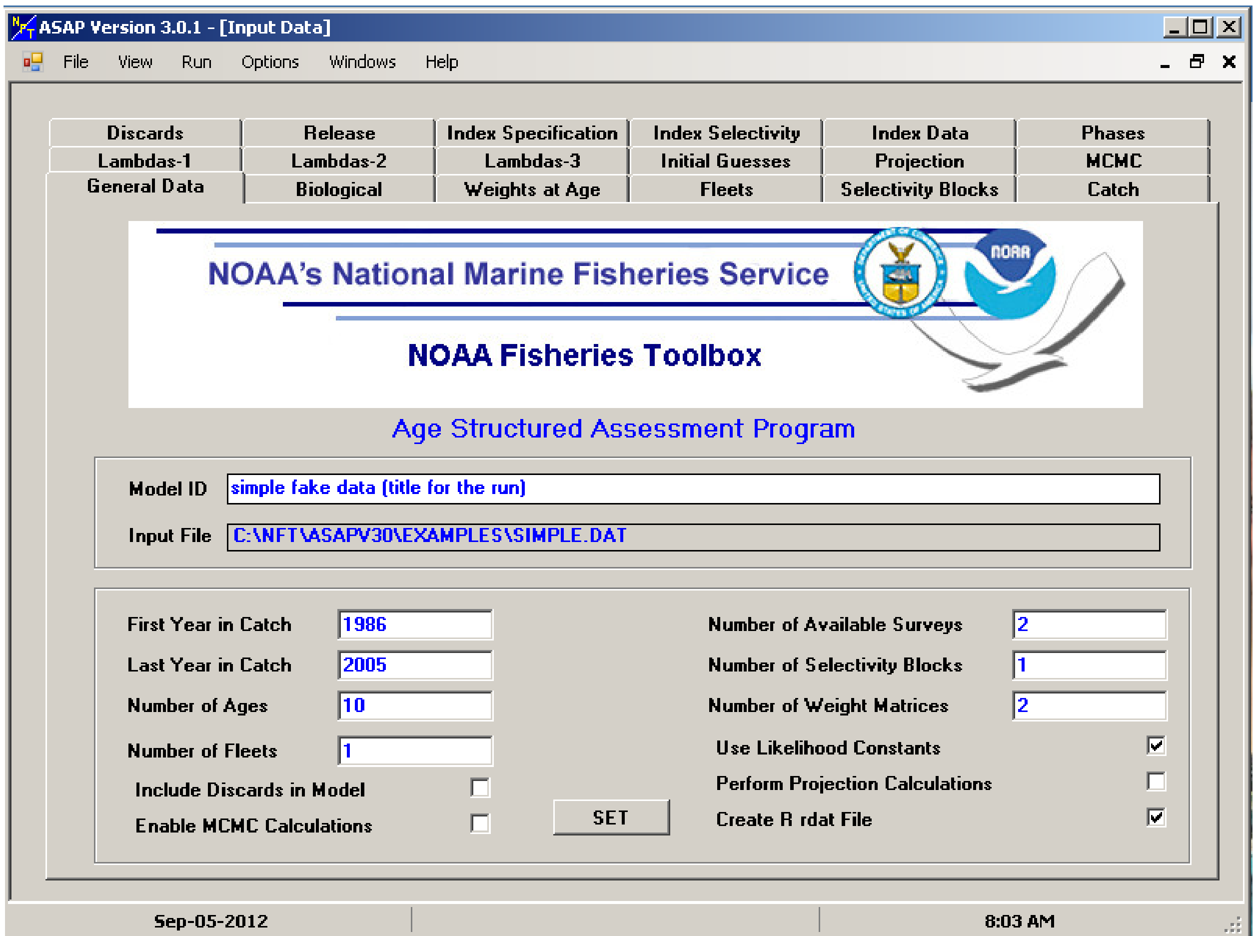
User Manual
for
ASAP 3

September 2012



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What’s New

There have been a number of changes to ASAP since the last release version 2.0. These changes are both structural and aesthetic, with an emphasis on usability. The main structural changes are in the stock recruitment relationship, weights at age, index fitting, and first year population at age estimation. The aesthetic changes are mainly in the improved graphical user interface (GUI) but also the optional production of a rdat file for use in the software package R. A file of R commands to make plots of standard diagnostics and model results is included in this release of ASAP. Version 2.0 ASAP files can be read into the GUI, but please check the settings to ensure that they are appropriate for your case. A number of additional error checks have been added behind the scenes to reduce the chances of bad input causing the program to crash (although this still can happen). Finally, previous limitations on files not being located in a directory with a space have been addressed so that all run modes can be used in any directory.

Introduction

This manual assumes a basic understanding of statistical catch at age modeling. A more detailed description of the ASAP program, along with the ADMB tpl code, is provided in the Technical Documentation for ASAP3 document. This manual is structured based on the GUI supplied as part of the NOAA Fisheries Toolbox. While the ASAP program can be run from the command line, the GUI provides guidance to the user in terms of which values are necessary and which can be ignored given a set of conditions, along with some additional checking of input values and nice graphics of the results. The GUI also allows easy MCMC usage, including the creation of a file for the AgePro software package in the NOAA Fisheries Toolbox, and easy examination of retrospective patterns.

Input

The following description assumes use of the GUI with sections on what is found in each tab and how they relate to each other.

General Data

The General Data tab contains the basic information necessary to dimension the problem; the range of years and number of ages, fleets, available surveys, selectivity blocks, and weights at age matrices. If any of these dimensions are changed, then the SET button must be clicked to ensure that data structures in all the other tabs are correctly resized. Changes must be made one at a time, with the exception that the first and last year in catch can be made together. However, multiple changes can be made in rapid succession, requiring only that the SET button is clicked between each change. When the number of fleets is reduced, a pop-up window will ask which fleet to remove but will not add the removed catch to any remaining fleet. Similarly, when the number of selectivity blocks is reduced, a pop-up window will ask which selectivity block to remove but will not fill in the year and fleet combinations where this selectivity block with a new selectivity block. The SET button does not need to be clicked when any of the boxes are checked or unchecked.

The user can enter as many surveys or tuning indices as they like and then select which ones to use in a particular run in the Index Specification tab. This facilitates running the model with and without given indices rapidly.

The user defines a number of selectivity blocks, which each contain their own parameters and initial guesses. The random walk approach to selectivity changes in the original ASAP is not supported to allow easier user control over the estimation process. For example, selectivity can now be fixed in the earliest and most recent years, but estimated in the remaining years, by fleet. The selectivity blocks are described more completely below in the associated tab.

The inclusion of discards as observations is determined through a check box. This means that when discards are combined with landings to produce total catch, as commonly done in many assessments, the user does not need to enter two large matrices of zeros as well as a number of other parameters. Checking the box means the user will provide observations regarding the total amount of discards and the proportions at age for the discards (in the Discards tab), as well as the proportion of fish caught which are released by age and year (in the Release tab). In this case, the catch labels refer to landings only, with the actual total catch derived as the sum of the input landings and discards. If the user had previously entered discards and now wants to remove them, unchecking the Include Discards in Model box will cause the GUI to write zeros in all the matrices in the Discards and Release tabs, so care should be taken when unchecking this box.

Full calculation of all likelihood terms in the objective function can be requested by checking the Use Likelihood Constants box. If this box is not checked, then the constants in the lognormal and multinomial error distributions will be ignored. Typically, this box should be checked. However, if the dimensions of the problem are very large, then these constants could cause the objective function to become impractically large (meaning an objective function value greater than say 1E8). Although in theory the inclusion of constants should not result in a different solution, because ADMB relies on numerical approximation to find the parameters with “zero” derivatives, the constants in effect create a slightly different solution space compared to not including the constants, and thus can arrive at a different solution. However, large differences in solutions between cases with and without the constants have not been found so far.

The Perform Projection Calculations box allows the user to conduct simple projections (see Projections section below). The original ASAP always conducted at least one year of projection. Not running projections causes quicker run times.

Checking the Enable MCMC button enables the MCMC tab where parameters for simple Monte Carlo Markov Chain (MCMC) runs can be entered. Note that even though this option is selected, it is only by choosing Run ASAP MCMC in the run menu that it will be performed (see Running the Model below).

The new feature added in ASAP3 in the General Data tab is a check box to create a rdat file for use in the software package R. This was available in ASAP2 as a pull down menu item that scanned in the results of a run. The tpl for ASAP3 now incorporates the ADMB2R package created by Mike Prager and others so that the rdat file can be created when the executable is run outside the GUI.

Biological

The Biological tab contains three sub-tabs: Natural Mortality, Maturity, and Fecundity. The first two are simply year by age matrices. The Fecundity sub-tab contains the same option as the original ASAP regarding the use of spawning stock biomass (select Multiply Maturity by Weight at Age) or fecundity (select Use Maturity Values Directly and enter eggs per adult in the Maturity sub-tab). In the Fecundity sub-tab is the definition of when during the year spawning occurs. The estimated population will be reduced by that proportion of total mortality for each age and year prior to calculating the spawning stock biomass (or number of eggs if Use Maturity Values Directly option selected). Note that ASAP3 does not distinguish males and females, so if only female spawning stock biomass is desired then the maximum proportion mature should be the sex ratio at age.

Weights at Age

The Weights at Age tab has been restructured in ASAP3. The user now enters as many year by age matrices of weights at age as et in the General Data tab. The user then associates which of the matrices to use for each of the fleets catch and discards, as well as the calculation of spawning stock biomass and January 1 biomass. The catch all fleets and discards all fleets matrices are used in the calculation of yield per recruit and projected yields. The fleet specific catch and discards weights at age matrices are used in computing the total weight caught in the Catch and Discards tabs. The SSB weights at age matrix is used to calculate the spawning stock biomass (SSB), if selected in the Fecundity sub-tab of the Biology tab. The JAN-1 Biomass weights at age matrix is used to compute the Jan-1 Total Biomass output as well as in the biomass average for Freport (see below). These weights at age matrices are also used for indices (see Index Specification below). The user can enter weights at age matrices that are not used at all to facilitate comparison among different measurements or assumptions. A single weights at age matrix could be used for all calculations if that is all the available data supports.

Fleets

For each fleet, a number of specifications are entered in top portion of this tab: a name for the fleet (although this can be a long character string containing spaces, it is best to use short names for ease in reading the output in the GUI), selectivity starting and ending ages, release mortality (only applicable if Include Discards in Model box is checked in the General Data tab), and a fleet directed flag. The staring and ending ages for selectivity determine which ages are used when comparing the observed and predicted proportions catch and discarded at age. These ages also determine the ages over which the total catch and discards in weight are computed. Thus, the starting and ending ages will commonly be 1 and the maximum age, with the exceptions being cases where specific fleets never catch young or old fish. The release mortality is actually the proportion of fish that are released which die, meaning 0.10 should be entered if 1 out of every ten released fish is expected to die. The Fleet Directed Flag is set to one when the fleet targets the stock and set to zero when the fleet catches the fish only as bycatch. This distinction is important in terms of calculating the fishing mortality reference points and projected yield. If in doubt, set all fleet directed flags to one.

The Selectivity Block Assignment portion of the Fleets tab contains sequential integers which define the years and fleets where selectivity is the same. The blocks will almost always be sequential years within a fleet, but two fleets could be assumed to have the same selectivity for a number of years.

The final information entered on the Fleets tab relates to the Average F feature of ASAP whereby a starting and ending age define a range of ages for which to report the total fishing mortality rate. The output will provide all three possibilities for weighting these ages each year: unweighted, weighted by population abundance in numbers, and weighted by population abundance in biomass. However, the fishing mortality reference points will only be computed according to the weighting option selected in the drop-down box. The .std and MCMC output files will only report the average F for the weighting option selected here as well. This average F approach is similar to the one in the NOAA Fisheries Toolbox Virtual Population Analysis program and facilitates comparison of fishing mortality rates over years when selectivity patterns or fishing intensity by different fleets change. Since the output contains fishing mortality matrices by each fleet, other types of weighting can be done by hand as well.

Selectivity Blocks

Each block is entered one at a time controlled by the Selectivity Block drop-down box. For each block, there are three selectivity options: By Age, Single Logistic, and Double Logistic. Depending on the choice made in the Selectivity Options drop-down box, the Selectivity Specification area will change to show only the type of data needed. For example, when By Age is selected, ages 1 through max age will appear as rows in the Selectivity Specification. The single and double logistic function parameters are entered in order A50 and slope (ascending first then descending for double logistic).

Whichever Selectivity Option is chosen, there are four columns of information to be entered: Initial Guess, Phase, Lambda, and Coefficient of Variation. The initial guess is self-explanatory. If the phase is set to a negative value, the initial guess will be held fixed throughout the estimation process. Note that any combination of estimated and not estimated parameters is allowed. However, when By Age is selected it is recommended that at least one age be fixed (preferably an age with selectivity one) to reduce correlations in parameters. This is because the separable assumption means that a given vector of F at age can result from an infinite combination of Fmult and selectivity values if none of the selectivity values are fixed. For example, F at age = (0.1,0.2,0.4) can be formed by Fmult=0.4 and selectivity=(0.25,0.5,1.0) or by Fmult=0.8 and selectivity=(0.125,0.25,0.5). The lambda determines if the objective function will have a term containing the difference between the initial guess and the final estimate for that parameter. Thus, if the phase for a parameter is turned off, the lambda should be set to zero. The coefficient of variation (CV) determines how closely the final estimate should match the initial guess (log scale). The CV is ignored when lambda is set to zero.

Catch

Catch information is entered by fleet according to the drop-down box at the top of the tab. For each fleet, the Catch at Age contains the information that will be used to create the observed proportions at age. Proportions can be entered here directly, or the catch at age in numbers can be entered and the program will compute the proportions. The Total Weight for each year will often be in units of metric tons. Note that the units for the estimated numbers at age in the population will be determined by the units used for the catch weight matrix (on the Weights at Age tab) and the units used for total weight here. For example, if catch weight at age is in kg and total weight it in metric tons, then the units for the population numbers at age will be thousands of fish.

Discards

The Discards tab is arranged exactly like the Catch tab. If discards are entered on this tab, then the catch tab should have only landings entered, do not enter catches twice. Only dead discards should be included in this tab, not discards that survive.

Release

The release tab is also entered fleet by fleet, similar to the Catch and Discards tabs. However, only the proportion at age and year released is entered, there is not a second entry box. These proportions will determine the fate of catches. The number released will be multiplied by the release mortality to produce the number of predicted discards to compare to those entered in the Discards tab.

Index Specification

Ten pieces of information for each index are entered on the Index Specification tab. The Index Tag is the name for the index, which will appear in some GUI plots and selection options. A new feature of ASAP3 is the ability to mix and match the units for each index when fitting the overall index and the proportions at age. The drop-down selections clearly show whether biomass or numbers are the units for each part of each index. Selecting biomass means that the predicted numbers at age will be multiplied by the weights at age matrix (column8 labeled Weight Matrix) when computing either the total aggregate index or the proportions at age. In the Month column, the start of a month is used to determine the timing of the index during the year (January 1 is entered as 1, December 31 is entered as 13). The Selectivity Link to Fleet allows the selectivity for an index to depend on the selectivity of one of the fleets, for example due to the index being a catch per unit effort from that fleet. If the index is linked to a fleet, enter the fleet number here as a positive value. If this is not the case, enter negative one. The Selectivity Start Age and End Age determine the age range to which this index applies. Indices can come from all ages, a subset of ages, or from just a single age. The single age option could be a recruitment index or an age-based index similar to many VPA applications. If the latter is the case, then the start and end age will be the same number. Checking the Use Index in Estimate box will cause that index to be used in the tuning process, while leaving it blank means it will be ignored. Note that at least one index should be used to tune the assessment. Finally, a new feature of ASAP3 is a check box to clearly define whether or not to Estimate Proportion at Age. This box should never be checked when the start age and end age are the same. This box allows the user to clearly tell the program whether or not to include the proportions at age component of each index in the objective function. Please note that the GUI will write zeros for the age proportions and sample size in the Index Data tab and not display these values when the box is not checked (meaning don't play around with this check box because you'll lose your data).

Index Selectivity

The Index Selectivity tab is arranged similarly to the Selectivity Blocks tab, whereby each index is entered one at a time with the three options for selectivity. When Selectivity Start Age is the same as Selectivity End Age in the Index Specification tab, the GUI automatically sets the Selectivity Option for that index to By Age and fills the initial guesses with zeroes for all ages except the Start (=End) age which it fills with a one, sets the phases for all ages to negative one, all lambdas to zero and CV to one. The user does not need to change this information for age specific indices. When Selectivity End Age is greater than Selectivity Start Age, then the three selectivity options all apply as in the Selectivity Blocks tab. A note appears under the selectivity option drop down box when an index is linked to a fleet. In this case, the selectivity option is irrelevant, but whichever option is selected the user should ensure that all phases are set to negative values.

Index Data

The Index Data tab also treats information for each index separately using a drop-down box at the top of the tab. When the Estimate Proportion at Age box in the Index Specification tab is not checked for an index, the only information that needs to be entered are the annual values and associated coefficients of variation which determine how closely the model will try to match the index values. When the Estimate Proportion at Age box is checked, then proportions at age along with an effective sample size must also be entered for each year. The GUI will automatically hide these columns if they are not required and set all the values in the hidden columns to zero. If the GUI is showing these columns, then the information in them will be used in calculating the objective function. If index selectivity parameters are estimated, but all effective sample sizes for that index are set to zero, the only information to estimate the parameters is the aggregate index, which can often be fit using a wide range of selectivity parameters. Thus, the program may crash or be unable to invert the Hessian if the user does not provide proportion at age information and positive sample size for at least one year.

Phases

Phases are used in ADMB to help the model get into the correct solution space using a limited number of parameters and then slowly adding parameters. Negative values mean that a parameter is not estimated, but rather fixed at its initial guess. Positive integers are used to determine when in the estimation process a given parameter becomes estimable. All parameters from previous phases are still estimated as the program moves to the next phase. Generally, it is recommended to set the scaling parameters to early phases and deviation parameters to later phases, when estimated.

Lambdas

The following three tabs all deal with how much emphasis to place on different portions of the objective function. A lambda of zero means that portion does not add at all to the objective function. In most cases, it is considered best practice to set all non-zero lambdas to one for base case runs and use a range of lambda values for a specific component to conduct sensitivity analyses. Note that in the original ASAP lambdas could mean either a weighting or an implied coefficient of variation. This ambiguity has been removed in ASAP3 where all lambdas mean emphasis factor and all components have an explicit CV. As described in the Technical Documentation, all input CV values of zero are replaced automatically by the program with a value of 100 to prevent taking the logarithm of zero or dividing by zero. Care should be taken by the user to input reasonable CV for all components with non-zero lambda.

Lambdas-1

Here the control of the total catch and discards in weight information is entered. A button at the top of the tab shows whether catch or discards are being entered at the moment. The first piece of information necessary is the CV, or how closely the model should try to fit the observed total catch (or discards) in weight each year for each fleet. Note that large CV values for large components of the total catch can cause the model to become unstable. The second matrix is the input effective sample size which is used in calculating the contribution to the objective function from the proportions at age for catch or discards. Entering a zero for a fleet and year combination means those proportions at age will be ignored. General rules of thumb for non-zero effective sample sizes are 50-200, although particularly bad or good sampling can lower or increase this range, respectively.

Lambdas-2

This tab contains the recruitment information. The lambda for recruitment deviations refers to the deviations between the recruitment predicted from the Beverton and Holt stock recruitment relationship and the estimated recruitment in that given year. Setting the lambda to zero means the model will be unconstrained with respect to estimating recruitment, provided the phase for recruitment deviations in the Phases tab is positive. This is not recommended, as solutions with one extremely large cohort often result. Instead, set the lambda to one and then use a large CV if the desire is to have minimal constraint on recruitment estimates. The annual recruitment CVs can also be used to cause the model to estimate recruitment directly from the B-H curve, for example in early years when no age information is available, by setting the CV to a small value, such as 0.001.

Lambdas-3

There are three separate sections on this tab, which depend on whether the components are fleet based, index based, or neither. For each component, a lambda is entered and an associated coefficient of variation.

Typical settings for the first box are to enter 1 for Lambda for Total Catch in Weight, 1 or 0 for Lambda for Total Discards in Weight depending on whether discards are included or not, respectively, 0 for Lambda for F-Mult in First Year (no constraint on this parameter estimate), a positive value such as 0.9 for the CV for F-Mult in First Year (this is ignored if the previous lambda is zero), 0 for Lambda for F-Mult Deviations (no constraint on how much F can change from year to year), a positive value such as 0.9 for CV for F-Mult Deviations (this is ignorned if the previous lambda is zero).

Typical settings for the second box are to enter 1 for each index (this means that no index is artificially given more weight than any others and the degree of fit among the indices will be determined by the index CVs entered in the Index Data tab), 0 for Lambda for Catchability and Lambda for Catchability Deviations (no constraint on these parameter estimates), a positive value such as 0.9 for the CVs (these are ignored if the lambdas are zero).

Typical settings for the third box are 0 for all three Lamdbas (meaning no constraint on the estimates) and a positive value such as 0.9 for the CVs (these are ignored if the lambdas are zero). It is not uncommon to find that there is insufficient information to estimate both stock recruitment parameters freely. When this happens, typically there are two different approaches used. Either the steepness parameter is fixed at 1 in the Initial Guesses tab and the phase for steepness set to a negative value in the Phases tab to cause the stock recruitment relationship to be a horizontal line or else a prior is put on the steepness parameter (the Lambda for Deviation from Initial Steepness is set to 1 and the CV is set to a positive value) determined by a meta-analysis.

Initial Guesses

Values to start the program are entered in this tab. When the phase for the associated component is set to zero, these values will be held fixed throughout the estimation. Note that all the values entered are in normal scale, as opposed to the original ASAP which required log scale values to be entered. There are two new features of ASAP3 in this tab. The Numbers at Age in 1st Year can be estimated as deviations from an exponential decline (as was done in ASAP2) or from these initial guesses (as was done in the original ASAP) through the use of the radio button at the bottom of the page. Note that this choice is irrelevant if the Phase for N in First Year is negative in the Phases tab. The second new feature in this tab is the ability to define the scaler in the stock recruitment relationship as either unexploited spawning stock biomass (as it was in ASAP2) or as unexploited recruitment (as is more commonly done in other statistical catch at age models). These two unexploited values are related by the unexploited spawners per recruit calculated using data from the last year in the available time series (S0 = SPR * R0).

Projections

When projections are conducted, the number of years to project is determined by the top box. For each year, recruitment can either be directly from the stock recruitment relationship (enter negative one) or else be a user supplied value (any positive value). The rule for each year is one of five options:

1. match an input yield (entered in Target Value column)
2. fish at a specified F%SPR (the SPR, value between zero and one, entered in Target Value column)
3. fish at Fmsy (Target Value ignored)
4. fish at the current F (Target Value ignored)
5. fish at an input F (entered in Target Value column)

The final column is a multiplier for the bycatch fisheries to control whether they remain the same (1.0), increase (value > 1.0) or decrease (value <1.0) in the projection years. These are simple, deterministic projections. For stochastic projections, the program AgePro is recommended with output from ASAP3 provided through the MCMC option.

MCMC

Monte Carlo Markov Chain (MCMC) is a common approach to estimate uncertainty in models. A complete description of the pros and cons of the method are beyond the scope of this manual. A simple MCMC call is implemented in the GUI requiring three values to define its operation: the number of MCMC iterations to output, the thinning factor for the MCMC algorithm, and a random number seed. The GUI will compute the total number of MCMC calculations as the product of the first two values above and then save only one value for every of the second value. For example, if 1000 MCMC outputs are desired and the thinning rate is set at 200, there will be 200,000 total MCMC calculations. The thinning rate should be set to a relatively large value to avoid autocorrelation in successive MCMC calculations, specifically it should be larger than the total number of estimated parameters. The random number seed should be a large positive integer.

The MCMC calculations create two output files: filename.mcm containing the F and SSB time series along with the MSY related reference points, and filename.bsn a file in the same format as the VPA bootstrapped numbers file for use in AgePro. This file for AgePro contains a number of realizations from the MCMC of numbers at age that can be used to start a stochastic projection. The file for AgePro can use either the final year in the stock assessment, which would be appropriate if an extra year of catch had been added to the regular series so that indices for early in the year could be applied, or else use the final year plus one, the standard approach. Once this choice is made, there are two or three options for how to enter the numbers at age 1 in the AgePro file. The first option is to use the model estimate of numbers at age 1, this is only available when the final year in the stock assessment is option is selected. The other two options for age 1 are available for both MCMC year options. The second age 1 option is to use the predicted value from the stock recruitment relationship. The third age 1 option is to use the geometric mean of previous years, which requires entering a start year and end year for the calculation of the geometric mean.

Running the Model

The ASAP3 program can be run in three distinct ways: the basic run, with MCMC, and with a retrospective analysis. These three options are available in the Run menu, and each has a corresponding ability to scan back the results of a previous run, so that a long run does not need to be repeated. The basic run conducted the standard ADMB minimization of the objective function and outputs the report file along with a number of helpful graphics in the GUI (described below in detail). The ADMB .std file of approximate standard errors from the Hessian for all parameters and a number of derived variables is also produced. Running ASAP3 with MCMC produces Monte Carlo Markov Chain estimates of uncertainty for the F, SSB, and Jan-1 biomass time series as well as the MSY related reference points and a file for input to the AgePro projection program. Running ASAP3 with a retrospective analysis produces a number of input and output files, the results of each can be viewed individually by opening them in the GUI, and summarizes how the estimates of F, SSB, Jan-1 biomass, exploitable biomass, and N at age change as years of data are removed from the model. This retrospective analysis can help identify problems in the data and assumptions that cause successive estimates to be biased as years of data are added or removed. Strong retrospective patterns are considered a red flag for an assessment and can be the basis for rejecting an assessment.

It is recommended that users rename the input file for each of the three options. This is because the scan feature will only work with one option at a time for a given input file, even though the files are available for each of the options. For example, if the basic run is called greenfish.dat, then save as greenfishMCMC.dat before running the MCMC option and save as greenfishretro.dat before running the retrospective option. Note that the program can be run in all three modes if the input file is located in a directory path which contains a space (e.g. on the desktop).

Output – Diagnostic Results

The output description is arranged by the tabs in the GUI for the two sets of output information: diagnostic results and model results. This separation was made to allow working groups to examine the diagnostics of different runs without being influenced by the model results. The user can switch back and forth between diagnostic and model results using the Windows pull down menu at the top of the program.

Model Fit Summary

This tab contains a summary report of the different components comprising the total objective function. Fleet and index specific results are further supplied in the report file, but are not shown here to reduce the number of components shown in the table. These totals are reflected in the lambda values, which are the sum over fleets and indices. Note that if the Hessian could not be inverted, then a warning message will show on this tab "Warning !! Model Not Converged". The diagnostic and model results for the run will still be displayed in the GUI, but these should only be used to determine what went wrong with the model run and to guide changes in the input formulation.

Catch & Discard ESS

A plot compares the input and estimated effective sample size (ESS) by year for each fleet for both catch and discards. The estimated ESS is based on the approach described in McAllister and Ianelli (1997 CJFAS 54: 284-300). A final assessment should have some similarity between the input and estimated ESS, although the values for each year are not expected to be exactly the same (see usage hints below).

Annual Catch & Discards

Time series plots for each fleet comparing the observed and predicted total catch or discards in weight or else the standardized residuals of these values. Standardized residuals are computed in log space based on the user input CV for each catch or discard value.

Catch & Discards at Age

Proportions at age for catch or discards by fleet and year are plotted as observed and predicted values in this tab. Note that the header of the graph provides the input effective sample size for that fleet and year. When input ESS is zero (see subtitle on each graph), the comparison between observed and predicted proportions at age is not meaningful because it has no impact on the objective function. At the bottom of the Year pull-down menu is a total which computes an average proportion at age for both observed and predicted values from only years for that fleet when input ESS is greater than zero. This is a simple overall comparison that has no meaning in terms of the objective function, but provides a quick summary of how well the fleet is fit over all years included in the fitting process.

Index Fit

Time series plots for each index comparing the observed and predicted index values or else the standardized residuals of these values. Standardized residuals are computed in log space based on the user input CV for each index value.

Index Proportion at Age

Similar to the Catch & Discards at Age, except the data is for the index proportions at age observed and expected. At the bottom of the Year pull-down menu is a total which compares the average proportions at age for all years with input ESS greater than zero. This is a simple comparison with no meaning in terms of the objective function, but provides a quick summary of how well the index proportions at age are fit over all years included in the fitting process.

Deviations

This tab compares the observed and predicted values (when meaningful) and provides the standardized residuals in log space based on the input CV for stock at age in year 1, F-Mult in year 1, F-Mult deviations, catchability in year 1, catchability deviations, steepness, and the stock recruitment scaler. When these deviations are not included in the objective function (phase turned off and/or lambda set to zero), blanks are shown in the results table. When stock at age in year 1 has lambda greater than zero, this tab also shows a plot comparing the observed and predicted values or the annual standardized residuals.

RMSE Table

The root mean square error (RMSE) computed for each set of residuals is presented in this table along with the number of residuals. See Usage Hints section below for possible ways to use this information.

Stage 2 Multipliers for Multinomials

The multipliers are estimated based on Method 1.8 of Francis (2011, CJFAS 68: 1124-1138). They are computed such that the stage 2 input effective sample sizes are equal to the current input effective sample sizes times the multiplier. Thus, a value of 1 leaves the input sample size unchanged, while values greater than 1 increase the input sample size and values less than 1 decrease the input sample size. Francis (2011) recommends only applying these multipliers once after all other model formulations have been determined. The New Input ESS values are the result of applying these stage 2 multipliers to the original input ESS (rounded to the nearest integer) and can be copied into a new input file.

Applied ESS

Time series plots comparing the input effective sample sizes and the resulting effective sample sizes after application of the Francis (2011) stage 2 multipliers. Note that the stage 2 applied values have not been rounded in these plots, so can be used to detect if a positive value has been rounded down to zero (something that should be avoided generally).

Output – ASAP Model Results

This section of the output is devoted to the model estimates that are of most interest to the final stock assessment. Please visit the Model Diagnostics first to ensure that a reasonable model fit has been obtained before examining the model results.

Reference Points

A number of common fishing mortality based reference points are provided:

- F0.1: F corresponding to Y/R with 10% of slope at the origin
- Fmax: F corresponding to maximum yield per recruit
- F30%SPR: F corresponding to 30% of unexploited spawners per recruit
- F40%SPR: F corresponding to 40% of unexploited spawners per recruit
- Fmsy: F corresponding to maximum sustainable yield (the associated spawning stock biomass and yield are also provided below the table)

All five reference points are calculated assuming the selectivity pattern, weights at age, natural mortality rate, and relative fishing intensity among fleets in the terminal year of the assessment. Note that if selectivity varies over time, due to either selectivity blocks or use of multiple fleets with changing relative intensities, the reference points in this table are not directly comparable to years other than the terminal year. The final column in the table provides a slope that can be plotted on the stock recruitment relationship (outside the GUI), its intersection with the stock recruitment relationship is the expected equilibrium point for that F.

Stock Recruitment

Parameters of the estimated or assumed stock recruitment relationship are presented along with a graph. Estimated steepness values close to one are an indication that the stock recruitment relationship could not be estimated well internally. This makes the MSY related reference points not informative.

The graph can show three different plots. The first type is the stock recruitment relationship itself, with both the underlying Beverton and Holt curve (denoted predicted) and the estimated recruitment values for each year (denoted observed). The second type shows the standardized residuals by year, calculated as (ln(obs)-ln(pred))/(recruitment sigma). The third type is a new feature of ASAP3 and plots the annual unexploited SSB and recruitment pairs to demonstrate the amount of variability in the SSB weights at age matrix, maturity, and natural mortality. If all three of these factors do not change over time, then the annual values will all equal the values presented in the table. However, if any of the three factors change over time, the unexploited values of SSB and recruitment will reflect these changes. This has been added to help the user understand the significance of changes in these factors over time and how they might impact biological reference points (see the report file for the corresponding time series of steepness and unexploited spawners per recruit).

Catchability

Index specific catchability coefficients are plotted over time for all years where positive index values were entered. This plot is typically only used when catchability deviations are allowed so that catchability changes over time, otherwise it will simply be a flat line showing which years had information for each index.

Time Series Plots

There are (six plus the number of fleets) time series plots presented in this tab: total stock numbers, spawning stock biomass, Jan-1 biomass, exploitable biomass, estimated recruitment (denoted observed recruitment), recruitment expected from the stock recruitment relationship (denoted predicted recruitment), and F-mult for each fleet. The spawning stock biomass, Jan-1 biomass, exploitable biomass, and observed recruitment plots also show the estimated uncertainty based on the .std file of plus and minus one standard deviation.

Directed F

Directed, but not discard, fishing mortality at age and year by fleet is plotted in this tab. This allows comparison among fleets of the fishing mortality associated with the landings both in trend and magnitude over ages and years.

Total F

Similar to the Directed F plots, but now combining all fleets and including both directed and discard F. This plot represents the total impacts of fishing on the stock by age and year.

Average F

When multiple selectivity blocks are operating, it can be difficult to compare the impact of fishing mortality among the blocks, especially when the blocks are associated with different fleets and have different types of selectivity (e.g. flat-topped vs domed). The approach used in virtual population analysis, where selectivity freely changes every year, is to select a range of ages deemed representative of the fishery and compute an average fishing mortality rate for these ages. This approach is used in ASAP3 as well. The average F is computed three ways: an unweighted average over the age range, weighted by associated population abundance in numbers (N-weighted), or weighted by associated population abundance in biomass (B-weighted). When selectivity is the same for the age range selected, these three average F values will be the same. However, when the selectivity differs by age within the age range selected, the values can be quite different. Typically, the three values will track each other quite well. Cases where this does not happen should be examined in more detail to determine which weighting approach is most appropriate.

Stock Numbers

The population numbers at age and year matrix can be viewed two ways in this tab: at age for a specific year or over all years for a specific age. The check box to set the y-axis to maximum in all years can be helpful for detecting large cohorts passing through the matrix.

Selectivity

Two types of selectivities are shown in this tab: fleet specific and index specific. The fleet specific selectivity plots are three dimensional showing changes over both age and year (year specific values depend on the selectivity blocks defined on input). The index specific selectivity plots show only selectivity at age under the assumption that all years have the same selectivity. This assumption is broken when an index selectivity is linked to a fleet selectivity, in which case only the first year selectivity is shown in the plot and the user must examine the correct fleet selectivity associated with that index.

Projection

This tab provides in graphical form all the output related to ASAP3 projections. There are seven plots with age as the x-axis and separate lines for each projection year: population numbers, directed F, bycatch F, non-directed F, catch (in numbers), discards (in numbers), and yield (in weight). These plots are followed in the drop down list by four plots with year as the x-axis summarizing annual totals: total yield (in weight), total discards (in weight), spawning stock biomass, and the ratio of spawning stock biomass to SSBmsy. Note that the projections in ASAP3 are relatively simple and do not include the uncertainty of current abundance at age or future recruitment. Use of AgePro (available in the NOAA Fisheries Toolbox) is recommended for more advanced stochastic projections.

So What Do I Do Now? (aka usage hints)

One way to get started quickly with ASAP3 is to import a virtual population analysis input file. This option is available under the File pull-down menu and assumes the latest NOAA Fisheries Toolbox VPA software was used to create the VPA input file. The import will create an ASAP3 input file that should run. However, the conversion program is relatively simple and users should carefully examine all inputs to ensure they are correct, especially lambda and CV values.

Another easy way to get started quickly is to open an input file created by ASAP2. The GUI will fill in default values for all required inputs. However, users should carefully examine these defaults to ensure they are consistent with desired formulations. Alternatively, a file can be created from scratch by filling in the dimensions on the General Data tab, clicking the set button, then working through the tabs in order filling in all required information. Note the file cannot be saved until information is entered in all tabs.

A file called “asap3input.log” is created each time the program is run. It reproduces the input as the input file is read and can be used to find problems in the input file itself. If the “asap3input.log” contains different information that your input file, it means an error was encountered while reading the input file. This should not happen when the GUI is used, but can occur if the input file is edited by hand outside the GUI.

As with all statistical catch-at-age models, there are many possible ways that the estimation process can produce unreliable results. If the model is not able to estimate the hessian (.std file not produced), this is an indication that the minimization of the objective function encountered a problem and results are suspect. This can happen when parameters are estimated but no data are provided to inform the estimation, for example, if an index selectivity is estimated but all the input effective sample sizes are zero for that index. Careful review of input settings should allow detection of this problem. Alternatively, changing the number of parameters estimated (by setting phases negative) can allow determination of which parameters are causing estimation problems. Using lambdas with loose CVs can sometimes allow estimation of parameters in cases when unconstrained estimation does not work.

Once a model does run to completion and the hessian is inverted, there is still a question regarding the suitability of the model. Standard diagnostics, such as runs of residuals, should of course be examined. If no standard diagnostics show a problem, then next step is to determine if the model inputs and outputs are compatible. A fully compatible model will have the input CVs exactly matched by the uncertainty in the output fits. This can be seen in both the effective sample sizes and the standardized residuals of fits. In reality, neither will ever match exactly due to random chance and model misspecification (all models are simplifications of reality), but the overall level should be compatible. When comparing the input and output effective sample sizes, the pattern and overall magnitude should be similar. However, there will be occasional cases when the output effective sample size becomes very large relative to all other years. This is just an artifact of the calculation of output effective sample size and can be ignored. The Francis (2011) stage 2 multipliers for effective sample sizes can also be examined. If they differ greatly from 1.0, then an additional run can be made with the new ESS copied into the appropriate input. Note that Francis (2011) does not recommend continued application of these stage

2 multipliers as the results can continue to increase or decrease with repeated application of the calculations.

The standardized residuals should all follow a normal distribution with mean zero and standard deviation one, meaning approximately 95% of the observations should fall within plus or minus 1.96. Another way of summarizing the standardized residuals is to compute the root mean square error (rmse) for the set of residuals. An infinite sample drawn from a N(0,1) distribution has rmse equal to one. However, when sample sizes are limited, as they often are in fisheries assessments, rmse values drawn from a true N(0,1) distribution can have a relatively wide range (Table 1 and Figure 1). This means that the goal of "tuning" an assessment should not necessarily be to get the rmse to exactly one, but rather to have the rmse fall within the confidence bounds associated with a N(0,1) distribution for that sample size. These sample sizes and rmse values are provided in the GUI output to help guide the "tuning" of the assessment. For example, if rmse is too low, the CV can be reduced, while if the rmse is too high, the CV can be increased. Alternatively, the model can be restructured such that the input and output CVs coincide. The former ad hoc approach to tuning is used in many assessments, but has also been criticized by some for its irreproducibility. The latter approach is preferred, but may not be achievable if the input CV's are too tight relative to all possible models due to the lack of process error in their calculation. This topic remains an active area of research in fisheries stock assessment.

Once a set of parameters have been found which appear to be reasonable, it is recommended that a series of sensitivity runs be conducted to examine how sensitive the results are to some of the input choices. One way to do this is to conduct a likelihood profile over a range of possible values for a parameter. Either of the stock-recruitment parameters are often useful for this exercise, as is changing the natural mortality matrix by a constant amount for all years and ages. Fix the parameter at a range of values both above and below the estimated value and compare the objective function components. This exercise will often identify which pieces of information are in agreement, the objective function components follow a similar trend, and which pieces of information are in conflict, the objective function components are minimized at different parameter values and follow different trends. This is often useful to help define specific sensitivity analyses which either remove or significantly downweight specific pieces of information to show how influential they are on the final result. Stock assessments with highly conflicting basic data will require either choosing one set over the other or else provision of advice based on both possibilities.

The file of R commands distributed with the GUI produces a large number of graphs and csv files which can be used as diagnostics or to compare results from different formulations. The script is written such that the user only has to change seven items at the top of the file. However, users familiar with R can see all the functions used to create the plots and csv files. These functions were created to simplify their replacement as improved graphics or diagnostics are developed. If you modify a function or create a new one, please feel free to send the function to Chris.Legault@noaa.gov or Liz.Brooks@noaa.gov for possible inclusion in future releases of the program. While many of the GUI graphs are replicated in the R script, there are a number of additional plots. One additional feature of note is the calculation of annual F reference points. Care should be taken when examining the output of the R script for the F reference points because both F.full and F.avg are reported. The meaning of F.full is the maximum F at age within that year when all sources of fishing mortality from all fleets is combined into the total F at age matrix. This differs from the Freport and F.avg values, which are synonyms and described above in this manual.

Due to continued confusion regarding the meaning of different lambdas in ASAP, Liz Brooks kindly provided the following text to help users understand their use.

Priors versus Weighting factors.

Lambdas can be used in two different ways to contribute to the overall objective function. Lambdas premultiply quantities comparing observed and predicted values (likelihoods). In this case, they act as weighting factors that increase or decrease how important the fit to those data are in the overall scheme of things. It is important to realize that if you change the weighting factors between model runs, then you lose the ability to use the total objective function value as a tool to identify the "better" model.

Lambdas can also be used to penalize the model from estimating a parameter away from a value that you believe to be a reasonable solution; in this case, if the lambda associated with that parameter is >0, then you have effectively specified a prior for that parameter and the value of lambda will determine how large of a penalty will be added to the objective function if the model moves away from the prior.

Analogy: Consider a simple linear regression. You observe $\{Y_i\}$. You then fit a model and estimate a slope (a) and intercept (b) and obtain predicted values $\{\hat{Y}_i\}$. You refine the estimates of a and b by minimizing the difference between the observed and predicted values (in this simple example, the sum of squares is the likelihood). You could apply a weighting factor but since there is only one quantity being minimized, it would have no effect. In this example, a and b are freely estimated; you do not observe a and b. If you had a strong hypothesis, or evidence from previous experience, that suggest that the intercept should be 2.4, then you could put a prior on the parameter a and refit the model by summing the likelihood (SS between Y_i and $\hat{Y}_i$) and the prior.

In ASAP, this simple analogy could be applied to fitting age composition data and estimating selectivities. Age composition data are observed, and they are also predicted based on the selectivity parameters that you estimate. The effective sample size (ESS) is the weighting factor. You don't actually observe selectivity parameters, they are more like the slope and intercept terms in the simple linear regression; they merely provide the coefficients to calculate predicted age composition. If you make a lambda>0 for a selectivity parameter, then this amounts to specifying a prior on its value, and the magnitude of lambda (and the associated CV) will determine how much the model is penalized for moving away from that prior value.

So, the simple rule of thumb is that if the lambda is referring to a quantity that you observed (and probably have data in a spreadsheet), then the lambda is a weighting factor. If the lambda refers to a quantity that you don't observe directly, but that the model uses to generate predicted values for comparison with something you *did* observe, then that lambda is probably controlling whether or not a prior is being specified to penalize solutions away from the value you specify.

Note: priors are sometimes used to constrain a parameter when there is little information for the model to estimate it. An alternative to specifying a prior, or perhaps the ultimate prior, would be to simply fix the quantity (set the phase to a negative value).

Table 1. Percentiles of the root mean square error from a normal distribution with mean zero and standard deviation one for a range of sample sizes.

# Resids	RMSE 5%	10%	median	90%	95%
1	0.063	0.126	0.674	1.644	1.960
3	0.348	0.441	0.888	1.447	1.619
5	0.473	0.565	0.938	1.358	1.487
10	0.634	0.699	0.967	1.263	1.351
20	0.737	0.786	0.984	1.190	1.253
30	0.786	0.828	0.988	1.159	1.211
40	0.815	0.852	0.990	1.140	1.183
50	0.832	0.867	0.994	1.125	1.162
100	0.883	0.906	0.997	1.088	1.116

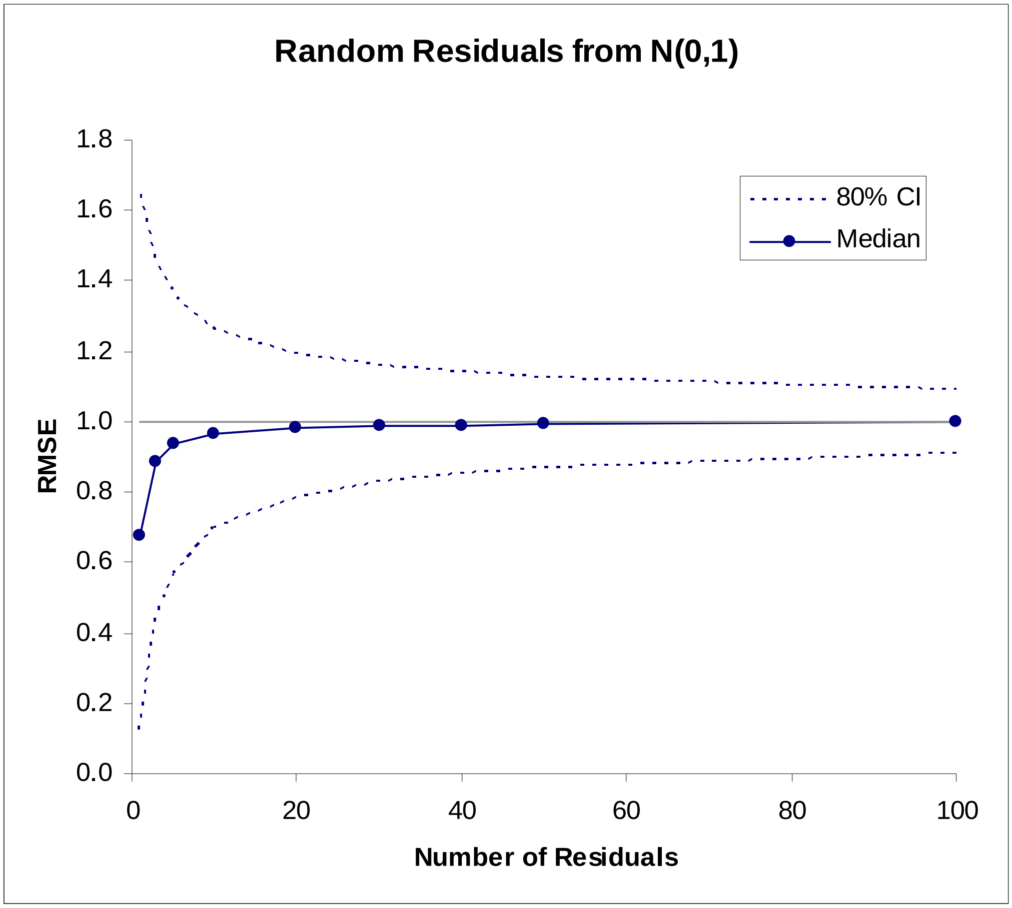

Figure 1. Median and 80% confidence interval of the root mean square error from a normal distribution with mean zero and standard deviation one for a range of sample sizes.