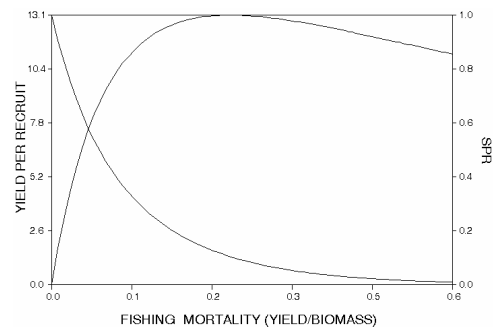
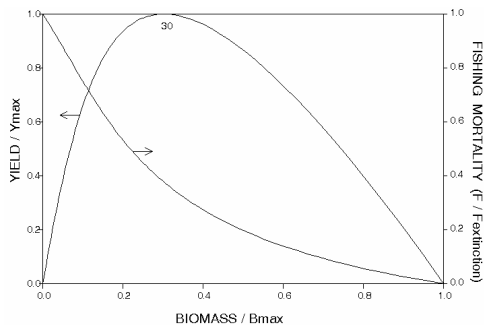
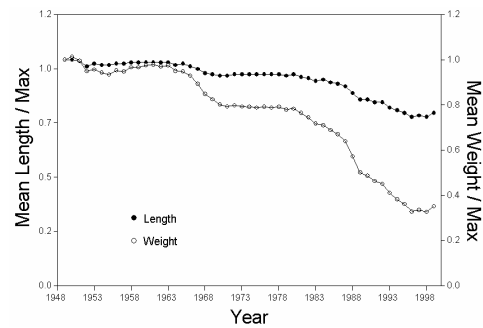
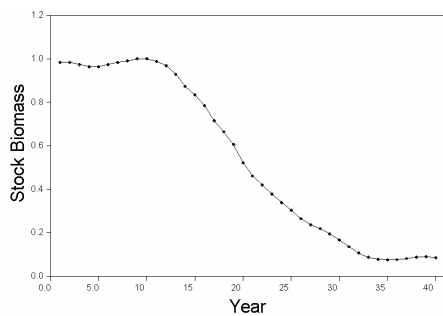
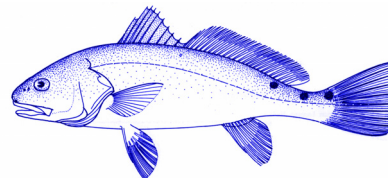


FSIM Version 3.0

User's Guide



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July 2003



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OVERVIEW

The FSIM program suite is a flexible software tool for simulating the response of fish populations to exploitation under many combinations of exploitation patterns and biological features of the species. It provides a convenient method to simulate many forms of fisheries data routinely collected from real fisheries. Analyses of these “known” simulated datasets facilitate studies of the robustness of alternative assessment methodologies. The model is also useful for exploring the implications of uncertainty about the dynamics of fish populations, forecasting consequences of management alternatives, and predicting future trends in population sizes and catches for a wide assortment of possible biological attributes under different management alternatives.

The FSIM program suite consists of several interrelated computer programs that are manipulated via the **FSIM Control Window.exe**. These include **fsim.exe**, **msy.exe**, **pma.exe**, **ypr.exe**, **plotlog.exe**, **plotpma.exe**, and **plotypr.exe**. **Fsim.exe** is used to simulate the population abundance in time, and to generate time series of population and catch statistics. **Msy.exe** computes Maximum Sustainable Yield (MSY) for the biological characteristics of the population given the selectivities in a particular year. **Pma.exe** determines equilibrium production at 100 levels of fishing mortality between $F=0$ and $F=F_{\text{extinction}}$ given the biological characteristics of the population and the selectivities in a particular year. **Plotpma.exe** is used to plot the output of **pma.exe**. **Ypr.exe** computes yield per recruit (YPR) for the biological characteristics of the population and fishery selectivities in a particular year, and **plotypr.exe** is used to plot YPR. The programs **plotlog.exe**, **plotpma.exe**, **plotypr.exe**, and **FSIM Control Window.exe** are written in Microsoft Visual Basic 6. **FSIM Control Window.exe** provides a graphical interface to the programs **fsim.exe**, **msy.exe**, **pma.exe**, and **ypr.exe**, and is used to edit the input data for each program. These latter four programs are written in Fortran 90 and have the same core representation of the population and fisheries.

GETTING STARTED

DISCLAIMER

FSIM has been used to examine a wide variety of problems and has been thoroughly tested in those applications, however the design allows analysis of very complicated problems, and not all combinations of possible factors have been verified. There are no known program bugs as of this writing, but there is no warranty of any kind. The author solicits comments regarding the program, especially including any suspected bugs, but does not offer formal technical support. Copies of the executable code and this user’s manual for FSIM may be distributed without restriction. Source code is available upon written request to the author if the requestor agrees to abide by certain restrictions.

SYSTEM REQUIREMENTS

- 80486, Pentium series, or compatible processor (standard PC’s and clones)
- Microsoft Windows (9x, 2000, NT, XT) operating system
- 4 MB of available hard disk space on the drive where the program will be installed
- Monitor with 1024x768 or 1280x1024 pixel resolution (required for the GUI)

INSTALLING FSIM

The files needed for a complete installation are normally sent as a self-extracting ZIP file (“FSIM Distribution Package.exe”). Follow these steps:

- Copy the file “FSIM Distribution Package.exe” to a temporary directory on your hard drive, then
- Execute “FSIM Distribution Package.exe”. The files will be extracted to “FSIM temp” which will contain 2 subdirectories, “FSIM_INSTALL” and “Sample species”
- Navigate to and open the “FSIM_INSTALL” directory just created.

- Execute the program “setup.exe” in that directory, and follow the instructions.
- If you choose *not* to install the programs into the default directory (“C:\Program Files\FSIM”), you must create an environment variable named “CPGFSIM” and set its value to the directory where you installed the program using methods described in the documentation for your operating system and reboot your system.
- Copy the “Sample Species” directory to a location of your choice.
- “FSIM Distribution Package.exe” and the two subdirectories “FSIM_INSTALL” and “Sample species” may then be deleted if desired.
- Although not required for program execution, setting the file associations in Table 1 will facilitate management of the data files and software that plots results. These file associations must be set manually using methods described in the documentation for your operating system.

Table 1. File associations for optimum performance of the FSIM Software package.

File Associations		
File Extension	Program to open	Function
.run	Fsim control window	Executes FSIM.EXE
.msy	Fsim control window	Executes MSY.exe and PMA.EXE
.ypr	Fsim control window	Executes YPR.EXE
.bio	Fsim control window	Manages the biological profile
.fst	Fsim control window	Manages the fisheries to be simulated
.ndf	Fsim control window	Manages the index file to be simulated
.yoy	Fsim control window	Manages the recruitment file
.log	Plotlog	Plots the FSIM output log file
.pmo	Plotpma	Plots the PMA output file
.yro	Plotypr	Plots the YPR output file

MODEL DESCRIPTION

Population Structure and Catch

The simulation time step is seasonal with a maximum number of seasons per year of 12 (monthly). The population (N) is stratified by sex (S), age (A), and growth morph (R) so that the entire population is represented by aggregating over N_{SAR}. Each growth morph is a subunit of the cohort of individuals spawned during the same reproductive period that share the same growth characteristics (are of the same length). Mean lengths by sex and age are read from an input file. The length distributions around these means are assumed to be normal (at least initially) and are represented by dividing the cumulative range of ± 3 standard deviations from the mean into an arbitrary number of intervals (maximum=101) of equal length increments (the morphs). The growth for the year is estimated from the change in individual biomass based on the change in weight (W) that occurs from one age to the next, i.e..

$$G_{sar} = \ln \left(\frac{W_{sa+1r}}{W_{sar}} \right)$$

where the W_{sar} are estimated from the lengths at age using length-weight equations that are specified in an input file. The seasonal fractions (λ) of the annual growth are also read from an input file and are used to calculate weights during the year such that the initial weight at the beginning of season p is given by

$$W_{sarp} = W_{sar1} G_{sar} \sum_{j=1}^{P-1} \lambda_j.$$

The L_{sarp} are calculated from the W_{sarp} using the length-weight equations for the appropriate sex. However, the lengths at the beginning of the each season for the first year of life are read from an input file rather than computed in this manner.

Initial recruitment to each morph is based on the proportion of the cumulative normal distribution within the length range represented by that morph. Growth within the year is seasonal. Each morph is modeled separately and population attributes are derived by summing across sexes, ages, and morphs. The number of survivors of sex s and morph r at age a and season p (N_{sarp}) is

$$N_{sarp} = R_{sar} \exp(-\mu_{sarp}),$$

where R_{sar} is the initial recruitment of age A of sex S represented by morph R , and μ_{sarp} is the cumulative total mortality suffered by morph r of sex s from recruitment to season p at age a , or

$$\mu_{sarp} = \sum_{a=0}^{A-1} \sum_{j=1}^{\Omega} (M_{saj} + F_{sarj}) + \sum_{j=1}^{P-1} (M_{saj} + F_{sarj}),$$

where Ω is the number of seasons within a year (maximum=12). The seasonal natural mortality by sex and age (M_{saj}) is the annual assumed rate divided by the number of seasons. The F_{sarj} is the instantaneous fishing mortality for sex s , morph r during season j when it was age a . A maximum of 10 fisheries can operate simultaneously during a simulation, and since the size of each morph of each sex and age is known each season, the fishing selectivities can be a function of either age or size. The fishing mortality rates by year, season, sex, fishery and age (or size if they are size dependent for the fishery) are read in from a file along with minimum and maximum legal sizes and total allowable catches for each fishery. In addition, if the selectivity pattern is age specific, a size at first vulnerability to the fishery may also be specified. The fishing mortality of sex s , age a , morph r , during season j is the sum of the partial fishing mortalities (h) from each fishery i , or

$$F_{sarj} = \sum_{i=1}^{\Psi} h_{sarji}$$

where Ψ is the number of fisheries (maximum=10). If the selectivity of fishery i is a function of size, then the mid-season length of the morph points to the element of an array of fishing mortalities at length which is then employed as the h_{sarji} , otherwise the h_{sarji} are specified directly from an input file. For ages and seasons when the morph is below a minimum or above a maximum legal size limit for the fishery, the fishing mortality is reduced to dh_{sarji} where d is the fraction of the discarded catch which dies.

All sources of mortality within a season are assumed to operate concurrently so that the catch in number and biomass from the morph for each fishery during a season is determined as the fraction of total deaths (A) suffered by the morph during the season attributable and that fishery i.e.,

$$A_{sarp} = 1 - \exp^{-Z_{sarj}} ,$$

where the total mortality, Z_{sarj} , is given by

$$Z_{sarj} = F_{sarj} + M_{saj} .$$

The catch in numbers of fish (C) from the morph for fishery i is

$$C_{sarji} = \frac{N_{sarj} A_{sarj} h_{sarji}}{Z_{sarj}} .$$

The catch in biomass (B) from the morph for fishery i is

$$B_{sarji} = \Phi C_{sarji} ,$$

Where Φ is the mean weight of the morph during the season and is computed as

$$\Phi = \frac{W_{sarj} \left[\exp^{(G_{sarj} - Z_{sarj})} - 1 \right]}{G_{sarj} - Z_{sarj}} .$$

The total catch in biomass and numbers for a season or year are obtained by summing the catches for each fishery.

Reproduction

Total population fecundity, or spawning biomass, is computed from the number of females of each growth morph and age at the beginning of a season specified to be the spawning season in an input file. The fecundity can be either a function of age or size.

Recruitment

Recruitment can be read from an input file or predicted from the simulated population fecundity. It is added to the population at the beginning of a season specified as the recruitment season in an input file. If the year-class strength is defined by a value read in from an input data file, that value is used to set the strength of the recruiting year class in the model population. If the year-class strength is not defined, then one of five options specified in an input file is employed to estimate recruitment.

Option 0: Recruitment is set equal to a constant (=mean recruitment) read from an input file.

Option 1: Recruitment is not estimated. In this case recruitment is set to zero and the model population will begin to reflect missing year classes.

Option 2: Recruitment is estimated as the product of mean egg to recruit survival and the present year's estimate of total population fecundity. The mean survival is calculated as the mean of the ratios of recruitment to simulated population fecundity for previous years in the simulation where annual recruitment was read from an input file.

Options 3 and 4: Recruitment (R) is estimated from a spawner-recruit curve which may be either a standard Ricker model (Option 3) or a Beverton-Holt curve (Option 4). In both cases, the density-dependent mortality is keyed to the size of the annual fecundity estimate; i.e., the value of parental stock size (P) in the standard notation for both equations is set equal to the total population fecundity. In terms of the present model notation, the Ricker model would be:

$$R = \alpha P \exp(-\beta P),$$

and the Beverton-Holt model would be:

$$R = 1/(\alpha + \beta / P).$$

The parameters of the stock-recruitment relation are internally computed by the program from input values for recruitment at MSY and the slope of the spawner-recruit curve at the origin.

If desired, stochastic variability can be added to the recruitment time series by specifying a value for the coefficient of variation of recruitment greater than zero. This is accomplished by multiplying the predicted (mean) recruitment from the stock-recruitment relationship by $\exp(R*CV - 0.5*CV^2)$, where R is a random normal deviate with mean of zero and a variance of 1.0; and CV is the coefficient of variation of the log of the random multiplier and is read from an input file.

Indices

The program provides the ability to generate indices of abundance based on simulated fishery-independent samples of the population or samples of the fisheries catch with or without error. The indices may be in units of numbers of individuals or biomass. Trends in catchability can be introduced, and if samples are drawn from the population, the selectivity of the sampling gear can be varied by sex, age, season and year. Indices drawn from the catch by a fishery are simply the product of the catch in number or biomass and scalar (index catchability or Q) which may be varied by year. Indices drawn from the population use selectivity algorithms identical to those of a fishery but do not remove fish from the population. These selectivity patterns must be specified in an input file.

Length and age samples

The program provides the ability to sample the simulated population or catch by the fisheries to obtain individual observations of lengths and age with or without error. This feature is useful for generating simulated size data that is very similar to size frequency data collected from actual fisheries. For example, such data could be used to examine the robustness of cohort slicing as a technique for aging catches as prelude to sequential population analysis. The user specifies the number of samples to be taken by season. These samples can be drawn from all fisheries in proportion to their catches, or from individual fisheries and/or the population through the index feature of the program. The simulated sampling procedure involves constructing an array based on all sex-age-morphs in the

sampled population or catch. This array contains the season catch or sampled abundance from each morph (depending on the user's sample specifications). The array is then normalized by dividing the value of each member by the array maximum. A uniformly-distributed random number drawn within the range of 1 to the number of array elements picks a trial cell in the array. If that cell's value is greater than or equal to a second random number drawn from a uniform distribution between 0 and 1.0, the morph corresponding to that array element is selected for the sample. If the cell is selected, the sex, age and/or length of the morph corresponding to the cell is saved as a simulated observation (with added error). This process produces a sample probability for each cell that is proportional to its relative abundance. The process is repeated until the number of observations specified by the user has been satisfied.

RUNNING FSIM

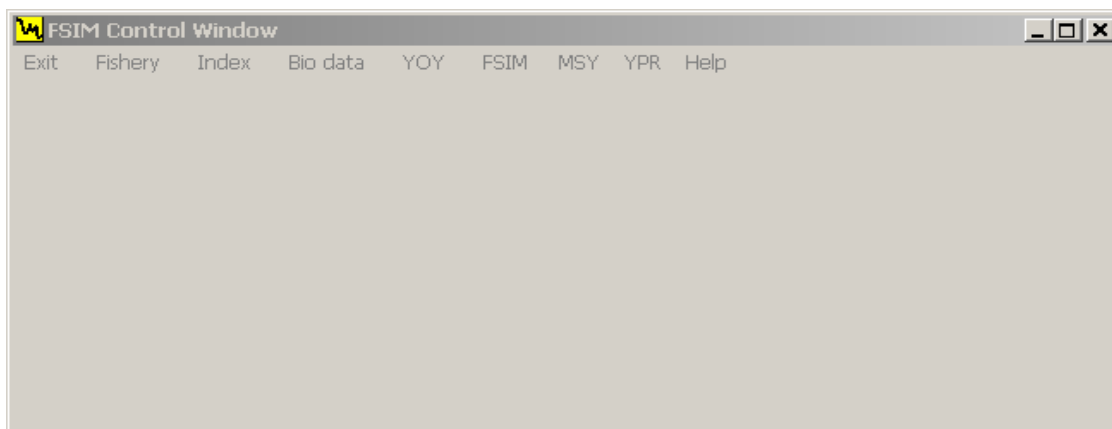
Each of the executables can be run from Windows or from the command mode. However, the application is designed to use the **FSIM control window** to manipulate the input files and execute the simulator programs. The simplest way to run the program is to navigate to FSIM directory in the Windows Start Menu and double click "FSIM control window.exe" (Start → Programs → FSIM → "FSIM control window.exe"). Once the program is loaded, the user can navigate to the working directory using the file open option in each menu selection. Alternatively, if the file associations listed in Table 1 are enabled, the appropriate module is loaded when an input or output file is clicked from Windows Explorer.

Each simulation requires input from files specifying the biological profile (*.bio) of the species, historical recruitment (*.yoy), and fishing mortality (*.mgt), and if population abundance indices are to be generated, a file defining the nature of the index to be simulated (*.ndf). The files containing the biological profile, recruitment data, and index characteristics are each managed by a separate menu selection in the **FSIM control window**. The *.mgt file specifying the time series of fishing mortality and related parameters is created from a fishery profile using the **Fishery** menu item in the **FSIM control window**. The fishery profile is maintained in a file (*.fst) which is also managed via the **Fishery** menu item in the **FSIM control window**.

The data files to be included in a simulation or to compute equilibrium production or yield per recruit are specified in a files with extensions *.run, *.msy, and *.ypr, respectively. Each of these files is managed from menu selections of the **FSIM control window**.

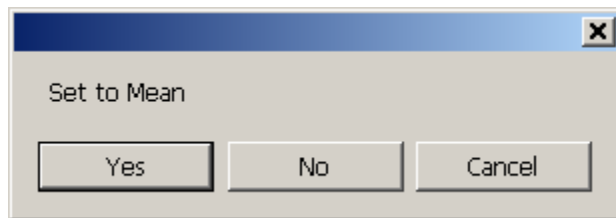
FSIM Control Window

The FSIM Control Window presents a graphical user interface to all program options and data files necessary to run the simulator. This window is displayed when the program is executed from the Programs folder of the Windows Start Menu:



Notes on the FSIM Control Window Graphical User Interface

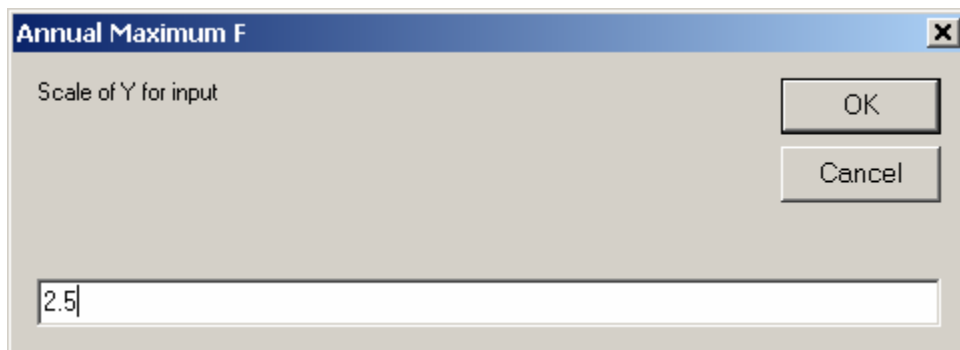
Many of the input time series can be input/edited by pointing at a graph of the time series and depressing and dragging the left mouse button. The edited data will be redrawn on the display. When an item is selected that leads to graphical input, the user is prompted for some additional information, generally this will consist of two or three items. The first allows the user to set all values the same (the mean) eg.,



If **yes** is selected, a dialog box will appear prompting the user for the mean value, with the existing mean as the default value, eg.,



The last prompt is for the user to specify the maximum value for the Y-Axis, which will control the maximum value that can be entered on the subsequent graph eg.,



Also:

- To edit/enter data, position the cursor on the graph in the desired position and depress the left mouse button.
- To exit the edit mode in a graph, position the cursor to the left of the plot area and depress the right mouse button.
- To save the image, position the cursor to the left of the plot area and depress the right mouse button.

FSIM Control Window Menu Options

- **Exit** – Closes the program.
- **Fishery** – Opens a window for entering/editing data related to the fishery(ies) to be simulated.
- **Index** – Opens a window for entering/editing data related to abundance indices to be constructed from a population simulation.
- **Bio data** – Opens a window for entering/editing data related to the fish species to be simulated.
- **YOY** – Opens a window for entering/editing data related to the recruitment history to be employed in a simulation.
- **FSIM** – Opens a window for entering/editing various simulation options including input-output filenames, and executing the simulation.
- **MSY** – Opens a window for entering/editing various options for estimating equilibrium production and related parameters for the simulated population, and executing programs that estimate Maximum Sustainable Yield and Equilibrium Production as a function of fishing mortality.
- **YPR** – Opens a window for entering/editing various options for estimating yield per recruit for the simulated population as a function of fishing mortality, and executing the program to perform the computations.
- **Help** – Displays information about the program.

Fishery Definition Window

Selecting the **Fishery** menu option brings up the following window:

The screenshot shows the 'swo.fst' window with the following fields and controls:

- First and last year:** 1949, 1999
- Number of Ages:** 100
- Number of sexes:** 2
- Number of Fisheries:** 1
- Number of seasons:** 12
- Load Fishery Data:**
 - Fishery ID:** 1
 - Buttons:** Annual F, TAC, Minimum sizes, Maximum sizes, Discard mortality
 - Seasonal Proportions:**
 - Initialize with Mean:** ☐ (selected)
 - Years equal:** ☐
 - Year:** 1949
 - Copy:** Prev Year, To last Year
 - Buttons:** Seasonal Fractions
- Total F Randomization Scalar:** 0
- Selectivities:**
 - Type:** A
 - Sexes equal:** ☐ (selected)
 - Years equal:** ☐
 - Min Vul Size:** 0
 - Initialize with 1.0:** ☐ (selected)
 - Year:** 1949
 - Copy:** To Other Sex, Prev Year, To last Year
 - Buttons:** Male, Female
- F Scalar:** 1.0
- Buttons:** Execute, Load Fishery Definition, Save Fishery Definition, Export Management

Fishery Definition Window Data Entries

File Operations

- **Load Fishery Definition** – Read a fishery definition file from disk .
- **Save Fishery Definition** – Save the current fishery definition file to disk .
- **Export Management** – Process the fishery definition data and export the information to an FSIM management input file.

Model Structure

- **First and Last year** – These are the first year and last year of the simulation.
- **Number of Ages** – The number of explicit ages in the simulated population.
- **Number of Sexes** – The number of sexes considered in the simulation. If only one sex is specified the format of Fishery Definition Window is modified so that the Male/Female option for inputting the selectivities is changed to unisex i.e.,

The screenshot shows the 'swo.fst' window with the following elements:

- Top Row:** 'First and last year' with input boxes for 1949 and 1999; 'Number of Ages' with input box 100; 'Number of sexes' with input box 1.
- Second Row:** 'Number of Fisheries' with input box 1; 'Number of seasons' with input box 12.
- Load Fishery Data Section:**
 - 'Fishery ID' with input box 1 and navigation arrows.
 - 'Total F Randomization Scalar' with input box 0.
 - Buttons: 'Annual F', 'TAC', 'Minimum sizes', 'Maximum sizes', 'Discard mortality'.
- Seasonal Proportions Section:**
 - 'Initialize with Mean' (radio button) and 'Years equal' (checkbox).
 - 'Year' with input box 1949 and navigation arrows.
 - 'Copy' section with 'Prev Year' and 'To last Year' radio buttons.
 - 'Seasonal Fractions' button.
- Selectivities Section:**
 - 'Type' dropdown set to 'A'; 'Sexes equal' (checkbox) and 'Years equal' (checkbox).
 - 'Min Vul Size' with input box 0; 'Initialize with 1.0' (radio button).
 - 'Year' with input box 1949 and navigation arrows.
 - 'Copy' section with 'To Other Sex', 'Prev Year', and 'To last Year' radio buttons.
 - 'UniSex' and 'Female' buttons.
- Bottom Row:**
 - 'F Scalar' with input box 1.0 and 'Execute' radio button.
 - 'Load Fishery Definition' button.
 - 'Save Fishery Definition' button.
 - 'Export Management' button.

- **Number of Fisheries** – Specifies the number of different fisheries to be simulated. The maximum is 10.
- **Number of seasons** – Specifies the number of seasons simulated per year (maximum 12).

Load Fishery Data – Except for the Total F Randomization Scalar, items in this frame are used to input/edit data for each fishery included in a simulation.

- **Total F Randomization Scalar** – A scalar which controls random variation in the total annual fishing mortality about the values specified in the management input file. It is CV in the expression $\exp(R*CV - 0.5*CV^2)$, where R is the 5 year running average of random normal deviates with mean of zero and a variance of 1.0. This variable is useful for generating multiple, but similar time series from a single fishery definition.
- **Fishery ID** – The fishery currently being edited.
- **Annual F** – Input/edit the total fishing mortality exerted on the most vulnerable sex-age-growth morph in the population by this fishery each year.
- **TAC** – Input/edit **Total Allowable Catch (Quota)** for this fishery each year. If the value of $TAC > 0$ and the value of the annual fishing mortality (as modified by minimum and maximum size limits) is sufficient to catch the TAC from the existing stock in any year, the catch will be limited to the specified TAC, otherwise the catch will be less than the TAC.
- **Minimum sizes** – Input/edit the annual minimum size for the fishery.
- **Maximum sizes** – Input/edit the annual maximum size for the fishery.
- **Discard mortality** – Input/edit the annual discard mortality of fish caught but not kept because of size limits.

Seasonal Proportions – Items in this frame are used to specify the seasonal fractions of the annual fishing mortality for the current fishery by year.

- **Year** – Specifies the current year being input/edited.
- **Initialize with Mean** – Sets the seasonal fraction of the annual fishing mortality for the current year equal to 1/the number of seasons.
- **Years equal** – Sets the seasonal proportions of all years to the values specified for the current year.
- **Seasonal Fractions** – Input/edit the seasonal proportions of the annual fishing mortality for the current year.
- **Copy Prev Year** – Sets the seasonal fractions of annual fishing mortality equal to the values for the previous year.
- **Copy To last Year** – Sets the seasonal fractions of annual fishing mortality of all subsequent years equal to the values for the current year.

Selectivities – Items in this frame are used to specify the relative exposure of fish of different ages or lengths to the fishing effort exerted by the current fishery.

- **Year** – Specifies the current year being input/edited.
- **Type** – Specifies whether the selectivities for the current fishery are based on age (**A**) or length (**L**). If length-based selectivities are selected, the Window is modified to input different information, e.g.,

The screenshot shows the 'swo.fst' window with the following configuration:

- First and last year:** 1949, 1999
- Number of Ages:** 100
- Number of sexes:** 2
- Number of Fisheries:** 1
- Number of seasons:** 12
- Load Fishery Data:**
 - Fishery ID:** 1
 - Buttons:** Annual F, TAC, Minimum sizes, Maximum sizes, Discard mortality
 - Seasonal Proportions:**
 - Initialize with Mean:** ☐ (selected)
 - Years equal:** ☐
 - Year:** 1949
 - Copy:**
 - Prev Year:** ☐
 - To last Year:** ☐
 - Seasonal Fractions:** (button)
- Selectivities:**
 - Type:** L
 - Sexes equal:** ☐
 - Years equal:** ☐
 - Nbins:** 50
 - Min:** (empty)
 - Max:** 0
 - Initialize with 1.0:** ☐
 - Year:** 1949
 - Copy:**
 - Male:** (button)
 - Female:** (button)
 - To Other Sex:** ☐
 - Prev Year:** ☐
 - To last Year:** ☐
- F Scalar:** 1.0
- Buttons:** Execute, Load Fishery Definition, Save Fishery Definition, Export Management

- **Sexes equal** – Check this box if the simulation considers both sexes but the selectivities are the same for each sex. The window will adopt the unisex format and the same selectivity data will be written to each sex.
- **Years equal** – Sets the selectivities for the current fishery for each year to equal to the values specified for the current year.
- **Min Vul Size** – This item appears if the selectivities are based on age. It specifies the minimum size of the fish vulnerable to the gear used by the current fishery.
- **Nbins** – This item appears if the selectivities are based on length. It specifies the number of discrete length intervals that will have different selectivities. The current structure of the model uses 50 intervals.
- **Min** – This item appears if the selectivities are based on length. It specifies the length of the fish at the beginning of the first interval. Fish smaller than this value are assumed not available to the fishery.
- **Max** – This item appears if the selectivities are based on length. It specifies the length of the fish at the end of the last interval. Fish larger than the value specified for max are assumed to have the same selectivity specified for the interval ending in max.
- **Male/Female/Unisex** – Input/edit the selectivities by age or sex to for the current year.
- **Initialize with 1.0** – Sets all selectivities for the current year and sex equal to 1.
- **Copy To Other Sex** – If unisex is not enabled this option sets the selectivities of the other sex equal to the values for the currently selected sex.
- **Copy Prev Year** – Sets the selectivities for the current sex equal to the values for the previous year.
- **Copy To last Year** – Sets the selectivities for the current sex in all subsequent years equal to the values for the current year.

F Scalar – Items in this frame are used to increase or decrease the existing fishing mortality vector for the current fishery by a constant. Enter the desired quantity and then click on the execute button to perform this operation.

Index Definition Window

Selecting the **Index** menu item of the FSIM Control Window brings up the Index Definition Window, e.g.,

The screenshot shows the 'swo.ndf' window with the following fields and controls:

- First and last year:** 1949, 1999
- Number of Ages:** 100
- Number of sexes:** 2
- Number of Indices:** 2
- Number of seasons:** 12
- Load Index Data:**
 - Index Characteristics:**
 - ID:** 2 (with left and right arrow buttons)
 - Fishery association:** 0 = Population, 1
 - Type:** w
 - Annual Q:** (button)
 - Index samples:**
 - Error:** 0
 - Index:** 0
 - Effort:** 0
 - Lengths:** 0
 - Ages:** 0
 - Sample size:** 0
 - Output file for index:** sample2.ndx

At the bottom right, there are two buttons: **Load Index Definition** and **Save Index Definition**.

Index Definition Window Data Entries

File Operations

- **Load Index Definition** – Read a Index definition file from disk .
- **Save Index Definition** – Save the current Index definition file to disk .
- **First and Last year** – These are the first year and last year of the simulation.

Model Structure

- **Number of Ages** – The number of explicit ages in the simulated population (maximum 100).
- **Number of Indices** – Specifies the number of different fisheries to be simulated. The maximum is 10.
- **Number of seasons** – Specifies the number of seasons simulated per year (maximum 12).
- **Number of Sexes** – The number of sexes considered in the simulation. If only one sex is specified the format of Index Definition Window is modified so that the **Male/Female** option for inputting the Index selectivities is changed to **UniSex** i.e.,

Load Index Data – Items in this frame are used to input/edit data for each Index included in a simulation.

Index Samples – Items in this frame control the output characteristics of the simulated abundance index.

- **Index error** – CV of the error added to the index (normal distribution).
- **Effort error** – CV of the error added to the measurement of index sampling effort (normal distribution).
- **Length sample size** – Number of animals measured from the index sample each season.
- **Age sample size** – Number of measured animals from the index sample each season which will be aged.
- **Length error** – CV of error in length measurements (normal distribution).
- **Age error** – CV of error in age determinations (normal distribution truncated to integer) for samples from the index.
- **Output file for index** – The name of the data file to which the simulated data for the current index will be saved. [Note – If the value of this field is set to “ASPIC” the index data will be saved in a file format suitable to be analyzed with the program ASPIC Version 3.82 (Prager 1994)].

Index Characteristics

- **ID** – The index currently being edited
- **Type** – The type of index (**N** or **W**). Type **N** is based on number of animals caught per unit effort. Type **W** is based on the biomass of animals caught per unit effort,
- **Annual Q** – Input/edit the annual catchability for the index, which may be constant or vary by year.
- **Fishery association** – The integer ID of the fishery associated with this index. If the index is to be drawn from the population, independent of a fishery, the **Fishery association** must be set to 0 (zero).

If the value of the **fishery association** for the current index is set to 0 (zero) so that the index will be sampled from the population rather than from a fishery, then the values input for the **Annual Q** are treated as annual effort for the sampling gear. The simulated samples do not influence survival in population (no removals). Also the sampling gear selectivities and seasonal sampling proportions must be set for each simulated year. The input frames for these data are very similar in structure and function to those for editing the same type of data for a fishery in the **Fishery Definition Window**. In this situation the **Index Definition Window** adds frames for these variables, e.g.,

The screenshot shows the 'swo.ndf' window with the following fields and controls:

- First and last year:** 1949, 1999
- Number of Ages:** 100
- Number of sexes:** 1
- Number of Indices:** 2
- Number of seasons:** 12
- Load Index Data:**
 - Index Characteristics:**
 - ID: 1
 - Fishery association: 0 = Population
 - Type: W
 - Annual Q button
 - Index samples:**
 - Error: 0
 - Index: 0
 - Effort: 0
 - Lengths: 0
 - Ages: 0
 - Sample size: 2
 - 5
 - Output file for index: sample.ndx
- Selectivities:**
 - Type: A
 - Sexes equal: ☐
 - Years equal: ☐
 - Min Vul Size: 0
 - Initialize with 1.0: ☐
 - Year: 1949
 - Copy:
 - To Other Sex: ☐
 - Prev Year: ☐
 - To last Year: ☐
 - UniSex button
 - Female button
- Seasonal Proportions:**
 - Initialize with Mean: ☐
 - Years equal: ☐
 - Year: 1949
 - Seasonal Fractions button
 - Copy:
 - Prev Year: ☐
 - To last Year: ☐
- Buttons:** Load Index Definition, Save Index Definition

Selectivities – Items in this frame are used to specify the relative exposure of fish of different ages or lengths to the fishing effort exerted by the current fishery.

- **Type** – Specifies whether the selectivities for the current index are based on age (A) or length (L). If length based selectivities are selected, the Window is modified to input different information (see Fishery selectivities)
- **Year** – Specifies the current year being input/edited.
- **Sexes equal** – Check this box if the simulation considers both sexes but the selectivities are the same for each sex. The window will adopt the unisex format and the same selectivity data will be written to each sex.
- **Years equal** – Sets the selectivities for the current index for each year to equal to the values specified for the current year.
- **Min Vul Size** – This item appears if the selectivities are based on age. It specifies the minimum size of the fish vulnerable to the gear used by the current fishery.
- **Nbins** – This item appears if the selectivities are based on length. It specifies the number of discrete length intervals that will have different selectivities. The current structure of the model uses 50 intervals.
- **Min** – This item appears if the selectivities are based on length. It specifies the length of the fish at the beginning of the first interval.
- **Max** – This item appears if the selectivities are based on length. It specifies the length of the fish at the end of the last interval. Fish larger than the value specified for max are assumed to have the same selectivity specified for the interval ending in max.

- **Male/Female/Unisex** – Input/edit the selectivities by age or length and sex to for the current year.
- **Initialize with 1.0** – Sets all selectivities for the current year and sex equal to 1.
- **Copy To Other Sex** – If unisex is not enabled this option sets the selectivities of the other sex equal to the values for the currently selected sex.
- **Copy Prev Year** – Sets the selectivities for the current sex equal to the values for the previous year.
- **Copy To last Year** – Sets the selectivities for the current sex in all subsequent years equal to the values for the current year.

Seasonal Proportions – Items in this frame are used to specify the seasonal fractions of the annual sampling effort for the current index by year.

- **Year** – Specifies the current year being input/edited.
- **Initialize with Mean** – Sets the seasonal fraction of the annual index sampling effort for the current year equal to $1/nszns$.
- **Years equal** – Sets the seasonal proportions of all years to the values specified for the current year.
- **Seasonal Fractions** – Input/edit the seasonal proportions of the annual index sampling effort for the current year.
- **Copy Prev Year** – Sets the seasonal fractions of annual index sampling effort equal to the values for the previous year.
- **Copy To last Year** – Sets the seasonal fractions of annual index sampling effort of all subsequent years equal to the values for the current year.

Biological Profile Window

Selecting the **Bio data** menu item of the FSIM Control Window brings up the **Biological Profile Window**, e.g.,

The screenshot shows a window titled "swo.bio" with a standard Windows-style title bar. The window is divided into two main sections. On the left, there is a list of parameters with corresponding input fields:

- Species: Swordfish
- Number of ages: 100
- Number of sexes: 2
- Number of seasons: 12
- Spawning season: 1
- Recruit Season: 3
- SR Option: 4
- SR slope at origin: 50
- MSY Recruitment: 100
- Recruitment CV: 0.15

On the right side, there are several buttons and labels:

- A group box labeled "Natural Mortality" containing two buttons: "Male" and "Female".
- A button labeled "Fecundity".
- A button labeled "Growth".
- At the bottom, two buttons labeled "Load File" and "Save File".

Biological Profile Window Data Entries

File Operations

- **Load File** – Read a Biological Profile file from disk .
- **Save File** – Save a Biological Profile definition file to disk .

Model Structure

- **Species** – Text descriptor of the species.
- **Number of Ages** – The number of explicit ages in the simulated population (maximum=100).
- **Number of Sexes** – The number of sexes considered in the simulation. If only one sex is specified, the format of Biological Profile Window is modified so that the **Male/Female** option for inputting the **Natural Mortality** is changed to **UniSex** i.e.,

The screenshot shows the 'swo.bio' window with the following data entries:

Parameter	Value
Species	Swordfish
Number of ages	100
Number of sexes	1
Number of seasons	12
Spawning season	1
Recruit Season	3
SR Option	4
SR slope at origin	50
MSY Recruitment	100
Recruitment CV	0.15

Buttons and options visible:

- Natural Mortality: Unisex (selected), Female
- Fecundity
- Growth
- Load File
- Save File

- **Number of seasons** – Specifies the number of seasons simulated per year (maximum 12).

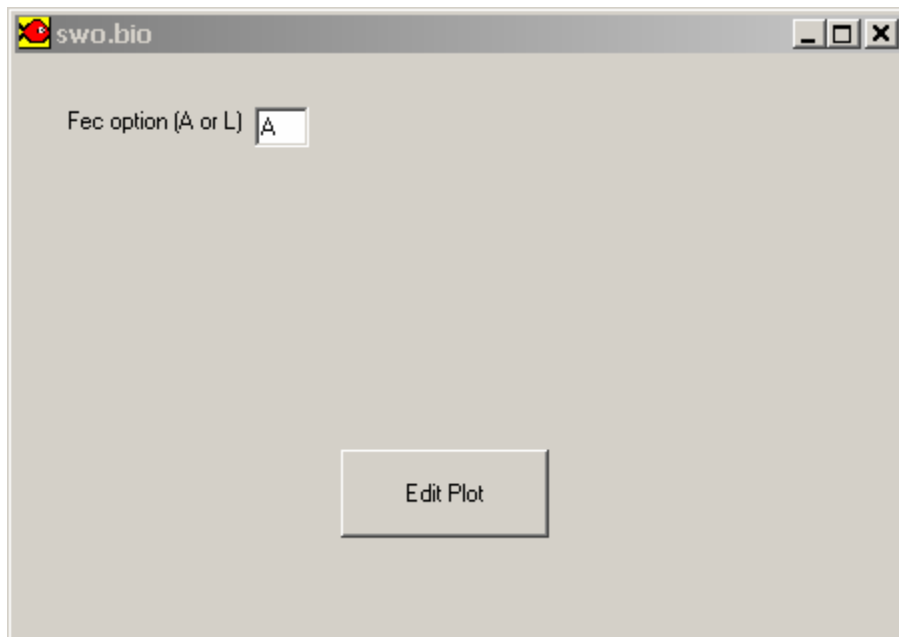
Biological Profile

- **Spawning season** – The total population fecundity is computed at the beginning of the specified season.
- **Recruit season** – This is the season that the survivors (recruits) from the annual spawn are added to the population vector.

- **SR Option** – This value specifies how recruitment will be modeled if it is not specified in the recruitment (*.YOY) file.

Value	Effect
0	Recruitment is set equal to a constant (=mean recruitment) read from the recruitment (*.YOY) file.
1	Recruitment is not estimated. In this case recruitment is set to zero and the model population will begin to reflect missing year classes.
2	Recruitment is estimated as the product of mean egg to recruit survival and the present year's estimate of total population fecundity. The mean survival is calculated as the mean of the ratios of recruitment to simulated population fecundity for previous years in the simulation where annual recruitment was read from an input file.
3	Recruitment is estimated from a standard Ricker spawner-recruit curve where the density-dependent mortality is keyed to the size of the annual fecundity estimated at the beginning of the spawning season.
4	Recruitment is estimated from a Beverton-Holt spawner-recruit curve where the density-dependent mortality is keyed to the size of the annual fecundity estimated at the beginning of the spawning season.

- **SR slope at the origin** – Slope at the origin of the unfished SR curve.
- **MSY Recruitment** – The value of recruitment when the population is being fished at MSY.
- **Recruitment CV** – The Coefficient of Variation of recruitment about the mean predicted from the stock-recruitment curve. This is applied if recruitment is estimated from a stock-recruitment curve. It is a multiplier on the deterministic SR curve prediction from the expression $\exp(R*CV - 0.5*CV^2)$.
- **Natural Mortality** – Input/edit the annual natural mortality rate (M) by sex (**Male/Female/Unisex**) and age
- **Fecundity** – Input/edit the individual fecundity (as a function of age (**A**) or length (**L**)). If **Fec option** is a function of age, the following window will appear:



If **Fec option** is a function of length, a window similar to the following **Fecundity-at-Size Input Window** will appear:

The screenshot shows a software window titled "rds.bio". It contains several input fields and a checkbox. The "Fec option (A or L)" dropdown is set to "L". The "Use equation" checkbox is checked. The "Size at First Reproduction" field is 35, "Maximum size allowed" is 100, and "Number length intervals" is 100. The "Fecundity Length Equation" section has the "Update" radio button selected, with a text input field showing ".000935" and a length input field showing "5.57" with a small "L" icon. An "Edit Plot" button is at the bottom.

Fecundity-at-Size Input Window

- **Size at First Reproduction** – The smallest length at which females spawn, also the minimum size for the graphical edit window.
 - **Maximum size allowed** – The maximum length allowed for the length-fecundity function, also the maximum size for the graphical edit window. During the simulations, fecundity of fish greater than this maximum size will be truncated to the value for the maximum size.
 - **Number of length intervals** – The number of discrete length intervals for the fecundity at length relation.
 - **Use equation** – If this box is checked a **Fecundity Length Equation** can be entered in the corresponding frame.
 - **Update** – This selection must be made to update the fecundity-length data used for the simulation. The equation itself is not used by the simulator.
-
- **Edit Plot** – In either case this selection will open a graphic interface to enter/edit the existing data.

- **Growth** – Input/edit individual size at age, and the length-weight relations by sex. When selected, a window similar to the following will appear:

Number of growth morphs: 51

☒ Use Von Bertalanffy

Length-Weight Equations

	a	b	CV
Male	1.158E-05	3.056	0.1
Female	1.158E-05	3.056	0.1

Von Bertalanffy Equations

	Loo	K	t0	Update Lengths
Male	87.78	0.16	0.0452	<input type="radio"/>
Female	87.78	0.16	0.0452	<input type="radio"/>

Mean Sizes at Age

Male Female

First Year Growth

Male Female

Seasonal Growth Fractions

Growth Input Window

- **Number of growth morphs** – The number of discrete cohorts of individuals of the same sex spawned during the same reproductive period that share the same growth characteristics (are of the same length). The minimum is 1 and the maximum is 101. Program execution speed decreases with increasing numbers of morphs. If the problem being evaluated is not sensitive to length, then the value may be set to 1. For many purposes where length is an important consideration, setting the number of morphs to 21 should be adequate. This provides 42 sex-age-size morphs for each age in the population.
- **Use von Bertalanffy** – This option allows filling the mean size at age vector with values predicted from a von Bertalanffy growth equation. Note...the equations themselves are not used by the simulator, and are not required input. The values used by the simulator are input/edited via the **Mean Sizes at Age** frame in this window.
- **Von Bertalanffy Equations** – This frame will be appear if the **Use von Bertalanffy** check box is enabled. The mean sizes at age may be entered using this option; however, the von Bertalanffy equations are not used by the simulator. To use the predicted lengths, the user must execute the **Update Lengths** button in this frame. Depending on the number of sexes specified for the model structure, the frame will present input boxes for males and females or unisex.
- **Update Lengths** – This button overwrites the existing size at age data with values predicted from the equations.
- **Length-Weight Equations** – This frame is used to input the length-weight equations that the simulator will use to convert between the two size measures. All size measurements, including minimum and maximum size limits, and the sizes of simulated samples of landed fish are in length units. However growth and yield computations are based on the weights which have been converted using these length-weight equations. Depending on the number of sexes specified for the model structure, the frame will present input boxes for males and females or unisex.
- **Mean sizes at Age** – Input/edit mean sizes at age at ages 1 and above. Depending on the number of sexes specified for the model structure, the frame will present input boxes for males and females or unisex.

- **First year growth** – This selection permits entry/edit of the mean sizes of individuals during their first year of life. Depending on the number of sexes specified for the model structure, the frame will present input boxes for males and females or unisex. If the minimum vulnerable size to any fishery includes fish that may be in their first year of life, the mean size specified for the beginning of the last season of age zero must be less than or equal to the mean size at age 1. The lengths must increase from one value to the next (no negative growth).
- **Seasonal growth fractions** – This selection allows input/edit of the seasonal proportions of the annual growth. The fractions are based on the fraction of annual growth in weight each season. The input fractions are automatically normalized so that the sum over the year is 1.0.

YOY (Recruitment) Definition Window

Selecting the **YOY** menu item of the FSIM Control Window brings up the Recruitment Definition Window, e.g.,

The screenshot shows a window titled "swo.yoy" with a standard Windows-style title bar (minimize, maximize, close buttons). Inside the window, there are the following elements:

- First and last year:** Two adjacent text input boxes containing the values "1949" and "1999".
- Mean recruitment:** A text input box containing the value "0".
- Buttons:** To the right of the "Mean recruitment" box is a button labeled "Recruitment". Below it is a button labeled "Growth".
- Checkboxes:** Below the "Recruitment" button is a checkbox labeled "Enable variable growth" which is unchecked. Below that is another checkbox labeled "Reset Growth to 1" which is also unchecked.
- File Operations:** At the bottom of the window, there are two large buttons: "Load Recruitment File" on the left and "Save Recruitment File" on the right.

Recruitment File Window Data Entries

File Operations

- **Load Recruitment File** – Read Recruitment file from disk .
- **Save Recruitment File** – Save Recruitment file to disk .

Model Structure

- **First and last year** – The first and last year simulated. **The data in this file control the years considered in a simulation.** The same data in other files are only used to set the dimensions of the input sequence. Failures of program execution may be related to a mismatch between the years sequences designated by the various input files
- **Number of Ages** – The number of explicit ages in the simulated population (maximum=100).

Year Class Data

- **Recruitment** – **Input**/edit year class strengths, measured at the beginning of the season during which they are first recruited to the model population. The stock-recruit functions will predict recruitment only for years where these values are set to 0 (zero).
- **Growth** – The model is designed to allow growth to vary by year class; however, this aspect has not been used/verified and the input routines for the year-class growth options are disabled. However, the input file data structure is required by the simulator and is automatically filled when the YOY file is saved. If the file is edited using an ASCII data editor, the user must insure that the dummy variables are included (see the YOY input file format specification).

FSIM Execution Control Window

Selecting the **FSIM** menu item of the **FSIM Control Window** brings up the **FSIM Execution Control Window** which is used to specify the input and output files, and various options, and execute **FSIM** simulations e.g.,

The screenshot shows a window titled "SWO.RUN" with a standard Windows-style title bar (minimize, maximize, close buttons). The window contains a list of input and output file fields, each with a text box for the filename. The fields are:

- Biological data input file: swo.bio
- Recruitment data file: swo.yoy
- Prior known reference points: NUL
- Initial conditions input file: NUL
- Management file: swo.mgt
- Index definition file: swo.ndf
- Lengths per fishery per season: 5
- Length measurement error: .01
- Length & age per fishery-season: 4
- Age measurement error: .1
- First year to output: 1949
- Last year to output: 1999
- Landings output file: NUL
- Catch statistics output file: NUL
- Stock statistics output file: NUL
- Catch length output file: lengths.txt
- File to put initial conditions: NUL
- Log file for output: swo.log
- Number of Replications: 1

On the right side of the window, there are three buttons: "Load run data", "Save run data", and "Execute". The "Execute" button is highlighted with a yellow background. Below the "Stock statistics output file" field, there is a yellow highlight with the text "'SEEPa' for SEEPa input file".

FSIM Execution Control Window Data Entries

File Operations

- **Load run data** – Read FSIM run file from disk.
- **Save run data** – Save FSIM run file to disk.
- **Execute** – Execute FSIM with the currently loaded options.

FSIM Run Data

- **Biological data input file*** – The name of the file containing the biological profile (*.bio) for the simulation.
- **Recruitment data file*** – The name of the file containing the recruitment history and beginning and ending year for the simulation
- **Prior known reference points** – The name of the file containing management benchmarks for the stock being simulated. If this file is specified, then the annual ratios of biomass to the unfished biomass, biomass to B_{MSY} , yield to MSY , F to F_{MSY} , the stockrecruitment, unfishedslope, CV for recruitment variability, a scalar to identify natural mortality, and a descriptor of the fishing mortality pattern will be output. These data are sometimes useful for studies comparing fishery model fits to actual conditions existing in the simulated population. See the section on file formats for the format of both the input and output file
- **Initial conditions input file** – The name of a file (*.inc) containing the initial state of the stock at the beginning of the first year of a simulation. This file is an output of a previous FSIM run. This is useful for running alternative forecasts of the future status of a stock under different management scenarios.
- **Management file*** – The name of the file (*.mgt) containing the processed fishery profile data. This file has information on catch limits, size restrictions, and partial F s by age or length and sex for each simulated year.
- **Index definition file** – The name of the file (*.ndf) containing information that defines the characteristics of any indices that are to be generated during the simulation.
- **Lengths per fishery per season** – The number of length samples to be taken from each fishery each season.
- **Length measurement error** – The CV of the (normally distributed) error in the length measurements .
- **Length & age per fishery-season** – The number of age determinations from the length samples to be taken from each fishery each season. This number must be less than or equal to the **Lengths per fishery per season** specified above.
- **Age measurement error** – The CV of the (normally distributed) error in the age determinations truncated to an integer.
- **First year to output*** – The first year of simulated data to be output.
- **Last year to output*** – The last year of simulated data to be output.
- **Landings output file** – The name of the output file to receive the detailed landings data (see file formats).
- **Catch statistics output file** – The name of the output file to receive the detailed catch statistics data (see file formats).
- **Stock statistics output file** – The name of the output file to receive the detailed standing stock data (see file formats). If “**SEEP**A” is specified, the output file will be formatted to be read by “**SEEP**A” which is another simulation model designed to simulate longline catch per unit effort.
- **Catch length output file** – The name of the output file to receive the simulated length and age samples from the fisheries.
- **File to put initial conditions** – The name of the file (*.inc) to receive the state variables at the end of the last year of a simulation. This file may be read by FSIM as an input to simulations that begin with the year after the current simulation ends.

- **Log file for output** – The name of the file (*.log) that traces the annual catch and status of the stock. This file can be plotted with the program “**plotlog.exe**” which is included in the FSIM distribution package.
- **Number of replicates*** – The number of times the simulation is to be run. This is useful for generating many data sets for analysis. However, if the **Total F Randomization Scalar** and the **Recruitment CV** are both 0 (zero) the simulated time series abundances and catches will be identical for each replicate. The simulated size and age samples and index data will still be different for each replicate.

* **Required field.** To omit filenames that are not required enter “NUL” (The input program will do it for you if you leave the entry blank).

MSY Execution Control Window

Selecting the **MSY** menu item of the **FSIM Control Window** brings up the **MSY Execution Control Window** which is used to specify the input and output files, options, and execute programs to characterize equilibrium production for the biological profile and fishery data specified for simulations e.g.,

MSY Execution Control Window Data Entries

File Operations

- **Load run data** – Read MSY run file from disk.
- **Save run data** – Save MSY run file to disk.

- **MSY** – Execute **MSY.exe** with the currently loaded run options which estimates MSY and related benchmarks for the biological profile and management data for a specified year or set of years.
- **Equilibrium Production** – Execute **PMA.exe** with the currently loaded run options which estimates equilibrium production for the biological profile and management data for a specified year or set of years. These data can be plotted with the program **plotpma.exe** which is distributed with the FSIM package.

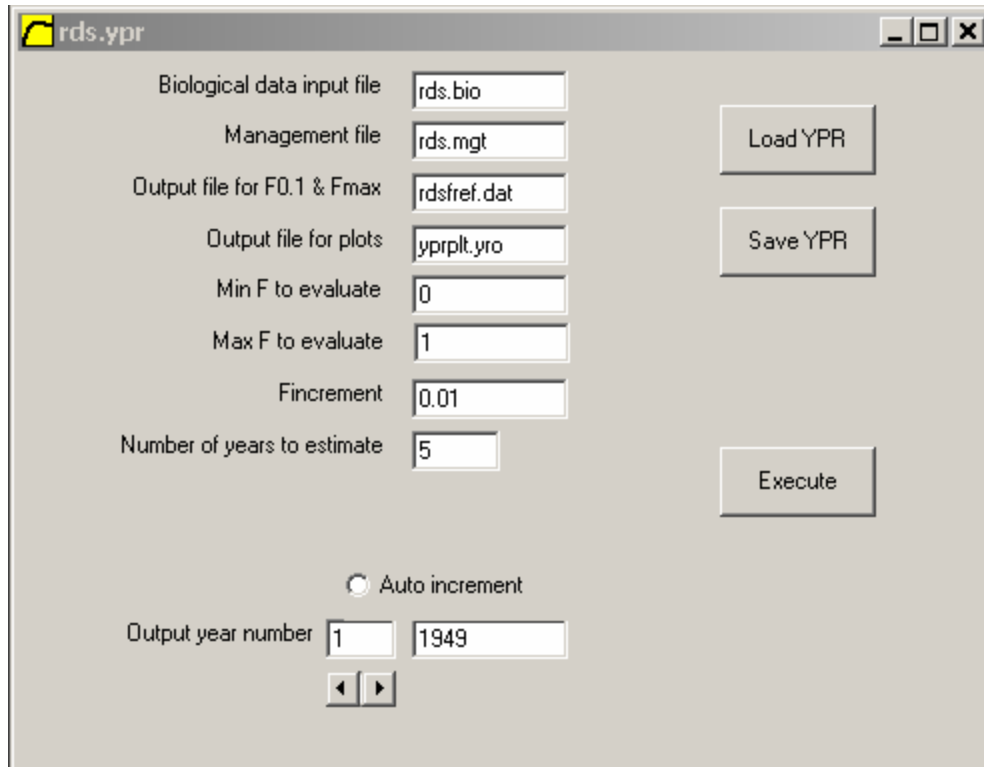
MSY Run Data

- **Biological data input file*** – The name of the file containing the biological profile (*.bio) for the simulation.
- **Management file*** – The name of the file (*.mgt) containing the processed fishery profile data. This file has information on catch limits, size restrictions, and partial Fs by age or length and sex for each simulated year.
- **MSY Output Table** – The name of a file to receive detailed output of MSY and related benchmarks
- **MSY Benchmark Table** – The name of a file to receive the MSY benchmarks in abbreviated form.
- **Equilibrium Production Table*** – The name of the file to receive the equilibrium production estimates. This file can be plotted with the program **plotpma.exe** which is distributed with the FSIM package. The file extension for this file should be *.pmo.
- **Title for run** – A short alphanumeric description of the run that will be saved with the output file.
- **Number of years to estimate*** – The number of years for which computations of MSY and/or equilibrium production will be made.
- **Output year number** – The item number pointing to the list of years to evaluate
- **Auto increment** – Selecting this option will cause the list of years to be filled in with successive years beginning with the one specified in the **Year** field and ending in the year corresponding to the first specified year + the **Number of years to estimate** -1.
- **Year** – The identity of the year corresponding output year number for which the fishery profile will be used to evaluate MSY or equilibrium production. If selectivities, size limits, etc do not vary with year, the results will be the same for each year. The specified years must be sequential.

* **Required field.** To omit filenames that are not required enter “NUL” (The input program will do it for you if you leave the entry blank.

YPR Execution Control Window

Selecting the **YPR** menu item of the **FSIM Control Window** brings up the **YPR Execution Control Window** which is used to specify the input and output files, and various options, and execute programs to characterize yield per recruit for the biological profile and fishery data specified for simulations e.g.,



YPR Execution Control Window Data Entries

File Operations

- **Load run data** – Read YPR run file from disk.
- **Save run data** – Save YPR run file to disk.
- **YPR** – Execute **YPR.exe** with the currently loaded run options which estimates MSY and related for the biological profile and management data for a specified year or set of years. These data can be plotted with the program **plotypr.exe** which is distributed with the FSIM package.

YPR Run Data

- **Biological data input file*** – The name of the file containing the biological profile (*.bio) for the simulation.
- **Management file*** – The name of the file (*.mgt) containing the processed fishery profile data. This file has information on catch limits, size restrictions, and partial Fs by age or length and sex for each simulated year.
- **Output File for F0.1 & Fmax** – The name of a file to receive YPR benchmarks
- **Output file for plots** – The name of the file that has equilibrium YPR estimates as a function of fishing mortality for the biological profile and management data for a specified year or set of years. These data can be

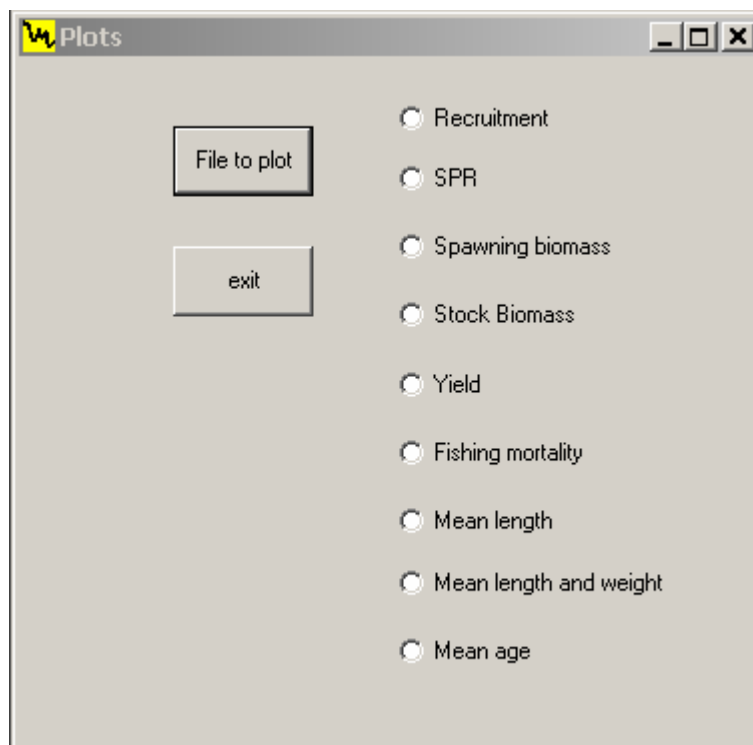
plotted with the program **plotypr.exe** which is distributed with the FSIM package. The plot program is designed to plot 101 equally-spaced equilibrium YPR estimates beginning with **Min F** and ending with **Max F**. The file extension for this file should be *.yro.

- **Min F to evaluate*** – The lowest level of fishing mortality to evaluate. The specified level of fishing mortality applies to fully selected age/sizes. For other age/sizes it is reduced by the appropriate selectivity values.
- **Max F to evaluate*** – The highest level of fishing mortality to evaluate. The specified level of fishing mortality applies to fully selected age/sizes. For other age/sizes it is reduced by the appropriate selectivity values.
- **Number of years to estimate*** – The number of years for which computations of YPR will be made.
- **Output year number** – The item number pointing to the list of years to evaluate
- **Auto increment** – Selecting this option will cause the list of years to be filled in with successive years beginning with the one specified in the **Year** field and ending in the year corresponding to the first specified year + the **Number of years to estimate** -1.
- **Year***– The identity of the year corresponding output year number for which the fishery profile will be used to evaluate YPR. If selectivities, size limits, etc do not vary with year, the results will be the same for each year.

SOFTWARE FOR PLOTTING RESULTS

PLOTLOG

This program is used to plot **FSIM** simulation results that are saved in a log file (*.log). To run this program select **plotlog.exe** from the **FSIM Folder** of the **Windows Run Menu**, navigate to the log file containing the data to be plotted and click on the filename of the input file to be plotted. Alternatively, if file association between **plotlog.exe** and file extension *.log is enabled, the program will load when a log file is selected from **Windows Explorer**. The program will display a Window such as:



PLOTLOG Control Window Options Operations

File Operations

- **File to plot** – Read FSIM log file to plot.
- **exit** – Close **plotlog.exe** and exit.

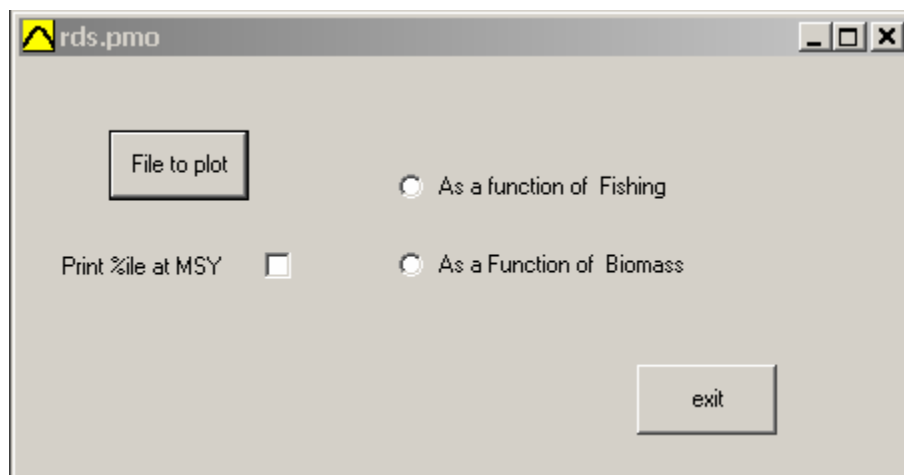
PLOTLOG Plot Selection Options*

- **Recruitment** – Plots a time series of realized recruitments during the simulation.
- **SPR** – Plots a time series of Spawning Potential Ratios of the simulated population.
- **Spawning biomass** – Plots a time series of the spawning biomass of the simulated population. The spawning biomass is the sum of individual female fecundities in the entire population at the beginning of the specified spawning season.
- **Stock Biomass** – Plots a time series of annual average stock biomass of the simulated population.
- **Yield** – Plots a time series of simulated total annual harvest in biomass.
- **Mean length** – Plots a time series of mean lengths of harvested fish. The units of length are the same as the units of the length-weight equation specified in the **biological profile** used by FSIM for the simulation.
- **Mean length and weight** – Plots a time series of mean lengths of harvested fish. The units of length and weight are the same as the units of length and weight of the length-weight equation specified in the **biological profile** used by FSIM for the simulation.
- **Mean age** – Plots a time series of mean ages of fish in the stock (not including age 0) and the mean lengths of harvested fish. The units of length are the same as the units of the length-weight equation specified in the **biological profile** used by FSIM for the simulation.

* The graphs are generally scaled to the maximum value simulated; however, the data in the log file are the actual simulated values and may be read into other graphics programs and plotted in the original units. A **PLOTLOG** graphic displayed on the computer screen can be saved by right-clicking the image window. A left click exits the plot window.

PLOTPMO

This program is used to plot equilibrium production estimates from **plotpmo.exe**. To run this program, select **plotpmo.exe** from the **FSIM Folder** of the **Windows Run Menu**, navigate to the equilibrium production output file (*.pmo) containing the data to be plotted and click on the filename of the input file to be plotted. Alternatively, if file association between **plotpmo.exe** and file extension *.pmo is enabled, the program will load when an equilibrium production output file is selected from **Windows Explorer**. When loaded the program will display:



PLOTPMO Control Window Options Operations

File Operations

- **File to plot** – Read equilibrium production output file (*.pmo) to plot.
- **exit** – Close **plotpmo.exe** and exit.

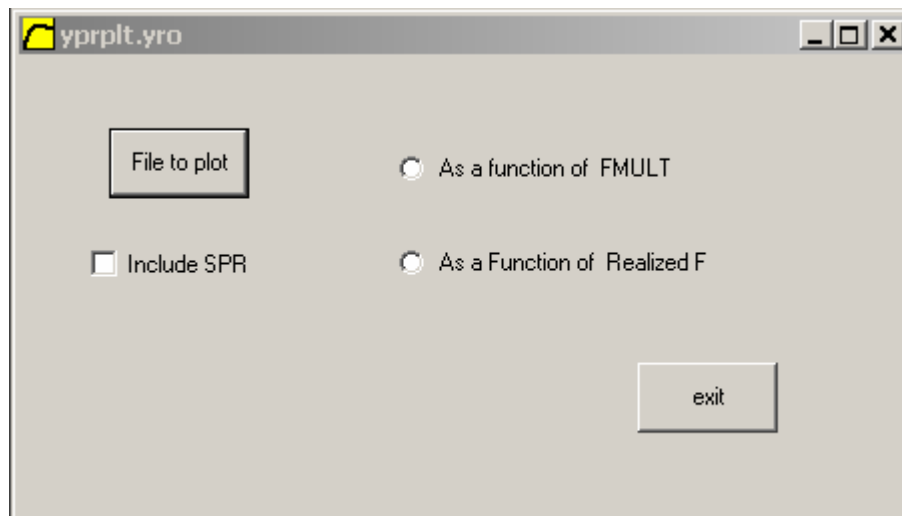
PLOTPMO Plot Selection Options*

- **As a function of Fishing** – Plots equilibrium production for the biological profile and the fishery selectivities in a given year as a function of total fishing mortality.
- **As a function of Biomass** – Plots equilibrium production for the biological profile and the fishery selectivities in a given year as a function of population biomass.
- **Print %tile at MSY** – prints the percent of unfished biomass corresponding to the biomass at MSY when the equilibrium production curve is plotted as a function of population biomass.

* The graphs are generally scaled to the maximum value calculated; however, the data in the input file are the actual values and may be read into other graphics programs and plotted in the original units. A **PLOTPMO** graphic displayed on the computer screen can be saved by right-clicking the image window. A left click exits the plot window.

PLOTYPR

This program is used to plot equilibrium production estimates from **plotmsy.exe**. To run this program select **plotmsy.exe** from the **FSIM Folder** of the **Windows Run Menu**, navigate to the **ypr.exe** output file (*.yro) containing the data to be plotted and click on the filename of the input file to be plotted. Alternatively, if file association between **plotypr.exe** and file extension ***.yro** is enabled, the program will load when an yield per recruit output file is selected from **Windows Explorer**. When loaded the program will display:



PLOTYPR Control Window Options Operations

File Operations

- **File to plot** – Read yield per recruit output file (*.yro) to plot.
- **exit** – Close **plotypr.exe** and exit.

PLOTYPR Plot Selection Options*

- **As a function FMULT** – Plots yield per recruit for the biological profile and the fishing selectivities in a given year as a function of the fishing mortality exerted on the fully selected morphs.
- **As a function of Realized F** – Plots yield per recruit for the biological profile and the fishing selectivities in a given year as a function of the realized fishing mortality computes as the (annual catch in biomass) / (annual mean biomass of the stock).
- **Include SPR** – Plots the spawning potential ratio as well as yield per recruit.

* The graphs are generally scaled to the maximum value computed; however, the data in the input file are the actual values and may be read into other graphics programs and plotted in the original units. A **PLOTYPR** graphic displayed on the computer screen can be saved by right-clicking the image window. A left click exits the plot window.

FILE FORMATS

Many of the input and output files are quite extensive, while others are simple. All are in ASCII and can be edited with a simple text editor. Where the format is relatively simple, a sample file is included in this section along with highlighted notes to the right of the data item, where appropriate. Where the format is complex, the code that reads or writes the file is displayed.

FSIM CONTROL WINDOW FILES

Format of Fishery Data File (.fst)*

```
Open #file
Print #file, fyr                                First year of simulation
Print #file, lyr                                Last year of simulation
Print #file, nsex                               Number of sexes simulated
Print #file, nszn                               Number of seasons in a year
Print #file, nage                               Number of ages simulated
Print #file, ngear                             Number of gears simulated
Print #file, fcv                               Multiplier for random variability in annual fishing mortality
npoints = lyr - fyr + 1

'Total allowable catches
For iyr = 1 To npoints
    Print #file, fyr + iyr - 1,
    For gear = 1 To ngear
        Print #file, TAC(iyr, gear),            Total allowable catch by gear and year
    Next
    Print #file,                                Terminate line of input
Next

'annual partial f's
For iyr = 1 To npoints
    For gear = 1 To ngear
        Print #file, f(iyr, gear);              Fishing mortality by gear and year for fully selected ages or sizes
    Next
    Print #file,                                Terminate line of input
Next

'sel by gear, year, age, sex
For gear = 1 To ngear

    Print #file, F_sel_type(gear)                Selectivity type for gear (A=age; L=length)
    If F_sel_type(gear) = "A" Then
        Print #file, minvulsiz((gear))           Minimum vulnerable size to the gear
        For iyr = 1 To npoints
            For age = 0 To nage
                For sex = 1 To nsex
                    Print #file, F_sel(gear, age, sex, iyr); Selectivities by gear, age, sex, and year
                Next
                Print #file,                      Terminate line of input
            Next
        Next
    ElseIf F_sel_type(gear) = "L" Then
        Print #file, f_nlngs(gear)               Number of length categories
        Print #file, f_minsiz(gear)              Length of fish at the start of the first category
        Print #file, f_maxsiz(gear)              Length of fish at the end of the last category
        For iyr = 1 To npoints
            For L = 1 To f_nlngs(gear)
                For sex = 1 To nsex
                    Print #file, F_sel(gear, L, sex, iyr); selectivities by gear, length, sex and year
                Next
                Print #file,                      Terminate line of input
            Next
        Next
    End If
```

```

For iyr = 1 To npoints
  For szn = 1 To nszn
    Print #file, f_szn(gear, szn, iyr);      Fractions of annual fishing mortality by gear season and year
  Next
  Print #file,                               Terminate line of input
  Print #file, sizelimit(1, gear, iyr); sizelimit(2, gear, iyr); sizelimit(3, gear, iyr)
Next
Next
Close #file      Minimum and maximum size limits and discard mortality rates by gear and year

```

Format of Management Data file (*.mgt)

```

Open #file
Print #file, fcw      Multiplier for random variability in annual fishing mortality

For iyr = 1 To nyrs + 1
  yr = fyr + iyr - 1
  Print #file, yr      Year
  If yr <= lyr Then
    Call f_putf(iyr)    Output partial F's for the year
  Else
    Call f_putf(iyr - 1) Output partial F's for the year after the last year
  End If
Next iyr

Close #file

Sub f_putf(oyr)
Print #file, ngear
For gear = 1 To ngear
  Print #file, F_sel_type(gear)      Selectivity type for gear (A=age; L=length)
  If F_sel_type(gear) = "A" Then
    Print #file, minvulsize(gear)    Minimum vulnerable size to the gear
  ElseIf F_sel_type(gear) = "L" Then
    Print #file, f_nlngs(gear)       Number of length categories
    Print #file, f_minsiz(gear)      Length of fish at the start of the first category
    Print #file, f_maxsiz(gear)      Length of fish at the end of the last category
  End If
  Print #file, TAC(oyr, gear)        Total allowable catch by gear and year
Next gear

For gear = 1 To ngear
  If F_sel_type(gear) = "A" Then
    For sex = 1 To nsex
      For age = 0 To nage
        For szn = 1 To nszn
          ff = f(oyr, gear) * f_szn(gear, szn, oyr) * F_sel(gear, age, sex, oyr)
          Print #file, ff      Partial F's for the gear, age, sex and year
        Next szn
      Next age
    Next sex
  ElseIf F_sel_type(gear) = "L" Then
    For sex = 1 To nsex
      For L = 1 To f_nlngs(gear)
        For szn = 1 To nszn
          ff = f(oyr, gear) * f_szn(gear, szn, oyr) * F_sel(gear, L, sex, oyr)
          Print #file, ff      Partial F's for the gear, fish length, sex and year
        Next szn
      Next L
    Next sex
  End If
  Print #file, sizelimit(1, gear, oyr)      Minimum size limits by gear and year
  Print #file, sizelimit(2, gear, oyr)      Maximum size limit by gear and year
  Print #file, sizelimit(3, gear, oyr)      Discard mortality rates by gear and year
Next
End sub

```

Format of Index Data File (*.ndf)

```

Open #file

Print #file, nindices
Print #file, fyr
Print #file, lyr
Print #file, nsex
Print #file, nage
Print #file, nszn
For ndx = 1 To nindices
    Print #file, indexsource(ndx)
    Print #file, meanq(ndx)
    Print #file, ndxofil(ndx)
    Print #file, ndxtype(ndx)
    Print #file, ndxerrmag(ndx)
    Print #file, ndxFerrmag(ndx)
    Print #file, ndxLngsmdl(ndx)
    Print #file, ndxLngerrmag(ndx)
    Print #file, ndxagesmdl(ndx)
    Print #file, ndxageerrmag(ndx)
Next ndx

'annual Q's
npoints = lyr - fyr + 1
For i = 1 To npoints
    Print #file, fyr + i - 1
    For ndx = 1 To nindices
        Print #file, indQ(ndx, i)
        If indexsource(ndx) = 0 Then
            Print #file, i_sel_type(ndx)
            If i_sel_type(ndx) = "A" Then
                For age = 0 To nage
                    For sex = 1 To nsex
                        Print #file, i_sel(ndx, age, sex, i)
                    Next sex
                Next age
            ElseIf i_sel_type(ndx) = "L" Then
                Print #file, I_nlngs(ndx)
                Print #file, I_minsiz(ndx)
                Print #file, I_maxsiz(ndx)
                For L = 1 To I_nlngs(ndx)
                    For sex = 1 To nsex
                        Print #file, i_sel(ndx, L, sex, i)
                    Next sex
                Next L
            End If
        End If
        For szn = 1 To nszn
            Print #file, I_szn(Index, szn, i)
        Next szn
    End If
Next ndx
Next i

Close #file

```

First year of simulation

Last year of simulation

Number of sexes simulated

Number of ages simulated

Number of seasons in a year

Type of index (0=drawn from population; 1-10 associated with fishery)

Mean catchability for index

Output file for index

Index type (W=Weight; N= Number)

CV of error in index

CV of error in effort measurement

Number of length measurements for this index

CV of error in length measurements

Number of age measurements for this index

CV of error in age measurements

Year

Catchability for index this year

Selectivity type for index sampling gear (A=age; L=length)

Selectivities by index, age, sex and year

Number of length categories

Length of fish at the start of the first category

Length of fish at the end of the last category

Selectivities by index, length, sex and year

Fractions of annual index effort by season and year

Format of Biological Data File (*.bio)

Open #file	
Print #file, nage; nmorph; nsex; nszn	Number of ages, morphs, sexes and seasons
Print #file, species	Short text descriptor for species
Print #file, spszn, rszn	Spawning season and recruit season
Print #file, SROption, slopeatorigin	Stock-recruit option and slope of the SR function at its origin
Print #file, MSYrecruitment, recruit_var	Recruitment at MSY, CV of random variability in recruitment
Print #file, fec_type	Fecundity type for computation (A=Age; L=length)
If fec_type = "A" Then	
For age = 0 To nage	
Print #file, age; fecund(age)	Fecundity by age
Next	
ElseIf fec_type = "L" Then	
Print #file, fec_nlngs	Number of length categories with discrete fecundity values
Print #file, fec_minsiz	Length of fish at the start of the first category
Print #file, fec_maxsiz	Length of fish at the start of the first category
Print #file, fec_a, fec_b	Fecundity power function coefficients (not used directly by FSIM)
For i = 1 To fec_nlngs	
Print #file, fecund(i)	Fecundity by length
Next	
End If	
For age = 0 To nage	
Print #file, age;	Age
For sex = 1 To nsex	
Print #file, M(age, sex);	Natural mortality by age and sex
Next	
Print #file,	Terminate line of input
Next	
For sex = 1 To nsex	
Print #file, lwa(sex); lwb(sex); cv(sex)	Coefficients of the length-weight equation and CV of size at age
Next	
For sex = 1 To nsex	
Print #file, vbLoo(sex); vbk(sex); vbt0(sex)	von Bertalanffy function coefficients (not used directly by FSIM)
Next	
For szn = 1 To nszn	
Print #file, szn; szngrow(szn)	Season and fraction of annual growth during season
Next	
For szn = 1 To nszn	
Print #file, szn;	Season
For sex = 1 To nsex	
Print #file, fylng(szn, sex);	Mean length of age 0 fish at the beginning of the season by sex
Next	
Print #file,	Terminate line of input
Next	
For age = 1 To nage	
Print #file, age;	Age
For sex = 1 To nsex	
Print #file, lng(age, sex);	Mean length at the beginning of the first season by age and sex
Next	
Print #file,	Terminate line of input
Next	
Close #file	

Recruitment (YOY) Data File (*.yoy)

```
Open #file

Print #file, byr, eyr          Beginning and Ending year for the simulation
Print #file, yoysw, yoymean    Dummy switch for yearclass growth variation; Historical average recruitment
npoints = eyr - byr + 1

For i = 1 To npoints
  Print #file, yoy(i), 1#      Yearclass strength at recruitment; Dummy variable for yearclass growth
Next i

Close #file
```

Format of FSIM Run File (*.run)

1	Number of replications
rds.bio	Name of biological profile input file
rds.yoy	Name of recruitment input file
NUL	Name of prior reference point input file
NUL	Name of initial conditions input file
rds.mgt	Name of fisheries management input file
rds.ndf	Name of index definition input file
10	Number of length samples to output per fishery per season
0.05	CV of length-measurement error
5	Number of age sample to be output with length samples per season
0.14	CV of age-measurement error
1949	First year to output
1999	Last year to output
NUL	Filename to receive summarized landings from the fishery(ies)
NUL	Filename to receive detailed catch statistics
NUL	Filename to receive detailed stock statistics
Fishery.lng	Filename to receive length samples from each fishery
NUL	Name of output file to write state variables to be used as an initial conditions input file
rds.log	Name of the log file

Format of MSY Control File (*.msy)

rds.bio	Name of biological profile input file
rds.mgt	Name of fisheries management input file
msy.tab	Name of MSY detailed output file
msybnch.tab	Name of MSY benchmark table file
rds.pmo	Name of equilibrium production output file
test	Short text description
4	Number of years to estimate
1977	year to estimate #1
1984	year to estimate #2
1990	year to estimate #3
1995	year to estimate #4

Format of YPR Control File (*.ypr)

rds.bio	Name of biological profile input file
rds.mgt	Name of fisheries management input file
ypr.tab	Name of YPR benchmark table file
ypr.yro	Name of YPR output file to receive the plot data
0	Lowest level of fishing mortality to evaluate
1.0	Highest level of fishing mortality to evaluate
0.01	F increment to evaluate
4	Number of years to estimate
1977	year to estimate #1
1984	year to estimate #2
1990	year to estimate #3
1995	year to estimate #4

FSIM INPUT-OUTPUT FILES

Most of the FSIM input files are managed by “**FSIM control window.exe**”, and are covered in that Section (above). However, an infrequently used file containing prior known biological reference points must be created and edited with an ASCII text editor.

Format of Prior Known Reference Points

Sample.rpo	Output file to receive reference point output data
0.517480E+04	Unfished biomass of the stock
0.1405E+03	Maximum Sustainable Yield (MSY)
0.1738E+04	Stock Biomass at MSY
0.0808	Fishing Mortality at MSY
0.20	M-Reference (Used to identify run)
UP	Pattern reference (Used to identify run)

Format of Log File (*.log)

SUMMARY STATISTICS									
YEAR	Recruits	SPR	Stock Biom	Mean Bulk	Yield	F	Mean Lngth	Mean Wt	Mean Age
1949	0.125E+03	0.929	0.176E+11	0.348E+04	0.210E+02	0.603E-02	0.612E+02	0.460E+01	9.832
1950	0.125E+03	0.926	0.176E+11	0.347E+04	0.561E+02	0.162E-01	0.612E+02	0.460E+01	9.822
1951	0.125E+03	0.917	0.174E+11	0.343E+04	0.489E+02	0.142E-01	0.612E+02	0.459E+01	9.807
1952	0.125E+03	0.908	0.172E+11	0.339E+04	0.716E+02	0.211E-01	0.611E+02	0.458E+01	9.782
1953	0.125E+03	0.894	0.170E+11	0.334E+04	0.797E+02	0.239E-01	0.610E+02	0.457E+01	9.745
1954	0.125E+03	0.880	0.167E+11	0.329E+04	0.706E+02	0.215E-01	0.609E+02	0.455E+01	9.704
1955	0.125E+03	0.868	0.165E+11	0.324E+04	0.803E+02	0.248E-01	0.608E+02	0.453E+01	9.656
1956	0.124E+03	0.856	0.162E+11	0.319E+04	0.748E+02	0.235E-01	0.606E+02	0.451E+01	9.604
1957	0.124E+03	0.843	0.160E+11	0.313E+04	0.101E+03	0.323E-01	0.605E+02	0.448E+01	9.542
				.					
				.					
				.					
1999	0.488E+01	0.025	0.512E+08	0.667E+01	0.503E+01	0.755E+00	0.362E+02	0.873E+00	2.166
2000	0.000E+00	0.000	0.000E+00	0.627E+01	0.473E+01	0.000E+00	0.000E+00	0.000E+00	0.000

Note: the last year of output is a projection of the catch for the last simulated year +1, using the standing stock at the end of the simulation and the realized fishing rates in the last simulated year.

Format of Landings Output File

```

1949 1 .1765E+01 .0000E+00      Year, season, fishery #1 landings, Fishery #2 landings...Fishery #10 landings
1949 2 .1752E+01 .0000E+00
1949 3 .1741E+01 .0000E+00
1949 4 .1732E+01 .0000E+00
1949 5 .1728E+01 .0000E+00
1949 6 .1729E+01 .0000E+00
.
.
1999 7 .1935E+00 .4493E+00
1999 8 .1866E+00 .3337E+00
1999 9 .1869E+00 .1377E+00
1999 10 .1920E+00 .0000E+00
1999 11 .1958E+00 .0000E+00
1999 12 .1930E+00 .0000E+00

```

Format of Detailed Landings Output File

For each year simulated:

```

WRITE (2,*) iyr      Year
WRITE (2,*) ngear    Number of fisheries
do 50, igr=1,ngear
50  WRITE (2,*) rlen(1,igr),rlen(2,igr),relmort(igr)      Minimum size limit, maximum size limit, discard mortality rate, each fishery on a separate line

DO 100, iage=0, nage      For each age
DO 100, isex=1, nsex      For each sex
DO 100, iszn=1, nszn      For each season
DO 100, igr=1, ngear      For each gear
WRITE (2,500) yld(iage,isex,iszn,igr),yldn(iage,isex,iszn,igr),sc(iage,iszn,isex)      Biomass landed, Number landed, Number in the stock
100 continue
500 FORMAT(E9.4,X,E9.4,X,E9.4)
WRITE (2,'(A1)') Lastyearflag      Last year flag ="L" when the last year has been output, otherwise Last year flag ="N"

```

Format of Detailed Stock Statistics Output File

First part of output file contains:

```

write (3,*) title      Short text title for run
write (3,*) iofyr      First year in file
write (3,*) iolyr      Last year in file
do 700, iage=0,nage      For each age
do 700, iszn= 1,nszn      for each season
write (3,*) (M(iage, iszn, isex),isex=1,nsex)      Natural mortality by age season and sex
700 continue

```

Then the rest of the file has for each year:

```

do 100, iage=0,nage      For each age
do 100, isex=1,nsex      For each sex
write(3,'(12(X,E9.4))') (sc(iage,iszn,isex), iszn=1,nszn)      Standing stock each season
100 continue

```

This output file contains estimates of the ratios of biomass to the unfished biomass (B/B_0), biomass to B_{MSY} (B/B_{MSY}), Yield to MSY (Y/MSY), F to F_{MSY} (F/F_{MSY}), the stockrecruiptoption(SR), unfishedslope (slope), CV for recruitment variability, a scalar to identify natural mortality (M), and a descriptor of the fishing mortality pattern (pattern)will be output one line for each year simulated:

Format of Fishery Length-age Sample Output File

Format of Index Output File

Format of ASPIC Enabled Output File

If “ASPIC” is entered as the output filename for the first index, the index data will be saved in a file format suitable to be analyzed with the program ASPIC Version 3.82 (Prager 1994). The indices will be saved with specified error; but in addition, a precise index (no error) of total stock biomass will be appended as the last set of data e.g.,

```
'Fishery    1'
'CE'
1949 0.6029E-02 0.2100E+02
1950 0.1619E-01 0.5611E+02
.
.
.
1998 0.3870E+00 0.3297E+01
1999 0.3951E+00 0.2634E+01
'Fishery    2'
'CE'
1949 0.0000E+00 0.0000E+00
1950 0.0000E+00 0.0000E+00
.
.
.
1998 0.3434E+00 0.2926E+01
1999 0.3596E+00 0.2398E+01
'Index      1'
'I1'
1949 0.3483E+04
1950 0.3465E+04
.
.
.
1998 0.8520E+01
1999 0.6667E+01
```

MSY OUTPUT FILES

Format of MSY Benchmark Output File

This file contains a header, and one line of data for each year evaluated. For each year's selectivities, the output lists the year evaluated, the unfished biomass (B_0), MSY(in biomass), B_{MSY} , F_{MULT} , and F_{BIO} . F_{MULT} is the fishing mortality rate for the fully selected ages or sizes in the stock at MSY. F_{BIO} is the ratio of the catch to stock biomass which is analogous to the fishing mortality in production models.

Yr	Bunfished	MSY	Bmsy	Fmult	Fbio
1950	0.384908E+04	0.102709E+03	0.116571E+04	0.961946E-01	0.881083E-01
1960	0.384908E+04	0.102709E+03	0.116571E+04	0.961950E-01	0.881087E-01
1980	0.384908E+04	0.101753E+03	0.112933E+04	0.182052E+00	0.901003E-01
1990	0.384908E+04	0.104045E+03	0.111497E+04	0.202506E+00	0.933169E-01
1999	0.384908E+04	0.104224E+03	0.111202E+04	0.209058E+00	0.937250E-01

Header
Year evaluated, B_0 , MSY, B_{MSY} , F_{MULT} , F_{BIO}

Format of MSY Detailed Output File

For each year evaluated, this file contains a header consisting of the first 7 lines, and then one line of data for each age in the simulated stock. The data for each age include 1) age, and 2) the emergent age-specific selectivity (SEL) for that age. Also for both MSY in number and biomass, 3) the emergent age-specific fishing mortality (F, sum of the total catch of all morphs for both sexes during the year divided by the initial sum at the beginning of the year, and corrected for natural mortality), and the number of fish harvested at age. The bottom of the output for each year summarizes various MSY statistics, including F_{MULT} , and F_{BIO} . F_{MULT} is the fishing mortality rate for the fully selected ages or sizes in the stock at MSY. F_{BIO} (labeled F(biomass) in the output) is the ratio of the catch to stock biomass which is analogous to the fishing mortality in production models.

MSY evaluations for selectivities in year				1950	
i age	SEL	AT MAXIMUM NUMBERS HARVESTED		AT MAXIMUM BIOMASS HARVESTED	
		F	N	F	N
0	0.0000	0.000	0.9780E+02	0.000	0.1138E+03
1	0.3707	0.069	0.8636E+02	0.036	0.1005E+03
2	0.5424	0.102	0.6282E+02	0.052	0.7559E+02
3	0.7362	0.138	0.4854E+02	0.071	0.6137E+02
4	0.8793	0.165	0.3755E+02	0.085	0.5077E+02
5	1.0000	0.187	0.2870E+02	0.096	0.4205E+02
6	0.9310	0.175	0.2153E+02	0.090	0.3456E+02
		.			
		.			
		.			
99	0.9310	0.175	0.1758E-09	0.090	0.7627E-06
100	0.9300	0.174	0.1336E-09	0.089	0.6310E-06
YIELD IN NUMBERS		0.4047E+02		0.3455E+02	
YIELD IN BIOMASS		0.8476E+02		0.1027E+03	
BIOMASS AT MSY		0.5012E+03		0.1166E+04	
FECUNDITY AT MSY		0.3604E+10		0.7370E+10	
F(biomass)		0.1691		0.0881	
Fmult		0.1875		0.0962	
RECRUITS		97.7979		113.7570	
SPR		0.24284		0.42694	

EQUILIBRIUM PRODUCTION OUTPUT FILE

Format of Equilibrium Production Output File (*.pmo)

The equilibrium production output file contains 103 lines per year evaluated. The first line identifies the year used to define the fishing selectivities for the analysis. The second is a header. The third line contains equilibrium recruitment and biomass for the unfished condition. The next 100 lines give equilibrium recruitment, stock biomass and catch in biomass at equally spaced intervals of fishing mortality between 0 and $F_{\text{EXTINCTION}}$. **Note that the fishing mortality rate in the output file is the ratio of the catch to stock biomass (F_{BIO}) which is analogous to the fishing mortality in production models. This differs from the annual fishing mortality rate (F) in the simulation model, which is applied only to the fully selected ages or sizes in the stock.**

1995					Year of fishing selectivities
Fbio	YOY	SPR	BIOMASS	CATCH	Header
0.0000	125.8199	1.00000	0.384908E+04	0.000000E+00	Fishing mortality, recruitment, SPR, Biomass, Catch
0.0048	125.2682	0.94216	0.355114E+04	0.169101E+02	
0.0096	124.7038	0.88953	0.328366E+04	0.313690E+02	
0.0144	124.1268	0.84147	0.304273E+04	0.437313E+02	
0.0192	123.5371	0.79744	0.282506E+04	0.542937E+02	
0.0241	122.9348	0.75699	0.262784E+04	0.633057E+02	
0.0290	122.3200	0.71972	0.244866E+04	0.709779E+02	
0.0339	121.6925	0.68528	0.228548E+04	0.774895E+02	
		.			
		.			
0.4242	10.4293	0.07226	0.142788E+02	0.605743E+01	
0.4275	8.3872	0.07109	0.113212E+02	0.484005E+01	
0.4308	6.3234	0.06995	0.841660E+01	0.362578E+01	
0.4340	4.2377	0.06883	0.556289E+01	0.241447E+01	
0.4372	2.1301	0.06774	0.275809E+01	0.120597E+01	
0.4404	0.0002	0.06667	0.311444E-03	0.137172E-03	

Note: plotpmo.exe will only plot the first year of data in the file. Other years may be plotted by copying the data for each year to a new file with a *.pmo file extension.

YIELD PER RECRUIT OUTPUT FILES

Format of Output File for Fishing Mortality Benchmarks

This file contains the benchmark estimates for $F_{0.1}$ and F_{MAX} in tabular form with one line for each year evaluated. F_{MULT} , F_{BIO} , SPR, and yield are given for each benchmark. F_{MULT} is the fishing mortality rate for the fully selected ages or sizes in the stock and F_{BIO} is the ratio of the catch to stock biomass which is analogous to the fishing mortality in production models.

Year	F0.1				Fmax			
	Fmult	Fbio	SPR	Yield	Fmult	Fbio	SPR	Yield
1949	0.0691	0.0681	0.5021	0.858E+00	0.1125	0.1103	0.3612	0.916E+00
1960	0.0691	0.0682	0.5021	0.858E+00	0.1125	0.1103	0.3613	0.916E+00
1970	0.0814	0.0722	0.4822	0.862E+00	0.1281	0.1147	0.3509	0.913E+00
1980	0.0822	0.0724	0.4816	0.861E+00	0.1293	0.1152	0.3502	0.912E+00
1990	0.0863	0.0744	0.4831	0.879E+00	0.1374	0.1196	0.3504	0.933E+00

Format of Yield per Recruit Output File for Plot (*.yro)

The first line of data for each year evaluated contains the year, model effort at $F_{0.1}$, Fmult at $F_{0.1}$, SPR at $F_{0.1}$, yield at $F_{0.1}$, model effort at F_{MAX} , Fmult at F_{MAX} , SPR at F_{MAX} , and yield at F_{MAX} . The model efforts are internal program variables and should be ignored. This is followed by a header, and 100 lines of data for the plot routine.

1949	0.114E+02	0.069	0.5021	0.858E+00	0.185E+02	0.112	0.3612	0.916E+00
Fmult	Fbiomass	Biomassyield	SPR					
0.5606E-15	0.0000E+00	0.0000E+00	0.1000E+01					
0.1000E-01	0.9935E-02	0.2606E+00	0.8875E+00					
0.2000E-01	0.1985E-01	0.4513E+00	0.7944E+00					
0.3000E-01	0.2974E-01	0.5913E+00	0.7160E+00					
0.4000E-01	0.3961E-01	0.6940E+00	0.6493E+00					
	.							
	.							
	.							
0.1049E+01	0.7428E+00	0.2798E+00	0.1224E-01					
0.1060E+01	0.7481E+00	0.2772E+00	0.1190E-01					
0.1070E+01	0.7533E+00	0.2746E+00	0.1158E-01					

Note: plotypr.exe will only plot the first year of data in the file. Other years may be plotted by copying the data for each year to a new file with a *.yro file extension.

REFERENCES

The following peer-reviewed papers were cited in the text of this manual or employed earlier versions of the FSIM code. These papers illustrate some of the problems to which the FSIM program has been applied.

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