APPENDIX/ANNEXE I

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APPENDIX/ANNEXE I (cont.)

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* until 20/4/07.

APPENDIX/ANNEXE II

LIST OF WORKING DOCUMENTS/LISTE DES DOCUMENTS DE TRAVAIL

	Title	Authors	Document reference	Contact
1	First approach for the identification of sardine populations *Sardina pilchardus* (Walbaum 1792) in the Moroccan Atlantic by allozymes	Malika Chlaida, Souad Kifani, Philippe Lenfant and Lahoussine Ouragh	SPWG/07/1	malikachlaida@yahoo.fr ma_chlaida@hotmail.com
2	Choice of age structure analysis models to assess chub mackerel stock state in Northwest Africa	Nikolai Timoshenko	SPWG/07/2	timoshenko@atlant.baltnet.ru
3	Rapport du sous-groupe sur la croissance de *Sardinella aurita*, Nouakchott, 28-31 août 2006	Ad Corten (présenter)	SPWG/07/3	adcorten@yahoo.co.uk
4	Spanish report of the activity of European pelagic trawlers fishing in Mauritania and landing in the port of Las Palmas de Gran Canaria, Spain. 2004, 2005, 2006.	P. Pascal-Alayón, E. Hernández, M.T.G. Santamaria, E.Balgueruias	SPWG/07/4	pedro.pascual@ca.ieo.es
5	Trawling surveys of pelagic fish recruitment in the Canary upwelling zone	Nikolai Timoshenko	SPWG/07/5	timoshenko@atlant.baltnet.ru
6	Standardisation des rendements de la pêche des flottilles industrielles en activité dans la ZEE mauritanienne par l'application du GLM	Mahfoud Ould Taleb	SPWG/07/6	mahfouddht@yahoo.fr

APPENDIX/ANNEXE III

BIOMASS DYNAMIC MODEL WITH ENVIRONMENTAL EFFECTS USER INSTRUCTIONS

by Pedro de Barros

1) General instructions

a) Data entry

Data and initial parameter estimates should be entered only in the cells coloured green (Figure 1). All other cells are either not used, or used to calculate quantities used by the model. Data must be entered for all the data columns coloured green, and also for initial values of the parameters. Additionally, the model control settings may be entered (in the cells coloured orange – Figure 1). If these control settings are not changed, they may be left at their default values.

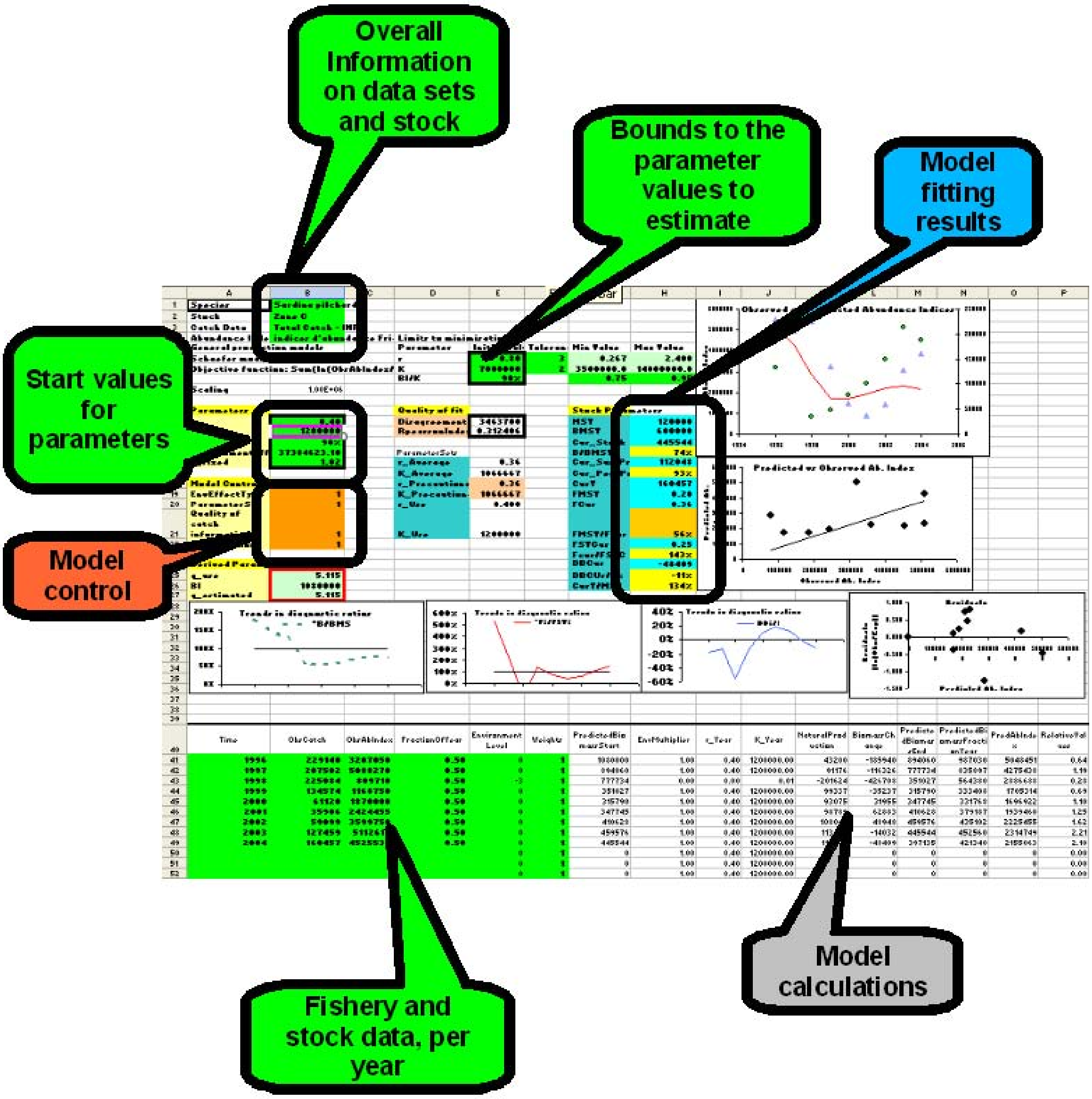

Figure 1. The main areas in the model worksheet

b) *Defining the parameters to be estimated non-linearly (using Solver)*

The non-linear estimation procedures suffer from a number of limitations, of which the most important is probably that the estimates obtained will depend on the start values defined. Therefore, one should try to keep the number of parameters to be estimated non-linearly to the minimum possible values.

As a minimum, one must estimate r and K by fitting the model to the data using the solver algorithm.

When defining the parameters to estimate, one should as much as possible set constraints (maximum and minimum values) so that the algorithm is limited to reasonable values, defined by the researchers. Use the spreadsheet area of Minimum and Maximum values to define these.

2) Detailed instructions

Entering data

The following data MUST be entered in the appropriate cells of the worksheet (Figure 2):

i) Years of the data (Year)

All years from the first to the last in the data set should be entered, consecutively. The first year should be entered in the cell immediately below the header "Year" and run consecutively until the last one. No empty cells should exist between the data, only after the last year;

ii) Total catch per year (ObsCatch)

Total catch is REQUIRED for ALL years in the data series. The model will fail if catch data is missing for any of the years (the reason is that catch is essential to calculating stock abundance the following year). This column should be filled like the one for year;

iii) Abundance index (ObsAbIndex)

This column should be filled like the previous ones. However, if there is no abundance index for a given year, this can be left blank. The model will still run correctly without a few years of data of Abundance indices (if there are many, however, the reliability of results will be doubtful);

iv) Timing of the abundance index (FractionOfYear)

When the abundance index corresponds to e.g. a scientific survey, or to a fishery concentrated in a short season, it will not represent the average abundance of the stock during the year, but rather this same abundance at the time of the survey or fishery. The values in this column represent the timing of the abundance index as a fraction of year (0.5 = July 1st). It should be set to a value corresponding roughly to the mid-point of the survey or of the fishing season. If the abundance index corresponds to a CPUE from a year-long fishery, this value should be set to 0.5 (mid-year).

v) Environment level

This column will include any index that can be considered to represent a deviation of the average growth conditions of the stock in each year. If a series of environmental indices exist (e.g. a series of upwelling indices) these can be used as the environmental level. If not, and there is external scientific evidence that there were particular years with exceptional conditions, then an arbitrary positive (for good growth) or negative (for poor growth) environmental level can be set for that year. If there is no information on environmental elements affecting the carrying capacity and/or the intrinsic growth rate of the stock, or it is considered that these parameters do not vary significantly, then the values in this column can be left at their default values of 0.

vi) Weights

Is some cases, there are doubts about the reliability or the representativeness (compared with the rest of the series) of one or a few of the abundance indices used (e.g. if there is a year with less complete coverage, or with uncommon distribution conditions). In these cases, the corresponding value of the abundance index will not be as reliable as the remaining of the series. These points can be given less weight in the fitting of the model, by setting a value less than **1** in the corresponding row of the column Weights.

Notes:

The number of consecutive non-empty cells in column Year is used to define the number of years in the data to fit. Therefore, only years for which catch data is available must be entered, and all cells below these must be empty (use “Delete”).
In the calculated columns (to the right of the column “Weights”) the rows below the last year of data should NOT be deleted. The worksheet will ignore those below the last year of data. Deleting these rows will force one to rebuild them when a new data point is entered.

Time	ObsCatch	ObsAbIndex	Environment Level	Weights
1996	229140	3207050	0	1
1997	207502	5088270	-3	1
1998	225084	809710	0	1
1999	134574	1168750	0	1
2000	61120	1870000	0	1
2001	35906	2424455	0	1
2002	59099	3599750	0	1
2003	127459	5112613	0	1
2004	160457	4525538	0	1
			0	1
			0	1
			0	1
			0	1
			0	1
			0	1

Figure 2. Spreadsheet section for entering the data for model fitting

Initial parameter values

Enter the initial values (initial “guesstimates”) of the parameters in the appropriate cells. As a minimum, initial values for the parameters **r** (intrinsic rate of growth), **K** (Carrying capacity, or Virgin Biomass) and **BI/K** (Stock Biomass at the start of the data series, as a proportion of the Virgin Biomass) are required.

Defining appropriate start values to these parameters may be difficult, and may require a bit of trial and error. However, setting adequate initial values is essential for the success of the estimation procedure.
One should start by defining an adequate value for BI/K.
To start the model running, it is necessary to give it a start point, the stock status at the start of the data series, BI (Initial Biomass). It is often very difficult to provide reasonable values for this parameter, but it may be easier to provide, from the knowledge of the scientists involved with the stock, a first estimate of the level of depletion of the stock at start of the data series available. This approach is similar to the idea of using the Exploitation Ratio (E) to start the calculation in a VPA, as suggested by Cadima (2004). The first estimate of this value will be named $\mathbf{BI/K_{Guess}}$.

A start value for r is usually found by setting r to a value similar to the natural mortality coefficient assumed for the stock.

A start value for K is usually more difficult, but a value consistent with the remaining parameters can also be found using a simple reasoning, as follows;

1- "Guess" the value of average stock Biomass during the period included in the assessment, (B_{Guess});
2- Calculate the average value of the Abundance Index used in the same period, ($AI_{Average}$). Make sure to include only real values of the abundance index, and to ignore any missing values;
3- Calculate a first estimate for the catchability coefficient **q**, as $q_{Guess} = AI_{Average} / B_{Guess}$;
4- Calculate a first estimate of the stock Biomass at the start of the series, (**B_{Start}**), using the value of the abundance Index at the start of the series, (**AI_{Start}**), and the first estimate of the catchability coefficient **q**, q_{Guess}, as **BStart = AIStart/qGuess**;
5- The first estimate of K (**K_{Guess}**) is then given by **$K_{Guess}=B_{Start}/(BI/K_{Guess})$**

This procedure is implemented in the worksheet "InitialValues", within the workbook supplied (Figure 3).

6			
7	AbIndexFirst	3207050	
8	BI/K	90%	This is arbitrated and depends on external information about wha
9			
10	AverageBiomass	3000000	"Guessed" from external information
11	AverageAbIndex	3089571	From real supplied data
12	CatchabilityGuess	1.029857	
13	BiomassFirst	3114073	
14	K_Guess	3460082	
15			

Figure 3. Estimation of the initial value for K implemented in the worksheet "InitialValues"

b) Setting limits to the estimation

When using non-linear estimation, it is advisable to set limits to the values the parameters may take. To do this, enter the appropriate values in the “tolerance” column for the estimation of **r** and **K**. If **BI/K** is to be estimated by the model, the upper and lower limits should be entered directly. Whenever the initial values for the parameters are modified, the values in cells InitialValues should be set to the same values entered in the cells used for the model parameters (Figure 4)

Initial Value	Tolerance	Min Value	Max Value
1.00	4	0.250	4.000
4993858	6	832309.6	29963145.4
90%		0.75	0.95

Figure 4. Process of defining the limits to the estimation in the model worksheet

c) Model control

In its current version, the model implementation allows the user to choose 3 main aspects of the calculation, (1) the type of environmental effect (simple multiplicative or exponential), (2) to estimate or not the catchability coefficient (q) and (3) the set of parameters to use for calculating the reference points and the current status of the stock relative to these reference points.

18	Model Control	
19	EnvEffectType	1
20	ParameterSet	1
21	Quality of catch information for last few years	1
22	q_Estimation	1

Figure 5. Cells of the spreadsheet used to control the options in the calculations of the model

i) Choice of environmental effect type:

The model includes two different formulations for the effect of the environment level on the r and K parameters of each year.
To select the type of environmental effect, set the value in cell EnvEffectType (Figure 5) to one of the following values:
0 – No effect
1 – Additive formulation: EM=1+(EE*|EL|^SIGN(EL))
2 - Exponential formulation: $EM=e^{(EE*EL)}$
EM: Environmental multiplier
EE: Environmental effect: Measures the overall intensity of the environmental effect. Usually estimated by Solver as a part of the fitting routines;
EL: Environmental level: Indicator of level of environment, for each year (normally, will be deviations from the average).

ii) Use of q

The user may choose to estimate the catchability coefficient **q**, or set it as fixed.
To select whether to estimate or to use the fixed value, set the value in cell **q_Estimation** (Figure 5) to one of the following values:
0 – Use the fixed value set for the start
1 – Estimate the catchability coefficient
The user should **never** include q as one more parameter to be estimated by Solver. If it is meant to be estimated, it should be estimated using the linear approximation given in the worksheet (just set q_estimation to 1).

iii) Estimation of current (in the last year of data) Biomass

Even if the absolute Biomass values are not used directly (and they may be misleading, given the degree of uncertainty involved in their estimation), they are necessary to estimate the F-values, since these are calculated as F=B/Y.
The stock Biomass in the last year of data, that is used as a main element in calculating the current status of the stock or the fishery, may be calculated in one of two ways: Either taken directly from the model, as the Biomass value predicted by the model, or using the observed abundance index for that year, and the estimated q, to calculate B=U/q.
The choice of the best option is not straightforward. However, if the quality of the total catch data in the last few years is low, this will affect strongly the reliability of the Biomass estimates from the model. In this case, it is better to calculate the Biomass using the Abundance Index for last year and the overall q. To achieve this, set **Quality of catch information for last few years** (Figure 5) to 0 (bad quality). Otherwise, set it to 1, to use the Biomass estimates from the model.
Notes: The quality referred to here is not of the LAST catch data point (it has no effect) but rather the few years before the last.

iv) Variable r and K (depending on environment level of each year)

When using the option of introducing an environmental level indicator, different values of r and K are calculated for every year in the data set. In this situation, it becomes difficult to choose which is the best value of the parameters to use in the calculation of the overall reference points. The best option will depend on the situation at hand. To define the option to use, set the value in cell "Parameter set" (Figure 5) to one of the following values:

1 – Overall r (estimated by the fitting procedure, independent of the environmental effects used in the fitting);

2 – Average value of the r-values estimated for each year in the data series (using the environmental levels for each year);

3 (or other value): Precautionary option – the smallest of the two previous values.

d) Running the model (estimating the parameters)

This is usually done using the "Solver" tool in Excel.

Call the tool (Figure 6).

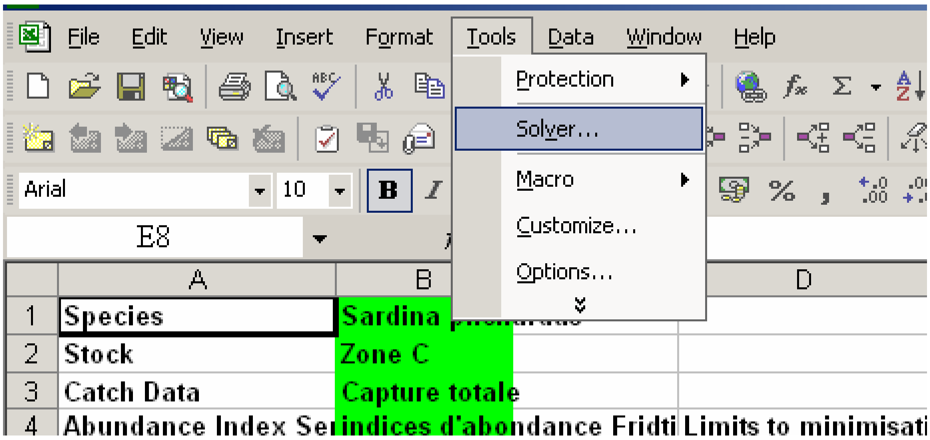

Figure 6. Starting the solver routine, for parameter estimation

Define the cell whose value is to be minimized Target cell (Objective Function) – Figure 7, and the cells that are to be manipulated for achieving this (By changing cells). You may choose all 4 parameters r, K, BI/K and EnvironmentEffect (if an environment effect is being estimated), or only a subset of these. You should not set the model to estimate q, as this is usually not defined enough by the data. Set also, as much as possible, the constraints – use the constraints area in the spreadsheet. Do not set constraints for the Environment effect.

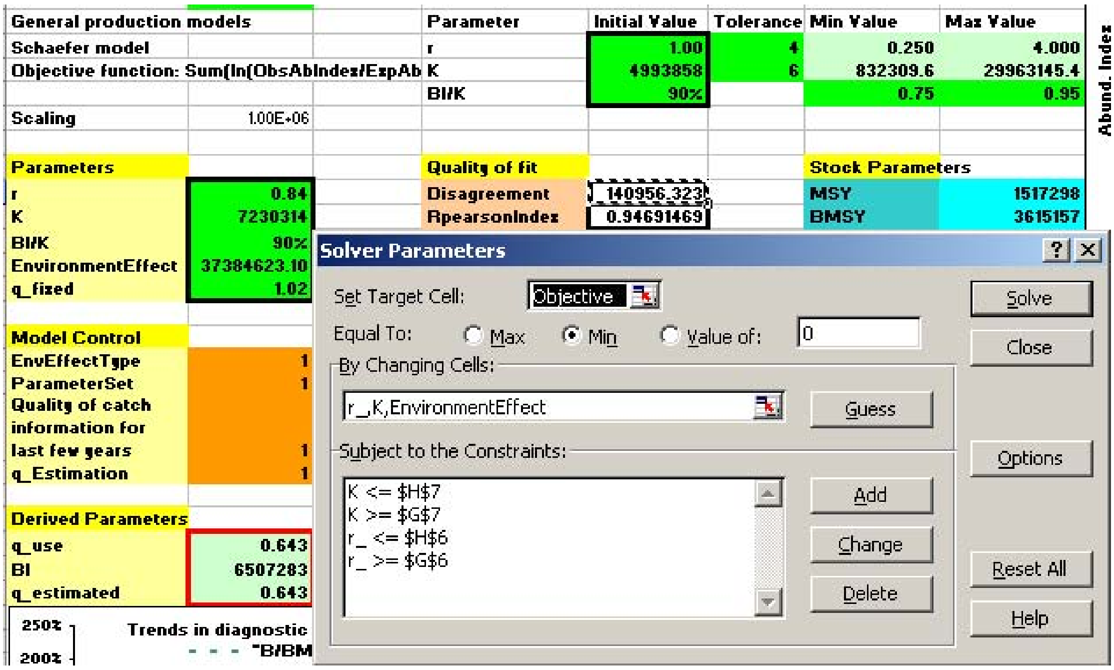

Figure 7. Setting the parameters for the solver routine.

After pressing "Solve", the following dialog should be seen.

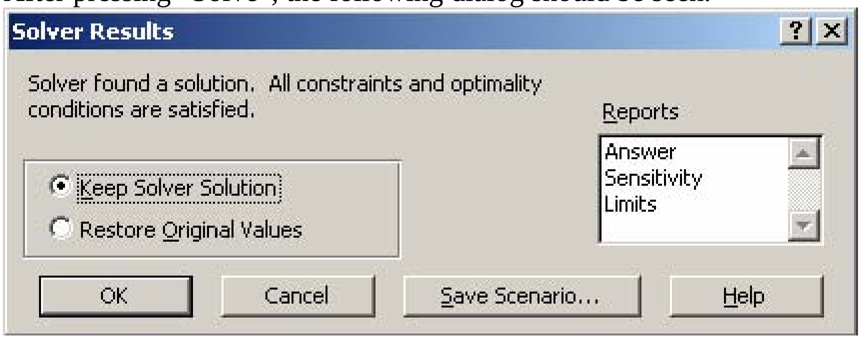

Figure 8. Dialog indicating the successful completion of the model fitting procedure

After pressing the OK button, the diagnostics can be assessed.

3) Diagnostics of fit

Like any model fitted to data, it is essential to assess the quality of the fit of the model to the particular data set used in each run. The model will almost always produce an estimate, but the reliability of the model fitting that produced these estimates should always be checked before accepting the results. There may be several reasons why a production model may not fit well a particular data set. Some of the most common ones are;

- Lack of contrast in the data
- "One-Way trip"
- Abundance index does not represent the whole stock
- Catch data are not representative of all catches, but come from only a part of the fleet, or are fixed estimates

To help assess the quality of this fit, a few indicators are provided.

a) Objective function

The actual value of the objective function (Figure 9) is the first measurement of the goodness-of-fit of the model. High values indicate a better fit. However, it is difficult to evaluate exactly what is “high”, and this is thus not usual as a diagnostics statistic.

Quality of fit	
Disagreement	1498416.332
RpearsonIndex	0.848396537

Figure 9. Cells holding the values of the objective function of the model fit, and of the Pearson linear correlation coefficient r.

b) Pearson linear regression coefficient between the predicted and observed abundance indices

This coefficient (Figure 9) will not detect a non-linear relation but will measure how closely the predicted abundance indices follow the observed ones. High values should be aimed for.

c) Plot of Predicted vs Observed Abundance Indices

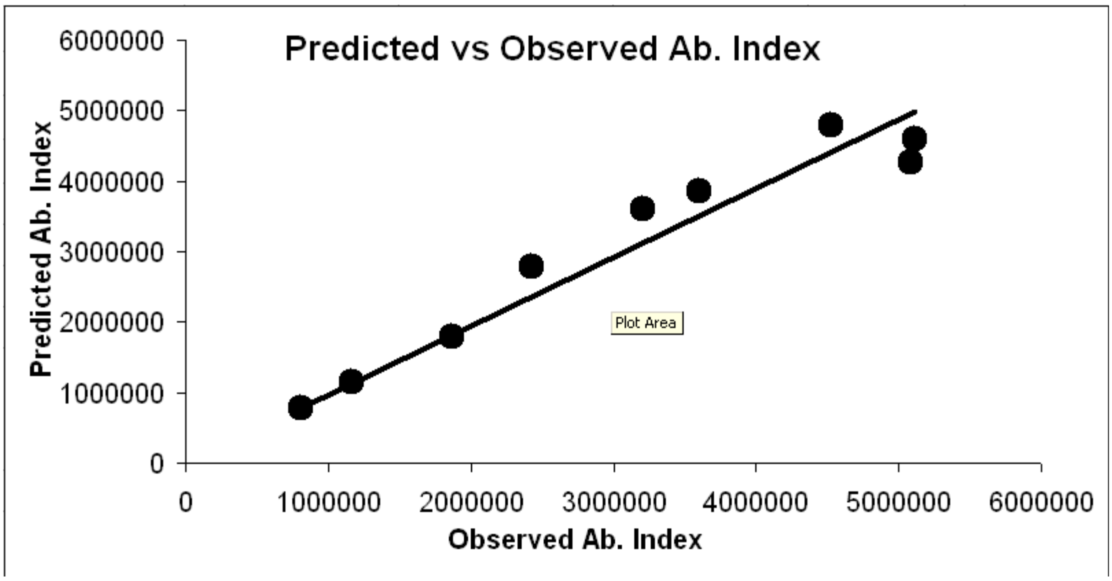

Figure 10. Plot of the relation between the predicted and the observed abundance indices. This plot can be used to detect severe deviations from the linear relationship between the observed abundance indices and those predicted by the model

This plot presents, in a graphical way, the relation between the Abundance Index observed (or given to the model) and the Abundance index estimated by the model, on the basis of the estimated biomass.
The desirable characteristics for this plot is a linear relation between the predicted and observed indices, with slope 1.
Undesirable characteristics include:
a) a flat plot (no relation between predicted and observed);
b) A non-linear relation (cyclic, asymptotic or curved relation)

d) Residual plot

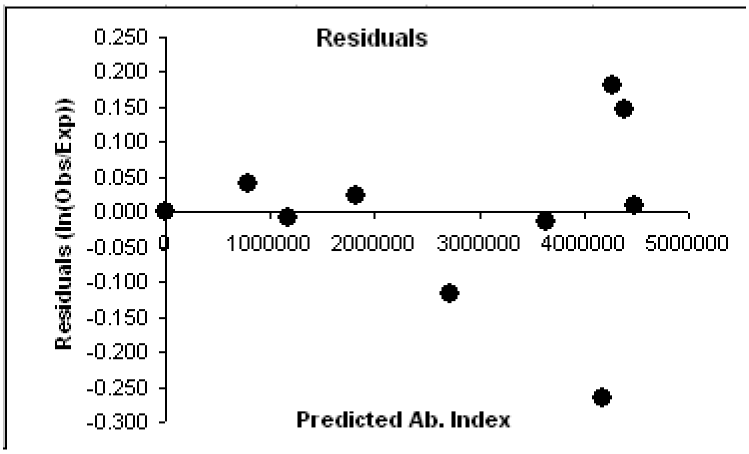

Figure 11. Plot of residuals used to assess if there are indications of any lack of fit in the adjustment of the model to the data

The residual plot is used to evaluate whether there are trends in the deviations between the observed and predicted abundance indices data. As long as the residuals are reasonably well-dispersed, with no patterns, there is usually no reason to concern. Unusually large or small residuals concentrated at a given range of the predicted abundances, however, should be looked into carefully, as they may indicate a model misspecification, or problems with the data

e) Trends in Biomass Indices and total catch data

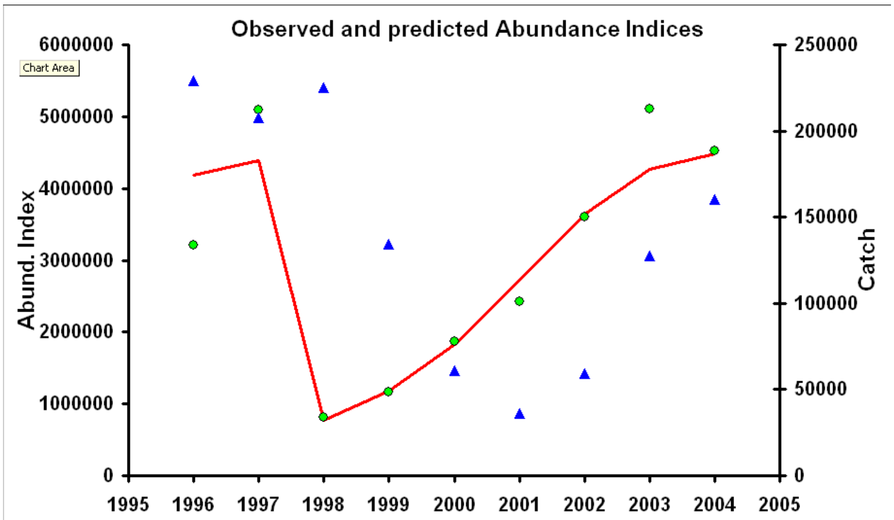

Figure 12. Plot of the trends in observed and estimated abundance indices, as well as of the reported catches, for each year in the period analysed.

The model is based on the assumptions that stock biomass tends to grow to a maximum level that can be sustained by the environment, and that this growth is decreased by the catches taken from it.
So, generally speaking, stock biomass trends should reflect the catches taken from it. A year with very high catches should see a reduction in stock biomass the following year, and vice-versa, a year with low catches should be followed by an increase in stock biomass.

Therefore, checking the plot of catches and stock abundance indices for these patterns gives a first indication of the reliability of the fit of the model to the data. A pattern where similar catch levels at similar Biomass levels are followed by both increases and decreases in biomass will in general indicate a contradiction between the data and the model. This may indicate several difficulties with the data, of which the most common are incomplete or inaccurate catch data, or abundance indices that do not represent the whole stock (e.g. they miss the larger adults or the juveniles). In some cases, however, a sudden change in the reaction of the stock to exploitation may also indicate that there was an environmental change or pulse that modified the average biomass growth rate of the stock (e.g. exceptional conditions that lead to a peak in recruitment). If the change in environmental conditions can be demonstrated by other, external data (e.g. similar anomalies arising simultaneously in several stocks, or Sea Surface Temperature data, or precipitation indices) then this can be included in the model by the introduction of an Environment level, for that year, that will account for the positive or negative changes in the growth conditions (intrinsic rate of increase and carrying capacity) observed or assumed for that year.

4) Interpretation of results

Once the model is satisfactorily fitted to the data, it is important to interpret the results from this fit. The model implementation provides several auxiliary ways to view and interpret the data.

a) Current (last year) situation

Usually, stock assessment scientists and managers are most concerned with the status of the stock in the last year of data. So, the model implementation computes several numerical and graphical diagnostics of the condition of the stock and the fishery in the last year (Figure 13).

Stock Parameters	
MSY	120000
BMSY	600000
Cur_Stock	445544
B/BMSY	74%
Cur_SustProd	112048
Cur_PercProd	93%
CurY	160457
FMSY	0.20
FCur	0.36
FMSY/Fcur	56%
FSYCur	0.25
Fcur/FSYCur	143%
DBCur	-48409
DBCUr/Bcur	-11%
CurY/MSY	134%

Figure 13. Summaries of the status of the stock and the fisheries in the last year of data

Of the different indices presented, the ones highlighted in yellow are the ones most important for the stock diagnostics, and of these, special importance is given to the ratios B/BMSY and FCur/FSYCur.

The first of these ratios indicates the current status of the stock biomass relative to the Biomass that would provide the Maximum sustainable yield, and provides an indication of the current stock status relative to a target stock status. In most situations, one would want the stock to be slightly above BMSY, i.e., with a B/BMSY ratio slightly above 1.

The second indicates the value of the yield currently being extracted from the stock, relative to the yield the same stock can provide while keeping its abundance constant for next year, i.e. to the sustainable yield of the stock. Values of this ratio below 1 indicate that the stock biomass will tend to grow, while values above 1 indicate a situation leading to a decline in stock biomass.

To ease the interpretation of the results for the last year of data, the estimated stock Biomass for the last year of data and the corresponding catch are presented relatively to the Biomass that would produce the Maximum Sustainable Yield and to the Sustainable Yield, respectively, in the plot in the chart sheet "CurrentSituation" (Figure 14).

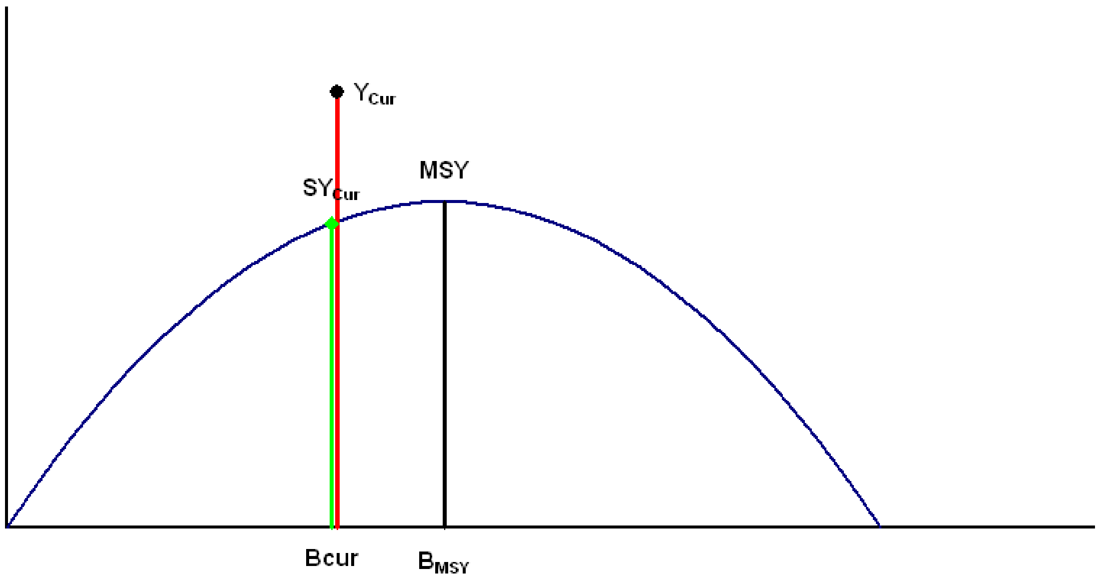

Figure 14. Graphical presentation of the status of the stock and the fishery in the last year of available data, relatively to the Reference Points estimated for the stock

b) Time-patterns

Besides the situation in the last year of data, it may be useful to assess the trends in these indices along the period analysed. All these indices are calculated for each year in the main spreadsheet, but for ease of presentation and interpretation they are also presented graphically (Figure 15).

Three main indicators are presented:

a) Ratio B_i/B_{MSY}. This ratio indicates whether the estimated stock biomass, in any given year, is above or below the Biomass producing the Maximum Sustainable Yield;

b) Ratio F_i/F_{SYi}. This ratio indicates whether the estimated fishing mortality coefficient, in any given year, is above or below the fishing mortality coefficient producing the sustainable yield in that year. Values below 100% indicate that the catch taken is lower than the natural production of the stock, and thus that stock biomass is expected to increase the following year, while values above 100% indicate a situation where fishing mortality exceeds the stock natural production, and thus where stock biomass will decline.

c) Ratio DB_i/B_i. This ratio indicates the change in estimated Biomass relative to current Biomass (in any given year). Positive values indicate a year of increase in Biomass, while negative values reflect years of declining biomass.

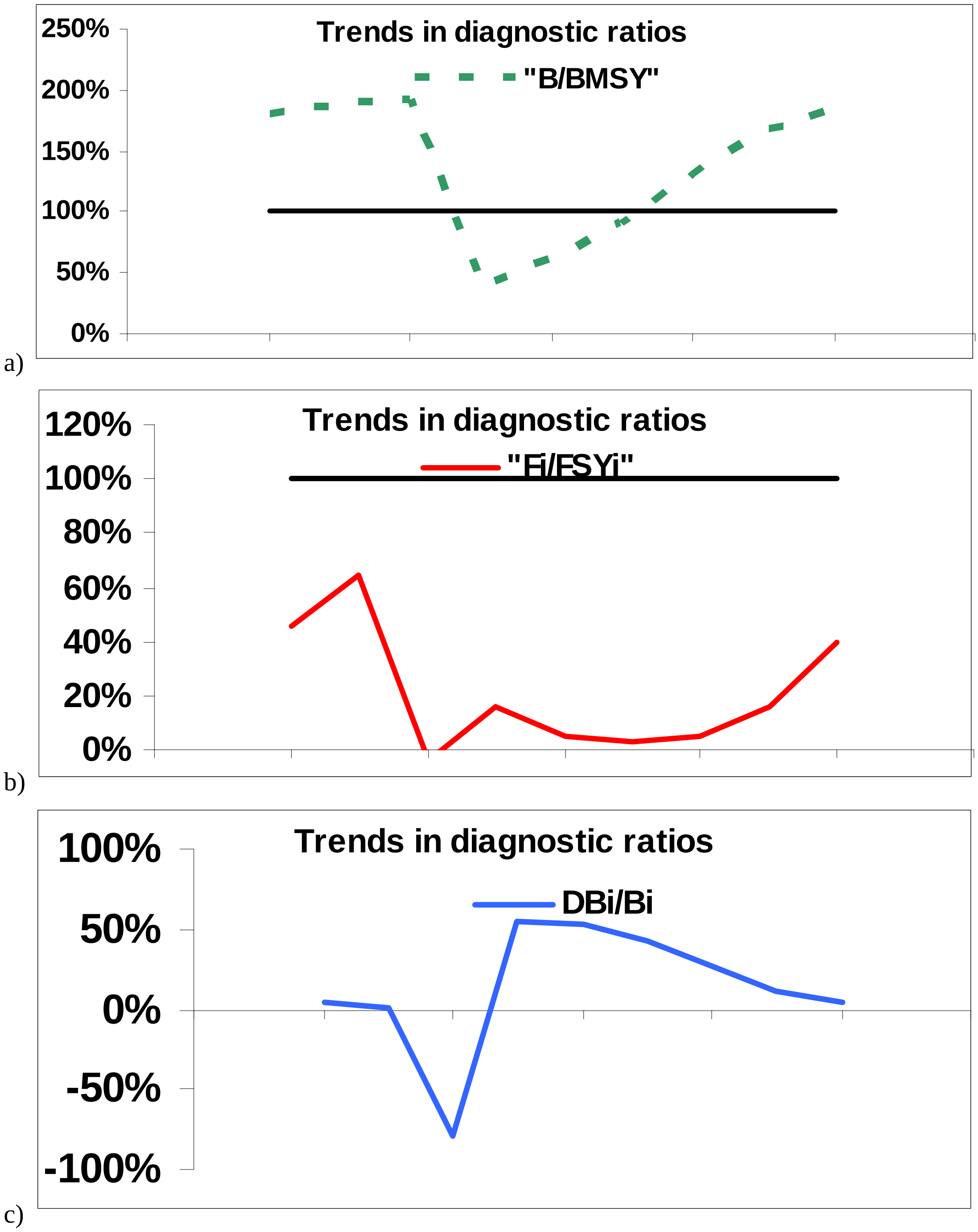

Figure 15. Graphical presentation of the evolution of the main stock status diagnostics along the period included in the analysis. a) Ratio $B_i/B_{MSY;}$ b) Ratio F_i/F_{SYi}; c) Ratio DB_i/B_i.

PROJECTIONS OF FUTURE YIELDS AND STOCK ABUNDANCE USING DYNAMIC SURPLUS PRODUCTION MODELS - GENERAL CONCEPTS AND IMPLEMENTATION AS EXCEL SPREADSHEETS

by Pedro de Barros

1. INTRODUCTION

a) Management measures available to fisheries managers

Fisheries managers have at their disposal a wide array of management measures that are usually classified into three groups, (a) input control measures; (b) output control measures and (c) technical measures. Input and output control measures aim to control the overall fishing level, i.e., the total mortality applied to the stock, while technical measures intend to control the way how this total mortality is distributed by the different size- or age-groups of the stock.

Input control measures include all the management measures that limit the fishing effort applied to the fishery, and include limitations of fishing licenses, of total number of fishing days, or any other similar measures;

Output control measures are those measures that limit the total catch removed from the stock, usually as total biomass removed, but sometimes also as numbers of individuals. Limitations of Total Allowable Catch (TAC) are the most common form of these measures.

Finally, technical measures include those measures like mesh size limitations, minimum landing sizes, or closed areas and seasons.

The advantages and disadvantages of different management measures are discussed by several reference books, like e.g. Hilborn & Walters (1992) or Hogarth *et al.* (2006).

b) Projections in the fish stock assessment process

The fish stock assessment process includes in general at least four main steps, besides the data collection steps:

1. Deciding the best model to represent the dynamics of the stock and the fisheries, based on (i) the characteristics of the stock and the fishery, (ii) the management measures considered, and (iii) the data available on the fishery and the catches;
2. Estimating the parameters of the model (fitting the model to the data available) and calculating, where possible, the Biological Reference Points (BRP's);
3. Assessing the current status and the historical trends of the stock and the fishery (in Biomass, Fishing Mortality, Average Size or any other indicator of stock status) relative to the BRP's chosen to manage the stock;
4. Evaluating the likely consequences, for the stock and the fishery, of alternative management options. This most often involves projecting the development of the stock and of the catches, as well as of other statistics of the stock and the fishery, under different options for management or future scenarios.

The projection of stock and fishery status under different assumptions regarding the dynamics of the stock and the management measures applied is an essential step in the provision of management advice, as it allows managers to evaluate the likely consequences, for the stock and the fishery, of the different management options at their disposal.

Projections can be done for the long-term, medium-term or short-term. Each of these has different purposes and properties that must be considered carefully when deciding which ones to carry out.

Long-term projections, also called equilibrium projections, are used to assess the average long-term relation between the main indicators of stock and fishery status on one hand and fishing level, or other quantities defining a fishery, on the other. They require the assumption that all conditions are kept constant for a time-period at least as long as the life-span of the target species, and do not depend on the current state of the stocks, which is not taken into account. Also, they do not include time as a variable. As such, they can not be used to assess management measures that vary with time (e.g. a policy of decreasing TAC progressively), nor do they allow one to predict the status of stocks or fisheries at any defined point in time. These projections are mostly used to estimate the values of Biological Reference Points, estimate desirable states of the fisheries and compare the long-term merits of alternative management measures.

Short-term projections, on the other hand, are usually made for a period of 1-2 years after the current year/period. They depend strongly on the current state of the stock and the fishery, and assess their evolution at different times after the current moment/time. Because they consider time explicitly, they can be used to assess the effects of management measures varying with time, and to predict the status of the stocks and fisheries at different points in time within the time-frame they consider.

Finally, mid-term projections are usually made for a period of 3-10 years from current time. They use the same equations as short-term projections, prolonging them for a longer period. They can thus be used for the same purposes as short-term projections. As they extend farther from the current year, however, they become more and more dependent on the assumptions of the model, and less on the estimates of current stock and fishery status. As such, particular care must be exercized when interpreting the results of such projections. This effect is more marked the shorter the life-span of the stocks being analysed, since with long-lived species the individuals currently present in the stock will influence its total abundance for a longer number of years.

Both long-term and short-term projections can be carried out based on production or structural models. However, only projections based on structural (age-, length- or stage-structured models) can be used to assess the effect of technical measures.

When the data available for a fishery are only total catch and effort, or catch and abundance indices, only production models can be used, and thus the only management measures that can be assessed are those based on input or output control.

When using and fitting Production Models, like the Schaefer logistic model, the estimation of the parameters leads in almost all cases to carrying out a long-term projection, since the average long-term response of the stock and the fishery to changes in fishing level are direct functions of the stock parameters.

Carrying out short-term and medium-term projections, however, requires carrying forward the dynamic version of the models, under different assumptions for the catches taken from the stock, as a consequence of different input or output control management measures. Even though the equations used for this forward projection of the stock and the fishery are the same as used for the population model of the fitting version, it is usual to separate the task of fitting the model to data (i.e. estimating its parameters) from the task of using the estimated parameters to analyse the consequences of different management measures. This is mostly because the calculations used to fit the models using the dynamic version of these models require intensive computations, and it is thus usually desired to keep the corresponding programmes as simple and light as possible.

It should be noted that projections, either long-term or short-term, should not be taken for predictions of actual stock abundance or catch values. As such, they should not be used to actually predict stock abundance or catch at any period. Rather, they should be used to assess the relative merits of alternative competing management options, and as such inform better the process of deciding which management measures are more likely to drive the stock and the fishery in the direction desired by managers.

2. WORKBOOKS FOR PROJECTIONS USING THE PRODUCTION MODELS

The spreadsheets used for fitting the dynamic version of the Schaefer logistic model are not meant for doing projections. In fact, the need of running numerical optimization routines for the estimation of the parameters implies that one should avoid very complicated sheets.

Accordingly, a new workbook was prepared, to run projections based on the data available and the parameters estimated for the stock and the fishery. It should be noted that this sheet should not be used for estimating parameters, but rather to analyse the likely consequences of different management options (set as changes in effort or total catch relative to current levels) on the future trends in catches and stock abundance.

This workbook is meant for doing deterministic projections, i.e., projections where the results are always the same for a given set of (a) initial conditions (stock size at the start of the projection period) (b) stock dynamics parameters and (c) stock exploitation strategy (TAC or Fishing Effort control).

3. ANALYSES POSSIBLE

The model implementation in the workbook can run projections with the following main characteristics:

a) Dynamic projections based on the Schaefer model;
b) Deterministic projections. Running a simulation with the same data and parameters will always produce the same results. Accordingly, this workbook will not produce stochastic simulations, and thus cannot be used for running e.g. risk analysis;
c) The stock dynamics are based on the Schaefer model parameters provided to the model;
d) The start point of the simulations is the stock status estimated by the model for the last year of available data;

It should be noted that because the simulation is based on a surplus production model, the workbook can not be used to simulate management strategies based on technical measures.

a) Management strategies simulated

The implementation of the model can currently simulate the following management strategies:

i) Constant exploitation strategies

In this kind of projection, it is assumed that the exploitation strategy (either total catch or total fishing mortality) is constant for all years being projected. The management measures under this type of can be defined as (1) TAC fixed at the same constant level for all years in the projection or (2) fishing mortality fixed at the same constant level for all years in the projection.

(1) Constant TAC

In this type of projection/simulation, total catch is fixed at the TAC level established by management from the first to the last year of the projection. It is assumed that there are no enforcement/declaration problems, so that the catch actually taken corresponds exactly to the TAC specified. For simplification, the TAC is given as a % of the average catch in the reference period (a period of the last 1 to 5 years of available data).

(2) Constant fixed total fishing mortality

This projection mode corresponds to a management option of fixing total effort, in the assumption that there is no change in catchability, and therefore that fishing mortality is effectively proportional to fishing effort. The actual management measures that will achieve this control of total fishing mortality are not specified, but the simulation assumes that fishing mortality is effectively controlled. For simplification, the fishing mortality for the projection is given as a percentage of the fishing mortality estimated for the last year of data available.

ii) Variable exploitation strategies

In this set of strategies, managers can allow for varying TAC or fishing mortality at each year in the projection time. This requires specifying the TAC or the fishing mortality (both as values relative to the average values in the reference period) for each time-period covered by the projection. Otherwise, the projection proceeds as for the case of the constant TAC or fishing mortality strategies.

An important issue to remember when defining the management strategy to simulate is how catch is related to stock abundance. When using TAC management control, the total catch taken each year is fixed externally. This catch does not depend on stock abundance or other aspects of stock status. When an effort control strategy is chosen, however, the total fishing effort exerted on the stock each year is fixed. In this system, total catch is determined by the effort applied to the average stock abundance during the year, and thus depends on stock abundance.

4. ORGANISATION/STRUCTURE OF THE WORKBOOK

The workbook is divided into several sheets that correspond to different parts of the operation of the simulation:

a) Data Input and projection control

The input of the stock and fisheries data, as well as the definition of the conditions for the projection, is separate from the calculations or the presentation of output. This way, it is possible to allow the users to specify the input data and parameters, as well as the conditions for the simulation, in a simpler setup than if this input was joined with the calculations. All input and control parameters are entered into the same sheet, sheet “Input”.

i) Sheet "Input"

This sheet is used to enter the model parameters estimated for the stock, historical data available for the stock and the fishery, and for defining the conditions for the projections. The following information is entered into this sheet:

a) Historical data
b) Stock model parameters
c) Model control parameters
d) Projection control parameters

b) Calculations

The calculations for the historical part of the model are separated from those of the projection part. This is done for logical reasons, but also to allow dimensioning separately each of the components of the calculations. Two sheets are used to do these calculations. Sheet "ObservedPast" holds all calculations for the historical part of the model, while sheet "Projected" contains the calculations for the projection part. These data are joined together in a sheet "DataPlots" that organizes the data into a single set, for the plots.

c) Output

The output is presented mostly in graphical form, in the plot sheets "Abundance" (Figure 10) and "Catches" (Figure 11). In both of these, the estimated and projected trends in stock abundance and catches are presented as values relative to adequate reference points. So, abundance is represented by the value of the estimated abundance index as a percentage of the value of this abundance index at the target biomass $B_{0.1}$, while catches are presented as a percentage of MSY.

i) Sheet "Data Plots"

This sheet contains the calculations for the plots of catches and stock abundance. It is not meant to be modified by the user, and it is protected to avoid accidental modifications to the workbook.

5. OPERATING INSTRUCTIONS

a) Setting overall options

The presentation of the data from the workbook relies on some Visual Basic procedures. Therefore, for the workbook to function properly, it is necessary to configure Excel in order to allow running macros. The following procedure should be used:

Open Excel with a blank worksheet

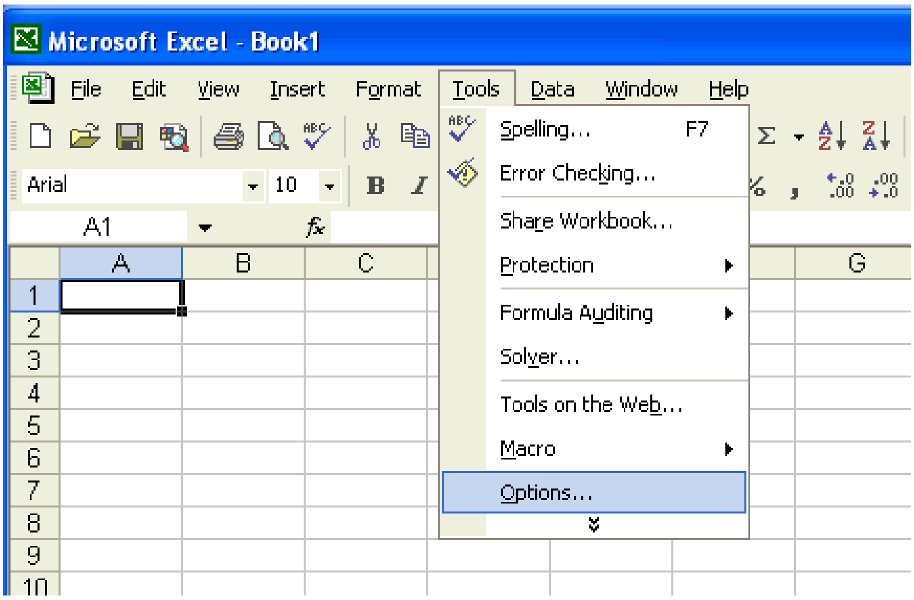

Figure 1- Selection of the “Options” dialogue

Under the menu item “Tools”, choose “Options”
Then in the “Security” tab click on “Macro security”

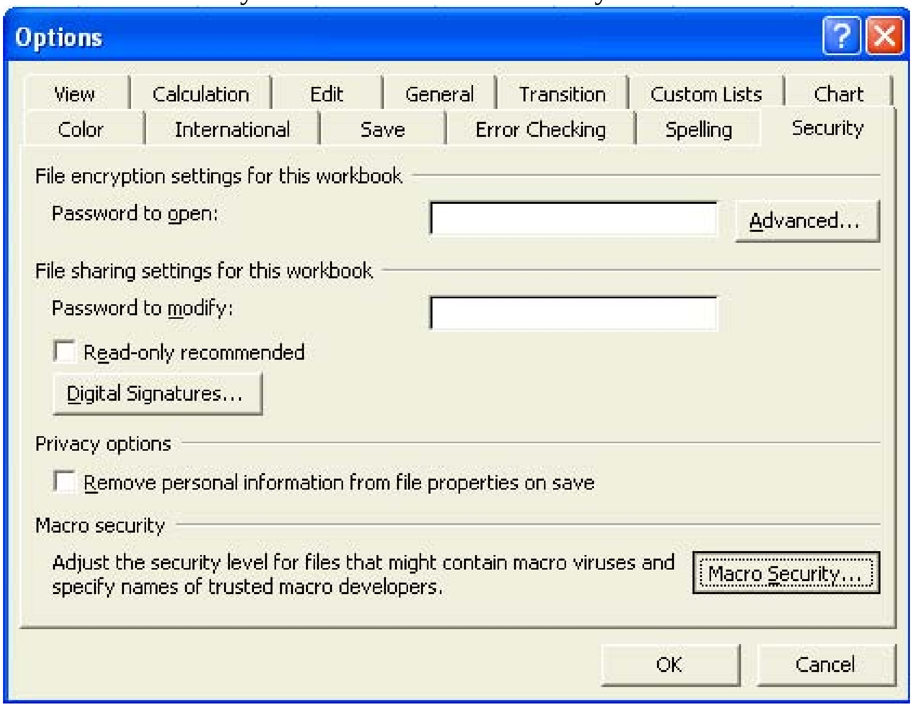

Figure 2. The “Security” tab under the “Options” dialogue

In the “Security Level” tab, choose “Medium” (Figure 3). This setting will allow you to permit running the macros in the worksheet without compromising the overall security of your computing environment.

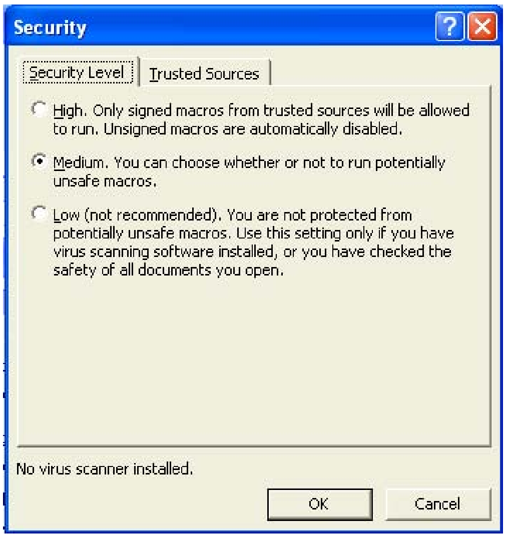

Figure 3. Setting the macro security level to “Medium”.

When opening the workbook, a warning message will appear, asking whether to allow the macros to run (Figure 4). Choose “Enable Macros” in this dialogue, and the sheet will load properly.

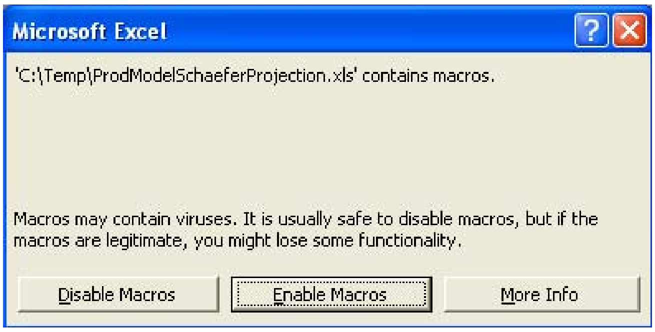

Figure 4. Dialogue that should appear when opening this workbook

Note: Under newer versions of Microsoft Excel, the procedure may be different from the one described above. In all cases, however, it will be necessary to set the macro security level to a level allowing selected macros to run, with previous user approval.

b) Data Entry

All data (for the historical period) and parameter estimates should be entered in the worksheet “Input”.

Data and parameter estimates (that may have been estimated by fitting the model to data using the fitting workbook) should be entered only in the cells coloured green (Figure 5). All other cells are either not used, or used to calculate quantities used by the model.

The parameters for the projection, including the number of years to project, and the values of catch or fishing effort to simulate (relative to the current “base” values) should also be set in this sheet.

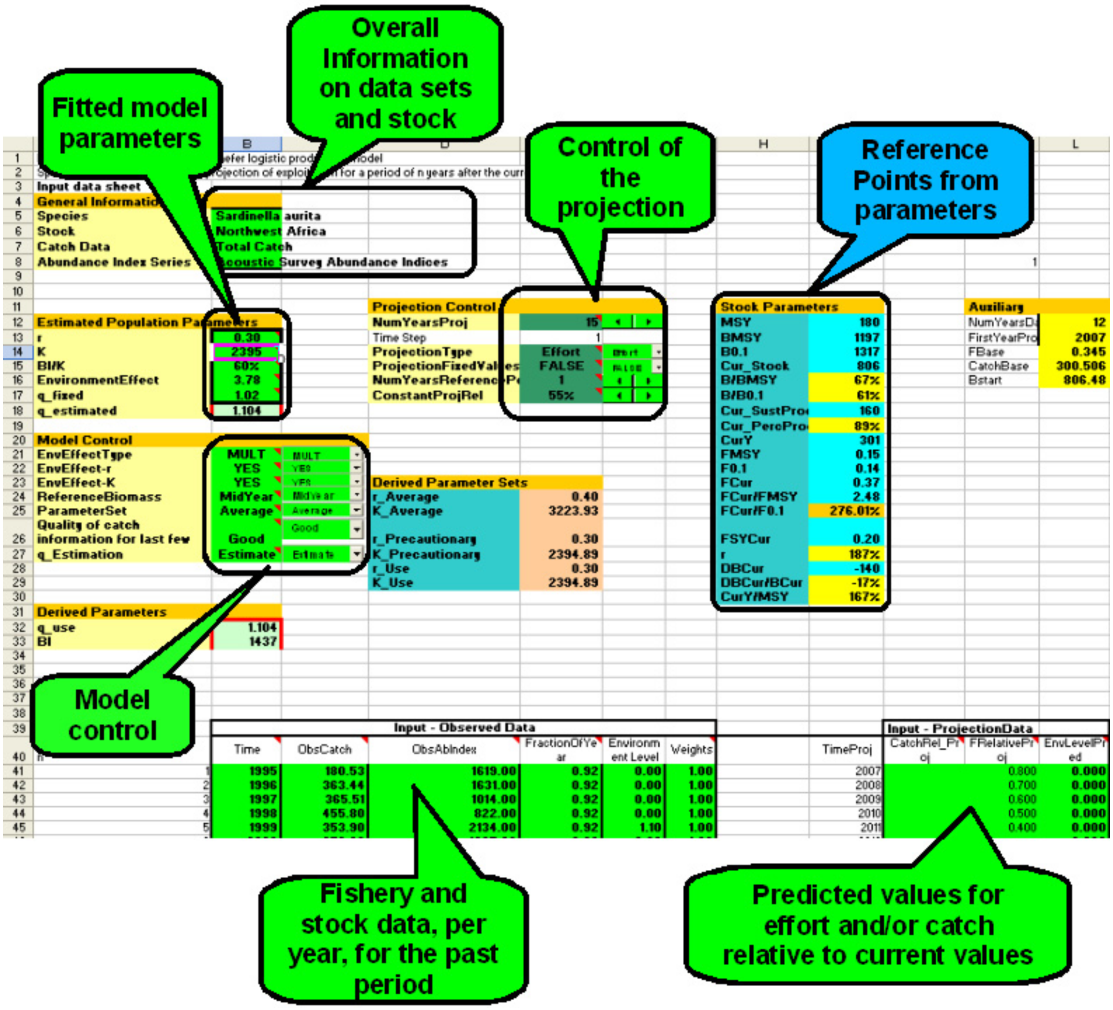

Figure 5. The main areas in the worksheet for model input and projection control

i) Entering historical data

The data for the historical period should be entered first (Figure 6). These data correspond to the data available to fit the model, and should be entered exactly as used for the fitting process. They will be used to replicate the estimated trends of catch and stock abundance in the historical period, and establish the base conditions to which the projection values are related.

Input - Observed Data					
Time	ObsCatch	ObsAbIndex	FractionOfYear	Environment Level	Weights
1995	180.00	1500.00	0.92	0.00	1.00
1996	353.00	1600.00	0.92	0.00	1.00
1997	430.00	1001.00	0.92	0.00	1.00
1998	500.00	800.00	0.92	0.00	1.00
1999	400.00	2020.00	0.92	1.00	1.00
2000	356.00	190.00	0.92	0.00	1.00
2001	298.00	1800.00	0.92	0.00	1.00
2002	280.00	1499.00	0.92	0.00	1.00
2003	345.00	1546.00	0.92	0.00	1.00
2004	264.00	3423.00	0.92	0.00	1.00
2005	305.00	3000.00	0.92	0.00	1.00

Figure 6. Section of the worksheet to enter the historical data

The settings in this section should be set exactly to the same values entered when fitting the model (estimating the parameters).

(1) Years of data (Time)

All years from the first to the last in the historical data set should be entered, consecutively. The first year should be entered in the cell immediately below the header “Year” and run consecutively until the last one. No empty cells should exist between the data, only after the last year. Note that the worksheet uses the number of consecutive non-empty cells in this column to define the time interval of the historical part of the modelling, and failing to fill this properly will result in inadequate calculations.

(2) Total Catch per year (ObsCatch)

Total catch is REQUIRED for ALL years in the historical data series. The model will fail if catch data is missing for any of these years (the reason is that catch is essential to calculating stock abundance the following year). This column should be filled like the one for year;

(3) Abundance Index (ObsAbIndex)

This column should be filled like the previous ones. It will contain an Index of stock abundance for as many years as possible, of the series of years considered. Only one index series can be entered, because it is considered impossible, or at least unreliable, to combine adequately several index series without detailed information on each of them. If it is desired to include information on more than one abundance index, these should be combined in a separate analysis that should take into account the relative reliability of each of the indices.

(4) Timing of the abundance index (FractionOfYear)

When the abundance index corresponds to e.g. a scientific survey, or to a fishery concentrated in a short season, it will not represent the average abundance of the stock during the year, but rather this same abundance at the time of the survey or fishery. The values in this column represent the timing of the abundance index as a fraction of year (0.5 = July 1st). It should be set to a value corresponding roughly to the mid-point of the survey or of the fishing season. If the abundance index corresponds to a CPUE from a year-long fishery, this value should be set to 0.5 (mid-year).

(5) Environment Level

This column contains an index of “relative environmental quality” for each year in the data series. This index should reflect, as much as possible, the overall quality of the environment for stock growth relative to the “average” years. Years considered as “average” should have the value “0” for this index, while years more favourable than the average will have a positive value, and years less favourable will have negative values. This column will include any index that can be considered to represent a deviation of the average growth conditions of the stock in each year. If a series of environmental indices exist (e.g. a series of upwelling indices) these can be used as the environmental level. If not, and there is external scientific evidence that there were particular years with exceptional conditions, then an arbitrary positive (for good growth) or negative (for poor growth) environmental level can be set for that year. If there is no information on environmental elements affecting the carrying capacity and/or the intrinsic growth rate of the stock, or it is considered that these parameters do not vary significantly, then the values in this column should be left at their default value of 0.

(6) Weights

This column will include the weights given to each estimate of the abundance index in the fitting procedure. These weights should be proportional to the reliability of the different estimates. This may mean that they should be proportional to the variance of the estimates, if this is available, but they may be used simply to downweigh some particularly troublesome or doubtful points. In some cases, there are doubts about the reliability or the representativeness (compared with the rest of the series) of one or a few of the abundance indices used (e.g. if there is a year with less complete coverage, or with uncommon distribution conditions). In these cases, the corresponding value of the abundance index will not be as reliable as the remaining of the series. These points can be given less weight in the fitting of the model, by setting a value less than **1** in the corresponding row of the column Weights. The weights are not used in the projection sheet, but should be entered, to establish a record to the fitting procedure used to obtain the current parameter estimates.

Notes:

The number of consecutive non-empty cells in column Year is used to define the number of years in the data to fit. Therefore, only years for which catch data is available must be entered, and all cells below these must be empty (use “Clear contents”);
In the calculated columns (to the right of the column “Weights”) the rows below the last year of data should NOT be deleted. The worksheet will ignore those below the last year of data. Deleting these rows will force one to rebuild them when a new data point is entered.

ii) Estimated stock parameters

The values estimated for the main stock parameters should be entered in the section headed “Estimated Population Parameters” (Figure 7). Values must be entered for **r** (intrinsic rate of growth), **K** (Carrying capacity, or Virgin Biomass) and **BI/K** (Stock Biomass at the start of the data series, as a proportion of the Virgin Biomass. The estimated value of the constant of proportionality between the estimated biomasses ad the corresponding abundance indices, **q** (sometimes called the catchability coefficient) should also be set. If an environment effect was used for fitting the model, the value of the estimated coefficient should also be entered in the appropriate cell.

It should be noted that the value of the parameters in this section should be set exactly to the same values estimated from fitting the model to the historical data.

Estimated Population Parameters	
r	0.14
K	4270
BI/K	50%
EnvironmentEffect	7.97
q_fixed	1.02
q_estimated	0.363

Figure 7. Spreadsheet area for entering the population parameters

iii) Model fitting control

The parameters of model fitting (figure 8) should also be entered in the appropriate section of the input sheet.

Model Control		
EnvEffectType	MULT	MULT
EnvEffect-r	YES	YES
EnvEffect-K	YES	YES
ReferenceBiomass	StartYear	StartYear
ParameterSet	Average	Average
Quality of catch information for last few years	Good	Good
q_Estimation	Fixed	Fixed

Figure 8. Spreadsheet area for entering the model control parameters

1) Type of Environment Effect: Select how the environment level affects the model parameters r and K. Select NONE (no effect), MULT (Multiplicative effect) or EXP (Exponential effect);
2) Environment Effect on r: Set to YES if the environment is assumed to affect the growth capacity of the stock (r);
3) Environment Effect on K: Set to YES if the environment is assumed to affect the maximum (virgin) stock Biomass (K);
4) Reference Biomass: Specifies whether the Biomass natural growth rate is assumed to depend on Biomass at the start of the year or at mid-year;
5) Parameter set: Specify which set of parameters to use for estimating the Biological Reference Points. When using the option of introducing an environmental level indicator, different values of r and K are calculated for every year in the data set. In this situation, it becomes difficult to choose which is the best value of the parameters to use in the calculation of the overall reference points. The best option will depend on the situation at hand. Three options are available: Fixed- Use the overall r and K parameters estimated by the model fitting; Average – Use the average of the year-specific r and K calculated for the series of years; Precautionary – Use the smallest of the two previous sets. It should be noted that all these sets will be equal if there is no Environment Effect;
6) Quality of catch information for the last years. Set to Good, if these data are reliable, or Poor otherwise. This parameter will influence the estimation of the abundance on the last year of data. If the catch data during the last years is considered good, the abundance on this last year is that calculated by the Schaefer model; However, if the quality of the total catch data in the last few years is poor, this will affect strongly the reliability of the Biomass estimates from the model. In this case, it is better to calculate the Biomass using the Abundance Index for last year and the overall coefficient of proportionality q, as B=U/q;
7) q estimation: Set to Fixed if the coefficient of proportionality q should be fixed (set to the value given by the user or estimated numerically); Set to Estimate if q should be estimated linearly from the series of estimated abundances and abundance indices;

The settings in this section should be set exactly to the same values/options used when fitting the model to the historical data. This way, the historical part of the fitted model will reproduce exactly the fitting procedure, and the projection will reflect the average conditions observed during the period used to fit the model.

iv) Projection control

To run the projection simulation, it is necessary to define the main aspects of this simulation,

Projection Control		
NumYearsProj	15	◄ ►
Time Step	1	
ProjectionType	Effort	Effort ▼
ProjectionFixedValues	FALSE	FALSE ▼
NumYearsReferencePeriod	1	◄ ►
ConstantProjRel	88%	◄ ►

Figure 9. Spreadsheet section used to control the options for the projections

The settings in this section define the options available for running the projections.

1) Number of years to project: This option simply defines the number of years (from the year immediately after the last year in the historical data series) to use for the projection;
2) Projection type: Set to Effort if it is intended to simulate a management strategy based on limitation of fishing mortality (effort); Set to Catch if the projection is based on a TAC-based management strategy;
3) Use Fixed Values: Set to TRUE if fixed Catch or Fishing Mortality values (in percentage of current values) are given for each year of the projection; Set to FALSE if a constant TAC or Fishing Mortality (both given as a percentage of the corresponding average value in the reference period) is used instead;
4) Number of Years in Reference Period: Number of years (in the end of the data series) to use as the Reference Period for the calculations of the relative changes in Catch or Fishing Mortality;
5) Constant value (in % of the values in the reference period) of the values of Catch or Fishing Mortality (depending on the projection type chosen) for the projection, if a Constant TAC or Fishing Mortality is chosen for the projection;

c) Output

The model outputs the projections of stock abundance and total catch for all years in the period covered by the projections.

In all cases, these are presented as values relative to the reference points adopted ($B_{0.1}$ and MSY). The main tools offered to analyse these projections are the plots in sheets "Abundance" (Figure 10) and "Catches" (Figure 11). In both of these, the current year, and thus the separation between the historical and the projected periods is indicated by a vertical line, allowing a better visualisation of the two periods that must be interpreted separately.

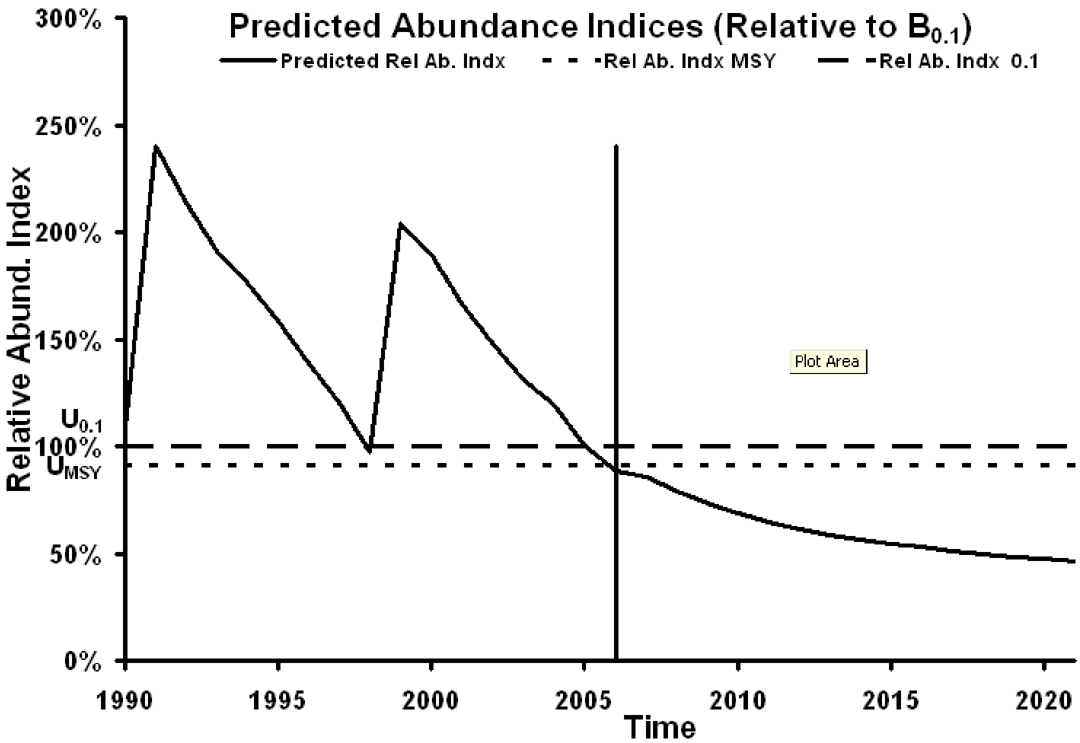

Figure 10. Spreadsheet Plot of the trends in observed and projected Abundance Indices (Relative to $U_{0.1}$)

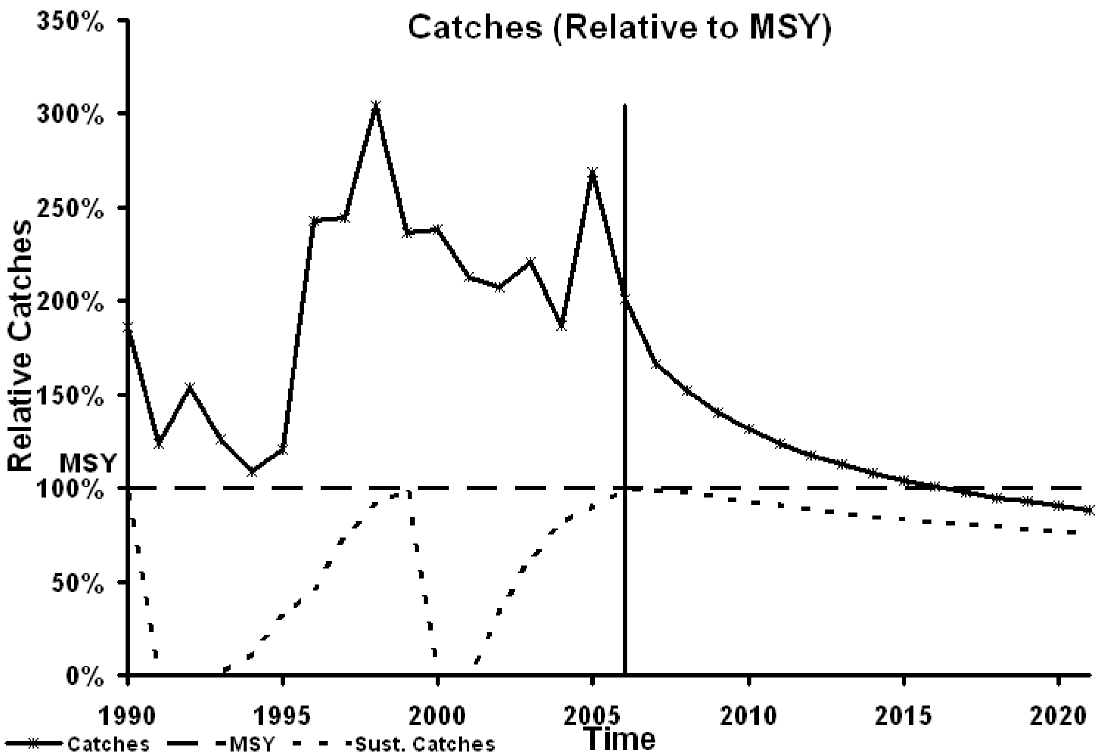

Figure 11. Spreadsheet Plot of the trends in observed and projected catches (Relative to MSY)

6) Editing the WorkBook

With the exception of the cells shown in green on sheet "Input", it is assumed that the user will not need to edit any part of the workbook. Therefore, most of the sheets are protected, to avoid accidentally modifying the formulas or the structure of the workbook. However, if any user wants to modify any sheet, it is enough to select "Unprotect sheet" from the menu item "Protection" (Figure 12). Users are urged to make a copy of the workbook before doing this, however, as they might accidentally modify the formulas or the structure of the workbook.

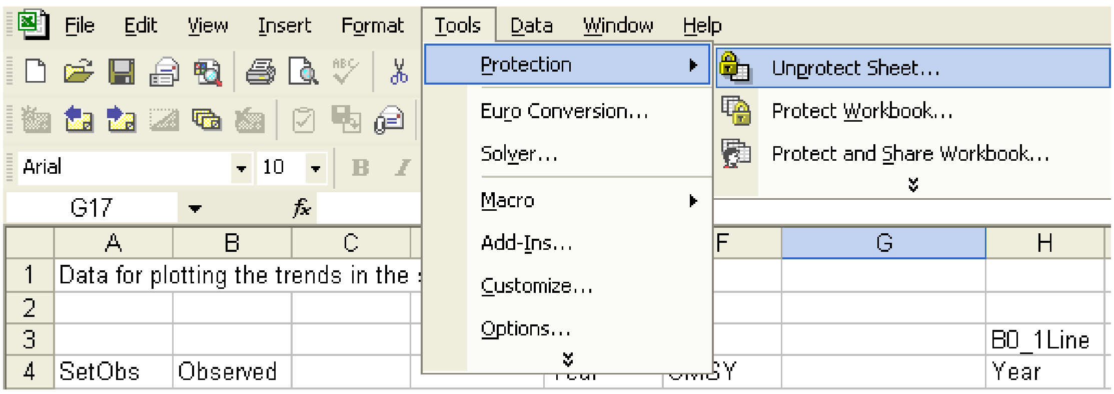

Figure 12. Procedure for unprotecting the worksheet "DataPlots"

7) Interpretation of results

The interpretation of the projection results should be done with caution. As mentioned in the introduction, projections are not forecasts, and should not be used as such.

REFERENCES

Hilborn, R. & Walters, C.J. 1992. Quantitative Fisheries Stock Assessment. Chapman and Hall, New York. 570 p.

Hogarth *et al.* 2006. Stock assessment for fishery management. A framework guide to the stock assessment tools of the Fisheries Management Science Programme. FAO Fisheries Technical Paper. No. 487. Rome, Italy. 261p. Includes a CD-Rom.

The seventh meeting of the FAO Working Group on the Assessment of Small Pelagic Fish off Northwest Africa was held in Agadir, Morocco, from 17 to 26 April 2007. The Group assessed the status of the small pelagic resources in Northwest Africa and made projections on the development of the status of the stocks and on future effort and catch levels. The advices for the stocks are given in relation to the agreed reference points $F_{0.1}$, F_{MSY}, $B_{0.1}$ and B_{MSY} and on the basis of the projections for the next five years. The results of the assessments indicate that the stock of round sardinella is overexploited and consequently a decrease in effort in the total sardinella fishery was recommended. The Atlantic horse mackerel was also found to be overexploited whereas the Cunene horse mackerel was found to be fully exploited. It was recommended that the effort in 2008 should decrease about 20 pour cent of the actual effort. The sardine stock in Zone A+B was found overexploited and the Working Group recommended to decrease the effort by 20 pour cent corresponding to a catch level of 350 000 tonnes in 2008. The stock of sardine in Zone C was found to be not fully exploited and it was noted that the total catch level may be temporarily increased, but should be adjusted to natural changes in the stock. The mackerel was found not to be fully exploited, the catches should not exceed in 2008 the current level of 200 000 tonnes. It was not possible to reach reliable conclusions from the assessment models applied to bonga and anchovy but, in the case of anchovy, acoustic estimates show a decrease in biomass from 2005 to 2006. As a precautionary measure, the catch level for this species should not exceed the average over the last three years of 115 000 tonnes. For bonga, the recommendation from 2006 is maintained as no new information is available on this species, and the Working Group recommended that the catch level should not exceed 42 000 tonnes.

La septième réunion du Groupe de travail de la FAO sur l'évaluation des petits pélagiques au large de l'Afrique nord-occidentale s'est tenue à Agadir, Maroc, du 17 au 26 avril 2007. Le Groupe a examiné l'état actuel des ressources de petits pélagiques en Afrique nord-occidentale et fait des projections sur le développement, l'effort futur et les niveaux de capture. Des conseils concernant l'état des stocks sont donnés par rapport aux points de référence approuvés, $F_{0.1}$, F_{MSY}, $B_{0.1}$ and B_{MSY} et sur la base des projections pour les cinq prochaines années. Les résultats des évaluations indiquent que le stock de sardinelle ronde est surexploité et par conséquent une diminution de l'effort pour la pêche totale de la sardinelle a été recommandée. Il a été constaté que le chinchard atlantique était aussi surexploité tandis que le chinchard du Cunène était pleinement exploité. Une diminution de 20 pour cent de l'effort actuel a été recommandée pour 2008. On a trouvé que le stock de sardine dans la Zone A+B était surexploité et le Groupe de travail a recommandé une diminution de l'effort actuel de 20 pour cent correspondant à un niveau des captures de 350 000 tonnes en 2008. On a noté que le stock de sardine dans la Zone C n'était pas complètement exploité et que le niveau total des captures pouvait être temporairement augmenté, mais qu'il doit être ajusté aux changements naturels du stock. Il s'est avéré que le maquereau n'était pas pleinement exploité, mais comme il s'agit d'une pêcherie mixte avec d'autres espèces, il a été recommandé que les captures en 2008 ne dépassent pas le niveau actuel de 200 000 tonnes. Aucune conclusion fiable n'a été tirée à partir des modèles d'évaluation appliqués à l'ethmalose et à l'anchois mais, pour l'anchois, les estimations acoustiques montrent une biomasse en diminution de 2005 à 2006. Comme mesure de précaution, le niveau de capture pour cette espèce ne devrait pas dépasser la moyenne de 115 000 tonnes des trois dernières années. Pour l'ethmalose, la recommandation de 2006 est maintenue car aucune information nouvelle n'est disponible pour cette espèce et le Groupe de travail a recommandé que le niveau de capture ne dépasse pas 42 000 tonnes.

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