approaches not explored with MEDITS data, but widely used elsewhere for the forecasting of the ecosystem health as well as the evolution of the mean trophic level and the "Abundance-Biomass Comparison" (ABC) based on the criterion of dominance was also included.

The choice of good indicators has to cope with the problem of the existing uncertainty on the dynamics of the stock life history features, on the used models and parameters. There exist uncertainty also in the determination of the current state of the stock. Finally, there is a component of uncertainty on the possibility of changes in the environment that may affect stock productivity.

All the assessment approaches contain some amount of error or bias. The problem is how to identify reference points or indicators that allows a correct identification of the exploitation status even when implemented according to imprecise or inaccurate stock assessments. The evaluation of the robustness of each specific method for setting a reference point or as an indicator of the stock health is necessary.

Only when changes in a variable are greater than the level of uncertainty of a change those can be considered as a "power" indicator.

While considering indicators that measure the evolution of certain variable potentially useful, the approaches that allows to define a reference value (for instance certain level of biomass, catch or exploitation rate assumed optimal) should be preferable when data needed for computations is available. In fact, in the Mediterranean, many stocks were in condition of overexploitation several years before the starting of a systematic data collection of several variables, and hence, when we deal with analyses of trends, there is no reference value assumed to represent a pristine condition or some level considered desirable or that reflects the situation when there was no fishing for comparison with the current status. In such conditions, direction of trends only suggest that the evolution of the stock is towards a better or worse situation, but nothing about if such condition is still sustainable or not.

The working document is published on the STECF web site on https://stecf.jrc.ec.europa.eu/home together with this report.

3.2. Overview of empirical indicators, selection process and methodologies for calculation

By Maria Teresa Spedicato (extended abstract of the presentation).

An overview was performed on the approach of indicators following the stream of the outcomes from INDECO, FISBOAT and IMAGE EU projects. In addition, the scientific literature regarding methodological aspects and indicators for the Mediterranean was also briefly reviewed and suggested as reference for future applications. The framework was that outlined in the ToR 3 of SGMED 10-01. Thus the focus was on the population (of fish, cephalopod and crustaceans) or stock level and the use of indicators defined as empirical, i.e. derived from raw or standardised data and not obtained as a results of application of formal stock-assessment processes and models. The outline of the candidate indicators also took into account the sources of potential information, including as much as possible, both the fishery independent (scientific surveys) and the fishery dependent (commercial catches/landings) ones. The operative context is that of data poor situation, where probably only one of the two sources of data is available or information is fragmentary along the time. The conceptual scheme used for categorising indicators and approach has been the widely accepted State-Pressure-Response framework (Garcia and Staples, 2000), where state indicators are those pertaining the ecosystem (albeit at population level), the pressure indicators are those conveying the information on the fishing pressure/impact, while the response indicators are those enabling the monitoring of the effects of management actions. Considering the Mediterranean management context this framework has been further simplified, at this stage, to a State-Pressure indicator scheme.
The attributes of each of these components will describe the following functions: the structure (e.g. length/age/weight), the abundance (e.g. number/biomass) the production (e.g. catches).
The possible indicators have been scrutinized following the results of the scientific literature, the list suggested in the ToRs and the DCF.
Possible candidate indicators are summarised in the following tables. Indicators already included in a table are not reported in the successive, even if mentioned by the cited Author.

(***from Rochet et al. 2007***)

OrganizationLevel	Indicator	Description	Expected effect of fishing
Population	lnNi	Population abundance for species *I*	decrease
	lnSNi	Spawning population abundance for species *i*	decrease
	Lbar Spawner	Average length of spawners of population *i*	decrease
	Lbar	Average length of population *i*	decrease
	Lmat	Length at maturity (50% mature)	decrease
	Lq,i; q = 0.95	Percentile of the population length distribution	decrease

(from Cotter et al., 2009)

OrganizationLevel	Indicator	Description	Expected effect of fishing
Population	*NaL*, *NaA*	N-at-length, N-at-age Population abundance at length or age class	Decrease (especially large fish)
	WPUE	Biomass in weight per unit effort	decrease
	C	Condition factor (health status)	? (auxiliary indicator)?
	GSI	Gonado-somatic index (feeding, maturation status)	? (auxiliary indicator)?
	agemat	age at maturity (50% mature)	decrease

(from Ceriola et al., 2008)

OrganizationLevel	Indicator	Description	Expected effect of fishing
Population	Frequency of occurrence	Percentage of the positive hauls over the total number of hauls	decrease
	Biomass index	Biomass of population *i* per unit area	decrease
	Recruit index	Number of recruit of population *i* per unit area	decrease
	Mean body	Total sample weight to total sample	decrease

weight	number ratio	
Mean body length excluding the recruits	Mean length of the population excluding the recruits	decrease
Lmean/Lmat	Ratio between mean length and length at first maturity	decrease

Besides the indicators reported above, some of the spatial indicators reported by Woillez et al. (2009) can also be considered. There can often be reasons to expect that the geographic distribution of fish stocks will change in response to fishing pressures, or to variations in oceanographic conditions or climate. Spatial indicators therefore provide another way of looking at a fish stock. Usefully, those shown in the following table are unaffected by zero catches. Considering the difficulties in establishing causative relationships between fishing pressure and spatial indicators predictable by a population dynamic model, these can have the role of auxiliary indicators.

(from Woillez et al., 2009)

Indicator	Symbol	Description and properties
Centre of gravity	CG	Mean location of the individuals of a population. A shift may reflect effects of fishing. CG is sensitive to high densities of fish.
Inertia	I	Variance of the location of the individuals of a population. Indicates dispersal but is sensitive to high densities of fish.
Global index of collocation	GIC	Measures the geographic distinctness or overlap of two populations of fish.
Positive area	PA	Measures the area where fish of a species occur. PA is greatly increased when fish occur at low densities over a large area.

Candidate indicators to measure pressure/impacts can be selected in the following list, where the total mortality is intended to be measured on raw (e.g. trawl-survey based) data.

List of candidate pressure indicators	References
Z	Rochet et al. 2007
catch	ToR
exploitation rate	
discard ratio	DCF
Number of vessels	Piet et al., 2008
Number of fishing days	Piet et al., 2008
Landings per vessel	Ceriola et al., 2008
Landings per day	Ceriola et al., 2008

Guidance on the selection of indicators for managing a fishery is provided by several Authors. Rice and Rochet (2005) argued that the number of indicators chosen should be minimal to prevent conflicting signals and arguments. Thus, they suggest to score indicators against selection criteria with the following basic properties: *concreteness, theoretical basis, public awareness, cost, measurement, historical data, sensitivity, responsiveness, specificity.* In addition, to these selection criteria, the principle of avoiding *redundancy* should be followed. Redundancy can be measured by pair-wise correlation of indicators.

Any two state indicators that are strongly correlated (regardless of the direction) can be classified as redundant and the significantly correlated indicator can be excluded because it does not convey extra information.
As a first step a list of 24 state indicators, 6 auxiliary indicators and 8 pressure indicators is proposed for the selection of a short-list of state, pressure and auxiliary indicators to be adopted by SGMED-10-01.

Trenkel and Cotter (2009) have illustrated special problems when using survey data as the unique source of data for carrying out a stock assessment, namely mismatch of survey area and stock area, selective catching of size and age classes that are not fully representative of the size or age structure of the stock, variation of survey catchability in space and time, the sampling effort too small given rareness of the resource (e.g. in multispecies surveys).

Thus, albeit not solving the problems, a number of checks to be performed before carrying out the estimation of indicators are suggested according to Trenkel and Cotter (2009), as:

i) examine the consistency of the survey protocol over the time series (e.g. gear, number of stations and their spatial distribution, sampling period;
ii) the ratio of abundance at age 2 in year $t + 1$ to abundance at age 1 in year t is larger than 1 in most years, that should not occur;
iii) if different survey series exist and lead to similar time trend estimates, the stock most likely was sampled such that catchability q was constant across length classes;
iv) strong variation of the Global Index of Collocation from year to year for life stages or ages;
v) percentage of tows where the species was present (occurrence) and the quantities that were caught. A limit can be set on the basis of survey characteristics. Based on empirical trials (Trenkel and Cotter, 2009) the exclusion of species with density <5 individuals/km^2 or <10 individuals/km^2 did not change consistently the number of species excluded (from 54 to 69 out 127).

If all the checks converge to a possible bias diagnosis the analysis should not be continued.

Among the general methodological considerations it is worth mentioning that the variance of each indicator is generally high and the statistical power for detecting trends is low for indicator series < 10 years (Nicholson & Jennings, 2004). Thus results from short series should be considered with caution.
Standardization and scaling of the indicators, that can be achieved normalising the time series, is useful for inter-indicators and inter-area or ecosystems comparative purposes. By this way a comparison of indicator sensitivity and fishing impacts can be performed. In addition selecting indicators that respond in the same direction to the pressure (e.g. decrease) would facilitate the analysis and the interpretation of results.

Among the others, the aim of the indicator approach is to estimate the current state of a stock of interest or of the ecosystem, with respect to management objectives. In the indicator approach the identification of reference points and levels is, however, a difficult task, because causative effects of fishing on the indicators, albeit conceptually and theoretically sound, are not quantitatively derived by an assessment model. In addition past reference level effectively contrasted with the current state, are difficult to be obtained. Thus, basic approaches generally considered are:

- the traffic-light that evaluate, in some cases using weighing factors, which is the relative influence of 'red', 'green' and 'yellow' coloured indicators to determine the desirable or undesirable state (Caddy, 2002; Caddy and Surette, 2005; Ceriola et al., 2008). Caddy and Surette (2005) provided a procedure to bound the green, yellow and red colours in the range of cumulative distribution of the time series, that was successively followed by Ceriola et al. (2008). The green colour was assigned to years with value >66th percentile of the time series; the yellow colour to years with value included between the 66th and 33rd percentile of time series; and the red colour to year with value <33rd percentile.
- the trend approach based on different models (from the uni- and multivariate, nonparametric statistical tests as in Cotter (2009) to the GAM model as in the Intersection Union Test developed by Trenkel and Rochet (2009));
- combining population and community indicators based on their biological meaning (Bertrand et al., 2004; Rochet et al., 2007), as for example log-transformed abundance ln(N), mean length, total mortality Z. Tables of cause (natural, anthropogenic)-effects on indicator trend are '*a priori*' established to interpret directions. Additional biological and pressure information can contribute to help the interpretation.
- application of industrial quality control schemes, e.g. CUSUM approach (Mesnil and Petitgas 2009), based on the Control charts that are part of the statistical process control (SPC) tools routinely used over decades to monitor manufacturing processes and signal anomalies. The charts' parameters are tuned to achieve a desired trade-off between the risk of false alarm and the ability to detect changes promptly. Also in this case the reference period has a key role.

Among the available tools in R to estimate indicators, trends and reference levels there are the R SUFI routines developed by Rochet et al. (2007), the spatial indicator routines in Woillez et al. (2009), the Intersection Union Test for trend analysis (fisboat web-site), the non-parametric statistical test from Cotter (2009, and fisboat web-site) and the Cusum based on R routine from Mesnil and Petitgas (2009).

3.3. WD 2: DRAFT - R code documentation to standardize, estimate trends and perform age slicing with MEDITS survey

By Valerio Bartolino, Giacomo Chato Osio, Graham Pilling and Finlay Scott

This document provides an overview of the rationale and the coding to build MEDITS trawl survey index standardization procedures with R. The script fits GLM's and predicts CPUE of total weight or numbers and performs age slicing and prediction of the CPUE of the numbers at age. The code and the results are provided and explained with the example of Hake (*Merluccius merluccius*) in GSA 7.

The working document is published on the STECF web site on https://stecf.jrc.ec.europa.eu/home together with this report.

3.4. Scorecard to assess the accuracy of data to be used for stock assessment

By Mark Dimech (abstract of the presentation).

The scorecard summarizes the key findings and recommendations of the Workshop on Methods to evaluate and estimate the accuracy of fisheries data used for assessment [ICES WKACCU] held in Bergen, Norway, 27–30 October 2008. The workshop examined procedures and other factors that could cause bias in fisheries data used in stock assessments, and provided recommendations for improved procedures that could reduce such bias.

The accuracy of fisheries data is determined by two components: (1) Systematic errors (bias), and (2) random errors as measured by precision. The focus of the workshop was on the bias component of accuracy. The WKACCU workshop primarily dealt with bias in fisheries-dependent data collection programs, but included a brief discussion of bias in scientific survey estimates of abundance indices and populations characteristics.

The workshop identified that it is difficult to quantify bias in fisheries data used for stock assessment. Whereas precision in fisheries statistics can be improved by increasing the sample sizes in data collection programs, this is not the case with bias. Bias is a systematic departure from the true values, and can generally not be quantified because the true values seldom are known. To the extent possible, it is therefore important to minimize or eliminate sources of bias by developing and following sound field data collection procedures and analytical methods. Workshop participants developed a practical framework for detecting potential sources of bias in fisheries data collection programs.

The focus of the evaluation conducted during the workshop was a list of key parameters of importance in stock assessments: A) Species Identification; B) Landings Weight; C) Discard Weight; D) Effort; E) Length Structure; F) Age Structure; G) Mean Weigh; H) Sex-ratio; and I) Maturity Stages. The workshop identified several indicators to detect bias in each of these parameters. A simple score-card was then developed where each indicator was rated as green (minimal or no risk of bias), yellow (some risk of bias), and red (established sources of bias). The workshop recognized that some of the parameters identified are interconnected, and that the final bias evaluation must consider the sources of bias encountered during all the data collection and processing. The final indicator of bias should take into account the propagation of systematic errors across interconnected parameters. The scorecard is a practical tool to evaluate the quality of data sources used for stock assessments, and can help reduce bias in future data collections by identifying steps in the data collection process that must be improved. The proposed scorecard was applied to the data collection program for the Norwegian Northeast Arctic saithe fishery in 2007. This case study suggested that the system is practical and useful, but it is recommended that more fisheries be evaluated to develop the scorecard further, especially in the case of the Mediterranean.

4. ToR 1 BIOLOGICAL PARAMETERS AND MODEL SET-UP FOR ANALYTICAL STOCK ASSESSMENTS

4.1. Synoptic tables of stock assessment parameters on a stock basis as used in the 2009 assessments

The tables below were compiled during the meeting. The parameters values were taken from the 2009 SGMED reports. Since not all the necessary information was available in the reports, it was not possible neither to compile all the tables requested in ToR 1, nor to identify the methodologies and input data used in the parameters estimation.

European hake (*Merluccius merluccius*)

MAXIMUM LENGTH, WEIGHT & AGE

GSA	Sex	Length	Weight	Age+
05	Both	72		
07	Female	96		
	Male	85		
10	Female	83		
	Male	45.5		

GROWTH PARAMETERS

GSA	Sex	Linf	k	t0
05	Both	85.0	0.172	-0.177
06	Both	106.7	0.200	0.003
07	Female	100.7	0.236	-0.350
	Male	72.8	0.233	-0.383
	Both	104.0	0.200	-0.030
09	Both	103.9	0.212	0.031
10	Female*	97.9	0.135	-0.40
	Male*	50.8	0.250	-0.40

LENGTH-WEIGHT

GSA	Sex	a	b
05	Both	0.0048	3.12
06	Both	0.0048	3.12
07	Both	0.0069	3.03
09	Both	0.0067	3.028
10	Female	0.0035	3.2
	Male	0.0086	3.215
	Both	0.0036	3.22

NATURAL MORTALITY OVER AGE

GSA	Sex	0	1	2	3	4	5	6	7
05	Both	1	0.7	0.5	0.4	0.4	0.4		
06	Both	1.43	0.68	0.47	0.42	0.39	0.37	0.36	0.35
07	Both	0.68	0.47	0.3	0.22	0.19	0.17	0.16	0.14
09	Both	1.3	0.6	0.46	0.41	0.3	0.2		
10	Both	0.85	0.46	0.37	0.33	0.31	0.29		

MEAN WEIGHT AT AGE (in Stock)

GSA	Sex	0	1	2	3	4	5	6	7
05	Both	0.016	0.065	0.203	0.438	0.777	1.377		
06	Both	0.020	0.117	0.453	1.149	1.752	2.791	3.773	4.332
07	Both	0.047	0.184	0.575	1.106	1.654	2.309	2.777	3.454
09	Both	0.01	0.13	0.60	1.36	2.29	3.29		

MATURITY OGIVE OVER AGE

GSA	Sex	0	1	2	3	4	5	6	7
05	Female	0	0.05	0.56	0.89	0.98	1		
06	Female	0	0.15	0.82	0.98	0.99	1	1	1
07	Female	0	0.03	0.77	0.99	1	1	1	1
09	Female	0	0.21	0.9	1	1	1		

MATURITY OGIVE OVER LENGTH

GSA	Sex	15	17	19	21	23	25	27	29	31
10	Female	0	0.032	0.041	0.092	0.217	0.367	0.565	0.3	0.211

33	35	37	39	41	43	45	47	49
0.476	0.364	0.714	0.714	0.909	0.375	0.8	0.909	1

Red mullet (*Mullus barbatus*)

GROWTH PARAMETERS

GSA	Sex	Linf	k	t0
07	Both	26	0.41	-0.4
09	Both	29	0.6	-0.1
11	Both	29.1	0.41	-0.39
25	Both	26.61	0.183	-2.488

LENGTH-WEIGHT

GSA	Sex	a	b
07	Both	0.0081	3.113
09	Both	0.00053	3.12
11	Both	0.001	3.02
25	Both	0.00797	3.12

NATURAL MORTALITY OVER AGE

GSA	Sex	0	1	2	3	4	5	6	7
07	Both	0.64	0.43	0.27	0.18	0.15	0.12		
09	Both	1.3	0.79	0.62	0.54	0.4			
11	Both	1.3	0.41	0.27	0.23				
25	Both	0.26	0.12	0.1	0.09	0.08	0.08	0.08	0.08

MEAN WEIGHT AT AGE (in Stock)

GSA	Sex	0	1	2	3	4	5	6	7
07	Both	0.005	0.027	0.063	0.099	0.13	0.153		
09	Both	0.0046	0.0039	0.0943	0.1326	0.1553			
11	Both	0.0007	0.0036	0.0081	0.013				
25	Both	0.015	0.028	0.043	0.061	0.079	0.097	0.113	0.128

MATURITY OGIVE OVER AGE

GSA	Sex	0	1	2	3	4	5	6	7
07	Female	0.17	0.61	0.89	0.96	0.98	0.99		
09	Female	0.0	1.0	1.0	1.0	1.0			
11	Female	0.43	0.63	0.83	0.91				
25	Female	0.470	0.900	0.940	1.000	1.000	1.000	1.000	1.000

MATURITY OGIVE OVER LENGTH

GSA	Sex	7	8	9	10	11	12	13	14	15	16	17
25	Female	0.00	0.33	0.60	0.87	0.88	0.88	0.94	0.95	0.98	0.99	1.00

Sardine (*Sardina pilchardus*)

MAXIMUM LENGTH, WEIGHT & AGE

GSA	Sex	Length	Weight	Age+
01	Both	23.2		5
06	Both	22.0		5
17	Both			6

GROWTH PARAMETERS

GSA	Sex	Linf	k	t0
01	Both	23.0844	0.3127	-2.2205
06	Both	22.9489	0.2506	-2.9262
17	Both	18.7830	0.3790	-2.3020
22	Both	19.5000	0.3900	-0.4800

LENGTH-WEIGHT

GSA	Sex	a	b
01	Both	0.00522	3.17746
06	Both	0.00520	3.14000
17	Both	0.00950	2.94000
22	Both	0.00003	3.21440

NATURAL MORTALITY OVER AGE

GSA	Sex	0	1	2	3	4	5	6
01	Both	1.17	0.44	0.32	0.27	0.25	0.24	
06	Both	1.20	0.46	0.34	0.29	0.26	0.25	
17	Both	0.71	0.47	0.32	0.28	0.25	0.25	0.25
22	Both	1.50	0.96	0.69	0.61	0.57	0.55	

MEAN LENGTH AT AGE

GSA	Sex	0	1	2	3	4	5	6	7	8
01	Both	13.46	16.10	18.67	19.83	20.49	21.23	21.54	22.33	22.68
06	Both	13.51	15.63	17.45	18.59	19.13	19.77	21.32		

MEAN WEIGHT AT AGE (in Catch)

GSA	Sex	0	1	2	3	4	5
01	Both	0.020	0.036	0.057	0.069	0.077	0.088
06	Both	0.019	0.031	0.043	0.052	0.057	0.064
22	Both	0.006	0.019	0.020	0.021	0.047	

MEAN WEIGHT AT AGE (in Stock)

GSA	Sex	0	1	2	3	4	5
01	Both	0.020	0.036	0.057	0.069	0.077	0.088
06	Both	0.019	0.031	0.043	0.052	0.057	0.064
22	Both	0.006	0.018	0.021	0.027	0.034	0.100

MATURITY OGIVE OVER AGE

GSA	Sex	0	1	2	3	4	5
01	Both	0.37	0.86	1.00	1.00	1.00	1.00
06	Both	0.38	0.85	1.00	1.00	1.00	1.00
22	Both	0.00	0.40	1.00	1.00	1.00	1.00

Anchovy (*Engraulis encrasicolus*)

MAXIMUM LENGTH, WEIGHT & AGE

GSA	Sex	Length	Weight	Age+
01	Both	17.5		3
06	Both	18.5		3
17	Both			4
22	Both			4

GROWTH PARAMETERS

GSA	Sex	Linf	k	t0
01	Both	19.00	0.34	-2.32
06	Both	19.00	0.34	-2.32
17	Both	16.15	0.40	-2.04
22	Both	19.10	0.39	-1.56

LENGTH-WEIGHT

GSA	Sex	a	b
01	Both	0.00401	3.19449
06	Both	0.00401	3.19449
17	Both	0.00250	3.37000
22	Both	0.00004	3.11570

NATURAL MORTALITY OVER AGE

GSA	Sex	0	1	2	3	4	5
01	Both	1.17	0.44	0.32	0.27		
06	Both	1.17	0.43	0.32	0.27		
17	Both	0.74	0.50	0.34	0.29	0.29	
22	Both	1.50	1.00	0.74	0.66	0.62	0.60

MEAN LENGTH AT AGE

GSA	Sex	0	1	2	3	4	5
01	Both	12.00	13.55	14.74	15.77		
06	Both	12.06	13.41	14.54	15.69		

MEAN WEIGHT AT AGE (in Catch)

GSA	Sex	0	1	2	3	4	5
01	Both	0.012	0.017	0.022	0.028		
06	Both	0.012	0.017	0.021	0.027		
22	Both	0.010	0.014	0.015	0.018	0.022	0.036

MEAN WEIGHT AT AGE (in Stock)

GSA	Sex	0	1	2	3	4	5
01	Both	0.012	0.017	0.022	0.028		
06	Both	0.012	0.017	0.021	0.027		
22	Both	0.002	0.008	0.017	0.022	0.023	0.038

MATURITY OGIVE OVER AGE

GSA	Sex	0	1	2	3	4	5
01	Both	0.50	0.89	1.00	1.00		
06	Both	0.50	0.89	1.00	1.00		
22	Both	0.00	0.40	0.98	1.00	1.00	1.00

Common sole (*Solea solea*)

GROWTH PARAMETERS

GSA	Sex	Linf	k	t0
17	Both	39.6	0.44	-0.46

LENGTH-WEIGHT

GSA	Sex	a	b
17	Both	0.007	3.0638

NATURAL MORTALITY OVER AGE

GSA	Sex	0	1	2	3	4	5
17	Both	0.69	0.34	0.27	0.25	0.23	0.22

MEAN WEIGHT AT AGE (in Stock)

GSA	Sex	0	1	2	3	4	5
17	Both	0.012	0.058	0.155	0.258	0.345	0.519

MATURITY OGIVE OVER AGE

GSA	Sex	0	1	2	3	4	5
17	Female	0	0.25	0.75	1	1	1

Blue and red shrimp (*Aristeus antennatus*)

GROWTH PARAMETERS

GSA	Sex	Linf	k	t0
06	Both	77	0.38	-0.065

LENGTH-WEIGHT

GSA	Sex	a	b
06	Both	0.0024	2.467

NATURAL MORTALITY OVER AGE

GSA	Sex	0	1	2	3	4
06	Female	0.45	0.45	0.45	0.45	0.45

MEAN WEIGHT AT AGE (in Stock)

GSA	Sex	0	1	2	3	4
06	Both	0.005	0.009	0.028	0.046	0.061

MATURITY OGIVE OVER AGE

GSA	Sex	0	1	2	3	4
06	Female	0.08	0.77	1	1	1

Pink shrimp (*Parapenaeus longirostris*)

GROWTH PARAMETERS

GSA	Sex	Linf	k	t0
06	Both	45	0.39	0.1019
09	Female	43.5	0.74	-0.13
	Male	33.1	0.93	-0.05
16	Female	43	0.68	-0.2
	Male	38	0.75	-0.2

LENGTH-WEIGHT

GSA	Sex	a	b
06	Both	0.0019	2.611
09	Both	0.00686	2.24
16	Female	0.0035	2.4457
	Male	0.0038	2.409

NATURAL MORTALITY OVER AGE

GSA	Sex	0	1	2	3	4	5	6	7
06	Both	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
09	Both	1.2	0.78	0.76	0.65	0.5			

MEAN WEIGHT AT AGE (in Stock)

GSA	Sex	0	1	2	3	4	5	6	7
06	Both	0.001	0.006	0.01	0.017	0.022	0.028	0.031	0.036
09	Both	0.002	0.009	0.017	0.023	0.030			

MATURITY OGIVE OVER AGE

GSA	Sex	0	1	2	3	4	5	6	7
06	Female	0.00	0.13	0.50	0.79	0.90	0.97	1.00	1.00
09	Female	0.3	0.8	1	1	1			

Norway lobster (*Nephrops norvegicus*)

MAXIMUM LENGTH, WEIGHT & AGE

GSA	Sex	Length	Weight	Age+
09	Male	72		
	Female	57		

GROWTH PARAMETERS

GSA	Sex	L_{inf}	k	t_0
09	Both	74.00	0.17	0
	Male	72.10	0.169	
	Female	56.00	0.214	
10	Male	75.00	0.150	-0.5
	Female	58.00	0.190	-0.2

LENGTH-WEIGHT

GSA	Sex	a	b
09	Both	0.00050	3.040
10	Male	0.73290	2.991
	Female	0.66800	3.027

NATURAL MORTALITY OVER AGE

GSA	Sex	0	1	2	3	4	5	6	7	8	9
09	Both	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40

MEAN WEIGHT AT AGE (in Stock)

GSA	Sex	0	1	2	3	4	5	6	7	8	9
09	Both	0.0027	0.0098	0.0219	0.0380	0.0570	0.0775	0.0973	0.1178	0.1367	0.1770

MATURITY OGIVE OVER AGE

GSA	Sex	0	1	2	3	4	5	6	7	8	9
09	Both	0.00	0.20	0.50	0.90	1.00	1.00	1.00	1.00	1.00	1.00

MATURITY OGIVE OVER LENGTH

GSA	Sex	2.6	2.8	3	3.2	3.4	3.6	3.8	4
10	Female	0.017	0.05	0.119	0.362	0.557	0.779	0.938	1

Giant red shrimp (*Aristaeomorpha foliacea*)

GROWTH PARAMETERS

GSA	Sex	Linf	k	t0
15 & 16	Male	42.00	0.700	-0.20
	Female*	69.00	0.610	-0.20
10	Male	44.00	0.50	-0.10
	Female	72.50	0.44	-0.10

LENGTH-WEIGHT

GSA	Sex	a	b
15 & 16	Male	0.0010	2.745
	Female	0.0013	2.636
10	Male	0.480	2.810
	Female	0.540	2.710

NATURAL MORTALITY OVER AGE

GSA	Sex	0	1	2	3	4	5
15 & 16	Female	0.62	0.30	0.23	0.19	0.17	0.16

MEAN WEIGHT AT AGE (in Stock)

GSA	Sex	0	1	2	3	4	5
15 & 16	Female	10.44	34.95	56.48	70.97	79.72	85.50

MATURITY OGIVE OVER AGE

GSA	Sex	0	1	2	3	4	5
15 & 16	Female	0.00	1.00	1.00	1.00	1.00	1.00

SGMED recommended in its meeting in Murcia SGMED-09-01, 2-6 March 2009, the following size ranges for growth parameters:

SGMED-09-01	**Parameters- recommended values**		
	Linf	k	
Merluccius merluccius	90-100		TL, cm
Mullus barbatus	27-31		TL, cm
Parapenaeus longirostris	43-45	0.45-0.6	CL, mm
Sardina pilchardus	20-22		TL, cm
Engraulis encrasicolus	19-20		TL, cm

4.2. Review the parameters, amend them as appropriate and recommend their use for future assessments

From the compiled tables, it is clear that in some of the species the values of the growth parameters used in the assessments are different. These differences in growth parameters explain the discrepancies in M vector by age and mean weight at age.

As already pointed out in the SGMED-09-01 report when discussing the differences in growth parameters used in the assessments, some of the observed growth differences can hardly be explained with spatial differences in factors affecting growth rate (e.g. genetic, environment, population density). These discrepancies seem mostly due to differences in methodological approaches used to obtain mean length at age (modal progression analysis and otolith reading).

SGMED discussed on the very negative **t_0** estimated for some stocks, which results from the fitting of the age-length key obtained from otolith reading, and recommends test the effect of using the growth parameters estimated from otolith reading on the M vector.

Regarding parameters a and b of the length- weight relationship, SGMED reiterates the sampling should include the whole size range of the species and be conducted during the whole year. Length- weight parameters estimated only from survey data collected during one single season are likely to be biased, since the survey will not allow to detect the seasonal differences in weight during the year, and will not collect the whole size range of the species because of the selectivity of the sampling gear. SGMED recommends to use all available data sets to estimate a and b, from both the fishery market (the whole year) and surveys.

In some cases, differences in the parameter values are just a change of scale, as in the case of parameter a of the length weight relationship.

In hake, M vector over age is quite different among GSAs, particularly regarding age 0, one of the main components of the trawl catch in numbers, and differences are also observed in the mean weight at age, which result from the differences in the growth parameters estimated in each GSA. Linf in GSA05 and of males in GSA10 is smaller than in the other GSAs, which results in a smaller natural mortality rates, particularly for age class 0. In red mullet the main difference in growth parameters regards GSA25. M at age are also quite different, especially for class 0, but not only for this class; weight at age and maturity are also different. Discrepancies are also evident on the estimated parameters for anchovy in GSA22 and those estimated for GSAs 6 and 9. As for the deep-sea rose shrimp, the estimated growth parameters are different among GSAs, which result in differences in M. Moreover, the maturity ogives are quite different in GSAs 6 and 9.

SGMED could not agree on parameter values to recommend for future assessments due to due time constraints. In any case, in the next SGMED-10-02 meeting, prior the start of the performance of the assessments, the experts tackling with different stocks of the same species will try to select parameter values which fall within agreed values ranges.

In those GSAs where no biological information is available for assessments to be carried out, SGMED recommends to use the values of the parameters from adjacent GSAs (as a proxy) to perform preliminary stock assessments.

Input data for the assessment of species with different growth between sexes

Some species, among them a number of the species considered as priority for assessment by SGMED, display sexual size dimorphism. In such a situation, using a single set of growth parameters results in an overestimation of fishing mortality in those age, or size, ranges males do not achieve.

SGMED agreed that, when assessing species with marked differences in growth between sexes, the size distributions of males and females will be transformed to ages using the corresponding growth parameters by sex. Input for the assessment will be the matrix of ages resulting from merging the males and females matrices.

Similarly, M vector will be estimated for males and females separately, using the corresponding growth parameters. Input data for the assessment will be the combination of M vectors by sex, weighed by the sex-ratio.

The input parameters a and b of the length- weight relationship will be those estimated for males+ females.

When a stock is exploited with several gears/strategies and consequently with different exploitation patterns and rates, information from the different métiers (size or age distributions, catches, etc) must be collected and in a second instance gathered properly for performing the stock assessment.

4.3. Species and stocks to be considered in future assessments

SGMED was requested to recommend the species and stocks to be considered in future assessments.

During 2008 and 2009 the species that were assessed, either in the frame of SGMED or GFCM-SCSA (General Fisheries Commission for the Mediterranean- Sub-Committee Stock Assessment) were the following: *Merluccius merluccius, Mullus barbatus, Mullus surmuletus, Parapenaeus longirostris, Engraulis encrasicolus, Sardina pilchardus, Solea solea, Aristeus antennatus, Aristaeomorpha foliacea,* and *Nephrops norvegicus* (table 1.3.2). These are the species for which current knowledge on their biology and exploitation in the Mediterranean is best. There remain however Geographical Sub-Areas (GSAs) where they have not yet been analytically assessed. *Lophius budegassa* and *Spicara smaris* have also been assessed in one GSA in the frame of GFCM (marked with X in table 4.3.3).

The stocks for which analytical assessments and short term advice was provided by SGMED in 2009 will be updated accordingly in 2010 (marked with X in the tables below). In addition, other stocks for which no assessment is available will be evaluated for the first time.

The criteria SGMED followed for the recommendation on the priority for additional species and stocks to be assessed were two fold: first priority is to be given to those stocks of the species mentioned above in areas where they have never been assessed; secondly, in accordance with the recommendations by SGMED-09-03 (ranking list), other species and stocks are proposed, depending on their importance as fishing targets in the different GSAs.

The tables below show the assessments (updating and assessment of stocks never evaluated) to be performed during the two SGMED meetings in 2010.

No assessment is available from GSAs 2, 8, 18, 19, and 20.

Table 4.3.1. Stocks proposed for assessment in areas where no assessment is available.

GSA	
2	*Aristeus antennatus*
8	no data collection
18	*Mullus barbatus*, *Merluccius merluccius* (combined with GSA 17), *Nephrops norvegicus*
19	*Merluccius merluccius, Aristeus antennatus*
20	*Merluccius merluccius, Mullus barbatus, Mullus surmuletus, Sardina pilchardus, Engraulis encrasicolus, Parapenaeus longirostris, Spicara smaris*

Table 4.3.2. Stocks assessed in 2009 and/or 2008 in the frame of SGMED and/or GFCM-SCSA, and the stock priorities for future assessments.

Species/GSA Area	1	5	6	7	9	10	11	15	16	15-16	17	22-23	25
Merluccius merluccius	1	X	X	X	X	X	1	-	-	X	1	1	np
Mullus barbatus	1	X	X	X	X	X	X	X	1	-	1	1	X
Mullus surmuletus	np	X	2	2	np	np	np	X	1	-	np	1	1
Parapenaeus longirostris	2	1	X	np	X	1	2	-	-	X	2	1	np
Engraulis encrasicolus	X	np	X	X(1)	1	2	np	np	X	-	X	X	np
Sardina pilchardus	X	np	X	X(1)	2	2	np	np	X	-	X	X	np
Solea solea	-	-	-	1	3(2)	-	-	-	-	-	X	2	np
Aristeus antennatus	1	X	X	2	2	2	2	np	3	-	-	np	np
Aristaeomorpha foliacea	np	np	np	np	2	X	1	-	-	X	-	np	np
Nephrops norvegicus	2	1	2	2	X	X	2	-	-	1	1	2	np

X assessed stocks
np no priority because the presence of the species in the landings is low, or absent

1, 2, 3 priority level (1 highest)
(1) acoustic assessment
(2) no DCF priority in GSA9, but important locally
- no DCF priority

in GSAs 15 and 16, some stocks are jointly assessed (*Merluccius merluccius, Parapenaeus longirostris, Aristaeomorpha foliacea*), while others are assessed separately for each GSA (*Mullus barbatus, Mullus surmuletus, Engraulis encrasicolus, Sardina pilchardus, Aristeus antennatus*).

Table 4.3.3. Stocks not yet assessed analytically, selected from the ranking list of species recommended in SGMED-09-03 report.

Species/GSA Area	1	5	6	7	9	10	11	15	16	15-16	17	22-23	25
Coryphaena hippurus										1			
Pagellus erythrinus					1				2				
Sparus aurata				1									
Dicentrarchus labrax				1									
Boops boops												2	1
Squilla mantis											2		
Spicara smaris												X	1
Lophius budegassa			X										

SGMED recommends, in addition to the updating of the assessments and short-term forecasts provided in 2009, priority for future assessments should be given firstly to the stocks in table 4.3.1; secondly to those in table 4.3.2, and finally, to the stocks in table 4.3.3.

The stocks that for the first time will be assessed are listed in Appendix 5. To ease the performance and efficacy of the group, participants to this meeting were asked to appoint themselves as coordinators for those stocks they are more interested or willing to assess during the next SGMED meetings. The stock coordinators list will be updated at the beginning of the next SGMED meetings.

Furthermore, the tasks foreseen for SGMED to implement in 2010 include application of the recommended empirical indicators and methodologies, in addition to those stocks that will be assessed, to species and stocks in data poor situations (see section 6 of the report).

5. ToR 2 Development and testing of trawl survey index standardization procedures with R

In preparation of SGMED meeting 10-01, V. Bartolino, G.C. Osio, F. Scott and G. Pilling, upon request of DG Mare, have developed an R code and user manual that performs the functions described in TOR 2. The code and user manual have been distributed to the SGMED scientists and the R script has been run and presented showing how it performs using MEDITS Hake data in GSA 07.

5.1. TOR 2.0 Testing the script data query and preparation

The following steps have been performed to test the R code:

1. The script and folder structure were copied on the user computers. The script was run on the machines of the workgroup participants and it performed well under R versions 2.8 and 2.10. R was set up to perform automated queries to the SGMED MEDITS Access database compiled by JRC and stored on the meeting network drive and it worked without errors although slowly.

2. The second step was to test the data returned from the SGMED MEDITS db to verify that the R script was tested on correct data before approaching the age slicing and index standardization. The following GSA's have been quality checked for Hake: 01, 02, 06, 07, 09, 10, 16, 17.

As many errors of different nature were found in the SGMED MEDITS db a detailed description of the errors and the suggested correction are described below:

MEDITS DB testing

GSA 1, 2

When entering data the subroutines in R program detected the following errors:

1. - For year 1994 it was not possible to estimate the swept area because of missing parameters of vertical and horizontal opening of the net.

2. - It seems that no distinction is made between GSA 1 and GSA2 for Hake data in this GSA 1

3. - There are some erroneous data on sex allocation Hake in the database. Instead of I, M or F appear: n o 0.

GSA 16

Errors were found while testing Hake data in this GSA: 16 tows where removed as the fields Latitude and Longitude contained values larger than 10000 while the data should be in format with three or four digits and two decimals. In addition when supposedly working with GSA 16, the database query returned also tows performed by the Malta GSA 15, with the additional problem that one tow from Malta was duplicated the same year.

GSA 9

As concerns GSA 9 MEDITS data, several differences and inconsistencies have been detected in the comparison of the database provided by SGMED MEDITS db with the data sent to the Italian National Correspondents by the GSA 9 Coordinator.

The main differences are:

The TA files of the SGMED MEDITS database are lacking of a considerable number of hauls, for each year of the time series. Probably most of these hauls have been transferred in the JRC database to the GSA 10; this could be caused by the GSA allocation criterion used.

In addition, the TA files of the SGMED MEDITS database are lacking a great number of hauls performed in 2003 with the vessels "CIRO" (code "CIR").

GSA 10

As concerns GSA10 MEDITS data for Hake, a difference in the number of hauls was discovered in the comparison of the database provided by SGMED MEDITS db with the database provided for the GSA10 by the Italian National Correspondent for the data call. In fact, the TA files on the SGMED MEDITS db have a considerable number of hauls that are not in the database of GSA 10, for each year of the time series. As previously communicated in 2008 to JRC these hauls belong to GSA9 and have been attributed to the GSA 10 in the SGMED MEDITS database, because there is discrepancy between MEDITS and GFCM GSA definition for those two GSAs.

GSA 17

Many years of data are missing and the years present are unbalanced as in some cases the data cover the entire GSA while other years the data is limited to the Italian side of the GSA (for details see table below). The MEDITS data for GSA 17 that have been submitted by the National Correspondents cover only the period 2002-2008. With the current MEDITS data available for this GSA it is impossible to perform any assessment based or relying on survey data for the entire GSA.

Table caption, Number of hauls performed during MEDITS survey that caught Hake in GSA 17. The 0's are indicative of data not available to SGMED.

year	HRV	ITA	SLO
1996	0	0	2
1997	0	0	2
1998	0	0	2
1999	0	0	2
2000	0	0	2
2001	0	0	2
2002	59	113	4
2003	0	116	2
2004	0	112	4
2005	59	114	2
2006	0	114	0
2007	0	121	9
2008	0	116	2
2009	0	0	2

GSA 6

Erroneous positions in the TA file resulted in hauls appearing on land for some years. This issue was corrected by entering the appropriate longitude/latitude data.

Conclusions

The SGMED MEDITS DB available to SGMED scientists contains a multitude of character, numeric and header row errors that have a serious impact on any attempt of using the DB and that needs to be corrected. This is true irrespectively of the further DB problems raised below.

The main concern is due to a serious structural error in the SGMED MEDITS DB. The original data base (tables TA, TB, TC) structure defined by the MEDITS Coordination (see Instruction Manual N.5, 2007) does not contemplate a field descriptor for GSA. As SGMED assessments are carried out by GSA units, a GSA column has been added to files TA on the basis of the GFCM GSA longitude and latitude boxes in an attempt to define GSA within the SGMED MEDITS DB.

This operation generates two types of errors:

1. There is discrepancy between MEDITS and GFCM GSA definition (for example between GSA 9 and 10). Using GFCM GSA definition for these GSA wrongly allocates hauls performed in GSA 9 to GSA 10 (according to MEDITS definition). This not only creates a problem of GSA identification, but also of data merging between file TA and TB-TC. As haul numbers can be the same between the GSAs (hauls have progressive numbering within each MEDITS data collection group), this could generate mismatches between haul information and biological information.
2. The second error is purely of database design. Tables TA, TB and TC should have unique tow identifiers, and adding a GSA column to TA, TB, TC would allow correct identification. However the safest solution would be that each tow can be identified uniquely across countries, years and GSA's. This will avoid any risk of matching haul information (from TA) with biological data from a different haul (from TB-TC), which is currently happening in the current SGMED MEDITS DB.

The conclusion is that the current database contains fundamental structural problems and errors and when used it generates unpredictable errors that can propagate into assessments.
For sake of the R code testing within the sub-working group it was decided to focus on data for Hake in GSA 16 as, once removed the most obvious errors, assessment results were available for comparison with age slicing.

SGMED MEDITS DB rebuild and suggestions for Data Call
In order for scientists to reliably use MEDITS data, it is advisable to rebuild the DB using correct GSA identifiers. The definition of GSA should reflect that of MEDITS and not that of GFCM. The reason is that data are collected consistently by MEDITS operating units that are structured according MEDITS GSA's.
The correct steps should be the following:

1. There needs to be a general quality check of the values in all the MEDITS files (1994-2009) to correct the many errors described and identified (incorrect sex identifiers, null wing spreads, etc.)
2. The row columns need to be consistent with the original standard (as in the instruction manual) or be consistent with good database practices of keeping the column names short and without spaces. As an example, in TC file in the SGMED MEDITS db there is a column header "NUMBER_OF_INDIVIDUALS_IN_THE_LENGTH_CLASS_AND_MATURITY_STAGE", such header is unacceptable. The corresponding code in the MEDITS instruction manual is "NbLon" which for any database management and data usage is acceptable
3. Each group involved in the MEDITS data collection needs to add a GSA column to the standard TA, TB and TC file.
4. The different files can then be merged together in a database

5.2. TOR 2.1 Age Slicing Testing
The age slicing function implemented in the R script was tested and compared with the LFDA software which is routinely used for age slicing and a third slicing function using mixed distributions.

Methods

Three methods for age slicing were compared:

1. The method described in FAO (Sparre and Venema, 1998), which is based on calculating the proportion of each observed length class in each age class, was implemented in R and described in the R code user manual.
2. LFDA, which uses a similar approach to the slicing (described below)
3. A method using mixed distributions that assumes that the variation of length at each age is taken to be Gaussian with time invariant coefficient of variation.

The test data used was hake from GSA 16. The absolute numbers at length, scaled by the swept area of each haul, was used. The numbers raised to account for the sample size (i.e. numbers at length * weight of the fraction / weight of the sample measured) was not used due to errors in the data.

1) Age slicing with R code slicing function
As described in the User Manual, the method implemented in R calculates a matrix of proportions which describes how the numbers at length are divided amongst the age classes. The numbers at age are then calculated using:

$$\mathbf{P}\,\mathbf{L} = \mathbf{A}$$

where **P** is the matrix of proportions, **L** is the vector of length frequencies and **A** is the vector of numbers at age. The columns of **P** sum to 1. By using R, this method was applied on the length frequency data that was disaggregated by year, haul and sex. The resulting numbers at age were then aggregated by haul and sex and scaled by the swept area to give total numbers at age. It is possible to use different von Bertalanffy growth equations for males and females. It is also possible to retain the haul disaggregation in the calculated numbers at age, meaning that the spatial distribution of abundance can be explored.

2) Age slicing using LFDA (from Hoggart et al., 2006)

The age-slicing method allows estimation of the age frequency distribution corresponding to each length frequency distribution using the estimated growth curve parameters. The method can be used whenever a non-seasonal von Bertalanffy growth curve has been fitted, or when a Hoenig and Choudary Hanumara seasonal growth curve has been fitted, provided C<1.

The underlying concept behind age-slicing is very simple. Suppose a non-seasonal von Bertalanffy growth curve has been fitted. Given estimates of L_∞ , K and t_0, the von Bertalanffy growth curve can easily be inverted to determine the age t of a fish of length L:

$$t = t_0 - \frac{1}{K}\ln(1 - \frac{L}{L_\infty})$$

Now suppose that a length frequency distribution has N fish in a length class containing lengths between L_1 and L_2. Using the above formula, it is easy to calculate the ages t_1 and t_2 corresponding to these two lengths. Suppose further that i_1 is the integer part of t_1 (i.e. if $t_1 = 3.47$, then $i_1 = 3$) and that i_2 is the integer part of t_2. There are then three possible cases to consider:

(a) $i_1 = i_2 = i$

In this case, all N fish in this length class will be assigned to age class i.

(b) $i_2 = i_1 + 1$

In this case, some of the fish in this length class should be assigned to age class i_1 and some to age class i_2. To work out how many, it is necessary to make an additional assumption. In LFDA, we assume that the N fish have lengths that are uniformly distributed between L_1 and L_2. Thus, if $L(i_2)$ is the length of a fish that has age exactly i_2, i.e. :

$$L(i_2) = L_\infty(1 - e^{-K(i_2 - t_0)})$$

then it is reasonable to assign $\frac{L(i_2) - L_1}{L_2 - L_1}N$ of the fish in the length class to age i1 and the remainder $\frac{L_2 - L(i_2)}{L_2 - L_1}N$ to age i_2.

(c) $i_2 > i_1 + 1$

This final case is the most complicated, as the fish in the length class now have to be distributed amongst more than two age classes. Again, we assume that the N fish have lengths that are uniformly distributed between L_1 and L_2. Define $L(i_1 + 1)$, $L(i_1 + 2)$, … , $L(i_2)$ as the lengths of fish aged exactly $i_1 + 1$, $i_1 + 2$, … , i_2 years. Then we assign the N fish to age classes as follows:

$\frac{L(i_1+1) - L_1}{L_2 - L_1}N$ fish to age class i1; $\frac{L(i_1+2) - L(i_1+1)}{L_2 - L_1}N$ fish to age class $i_1 + 1$; …..; $\frac{L(i_2) - L(i_2-1)}{L_2 - L_1}N$ fish to age class i_2 -1; and $\frac{L_2 - L(i_2)}{L_2 - L_1}N$ fish to age class i_2.

This process is repeated for each length class in a length frequency distribution and the age-sliced distribution is calculated by summing up the contributions from each length class to each age class.

Exactly the same procedure is used when a Hoenig seasonal growth curve is fitted, but the formulas are a little more complicated.

LFDA method application

We converted standardized length frequency distributions (lfds, $n*km^{-2}$) of hake in GSA 16 in age distributions using 15 years of MEDITS data (1994 to 2009) using both ad hoc R scripts and LFDA.

Age slicing was conducted on each sex separately using sex specific von Bertalanffy growth parameters and assuming a sex ratio (F/F+M) of 0.5 for unsexed (undetermined) individuals. Estimated numbers-at-age for the two sexes were then pooled to obtain a single matrix of $n*km^{-2}$ for each age class (0^+ - 5_{plus}) and year (1994-2009).

3) Age slicing by mixed distribution method

As mentioned above, the mixed distribution method assumes that the variation of length at each age is taken to be Gaussian with time invariant coefficient of variation (Parrack and Cummings, 2003). The variance of length at age is directly proportional to age resulting in an age invariant coefficient of variation. The mean length at age is calculated using the von Bertalanffy growth parameters. This results in the linear system:

$\mathbf{P\,A = L}$

Where **A** and **L** are proportions, not absolute numbers. It is not possible to solve for **A** using standard linear methods as there are two constraints: each element of **A** must be between 0 and 1, and the sum of **A** must be equal to 1. The numbers at age and the coefficient of variation are therefore estimated using optimising routines. The method is implemented in R using the *mixdist* package (Du 2002).

For the FAO method described above the proportion of the observed length frequency in each age class is determined by the observed length classes and the von Bertalanffy growth parameters. For method 3, the proportion of each age class that is in length class is also a function of the estimated time invariant coefficient of variation.

Results

It is possible to use the R code to plot how the proportion matrix will look. This is a very useful method to visually inspect how the length classes will be sliced. The matrix is calculated using the von Bertalanffy growth parameters and the length classes in the observed data. This means that plotting the proportion matrix allows you to see the impact of using different values of the growth parameters on the length ranges of different ages. It is therefore easy to check if the growth parameters are appropriate for the stock in question.

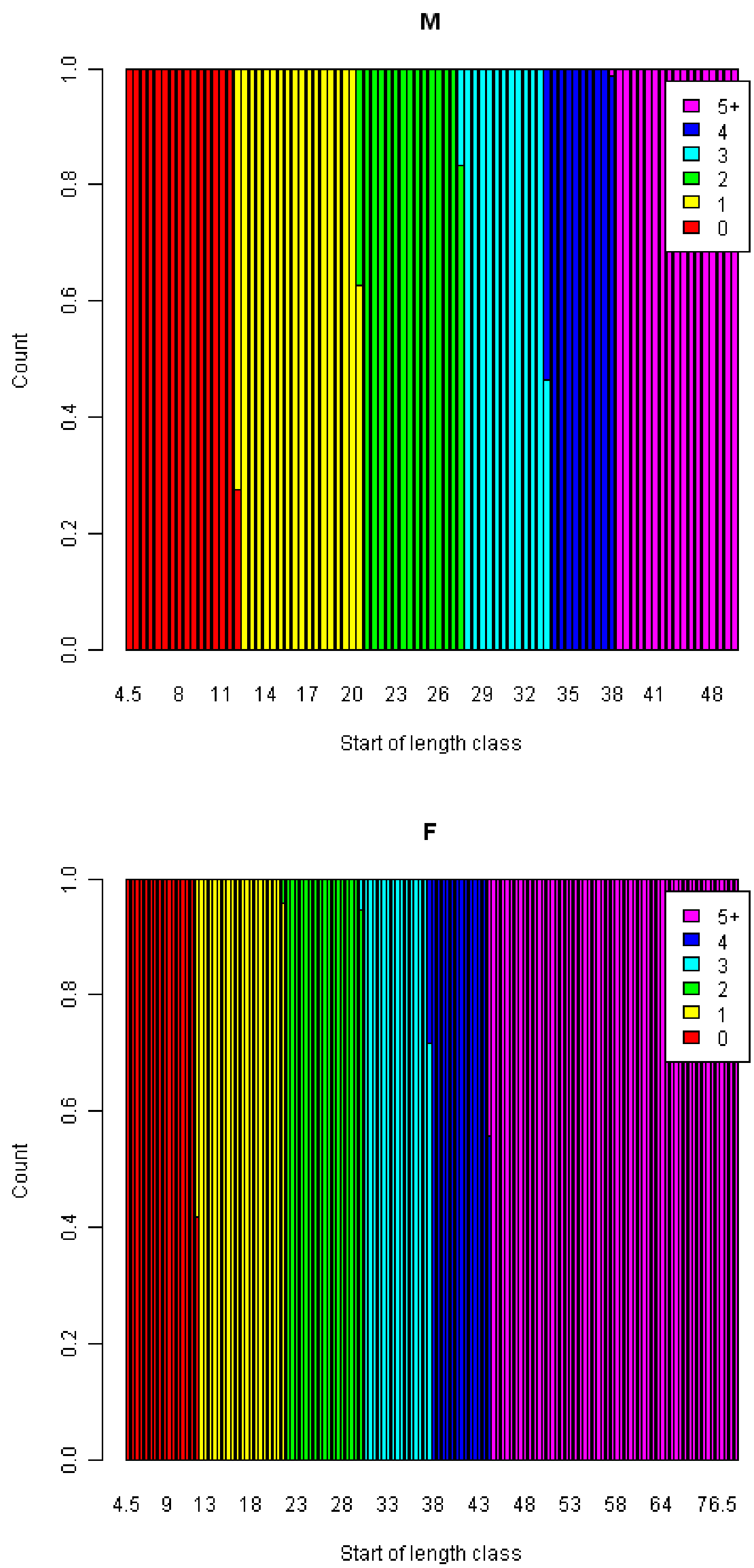

Fig. 5.1. Example, proportion matrices for males and females calculated using the R code.

The proportion matrix is multiplied by the length frequency to calculate the numbers at age. An example is shown below.

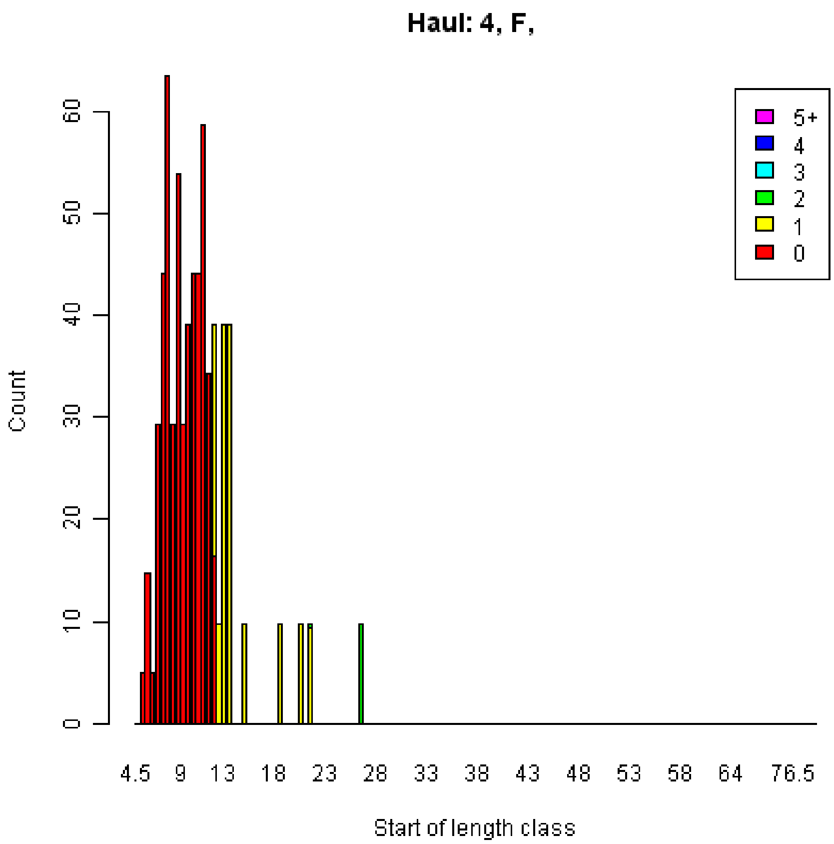

Fig. 5.2. An example of age slicing a sex disaggregated individual haul.

The aggregated numbers at age calculated using R and LFDA were compared. It can be seen that they are virtually identical. This demonstrates that the age slicing routine that is implemented in R replicates the method used in LFDA. However, there are a number of advantages to using the method in R. All of the operations, including database interrogation, data exploration, age slicing, analysis and model fitting can be performed in the same R environment. This means that the analysis can be easily repeated and the consequences of using different parameter values, for example, can be explored.

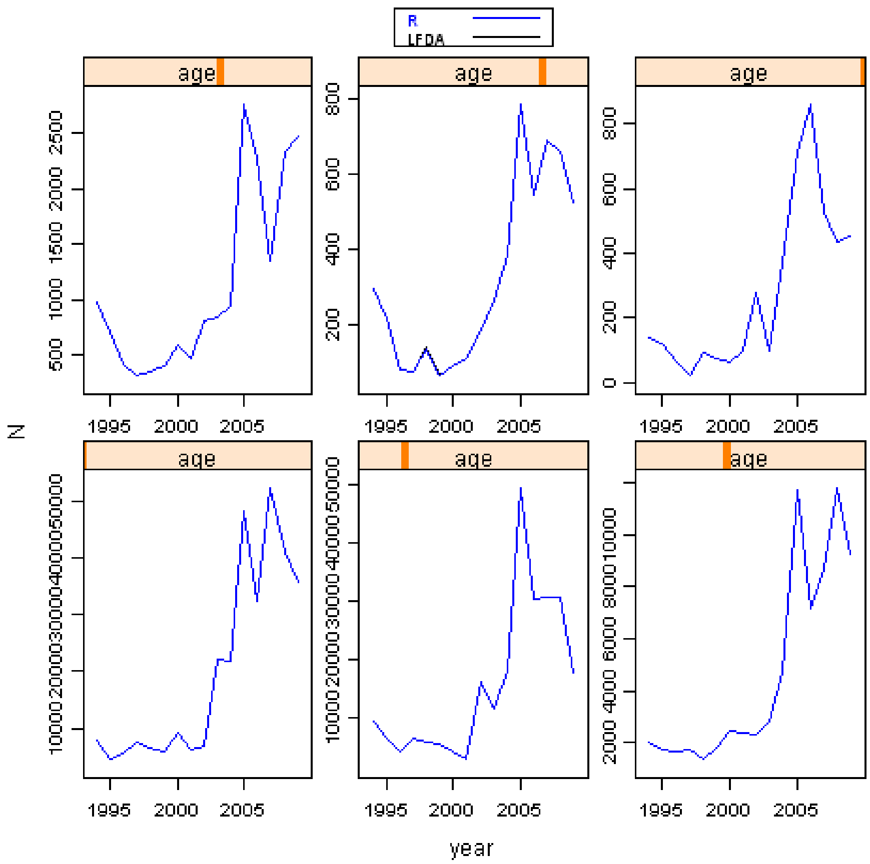

Fig. 5.3. Comparing the aggregated numbers at age as calculated using R and LFDA. The results are virtually identical. It should be noted that the plot is *not* an index of abundance. It is simply plotting the total number of fish caught in that year and does not take into account the number of hauls (which has almost tripled over the duration of the time series). The plot is only to compare the outputs from the two slicing methods.

Once the data has been processed it is possible to use R to easily perform detailed data analysis and exploration. For example, a bubble plot can be used to explore cohorts (see below), stock assessment performed etc.

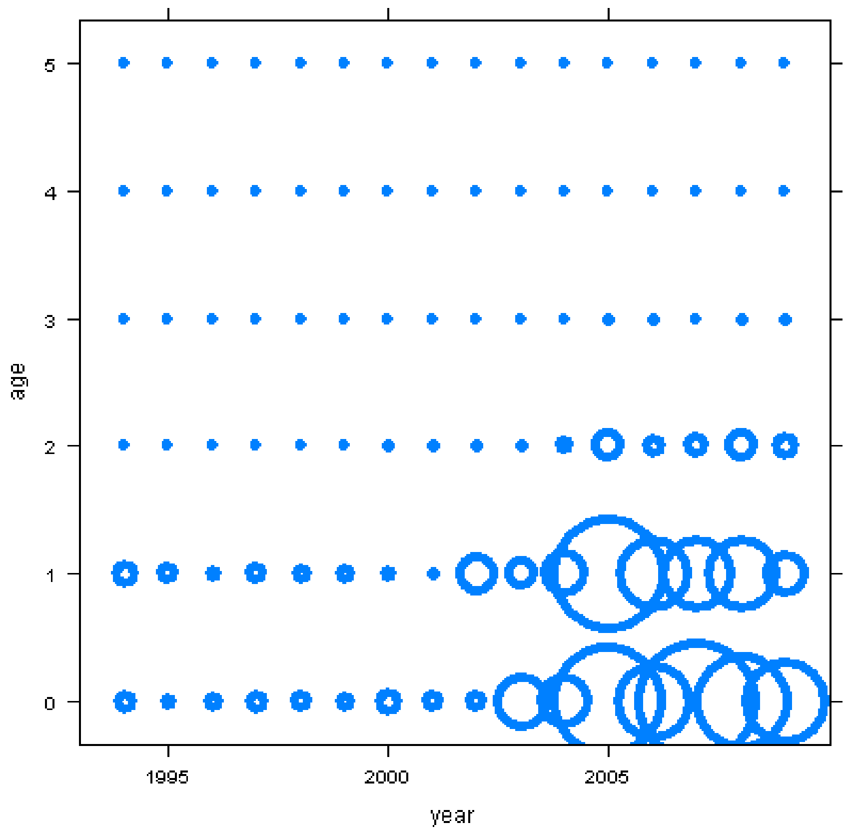

Fig. 5.4. An illustration of how a bubble plot in R can be used to explore cohorts in the numbers at age data. The size of the bubble is the relative abundance (the data is not an index of abundance, the plot is included is an illustration only).

As mentioned above, another advantage of using R is that it is possible to perform age slicing on a haul by haul basis. This allows the spatial distribution of numbers at age to be explored and is illustrated below.

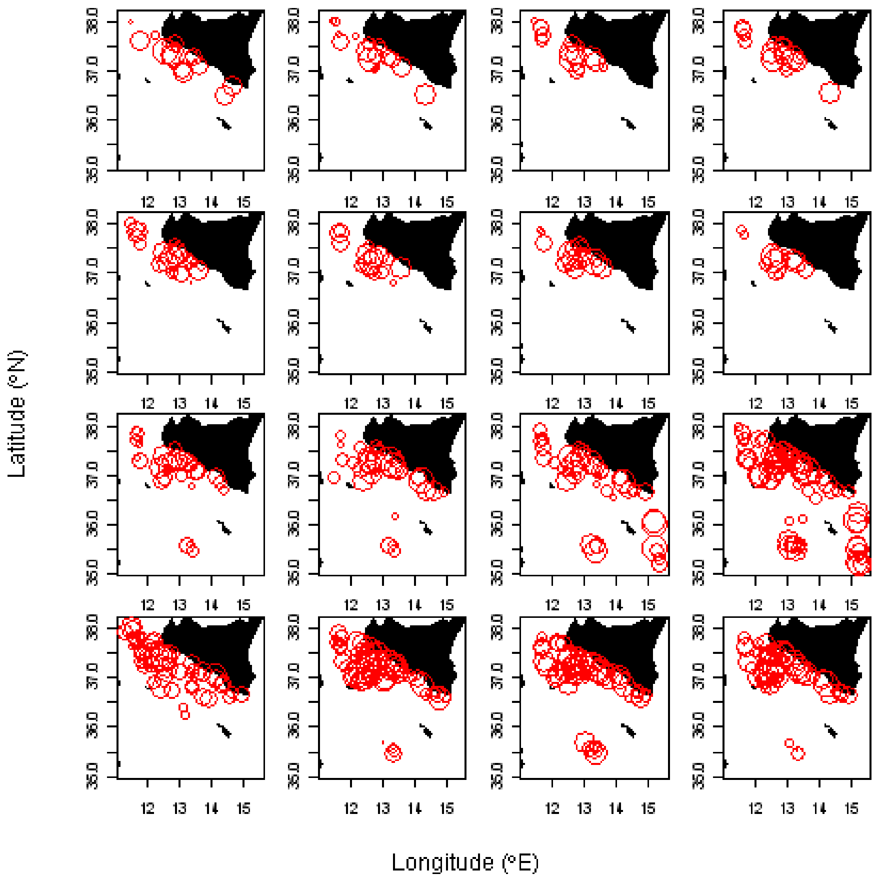

Fig. 5.5. An illustration of spatially plotting the numbers at age. The plot shows the relative numbers of Hake at age 0 from 1994 (top left) to 2009 (bottom right) in GSA 16, moving from left to right.

The mixed distribution method was implemented using the R package *mixdist* to solve for the proportions at age and the constant coefficient of variation. However, the results were found to be very sensitive to the initial parameter estimates. Consequently it is recommended that further exploration of this method is carried out before it is used. Additionally, as with LFDA, this method is only applied to the aggregated length frequency data and so it is not possible to see the spatial disaggregation of the numbers at age. An illustration of the results of the method is shown below.

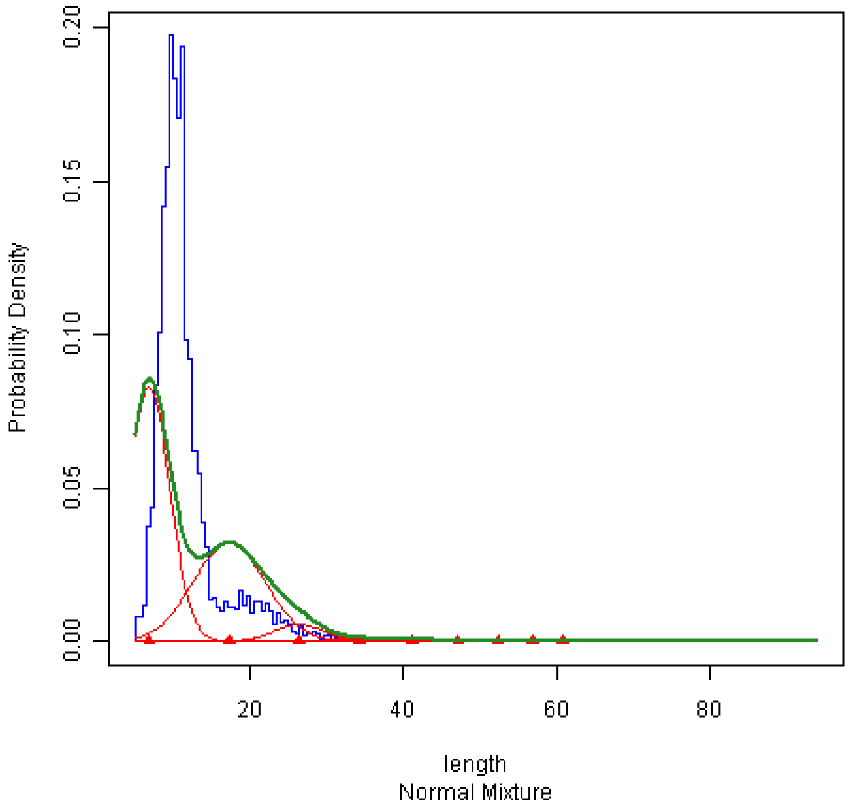

Fig. 5.6. An illustration of the mixed distribution method. The blue line is the aggregated length frequency data in 2008. The red lines show the distribution of lengths at age. The mean of each distribution is given by the mean length from the von Bertalanffy growth parameters and the coefficient of variation is estimated and time invariant i.e. the standard deviation of each distribution is proportional to age. The green line is the fitted length frequency distribution using the estimated proportions at age.

Age slicing of Hake in GSA 10

A second testing of age slicing was performed on MEDITS data from GSA 10 (in this case using original MEDITS data from the Italian national correspondent). The R script was used with growth parameters for age slicing equal for males and females:

L_∞=100, k=0.15, t_0= - 0.2.

Looking at the number at age and at the cohort plots:

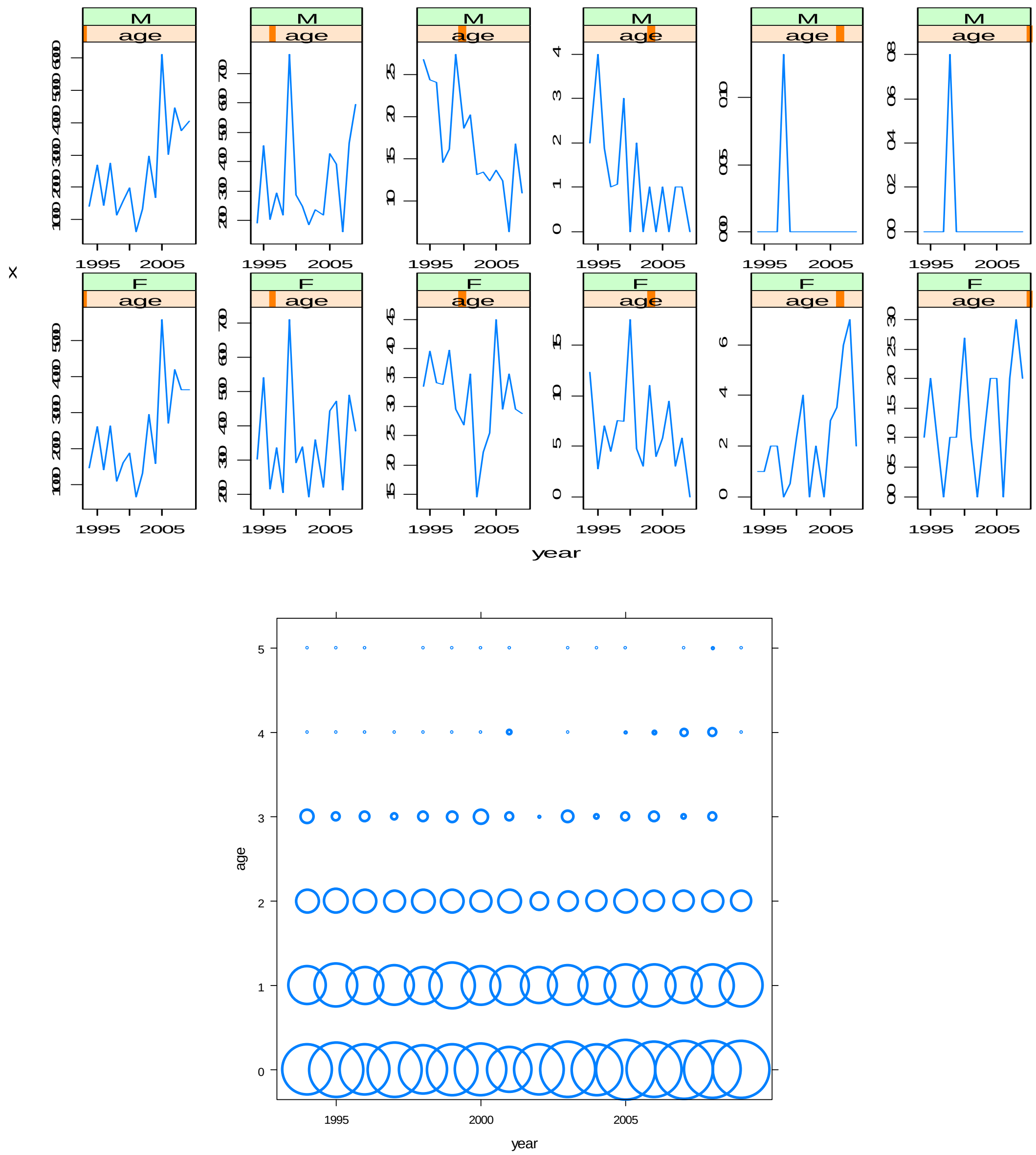

Fig. 5.7. Number of males and females at age and cohort plot of hake in GSA10.

we observe that age 0, 1, 2 groups are present all the years, while age 3 is not present in 2009, age 4 in 2002 and 2004 and age 5 in 1997, 2002, 2006. We can also plot the mean CPUE by year in space:

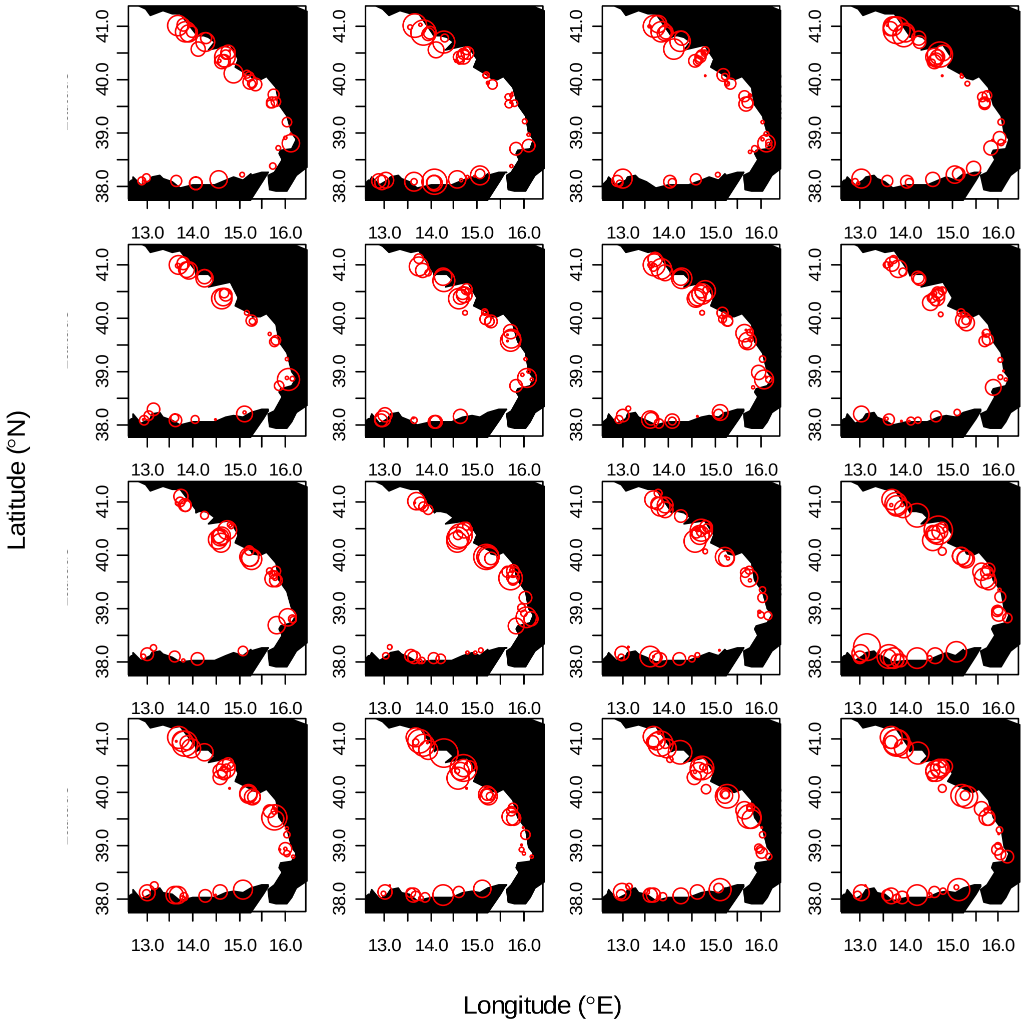

Fig. 5.8. Yearly CPUE (Numbers per km^2) for hake in GSA 10. The plot shows the relative numbers of Hake at age 0 from 1994 (top left) to 2009 (bottom right) in GSA 10, moving from left to right.

We chose a haul (115) in order to plot the proportion matrix and a sex (F) and a year (1996) for the age slicing:

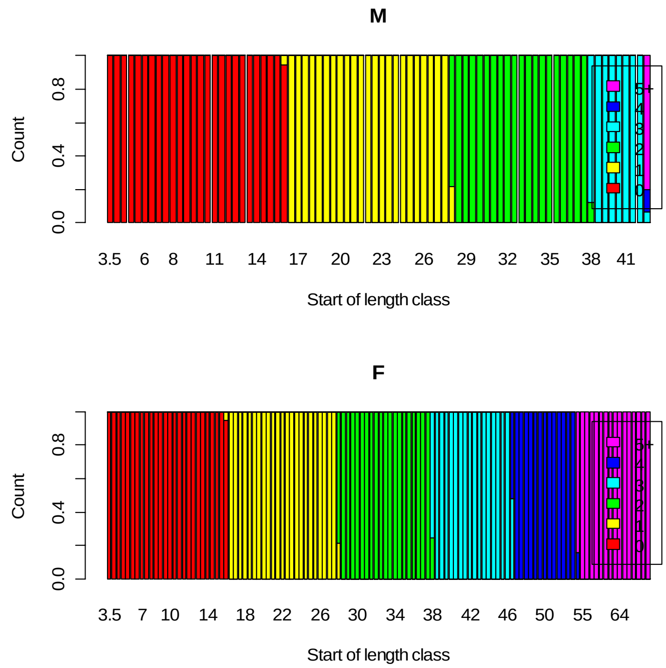

Fig. 5.9. Proportion matrix for hake in GSA10.

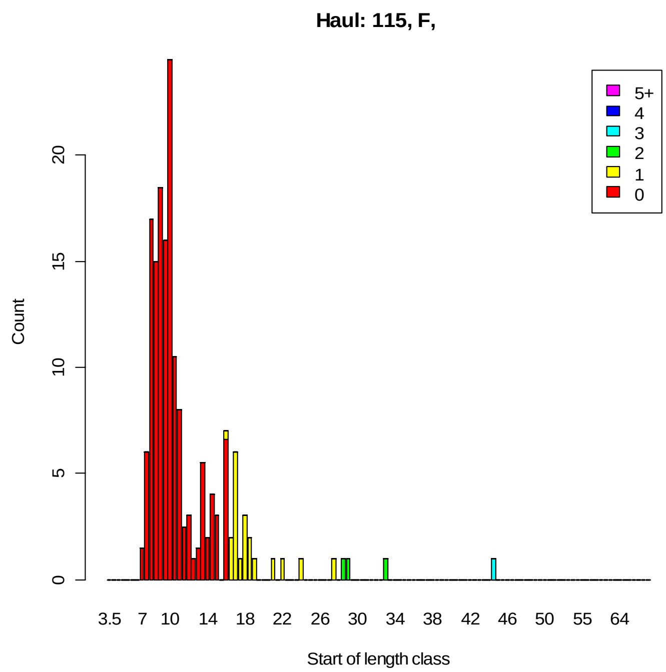

Fig. 5.10. Example of age slicing for hake in GSA10 (females, haul 115, year 1996).

We made a comparison between the age slicing computed by the R routine and by LFDA; then we plotted by means of R the results:

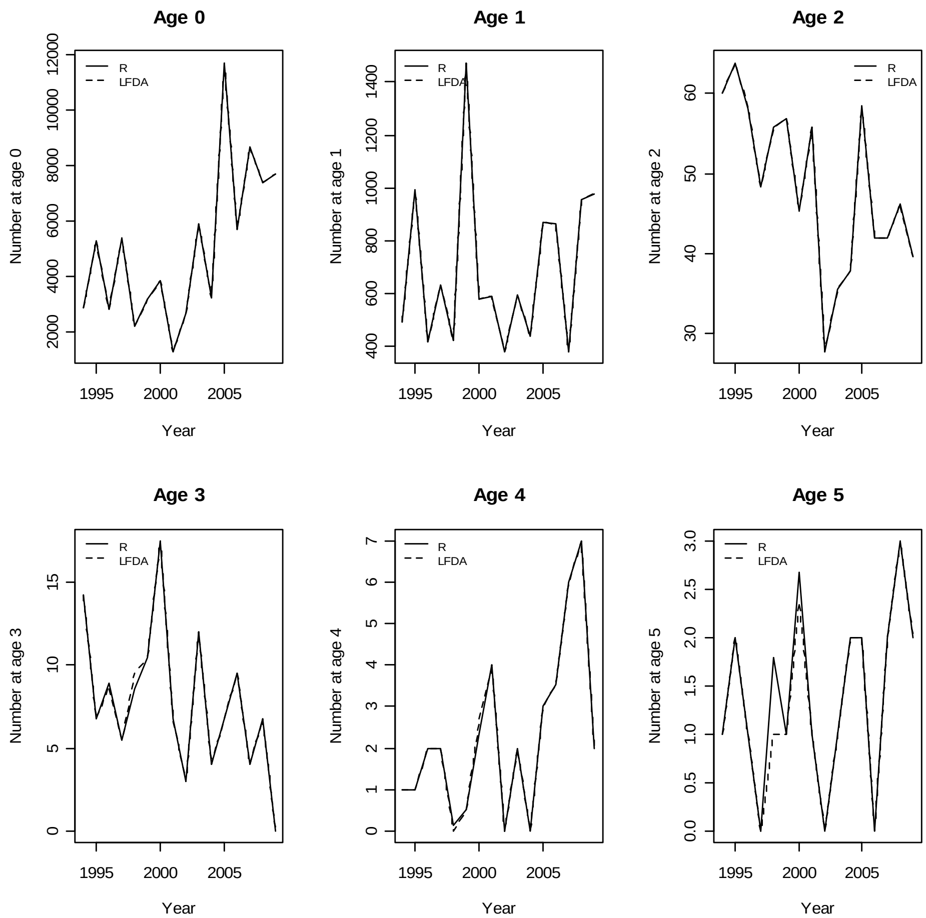

Fig. 5.11. Comparison of the aggregated numbers at age as calculated using R and LFDA for hake in GSA10.

The results are almost coincident.

5.3. TOR 2.4 Transform the estimated indices of abundance by age into the input table formats of SURBA and XSA stock assessment programs.

Numbers at age are routine output of the R code developed and are saved as .csv file in the “output” folder. The user needs to copy and paste the numbers into the SURBA or XSA data input template. Within the meeting in Barcelona it was the intention of the working group to compare a SURBA assessment using the non-standardized numbers at age with a standardized one. However not enough time was available to perform this analysis.

5.4. TOR 2.2 Estimate annual trends in stock abundance and biomass indices (CPUE). In addition, such scripts should allow the use of GLM/GAM models to standardize the indices against theoretical or estimated statistical distribution patterns and provide diagnostics to assess best performing type of models, link function, family distribution and predictors.

CPUE index standardization using GLMs and GAMs

Further testing of the R code was performed on CPUE standardization using GLMs as well as GAMs. The R script leaves the user free to specify different types of models and different sets of models were fitted to Hake in GSA 16.

As many errors were found in the MEDITS data for Hake in GSA 16, an attempt has been made to fix and clean the data (e.g. remove tow with Latitude and Longitude >100 Deg, remove hauls performed by GSA 15, remove duplicates), however there is no certainty that the data is correct or still consistent, so the results of the standardization might be strongly biased by the errors. For instance, despite the cleaning in 2006 there are many

tows that appear 2 times (this should be impossible) and this likely reflects in the high estimated CPUE that year as shown in the model fits.
Given the concerns of using the SGMED MEDITS data, the R code was used to standardize trawl survey index of abundance using Hake original MEDITS data provided by GSA 01, and by GSA 10. Of these two cases, given the use of mostly the same code, we report the main results and diagnostic plots for the sake of brevity.
Additionally the R code was also tested using "rapido" trawl survey data for *Solea* from GSA 17. This data set, provided by G Scarcella, has been reshaped so that the R script would be able to perform the routines for index standardization and slicing. The R code worked properly and was able to perform all the routines including standardization of the CPUE of the Numbers at Age. For brevity this example is included in the report in it's results and diagnostics.

Data Preparation for Hake index standardization in GSA 16

Run the code std_indexMEDITS.r having selected Hake (MERLMER) and GSA 16, and correct some errors by removing wrong positions and countries.

```
TB<-subset(TB, Latitude<100 & Longitude<100)
TB<-subset(TB, COUNTRY==”ITA”)
TB<-unique(TB)
```

GLM standardization of CPUE of NBTOT/swept for Hake in GSA 16

```
# only first order effects
# we observed collinearity between Lat and Long so we use only Lat

fit0.gauss <- glm(log(CPUE+1)~1, family=gaussian(link='identity'), data=TB) #AIC: 6815.6

fit0.gamma <- glm(log(CPUE+1.1)~1, family=Gamma(link='identity'), data=TB) #AIC: 7142.2

fit1 <- glm(log(CPUE+1)~factor(YEAR)+factor(MONTH)+Latitude+DEPTH, family=gaussian(link="identity"), data=TB)

# latitude x longitude interaction
# fit2 <- glm(CPUE~factor(YEAR)+factor(MONTH)+Latitude*Longitude+DEPTH, family=gaussian(link="identity"), data=TB)

# second order effect of DEPTH (~...+x+x^2)
fit3 <- glm(log(CPUE+1)~factor(YEAR)+factor(MONTH)+Latitude+DEPTH+I(DEPTH^2), family=gaussian(link="identity"), data=TB)

AIC(fit0.gauss, fit1, fit3)
```

Model	df	AIC
fit0.gauss	2	5599.784
fit1	22	5130.407
fit3	23	4862.596

Best model is fit3

```
> summary(fit3)

Call:
glm(formula = log(CPUE + 1) ~ factor(YEAR) + factor(MONTH) +
    Latitude + DEPTH + I(DEPTH^2), family = gaussian(link = "identity"), data =
TB)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-6.1640  -1.1011   0.1838   1.3699   6.0103
```

```
Coefficients:
                   Estimate Std. Error t value Pr(>|t|)
(Intercept)       1.464e-01  4.650e+00   0.031    0.975
factor(YEAR)1995 -3.833e-01  4.696e-01  -0.816    0.415
factor(YEAR)1996 -5.014e-01  4.700e-01  -1.067    0.286
factor(YEAR)1997 -3.015e-01  4.696e-01  -0.642    0.521
factor(YEAR)1998 -3.830e-01  4.670e-01  -0.820    0.412
factor(YEAR)1999 -5.373e-01  4.723e-01  -1.138    0.256
factor(YEAR)2000 -1.075e-01  4.794e-01  -0.224    0.823
factor(YEAR)2001 -3.300e-01  5.001e-01  -0.660    0.509
factor(YEAR)2002 -4.627e-01  5.284e-01  -0.876    0.381
factor(YEAR)2003 -3.545e-01  5.366e-01  -0.661    0.509
factor(YEAR)2004  2.839e-01  4.525e-01   0.627    0.531
factor(YEAR)2005  5.933e-01  5.197e-01   1.141    0.254
factor(YEAR)2006  8.463e-04  4.072e-01   0.002    0.998
factor(YEAR)2007  4.605e-01  4.055e-01   1.136    0.256
factor(YEAR)2008  2.461e-01  4.160e-01   0.592    0.554
factor(YEAR)2009  2.650e-01  4.020e-01   0.659    0.510
factor(MONTH)6   -8.450e-02  1.977e-01  -0.427    0.669
factor(MONTH)7    4.836e-03  3.716e-01   0.013    0.990
factor(MONTH)8   -1.449e-01  4.866e-01  -0.298    0.766
Latitude          1.227e-01  1.240e-01   0.990    0.322
DEPTH             1.297e-02  1.186e-03  10.944   <2e-16 ***
I(DEPTH^2)       -2.847e-05  1.647e-06 -17.289   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for gaussian family taken to be 4.287302)

    Null deviance: 9458.2  on 1126  degrees of freedom
Residual deviance: 4737.5  on 1105  degrees of freedom
AIC: 4862.6

Number of Fisher Scoring iterations: 2
```

The best model is fit3 although the diagnostic plots are not very good and further models with and without interactions should be fitted.

Compare the model fit vs observed data and plot for 2006 the observed vs predicted mean CPUE

```
pred <- predict(fit3, type="response")

yr <- 2006

par(mfrow=c(1,3))
plot(fit1$model[,1],pred, cex=0.8, xlab="observed", ylab="predicted")

  plot(1,1,type="n",xlim=c(min(TB$Longitude)-0.1,           max(TB$Longitude)+0.1),
ylim=c(min(TB$Latitude)-0.1,        max(TB$Latitude)+0.1),        xlab="Longitude",
ylab="Latitude",  main=paste("observed CPUE",yr,sep=" - "))
  map("worldHires", fill=T, col="black",add=T)
  points(TB$Longitude[TB$YEAR==yr],                      TB$Latitude[TB$YEAR==yr],
cex=3*fit1$model[TB$YEAR==yr,1]/max(fit1$model[TB$YEAR==yr,1]))

  plot(1,1,type="n",xlim=c(min(TB$Longitude)-0.1,           max(TB$Longitude)+0.1),
ylim=c(min(TB$Latitude)-0.1,        max(TB$Latitude)+0.1),        xlab="Longitude",
ylab="Latitude",  main=paste("predicted CPUE",yr,sep=" - "))
  map("worldHires", fill=T, col="black",add=T)
  points(TB$Longitude[TB$YEAR==yr],                      TB$Latitude[TB$YEAR==yr],
cex=3*pred[TB$YEAR==yr]/max(fit1$model[TB$YEAR==yr,1]), col="red")
```

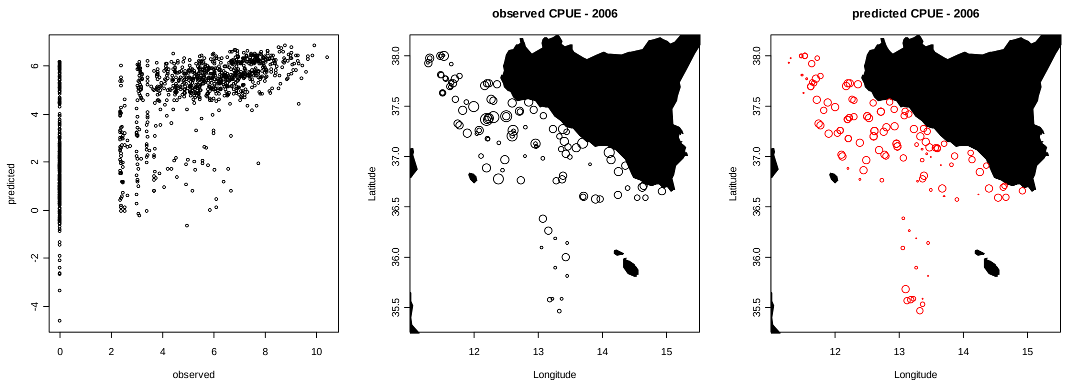

Fig. 5.12. Observed mean CPUE (Numbers per km^2) vs predicted for year 2006 for Hake in GSA 16.

```
yr.ref <- as.numeric(names(which.max(table(TB$YEAR))))
mod.variab <- c("YEAR", "MONTH", "Latitude","DEPTH")
pred.grid <- TB[TB$YEAR==yr.ref,mod.variab]
tmp <- rep(unique(TB$YEAR),rep(dim(pred.grid)[1],length(unique(TB$YEAR))))

for(i in 1:(length(unique(TB$YEAR))-1)){
  pred.grid <- rbind(pred.grid,TB[TB$YEAR==yr.ref,mod.variab])
}
pred.grid$YEAR <- tmp
par(mfrow=c(1,1))

pred <- predict(fit3, pred.grid, type="response", se=TRUE)

obs.yr <- aggregate(fit3$model[,1], list(TB$YEAR), mean)

pred.yr <- aggregate(pred$fit, list(pred.grid$YEAR), mean)
pred.yr.se.up <- aggregate(pred$fit+1.96*pred$se.fit, list(pred.grid$YEAR), mean)
pred.yr.se.lo <- aggregate(pred$fit-1.96*pred$se.fit, list(pred.grid$YEAR), mean)
plot(obs.yr[,1],                          obs.yr$x,                          type="p",
ylim=c(min(pred.yr.se.lo$x),max(pred.yr.se.up$x)), xlab="Year", ylab="mean CPUE")
lines(pred.yr[,1], pred.yr$x, lty=1)
lines(pred.yr.se.up[,1], pred.yr.se.up$x, lty=2)
lines(pred.yr.se.lo[,1], pred.yr.se.lo$x, lty=2)
legend("topleft",   paste(c("observed","predicted","95%   CI")),   pch=c(1,NA,NA),
lty=c(NA,1,2), bty="n", cex=0.8)
```

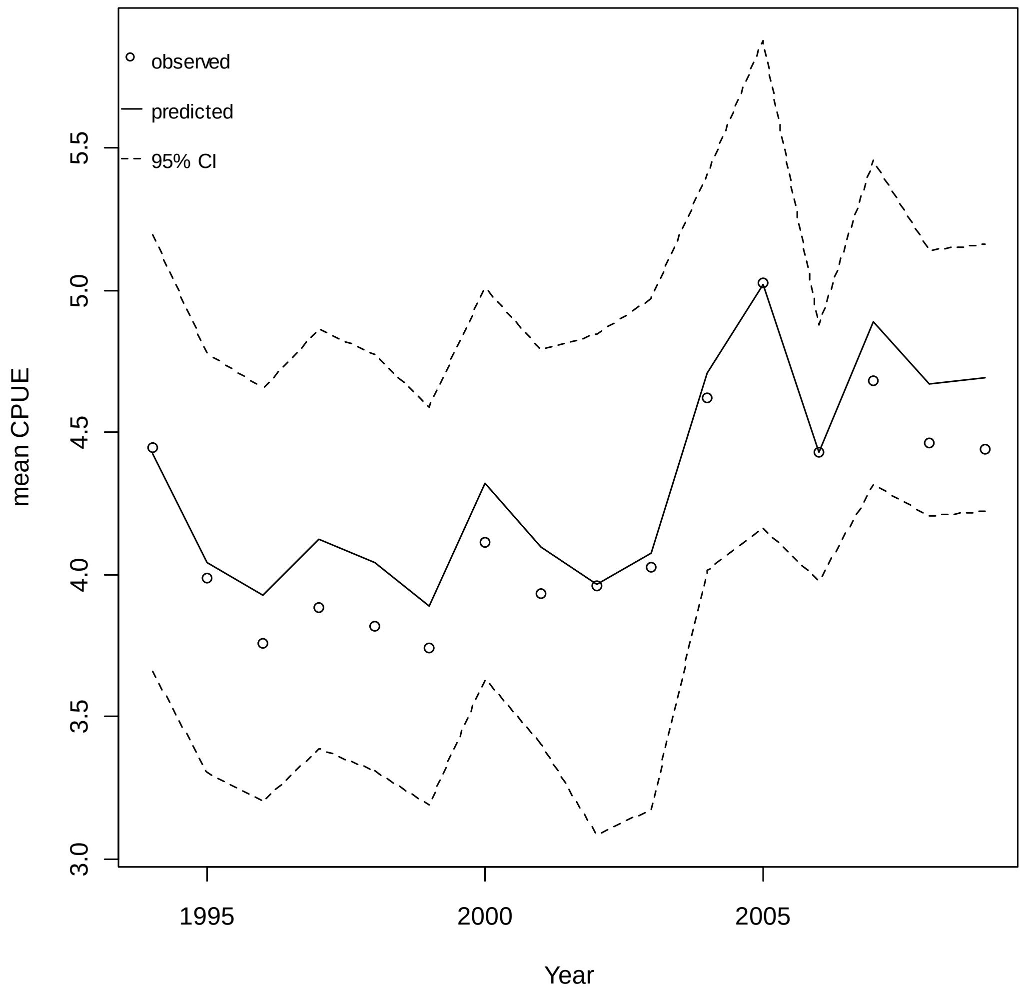

Fig. 5.13. Predicted vs Observed Log of mean annual CPUE using fit 3 for Hake in GSA 16.

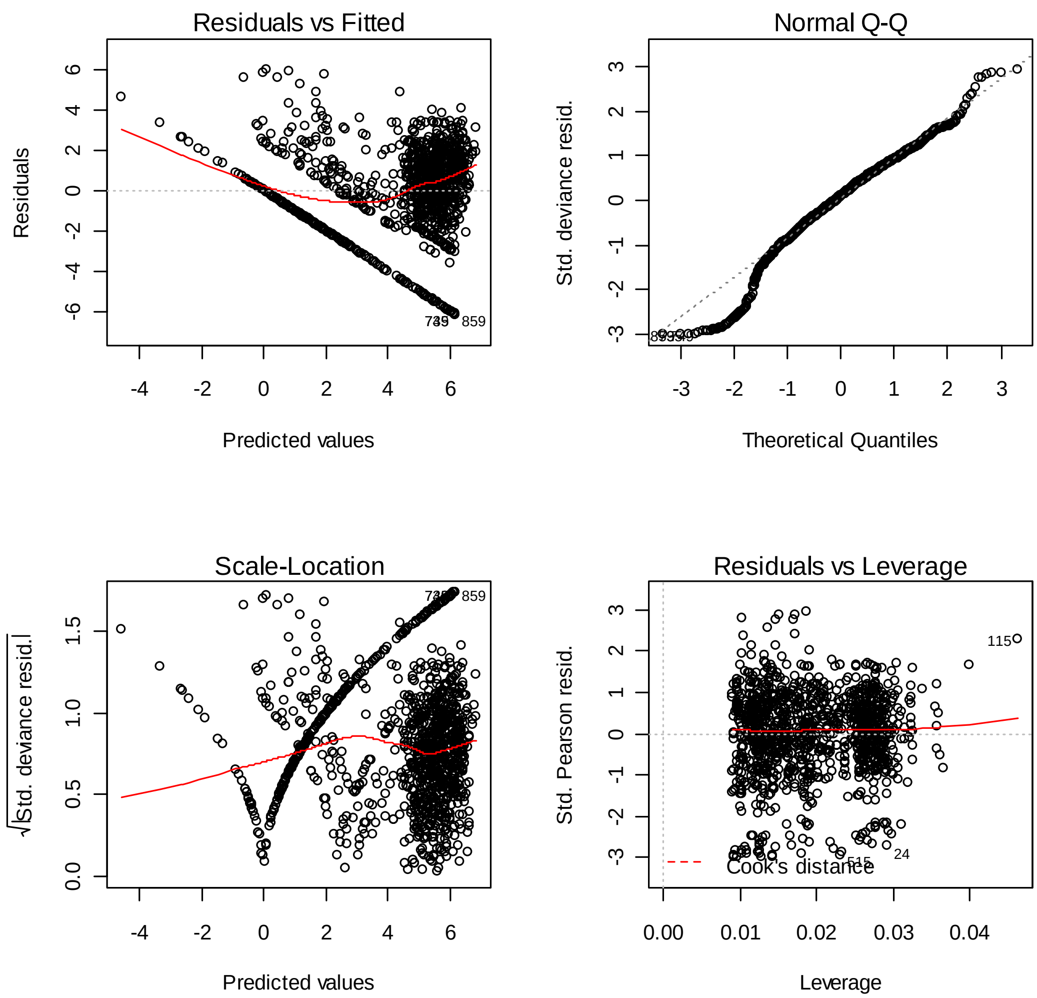

Fig. 5.14 Diagnostic plots for model fit3.

GAM standardization of CPUE of NBTOT/swept for Hake in GSA 16

```
library(mgcv) # need S. Wood library
# works on the appropriate TB file
gaussianfull <- gam(CPUE ~  factor(YEAR) + factor(MONTH) + s(k=5, Latitude) +
s(k=5, DEPTH) , na.action=na.omit, family=gaussian(link="identity"), gamma=1.4,
data=TB)

#gaussian - log
gaussianlogfull <- gam((CPUE+1) ~  factor(YEAR) + factor(MONTH)  + s(k=5,
Latitude) + s(k=5, DEPTH) , na.action=na.omit, family=gaussian(link="log"),
gamma=1.4, data=TB)
#Gamma - log
Gammafull <- gam((CPUE+1.1) ~  factor(YEAR) + factor(MONTH)  + s(k=5, Latitude) +
s(k=5, DEPTH) , na.action=na.omit, family=Gamma(link="log"), gamma=1.4, data=TB)

AIC(gaussianfull, gaussianlogfull, Gammafull) #Gamma full is the best
```

Model	df	AIC
Gaussianfull	26.51315	21336.53
Gaussianlogfull	26.93604	21024.33

Gammafull	27.69641	15390.76

```
# SELECT THE BEST MODEL FROM A SERIES OF CANDIDATE MODELS
# BASED ON THE GENERALIZED CROSS VALIDATION CRITERION (implemented in mgcv() library from S. Wood)
# Here we investigate 9 models, that we think one of them may be
# explaining a great deal of the variance in CPUE (dependent variable)
# g0: Null model (overal mean of CPUE): CPUE ~ 1
# g1: Full model: CPUE~ Year + Month + Latitude + DEPTH
# g2: CPUE~ Year
# g3: CPUE~ Year + Month ### month actually doesn't add much to the deviance explained (in the case of hake GSA16)
# g4: CPUE~ Year + Month + Latitude
# g5: CPUE~ Year + Month + DEPTH
# g6: CPUE ~ Year + Latitude
# g7: CPUE ~ Year + DEPTH
# g8: CPUE ~ Year + Latitude*DEPTH

g0 <- gam((CPUE+1.1) ~ 1 , na.action=na.omit, family=Gamma(link="log"), gamma=1.4, data=TB)
g1 <- Gammafull
g2 <- gam((CPUE+1.1) ~ factor(YEAR), na.action=na.omit, family=Gamma(link="log"), gamma=1.4, data=TB)
g3 <- gam((CPUE+1.1) ~ factor(YEAR)+factor(MONTH), na.action=na.omit, family=Gamma(link="log"), gamma=1.4, data=TB)
g4 <- gam((CPUE+1.1) ~ factor(YEAR)+factor(MONTH)+s(k=5, Latitude), na.action=na.omit, family=Gamma(link="log"), gamma=1.4, data=TB)
g5 <- gam((CPUE+1.1) ~ factor(YEAR)+factor(MONTH)+s(k=5, DEPTH), na.action=na.omit, family=Gamma(link="log"), gamma=1.4, data=TB)
g6 <- gam((CPUE+1.1) ~ factor(YEAR)+s(k=5, Latitude), na.action=na.omit, family=Gamma(link="log"), gamma=1.4, data=TB)
g7 <- gam((CPUE+1.1) ~ factor(YEAR)+s(k=5, DEPTH), na.action=na.omit, family=Gamma(link="log"), gamma=1.4, data=TB)
g8 <- gam((CPUE+1.1) ~ factor(YEAR)+s(k=5, DEPTH, Latitude), na.action=na.omit, family=Gamma(link="log"), gamma=1.4, data=TB)


models <- c("g0-NULL", "g1-FULL", "g2", "g3", "g4", "g5", "g6", "g7", "g8")
aiccs<-as.matrix(as.numeric(c(g0$aic, g1$aic, g2$aic, g3$aic, g4$aic, g5$aic, g6$aic, g7$aic, g8$aic)))
```

model	AIC
g1-FULL	15390.7573620315
g5	15511.9109138375
g7	15514.4658318283
g8	15521.4457928503
g6	15986.1314949778
g4	15990.8002278951
g2	16242.6153421034
g3	16243.4053579137
g0-NULL	16308.4699098672

Model g1 summary table

```
Family: Gamma
Link function: log

Formula:
(CPUE + 1.1) ~ factor(YEAR) + factor(MONTH) + s(k = 5, Latitude) +
```

```
    s(k = 5, DEPTH)

Parametric coefficients:
                 Estimate Std. Error t value Pr(>|t|)    
(Intercept)       5.64145    0.31356  17.992  < 2e-16 ***
factor(YEAR)1995 -0.45256    0.37399  -1.210  0.22649    
factor(YEAR)1996 -0.97028    0.37433  -2.592  0.00966 ** 
factor(YEAR)1997 -0.13876    0.37401  -0.371  0.71070    
factor(YEAR)1998 -0.89191    0.37191  -2.398  0.01663 *  
factor(YEAR)1999 -0.78366    0.37588  -2.085  0.03730 *  
factor(YEAR)2000 -0.52587    0.38132  -1.379  0.16814    
factor(YEAR)2001 -0.94081    0.39752  -2.367  0.01811 *  
factor(YEAR)2002 -1.26435    0.41963  -3.013  0.00264 ** 
factor(YEAR)2003 -0.99588    0.42734  -2.330  0.01996 *  
factor(YEAR)2004 -0.51408    0.35593  -1.444  0.14892    
factor(YEAR)2005  0.02653    0.41465   0.064  0.94899    
factor(YEAR)2006  1.83426    0.31866   5.756 1.10e-08 ***
factor(YEAR)2007 -0.07058    0.32280  -0.219  0.82696    
factor(YEAR)2008 -0.19136    0.33103  -0.578  0.56333    
factor(YEAR)2009 -0.07825    0.31991  -0.245  0.80681    
factor(MONTH)6    0.03233    0.15795   0.205  0.83786    
factor(MONTH)7    0.53621    0.29909   1.793  0.07327 .  
factor(MONTH)8    0.29785    0.39453   0.755  0.45044    
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
              edf Ref.df      F  p-value    
s(Latitude) 3.866  4.366  18.59 6.54e-16 ***
s(DEPTH)    3.831  4.331 205.55  < 2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  -2.68   Deviance explained = 44.5%
GCV score = 2.8323   Scale est. = 2.7174    n = 1182
#g1, the full model is the best, Deviance explained 44.5 %%
```

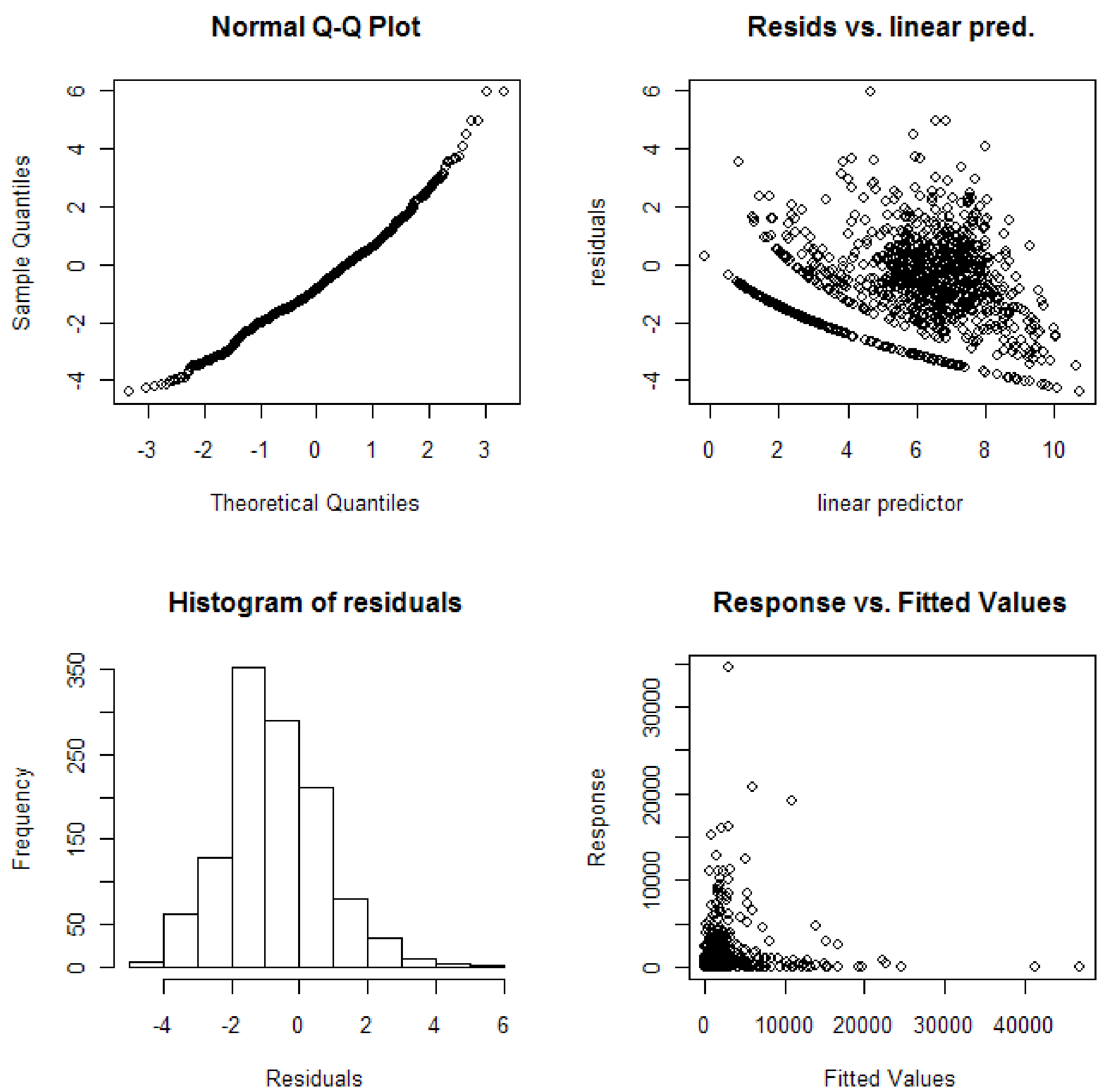

Fig. 5.15. Diagnostic plots for model “g1”.

Build prediction grid and make prediction using best model *g1*

```
yr.ref <- as.numeric(names(which.max(table(TB$YEAR))))
mod.variab <- c("Latitude","DEPTH","YEAR","MONTH")
pred.grid <- TB[TB$YEAR==yr.ref,mod.variab]
tmp <- rep(unique(TB$YEAR),rep(dim(pred.grid)[1],length(unique(TB$YEAR))))

for(i in 1:(length(unique(TB$YEAR))-1)){
  pred.grid <- rbind(pred.grid,TB[TB$YEAR==yr.ref,mod.variab])
}
pred.grid$YEAR <- tmp

pred.gam <- predict(g1, pred.grid, type="response", se=TRUE)
obs.yr <- aggregate(g1$model[,1], list(TB$YEAR), mean)

pred.gam.yr <- aggregate(pred.gam$fit, list(pred.grid$YEAR), mean)
pred.gam.yr.se.up          <-          aggregate(pred.gam$fit+1.96*pred.gam$se.fit,
list(pred.grid$YEAR), mean)
```

```
pred.gam.yr.se.lo         <-         aggregate(pred.gam$fit-1.96*pred.gam$se.fit,
list(pred.grid$YEAR), mean)

plot(obs.yr[,1],   obs.yr[,2],   type="p",     xlab="Year",   ylab="mean   CPUE",
ylim=c(min(pred.gam.yr.se.lo$x),max(pred.gam.yr.se.up$x)))
# g1 (full) best fitting model
lines(pred.gam.yr[,1], pred.gam.yr[,2], lty=1, col='red')
lines(pred.gam.yr.se.up[,1], pred.gam.yr.se.up$x, lty=2, col='red')
lines(pred.gam.yr.se.lo[,1], pred.gam.yr.se.lo$x, lty=2, col='red')

# lines(pred.yr.se.up[,1], pred.yr.se.up$x, lty=2)
# lines(pred.yr.se.lo[,1], pred.yr.se.lo$x, lty=2)
legend("topleft", paste(c("observed", "predicted", "95% CI")), pch=c(1,NA,NA,NA),
lty=c(NA,1,2,2), col=c("black", "red", "red", "red"), bty="n", cex=0.8)
```

The predicted CPUE, figure below, is less variable than the observed CPUE and in 2006 there is likely a problem with duplicate tows.

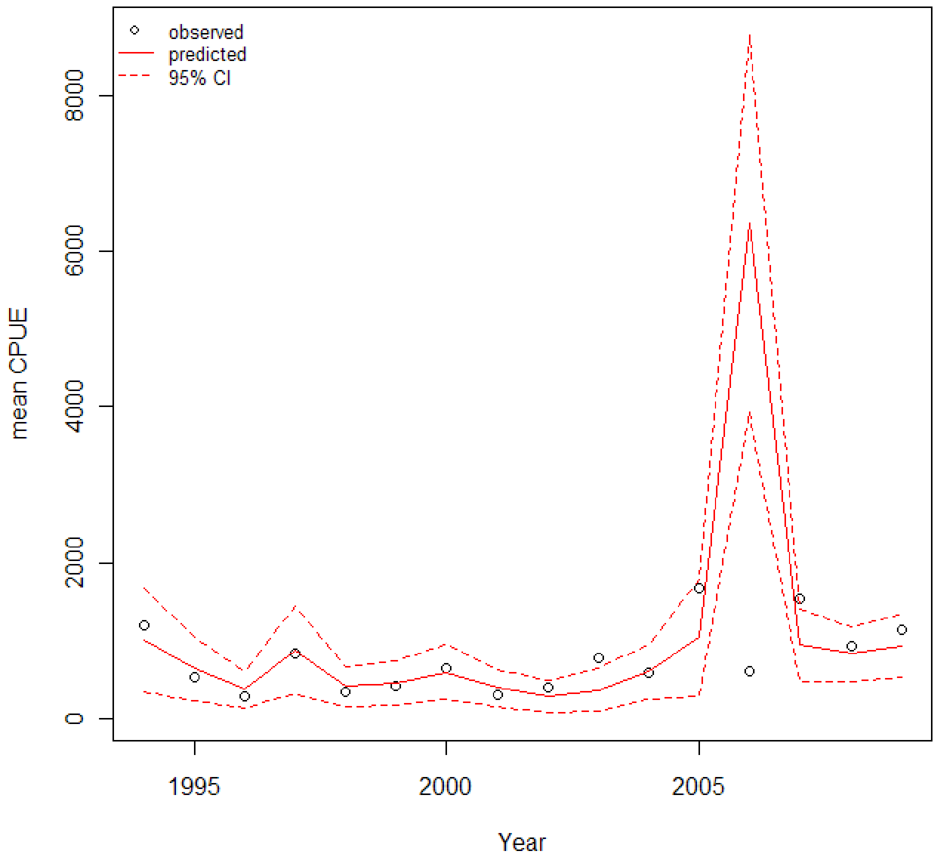

Fig. 5.16. Predicted vs Observed mean annual CPUE (Nb individuals/km^2) of Hake in GSA 16.

GLM/GAM standardization of CPUE Hake GSA01

The variable under analysis is CPUE of hake (Nb of individuals/km^2) for the period 1994-2009, using MEDITS-ES corrected data.

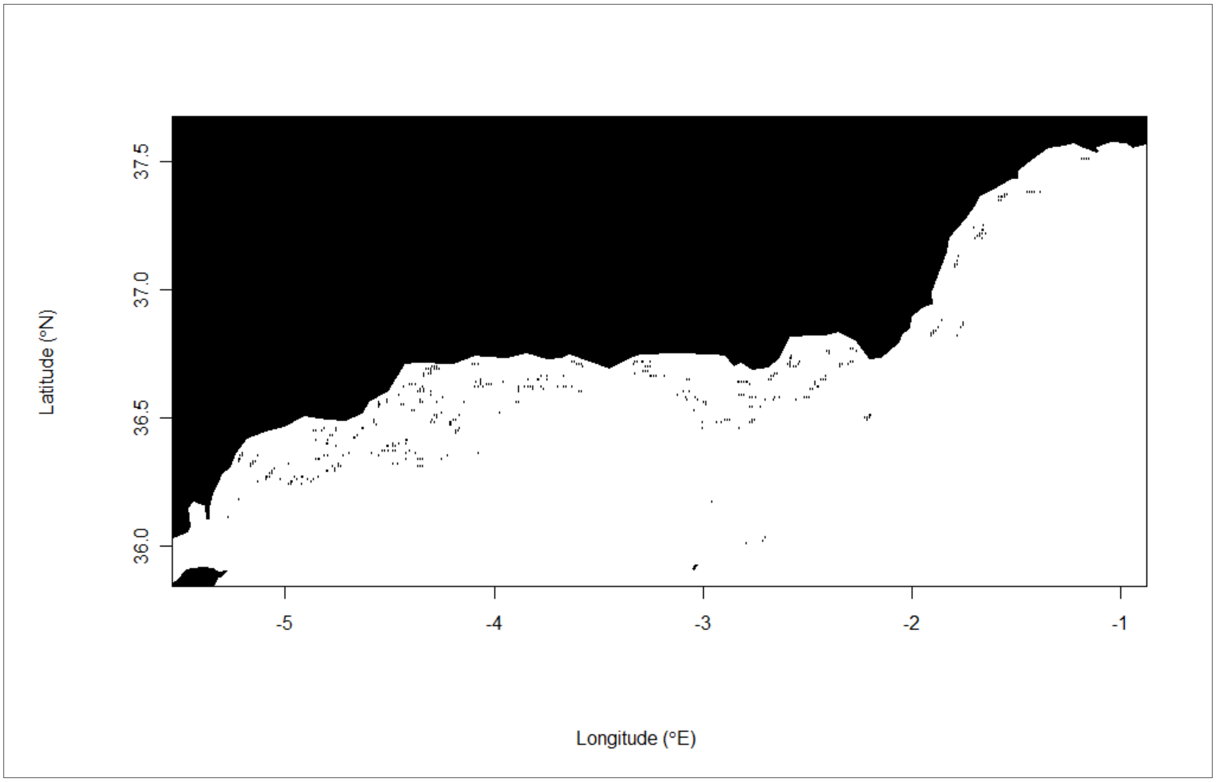

Fig. 5.17. Valid tow positions of MEDITS-ES survey for the period 1994-2008.

Distribution function

To decide the distribution family and link of the data a comparison was made between Null models of CPUE (Nb of individuals/km^2) using log-gaussian or log-gamma distribution functions. This comparison showed that the data (total number of individuals / km^2) are likely to be log-gaussian distributed (AIC null model gamma: 16128.22; AIC null model gaussian 9790.25).

GLM Model selection

Several GLM models, increasingly more complex, were tried and compared against the base or Null model. The two best models are shown in the following table, but it is apparent that even the best model (last row) with a quadratic term has a low explanatory power:

	AIC	% deviance explained
CPUE~1 (Null model)	9790.25	0
CPUE~year+month+latitude+depth	9756.166	11.80%
CPUE~year+month+latitude+depth+depth^2	9611.211	31.72%

The GLM model that would be selected is the 3rd model, in the previous table, which includes a quadratic term on depth. However, this model accounts only for 31.72% of the variance in the data.

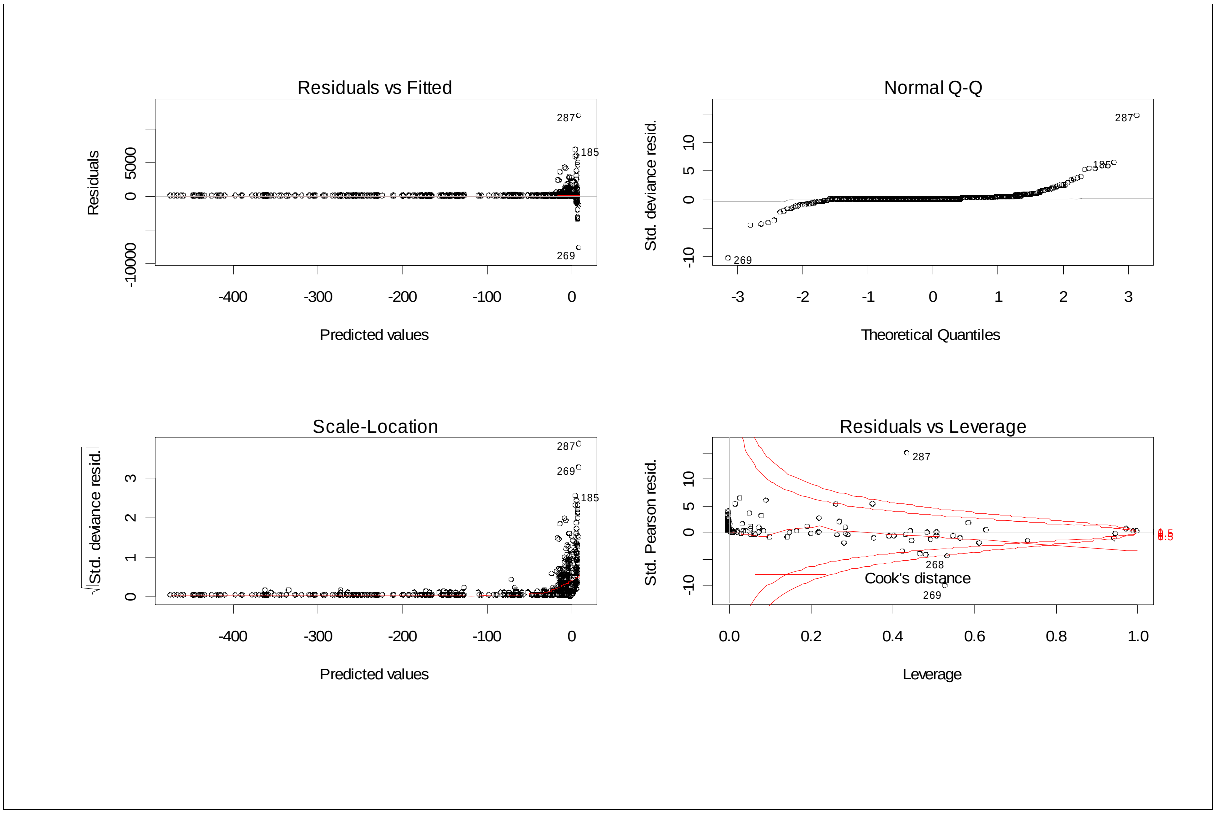

Fig. 5.18. Diagnostic plots of the GLM selected model.

The prediction from the best-fitting GLM model is given in the following figure:

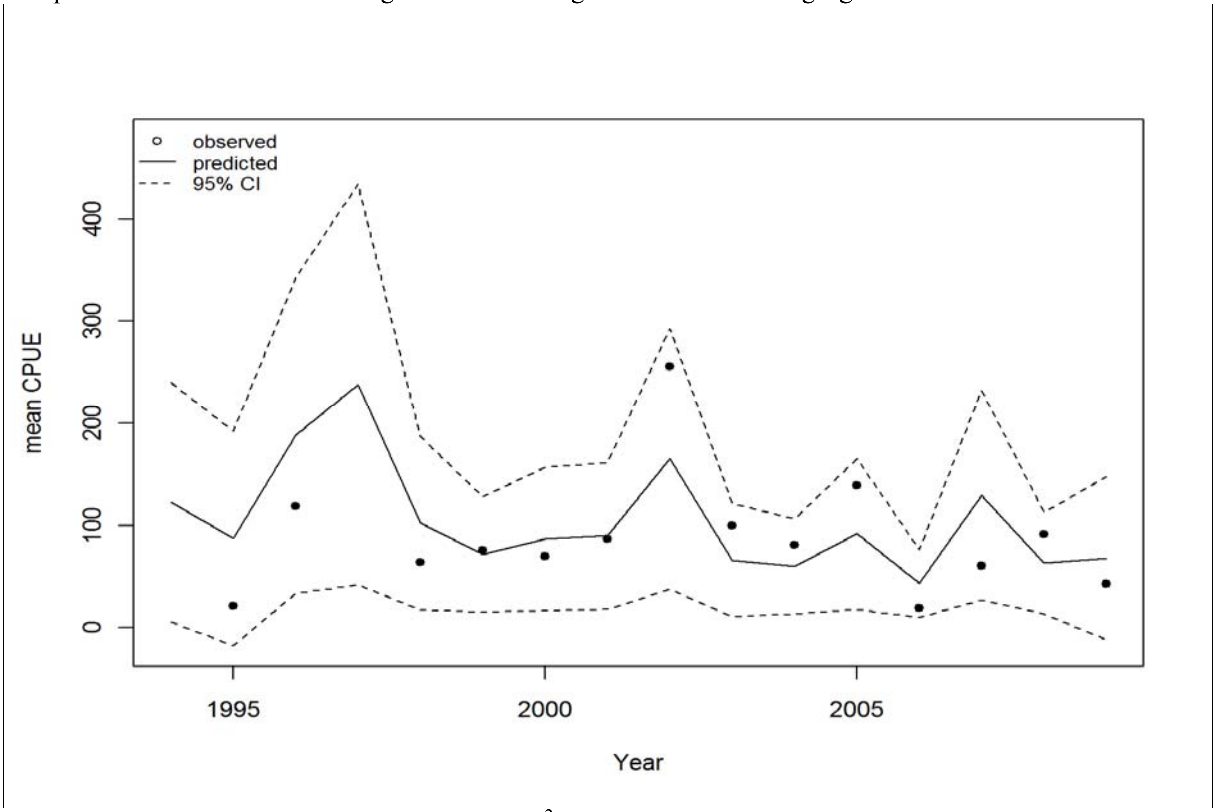

Fig. 5.19. Observed annual mean CPUE (Nb/km^2) of hake in GSA01 (blank circles) and GLM-predicted CPUE with 95% confidence intervals.

GAM Model selection
Several GAM models were fitted to the same data set, with the results of the model selection process given in the following table, ordered by AIC:

	AIC	% deviance explained
CPUE~year+month+s(latitude)+s(depth)	5375.00836252587	62.5%
CPUE~year+month+s(depth)	5429.39053241518	59.5%
CPUE~year+s(depth)	5429.56499725581	59.3%
CPUE~year+s(depth, latitude)	5456.46330905785	57.8%
CPUE~year+month+s(latitude)	5966.53645232316	20.8%
CPUE~year+s(latitude)	5967.5106714001	20.3%
CPUE~year+month	6090.86539305363	7.83%
CPUE~year	6098.52743130981	6.59%
CPUE~1 (Null model)	6128.13560298253	0.%

We observed how all the GAM models that include a non-parametric term for depth (s) have % of deviance explained higher than 50%. The result of the GAM model is more satisfactory than the best GLM, both in terms of AIC and in terms of deviance explained. It is likely that depth is a primary explanatory variable behaving non-linearly in this species and the inclusion of a depth^2 term in the GLM is not sufficient to capture the complex non-linear shape that is easily modelled with a spline of degree 5. The figure of partial residuals of the GAM shows this effect clearly:

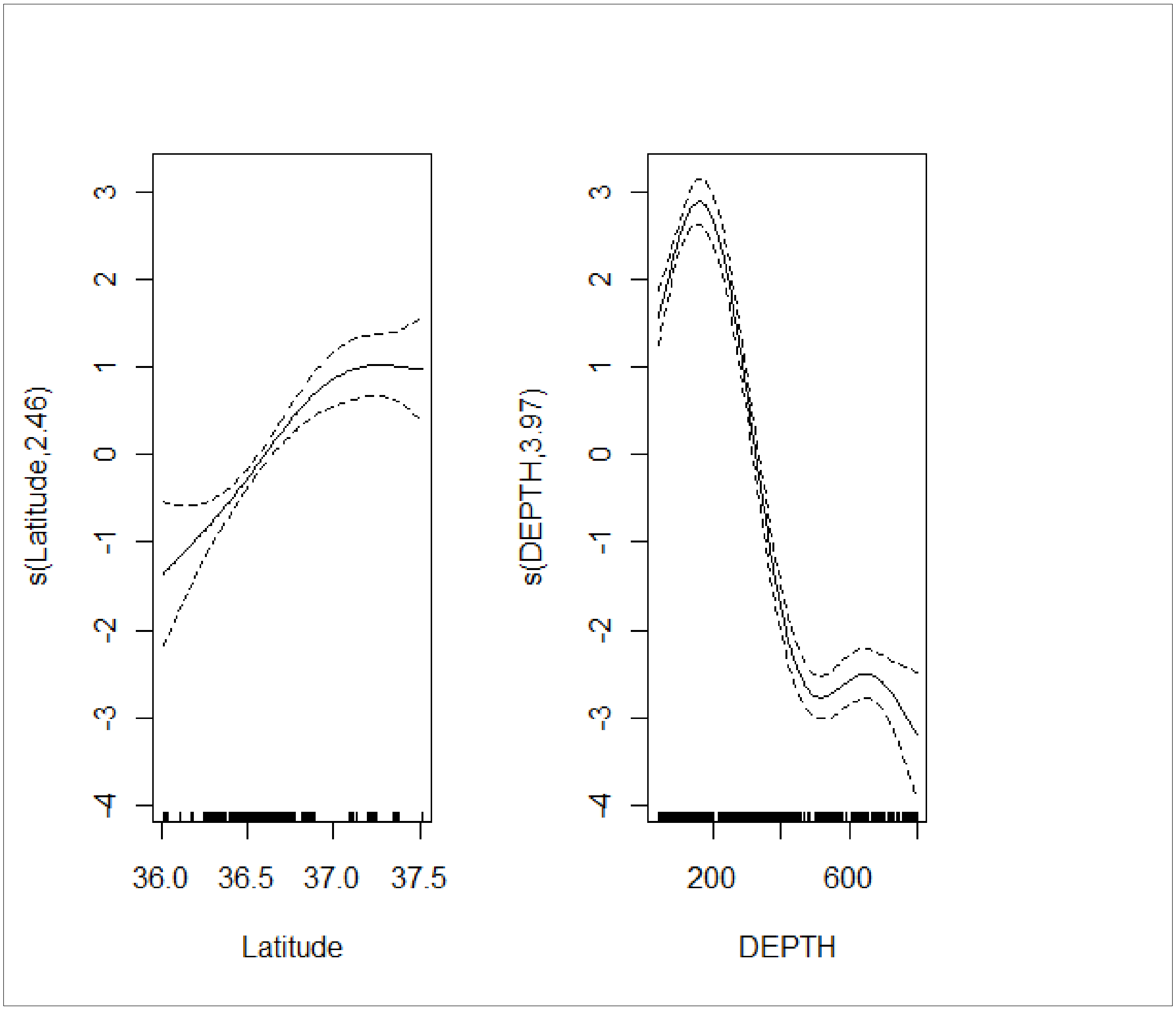

Fig. 5.20. Partial residuals of the non-parametric terms in the selected GAM model for hake in GSA01.

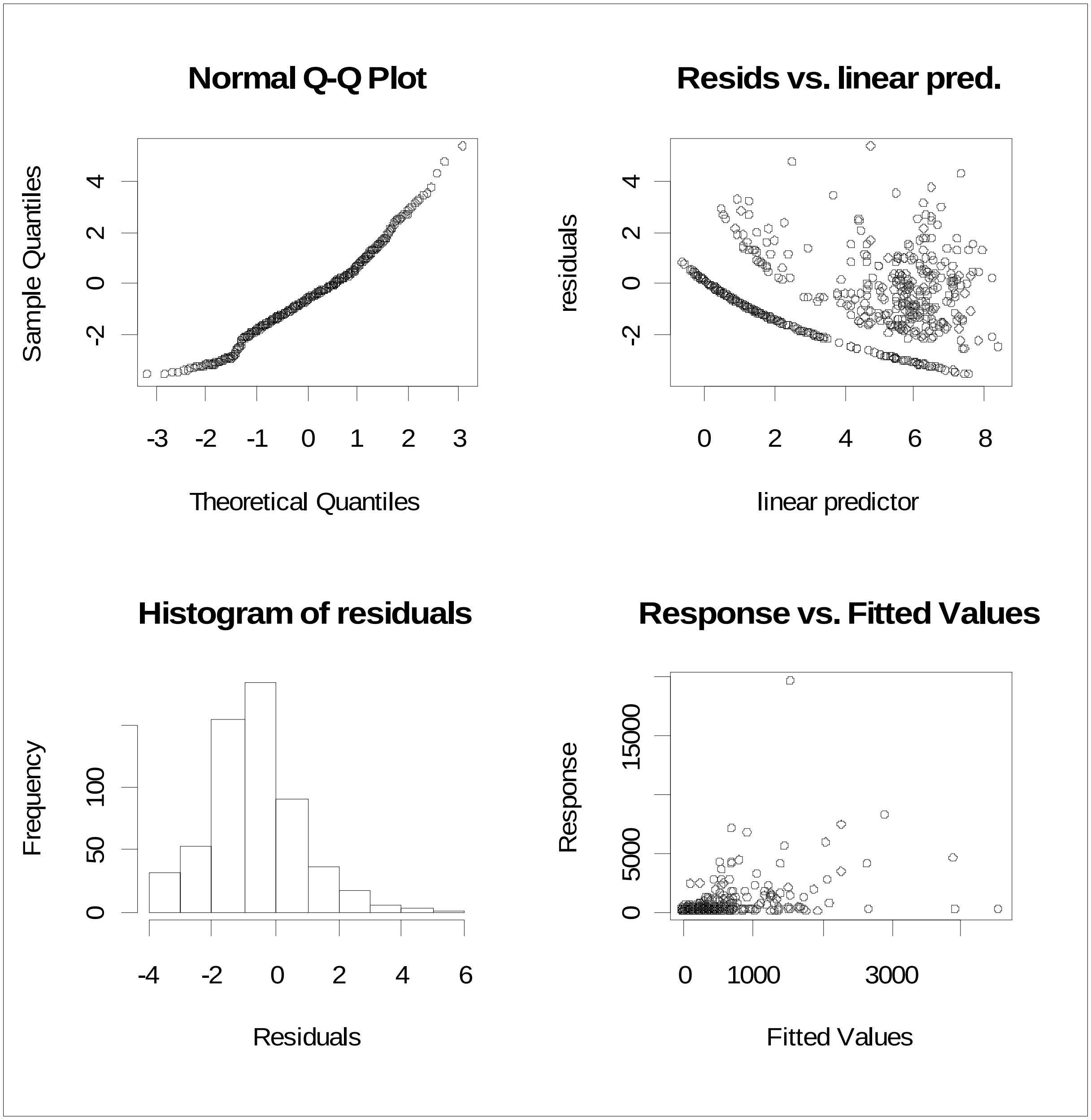

Fig. 5.21. Diagnostic plots of the best-fitting GAM model.

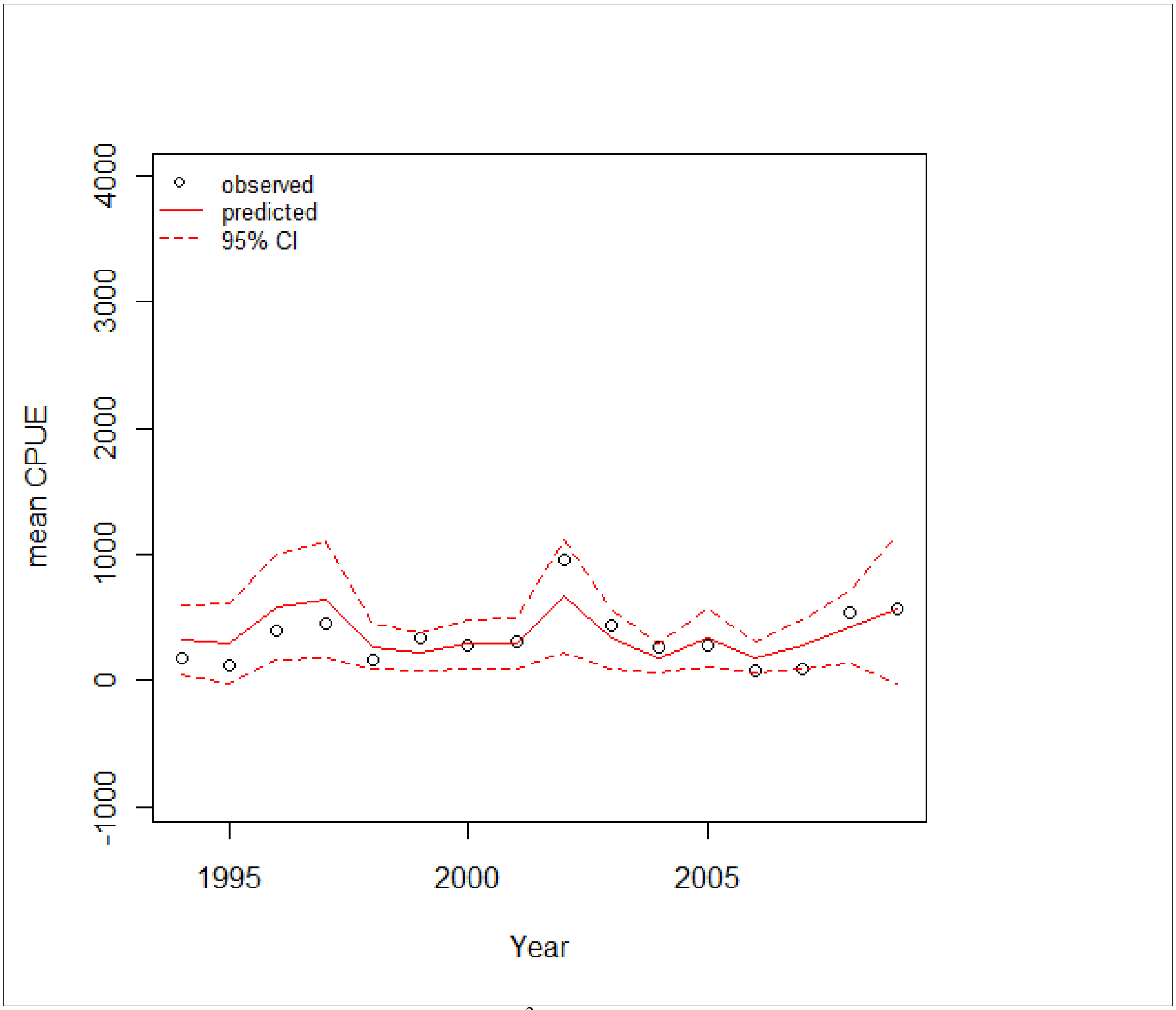

Fig. 5.22. Observed annual mean CPUE (Nb/km^2) of hake in GSA01 (blank circles) and GAM-predicted CPUE with 95% confidence intervals.

GSA 10:CPUE index standardization using GLMs
Data Preparation
After a careful check of the GSA 10 database and implementation of a query in order to obtain the correct dataset, the script "*std_indexMEDITS.r*" was run having selected Hake (MERLMER) in the GSA 10 and defined $CPUE = \frac{Number\_tot}{swept}$.

Data investigation
After the computation of the collinearity coefficients, we decided, for the geography of the area, to use Lat, Long and Depth for the model selection.

Table 5.1. Collinearity coefficients between possible explicative variables for hake in GSA10.

	Longitude	Latitude	DEPTH	YEAR	MONTH	swept
Longitude	1	-0.05975	0.27047	-0.00873	-0.00164	0.220927
Latitude	-0.05975	1	0.007305	-0.00229	0.130147	0.017951
DEPTH	0.27047	0.007305	1	-0.00252	-0.02764	0.840951
YEAR	-0.00873	-0.00229	-0.00252	1	0.254844	0.099098
MONTH	-0.00164	0.130147	-0.02764	0.254844	1	0.015687
swept	0.220927	0.017951	0.840951	0.099098	0.015687	1

GLM model selection

```
fit1 <-glm(CPUE~factor(YEAR)+factor(MONTH)+Longitude*DEPTH+Latitude*DEPTH,
family=gaussian(link="identity"), data=TB)
fit2                                                                              <-
glm(CPUE~factor(YEAR)+factor(MONTH)+Longitude*Latitude+DEPTH+I(DEPTH^2),family=gaussian(link="identity"
), data=TB)
fit3                          <-glm(CPUE~factor(YEAR)+factor(MONTH)+Longitude*Latitude*DEPTH+I(DEPTH^2),
family=gaussian(link="identity"), data=TB)
```

Table 5.2. AIC of three possible models fitting CPUE data for hake in GSA 10

	df	AIC
fit1	26	23506.59
fit2	26	23528.04
fit3	29	23471.71

The best model results to be *fit3*; moreover the explicative variables Latitude, Longitude, Depth and their combinations have a good level of significance (P<α=0.001).
The Residuals versus Fitted plot shows that the residuals spread increases for larger fitted values, indicating heterogeneity.

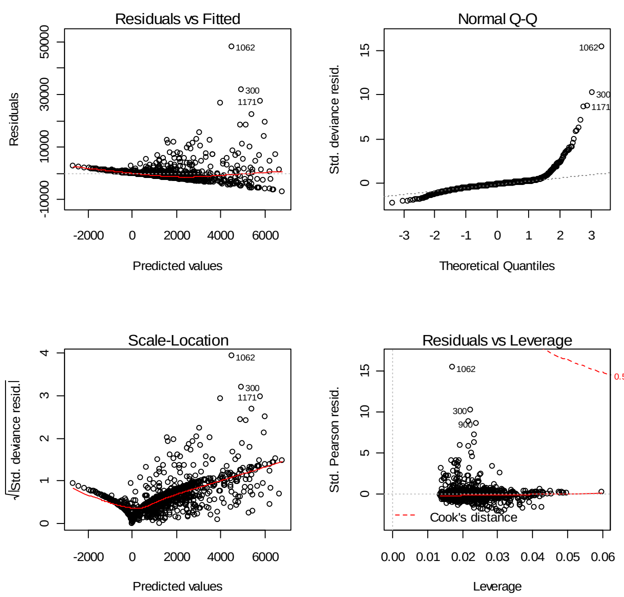

Fig. 5.23. Diagnostic plots for hake in GSA10 for model *fit3*.

Plotting *fit3* we obtain a good fitting of model to the data, although with a very wide CI:

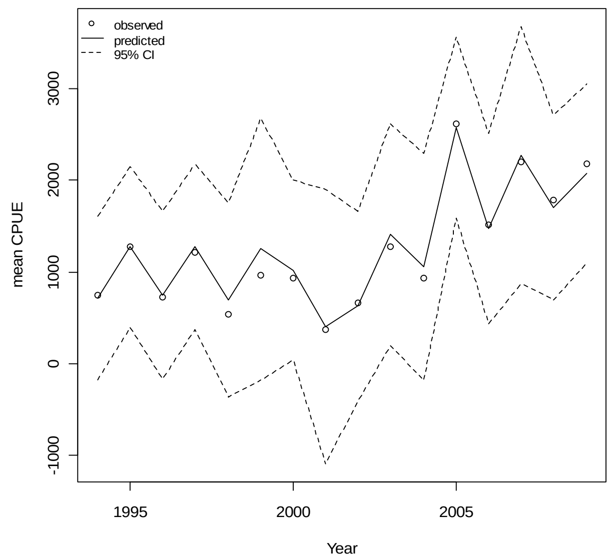

Fig. 5.24. Observed vs Predicted mean annual CPUE of Hake in GSA 10 fitting model *fit3*.

Q-Q plot highlights a non-normal distribution of data. We have thus performed a second exercise using log-transformed data and repeating the analysis for different models:

```
fit1 <-glm(log(CPUE+1)~factor(YEAR)+factor(MONTH)+Longitude*DEPTH+Latitude*DEPTH,
family=gaussian(link="identity"), data=TB)
fit2                                                                                <-
glm(log(CPUE+1)~factor(YEAR)+factor(MONTH)+Longitude*Latitude+DEPTH+I(DEPTH^2),family=gaussian(link="id
entity"), data=TB)
fit3              <-glm(log(CPUE+1)~factor(YEAR)+factor(MONTH)+Longitude*Latitude*DEPTH+I(DEPTH^2),
family=gaussian(link="identity"), data=TB)
AIC(fit1,fit2,fit3)
```

Table 5.3. AIC of three possible models fitting log-transformed CPUE data for hake in GSA 10

Model	df	AIC
fit1	26	5645.367
fit2	26	5236.484
fit3	29	5141.671

Again the best model is *fit3*. Plotting the diagnostic plots, we obtain:

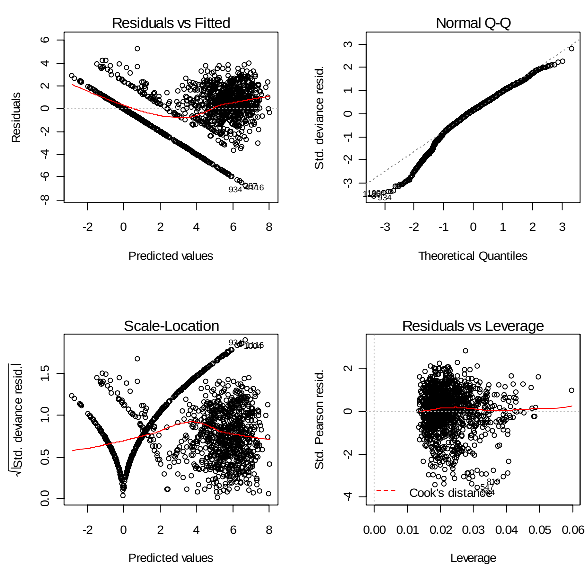

Fig. 5.25. Diagnostic plots for Hake in GSA10 for model *fit3*(log-transformed data).

Now the q-q plot approaches the normal distribution pattern. The fit of model *fit3* on Log scale shows greater differences with the observed data than the non Log *fit3* model. In principle the log transformed model having better diagnostic plots should be a better model, however the diagnostic plots still show spread of the residuals at increasing predicted values. Further models should be tested to see if better fits can be achieved.

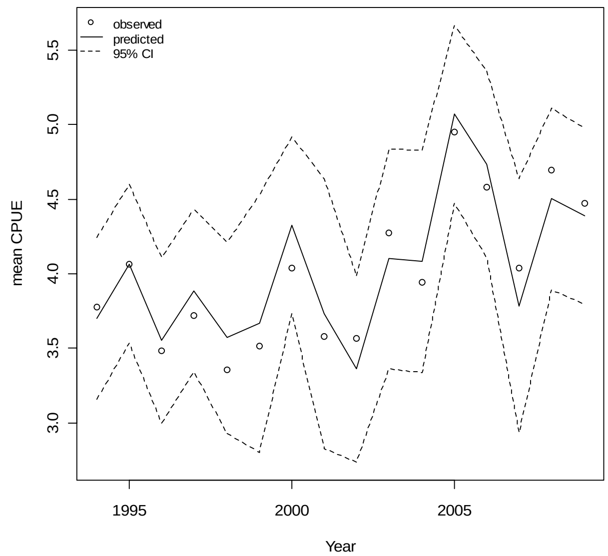

Fig. 5.26. Observed vs Predicted Log mean annual CPUE of hake in GSA 10 fitting model *fit3*(log-transformed data).

Conclusion on MEDITS index standardization

A small subset of models (GLMs and GAMs) was fitted to only two species in four different GSA's using different sources of Medits data and a different demersal survey in the case of Solea in GSA 17 (shown below). In many cases model diagnostics showed heterogeneity, non normality and in addition overdispersion and zero inflation were not investigated. Therefore no general conclusion should be drawn on the advantage of standardizing by fitting regression models. This is a very important matter as it should be understood whether standardization does or not actually change and improves the estimates of the yearly trends in CPUE of Number or Weight of the individuals or of the CPUE of the numbers at age. An in depth assessment on the advantages/disadvantages of standardizing with regression models should be carried out along a cost benefit assessment. CPUE standardization through model fitting and model selection is a time consuming exercise as it needs to be carried out by each species and GSA and eventually even by age class. Additionally the user must have a good statistical understanding of the proposed statistical models. It is therefore advisable, once a MEDITS error free database will be available, to have an ad hoc working group that will perform survey index standardization using GLMs and GAMs and adopting methods that account for zero inflation/truncation (like the Delta method and Zero Inflated Models) (Zuur et al., 2009). Additionally it would be more appropriate to model the catch and/or the cpue using the offset of the swept area given the differences in tow swept area between shallow and deep hauls (Zuur et al., 2009).

2.3 estimate annual trends in stock abundance by length and age. In addition, such scripts should allow the use of GLM/GAM models to standardize the indices against theoretical or estimated statistical distribution patterns and provide diagnostics to assess best performing type of models, link function, family distribution and predictors.

Given time constraints and the errors in the MEDITS database very little time was spent in the standardization of the CPUE by Age classes. Some time was however allocated to this exercize for *Solea* in GSA17 from "rapido" trawl survey Solemon.

The R code was tested on this data set for *Solea solea* in the Adriatic Sea. In this case the focus has been on standardizing the CPUE of the Numbers of each age group (Numbers at Age (1→5+)/swept) using the R script "std_indexMEDITS_byage.r".
The data were loaded and shaped according to the sourced functions ("db.connect.R") and age slicing (by sourcing "length_slicing_final.r") was performed using separate von Bertalanffy growth parameters for males and females and a plus group of 5 :

```
VBparams <- list(M=c(Linf=39.6,K=0.44,t0=-0.46),
                 F=c(Linf=39.6,K=0.44,t0=-0.46))
```

Each age group was modeled separately allowing the retention of the spatial structure of the CPUE as shown in figures below for Age 0 and 1.

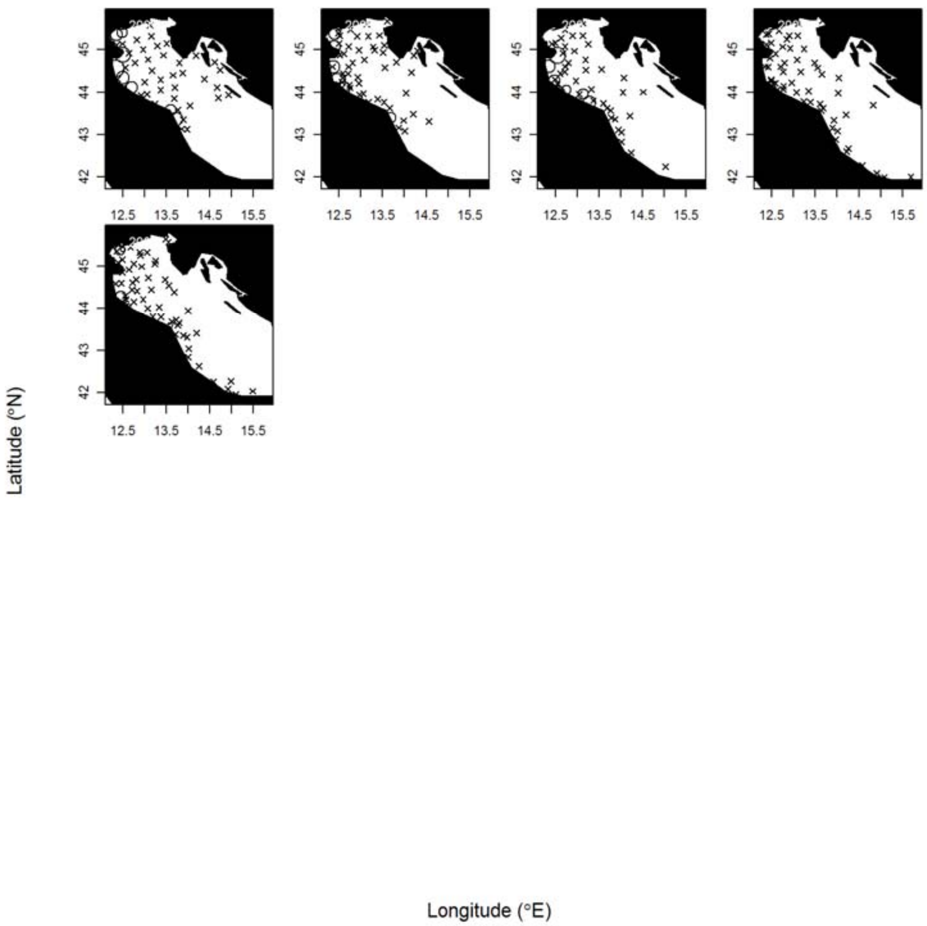

Fig. 5.27. Spatial distribution of the yearly CPUE of Numbers/swept of Age 0 of *Solea* in GSA 17.

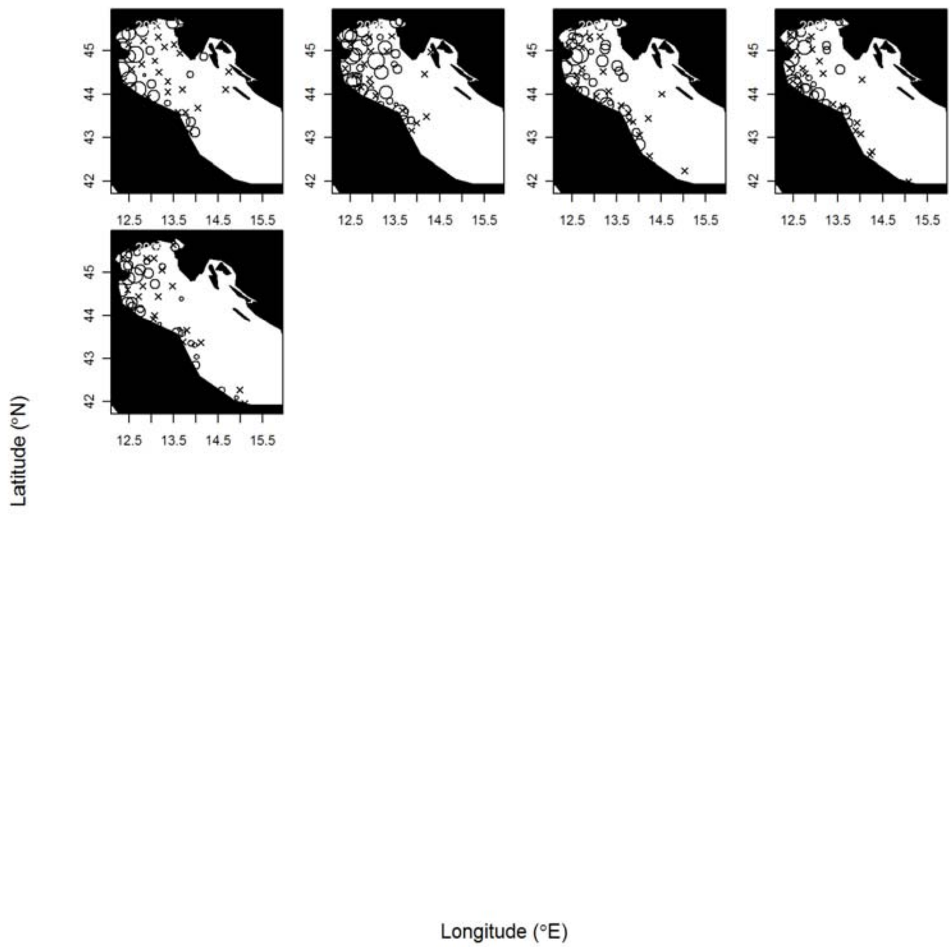

Fig. 5.28. Caption Spatial distribution of the yearly CPUE of Numbers/swept of Age 1 of *Solea* in GSA 17.

The CPUE of each age class was standardized using only one simple Gaussian model for the sake of showing the process. The model is the following and was fitted to both sex combined:

```
# response variable
y <- "CPUE"
TC.age$CPUE <- TC.age$NUM/TC.age$swept
a <- 0 # specify the age class
sex <- "both" # choose between "F", "M" or "both"

# model formulation
mod   <-   glm(CPUE~factor(YEAR)+Latitude+Longitude+DEPTH,   family=   gaussian   ,
data=subdat)
```

The model summary for Age 0 is below and shows large deviance residuals and diagnostics plots that are not satisfactory.

```
Call:
glm(formula = CPUE ~ factor(YEAR) + Latitude + Longitude + DEPTH,
    family = gaussian, data = subdat)

Deviance Residuals:
   Min      1Q  Median      3Q     Max
-20191  -10655   -5567    1631  220649
```

```
Coefficients:
                    Estimate Std. Error t value Pr(>|t|)
(Intercept)        349925.05  139389.07   2.510 0.012561 *
factor(YEAR)2006    -6506.85    4721.66  -1.378 0.169158
factor(YEAR)2007    -4139.42    4924.99  -0.840 0.401272
factor(YEAR)2008    -4994.29    4793.89  -1.042 0.298304
factor(YEAR)2009    -9334.80    4811.50  -1.940 0.053262 .
Latitude            -3937.33    2419.91  -1.627 0.104728
Longitude          -11948.86    3239.49  -3.688 0.000266 ***
DEPTH                -112.89      91.12  -1.239 0.216323
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for gaussian family taken to be 711558188)

    Null deviance: 2.4968e+11  on 321  degrees of freedom
Residual deviance: 2.2343e+11  on 314  degrees of freedom
AIC: 7487

Number of Fisher Scoring iterations: 2
```

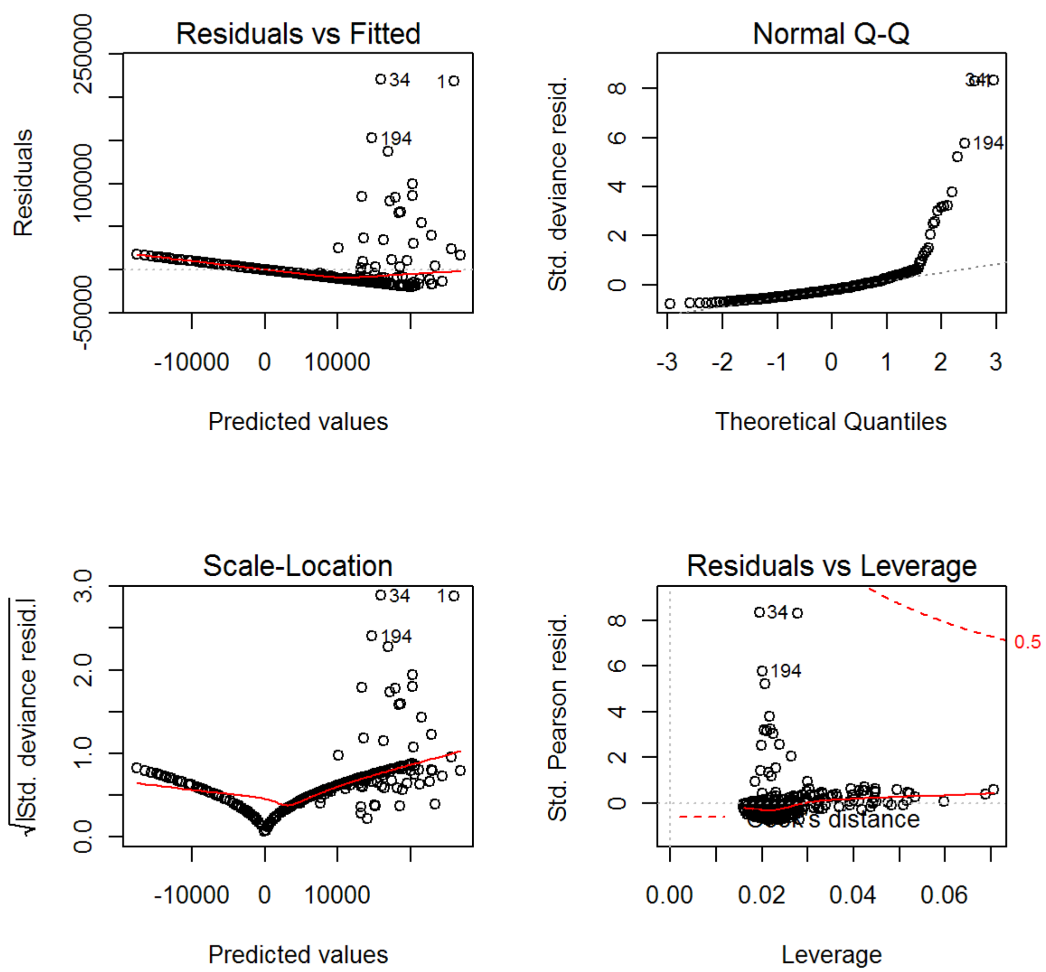

Fig. 5.29. Caption Diagnostic plot for glm model fitted to CPUE of Age 0 of Solea in GSA 17.

The model prediction for the fit of Age 0, although not from a good fitting model, is compared to the observed CPUE as show in figure below.

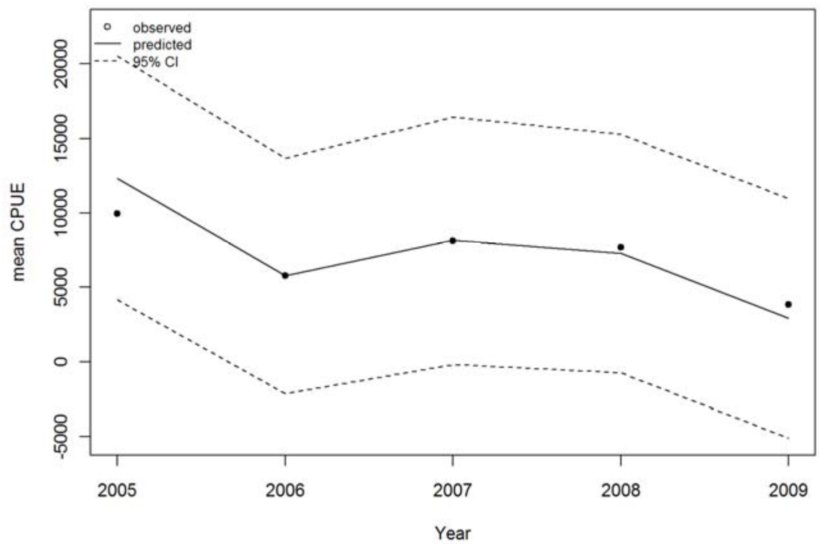

Fig. 5.30. Observed vs Predicted mean annual CPUE for Age 0 of Solea in GSA 17.

To each age class was fitted, in a similar process to Age 0, the same glm model and predictions were made. In all cases such simple model was not fitting well and all the diagnostics and results will not be presented here. However the potential of modeling separate age classes shows great potential if good models could be fitted.

Overall it appears that the percentages of the deviance explained by the models were quite low in all cases, due to the features of the model utilized (for *Solea* also because of the short data series) and the low number of explanatory variables used. A more in depth standardization with more appropriate models will be worthwhile pursuing. It is likely that when higher age classes are modelled the numbers of zeroes will rapidly increase. Therefore it is very likely that there will be cases of zero inflation and over-dispersion that will need to be addressed with the appropriate models.

This task remains very important and should be further tested. The same comments on the index standardization made in TOR 2.2 remain valid as the steps that need to be undertaken are the same.

2.4 transform the estimated indices of abundance by age into the input table formats of SURBA and XSA stock assessment programs.

The R code outputs and saves a file (.csv) containing a table with the observed and predicted number of fish at Age. These data need to be copied and pasted in a SURBA or XSA input file template in order to run either program.
Due to lack of time and problems with MEDITS database, it was not possible to perform comparative SURBA assessments with standardized and non-standardized numbers at age. This remains an important aspect that needs to be investigated in order to assess the benefits and cost of doing the time consuming step of index standardization.

PROPOSED TORs for future meetings

1) Further testing of the R code slicing function, implementation of suggested changes following the meeting. Slicing with this routine should be applied to multiple GSA's and species to verify that it performs correctly across a range of different data types.

2) Test the R code to perform MEDITS survey CPUE index (both on weight and numbers of species in addition to Hake) standardization with GLMs and GAMs and assess if the cost/benefit is positive. In the R script routines to address zero inflation/truncation should be developed (Delta method or other).

3) Perform SURBA assessments with raw numbers at age and standardized numbers at age to assess if there is a positive impact of standardizing and the overall cost/benefit of such procedure.

4) The R code proved useful in importing and handling MEDITS data and it could be an appropriate platform to implement routines to explore different types of fisheries indicators. For example all fisheries state indicators described in TOR 3 can be derived from MEDITS by implementation of specific routines that quickly produce numerical and graphical output. In fact some indicators are already part of the R script developed for TOR 2 like positive area distribution by age class and biomass index. Future work should be made to develop R script that produce the requested fisheries indicators.

6. ToR 3 Development of methodologies for the estimation of empirical indicators of stock status in data poor situations

6.1. Introduction

The sub-group selected a set of empirical indicators of stocks and fisheries considered as the most suitable for catching reliable signals of the status of the stocks. The use of indicators is connected with the difficulty to expand to a significant number of stocks the assessment approaches used for a small number of top-valued better-known species and fisheries.

Garcia and Staples (2000) define a fishery indicator as a variable or pointer for a given criterion, fluctuations of which reveal changes in key attributes linked with sustainability. It is quite common to analyse for such purposes the changes in time of certain indicators of status or pressure. The current situation or the evolution in time of and indicator will hopefully be related to a Reference value in order to define (or to have a better perception of) the status of the stock. In several cases, however, time series are relatively short and represent small contrasting situations. For many stocks, overexploitation precedes the starting of a systematic biological and fisheries data collection and hence there are no available references in abundance or mortality rates characteristic of the conditions of light fishing pressure. In such circumstances, the direction of trends only shows the evolution of the stock (steady state, towards a better or worse situation), but is not very informative regarding the fact if such fishing rate or level of biomass is sustainable.

In the stock assessment processes, the level of uncertainty on the dynamics of the stock life history features, on the used models and parameters, on the determination of the current state of the stock as well as on the possibility that changes in the environment may affect stock productivity is very high. Therefore the need of simple but relevant and robust indicators based on accessible data is emphasised. In fact, all the assessment approaches contain some amount of error or bias. The problem of robustness is related to how to select indicators that allow correct identification of the exploitation status even when implemented according to imprecise or inaccurate stock data. The evaluation of the robustness of each indicator of the stock health is necessary.

One important criterion for choosing suitable indicators is the level of precision with which the indicator can be measured, and its stochastic variability. The group selected a set of indicators considered descriptors of both status and pressure. In the choice, “power” indicators were considered those for which the changes in the measured variable are expected to be greater than the level of uncertainty of a change. When a set of indicators have to be used to provide some perception on the status of the stock, in the case where more than one indicator is considered equally powerful for measuring the same phenomenon, only one of them has to be taken into consideration, in order to avoid redundancy, which produces an excessive weight (influence) of such measured variable in the set.

Table 6.1. Selected Indicators of state and pressure.

State indicators

Characteristic	List of candidate indicators	References	Attribute	Expected effect of increasing fishing (direction of changes)	Main processes affecting indicator	Data source
state	mean length of the stock	ToR	demographic structure	decrease	recruitment, growth, fishing and natural mortality	Scientific surveys (MEDITS/MEDIAS)
state	average maximum length	ToR	demographic structure	decrease	growth, fishing and natural mortality	Scientific surveys (MEDITS/MEDIAS)
state	population abundance lnNi	Rochet et al., 2007	Abundance	decrease	fishing and natural mortality, reproduction, migrations	Scientific surveys (MEDITS/MEDIAS)
state	Percentiles of the population length distribution	Rochet et al., 2007	demographic structure	decrease	recruitment, growth, fishing and natural mortality	Scientific surveys (MEDITS/MEDIAS)
state	Size at maturation of exploited fish species	DCF	demographic structure	decrease	growth, maturation and fishing evolutionary selection	Scientific surveys (MEDITS/MEDIAS) and other seasonal biological sampling
state	mean weight of the stock (biomass/number)	Cotter et al., 2009	Abundance	decrease	fishing and natural mortality, growth and feeding	Scientific surveys (MEDITS/MEDIAS)
state	Condition factors	Cotter et al., 2009	auxiliary (health indicator)	_	feeding, growth, spawning cycle, health status	DCF or other seasonal biological samplings
state	Frequency of occurrence	Ceriola et al., 2008	auxiliary (spatial structure)	_	fishing and natural mortality, environmental changes, migrations	Scientific surveys (MEDITS/MEDIAS)
state	Biomass index	Ceriola et al., 2008	abundance	decrease	fishing and natural mortality, reproduction, migrations, growth and feeding	Scientific surveys (MEDITS/MEDIAS)
state	Recruit index	Ceriola et al., 2008	abundance	decrease	fishing and natural mortality, reproduction, community, environment	Scientific surveys (MEDITS/MEDIAS)
state	Mean body length excluding the recruits	Ceriola et al., 2008	structure	decrease	fishing and natural mortality, growth	Scientific surveys (MEDITS/MEDIAS)
state	Positive area by life stage (recruits and adults)	Woillez et al., 2009	auxiliary (spatial structure)	_	biological factors, spatial occupation, anthropogenic factors	Scientific surveys (MEDITS/MEDIAS)
state	Spreading area (recruits and adults)	Woillez et al., 2009	auxiliary (spatial structure)	_	biological factors, spatial occupation, anthropogenic factors	Scientific surveys (MEDITS/MEDIAS)

Pressure indicators

Characteristic	List of candidate indicators	References	Impact level/measurement resolution	Expected effect of increasing fishing (direction of changes)	Main processes affecting indicator	
Pressure	Z	Gedamke & Hoenig 2006; Sinclair 2001	population	Increase	Fishing mortality, natural mortality	Scientific surveys (MEDITS/MEDIAS),
Pressure	Harvest Ratio	Abella et al.,	population	Increase	population abundance, catch levels	Scientific surveys (MEDITS/MEDIAS), catch data by species (DCF)
Pressure	exploitation rate	Patterson, 1992	population	Increase	Fishing mortality, natural mortality	Scientific surveys (MEDITS/MEDIAS)
Pressure	discard ratio	DCF	population	increase	Fleet Characteristics, gear characteristics, spatial aggregation of population/stages, spatial distribution of effort	discard monitoring program (DCF)
Pressure	Number of vessels	DCF	community	Increase	Fleet Characteristics	DCF (FT_LVL3-LVL5)
Pressure	Number of fishing days	DCF	community	Increase	Fishing activity	DCF (FT_LVL3-LVL5)
Pressure	Landings per vessel	Ceriola et al., 2008	community	decrease	Fishing activity, fishing efficiency	DCF (FT_LVL3-LVL5)
Pressure	Landings per day	Ceriola et al., 2008	community	decrease	Fishing activity, fishing efficiency	DCF (FT_LVL3-LVL5)
Pressure	Catch rate (CPUE)	DCF	community	decrease	number of vessels, no of fishing days, fishing efficiency, resource abundance	DCF (FT_LVL3-LVL5)

6.2. Description of State indicators

6.2.1. Mean length of the stock

The mean length of the stock (L_{bar}) contributes to a simple description of the demographic structure of the population and on its status because is informative on the relative abundance of large and small individuals in the population. The mean length of the stock, however, can be strongly influenced by recruitment and when applied to surveys data their changes need to be interpreted with caution.

6.2.2. Average maximum length

The average maximum length ($\overline{L}_{\max_m}$) is defined as the average maximum length of the length frequency distribution from all the positive hauls for the stock. This indicator thus quantifies the level of depletion of large fish in the stock due to changes in fishing pressure.

6.2.3. Population abundance

It is an index which describes the total abundance of the stock. For the analysis of time series of such variable, it is recommended to proceed with a ln transformation of the population abundance in N/km^2.

6.2.4. Percentiles of the population length distribution

The indicator is the XXth percentile of the population's length frequency distribution (L25, L50, L75,...)

6.2.5. Size at maturation of exploited fish species

According to the DCF, the indicator is the probabilistic maturation reaction norm, i.e. the probability of maturing at size.

6.2.6. Mean weight of the stock (biomass/number)

The mean weight is particularly useful for those species caught in the trawl surveys for which no data on individual size is collected. This rate gives a rough idea of the size demographic composition (if they are on average big or small) and their changes in time are likely linked to changes in fishing pressure.
Mean weight of the stock (WPUE) is the total weight of one (or more) species caught per station on a survey standardised per unit of effort, either trawling hours or distance towed. The latter is likely to produce better standardisation of catches for demersal species. Mean number has been already defined.
It can be computed as: Total weight catches * swept area^{-1} by haul/ Total number * swept area^{-1} by haul

6.2.7. Condition factor

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 (Shulman and Love, 1999).
Overall, it is evident that measuring the physiological condition of exploited fish may be used for assessment (Lloret et al 2009; Young et al., 2006). 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, apart from the Black Sea, fish condition has never been taken into account for stock assessment and management (Lloret et al 2009). Condition of fish can be assessed by a variety of criteria ranging from simple morphometric (weight-length) and physiological (liver and gonad weights) measures to biochemical measures such as lipid or protein content.
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 (but not all) fishery species (see e.g. Bolger and Connolly 1989). These morphometric condition factors are constructed with simple weight and length data. From all morphometric condition factors, **the relative condition index (Kn)** should be selected because, unlike other condition indices (e.g., Fulton's K), it does not assume isometric growth. The relative condition index compares the actual weight to a standard predicted by the weight–length relationship based on the population from which the fish was sampled. The relative condition index Kn for each individual is calculated as:
Kn=100 (W/W′)

where W is the observed fish weight and W′ is the predicted length-specific weight (estimated from the weight–length relationship of all individuals). The use of **eviscerated weights** instead of total weights is preferred, because the latter are not affected by the viscera and gonad weights. Survey as well as commercial weight-length data can be used.

Because in many benthic and demersal fish the main energy reserve is stored in liver, **a liver or hepatosomatic index (HSI)** would measure more accurately the condition of such fish (Shulman and Love, 1999). However, the evaluation of a liver index takes is more time consuming because individuals need to be dissected in order to remove and weigh their livers. Then, for a number of economically important demersal species such as hake, the periodical evaluation of a liver index would be a more reliable measure of its condition than simple morphometric indices. Thus, whenever liver weights are periodically collected (e.g. for hake in some parts of GSA 6 by Spanish MEDITS surveys, which started in 2009), a liver index should be computed along with the condition factor Kn. The HSI should be calculated as:

HSI=100(LW/W)

where LW and W represent liver and eviscerated individual weights respectively.

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 (whatever the index used), or any mean value below a reference level (from literature), particularly during the reproductive period, should be considered (as an auxiliary indicator of stock status).

6.2.8. Frequency of occurrence

The indicator measures the occurrence of a species as % of positive hauls over the total during the survey. It is assumed that the size of the spreading area of a stock is mainly dependent on its abundance.

It can be computed as: Positive hauls * Total hauls^{-1} *100

6.2.9. Biomass index

The indicator measures the total biomass of a species per unit area. It is computed as the Geometric mean 75th percentile

6.2.10. Recruitment index

The indicator measures the number of recruits to the sampling gear per unit area (for the separation of recruits from the population see the paragraph on approach and methods to estimate indicators)

6.2.11. Mean body length excluding the recruits

The indicator measures the average individual length of the population potential within a population area, having removed the recruits.

It can be calculated as the Arithmetic mean, or median.

6.2.12. Positive area by life stage (recruits and adults)

The indicator measures the spatial occupation of the population by population stages (recruits and adults).

The positive area (PA) is estimated as the sum of the areas of influence around samples where there are fish densities > 0 (Woillez et al., 2009).

6.2.13. Spreading area (recruits and adults)

The spreading area (SA) describes how the population is distributed in space as the index of the area occupied by the population taking into account the variations in fish density (Woillez et al. 2007). The spreading area (SA) is estimated as described in Woillez et al. (2009).

6.3. Description of Pressure indicators

6.3.1. Instantaneous total mortality rate Z

Total mortality rate Z defines the rate at with which the stock numbers decline. Under an exponential decay model and using instantaneous rates, it is the simple sum of natural and fishing mortality rates M and F. An increase in Z, if we consider M almost constant, can be imputed to an increase of the fishing pressure. It has been suggested as a robust indicator for exploited populations (Die and Caddy 1997). Two methods were proposed to be used by SGMED for the estimation of Z in data poor situations:

6.3.2. Total mortality rate from survivors

The proposed estimation method for total mortality is based on a simple age-structured population dynamics model. Ages can be used or alternatively pseudo-ages can be obtained by slicing using the von Bertalanffy growth function. The proposed indicator consists of the total mortality for a given age range (age_min to age_max), i.e. the mortality rate of all individuals aged a_min to a_max-1 between years t-1 and t., estimated from the survival rate as proposed by Sinclair (2001). This approach is implemented in R-sufi routines (Rochet et al. 2007; MEDITS indicator proposal, modified). It is necessary to assume that the decrease is real and not an artifact due to different catchabilities by age along the analysed time interval.
A better alternative is the use of SURBA software, but its proper use depends on the availability of long enough time series of trawl surveys which contents size distributions and on the knowledge of catchability at age. The use of SURBA is recommended when such information is available and considered reliable.

6.3.3. Total mortality rates from mean length

The Beverton–Holt length-based mortality estimator has received widespread use primarily due to its applicability in data-limited situations. The mean length of animals that are fully vulnerable to the sampling gear can be used to estimate total mortality from basic growth parameters and a known length at fully capture (l'). This method however requires equilibrium conditions because the mean length of a population will change only gradually after a change in mortality. Gedamke and Hoenig (2006) derived the transitional behavior of the mean length statistic for use in non-equilibrium conditions and proposed a new procedure that allows a series of total mortality rates to be estimated from mean length data representing non-equilibrium conditions in multiple years. The method was implemented in the package SEINE from NOAA (NOAA Fisheries Toolbox NMFS, http://nft.nefsc.noaa.gov/index.html). Is necessary to assume similar availability and vulnerability for the individuals belonging to all the length classes over the L'. Otherwise, Z will be overestimated.

6.3.4. Exploitation rate

The exploitation rate (E) is classically defined as the ratio of fishing mortality rate out of the total mortality rate and represents the fraction of the total removed production due to the fishing activity. In case of data poor situation, having an estimate of natural mortality M, the exploitation rate can be estimated as (Z-M)/Z.

6.3.5. Harvest rate

An index of F can be obtained in the case there is information on total catches of a stock and an index of biomass at sea. This index (Harvest rate H) is assumed proportional to F and its evolution is assumed to express changes in fishing pressure. The value can be lower or higher than 1, depending on the way the index of biomass is expressed.
The data needed for its calculation can be obtained by DCF transversal module and module for biological variables (scientific surveys).

6.3.6. Number of Vessels

The changes in number of vessels per métier, according to level 5 of appendix IV of Commission Decision 949/08, separated also by LOA classes (m) is considered a proxy of fishing effort. In the future, with more detailed data on métiers, it is expected that using aggregation at level 6, such indicator will be more powerful.

6.3.7. Number of Fishing days

The number of fishing days per métier, according to level 5 of appendix IV of Commission Decision 949/08 separated also by LOA classes (m) is considered a more precise indicator of fishing pressure.

6.3.8. Landings per vessel (tonnes)

Average production (weight of landings) by species per vessel by métier, according to level 5 of appendix IV of Commission Decision 949/08 separated also by LOA classes (m) alone can be used as an indicator of fishing pressure only in the case the vessels have maintained unchanged their spatial distribution, target, technology, etc. Information on landings can be combined with other information.

6.3.9. Landings per day (tonnes)

Average production (weight of landings) by species per fishing day, by métier, according to level 5 of appendix IV of Commission Decision 949/08 separated also by LOA classes (m) can be considered as an index of biomass, since in this case activity is included, assuming that fleet behaviour and technology did not substantially change along the studied period.

6.3.10. Discarding rates of commercially exploited species, in weight and numbers

This is an indicator of the rate of discarding of commercially exploited species in relation to total catches. The discarded weight and numbers are expressed as a proportion of the total catch, by species, fishing technique, quarter and year. As the indicator is a ratio it may be calculated with discards and landings data collected on the same trips or with raised data. It is assumed that discard rate of commercial species will increase as the proportion of small-sized individuals in the whole stock at sea increases.

6.3.11. Catch rate (CPUE)

The catch per unit of effort (CPUE) is defined as the total catch by species per unit of effort (number of fishing days and/or number of vessels). The CPUE should be calculated per métier, according to level 5 of appendix IV of Commission Decision 949/08 separated also by LOA classes (m). CPUE is a good indicator of abundance in the case of demersal species and only in the case the fleet target and fishing technology did not change along the study period. It is premature to propose the use of indicators based on CPUE's for artisanal fisheries.

6.4. Approach and methods to estimate indicators

A number of checks are suggested according to Trenkel and Cotter (2009), before estimating indicators:

i) examine the consistency of the survey protocol over the time series (e.g. gear, number of stations and their spatial distribution, sampling period;
ii) the ratio of abundance at age 2 in year $t + 1$ to abundance at age 1 in year t larger than 1 in most years should not occur;
iii) if different survey series do exist and lead to similar time trend estimates, the stock was most likely sampled so that catchability q was constant across length classes;
iv) strong variation of the Global Index of Collocation from year to year for life stages or ages;
v) percentage of tows where the species was present (occurrence) and the quantities that were caught. A limit can be set on the basis of survey characteristics. Based on empirical trials (Trenkel and Cotter, 2009) the exclusion of species with density <5 individuals/km^2 or <10 individuals/km^2 did not change consistently the number of species excluded (from 54 to 69 out of 127).

If all the checks converge to a possible bias diagnosis the analysis should not be continued.

Among the general methodological considerations, it is worth mentioning that the variance of each indicator is generally high and the statistical power for detecting trends is low for indicator series < 10 years (Nicholson & Jennings, 2004). Thus results from short series should be considered with caution.

Standardization and scaling of the indicators, that can be achieved normalising the time series, is useful for inter-indicators and inter-area or ecosystems comparative purposes. In this way a comparison of indicator sensitivity and fishing impacts can be performed.

Regarding the population structure indicators, the means (e.g. length) will be estimated as mean over the number of individuals, while other metrics, such as mean over the number of hauls or the use of geometric mean, instead of arithmetic mean, will be tested if suitable routine is available.

Data source for the estimate of the indicators is reported in table 6.1. In table 6.2 the estimation methods for state indicators are summarised, while those for pressure indicators are in table 6.3.

Table 6.2. Estimation methods for state indicators (data standardized to the square km) (from Rochet et al. 2007; MEDITS-website indicator proposal, modified).

Standardization to the square km

Population indicators	Definition	Required data	Estimator
N_i	population abundance index for species *i*	Catch haul *k* stratum *j* $y_{k,j}$ Swept area $a_{k,j}$ Stratum area A_j	$N_i = \sum_j N_{i,j} = \sum_j A_j \sum_{k=1}^{n_j} y_{k,j} \Big/ \sum_{k=1}^{n_j} a_{k,j}$ $Var(N_i) = \sum_j \frac{A_j^2}{n_j - 1} \sum_{k=1}^{n_j} \left(\frac{y_{k,j}}{a_{k,j}} - \frac{\sum_{k=1}^{n_j} y_{k,j}}{\sum_{k=1}^{n_j} a_{k,j}} \right)^2$
B_i	Biomass index for species *i*	as for indicator N_i	as for indicator N_i
R_i	Abundance index of recruits for species *i*	as for indicator N_i	as for indicator N_i
L_{bar_i}	mean length of the stock	Catch per length class $y_{l,i}$	$L_{bar_i} = \frac{\sum_{l=1}^{L} y_{l,i}\, l}{y_i}$ with $y_i = \sum_{l=1}^{L} y_{l,i}$ $Var[L_{bar_i}] = \left(\frac{\sum_{l=1}^{L} y_{l,i}\, l^2}{y_i} - L_{bar_i}^2 \right) \Big/ y_i$
$L_{q,i}$ $q = 0.95$	Percentile of the population length distribution	Catch per length class $y_{l,i}$	$L_{q,i} = l_{q,i} \left\vert \frac{\sum_{l=1}^{l_q} y_{l,i}}{y_i} = q \right.$ $Var[L_{q,i}] = \frac{q(1-q)}{y_i \left(y_{l_q,i} / y_i \right)^2}$
$\overline{L}_{\max_m}$	Average maximum length in population	Catch per length class $y_{l,i}$ L_{maxm} is the maximum length observed in the haul *m* *M* is the total number of hauls	$\overline{L}_{\max_m} = \frac{\sum_{m=1}^{M} l_{\max_m}}{M}$ $Var[L_{\max_m}] \frac{\sum \left(l_{\max_m} - \overline{L}_{\max_m} \right)^2}{M - 1}$
NRL_{bar_i}	Mean body length excluding the recruits	Catch per length class $y_{l,i}$	As for L_{bar}
Foc	The frequency of occurrence of a given species sp.	Catch haul k stratum j yk,j Catch haul s stratum j ysp,j	$Foc = \frac{\sum_{j=1}^{n} y_{sp,j}}{\sum_{j=1}^{n} y_{k,j}} \cdot 100$

Population indicators	Definition	Required data	Estimator
wpue			B_i / N_i

Table 6.3. Estimation methods for pressure indicators

Indicator	Required information	Model	Estimation method
Z_i	$N_{l,i}(t)$; k_i, L_{∞_i}, *l'= length at fully capture*	$Z = \frac{k(L_\infty - \bar{l})}{\bar{l} - l'}$ with *lbar*= the mean length of animals larger than *l'*.	The non equilibrium approach as implemented in SEINE package
Z_i	$N_{l,i}(t)$, t_{0_i} k_i, L_{∞_i}	$N_a(t) = N_{a-1}(t-1)\ exp(-Z)$ $Z_a = -log(N_a(t)/N_{a-1}(t-1))$ *age = t0 – 1/k log(1 – l/Linf))*	$Z(t) = -\log\left(\sum_{i=a\_\min+1}^{a\_\max} N_i(t) / \sum_{i=a\_\min}^{a\_\max-1} N_i(t-1) \right)$ *Var(Z)* by boostrap According to R-Sufi routine
E	Z, M (point estimate)	(Z-M)/Z.	

6.4.1. Size at maturation of exploited fish species, according to the DCF indications as below reported:

Calculation of indicator: The indicator is the probabilistic maturation reaction norm (i.e. the probability of maturing) and this is derived from the maturity ogive (i.e., the probability of being mature) and from the mean annual growth at age as:

$m(a,l)=(o(a,l)-o(a-1, l-\Delta l(a)))/(1-o(a-1,l-\Delta l(a)))$

where *a* is age, *s* is length, $o(a,l)$ is the maturity ogive, and $\Delta l(a)$ is the length gained from age *a*-1 to *a*. Estimation of the probabilistic maturation reaction norm thus requires (i) estimation of maturity ogives, (ii) estimation of growth rates (from length at age), (iii) estimation of the probabilities of maturing, and (iv) estimation of confidence intervals around the obtained maturation probabilities (see STECF_SGRN 06-01 report for further details).

6.4.2. Identification of Recruits:

Young-of-the-year (YOY), corresponding to individuals in their first year of life, are identified by splitting standardised Length Frequency Distributions (LFDs, combined sexes) into components. Preferably analyses should be performed separately for each survey to take into account interannual variability and hence avoid the use of a fixed cut-off length. The analysis of LFDs according to e.g. Bhattacharya method (1967) estimates the main statistical parameters (mean, standard deviation and number of individuals) of each normal component. Young-of-the year are defined as those individuals belonging to the smallest component in LFDs and their density indices by haul for each survey is calculated as the number of individuals with length below the mean of the first normal component+ 1 standard deviation.

If VBGF parameters are available, YOY will be estimated by age slicing (preferably by SGMED R ad hoc procedures) as individuals by hauls belonging to the age group 0+.

In the case age 0 group is not fully recruited to sampling, an index of **juveniles** by hauls will be estimated as number of individuals with length below the mean length + 1 standard deviation of immature stage or below to the length at 50% of maturity.

6.5. Reference points derived from indicators

The problem of indicators is the predictive capability of the approaches based on them and the difficulties of implementation of management measures. This is because the likely consequences of any change in fishing pressure on the value of the indicator itself cannot be easily quantified. Looking at the evolution of an indicator through time, even in the case a robust and efficient indicator is used, the only conclusion we are able to derive is that the situation of some key attribute linked with stocks health is getting worse or inversely that it is improving. The main difficulty found is how to define an acceptable limit of deterioration or the level we want to reach. In some cases, it is possible to define, through the analysis of the data series some reference values that allow to assess, even though approximately, the exploitation status, by comparing such reference value with the current situation or with its evolution. There have been proposed some RPs based on mortality as well as on stock and related recruitment that can be considered as candidates for performing such preliminary stock assessments in data poor conditions. The methods have been published in peer reviewed journals, tested in experts groups, and some of them adopted in some countries for giving advice for stocks in data shortage situations.

Table 6.4 Reference points derived from indicators.

Characteristic	List of candidate indicators	Reference Point/reference level/trend	Methods
state	mean length of the stock		
state	average maximum length		
state	population abundance lnNi		
state	Percentiles of the population length distribution		
state	Size at maturation of exploited fish species		
state	mean weight of the stock (biomass/number)		
state	Condition factors		
state	Frequency of occurrence		
state	Biomass index	Limit values of B or F for recruitment overfishing if couples of SSB and R are available	ICES B_{pa}, B_{crash} or Sissenwine & Shepherd (1987) F_{med}, F_{rep}, F_{crash} or equivalent RPs expressed as Z
state	Recruit index		
state	Mean body length excluding the recruits		
state	Positive area by life stage (recruits and adults)		
state	Spreading area (recruits and adults)		
Pressure	Z	Several RPs based in Z can be derived: Z* Z_{MBP}; Z_{MSY}	Z*Die & Caddy (1997) Z_{MBP}, Z_{MSY} using trawl surveys or commercial catches Caddy & Csirke (1983)
Pressure	Harvest Ratio (H)	RP based on replacement	Sustainable value for H
Pressure	exploitation rate	E=0.4 for small pelagics	Patterson (1992)

Characteristic	List of candidate indicators	Reference Point/reference level/trend	Methods
Pressure	discard ratio		
Pressure	Number of vessels		
Pressure	Number of fishing days		
Pressure	Landings per vessel		
Pressure	Landings per day		
Pressure	Catch rate (CPUE)		

CD*=cumulative distribution

6.5.1. Reference Points based on Spawners Stock and Recruits

Serebryakov (1991) suggested a non-parametric method for estimating a threshold biomass. This threshold is defined by the intersection of the upper 90th percentile of the observed survival ratio and the upper 90th percentile of the observations of recruitment. Unfortunately, the method is extremely sensitive to the range of the data observed with the threshold tending to be underestimated.

Two percentiles have been used as reference points for overfishing thresholds based on estimates on spawning stock and recruits, namely the 90th percentile denoted as F_{high}; (Shepherd 1982) and the median denoted as F_{med} (Sissenwine and Shepherd, 1987). Both are considered indicators of *recruitment overfishing*. The tangent at the origin of a S/R relationship corresponds to $F_{extinction}$.

It is considered that F_{high} may overestimate the tangent because highest survival ratios may reflect particularly favorable environmental conditions. F_{med} may underestimate the slope if the data exhibit compensation (concavity). It is advisable to use F_{med} as an estimate of F_{rep} (F-replacement), defined as the fishing mortality rate corresponding to the observed average survival ratio. F_{rep} is the fishing mortality rate that, on average, allows for replacement of successive generations over the observed range of stock and recruitment data. When the observations only regard low stock sizes or when there is little compensation in the relationship, F_{rep} is a valid approximation of the slope at the origin. F_{med} (ICES, 1984, 1985; Sissenwine and Shepherd, 1987) allows the identification of the level of mortality (fishing or total mortality Z, according to the available information) that should guarantee adequate and sustainable yields. Z_{med} is considered a limit reference point that corresponds to the line representing an average survival, S/R=1, at which stock replaces itself. At this level of Z, recruitment overbalances, in about half of the years, the losses due to mortality. If fishing is maintained at the Z_{med} rate, it is assumed that the stock will be sustained.

Warnings: Zmed estimate may correspond to non sustainable F levels when data used in the computations refer only to situations of high fishing pressure. Its use is limited to stocks for which information on spawners and recruits regard situations of low and high exerted fishing pressure.

6.5.2. Reference Points based on Catch and Biomass

An Index Method (AIM) (Rago, 2008) allows the user to fit a relationship between time series of relative stock abundance indices and catch data. Underlying the methodology is a linear model of population growth, which characterizes the population response to varying levels of fishing mortality. If the underlying model is valid, AIM can be used to estimate the level of relative fishing mortality at which the population is likely to be stable. The index methodology can be used to construct reference points based on relative abundance indices and catches and to perform deterministic or stochastic projections to achieve a target stock size.

This index-based approach was developed for greater utilization of the data sets from the surveys and historical landings. The method is based on linear population models, modern graphical methods, and robust statistical models. From data in abundance and fishing mortality, deducible from a time series of **catch and survey indices**, relative fishing mortality rate can be defined as the ratio of catch to survey index. The AIM calculates two derived quantities, namely **Replacement Ratio** and **Relative F**.

Warnings: The theoretical basis suggests that it may be a useful proxy for F_{MSY}, only when the data used in its estimation include information from a period when the stock was fluctuating around B_{MSY}.

Ref: AIM was developed by Dr. Paul Rago at the NMFS Northeast Fisheries Science Center

Software: NOAA Fisheries Toolbox. An Index Method (AIM) Version 2.1.

6.5.3. Reference Point Z_{MSY}. Biomass Dynamic Model derived from trawl surveys

A series of data of estimates of biomass indices and total mortality rates can be used for fitting a non-equilibrium version of surplus production model. Biomass and total mortality estimates time series can be derived from trawl surveys. With this approach **the parameters of the population growth model *r* and *K* can be estimated**. The problem of the lacking of information on catch per year included in the equation is solved by substituting *C* by the Baranov catch equation.

Annual indexes of biomass and total mortality rates can be derived exclusively from trawl surveys. Data on catch per tow allows estimating indexes of biomass or of abundance using the swept area method (Alverson & Pereira, 1969) and total mortality rates through the analysis of the reconstructed demographic structure of the stock in each area. The approach needs an estimate of the annual natural mortality rate.

The approach can be based for example on the modified Schaefer logistic equation of population growth (Walters and Hilborn, 1976):

$$B_{t+1} = B_t + rB_t(1-(B_t / k)) - qf_tB_t$$

If information on q and fishing effort is not available, the above equation can be written as follows:

$$B_{t+1} = B_t + rB_t(1-(B_t / k)) - Y_t$$

and catch in weight (Y_t) substituted by the classic Baranov (1918) catch equation corrected in weight:

$$B_{t+1} = B_t + rB_t(1-(B_t / k)) – (F/Z)\ N(1-exp(-Zt)\ )(W_{t+1}/W_t)$$

Warnings: the method furnish more reliable results as major is the contrast regarding fishing mortality rates and relative status of the stock along the time series.

6.5.4. Z_{MBP} with composite models

Composite models (Munro, 1980) use spatial information proceeding from ecologically similar sub-areas exploited at different rates but for which similar pristine productivity and evolution under changes in fishing pressure are assumed. The change from a time to space-based data set allows the utilization of production models even when long data series on catch and effort are not available. The model can be used with commercial data and allows estimating MSY and f_{MSY}. If only trawl surveys data are used, a combination of a Composite Model with the Caddy and Csirke (1983) variant of Surplus Production models that use the instantaneous total mortality rate Z as a direct index of effort, and a catch rate (kg/h) or index of biomass (Kg/unit area) as abundance index can be used. In this case, the approach allows calculating the situation of each single stock relative to Z at Maximum Biological Production (Z_{MBP}). Maximum Biological Production (MBP) (Caddy and Csirke, 1983) includes both, the production removed by the fishing activity and biomass losses due to natural causes. According to Hilborn and Walters, (1992), the only types of equilibrium surplus production analyses that appear to be useful are those that involve spatial contrast in fishing effort. Within each area it is possible to use average values derived from 2 or 3 points in order to approximate to equilibrium.

As noted by Die and Caddy (1997) the Z_{MBP} reference point can be considered precautionary. It corresponds to a slightly lower exploitation rate than the one corresponding to Z_{MSY}. It is potentially useful for the Mediterranean, considering that on their narrow continental shelves, most of the times contained within the national waters, fish resources are exclusively exploited by local fleets. When the species do not show important migratory movements, the fleets operating in this specific area are the main responsible of the local changes in demographic structure and size of the stocks. Such changes not necessarily are automatically transmitted to neighbouring areas and hence the status in each area is mainly the result of the impact of the local fishing pressure. The availability of information on fishing pressure and abundance in areas exploited with different rates can be considered equivalent to the information derived from a long time series in a single area. The shortage of data series and the lacking of enough contrast in many Mediterranean data bases make impossible the use of traditional production models, while this variant can be used in alternative if only few years of data are available for each area. Moreover, the use of such approach may increase the informative value of the data when the analysed areas are exploited at different rates.

Warnings: it is necessary to assume that the areas included in the analysis are ecologically similar (productivity, ecosystem response to fishing) and hence, the current rates of mortality and biomass levels (and their evolution) are mainly conditioned by local changes in fishing pressure.

6.5.5. Reference Point Z*

Die and Caddy (1997) defined a reference point Z*, aimed at a rough assessment of the likely effects of fishing on the spawning stock and successive future recruitment. This approach is based on the classical Beverton and Holt (1957) equation that allows the estimation of Z if the size of first capture L_C, the average length of the entire catch $\bar{L}$ and the von Bertalanffy growth parameters K and L_∞ are supplied. For the utilisation of this index, the knowledge of the size at first maturity, L_m is needed. The basic idea is that when the mean size in the catch is longer than the size at first maturity, on average, an individual fish has spawned at least once before it was caught.

Based on the Beverton & Holt (1957) equation:

$$Z = \frac{(L_\infty - \bar{L})K}{(\bar{L} - L_c)}$$

By incorporating the inequality $\bar{L} < L_c$ and by substituting L_c by L_m, the following inequality that furnishes an upper limit reference point based on Z, is obtained:

$$Z^* < \frac{(L_\infty - L_m)K}{(L_m - L_c)}$$

Warnings: the approach does not work properly for short-lived species, especially for those with an early age of first capture.

6.5.6. Exploitation rate

It is possible to define F-based RPs in terms of the natural mortality rates characteristic of a stock, considered the pristine level of risk that the stock is faced to. Gulland (1971) proposed that M should be approximately equal to M at MSY. Assuming a logistic model, MSY will be:

*MSY = 0.5*M*B0*

Such equation (and in particular the proposed proportion of M (P=0.5) has been questioned by several authors. It is considered very optimistic as a general rule that MSY is reached when F is almost equal to M, especially for short-lived animals. It was suggested that P should be lower for short-lived species. Patterson (1992) proposed as more appropriate for small pelagics a value of P = 0.4 (FMSY = 0.4M).
After stating that objective data on this point are difficult to find, Caddy and Mahon (1998) proposed an alternative solution assuming that P declines linearly with M, and hence F limit value (Flim) will be much smaller to M for short-lived species than for long-lived ones. Caddy postulated a linear decline in P with natural mortality rate between extreme values. The proposed empirical relationship will be:
Flim = 0.981M-0.194M2

Table 6.5.6.1. Estimated proportion of M for different natural mortality rates and corresponding Flim.

M	P	Flim
0.1	0.10	0.01
0.2	0.19	0.04
0.3	0.28	0.08
0.4	0.36	0.14
0.5	0.44	0.22
0.6	0.52	0.31
0.7	0.59	0.41
0.8	0.66	0.53
0.9	0.73	0.65
1	0.79	0.79
1.1	0.84	0.93
1.2	0.90	1.08

1.3	0.95	1.23
1.4	0.99	1.39
1.5	1.04	1.55

Warnings: the more suitable F value is highly uncertain and species-specific. Moreover, it may change as a result of changes in age of first capture due to selectivity changes. The estimated values derived from the described equation or others can be extremely high for stocks that are exploited since very young stages.

6.5.7. Reference points based on yield-per-recruit

Yield-per-recruit curves can be constructed also in the case of stocks for which information is poor. The dynamic pool models are useful for calculating yield per recruit as a function of instantaneous fishing mortality and age at first capture A set of growth parameters, a length/weight relationship and an estimate of M is the only information needed. F_{MAX} is a widely used Reference Point that can be estimated with such analysis. It can be considered a Limit RP. Some times, this maximum can be obtained at very high fishing mortality rates, especially in the cases when the Y/R curve is almost flat over certain values of F. The Gulland and Boerema (1973) $F_{0.1}$ is commonly used as its corresponding TRP. Both RPs may change if age structure of the stock, recruitment or selectivity do change. In some countries, the more precautionary value $F_{0.2}$ is used. Such RP has been used as a target for fisheries management (Butterworth et al., 1997).

The dynamic pool models can also be used to examine the effects of the control variables (F and tc) on spawning stock biomass per recruit (SSB/R). Although this usage is potentially useful, also for an estimation of F_{MSY}, in the area this option has been seldom considered due to the lacking of knowledge of the Stock/Recruitment relationship and hence, for data poor situations, the only RP that can be estimated in the F_{MSY} proxy $F_{0.1}$. SGMED has proposed the use $F_{0.1}$ as a proxy of F_{MSY} and this value can be estimated for several stocks and compared with current values of F estimated from available data (i.e. use of SURBA with trawl surveys data).

Warning: the use of extremely high values of F_{max} as a limit and $F_{0.1}$ as a target and the recommendation of keeping F within the range defined by those reference values can be not precautionary.

6.6. Species and stocks to be considered in data poor assessments

The stocks, for which in each GSA the performance of stock assessment with formal methods is considered feasible are listed in section 4.3, tables 4.3.1, 4.3.2 and 4.3.3. As regards the other species included in the frame of the DCR, it is expected for the next meetings SGMED will be able to explore the quality of available information and, when possible, to start with the performance of formal assessments. The species selected, for which information is requested in the data call, are: *Boops boops, Coryphaena hippurus, Dicentrarchus labrax, Eutrigla gurnardus, Lophius budegassa, Lophius piscatorius, Micromesistius poutassou, Mugilidae, Mullus surmuletus, Pagellus erythrinus, Penaeus kerathurus, Scomber spp., Solea solea, Sparus aurata, Spicara smaris, Squilla mantis, Trachurus mediterraneus, Trachurus trachurus, Chelidonichthys lucerna, Diplodus spp., Pagellus acarne, Pagellus bogaraveo, Phycis blennoides, Trisopterus minutus.*

In the case formal approaches is considered not feasible, it is suggested the use of the identified indicators (and when possible RPs derived from them) to allow a preliminary assessment of their exploitation situation. The number of the selected indicators applied to each stock in data poor situation should be as many as possible, depending on the data available.

The use of the indicators is also proposed for those species for which formal assessments have already been performed (or it is intended to be done in the next future). Such exercise, and in particular the analysis of consistency among approaches, is considered very useful because it may illustrate the consequences of model choices and provides guidance on uncertainty, allows the exploration of the performance and limitations of both, formal approaches and indicators, and can demonstrate the limitations and consequences of lacking of information.

6.7. Format of the data call

The format of the previous data call was revised to check whether, on the basis of the recommended indicators and methodologies to be applied, changes to the format are needed in order to enable data poor assessments.

The template used in the discussion with the new data requested is presented in Appendix 6.

The new data requested include:
- data on two new species (*Spicara smaris* and *Mullus surmuletus)*
- three more tables (maturity ogive by age, sex ratio at age and age distribution of discards)
- for the research surveys at sea (MEDITS), two more table for cross- checking (TD and TT files, Temperature data and codes for the temperature measuring systems and list of hauls per stratum).

SGMED recommends the fishery data be submitted also for the total catch.

In order to compute condition factors, and in line with SGMED recommendation in section 1.2 on the use of all available data sets to estimate parameters a and b of the length- weight relationship, the participants agreed to bring to the next meeting the available individual length- weight data, collected in their area of expertise, for some of the stocks. Therefore length- weight data data will not be requested in the data call but will be provided on a voluntary basis by the experts.

7. TOR 4 PLAN OF SGMED WORK IN 2010

The next SGMED meetings will be held on:

SGMED-10-02: 31 May- 4 June in Crete (to be confirmed)
SGMED-10-03: 13- 17 December in Sicily (to be confirmed)

SGMED proposes the following Terms of Reference for SGMED-10-02:

1. Analytical stock assessment

The species assessed by SGMED are M*erluccius merluccius, Mullus barbatus, Mullus surmuletus, Parapenaeus longirostris, Engraulis encrasicolus, Sardina pilchardus, Solea solea, Aristeus antennatus, Aristaeomorpha foliacea,* and *Nephrops norvegicus.* In addition to the updating of the assessments and short-term forecasts provided in 2009, priority for future assessments should be given firstly to the stocks in table 4.3.1, secondly to those in table 4.3.2, and finally, to the stocks in table 4.3.3.

2. Stock assessment in data poor situation

SGMED in its SGMED-10-01 meeting selected empirical indicators and methodologies for their calculation to be applied in data poor situations which do not allow the performance of standard stock assessment.

2.1 The selected empirical indicators and the derived reference points (fishery dependent and non-dependent) will be applied to the species specified in section 6 of the report.

2.2 The selected empirical indicators and the derived reference points (fishery dependent and non-dependent) will also be applied to the stocks analytically assessed.

3. R code to standardize, estimate trends and perform age slicing with MEDITS data and for estimation of fisheries indicators out of MEDITS

3.1 Further testing of the R code slicing function, implementation of suggested changes following the meeting. Slicing with this routine should be applied to multiple GSA's and species to verify that it performs correctly across a range of different data types.

3.2 Test the R code to perform MEDITS survey CPUE index (both on weight and numbers of species in addition to Hake) standardization with GLMs and GAMs and assess if the cost/benefit is positive. In the R script routines to address zero inflation/truncation should be developed (Delta method or other).

3.3 Perform SURBA assessments with raw numbers at age and standardized numbers at age to assess if there is a positive impact of standardizing and the overall cost/benefit of such procedure.

3.4 The R code proved useful in importing and handling MEDITS data and it could be an appropriate platform to implement routines to explore different types of fisheries indicators. For example, all fisheries state indicators described in TOR 3 can be derived from MEDITS by implementation of specific routines that quickly produce numerical and graphical output. In fact, some indicators are already part of the R script developed for TOR 2 like positive area distribution by age class and biomass index. Future work should be made to develop R script that produce the requested fisheries indicators.

4. Test the differences in the assessment resulting from using
4.1 age slicing and the age-length key
4.2 the growth parameters estimated from otolith reading on the M vector.

5. Test the use of scorecard to assess the accuracy of data to be used for stock assessment

This test will be done with the data submitted by at least one Member State.

SGMED proposes the following Terms of Reference for SGMED-10-03:

Continue with the tasks proposed for SGMED10-02.

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9. 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

[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

potentials and the sustainability of the stock by using both echo and/or DEPM 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.

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.

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11. APPENDIX 3. LIST OF RECOMMENDED STOCKS TO BE ASSESSED BY SGMED IN 2010.

New stocks to be assessed by SGMED in 2010: level priority 1,2 and 3 (1 highest)

Updating of assessments-Priority 1

GSA	stock	stock coordinator
1	*Engraulis encrasicolus*	Jose María Bellido, Luis Quintanilla
	Sardina pilchardus	Jose María Bellido, Luis Quintanilla
5	*Merluccius merluccius*	Beatriz Guijarro
6	*Merluccius merluccius*	Mariano García
	Mullus barbatus	Mariano García
	Parapenaeus longirostris	Mariano García
	Engraulis encrasicolus	Jose María Bellido, Luis Quintanilla
	Sardina pilchardus	Jose María Bellido, Luis Quintanilla
7	*Merluccius merluccius*	Angelique Jadaud and Beatriz Guijarro
	Mullus barbatus	Angelique Jadaud and Beatriz Guijarro
9	*Mullus barbatus*	stocks in GSA 9 coordinated by
	Merluccius merluccius	Paolo Sartor, Francesco Colloca and Alvaro Abella
	Nephrops norvegicus	
	Parapenaeus longirostris	
17	*Solea solea*	Giuseppe Scarcella

FIRST PRIORITY (Table 4.3.1) Stocks in areas where no assessment is available

GSA	stock	priority	stock coordinator
2	*Aristeus antennatus*	1	
8	*no data collection*	1	
18	*Mullus barbatus*	1	Spedicato Maria-Teresa
	Merluccius merluccius (combined with GSA17)	1	Spedicato Maria-Teresa
	Nephrops norvegicus	1	Spedicato Maria-Teresa
19	*Merluccius merluccius*	1	Bitetto Isabella
	Aristeus antennatus	1	Bitetto Isabella
20	*Merluccius merluccius*	1	
	Mullus barbatus	1	
	Mullus surmuletus	1	
	Sardina pilchardus	1	
	Engraulis encrasicolus	1	
	Parapenaeus longirostris	1	
	Spicara smaris	1	

SECOND PRIORITY (Table 4.3.2) Stocks in areas where assessments are available for some of the priority species selected by SGMED in 2008 and 2009

GSA	stock	priority	stock coordinator
1	*Merluccius merluccius*	1	
	Mullus barbatus	1	
	Parapenaeus longirostris	2	
	Aristeus antennatus	1	
	Nephrops norvegicus	2	
5	*Mullus barbatus*	2	Antoni Quetglas
	Mullus surmuletus	1	Antoni Quetglas
	Aristeus antennatus	1	
	Parapenaeus longirostris	1	Beatriz Guijarro - Antoni Quetglas
	Nephrops norvegicus	1	Beatriz Guijarro - Antoni Quetglas
6	*Mullus surmuletus*	2	Mariano García
	Nephrops norvegicus	2	Mariano García
7	*Mullus surmuletus*	2	Length data coming only from trawlers, nearly nothing from small scale fisheries : NO ASSESSEMENT POSSIBLE at that time Josep Lloret
	Engraulis encrasicolus	1	Jean-Louis BIGOT
	Sardina pilchardus	1	Jean-Louis BIGOT
	Solea solea	1	No data (only 2009) : NO ASSESSEMENT POSSIBLE at that time Giuseppe Scarcella
	Aristeus antennatus	2	No data from landings + Only MEDITS data
	Nephrops norvegicus	2	No data from landings + Only MEDITS data
9	*Engraulis encrasicolus*	1	Paolo Sartor
	Sardina pilchardus	2	Paolo Sartor
	Solea solea	3	Alvaro Abella, Giuseppe Scarcella
	Aristeus antennatus	2	Francesco Colloca
	Aristaeomorpha foliacea	2	Francesco Colloca
10	*Parapenaeus longirostris*	1	Spedicato Maria-Teresa
	Engraulis encrasicolus	2	
	Sardina pilchardus	2	
	Aristeus antennatus	2	Bitetto Isabella
11	*Merluccius merluccius*	1	
	Parapenaeus longirostris	2	
	Aristeus antennatus	2	
	Aristaeomorpha foliacea	1	
	Nephrops norvegicus	2	
16	*Mullus barbatus*	1	Fabio Fiorentino
	Mullus surmuletus	1	Fabio Fiorentino
	Aristeus antennatus	3	Fabio Fiorentino
15+16	*Nephrops norvegicus*	1	Leyla Knittweis
17	*Merluccius merluccius*	1	Giuseppe Scarcella
	Mullus barbatus	1	Giuseppe Scarcella
	Parapenaeus longirostris	2	Giuseppe Scarcella
	Nephrops norvegicus	1	Giuseppe Scarcella
22+23	*Merluccius merluccius*	1	
	Mullus barbatus	1	
	Mullus surmuletus	1	
	Parapenaeus longirostris	1	
	Solea solea	2	Giuseppe Scarcella
	Nephrops norvegicus	2	
25	*Mullus surmuletus*	1	

THIRD PRIORITY (Table 4.3.3) Stocks not yet assessed analytically, selected from the ranking listed recommended in SGMED-09-03 report

GSA	stock	priority	stock coordinator
7	*Sparus aurata*	1	Length data coming only from trawlers (~30% of the catches), nearly nothing from small scale fisheries (~70% of the catches) NO ASSESSEMENT POSSIBLE at that time
	Dicentrarchus labrax	1	Length data coming only from trawlers (~50% of the catches), nearly nothing from small scale fisheries (~50% of the catches) NO ASSESSEMENT POSSIBLE at that time
9	*Pagellus erythrinus*	1	Alvaro Abella, Josep Lloret
16	*Pagellus erythrinus*	2	Josep Lloret
15+16	*Coryphaena hippurus*	1	Leyla Knittweis
17	*Squilla mantis*	2	
22+23	*Boops boops*	2	
25	*Boops boops*	1	
	Spicara smaris	1	

12. APPENDIX 4. SGMED DATA CALL- APRIL 2010

DATA CALL: 12 APRIL 2010
DEADLINE for uploading files: 10 MAY 2010

The call covers the years:

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

Species requested:

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

New species:

- *Spicara smaris* (Picarel)
- *Mullus surmuletus* (Striped red mullet)

TABLE 1: Additional species as included in the data collection regulations and for which Member States are invited to provide relevant data before 24 November 2009.

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 2: Additional species not included in the data collection regulations and for which interested Member States are invited to provide relevant data before 24 November 2009.

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

For the fisheries data we propose to ask for three more tables
Fisheries data

- Landings
- Effort
- Length distribution of landings
- Age distribution of landings
- Maturity ogive by length
- Maturity ogive by age (New data requested)
- Growth parameters
- Sex ratio at length
- Sex ratio at age (New data requested)
- Discards
- Length distribution of discards
- Age distribution of discards (New data requested)

Vessel length classes
According to DRC the following vessel length categories were requested
VL0012 = vessels less than 12 metres in length
VL1224 = vessels between 12 metres and 24 metres in length
VL2440 = vessels between 24 metres and 40 metres in length
VL40XX = vessels greater than 40 metres in length

According to DCF the vessel length classes are:
Appendix III
Fleet segmentation by region
Length classes (LOA)
0-< 6 m
6-< 12 m
12-< 18 m
18-< 24 m
24-< 40 m
40 m or larger

Fishing technique
Until now the Level of aggregation of fishing technique (FT LVL) should be 3, 4 or 5 according to the Appendix IV on the new draft implementing Decision of EC Regulation 199/2008.
List in priority order LVL 5, 4, 3.

According to DCF
B1. Metier-related variables
Variables
Sampling must be performed in order to evaluate the quarterly length distribution of species in the catches, and the quarterly volume of discards. Data shall be collected by metier referred to as level 6 of the matrix defined in Appendix IV (1 to 5) and for the stocks listed in Appendix VII.

For the Research Surveys at Sea (Medits) we propose to ask for two more table for cross-checking

- TA
- TB
- TC
- TT files (List of hauls by stratum)
- TD (temperature data and codes for the temperature measuring systems)

ADD in every file column called GSA

Small pelagic Survey

- Length distribution
- Age distribution
- Maturity at age

Economic variables

Table 1. Requirements for 2008 DCF data submission.

Variable group	Variable	Acronym	Aggregation level
Employment	Number of engaged crew	totJOB	Yearly, Fleet segment, Supra Region
Income	Value of landings	totLandgInc	
	Income from fishing rights	totRightsInc	
	Direct subsidies	totDirSub	
	Other income	totOtherInc	
Expenditure	Crew wages	totCrewWage	
	Value of unpaid labour	totUnpaidLab	
	Energy costs	totEnerCost	
	Repair costs	totRepCost	
	Variable costs	totVarCost	
	Non variable costs	totNoVarCost	
	Rights costs	totRightsCost	
	Depreciation	totDepCost	
Capital and Investments	Vessel replacement value	totDepRep	
	Value of fishing rights	totRights	
	In-year investments	totInvest	
	Financial position	FinPos	
Capacity	Number of vessels	totVes	
	Mean length overall	avgLOA	
	Mean GT	avgGT	
	Mean kW	avgKw	
	Mean age	avgAge	
Effort	Days at Sea	totSeaDays	Yearly, Fleet segment, FAO Area level 3
	Fishing days	totFishDays	
	Energy Consumption	totEnerCons	Yearly, Fleet segment, Supra Region
	Number of trips	totTrips	
	Number of pots and traps	totTraps	
Landings	Weight of landings per species	totWghtLandg	Yearly, Fleet segment,

	Value of landings per species	totValLandg	FAO Area level 3
	Price per species	totPriceLandg	

Table 2. Requirements for 2002-2007 DCR data submission

Variables group	Variables	Aggregation levels	Other requested fields
Capacity	Number of vessels, gross tonnage, engine power, average age	Yearly, fleet segment of Appendix III	Precision Level
Employment	Total, full-time, part-time, full-time equivalents	Yearly, fleet segment of Appendix III	
Revenue, costs and fuel consumption	Income, cost (crew, fuel, operational, capital, repair and maintenance, fixed), fuel (volume)	Yearly, fleet segment of Appendix III	
Financial position	Borrowing and investment	Yearly, fleet segment of Appendix III	
Price	Live weight	Yearly, species, fleet segment of Appendix III.	

Year period
The year period is defined in terms of years

YEAR = 2003 etc.
YEAR PERIOD (for some biological data) = 2003-2005, 2006-2008, 2009-2011

BIOLOGICAL DATA
Landings
Aggregated on species, year period, fleet segment and area where fish were caught.

Variable name	Description	Fields
LW	Weight declared on landing	UNIT (t)
LN	Number of fish landed	UNIT (thousands)
COMMENTS	Any relevant comments	Text max 250 characters

Effort
Aggregated on year period, fleet segment and area where fish were caught. For some calls for data the area may not be requested.

Variable name	Description	Fields
DAYS	Number of days each vessel spends at sea over the year period in question - sum for whole fleet segment	UNIT (days)
KWDAYS	Sum of effort for each vessel in segment over year period in question. KWDAYS of each vessel is number of days at sea multiplied by engine power in kW	
GTDAYS	Sum of effort for each vessel in segment over year period in question. GTDAYS of each vessel is number of days at sea multiplied by gross tonnage	
COMMENTS	Any relevant comments	Text max 250 characters

Length Distribution of Landings
Annual length structure of the total landings (numbers per length class raised to landings per length class). Aggregated on year period, fleet segment, species, length class, sex and area where fish were caught.

Variable name	Description	Fields
LN	Number of fish per length class raised to landings per length class	UNIT (thousands)
LW	Mean weight per length class	UNIT (t)
MEAN_IND_WEIGHT	Mean individual weight	UNIT (g)
LENGTH_CLASS	All length classes should be represented in the data file including zero values	UNIT (centimetres)
SPECIES	Species code as defined by FAO	TYPE (FAO SPECIES CODE)
COMMENTS	Any relevant comments	Text max 250 characters

Age Distribution of Landings
Annual age structure of the total landings (number of individuals per age class raised to landings by age class). Aggregated on year period, fleet segment, species, age class, sex and area where fish were caught.

Variable name	Description	Fields
LN	Number per age class raised to landings per age class	UNIT (thousands)
LW	Mean weight per age class	UNIT (t)
MEAN_IND_WEIGHT	Mean individual weight	UNIT (g)
AGE_CLASS	All age classes should be represented in the data file including zero values	UNIT (numbers)
SPECIES	Species code as defined by FAO	TYPE (FAO SPECIES CODE)
COMMENTS	Any relevant comments	Text max 250 characters

Maturity ogive by length
The proportion of mature individuals per length class according to the classification of the length distribution file (landings).
Aggregated on year period, species, length class, sex and area where fish were caught.

Variable name	Description	Fields
LENGTH_CLASS	All length classes should be represented in the data file including zero values	UNIT (centimetres)
PRM	Proportion of mature individuals per length class	UNIT (Proportion 0 to 1)
METHOD_USED	Any relevant information	Text max 250 characters
SPECIES	Species code as defined by FAO	TYPE (FAO SPECIES CODE)

Maturity ogive by age
The proportion of mature individuals per age class according to the classification of the age distribution file (landings).
Aggregated on year period, species, age class, sex and area where fish were caught.

Variable name	Description	Fields

AGE_CLASS	All age classes should be represented in the data file including zero values	UNIT (numbers)
PRM	Proportion of mature individuals per age class	UNIT (Proportion 0 to 1)
METHOD_USED	Any relevant information	Text max 250 characters
SPECIES	Species code as defined by FAO	TYPE (FAO SPECIES CODE)

Growth parameters
Aggregated on year period, species, sex and area where fish were caught.

Variable name	Description	Fields
L_INF	Von Bertalanffy growth parameters	UNIT (centimetres)
K	Von Bertalanffy growth parameters	UNIT (year^{-1})
T0	Von Bertalanffy growth parameters	UNIT (year)
A	Length-weight relationship parameter	UNITS to be used (cm, g)
B	Length-weight relationship parameter	UNITS to be used (cm, g)
METHOD_USED	Method used for ageing and to calculate the growth parameters	Text max 250 characters
SPAWNING_PERIOD	The spawning season in range of months	UNITS (months)
SPAWNING_PEAK	The peak of the spawning period with the highest proportion of spawners	UNITS (months)
SPECIES	Species code as defined by FAO	TYPE (FAO SPECIES CODE)

Sex ratio at length
Aggregated on year period, species, length class and area where fish were caught.

Variable name	Description	Fields
LENGTH_CLASS	All length classes should be represented in the data file including zero values	UNIT (centimetres)
SEX_RATIO	Proportion of each sex to the total number of sex determined individuals in each length class according to the length distribution file	UNIT (Proportion 0 to 1)
COMMENTS	Any relevant comments	Text max 250 characters
SPECIES	Species code as defined by FAO	TYPE (FAO SPECIES CODE)

Sex ratio at age
Aggregated on year period, species, age class and area where fish were caught.

Variable name	Description	Fields
AGE_CLASS	All age classes should be represented in the data file including zero values	UNIT (numbers)
SEX_RATIO	Proportion of each sex to the total number of sex determined individuals in each age class according to the age distribution file	UNIT (Proportion 0 to 1)
COMMENTS	Any relevant comments	Text max 250 characters
SPECIES	Species code as defined by FAO	TYPE (FAO SPECIES

		CODE)

Discards
Aggregated on species, year period, fleet segment and area where fish were caught.

Variable name	Description	Fields
DN	Number of fish estimated	UNIT (thousands)
DW	Weight estimated	UNIT (t)
COMMENTS	Any relevant comments	Text max 250 characters

Length Distribution of Discards
Annual length structure of the discards (numbers per length class raised to discards per length class). Aggregated on year period, fleet segment, species, length class, sex and area where fish were caught.

Variable name	Description	Fields
DN	Number of fish per length class raised to discards per length class	UNIT (thousands)
DW	Mean weight per length class	UNIT (t)
MEAN_IND_WEIGHT	Mean individual weight	UNIT (g)
LENGTH_CLASS	All length classes should be represented in the data file including zero values	UNIT (centimetres)
SPECIES	Species code as defined by FAO	TYPE (FAO SPECIES CODE)

Age Distribution of Discards
Annual age structure of the discards (numbers per age class raised to discards per age class).
Aggregated on year period, fleet segment, species, age class, sex and area where fish were caught.

Variable name	Description	Fields
DN	Number of fish per age class raised to discards per age class	UNIT (thousands)
DW	Mean weight per age class	UNIT (t)
MEAN_IND_WEIGHT	Mean individual weight	UNIT (g)
AGE_CLASS	All age classes should be represented in the data file including zero values	UNIT (numbers)
SPECIES	Species code as defined by FAO	TYPE (FAO SPECIES CODE)

Research Surveys at sea

MEDITS by GSA
Refer to the International Bottom Trawl Survey in the Mediterranean (MEDITS).
http://www.sibm.it/SITO%20MEDITS/principaleprogramme.htm

The complete MEDITS dataset is requested. Instruction manual, Version 5, April 2007
http://www.sibm.it/SITO%20MEDITS/file.doc/Medits-Handbook_V5-2007.pdf

Type of file	Description
Type A files	Data on the haul

Type B files	Catches by haul
Type C files	Biological parameters
Type D files	Temperature data and codes for the temperature measuring systems
Type T files	List of hauls by stratum

SMALL PELAGIC SURVEY
Refers to ECOMED, PELMED, DEPM, and all hydro acoustic surveys

Length Distribution
Length structure of the survey data (numbers and biomass per length class by species and sex). Aggregated on year period, species, length class, sex and area.

Variable name	Description	Fields
NUMBER	Number of fish per length class	UNIT (thousands)
BIOMASS	Biomass per length class	UNIT (t)
LENGTH_CLASS	All length classes should be represented in the data file including zero values	UNIT (centimetres)
SPECIES	Species code as defined by FAO	TYPE (FAO SPECIES CODE)
COMMENTS	Any relevant comments	Text max 250 characters
NAME_OF_SURVEY	Name of the survey	TEXT

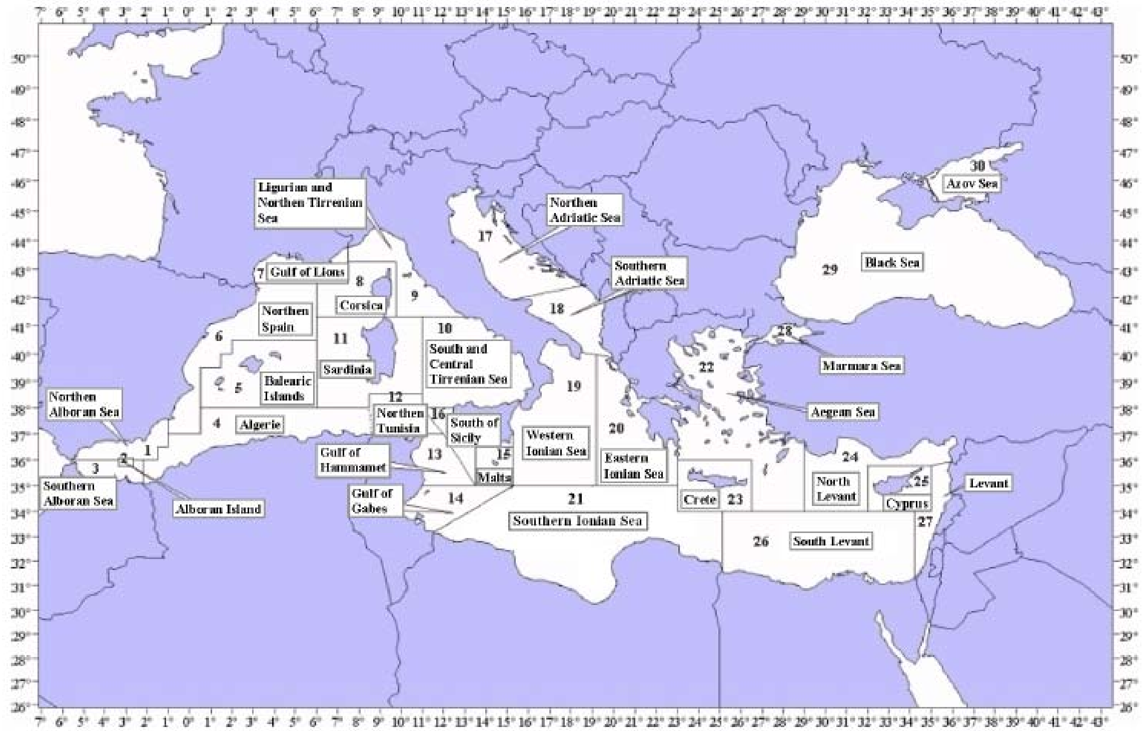
Age Distribution of Landings
Age structure of the survey data (numbers and biomass per age class by species and sex).
Aggregated on year period, species, age class, sex and area.

Variable name	Description	Fields
NUMBER	Number of fish per age class	UNIT (thousands)
BIOMASS	Biomass per age class	UNIT (t)
AGE_CLASS	All age classes should be represented in the data file including zero values	UNIT (natural numbers)
SPECIES	Species code as defined by FAO	TYPE (FAO SPECIES CODE)
COMMENTS	Any relevant comments	Text max 250 characters
NAME_OF_SURVEY	Name of the survey	TEXT

Maturity at age
The proportion of mature individuals per age class according to the classification of the age distribution file.
Aggregated on year period, species, age class, sex and area.

Variable name	Description	Fields
AGE_CLASS	All age classes should be represented in the data file including zero values	UNIT (natural numbers)
PRM	Proportion of mature individuals per age class	UNIT (Proportion 0 to 1)
SPECIES	Species code as defined by FAO	TYPE (FAO SPECIES CODE)
COMMENTS	Any relevant comments	Text max 250 characters
NAME_OF_SURVEY	Name of the survey	TEXT

13. APPENDIX 5. GFCM GSAS



14. 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.

European Commission

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Abstract
SGMED-10-01 meeting was held on 22-26 March 2010 in Barcelona (Spain). The meeting was dedicated to the preparation of the stock assessment process for the Mediterranean stocks and fisheries to be implemented during 2010.STECF reviewed the report during its plenary meeting on 26-30 April in Norwich.

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