User Manual for the Integrated Analysis Program Stock Synthesis 2 (SS2)

Model Version 2.00c

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Introduction

This manual provides a guide for using the stock assessment program, Stock Synthesis (SS2). The guide contains a description of the input and output files and usage instructions. A technical description of the model itself is in Methot (2006 in prep). SS2 is programmed using Otter Research's AutoDifferentiation Model Builder (ADMB; Fournier 2001) augmentation of C++. SS2 currently is compiled using ADMB version 7.0.1 using the Microsoft C++ compiler version 6.0.

The model and a graphical user interface is available from the NOAA Fisheries Stock Assessment Toolbox website: http://nft.nefsc.noaa.gov/.

Starting SS2

SS2 runs as a text-based DOS program. It can be run at the command prompt in a DOS window, or called from another program, such as S-Plus or the SS2-GUI written in Visual Basic. Communication with the program is through text files. When the program first starts, it reads the file STARTER.SS2, which must be located in the same directory from which SS2 is being run. The file STARTER.SS2 contains required input information plus references to other required input files, as described in the Fie Organization section. Output from SS2 is as text files containing specific keywords. Output processing programs, such as the SS2 GUI, Excel, S-Plus can search for these keywords and parse the specific information located below that keyword in the text file.

Computer Requirements and Recommendations

SS2 is compiled to run under DOS with a 32-bit Windows operating system. It is recommended that the computer have at least a 2.0 Ghz processor and 2 GB of RAM.

File Organization

<u>Overview</u>

Input Files

1. *STARTER.SS2*: required file containing filenames of the data file and the control file plus other run controls.
2. <*datafile*>: file containing model dimensions and the data
3. <*control file*>: file containing set-up for the parameters
4. *SS2.PAR*: previously created parameter file that can be read to overwrite the initial parameter values in the control file (optional)
5. *FORECAST.SS2*: file containing specifications for forecasts
6. *RUNNUMBER*.SS2: file containing a single number
7. *PROFILEVALUES*.SS2: file contain special conditions for batch file processing

Output Files

1. *SS2.PAR, SS2.STD, SS2.REP, SS2.COR* etc. standard ADMB output files
2. *SS2-NUDATA.DAT*: contains a user-specified number of datafiles, generated through a parametric bootstrap procedure, and written sequentially to this file

3. *SS2-REPORT.TXT*: file containing a brief version of the run output, output is appended to current content of file so results of several runs can be collected together. This is especially important when a batch of runs is being processed.
4. *SS2-CHECKUP.TXT*: Contains details of selectivity parameters and resulting vectors. This is written during the first call of the objective function.
5. *SS2-NUCONTROL.CTL*: Updated version of the control file with final parameter values replacing the Init parameter values. Note that, at this time, the dev vectors are not written to this file.
8. *SS2-FORECAST-REPORT.TXT*: Output of management quantities and for forecasts
9. *REBUILD.DAT*: Output formatted for direct input to Andre Punt's rebuilding analysis package. Cumulative output is output to *REBUILD.SS2* (useful when doing MCMC or profiles).

Auxiliary Files

1. *SS2-OUTPUT.XLS*: Excel file with macros to read *SS2.REP* and display results
2. *SS2-NUDATA.XLS*: Excel file with macros to read SS2-*NUDATA.DAT* and parses into individual SS2-compatible datafiles with user-specified prefix and sequential suffix.
3. *SELEX-24.XLS*: Excel file to test parameterization of new selectivity options 20 (age) and 24 (length)
4. *PRIOR-TESTER.XLS*: Shows how the various options for defining parameter priors works

STARTER.SS2

This starter file contains:

Value	*Description*
GFISH.DAT	Filename of data file
GFISH.CTL	Filename of control file
0	Read SS2.PAR (0=no, 1=yes)
1	Verbosity of console display during run, where: 0 creates no output for each function call 1 causes display of Phase, Log(L), Spbio in startyr and endyr 2 causes display of log(L) for each component and provides display of crash penalty situations
1	Produce_detailed_.rep_file_(0/1)
0	Number of bootstrap datafiles to create in *SS2-NUDATA.DAT*
4	Phases greater than this value are set to –1; good for debugging input. Set value to 0 to get SS2.rep file based only on the input parameter values
Code_version_:_	String containing prefix for output of version number
10	Burn in for mcmc chain
2	Thinning interval for mcmc
0.0	Jitter initial parm values, see explanation below
0.01	Push initial parm values away from max-min bounds
-1	Min year for spbio sd report (negative value sets to styr-2; the virgin level)
-1	Max year for spbio sd_report (negative value sets to endyr)
1.0e-5	Convergence criterion for maximum gradient. A value at least as small as about 1.0 e-3 should be used.

New controls in V2.00

0	Retrospective year (relative to endyr), beyond which observation data are nullified 0 means no retro; Negative value is the number of years for which the survey, discard, body wt, and comps have their values set to ignore in the log(L) calculation. Also, the last year for recruitment devs is set to the retro_year, so that recruitment devs during the retro period are part of the forecast recruitment devs. Default = 0
1	Fishery keeper 1=keep catches 0=set catches to nil (use this when calculating dynamic Bzero) Default = 1

0.1	F_ballpark
2002	F_ballpark_yr (negative value causes F_ballpark to be ignored)
1	F method 1 = Pope's approx (as in SS2 V1.xx) 2 = continuous F
2	summary age (moved from forecast.ss2)
1	Forecast option (moved from forecast.ss2 and change index assignment) 0 = no forecast 1 = use F(spr) for forecast 2 = use F(msy) for forecast 3 = use F(btarget) for forecast 4 = use ending year F for forecast
2	MSY option (moved from forecast.ss2 and change index assignment) 0 = no MSY calc 1 = set F(msy) = F(spr) 2 = calc F(msy) 3 = set F(msy) = F(Btarget) 4 = set F(msy) = ending year F Note: when using option 2, the search for Fmsy starts at FBtarget and is upper-limited by a factor applied to this starting F value; so provide a reasonable value for SPR which is used to calculate Fbtarget.
1	Do output for west coast groundfish rebuilder package 0=skip, but items two below still must exist to be read. Also, if forecast is turned off, then this should be turned off also. 1=do
-1	year declared for rebuilder package This is the first year for which catch could have been set to zero (Ydecl). SS2 will output the age composition at the beginning of this year. Default = -1 will set to 1999
-1	start year for rebuilder package This is the year from which the rebuilder package will start simulations (Yinit). SS2 will output the age composition at the beginning of this year. Default = -1 will set to endyr+1

The *Jitter* factor works by adding:

random normal deviate * *Jitter* * (Parm_max-Parm_min) to the initial value of the parameter. Except, (Parm_max-Parm_min) is replaced by the value 4.0 when applying *Jitter* to the recruitment deviation vector.

The Push factor works by checking to see if a parameter's initial value is at or beyond the upper or lower bound, and then moving it this fraction of the way inside the bound. For example, if Parm_init < parm_min:

Parm_init = parm_min + Push*(Parm_max-Parm_min).

Push is applied after Jitter in case Jitter causes a parameter to move beyond the bound.

RUNNUMBER.SS2

This file contains a single integer value. It is read when the program starts, incremented by 1, used when processing the profile value inputs (see below), used as an identifier in the batch output, then saved with the incremented value. Note that this incrementation may not occur if a run crashes.

PROFILEVALUES.SS2

This file contains information for changing the value of selected parameters for each run in a batch. In the ctl file, each parameter that will be subject to modification by *PROFILEVALUES.SS2* is designated by setting its phase to -9999.

The first value in *PROFILEVALUES.SS2* is the number of parameters to be batched. This value MUST match the number of parameters with phase set equal to -9999 in the ctl file. The program performs no checks for this equality. If the value is zero in the first field, then nothing else will be read. Otherwise, the model will read runnumber * Nparameters values and use the last Nparameters of these to replace the initial values of parameters designated with phase = -9999 in the ctl file.

USAGE Note: if one of the batch runs crashes before saving the updated value of runnumber.ss2, then the processing of the profilevalue.ss2 will not proceed as expected. Check the output carefully until a more robust procedure is developed.

Data File

Overview of Data File

1. Dimensions (years, ages, N fleets, N surveys, etc.)
2. Fleet and survey names
3. Survey timing
4. Catch biomass
5. Discard data
6. Mean body weight data
7. Composition data conditioning (min fraction, added constant)
8. Length bin definition

9. Length composition data
10. Age bin definition
11. Ageing imprecision definitions
12. Age composition data
13. Mean length-at-age data
14. Environmental data

Units of Measure

The normal units of measure are as follows:
Catch biomass – metric tons
Body weight – kilograms
Body length – usually in cm, but weight at length parameters must correspond to the units of body length and body weight.
Survey abundance – any units if q is freely scaled; metric tons or thousands of fish if q has a quantitative interpretation
Output biomass – metric tons
Numbers – thousands of fish, because catch is in mtons and body weight is in kg
Spawning biomass – metric tons of mature females if eggs/kg = 1 for all weights; otherwise has units that are proportional to egg production.

Data File Syntax

Syntax rules:
the ”#” symbol tells the program to stop reading rest of line
blank lines can be inserted for clarity

<u>Model Dimensions</u>

1971 # start year

2001 # end year

1 # N seasons per year

12 # vector with N months in each season

1 # spawning season; spawning occus at beginning of this season

1 # N fishing fleets

1 # N surveys; data type ID below is sequential with the fisheries

WA_Trawl%Triennial_Shelf #string containing names for each fishery and survey, delimited by the “%” character

0.5 0.75 # vector containing the timing of each fishery CPUE and each survey. A value must exist for each type, starting with the fisheries and then the surveys. Values are the fraction of the season elapsed before the CPUE is measured or the survey conducted. Values have no impact on the fishery timing, which removes the catch after $e^{-M*0.5*seasdur}$ has occurred. Beware: if there is a multiple season setup and a CPUE or survey occurs in more than one season, then this timing fraction is the same in each season.

2 # number of genders (1/2); females are gender 1

40 # accumulator age; model always starts with age 0. Make this a reasonably large value so that fish at this age will be a very large (say 99%) of Linfinity. Make this larger than the largest bin age so that the misaging of old fish can be handled well. SS2 does not have the SS1 factor called "old fish discount" that was applied to try to account for dynamics <u>within</u> the accumulator age

<u>Catch Data</u>
catch (units are mt)
3115 # initial equil catch for each fishery (Enter annual init. eq. values even if model has >1 season)

fishery-1 fishery-2….. fishery-N for year season
5624 # 1971 1; catch for each fishery in first year/season
catch is the RETAINED catch, not the total catch
7694 # 1972 1
………
6840 # 2001 1; catch for last year/season

<u>Abundance Indices (surveys)</u>
6 N observations (Need to do manual count and enter N here)

Year	Seas	Type	Value	s
1991	**1**	**2**	**80000**	**0.056**
1995	**1**	**2**	**65000**	**0.056**
……….				
2000	**1**	**2**	**42000**	**0.056**

Type is sequential with the fishery types

Zero or negative value for datum causes it to be ignored

Abundance indices have a lognormal error structure. The "s" values have units of standard deviation of log_e(index). Generally the value of s can be approximated as log_e(1+CV), where CV is the standard error of the observation divided by the value of the observation.

Duplicate survey observations are not allowed.
Observations must be entered in chronological order.

With version 2.00, four new survey types are allowed. Here in the survey data section, there is no change in the way in which these survey data are entered. Then in the size-selectivity section of the control file, the selectivity pattern used to generate expected values for these surveys is specified by entering the selectivity pattern as 30, 31, 32, or 33.

Previously, there was a shortcoming in the logic for selectivity pattern #4 which used spawning biomass as a survey index. The problem is that spawning biomass is only defined for the beginning of the year and surveys are defined to occur a specified fraction of the way through the year (usually 0.5). But no matter when you place the survey, it only affects calculations of the numbers at that time; the model always uses the size-at-age from the middle of the season for the survey calculations. Consequently, the "spawning biomass" calculated as expected value for an egg&larvae survey will differ from the real spawning biomass. Selex pattern #4 will be discontinued. The four survey "selectivity" pattern options bypass the explicit calculation of survey selectivity, thus avoiding the above problem.

Pattern Number	Expected Value equals:	Description
30	Spawning Biomass	Spawning biomass: e.g. for a egg&larvae survey
31	Exp(Recruitment deviation)	useful for environmental index affecting recruitment
32	SpawnBio * Exp(RecrDev)	For a pre-recruit survey occurring before density-dependence
33	Recruitment	Age 0 recruits

If the environmental data exists as a normalized Z-score, you must enter the data as exp(Z-score) because it will be logged by SS2.

<u>Discard Biomass</u>

2 # 1 means values are biomass(mt) discarded;
2 means values are fraction of total catch discarded

2 # N observations
Negative value for datum causes it to be ignored

#Year	Seas	Type	Value	CV
1980	**1**	**1**	**-.01**	**0.25**
1991	**1**	**1**	**0.01**	**0.25**

Discard observations have a normal error structure. The "cv" values have units of coefficient of variation of the observed discard value.

<u>Mean BodyWt</u>

2 # N observations

New specification here is "Partition", where:
Partition=1 means discarded catch
Partition=2 means retained catch
Partition=0 means whole catch (discard+retained)

# Year	Seas	Type	Partition	Value	CV
1990	**1**	**1**	**0**	**4.**	**0.95**
1990	**1**	**1**	**1**	**1.**	**0.95**

Meanbodywt observations have a normal error structure. The "cv" values have units of coefficient of variation of the observed meanbodywt value. Units are must correspond to the units of body weight, normally kilograms.

Composition conditioners

-0.0001 # compress tails of composition until observed proportion is greater than this value;
negative value causes no compression;
Advise using no compression if data are very sparse, and especially if the set-up is using agecomp within length bins because of the sparseness of these data

0.0001 # constant added to observed and expected proportions at length and age;
tail compression occurs first;
renormalized to sum to 1.0 after constant is added

<u>Length Composition</u>

22 # N length bins

Vector containing lower edge of length bins. Example bins:

32 34 36 ….. 64 68 72 76 80 90

The last length bin set to have same width as next lower bin

Be sure to provide a wide enough range of size bins so that the mean body weight-at-age will be calculated correctly.

Fish smaller than the first bin are placed in the first bin. The mean weight-at-length and maturity-at-length are based on the mid-length of the bin. Size-selectivity is calculated using the mid-length of the bin.

Note that the bin width does not need to be uniform.

These bins are used to define the structure of the length composition data AND to define the structure of the underlying population. A bin structure that provides adequate coverage for the largest fish is important to getting accurate calculation of the expected fish weights (critical for calculating catch biomass and population biomass).

30 #N Length comp observations

Each observation can be stored as one row for ease of data management in a spreadsheet. Example below inserts 3 “# end” phrases and wraps lines just for ease of display

Gender = 0 means combined male and female (must already be combined and information placed in the female portion of the data vector) (entries in male portion of vector must exist and will be ignored). If model has only one gender defined in the set-up, all observations must have gender set equal to 0 or 1.
Gender = 1 means female only (male entries must exist and will be ignored)
Gender = 2 means male only (female entries must exist and will be ignored after being read)
Gender = 3 means both genders that together sum to 1.0
The data vector has female data followed by male data. These will be rescaled to be proportions (summing to 1.0 across males and females combined) after being read, so the read values can be in any units
Partition (0, 1, 2) between discarded and retained uses same syntax as with the mean body weight data

In version 1.xx of SS2, composition observations needed to be sorted by year-season and type. This requirement is relaxed in V2.00 so that the composition observations can be in any order. However, if the super-year approach is used, then these observations must be inserted in chronological order within type.

Year	Seas	Type	Gender	Partition	Nsamp	data vector
1986	**1**	**1**	**3**	**0**	**20**	**<female then male data>**

< 29 more length comp observations not shown >

<u>Age Composition</u>

17 # N age' bins
can be equal to 0 if age data not used; do not include a vector of agebins if Nage’bins is set equal to 0;

1 2 3 4 5 6 7 8 9 10 11 12
13 14 15 20 25

vector with lower age of age' bins
note that there is no age’ 0 bin in this example,
so any selected age 0 fish would be placed in the age’ 1 bin

2 # number of unique ageing error matrices to generate
in principle, one could have year, or laboratory specific matrices
for each matrix, enter a vector with mean age’ for each true age; if there is no ageing bias, then set age’ equal to true age + 0.5
followed by a vector with the stddev of age’ for each true age
-1 value for mean age’ means to set it equal to true age plus 0.5

If no age data, there can be 0 vectors

-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 #age' = age
0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001
0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001
0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001
0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 # nil imprecision
0.5 1.5 2.5 3.5 4.5 5.5 6.5 7.5 8.5 9.5 10.5 11.5
12.5 13.5 14.5 15.5 16.5 17.5 18.5 19.5 20.5 21.5 22.5
23.5 24.5 25.5 26.5 27.5 28.5 29.5 30.5 31.5 32.5 33.5
34.5 35.5 36.5 37.5 38.5 39.5 40.5 # age' = age
0.5 0.65 0.67 0.7 0.73 0.76 0.8 0.84 0.88 0.92 0.97 1.03
1.09 1.16 1.23 1.32 1.41 1.51 1.62 1.75 1.89 2.05 2.23
2.45 2.71 3 3 3 3 3 3 3 3 3
3 3 3 3 3 3 3

26 # N age observations (need to count and enter value here)

Year	Seas	Type	Gender	Partition	ageerr	Lbin lo	Lbin hi	Nsamp	data vector
1987	**1**	**1**	**3**	**0**	**2**	**-1**	**-1**	**79**	values

Syntax for *Gender*, *Partition*, and *data vector* are same as for length
Ageerr identifies which ageing error matrix to use to generate expected value for this observation
Lbin lo, and *Lbin hi* are the range of length bins that this age composition observation refers to. Normally these are entered with a value of 1 and Maxbin. Note that the entered values are bin index numbers, not the body lengths associated with these bins.
Entering value of 0 or –1 for *Lbin lo* converts *Lbin lo* to 1;
Entering value of 0 or –1 for *Lbin hi* converts *Lbin hi* to Maxbin;
Other scenarios for use of *Lbin lo* and *Lbin hi* are to: enter a subset of the size bin range (say if small fish were observed but ever aged), or to enter an age comp for each length bin (say if the age composition samples were length-stratified).
The data vector has female values then male values.

Mean Size-at-age

1 # N size@age' observations

Year	Seas	Fleet	Gender	Part-ition	Age err	Nsamp	Female Data	Male Data	Female N	Male N
1989	**1**	**1**	**3**	**0**	**2**	**2**	**Values**	**Values**	**N fish**	**N fish**

Nsamp value is ignored if positive, but a negative value cause the entire observation to be ignored
Negatively valued mean size entries will be ignored in fitting
Nfish value of 0 will cause mean size value to be ignored in fitting

<u>Environmental data</u>

Parameter values can be a function of an environmental data series

2	#N environmental variables	
10	#	N environmental observations
# Year	Variable	Value
1990	**1**	**0.1**
… … …		
1999	**2**	**-0.134**
1999	**1**	**-0.1**
999	#end of data file marker	

Environmental data can be read for up to 100 years after the end year of the model. Then, if the recruitment-environment link has been activated, the future recruitments will be influenced by any future environmental data. This could be used to create a future "regime shift" by setting historical values of the relevant environmental variable equal to zero and future values equal to 1, in which case the magnitude of the regime shift would be dictated by the value of the environmental linkage parameter. Note that only future recruitment can be modified by the environmental inputs; there are no options to allow environmentally-linked growth or selectivity in the forecast years.

<u>Super Years</u>

The "Super-Year" capability allows the user to introduce data that represent a blend across multiple years and to cause the model to create a expected value for this observation that uses the same blend of years. The option is available for all types of data and a similar syntax is used. For length comp obs:

A Nsamp value of -9999 denotes the first year of the superyear.

A Nsamp value of -9998 ends the superyear sequence.

All superyear observations must be contiguous in the data file, but not all years in the sequence need to be included. Typically, all but one of the years in the sequence will have a negative value for the Nsamp field so the data associated with these negative Nsamp observations will be ignored. The observed values must be combined outside of the model and then inserted into the data file. Only the info for the observation assigned a positive Nsamp value matters.

An expected length comp will be computed for each time period in the super year sequence. All of these expected compositions will have equal weight in the calculation of the expected super year value (that is, they are not weighted by the absolute value of the Nsamps). Any observations in the super year sequence with a positive Nsamp value must contain real data to be compared to the blended super year expected value.

It is tricky to create a super year with only 2 obs since one must start and one must end the sequence, so there is none to contain a positive Nsamp with the real data. So you'll need to create a 4 observation sequence. The first will have the starting superyr code, the second will be a dummy obs and must have the same year as the first, the third will hold the positive Nsamp value and have the same year as the ending obs, and fourth obs to have the ending Nsamp code. So the first year and the second year are equally represented in the super year sequence, so the expected value will be properly balanced across the two years.

For Survey Index super years, use the same syntax as for lengthcomp except use the -9999 and -9998 start-stop values in the CV field. The obs itself must have a negative value (ignore) for the obs that store the codes.

For Discard Obs, same as for survey index obs

For Agecomp Obs, same as for lengthcomp

For Length-at-Age Obs, same as for lengthcomp - put the code in the sample size field which is otherwise unused. Note that only the expected mean size is blended across years, the expected value for the se of meansize is calculated for each year individually.

The Super-year concept can also be used within year for a model setup with multiple seasons. For example, enter the –9999 for a season 1 pseudo-observation, put the actual annual data in a season 2 observation and put the –9998 in season 3 to end the super-season sequence. This usage could be preferred if: fish are growing rapidly within the year so their effective age selectivity is changing within year as they grow; fish are growing within the year so fishery data collected year round have a broader size-at-age modes than a mid-year model approximation can produce; and it could be useful in situations with very high fishing mortality (but note that all seasons get equal weight in the super-season combination process).

Control File

With the evolution to SS2 V2.0 in 2007, there are several changes to the syntax and content of the control file. An auxiliary program, SS2converter.exe, has been developed to read SS2 V1.23 files and write SS2 V2.00 control files. This same conversion capability has been built into the GUI. The V2.0 format of the control file is described below. Major revisions include:

- modification and augmentation of morph concept
- install migration/movement between areas
- seasonal recruitment
- more options for input of growth and biological parameters
- more options for recruitment deviations
- add options for variability in survey catchability and restructure catchability input syntax
- more options for parameter priors
- Student's T-distribution for more robust treatment of outliers
- Revision to method for adjustment of parameters through block, environmental link, or random deviation. This revision is to assure that adjusted parameter value stays within the bounds of the base parameter.

Overview of Control File

1. Number of growth patterns and sub-morphs (rev)
2. N areas and area assignment for each fleet & survey
3. Design matrix for assignment of recruitment to area/season/growth pattern (new)
4. Migration/movement (new)
5. Definition of time blocks that can be used for time-varying parameters
6. Expanded set of specifications and options for mortality and growth (rev, new)
7. Phase for any MG parameters that use random annual deviations
8. Natural mortality and growth parameters for each gender x growth pattern (rev)
9. Maturity, fecundity and weight-length for each gender
10. Recruitment distribution parameters for each area, season, growth pattern (rev)
11. Cohort growth deviation (new)
12. Environmental link parameters for any MG parameters that use a link
13. Time-varying setup for any MG parms that use blocks
14. Spawner-Recruitment parameters and controls (rev, new)
15. Initial equilibrium F for each fleet – parameter
16. Catchability setup for each fleet and survey (rev, new)
17. Catchability parameters (rev)
18. Length selectivity, retention, discard mortality setup for each fleet and survey
19. Age selectivity setup for each fleet and survey
20. Parameters for length selectivity, retention, discard mortality for each fleet and survey
21. Parameters for age selectivity for each fleet and survey
22. Environmental link parameters for any selectivity/retention parameters that use a link

23. Time-varying setup for any selectivity/retention parameters that use blocks
24. Phase for any selectivity/retention parameters that use random annual deviations
25. Variance adjustments
26. Degrees of freedom for T-distribution for discard and mean body weight (new)
27. Lambdas for likelihood components

Parameter Line Elements

A primary role of the SS2 control file is to define the parameters to be used by the model. The general syntax of a parameter line is described here. Parameter lines will be used in three sections of the control file: (1) natural mortality and growth; (2) spawner-recruitment, initial F and catchability; and (3) selectivity. The first seven elements of a parameter line are used in every section and will be referred to as a short parameter line. The remaining elements are used just in sections (1) and (3). Each parameter line contains:

Column	Element	Description
1	LO	Minimum value for the parameter
2	HI	Maximum value for the parameter
3	INIT	Initial value for the parameter. If the SS2.PAR file is read, it overwrites these INIT values.
4	PRIOR	Expected value for the parameter. This value is ignored if the Prior_type is –1 or 1
5	Prior_type	-1 = none, 0=normal, 1=symmetric beta, 2=full beta
6	SD	Standard deviation for the PRIOR, used to calculate likelihood of the current parameter value. This value is ignored if Prior_type is –1
7	PHASE	Phase in which parameter begins to be estimated. A negative value causes the parameter to retain its INIT value (or value read from SS2.PAR).
Short parameter lines have only the above 7 elements. Extended parameter line for the Mortality-Growth and Selectivity sections also have:		
8	ENV	A positive value, *g*, causes SS2 to set the annual working value of this parameter equal to a function of Environmental Variable *g:* *parm'(y) = parm * exp(link * env(y,g))* Where, *link* is value of an environmental link parameter. Separately for the growth and selectivity sections, SS2 counts the number of parameters that invoke use of an Environmental Variable. After SS2 finishes reading the section's parameter lines, it then creates/reads additional short parameter line(s) to set up the link parameters. If custom=0, then one short parameter line is used to define the min, max, init, etc, for each of the link parameters. If custom=1, then a separate line is read for each.

The following 4 elements on the extended parameter line define a deviation vector for the parameter. When in use, parm' = baseparm + dev. SS2 will automatically set up a dev vector of the specified length.		
<u>9</u>	USE_Dev	A value of 1 invokes use of the dev vector
<u>10</u>	DEV min yr	Beginning year for the dev vector
<u>11</u>	DEV max yr	Ending year for the dev vector
<u>12</u>	DEV std.dev.	Standard deviation for elements in the dev vector.
The following 2 elements on the extended parameter line links parameters to defined time blocks. Separately for the growth and selectivity sections, SS2 counts the number, *h*, of parameters that invoke use of Blocks. After SS2 finishes reading the section's parameter lines, it then reads additional short parameter line(s) to set up the block parameters. If custom=0, then one short parameter line is used to define the min, max, init, etc, for each of the block parameters. If custom=1, then a separate line is read for each.		
<u>13</u>	USE-BLOCK	A positive value identifies which block pattern will be used for time changes to a parameter value. Blocks are simply numbered sequentially as they are defined, so the index here must be correct for the order in which they are defined. More than one parameter can use the same block definition. The order of generated block parameters is by the order of the parameters that call for creation of the block parameters, then by the order of the blocks.
<u>14</u>	BLOCK-TYPE	This selects the way in which the block parameter creates an offset from the base parameter. 0 means that parm' = baseparm * exp(blockparm) 1 means that parm' = baseparm + blockparm 2 means that parm' = blockparm.

Control File Syntax

The new top section of the control file is described here using a set-up with 3 seasons (as defined in data file), 2 areas, 2 growth morphs, 2 genders (as defined in data file), and 3 sub-morphs:

VALUE	LABEL (as output to SS2nucontrol.ctl)	Comments and Options
2	N_growth patterns	
3	N_sub-morphs per gender x growth pattern	Permissable values are 1, 3, 5 only
2	N_areas	
1 2 1 2	Area_assignments_for_each_fishery_and_survey	
1 0	Pattern 1, Birthseason 1, area 1 and 2	Recr_dist_pattern_(G_Pattern_x_birthseas_x_area)_X_0/1_flag. Enter value >0 to allow recruits in designated cell. See Note 4 regarding seasonal recruitment. If there is just a single season, area, and growth pattern, then just enter a single value of 1.
1 0	Pattern 1, Birthseason 2, area 1 and 2	
1 0	Pattern 1, Birthseason 3, area 1 and 2	
0 1	Pattern 2, Birthseason 1, area 1 and 2	
0 1	Pattern 2, Birthseason 2, area 1 and 2	
0 1	Pattern 2, Birthseason 3, area 1 and 2	
0	Recr_distr_interaction	Enter 1 to invoke additional parameters for full set of interaction terms among Pattern x Birthseasaon x area.
1	Do_migration (movement between areas)	(0=No / 1=Yes)
0 4 10	Area 1 to area 1 in season 1	Movement_pattern_by_season_x_source_x_destination. Three values are 0/1 flag, startage, endage for ramp. Two parameters will be read for each area pair with flag>0 If there is only one area, then a single set of 3 values must still be entered.
1 4 10	Area 1 to area 2 in season 1	
1 4 10	Area 2 to area 1 in season 1	
0 4 10	Area 2 to area 2 in season 1	
0 4 10	Area 1 to area 1 in season 2	
1 4 10	Area 1 to area 2 in season 2	
1 4 10	Area 2 to area 1 in season 2	
0 4 10	Area 2 to area 2 in season 2	

0 4 10	Area 1 to area 1 in season 3		
1 4 10	Area 1 to area 2 in season 3		
1 4 10	Area 2 to area 1 in season 3		
0 4 10	Area 2 to area 2 in season 3		
2	Nblock_patterns		
3 1	Blocks_per_pattern		
1975 19851986 1990 1995 2001			vector of beginning and ending years for blocks in design 1
1999 2002			vector of beginning and ending years for blocks in design 2
0.5		fracfemale	A constant that applies to all growth patterns
1.0		submorph_between/within	Ratio of the amount of growth variability between sub-morphs to within sub-morphs
-1 1 1		vector_submorphdist	Enter –1 for first value of vector to get a normal approx: { 0.15,0.70,0.15} for 3 sub-morphs { 0.031, 0.237, 0.464, 0.237, 0.031} for 5 sub-morphs
4		natM_amin	Last age for constant young natM
15		natM_amax	First age for constant old natM
1.66		Growth_Amin	Reference age for first size-at-age parameter; growth is linear below this age, starting from size=Lmin at an age of 0 at the beginning of the cohort's birthseason
25		Growth_Amax	Reference age for second size-at-age parameter
0		SD_add_to_LAA	Enter 0.1 to mimic SS2 V1.xx. See Note 5.
1		CV_Pattern	0 CV=f(LAA); 1 CV=f(A); 2 SD=f(LAA); 3 SD=f(A)
2		Maturity_option	1=length logistic; 2=age logistic; 3=read age-maturity for each growth_pattern
1		First_Mature_Age	Overridden if maturity option = 3

2	MGparm_as_offset	1 = direct assignment; 2 = each parameter by pattern x gender as offset from pattern 1 gender 1; 3 = offsets same as SS2 V1.xx with natmort old and Cvgrowth old as offset from young values for that pattern x gender
1	MGparm_Adjust_Method	1 = parameter adjustments for env, block and dev are as in V1.xx 2 = parameter adjustments use a logistic transformation to assure that adjusted parameter value stays within bounds of base parameter
-1	MGparm_Dev_Phase	

<u>Growth patterns</u>

Multiple growth patterns: In V1.xx, the user specified a number of morphs and designated a gender for each morph and a fraction of the recruits assigned to each morph. Each morph had a unique set of growth and M parameters, so multiple morphs per gender could be custom-created by the user. This approach was flexible, but cumbersome. Now in V2.00, the user specifies a number of growth patterns (usually just 1) and a number of genders (usually 2), and the number of sub-morphs per gender (1, 3, or 5 are permissible values). The fraction of recruits that are female is specified as an input value (not a parameter), and the fraction of recruits assigned to each sub-morph is custom-input or designated to be a normal approximation. When multiple sub-morphs are designated, an additional input is the ratio of between sub-morph to within sub-morph variability in size-at-age. This is used to partition the total growth variability. Growth parameters are read for each growth pattern x gender combination. For the sub-morphs, their size-at-age is calculated as a factor (determined from the between-within variability calculation) times the size-at-age of the central morph which is determined from the growth parameters for the growth pattern x gender.

Growth at youngest ages: Previously, the calculated mean size-at-age could go negative at some of the youngest ages if VBK was sufficiently large and Amin (the age at L1) was sufficiently high. These tiny fish would still be accumulated up into the smallest size bin, but the calculated standard deviation of size-at-age would be negative also and would cause a model crash. The solution in SS2 V1.xx was to add a small constant (0.1) to the standard deviation of size-at-age to keep it positive. A different approach has been implemented in SS2 V2.00. Age 0.0 fish are assigned a size equal to the lower edge of the first size bin and they are given linear growth until they reach the age A1. The VB generated growth trajectory is still calculated, but the size-at-age used by SS2 is the linear replacement. Because the linear growth trajectory can never go negative, there is no need for the additive constant to the stddev, but the option to add a constant has been retained in the model.

Read Mortality-Growth Parameters

Next, SS2 reads the MG growth parameters. It reads the entire section as one matrix, but on output to SS2.REP and to SS2-nucontrol.ctl it attaches some embedded, commented (#) out labels. Example setups can be found in SS2-ExampleSetups.XLS. The required growth parameters for the above example are:

N parameters	Basis for N parameters	Description
7	Fixed: 2 natmort, 3 growth, 2 CV	natural mortality and growth in growth pattern = 1, gender = 1; see note 1
7	Fixed	natural mortality and growth in growth pattern = 1, gender = 2
7	Fixed	natural mortality and growth in growth pattern = 2, gender = 1
7	Fixed	natural mortality and growth in growth pattern = 2, gender = 2
6	Fixed: 2 wt-len, 2 maturity, 2 eggs/gm (see note 7)	Female biology
2	Fixed: 2 wt-len	Male biology (if 2 genders exist)
2	Variable - N growth patterns	Recruitment apportionment – see note 2
2	Variable - N areas	Recruitment apportionment
3	Variable - N seasons	Recruitment apportionment
0	Variable - N patterns x N areas x N seasons	Only if Recr_Dist_Interaction =1 (on)
1	Fixed	Cohort growth deviation – see note 3
12	Variable: 2 x N selected movement pairs	Movement parameters, see note 4

Note 1: The mortality, growth, body weight and reproduction parameters are:

Natmort_young	Natural mortality for ages <= NMyoung (units are per year)
Natmort_old	Natural mortality for ages >= NMold. For intermediate ages, do a linear interpolation of NM on age.
Lmin	Body length at Amin (units in cm)
Lmax	Body length at Amax (units in cm)
VBK	Von Bertalanffy growth coefficient (units are per year)
CV-young	Variability for size at age at age<=AFIX (units are fraction). Note that CV cannot vary over time, so do not set up an env-link or a dev vector. Also, units are either as CV or as stddev, depending on assigned value of CV_pattern.

CV-old	Variability for size at age at age>=AFIX2. For intermediate ages, do a linear interpolation of CV on mean size-at-age. Note that the units for CV will depend on the CV_pattern and the value of Mgparm_as_offset.
Female_scale	coefficient to convert L in cm to Wt in kg
Female_exp	Exponent in female L-W conversion
Mat_inflect	Maturity logistic inflection (in cm or years). Where Female Maturity-at-length (or age) is a logistic function: mat=1/(1 + exp(slope*(<size or age>-inflection)))
Mat_slope	Logistic slope (must have a negative value)
Alpha	Intercept for fecundity: Eggs = Alpha + Beta*BodyWeight. so Alpha=1 and Beta=0 causes fecundity to be the same as spawning biomass.
Beta	
Male_scale	Male body weight at length parameters. Only include these in a 2 gender model.
Male_exp	

Seasonal Recruitment and Recruitment Apportionment

In SS2 V1.xx, all recruitment occurred at age 0.0 on Jan 1, even though spawning biomass may have been defined to occur at the beginning of a later season in the year. Now, recruitment can occur in any defined season. There still is just one value of spawning biomass calculated annually at the beginning of the specified season and this spawning biomass produces one annual recruitment value. This annual recruitment is distributed among seasons, areas, and growth types according to other model parameters. These distribution parameters can be time-varying, so the fraction of the recruits that occur in a particular season can change from year to year. Seasonal recruitment is coded to work smoothly with growth patterns. If the recruitment occurring in each season is assigned the same growth pattern, then each seasonal cohorts growth trajectory is "simply" shifted along the age/time axis. At the end of the year, the early born cohorts will be larger, but all are growing with the same growth parameters so all will converge in size as they approach their common Lmax. For the recruitment apportionment, the parameter values are the ln(apportionment weight), so should have values ranging from about –4 to +4. The product of all apportionment weights is calculated for each pattern x area x season cell that has been designated to receive recruits in the recruitment design matrix. Then the apportionment weights are scaled to sum to 1.0 (within year, not within season) so that the total annual recruitment is distributed among the cells designated to receive recruitment.

Cohort Growth Deviation

This new parameter must be given a value of 1.0 and be given a negative phase so it is not estimated. Its importance is in serving as a base for blocks or annual devs around this base value of 1.0.

Movement Parameters

There are 2 movement parameters per area pair flagged in the movement design matrix as needing estimable movement parameters. For each, the first parameter is for the movement coefficient for young fish and the second is for old fish (with intermediate ramp calculated using the designated start age and end age. Parameter values are the ln(movement coefficient). For fish that stay in their source area (e.g. move from area 1 to area 1 in season 1), they are given a movement coefficient of ln(1)=0, but this default value is replaced if the stay movement is selected as needed parameters. For each source area, each movement coefficient is exponentiated and then they are scaled to sum to 1.0. At least one needs to not be estimated so that all others are estimated relative to it.

Special Age-Maturity

After reading the MG-parameters, then: if maturity option is set to 3, read special age maturity. Syntax is (N Growth Pattern) rows by (nages + 1) columns (for ages 0 to nages).

Environmental Linkage for MGparms

0 # (0/1) Custom environmental linkage setup for MGparms; this entry is needed even if there are no Mgparms using env-linkage
Include no setup lines below if no MG-parms have Env-var>0
If there is at least one MG-parm with Env-var>0, then
If custom=0, then read one setup and apply to all env fxns;
If custom>0, then read a setup line for each MG-parm with Env-var>0

< proper number of set-up lines (0, 1, several) for the MG-parm environmental linkages>

# LO	HI	INIT	PRIOR	Pr_type	SD	PHASE
-10	10	0.0	0	0	4	4

0 # (0/1) Custom block setup for Mgparms; this entry is needed even if there are no Mgparms using blocks
Include no setup lines below if no MG-parms have Block>0
If there is at least one MG-parm with Block>0, then
If custom=0, then read one setup and apply to all Block fxns;
If custom>0, then read a setup line for each MG-parm with Block>0; custom is used to give different blocks a specific INIT value

< proper number of set-up lines (0, 1, several) for the MG-parm block linkages>

# LO	HI	INIT	PRIOR	Pr_type	SD	PHASE
# -10	10	0.0	0	0	4	4

Spawner-Recruitment

3	spawner-recruitment function form. The 4 forms are: 1 = Beverton-Holt with flat-top beyond Bzero 2 = Ricker 3 = standard Beverton-Holt

	4 = ignore steepness and no bias adjustment. Use this in conjunction with very low emphasis on recruitment deviations to get CAGEAN-like unconstrained recruitment estimates.

read 6 short parameter set-up lines. These parameters are:

log(R0)	log of virgin recruitment level
steepness	steepness of S-R; bound by 0.2 and 1.0 for Beverton-Holt
sigma-r	std.dev. of log recruitment; used to define offset of S-R curve
env-link	recruitment - environmental linkage coefficient
log(R1)	offset for initial equil recruitment relative to virgin recruitment. This is typically set to zero and not estimated.
Future	Location reserved for future implementation of an autocorrelation parameter.

Then read additional spawner-recruitment conditions:

0	SR_env_link	This is the environmental variable that will be used in the adjustment of SR expectations. Unchanged, except now can extend into the forecast period.
3	SR_env_target	This is a new capability that determines what aspect of spawner-recruitment is affected by the environmental variable. The options are: 1=annual deviations (this was the only option in V1.xx) 2=R0 3=steepness If the application needs to compare the environment to annual recruitment deviations, then the preferred option is to transform the environmental variable into an age 0 pre-recruit survey and enter these as a survey with expected value based on selectivity option #31. Use of SR_env_target=1 is discouraged because it interacts with the level of residual recruitment variability and there is no implementation of a bias correction for the variability in recruitment caused by the environmental variable. If the application is investigating regime shifts, then enter an environmental variable with a time series of zeroes and ones to describe the regime periods, then use SR_env_target of 2 or 3 to adjust the expected level of recruitment according to the regime variable. Note that MSY related quantities will be calculated with the regime in the zero state only. However, the forecast can be responsive to designated regime

		levels.
1	Do_recr_dev	This selects the way in which recruitment deviations are coded: 0=none 1=devvector (previously the only option). Here the deviations are encoded as a dev_vector, so ADMB enforces a sum-to-zero constraint. This is the V1.xx default 2=simple deviations. Here the deviations do not have an explicit constraint to sum to zero, although they still should end up having close to a zero sum. The difference in model performance between options (1) and (2) has not been fully explored to date.
1971 1999	Recruitment deviations begin and end year	If begin year is less than the model start year, then the early deviations are used to modify the initial age composition
-10 10 2	Min, max, phase	Min and max value for recruitment deviation and the phase in which estimation begins
1976	First_yr_fullbias_adj_in_MPD	Enter the first year (as a year value, not an offset year) for which the full recruitment bias adjustment is applied. For years before this year minus maxage, no bias adjustment will be applied. For intervening years, the amount of bias adjustment that will be applied is linearly phased in. To get a result comparable to SS2 V1.xx, set this year to be very early (say 1492), so that the bias adjustment will always be fully applied. For investigation purposes, the recommendation is to set this year to be a few years into the data-rich period so that SS2 will apply the full bias-correction only to those recruitment deviations that have enough data to inform the model about the full range of recruitment variability. This should result in MPD estimates that are closer to the mean of the MCMC estimates. NOTE: In MCMC mode, the bias correction should always be fully applied and I’ll create a future internal code switch to make this happen.

For further information on use of the spawner-recruitment options, see the Recruitment Issue Advisory section.

Initial Age Composition

A non-equilibrium initial age composition is achieved by setting the first year of the recruitment deviations before the model start year. These pre-start year recruitment deviations will be applied to the initial equilibrium age composition to adjust this composition before starting the time series. Because the older ages in the initial age composition will have progressively less information from which to estimate their true deviation, a linear decrease in the bias adjustment is applied as a function of age as these devs are applied to older ages. Note that first year with recruitment deviations cannot be more than nages years earlier than start year; the model will trap for this condition.

Note: In the future there will be the need to add some additional control info so that the dev vector can be included in the SS2-NuControl.ctl output file.

Initial Fishing Mortality

Read a short parameter setup line for each fishery. The parameters are the fishing mortalities for the initial equilibrium. Do not try to estimate parameters for fisheries with zero initial equilibrium catch. If there is catch, then give a starting value greater than zero and it generally is best to estimate the parameter in phase 1.

Catchability

For each fishery and survey, enter a row with these 6 entries: Note that the order of these entries differs from the order in SS2 V1.xx. The SS2Converter program does the re-ordering.

1. – Do_Power

0 = skip, so survey is directly proportional to abundance
1 = establish a parameter for non-linearity in survey-abundance linkage
Default = 0

2. – Do_Env_Link

0 = skip, no environmental effect on Q
1 = establish a parameter to create environmental effect on Q
Default = 0

3. – Do_extra SD

0 = skip
1 = estimate a parameter that will contain an additive constant to be added to the input stddev (in ln units) of the survey variability. It is not advised to estimate this parameter and to use the iterative variance adjustment factors.
Default = 0

4. – Q type (**EXPANDED OPTIONS**)

<0=mirror the Q from another (lower numbered) survey designated by abs(value)
0 = set Q as a scaling factor such that the estimate is median unbiased. This is comparable to the old "float" option
1 = set Q as a scaling factor such that the estimate is mean unbiased

2 = establish a parameter that will be the ln(Q)
3 = establish a parameter that will be the ln(Q) and a set of additional parameters for each year of the survey that will be deviations in ln(Q). These deviation parameters are full parameters, so each has a prior and variance, so surveys with high uncertainty in their calibration can be given a more diffuse prior to allow a larger deviation.
Because each of these Q deviations is coded as a separate parameter, rather than a member of a dev_vector, the contribution of these deviations to the model's objective function is captured in the parameter prior section. However, because there is no inherent constraint that these deviations have a zero sum, a separate log(L) contribution is calculated from the sum of the devs (=square(1.+square(sum_devs))-1.) and added to the "parm_dev_like" component.
4 = establish a parameter that will be the ln(Q) and a set of additional parameters for each year of the survey that will be deviations in random walk of ln(Q). These deviation parameters are otherwise treated identically to those generated by option (3) above, except that the extra contribution for the mean deviation is not calculated.
Default = 2

5. – Units – This is used to set both the units for surveys and for catch and discard
0 = numbers
1 = biomass
Default = 1
6. - Error_type
0 = lognormal
>0 = Student's T-distribution with degrees of freedom equal to this value. For DF>30, results will be nearly identical to that for lognormal distribution. A DF value of about 4 gives a nice fat-tail to the distribution (see Chen (19xx)).
Default = 30 to be like SS2 V1.xx; =4 for a fat-tail

<For each element selected above, read a parameter setup line>
The order is: fishery 1 through survey N within power transformation, then within environment link, then within extra stddev, then within Q.

If no elements are selected, then there must be no parameter setup lines.

Selectivity and Retention

For each fleet and survey, read a definition line for size selectivity and retention. The four values to be read are:

TYPE valid length selectivity type (0-10).
RETENTION (0/1/2) If value is 1, then program will read 4 retention parameters after reading the specified number of selectivity parameters. If the value is 2, then the program will read 4 retention parameters and 4 discard mortality parameters.
MALE (0/1/2) If value is 1, then program will read 4 additional parameters to define the male selectivity relative to the female selectivity. Anytime the

male selectivity is caused to be greater than 1.0; the entire male/female matrix of selectivity values is scaled by the max so that the realized max is 1.0. Hopefully this does not cause gradient problems. If the value is 2, then the main selectivity parameters define male selectivity and female selectivity is estimated as an offset from male selectivity. This alternative is preferable if female selectivity is less than male selectivity.

SPECIAL (0/value). This value is used in different ways depending on the context. If the selectivity type is to mirror another selectivity type, then put the index of that source fleet or survey here. It must refer to a lower numbered fleet/survey. If the selectivity type is 6 (linear segment), then put the number of segments here. If the selectivity type is 7, then put a 1 here to keep selectivity constant above the mean average size for old fish of morph 1.

For each fleet and survey, read a definition line for age selectivity. The 4 values to be read are the same as for the size-selectivity. However, the retention value must be set to 0.

Selectivity Patterns

The currently defined selectivity patterns, and corresponding required number of parameters, are:

Pattern	N Parameters	Description
SIZE SELECTIVITY		
0	0	Selex=1.0 for all sizes
1	2	Logistic
2	8	Double logistic, with defined peak, uses IF joiners. Do not use.
3	6	flat middle, power up, power down
4	0	set size selex=female fecundity. Do not use this anymore. Use pattern #30 instead
5	2	mirror another selex, parameters select bin range
6	2+special value	Non-parametric
7	8	Double logistic, with defined peak, uses smooth joiners; special=1 causes constant selex above Linf for morph 1. Do not use in V2.00
8	8	Small modification from selex pattern #7
9	6	Simple double logistic, no defined peak
22	4	Double normal; similar to CASAL
23	6	Double normal with defined init and final level
24	6	Double normal with defined init and final level – Recommended option. Test using SELEX-24.xls
30	0	Sets expected survey abundance equal to spawning biomass (population fecundity)
31	0	Sets expected survey abundance equal to exp(recruitment deviation). This is useful if environmental data is used as an index of recruitment variability.
32	0	Sets expected survey abundance equal to exp(recruitment deviation) * SpawnBiomass. So this is recruitment without density-dependence (for pre-recruit survey) because most ecological logic places the density-dependent stage during the juvenile period following the larval stage that is most sensitive to environmental perturbation.
33	0	Sets expected survey abundance equal to age 0 recruitment.
Do not input any size/age comp for surveys using pattern 30-33. The “catchability” coefficient for these selectivity patterns 30-33 have all the general properties of the catchability coefficient for real surveys, e.g. they can be time-varying, use power relationship, etc.		

AGE SELECTIVITY		
10	0	Age selex=1.0 for all ages beginning at age 1[1]
11	2	Pick min-max age
12	2	Logistic
13	8	Double logistic, IF joiners
14	nages+1	Each age, value at age is 1/(1+exp(-x))
15	0	Mirror another selex
16	2	Coleraine single Gaussian
17	5	Logistic, with added features
18	8	Double logistic, with defined peak, uses smooth joiners
19	6	Simple double logistic, no defined peak
20	6	Double normal with defined init and final level – Recommended option. Test using SELEX-24.xls

Size-Selectivity Details

Parameter usage (also see spreadsheet SS2-ExampleSetups.xls)

Pattern 4 (spawner output): Sets selectivity equal to female fecundity (maturity x body wt x eggs/gram), so can only be used to create expected value for a spawning biomass survey. When this selectivity pattern is selected, the survey biomass/numbers option must be set to numbers because the body weight contribution is now embedded in the “selectivity”. Note that no size/age composition observations can be assigned to this survey because the “selectivity” is only for females and will take on values greater than 1.0. Note also that the estimated values for the spawning biomass will differ slightly from the actual spawning biomass because the actual spawning biomass is calculated at the beginning of the time period and surveys use numbers-at-age from the middle of the time period. Use of this pattern should be discontinued and replaced by pattern 30.

Pattern 5 (mirror size) 2 parameters select the min and max Bin number (not min max size) of the source pattern. If first parameter has value <=0, then interpreted as value of 1 (e.g. first bin). If second parameter has value <=0, then interpreted as value of nlength (e.g. last bin). The source pattern must have a lower type number.

Pattern 6 (non-parametric size selectivity) uses a set of linear segments. The first waypoint is at Lbin = p1 and the last waypoint is at Lbin=p2. The total number

[1] Note. For SS2 versions 1.20 and earlier, the selex was set to 1.0 beginning at age 0. If it is desired that age 0 fish be selected when using version 1.21, then use pattern #11 and set the minimum age to 0.

of waypoints the value of the Special factor in the selectivity set-up, so the N intervals is one less than the number of waypoints. Intermediate waypoints are located at equidistant intervals between p1 and p2. Parameters 3 to N are the selectivity values at the waypoints, entered as logistic, e.g. 1/(1+exp(-x)). Ramps from –10 to p3 if L<p1. Constant at pN if L>p2. Note, in the future this will probably be converted to a cubic spline and the waypoints will be in terms of length, not in terms of bin number.

Patterns 1 and 12 (logistic):

p1 – size (age) at inflection

p2 – width for 95% selection; a negative width causes a descending curve

Patterns 2, 7, 13 and 18(double logistic):

p1 – PEAK: size (age) for peak. Should be an integer and should be at bin boundary and not estimated. But options 7 and 18 may allow estimation

p2 – INIT: selectivity at lengthbin=1 (minL) or age=0

p3 – INFL1: size (age) at which selectivity is halfway between INIT and 1. A logit transform (1/(1+exp(-x)) is used so that the transformed value will be between 0 and 1. So a p1 value of –1.1 will be transformed to 0.25 and used to set the selectivity equal to 0.5 at a size (age) equal to 0.25 of the way between minL and PEAK. (see SS2-selex.xls).

p4 – SLOPE1: slope of left side (ascending) selectivity

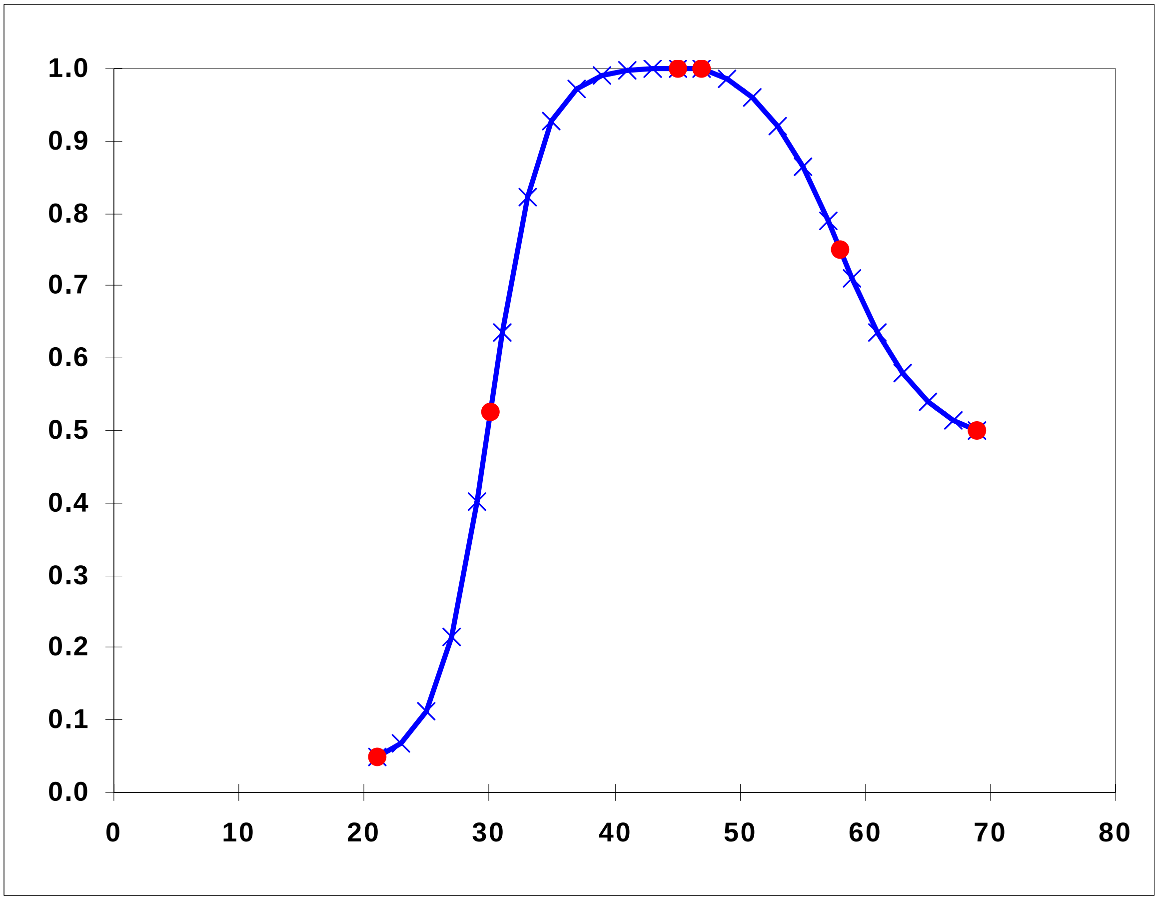
p5 – FINAL: logit transform for selectivity at maxL (or maxage)

p6 – INFL2: logit transform for size(age) at right side selectivity equal to half way between PEAK+PEAKWIDTH and maxL (or max age)

p7 – SLOPE2: slope of right side (descending) selex

p8 – PEAKWIDTH: in width of flattop

Patterns 2 and 13 join the ascending, flat peak and descending portions with IF statements. Patterns 7 and 18 use steep, complementary logistic functions to join the sections.



Pattern 8 – same as pattern 7, except P4 and P7 (slope parameters) are now entered as ln(slope), which makes it easier to keep them in positive space. Usage Note (9/15/2005): Although the double logistic selex patterns (especially #8) are designed to be fully differentiable so that all parameters can be estimated, in practice there remain situations in which the "peak" parameter is not robustly converging. In many cases it is advisable to fix the "peak" parameter at a reasonable value and allow the other parameters to define the best shape.

Pattern 9 and 19 – simple double logistic with no defined peak

p1 – INFL1: ascending inflection size (in cm)
p2 – SLOPE1: ascending slope
p3 – INFL2: descending inflection size (in cm)
p4 – SLOPE2: descending slope
p5 – first BIN: bin number for the first bin with non-zero selectivity (must be an integer bin number, not a size)
p6 – offset: enter 0 if P3 is independent of P1; enter 1 if P3 is an offset from P1

Pattern 22 – double normal with plateau

p1 – PEAK1: beginning size for the plateau (in cm)

p2 – PEAK2: ending size for the plateau. Calculated as a fraction of the distance between PEAK1 and 99% of the lower edge of the last size bin in the model. Transformed as (1/(1+exp(-p2)). So a value of 0 results in PEAK2 being halfway between PEAK1 and 99% of the last bin
p3 – upslope: ln(variance) on ascending side
p4 – downslope: ln(variance) on descending side
NOTE: this patern will be deleted, switch to pattern #24

Pattern 23 – double normal with plateau and defined initial and final levels

p1 – p4: as with pattern #22
p5 – INIT: selectivity at the first size bin transformed as (1/(1+exp(-p5))
p6 – FINAL: selectivity at the last size bin transformed as (1/(1+exp(-p6))
NOTE: this patern will be deleted, switch to pattern #24

Pattern 24 (recommended double normal).
See spreadsheet SELEX-24.xls

p1 – PEAK: ascending inflection size (in cm)
p2 – TOP: width of plateau, as logistic between PEAK and MAXLEN
p3 – ASC-WIDTH: parameter value is ln(width)
p4 – DESC-WIDTH: parameter value is ln(width)
p5 – INIT: selectivity at first bin, as logistic between 0 and 1.
P6 – FINAL: selectivity at last bin, as logistic between 0 and 1.

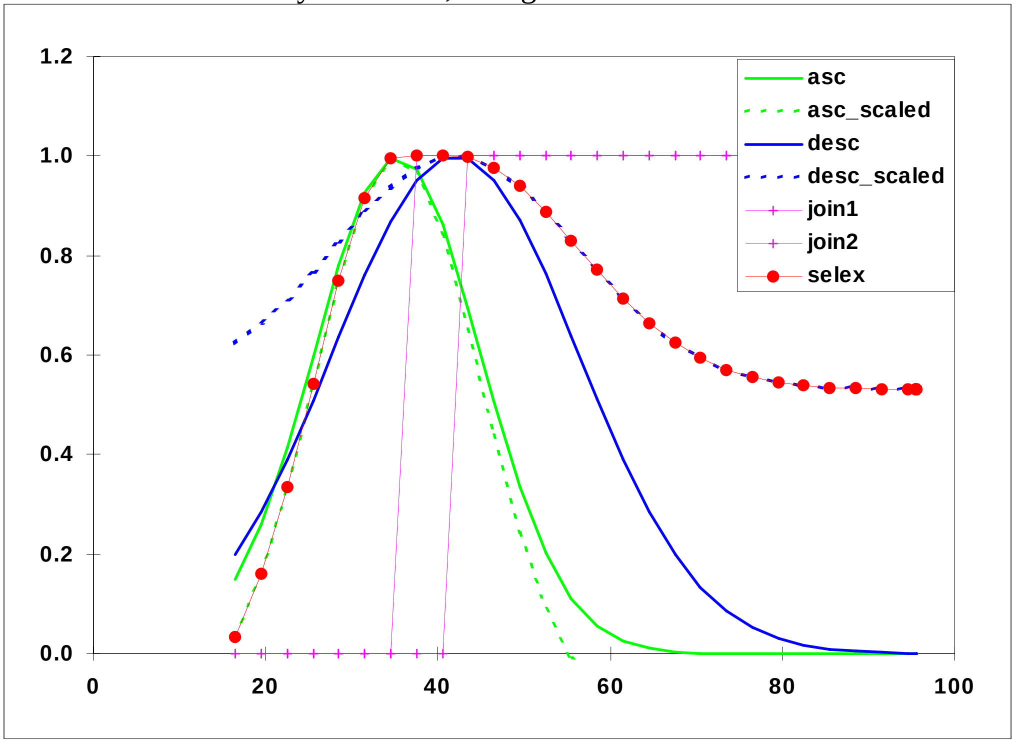


Figure 1 Selectivity pattern 24, double normal, showing sub-functions.

Figure 2

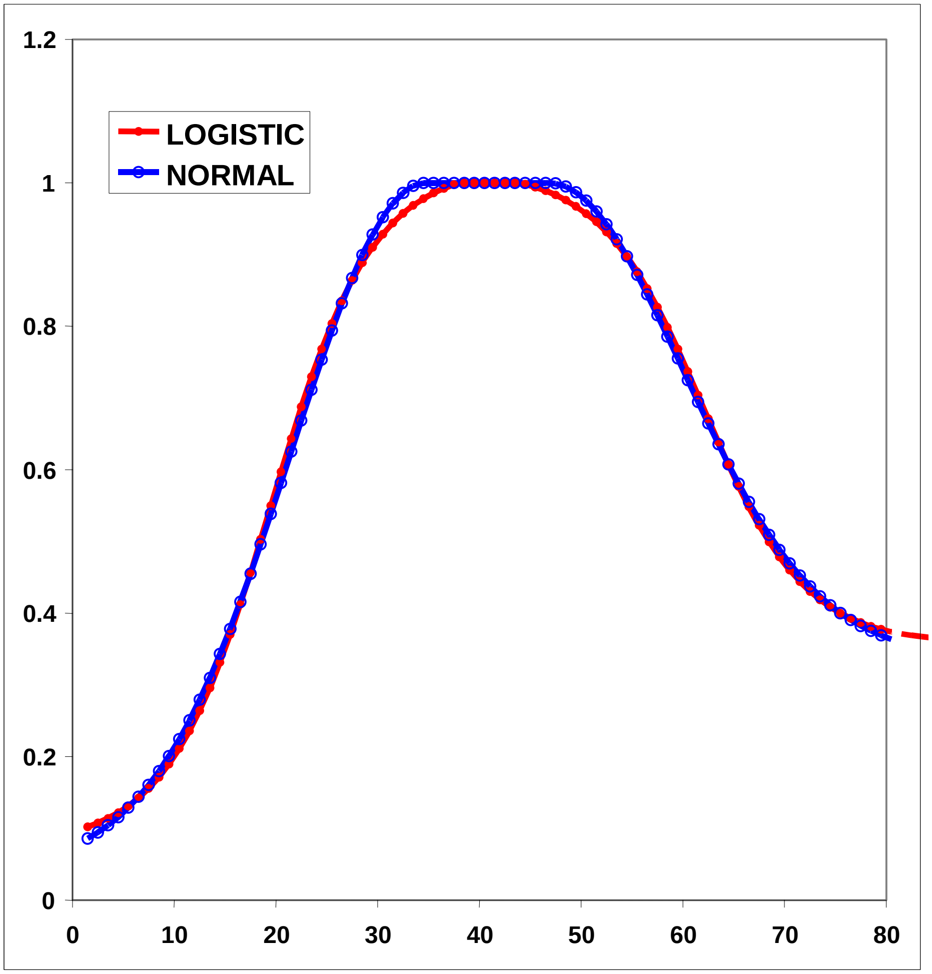


Figure 3. Comparison of 6-parameter double normal with 8-parameter double logistic tuned to match the double normal.

Age- selectivity details

Pattern 15 (mirror age) no parameters. Whole age range is mirrored.

Pattern 16 Gaussian: like Coleraine.

P1 – age below which selectivity declines

P2 – scaling factor for decline

Pattern 17 (logistic plus)

p1 – age below which selectivity=0, must be an integer and not estimated

p2 – age above which selectivity is constant; must be integer and not estimated p3 – age used for scaling curve to 1.0; must be integer and normally is the minage or the maxage;

p4 – age at inflection

p5 – slope

Pattern 9 and 19 (simple double logistic)

p1 – ascending inflection age/size

p2 – ascending slope

p3 – descending inflection age/size

p4 – descending slope

p5 – age or size at first selection; this is a specification parameter, so must not be estimated. Enter integer that is age for pattern 19 and is bin number for pattern 9

p6 – (0/1) where a value of 0 causes the descending inflection to be a standalone parameter, and a value of 1 causes the descending inflection to be interpreted as an offset from the ascending inflection. This is a specification parameter, so must not be estimated.

A value of 1.0e-6 is added to the selectivity for all ages, even those below the minage.

Retention

Retention is defined as a logistic function of size. It does not apply to surveys. Four parameters are used:

P1 – inflection
P2 – slope
P3 – asymptotic retention (often a time-varying quantity to match the observed amount of discard)
P4 – male offset to inflection (arithmetic, not multiplicative)

Retention = P3 / (1+exp(-(L-(P1+p4*male))/P2)).

Discard mortality

Discard mortality is defined as a logistic function of size such that mortality declines from 1.0 to an asymptotic level as fish get larger. It does not apply to surveys and it does not affect the calculation of expected values for discard data. It is applied so that the total mortality rate is:

deadfish = selex * (retain + (1.0-retain)*discmort).

If discmort is 1.0, all selected fish are dead;

If discmort is 0.0, only the retained fish are dead.

Four parameters are used:

P1 – inflection
P2 – slope
P3 – asymptotic mortality
P4 – male offset to inflection (arithmetic, not multiplicative)
Mortality = 1 – (1-P3) / (1+exp(-(L-(P1+p4*male))/P2)).

Male Selectivity

If the "domale" flag is set to 1, then the selectivity parameters define female selectivity and the offset defined below sets male selectivity relative to female selectivity. The two genders switch roles if the "domale" flag is set to 2. Generally it is best to select the domale options so that the dependent gender has lower selectivity, thus obviating the need to rescale for selectivities that are greater than 1.0. Gender specific selectivity is done the same way for all size and age selectivity options.

P1 – size (age) at which a dogleg occurs (set to an integer at a bin boundary and do not estimate)
P2 – log(relative male selectivity) at minL or age=0
P3 – log(relative male selectivity) at the dogleg
P4 – log(relative male selectivity) at maxL or max age.

For intermediate ages, the log values are linearly interpolated on size (age).

If selectivity for the dependent gender is greater than selectivity for the first gender (which always peaks at 1.0), then the male-female selectivity matrix is rescaled to have a maximum of 1.0. Still need to check consequences for gradient calculations.

Reading The Selectivity And Retention Parameters

Read the required number of parameter setup lines as specified by the definition lines above. The complete order of the parameter setup lines is:

Size selectivity for fishery 1

Retention for fishery 1

Male offsets for size selectivity for fishery 1

<repeat for additional fleets and surveys>.

Age selectivity for fishery 1

Male offsets for age selectivity for fishery 1

<repeat for additional fleets and surveys>.

Note that the male selectivity offsets currently cannot be time-varying. Because they are offsets from female selectivity, they inherit the time-varying characteristics of the female selectivity. After reading the selectivity parameters, which will include possible instructions to create environmental link, blocks, or dev vectors, then read the following.

1	Selparm_Adjust_Method	1 = parameter adjustments for env, block and dev are as in V1.xx 2 = parameter adjustments use a logistic transformation to assure that adjusted parameter value stays within bounds of base parameter
0	Custom_Env_linkage	Include no setup lines below if no SEL-parms have Env-var>0 If there is at least one SEL-parm with Env-var>0, then If custom=0, then read one setup and apply to all env fxns; If custom>0, then read a setup line for each SEL-parm with Env-var>0
Enter proper number of short set-up lines (0, 1, several) for the SEL-parm environmental linkages. Each line will have 7 values: LO, HI, INIT, PRIOR, PR_type, SD, PHASE.		
0	Custom_block_setup	Include no setup lines below if no SEL-parms have Block>0 If there is at least one SEL-parm with Block>0, then If custom=0, then read one setup and apply to all Block fxns; If custom>0, then read a setup line for each SEL-parm with Block>0. Note that the SS2-nuControl.ctl will write out with custom=1 so it can write all the parameter values.
Enter proper number of short set-up lines (0, 1, several) for the SEL-parm block linkages. Each line will have 7 values: LO, HI, INIT, PRIOR, PR_type, SD, PHASE.		
-4	Selparm_dev_phase	Phase in which selparm devs, if any, are estimated

<u>Variance Adjustment Factors</u>

When doing iterative reweighting of the input variance factors, it is convenient to do this in the control file, rather than the data file. This section creates that capability. There are six rows and a value for each Fleet&survey on each row.

row 1 value added to survey CV (set to 0.0 for no effect, negative values are OK, but will crash if adjusted value becomes negative.)

row 2 value added to discard stddev (set to 0.0 for no effect)

row 3 value added to mean body wt stddev (set to 0.0 for no effect)

row 4 multiplier for lencomp effective N (set to 1.0 for no effect)

row 5 multiplier for agecomp effective N (set to 1.0 for no effect)

row 6 multiplier for size-at-age effective N (set to 1.0 for no effect)

Usage note: the ss2.rep output file contains information useful for determining if an adjustment of these input values is warranted to better match the scale of the average residual to the input variance scale.

Usage note: because the actual input variance factors are modified, it is these modified variance factors that are used when creating parametric bootstrap data files. So, the control files used to analyze bootstrap generated data files should have the variance adjustment factors reset to null levels.

Degrees of Freedom for Discard and Mean Body Weight

30 Degrees of freedom for Student's T distribution used to scale discard deviations

30 Degrees of freedom for Student's T distribution used to scale mean body weight deviations.

Lambdas (emphasis factors)

These values are multiplied by the corresponding likelihood component to calculate the overall negative log likelihood to be minimized.

1	Max_lambda_phase: read this number of lambda values for each element below. The last lambda value is used for all higher numbered phases
0	sd_offset; value=0 causes log(like) to omit the +log(s) term; value=1 causes log(like) to include the log(s) term for CPUE, discard, meanbodywt, recruitment deviations.

USAGE Note: If the CV for size-at-age is being estimated and the model contains mean size-at-age data, then the flag for inclusion of the +log(stddev) term in the likelihood must be included. Otherwise, the model will always get a better fit to the mean size-at-age data by increasing the parameter for CV of size-at-age.

The order of reading is:
CPUE lambda for each fleet and survey
Discard lambda for each fleet and survey (even though survey discard data never exist)
MeanBodyWeight lambda (one value)
Length composition lambda for each fleet and survey
Age composition lambda for each fleet and survey
Mean size-at-age lambda for each fleet and survey
Initial Equilibrium F lambda (one value)
Recruitment deviations lambda (one value)
Parameter prior lambda (one value)
Parameter deviation time series lambda (one value)
Crash penalty lambda for high harvest rates (one value)

For example, if Max_lambda_phase is 2, and there is one fishery and one survey, the first few values would be:

10	1	lambdas for phase 1 and phases 2+ for fleet 1 CPUE

100	1	lambdas for phase 1 and phases 2+ for survey index
1	1	lambdas for phases 1 and phases 2+ for fleet 1 discard

0.9 Maximum allowable harvest rate

End Control File
999 #_end-of-file

<u>Forecast Specification</u>
The specification of options for forecasts is contained in the mandatory input file named *FORECAST.SS2*. Note that the values for summary age, forecast option and MSY option have been moved to the STARTER.SS2 file in V2.00.

The contents of this file are:

0.5	Target SPR. This is used for calculating both the Fspr and the Fbtarget
3	Number of forecast years
3	Number of forecast years with stddev, must be less than or equal to total forecast years. Nearly all model dimensioning uses this value.
100	Recruitment deviation emphasis – see below
0	Fraction of log-bias adjustment to use before endyr+1– see below
0	Fraction of log-bias adjustment to use after endyr – see below
.40	Top end of OY 40:10 option; set to 0.0 for no reduction in harvest rate at low biomass
0.10	Bottom end of OY 40:10 option; forecast catch=0 when spawn biomass below this level
-3	First year (relative to endyr) for averaging fishery selectivity to be used in the forecast. It is OK to enter an absolute year, rather than a relative year.
0	Last year (relative to endyr) for averaging fishery selectivity to be used in the forecast. It is OK to enter an absolute year, rather than a relative year.
1.00	OY scalar relative to ABC. Values less than or equal to 1.0 invoke the PFMC relationship that scales catch to spawning biomass and uses this value as an additional scaler on F. A value greater than 1.0 and less than or equal to 2.0 invokes a relationship between F and spawning biomass and sets the F scalar equal to this factor value minus 1.0.
1	Relative F option 1=set relative F from endyr; 2=use relative F read below Then enter the pattern of relative harvest rate to be used when Option 2 above is selected. Otherwise, the pattern of harvest rates across seasons and fleets in the endyear is used when finding Fmsy, Fspr and doing the forecast.
1.	# relative harvest rate for fleet 1 in season 1
.25	# relative harvest rate for fleet 2 in season 1
0.01	# relative harvest rate for fleet 1 in season 2
1.00	# relative harvest rate for fleet 2 in season 2
999	verification value to be sure that correct number of relative rate values were read
	Retained catch in each forecast year, season, fleet. Positive value overrides the forecast harvest rate. Generally, at least one year will have specified catches set equal to the actual or expected actual catch because these years are too soon to be influenced by the outcome of the assessment.
500	year 1 season 1 fleet 1 for forecast years
75	year 1 season 1 fleet 2 for forecast years

1	year 1 season 2 fleet 1 for forecast years
550	year 1 season 2 fleet 2 for forecast years
-1	year 2 season 1 fleet 1 for forecast years
-1	year 2 season 1 fleet 2 for forecast years
-1	year 2 season 2 fleet 1 for forecast years
-1	year 2 season 2 fleet 2 for forecast years
-1	year 3 season 1 fleet 1 for forecast years
-1	year 3 season 1 fleet 2 for forecast years
-1	year 3 season 2 fleet 1 for forecast years
-1	year 3 season 2 fleet 2 for forecast years

The vector of forecast recruitment deviations is estimated during an additional model estimation phase. This vector includes any years after the end of the recrdev time series and before or at the endyear. When this vector starts before the ending year of the time series, then the estimates of these recruitments will be influenced by the data in these final years. This is problematic, because the original reason for not estimating these recruitments at the end of the time series was the poor signal/noise ratio in the available data. It is not that these data are worse than data from earlier in the time series, but the low amount of data accumulated for each cohort allows an individual datum to dominate the model's fit. Thus, an additional control is provided so that forecast recruitment deviations during these years can receive an extra weighting in order to counter-balance the influence of noisy data at the end of the time series.

An additional control is provided for the fraction of the log-bias adjustment to apply to the forecast recruitments. Recall that R is the expected mean level of recruitment for a particular year as specified by the spawner-recruitment curve and R' is the geometric mean recruitment level calculated by discounting R with the log-bias correction factor e-0.5s^2. Thus a lognormal distribution of recruitment deviations centered on R' will produce a mean level of recruitment equal to R. During the modeled time series, the virgin recruitment level and any recruitments prior to the first year of recruitment deviations are set at the level of R, and the lognormal recruitment deviations are centered on the R' level. For the forecast recruitments, the fraction control can be set to 1.0 so that 100% of the log-bias correction is applied and the forecast recruitment deviations will be based on the R' level. This is certainly the configuration to use when the model is in MCMC mode. Setting the fraction to 0.0 during maximum likelihood forecasts would center the recruitment deviations, which all have a value of 0.0 in ML mode, on R. Thus would provide a mean forecast that would be more comparable to the mean of the ensemble of forecasts produced in MCMC mode. Further work on this topic is underway.

Changes in Forecast Functionality in V2.00

1. Cohorts continue growing according to their specific growth parameters in the forecast period rather than staying static at the endyr values.

2. Environmental data entered for future years can be used to adjust expected recruitment levels. However, environmental data will not affect growth or selectivity parameters in the forecast.

3. Additional options for which F to use in the forecast (see STARTER.SS2).

4. A new option to average fishery selectivity over a range of years for use in the MSY, SPR and forecast. Note that a comparable function to average the size-at-age and fecundity across years has not been developed.

Output Files

standard ADMB output files
SS2.PAR, *SS2.STD*, *SS2.REP*, *SS2.COR* etc.

The *SS2.STD* file contains some derived quantities so that their variance can be displayed. These are:

R0 – the equilibrium recruitment in an unfished state
S0 – the spawning biomass corresponding to R0
Spbio_std: time series of spawning biomass for the range of years specified in the ss2names.nam file.
Recr_std: time series of recruitment for the same range of years.
Depletion: this is a multi-component vector containing:

Depletion(0) = Spbio(endyr)/S0
Depletion(1)=Spbio(endyr+1)/S0

If MSY is not calculated, then:
depletion(2)=-Spbio(endyr-1);
depletion(3)=-Spbio(endyr);
depletion(4)=-Spbio(endyr+1);
The above 3 outputs are duplicative, but something needs to be there to get a well-behaved Hessian.

If MSY is calculated, then:
depletion(2)=MSY;
depletion(3)=Bmsy;
depletion(4)=SPR;

Then if the forecast is turned on:
Spbio(endyr+1, endyr+N_forecast_yrs_std)
Recruitment(endyr+1, endyr+N_forecast_yrs_std)
Depletion(endyr+1, endyr+N_forecast_yrs_std)
TotalCatch or total harvest rate(endyr+1, endyr+N_forecast_yrs_std)
TotalCatch/SummaryBiomass(endyr+1, endyr+N_forecast_yrs_std)

Brief cumulative output
SS2-REPORT.TXT: contains a brief version of the run output, which is appended to current content of file so results of several runs can be collected together. This is especially useful when a batch of runs is being processed. Unless this file is deleted, it will contain a cumulative record of all runs done in that subdirectory. The first column contains the run number. The contents (columns truncated to fit the page) are:

40	likegfish.dat	likegfish.CTL	1491.17	56792.		4530.25	Thu Jan 19

							13:37:32 2006		
40	Like-Emph	Total		1	Indices	1	1	1	Discard
40	Var_adjust	X		X	Index_extra_CV	0	0	0	Discard _extra_ CV
40	Like-Value		1491.17	1491.17	-7.2568	0	-5.21126	-2.04554	0
40	Phase		1779.45	1643.62	1503.66	1491.17	1491.17		
40	TimeSeries	Year		Vir	Equ	1971	1972	1973	1974
40	Timeseries	Spbio		56792.7	56074.3	56074.3	56071.6	56061.6	55672.8
40	Timeseries	Recruit		7699.42	7679.07	5448.81	8278.28	6575.76	7164.24
40	Timeseries	TotBio		148714	147083	146716	146599	146177	144946
40	Timeseries	SmryBio-2		145430	143808	143808	143808	142927	142046
40	Timeseries	TotCatch		0	100.002	100	100	1000	1000
40	Timeseries	RetCatch		0	0	100	100	1000	1000
40	MG_Parms		0.1	0	36	70	0.15	0.1	0.25
40	SR_Parms		8.9489	0.401773	0.56	0	-0.00265		
40	Q_Parms								
40	Sel_Parms		52.1741	25.8085	28.738	3.52001	0	40	0
40	Index:2	Year		1977	1980	1983	1986	1989	1992
40	Index:2	VBIO		138529	123887	100056	75110.4	57039	46050.6
40	Index:2	OBS		122005	130363	67074.8	37852.3	41481.1	82380.5
40	Index:2	EXP		120363	107641	86935.1	65261	49559.3	40011.8
40	Index:3	Year		1990	1991	1992	1993	1994	1995
40	Index:3	VBIO		3847.23	2824.63	1250.02	1112.67	3819.82	3495.18
40	Len:1	YR		1971	1972	1973	1974	1975	1976
40	Len:1	effN		240.571	121.014	135.712	185.951	81.0073	151.215
40	Len:2	YR		1977	1980	1983	1986	1989	1992
40	Len:2	effN		141.151	129.342	113.115	102.136	113.378	175.735
40	Age:1	YR		1971	1972	1973	1974	1975	1976
40	Age:1	effN		122.486	58.2216	64.5374	84.8333	82.6058	114.054

<u>Output for Rebuilder Package</u>

Output filename is REBUILD.DAT

#Title # various run summary outputs
SS2_default_rebuild.dat
Number of sexes
2
Age range to consider (minimum age; maximum age)
0 40
Number of fleets
1
First year of projection (Yinit)
2002
First Year of rebuilding period (Ydecl)
1999
Is the maximum age a plus-group (1=Yes;2=No)
1
Generate future recruitments using historical recruitments (1) historical recruits/spawner (2) or a stock-recruitment (3)
3
Constant fishing mortality (1) or constant Catch (2) projections
1
Fishing mortality based on SPR (1) or actual rate (2)
1
Pre-specify the year of recovery (or -1) to ignore
-1
Fecundity-at-age
0 1 2 3 4 5 6 7 8 9 10 <deleted values>
 0 0.00159008 0.0128943 <deleted values> #female fecundity; weighted by N in year Y_init across morphs and areas
Age specific selectivity and weight adjusted for discard and discard mortality
 #selex and wt for gender,fleet: 1 1
 0.114191 0.174077 0.245545 <deleted values>
 0.0248207 0.0707095 0.157683 <deleted values>
 #selex and wt for gender,fleet: 2 1
 0.114191 0.174077 0.245545 <deleted values>
 0.0248207 0.0707095 0.157683 <deleted values>
M and current age-structure in year Yinit: 2002
 # gender = 1
 0.1 0.1 0.1 0.1 0.1 <deleted values>
 1037.67 696.042 1468.49 <deleted values>
 # gender = 2
 0.1 0.1 0.1 0.1 <deleted values
 1037.67 696.042 1468.49 <deleted values>
Age-structure at Ydecl= 1999

902.589 668.071 1145.47 537.282 <deleted values>
902.589 668.071 1145.47 537.282 <deleted values>
Year for Tmin Age-structure (set to Ydecl by SS2)
1999
Number of simulations
1000
recruitment and biomass
Number of historical assessment years
93
Historical data
year recruitment spawner in B0 in R project in R/S project
1910 1911 1912 1913 1914 1915 1916 1917 1918 1919 <deleted values> 2001 2002
#years (with first value representing R0)
8853.43 8658.22 8651.96 8645.41 8638.43 8630.75 <deleted values> 1594.53 2075.34
#recruits; first value is R0 (virgin)
63679.5 63679.5 63679.3 63678.3 63673.9 63661.6 <deleted values> 8614.18 7313.2
#spbio; first value is S0 (virgin)
1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 <deleted values> 0 0 # in Bzero
0 1 1 1 1 1 1 <deleted values> 1 1 0 0 0 # in R project
0 1 1 1 1 1 1 <deleted values> 1 1 0 0 0 # in R/S project
Number of years with pre-specified catches
0
catches for years with pre-specified catches go next
Number of future recruitments to override
0
Process for overiding (-1 for average otherwise index in data list)
Which probability to product detailed results for (1=0.5; 2=0.6; etc.)
3
Steepness sigma-R Auto-correlation
0.371059 0.5 0
Target SPR rate (FMSY Proxy); manually change to SPR_MSY if not using SPR_target
0.5
Target SPR information: Use (1=Yes) and power
0 20
Discount rate (for cumulative catch)
0.1
Truncate the series when 0.4B0 is reached (1=Yes)
0
Set F to FMSY once 0.4B0 is reached (1=Yes)
0
Percentage of FMSY which defines Ftarget
0.75
Maximum possible F for projection (-1 to set to FMSY)
-1
Conduct MacCall transition policy (1=Yes)

```
0
# Defintion of recovery (1=now only;2=now or before)
2
# Results for rec probs by Tmax (1) or 0.5 prob for various Ttargets (2)
1
# Definition of the 40-10 rule
10 40
# Produce the risk-reward plots (1=Yes)
0
# Calculate coefficients of variation (1=Yes)
0
# Number of replicates to use
10
# Random number seed
-99004
# Conduct projections for multiple starting values (0=No;else yes)
0
# File with multiple parameter vectors
rebuild.ss2
# Number of parameter vectors: value is placeholder only, user needs to change it
1
# User-specific projection (1=Yes); Output replaced (1->9)
0  5  0  0.1
# Catches and Fs (Year; 1/2/3 (F or C or SPR); value); Final row is -1
2002 1 1
-1 -1 -1
# Split of Fs
2002 0.6
-1  99
# Time varying weight-at-age (1=Yes;0=No)
0
# File with time series of weight-at-age data
none
# Use bisection (0) or linear interpolation (1)
1
# Target Depletion
0.4
# Project with Historical recruitments when computing Tmin (1=Yes)
0
# CV of implementation error
0
```

Bootstrap data files

SS2-NUDATA.DAT: contains a user-specified number of datafiles, generated through a parametric bootstrap procedure, and written sequentially to this file. These can be parsed into individual data files and re-run with the model.

Updated control file

SS2-NUCONTROL.CTL: Updated version of the control file with final parameter values replacing the Init parameter values. Note that, at this time, the dev vectors are not written to this file.

<u>Forecast and reference points</u>

SS2-FORECAST-REPORT.TXT: This file contains output of fishery reference points and forecasts. It is designed to meet the needs of the Pacific Fishery Management Council's Groundfish Fishery Management Plan, but it should be quite feasible to develop other regionally specific variants of this output.

The top of this file shows the search for Fspr and the search for Fmsy so the user can verify convergence. Note: if the STD file shows aberrant results, such as all the standard deviations being the same value for all recruitments, then check the Fmsy search for convergence.

The Fmsy can be calculated, or set equal to one of the other F reference points per the selection made in STARTER.SS2.

The reference point output is shown in the table below:

Management_report						
Steepness_R0_S0	0.371	8853	63680			
+	(B_in_mT;_N_in_thousands)					
Element	Value	B_per_Recr	B_per_R0	B_Total	N_per_Recr	N_total
Recr_unfished(R0)	--	1.000	1.000	8853		
SPB_unfished(S0)	--	7.193	7.193	63680		
BIO_Smry_unfished	--	18.493	18.493	163727		
+	+	+	+	+		
SPR_target	0.500					
SPR_calc	0.500					
Fmult	0.261					
Exploit(Y/Bsmry)	0.052					
Recruit	--	--	0.265	2343		
SPBio	--	3.596	--	8426		
YPR_encountered	--	0.550	--	1289		
YPR_dead	--	0.550	--	1289	0.257	602
YPR_retain	--	0.550	--	1289		
Biomass_Smry	--	10.517	--	24641		
+	+	+	+	+		
Btarget_rel_to_S0	0.500					
Btgt_calc	0.500					
SPR	0.712					
Fmult	0.116					
Exploit(Y/Bsmry)	0.024					
Recruit	--	--	0.702	6218		
SPBio	--	5.120	--	31840		
YPR_encountered	--	0.335	--	2085		
YPR_dead	--	0.335	--	2085	0.141	880
YPR_retain	--	0.335	--	2085		
Biomass_Smry	--	13.947	--	86730		
+	+	+	+	+		
calculate_FMSY						
SPR	0.660					
Fmult	0.144					
Exploit(Y/Bsmry)	0.030					
Recruits	--	--	0.622	5506		
SPBio	--	4.750	--	26157		
SPBmsy/SPBzero(using_S0)	--	0.411	--	--		
SPBmsy/SPBzero(using_endyear_LifeHistory)	--	0.411	--	--		
MSY_for_optimize	--	0.391	--	2151		
MSY_encountered	--	0.391	--	2151		
MSY_dead	--	0.391	--	2151	0.168	927
MSY_retain	--	0.391	--	2151		
Biomass_Smry	--	13.124	--	72263		

The forecast is done once using the Target SPR and once using the adjustments specified in the 40:10 section of forecast.ss2 input. Each section contains a time series of seasonal biomass and catch, followed by a time series of population numbers-at-age for each morph.

Forecast_using_Fspr															
Allocation_Pattern_as_in_endyear															
Harvest_Rates_by_Season&Fleet_(equals_selected_forecast_Fmult_*_Allocation_pattern															
Season	fleet:1														
1	0.0802														
+															
Forecast_recruitments_use_this_fraction_of_logbias_adj_before_endyr+1:	1														
and_this_value_after_endyr:	0														
Extra_emphasis_on_forecast_recrdevs_before_endyr+1:	1														
N_forecast_yrs;_and_with_stddev:	6	6													
OY_Control:	Top;	Bottom;	Scale												
+	0.4	0.1	1												
+															
FORECAST:_Without_40:10															
pop	year	season	4010	bio-all	bio-Smry	SpawnBio	Depletion	recruit-0	dead_cat_B-1	retain_B-1	dead_cat_N-1	retain_N-1	Hrate-1	opt	ABC
1	2002	1	1	22361	21634	7313	0.115	2075	1116	1116	533	533	0.0802	R	1116
1	2003	1	1	22472	21613	7341	0.115	2082	1123	1123	534	534	0.0802	R	1123
+															
Forecast-NUMBERS_AT_AGE	<not shown here>														
FORECAST:__with_40:10_Adjustmen	0.4	0.1	1												
pop	year	season	4010	bio-all	bio-Smry	SpawnBio	Depletion	recruit-0	dead_cat_B-1	retain_B-1	dead_cat_N-1	retain_N-1	Hrate-1	opt	ABC
1	2002	1	0.17242	22361	21634	7313	0.115	2075	192	192	92	92	0.0138	R	1116
1	2003	1	0.226996	23357	22481	7674	0.121	2163	266	266	125	125	0.0182	R	1171
+															
Annual_all_area_values_stored_in_sdreport_vector_'depletion'_beginning_in_element_6															
Year	Spbio	Recruits	Depletion	Catch_or_	Exploitation										
2002	7313	2075	0.115	192.4	0.0089										
2003	7674	2163	0.121	265.8	0.0118										

Where:

40:10 is the magnitude of the adjustment of harvest multiplier to implement the OY policy

bio-all is the biomass of all ages

bio-smry is the biomass for ages at or above the summary age

Spawnbio is the female spawning output

Depletion is the spawnbio divided by the unfished spawnbio

Recruit-0 is the recruitment of age-o fish in this year

Dead_cat_B-1 is the total dead (retained plus dead discard) catch in MT for fleet 1;

Retain_B-1 is fleet 1's retained catch in MT

Equivalent catch in numbers is then reported.

Hrate-1 is the harvest rate, as adjusted by the 40:10 policy. The units will depend on the F method selected (Pope's method giving mid-year harvest rate or the continuous F.

Opt=C means that the rate was calculated from an input catch level (and crashed means that this caused an excessive harvest rate.

Opt=R means that the catch was calculated from the target harvest rate.

ABC is equal to the Total-Catch when the 40:10 option is not used (upper portion of table). When the 40:10 is on (lower table), the ABC is the catch level corresponding to no 40:10 adjustment after accounting for catch in previous year's from the 40:10.

The time series output described above is detailed by season, area, morph and fishery. It is usually more convenient to have annual values summed across areas, morphs and fisheries. This is done for the 40:10 output and a subset of these values are replicated in the depletion vector in the sd_report so that variance estimates can be obtained. The elements of the depletion vector in the sd_report are:

1. depletion level in end year
2. depletion level in end year+1
3. MSY (if calculated, else spbio in endyr-1)
4. BMSY (if calculated, else spbio in endyr)
5. SPRMSY (if calculated, else spbio in endyr+1)

then the time series of:

a. Spawning biomass

b. Recruitment

c. depletion level

d. total catch (if forecast calculated catch from rates) or sum of fishery-specific harvest rates (if forecast is based on fixed input catch level in this year)

e. Total exploitation rate (total dead catch / summary biomass at beginning of year).

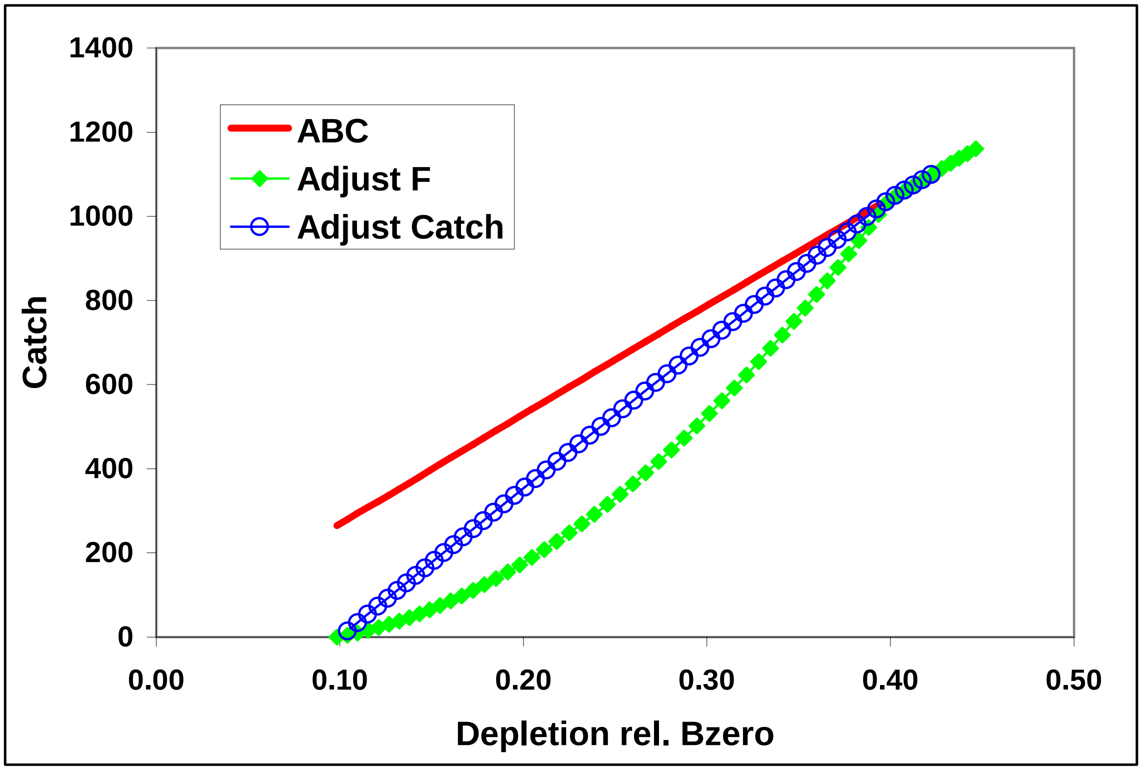


Figure 4. Two examples of harvest forecast adjustment: one adjusts catch and the other adjusts F.

Main output file

SS2.REP: This is the primary output file. Its major sections are listed below. Each has an associated label. The Excel spreadsheet ss2-output.xls reads this ss2.rep file, searches for labels in the first column, and copies the adjacent information into specific worksheets for detailed display. Similar capability has been built using R routines and has been included in the GUI.

LIKELIHOOD

Final values of the negative log(likelihood) are presented.

PARAMETERS

The parameters are listed here. For the estimated parameters, the display shows: Value, Phase, Min, Max, Init, Prior, PR_type, SD, Active_Cnt, Prior_Like, and Bound. The Active_Cnt entry is a count of the parameters in the same order they would appear in the ss2.cor file.

MGParm_Block_Assignments

Selex_Block_Assignments

If parameter time blocks are used, then for each base parameter that uses blocks, the parameter number of the block offset is shown for each year of the time series. A value of zero means that the base parameter retains its value for that year.

RECR_DIST

This block shows the distribution of recruitment across growth patterns, genders, birthseasons, and areas in the endyr of the model.

SUBMORPHDIST

This block shows a vector with the distribution of recruitment among sub-morphs within each growth pattern x gender x birthseason x area.

MGparm_By_Year_after_adjustments

This block shows the time series of Mgparms by year after adjustment by environmental links, blocks and deviations.

SELparm(Size)_By_Year_after_adjustments

This block shows the size selectivity parameters, after adjustment, for each year in which a change occurs.

SELparm(Age)_By_Year_after_adjustments

This block shows the age selectivity parameters, after adjustment, for each year in which a change occurs.

EXPLOITATION

This block shows the harvest rate (if Pope's approximation is used) or F by year and fleet.

TIME_SERIES

This section reports the time series of abundance, recruitment and catch for each of the areas (populations). It extends into the forecast period.

SPR_series

This section reports on the annual yield per recruit and biomass per recruit calculations. The level of recruitment used for the calculations is R0, the virgin recruitment level. Reported values are the levels that would occur if life history remained at the current year's values and fishery intensity and selectivity remained at the current year's levels. The report contains: Bio_all (fished total biomass at R0); Bio_Smry(fished summary biomass at R0); SPBzero (unfished spawning biomass at R0 and current year's life history); SPBfished (fished spawning biomass at R0 and current year's life history); SPBfished/R (fished spawning biomass per recruit); SPR (spawning potential ratio equal to SPBfished/SPBzero); Y/R (yield per recruit); GenTime (unfished generation time equal to mean age weighted by fecundity at age). Additional exploitation statistics are the AveF (average F across ages beginning at the summary age) for each gender, and the maxF (simply Z-M) among ages for each gender. This report section extends into the forecast period.

SPAWN_RECRUIT

This section shows the relationship among the steps to calculating recruitment. The column "exp-recr" shows the level estimated by the spawner-recruitment curve. The column "with-env" adjusts this value according to the inputted environmental conditions for that year. The column "bias-adj" adjusts the expected value downwards to the expected geometric mean to serve as the point of central tendency for the log-scale deviations. Finally, the column "pred-recr" shows the value used in the model after adjusting for the year specific recruitment deviation. Early years (prior to start of the recruitment deviations), including the virgin recruitment level, use the "exp-recr" level of recruitment. If the recruitment deviations stop before the ending year, then recruitment deviations for those years can be estimated as forecast recruitment deviations and will be labeled with "forecast" in this output. The root mean squared error of the recruitment deviations (not including deviations from the forecast vector) is shown below the time series.

INDEX_1

This section lists the options used for processing the abundance index data.

INDEX_2

This section reports the observed and expected values for each index. All are reported in one list with index number included as a selection field. At the bottom of this section, the root mean squared error of the fit to each index is compared to the mean input error level to assist the user in gauging the goodness-of-fit and potentially adjusting the input level of imprecision.

INDEX_3
This section shows the parameter number assigned to each parameter used in this section.

DISCARD
This is the list of observed and expected values for the amount (or fraction) discard.

MEAN_BODY_WT
This is the list of observed and expected values for the mean body weight.

FIT_LEN_COMPS
This is the list of the goodness of fit to the length compositions. The input and output levels of effective sample size are shown as a guide to adjusting the input levels to better match the model's ability to replicate these observations.

FIT_AGE_COMPS
This has the same format as the length composition section.

LEN_SELEX
Here is reported the time series of length selectivity for each fishery and survey.

RETENTION

DISCARD_MORT

KEEPERS – combination of length selectivity and retention

DEADFISH – this is sel*(retain+(1-retain)*discmort)

AGE_SELEX
Here is reported the time series of age selectivity for each fishery and survey.

AGE_SELEX_IN_ENDYEAR_FROM_SIZE_SELEX
This section shows the combination of length selectivity and the age-length key in the ending year. The overall age selectivity is the product of direct age selectivity and this age selectivity derived from length selectivity.

ENVIRONMENTAL_DATA

The input values of environmental data are echoed here. In the future, the summary biomass in the previous year will be mirrored into environmental column –2 and that the age zero recruitment deviation into environmental column –1.

NUMBERS_AT_AGE

The output is shown for each morph in each area.

CATCH_AT_AGE

The output is shown for each morph by each fleet. It is not necessary to show by area because each fleet operates in only one area.

BIOLOGY

The first biology section shows the length-specific quantities in the ending year of the time series only. The derived quantity spawn is the product of female body weight, maturity and fecundity per weight.

The second biology section shows the derived age-specific quantities for the population and, by taking into account size-selectivity, each fishery and survey.

Growth_Parameters

This section shows the growth parameters, and associated derived quantities, for each year in which a change is estimated.

MEAN_BODY_WT(begin)

This section reports the time series of mean body weight for each morph. Values shown are for the beginning of each season of each year.

MEAN_SIZE_TIMESERIES

This section shows the time series of mean length-at-age for each morph.

AGE_LENGTH_KEY

This is reported for the midpoint of each season in the ending year.

AGE_AGE_KEY

This is the calculated distribution of observed ages for each true age for each of the defined ageing keys.

Composition_Database

This section contains the length composition, age composition, and mean length-at-age observed and expected values. It is arranged in a database format, rather than an array of vectors. Software to filter the output allows display of subsets of the database.

Selectivity_Database.

This section contains the selectivities organized as a database, rather than as a set of vectors.

Running SS2

SS2 can be run from a DOS window in a directory containing the file SS2.EXE (or a path to SS2.EXE) and the necessary SS2 input files. Simply type SS2 at the DOS prompt. This will start the executable and the first step will be to open and read the file named *SS2NAMES.NAM* which contains necessary run information.

As with all ADMB-based programs, switches are typed immediately after a space. For example,

SS2 –nohess

would run SS2 without calculating the Hessian matrix.

Alternatively, one can create a DOS batch file to invoke SS2 from a different directory and process various commands. The example below renames a file to ss2names.nam, calls SS2.exe, and then copies one of the output files to save it from being overwritten. This sequence is repeated 3 times here and can be repeated an unlimited number of times. The batch file can have any name with the .bat extension, and there is no particular limit to the DOS commands invoked. Note that brief output from each run will be appended to ss2-report.txt (see below).

<u>Example of DOS batch input file</u>

Simple batch

This first example relies upon having a set of ss2names.* files that can be renamed to *SS2NAMES.NAM* and then used to direct the running of SS2

```
del ss2.cor
del ss2.std
copy ss2names.r01 ss2names.nam
c:\admodel\ss2\ss2.exe -sdonly
copy ss2.std ss2-std01.txt

copy ss2names.r02 ss2names.nam
c:\admodel\ss2\ss2.exe -sdonly
copy ss2.std ss2-std02.txt
```

Complicated batch

This second example processes 25 dat files from a different directory, each time using the same ctl and nam file. The loop index is used in the file names, and the output is searched for particular keywords to accumulate a few key results into the file *SUMMARY.TXT*. Comparable batch processing can be accomplished by using R or other script processing programs.

```
del summary.txt
del ss2-report.txt
```

```
copy /Y runnumber.zero runnumber.ss2

FOR /L %%i IN (1,1,25) DO (
copy /Y ..\MakeData\A1-D1-%%i.dat  Asel.dat
del ss2.std
del ss2.cor
del ss2.par
c:\admodel\ss2\ss2.exe
copy /Y ss2.par A1-D1-A1-%%i.par
copy /Y ss2.std A1-D1-A1-%%i.std
find "Number" A1-D1-A1-%%i.par >> Summary.txt
find "hessian" ss2.cor >> Summary.txt)
```

Batch using PROFILEVALUES.SS2

This example will run a profile on natural mortality and spawner-recruitment steepness, of course.

Edit the control file so that the natural mortality parameter and steepness parameter lines have the phase set to –9999

Edit STARTER.SS2 to refer to this control file and the appropriate data file

Create a PROFILEVALUES.SS2 file

```
2     # number of parameters using profile feature
0.16  # value for first selected parameter when runnumber equals 1
0.35  # value for second selected parameter when runnumber equals 1
0.16  # value for first selected parameter when runnumber equals 2
0.40  # value for second selected parameter when runnumber equals 2
0.18  # value for first selected parameter when runnumber equals 3
0.40  # value for second selected parameter when runnumber equals 3
```

etc.; make it as long as you like.

Create a batch file that looks something like this. Or make it more complicated as in the example above.

```
del ss2-report.txt
copy /Y runnumber.zero runnumber.ss2   % so you will start with runnumber=0
C:\SS2\ss2.exe
C:\SS2\ss2.exe
C:\SS2\ss2.exe
C:\SS2\ss2.exe
```

Repeat as many times as you have set up conditions in the PROFILEVALUES.SS2 file.

The summary results will all be collected in the SS2-REPORT.TXT file. Each step of the profile will have an unique Runnumber and its output will include the values of the natmort and steepness parameters for that run.

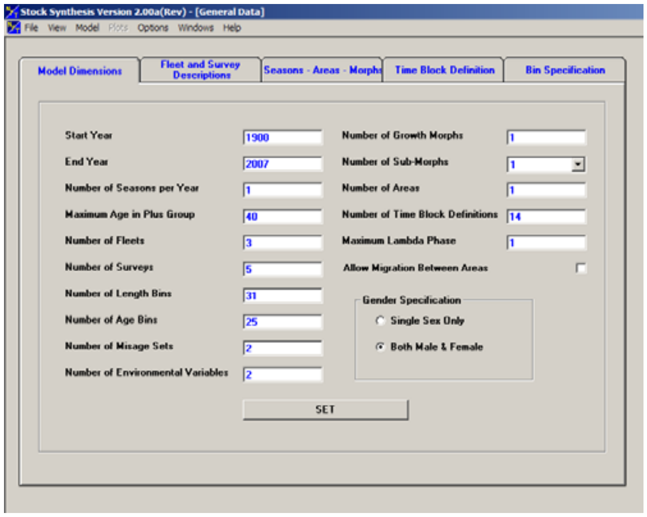
Graphical Interface

The SS2 graphical interface uses the same general approach as other stock assessment models in the NOAA Fisheries Assessment Toolbox. The GUI reads and writes DOS text files that are identical in content to the text files described in this document. When the GUI is started, the user sees the Input Files screen. Click on File-Open Existing SS2 File, navigate to the folder containing the target files, and open STARTER.SS2. The GUI opens all necessary files

After reading the files, the user can then select one of the 5 windows for reviewing and editing input information. These windows are:

1. Starter file
2. General data (basically model dimensions)
3. Forecast specifications
4. Observed data (most information from the dat file)
5. Control parameters (most information from the ctl file).

Each window contains a multiple document interface with different tabs for different categories of information.



The GUI contains an internal editing window that allows for editing a cell, or continuously editing within a row or column. Marking a block of cells or clicking on a row or column header calls up a cut – paste option. In addition, blocks of information can be cut from external text editors or spreadsheets and pasted into the GUI cells, but only if the size of the block conforms. Also the user can resize the width of columns to allow viewing the most relevant columns more easily.

If you give the GUI a command that results in resizing arrays (such as changing the selectivity pattern to be used for a particular fishery so that the required number of parameters is changed) then the set of new parameters will be set to blank. The user could then select a block of control specifications from SS2-examples.xls for the newly invoked selectivity function and paste them into this blank area.

When the user is ready to run the program, select Model – Run. The GUI will then save all the input files, run the program, return to the GUI, scan the output files, and return control to the user for viewing the output.

Before using the GUI, it is wise to save a back-up copy of all input files. This is because all custom comments you have placed in these text files will be lost when they are read and rewritten by the GUI. Also, possible GUI crashes may cause loss of some information when the input files are being written.

Future developments with the GUI may include more internal business rules to check for illegal or illogical combinations of input choices, more context-sensitive help, scanning of more output files, etc.

<u>Debugging Tips</u>

When SS2 input files are causing the program to crash or fail to produce sensible results, there are a few steps that can be taken to diagnose the problem.

a. set the turn_off_phase switch to 0 in the STARTER.SS2 file. This will cause the mode to not attempt to adjust any parameters and simply converges a dummy parameter. It will still produce a SS2.REP file, which can be examined to see what has been calculated from the initial parameter values.

b. turn the verbosity level to 2 in the STARTER.SS2 file. This will cause the program to display the value of each likelihood component to the screen on each interation. So it the program is creating an illegal computation (e.g. divide by zero), it may show you which likelihood component contains the problematic calculation. If the program is producing a SS2.REP file, you may then see which observation is causing the illegal calculation.

c. run the program with the command SS2 >>SS2pipe.txt. This will cause all screen display to go to the specified text file (note, delete this file before running because it will be appended to). Examination of this file will show detailed statements produced during the reading and preprocessing of input files.

d. *SS2-CHECKUP.TXT*: This file is written during the first iteration of the program. It contains details of selectivity and other calculations as an aid to debugging model problems.

Special Issues

Recruitment Variability and Bias Corrections

Recruitments in SS2 are defined as lognormal deviates around a log-bias adjusted spawner-recruitment curve. The magnitude of the log-bias adjustment is calculated from the level of σ_R, which is the standard deviation of the recruitment deviations (in log-space). There are 5 segments of the time series in which to consider the effect of the log-bias adjustment: virgin; initial equilibrium; early data-poor period; data-rich period; very-recent/forecast.

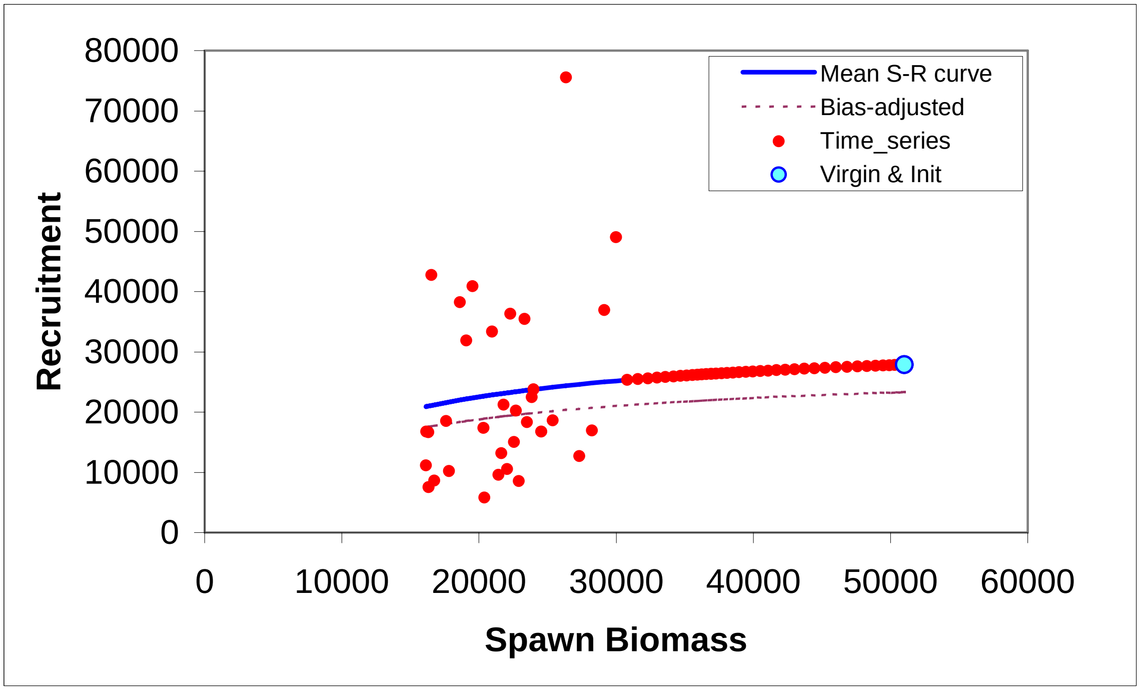


Figure. Spawner-recruitment results with a 72 year time series, no initial equilibrium catch, σ_R set to 0.6, estimated recruitments for last 32 years only, steepness and R_0 parameters estimated.

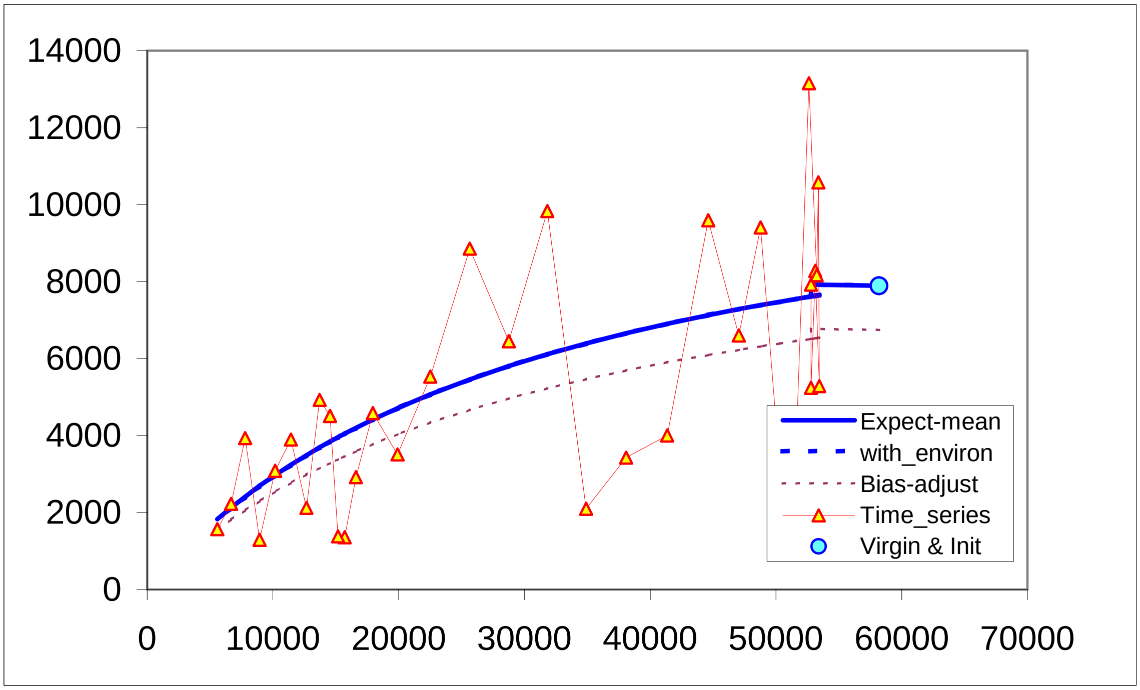


Figure. Spawner-recruitment results with a 30-year time series, initial equilibrium catch of 500 mtons, σ_R set to 0.56, estimated recruitments for all years, steepness and R_0 parameters estimated.

1. Virgin – the R_0 level of recruitment is a parameter of the spawner-recruitment curve. This recruitment and the corresponding spawning biomass, S_0, are expected to represent the long-term arithmetic mean.

2. Initial equilibrium – the level of recruitment is typically maintained at the R_0 level even though the initial equilibrium catch will reduce the spawning biomass below the virgin level. If steepness is moderately low or the initial F is high, then the lack of response in recruitment level may appear paradoxical. The logic is that building in the spawner-recruitment response to initial F would significantly complicate the calculations and would imply that the initial equilibrium catch level had been going on for multiple generations. If the lack of response is considered to be problematic in a particular application, then start the model at an earlier year and with a lower initial equilibrium catch so that the dynamics of the spawner-recruitment response get captured in the early period, rather than getting lost in the initial equilibrium.

3. Early data-poor period – This is the early part of the time series where the only data typically are landed catch. There are no data to inform the model about the specific year-to-year fluctuations in recruitment, although the ending years of this period will begin to be influenced by the data. The "early time period" is not a formal concept. It is up to the user to decide whether to start estimating recruitment deviations beginning with the first year of the model, or to delay such estimation until the data become more informative.

Option A: do not estimate recruitment deviations during this early period. During years prior to the first year of recruitment deviations, the model will set the recruitment equal to the level of the spawner-recruitment curve. Thus, it is a mean-based level of recruitment. Because these annual parameters are fixed to the level of the spawner-recruitment curve, they have no additional uncertainty and make no contribution to the variance of the model.

This approach may produce relatively large, or small, magnitude deviations at the very beginning of the subsequent period, as the model "catches up" to any slight signal that could not be captured through estimated deviations in the early data-poor period. There may be some effect on the estimate of R_0 as a result of lack of model flexibility in balancing early period removals with signal in the early portion of the data-rich period.

Option B: estimate recruitment deviations for all the early years. Each of these recruitment deviations is now a dev parameter so will have a variance that contributes to the total model variance. The estimated standard deviation of each of these dev parameters should be equal to σ_R because σ_R is the only constraint on these parameters (however, the last few in the sequence will begin to feel the effect of the data so should have lower standard deviations).

MPD: The maximum posterior density will occur when these early recruitment deviations are at zero (except those influenced by the data). Because there are no year-to-year, lognormally distributed changes in these recruitments, their arithmetic mean declines to equal their geometric mean. Thus, the biomass at the end of the early period will decline below the initial equilibrium level just because recruitments are now at the lower geometric mean level. The magnitude of this decline depends on the magnitude of σ_R and the duration of the early period. Thus, reported depletion levels during this early period are an artifact of the MPD and should not be interpreted with respect to the status of the stock.

If the first year of recruitment devs is much before the onset of data that are informative about recruitment fluctuations, then it would be useful for the MPD estimation to have more control over the degree of log-bias adjustment to apply, similar to the control for the forecast recruitments. This could be done by creating another dev vector called "early recruitment deviations" so that the user can control use of the log-bias adjustment during the early period separately from the data-rich period.

MCMC: During the MCMC, the model will draw the recruitment deviation values from the lognormal distribution. Because these draws now have lognormal variability in year-to-year recruitment, the average biomass from the converged MCMC chain will behave as if arithmetic mean recruitment was occurring. Therefore, the early biomass levels in MCMC are in equivalent terms to the virgin biomass, so reported depletion levels are meaningful.

4. Data-rich period: Here the data inform the model on the year-to-year level of recruitment. These fluctuations in recruitment are assumed to have a lognormal

distribution around the log-bias adjusted spawner-recruitment curve. The level of σ_R input to the model should match this level of fluctuation to a reasonable degree. Because the recruitments are lognormal, they produce a mean biomass level that is comparable to the virgin biomass and thus the depletion level can be calculated without bias. However, if the early period has recruitment deviations estimated by MPD, then the depletion levels during the early part of the data-rich period may have some lingering effect of negative bias during the early time period.

The level of σ_R should be reasonably close to the level of variability in these estimated recruitments. If too high a level of σ_R is used, then a bias can occur in the estimate of spawner-recruitment steepness, which determines the trend in recruitment. This occurs when the early recruitments are taken directly from the spawner-recruitment curve, so are mean unbiased, then the later recruitments are estimated as deviations from the log-bias adjusted curve. If σ_R is too large, then the bias-adjustment is too large, and the model may compensate by increasing steepness to keep the mean level of recent recruitments at the correct level.

5. Recent Years/Forecast: Here the situation is very similar to the early time period in that there are no data to inform the model about the year-to-year pattern in recruitment fluctuations so all devs will be pulled to a zero level in the MPD. A control has been introduced so that the user can select the fraction of the log-bias adjustment to use during the forecast. Setting this at 0.0 for the MPD will cause future recruitments to be at the mean level. Setting this to 1.0 for the MCMC will cause the future recruitments to have a lognormal distribution around the geometric mean, thus creating an expected arithmetic mean that should be the same as the arithmetic mean without log-bias adjustment. The structure of SS2 creates no sharp dividing line between the estimation period and the forecast period. In many cases one or more recruitments at the end of the time series will lack appreciable signal in the data and should therefore be treated as forecast recruit deviations. To the degree that some variability is observed in these recruitments, partial or full bias correction may be desirable for these devs separate from the purely forecast devs, there is therefore an additional control for the level of bias correction applied to forecast deviations occurring prior to endyear+1.

Issues with Including Environmental Effects:

The expected level of recruitment is a function of spawning biomass, an environmental time series, and a log-bias adjustment.

$$E(\text{Recruitment}) = f(\text{SpBio}) * \exp(\beta*\text{envdata}) * \exp(-0.5 * \sigma_R \text{^}2)$$

σ_R is the variability of the deviations, so it is in addition to the variance “created” by the environmental effect. So, as more of the total recruitment variability is explained by the environmental effect, the residual σ_R should be decreased. The model does not do this automatically.

The environmental effect is inherently lognormal. So when an environmental effect is included in the model, the arithmetic mean recruitment level will be increased above the level predicted by f(SpBio) alone. The consequences of this have not yet been thoroughly investigated, but there probably should be another bias correction based on the variability of the environmental data as scaled by the estimated linkage parameter, β. It is also problematic that the environmental effect time series used as input is assumed to be measured without error.

The preferred approach to including environmental effects on recruitment is not to use the environmental effect in the direct calculation of the expected level of recruitment. Instead, the environmental data would be used as if it was a survey observation of the recruitment deviation. This approach is similar to using the environmental index as if it was a survey of age 0 recruitment abundance because by focusing on the fit to the deviations it removes the effect of SpBio on recruitment. In this alternative, the σ_R would not be changed by the environmental data; instead the environmental data would be used to explain some of the total variability represented by σ_R. This approach may also allow greater uncertainty in forecasts, as the variability in projected recruitments would reflect both the uncertainty in the environmental observations themselves and the model fit to these observations.

Initial Age Composition – If the first year with recruitment deviations is set less than the start year of the model, then these early deviations will modify the initial age composition. The amount of information on historical recruitment variability certainly will degrade as the model attempts to estimate deviations for older age groups in the initial equilibrium. So the degree of bias correction is reduced linearly in proportion to age so that the correction disappears when maximum age is reached. The initial age composition approach normally produces a result that is indistinguishable from a configuration that starts earlier in the time series and estimates a longer time series of recruitments. However, because the initial equilibrium is calculated from a recruitment level unaffected by spawner-recruitment steepness and initial age composition adjustments are applied after the initial equilibrium is calculated, it is possible that the initial age composition approach will produce a slightly different result than if the time series was started earlier and the deviations were being applied to the recruitment levels predicted from the spawner-recruitment curve.

Version Log

This section records changes made to the SS2 code and features since version 1.19 in April 2005 through version 1.23e in Nov 2006.

<u>Version 1.19a-b; May 2005</u>

- Code improvement:
    - Improvement to search for Fmsy
    - Augment output to forecast file

<u>Version 1.19c; June 2005</u>

- Code improvement:
    - Selectivity mirror option was not handling males correctly

<u>Version 1.20; July 2005</u>

- Super-years: introduce capability to specify that a datum spans several years.
    - Input Files: no mandatory changes, but –9998 and –9999 are now reserved values in sample size input.
    - Output files: no changes
- Code improvement
    - Size-at-age data ignore: negative value for overall sample size allows ignore of entire size-at-age sample in likelihood
    - Many changes to ss2.rep and forecast
    - Complete the implementation of age selectivity option #18
- Batch file options: create runnumber.ss2 and profilevalues.ss2
    - Input Files: require these two files.
    - Output files: no changes
- Convergence criterion: add user specified convergence criterion
    - Input Files: require value at end of ss2names.nam
    - Output files: no changes
- Input variance adjustment: add capability to adjust the composition sample sizes and the survey CVs for each type of input
    - Input Files: require six rows above the lambdas in the control file
    - Output files: no changes
- New Selectivity option #8: add a variation on the double-logistic selectivity option
    - Input Files: no mandatory changes
    - Output files: no changes
- Male selectivity offset: allow female selectivity to be defined relative to male
    - Input Files: male selectivity options are now 0/1/2, so “2” now has specific meaning
    - Output files: no changes

<u>Version 1.20a; October 2005</u>

- Rebuilding output: introduce output in specific format of Andre Punt’s rebuilding analysis program
    - Input Files: no changes
    - Output files: new file SS2-rebuilder.txt is produced

<u>Version 1.20b; October 2005</u>

- Data bootstrap: revise bootstrap data generator to produce true multinomial.
  - Input Files: no changes
  - Output files: no changes

<u>Version 1.21; November 2005</u>

- New selectivity option #19: six parameter double logistic.
  - Input Files: no mandatory changes
  - Output files: no changes
- Age-specific maturity: add option to input age-specific maturity by morph. Note that this option has not been included in the Toolbox GUI.
  - Input Files: no mandatory changes
  - Output files: no changes
- Revise age-selectivity option #10: age-selectivity is set to 0.0 for age 0. Previously this option selected all ages beginning at age 0. This change could slightly altered some results, but see age selectivity option #11 to regain access to age 0.
  - Input Files: no mandatory changes
  - Output files: no changes

<u>Version 1.21; January 2006</u>

- Code improvement
  - Introduce trap in application of input variance adjustment to prevent negative variance calculations

<u>Version 1.22; January 2006</u>

- Initial age composition: Allow the first year for recruitment deviations to be before the start year of the model in order to calculate non-equilibrium initial age composition.
  - Input Files: no mandatory changes
  - Output files: no changes

<u>Version 1.23; February 27, 2006</u>

- Discard mortality: Introduce fractional discard mortality. Previously all selected but discarded fish were assumed to be dead. Now the model calculates selected (e.g. encountered) fish, dead fish and retained fish.
  - Input Files: no mandatory changes. When option is selected; 4 additional parameters are required per fishery that uses this option.
  - Output files: Changes made to ss2.rep and to the forecast output.
- MSY and Forecast: change code so that MSY calculation and forecast will occur in the Final_Section if it has not already occurred in the SD_phase.
  - Input Files: no changes
  - Output files: no changes
- Code improvement – note that these could have a small effect on some model configurations.
  - Fix inaccurate application of male offset in the retention function

  - Fix inaccurate application of age-varying natural mortality when calculating survivorship
  - Delete contribution of age zero fish to spawning biomass in the initial equilibrium to make it consistent with calculations during the time series

Version 1.23d; April 2006

- Length selectivity mirroring
  - When specifying the bin range for length selectivity mirroring (pattern #5) it is now permissible to use default values; see updated pattern #5 description.
- Survey Q documentation
  - Update documentation on the FLOAT options. A FLOAT value of 0 invokes median unbiased. Documentation had it vice versa.
- Survey Q new option
  - Change so that FLOAT=-9999 now invokes scaling log(Q) with variable CV taken into account
  - FLOAT = -<type> causes the Q to mirror Q for the specified lowered number type.
- Survey catchability documentation: correct the description of the order of survey parameters
- Add new size-selectivity option #22 – a 4 parameter double normal with plateau

Version 1.23e; Nov 2006

- Add new size-selectivity option #23 – a 6 parameter double normal with plateau and initial and final levels defined
- Clarify description of selectivity option #4 (spawner biomass)
- Correct documentation on environmental data link, which is multiplicative not linear
- Add capability to read environmental data for future years and to use in the recruitment function. Note that use of environmental data to modify growth or selectivity in the forecast years is not possible.
- Add section on debugging to this documentation
- Modify program operation when the turn_off_phase is set to zero. With this modification, estimation of forecast recruitments will also be turned off.

<u>Version 2.00a; March 2007</u>

Issues with V1.xx that are addressed in V2.00

- Make correction to application of age-specific M; V1.xx was referring to current age, not previous age in calculating survivorship;
- Note that spawning biomass is a model quantity, not a survey, so selectivity option #4 that tried to do spawning biomass as a mid-season survey could not exactly match the actual beginning of season spawning biomass
- Expected value of discard amount is now taken from the actual model quantity, not from a mid-season calculation that was equivalent to a survey
- The male offset for retention was not fully implemented in V 1.xx
- Gender selectivity offsets could not be time-varying in V 1.xx

- Log(L) penalty on the initial recruitment (R1) parameter was incorrectly implemented in V 1.xx.
- Method for adjustment of parameters through blocks or environmental links could cause the adjusted parameter value to go outside bounds on the base parameter

Major new features in V 2.00

Growth

- Re-work morph concept into growth patterns; involves major rework of the parameter setup for apportionment of recruitment among growth patterns, genders, birth seasons, and areas
- Create easy implementation of sub-morphs within growth pattern x gender
- More maturity and growth variability options
- Introduce cohort growth deviation to allow each cohort to have different effective K
- Change growth calculation so that linear growth occurs below the age Amin.

Recruitment

- Introduce seasonal recruitment options
- More control over the bias correction in recruitment
- Allow environmental factors to influence S-R parameters for R0 and steepness
- Add 6^{th} parameter for future implementation of auto-correlation

Selectivity

- New double normal selectivity as preferred dome-shaped option

Survey

- Major rework of survey catchabiity setup, including time-varying survey catchability as random devs or random walk
- Introduce 4 new survey types for spawning biomass, recruitment deviations, juvenile surveys (before density-dependence), and recruitment.

Statistical

- New symmetric beta prior distribution
- Estimate extra variance associated with surveys
- Introduce option for T-distribution in addition to sum of squares

Reference Points and Forecast

- Expanded and revised forecast options
- Output for Andre Punt's rebuilding analysis software
- Add capability to average fishery selectivity over past xxx years before doing reference point calculation and forecasts
- Report reference point and forecast results in terms of biomass and catch numbers.
- End time series calculations at endyear, not endyear+1. To get endyear+1, do a one year forecast. Also append all forecast calculations to the time series reporting in SS2.rep

- Allow growth deviations to propagate into the forecast
- Allow environmental data to extend into the forecast, but only for purpose of affecting the spawner-recruitment expected values

Miscellaneous

- Allow composition data to be read in any sort order
- Introduce alternative method for calculation of environmental links and blocks to keep the adjusted value in bounds of base parameter
- Modify method for robust MSY search
- Introduce continuous F option (with Fs as hidden parameters) while maintaining Pope's approximation
- Revise calculation of crash penalty and F ballpark to aid model robustness
- change tail compression so it checks for existence of obs in more than 1 bin for that gender before doing compression
- Implement movement between areas
- Allow recruitment deviations to be either a dev_vector (sum to zero constraint), or simple penalized deviations
- Various realignments of input between STARTER.SS2 and FORECAST.SS2 inputs.

Example Files

STARTER.SS2

```
Testrecr1.dat
Testrecr1.CTL
0       # 0=no Parameter read; use the init values in the CTL file;
1=use SS2.PAR
1     #Show_run_progress_on_console_(0/1/2)
1     #Produce_detailed_.rep_file_(0/1)
1     #_N_nudata
6      #_last_phase
Code_version_:_      # a simple string that starts the version label
10      # burn in for mcmc chain
2       # thinning interval for mcmc chain
.000  # jitter initial parm values by this fraction within parm bounds
0.01  # push initial parm values away from bounds
-1    # min year for spbio sd_report (negative value sets to styr-2;
the virgin level)
-1    # max year for spbio sd_report (negative value sets to endyr+1)
1.0e-4      # convergence criterion for maximum gradient
#  new stuff below

0     # retro year relative to endyr
1     # 1=keep catches; 0=set catches to nil
0.1   #F_ballpark   NEW
1999  #F_ballpark_yr  NEW
1       # 1=Pope's approx; 2=continuous F  (only for time series at
this time)

2     # summary age for biomass reporting

#Forecast_option (more details in forecast.ss2)
#0== no forecast
1 #== use F(spr) for forecast
#2 #== use F(msy) for forecast
#3 #== use F(btarget) for forecast
#4 #== use ending year F for forecast

#MSY options
#0 #== no MSY calc
#1 #== set F(msy) = F(spr)
2 #== calc F(msy)
#3 #== set F(msy) = F(btarget)
#4 #== set F(msy) = ending year F

#Input for west coast groundfish rebuilder program
1  # do rebuilder
1999 # first year for which catch could have been set to zero (Ydecl)(-
1 to set to endyear+1)
-1 # year for current age structure (Yinit) (-1 to set to endyear+1)
```

RUNNUMBER.SS2

```
7
```

PROFILEVALUES.SS2

```
2     # number of parameters using profile feature
0.4   # value for first selected parameter when runnumber equals 1
11.0  # value for second selected parameter when runnumber equals 1
0.5   # value for first selected parameter when runnumber equals 2
11.0  # value for second selected parameter when runnumber equals 2
0.4   # value for first selected parameter when runnumber equals 3
13.0  # value for second selected parameter when runnumber equals 3
```

etc.

FORECAST.SS2

0.5 # target SPR
6 # number of forecast years
6 # number of forecast years with stddev
1 # emphasis for the forecast recrutment devs that occur prior to endyyr+1
1 # fraction of bias adjustment to use with forecast_recruitment_devs before endyr+1
0 # fraction of bias adjustment to use with forecast_recruitment_devs after endyr
0.40 # topend of 40:10 option; set to 0.0 for no 40:10
0.10 # bottomend of 40:10 option
1.0 # OY scalar relative to ABC
-3 # first yr for average fish selex to use in MSY and forecast
0 # last yr for average fish selex to use in MSY and forecast
1 # for forecast: 1=set relative F from endyr; 2=use relative F read below
1 # relative F for forecast when using F; seasons; fleets within season

999 # verification read
-500 # year 1 season 1 fleet 1
-500 # year 2 season 1 fleet 1
-500 # year 3 season 1 fleet 1
-500 # year 4 season 1 fleet 1
-500 # year 5 season 1 fleet 1
-500 # year 6 season 1 fleet 1

CONTROL FILE

```
#_data_and_control_files:
#_Code_version_:__2.0_beta-
l;_01/10/07;_Stock_Synthesis_2_by_Richard_Methot_(NOAA);_using_Otter_Re
search_ADMB_7.0.1
1  #_N_growthpatterns
1 #_N_submorphs

1 #_N_areas
 1 1 1 1  #_area_assignments_for_each_fishery_and_survey

 #_recruit_design_(G_Pattern_x_birthseas_x_area)_X_(0/1_flag)
 1
0 #_recr_distr_interaction
0 #_Do_migration

#_movement_pattern_(season_x_source_x_destination)_x_(0/1_flag)_minage_
maxage
 0 1 1

3 #_Nblock_Designs
 3 2 1 #_blocks_per_design
 1975 1985 1986 1990 1995 2001
 1987 1990 1995 2001
 1999 2000

0.5 #_fracfemale
1000 #_submorph_between/within
 1 #vector_submorphdist_(-1_first_val_for_normal_approx)
4 #_natM_amin
15 #_natM_amax
1.66 #_Growth_Age-at-L1
25 #_Growth_Age-at-L2
0 #_SD_add_to_LAA
0 #_CV_Growth_Pattern
1 #_maturity_option
1 #_First_Mature_Age
2 #_parameter_offset_approach
1 #_MGparm_adjust_method
4 #_MGparm_Dev_Phase

#_growth_parms
#_LO HI INIT PRIOR PR_type SD PHASE env-var use_dev dev_minyr dev_maxyr
dev_stddev Block Block_Fxn
0.05 0.15 0.1 0.1 -1 99 -3 0 0 0 0 0.5 0 0 #_Gpattern:_1_Gender:_1
-3 3 0.1 0 -1 99 -3 0 0 0 0 0.5 0 0
10 55 36. 34 -1 99 -2 0 0 1980 1983 0.5 0 0
40 90 70 70 -1 99 -2 0 0 0 0 0.5 0 0
0.05 0.25 0.15 0.15 -1 99 -3 0 0 0 0 0.5 0 0
0.05 0.25 0.1 0.1 -1 99 -3 0 0 0 0 0.5 0 0
-3 3 0.1 0 -1 99 -3 0 0 0 0 0.5 0 0
0.05 0.15 0 0.1 -1 99 -3 0 0 0 0 0.5 0 0 #_Gpattern:_1_Gender:_2
-3 3 0 0 -1 99 -3 0 0 0 0 0.5 0 0
-1 1 0 0 -1 99 -2 0 0 0 0 0.5 0 0
-1 1 0 0 -1 99 -2 0 0 0 0 0.5 0 0
```

```
-1 1 0 0 -1 99 -3 0 0 0 0 0.5 0 0
0.05 0.25 0 0.1 -1 99 -3 0 0 0 0 0.5 0 0
-3 3 0 0 -1 99 -3 0 0 0 0 0.5 0 0
-3 3 2.44E-06 2.44E-06 -1 99 -3 0 0 0 0 0.5 0 0 #_wt-len&maturity
-3 3 3.34694 3.34694 -1 99 -3 0 0 0 0 0.5 0 0
-3 3 55 55 -1 99 -3 0 0 0 0 0.5 0 0
-3 3 -0.25 -0.25 -1 99 -3 0 0 0 0 0.5 0 0
-3 3 1 1 -1 99 -3 0 0 0 0 0.5 0 0
-3 3 0 0 -1 99 -3 0 0 0 0 0.5 0 0
-3 3 2.44E-06 2.44E-06 -1 99 -3 0 0 0 0 0.5 0 0
-3 3 3.34694 3.34694 -1 99 -3 0 0 0 0 0.5 0 0
-4 4 0 1 -1 99 -3 0 0 0 0 0.5 0 0 #_recrdistribution_by_growth_pattern
-4 4 0 1 -1 99 -3 0 0 0 0 0.5 0 0 #_recrdistribution_by_area
-4 4 0 1 -1 99 -3 0 0 0 0 0.5 0 0 #_recrdistribution_by_season
-1 2 1 1 -1 99 -3 0 0 1980 1983 0.5 0 0 #_cohort_growth_deviation

0 #_custom_MG-env_setup

0 #_custom_MG-block_setup

#_Spawner-Recruitment
3 #_SR_function
#_LO HI INIT PRIOR PR_type SD PHASE
7  11  8.7  9.3  -1  10  1
0.2  1  0.55  0.55  1  0.2  3
0  2  .5  0.8  -1  0.8  -3
-5  5  0  0  1  0.2  -3
-5  5  0  0  -1  1  -3
0  2  0  0  -1 1 -3
3  #_SR_env_link
2  #_SR_env_target_1=devs;_2=R0;_3=steepness
1  #do_recr_dev:_0=none;_1=devvector;_2=simple
1911  2001  -15  15  3  #_recr_devs
1971  #_first_yr_fullbias_adj_in_MPD

#_initial_F_parms
#_LO HI INIT PRIOR PR_type SD PHASE
 0 1 0 0.01 0 99 -1

#_Q_setup
 # A=do power, B=env-var, C=extra SD, D=devtype(<0=mirror, 0/1=none,
2=cons, 3=rand, 4=randwalk); E=0=num/1=bio, F=err_type
 #_A  B  C  D  E  F
 0 0 0 0 1 0
 0 0 1 2 1 30
 0 0 1 2 0 30
 0 0 1 0 0 30

#_Q_parms(if_any)
# LO HI INIT PRIOR PR_type SD PHASE
 0 1 0.0 0.1 0 99 -2
 0 1 0.0 0.1 0 99 -2
 0 1 0.0 0.1 0 99 -2
 -10 10 0.0 0 0 99 1
 -10 10 -4.0 0 0 99 1
# -10 10 -4.0 0 0 99 -1
```

```
#_size_selex_types
#_Pattern Discard Male Special
 1 0 0 0 # 1
 1 0 0 0 # 2
 0 0 0 0 # 3
 31 0 0 0 # 4

#_age_selex_types
#_Pattern Discard Male Special
 11 0 0 0 # 1
 11 0 0 0 # 2
 11 0 0 0 # 3
 10 0 0 0 # 4

#_selex_parms
#_LO HI INIT PRIOR PR_type SD PHASE env-var use_dev dev_minyr dev_maxyr
dev_stddev Block Block_Fxn
#_size_sel: 1
 19 70 44.3838 50 0 99 2 0 0 0 0 0.5 0 0 # 1
 0.01 60 24.7414 15 0 99 3 0 0 0 0 0.5 0 0 # 2
#_size_sel: 2
 26 36 30.1229 30 0 99 2 0 0 0 0 0.5 2 0 # 3
 0.01 60 10.1321 2 0 99 3 0 0 0 0 0.5 0 0 # 4
#_size_sel: 3
#_age_sel: 1
 0 40 0 5 0 99 -1 0 0 0 0 0.5 0 0 # 5
 0 40 40 6 0 99 -1 0 0 0 0 0.5 0 0 # 6
#_age_sel: 2
 0 40 0 5 0 99 -1 0 0 0 0 0.5 0 0 # 5
 0 40 40 6 0 99 -1 0 0 0 0 0.5 0 0 # 6
#_age_sel: 3
 0 40 0 5 0 99 -1 0 0 0 0 0.5 0 0 # 9
 0 40 0 6 0 99 -1 0 0 0 0 0.5 0 0 # 10

1 #_selparm_adjust_method
0 #_custom_sel-env_setup

0 #_custom_sel-block_setup
 -10 10 0.0 0 0 99 3 # 1

-4 #_selparmdev-phase

#_Variance_adjustments_to_input_values
#_1 2 3
 0 0 0 0 #_add_to_survey_CV
 0 0 0 0 #_add_to_discard_CV
 0 0 0 0 #_add_to_bodywt_CV
 1 1 1 1 #_mult_by_lencomp_N
 1 1 1 1 #_mult_by_agecomp_N
 1 1 1 1 #_mult_by_size-at-age_N
30 #_DF_for_discard_like
30 #_DF_for_meanbodywt_like

1 #_maxlambdaphase
1 #_sd_offset
#_lambdas_(columns_for_phases)
 1 #_CPUE/survey:_1
```

```
 1 #_CPUE/survey:_2
 1 #_CPUE/survey:_3
 0.0000001 #_CPUE/survey:_4
 0 #_discard:_1
 0 #_discard:_2
 0 #_discard:_3
 0 #_discard:_4
 0 #_meanbodyweight
 1 #_lencomp:_1
 1 #_lencomp:_2
 0 #_lencomp:_3
 0 #_lencomp:_4
 1 #_agecomp:_1
 1 #_agecomp:_2
 0 #_agecomp:_3
 0 #_agecomp:_4
 1 #_size-age:_1
 1 #_size-age:_2
 0 #_size-age:_3
 0 #_size-age:_4
 1 #_init_equ_catch
 1 #_recruitments
 1 #_parameter-priors
 1 #_parameter-dev-vectors
 100 #_crashPenLambda
0.9 #_maximum allowed harvest rate
999
```

DATA FILE

This file was produced by the parametric bootstrap feature in SS2.

```
1971 #_styr
2001 #_endyr
1 #_nseas
 12 #_months/season
1 #_spawn_seas
1 #_Nfleet
2 #_Nsurv
fishery1%survey1%survey2
 0.5 0.5 0.5 #_surveytiming_in_season
2 #_Ngenders
40 #_Nages
 100 #_init_equil_catch_for_each_fishery
#_catch_biomass(mtons):_columns_are_fisheries,_rows_are_year*season
 100
 123
 334

<Other catch values not shown here >

21 #_N_cpue_and_surveyabundance_observations
#_year seas index obs se(log)
1977 1 2 122005 0.3 #_orig_obs: 119050
1980 1 2 132023 0.3 #_orig_obs: 120450
< Other observations not shown here>

2 #_discard_type
0 #_N_discard_obs

0 #_N_meanbodywt_obs

0.0001 #_comp_tail_compression
0.0001 #_add_to_comp
25 #_N_LengthBins
 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60 62 64 68 72 76
80 90
40 #_N_Length_obs
#Yr Seas Flt/Svy Gender Part Nsamp datavector(female-male)
 1971 1 1 3 0 125  0 0.000791155 0.00124062 0.00999098 0.00797124 0
0.01084 0.011184 0.00654239 0.0159407 0.0351658 0.00138704 0.0293268
0.0196292 0.028542 0.0176215 0.0474864 0.0485146 0.024989 0.0778868
0.0824308 0.0439587 0.0347553 0.0223618 0 0 0 0 0.0264763 0 0.00199439
6.22206e-006 0.0113543 0.00542478 0.00189418 0.0115132 0.04064
0.0307028 0.00786173 0.00922623 0.0649743 0.0248022 0.0406071 0.0338362
0.0627121 0.0790098 0.0526452 0.0667213 0 0
<other observations not shown here>

17 #_N_age_bins
 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 20 25
2 #_N_ageerror_definitions
```

```
 0.5 1.5 2.5 3.5 4.5 5.5 6.5 7.5 8.5 9.5 10.5 11.5 12.5 13.5 14.5 15.5
16.5 17.5 18.5 19.5 20.5 21.5 22.5 23.5 24.5 25.5 26.5 27.5 28.5 29.5
30.5 31.5 32.5 33.5 34.5 35.5 36.5 37.5 38.5 39.5 40.5
 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001
0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001
0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001
0.001 0.001 0.001 0.001 0.001 0.001
 0.5 1.5 2.5 3.5 4.5 5.5 6.5 7.5 8.5 9.5 10.5 11.5 12.5 13.5 14.5 15.5
16.5 17.5 18.5 19.5 20.5 21.5 22.5 23.5 24.5 25.5 26.5 27.5 28.5 29.5
30.5 31.5 32.5 33.5 34.5 35.5 36.5 37.5 38.5 39.5 40.5
 0.5 0.65 0.67 0.7 0.73 0.76 0.8 0.84 0.88 0.92 0.97 1.03 1.09 1.16
1.23 1.32 1.41 1.51 1.62 1.75 1.89 2.05 2.23 2.45 2.71 3 3 3 3 3 3 3 3
3 3 3 3 3 3 3 3
40 #_N_Agecomp_obs
#Yr Seas Flt/Svy Gender Part Ageerr Lbin_lo Lbin_hi Nsamp
datavector(female-male)
 1971 1 1 3 0 2 1 22 75  0 0.0235247 0.0544669 0.0331873 0.0151487
0.0387991 0.0159349 0.0544803 0 0.0176774 0.0203709 0.0293179
0.00268583 0.0425459 0.0518871 0.0306075 0.0381912 0 0 0.0363396
0.0307277 0.0388453 0.0422087 0.0251037 0.01662 0.0574958 0.0118836
0.0311201 0.0201475 0.0179814 0.00941838 0.0839424 0.0372923 0.0811173
<Other observations not shown here >

4 #_N_MeanSize-at-Age_obs
#Yr Seas Flt/Svy Gender Part Ageerr Ignore datavector(female-male)
#                                          samplesize(female-male)
 1971 1 1 3 0 1 2 34.2271 41.1992 46.1769 51.4224 51.9932 54.2557
57.179 58.9116 61.2752 63.1606 67.3182 64.9895 65.3211 65.6548 70.0698
72.8268 74.5144 35.5693 41.0431 45.8248 50.6443 54.6857 55.0886 57.7021
56.9574 62.1362 63.9436 65.4442 64.9849 66.2666 68.1793 70.9747 71.2221
71.3133
 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20
20 20 20 20 20 20 20 20 20 20 20
< Other observations not shown here >

1 #_N_environ_variables
0 #_N_environ_obs

999
```