CloseTest

A program for testing capture-recapture data for closure

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Introduction to CloseTest

CloseTest is a Windows program for testing capture-recapture data for closure, where closure means no individuals were added to or lost from the population of interest over the sampling period. Two closure tests are computed by the program: 1) the Stanley and Burnham (1999, *Environmental and Ecological Statistics*, 6:197-209) test, which was developed under a null model allowing for time-specific variation in capture probabilities under closure, and 2) the Otis et al. (1978, *Wildlife Monographs, 62)* test, which was developed under a null model allowing for heterogeneity in capture probabilities under closure. *CloseTest* allows you to select capture history data files for analysis, edit those files, analyze the data (i.e., compute the closure test statistics), and view and save the results of the analysis. Some facility is provided for verifying correct data formats and printing-results.

CloseTest *Splash Screen*

CloseTest displays a splash screen the first time it is launched. The splash screen provides information about the *CloseTest* program superimposed on a figure. You have five options to choose from on this screen.

Do not show this screen again.

If you do not want to see the splash screen each time *CloseTest* is launched check this box.

Main Menu.

This is the most likely option to choose from the splash screen. Selecting **Main Menu** will direct you to the ***CloseTest* Main Menu** dialog, where you will be able to specify an input file for analysis and view closure test results. After you go to the **Main Menu**, you'll not return to the splash screen until the next time you launch the CloseTest program.

Help.

Select this option to initiate a *CloseTest* help session. This ***CloseTest* Splash Screen** topic is shown, however, you can use the Windows help features to navigate throughout the *CloseTest* help. When you choose to go to the ***CloseTest* Main Menu**, this help session is closed.

Exit.

Select this option to exit the *CloseTest* program.

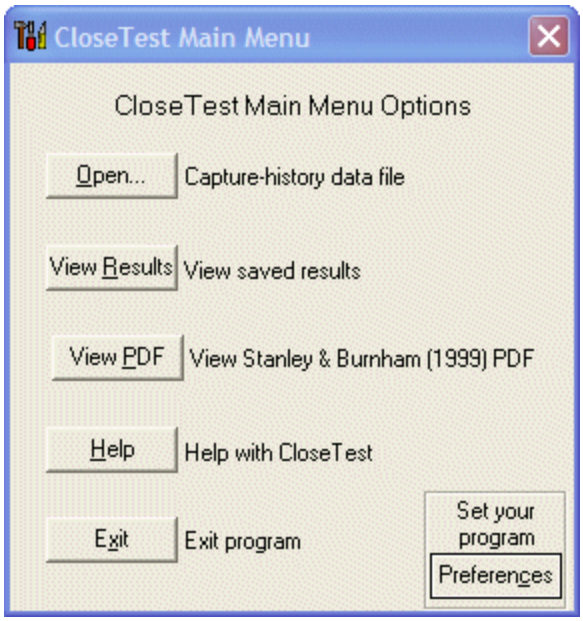
View PDF.

You can view a reprint of Stanley and Burnham (1999) by selecting this option. The reprint is provided in Adobe Portable Document Format (PDF) so your computer must have Adobe Acrobat Reader installed. We are grateful to Kluwer Academic Publishers for their permission to reproduce this reprint.

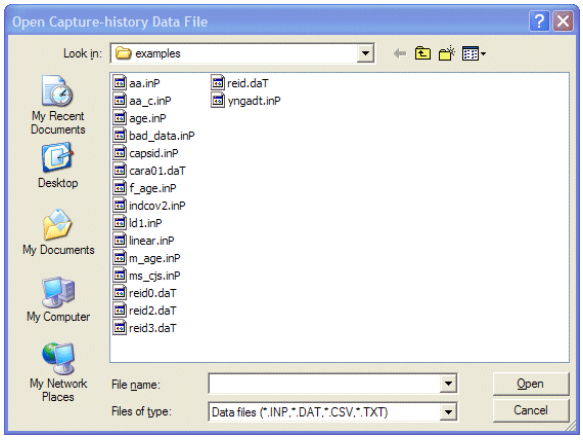
Stanley, T.R., and K.P. Burnham (1999). A closure test for time-specific capture-recapture data. *Environmental and Ecological Statistics* **6**, 197-209.

CloseTest *Main Menu*

The ***CloseTest*** **Main Menu** dialog is the heart of the *CloseTest* program. This is where you initiate most of the actions controlling the program. There are five control options on the **Main Menu** and an option to change your *CloseTest* program preferences.



Open ...



Select this option to open a capture-recapture data file to test for closure. Upon selecting this option, a common Windows "**Open Capture-history Data File**" dialog box appears. You can use this dialog box to navigate within the file system (folders) and select the data file. By default, these files are assumed to have the extensions ***INP***, ***DAT***, ***CSV***, or ***TXT***, and files with these extensions are listed automatically. You can use the drop down list box control to change the types of files listed to include all files ***All files (*.*)***. It is not necessary that the input file have a default extension. However, it is necessary that the input file be in an ASCII text format. The values may be separated by commas (***CSV*** or ***C***omma-***S***eparated ***V***alue format).

The **Capture-history Data File** dialog box comes up after you select the file containing the capture-history data you wish to analyze. From this dialog, you can view, edit, and analyze the capture history.

View Results.

Choose this option to view previously saved analytical results in the **View Results** window. A common Windows "**Open CloseTest Output File**" dialog box appears showing files with extensions ***OUT***, ***LST***, or ***TXT***. *CloseTest* creates an output file by concatenating the prefix of the input filename (*i.e.*, the file extension is stripped off) and the extension ***OUT*** (*i.e.*, the default output file extension of *CloseTest* is ***OUT***). Files with other extensions can be listed by setting the "*Files of type*" drop down list box to "***All files (*.*)***". The **View Results** window doesn't require a filename with the default extension.

View PDF.

You can view a reprint of Stanley and Burnham (1999) by selecting this option. The reprint is provided in Adobe Portable Document Format (PDF) so your computer must have Adobe Acrobat Reader installed.

> Stanley, T.R., and K.P. Burnham (1999). A closure test for time-specific capture-recapture data. *Environmental and Ecological Statistics* **6**, 197-209.

Help.

Select this option to initiate a *CloseTest* help session. This ***CloseTest*** **Main Menu** topic is shown. You can use the Windows help features to navigate throughout the *CloseTest* help.

Exit.

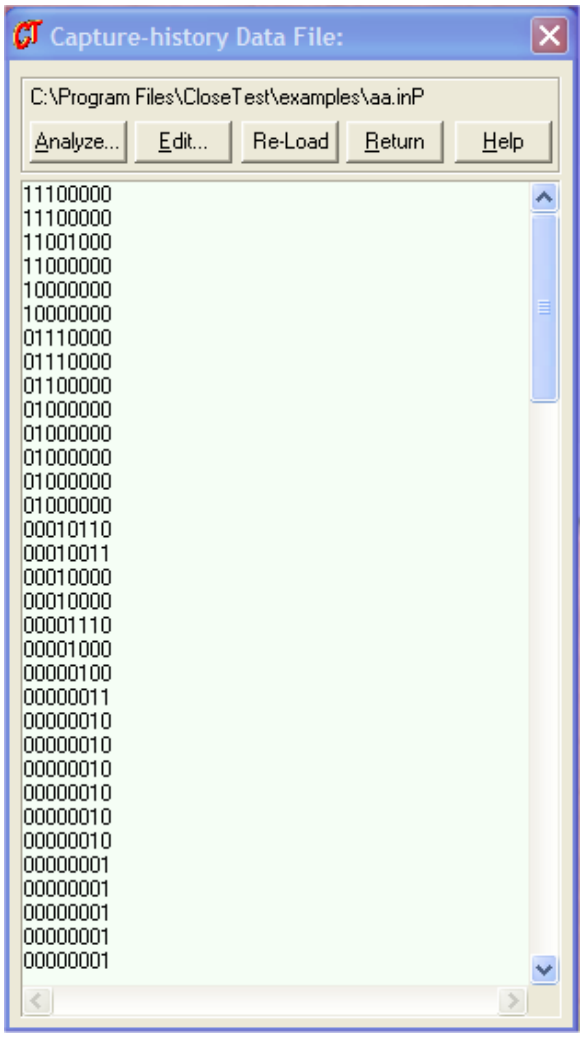
Select this option to exit the *CloseTest* program.

Preferences.

This option will allow you to set certain preferences in this program in the ***CloseTest*** **Preferences** dialog. In that dialog you can choose to have the splash screen suppressed, select an editor of your choice or use the *CloseTest* internal data editor, select font attributes for the output and internal editor, and to optionally show "line numbers" as comments in the input file when the file does not include "line numbers."

See **Creating *CloseTest* Data Files**.

Capture-history Data File



The **Capture-history Data File** dialog box displays a view of the capture-history data file you have opened for analysis.

The full path to the data file is displayed near the top of the dialog box. If the path and filename are long, the full path may not be visible here.

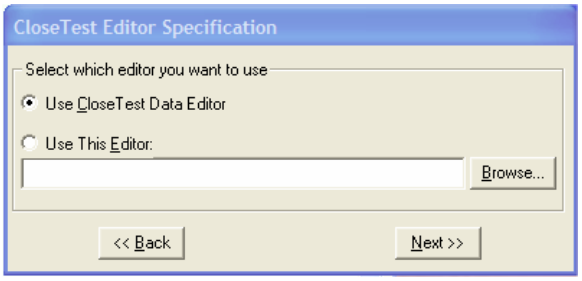
Five buttons represent five user options for user action.

Analyze.

Select this option to analyze the capture history data file for closure.

Edit.

Select this option to edit the capture history data file. The first time you invoke an edit session, *CloseTest* will prompt you to specify whether to use the *CloseTest* internal text editor or an external text editor program of your choice. You can re-specify your choice of text editor at any time from the **Preferences** selection on the ***CloseTest* Main Menu**. More help is available on the ***CloseTest* Data Editor**.



Re-Load.

Select this option to re-load the data file if, after opening it within *CloseTest*, you edited the file with an external editor (reloading is not necessary if you used the *CloseTest* default editor unless you saved the file with a new name) or the display panel is blank.

Return.

This option closes the **Capture-history Data File** dialog box and returns to the ***CloseTest*** **Main Menu**.

Help.

Select this option for help with the **Capture-history Data File** dialog.

Below the buttons is a display panel that shows the contents of the capture history data file. If the width or length of the file exceeds the panel size, use the horizontal and vertical scroll bars.

Note: If you have selected to "*Show line numbers as comments in capture history view*" as a **preference**, line numbers are appended to the view of each line by a semi-colon followed by the physical line number in the capture history data file. This can be useful if you suspect any problems in the data file and desire to have the line numbers displayed. Alternatively, you may have such comments already present in your data file.

See **Creating *CloseTest* Data Files**.

See **Setting *CloseTest* Preferences**.

Capture-history Analyze

When you press the **Analyze** button on the **Capture-history Data File** dialog, *CloseTest* reads the data file again, looking for possible problems with the data set.

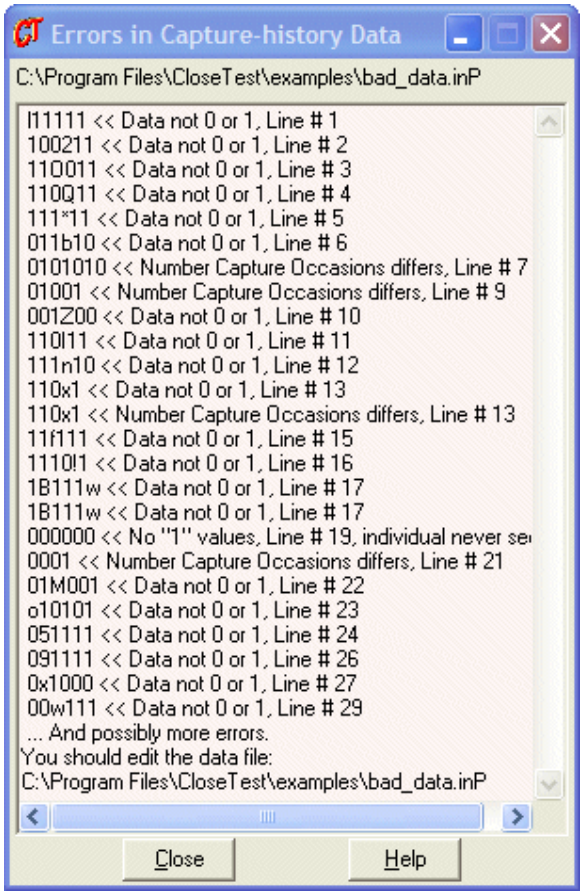
See **Creating CloseTest Data Files** for instructions on proper data set formats.

The **Errors in Capture-history Data** dialog box will appear if there are problems with the data file. It gives a summary of the first 25 (or fewer) errors encountered. You need to **edit** and correct any deficiencies in the data file before *CloseTest* can analyze the data.

If there are no problems with the data file, *CloseTest* computes the closure test statistics and *p*-values using the capture history data. It creates an output file using the capture history data filename with an ***OUT*** extension, and displays the results in the ***CloseTest*** **View Results** window. Results from subsequent analyses are appended to the first output of a session in the ***CloseTest*** **View Results** window; however separate output files are created for each analysis.

See **Interpreting *CloseTest* Results** for details on this output.

Errors in Capture-history Data



This dialog appears if there are any problems detected in the capture history data file. The dialog displays up to 25 errors. Each problem data line is displayed with a brief description of the problem.

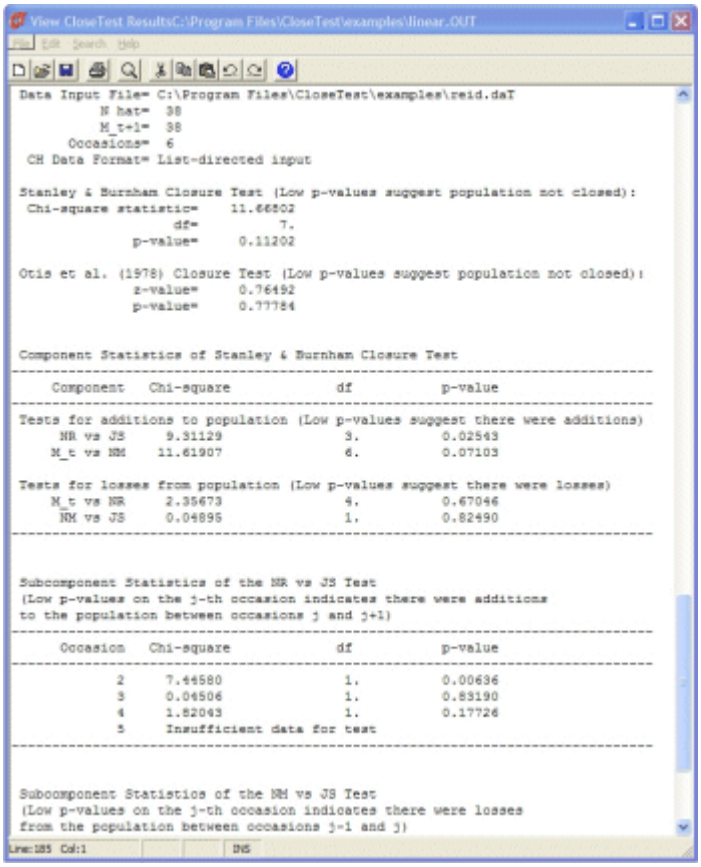
You can edit the data file with the **CloseTest Capture-history Data Editor**.

See **Creating CloseTest Data Files** for instructions on proper data file formats.

You can close this dialog box by pressing the **Close** button; however you may wish to keep this dialog open for reference while you edit your data.

Press the **Help** button to get help concerning the **Errors in Capture-history Data** dialog.

CloseTest *View Results*



When the *CloseTest* program analyzes the capture history data file, it creates an output file using the same prefix as that for the capture history data file and appends an ***OUT*** extension to the filename. For example, if the capture history data filename is *southmeadow.inp*, the results are in an output file named *southmeadow.OUT*.

When you analyze a capture history data set, *CloseTest* runs the analysis, creates the output file, and opens the ***CloseTest*** **View Results** window (if that window is not already open) showing the contents of the output file. If the ***CloseTest*** **View Results** window is already open, the result of any subsequent analysis is appended to the contents. For information on the contents of this window refer to the section on **Interpreting *CloseTest* Results**.

The ***CloseTest*** **View Results** is an edit window. This means that the output goes to an edit session of the output file. You can move the cursor around in the edit window, enter and delete text, copy all or parts of the contents, print all or a selection of the file, or perform any of the edit functions available in this window. This feature is for your benefit to annotate or reformat the results. There is a status bar at the bottom of the window indicating the line number and column number of the edit cursor and whether the editor is in the insert or overwrite mode.

Note that the name of the first output file of a session is used as the default for the filename in the ***CloseTest*** **View Results** edit window. If you want to annotate and save a unique output file, use the **Save As** feature of the **File** selection of the **edit window menu bar**.

Edit window menu bar

File

> **New** Ctrl-N: Create a new file for editing. This closes the currently opened window and opens a blank file for editing.

Open Ctrl-O: Open a file to view. This selection uses a common Windows open file dialog box to select and open a file to view. Default extensions are ***OUT***, ***LST***, ***CSV***, and ***TXT;*** however you can specify to see all files and open any file type you want. Since the usual output file for *CloseTest* is small, the amount of information displayed from a large file may be limited.

Save Ctrl-S: Save current file. Any changes you made to the current open file are saved as the current open filename.

Save As F12: Save contents of current edit window as a new filename you will specify. A common Windows save dialog box is used to specify the name and path of the file.

Print Ctrl-P: Print the contents of the edit window. This invokes the common Windows Page Setup dialog box, from which you may also specify the printer and its properties.

Print Selection: Prints a selected (highlighted) portion of the edit window contents.

Exit: Closes the ***CloseTest*** **View Results** window.

Edit

Undo Ctrl-Z: Undo any previous edit command.

Redo Ctrl-Y: Do any previous edit command again.

Cut Ctrl-X: Remove a selected portion of text from the edit window. Contents are placed in the Windows Clipboard buffer and can be pasted elsewhere in the window or another Windows edit session.

Copy Ctrl-C: Copy the selected portion of text to the Windows Clipboard buffer. Contents can be pasted elsewhere in the window or another Windows edit session.

Paste Ctrl-V: Paste the contents of the Windows Clipboard buffer to the position of the edit cursor. These contents may come from the current document or any Windows edit session.

Delete Del: Delete selected portion of text. If this is done in error, use the undo feature, above.

Select All Ctrl-A: Select (highlight) the entire contents of the edit window. To select only a portion of the window, highlight as usual using the mouse.

Search

Find Ctrl-F: Search the contents of the edit window with a common Windows Find dialog.

Find Next F3: Repeat a previous Find command.

Replace Ctrl-H: Does a Search and Replace of text within the edit window using a common Windows replace dialog.

Help

CloseTest Help F1: Get help information on *CloseTest*.

Stanley & Burnham, 1999 (PDF file): Invoke Adobe Acrobat PDF viewer to see a reprint of Stanley, T.R., and K.P. Burnham (1999). A closure test for time-specific capture-recapture data. *Environmental and Ecological Statistics* **6**, 197-209.

About CloseTest: Show dialog with brief information about *CloseTest* program.

Edit Capture-history Data

The capture history data file can be edited either with the internal ***CloseTest* Data Editor,** or the user may specify an external text editor (e.g., Notepad.exe).

Using an External, User-specified Editor

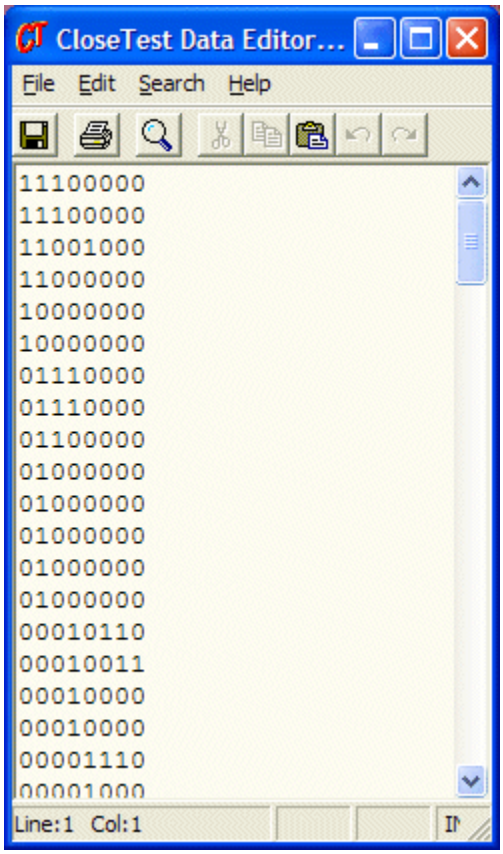
If you have a favorite text editor, especially one with column editing capabilities, that editor may be selected as the editor of choice. The first time an edit session is invoked, you can specify this editor. You need to enter the fully qualified path to the editor on your system. You may use the **Browse** button to invoke a common Windows select file dialog box to specify the path and filename explicitly.

You can change editor preference at any time from the **Preferences** button on the ***CloseTest* Main Menu**.

When you invoke an editor, the **Capture-history Data File** display panel displays a message that you should press the **Re-Load** button when you are finished editing. This will ensure the latest edited version of your data file is loaded. Also there is a warning that if you save your file with a new filename, you should use the **Open** button from the ***CloseTest* Main Menu** to open the new file.

Using the *CloseTest* Data Editor

The ***CloseTest* Data Editor** is provided for users who don't have a good external data editor. It is a minimal data editor with limited functions. The editor has a menu bar and an icon bar at the top of the window. There is a status bar at the bottom of the window indicating the line number and column number of the edit cursor and whether the editor is in the insert or overwrite mode.



Edit window menu bar

File

New Ctrl-N: Create a new file for editing. This closes the currently opened window and opens a blank file for editing.

Open Ctrl-O: Open a file to view. This selection uses a common windows open

file dialog box to select and open a file to view. Default extensions are ***OUT***, ***LST***, ***CSV***, and ***TXT***; however you can specify to see all files and open any file type you want. Since the usual output file for *CloseTest* is small, the amount of information displayed from a large file may be limited.

Save Ctrl-S: Save current file. Any changes you made to the current open file are saved as the current open filename.

Save As F12: Save contents of current edit window as a new filename you will specify. A common Windows save dialog box is used to specify the name and placement of the file. Note: If you save as a new filename, you must **Open** the new file from the ***CloseTest*** **Main Menu**.

Print Ctrl-P: Print the contents of the edit window. This invokes the common Windows Page Setup dialog box, from which you may also specify the printer and its properties.

Print Selection: Prints a selected (highlighted) portion of the edit window contents.

Exit: Closes the **Edit Capture History Data** window.

Edit

Undo Ctrl-Z: Undo any previous edit command.

Redo Ctrl-Y: Do any previous edit command again.

Cut Ctrl-X: Remove a selected portion of text from the edit window. Contents are placed in the Windows Clipboard buffer and can be pasted elsewhere in the window or another Windows edit session.

Copy Ctrl-C: Copy the selected portion of text to the Windows Clipboard buffer. Contents can be pasted elsewhere in the window or another Windows edit session.

Paste Ctrl-V: Paste the contents of the Windows Clipboard buffer to the position of the edit cursor. These contents may come from the current document or any Windows edit session.

Delete Del: Delete selected portion of text. If this is done in error, use the undo feature, above.

Select All Ctrl-A: Select (highlight) the entire contents of the edit window. To select only a portion of the window, highlight as usual using the mouse.

Search

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Find Next F3: Repeat a previous Find command.

Replace Ctrl-H: Does a Search and Replace of text within the edit window using a common Windows replace dialog.

Help

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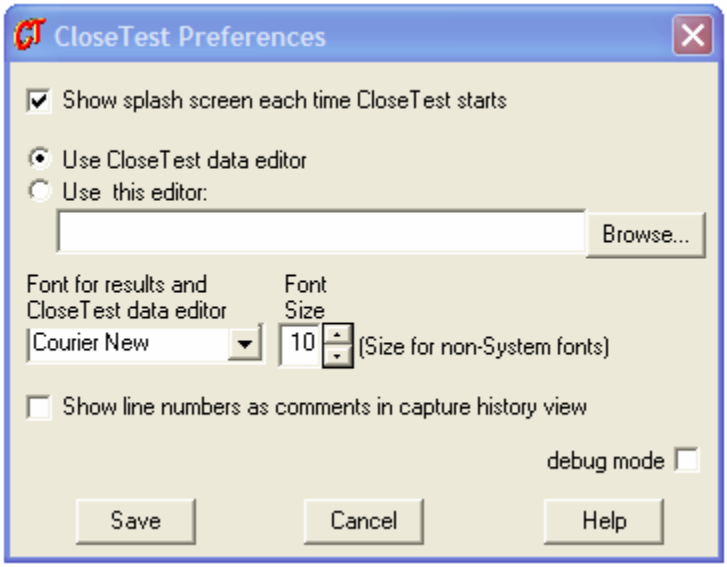
About CloseTest: Show dialog with brief information about *CloseTest* program.

Edit window tool bar

The edit window tool bar has icons for a few of the edit functions discussed above: **Save**, **Print**, **Find**, **Cut**, **Copy**, **Paste**, **Undo**, and **Redo**.

CloseTest *Preferences*



Select **Preferences** from the ***CloseTest*** **Main Menu** to change your program preferences.

Splash Screen

By default, *CloseTest* shows a splash screen when it is launched. You can uncheck the line "*Show splash screen each time CloseTest starts*" to keep this screen from appearing. Then when *CloseTest* starts, the program goes directly to the ***CloseTest*** **Main Menu**.

Editor Preference

You can use the ***CloseTest*** **Data Editor** or select a text editor of your choice to edit the capture history data files. The internal ***CloseTest*** **Data Editor** provides minimal edit function to users without an external text editor. You may select an external text editor by entering the fully qualified path and filename to the editor. Click the **Browse** button to open a common Windows select file dialog to specify the path and filename easily.

Font Preferences

CloseTest can use five different fonts in the ***CloseTest*** **View Results** and ***CloseTest*** **Data Editor** windows. In reality, there is no font information saved in either the capture history data file or the output file. The fonts are only activated for display and printing purposes.

Font Faces:

- *Courier New* - fixed serif font - this is the *CloseTest* default font.
- *System Proportional* - proportional font
- *System Fixed* - fixed font - the size of this font is always *10* point.
- *Times New Roman* - proportional serif font
- *Arial* - proportional, sans serif font

Font sizes may be specified from *8* to *14* points. The *System Fixed* font is always *10* point. *CloseTest* uses the default size of *10* point. These sizes are for display and print purposes only, there is no font specification saved with any file.

Line Numbers

CloseTest capture history data must consist of *1* and *0* only. However comments can be inserted into the data file: any characters after a semicolon (including the semicolon) are considered to be a comment. One handy way to keep a data set neatly described is to have line numbers following the data in each line. (A line of data represents the capture history of one individual). Alternatively, any designation you desire may be entered as a comment.

Example:

```
; This is my South Meadow data
; for the summer of 2003.
110111 ; 1 - "Old Gimpy"
100100 ; 2
100110 ; 3
   ...
000011 ; 23
000001 ; 24
; end of data
```

You may have no line numbers in your data, but may wish *CloseTest* to show your data as if you had line numbers. If you check "Show line numbers as comments in capture history view", a semi-colon and sequential line number shows up in the **Capture-history Data File** display area.

See **Creating CloseTest Data Files** for instructions on proper data file formats.

Debug Log

If *CloseTest* is not working properly check the "*debug mode*" box. When *CloseTest* runs with the debug mode turned on, an extensive debug log file is kept (called *debug* while the program is running). When *CloseTest* stops, the file is copied to a file with the date and time as the filename with a ***DBG*** extension. E-mail this file, your data file, and any pertinent information to

jon_richards@usgs.gov

or

tom_stanley@usgs.gov

or send them to:

Jon D. Richards
Fort Collins Science Center
USGS
2150 Centre Ave. Bldg C
Fort Collins CO 80526-8118

Buttons

There are three buttons on the ***CloseTest*** **Preferences** dialog box.

Save

Save the preferences you chose. You must click this button to save any preferences you changed.

Cancel

Quit the ***CloseTest*** **Preferences** dialog without saving anything. No changes are made to your preferences.

Help

Invokes *CloseTest* help concerning the ***CloseTest*** **Preferences** dialog.

Creating CloseTest *Data Files*

Data of *1* and *0* only

For analysis of capture-recapture data by the *CloseTest* program, data must be entered into input files in the form of a capture-history matrix, where each row (i.e., line of the file) represents the capture history for a distinct individual and each column represents a distinct capture occasion. Data can consist of *1*'s and *0*'s only, where *1* indicates an individual was captured on a particular occasion and *0* indicates it was not captured. The number of *1*'s and *0*'s (i.e., capture occasions) in each row of the capture-history matrix must be the same for all individuals. Note that whereas the test described in Stanley and Burnham (1999) allows for losses on capture, the *CloseTest* software is not set up to handle losses on capture (typically coded as *-1*) and such cases must be removed from the capture-history matrix prior to analysis.

If you have data in "Frequency Format" (described below), the *1* and *0* data are followed by the frequency of the capture history described by the *1*'s and *0*'s. The frequency count number should be an integer and it is, of course, not limited to *1*'s or *0*'s. There should be a space between the observation data and the frequency count.

Formats allowed

CloseTest data files must be in an ASCII text format (e.g., if the capture-history matrix is created in a spreadsheet such as Excel, it must be saved as a text file) and the line format may be delimited or compressed.

Delimited format. The delimited format allows blanks, tabs, and commas between the *1* and *0* data. Any combination of these delimiters can be used in a data file, so long as there are the same number of capture occasions recorded for each individual.

Example:

```
1, 1, 1, 0
1, 1, 0, 0
0, 1, 1, 0
0, 1, 0, 0
... and so on ...
```

Compressed format. The compressed format consists of *1* and *0* data with no intervening delimiters.

Example:

```
1110
1100
0110
0100
```

```
... and so on ...
```

Mixed format. The above delimited and compressed formats can be combined in a data file. It is not necessary to be consistent between occasions or individuals with delimiters. Essentially, the *CloseTest* data parser removes all blanks, tabs, and commas and creates a compressed format of each capture occasion. So long as the data consist of only *1* and *0* and there are the same number of capture occasions for each individual, the file should be acceptable.

Frequency format. The data may be in Frequency Format, which consists of *1* and *0* observation data similar to the compressed format described above. The observations are a contiguous set of *1*'s and *0*'s. This is followed by a space (blank) followed by the frequency count of the number of individuals having the described capture history. This format commonly has a semicolon ending each line. *CloseTest* doesn't require but accepts the semicolon.

Example:

```
1110 2;
1100 3;
0110 1;
0100 2;

The frequency format above is the same as the compressed
format:

1110
1110
1100
1100
1100
0110
0100
0100
```

No all *0* rows allowed

An individual should not be recorded that was never captured: each individual must have been captured at least once to be included in the data file. In other words, the data file should have no rows that consist only of *0* values.

All *0* columns are dropped

A capture occasion where no captures of any individual occurred has no meaning in *CloseTest*. If the data file has columns that consist only of *0* values, that column will be dropped from analysis and the results will be based on the data with those columns dropped.

Comments in the capture history data file

CloseTest allows you to include comments in your capture history data file. There are two forms of comments in *CloseTest*.

Unbounded Comments. Unbounded comments begin with a semi-colon and continue to the end of the line. If a semi-colon occurs as the first character of a line (or if the line is blank) the entire line is considered a comment and is ignored (it is not counted as an individual). Anything after a semicolon is considered a comment and is ignored by *CloseTest* during analysis.

Bounded Comments. Bounded comments begin with /* and end with */ and these are called the beginning-of-comment marker and end-of-comment marker, respectively. You can place a bounded comment on a line before the data, after the data, or between the contiguous *1*/*0* data and the frequency count for frequency format data sets. Anything outside a bounded comment is considered data (up to any semicolons, of course). In CloseTest, the end-of-comment marker should be on the same line as the beginning-of-comment marker. However, if there is no end-of-comment marker, the end of the physical line is the end of the comment.

Comments are especially useful if you want to include individual identifiers.

Example:

```
1110 ; 1
1100 ; 2
0110 ; 3
0100 ; 4
... and so on ...
```

Comments can be useful to insert internal documentation into the data file.

Example:

```
; Data for South Meadow,
; field season, 2001
; Capture occasions: 5/15-17-18-19
; giraffe data
1110 ; 1 - Jimmy
1100 ; 2 - Ben
0110 ; 3 - Spot
0100 ; 4 - Shorty
... and so on ...
```

Example:

```
/* Data for South Meadow, */
/* field season, 2001 */
/* Capture occasions: 5/15-17-18-19 */
; giraffe data
/* 1 */ 1110 ; Jimmy
/* 2 */ 1100 ; Ben
```

```
/* 3 */ 0110 ; Spot
/* 4 */ 0100 /* Shorty */
... and so on ...
```

Example:

```
; Data in Frequency Format
/*  1 */ 1000 1;
/*  2 */ 1000 1;
/*  3 */ 1000 1;
/*  4 */ 1100 2;
/*  5 */ 1010 2;
/*  6 */ 1011 3;
/*  7 */ 1111 4;
/*  8 */ 0100 1;
/*  9 */ 0100 1;
/* 10 */ 0100 1;
/* 11 */ 0110 2;
/* 12 */ 0101 2;
/* 13 */ 0010 1;
/* 14 */ 0010 1;
/* 15 */ 0010 1;
/* 16 */ 0011 2;
/* 17 */ 0001 1;
/* 18 */ 0001 1;
/* 19 */ 0001 1;
```

Filenames and extensions

You can use any legal Windows file names and extensions (or you may omit an extension). By default *CloseTest* displays files with ***INP***, ***DAT***, ***CSV***, or ***TXT*** extensions when you attempt to open a data file, although you can also see all file types with the dialog boxes of *CloseTest*.

When problems occur

If there are any problems with the data file, when you attempt to analyze the file *CloseTest* will open an **Errors in Capture-history Data** dialog that will summarize the first 25 (or fewer) problems seen in the data. When this occurs, you should edit the data file and make any corrections necessary. After editing, you can attempt to analyze the data again.

Interpreting CloseTest *Results*

An example of the output produced by *CloseTest* is provided below. Click on the blue highlighted text for a brief description of the item, and its equivalent representation in Stanley and Burnham (1999) or Otis et al. (1978). For a description of how individual statistics or their subcomponent statistics should be interpreted, see Stanley, T.R., and K.P. Burnham (1999). A closure test for time-specific capture-recapture data. *Environmental and Ecological Statistics* **6**, 197-209. An Adobe Portable Document Format (*PDF*) reprint of this paper is included with the *CloseTest* distribution.

Typical Results:

```
Data Input File= C:\Projects MESC\TomStanley\nex3\mydata\reid2.dat
          N hat= 38
          M_t+1=  38
      Occasions=  6
 CH Data Format= List-directed input

 Stanley & Burnham Closure Test (Low p-values suggest population not closed):
  Chi-square statistic=    11.66802
                   df=          7.
              p-value=     0.11202

 Otis et al. (1978) Closure Test (Low p-values suggest population not closed):
               z-value=     0.76492
               p-value=     0.77784


Component Statistics of Stanley & Burnham Closure Test
-------------------------------------------------------------------------------
     Component   Chi-square             df           p-value
-------------------------------------------------------------------------------
 Tests for additions to population (Low p-values suggest there were additions)
      NR vs JS     9.31129              3.           0.02543
     M_t vs NM    11.61907              6.           0.07103

Tests for losses from population (Low p-values suggest there were losses)
     M_t vs NR     2.35673              4.           0.67046
      NM vs JS     0.04895              1.           0.82490
-------------------------------------------------------------------------------

 Subcomponent Statistics of the NR vs JS Test
(Low p-values on the j-th occasion indicates there were additions
 to the population between occasions j and j+1)
-------------------------------------------------------------------------------
      Occasion   Chi-square             df           p-value
-------------------------------------------------------------------------------
             2     7.44580              1.           0.00636
             3     0.04506              1.           0.83190
             4     1.82043              1.           0.17726
             5     Insufficient data for test
-------------------------------------------------------------------------------


Subcomponent Statistics of the NM vs JS Test
(Low p-values on the j-th occasion indicates there were losses
 from the population between occasions j-1 and j)
-------------------------------------------------------------------------------
      Occasion   Chi-square             df           p-value
-------------------------------------------------------------------------------
             2     Insufficient data for test
             3     Insufficient data for test
             4     Insufficient data for test
             5     0.04895              1.           0.82490
-------------------------------------------------------------------------------
```

Glossary

Chi-square statistic - This is equivalent to χ^2_c in Stanley and Burnham (1999), and is the test statistic for the overall closure test presented in that paper. Extreme values of this statistic result in low *p*-values, and suggests the population is not closed.

Component Statistics - The overall test for closure in Stanley and Burnham (1999), χ^2_c, is a composite statistic such that $\chi^2_c = \chi^2_{NM} + \chi^2_{tNM} = \chi^2_{NR} + \chi^2_{tNR}$. In this section, the test statistic, degrees of freedom, and *p*-value for each component statistic of χ^2_c is reported.

df - This is equivalent to df_c in Stanley and Burnham (1999), and is the degrees of freedom for the overall closure test presented in that paper.

M_h - This is equivalent to M_h in Otis et al. (1978), and represents the closed- population capture-recapture model allowing for individual heterogeneity in capture probabilities.

M_t - This is equivalent to M_t in Otis et al. (1978), and represents the closed- population capture-recapture model allowing for time variation in capture probabilities.

M_t+1 - This is equivalent to M_{t+1} in Otis et al. (1978), and is the number of distinct individuals captured over the entire period of sampling. This value is determined by counting the number of rows in the capture-history matrix used as input to *CloseTest*.

M_t vs *NM* – This component test evaluates whether there is evidence of additions to the population. It tests the fit of the closed-population model M_t (H_0: M_t) against the No-mortality model (H_a: *NM*) as a specific alternative. The numbers reported in the "Chi-square" and "df" columns represent the values for χ^2_{tNM} and df_{tNM}, respectively.

M_t vs *NR* – This component test evaluates whether there is evidence of losses from the population. It tests the fit of the closed-population model M_t (H_0: M_t) against the No-recruitment model (H_a: *NR*) as a specific alternative. The numbers reported in the "Chi-square" and "df" columns represent the values for χ^2_{tNR} and df_{tNR}, respectively.

N_hat – This is equivalent to $\hat{N}$ in Stanley and Burnham (1999), and is the maximum likelihood estimate of the number of animals at risk of capture on the first capture occasion, *N*, estimated conditionally under null model *M_t*.

NM vs *JS* – This component test evaluates whether there is evidence of losses from the population. It tests the fit of the No-mortality model (H_0: *NM*) against the Jolly-Seber model (H_a: *JS*) as a specific alternative. The numbers reported in the "Chi-square" and "df" columns represent the values for χ^2_{NM} and df_{NM}, respectively.

NR vs *JS* – This component test evaluates whether there is evidence of additions to the population. It tests the fit of the No-recruitment model (H_0: *NR*) against the Jolly-Seber

model (H_a: *JS*) as a specific alternative. The numbers reported in the "Chi-square" and "df" columns represent the values for χ^2_{NR} and df_{NR}, respectively.

Occasions – The number of distinct sampling (i.e., capture) occasions in a capture-recapture study. This value is determined by counting the number of columns in the capture-history matrix used as input to *CloseTest*.

p-value The probability under the null hypothesis that a test statistic will equal or exceed the observed value of the test statistic.

Subcomponent Statistics of the NM vs JS test – The component test *NM* vs *JS* (i.e., χ^2_{NM} in Stanley and Burnham (1999)) is a composite statistic such that $\chi^2_{NM} = \chi^2_{NM,2} + \ldots + \chi^2_{NM,k-1}$. In this section, the value of the test statistic, degrees of freedom, and *p*-value for the subcomponent statistics $\chi^2_{NM,2}, \ldots, \chi^2_{NM,k-1}$ are reported.

Subcomponent Statistics of the NR vs JS test – The component test *NR* vs *JS* (i.e., χ^2_{NR} in Stanley and Burnham (1999)) is a composite statistic such that $\chi^2_{NR} = \chi^2_{NR,2} + \ldots + \chi^2_{NR,k-1}$. In this section, the value of the test statistic, degrees of freedom, and *p*-value for the subcomponent statistics $\chi^2_{NR,2}, \ldots, \chi^2_{NR,k-1}$ are reported.

z-value – The computed value of the closure test statistic described in Otis, *et al*. (1978). Extreme values of this statistic result in low *p*-values, and suggests the population is not closed.