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The utilization of trawl surveys data for stock assessment purposes using two variants of surplus production models

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Introduction

Trawl surveys are carried out in several Mediterranean countries for demersal resources. The surveys are useful for a better knowledge of life history and exploitation status of several marine species, including those economically important. Information from trawl-surveys has been used in the area for mapping the spatial distribution of the resources and also for providing indices of relative abundance over space and time. The analysis of trawl surveys data also allows the evaluation of fishing activity impact on biodiversity. The reconstructed size structure proceeding from trawl-surveys has been frequently used for the estimation of total mortality rates. Detected variations in Z throughout years can provide useful information for management, for giving advice and allowing an adaptive strategy. All the mentioned indices, considering that sampling procedures remained unchanged along time, should provide potentially useful information to derive a picture of the variations occurring throughout the years,.

The traditional source of data for stock assessment has been the commercial activity, because furnishes information on age structure, effective effort and its spatial and temporal allocation, total catches, etc. In many Mediterranean countries, this kind of information is however not available or it results necessary to reassess and to adapt the conventional methods in order to find those more suitable for a sound assessment of the demersal resources of the area. Adaptations have to consider that exploited resources many times are constituted by fast-growing species, that they are caught too early as regards their life spans and also the large number of species that almost always are contemporarily harvested with many gears competing for the same resources.

In the last years, also in the Northern countries the traditional approaches based on the commercial activity have shown some signals of crisis mainly due to objective difficulties for their correct sampling, the frequent under-reporting of catches, etc. The presence of such unreliable information combined with uncertainty in processes and implementation of management measures have often made advice based on traditional fishery models ineffective. Programs based on the collection of fishery independent data have been in consequence promoted also in these countries. The goals of these projects were in consequence not only the estimates of biomass, biological data collection or catch rates estimates useful for VPA tuning, but also for giving advice as regards the way to better exploit the stocks.

Several proposals have been made in the last years for the use of trawl surveys data for stock assessment purposes. They range from the derivation of simple indicators of stock or ecosystem status, the anaysis of time series of abundance, age-based analytical approaches, the use of production modelling using total mortality in place of fishing effort. The goal of all these attempts is the finding of indicators of the health of the resources and the definition of sustainable yield levels or catch rates.

In this note, we briefly describe two stock assessment approaches based on a traditional production model that can be applied if only fisheries independent data derived from trawl surveys are available. As stated by Die and Caddy (1997) simple methods as those described here should be judged by their capacity for providing useful advice and they are not conceived for a full replacement of proper stock assessments.

Problems for data collection, fitting aspects, the assumption of equilibrium and *management failures for resources which assessments were based on surplus production models have been among the main reasons why traditional surplus production models became in the last years less popular. The new variants here proposed avoid many of the problems that researchers faced in the past.*

Two approaches based on surplus production models are presented here. These approaches can be utilised for an assessment of the status of demersal stocks utilizing exclusively available data of trawl surveys performed in the frame of the MEDITS programme. The first one, uses information on the spatial distribution of abundance indices on areas exploited at different rates, coupled with an analysis of demographic structure that is assumed to be locally modified according to the geographical allocation of the fishing effort. The second one, analyses time series of an abundance index (kg/km2) and the total mortality rate Z in order to estimate the parameters of a Schaefer population growth model which do not make the equilibrium assumption and successively allows the definition of the level of mortality rate corresponding to the Maximum Sustainable Yield.

The concept of Surplus Production

The level of the biomass of a population at time t+1 will depend to different phenomena. While recruitment and individual growth contribute to its increase, mortality due to both natural causes and removals will contribute to its decline:

Bt+1 = Bt + (recruitment and growth effects) - (Natural Mortality + Catch)

When there is no fishing, the combination of recruitment and growth is called Production:

Bt+1 = Bt + Production (P) - Natural Mortality (M)

In the case P>M, the population will grow. The "Surplus Production" is defined as the increased amount of the population biomass in the absence of fishing or the amount of catch that can be harvested keeping biomass constant.

Bt+1 = Bt + Surplus Production – Catch

It is clear that in the case Catch>Surplus Production, the biomass will decrease.

In Figure 1 the expected relationship between biomass level and surplus production is shown.

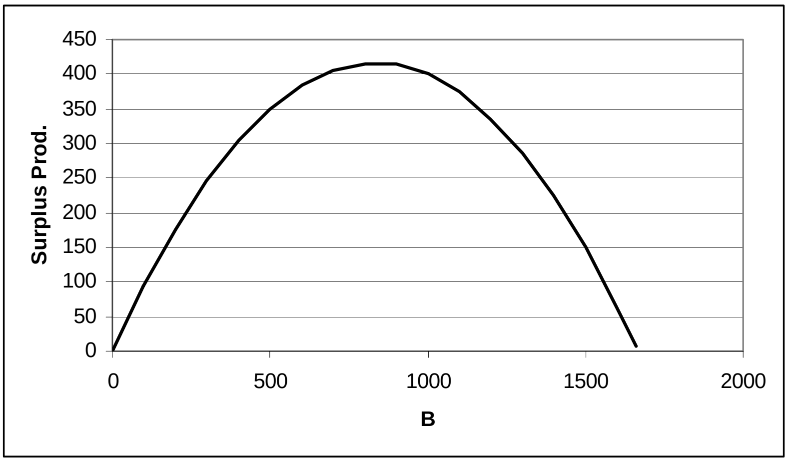

Fig.1. The more classical relationship between stock biomass and surplus production

In general, there is no available information on Biomass, but on an abundance index as CPUE (Catch per unit of effort). If an independent estimate of the relationship between the real abundance and the defined index is available (catchability), the biomass over time can be reconstructed.

The most popular versions of production models use data of fishing effort in order to define which is the yield that is likely to be produced at different levels of exploitation. They are based on time series of data of catch and effort. There are however some problems for the use of such models, especially for the more simplistic versions, that many times make results obtained with these approaches not reliable. These models assume that the population adapt to the different levels of effort and reach a new level of equilibrium under each exploitation rate. In this case, a direct relationship between fishing effort and biomass in equilibrium (and hence with catch) can be defined (see Figure 2). If the equilibrium is hypothesised, the application of a certain level of effort for only a year should produce the same yield to that expected if the same exploitation rate remains unchanged for several years of fishing. The problem is that in reality only after some years equilibrium will be reached because stock size, the performance of population growth at this size of the stock related to the carrying capacity of the environment and the demographic structure of the stock need time to adjust to this particular level of effort. Moreover, in a time series, the standardization of catch and effort data may be difficult, and is necessary that no changes had occurred along the studied period regarding fishing strategy (i.e. target species, operational areas, discard procedures, employed tecnology, etc).

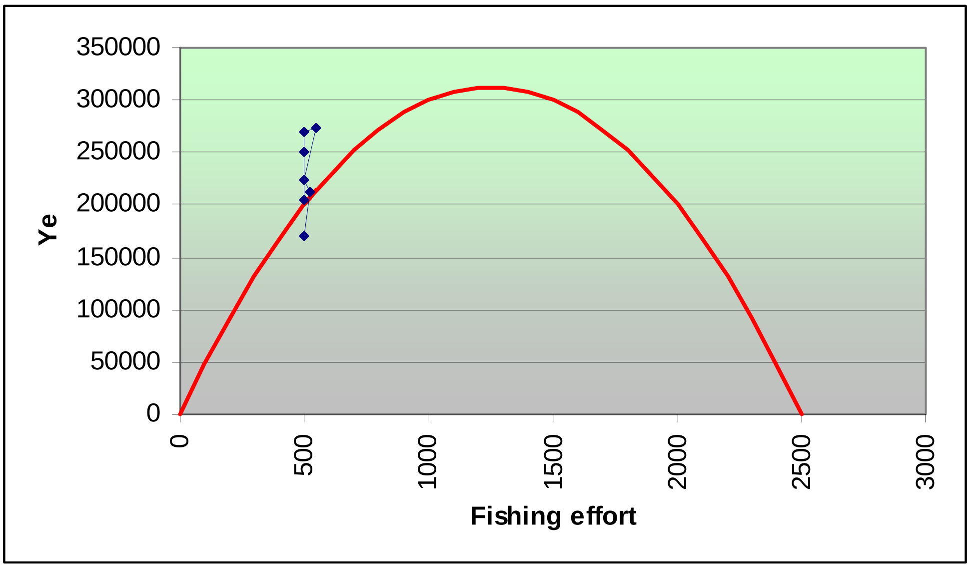

Fig.2 Theoretical gradual approach to yield in equilibrium in the case effort be kept unchanged for several years.

Using Z as a direct index of effort.

Trawl surveys data does not allow obtaining data on direct effort exerted on a single or a group of species nor on commercial catches. This fact precludes any possibility to use the traditional surplus production models based on catch and effort data. Csirke and Caddy (1983) have proposed two approaches that use Z as a direct index of fishing effort. The mentioned authors state that is extension of the well known traditional surplus production models became useful in permitting production models to be developed for use in conjunction with annual estimates of overall mortality Z. This estimates are among the most simple ones to obtain. For instance Z can be estimated from the analysis of the size structure of the stock at sea, information that may proceed from trawl surveys.

Caddy and Defeo (1996) stated that one of the major advantages of fitting production models directly to mortality data is a strong reduction of errors due to a poor calibration of fishing effort as well as to changes in catchability along time due to increased experience of fishers and/or dependent on fishing intensity or biomass.

Composite model

An assessment with a composite model (Munro, 1980) was already done in the Mediterranean for Merluccius merluccius and Mullus barbatus (Abella et al, 1999). Composite models use spatial information proceeding from ecologically similar sub-areas exploited at different rates but for whom similar pristine productivity and evolution under changes in fishing pressure are assumed. The change from a time to a space-based data set allows utilizing production models even in the case long data series on catch and effort are not available. The above mentioned analysis covered the whole western Italian coast and the eastern coasts of Corsica. Trawl surveys data from the MEDITS European research program available for the whole area were used. The approach was a combination of a Composite Model with the Caddy and Csirke (1983) variant of Surplus Production models that uses the instantaneous total mortality rate Z as a direct index of effort, and a catch rate (Kg/h) as abundance index. The use of Z is justified to the lacking of reliable information on fishing effort in the analysed area. The approach allows calculating the situation of each single sub-area relative to the total mortality rate, and in particular to calculate its position relative to the Z at Maximum Biological Production (Z_{MBP}). When, as in this case, we are not using total biomass, but an index U, the approach does not allow

calculating the absolute Maximum Biological Production (the total production removed by both fishing and by natural causes but a relative value.
Starting from a traditional Schaefer model that relates effort with an index of abundance U

$U = U_\infty - bf$

By replacing f by F/q we obtain:

$U = U_\infty - b'F$ (where $b' = b/q$)

Then replace F above (where F= Z - M):

$U = U_\infty - b'(Z - M) = U_\infty - b'Z + b'M$

$U = (U_\infty + b'M) - b'Z$

$UZ = Z(U_\infty + b'M) - b'Z^2$ (Biological Production)

The availability of data of Z and of the index of abundance in the different considered areas allows to fit the model. The proposed appraoch has two main advantages, related to 1)the problem of the assumption of equilibrium and 2) the need of contrasting enough data.
1)The assumption of equilibrium (a stock with little or no change over time in size, growth rates, demographic structure) is difficult to support when we are working with time series, where changes in exploitation strategy, vessels charcteristics, in fishing pressure and efficiency, in fishers learning are likely to have occurred along time. In these cases, observed yields at different levels of fishing pressure are not those expected at equilibrium. In the case of the composite approach, information should regard fleets that in the last years didn't show important changes in size, activity, tecnology and consequently with stocks exposed to quite similar exploitation rates for a relatively long time. In these cases, situations close to equilibrium can be hypothesised inside each of them and this can be checked, for instance analysing if important changes in Z did occur in the last years.
2)In order to obtain good results through the fitting of data, these data should show a rather good amount of contrast, with situations representative of light, medium or heavy levels of exploitation. The availability of such kind of information is rare, because seldom the anaysed data in a single area regards different periods of development of the fishery. In the case of the utilization of information proceeding from different areas where resources are exploited at different rates, contrast can be reasonably expected.

Non-equilibrium Biomass Dynamic model

Data on catch per tow allow to estimate, for each species and year, 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.
With this information, it is possible to fit a variant of the Schaefer model to estimate the parameters r and K of the logistic population growth model and to estimate the level of fishing mortality F corresponding to the Maximum Sustainable Yield.

The approach is based on the modified Schaefer logistic equation modified by Walters and Hilborn (1976):

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

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:

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

Equivalent results for the parameters r and K(in weight) can be obtained using Biomass instead of Numbers in the third term of the equation:

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

For the fitting of a non-equilibrium model with time series of an annual index of Biomass and of total mortality rate, data were derived from Italian trawl surveys performed from 1990 to 2005 in the Southern Ligurian-Northern Tyrrhenian seas. The simplest fitting can be performed with the MS Excel solver by minimizing the sum of the squared deviations between observed and estimated values of Biomass (or its logarithms) by changing the seed values of r and K. The definition of these parameters allows the estimation of the value of fishing mortality rate that produces the Maximum Sustainable Yield (Fmsy). However, being the biomass estimates only indexes of the real biomass at sea, the approach does not allow the estimation of an absolute value for MSY but only the level of F in the curve that produces the MSY. Statistically robust approaches allows a dynamic fitting that takes into consideration observation errors. With results of this last mentioned procedure that quantifies the uncertainty related to the estimation of parameters it is possible to derive approximate confidence bounds by constructing a likelihood profile or through bootstrapping.

Examples of utilization of the proposed approaches

1) Composite model

An assessment of the state of the fisheries of Merluccius merluccius and Mullus barbatus that covered the whole western Italian coast and the eastern coasts of Corsica was performed by using trawl surveys data from MEDITS (Abella et al, 1999). The assessment was done using a Composite Model combined with the Caddy and Csirke (1983) variant of Surplus Production Model that uses the instantaneous total mortality rate Z as a direct index of effort, and catch per unit effort as an abundance index (see Figures 3 and 4).

This approach allowed calculating the situation of each single sub-area relative to the total mortality rate and, in particular, the Z position relative to the Maximum Biological Production (Z_{MBP}). As noted by Die and Caddy (1997) this reference point can be considered precautionary, as it corresponds to a slightly lower exploitation rate than the Maximum Sustainable Yield, and it is relatively stable and easy to calculate.

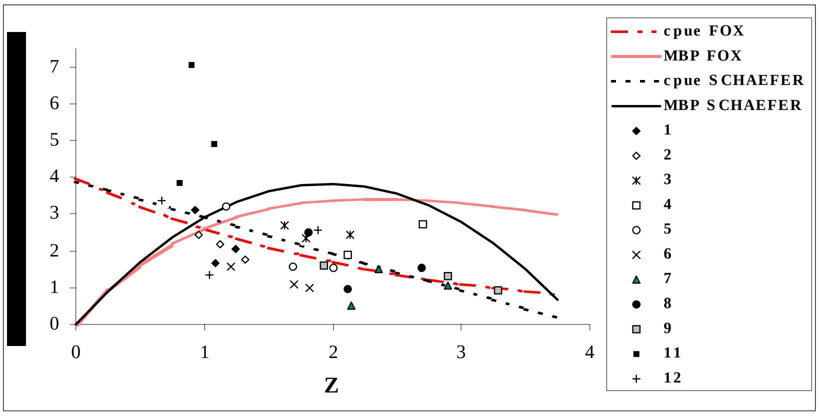

Fig. 3 Composite model for European hake in the Southern Ligurian-Tyrrhenian Sea using Z as index of effort following the models of Schaefer(1954) and Fox(1970)

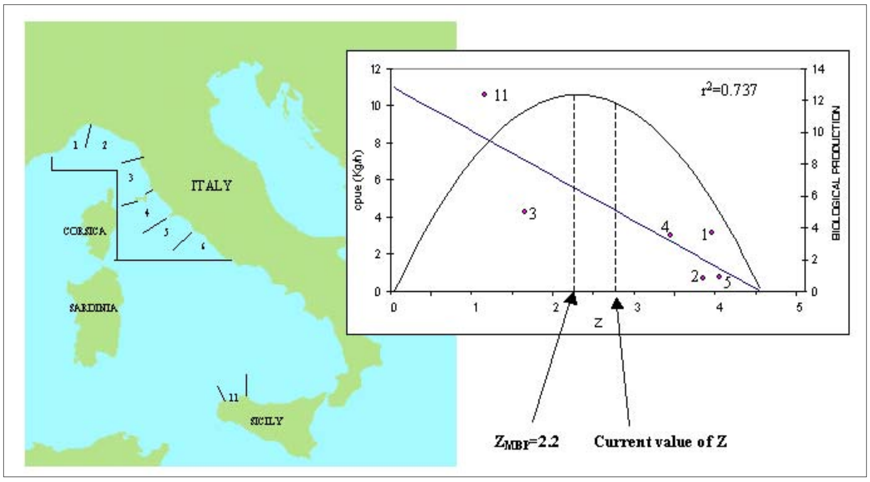

Fig.4 Composite model for Red mullet in the Southern Ligurian-Northern Tyrrhenian Sea (GSA9) using Z as index of effort following the model of Schaefer(1954)

In order to check the consistency between the obtained estimates and what we know about the commercial fisheries in the study areas, a correlation between a rough index of fishing intensity (number of vessels/surface of fishing area) and Z estimates was plotted. Results for hake and red mullet are shown in Figure 5.

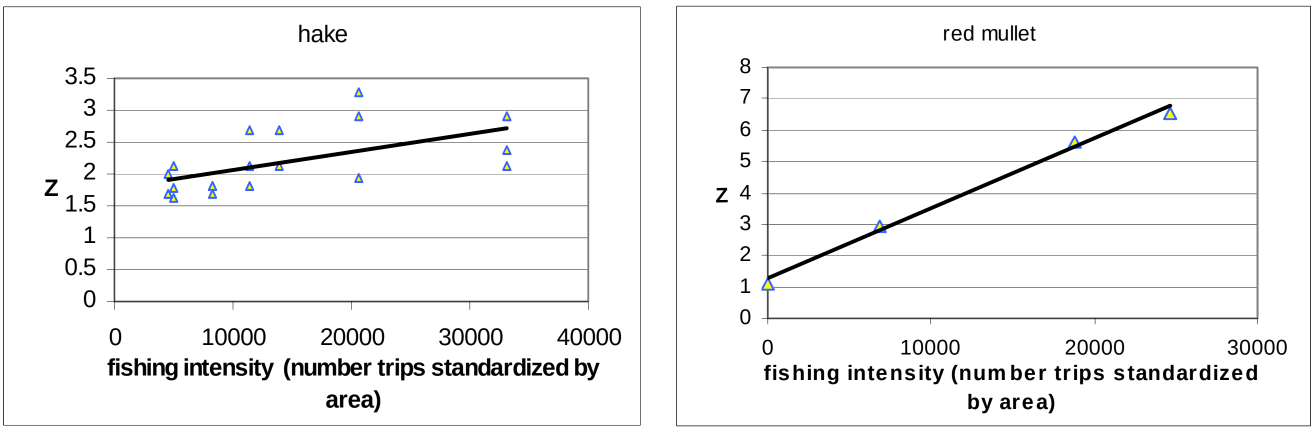

Fig.5 Correlation between fishing intensity and corresponding total mortality rates for each one of the analysed areas for European hake (left) and red mullet (right).

2) Biomass dynamic approach using Z and Biomass time series proceeding from trawl surveys

A time series of data of estimates of Biomass and Total Mortality rates were used for fitting a version of the logistic Schaefer model. Biomass and total mortality estimates time series were derived from trawl surveys performed within the GFCM GSA9. In this case a non-equilibrium production model was fitted. With this approach the parameters of the logistic population growth model r and K were estimated. The problem of the lacking of information on catch per year included in the equation was solved by substituting C by the Baranov catch equation. In this case we only need, as complementary information, of an estimate of natural mortality. This procedure is acceptable in the case we assume that the used F value is such a weighted average value that apply for the whole range of exploited ages of the stock.

Data from the Italian trawl surveys was used here. The fitting was performed with the MS Excel solver by minimizing, with a non-linear procedure, the sum of the squared deviations between observed and estimated values of Biomass by changing seed values of r and K (Fig. 6).

Mullus barbatus

r	0.65
K	452976.45

M=	0.8

Year	Observed Z	Predicted B	Observed B	ln(obs/exp)^2	
1990	2.970		74151.19		
1991	3.370	63265.07	85001.96	0.087226	
1992	3.330	67518.01	72574.44	0.005215	
1993		59224.67			
1994	3.290		44805.99		
1995	3.190	38534.22	32356.99	0.030526	
1996	3.530	28741.16	35809.16	0.048344	
1997	3.270	30471.29	48036.80	0.207191	
1998	3.100	41185.06	30854.05	0.083410	
1999		27777.21			
2000	3.240		51210.15		
2001	3.150	43827.64	32428.40	0.090740	
2002	3.240	28940.92	48547.43	0.267583	
2003	3.340	41735.21	25923.84	0.226749	
2004	2.320	22874.41	16748.44	0.097166	
2005		17390.68		1.144151	sum
				minimize	

Fig. 6 MS Excel spreadsheet used for the estimation of parameters r and K

Even if more statistically robust approaches can be used aimed at a dynamic fitting of data that takes into consideration observation errors, results obtained with the simplified methodology included in the spreadsheet that is intended to use during the workshop are satisfactory (Fig 7).

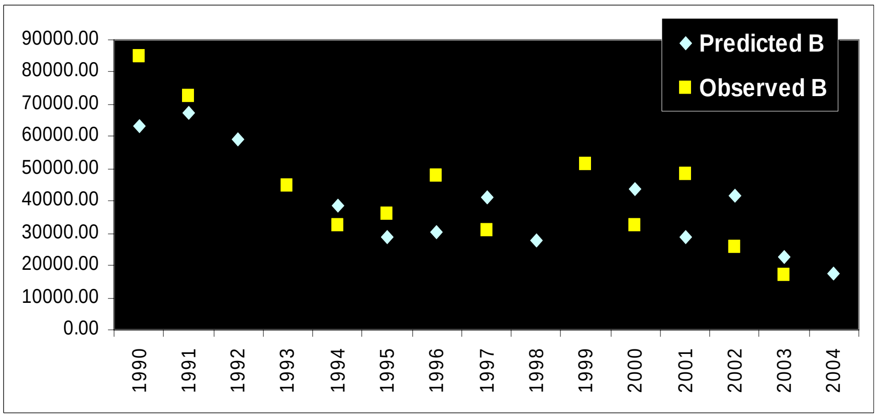

Fig.7. Estimates of evolution of biomass obtained with the non-equilibrium biomass dynamic model compared with the observed values.

With the output values derived from this approach, we can construct equilibrium curves and to estimate the likely consequences of changes in fishing pressure as regards relative yields and biomass (Fig.8).

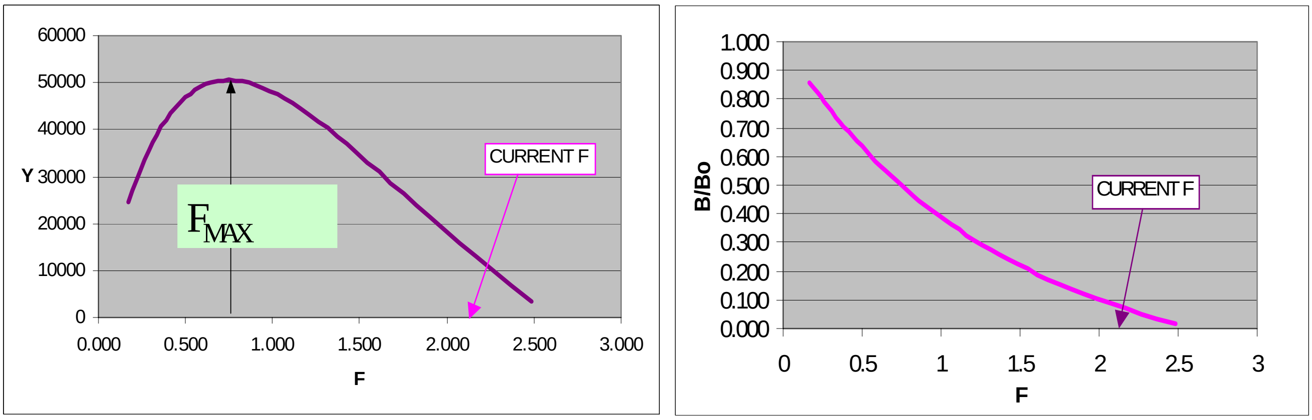

Fig.8. Equilibrim Y/F model (left) and evolution of the Current Biomass/Pristine Biomass rate under different levels of Fishing Mortality. Arrows show the current value of F.

Preparation of data for the anaysis (in bold the recommended procedures)

MEDITS data allow the reconstruction of the size structure at sea for the species considered vulnerable to the gear in use (obviously this apply to the sizes considered completely recruited to the gear). With this size structure, it is possible to make an estimation of the ***instantaneous mortality rate Z****. For the estimation of Z it can be used the length converted catch curve to analyse the right (descending) portion of the curve (the method however is not suitable for very fast growing species when samples proceed only from one season). Moreover, we have to assume steady state and same mortality rates and recruitment strength for all the age classes represented in the samples and used in the analyses. For a proper use of the length converted catch curve method, it should be necessary to keep separated males and females, especially for those species that show important sexual dimorphism as regards size-at-age. In this way, estimates will be more precise and not biased. It is recommended to perform estimates of Z separately and successively to proceed to compute a weighted average based on numbers of each sex in the total sample*

Z can be also estimated as the -logarithm of the survival rate between the numbers of two successive year classes: Z= –Ln(Nt+1/Nt). In this last case, it is neccesary to separate the cohorts through the use of some statistical package (i.e. MIX) or with one of the two approaches included in FISAT (Sparre& Venema, 1998) or with some of the three methods included in the new FAO stock assessment tools (Hoggarth et al. 2006), in particular within the LFDA5 software (slicing procedure). Even if it is possible to estimate survival rates by comparing the numbers of survivals of two successive years in the same size distribution, in this case we have to assume equilibrium and similar recruitment strength every year. ***It should be better to compare survivals of the same cohort in successive years****. For instance, we can estimate the survival rate between the 2-year-old individuals in the survey of year x with the surviving individuals (3-year-old) present in survey of year X+1. Separation of cohorts (modes) is easier if sexes are kept separated. Successively individuals of both sexes of the same age can be added and a single survival rate can be estimated.*

Another alternative for the estimation of Z is the use of the Beverton & Holt equation (Beverton & Holt, 1956) or Z/K with the Power-Wetherall method (Powel,1979; Wetherall, Polovina and Ralston,1987). In the case of species with very strong and discrete recruitment, it is convenient to eliminate the first cohort in order to avoid misleading results. Size-at-age differences between sexes may create also in these cases some problems.

It is necessary to remind that for the estimates of the series of Z, it is necessary to use always the same method and to be sure about the consistency of data for the whole time series. Moreover, in the case of the composite model, all the compared data sets (those of the different areas) have to be estimated with identical methodology.

Considering that trawl surveys are performed in a very restricted period, it is possible that both, the estimates of Z and the index of biomass will be biased, but this fact it is likely that will not create major problems when the bias is always the same.

Catch rates can be estimated with the swept area method if the gear width and swept distance are known using eletro-acustic and geo-postioning tools. A rough estimate of the swept area can be obtained by multiplying the width of the mouth of the net estimated with some empirical equation by the covered distance (speed x time) (Sparre & Venema, 1998). Catch rates might be expressed per unit of surface (kg/km2). Alternatively, catch per hour can be used, but probably results will be less precise. As soon as time series of yearly estimates of Z and abundance index are available, data can be included as input in the spreadsheets and proceed with the estimations. An external estimate of M is needed. M can be estimated through the use of some empirical equation (i.e. Pauly's formula) or may be derived from other source of information.

It is suggested to prepare,when possible, time series data of Z and kg/km2 for Merluccius merluccius, Mullus barbatus, Nephrops norvegicus, Parapenaeus longirostris as well as for other species that may have some local importance, not very contagious distributions and good catches. It is possible that this information be already available for most of the countries that have participated to the MEDITS project because the analysis of trends of these variables were already used as indicators during the Nantes workshop.

Data have to be preferably presented in the following Excel format:

M=	0.57

Year	Z	Kg/km2
1994	0.45	34
1995	0.56	32
1996	0.55	33
1997	0.63	27
1998	0.64	25
1999	0.7	20
And so on…		

Table 1 . Example of presentation of input table (an MS Excel file is preferred)

Warning.

A complete standardization of procedures will be necessary. Even if in this document many recommendations facing to this problem are included, the list obviously can not be exhaustive and it is possible that in some cases will be still necessary some adjustement. It is in consequence necessary to bring not only the input table described above but also the rough data used for the estimations (but prepared following the recommendations written below for participants that will not bring elaborated data). This will allow, if necessary, re-calculations in the case indicators proceeding from different GSA's will be jointly used in some elaboration (i.e. composite model)

Conclusions

Both approaches presented here use data that are routinelly estimated in the MEDITS project. They are simple and furnish results easy to understand and to translate in measurable actions. Being data not very precise and some times biased due to different causes, the results of the assessments have to be managed with caution. Moreover, they do not explicitly take under consideration the interactions among species, even if the use of Z instead of fishing effort data in some way considers the likely influence of other species (ie: predation, competition) in the natural mortality rate that is a component of Z.

Nevertheless, the use of such approaches constitute an unique opportunity to have at least a rough idea of the current status of the single species and for the evaluation of the likely consequences of changes in fishing pressure when fisheries dependent information is completely lacking or not reliable.

The proposal is to encourage people to test the described approaches with their own data, during the MEDITS-GFCM workshop that will held in march in Rome.

For the use of the composite model approach, Z and the abundance index might be estimated considering the hauls performed within the whole GSA. In the case internally to a GSA it is possible to define sub-areas exploited with very different rates, couples of Z and Kg/km2 may proceed from fractions of a GSA. This fine division is only possible if we *have good enough information on the size and approximate operation areas of the fleets fishing within the GSA.*

With the composite model it is possible to simultaneously analyse the data proceeding from all the GSA's, but is better that the anaysis be performed including areas exploited with different rates (necessity of contrasting data) but that are homogeneous under an ecological point of view (similar pristine productivity and evolution under changes of fishing pressure). For instance, it could be done an analysis including several GSA's belonging to the same sea (Ionian, Tyrrhenian, Adriatic, Aegean) or for more wider areas only when for whom similar characteristics can be hypothesized.

There is however the possibility to perform an exercice putting together all the data sets from all the areas as proposed by Caddy during the SAC-GFCM meeting held in Istanbul, 8-10 March, 2006 (GFCM- SAC Meeting on Stock assessment methodology Permanent Working Group on Stock Assessment Methodology and Black Sea Commission). It is possible that an important contrast among exploitation rates be more important and informative than the noise produced by the likely differences of productivity among distant areas. We have to make many trials with real data proceeding from different areas of the Mediterranean sea. It is likely that in this way we can better define spatial scales and produce further improvements of the quality of the approaches described in this document.

In the case of the non-equilibrium production model, it is possible that for those areas where fishing pressure has remained almost unchanged along the years for which data is available this kind of analysis will not produce satisfactory results.

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Recommendations for all the participants:

For the estimates of abundance indexes, for computations it is recommended to only use the data of the tows of the depth interval where the species is more abundant. It is proposed to use for some species exclusively the tows made in the depth interval 0-200, for others only the tows made over 200m, or for those species distributed within a wide depth range, data of all the tows. It is difficult to suggest for each single species a common criterium suitable for all the GSA's, but is important to proceed in this way in order to avoid the introduction of bias, especially if the relative sampling density among depth intervals has changed along time.

Size classes will be structured by 1 cm for fishes (size class 0 include individuals up to 0.9999 cm and so on) , 0.5 cm for molluscs (size class 0 include individuals up to 0.4999 cm and so on) and for crustaceans by 2mm, (for instance class 0 should include individuals from 0 to 1.99999mm). In consequence the size intervals for fish will be 0,1,2,3 etc for molluscs 0,0.5,1,1.5, etc and for crustaceans 0, 2,4, 6 etc. In order to save time, all the size distributions should start from 0.

Warning: There are some difficulties for the estimation of Z for hake, due to the differences in the importance of the recruitment by area and depending on the annual differences in the date when surveys were carryied out in successive years. This problem is very general, and independent to the used method. It is suggested for this species to eliminate from the data the age class 0. If the Beverton & Holt method is used, in this case (removal of age 0 individuals) the size completely recruited (called Lc or L') has to be arbitrarily set to the size at which individuals reach age 1 (i.e. 14 cm). For red mullet, spring surveys are ok because they are done before the occurrence of the massive recruitment, that may produce important noise and Length Converted Catch Curve may work. For *Nephrops*, our experience suggest that for the estimation of Z, the LCCC works quite well even with only one sample per year. For *Parapenaeus* there is less experience but LCCC could be used (with more caution).

For participants that will bring rough data

Considering that is expected that some participants, due to different causes, will not be able to bring the requested elaborated data (time series of Z and Kg/km^2), some reccomendations are furnished in order to standardize procedures and to optimize the use of the limited time available for the development of the workshop.

Abundance index (kg/km2)

For each tow, those participants should bring at least information for each tow on **depth**, catch per species expressed in Kg, the **area of each depth stratum** and some measure of the **horizontal opening of the net** (wing spread) and the **covered distance** (calculated as towing speed/towing time or with the vessel's log). Instead of towing speed/time or distance estimated with the log, the distance (expressed in nautical miles) covered can be also estimated using the geographic position of the beginning (Lat1, Long1) and end (Lat 2, Long2) of the tow as:

$$D = 60 * \text{SQUAREDROOT}((\text{Lat1-Lat2})^2 + (\text{Long1-Lat2})^2 * \text{COS}^2\ (0.5(\text{Lat1+ Lat2})))$$

By multiplying the distance (converted in Km2) by the net width (also in Km2) we will obtain the swept area. By dividing the catch by the swept area, we obtain the kg/km2 in each tow. Successively, we can calculate the mean index of abundance for the stratum and its variance and successively to estimate the overall average value for the considered strata where this particular species live. (see MSExcel sheets included in the file **UTILITY.xls** enclosed)

Estimates of Z

For the estimates of Z, participants that will have not time to prepare data as requested should bring the **size distributions by haul standardized to one hour towing**, when possible **divided by sex**, and specifying the **depth**. It is advisable that each distribution be positioned in one column of a Excel spreadsheet with an **identification header, (station, date, year, sex)** and a common first column with the size intervals.

This will make possible to paste all the size frequencies in one of the softwares that is expected will be used for the estimates (i.e. LFDA5 of the new software FAO Tech Pap 487 is very useful and fast). The mentioned software allows the estimation of Z with the LC Catch Curve, and also with the Power-Wetherall and Beverton & Holt methods , allows estimating the Von Bertalanffy growth parameters as well as the transformation (after the definition of the growth parameters) of the size distributions in age distributions. With these data structured by age, it will be possible to compute mortality rates as the –Ln of the survival rate for the same cohort in two successive surveys.

In the file **UTILITIES.xls,** the preferred format for the preparation of rough data is shown. The file also includes some simple routines that is expected will facilitate some calculations. These regards:

1) the estimation of the swept area when no direct measurements have been done of net wings spread and tow covered distance, but some other available information make possible to proceed with an approximated estimation

2) The estimation of the mean abundance index (kg/km2) derived from a stratified sampling

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