Removal Sampling 2

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by Pisces Conservation Ltd

Removal Sampling 2 offers a number of methods for the estimation of population size using removal sampling methods.

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Removal Sampling 2

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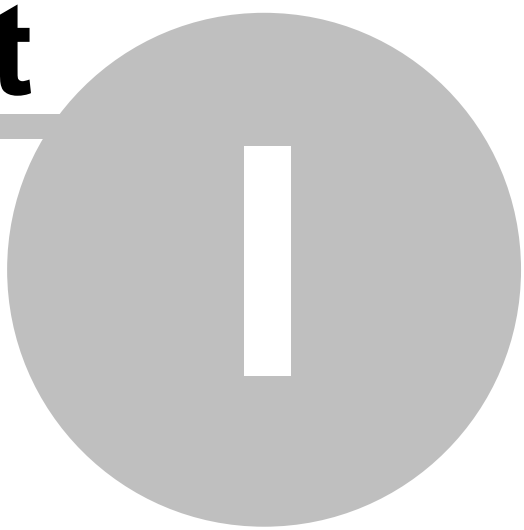


1 Introduction

Removal Sampling 2 is designed to help you to estimate population size using modern removal sampling techniques.

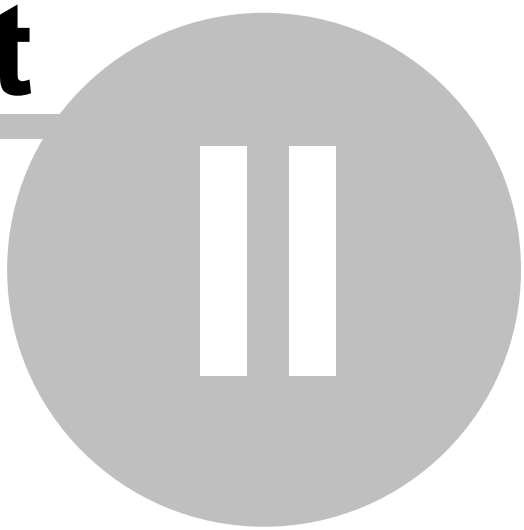
The program also offers some statistical tests for the appropriateness of the model used, and a graphical presentation of the results. This program is suitable for both scientists and students with limited mathematical knowledge.

With its easy to use interface and extensive help, *Removal Sampling* v2 is an ideal program for undergraduate and post-graduate students.

Removal Sampling Version 2 includes the following additions and enhancements:

- An improved user interface and graphics
- Improved help system with tutorials

Part



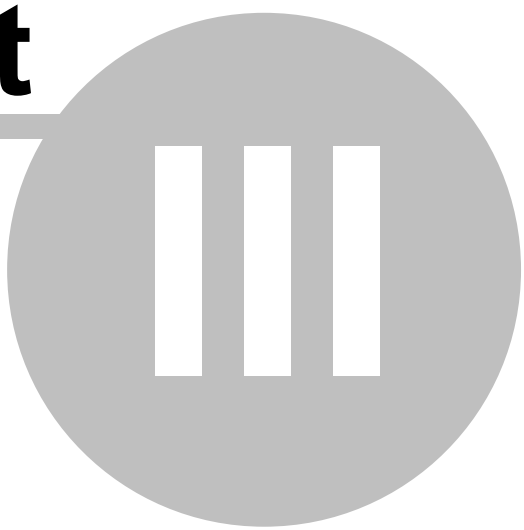
2 Getting Started

This page helps you navigate to the areas of the help file to get you started.

Select the jumps below for help on
Installation
entering your data
Open a data file
Choosing a method
Printing your Results
Copying your Results.

The quickest way to understand how to use the program is by using the demonstration data set.

Part



3 Using Removal Sampling 2

Removal Sampling 2 offers a number of methods for the estimation of population size using removal sampling methods. For details of the methods see:

Constant p
Variable p
Regression
Carle & Strub

For details about how to use the program see:

Main window
Editing and changing graphs
Editing data
Printing and exporting your results
Copying
Entering data

To see a worked example see the tutorial.

3.1 Entering data

Demonstration data sets
An example data set is supplied with the program. This allows the user to test the program, and can be opened in a spreadsheet or word-processor program to examine the way the data are organised.

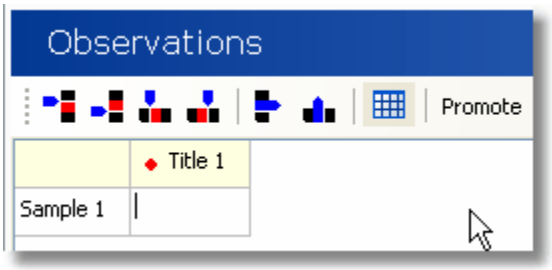
Creating data sets
Data sets can be created within Removal Sampling 2, or by using a spreadsheet such as Microsoft Excel, or many other spreadsheets, word processors, database programs, etc. We recommend that you organise large data sets using a spreadsheet such as Excel, as this will give access to a wide range of sorting and editing procedures to ease your task.

Creating a data file using a spreadsheet

Creating a new data set within Removal Sampling 2

3.1.1 Creating a new data set within Removal Sampling 2

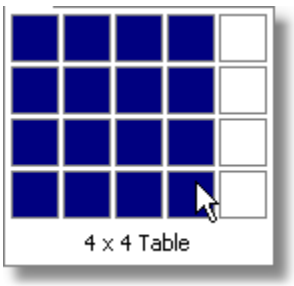
Datasets can be created both within and outside *Removal Sampling 2*. To start a new dataset from within *Removal Sampling 2* select **File|New**. This will open a blank grid into which you can type your data.



The data comprise the number of animals captured for the first time in samples 1 to n, arranged in columns. Enter data in each cell by clicking on the cell and typing. Columns and rows can be added or deleted using the tool bar above the grid.

To set an initial number of rows and columns use the size grid tool on the tool bar which has the square icon-

To select a row and column number just drag the mouse over the grid with the left-hand button depressed and then release. As the pointer is dragged over the grid the selected size will be shown in blue as follows -



Remember that for larger data sets you are advised to use a spreadsheet to create your dataset, as it will give you superior editing and data search facilities. See Creating a data file using a spreadsheet.

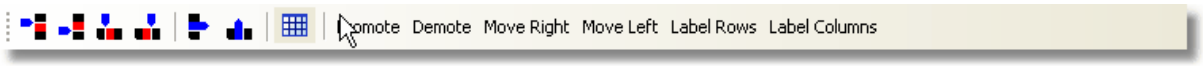
To see an example of data collected using electric fishing in a stream, open **RemovalDemo.csv** - stored by default in **..\My Documents\Removal Sampling Data\Demo Data.**

3.1.1.1 Editing data

To edit an open data set click on **Data** tab to display the data grid. Double click on the cell you wish to edit and type in the new value. If you wish to undo an alteration use **Edit|Undo** or **Ctrl-Z**

Above the data grid there is a tool bar which allows the shape of the grid to be changed

by adding or removing rows and columns. The purpose of each button will be displayed if you hover with the cursor over any of the buttons.



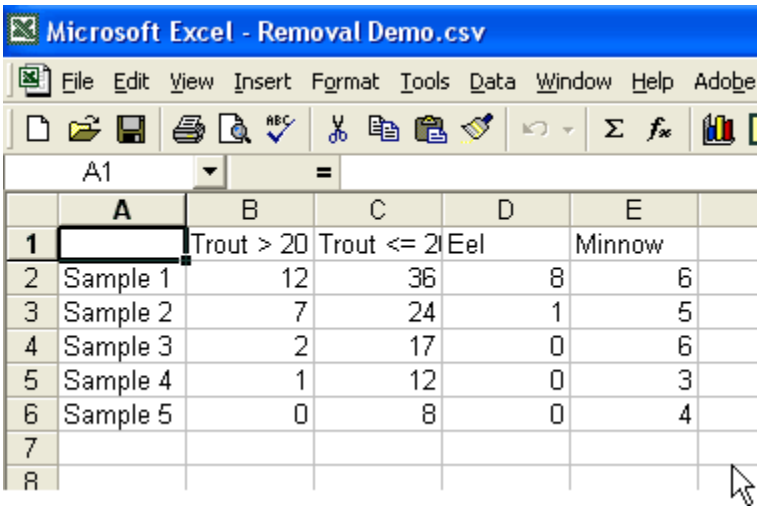
By default, the toolbar is docked on the main program window; if you wish, you can drag it so that is displayed free from the main window, by clicking on the dotted vertical line at the left of the toolbar, and dragging:

To re-dock the toolbar on the main window, either click the X in the top right corner of the toolbar, or drag it back to its original position on the main program window.

To make major changes to a large data set it may be quicker to open the data set in a spreadsheet program.

3.1.2 Creating a data file using a spreadsheet

A data set is stored as a comma-delimited text file with the extension **.csv**. *Removal Sampling* will also open Excel files. It is normal to initially organize your data in a spreadsheet such as Excel. The data are organized as a simple 2-dimensional array as follows:

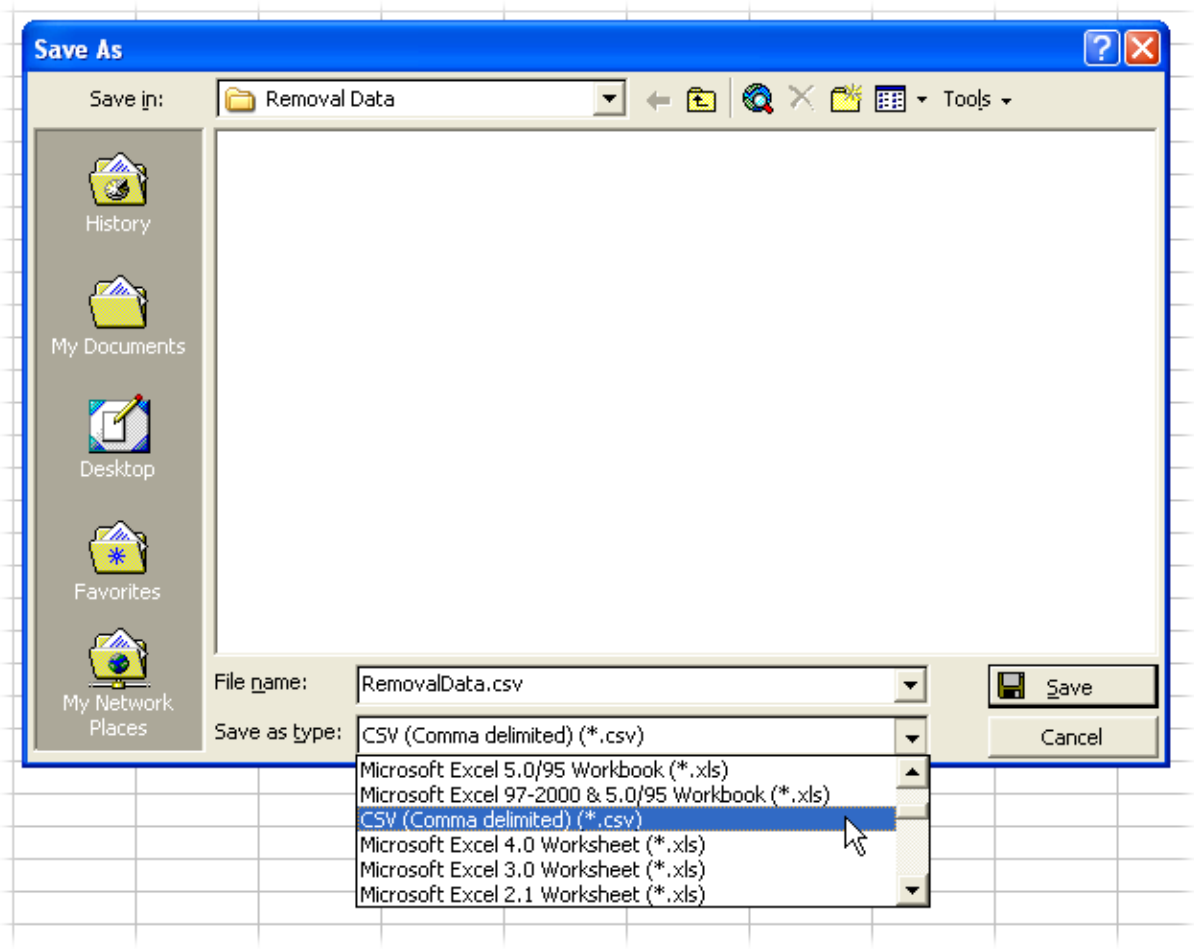


	A	B	C	D	E
1		Trout > 20	Trout <= 2	Eel	Minnow
2	Sample 1	12	36	8	6
3	Sample 2	7	24	1	5
4	Sample 3	2	17	0	6
5	Sample 4	1	12	0	3
6	Sample 5	0	8	0	4
7					
8					

This example is the demonstration file **RemovalDemo.csv** opened in Excel.

You should create a completely new spreadsheet file, and enter your data into it, rather than create a new sheet on an existing spreadsheet - which might for instance contain raw data and other information from your sampling. This is because the csv file format can only support a single worksheet. Make sure that no other data apart from the sample data grid is present on the worksheet. It is good practice to select the first 10 or so rows and columns, below and to the right of the data grid, and press the Delete key, to remove any data or blank spaces accidentally entered into cells outside the data grid.

When you have added all the data to your data set, click File: Save As, choose a name for your file, and select **CSV (Comma delimited) (*.csv)** from the Save as type drop-down menu (see below). You will receive a warning that the CSV file type does not support workbooks containing multiple sheets; press OK to ignore this warning, then click 'Yes' to ignore the next warning, that the sheet might contain features not compatible with CSV.

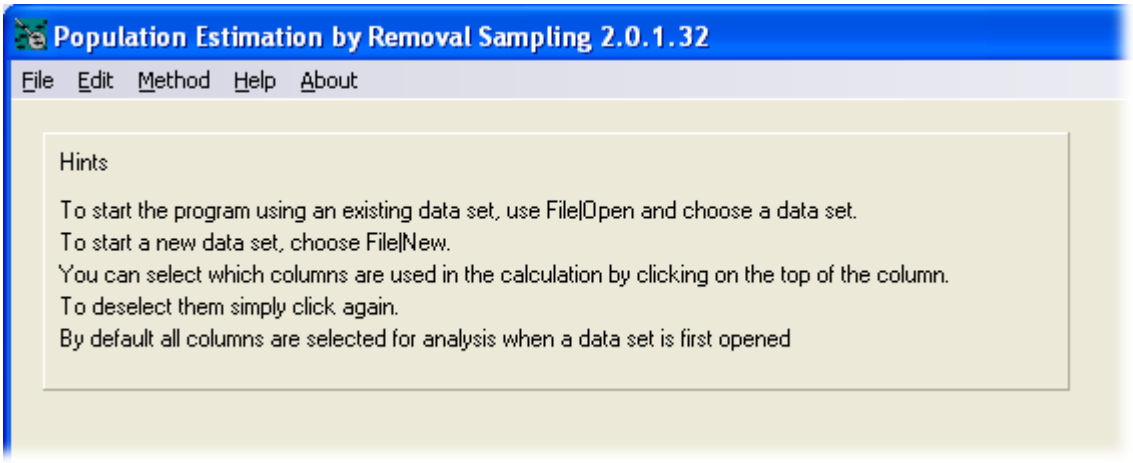


3.1.3 Maximum size of the data set

Removal Sampling 2 has been written to handle 100 columns by 100 rows of data set. A larger version can be made on request - contact us

3.2 Main Window

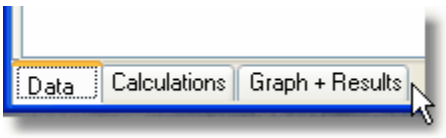
Start *Removal Sampling 2* in the normal Windows fashion either by clicking on the desktop icon or from the Start menu. The program appears with no open data set, as shown below:



Along the top bar are a number of drop-down menus. These work in the same way as most standard Windows programs.

File: To open and create data sets, save files and print results.
Edit: To copy or export the graph or the data and predicted results.
Method: To select a model to estimate population size.
Help: to enter the Help system. Context specific help can also be obtained for each method by opening its window and then clicking on the right hand mouse button, or by pressing the F1 key on your keyboard.

The data and results are shown in three tabbed windows. Just left click on a tab to select it.



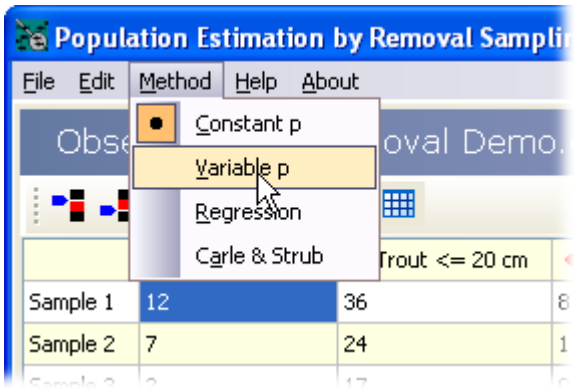
Data: This tab shows age and size data. For example, it will be displayed if you have entered or opened a data set that comprises age and length data for individual organisms.
Calculations: This tab presents the observed and predicted values.

Graph + Results: This tab presented a plot of the observed and predicted fit plus model parameters and diagnostics for length data.

To get you started *Removal Sampling 2* comes with a demo data set.

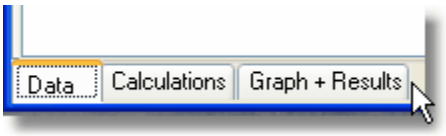
Use **File|Open** to find and open **RemovalDemo.csv** (saved by default during installation in the folder **..\My Documents\Removal Sampling Data\Demo Data**)

This will give a plot of your data in a tabbed output. Upon opening the data set *Removal Sampling 2* automatically fits a constant probability model using non-linear methods. If you wish to fit another model, this is easily accomplished - choose another from the Method drop-down menu:

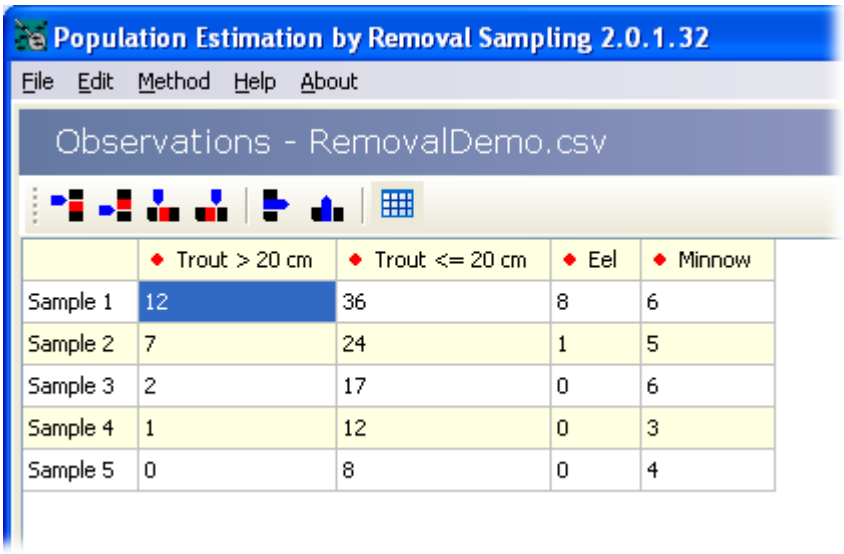


3.2.1 Data Tab

Click on this tab at the bottom of the main window to show the data grid.



The example below is the data for our demonstration data set **RemovalDemo.csv**

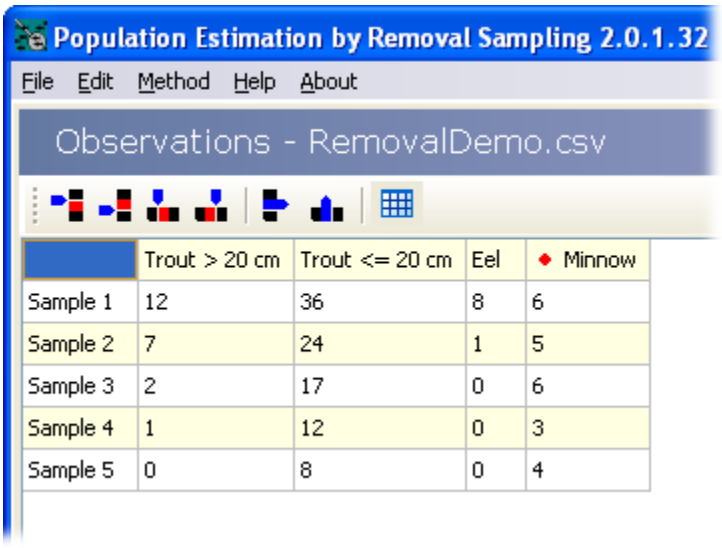


	Trout > 20 cm	Trout <= 20 cm	Eel	Minnow
Sample 1	12	36	8	6
Sample 2	7	24	1	5
Sample 3	2	17	0	6
Sample 4	1	12	0	3
Sample 5	0	8	0	4

Data can be edited, saved, copied or printed.

To print, export or copy the grid see Print Grid and Copy Grid

If you have a number of columns of data for different species, as in the example above, *Removal Sampling 2* will initially analyse the *summed* data for all the columns. You can select which of the columns to analyse, by clicking in to the column title cell, so that a red dot is displayed (see image above) in the column(s) you wish to analyse. Click again to remove the red dot, and deselect that column. For example, to only analyse Minnow, click on the title cells of the other three columns, so that only the red dot alongside Minnow remains.

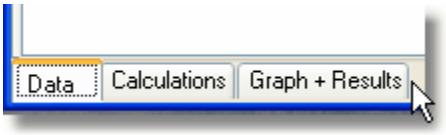


	Trout > 20 cm	Trout <= 20 cm	Eel	Minnow
Sample 1	12	36	8	6
Sample 2	7	24	1	5
Sample 3	2	17	0	6
Sample 4	1	12	0	3
Sample 5	0	8	0	4

Each time a column is selected or deselected, the calculations are performed on the selected columns, using the default model from the Method menu, and the results are displayed on the Calculations and Graph + Results tabs. To use a different model, simply select the one you want from the Method drop-down menu.

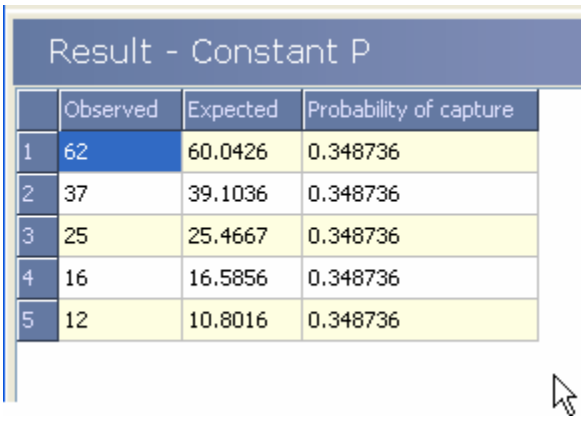
3.2.2 Calculations Tab

This tab at the bottom of the main window shows the calculations for the selected model.



This tab shows a grid giving both the Observed (entered data) and the Expected numbers of captures for each run for the selected model. The model used is shown in the title of the Results grid. The third column gives the estimated probability of capture. If a Constant P model has been chosen, then this value will be the same for each run.

The grid below shows the results for a constant probability model using the file **RemovalDemo.csv**.



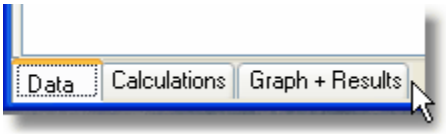
Result - Constant P

	Observed	Expected	Probability of capture
1	62	60.0426	0.348736
2	37	39.1036	0.348736
3	25	25.4667	0.348736
4	16	16.5856	0.348736
5	12	10.8016	0.348736

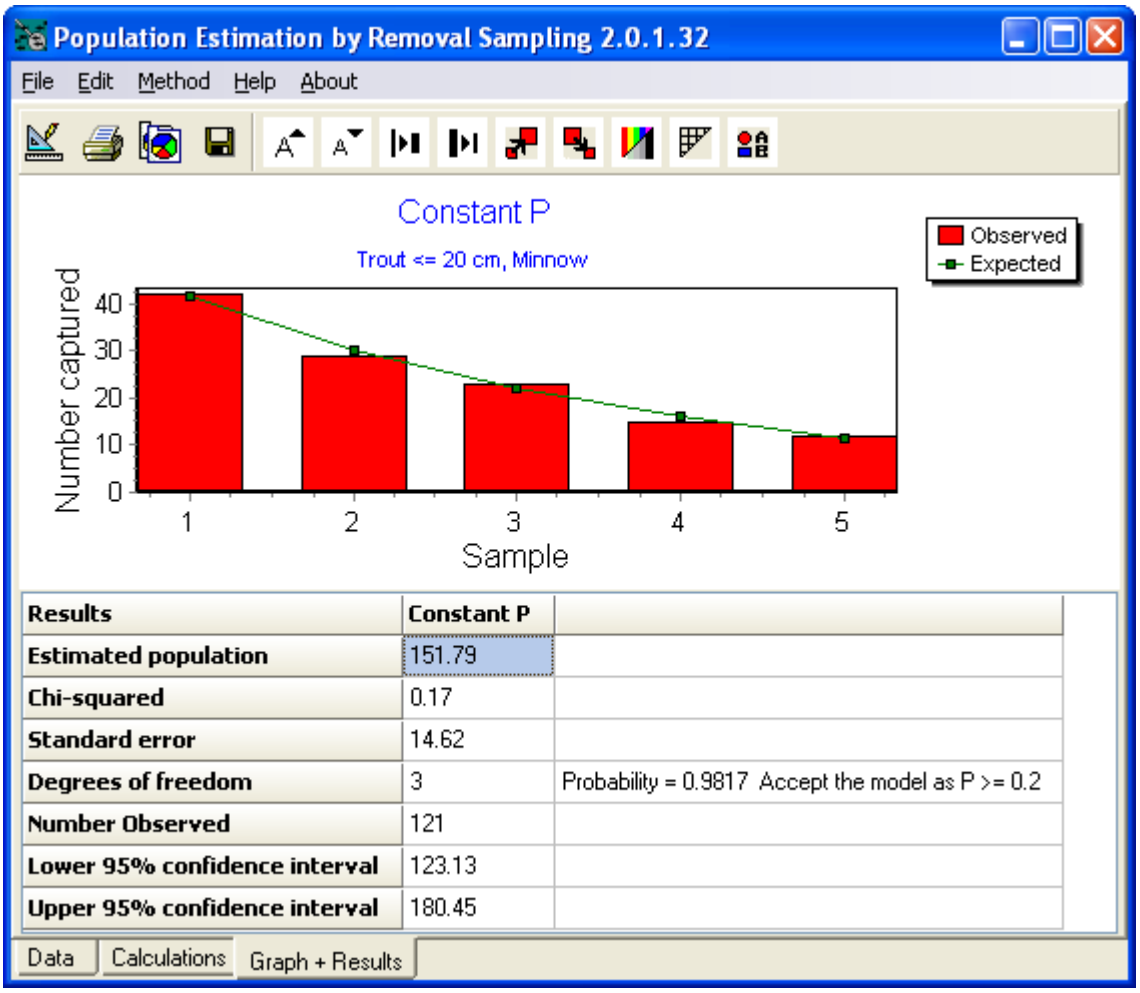
To print, export or copy the grid see Print Grid and Copy Grid

3.2.3 Graph + Results Tab

This tab at the bottom of the main window shows the plot for the selected model.



Click on this tab to see a plot of your data, plus the fitted model and a grid of the parameter estimates and statistical diagnostics.
The screen is arranged into a number of panels.



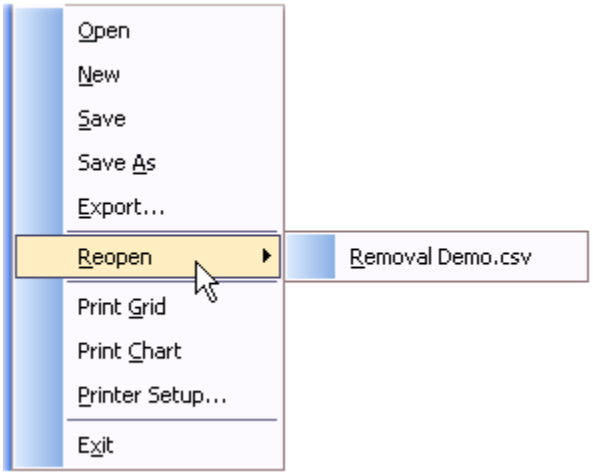
The graphical menu bar at the top of the chart can be used to change many features of the plot.
The chart is active, and features of the plot can be edited by moving the cursor over them and double-clicking.
The results are tabulated in the bottom grid. The data in this grid can be printed, copied and exported.

For a fuller exploration of using the graph, see Editing and changing graphs.

The grid below the chart gives the parameters and diagnostics for the selected model (shown in the title of the plot and at the top of the grid).

3.3 File

Use this drop-down menu to open and create data sets, save files and print results.



Options are as follows:
Open
New
Save: saves the data file as a csv file.
Save As: allows you to select a name for the saved file.
Export: exports the data in a variety of formats
Reopen: Lists the most recently-used data files
Print Chart
Print Grid
Printer Setup: allows you to select printer options
Exit

3.3.1 Saving a data set

To save the current data set, use Save or Save As from the **File** menu.

Save your data as either a .csv (Comma-separated values) file, or an .xls (Excel) file.

.csv files are more flexible as they can be opened and edited in many different programs.

3.3.2 Export data

The Export Active Grid function allows you to save the data grid on the active (i.e. visible) tab, in a variety of formats:

CSV - As a comma-separated value (.csv) text file, which can be opened in Excel, other spreadsheets, word processing software, or notepad.
ASCII - As a plain ASCII text file.
XLS - As a formatted Excel spreadsheet file.
HTML - As a formatted table for use in an HTML document such as a web page.

3.3.3 Closing the program

Choose Exit from the File menu, or the cross symbol at the top right corner of the program window to close *Removal Sampling 2*.

3.3.4 Open an existing data file

Use **File|Open** to select a data file for analysis. To choose the type of file to open, select the relevant extension from the *Files of type* drop-down menu on the Open File dialog. To reopen a recently opened dataset select one from the **Reopen:** list on the menu.

Removal Sampling 2 can open .csv (Comma-separated value) files and .xls (Excel) files. .csv files can be created in many programs including Excel, Lotus, Word, Notepad and Write.

3.4 Methods offered in Removal Sampling 2

Removal Sampling 2 offers four methods of estimation for the total population size.

Constant p
Variable p
Regression
Carle & Strub

Generally, you should use the Constant p (probability method). This is also known as Zippin's method.

3.4.1 Constant probability of capture

This is called the constant p method in the program (p for probability of capture). It is also known as Zippin's method, although this probably more correctly refers to a method of solution.

Maximum Likelihood (ML) estimates for estimating population size (N) for a constant probability of capture model were first published by Moran, 1951 and developed by Zippin, 1956. To apply the method the following conditions must be satisfied:

1. The catching or trapping procedure must not lower (or increase) the probability of an animal being caught. For example, the method will not be applicable if animals are being searched for and, as is likely, the most conspicuous ones are removed first.

2. The population must remain stable during the trapping or catching period; there must not be any significant natality, mortality (other than by the trapping) or migration. The experimental procedure must not disturb the animals so that they flee from the area.

3. The population must not be so large that the catching of one member interferes with the catching of another. This is seldom likely to be a problem with insects or fish where each sample can take many individuals, but may be significant in vertebrate populations where one trap can only hold one animal.

4. The chance of being caught must be equal for all animals. This is the most serious limitation in practice. Some individuals of a population, perhaps those of a certain age, may never visit traps and so will not be exposed to collection. In vertebrates, 'trap-shyness' may be exhibited by part of the population such as one sex. In electric fishing, where the method is used extensively, smaller individuals are more difficult to stun, and individuals occupying territories under banks or other obstructions may be particularly difficult to catch.

Zippin (1956 & 1958) has considered some of the specific effects of failures in the above assumptions. If the probability of capture falls off with time the population will be underestimated, but if the animals become progressively more susceptible to capture, the population will be overestimated. Changes in susceptibility to capture will arise not only from the effect of the experiment on the animal, but also from changes in behaviour associated with weather conditions or a diel periodicity cycle.

The expected number captured on each sampling occasion E(us) is

$$E(\ _s = u\ \ ()-\ \ )N^{s-1}$$

where p is the probability of capture on each sampling occasion.

Thus, for the first sampling occasion the expected number caught is Np and for the second N(1-p)p, and so on.

The ML estimates for N and p are given by solving numerically the equations:

$$\hat{N} = \frac{T}{(1-\hat{q}^s)}.$$

and

$$\frac{\hat{q}}{\hat{p}} - \frac{k\hat{q}^s}{(1-\hat{q}^s)} = \frac{\sum_{i=1}^{s}(i-1)u_i}{T} = R.$$

where T is the total number caught over all k samples and q = 1-p. First R is calculated and then Eq. 7.3 is solved numerically for q. This value is then used in Eq. 7.2 to estimate N.

The standard error of the estimate of N is given by:

$$SE(\hat{N}) = \sqrt{\frac{\hat{N}(\hat{N}-T)T}{T^2 - \hat{N}(\hat{N}-T)\left[(sp)^2 / (1-p)\right]}}$$

where the notation is as above

If the lower confidence interval is less than the total number of captures, T, then T should be taken as the lower confidence interval
It has been shown by Zippin (1956 & 1958) that a comparatively large proportion of the population must be caught to obtain reasonably precise estimates. His conclusions are presented in Table 1, from which it may be seen that, to obtain a coefficient of variation (C.V. = Estimate/Standard error x 100) of 30%, more than half the animals would have

to be removed from a population of less than 200.

Table 1: Proportion of total population required to be trapped for specified coefficient of variation of N (after Zippin 1956).

Coefficient of variation	**30%**	**20%**	**10%**	**5%**
200	.55	.60	.75	.90
300	.50	.60	.75	.85
500	.45	.55	.70	.80
1,000	.40	.45	.60	.75
10,000	.20	.25	.35	.50
100,00	.10	.15	.20	.30

3.4.2 Variable probabilities of capture

Removal Sampling 2 offers a model in which the probability of capture on the first sampling occasion is different from that on subsequent samples.

To use the variable p method, sampling must have been carried out on at least 4 occasions.

It will often be observed that the probability of capture changes during the course of a study. For example, larger fish are more easily caught when electric fishing. Thus the first sweep along a reach of a stream will tend to have a higher rate of capture. Generally the best way to deal with this problem is to divide the population into a number of groups, each of which can be independently estimated with a constant probability model. This is easily done using *Removal Sampling 2*, as each column can comprise a particular species or size class. An example of such a subdivision is shown in the demonstration data set **RemovalDemo.csv.**

In an electric fishing survey of a stream it might be appropriate to undertake independent analyses for eel, trout and minnow and to further subdivide the trout into size (age) classes. However, the ability to avoid capture even varies between individuals of a single age or size class, and if this effect is large the mean probability of capture will change in what the observer perceives as a homogeneous population. When a constant probability model has been rejected, and it is not possible to subdivide the population then the generalized removal method of Otis et al. 1978 can be used.

A removal experiment does not generate sufficient information to allow the calculation of a model in which the mean probability of capture on each sampling occasion is different. This is because there are too many parameters to estimate, given the number of observations. Otis et al. (1978) noted that as animals with a higher probability of capture tend to be caught first, the mean probability of capture on sampling occasion k, p_k tends

to decline with increasing k, so that after, say, m samples, p_k can be assumed constant. A family of models can therefore be constructed in which the first 1,2,3 .. k-2 samples are assumed to have different values for p and all later samples a constant p. In the ideal world the logical approach would be to work upwards from m = 1 and stop when a X^2 test shows that the model can no longer be rejected. In practice it is rarely worth using a model with k >1 because of the short data series typically collected in removal sampling experiments and the increased standard error of the population estimate as the number of estimated parameters increases. In *Removal Sampling 2* we therefore only include a model for the situation where capture probability on the first sampling occasion is different. To use the variable p method, sampling must have been carried out on at least 4 occasions.

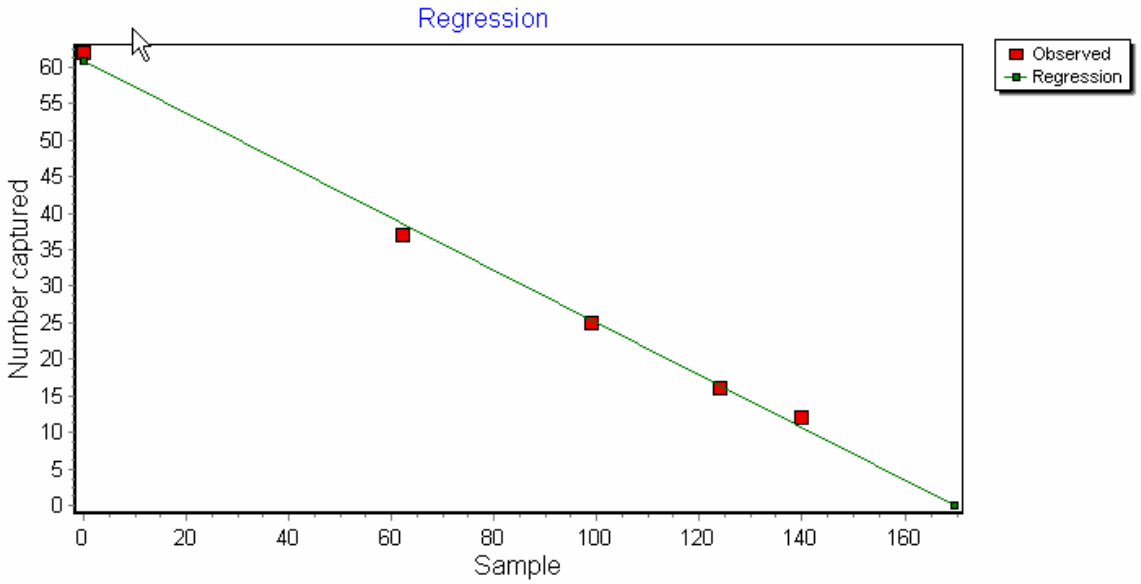
The probabilities of capture are calculated using ML methods similar to those used for the constant probability of capture model.

There is a third approach that can be taken if the probability of capture during the first few samples is lower than in later samples. This effect is observed when sampling fish such as lampreys which are buried in the substrate and tend to require a number of passes while electric fishing before they are drawn to the surface where they can be captured. Examine the graph of the pattern of capture, and remove from the analysis the initial samples when the probability of capture was low. Then calculate the population size using the remaining samples with a constant probability model. The total population is given by the number of captures in the not-used initial samples, plus the population estimate.

3.4.3 The regression method

This is an old method used before the ready availability of computers to solve the Maximum Likelihood equations. This method assumes a constant probability of capture. Because graphical and regression methods have been so widely used and are still frequently applied, we have included one in the program. It is inferior to the maximum likelihood approach, and does not give valid estimates of the standard error of the estimated population size.

If the number caught on the i^{th} occasion is plotted against the total catch up to occasion i-1, a straight line may be fitted by linear regression (Zippin 1956). The point where this line cuts the x-axis gives the estimated population size. In the example below, it is 169.66 or 170.



3.4.4 Carle & Strub

This method was developed by Carle & Strub (1978) and is also called the Maximum weighted likelihood method. It was developed for use with catch data that is poor and fails to provide valid estimates using the maximum likelihood method.

The parameter M is calculated using:

$$M = \sum_{i=1}^{k} (k-i)u_i$$

where k is the number of samples taken, and u_i the number of animals caught in the ith sample.
The population size, N is estimated as the smallest integer greater than the total catch, T, that satisfies the inequality

$$\left(\frac{N+1}{N-T+1}\right)\left(\frac{kN-M-T+0.5k}{kN-M+1+0.5k}\right)^{k} \leq 1.$$

The above inequality is an approximation of a summation, and can fail for samples when k=2. The standard error is calculated as described for the maximum likelihood (Zippin's) method.

You should only use this method when the Constant probability and variable probability models have failed to give sensible results. This will normally occur when your data do not show a steady decline in the numbers caught with the number of samples.

3.5 Editing and changing graphs

Almost all aspects of the charts in *Removal Sampling* can be edited.

Many useful changes can be quickly accomplished using the graphical menu bar buttons.

For instructions to zoom in and out of part of a graphing see enlarging part of a chart.

Many chart features can be edited directly from the chart by simply holding down the Shift key and clicking on the chart.

3.5.1 Graphical Menu Bar

The graphics bar situated above the charts in *Removal Sampling 2* allows you to quickly edit many features of your graphs.

The functions of the individual buttons are as follows.

Opens the main graphics dialog window which allows you to edit every feature of the chart.

Prints the chart see Print Chart for more details.

Copies the chart to the clipboard. See Copy/Export Chart for information on file formats.

Saves the chart to a file. See Copy/Export Chart for information on file formats.

Increases the size of the text on the chart.

Decreases the size of the text on the chart.

Increases the thickness of the curve predicted by the model.

Decreases the thickness of the curve predicted by the model.

Increases the size of the observed data points on the chart.

Decreases the size of the observed data points on the chart.

Switches between black and white and colour graphics.

Switches grid on and off on the graph.

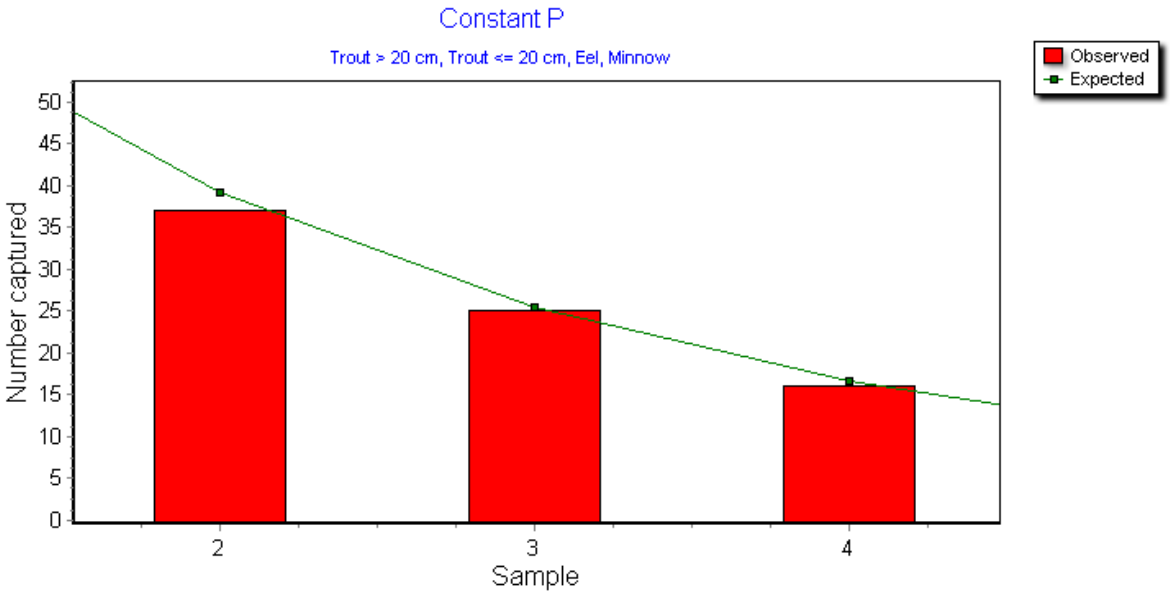
Switches the legend on and off.

Click to select a theme (a style) for your graph.

3.5.2 Enlarging (zooming) part of a chart

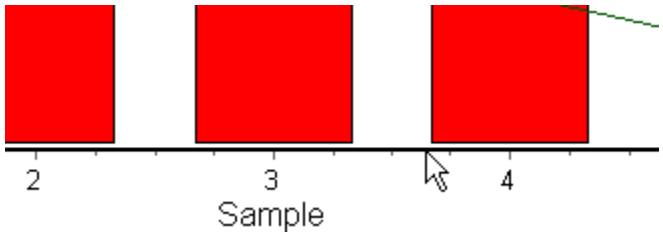
To zoom in on part of the chart, move the cursor to the upper right hand corner of the area you wish to magnify, and hold down the the left hand mouse button. Now without releasing the button, drag diagonally downwards and to the right. A yellow box will appear (see below) showing the area that will be enlarged. Release the button and the highlighted part of the plot will be enlarged. To return to the full plot simply reverse the process by left clicking and dragging the cursor up and to the left.

The enlarged area of the plot is shown below.

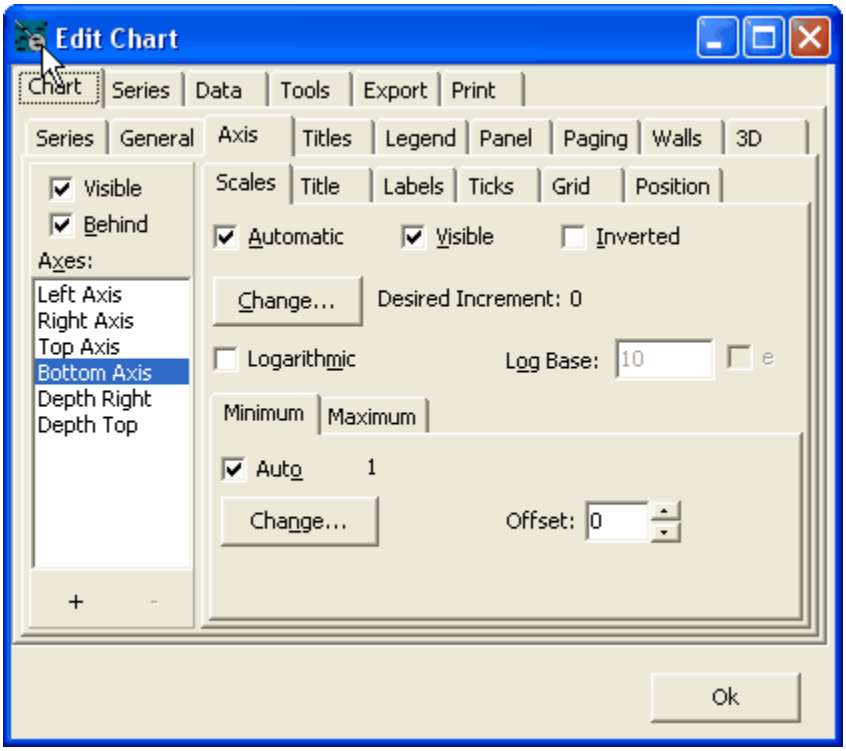


3.5.3 Editing directly from the chart

The chart is active, and features of the plot can be edited by moving the cursor over them and double-clicking on the feature of the plot you wish to alter. For example, to edit the x-axis, move the cursor over the axis like this:



and then double-click. The following dialog window will pop up allowing you to change the chart defaults.



3.6 Printing and exporting your results

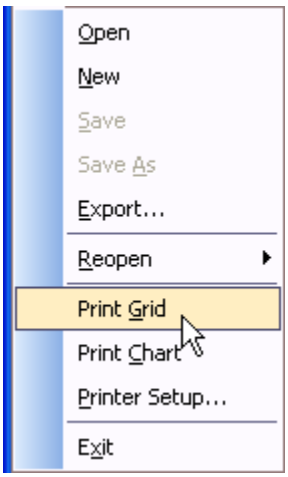
The data grids and graphs can be printed using the **Print** option from the **File** menu.

Different printing options are offered for graphs and grids.

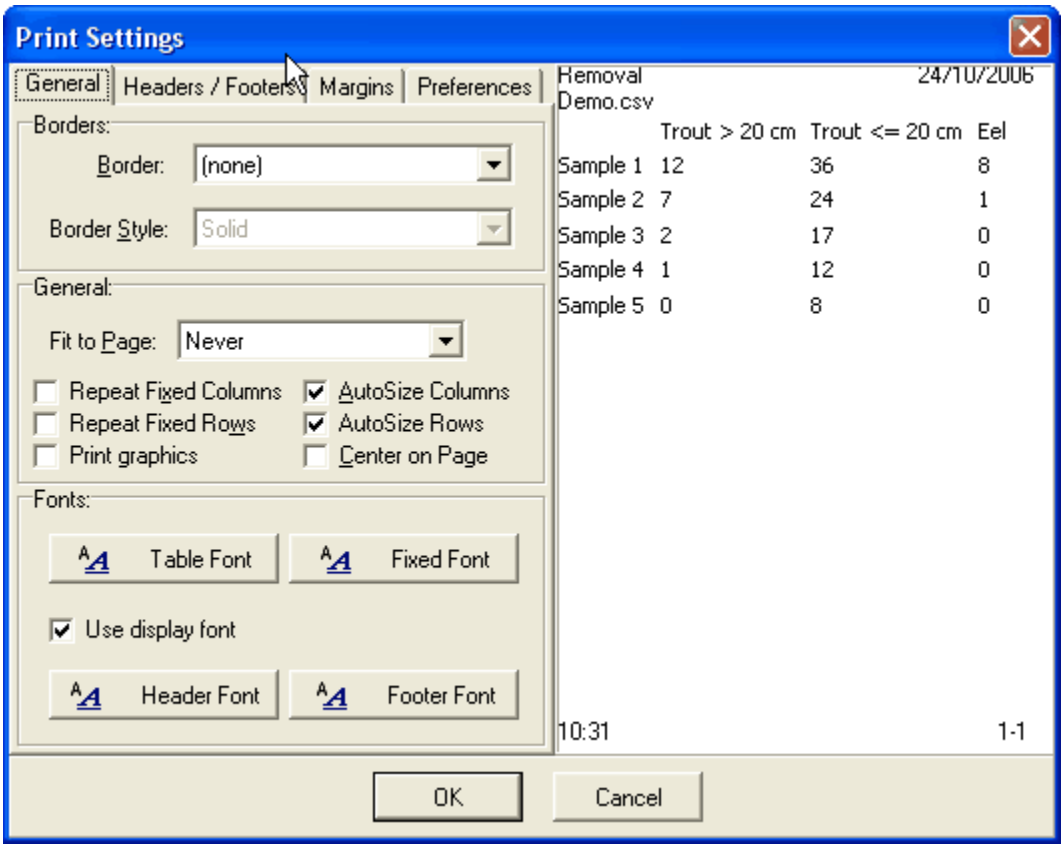
Print Grid
Print Chart

3.6.1 Print Grid

Selecting **File|Print Grid**

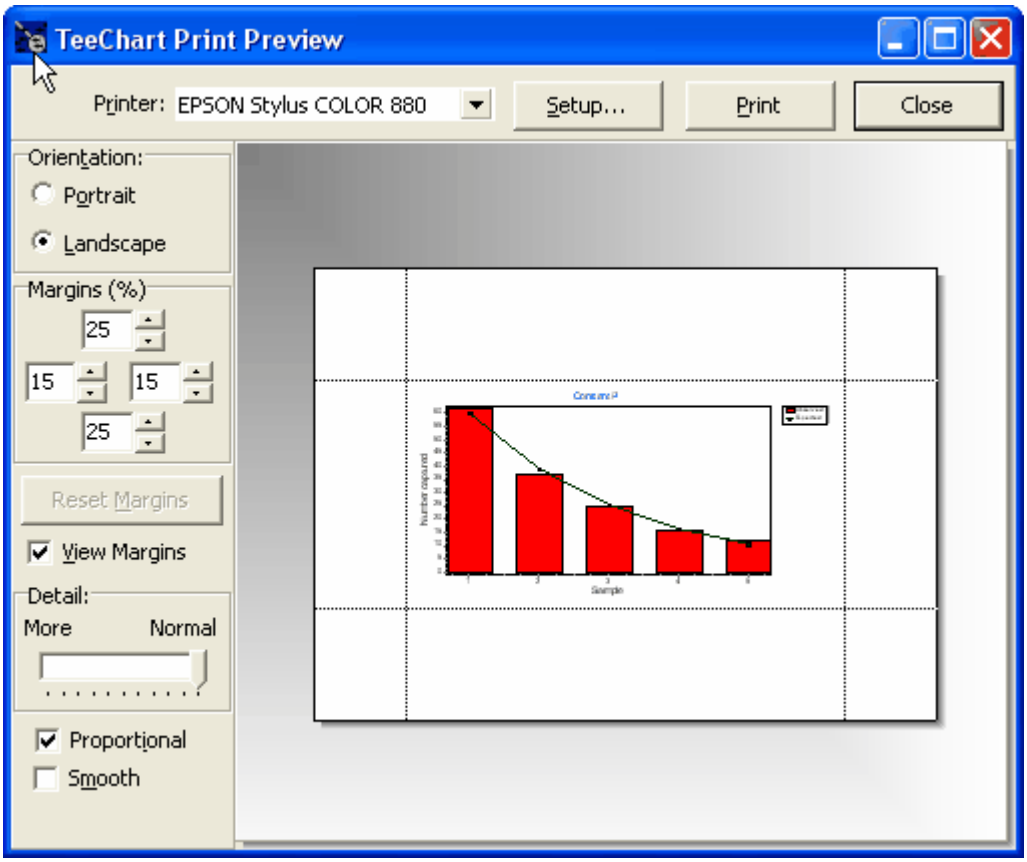


opens the grid printing dialog, which allows the font and page layout to be selected before printing.



3.6.2 Print Chart

Selecting **File|Print Chart** opens the grid printing dialog, which allows the chart and page layout to be selected before printing.



This window shows a representation of the graph on the paper. The print margins are displayed as dotted lines, and can be dragged by moving the cursor over the margin, holding down the left hand mouse button and dragging.

3.7 Copying

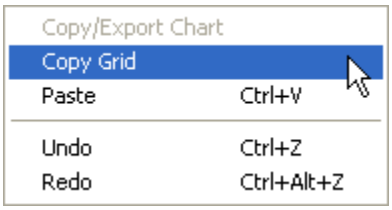
The data grids and graphs can be copied to the clipboard or exported in different formations, using the **Copy** drop-down menu.

Different options are offered for graphs and grids.

Copying tabulated data (grids)
Copying Charts

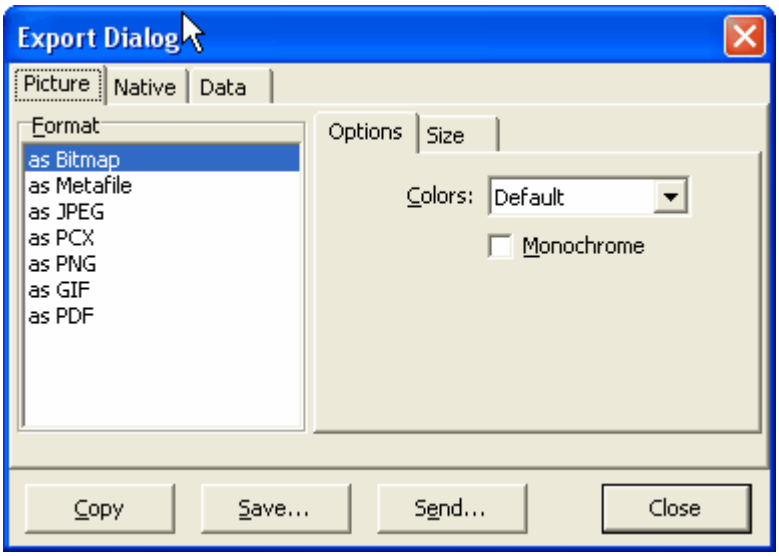
3.7.1 Copy Grid

Select this option to copy the data grid from the active (visible) tabbed page to the Windows clipboard. The data can then be pasted into some other program using **Paste** or **Ctrl+V**. Once the file is copied you will see a confirmation dialog.



3.7.2 Copy/Export Chart

Selecting **Copy|Copy/Export Chart** opens the Export dialog.



You can change the colour depth and size of the image if desired. The default file format for the file is a bitmap; select another file format by left clicking on the format of choice in the list.

You can also copy a chart using the Copy button on the graphical menu bar.

File formats
The chart can be saved in a number of different file formats: Bitmap (*.bmp), Metafile (*.emf), PDF (*.pdf), GIF (*.gif), PNG (*.png), PCX, (*.pcx) and JPEG (*.jpg). Each file format has advantages and disadvantages.

- Bitmaps are a lossless method of saving; the stored file will not lose any of the original's detail. Because of this, bitmaps tend to be much larger than compressed files such as Enhanced Metafiles, GIFs or JPEGs.
- The advantage of Enhanced Metafile is that, if pasted into, for instance, a Word document, it can be resized by dragging, without losing resolution.
- PDF is an Adobe Acrobat file, which is a useful format to send to other people or for inclusion in a pdf document.
- GIFs offer advantages for web use, as they compress the file.
- JPEGs are file formats which can be compressed to take up less space - useful if you wish to send one by email, put it on a website, or paste it in to a document. If they are compressed too heavily, they can lose resolution and detail, and spoil colours.

- PNG and PCX are graphics file formats in common use. PCX format is one of the most usable graphic formats. Originally it was designed by Zsoft for PC Paintbrush MS-DOS. PNG (Portable Network Graphics) is a bitmap image format that employs lossless data compression. PNG was created to both improve upon and replace the GIF format with an image file format that does not require a patent licence to use.

There are three buttons at the bottom of the screen. Select

Copy to copy to the clipboard
Save to open a save file dialog window and
Send to activate your email system and send the file

Part

4 Tutorials and demonstration data sets

Upon installation of *Removal Sampling 2* a demonstration data set called **RemovalDemo.csv** will also be placed on your hard disk. These data are saved by default in the folder **..\My Documents\Removal Sampling Data\Demo Data.** This data set is used in the help tutorial system.

A demonstration using electric fishing data.

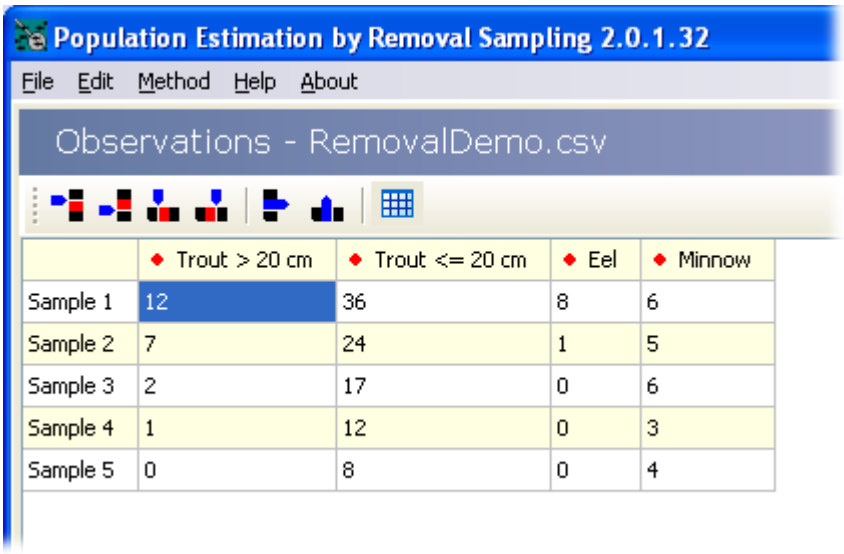
4.1 Electric fishing demo

For this tutorial we will use the demonstration data set **RemovalDemo.csv** supplied with *Removal Sampling 2*. This data set was collected during an electric fishing survey of a small English chalk stream called the Chitterne Brook. A summary of the method used is as follows:

Quantitative electric fishing was undertaken at three sites on the Chitterne Brook on the 19th June 2001. This date was chosen to be prior to the introduction of stream support pumping. At each site a 30 m reach was isolated by stop nets and electric fished in an upstream direction. All of the fish captured were identified to species and standard lengths were measured to the nearest millimetre. Systematic fishing of the sites was repeated until the number of fish captured for all abundant species had declined over 3 successive passes. This was to allow a removal trapping method to be used to estimate population density. All the captured fish were subsequently released alive. Populations were estimated using the commercial software package Removal Sampling (Pisces Conservation Ltd.) to calculate population size using Zippin's method. This method assumes a constant probability of capture.

To open the data set use **File|Open** and select **RemovalDemo.csv** - stored by default in **..\My Documents\Removal Sampling Data\Demo Data**

Removal Sampling 2 will open the data and display the data grid as shown below.

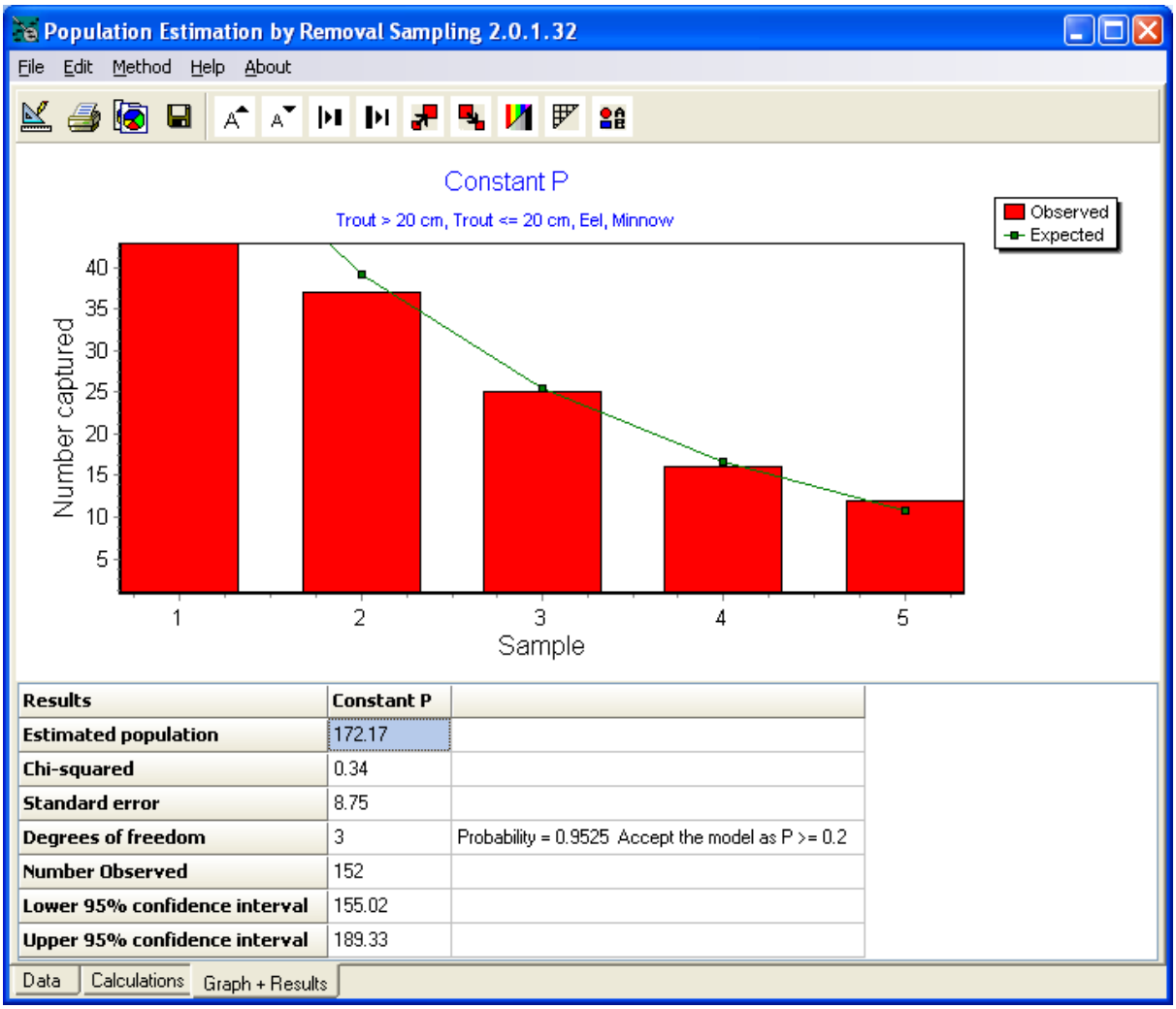


	Trout > 20 cm	Trout <= 20 cm	Eel	Minnow
Sample 1	12	36	8	6
Sample 2	7	24	1	5
Sample 3	2	17	0	6
Sample 4	1	12	0	3
Sample 5	0	8	0	4

In this case we undertook 5 electric fishing sweeps of the 30 m stretch of stream. Only three species were caught; trout, eel and minnow. Because large trout are very much easier to catch than small trout, the trout numbers have been divided into fish more than 20 cm in length and those less than or equal to 20 cm in length.

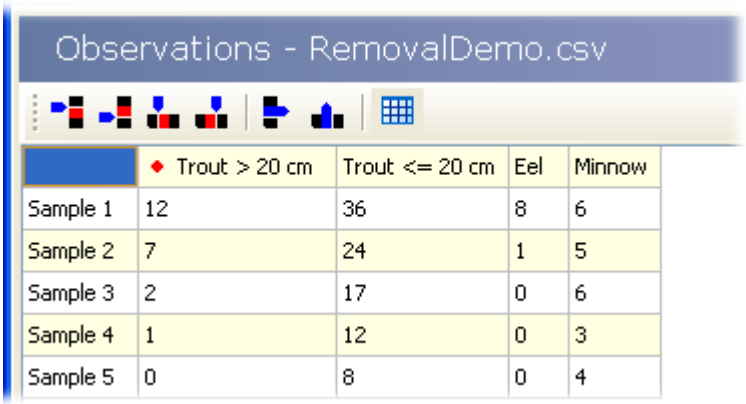
When the data set was loaded *Removal Sampling 2* immediately undertook a constant p method using the sum of all the fish.

Click on the Graph + Results tab and you will see at the bottom the estimate for the total number of fish in this 30 m reach of stream (the screen is shown below). The estimated population size is 172, with upper and lower 95% confidence intervals of 155 and 189. A glance at the graph indicates that the predicted number of captures is quite a good fit to the data, and the constant probability model was found to give a good fit (Chi-squared = 0.34, $p > 0.9525$)



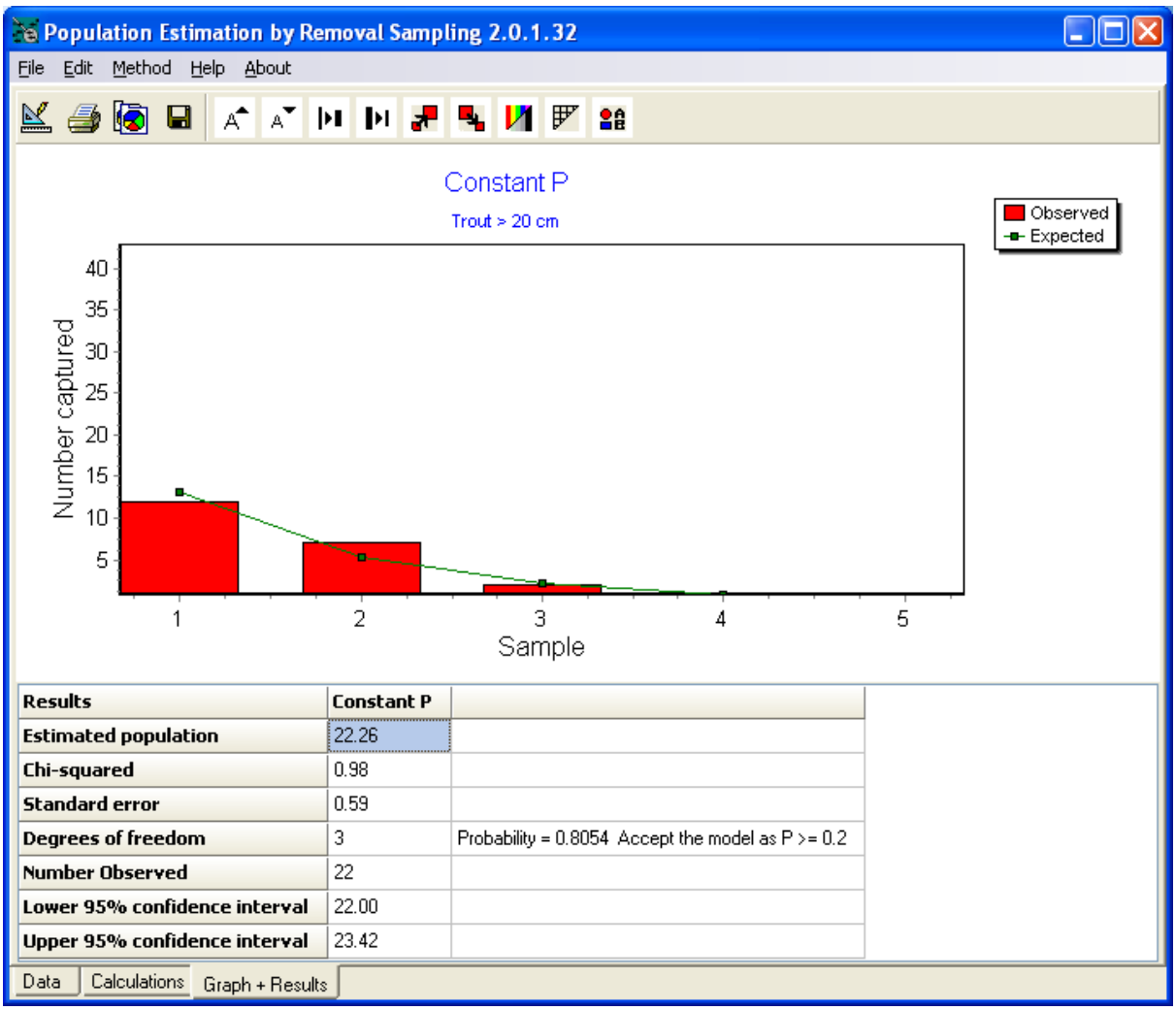
Now we will examine the estimate for large trout alone.

First click on the Data tab again, and click on the title columns until only the > 20 cm trout column has a red dot in. It will look like this:



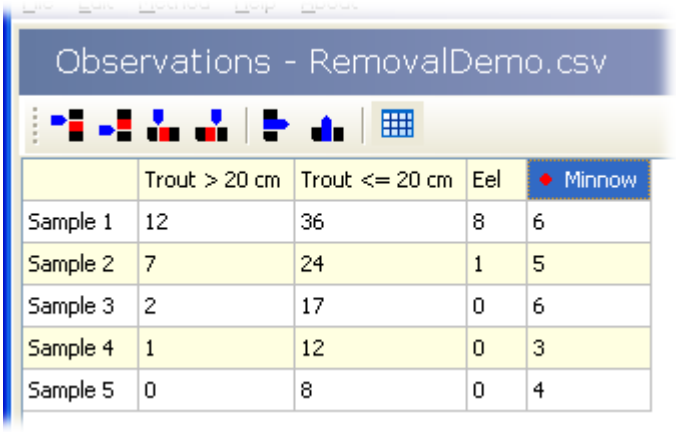
	Trout > 20 cm	Trout <= 20 cm	Eel	Minnow
Sample 1	12	36	8	6
Sample 2	7	24	1	5
Sample 3	2	17	0	6
Sample 4	1	12	0	3
Sample 5	0	8	0	4

Now select the Constant p method from the **Method** drop-down menu. To look at the result click on the Graph + Results tab, and you will see the graph shown below. This gives a population estimate for large trout of 22 with upper and lower 95% confidence intervals of 22 and 23.4. A glance at the graph indicates that the predicted number of captures is quite a good fit to the data and the constant probability model was found to give a good fit (Chi-squared = 0.98, p = 0.8054)



Trout clearly fit the constant p model rather well; now we will look at the minnow data. The minnow is a small fish and, due to its size, it is difficult to sample well with electric fishing equipment. So we expect a much lower probability of capture.

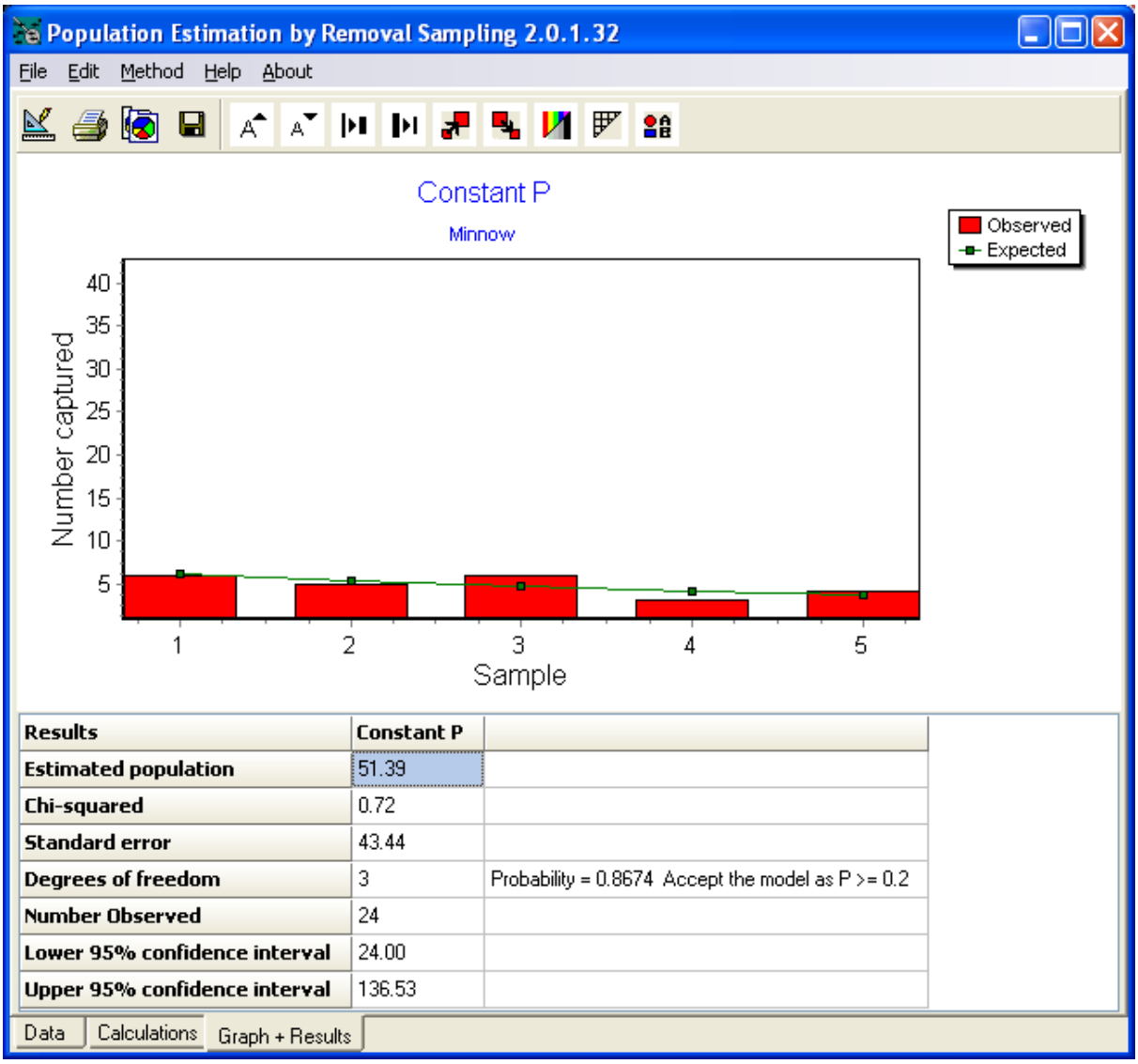
First open the Data tab again and click on the title columns until you see a red dot in the Minnow column:



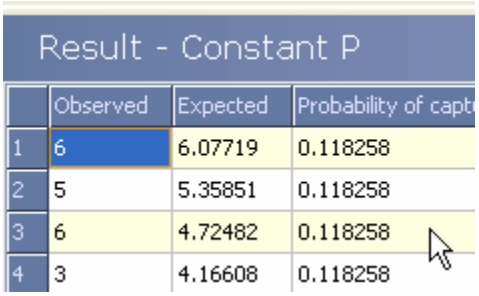
Observations - RemovalDemo.csv

	Trout > 20 cm	Trout <= 20 cm	Eel	Minnow
Sample 1	12	36	8	6
Sample 2	7	24	1	5
Sample 3	2	17	0	6
Sample 4	1	12	0	3
Sample 5	0	8	0	4

Now select the Constant p method from the **Method** drop-down menu. To look at the results, click on the Graph + Results tab and you will see the graph shown below.



This gives a population estimate for minnow of 51 with upper and lower 95% confidence intervals of 24 and 137. These confidence intervals are wide and reflect the fact that the graph shows that minnow numbers did not decline sharply with increased sampling. This is shown by looking at the Calculations tab which shows that the estimated probability of capture of a minnow on each sweep of the stream is only 0.118 or about 12%. In contrast the probability of capture of a large trout was about 59%.



	Observed	Expected	Probability of capt
1	6	6.07719	0.118258
2	5	5.35851	0.118258
3	6	4.72482	0.118258
4	3	4.16608	0.118258

Part V

5 Installation

- Place the *Removal Sampling 2* CD in the drive.
- The installation process should begin automatically; follow the on-screen instructions.
- If the CD does not auto-run, browse in Windows Explorer or My Computer, and double-click the file named **Setup.exe** in the root directory of the CD.

When installation is complete there will be a *Removal Sampling* entry on your Start menu and a folder (directory) called *C:\Program Files\Removal Sampling,* which holds the program and associated files. An uninstall program will also be created, accessible from the Start menu should you wish to remove the program. If you wish to make a shortcut to the program on your desktop, go to the *Removal Sampling 2* entry on the Start menu, right-click on it, and choose *Send To: Desktop (create shortcut)*.

Part VI

6 System requirements

- An IBM-compatible PC with CD-ROM drive.
- 10 MB of free hard disk space
- Windows XP or Vista operating system.

Although Removal Sampling is designed for Windows XP and Vista, it should function perfectly on older versions of Windows, from 98 onwards. However, we are not able to guarantee its performance with older operating systems. We do not produce any software designed to run under the Mac OS, however, our programs should run satisfactorily using Windows emulation software. Similarly, though we do not produce software to run under Linux, our programs should run under WINE. We recommend downloading one of our demo versions to test this.

Part VII

7 How to reference this program

This program should be referenced as:

Seaby, R. M. H. & Henderson, P. A. (2007) *Removal Sampling 2*. Pisces Conservation Ltd., Lymington, England.

Part VIII

8 References

Carle, F. L. & Strub, M. R. (1978) A new method for estimating population size from removal data. Biometrics, 34, 621-830.

Cowx, I. G. Review of methods for estimating fish population size from survey removal data. Fisheries Management 14, 67-82.

Moran, P. A. P. (1951). A mathematical theory of animal trapping. Biometrica, 38, 307-311.

Otis, D. L., Burnham, K. P., White, G. C., and Anderson, D. R. (1978). Statistical inference from capture data on closed animal populations. Wildlife monographs, 62, 1-135.

Zippin, C. (1956). An evaluation of the removal method of estimating animal populations. Biometrics, 12, 163-189.

Zippin, C. (1958). The removal method of population estimation. Journal of Wildlife Management, 22, 82-90.

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9 Contact Pisces

For most active windows, context sensitive help can be obtained by pressing F1, clicking on the Help button, selecting the Help drop down menu. or clicking on the right-hand mouse button and choosing Help from the pop-up menu.

If pressing F1, make sure that the window that you are seeking help for is the active one.

If you have problems using the program or entering data which you cannot solve, then contact Pisces Conservation Ltd by e-mailing pisces@pisces-conservation.com or by phone to UK (0)1590 674000 during office hours (09.00 to 17.00 GMT/BST).

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For more information, details of our other software, and answers to a range of technical queries, visit our web site at http://www.pisces-conservation.com

To buy software online, visit our shop at www.piscesconservation.com/shop

For details about our consultancy and research work, visit
http://www.irchouse.demon.co.uk

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