parfish

PARTICIPATORY FISHERIES STOCK ASSESSMENT

SOFTWARE MANUAL

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Contents

Introduction

What is ParFish?

Participatory Fisheries Stock Assessment (ParFish) is an adaptive approach to fisheries management through the use of rapid and participatory stock assessments. The aim is to provide advice on management measures based on rapidly collected and diverse data sources. ParFish encourages participation of fishers and other key stakeholders, and is a valuable tool for supporting existing and developing co-management systems.

The aim of ParFish is three-fold:

- to focus on the impact of fishing on stock size and investigate the level of fishing that will maximise benefits to the fishing community;
- to assess relevant information to estimate the outcomes of different levels of fishing and indicate how good those estimates are;
- to encourage fishers to become involved in stock assessments and decisions affecting management of the fishery.

How does the ParFish Software fit into the wider ParFish approach?

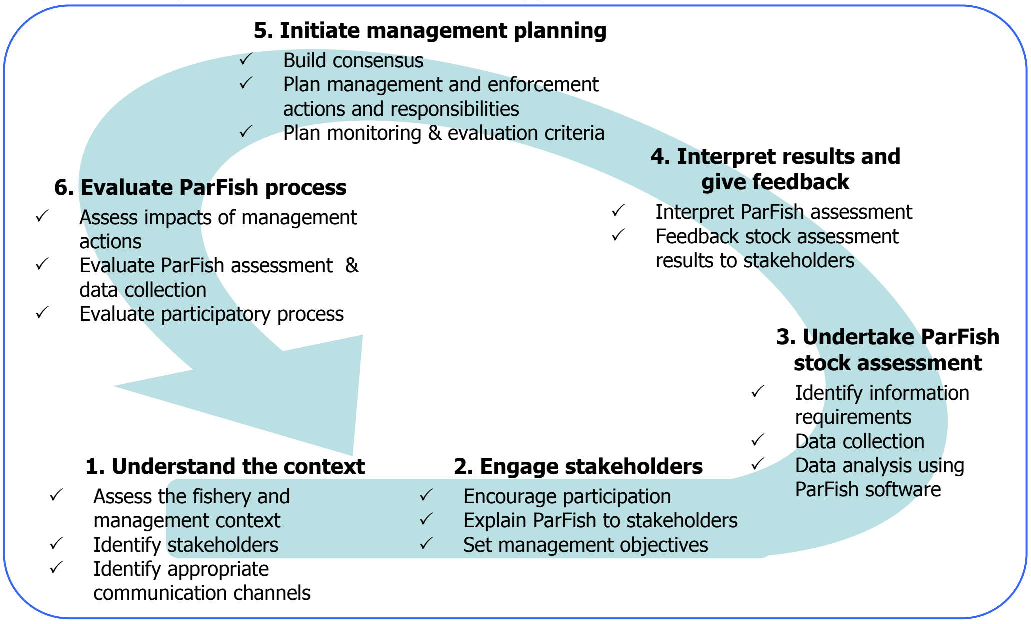
The ParFish Software forms part of the ParFish Toolkit. The Toolkit consists of:

- ParFish Guidelines: describe the overall approach for implementing ParFish to assist fishers and other stakeholders enter a cycle of learning, management planning, implementation and evaluation;
- ParFish Software: allows data from the ParFish assessment to be entered and analysed;
- ParFish Software Manual (this document): explains how to use the Software with step-by-step instructions.

The ParFish approach (Figure 1) covers six stages that take the user from understanding the context (Stage 1), engaging stakeholders (Stage 2) through undertaking the stock assessment (Stage 3), interpreting the results and giving feedback (Stage 4), to participatory management planning (Stage 5), evaluating the process and re-starting the cycle (Stage 6).

The ParFish stock assessment forms part of the broader ParFish approach; use of the Software comes in Stage 3.

Figure 1: Stages involved in the ParFish Approach



User Notes: The ParFish Software and Software Manual

Step-by-Step Guidance

This **Software Manual** gives guidance on using the **ParFish Software**, which provides a methodology for fisheries stock assessment which is at the heart of the ParFish approach. The Software contains a help file, which provides on-screen information and support while using the Software. This Software Manual takes you through a step-by-step approach for data entry and analysis. See the **ParFish Guidelines** for assistance with data collection.

The ParFish Software is split into six steps, which guide you through the process of data input, model construction and analysis. These six steps are laid out on the main page of the Software, and in summary are as follows:

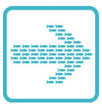
Step 1: Basic Information	Records background information on the fishery in question and identifies the units.
Step 2: MS Excel Input Data	Helps you input your data in the correct format using an Excel template
Step 3: Probability Models	Construct a hierarchy of stock assessment models for your data
Step 4: Preferences	Set preferences and discount rates, enter fisher preference data from interviews
Step 5: Controls	Enter levels of controls for quota, effort or closed areas
Step 6: Analysis	Run various scenarios based on different controls to determine the control level with highest expected preference

Each Step has a page associated with it in the Software. In the case of Step 1, this is the Main Page. For Step 2, this is the Excel ParFish Template that will open when you click on the arrow, to assist with data input. Step 3 allows you to set up probability models, Step 4 is where preference information from fishers is entered, Step 5 covers information on controls and Step 6 allows the user to conduct the analysis.

You should go through each step in turn to ensure that your analysis will run correctly, but you have the opportunity to revisit all of the steps at any time to alter information and settings. This is particularly important for the probability models, so that you can add additional data as and when they become available. For example, you may be able to add additional monitoring data and models as such information becomes available and update the full assessment.

Instructions given in the Software Manual

The following instructions and icons are used throughout the Software Manual:



Refers to another section of the Software Manual, or of the ParFish Guidelines.

Hints: Indicates extra guidance for carrying out a certain task, or a hint of how to solve potential problems you might encounter

'Click' — Means left-click on the mouse. 'Right-click' is always specified as such.

File ⇨ Save — Indication of a menu command. In this example the instruction is to open the File menu and choose the Save command.

1,2,3 ..... — Throughout the Software Manual, numbered steps within each section indicate how to carry out certain tasks.

Requirements for using the Software

Preparation Activities

Before undertaking the assessment using the Parfish Software you should have consulted the ParFish Guidelines and should have gone through Stages 1 – 3:

1. Understand the context;
2. Engage stakeholders;
3. Undertake stock assessment (gathering data on the fishery including at least stock assessment and Preference Interviews).

However you may want to familiarise yourself with the ParFish Software before initiating the ParFish process, and enter any data on the fishery already available.

System Requirements

The ParFish Software should run on any computer with a Windows 2000 or later operating system. However, the Software can use significant CPU (central processing unit), memory and hard disk resources. The Software relies on Monte Carlo simulations which require repeating calculations many times and storing results. Machines with CPU clock speeds less than 500MHz may be very slow and this will make the Software difficult to use.

Skills

The Software, when used together with this Manual, is designed to be suitable for users without specialist knowledge of statistics and stock assessment. However, having some basic knowledge will help you understand and manipulate the Software, use some of its more advanced functionalities for constructing models, and interpret the results.

The following skills are required for using the ParFish Software:

- ☑ Computer literate;
- ☑ Working knowledge of Microsoft Excel;
- ☑ Understanding of the basics of Stock Assessment (consult Hilborn and Walters listed in references below);
- ☑ Understanding of the basics of Bayesian Statistics (see section below).

Further information

For further information consult the ParFish Guidelines or contact us at the address below.

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The ParFish Assessment Methodology

This section covers:

- ✓ Background to Bayesian statistics and decision theory;
- ✓ How the Software uses Bayesian statistics and decision theory to carry out a stock assessment;
- ✓ Inputs to the Software;
- ✓ Data analysis;
- ✓ Outputs from the analysis.

Background

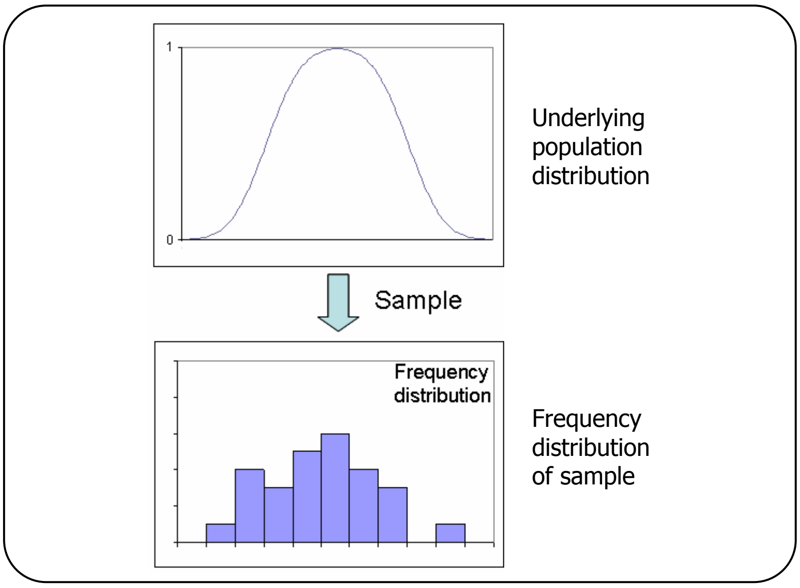
Bayesian Statistics and Decision Theory

The ParFish methodology is based on Bayesian statistics which allows information from a variety of sources, which are directly relevant to determining the optimal control level, to be combined in the assessment. The results can be expressed in terms of probability and uncertainty.

Bayesian statistics is a statistical approach for calculating the probability of an unobserved event based on earlier probability estimates which have been derived from empirical data (based on samples or observations). Bayesian methods make explicit use of probability for quantifying uncertainty. They also allow data from different sources to be combined.

Statistics are often based on the principle of populations having normal or skewed distributions. Observed measurements are taken from a population and assumed to fit a defined distribution (Figure 2).

Figure 2: Drawing samples from a population with a normal distribution



In Bayesian statistics the probability distribution, or 'probability density function' (PDF), is estimated based on the samples of the population or observed data points (Figure 3). No underlying distribution is assumed.

In order to estimate a PDF it is necessary to start with '**prior**' PDFs which can then be updated with probabilities from other sources of information to form a '**posterior**' PDF (Figure 4). A number of PDFs from different sources can be combined in this way to produce a singe posterior.

Figure 3: Drawing probability density functions based on observed data

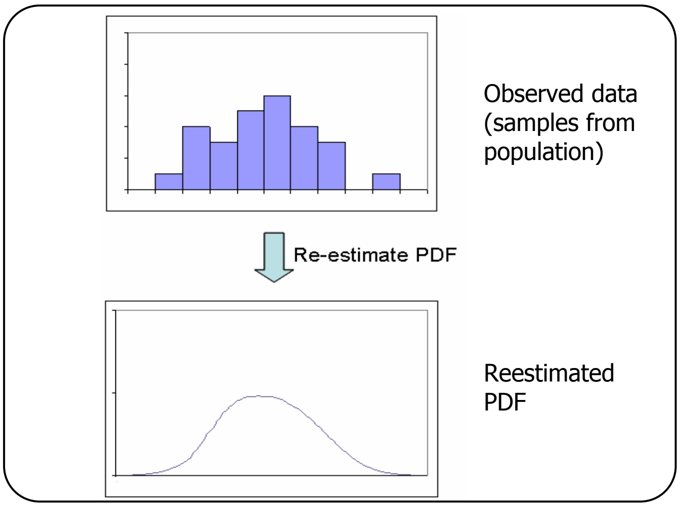
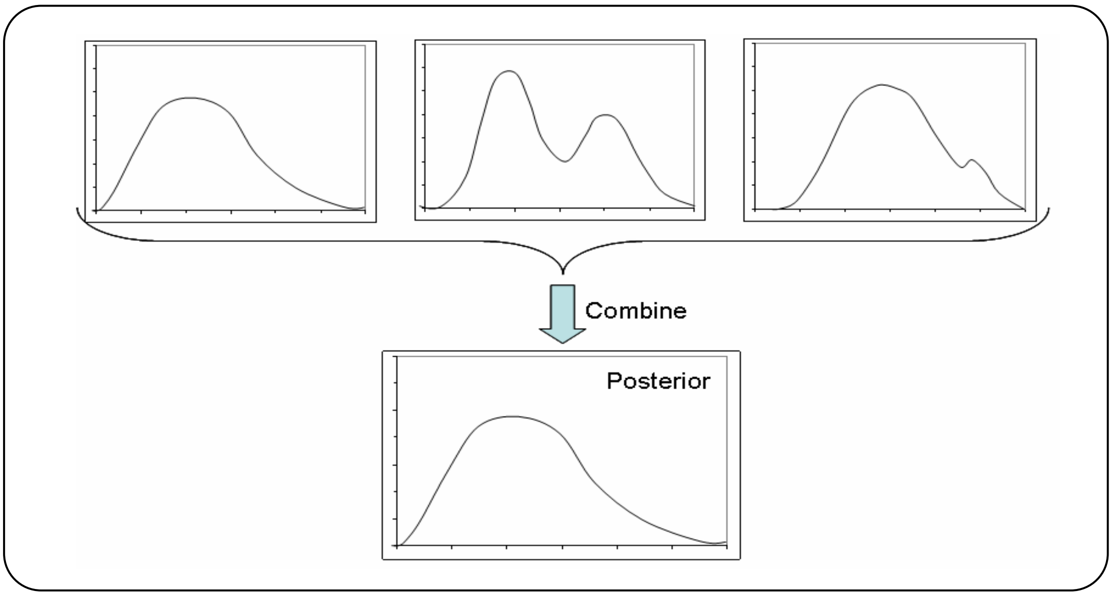


Figure 4: Combining individual PDFs to produce a posterior PDF



The **ParFish Software** uses **Bayesian statistics** to estimate PDFs for each of the parameters in the stock assessment model from each data sources. The individual PDFs are then combined into a posterior PDF which contains information from all the sources available.

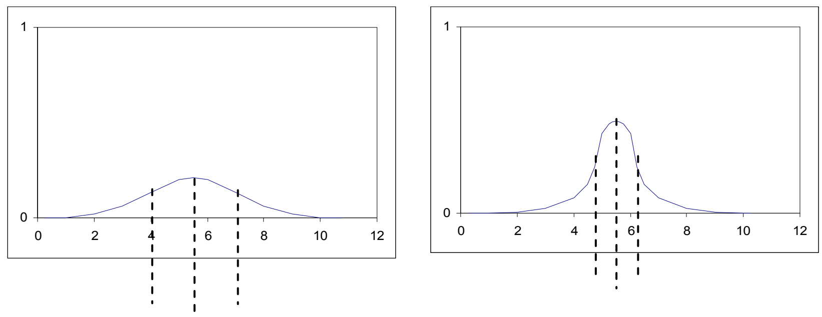
Probability and uncertainty

The ParFish analysis uses Bayesian statistics in which the results are expressed as PDFs. A PDF is a probability curve, where the area under the curve can be used to calculate the probability of a certain value being true. It provides an estimate of the most likely value for a certain parameter together with a measure of the uncertainty surrounding that value.

For example, consider the graphs in Figure 5, which show probability curves. The maximum likelihood value is the value on the x-axis where the curve is highest, which in both cases is roughly 5.5 (centre dotted line). The graph on the left has quite a low, flat curve, indicating high uncertainty around the value: if we take the middle 50% of the probability density, indicated by the two lines either side of the middle line (with roughly 25% of the area under the curve on either side of this central area), the range is from about 4 – 7. In contrast, the graph on the right has a higher, narrower curve, indicating more certainty around the estimate of the value. The two lines either side of the middle line encompass a range of about 4.75 – 6.25, a narrower range than in the left hand graph. We can therefore be more certain about our estimate of the value of the parameter in the second graph than in the first one.

The outputs of the ParFish Software are presented as probability curves, and so you need to be able to interpret them, considering the spread and height of the curve as an indication of the uncertainty around the parameter estimate.

Figure 5: Graphs showing parameter estimates with the same maximum likelihood value but different levels of uncertainty

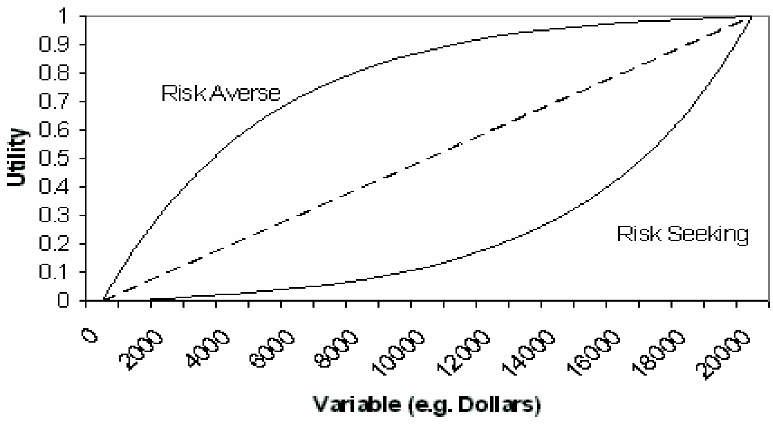


Utility and Decision Theory

Utility (or **preference** as it is referred to in the Software) is a measure of the level of satisfaction a person gets from something.

For example in Figure 6 the utility or preference for obtaining certain amounts of money is plotted on a graph. The risk of not receiving the money increases with the higher values of money. Those with risk adverse behaviour will therefore have higher preference for lower returns, whereas those with risk seeking behaviour will have high preference for higher amounts of money.

Figure 6: Changing utility with increases in the variable



Decision Theory allows us to model outcomes from different decisions and highlight the decision that maximises overall utility (the probabiltiy of the outcome happening combined with its utility if it does happen). Decision Theory in the Software helps us to determine the control level that can be applied to the fishery and result in catch rates that maximise the overall utility of those taking part in the Preference Interview (i.e. fishers).

ParFish measures fishers' preferences (utility) for different outcomes in terms of catch rates through the Preference Interview (see Tool 17 in Stage 3 of the **ParFish Guidelines**). The outcomes for a range of control levels are simulated. The control level which maximises the overall utility is the **target control**.

How the Software uses Bayesian Statistics and Decision Theory

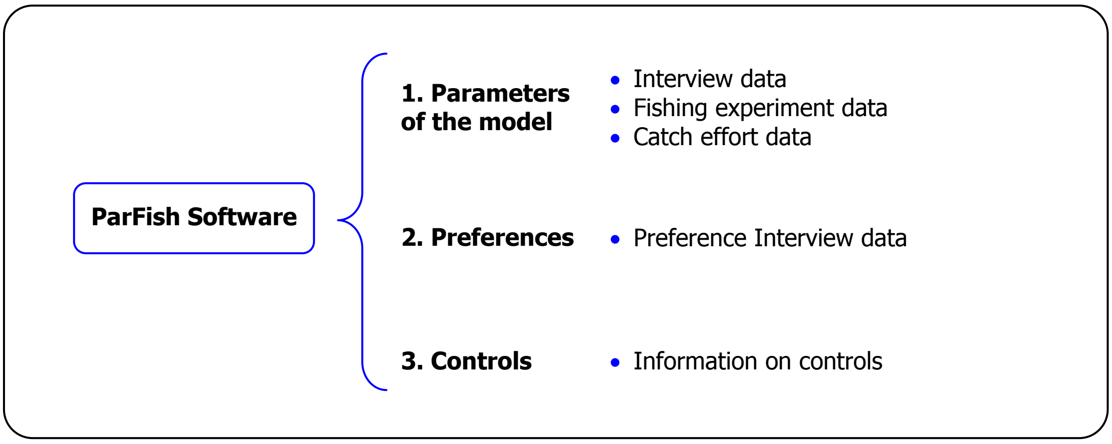
The ParFish Software is based on Bayesian statistics and accepts data, from a variety of sources, directly relevant to working out the optimal control level (effort, quota etc.). To do this, the Software uses a target simulation model (in this version only one such simulation model is available – the logistic population model) to describe the way the fish population(s) behaves. Individual models are created for each data source, to estimate PDFs for the parameters of the target simulation model. The PDFs from each model are then combined to provide posterior PDFs for each parameter.

Once we have these parameter estimates, we can model how the stock is expected to respond to fishing. Parameters are not treated as point estimates but as probability distributions. Therefore the uncertainty associated with their estimation is incorporated in the model. Fisher preferences (utility) are measured through the Preferences Interview, and are applied to the outcomes of the analyses to identify which control level would have the highest preference among fishers.

Inputs to the Software

The ParFish Software requires certain **data inputs** before the **analysis** can be run. There are three types of data inputs as illustrated in Figure 7.

Figure 7: Illustration of the data types required as inputs into the ParFish Software.



1. Parameters of the fish stock

This version of the ParFish Software has been developed based on logistical biomass growth model. Four key parameters, which describe the behaviour of the fish population, are therefore required as the first input:

- Current biomass (Bnow);
- Unexploited biomass (Binf);
- Growth rates (r);
- Catchability (q).

ParFish supports analysis of particular types of data, e.g. catch and effort, which are often collected in fisheries, and other types of data which can be generated quickly, i.e. fisher interviews and fishing experiment data. These data can be used to generate the parameter frequencies.

As indicated above, the Software is based on Bayesian statistics and it is therefore necessary to start with **prior** probabilities of the parameters. These can then be updated as additional information on the parameters becomes available. Prior probabilities for each of the four parameters are provided through interviews with fishers. When interview data is loaded into the Software it converts the information to parameter frequencies for each parameter.

Additional information in the form of catch and effort data or fishing experiment data can then be loaded into the Software to update the probabilities for certain parameters as shown in the Table 1 below. Each data source is used within set models and converted automatically by the Software into PDFs for each parameter.

Table 1 : Information on parameters provided by different information sources

Interview Data	Bnow, Binf, r, q
Catch & Effort Data	Bnow, Binf, r, q
Fishing Experiments	Bnow, Binf, q
Closed area index data	Binf, r

If you have data that do not fit any of the models in the Software, they can be added if you are able to fit the data to a model in a different programme and generate repeated **parameter frequencies** (e.g. in Excel). These can then be loaded into the Software directly (see Step 3). Parameter frequencies are interpreted as drawn from an underlying probability for the parameters represented. The ParFish Software reconstructs the PDF from the frequency data.

Once all the information has been entered it is possible to generate the **posterior** PDFs for the parameters of the target simulation model.

2. Fisher preferences

The innovative design of ParFish enables fishers' preferences for the outcomes of different management controls to be incorporated within the assessment.

Fisher preferences are collected through a specially designed interview that determines whether fishers are risk-taking or risk-averse and what level of catch per unit effort is most preferred by them. The Preference Interview also captures information on fisher discount rates (i.e. the extent to which having something today is more valuable than having it at a later date).

Using decision theory, the preference (or utility) of resource users is combined with information on the probability of different outcomes on the resource from a range of control levels, to determine the optimal level of control. This level of control will provide outcomes in terms of catch rates that maximise the overall utility of fishers.

For example, if fishers as a whole demonstrate risk-averse behaviour (i.e. they would rather consistently catch 10kg a day rather than sometimes catch 20kg and at other times catch only 5kg), then recommended control options would take this into account so that the stock is managed within safe limits and catches are consistent, although not as high as they could be. If fishers show risk-prone behaviour (i.e. they would rather have the chance of sometimes catching 20kg of fish a day even if other days they only catch 5kg, rather than consistently catching 10kg a day), then management controls will be recommended that would exploit the stock more heavily, thus allowing higher catches but with associated increased risk of over-fishing and reduced catches.

3. Management Controls

The last input required in the Software, before the analysis can be run, is information on the current control levels in the fishery, and the range of control levels over which the analyses will be run. There are three main controls covered by the Software: effort, quota and closed area.

Note that the term 'increase in control level', is used to refer to an increase in the amount of fishing allowed, for example, increased effort, a higher quota, or a reduction in the size of a closed area. 'Decrease in control level' refers to a reduction in the amount of fishing allowed, such as a reduction of effort, smaller quota, or increase in the size of a closed area.

Data analysis

Following input of the Software data requirements it is then possible to run the analysis. This can be done by running a number of different **scenarios** to provide a range of target and limit controls. It is possible to alter the following variables when running the Software:

- **The information sources used in the assessment:** For example the analysis can be run using only the interview information from fishers, or using only catch and effort or fishing experiment data. It is also possible to use a combination of the above.

- **The use of fisher preference data**: This can be turned off or on within the analysis, and when it is not used a simple benefit: cost ratio is used.

- **The use of the fisher discount rate**: The analysis can be varied to use either the discount rate given by fishers or a standard default rate.

- **The types of controls used**: If information on more than one control is available the types of controls used or the combination of these can be varied in the analysis.

- **Importance placed on different fishers:** A scenario can be run where a greater weight is given to the preferences of fishers depending on the weighting given to them, which may be based on how dependent on they are on the fishery, how poor they are, or some other measure.

Outputs from the analysis

The following outputs are given for each scenario run:

- **Target control level** for the fishery that maximises the preferences of fishers. This is the control level where expected catch rates maximise the preference of resource users/fishers.

- **Limit control level** for the fishery that reduces the chance of the stock being over-exploited to a defined level. For example, the level of control that reduces the chance of the stock being below 50% of the unexploited biomass to 10%. Both values (the proportion of the unexploited biomass remaining at which the stock is considered overfished, and the chance of this happening) can be changed by the user, e.g. to a chance of 15 or 20%, and 30% of the unexploited biomass remaining.

- **Probabilities** for different outcomes of the fishery:
    - Probability that the current state of the stock is below 50% of the unexploited biomass;
    - Probability of an increase or decrease in the catch per unit effort over time if implementing the target control.

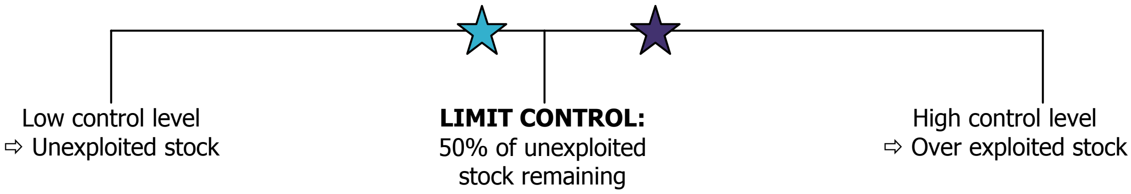
- **Standard stock assessment indicators and reference points**;
    - Maximum Sustainable Yield (MSY);
    - Fishing mortality (F).

- **The uncertainty** surrounding estimates of resource exploitation.

Precautionary vs Adaptive Approaches

The ParFish analysis treats target and limit controls slightly differently from more 'conventional' stock assessments. In conventional stock assessments, the limit control represents the point beyond which the control must not go, and the target control represents the control level you are aiming for. In ParFish, the limit control is influenced by the uncertainty in the data, so if your data have a high uncertainty, which they may do in an initial assessment, the limit control will require unreasonable restrictions to be put on the fishery in order to fish within 'safe' limits. The target control represents the control that has the highest overall preference amongst fishers. Here, different scenarios of the relative values of target, limit and current control levels are explored, and the implications for management decisions are explained. In the diagrams, 'high control level' means a high level of effort or quota, i.e. high exploitation of the stock; 'low control level' means a low level of effort or quota, i.e. little exploitation of the stock.

1) Conventional Stock Assessment



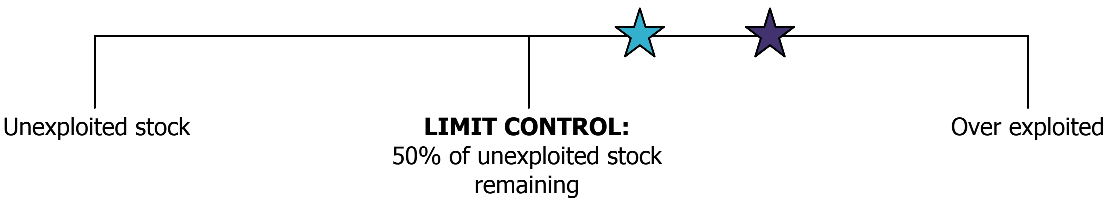
This is a fully precautionary approach where the target control is always lower than the limit. The target is where we want to be and the limit is what we cannot fall behind or there may be a significant change in the fishery. The problem with this approach is that very often we do not know where the fishery is in relation to the correct limit control. Setting the limit control needs to take account of the risk we are willing to take. To guarantee that the stock is not overexploited, we may have to decrease the control to such a low level, it would be unacceptable to the fishers. Therefore conventional stock assessment can only be applied effectively where there is a lot of information on the fish stock.

2) ParFish Approach

Where there is considerable scientific knowledge about the resource, ParFish should give the same results as conventional stock assessment. Differences arise where there is uncertainty, because ParFish requires that we take full account of risks rather than assuming we know for certain the state of the stock and thus the limit control we need to apply. This can lead to a precautionary limit control lying below the target control.

The ParFish approach is not precautionary in the traditional sense. It takes the target control level as the level that will result in catch rates preferred by fishers, and therefore sets targets that can be realistically achieved by management rather than idealistic or theoretical controls which can never be applied. It is precautionary in the sense that it recommends moving towards a precautionary limit control level where possible. Whether you intend to adhere to the limit control or the target control will depend upon, among other things, the risk policy operating towards the fishery.

Example A

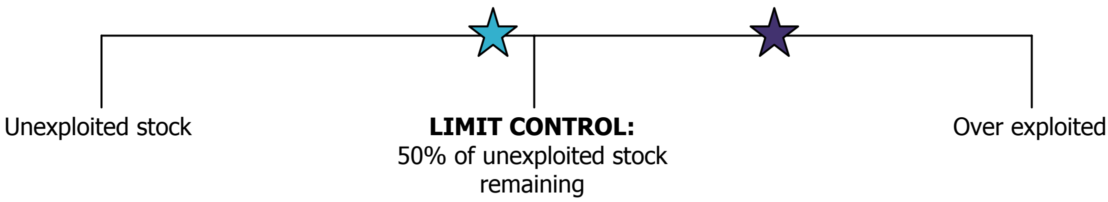


In the case above (Example A) the target level is above the limit control level. Here it is recommended that it is better to move towards the target level than to stay at current effort even though it is still a higher level of effort than the limit control. We would also recommend taking this action and collecting further information about the fishery to see a) an impact of the change in control; b) further understand the fishery to be sure of the right action to take. Because ParFish defines the limit control based on risk, the more information we have, the higher the limit control may be.

It is recommended that in most cases some action should be taken. This may be to collect more information, but the results of ParFish should indicate at the very least the direction that effort or fishing mortality should move (i.e. increase or decrease). Generally, any change you make to effort or fishing mortality should allow you to learn more about the fishery by measuring the impact of the change. How big the change needs to be in order to observe an impact is under the discretion of the researchers involved as this version of ParFish does not provide advice specifically concerning this. The costs and benefits to the fishers of different catch rates are collected in the Preference Interviews, but the costs of enforcement and monitoring actions will need to be discussed after the assessment, during management planning.

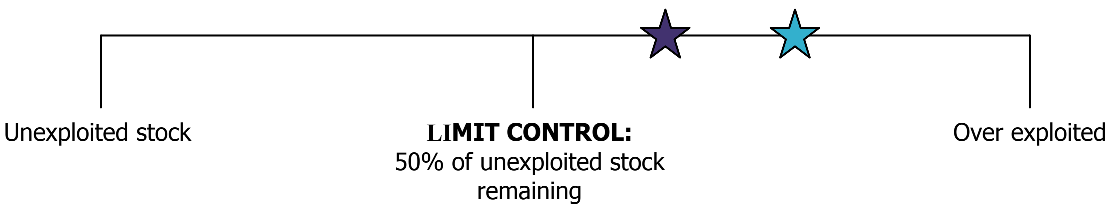
Example B

In this example it is possible to recommend a move towards the target control level and be precautionary. ParFish is adaptive in the sense that it would also recommend collecting more information to measure the impact of the action taken.



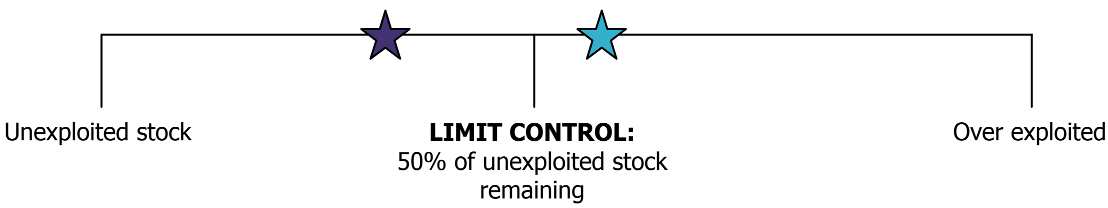
Example C

In the following situation, the target is greater than the current level and would move the fishery further away from the limit control. This can occur if the fishers are risk seeking and there is very little information on the stock. The fishers may choose to increase fishing effort if they are able, but you should be wary of recommending an increase in fishing activity. Usually fisheries scientists would suggest moving towards the limit control or keeping the control at the current level until more information was obtained.



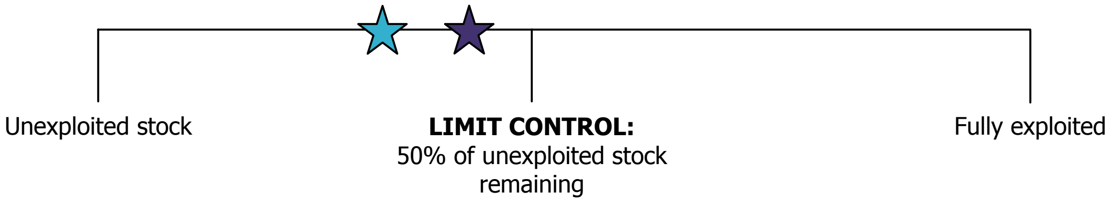
Example D

You may also encounter the situation where the current control is lower than the limit, but the estimated target is greater than the limit. In the example here the target control level would take the fishing activity over the limit control level. Clearly, in this situation the best option would be to move the fishery toward the limit and target, if possible, while monitoring the behaviour of the stock.



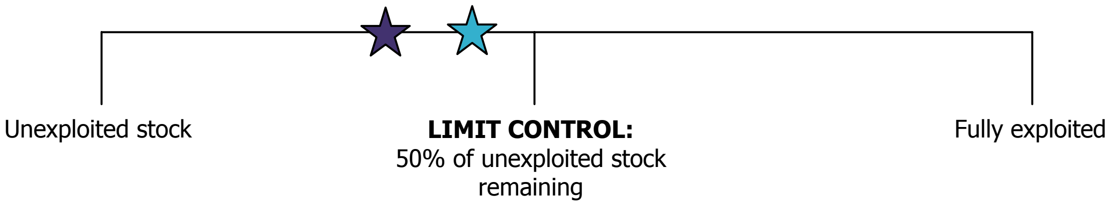
Example E

In this example, the current control level is below the limit control level, and the target control suggests a further decrease in control level. It is recommended to implement a reduction in control level towards the target, as this will be further reducing the chance of the stock being over-exploited, and is in line with the fishers' preferences.



Example F

The current control level is below the limit control, and the target control is higher than the current control. It is recommended that the control level could be increased, towards the target, resulting in higher catches for fishers, whilst still within the limit control, with a less than 10% chance of the stock being overfished.



Additional sources of information

Hilborn, R. & Walters, C.J. (1992). Quantitative Fisheries Stock Assessment: Choice, Dynamics and Uncertainty. Chapman & Hall, New York

Installing and Opening the Software

Installation

The Software is distributed as a single 'ParFishsetup.exe' file. You should run this executable file and follow the instructions in the InstallShield Wizard. The Software will give you an opportunity to change the locations of files. See the Readme.rtf file for more information.

The installation process will create a folder named 'ParFish' in your c:\programs folder (default settings), and a 'ParFish' folder in your c:\My Documents folder where the data files and Excel Templates will be saved.

Opening the Software

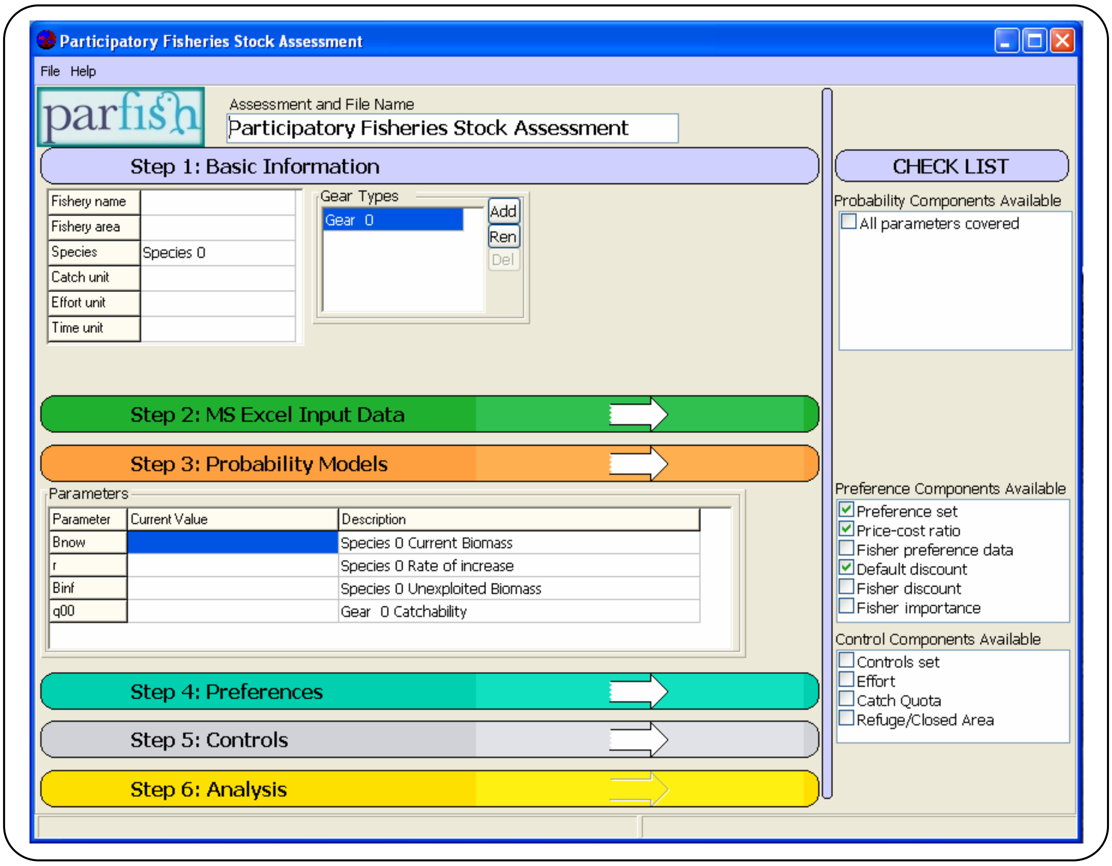
To open the ParFish Software, install it (see above), then:

1. **Double-click on the ParFish icon or select ParFish from All Programs under the Start menu.**

The main form of the Software will appear, as in Figure 8.

If you encounter a problem opening the Software, try opening it from the c:\Programs\ParFish folder.

Figure 8: The main form of the ParFish Software



The different features of the main page are explained below in the section 'The Main Page'

Hint: Press **F1** or select **Help** from the menu to get help at any time. Hints are displayed when you move the mouse cursor over a button, edit box or input table. They give an explanation of the item.

Hint: Note that if you may need Administrator-level access rights on the computer you are using in order for the Software to run properly. If you have limited User access rights, seek greater access permissions from your system administrator.

The Main Page

The main page is split into two vertical areas:

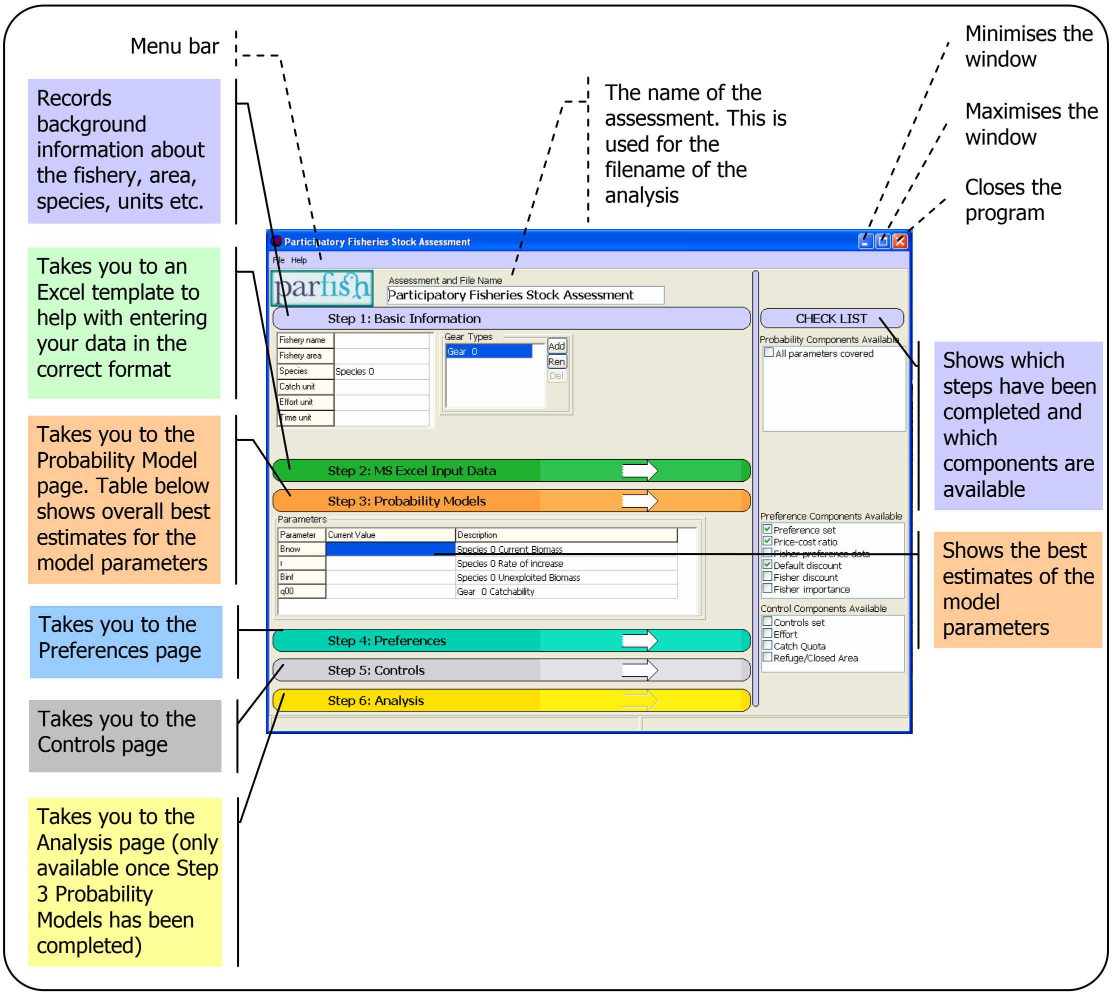
- the **Main Area** on the left-hand area shows the steps involved and buttons to take you to those steps;
- the **Check List** on the right-hand side shows the different components available which charts your progress through the Software.

The Main Area

The white arrows ⇨ will take you to the respective pages of the Software, for building **Probability Models**, inputting **Preferences**, **Controls** and carrying out **Analysis**. The back arrow (⇦) in the top left hand corner of each of these pages will take you back to the main page.

Figure 9 annotates the key features of the main page. Brief details of each step are shown and will be described in more detail in the following sections.

Figure 9: Key features of the Main Page



The Check List

The check list illustrates whether you have inputted the required information for the analysis, and also shows what different components are available, which depends on the data that has been inputted.

For example, to undertake an analysis, the following check boxes, that appear on the first line of each part of the Check List, must be ticked:

- ☑ All parameters covered (addressed in Step 3)
- ☑ Preference set (addressed in Step 4)
- ☑ Controls set (addressed in Step 5)

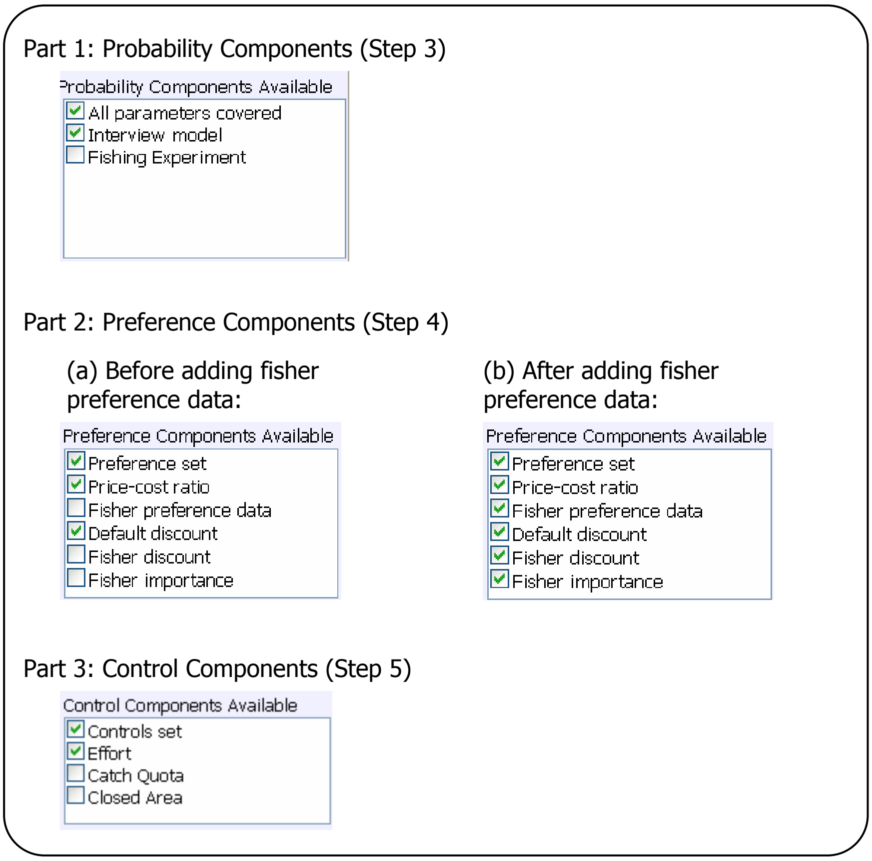
The top box (Probability Components Available) refers to Step 3 (Probability Models), and as you add models and data, further check boxes will be illustrated in this box. The 'All parameters covered' check box must be ticked in order to be able to carry out any analysis, as explained above.

The example in Figure 10 (Part 1) shows models have been added for the Stock Assessment Interview data, and for a fishing experiment. However, as the fishing experiment check box is not ticked, it indicates that this model is not yet complete.

The middle box, Preference Components Available refers to Step 4 (Preferences). Figure 10: Part 2, (a) shows the preference check list when the Software is opened, before any data are added. Price-cost ratio is the default preference setting; when you have added data from the Preference Interviews, 'Fisher preference data' will be ticked as an available component (see (b)). In addition a default discount rate is available and once preference data have been added, the 'Fisher discount' is also available and will be shown ticked. Fisher importance is a weighting factor based on the dependency of the fisher on the fishery (or another weighting factor). It can be turned on or off and becomes available (ticked) after the preference data has been added.

The bottom box, Control Components Available (see Figure 10 (Part C)) refers to Step 5. When you fill in the values on the Control page, the different control components will become available (check boxes ticked). When at least one control has been set, the 'Controls set' check box is ticked.

Figure 10: Check List detail



You should return to the **Check List** (and these instructions) as you are moving through the steps of the Software as they will help you chart your progress.

Hint: Once you have been through all the steps and entered the required data, the first item in each part of the Check List will be ticked, (All parameters covered, Preference set, Controls set), and the Analysis step will become active so that analyses can be carried out. The check boxes beneath the top check box illustrate the components that are available to be used in the analysis. They will appear and become ticked as you complete steps in the Software.

Step 1: Basic Information

This Step covers:

- ✓ **Filling in the Basic Information about the assessment**
- ✓ **Naming and adding gears**

Filling in the Basic Information about the assessment

For this section, the following is assumed to be true:

- ✓ Your computer meets the System Requirements outlined in the **Introduction** section of this Manual;
- ✓ You have installed the ParFish Software and associated files on your computer;
- ✓ You have opened the ParFish Software;
- ✓ You have background information on the fishery concerned, such as its name, species, gears, catch and effort units.

Fill in the basic information about the assessment (see Figure 11) on the Main Page of the Software as follows:

1. **Select 'Participatory Fisheries Stock Assessment' and enter your chosen name for the assessment.**
   This name will be used to name the file, and will be used to identify the Excel data file for importing data.

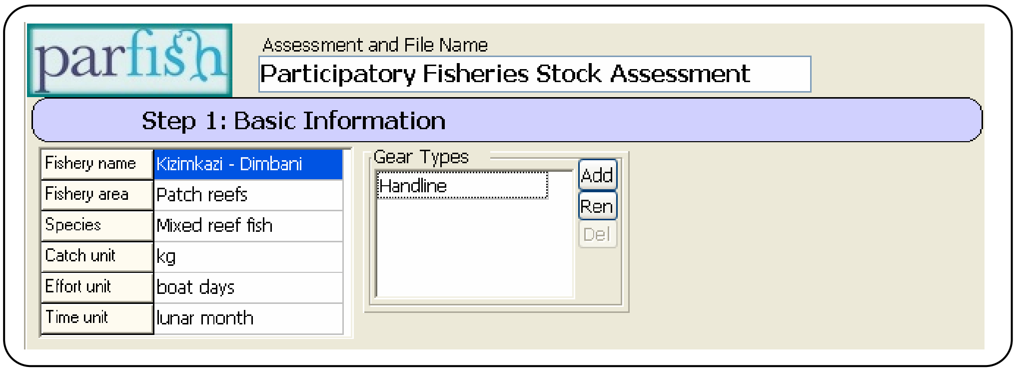
2. **Type in the name of the fishery in the 'Fishery name' field.**
   This is for reference purposes, for example, you may enter the name of the village taking part in the assessment.

3. **Type in the area in which the fishery takes place in the 'Fishery area' field.**
   For example, 'fringing reef', 'lagoon', 'patch reefs' etc., or the name of the lake, or reef etc.

4. **Type in the species the fishery targets in the 'Species' field.**
   The species or type of animal being caught e.g. grouper, lobster, octopus or mixed reef fish.

5. **Type in the units that are used for catches in the assessment in the 'Catch unit' field.**
   The unit used throughout the analysis and interviews for measuring catches, for example, 'kilograms', 'tonnes' etc.

Figure 11: Step 1: Basic Information



6. **Type in the units that are used for effort in the assessment in the 'Effort unit' field.**
   The unit used throughout the analysis for the effort, e.g. 'boat days', 'days', 'weeks' etc.

7. **Type in the units that are used for the time in the assessment in the 'Time unit' field.**
   The time unit used throughout the analysis for the overall time, for example 'lunar month', 'month', 'year' etc.

Naming and adding gears

1. **Left-click on 'Ren' (Rename) and type the name of the first gear type assessed, then press Return.**
   Enter the names of the gear types included in the assessment e.g. hand line, nets, traps etc. If you are assessing more than one gear, go to 2.

2. **Left-click on 'Add' (Add new gear) and type the name of the second gear type assessed, then press Return.**
   Repeat this for each gear assessed.

Hints:

- You can move between fields using either the mouse, Tab or the cursors.
- When renaming the gears, you can also press F2 instead of clicking 'Ren'.
- To delete a gear mistakenly added, left-click on 'Del' (Delete).

Step 2: MS Excel Input Data

This step covers:

- ✓ **Options for data input**
- ✓ **Opening the Excel ParFish Template**
- ✓ **Inputting Stock Assessment Interview data**
- ✓ **Inputting Long Term Time Series data e.g. Catch and Effort**
- ✓ **Inputting Short Term Time Series data e.g. Fishing Experiments**
- ✓ **Inputting Preference data**
- ✓ **Inputting Discount Rate data**

Options for data input

ParFish supports two types of data:

(i) particular types of data such as catch and effort, fishing experiment data and interview data outlined in the ParFish Guidelines; and
(ii) parameter frequencies obtained from fitting models to data in other software.

Type (i) data are used by the Software to generate the parameter frequencies and are the focus of this section.

You can either:
(i) input your data manually into the Software, or
(ii) input your data into the Excel ParFish Template, which provides the correct layout for your data so that it can be directly imported into the Software in Step 3.

The ParFish Template is linked to the Software, and a specific Template file will be created for your ParFish analysis, with the same file name as you gave your assessment in Step 1. If you have previously inputted your data into a separate Excel sheet, it is recommended that you copy and transfer the data into the ParFish Template.

The table below summarises the possible status of your data, and gives instructions on what you should do next in each case:

Status of Data	**Instructions**
Have not yet entered your data into the Template or another Excel or database file.	You have two options: 1) Enter data into the ParFish Template (following instructions **below**) (recommended); or 2) Enter data later directly into the models as you are setting them up (Step 3). Go to **Step 3: Probability Models.**
Have previously entered your data into a file but not into the Template.	You have two options: 1) Open the Template and copy and paste the data from the other file(s) into the Template file in the appropriate format (**recommended**) (see **below** for details); or 2) Copy and paste your data from the file directly into the Software in **Step 3: Probability Models..**

Opening the Excel ParFish Template

For this section, the following is assumed to be true:

- ✓ Your computer meets the System Requirements outlined in the **Introduction** section of this Manual;
- ✓ You have installed the ParFish Software and associated files on your computer;
- ✓ You have opened the ParFish Software.

To open the MS Excel template provided to input your data, follow these steps:

1. Click on 'Step 2: MS Excel Input Data'
MS Excel will start up and a template for inputting data will open, as shown in Figure 12.

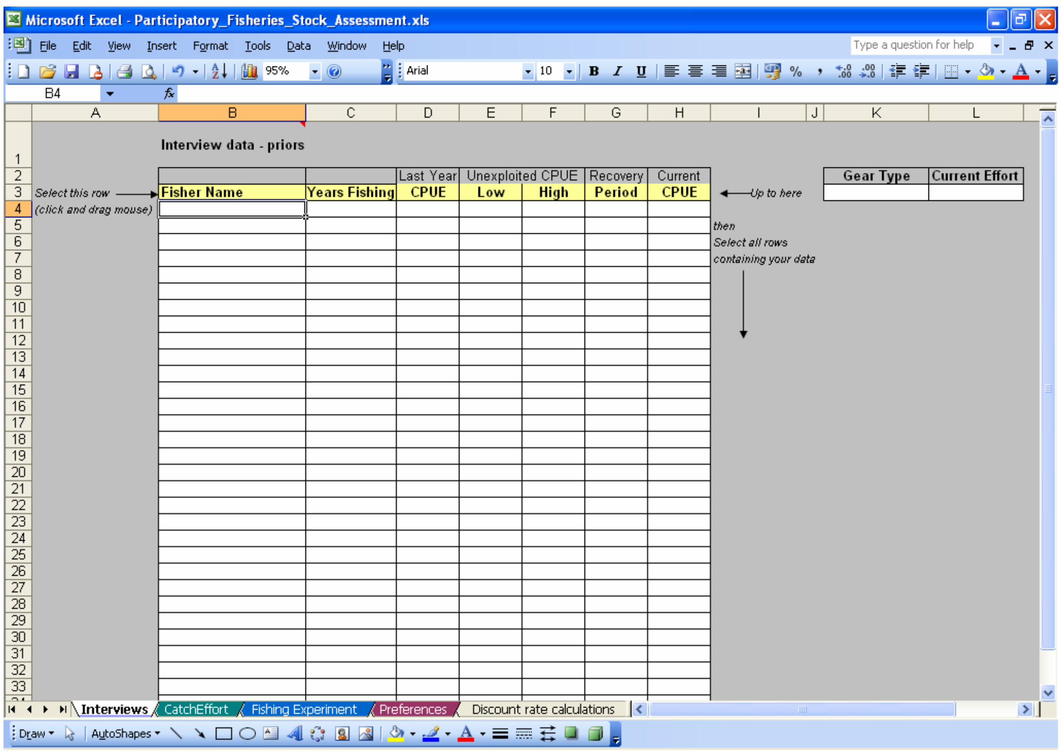
Hint: If the ParFish Template does not open, or if you wish to open the Template without opening the Software, you can open it manually from the ParFish folder on your computer (c:\programs\ParFish if you have accepted the default installation options). The file is called 'ParFish Template.xls'.

The Template contains 5 different worksheets to input different types of information:

- '**Interviews**' for Stock Assessment Interview data;
- '**CatchEffort**' for long term catch and effort data, or other long term time series data;
- '**Fishing Experiment**' for fishing experiment data;
- '**Preferences**' for the Preference Interview data;
- '**Discount rate calculations**' to input data from the Preference Interviews in order to calculate the discount rate.

2. Choose File ⇨ Save to save the file with the same name as the assessment.
The file will be saved in the c:\My Documents\ParFish folder, if you have installed the programme using the default settings.

Figure 12: The MS Excel Template



Inputting Stock Assessment Interview data

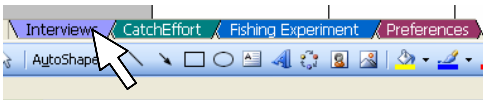
For this section, the following is assumed to be true:

- ✓ You have opened the ParFish Template in MS Excel (see **Opening the Excel ParFish Template** above);
- ✓ You have carried out Stock Assessment Interviews with a sample of fishers for the fishery concerned (see **Tool 16: Stock Assessment Interview** in the **ParFish Guidelines**).

To input Stock Assessment Interview data, follow these steps:

1. Click on the 'Interview' tab of the ParFish Template in Excel to go to the Stock Assessment Interview worksheet.
Figure 13 indicates where to click. When you open the ParFish Template for the first time, this worksheet is already open. You will see the worksheet shown in Figure 12.

Figure 13: Click on the 'Interview' tab to open the Stock Assessment Interview worksheet



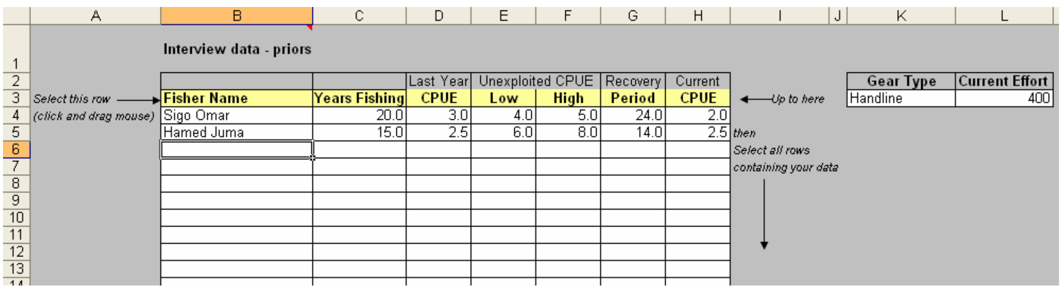
2. Enter the data from the Stock Assessment Interview, using one row for each fisher.
An example is shown in Figure 14. Enter the data as follows (the interview question number that relates to the data to be entered is indicated in brackets):

- Column B – enter the fisher's name (Background Information);
- Column C – enter the number of years' fishing (Question 1), or another measure of fisher importance;
- Column D – enter last year's CPUE for the fisher (Question 7);
- Column E – enter the fisher's minimum estimate of CPUE in an area never fished before (Question 8, 'Min');
- Column F – enter the fisher's maximum estimate of CPUE in an area never fished before (Question 8, 'Max');
- Column G – enter the time (in the units the assessment is dealing with e.g. years or months) the fisher thinks stocks would take to recover fully (Question 9);
- Column H – enter the fisher's current CPUE (Question 5).
- Cell K3 – type the gear type that this interview data refers to (Question 2, but it must be the same gear for all the interviews inputted on the worksheet).
- Cell L3 – Enter the current effort in the fishery, based on last year's effort or an estimate of this year's effort (see **Tool 2: Background Information to Compile**, and **Stage 1: Understand the Context** in the ParFish Guidelines).

Important!

- Make sure you type the gear name in the Excel Template exactly as it is typed in Step 1 'Basic Information' on the Main Page of the ParFish Software, otherwise there will be an error when you try to import the data.
- Interview questions not entered here will be entered in the worksheet 'Preferences'.

Figure 14: Example of Stock Assessment Interview data in the Excel Template



	Fisher Name	Years Fishing	Last Year CPUE	Unexploited CPUE Low	Unexploited CPUE High	Recovery Period	Current CPUE		Gear Type	Current Effort
4	Sigo Omar	20.0	3.0	4.0	5.0	24.0	2.0		Handline	400
5	Hamed Juma	15.0	2.5	6.0	8.0	14.0	2.5			

Inputting long term time series data (Catch and Effort)

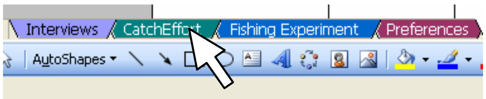
For this section, the following is assumed to be true:

- ✓ You have opened the ParFish Template in MS Excel;
- ✓ You have compiled long-term catch and effort data for the fishery concerned (see **Tool 19: Using existing Catch and Effort Data** in the **ParFish Guidelines**) (if you have not collected catch and effort data skip this section).

To input long term time series data such as Catch and Effort, follow these steps:

1. Click on the 'CatchEffort' tab of the ParFish Template in Excel to go to the Catch Effort data worksheet.
Figure 15 indicates where to click. The worksheet in Figure 16 appears.

Figure 15: Click on the 'CatchEffort' tab to open the Catch Effort worksheet



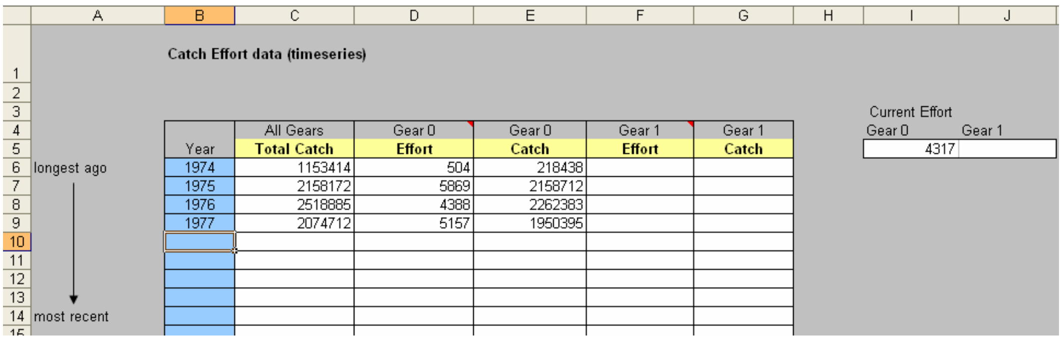
2. Enter the Catch and Effort data, using one row for each year, with the oldest data first.
An example is shown in Figure 16. Enter the data as follows:

- Column B – enter the year or time, oldest data first (this is for your reference and is not used by the Software);
- Column C – enter the total catch for the fishery for each time unit, from all gears;
- Column D – enter the effort that corresponds to 'Gear 0' ('Gear 0' is the first gear you are assessing; 'Gear 1' is the second gear, etc.);
- Column E – enter the catch that relates to 'Gear 0';
- Column F – enter the effort that corresponds to 'Gear 1';
- Column G – enter the catch that relates to 'Gear 1';
- Cell I5 – enter the current effort for Gear 0;
- Cell J5 – enter the current effort for Gear 1;
- If you have more than two gears, insert further columns for Effort and Catch for each gear, and insert further cells in row 5 for Current Effort for each extra gear;
- If you have extra data such as a population index (e.g. a survey index), add an extra column. Data for such an index may have been collected through underwater visual census, for example.

Hint!

- Column C must be completed for all years with no gaps;
- Columns D – G may have gaps i.e. empty cells

Figure 16: Example of the Catch Effort Worksheet for long term time series data in the ParFish Template



Catch Effort data (timeseries)

	A	B	C	D	E	F	G	H	I	J
1										
2										
3									Current Effort	
4			All Gears	Gear 0	Gear 0	Gear 1	Gear 1		Gear 0	Gear 1
5		Year	Total Catch	Effort	Catch	Effort	Catch		4317	
6	longest ago	1974	1153414	504	218438					
7		1975	2158172	5869	2158712					
8		1976	2518885	4388	2262383					
9		1977	2074712	5157	1950395					
10										
11										
12										
13										
14	most recent									

Inputting short term time series data (fishing experiments)

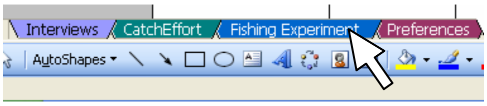
For this section, the following is assumed to be true:

- ✓ You have opened the ParFish Template in MS Excel;
- ✓ You have carried out a Fishing Experiment for the fishery concerned (see **Tool 18: Fishing Experiments** in the **ParFish Guidelines**)(if you have not carried out fishing experiments skip this section).

To input short term time series data such as Fishing Experiment data, follow these steps:

1. **Click on the 'Fishing Experiment' tab of the ParFish Template in Excel to go to the Fishing Experiment (short term time series) data worksheet.**
   Figure 17 indicates where to click. The worksheet in Figure 18 appears.

Figure 17: Click on the 'Fishing Experiment' tab to open the Fishing Experiment worksheet



2. **Enter the Fishing Experiment data, using one row for each day or time unit, starting with the oldest data first.**
   Enter the data as follows:

- Column B – the time units e.g. day, have already been entered, but you may alter this if you wish for your reference (this is not used by the Software);
- Column C – enter the total catch from the experiment for each day, from all gears (oldest data first);
- Column D – enter the effort that corresponds to 'Gear 0' for each day of the experiment ('Gear 0' corresponds to the first gear you were assessing, 'Gear 1' to the second gear, etc.);
- Column E – enter the catch for 'Gear 0' that was caught through the effort in column D;
- Column F – if available, enter a survey index or population index (see **hint** below and **Tool 19: Fishing Experiments** in the **ParFish Guidelines**);
- Columns G & H – Add further columns for Effort and Catch, repeating columns D and E, for each gear assessed.
- Add further columns similar to column F if you have more than one Survey Index.

Figure 18: Example of the Fishing Experiment Worksheet for short term time series data in the ParFish Template

Fishing Experiment Data

Time (days)	All Gears Total Catch	Gear 0 Effort	Gear 0 Catch	Survey Index
0	322.68	28	322.68	0.76814
1	398.4	40	398.4	0.9801
2	776	34	776	
3	856.08	41	856.08	0.25483
4	329.99	43	329.99	
5	274.5	42	274.5	0.49697
6				
7				

Hint! The Survey Index is a way of cross referencing the fishing experiment data. It may be made up of counts of target fish species from an underwater visual survey, for example, carried out on the same day as the fishing. The units are not important, but must be standardised, e.g. counts of fish per standard transect. The template does not support these calculations as each case may be different, depending on the experiment and survey carried out. You should therefore carry out the calculations to obtain the survey index independently in a separate Excel worksheet, and copy them into the ParFish Template.

Inputting Preferences data

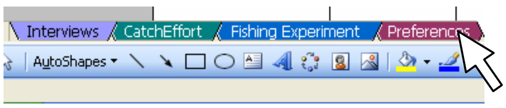
For this section, the following is assumed to be true:

- ✓ You have opened the ParFish Template in MS Excel;
- ✓ You have carried out Stock Assessment and Preference Interviews with a sample of fishers for the fishery concerned (see **Tool 16: Stock Assessment Interview, and Tool 17: Preference Interview** in the **ParFish Guidelines**) (data from both interviews are required).

To input Preference Interview data, follow these steps:

1. Click on the 'Preferences' tab of the ParFish Template in Excel to go to the Preferences data worksheet.
Figure 19 indicates where to click. A worksheet similar to that in Figure 20 appears (see over the page).

Figure 19: Click on the 'Preferences' tab to open the Preferences worksheet

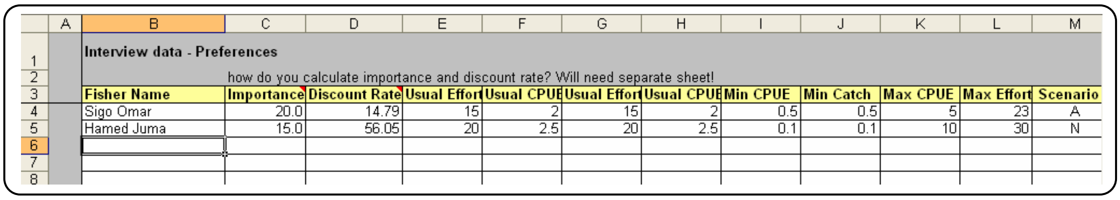


2. Enter the Preferences data, using one row for each fisher.
Enter the data, using one row for each fisher, as follows (the interview question number from the Preference or Stock Assessment Interviews relating to the data to be entered is indicated in brackets):

- Column B – enter the fishers' name (Background Information);
- Column C – enter the fisher's importance, which is the weighting you want to give the fisher's preferences in the analysis. This could be based on the number of dependents the fisher has (Question 15(b) of Preference Interview), or the proportion of income from fishing (Question 15(c) of Preference Interview) or another measure of fisher importance (Question 15(a) of Preference Interview);
- Column D – enter the Discount Rate, which can be calculated for each fisher using the 'Discount Rate Calculations' worksheet in the ParFish Excel Template (Question 16) (see below);
- Column E – enter the fisher's usual effort in each unit of time, for example an effort level such as the number of boat days in a lunar month (Question 3 of Stock Assessment Interview);
- Column F – enter the fisher's usual CPUE (Question 5 of Stock Assessment Interview);
- If you are carrying out the assessment for more than one gear, copy columns E and F by highlighting the grey bar at the top of columns E & F (as in Figure 21), choose Edit ⇨ Copy from the menu, then highlight column G and choose Insert ⇨ Copied Cells from the menu. Do this for each extra gear you are assessing and enter the data for each gear as in columns E and F. The columns referred to below assume the assessment is done for one gear only, therefore if you have more than one gear type, the columns will have different letters from those referred to here as a result of the extra columns you have pasted in.
- Column G – enter the minimum CPUE the fisher would accept, below which it would not be worth going fishing (Question 11);
- Column H – enter the minimum catch per unit of time that the fisher would accept, below which it would not be worth going fishing (Question 12);
- Column I – enter the maximum CPUE that the fisher could cope with with his or her current gear (Question 13);
- Column J – enter the maximum effort that the fisher could apply with his or her current gear in one unit of time (Question 14);

- Columns K–AA – enter the rank order of the scenarios from the Preference Interview ('Catch and Effort Preference'), entering the letter for one scenario in each column, from most preferred (column M) to least preferred (column AC);
- Columns AD–AS – enter the preference score (0-4) for each pair of ranked scenarios: the score for the preference of the most preferred scenario (1) over the second most preferred scenario (2), goes in column AD ('Score 1'); the preference score for the second most preferred scenario (2) over the third most preferred scenario (3) goes in column AE ('Score 2') and so on.

Figure 20: Example of the Preferences Worksheet for Preference Interview data in the ParFish Template

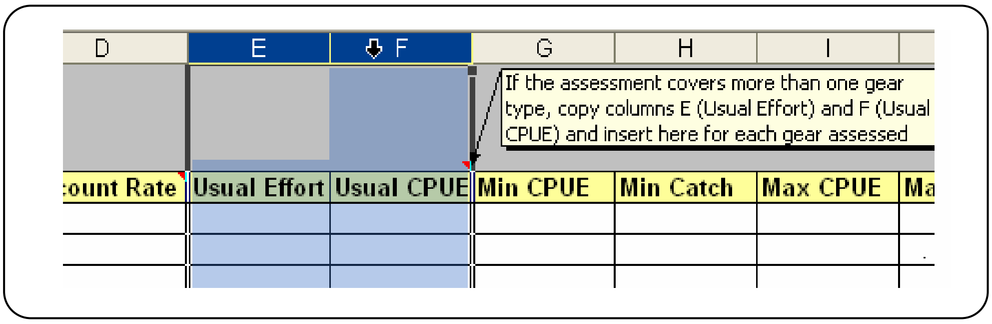


Interview data - Preferences

how do you calculate importance and discount rate? Will need separate sheet!

Fisher Name	Importance	Discount Rate	Usual Effort	Usual CPUE	Usual Effort	Usual CPUE	Min CPUE	Min Catch	Max CPUE	Max Effort	Scenario
Sigo Omar	20.0	14.79	15	2	15	2	0.5	0.5	5	23	A
Hamed Juma	15.0	56.05	20	2.5	20	2.5	0.1	0.1	10	30	N

Figure 21: Copying columns E and F to repeat them for other gears being assessed



Inputting Discount Rate data

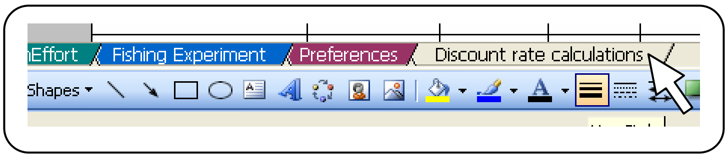
For this section, the following is assumed to be true:

- ✓ You have opened the ParFish Template in MS Excel;
- ✓ You have carried out Preference Interviews with a sample of fishers for the fishery concerned (see **Tool 17: Preference Interview** in the **ParFish Guidelines**).

To input Discount Rate data, follow these steps:

1. Click on the 'Discount rate calculations' tab of the ParFish Template in Excel to go to the Discount Rate data worksheet.
Figure 22 indicates where to click. A worksheet similar to that in Figure 23 appears.

Figure 22: Click on the 'Discount rate calculations' tab to open the Discount Rate worksheet



2. Enter the Discount rate data.
Enter the data, using one row for each fisher, as follows (the fishers' names are linked to the names on the Preferences Worksheet). Refer to **Tool 17: Preference Interview** in the **ParFish Guidelines** for explanation of the questions used to collect this data:

- Column B – the fisher's names should appear automatically from the Preferences Worksheet (Background Information);
- Column C – enter the value of the payoff 'now' (= χ, or current monthly earnings) offered to the fisher (Question 16, χ);
- Column D – enter the value of the payoff later, after a time delay (=χ + 20%) offered to the fisher (Question 16, χ+20%);
- Column E – enter the time delay that the fisher has no preference for receiving χ now, or χ+20% later, using the same time units as the assessment (Question 16).

3. Select the cells in Column F.
Select the cells with the discount rate data in Column F of the Discount rate calculations worksheet.

4. Choose Edit ⇨ Copy from the menu.
This copies the information in the selected cells.

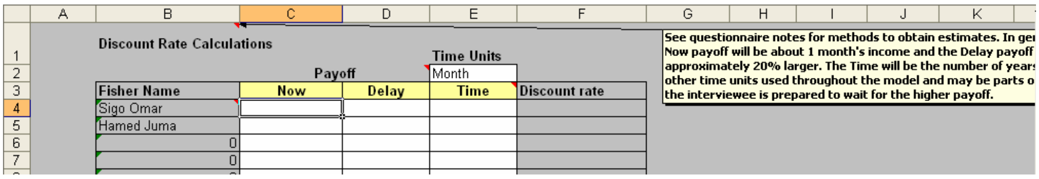
5. Click on the 'Preferences' tab.
This will take you to the Preferences worksheet.

6. Click on the first cell of the Discount Rate column (cell D4).
This will be the first cell where the Discount Rate data is copied to.

7. Choose Edit ⇨ Paste Special from the menu.
The Paste Special dialogue box appears. You can also access the Paste Special dialogue box by right-clicking on the mouse and choosing 'Paste Special'.

8. Click 'Values' and then 'OK'.
The values from the Discount Rate calculations will be pasted into the Preferences Worksheet. This pastes just the values, rather than the formulae, from the Discount Rate worksheet.

Figure 23: Example of the Discount rate calculations worksheet for discount rate data in the ParFish Template



If you cannot paste in the discount rate data because the worksheet is 'protected', choose Tools ⇨ Protection ⇨ Unprotect sheet from the menu and enter the password 'pfsa'.

Saving your data

Save your data by following these steps:

1. **Choose File ⇨ Save As on the menu.**
The Save As dialogue box appears.

2. **Type the file name and select the location for the file and click on 'Save'.**
The Template should automatically be given the same name as you used for the ParFish Software file (in Assessment and File Name). You should keep this same name.

If you are going to continue using the Software to building probability models, you should keep the Excel Template with your data open.

Step 3: Probability Models

This Step covers:

- ✓ **The Probability Models page**
- ✓ **Adding a model for the Stock Assessment Interview data**
- ✓ **Adding a model for long term time series data e.g. catch and effort**
- ✓ **Adding a model for short term time series data e.g. fishing experiments**
- ✓ **What to do if smoothing parameters could not be fitted**
- ✓ **Generating parameter frequencies for the models**
- ✓ **Drawing a posterior sample**

Step 3 guides you through the process of setting up and fitting a hierarchy of models that contain all your data on the fishery. The models all provide information on ***parameters*** of the fish stock. The overall model used for the assessment in this version of the ParFish Software is the Logistic Biomass Growth model, and therefore the parameters used are:

Bnow	= 'Biomass now', the estimated total biomass of the fish stock at the current time.
Binf	= 'Biomass at infinity', the estimated total biomass of the unexploited fish stock.
r	= 'Reproduction rate', the estimated growth rate of the fish stock, or rate of reproduction.
q	= 'Catchability', an estimated index of the ease of catching the fish with the gear under consideration.

These parameters are estimated from the data, through the use of models, and provide information on how the stock is expected to respond to changes in controls e.g. quotas, effort levels or closed areas. The models used are accepted stock assessment models developed by fisheries scientists to describe how fish stocks behave (i.e. their size, rate of growth, and mortality). Here we will not go into the details of the underlying models, but will guide you through setting up the models for use in ParFish.

The main model types supported by the Software are:

- Interview model – for the Stock Assessment Interview data – logistic population model;
- Catch-Effort model – for long term catch and effort data – logistic population model;
- Fishing Experiment – for short term catch and effort data – linear depletion model with associated population index:
  - linear normal;
  - multiplicative poisson;
  - multiplicative log-normal.

The Stock Assessment Interview data provide **prior** probability estimates as PDFs for all of the parameters. These PDFs are the starting point for our assessment. Further models and data that we add update these estimates, to give **posterior** PDFs (see the section on **Background Information** for more details). Each time more data is added, the estimates of the parameters should become closer to reality.

The overall process for Step 3 is as follows:

1. Set up an Interview Model, load in your data, and check the model fits
2. Set up other models for your other data e.g. catch and effort, or fishing experiment depending on the data you have collected.
3. Fit these models and check that the smoothing matrix has been successful
4. Generate parameter frequencies for the models
5. Draw posterior samples for the overall model for estimates of the parameter

The Probability Models page

For this section, the following is assumed to be true:

- ✓ You have installed and opened the ParFish Software.

To open the Probability Models page, follow these steps:

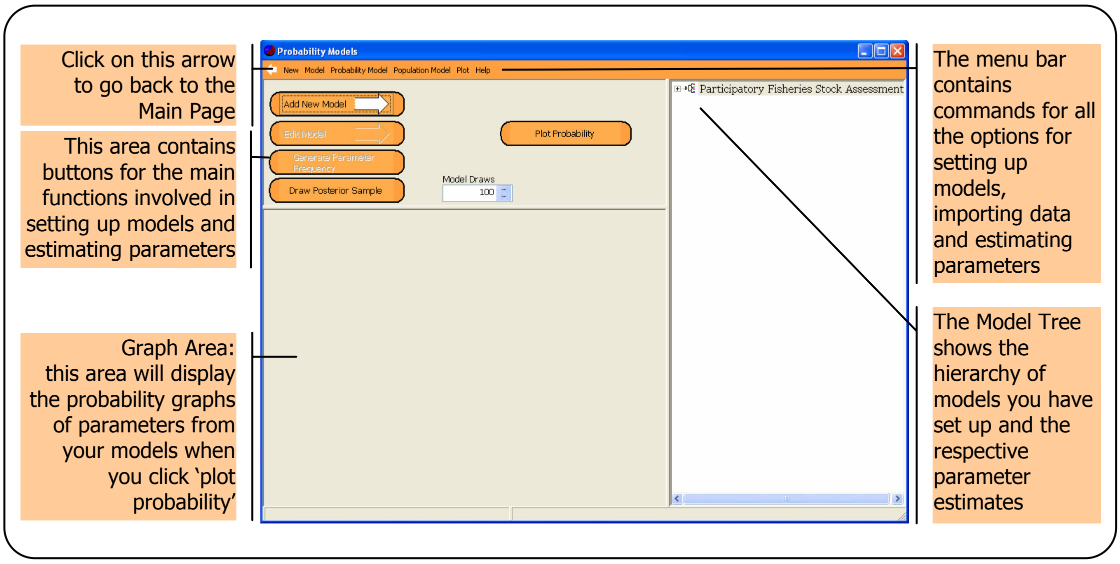
1. Click on 'Step 3: Probability Models' on the Main Page.
The Probability Models page appears, as in Figure 24.

You can set up models easily using the New Model wizard, which takes you through the steps of building the 3 most common types of model:

- '**Interview model**' for the Stock Assessment Interview data;
- '**Long term catch effort time series**' for catch and effort data, or other long term time series data;
- '**Fishing experiment**' for short term time series data such as fishing experiments.

Setting up each model is explained below. You should first set up the logistical population model based on the interview data. This sets the prior probabilities to which further information is added through other models and data.

Figure 24: The Probability Models page, Step 3



Adding a model for the Stock Assessment Interview data

For this section, the following is assumed to be true:

- ✓ You have completed the Basic Information in Step 1, including naming the gear types;
- ✓ You have carried out Stock Assessment Interviews with a sample of fishers for the fishery concerned (see **Tool 16: Stock Assessment Interview** in the **ParFish Guidelines**);
- ✓ You have installed and opened the ParFish Software and have the Probability Models page (Step 3) open;
- ✓ If you wish to import your data from the MS Excel ParFish Template (recommended), you have inputted your data to the Template (see Step 2).

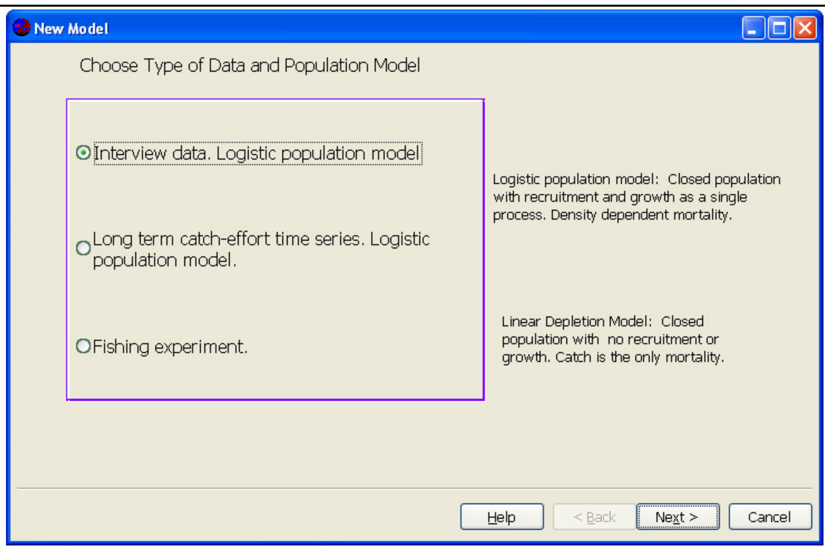
To add a model for the Stock Assessment Interview data, follow these steps:

1. Click on the 'Add New Model' button on the Probability Models page.
The New Model wizard dialogue box appears, as shown in Figure 25.

2. Select 'Interview data. Logistic population model' and then click Next.
The 'Get Stock Assessment Interview data' dialogue box appears. You can either:

- import your data from the ParFish Template (recommended) (see **Step 2: MS Excel Input Data**) (go to #3 below); or
- enter your data manually (skip to #7 below).

Figure 25: The 'New Model' wizard allows you to select which type of model you want to add



3. Click on 'Select' in the New Model wizard in the ParFish Software.
The ParFish Template (with your data in it, if you entered it in Step 2) will open in MS Excel. You will be taken to MS Excel. If you are not automatically taken to Excel, go to Excel manually by clicking on the Excel tab in the windows task bar.

4. Go to the 'Interviews' worksheet, select the yellow header cells (B3 to H3) and all the cells containing data for the fishers.
It is important that you select the correct cells and select all the data. See Figure 26 for an example.

5. Return to the ParFish Software and click 'Load'. Then skip to #7.
You can return to the ParFish Software by clicking on the ParFish tab at the bottom of your screen (Figure 27). The highlighted data will appear in the New Model wizard as in Figure 28.

6. To manually input your data, enter the data in the corresponding cells in the table, using the mouse, tab or cursors to move between cells. The column headings are the same as those in Excel so you can refer to the explanations given in 'Inputting Stock Assessment Interview Data' on page 23.

Figure 26: Select the yellow header cells and all the cells below containing the interview data

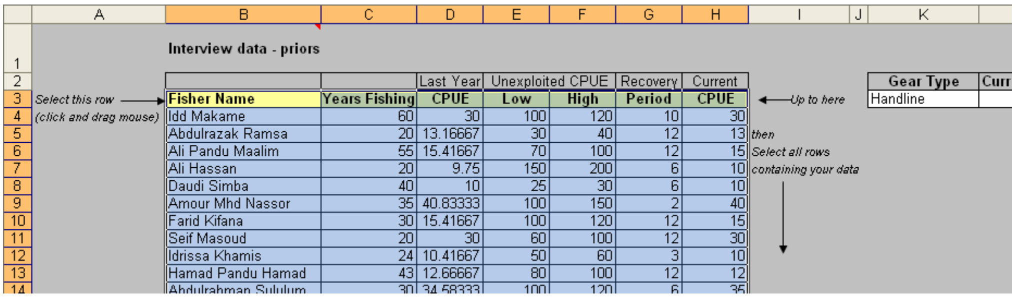


Figure 27: Click on the tab to return to the ParFish Software from the Excel Template

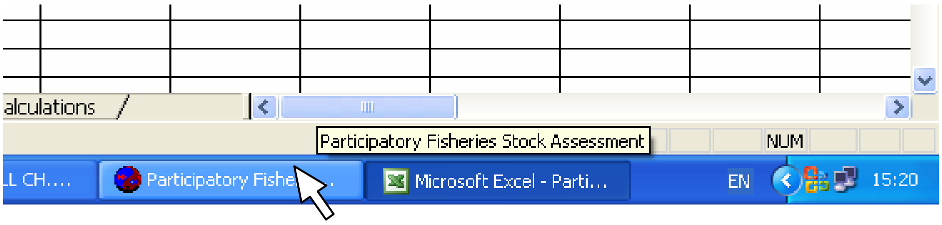
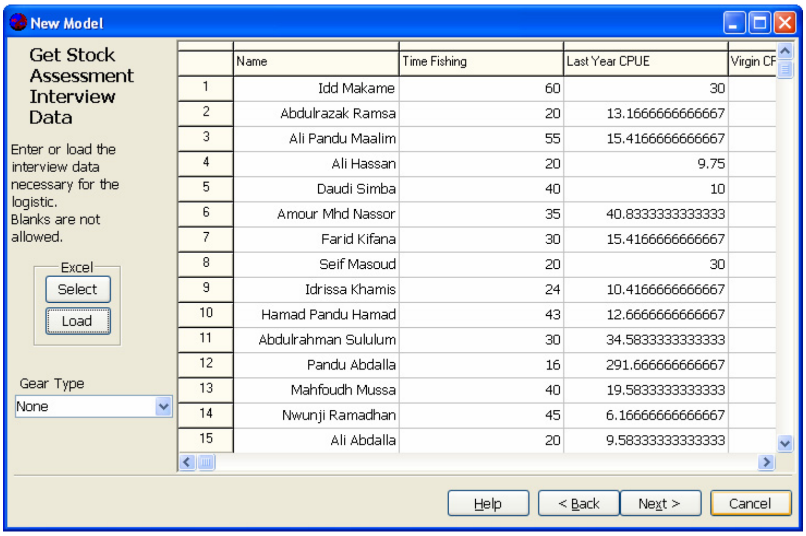


Figure 28: The selected data appear in the wizard



7. **Select the Gear Type that the data applies to, from the drop-down list.**
   The gear type options provided are the gear types you entered in **Step 1: Basic Information** on the Main Page of the Software.

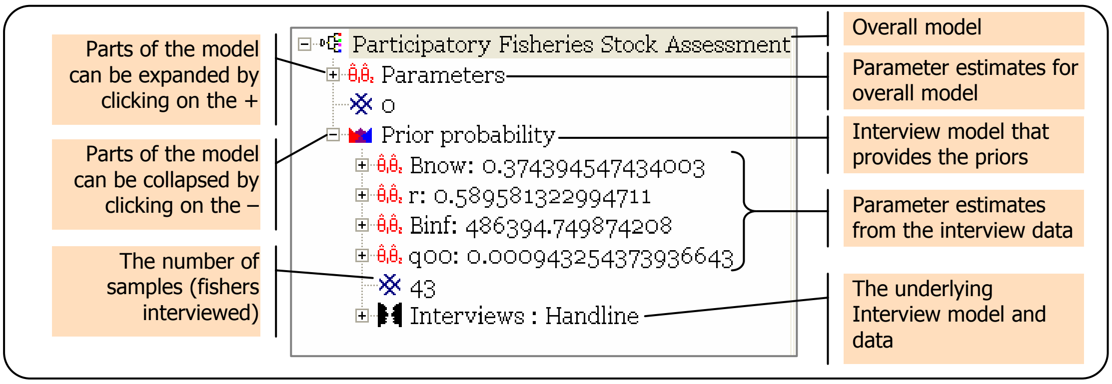
8. **Click Next.**
   The total effort dialogue box of the New Model wizard appears.

9. **Enter the total current effort (or last year's effort) in the fishery for each gear type, then click Finish.**
   You should have an estimate for current effort from compiling background information (see **Tool 2: Background Information to Compile**, and **Stage 1: Understand the Context** in the ParFish Guidelines).

   The ParFish Software will build a model based on the interview data and it will appear in the Model Tree, similar to the one shown in Figure 29, although the actual values for the parameters will differ depending on your data.

When you return to the ParFish Software, if the New Model wizard is not visible, just click on the 'Add New Model' button again, and the wizard should appear at the stage you were on when you left the Software.

Figure 29: Prior probability model for the Stock Assessment Interview data



10. If you wish to rename the model, right-click on 'Prior probability' and then choose Rename, type a new name and press enter.
The model is renamed with your chosen name.

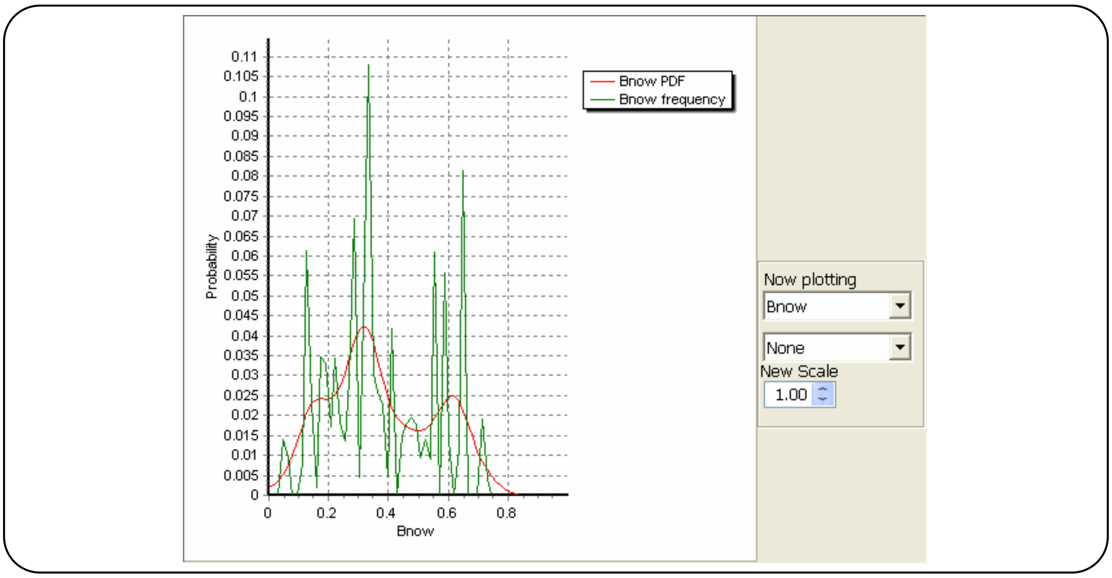
11. Select the prior probability (or otherwise named) model so that is highlighted and click the 'Plot Probability' button to plot the probability density functions (PDFs) for the parameters of the model.
A graph will appear in the Graph Area, with green and red lines, similar to that shown in Figure 30.

If you receive the message 'Smoothing parameters could not be fitted …' see the section below on ***What to do if smoothing parameters could not be fitted***.

12. Select different parameters from the 'Now plotting' drop down menu.
You should check the graphs for all four parameters of the model (Bnow, Binf, r and q) using the drop down menu on the right hand side of the graph under 'Now Plotting'.

The probability graphs help you check whether the models have fitted correctly or not. The green spiky line shows the actual data; the red smoother line is the estimated probability distribution, which is obtained by applying a smoothing matrix to the actual data. The smooth red line should roughly follow the green spiky line, as in Figure 30.

Figure 30: Probability Density Function (PDF) for the Prior probabilities



Adding a model for long term time series data (Catch-Effort)

For this section, the following is assumed to be true:

- ✓ You have completed the Basic Information in Step 1, including naming the gear types;
- ✓ You have compiled long-term catch and effort data for the fishery concerned (see **Tool 19: Using existing Catch and Effort Data** in the **ParFish Guidelines**);
- ✓ You have installed and opened the ParFish Software and have the Probability Models page (Step 3) open;
- ✓ If you wish to import your data from the MS Excel ParFish Template (recommended), you have inputted your data to the Template (see Step 2);
- ✓ You have entered interview data form the Stock Assessment Interview to set up the prior probabilities.

To add a model for the Stock Assessment Interview data, follow these steps:

1. **Click on the 'Add New Model' button on the Probability Models page.**
   The New Model wizard dialogue box appears, as shown in Figure 25.

2. **Select 'Long term catch-effort time series: Logistic population model' and then click Next.**
   The 'Get Total Catch Data' dialogue box appears. You can either:
   - import your data from the ParFish Template (recommended) (see **Step 2: MS Excel Input Data**) and go to #3 below; or
   - enter your data manually (skip to #6 below).

3. **Click on 'Select' in the New Model wizard.**
   The ParFish Template that contains your data will open and you will be taken to MS Excel. If the Template was already open, you should go to Excel manually by clicking on the Excel tab on the task bar.

4. **Go to the 'CatchEffort' worksheet, select the yellow header cell for 'Total Catch' (cell C5) and all the cells in the column that contain the total catch data.**
   See Figure 31 for an example.

5. **Return to the ParFish Software and click 'Load'. Then skip to #7 below.**
   The highlighted data will appear in the New Model wizard.

6. **To manually input your data, enter the total catch data in the cells in the table, starting with the oldest data first. Use the mouse, tab or cursors to move between the cells.**

7. **Click 'Next'.**
   The 'Set Catch and Effort or Index Series' dialogue box appears, as shown in Figure 32.

8. **Select the default, 'Catch and Effort' in the Index Type box.**

9. **Select the gear that the data you are going to load in applies to, from the drop down list.**

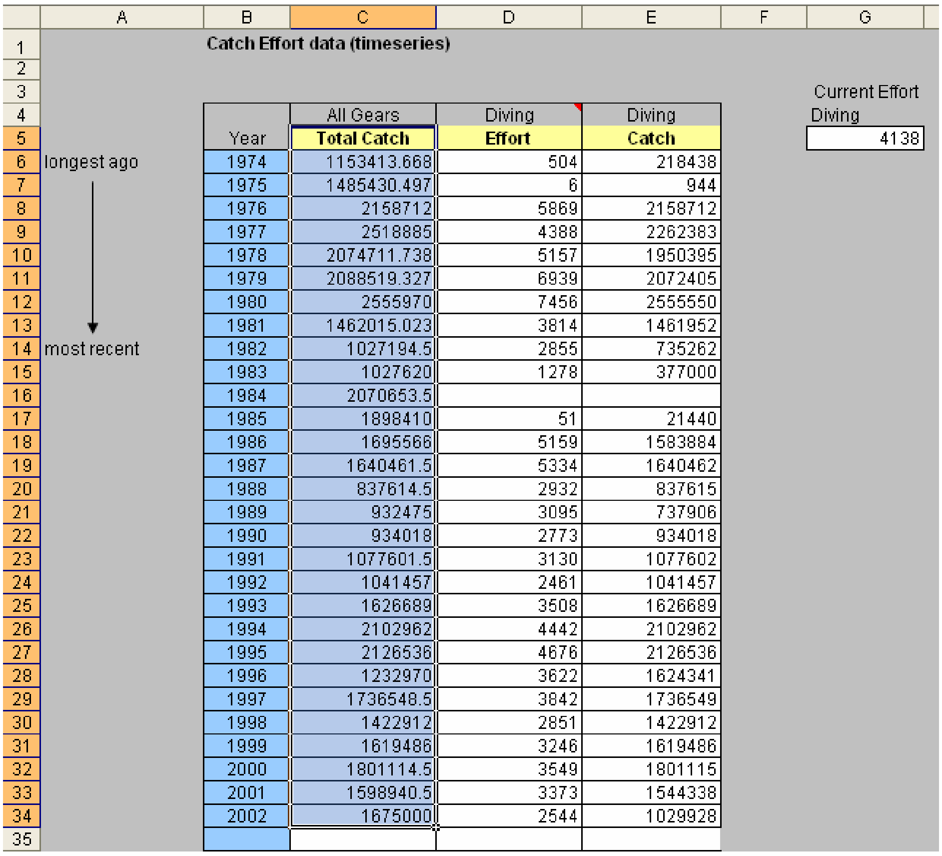
10. **Click on 'Select'.**
    You will be taken to MS Excel.

11. **Go to the 'CatchEffort' worksheet, select the yellow header cells for 'Effort' and 'Catch' (cells D5 and E5) and all the cells containing catch and effort data up to the most recent year, including the years for which no data exist.**

12. **Return to the ParFish Software and click 'Load'. Then skip to #14 below.**
    The selected data will appear in the New Model wizard.

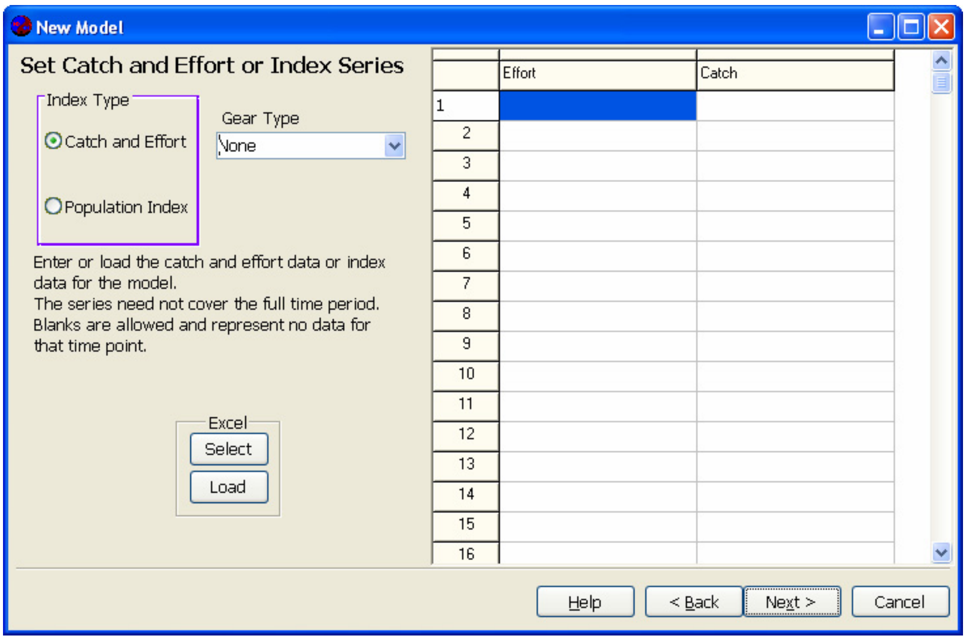
13. **To manually input your data, enter the effort and catch data for the gear in the cells in the table, starting with the oldest data first.**
    The rows must correspond to the rows for the same year as the 'Total Catch' data. Leave blanks in a row if data do not exist for that year.

Figure 31: Select the yellow header cell for Total Catch and all the cells containing total catch data



	A	B	C	D	E	F	G
1		Catch Effort data (timeseries)					
2							
3							Current Effort
4			All Gears	Diving	Diving		Diving
5		Year	Total Catch	Effort	Catch		4138
6	longest ago	1974	1153413.668	504	218438		
7		1975	1485430.497	6	944		
8		1976	2158712	5869	2158712		
9		1977	2518885	4388	2262383		
10		1978	2074711.738	5157	1950395		
11		1979	2088519.327	6939	2072405		
12		1980	2555970	7456	2555550		
13		1981	1462015.023	3814	1461952		
14	most recent	1982	1027194.5	2855	735262		
15		1983	1027620	1278	377000		
16		1984	2070653.5				
17		1985	1898410	51	21440		
18		1986	1695566	5159	1583884		
19		1987	1640461.5	5334	1640462		
20		1988	837614.5	2932	837615		
21		1989	932475	3095	737906		
22		1990	934018	2773	934018		
23		1991	1077601.5	3130	1077602		
24		1992	1041457	2461	1041457		
25		1993	1626689	3508	1626689		
26		1994	2102962	4442	2102962		
27		1995	2126536	4676	2126536		
28		1996	1232970	3622	1624341		
29		1997	1736548.5	3842	1736549		
30		1998	1422912	2851	1422912		
31		1999	1619486	3246	1619486		
32		2000	1801114.5	3549	1801115		
33		2001	1598940.5	3373	1544338		
34		2002	1675000	2544	1029928		
35							

Figure 32: The 'Set Catch and Effort or Index Series' dialogue box of the New Model wizard, for a long term time series model



14. Click Next.
The Model Name and Another Index Model dialogue box appears.

15. Type a new name for the model in the 'Model Name' field if you wish.

16. If you have catch and effort data for other gears, or if you have data on a population index that relates to the stock size, select 'Yes' in the 'Another Index Model' box and then click Next. Go to #18. If you do not have data for other gears or an index, select 'No' in the 'Another Index Model' box, then skip to #20.

17. For catch and effort data from other gears, repeat steps 9 – 17 for each gear type. For an index model go to #18.

18. Select 'Population Index' in the Index Type box. Either click on 'Select', select your data in Excel, return to the ParFish Software and then click on 'Load', or manually input the index data. Then click Next.
The Index Model Type dialogue box will appear, with the option of three different model types.

19. Select the type of Index Model Type from the box and click Next. Repeat steps 15 - 16.
You may keep the default model type (multiplicative poisson) unless you have reason to believe one of the alternative models provides a better fit for your data.

20. Click Next.
A graph will appear similar to the one in Figure 33, which shows the observed values (the data points, as green squares) and expected values (according to the model, as a red line).

The graph should look similar to the one in Figure 33, with a red line (expected values) that follows the trend of the green squares (the observed data points), indicating that the model has successfully fitted. If the red line does not follow the trend of the green squares (see the example in Figure 34), the model has not fitted correctly. If this occurs, you should either add more data (for example, another index if you have one), try reestimating the smoothing matrix (see the section below on ***What to do if smoothing parameters could not be fitted*** or delete the model from the analysis. The dialogue box below the graph also gives you an explanation on how to check if the model has fitted.

Figure 33: Example of observed and expected values from fitting a long term time series model to catch and effort data.

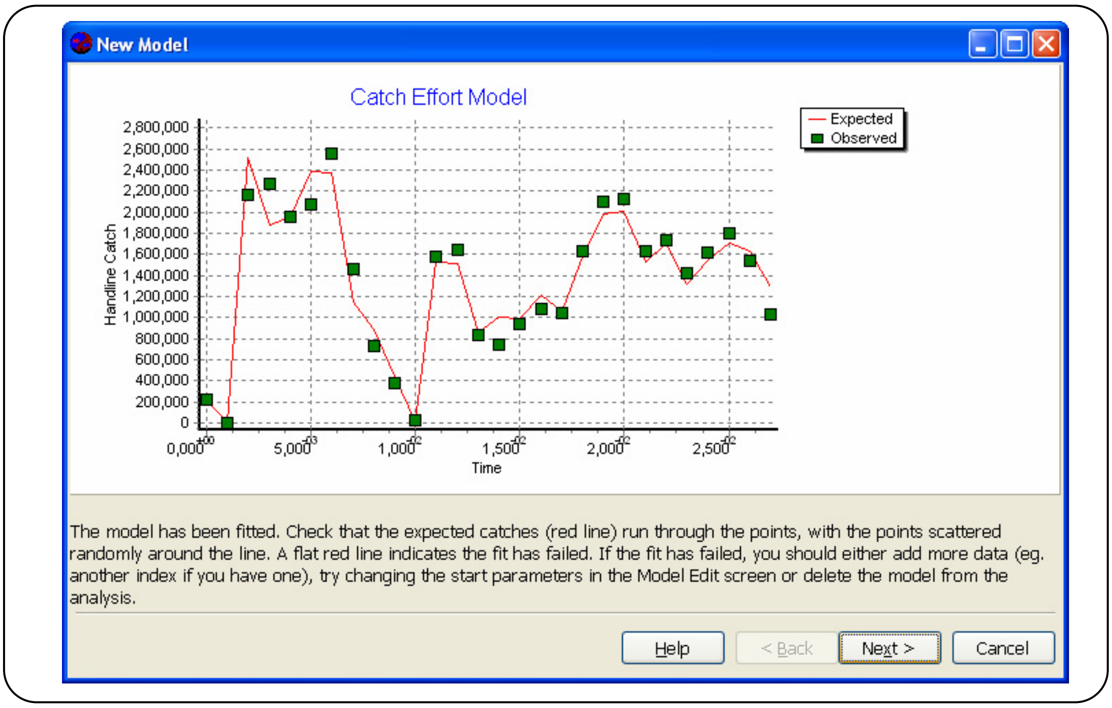
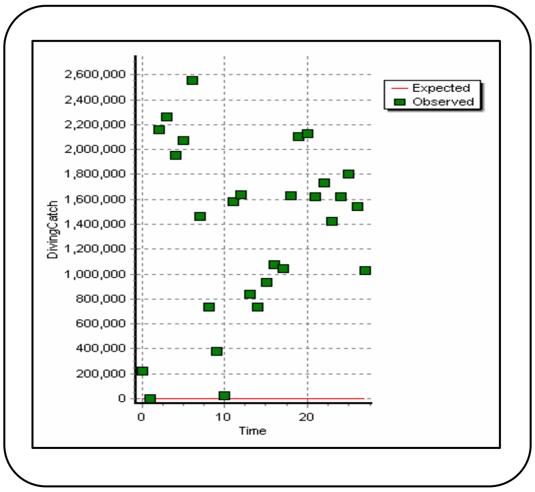


Figure 34: Example of a graph showing the model did not fit successfully



21. Click Next or Finish.

For each index model and gear type that you added, a separate graph will be displayed. The dialogue box below the graph gives you an explanation on how to check if the model has fitted. When all graphs have been displayed, you will be able to click Finish.

The Software will attempt to generate parameter frequencies (repeated estimates of the model parameters, based on the data provided), and build the probability density function for the parameters. A model similar to the one shown in Figure 35 will appear in the Model Tree, with estimates for the parameters for the Catch and Effort Model.

22. If you wish to rename the model, right-click on 'Logistic biomass growth Probability' and choose Rename, type a new name, then press Enter.

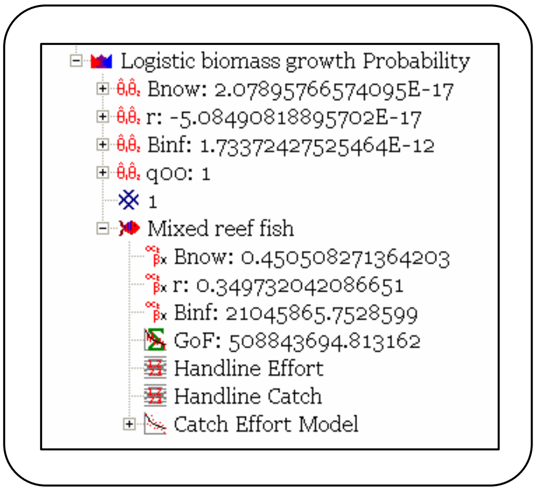
The model is renamed with your chosen name.

23. With the model name highlighted click the 'Plot Probability' button to plot the probability density functions (PDFs) for the parameters of the model.

A graph will appear in the Graph Area, with green and red lines, similar to that shown previously in Figure 30.

If you receive the message 'Smoothing parameters could not be fitted …' see the section below on ***What to do if smoothing parameters could not be fitted***.

Figure 35: Example of a long term time series model in the Model Tree



24. Select different parameters from the 'Now plotting' drop down menu.

You should check the graphs for all four parameters of the model (Bnow, Binf, r and q).

The probability graphs help you check whether the models have fitted correctly or not. The green spiky line shows the actual data; the red smoother line is the estimated probability distribution, which is obtained by applying a smoothing matrix to the actual data. The smooth red line should roughly follow the green spiky line, as in Figure 30.

Adding a model for short term time series data (e.g. fishing experiment)

For this section, the following is assumed to be true:

- ✓ You have completed the Basic Information in Step 1, including naming the gear types;
- ✓ You have carried out a Fishing Experiment (see **Tool 18: Fishing Experiments** in the **ParFish Guidelines**);
- ✓ You have installed and opened the ParFish Software and have the Probability Models page (Step 3) open;
- ✓ If you wish to import your data from the MS Excel ParFish Template (recommended), you have inputted your data to the Template (see Step 2).

To add a model for the Stock Assessment Interview data, follow these steps:

1. **Click on the 'Add New Model' button on the Probability Models page.**
   The New Model wizard dialogue box appears, as shown in Figure 25.

2. **Select 'Fishing experiment' and then click Next.**
   The 'Get Total Catch Data' dialogue box appears. You can either:
   - import your data from the ParFish Template (recommended) (see **Step 2: MS Excel Input Data**) (go to #3 below); or
   - enter your data manually (skip to #7 below).

3. **Click on 'Select' in the New Model wizard.**
   The ParFish Template that contains your data will open and you will be taken to MS Excel. If the Template was already open, you should go to Excel manually by clicking on the Excel tab on the task bar.

4. **Go to the 'Fishing Experiment' worksheet, select the yellow header cell for 'Total Catch' (cell C3) and all the cells in the column that contain the total catch data.**

5. **Return to the ParFish Software and click 'Load'. Then skip to #7 below.**
   The highlighted data will appear in the New Model wizard.

6. **To manually input your data, enter the total catch data in the cells in the table, starting with the oldest data first. Use the mouse, tab or cursors to move between the cells.**

7. **Click 'Next'.**
   The 'Set Catch and Effort or Index Series' dialogue box appears, as shown in Figure 32.

8. **Select the default, 'Catch and Effort' in the Index Type box.**

9. **Select the gear that the data you are going to load in applies to, from the drop down list.**

   If data already appear in the table in the New Model wizard, you should select the other index type, and then re-select the index type you want. This should clear the table.

10. **Click on 'Select'.**
    You will be taken to MS Excel.

11. **Go to the 'Fishing Experiment' worksheet, select the yellow header cells for 'Effort' and 'Catch' (cells D3 and E3) and all the cells containing catch and effort data up to the last time unit (day).**

12. **Return to the ParFish Software and click 'Load'. Then skip to #14 below.**
    The selected data will appear in the New Model wizard.

13. **To manually input your data, enter the effort and catch data for the gear in the cells in the table, starting with the first day of the experiment first.**
    The rows must correspond to the rows for the same days as the 'Total Catch' data. Leave blanks in a row if data do not exist for that day.

14. **Click Next.**
    The Model Name and Another Index Model dialogue box appears.

15. **Type a new name for the model in the 'Model Name' field if you wish.**

16. **If you have fishing experiment catch and effort data for other gears, or if you have data on a population index that relates to the stock size (e.g. underwater visual censuses carried out during the fishing experiment), select 'Yes' in the 'Another Index Model' box and then click Next. Go to #17. If you do not have data for other gears or an index, select 'No' in the 'Another Index Model' box, then skip to #20.**

17. **For fishing experiment catch and effort data from other gears, repeat steps 8 – 16 for each gear type. For an index model go to #18.**

18. **Select 'Population Index' in the Index Type box. Either click on 'Select', select your data in Excel, return to the ParFish Software and then click on 'Load', or manually input the index data. Then click Next.**
    The Index Model Type dialogue box will appear, with the option of three different model types.

19. **Select the type of Index Model Type from the box and click Next. Repeat steps 15 - 16.**
    You may keep the default model type (multiplicative poisson) unless you have reason to believe one of the alternative models provides a better fit for your data.

20. **Click Next.**
    You will be asked if you have another index model to add. Click No and then click next. A graph will appear similar to the catch-effort graph in Figure 33, but for the Fishing Experiment, which shows the observed values (the data points, as green squares) and expected values (according to the model, as a red line).

21. **Click Next and then Finish.**
    For each gear type and index model that you added, a separate graph will be displayed. Check that each one has fitted properly (red line follows the green points). The dialogue box below the graph also gives you an explanation on how to check if the model has fitted. When all graphs have been displayed, you will be able to click Finish.

    The Software will attempt to generate a parameter frequency (repeated estimates of the model parameters, based on the data provided), and build the probability density function for the parameters. A model similar to the one shown in Figure 36 will appear in the Model Tree, with estimates for the parameters for the Fishing Experiment Model.

22. **If you wish to rename the model, right-click on 'Logistic biomass growth Probability' and choose Rename, type a new name, then press Enter.**
    The model is renamed with your chosen name.

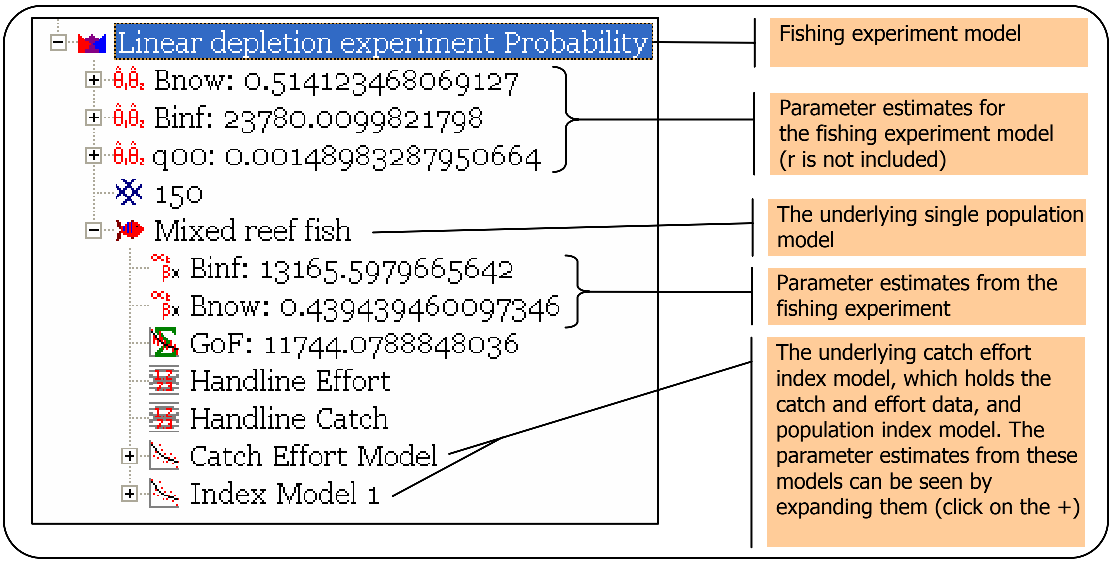
23. **With the name of the model highlighted, click the 'Plot Probability' button to plot the probability density functions (PDFs) for the parameters of the model.**
    A graph will appear in the Graph Area, with green and red lines, similar to that shown previously in Figure 30.

    If you receive the message 'Smoothing parameters could not be fitted …' see the section below on ***What to do if smoothing parameters could not be fitted***.

24. **Select different parameters from the 'Now plotting' drop down menu.**
    You should check the graphs for all parameters of the model (Bnow, Binf and q).

    The model for the fishing experiment only contains information on three of the model parameters (Bnow, Binf and q). Growth rate (r) is not measured in fishing experiments.

Figure 36: An example linear depletion experiment Probability model (fishing experiment) in the model tree



Adding data as Parameter Frequencies

If you have data that do not fit the models provided in the ParFish Software, you can still use them in the analysis if you are able to fit them to another model and generate repeated estimates (parameter frequencies) of the parameters used in your overall model (i.e. Bnow, r, Binf and q for the logistic biomass model). These parameter frequencies can be loaded directly into a model in the model tree. Here we do not deal with fitting the data to a different model, only with loading in the parameter frequencies to the ParFish Software.

For this section, the following is assumed to be true:

- ✓ You have data that did not fit the standard models provided in the ParFish Software;
- ✓ You have fitted these data to a different model and generated repeated parameter frequencies of the parameters used in the overall model in ParFish;
- ✓ You have installed and opened the ParFish Software and have the Probability Models page (Step 3) open.

To load in parameter frequencies, follow these steps:

1. **Choose New ⇨ Frequency Data from the main menu.**
   The 'Parameters' box appears.

2. **Tick the boxes next to the parameters that you have frequencies for (see** Error! Reference source not found.**), and then click OK.**
   A model named 'New parameter frequency' appears in the model tree, with the parameters that you selected. The parameters will be greyed out, with estimated values of 0 as you have not added any data yet.

3. **Lay out your parameter frequencies in Excel (or other spreadsheet programme) in columns, in the same order as the parameters appeared in the 'Parameters' dialogue box, i.e. from left to right: Bnow, r, Binf, q. Each parameter must have the same number of estimates.**

4. **Select the cells containing your data in Excel**
   See **Error! Reference source not found.** for an example.

5. **Select Edit ⇨ Copy from the main menu or press `Ctrl+v` on the keyboard to copy the data.**
   Only select the cells containing your data, and not the header row.

6. **Return to the ParFish Software.**

7. **Right-click on 'New Parameter Frequency' in the model tree and choose 'Edit Data', or, select Model ⇨ Edit Data from the main menu.**
   The Data Edit screen appears as in **Error! Reference source not found.**.

8. **Click in the top left hand box and press `Ctrl+v` on your keyboard to paste the data in.**
   Check that the data for each parameter has been copied into the correct column on the screen.

9. **Click Save.**
   The estimates for each parameter will appear in the model on the model tree, as in **Error! Reference source not found.**. The number of draws will be equal to the number of frequencies you copied in. You cannot regenerate parameter frequencies with a larger number of model draws for this type of model.

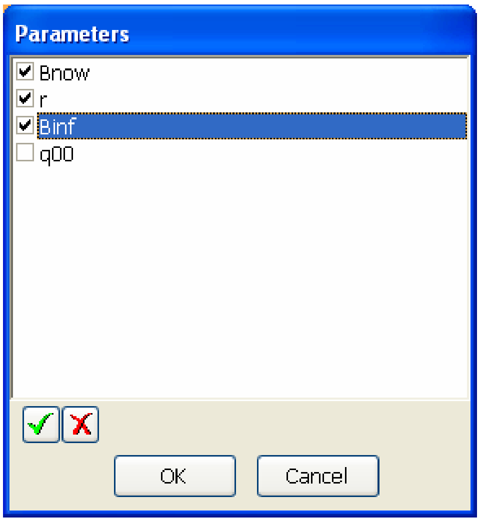


Figure 38: The Parameters box

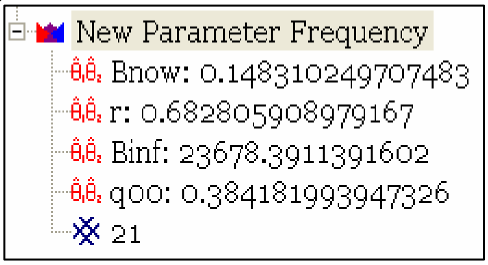
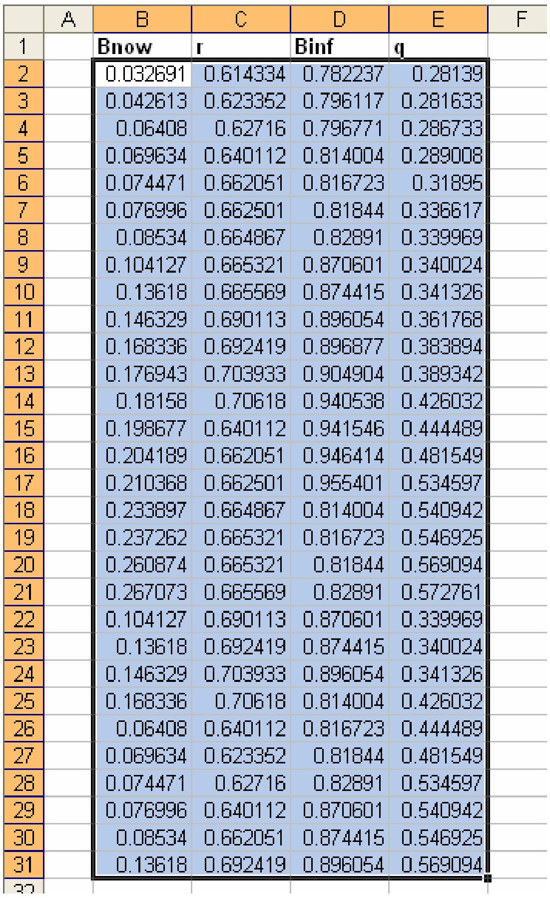


Figure 39: New Parameter Frequency model in the model tree



	A	B	C	D	E	F
1		Bnow	r	Binf	q	
2		0.032691	0.614334	0.782237	0.28139	
3		0.042613	0.623352	0.796117	0.281633	
4		0.06408	0.62716	0.796771	0.286733	
5		0.069634	0.640112	0.814004	0.289008	
6		0.074471	0.662051	0.816723	0.31895	
7		0.076996	0.662501	0.81844	0.336617	
8		0.08534	0.664867	0.82891	0.339969	
9		0.104127	0.665321	0.870601	0.340024	
10		0.13618	0.665569	0.874415	0.341326	
11		0.146329	0.690113	0.896054	0.361768	
12		0.168336	0.692419	0.896877	0.383894	
13		0.176943	0.703933	0.904904	0.389342	
14		0.18158	0.70618	0.940538	0.426032	
15		0.198677	0.640112	0.941546	0.444489	
16		0.204189	0.662051	0.946414	0.481549	
17		0.210368	0.662501	0.955401	0.534597	
18		0.233897	0.664867	0.814004	0.540942	
19		0.237262	0.665321	0.816723	0.546925	
20		0.260874	0.665321	0.81844	0.569094	
21		0.267073	0.665569	0.82891	0.572761	
22		0.104127	0.690113	0.870601	0.339969	
23		0.13618	0.692419	0.874415	0.340024	
24		0.146329	0.703933	0.896054	0.341326	
25		0.168336	0.70618	0.814004	0.426032	
26		0.06408	0.640112	0.816723	0.444489	
27		0.069634	0.623352	0.81844	0.481549	
28		0.074471	0.62716	0.82891	0.534597	
29		0.076996	0.640112	0.870601	0.540942	
30		0.08534	0.662051	0.874415	0.546925	
31		0.13618	0.692419	0.896054	0.569094	

Figure 37: Parameter frequencies laid out in Excel

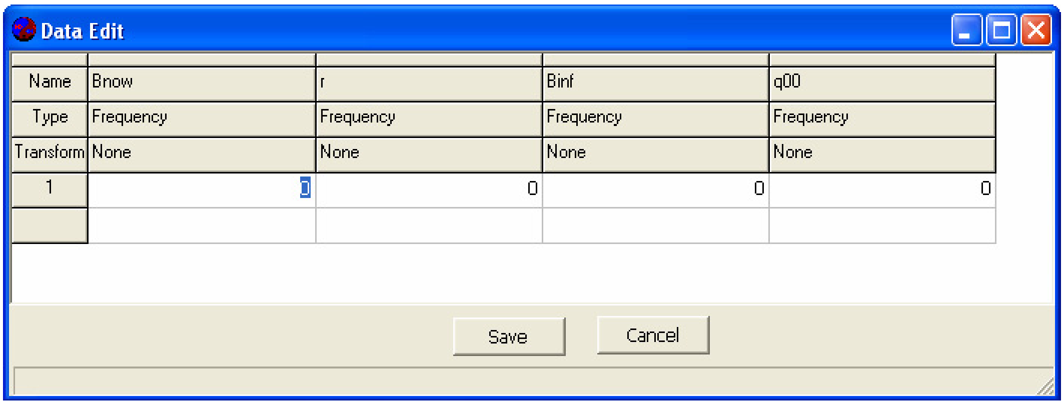


Figure 40: Data Edit Screen

What to do if smoothing parameters could not be fitted

When you plot the probability graphs for your models, you may receive the message:

‘Smoothing parameters could not be fitted as there is not enough data’ (see Figure 41)

Figure 41: Smoothing parameters dialogue box

If you receive this message then the smoothing parameters, which calculate the PDF from the observed data, were not able to be fitted. This results in PDFs that are not robust and cannot or should not be used in the analysis. Possible reasons for this are:

- You may have insufficient data, in which case you should either collect more data (e.g. carry out more interviews), or discard the data;
- The model did not fit correctly but the problem can be rectified, in which case you can try the following in turn:
    1. Recalculate the smoothing parameters;
    2. Generate parameter frequencies;
    3. Update all models.

1. Recalculate the smoothing parameters

To recalculate the smoothing parameters for the model, follow these steps:

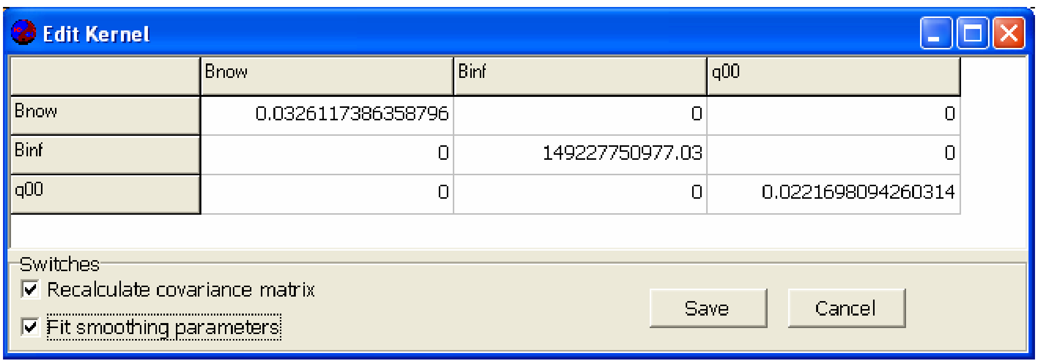
1. **Select the relevant model in the Model Tree for which smoothing failed.**

2. **Click on the ‘Edit Model’ button on the left hand side of the screen.**
The ‘Edit Kernel’ dialogue box appears, as shown in Figure 42.

3. **Tick the boxes ‘Recalculate covariance matrix’ and ‘Fit smoothing parameters’ at the bottom of the dialogue box. Then click Save.**

4. **Click the ‘Plot Probability’ button.**
The PDFs (probability graphs) for the model will be drawn. If smoothing was successful, the probability graphs appear, without the smoothing parameters dialogue box appearing.

Figure 42: The Edit Kernel dialogue box, showing a failed smoothing matrix (0’s present)



2. Generate parameter frequencies

To re-generate parameter frequencies for the model, follow these steps:

1. **Select the relevant model in the Model Tree for which the smoothing failed.**

2. **Click on 'Generate Parameter Frequency'.**
   Estimates of the parameters will be recalculated. You will see a change in the values of the parameters for the model in the Model Tree.

3. **Click on 'Plot Probability' again.**
   If smoothing was successful, the probability graphs appear, without the smoothing parameters dialogue box appearing.

3. Update all models

To update all models, follow these steps:

1. **Choose Model ⇨ Update All Models from the main menu.**
   The parameter frequencies for all the models are updated.

2. **Click on 'Plot Probability' again.**
   If smoothing was successful, the probability graphs appear, without the smoothing parameters dialogue box appearing.

Generating parameter frequencies for the models

As you set up models in the Model Tree, the number of repetitions that the Software carries out to generate parameter frequencies is restricted. This makes building and checking the models quicker. However, once you have set up your models and checked the PDFs, you should re-generate the parameter frequencies for each model with more repetitions, or 'model draws' (except the interview model, for which the number of draws is limited to the number of interviews carried out). To generate parameter frequencies, follow these steps:

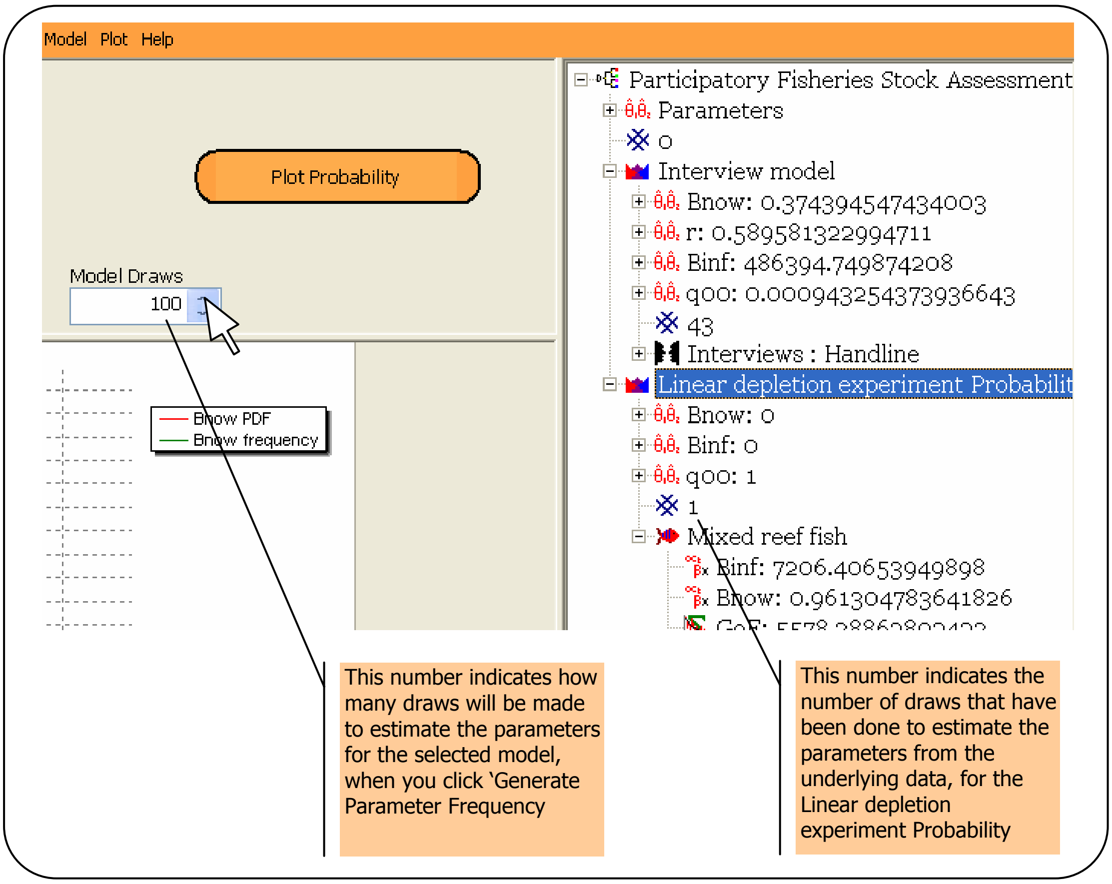
1. **Select the relevant model in the Model Tree.**

2. **Increase the number of Model Draws.**
See Figure 43. Try increasing the number incrementally, for example, first of all try 250. If this is completed quickly (see #3 below), increase it to 500, then try 1000 etc. When generating the parameter frequencies becomes slow or unmanageable, do not increase the number any further.

3. **Click on 'Generate Parameter Frequency'.**
The parameter frequencies for the model will be recalculated, with the number of draws specified in the 'Model Draws' box. The number by the symbol indicates the number of draws that have been done to generate the parameter frequencies for the model (see Figure 43).

4. **Repeat steps 1 – 3 for each model in the tree (except the model containing interview data and the overall model.**
In most cases, you will need to generate the parameter frequencies for the catch-effort model and/or the fishing experiment model.

Figure 43: Setting the number of Model Draws for a model before generating parameter frequencies



Drawing a posterior sample

Once you have set up all your models, loaded in all your data, checked the models fit, and generated parameter frequencies for the models, you need to draw a posterior sample for the overall model, which provides the overall estimates (probability distributions) for the parameters. This involves the software taking repeated estimates of each parameter from your underlying models (interview model, catch-effort model, fishing experiment model etc.) and using these to estimate the overall value of each parameter. To draw a posterior sample, follow these steps:

1. **Select the overall model at the top of the tree.**
   The overall model will have the same name as the 'Assessment and File Name' you entered in ***Step 1: Basic Information*** on the Main Page of the Software. The example shown here has the default name 'Participatory Fisheries Stock Assessment', but you should have changed this for your assessment.

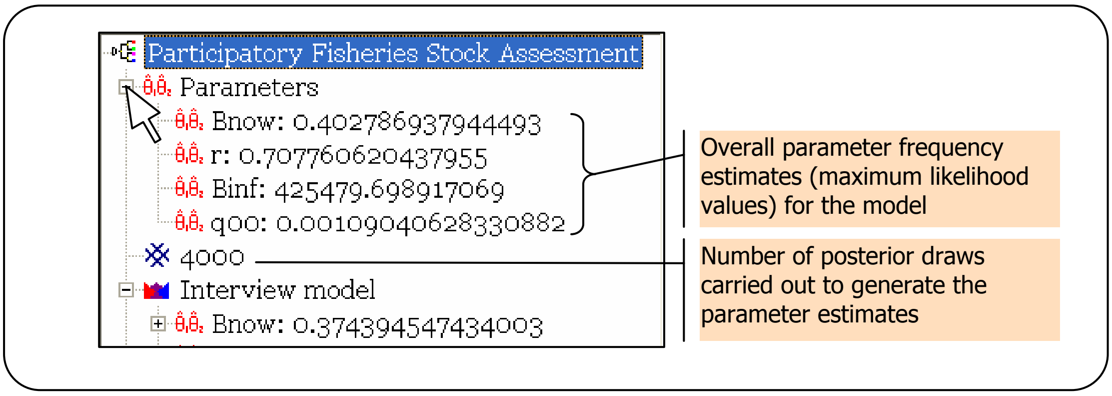
2. **Set the number of Model Draws to a minimum of 1000.**
   Drawing the posterior sample is much quicker than generating parameter frequencies (see above), therefore you can start with a higher number of draws, and then increase it.

3. **Click on 'Draw Posterior Sample'.**
   Repeated parameter frequencies will be calculated for the overall model, and the number of draws appears next to the symbol on the Model Tree for the overall model.

4. **Click on the '+' next to 'Parameters' on the Model Tree for the overall model to expand the model to see the parameter estimates.**
   See Figure 44.

5. **Click on 'Plot Probability' and look at how each parameter is fitted for the overall model (posterior PDF)**.
   The graphs will appear in the graph area.

Figure 44: The overall model parameter estimates, after drawing posterior sample (4000 model draws) can be seen by clicking on the '+'.



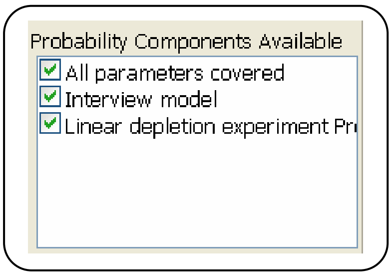
Return to the Main Page

Return to the Main Page of the Software by clicking on the ⇦ in the top left hand corner, or by closing the window.

Save your models by choosing File ⇨ Save on the main menu.

On the Main Page, the 'Probability Components Available' box in the Check List should reflect the models that you have added, and the 'All parameters covered' box should be ticked, as in Figure 45. If one of the check-boxes is not ticked where you would expect it to be (for example if you have loaded in fishing experiment data but the corresponding check box is not ticked) this indicates a problem with the model. You should go back to the model set up to try and rectify the problem (e.g. check that the models have been fitted and the model is enabled (right-click and choose Enable from the menu) or delete this model and start again. You can delete a model by right clicking on the model and choosing ⇨ Delete.

Figure 45: Probability Components Available Check List, after adding an Interview model and a fishing experiment model ('Linear depletion experiment')



Step 4: Preferences

This Step covers:

- ✓ **The Preferences page**
- ✓ **Inputting preferences data**

Step 4 guides you through the process of setting the discount rate and catch and effort preferences for the analysis. The preferences provide information on how much fishers would like different possible outcomes of management actions on the fishery. This enables the analysis to indicate which management control level would result in the most acceptable or desirable conditions in the fishery, according to the fishers' preferences.

You can use the default discount rate (10%) and default preference (a price-cost ratio). However, it is recommended that the fishers' preferences are used, which are collected through the preferences interview. The preferences interview encourages fishers to express their preference for a number of situations displayed on scenario cards, of differing relative fishing catch and fishing effort, in relation to their current catch and effort. See **Stage 3: Undertake ParFish Stock Assessment** and **Tool 17: Preference Interview** in the **ParFish Guidelines** for details of the methodology.

Definitions

- **Preference:** a representation of an individual's trade-off between costs (e.g. time spent fishing) and benefits (e.g. fish catch)
- **Discount rate:** an expression of people's attitude towards current benefits in contrast to future benefits

The preferences data are used in the ParFish analysis to determine the level of control in the fishery that would be most preferred by the fishers overall in terms of the expected outcome of the control on their catch and effort. Note that the overall preference is for the combined preferences of all the fishers that were interviewed. This means that there may be fishers for whom the recommended outcome is not their most preferred – who would like to fish more or less than the recommended outcome.

The Preferences page

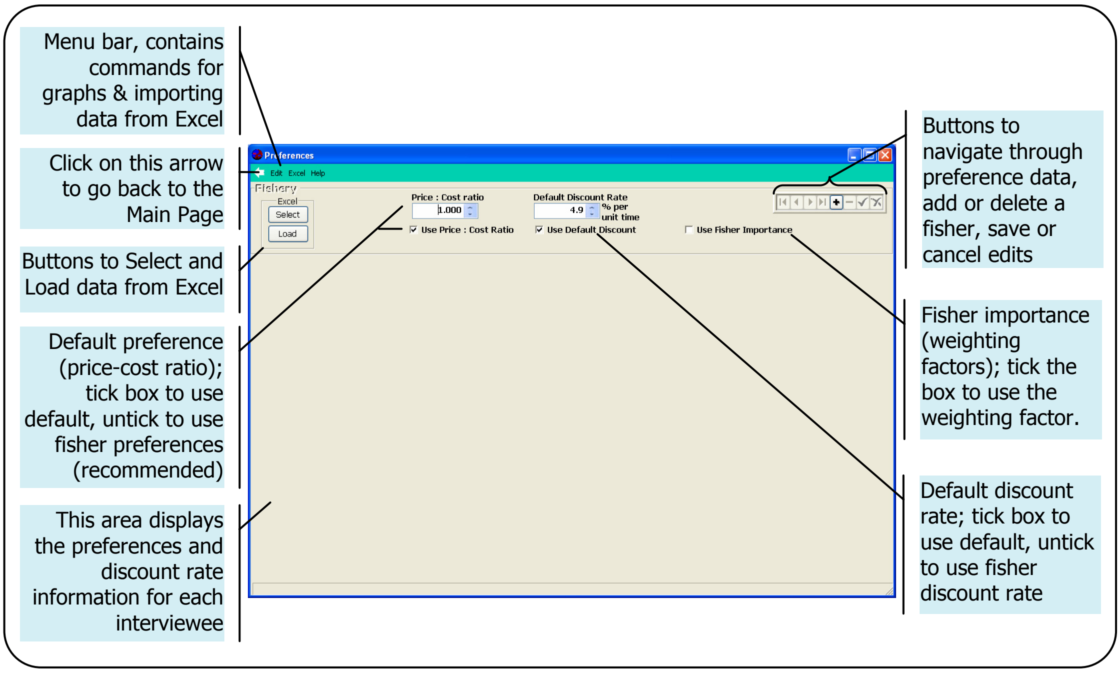
For this section, the following is assumed to be true:

- ✓ You have installed and opened the ParFish Software.

To open the Preferences page, follow these steps:

1. **Click on 'Step 4: Preferences' on the Main Page.**
The Preferences page appears, as in Figure 46.

Figure 46: The Preferences page, Step 4



Inputting Preferences data

For this section, the following is assumed to be true:

- ✓ You have carried out Preference Interviews with a sample of fishers for the fishery concerned (see **Tool 17: Preference Interview** in the **ParFish Guidelines**);
- ✓ You have installed and opened the ParFish Software and have the Preferences page (Step 4) open.

Data from the Preference Interview can be input in two ways:

- Imported from the ParFish Template (see **Step 2: MS Excel Input Data**) (recommended);
- Input data directly into the Software.

Importing preferences data from Excel

1. **Click on 'Select' on the Preferences page in the ParFish Software.**
   The ParFish Template that contains your data will open and you will be taken to MS Excel. If the Template was already open, you should go to Excel manually by clicking on the Excel tab on the task bar.

2. **Go to the 'Preferences' worksheet, select the yellow header cells from 'Fisher name' (cell B3), to 'Score 16', and all the cells that contain data.**

3. **Return to the ParFish Software and click 'Load'.**
   The highlighted data will appear in the Preferences page, as in Figure 47.

4. **Switch between the current catch and effort data and the preference data by clicking on the relevant tab for 'Current Catch and Effort Reference Point' or 'Catch and Effort Preference'.**
   The catch and effort reference point data gives details on the usual effort and CPUE. When you click on 'Catch and Effort Preference', a screen similar to the one in Figure 48 appears.

5. **Browse all the fishers' data using the buttons in the top right hand corner of the page, as indicated in Figure 49.**

Figure 47: The Preferences page showing Preference Interview data loaded in

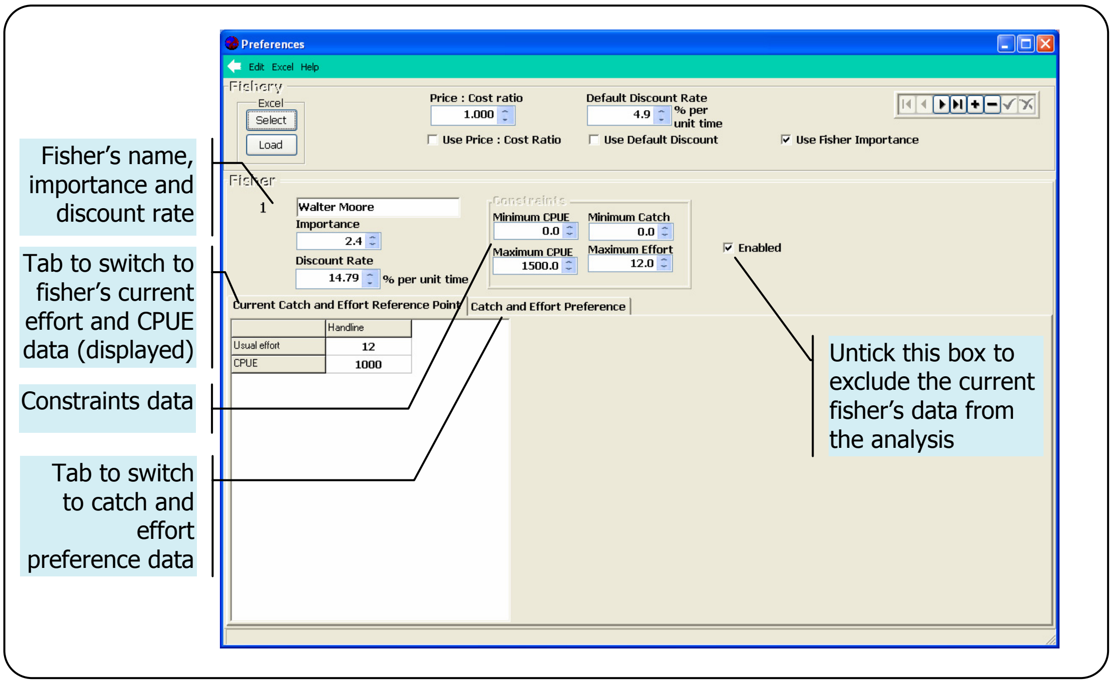


Figure 48: The Preferences page showing Catch and Effort Preference

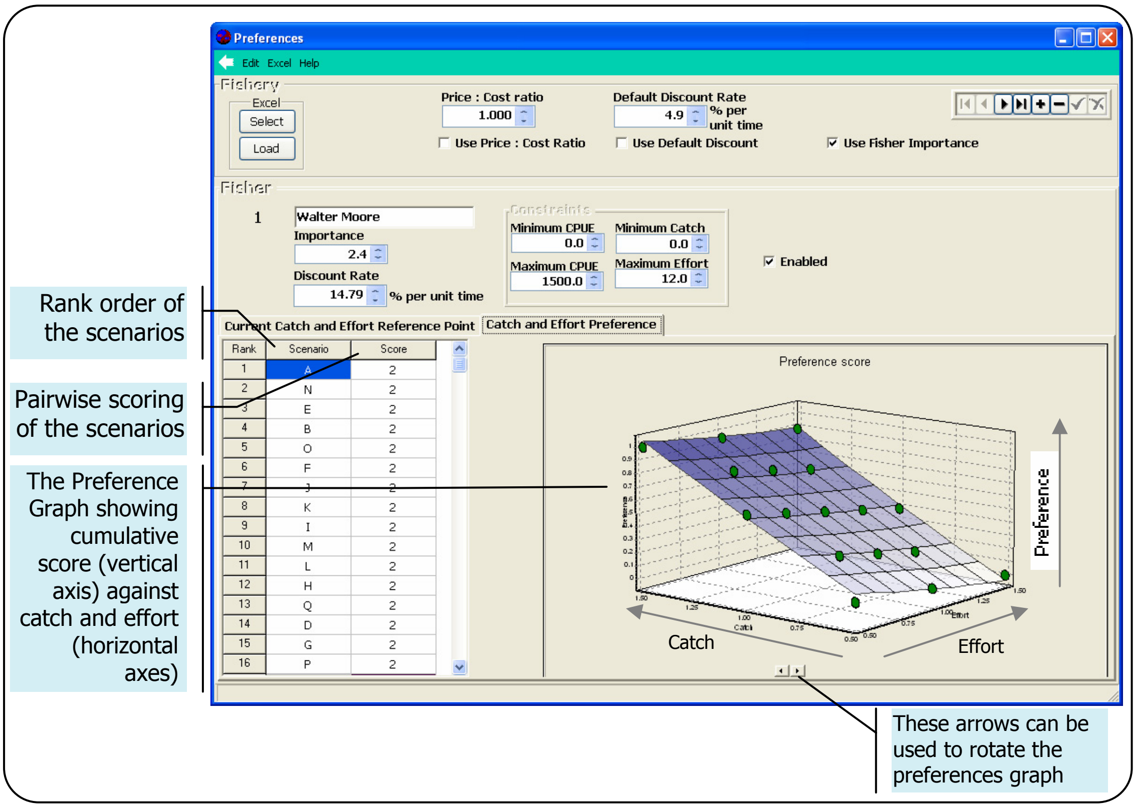
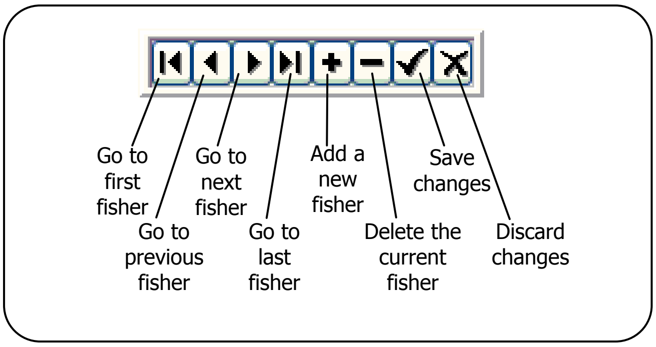


Figure 49: Buttons to browse through fishers' data, add, delete and save data



Inputting preferences data manually into the Software

To input preferences data manually into the Software, follow these steps:

1. **Click on the**  **button at the top right of the page to add data for a new fisher.**
   Data input fields will appear, similar to those in Figure 47.

2. **Enter the data about the fisher, constraints and catch and effort, as follows (you can use the Tab key or the mouse to move between fields):**
   - In the first field, by the number ('1' for the first record you enter) - enter the fisher's name (from Background Information in the Preference Interview);
   - 'Importance' - enter the measure of fisher importance (Question 15 (a), (b) or (c) from the Preference Interview);
   - 'Discount Rate' – enter the Discount Rate (Question 16 of the Preference Interview, using the 'Discount Rate Calculations' worksheet in the ParFish Template to calculate the discount rate);
   - 'Minimum CPUE' - enter the minimum CPUE the fisher would accept, below which it would not be worth going fishing (Question 11 from 'Constraints' in the Stock Assessment Interview);
   - 'Maximum CPUE' – enter the maximum CPUE that the fisher could cope with with his or her current gear (Question 13 from 'Constraints' in the Stock Assessment Interview);
   - 'Minimum catch' – enter the minimum catch the fisher would accept, below which it would not be worth going fishing (Question 12 from 'Constraints' in the Stock Assessment Interview);
   - 'Maximum effort' – enter the maximum effort that the fisher could apply with his or her current gear in one unit of time (Question 14 from 'Constraints' in the Stock Assessment Interview);

   Under the 'Current Catch and Effort Reference Point', in the field:

   - 'Usual effort' – enter the fisher's usual effort in each unit of time (Question 3 of Stock Assessment Interview);
   - 'CPUE' – enter the fisher's usual CPUE (Question 5 of Stock Assessment Interview).

3. **Click on the 'Catch and Effort Preference' tab.**
   Data input fields for scenario card ranking and scoring will appear, similar to those in Figure 48.

4. **Enter the data about the rank order of the scenario cards and the scores (you can use the Tab, Enter or cursor keys or the mouse to move between fields) as follows:**
   - Rank 1, Score column – enter the score given to the preference of scenario card A (automatically indicated as the best scenario card) and the next best scenario card;
   - Rank 2, Scenario – enter the letter of the next (2nd) most preferred scenario card;
   - Rank 2, Score – enter the score given to the 2nd most preferred scenario card over the next best scenario card;
   - Continue this, until you have entered the letter of all the scenarios, in rank order from best (A) to worst (C).

5. **Click on the**  **button to save the data.**
   The preferences graph appears.

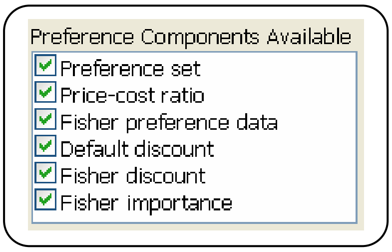
6. **Repeat steps 1 – 5 for each fisher.**

Returning to the Main Page

Return to the Main Page of the Software by clicking on the in the top left hand corner, or by closing the window.

On the Main Page, the 'Preference Components Available' box in the Check List should reflect the data that you have added; the Fisher preference data, Fisher discount and Fisher importance boxes should be ticked, as in Figure 50.

Figure 50: Preference Components Available Check List, after adding fisher preference data



Step 5: Controls

This Step covers:

- ✓ **The Controls page**
- ✓ **Inputting control data**

Step 5 guides you through the process of setting the control levels for the analysis. There are three different types of control available in ParFish:

- Effort;
- Quota;
- Refuge (closed area).

When you carry out an analysis, controls are applied to the stock model, which is projected forward into the future to predict the outcome of the controls on the stock biomass and therefore the fishers' catches and catch per unit effort. Controls are applied within a user-defined range, which should be realistic, and is set by the 'Maximum' and 'Minimum' fields. The 'current' and proposed 'new' control level should also be defined.

Both single (only one control type) and combination controls (e.g. a closed area with an effort control in the fishable area) can be applied.

Definitions:

- **Effort control**: a control that limits the amount of fishing effort, e.g. a restriction on the number of days during which the fishery is open, or the number of boats permitted to fish.
- **Quota control**: a control that limits the amount of fish that can be caught or landed, possibly through quotas and licences to each fisher. This may be applicable to single-species high-value fisheries such as conch, but can be very difficult to implement in multi-species small-scale fisheries.
- **Refuge**: a control that protects a proportion of the stock from fishing pressure, for example, through the implementation of a closed area where fishing is not allowed. The model assumes fishing effort from the closed area is displaced to the fishable area.

The Controls page

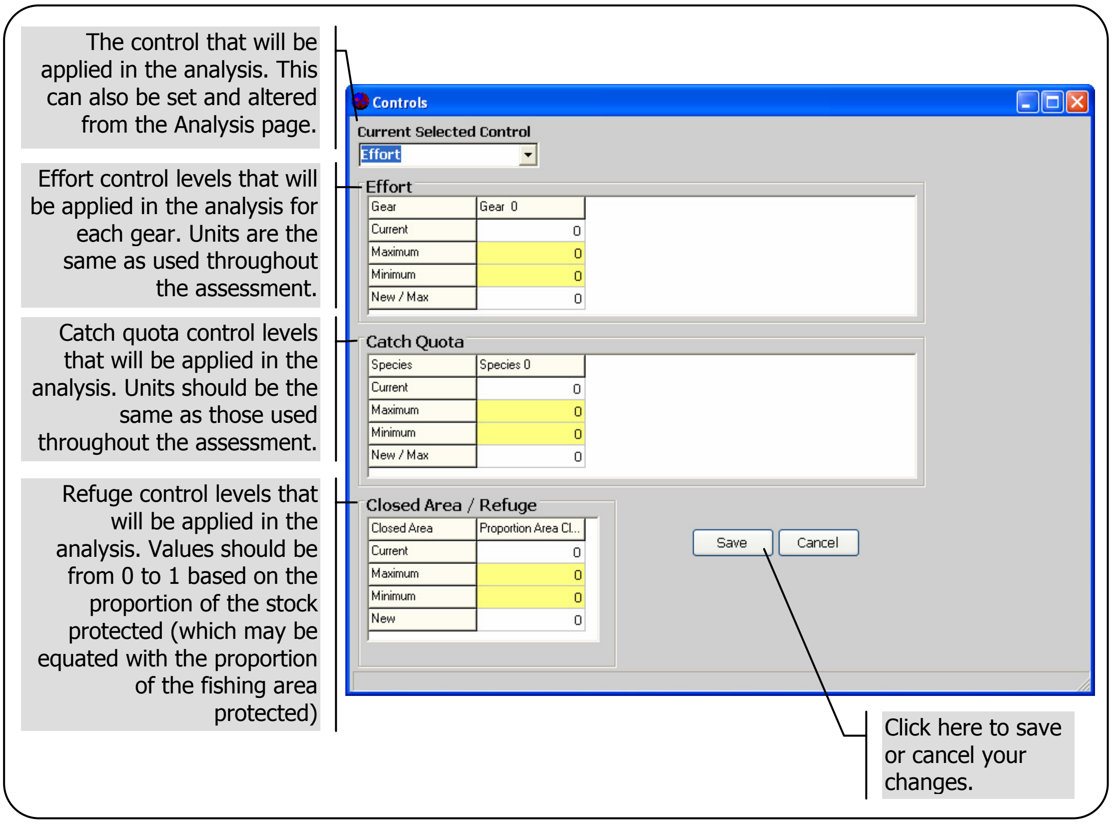
For this section, the following is assumed to be true:

✓ You have installed and opened the ParFish Software.

To open the Controls page, follow these steps:

1. **Click on 'Step 5: Controls' on the Main Page.**
The Controls page appears, as in Figure 51.

Figure 51: The Controls page, Step 5



Inputting Control data

To input control data, follow these steps:

1. **Enter Control data for each control type that you would like to explore the effects of. An example is given for the Effort control:**

   - 'Current' control level is the current effort in the fishery (or last year's effort) (collected as part of the background information to compile, see **Tool 2: Background Information to Compile** in the **ParFish Guidelines**).

   - 'Minimum' control level is the lowest effort level that you want to explore the effects of applying in the analysis. When you run the analysis, the control will be applied across a range of values, from 'minimum' to 'maximum'.

   - 'Maximum' control level is the maximum effort level that you want to explore the effects of in the analysis. The control will be applied across a range of values, up to this level.

- 'New' control level is the level of the control that will be applied when you run an analysis for a **different** control type. For example, if you run a closed area control to explore the effects of implementing a closed area of between 0% (=0.1) of the fishery area and 50% (=0.5) of the fishery area, the scenario will be run assuming the effort is at the level set in the 'New' field for the Effort control. You can keep 'New' the same as the 'Current' to explore the effects of other controls with the same effort in the fishery. If you want to explore combination controls, you can set 'New' effort to a different level from the current effort, and try a closed area control, for example.

2. Repeat #1 for other control types you wish to apply in the analysis.
You need to fill in data for at least one type of control (effort, catch or refuge), and can complete it for all three if desired.

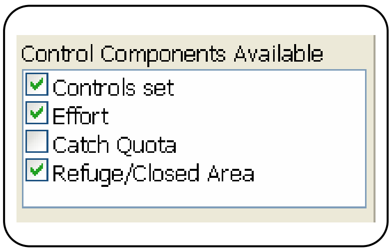
Hint: When you run different scenarios in the Analysis (Step 6), you will be able to select which control, or combination of controls, is applied.
Hint: You cannot leave blanks, but instead should leave zero for those controls that you do not want to include.

Returning to the Main Page

Return to the Main Page of the Software by clicking on the 'Save' button.

On the Main Page, the 'Control Components Available' box in the Check List should reflect the controls you have defined; the 'Controls set' box should be ticked, and the boxes for the control types that you have set should be ticked. Figure 52 shows an example where effort and closed area controls have been set.

Figure 52: Control Components Available Check List, after adding control data



Step 6: Analysis

This Step covers:

- ✓ **The Analysis page**
- ✓ **Running scenarios to analyse the data**
- ✓ **Interpreting the outputs**

Step 5 guides you through the analysis process of ParFish. See **Background Information** in this Manual for further information on the analysis and expected outputs.

The analysis calculates the current state of the stock, and projects the fishery into the future to explore the effects of applying different controls on the stock. The fisher (or default) preferences are used to determine which outcomes would provide the resulting catch rates most preferred by fishers overall.

The analysis provides target and limit reference points. The **target control level** is the level of control that is expected to provide outcomes that would be most preferred by fishers. The **limit control level** is the level of control that would result in a defined chance of the stock being in an overfished state (default is a 10% chance of less than 50% of the unexploited biomass, but these values can be altered by the user).

As the limit control level is dependent on probability and uncertainty, if the data show a high uncertainty, this will result in a very low control level being defined for the limit control, in order to bring the chance of overfishing down to the specified level. This is not necessarily the level of control that should not be exceeded, but rather provides an indication of the uncertainty in your data. For example, if the target effort control is much higher than the limit effort control, you should aim towards the target control but seek to collect more data on the fishery to reduce the uncertainty in the data.

The Analysis page

For this section, the following is assumed to be true:

- ✓ You have gone through the ParFish Guidelines Stages 1 – 3;
- ✓ You have carried out Stock Assessment and Preference Interviews with the fishers;
- ✓ You have gathered other background data, if possible;
- ✓ You have installed and opened the ParFish Software;
- ✓ You have input background information and named the gear(s) for the analysis (Step 1);
- ✓ Inputted your data into Excel, or recorded this data elsewhere if you are going to input the data directly into the Software (Step 2);
- ✓ You have set up probability models containing your data including a Stock Assessment Interview model (Step 3);
- ✓ You have input preferences data (Step 4);
- ✓ You have set control levels for the analysis (Step 5).

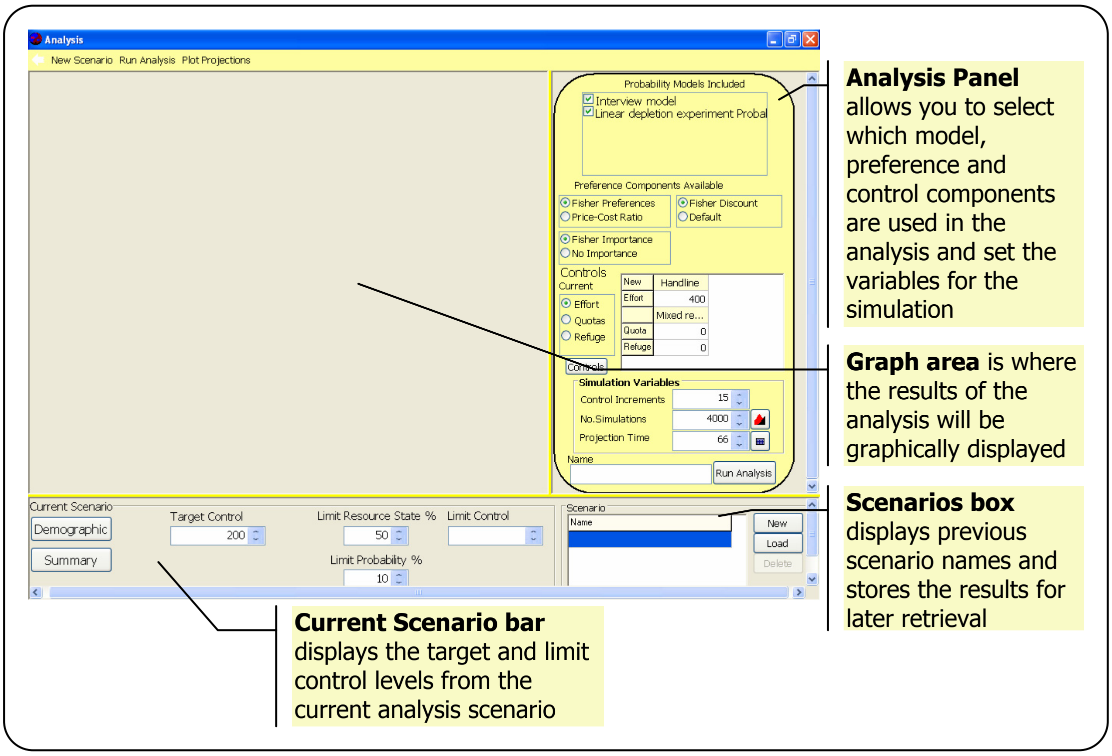
To open the Analysis page, follow these steps:

1. Click on 'Step 6: Analysis' on the Main Page.
The Analysis page appears, as in Figure 53.

The Analysis page is split into three main areas:

- **Analysis Panel;**
- **Graph area;**
- **Lower bar** containing the **Current Scenario** bar and the **Scenarios** box.

Figure 53: The Analysis page



The Analysis Panel

The Analysis Panel on the right hand side of the Analysis page allows you to enable and disable different model components for the scenario you are going to run. This enables you to consider the influence of different data sources on the outputs and recommendations of the analysis. For example, you may choose to run a scenario using all the available data sources, or using just the fisher interviews.

You may also choose between the default discount and preference data, or the fisher preference data, and whether to weight the fisher data according to their importance score. Here you can also set what control type to implement, and the variables for the simulation.

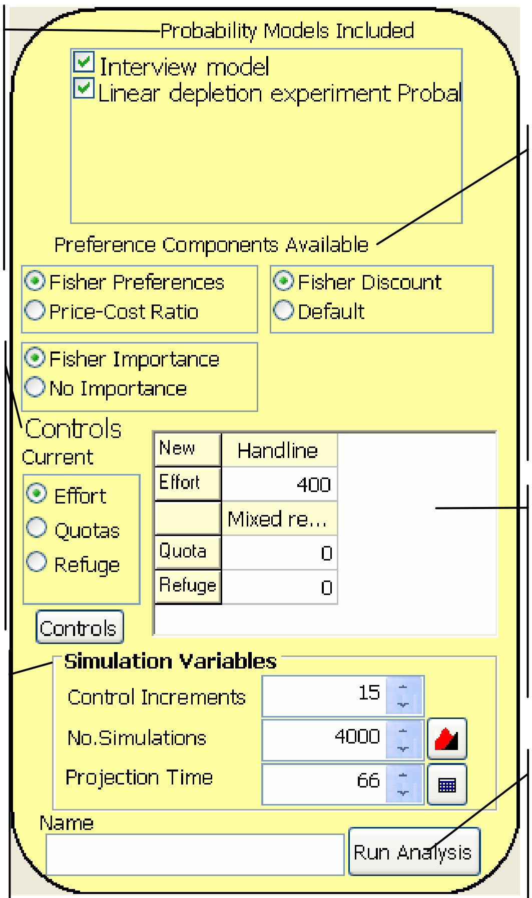
Details of each component are provided in Figure 54.

Figure 54: Detail of the Analysis Panel on the Analysis page

Probability Models Included: this shows the available models that you set up in Step 3. Select which models to include (one, more, or all) by ticking the boxes, and deactivate or deselect models by unticking the boxes (click with mouse).

Controls: this allows you to select whether the analysis is based on an effort, quota or refuge control, according to the values entered in the Controls page (Step 5). Select by clicking the buttons. You can only select those controls that you have entered values

Simulation variables: control the variables for the analysis simulations. ***Control increments***: the number of increments between the minimum and maximum control levels. ***No. simulations***: the number of simulations carried out - the more simulations, the better the final estimates but the longer it will take. ***Projection time***: the number of time units that the simulation will be run into the future.



Preference Components Available: this allows you to choose whether you use fisher preferences or the default preference (price-cost ratio); fisher discount or the default discount; fisher importance as a weighting factor or not. To select between the options, use the mouse to click the buttons.

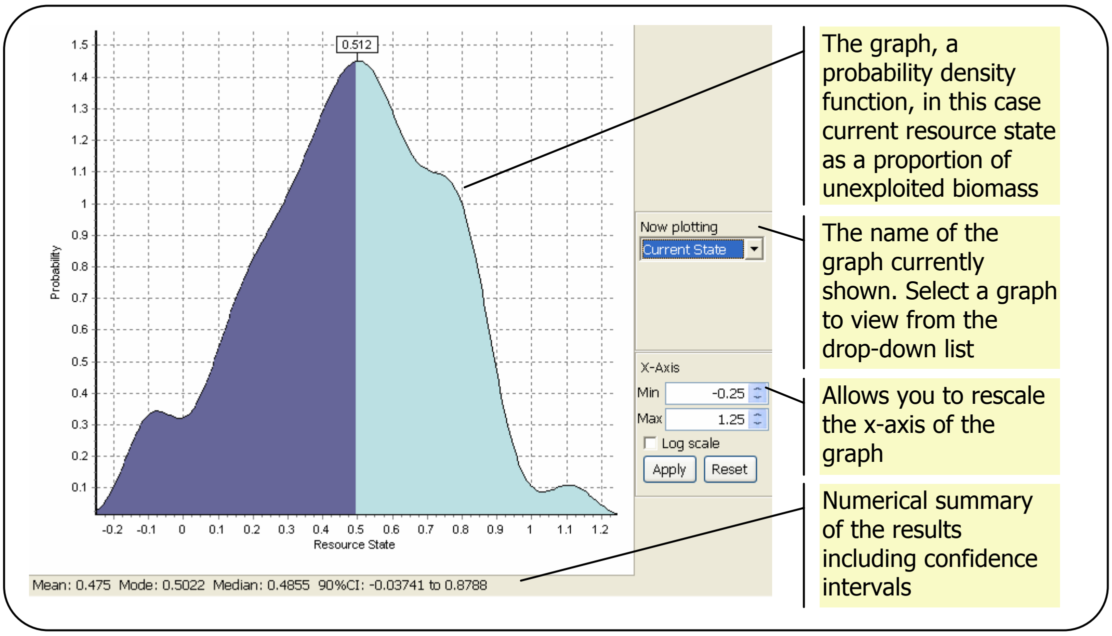
This area shows the 'new' control level to be applied for each control type when the analysis is being run for a **different** control. You can edit the levels by clicking on the value and typing a new value.

Run Analysis: Enter a name for the scenario and click this button to carry out the analysis based on the selected components and control levels.

The Graph Area

The Graph Area (Figure 55) is where the results of the scenario are displayed in graphical form. Most graphs are displayed as probability density functions, PDFs (only the Preference and Preference Projection graphs are not). You can select which graph is displayed from the drop-down list, and for certain graphs (the resource states and preference projections), you can rotate, zoom in and out and change the elevation of the graphs.

Figure 55: The Graph Area of the Analysis page

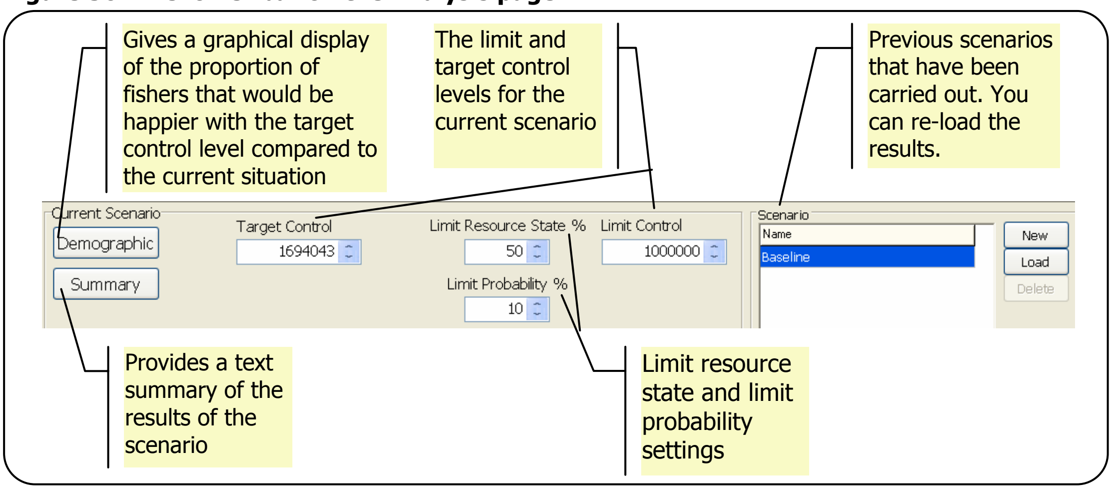


The lower bar

The lower bar contains the **current scenario** bar, which displays the target and limit control levels, and the resource state and probability on which the limit control is based. It also contains the **Scenarios** box, which displays the names of the previous scenarios you have run, and allows you to re-load the results.

You can alter the % limit resource state and the % limit probability for the **limit control level**. The Limit Resource State % indicates the percentage of unexploited biomass remaining at which the stock is considered to be overfished. Therefore, a limit resource state of 50% means the stock would be considered to be overfished when the biomass is half of the unexploited biomass (B=0.5). This is considered sustainable and a realistic target for fisheries management for ParFish assessments. Limit Probability % indicates the acceptable chance or probability of the stock being overfished. The default values are a 10% chance of the current stock biomass being 50% or less of the unexploited biomass. You can alter these values. For example, if you have a fishery in which the fishers are very risk-prone, they may accept a higher chance of overfishing (15 or 20%), or if the fishers are very risk-averse, even a 10% chance that the stock is overfished may be too risky.

Figure 56: The lower bar on the Analysis page

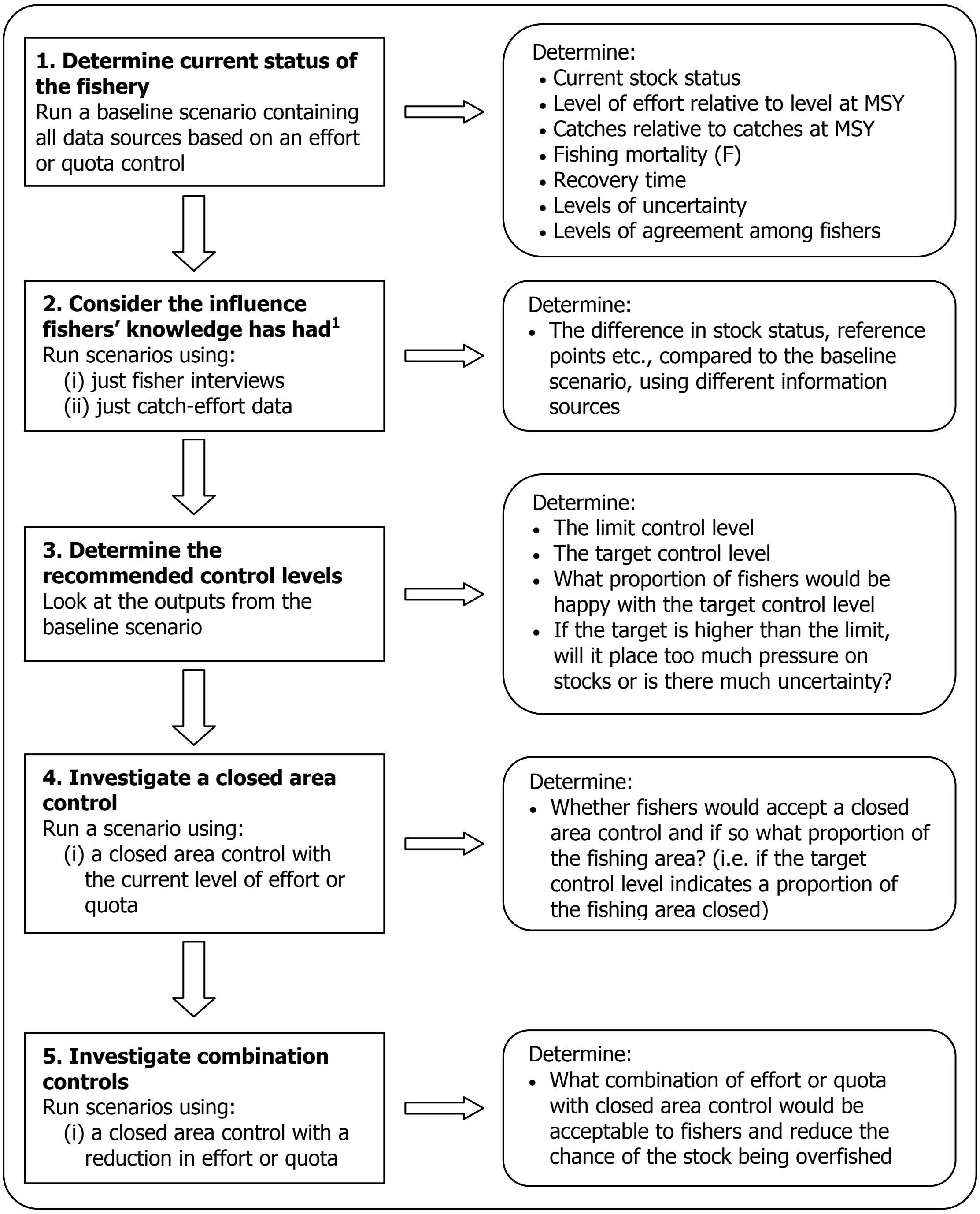


Running scenarios to analyse the data

The analysis is carried out through the use of **scenarios**, which are simulations with varying settings for the inputs to the analysis. When carrying out analyses with ParFish, you should try a variety of different scenarios. For example, you might run one scenario using data from the interview model and a fishing experiment model with fisher preferences, and another using the same data, but using the default preference setting instead. Or, you might run one scenario using the interview and fishing experiment data, and another scenario using just the interview data to see what influence the fishing experiment had on the certainty of the results. As an overall framework for carrying out the analysis, it is recommended you use the flow diagram in Figure 57 to guide your analysis. Recommended scenarios to try are as follows:

Scenario	**Data**			**Preferences / Discount / Importance**						**Why?**
Number / Name	Description	Interview model	Other models	Fisher Preference	Default Preference	Fisher Discount	Default Discount	Fisher Importance	No Importance	
Baseline	Use all data models available	✓	✓	✓		✓			✓	Incorporates all possible data sources, therefore should provide the current best estimate of the state of the stock.
2	Using only the Fisher Interview Model (optional)	✓		✓		✓			✓	To demonstrate how the data collected from the fishers is similar to, or different from, traditional stock assessment data, and explore how the fishers would agree or disagree with traditional analyses.
3	Using only 'traditional' stock assessment data e.g. Catch Effort model (optional)		✓	✓		✓			✓	To show the recommendations that the traditional data sources provide, and compare them to the results that just the fisher interviews give.
4	Baseline using default preferences (optional)	✓	✓		✓		✓		✓	To show how the recommendations differ when fisher preferences are not taken into account, to demonstrate that their preferences have had an influence on the recommended control levels.
6	Baseline with fisher importance (optional)	✓	✓	✓		✓		✓		To explore how fisher importance influences the recommendations for control levels.
7	Closed Area Scenario	✓	✓							To explore the possibility of a closed area control.
8	Combination controls	✓	✓							To explore the possibilities of implementing two controls together e.g. if we close 5% of the fishing area, by how much do we need to decrease fishing effort to reduce the chance of the stock being overfished to 10%?

Figure 57: Flow diagram showing the main steps involved in the analysis



[1] If you only have fisher interviews and fishing experiment data, you can run a scenario using just fisher interviews, but not using just fishing experiment data, as the fishing experiment does not provide information about all four model parameters.

To run a scenario, follow these steps:

1. **Select the probability models you want as inputs to the scenario in the Analysis Panel.**

2. **Select the preference components you want to use in the Analysis Panel i.e. fisher preferences or default preferences, fisher discount or default discount, and fisher importance or no importance.**

3. **Select the control type you want to apply. If you want to apply only a single control type, check that the 'New' level of the other available controls are set to the same as their current levels.**

4. **Set the simulation variables for the scenario in the Analysis Panel.**

5. **Type a name for the scenario e.g. 'Baseline' or 'Interview only' in the 'Name' field.**

6. **Click 'Run Analysis'.**
   The analysis will run. This may take a few minutes, depending on the number of simulations to be run and the speed of your computer. A graph will appear in the Graph Area of the Analysis Page, showing either a single black line or multiple red lines, depending on whether you have chosen the default preference or the fisher preferences, respectively. When the analysis has completed, a graph will appear in the Graph Area, and new Limit and Target control levels will be shown in the lower bar.

   The analysis provides a number of different graphs as outputs. These are explained in the next section, ***Interpreting the outputs***. A text summary for each scenario that can be printed out and kept as a record to compare with other scenarios, is also provided when you click the 'Summary' button.

When you run the analysis, if you receive the message 'Invalid floating point operation', try the following: Open Step 3: Probability Models, choose Model ⇨ Update All Models from the main menu, then click on the overall probability model, and click on 'Draw Posterior Sample'. Then return to the Analysis Page and rerun the analysis.

Interpreting the Outputs

Throughout this section an example assessment from Dimbani, Zanzibar is referred to. The most important graphics are the:

- Demographic
- Resource states graph
- Reference point probability graph
- Preference graph
- CPUE projection graph
- Preferences projections graph
- Current state graph

Other graphs are also provided which provide information that can be compared with outcomes from other stock assessment methodologies. These include:

- Unexploited CPUE
- Recovery time graph
- MSY
- Relative MSY
- F at MSY
- Relative F at MSY
- Effort at MSY
- F at Optimum
- Relative F at Optimum

Target and Limit control levels

The target and limit control levels are shown in the lower bar at the bottom of the Analysis Page. They have the same units as the control type you chose for the scenario, for example:

- Effort control: boat days;
- Quota control: kg or tonnes;
- Closed area control: proportion of the fishing area closed.

The **limit control** is the level of control that would result in the chance of the stock being overfished (less than the **limit resource state** of the unexploited biomass) to the **limit probability**. In other words, the default settings are **10% limit probability** and **50% limit resource state**. So, the limit control would be the control level which results in a 10% chance of the stock biomass being 50% or less of the unexploited biomass.

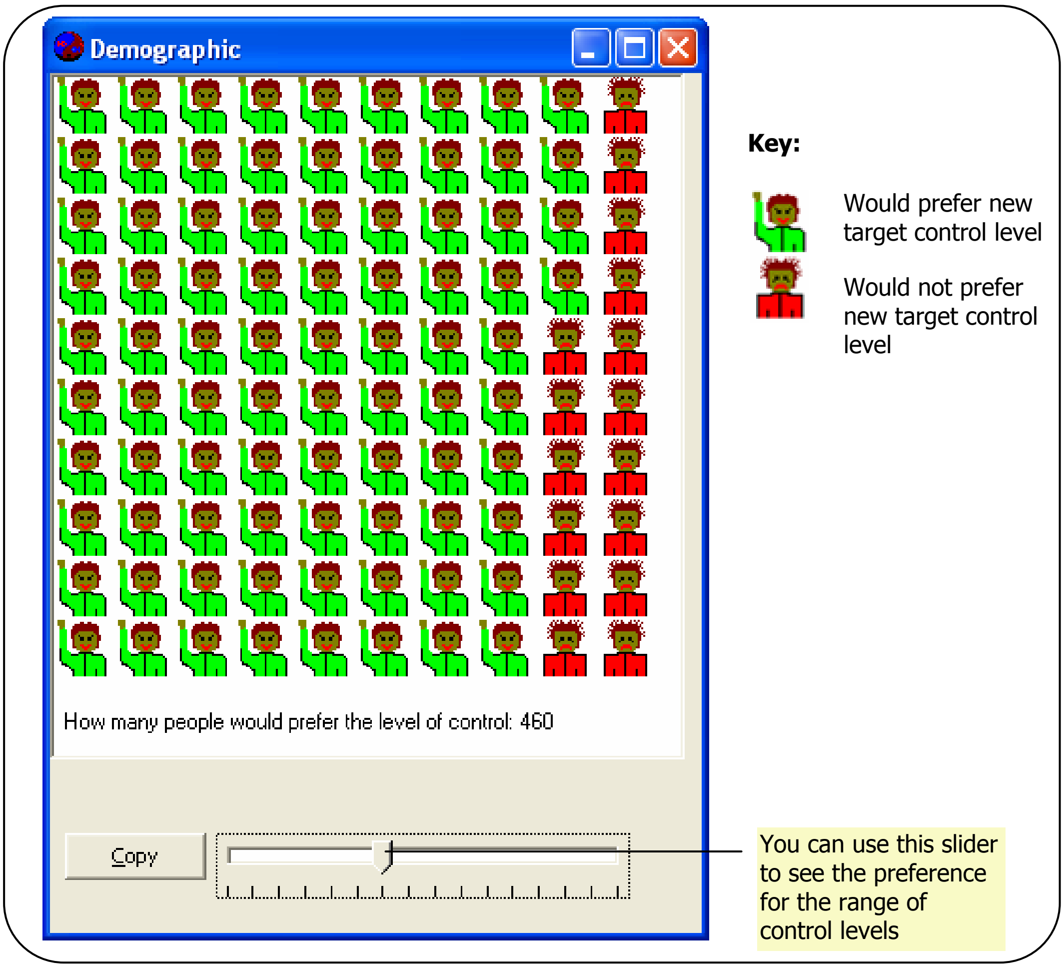
The **target control** is the level of control that would result in the highest overall preferences of fishers.

Demographic

1. **Click on the 'Demographic' button in the lower bar.**
   The 'Demographic' graphic appears, similar to that shown in Figure 58. This represents the proportion of the fishers that would prefer, be indifferent to, or not prefer, the outcomes of the new target control over the current situation. This can be likened to the number of people out of a room full of 100 people that would vote for the target control over the current control if given the choice.

   In the example in Figure 58, 8479% of fishers would prefer the outcomes of the new target control level (443 boat days, best represented by the demographic for 460 boat days) to the current control level (550 boat days), and 16% would not prefer the target control over the current control level.

Figure 58: Demographic for recommended control level, Kizimkazi - Dimbani



Step 6: Analysis

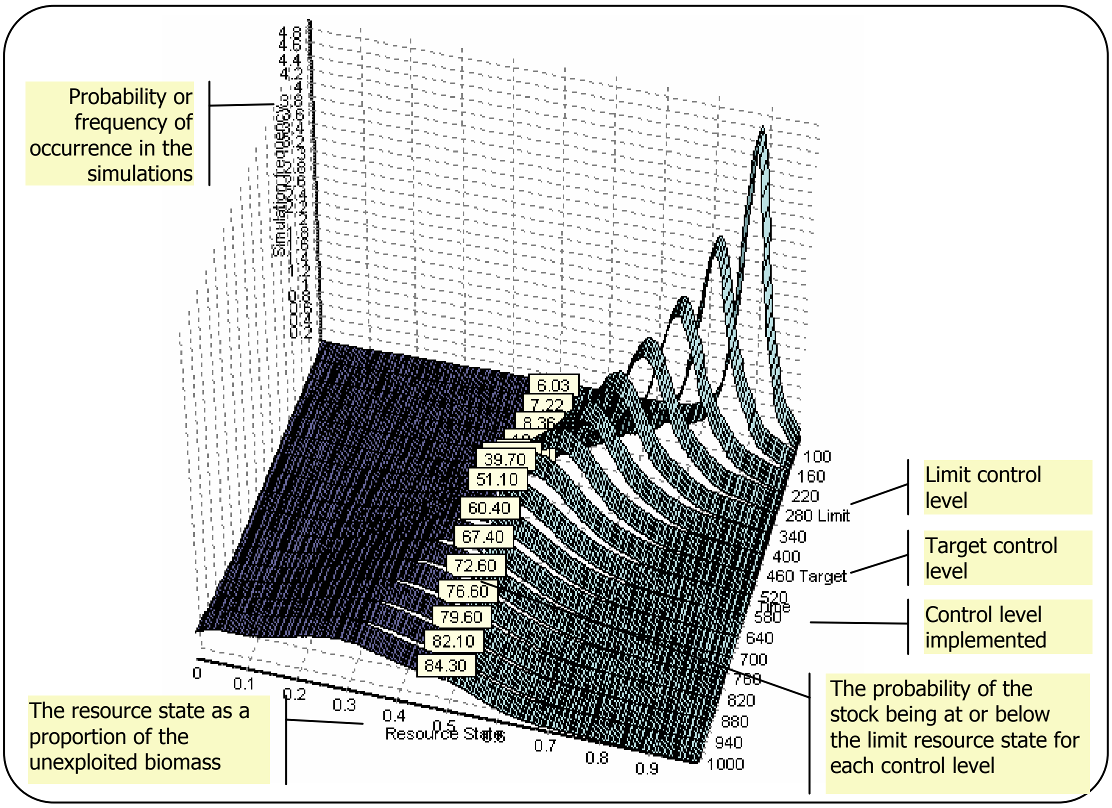
Resource States graph

1. **Select 'Resource States' from the drop-down menu in the Graph Area on the Analysis Page.** The Resource States graph appears, similar to the one in Figure 59.

   Each bar on the graph can be interpreted as the PDF for the state of the resource at a specific control level. The flatter the distribution, the less certain the resulting state of the resource will be. In general, the curves become flatter and peak further to the left at higher effort levels (towards the front of the graph), illustrating the higher level of uncertainty of the outcomes and the higher chance of overfishing at higher control levels, e.g. higher levels of effort. You can zoom in, rotate and change the elevation of the graph using the sliding bars at the top right hand corner of the Graph Area.

   The resource states graph is used, along with the reference point probability graph, to identify the limit control level. The target and limit control levels are indicated on the horizontal axis.

Figure 59: Resource States graph for outer patch reefs, Kizimkazi - Dimbani



The graph shows probability distributions for the resource state at various levels of control. The control being applied here is effort in boat days (axis on the right side of the graph). The resource state (on the bottom axis) is the current biomass measured as a proportion of the unexploited biomass. It varies from 0 (extinct) to 1.0 (unexploited) with MSY at 0.5. The probability density (on the vertical axis) indicates the chance that stock is in a particular state during the simulation. The cumulative probability (as %), shown as labels, is the probability of the stock being below the limit resource state, in this case the MSY reference point (0.5).

This graph illustrates that if the **limit control** level were implemented the resulting resource state is best represented by the curve showing an effort of 280 boat days per month, corresponding to a 10.2% likelihood of the stock being overfished. The exact value for the limit control level (=276) can be seen in the Scenario Results box of the Analysis screen in the Software, and the chance of overfishing in this example would be 10% (as the default unless changed). The **target control** is at 434 boat days which relates to a 28.0% likelihood of the stock being overfished and is best represented by the curve for 460 boat days. To determine how many boats should be fishing in the fishery, you can divide the number of recommended boat days by the average number of days fishing of each boat per month.

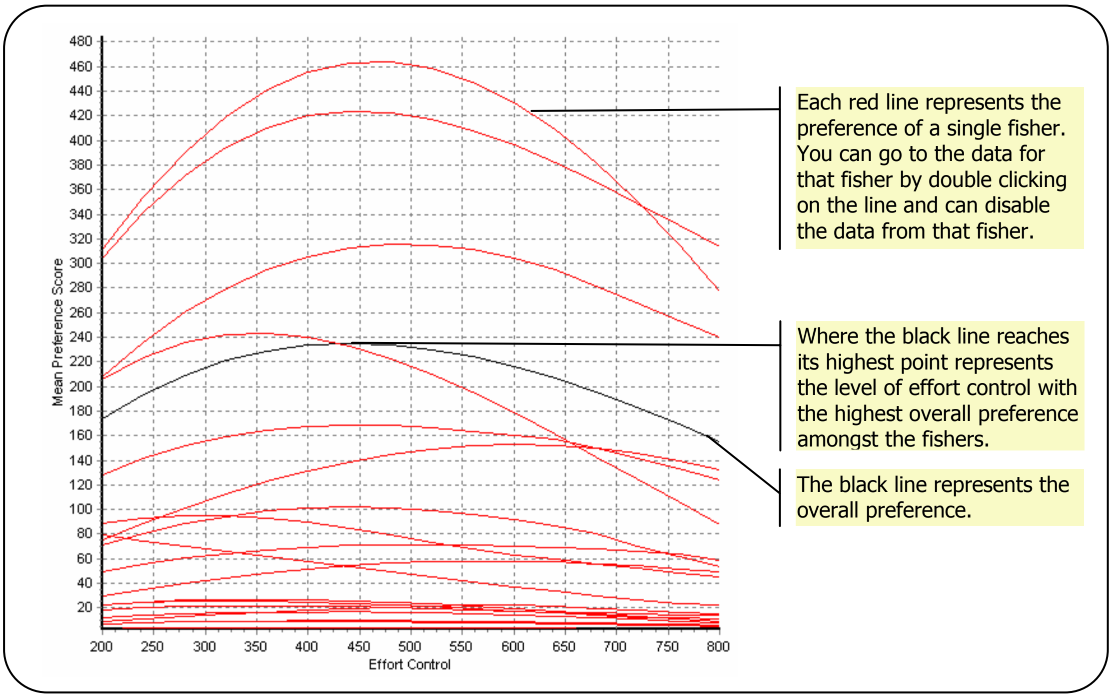
The target control level may be greater than the limit control level initially, due to uncertainty in the data rather than due to overexploitation. Therefore, the limit should be seen not as a limit that must not be exceeded, but rather as a guide to how much data you have. You should gather more data until the limit is greater than the target.

Preference graph

1. **Select 'Preference' from the drop-down menu in the Graph Area on the Analysis Page.**
   The Preference graph appears, similar to the one in Figure 60.

   Each red line represents the preferences of a single fisher. The black line represents the overall preference. The preference is used to identify the target control point. The maximum overall preference (black line) indicates the target control. However, the curvature of the curves indicates how much might be expected to be lost by applying alternative controls; a flat graph indicates little difference and greater leeway in negotiation.

Figure 60: Preference graph for outer patch reefs, Kizimkazi - Dimbani



The average (black) line peaks at around 440 boat days which is less than the current effort on the Dimbani offshore reefs of 550 boat days. Therefore, the results suggest that if effort is reduced by 20%, this would result in catch rates that the average fisher would prefer, compared to the current catch rates.

The results indicate the expected preference and are not a prediction. The decision is in fact a gamble. Based on the probability generated by the interviews and assessment methods, the computer can estimate the chance of the different outcomes in response to changes in the management control. The costs or benefits as relative preferences for each outcome can be obtained from the preference information. The graph indicates the average preference summed over all possible outcomes for that action. This is a rational response to uncertainty but cannot guarantee a good outcome. Identifying the true best action can only be determined through more and better data collection and stock assessment.

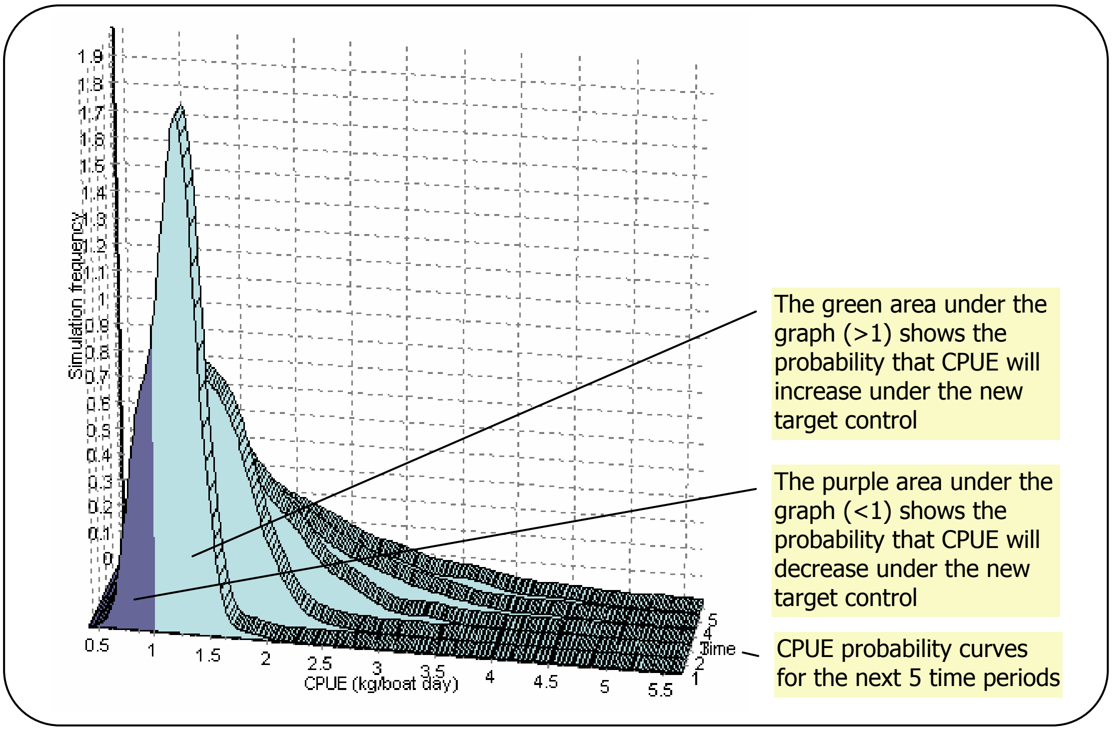
CPUE Projection

1. **Select 'CPUE Projection' from the drop-down menu in the Graph Area on the Analysis Page.** The CPUE Projection graph appears, similar to the one in Figure 61.

   The CPUE projection indicates the probability distribution for the CPUE as a proportion of the current CPUE for the next 5 time units. A value of 1.0 means no change, less than one indicates a decline in CPUE, greater than 1.0 indicates an increase. The dark coloured area is proportional to the probability that the CPUE will decline. In general, the distribution will flatten through time as uncertainty increases on what will happen. It is possible that the target will induce a decrease in CPUE as any increase in catches from the present will produce a decrease in CPUE as the population declines. This does NOT mean overfishing.

   You can zoom in, rotate and change the elevation of the graph using the sliding bars at the top right hand corner of the Graph Area.

   Figure 61: CPUE Projection graph



   This graph shows that the balance of probabilities lies in favour of the CPUE increasing relative to the current CPUE in the first time period after the control is implemented. Over the subsequent four time periods, uncertainty increases so the curves become flatter, but the chance is still that CPUE will be greater than the current CPUE, as the area under the curve greater than 1 (shaded pale green) is greater than the area under the curve less than 1 (shaded dark purple).

Preference Projections

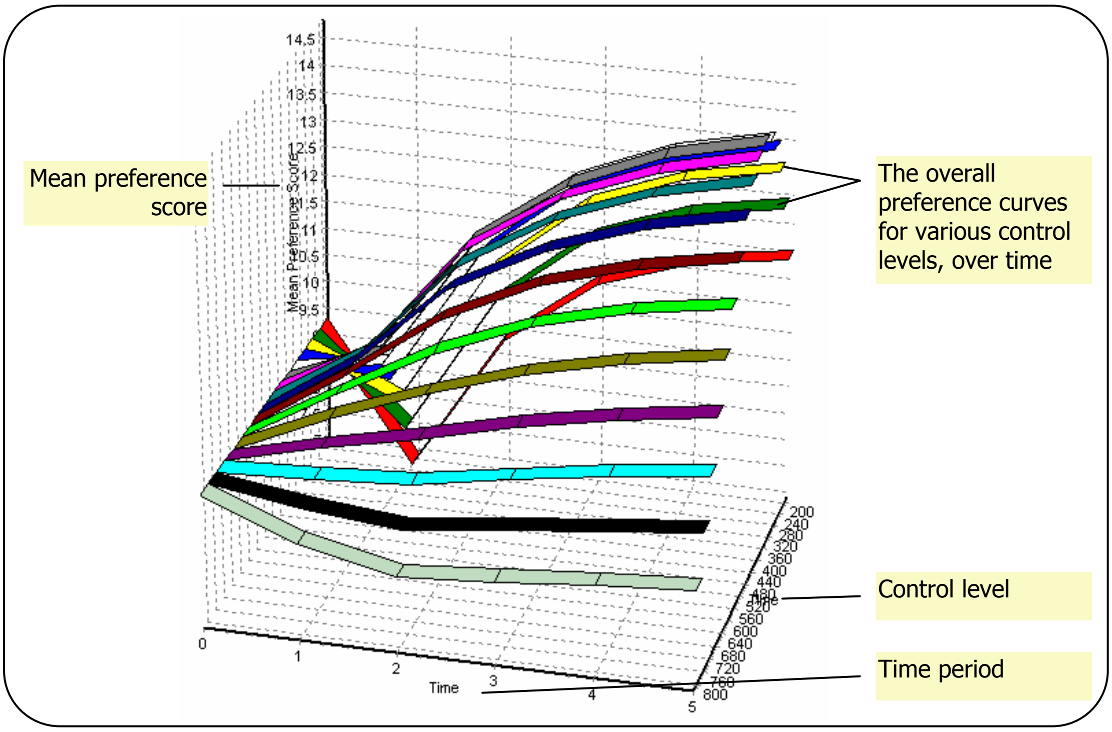
1. **Select 'Preference Projections' from the drop-down menu in the Graph Area on the Analysis Page.**
   The Preference Projections graph appears, similar to the one in Figure 62.

   The preference projections show how the preference for the conditions in fishery are expected to change in the fishery in response to each control level over the next 5 time units. The graphs are available for all fishers combined as well as for each fisher interviewee. They should show the same general shape. Any decrease in the control level (e.g. reduction in effort or quota or increase in the size of a closed area) is likely to show an initial dip in preference (things get initially worse) followed by an increase to a new equilibrium as the fishery responds to the management change. Conversely an increase in the control level (increase in effort or quota) would tend to have the opposite effect, an immediate increase in preference followed by a decrease as catch rates reduce in response to the greater fishing activity. The target results from the sum over all initial gains or losses and long term results of the control over the time period over which the analysis was run. Note the benefits and losses are discounted, so changes happening further in the future are weighted downwards.

   Rotating and changing the elevation of the graph will help you see the change in preference over time for each control level.

   You can see the preference projections for individual fishers by selecting the name of the fisher you want to see from the lower drop-down menu on the Graph Area.

Figure 62: Preference Projections graph

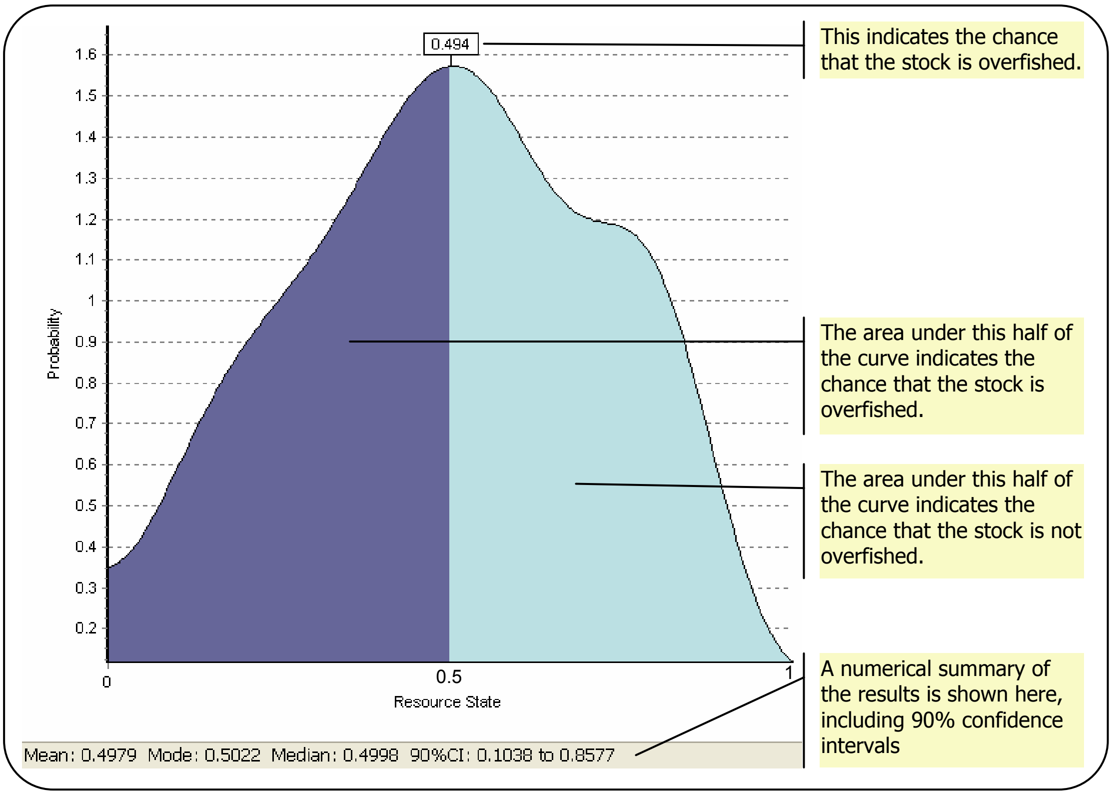


Current State graph

1. **Select 'Current State' from the drop-down menu in the Graph Area on the Analysis Page.** The Current State graph appears, similar to the one in Figure 63.

   The current state is the current biomass divided by the unexploited biomass. Often this is poorly known so the graph may be quite flat. Better estimates of the current biomass (Bnow) and the unexploited biomass (Binf) can yield much better estimates of this. Better estimates of unexploited biomass may be obtained from monitoring the recovery of closed areas. You can change the scale on the x-axis using the Min and Max fields in the Graph Area and clicking 'Apply'.

Figure 63: Current state graph for patch reefs, Kizimkazi - Dimbani



The wide spread of the curve in Figure 63 illustrates that there is a high level of uncertainty (the resource state could be between 0.10 and 0.86 of Binf (90% CI)). This is likely to be the case in an initial assessment where there is limited information, and illustrates the need to collect further data on the fishery using the resources available. There is a 49% chance that the stock is over-fished, i.e. that the current resource biomass is less than half of the unexploited biomass.

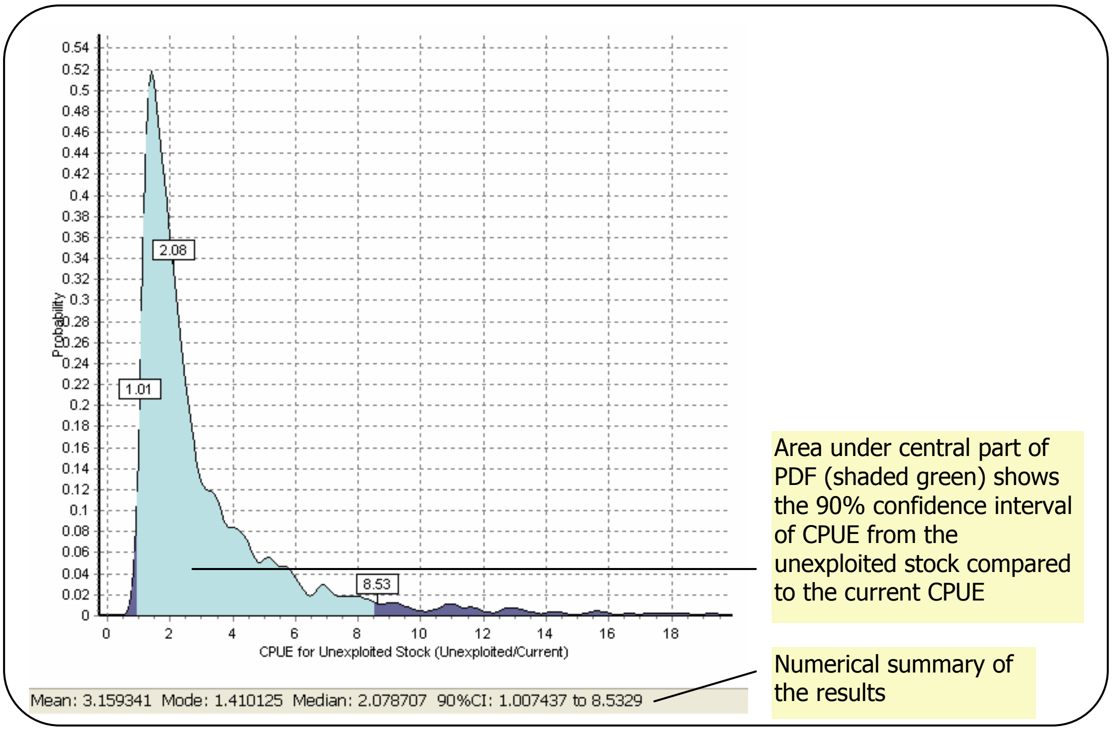
Unexploited CPUE

1. **Select 'Unexploited CPUE' from the drop-down menu in the Graph Area on the Analysis Page.**
   The Unexploited CPUE graph appears, similar to the one in Figure 64.

   Unexploited CPUE is one of the questions asked in the Stock Assessment Interview. This graph gives feedback on what the best estimate for the value is as a proportion of the fishers' current CPUE. If you run a scenario using ***only*** the fisher interview probability model, this graph will indicate what the fishers thought the CPUE on an unexploited or lightly fished stock would be. If you run a scenario adding in ***other*** information sources, this will show what the Bayesian method estimates that the fishers would think, if they were to take into account the new information. A shift in the median value indicates a change in bias (what the average should think) and a change in spread indicates the precision (whether we are more or less certain).

   You can change the scale on the x-axis using the Min and Max fields in the Graph Area and clicking 'Apply'.

Figure 64: Unexploited CPUE graph



This graph shows that the range of the unexploited CPUE is between 1 and 8.5 times the current CPUE. The median indicates the unexploited CPUE is roughly double the current CPUE. The mode or median are better measures to choose than the mean, as the mean is influenced by extreme values.

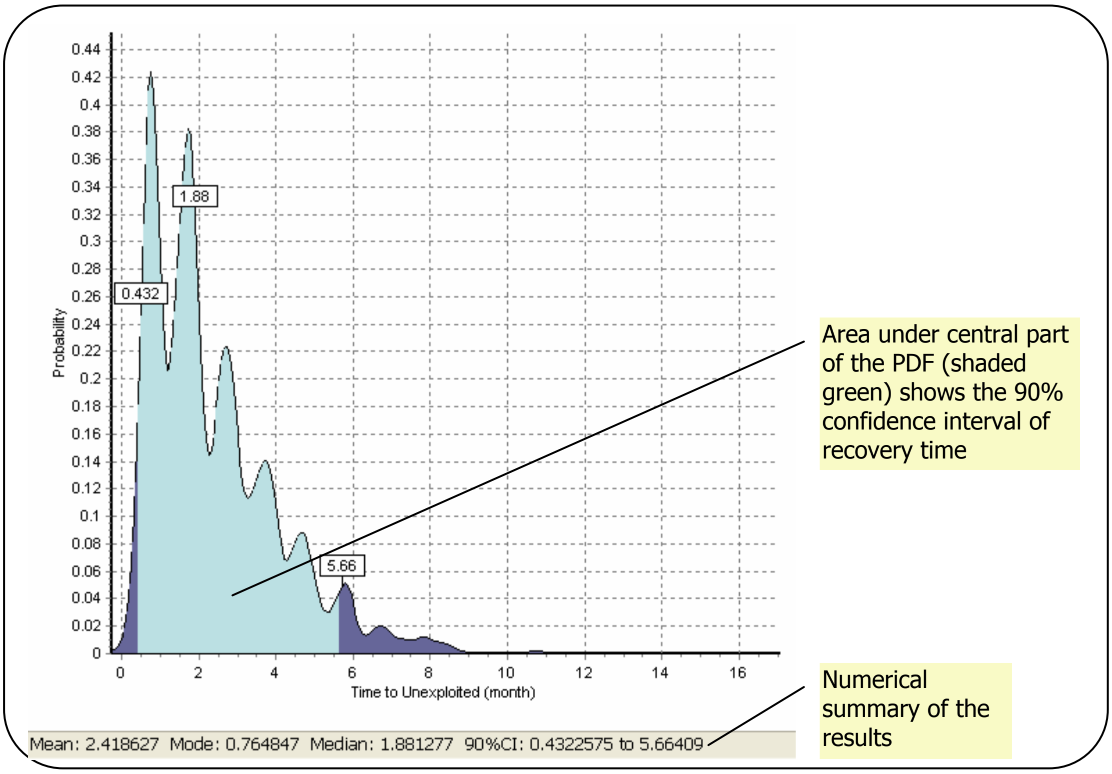
Recovery Time graph

1. **Select 'Recovery time' from the drop-down menu in the Graph Area on the Analysis Page.** The Recovery time graph appears, similar to the one in Figure 65.

The recovery time is asked in the interview. This is the time taken for the resource to return from its current state to the unexploited state. The longer it is, the lower the productivity of the resource. It can be processed as above in the Unexploited CPUE section to see the level of agreement among fishers (by running the analysis using only the interview model) and test how much information is available to improve the estimate given by the fishers (by running the analysis including other models available).

You can change the scale on the x-axis using the Min and Max fields in the Graph Area and clicking 'Apply'.

Figure 65: Recovery time graph



This graph shows that the stock would take between 0.4 and 5.7 time units (months, in this case, as defined in Step 1 and used in the interviews) to recover to the unexploited state if fishing were to stop. This can indicate the length of time a closed area should be set aside for to allow stocks to recover. The information for this graph, in this analysis, is based only on the fisher interviews, and indicates how long the fishers believe the stock would take to recover. It seems quite a short length of time, indicating that they believe the stock is very productive, or growth may be influenced by immigration of fish from other less heavily exploited areas.

To increase the certainty of this estimate, it would be necessary to monitor the recovery of a closed area to obtain further data on the growth rate of the stock.

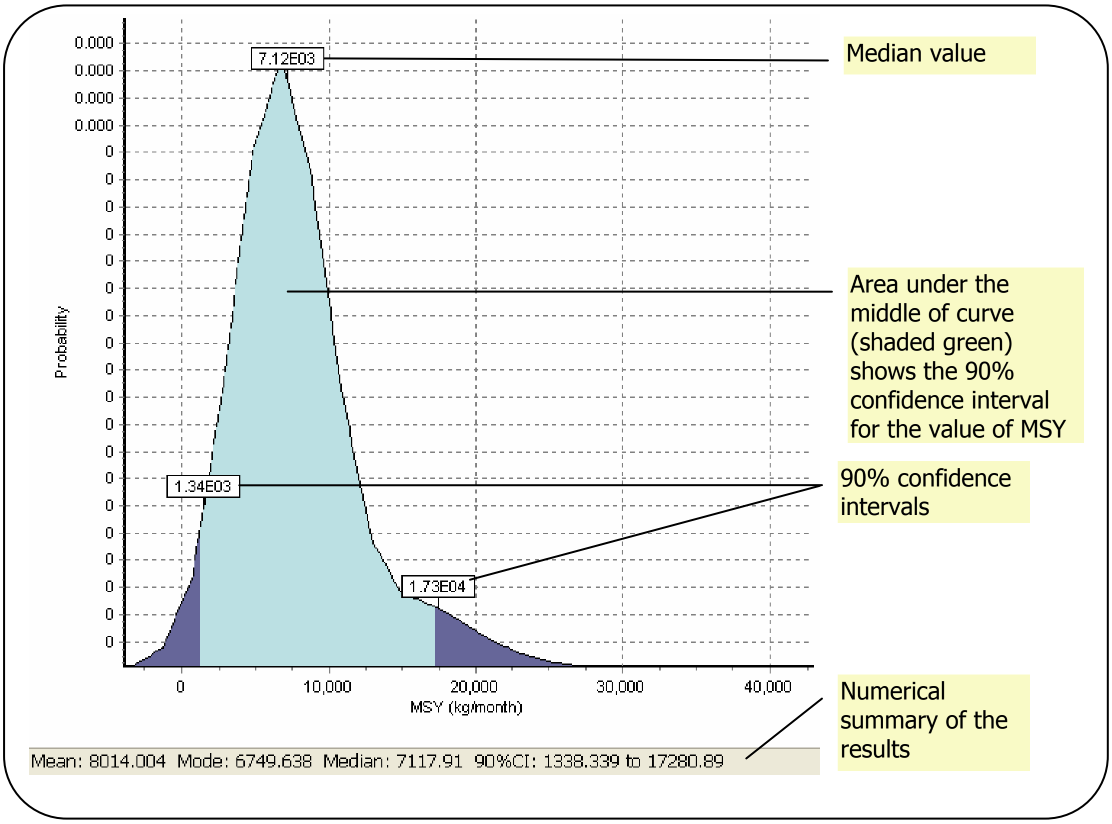
MSY

1. **Select 'MSY' from the drop-down menu in the Graph Area on the Analysis Page.**
   The MSY graph appears, similar to the one in Figure 66.

   The MSY graph shows the maximum catch that can be sustained. A quota should never be set greater than MSY, otherwise it will never be applied and will serve no purpose. MSY defines the point of overfishing. Beyond this point, any decrease in effort will yield greater catch, eventually.

   You can change the scale on the x-axis using the Min and Max fields in the Graph Area and clicking 'Apply'.

Figure 66: MSY graph



This graph shows that the MSY lies between 1338 and 17281 kg per month (90% confidence interval). The median value is 7118 kg per month.

Note that the values marked on the graph for median and 90% confidence intervals are in the following format:

7.12E03 = 7.12×10^3 = 7120

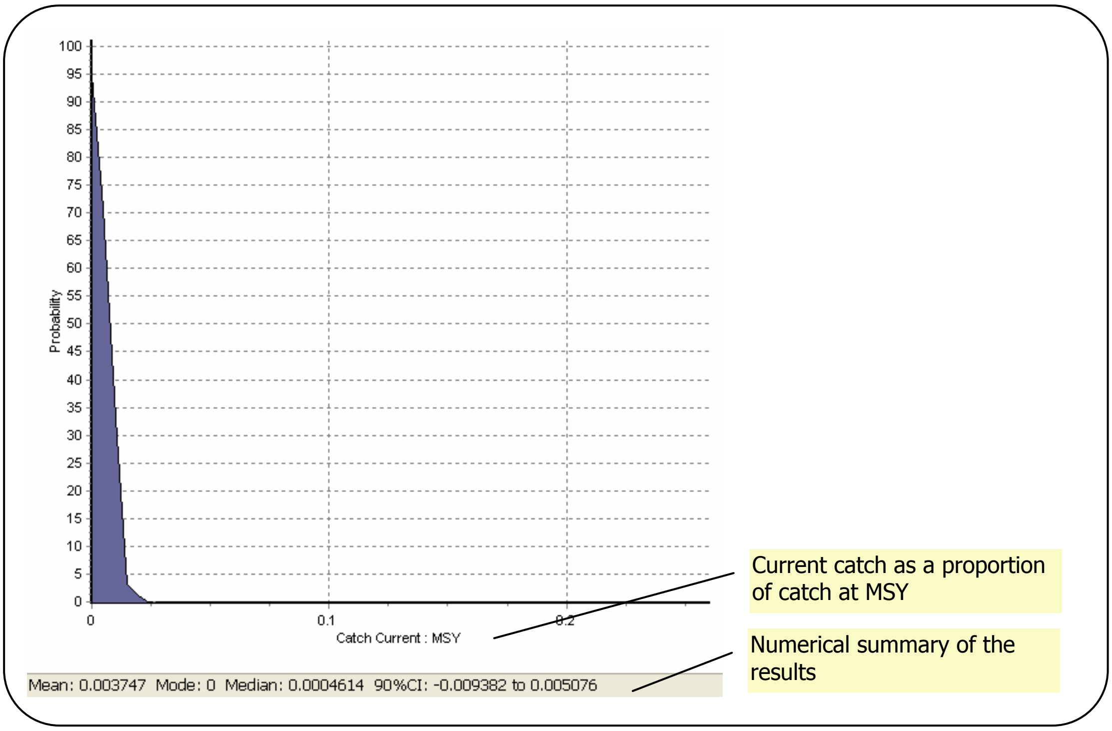
Relative MSY

1. **Select 'Relative MSY' from the drop-down menu in the Graph Area on the Analysis Page.**
   The Relative MSY graph appears, similar to the one in Figure 67.

   This graph shows the current catch divided by MSY (catch). This allows a calculation of the probability that current catches are too high (i.e. the probability that relative MSY > 1.0).

    1 = catches are equal to catches at MSY
   >1 = catches are too high, i.e. higher than MSY
   <1 = catches are lower than MSY

Figure 67: Relative MSY



F at MSY

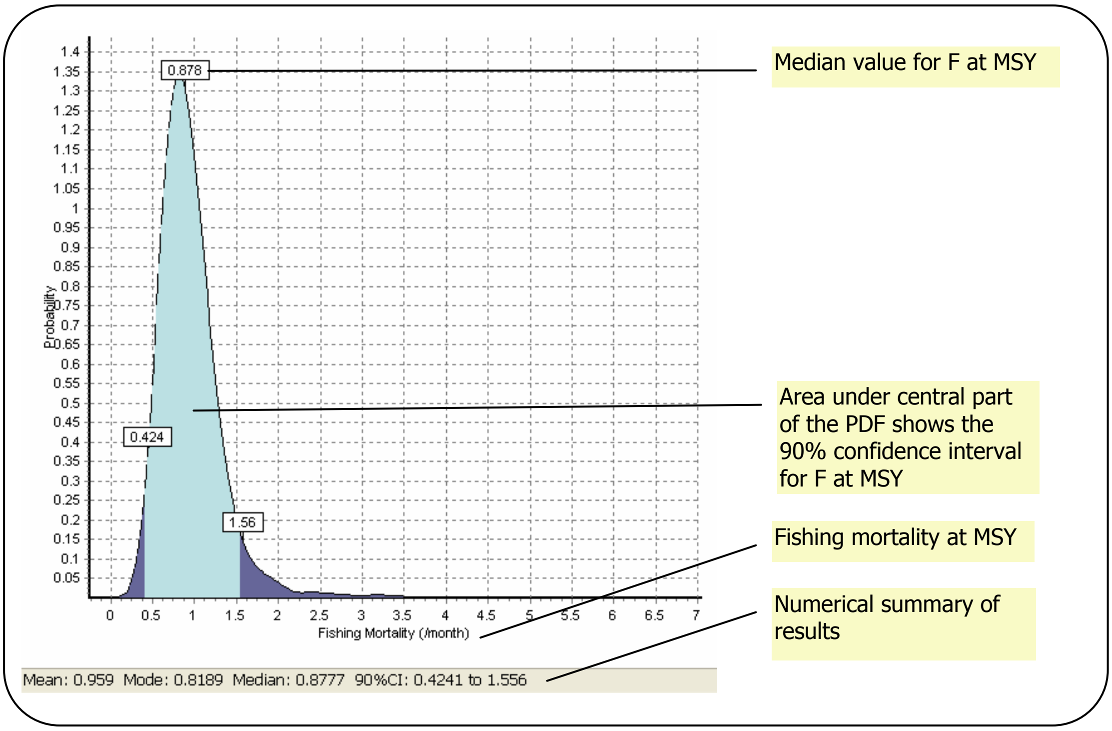
1. **Select 'F at MSY' from the drop-down menu in the Graph Area on the Analysis Page.**
The F at MSY graph appears, similar to the one in Figure 68.

This graph shows the Fishing mortality (F) at the MSY point. F is approximately the proportion of the stock captured by the fishery. In fact, the catch is = $B_t(1-\exp(-F))$, so at very high F's the proportion of the biomass that is caught approaches but never reaches 100%. So with any particular catch there is an associated fishing mortality. When the catch is equal to MSY and the population is at equilibrium, a particular F can be calculated. This is another way of defining the MSY point. You would hope to see fishing mortality at MSY to be below 0.5, although this will depend on the species involved in the fishery, for example, F for fast growing, short-lived species may be higher.

This graph helps indicate if the model is acceptable and realistic. For example, if F at MSY is >1, this would be a cause for concern, and may reflect unrealistic expectations from the fisher interviews or other unreliable data sources.

You can change the scale on the x-axis using the Min and Max fields in the Graph Area and clicking 'Apply'.

Figure 68: F at MSY graph



This graph shows the fishing mortality at MSY lies between 0.42 and 1.56 of the stock per month (90% confidence interval) with the median at 0.88 of the stock per month.

Step 6: Analysis

Relative F at MSY

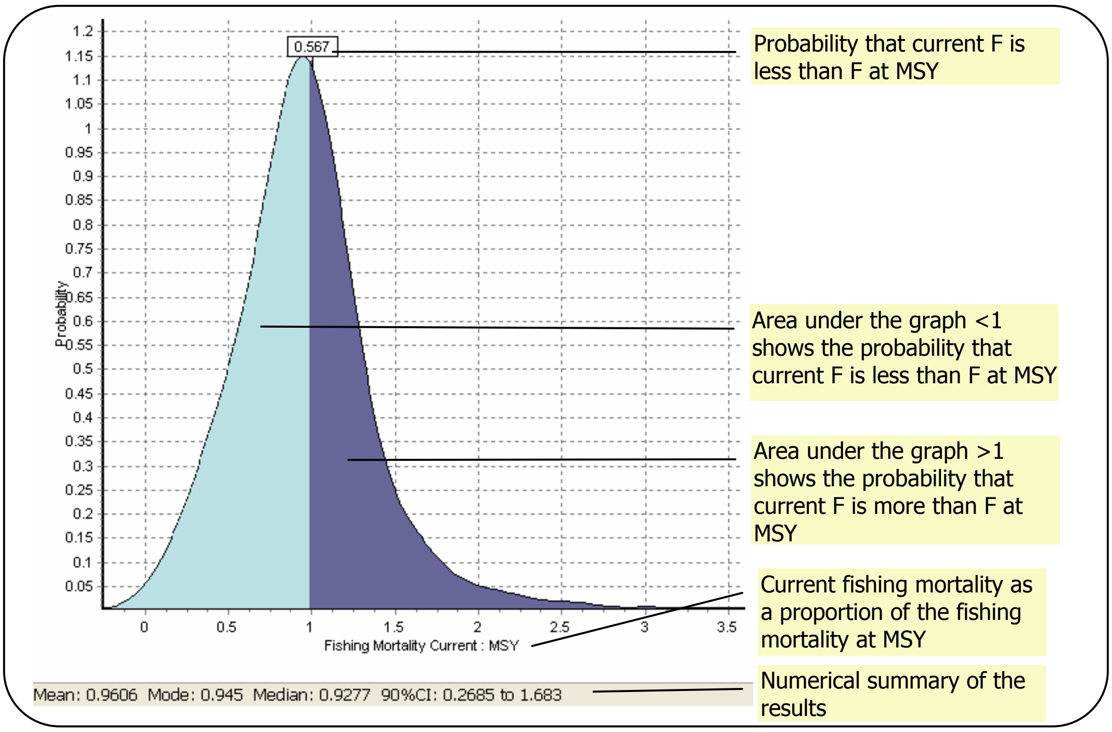
1. **Select 'Relative F at MSY' from the drop-down menu in the Graph Area on the Analysis Page.**
   The Relative F at MSY graph appears, similar to the one in Figure 69.

   This graph shows whether overfishing is occurring. It shows the current F divided by the F at MSY. Relative F > 1.0 implies fishing will push the resource to below the MSY point and can be designated as overfishing.

   F is proportional to fishing effort in this model, so it can be directly translated to effort. In this case, the relative F at MSY is exactly the same as the relative effort at MSY as the catchability cancels out. Effort may be easier for fishers and others to understand than fishing mortality.

   You can change the scale on the x-axis using the Min and Max fields in the Graph Area and clicking 'Apply'.

Figure 69: Relative F at MSY graph



This graph shows there is a 56.7% probability that the current fishing mortality is less than the fishing mortality at MSY. In this model, fishing mortality can be equated to fishing effort, so there is a 56.7% probability that current fishing effort is less than fishing effort at MSY. It is possible that overfishing is occurring although the results are not conclusive.

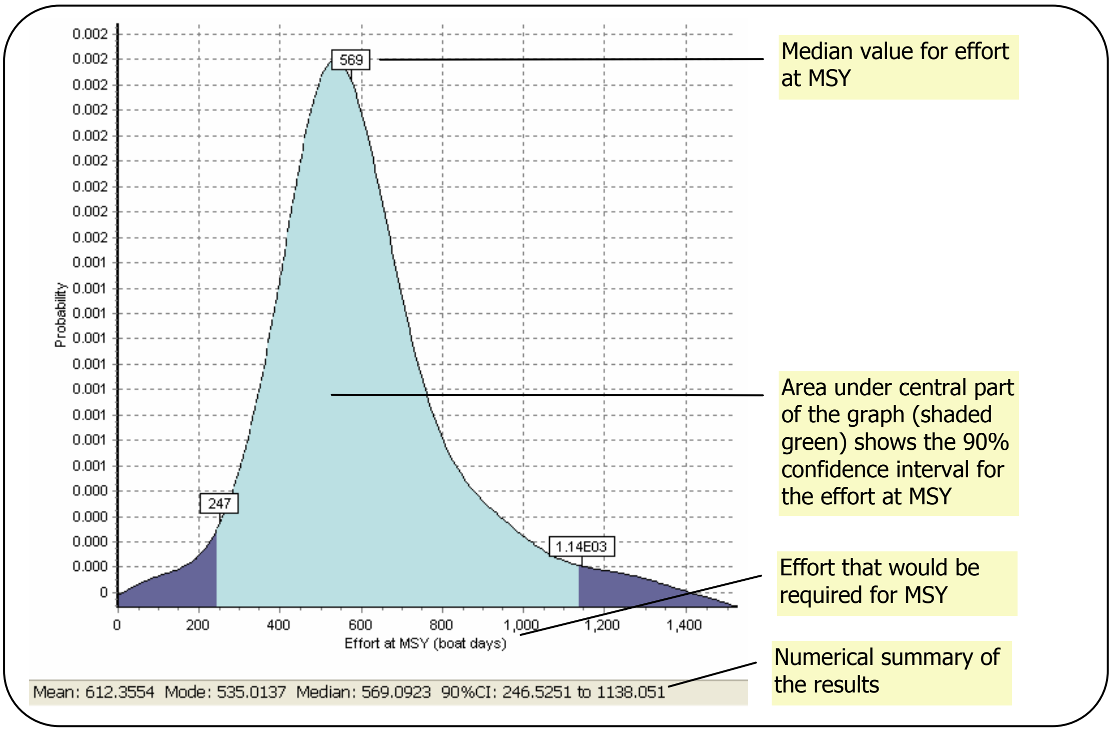
Effort at MSY

1. **Select 'Effort at MSY' from the drop-down menu in the Graph Area on the Analysis Page.**
   The Effort at MSY graph appears, similar to the one in Figure 70.

   This graph indicates what the effort should be to attain MSY.

   You can change the scale on the x-axis using the Min and Max fields in the Graph Area and clicking 'Apply'.

Figure 70: Effort at MSY graph



This graph shows that the median value for effort at MSY is 698 boat days, and between 344 and 1184 boat days with a 90% confidence interval. Compared to the current effort of 591 boat days, this indicates that effort may be able to increase without overexploiting the resource. However, due to the uncertainty involved (effort at MSY could be as low as 344 boat days, less than the current effort), the calculated target and limit controls are lower than the current effort.

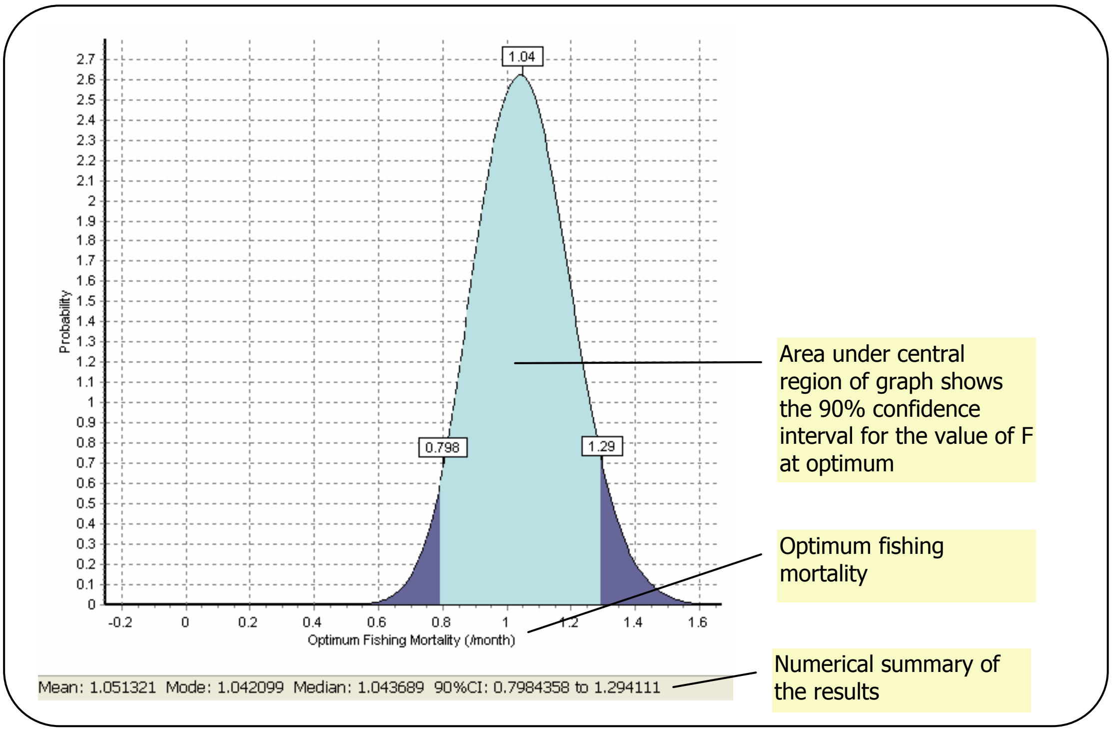
F at Optimum

1. **Select 'F at Optimum' from the drop-down menu in the Graph Area on the Analysis Page.**
The F at Optimum graph appears, similar to the one in Figure 71.

F at optimum (Fopt) is the F which maximises the preference score for the fishery. In contrast to MSY, the optimum needs cost and benefit information (i.e. discount rate and preferences). The optimum is the target, where we want to be, whereas MSY is a limit, where we do not want to be beyond. The target is usually, but not always, below the MSY point. With a low discount rate, the Fopt should be lower than F at MSY. However, our limit is based on probability, so the target can exceed the limit depending on the risk we have considered acceptable.

You can change the scale on the x-axis using the Min and Max fields in the Graph Area and clicking 'Apply'.

Figure 71: F at Optimum graph



This graph shows the value for fishing mortality at optimum (highest preference score) is 1.04 (median), and between 0.80 and 1.29 (90% confidence interval).

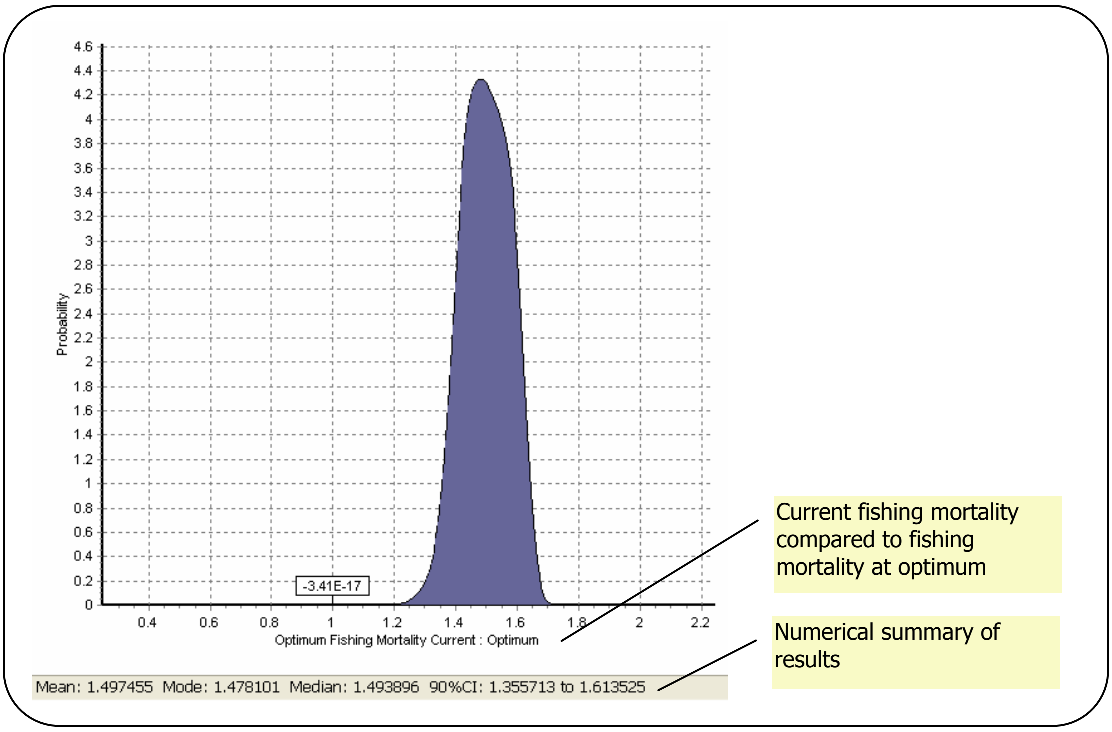
Relative F at Optimum

1. **Select 'Relative F at Optimum' from the drop-down menu in the Graph Area on the Analysis Page.**
   The Relative F at Optimum graph appears, similar to the one in Figure 72.

   This is similar to the F at Optimum graph, but shows the current F divided by Fopt. This allows us to calculate the probability of whether the fishing effort needs to be decreased on increased to reach the target (i.e. the probability that relative effort > 1.0). This can be used for qualitative advice.

   If the relative F is > 1, this indicates current effort is greater than Fopt, and we should be decreasing effort. If relative F is < 1, this indicates current effort is less than Fopt, and we could be increasing effort.

Figure 72: Relative F at Optimum



This graph suggests that current F divided by Fopt is greater than 1, and therefore if we reduce effort, catches should increase and the fishers would be happier. However, the graph does not indicate by how much effort should be decreased.

Reference Point Probability

1. **Select 'Ref. Pt. Probability' from the drop-down menu in the Graph Area on the Analysis Page.**
   The Reference Point Probability graph appears, similar to the one in Figure 73.

   The reference point probability graph shows how the limit control based on probability is calculated. The graph shows a cross section through the cumulative probability distributions for the resource state graph, i.e. it plots the values in the little boxed labels. The limit reference point control is chosen so that the probability from this graph equals the limit reference point probability specified by the user. At this control, there is an x% chance that any state chosen at random from all the simulated states will be below the limit state (0.5 for MSY).

Figure 73: Reference Point Probability graph