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Northwest Atlantic Fisheries Organization

Serial No. N4326 **NAFO SCR Doc. 00/70**

SCIENTIFIC COUNCIL MEETING – SEPTEMBER 2000
Workshop on Assessment Methods

Fisheries Assessment Compilation Toolbox (FACT)

2. AGEPRO

Outlines and Data Sets

by

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Abstract

FACT is the Fishery Assessment Compilation Toolbox and the Woods Hole Assessment Toolbox's successor. Several existing assessment programs have been added to FACT making it a powerful and user-friendly tool. The assessment programs previously existed in a DOS or UNIX environment. These programs now have a user-friendly interface that makes editing of inputs and analyzing data easier, and completion of assessments more intuitive.

AGEPRO was added to FACT to allow a seamless transition from VPA results to catch forecasts. The AGEPRO program performs stochastic projections of the abundance of an exploited age-structured population over a time horizon of up to 25 years. The primary purpose of the AGEPRO model is to characterize the sampling distribution of key fishery system outputs such as landings, spawning stock biomass, and recruitment under uncertainty. The acronym "AGEPRO" indicates that the program performs age-structured projections in contrast to size- or biomass-based projection models.

This document shows how to run AGEPRO using a sample input file to define the run parameters, recruitment options and biological inputs. A description of the various files containing the VPA bootstrap results that are required to initiate the catch projections is given. Sample results from the completion of a set of projections under 4 recruitment options are also provided, and a description of the output file containing the projection results is given.

Introduction

The overall purpose of FACT is to develop a set of standard tools for scientists to use for stock assessment. There is a growing need for a set of standardized and verified software for conducting stock assessments. The toolbox allows analysts to use a variety of assessment models to select options and produce diagnostics appropriate to a particular methodology. A suite of programs has been developed which includes modules for data input, formatting and error checking, and exploratory data analysis for a variety of assessment approaches.

The individual models of the toolbox were stand-alone, DOS or Unix based components, which were recompiled into dynamic link libraries and integrated with a Windows interface. At present the available models include Virtual Population Analysis (VPA) with retrospective and bootstrapping capabilities (ADAPT), Age Projection (AGEPRO), Yield per Recruit and Spawning Biomass per Recruit, and A Stock-Production model Including Covariates (ASPIC) with projection, and Precautionary Approach software. A comprehensive on-line help is also available with FACT.

In this Workshop we will use two of the modules, ADAPT and AGEPRO. This document describes the use of the AGEPRO module.

AGEPRO

This module is the implementation of age-based stochastic projection software in FACT. The stock sizes at age estimated at the end of the terminal year of the VPA are used as input for the forward projection. The stochastic aspect of the projection is based on 2 sets of input data:

1. The results of the Bootstrap procedure run in ADAPT. The example bootstrap file, **gmcod2000_base.2bootN**, contains 1 row for each bootstrap iteration performed in ADAPT. Each age is in a separate column.

2. The incoming recruitment estimated for each year in the projection time horizon.

AGEPRO is generally used to forecast catches several years ahead, based on an input set of annual fully recruited instantaneous fishing mortality rates. AGEPRO can also iteratively solve for F, given an input set of annual catches. It is also possible to specify a target SSB level, and AGEPRO will determine the probability of exceeding the target in each year of the projection time horizon.

Input

All of the Workshop example data files for FACT are in: **C:\Workshop\Fact**

The age-based forward projection starts in the year immediately following the terminal year of the VPA. In addition to the initial stock sizes at age and incoming recruitment, many of the same input data used in the VPA are required in AGEPRO, including:

Mean catch weights at age
Mean stock weights at age
Natural mortality
Maturation ogive
Partial recruitment at age

In the case of AGEPRO, however, these data are input as smoothed multi-year averages, that are judged to be representative of the projection time horizon.

There are also many initialization and control flags, which may be specified. All of these data are in a several example files, depending on the recruitment model:

gmc99mod2.in Recruitment model 2 - Recruits per spawning biomass distribution
gmc99mod3.in Recruitment model 3 - Empirical recruitment distribution
gmc99mod5.in Recruitment model 5 - Beverton-Holt model with Log-normal error
gmc99mod9.in Recruitment model 9 - Time-vary empirical recruitment distribution

There are 9 recruitment models in AGEPRO, but we will use these 4 in our examples.

Output

After AGEPRO has run successfully, formatted output will be written to a file named during the run by the user. These files should be brought into a word processor for viewing and printing.

AgePro Introduction

Introduction

AgePro was added to FACT in 1999 to allow a seamless transfer of data to the VPA. A windows interface was added. In addition, the spawning stock biomass (SSB) is no longer back calculated from the population numbers and fishing mortality. Those numbers are now taken directly from a bootstrapped FACT ADAPT/VPA file (filename.BOOTN, filename.BOOTSSB).

The AgePro User's guide written by Jon K.T. Brodziak and Paul J. Rago has been adapted by Hugh Popenoe for this version with new documentation for the user interface.

The AGEPRO program performs stochastic projections of the abundance of an exploited age-structured population over a time horizon of up to 25 years. The primary purpose of the AGEPRO model is to characterize the sampling distribution of key fishery system outputs such as landings, spawning stock biomass, and recruitment under uncertainty. The acronym "AGEPRO" indicates that the program performs age-structured projections in contrast to size- or biomass-based projection models. In this framework, the USER chooses the level of harvest that will be taken from the population by setting quotas or fishing mortality rates in each year of the time horizon. There are three elements of uncertainty incorporated in the AGEPRO model: recruitment, initial population size, and natural mortality. Recruitment is the primary stochastic element in the population model in AGEPRO, where recruitment is either the number of age-1 or age-2 fish in the population at the beginning of each year in the time horizon. There are a total of nine stochastic recruitment submodels that can be used for population projection. It should be noted that it is possible to simulate the case of deterministic recruitment with AGEPRO through a suitable choice of recruitment submodel and input data. Initial population size is a second potential source of uncertainty in AGEPRO that can be incorporated into population projection. To use this feature, the USER must have an initial distribution of population sizes that can be projected through the time horizon. Alternatively, the USER can choose to base the projections on a single estimate of initial population size. A third potential source of uncertainty in the AGEPRO model is natural mortality. In particular, the instantaneous natural mortality rate is assumed to be equal for all age classes in the population. The USER can choose to have a constant or a stochastic natural mortality rate. In the stochastic case, the natural mortality rates are taken to be realizations from a uniform distribution specified by the USER.

The AGEPRO model was conceived as part of a study to determine optimal strategies to rebuild a depleted fish stock. The AGEPRO model was initially developed in winter 1994 to compare the effects of various harvesting scenarios on a depleted stock. Subsequently, a manuscript describing the model was presented at the May 1994 meeting of the NEFSC Methods Working Group (Brodziak and Rago, Unpublished manuscript). This software was then applied to assessment results for several stocks at the 18th SARC (NEFSC 1994) to evaluate the potential consequences of harvest policies. The model was extended in autumn 1994 to assist the Groundfish Plan Development Team and was also revised during summer 1995 to assist in the evaluation of Amendment 7 to the Northeast Multispecies Fishery Management Plan. Throughout these developments, the AGEPRO software was considered to be research software that had no documentation, except for comments in the source code. As a result, this USER'S GUIDE was written to provide documentation for the AGEPRO model and software.

Demonstration of AgePro With sample program

AgePro Input File

The sample file shown below illustrates the format for input parameters for AgePro. **The line numbers and description have been added for a reference and should not be included as part of the input file.**

For a run of AgePro, a second file is also needed, which contain the bootstrapped population numbers (BOOTN) or bootstrapped spawning stock biomass (BOOTSSB). These files are created by a bootstrapped FACT ADAPT/VPA run.

Download AgePro sample input.

If you cannot download the sample file as a file or the file opens in the browser, see Troubleshooting downloading of input sample files

AgePro Sample ## Name of projection run

1998 ## First year of projection run

3 ## Length of planning horizon (between 1 and 25)

100 ## Number of simulations per initial population vector (between 1 and 200)

123456 ## Number of reps to initialize the random number generator

0 ## lag recruitment flag

1 ## Catch projections based on a mixture of F and Q

1 ## Discard flag (1=true, 0=false)

0 ## quota based management flag

0 ## Constant harvest strategy flag (1=true, 0=false)

0 ## F target flag Print (1=true, 0=false)

0 ## Index flag

1 ## threshold flag

0 ## market category flag

0 ## total mortality flag

0 ## partial recruitment flag

1 ## constant discard flag

0 ## bounded recruitment flag

1 ## constant natural mortality flag

1 ## bootstrap flag

6 1 ## number of age classes and age of recruitment

0.2 ## constant natural mortality

0.028 0.125 0.268 0.409 0.516 0.785 ## mean spawning weights at age

0.15 0.34 0.39 0.47 0.58 0.785 ## mean landed weights at age

0.056 0.235 0.365 0.463 0.582 0.785 ## mean discard weights at age

1 1 1 1 1 1 ## fraction mature at age

0 ## fraction of total mortality that occurs before spawning

3 ## Model number

13 ## number of observed recruitments

9891000 4712000 6755000 21230000 7700000 6293000 9176000 7306000 7455000 6839000 6554000 6829000 3397000 ## observed recruitments

10 ## number of bootstraps

D:\FACThelp\Agepro\AgeProBootN.bootN ## name of bootstrap N's file

1000 ## units for bootstrap

6100000 ## thresholds

0.02 0.14 0.66 1 1 1 ## Constant partial recruitment

1 0.67 0.24 0.09 0.05 0.02 ## constant discard fraction

1 0 0 ## How to mix Quota and F

1320000 0 0 ## Q series

0 1.01 1.01 ## F series

Catch projections based on a mixture of F and Q flag

The seventh input is the mixture flag for harvesting. If true, catch projections are based on a mixture of F-based and quota-based management by year; otherwise, the harvest is based on one management strategy.

Discard Flag

The eighth input is the discard flag. If true, discards at age are included in the projection analysis; otherwise, no discards are included in the analysis.

Quota-based management flag

The ninth input is the quota-based management flag. If true, catch projections are based on quotas; otherwise catch projections are F-based.

Constant harvest strategy flag

The tenth input is the constant harvest strategy flag. If true, the harvest strategy does not change in time, e.g. the F or the quota is fixed; otherwise the harvest strategy can vary from year to year.

F target flag

The eleventh input is the F-target flag. If true, then a target value of F is applied in the year after any year when the SSB threshold is achieved; otherwise no change occurs.

Index Flag

The twelfth input is the index flag. If true, a prediction of an age-specific recruitment index is made; otherwise no prediction is made.

SSB threshold flag

The thirteenth input is the SSB threshold flag. If true, realized SSB levels are compared to a threshold level; otherwise no comparisons are made.

Market category flag

The fourteenth input is the market category flag. If true, landings are summarized by market category and output to file; otherwise no market category summaries are made.

Total Mortality flag

The fifteenth input is the total mortality flag. If true, the fraction of total mortality that occurs prior to spawning can vary from year to year; otherwise there is no annual variation.

Partial Recruitment Flag

The sixteenth input is the partial recruitment flag. If true, the partial recruitment to fishing mortality vector can vary from year to year; otherwise there is no annual variation.

Constant discard flag

The seventeenth input is the constant discard flag. If true, the fraction discarded at age is constant; otherwise the fraction discarded at age can vary from year to year.

Bounded recruitment flag

The eighteenth input is the bounded recruitment flag. If true, then realized recruitments generated with the lognormal, Beverton-Holt, Ricker, and Shepherd stock-recruitment models will be bounded based on realized R/SSB ratios; otherwise no bounds are applied.

Constant Natural mortality Flag

The nineteenth input is the constant natural mortality flag. If true, natural mortality is constant; otherwise it is a uniformly distributed random variable.

Bootstrap flag

The twentieth input is the bootstrap flag. If true, a file of bootstrapped initial population vectors is used in the projection analysis; otherwise a single initial population vector is used.

Natural Mortality rates

The twenty-second input is the instantaneous natural mortality rate (M), if M is constant. If M is not constant, the twenty-second input is the interval [L_M , U_M] for stochastic natural mortality. The input criteria for natural mortality rates varies depending on the **Constant natural mortality flag** (input #19) and **Recruitment lag flag** (input # 6).

For input conditions

If **constant natural mortality flag** (input #19) = true, then input: M

If **constant natural mortality flag** (input #19) = false and **Recruitment lag flag** (input #6)= false, then lower (L_M) and upper (U_M) bounds for random natural mortality.

If **constant natural mortality flag** (input #19) = false and **Recruitment lag flag** (input #6)= true, then input: lower (L_M) and upper (U_M) bounds for random natural mortality and on the next line input: M(0)

Mean spawning weights at age

The twenty-third input is the vector of mean weights at age in the stock ordered from youngest (left) to oldest (right) separated by spaces.

Input: $W_{S,1}$, $W_{S,2}$,$W_{S,3}$,... , $W_{S,A}$

Mean landed weights at age

The twenty-fourth input is the vector of mean weights at age in the landings ordered from youngest (left) to oldest (right) separated by spaces.

Input: $W_{L,1}$, $W_{L,2}$,$W_{L,3}$,... , $W_{L,A}$

Mean discarded weights at age

If discards at age are included in the projection, the twenty-fifth input is the vector of mean weights at age of discarded fish ordered from youngest (left) to oldest (right) separated by spaces.

Input: $W_{D,1}$, $W_{D,2}$,$W_{D,3}$,... , $W_{D,A}$

Input required if **Discard flag** input #8 = true, otherwise not.

Fraction mature at age

The twenty-sixth input is the vector of fraction mature at age ordered from youngest (left) to oldest (right) separated by spaces.

Input: FM_1 , FM_2 , FM_3 ,... , FM_A

Fraction of total mortality that occurs before spawning

The twenty-seventh input is the fraction of total mortality that occurs prior to spawning (ZPROJ). If the **total mortality flag** (input 15) is true, then a set of values of ZPROJ must be input. In particular, if the **total mortality flag** is true and the **recruitment age is age-2** then the value of ZPROJ in the previous year is input first on one line followed by a line with the vector of values of ZPROJ ordered from the first (left) to the last (right) year of the time horizon is input. If the total mortality flag is false, then the constant value of ZPROJ is input, regardless of whether the recruitment age is age-2.

In other words,

If input **total mortality flag** (input #19) = false, then input: ZPROJ

If **total mortality flag** (input #19) = true and **Recruitment lag flag** (input #6) = false, input: ZPROJ(1) , ZPROJ(2) , ..., ZPROJ(Y)

If **total mortality flag** (input #19) = true and **Recruitment lag flag** (input #6) = true, input: ZPROJ(0) and on the next line input: ZPROJ(1) , ZPROJ(2) , ..., ZPROJ(Y)

Model number

The twenty-eighth input is the recruitment flag which is a number from 1 to 9 that identifies the choice of stochastic stock-recruitment model to be used. These models are numbered 1 to 9 in exact correspondence with their descriptions (see Stock-Recruitment Relationship).

Recruitment model parameters

The thirtieth input is the set of parameters needed for the chosen stock-recruitment model. The set of parameters depends on the chosen model and are specified below for each of the nine stock-recruitment models.

1. Markov Matrix
2. Recruits Per Spawning Biomass Distribution
3. Empirical Recruitment Distribution
4. Two-Stage Recruits Per Spawning Biomass Distribution
5. Beverton-Holt Curve with Lognormal Error
6. Ricker Curve with Lognormal Error
7. Shepherd Curve with Lognormal Error
8. Lognormal Distribution
9. Time-Varying Empirical Recruitment Distribution

if input #28=1, **Model 1 - Markov Matrix**

Input the number of recruitment levels: K

and on the next line input the recruitment levels: $N_{R,1}$, $N_{R,2}$, $N_{R,3}$, ..., $N_{R,K}$

and on the next line input the number of spawning stock levels: J

and on the next line input the ssb cut points to define spawning stock levels: SSB_2 , SSB_3 , SSB_4 , ..., SSB_J

and on the next J lines input the probability of recruitment level (k) given ssb level (j)

$p_{1,1}$, $p_{1,2}$, $p_{1,3}$, ..., $p_{1,K}$

$p_{2,1}$, $p_{2,2}$, $p_{2,3}$, ..., $p_{2,K}$

...

$p_{J,1}$, $p_{J,2}$, $p_{J,3}$, ..., $p_{J,K}$

If input #28=2, **Model 2 - Recruits Per Spawning Biomass Distribution**

Input the number of observed recruitment/SSB data points: T

and on the next line input the observed recruitment series: $N_R(1)$, $N_R(2)$, $N_R(3)$, ..., $N_R(T)$

and on the next line input the observed SSB series: SSB(1-R) , SSB(2-R) , SSB(3-R) , ..., SSB(T-R)

If input #28=3, **Model 3 - Empirical Recruitment Distribution**

Input the number of observed recruitments: T

and on the next line input the observed recruitment series: $N_R(1)$, $N_R(2)$, $N_R(3)$, ..., $N_R(T)$;

If input #28=4, **Model 4 - Two-stage Recruits per Spawning Biomass Distribution**

Input the low (1) and the high (2) SSB data points: T_{LOW} , T_{HIGH} ;

and on the next line input the cut point between the low and the high SSB states: SSB*;

and on the next line the LOW-SSB STATE RECRUITMENTS: $N_R(1)$, $N_R(2)$, $N_R(3)$, ..., $N_R(T_{LOW})$

and on the next line the LOW-SSB STATE SSBs: SSB(1-R) , SSB(2-R) , SSB(3-R) , ..., $SSB(T_{LOW}\text{-}R)$

and on the next line the HIGH-SSB STATE RECRUITMENTS: $N_R(1)$, $N_R(2)$, $N_R(3)$, ..., $N_R(T_{HIGH})$

and on the next line the HIGH-SSB STATE SSBs: SSB(1-R) , SSB(2-R) , SSB(3-R) , ..., $SSB(T_{HIGH}\text{-}R)$

If input #28=5, **Model 5 - Beverton-Holt Curve with Lognormal Error**

input: a , b , σ_w^2 stock recruitment parameters.

and on the next line input the conversion coefficients for spawning stock biomass and recruitment: c_{SSB} , c_R

If input #28=6, **Model 6 - Ricker Curve with Lognormal Error**

input: a , b , σ_w^2 stock recruitment parameters.

and on the next line input the conversion coefficients for spawning stock biomass and recruitment: c_{SSB} , c_R

If input #28=7, **Model 7 - Shepherd Curve with Lognormal Error**

input: a , b, k , σ_w^2 stock recruitment parameters.

and on the next line input the conversion coefficients for spawning stock biomass and recruitment: c_{SSB} , c_R

If input #28=8, **Model 8 - Lognormal Distribution**

input: μ_{logR} and σ_{logR}

and on the next line input the conversion coefficients for spawning stock biomass and recruitment: c_{SSB} , c_R

If input #28=9, **Model 9 - Time-Varying Empirical Recruitment Distribution**

Input the number of observed recruitments for each year in the time horizon: T

and on the next line input: $N_R(1,1)$, $N_R(1,2)$, $N_R(1,3)$, ..., $N_R(1,T)$

and on the next line input: $N_R(2,1)$, $N_R(2,2)$, $N_R(2,3)$, ..., $N_R(2,T)$

...

and on the next line input: $N_R(Y,1)$, $N_R(Y,2)$, $N_R(Y,3)$, ..., $N_R(Y,T)$

Number of Bootstraps

This is the number of lines in a bootstrapped ADAPT/VPA file.

File with bootstraps

The filename and location of the bootstrapped ADAPT/VPA file.

Bootstrap units

This is the units used in the bootstrapped N or SSB file (i.e. 1000, 10,000 or 1,000,000).

Time varying Partial Recruitment

The Partial recruitment vector ordered from youngest (left) to oldest (right) for all ageclasses.

Time varying Discard Fraction

The discard fraction vector ordered from youngest (left) to oldest (right) for all ageclasses.

How to mix quota and F

This input determines how the catch projections are based on quota or fishing mortality (F) for the number of years to be projected. Catch projection can be based on both, F and quota. Use inputs 1 for F and 0 for quota for each year of projection.

Quota series

This input contains the quota numbers for each year to be projected. In the case of when catch projection are based on a mixture of quota and fishing mortality (How to mix quota and F) , use 0 or -1 as a placeholder for years when catch projections are based on F.

F Series

This input contains the fishing mortality (F) numbers for each year to be projected. In the case of when catch projection are based on a mixture of quota and fishing mortality (How to mix quota and F) , use 0 or -1 as a placeholder for years when catch projections are based on quota.

AGEPRO Model 2 Results

Input File: gmc99mod2.in

Recruitment model 2 - Recruits per spawning biomass distribution

07 Sep 2000 at 10:47.15

PROJECTION RUN: GM Cod F=Fmax SSB Target
INPUT FILE: C:\Nafo\Workshop\gmcod\gmc99mod2.in
OUTPUT FILE: C:\Nafo\Workshop\gmcod\gmc99mod2.out
RECRUITMENT MODEL: 2
NUMBER OF SIMULATIONS: 1

Bootstrapped Population Numbers

AGE	AVG N	STD
1	5076.259	156.209
2	4457.452	1592.477
3	2356.606	634.759
4	1242.444	341.000
5	463.895	157.366
6	329.767	124.461
7	174.981	44.895

PERCENTILES OF Bootstrapped Population Numbers

Age	1%	5%	10%	25%	50%	75%	90%	95%	99%
1	4652.896	4819.785	4857.587	4955.638	5088.163	5179.793	5244.828	5330.930	5447.146
2	1665.745	2286.521	2548.306	3368.059	4262.300	5355.144	6045.256	7813.131	9363.643
3	1271.062	1323.649	1555.983	1977.917	2310.130	2657.227	3071.718	3433.747	4099.466
4	450.096	736.132	807.075	1015.968	1210.729	1470.548	1671.914	1821.812	2162.420
5	220.540	267.481	298.548	351.413	432.922	543.687	673.343	791.504	880.318
6	119.558	146.389	187.788	235.576	306.653	390.245	498.722	530.817	710.647
7	92.089	110.333	124.155	146.377	165.140	200.252	239.598	251.869	289.561

F-BASED PROJECTIONS
TIME-VARYING F

YEAR	F
2000	0.640
2001	0.270
2002	0.270
2003	0.270
2004	0.270
2005	0.270
2006	0.270
2007	0.270
2008	0.270
2009	0.270
2010	0.270

SPAWNING STOCK BIOMASS (THOUSAND MT)

YEAR	AVG SSB (000 MT)	STD
2000	11.927	1.738
2001	12.922	1.887
2002	15.759	2.297
2003	18.198	4.223
2004	20.898	5.162
2005	23.972	6.343
2006	26.718	8.294
2007	29.527	11.051
2008	34.354	14.617
2009	38.574	17.392
2010	43.429	21.172

PERCENTILES OF SPAWNING STOCK BIOMASS (000 MT)

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
2000	8.570	9.122	9.528	10.543	12.055	13.068	13.860	14.294	15.521
2001	9.361	10.082	10.452	11.432	12.685	13.899	15.144	15.938	17.875
2002	9.687	12.359	13.496	14.280	15.450	17.023	18.935	20.248	21.872
2003	4.782	13.054	14.205	16.190	17.475	20.086	22.498	24.506	32.967
2004	6.761	13.609	15.488	18.143	20.356	23.508	27.778	29.865	35.984
2005	7.449	13.616	16.422	19.756	23.547	27.395	31.269	34.551	40.968
2006	4.877	13.892	16.110	21.134	25.533	31.107	37.664	40.576	47.380
2007	7.365	9.223	16.776	23.401	27.938	35.097	42.591	48.439	54.082
2008	6.555	11.514	18.578	23.709	31.150	43.340	55.451	59.344	73.576
2009	0.000	14.762	17.100	26.656	35.865	49.890	62.309	67.943	79.789
2010	0.883	9.898	19.153	29.070	38.961	57.744	68.914	81.472	105.145

ANNUAL PROBABILITY THAT SSB EXCEEDS THRESHOLD: 20.0000000000000
THOUSAND MT

YEAR	Pr(SSB > Threshold Value)
2000	0.000
2001	0.000
2002	0.060
2003	0.270
2004	0.530
2005	0.740
2006	0.820
2007	0.820
2008	0.860
2009	0.880
2010	0.890

RECRUITMENT UNITS ARE: 1000.00000000000 FISH
BIRTH

YEAR	AVG RECRUITMENT	STD
2000	3771.955	4138.616
2001	5023.582	3910.124
2002	4599.980	3522.927
2003	5704.606	6196.019
2004	6021.897	5847.902
2005	9540.633	9180.435
2006	8627.503	7717.078
2007	11317.765	10119.496
2008	8836.019	12703.966
2009	8218.734	15610.798
2010	12557.458	16867.532

PERCENTILES OF RECRUITMENT UNITS ARE: 1000.00000000000 FISH
BIRTH

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
2000	-1.000	-1.000	1634.712	2203.101	3007.786	5563.592	7418.228	8301.357	20369.121
2001	-1.000	1584.825	2051.683	2647.278	3538.214	6353.408	11311.377	13610.217	15188.391
2002	-1.000	1767.971	2112.018	3005.495	4183.826	5776.122	8716.215	10300.094	13834.771
2003	-1.000	-1.000	1744.763	3125.165	4585.605	7784.733	14082.071	17331.565	21487.979
2004	-1.000	2201.200	2505.358	3668.626	5066.776	7412.867	11446.517	17009.771	21014.784
2005	-1.000	2902.946	3291.348	4270.108	6237.009	11291.537	23173.395	28673.886	38097.796
2006	-1.000	2408.972	3457.207	4863.953	6574.482	9680.319	17362.270	22686.375	40322.484
2007	-1.000	2459.435	3029.401	5682.541	8258.234	12833.842	21886.239	30464.816	48429.732
2008	-1.000	-1.000	2700.420	4756.274	8361.203	14006.224	21229.637	23059.846	37453.869
2009	-1.000	-1.000	-1.000	4545.936	9196.852	12660.618	18554.506	25931.298	58293.030
2010	-1.000	-1.000	2677.952	5534.992	10536.140	18627.135	29104.727	32218.910	63289.866

LANDINGS FOR F-BASED PROJECTIONS

YEAR	AVG LANDINGS (000 MT)	STD
2000	7.550	1.071
2001	3.684	0.522
2002	4.471	0.694
2003	5.148	1.191
2004	5.902	1.468
2005	6.654	1.825
2006	7.357	2.430
2007	8.233	3.146
2008	9.521	4.118
2009	10.736	4.946
2010	11.990	5.855

PERCENTILES OF LANDINGS (000 MT)

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
2000	5.431	5.797	6.101	6.677	7.620	8.290	8.658	9.235	9.856
2001	2.674	2.890	3.040	3.319	3.645	3.942	4.303	4.558	5.048
2002	2.512	3.286	3.752	4.036	4.342	4.793	5.395	5.662	6.470
2003	1.509	3.713	3.984	4.561	4.989	5.670	6.420	7.100	9.159
2004	1.872	3.905	4.281	5.048	5.742	6.675	7.949	8.683	10.140
2005	2.023	3.794	4.459	5.445	6.530	7.619	8.528	9.956	11.537
2006	1.269	3.188	4.402	5.719	7.003	8.531	10.614	11.591	13.788
2007	1.953	2.688	4.437	6.309	8.005	9.739	12.261	13.698	15.418
2008	1.192	3.151	4.829	6.441	8.739	12.184	15.361	16.746	20.530
2009	0.000	3.729	4.667	7.257	9.960	13.685	17.367	18.536	23.437
2010	0.025	2.506	5.218	8.053	10.574	16.099	18.870	22.276	28.999

50th PERCENTILES OF NUMBERS AT AGE

	1	2	3	4	5	6	7
2000	5088.	4262.	2310.	1211.	433.	307.	165.
2001	3008.	4005.	2749.	1047.	523.	187.	212.
2002	3538.	2422.	2965.	1753.	654.	327.	254.
2003	4184.	2849.	1793.	1892.	1096.	409.	365.
2004	4586.	3369.	2109.	1144.	1182.	685.	497.
2005	5067.	3693.	2494.	1346.	715.	739.	732.
2006	6237.	4080.	2734.	1591.	841.	447.	923.
2007	6574.	5022.	3020.	1744.	994.	526.	866.
2008	8258.	5294.	3718.	1927.	1090.	622.	951.
2009	8361.	6650.	3919.	2372.	1204.	681.	1034.
2010	9197.	6733.	4923.	2500.	1483.	753.	1101.

AGEPRO Model 3 Results

Input File: gmc99mod3.in

Recruitment model 3 - Empirical recruitment distribution

```
GM Cod F=Fmax SSB Target    ## Name of projection run
 2000          ## First year of projection run
 11            ## Length of planning horizon (between 1 and 25)
 1             ## Number of simulations per initial population vector (between 1 and 200)
 24680         ## Number of reps to initialize the random number generator
 0             ## lag recruitment flag
 0             ## Catch projections based on a mixture of F and Q
 0             ## Discard flag (1=true, 0=false)
 0             ## quota based management flag
 0             ## Constant harvest strategy flag (1=true, 0=false)
 0             ## F target flag Print (1=true, 0=false)
 0             ## Index flag
 1             ## threshold flag
 0             ## market category flag
 0             ## total mortality flag
 0             ## partial recruitment flag
 0             ## constant discard flag
 0             ## bounded recruitment flag
 1             ## constant natural mortality flag
 1             ## bootstrap flag
 7              1            ## number of age classes and age of recruitment
 0.2           ## constant natural mortality
 0.613  1.087  1.79  2.347  3.21  4.712  11.635 ## mean spawning weights at age
 0.9  1.563  2.024  2.764  3.957  6.524  11.635 ## mean landed weights at age
 0  0.38  0.89  0.99  1  1  1 ## fraction mature at age
 0.1667        ## fraction of total mortality that occurs before spawning
 3             ## Model number
 16            ## number of observed recruitments
 5534000  7746000  4914000  7410000  9954000  21648000  3376000  3391000  5883000  5309000
8260000  3090000  2912000  1983000  2204000  3490000 ## observed recruitments

 100           ## number of bootstraps
C:\Nafo\Workshop\gmcod\gmcod2000_base.2bootN            ## name of bootstrap N's file
 1000          ## units for bootstrap
 20000000      ## thresholds
 0.0614  0.373  0.924  1  1  1  1 ## Constant partial recruitment
 0.64  0.27  0.27  0.27  0.27  0.27  0.27  0.27  0.27  0.27  0.27 ## F series
```

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PROJECTION RUN: GM Cod F=Fmax SSB Target
INPUT FILE: C:\Nafo\Workshop\gmcod\gmc99mod3.in
OUTPUT FILE: C:\Nafo\Workshop\gmcod\gmc99mod3.out
RECRUITMENT MODEL: 3
NUMBER OF SIMULATIONS: 1

Bootstrapped Population Numbers

AGE	AVG N	STD
1	5076.259	156.209
2	4457.452	1592.477
3	2356.606	634.759
4	1242.444	341.000
5	463.895	157.366
6	329.767	124.461
7	174.981	44.895

PERCENTILES OF Bootstrapped Population Numbers

Age	1%	5%	10%	25%	50%	75%	90%	95%	99%
1	4652.896	4819.785	4857.587	4955.638	5088.163	5179.793	5244.828	5330.930	5447.146
2	1665.745	2286.521	2548.306	3368.059	4262.300	5355.144	6045.256	7813.131	9363.643
3	1271.062	1323.649	1555.983	1977.917	2310.130	2657.227	3071.718	3433.747	4099.466
4	450.096	736.132	807.075	1015.968	1210.729	1470.548	1671.914	1821.812	2162.420
5	220.540	267.481	298.548	351.413	432.922	543.687	673.343	791.504	880.318
6	119.558	146.389	187.788	235.576	306.653	390.245	498.722	530.817	710.647
7	92.089	110.333	124.155	146.377	165.140	200.252	239.598	251.869	289.561

F-BASED PROJECTIONS
TIME-VARYING F

YEAR	F
2000	0.640
2001	0.270
2002	0.270
2003	0.270
2004	0.270
2005	0.270
2006	0.270
2007	0.270
2008	0.270
2009	0.270
2010	0.270

SPAWNING STOCK BIOMASS (THOUSAND MT)

YEAR	AVG SSB (000 MT)	STD
2000	11.927	1.738
2001	12.922	1.887
2002	16.661	2.510
2003	21.018	5.792
2004	24.499	7.142
2005	28.338	7.778
2006	31.540	8.833
2007	34.132	10.689
2008	35.243	10.486
2009	35.841	9.975
2010	36.594	10.123

PERCENTILES OF SPAWNING STOCK BIOMASS (000 MT)

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
2000	8.570	9.122	9.528	10.543	12.055	13.068	13.860	14.294	15.521
2001	9.361	10.082	10.452	11.432	12.685	13.899	15.144	15.938	17.875
2002	12.036	12.974	13.632	15.032	16.330	17.934	19.955	20.877	23.157
2003	13.060	14.402	15.457	17.196	19.285	22.705	31.689	32.842	38.681
2004	14.736	16.733	17.408	19.624	22.148	27.229	35.452	36.803	49.303
2005	17.594	19.042	19.985	22.636	25.635	33.172	40.510	41.854	50.117
2006	19.814	21.464	22.549	24.747	28.920	37.422	45.172	48.641	54.344
2007	19.345	21.491	22.658	25.281	30.685	41.623	45.939	55.264	61.432
2008	20.243	22.510	23.357	27.310	32.910	41.481	49.103	54.344	64.970
2009	19.643	22.327	24.018	27.298	34.205	41.427	48.693	51.881	59.622
2010	18.748	22.590	24.809	29.389	34.160	44.156	50.775	55.624	62.451

ANNUAL PROBABILITY THAT SSB EXCEEDS THRESHOLD: 20.0000000000000
THOUSAND MT

YEAR	Pr(SSB > Threshold Value)
2000	0.000
2001	0.000
2002	0.100
2003	0.430
2004	0.730
2005	0.900
2006	0.990
2007	0.990
2008	1.000
2009	0.990
2010	0.990

RECRUITMENT UNITS ARE: 1000.00000000000 FISH

BIRTH YEAR	AVG RECRUITMENT	STD
2000	6623.620	5989.008
2001	5994.250	5059.887
2002	5915.250	4302.677
2003	6973.890	5839.783
2004	6332.510	4576.114
2005	6031.090	4113.056
2006	6196.190	4791.176
2007	5641.680	4072.855
2008	6512.660	4981.173
2009	6688.360	4679.051
2010	6408.220	5063.186

PERCENTILES OF RECRUITMENT UNITS ARE: 1000.00000000000 FISH

BIRTH YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
2000	1983.000	1983.000	2204.000	2912.000	3490.000	7410.000	21648.000	21648.000	21648.000
2001	1983.000	1983.000	2204.000	3376.000	3490.000	7410.000	8260.000	21648.000	21648.000
2002	1983.000	2204.000	2912.000	3376.000	4914.000	7410.000	9954.000	9954.000	21648.000
2003	1983.000	1983.000	2204.000	3090.000	5309.000	7746.000	21648.000	21648.000	21648.000
2004	1983.000	1983.000	2204.000	3376.000	5309.000	7746.000	9954.000	21648.000	21648.000
2005	1983.000	1983.000	2204.000	3376.000	5309.000	7746.000	9954.000	9954.000	21648.000
2006	1983.000	1983.000	2912.000	3376.000	4914.000	7746.000	9954.000	21648.000	21648.000
2007	1983.000	1983.000	2204.000	3090.000	4914.000	7410.000	9954.000	9954.000	21648.000
2008	1983.000	2204.000	2912.000	3376.000	5309.000	7746.000	9954.000	21648.000	21648.000
2009	1983.000	2204.000	2912.000	3391.000	5534.000	7746.000	9954.000	21648.000	21648.000
2010	1983.000	1983.000	2204.000	3090.000	5309.000	7746.000	9954.000	21648.000	21648.000

LANDINGS FOR F-BASED PROJECTIONS

YEAR	AVG LANDINGS (000 MT)	STD
2000	7.550	1.071
2001	3.722	0.517
2002	4.796	0.808
2003	5.963	1.640
2004	6.944	2.010
2005	7.914	2.206
2006	8.742	2.584
2007	9.312	2.884
2008	9.571	2.789
2009	9.734	2.699
2010	9.880	2.671

PERCENTILES OF LANDINGS (000 MT)

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
2000	5.431	5.797	6.101	6.677	7.620	8.290	8.658	9.235	9.856
2001	2.704	2.903	3.084	3.404	3.675	3.981	4.315	4.577	5.284
2002	3.336	3.664	3.906	4.261	4.668	5.060	5.974	6.300	6.920
2003	3.690	4.131	4.356	4.819	5.476	6.602	8.846	9.131	11.174
2004	4.169	4.789	4.925	5.508	6.310	7.864	10.110	10.432	13.757
2005	4.931	5.332	5.571	6.257	7.128	9.334	11.206	11.728	13.807
2006	5.328	5.869	6.053	6.669	7.932	10.531	12.627	13.835	15.017
2007	5.260	5.936	6.175	6.883	8.519	11.237	12.469	15.023	16.141
2008	5.524	6.104	6.373	7.389	9.024	11.210	13.355	14.499	16.715
2009	5.222	5.980	6.553	7.464	9.186	11.235	13.451	14.026	16.530
2010	5.068	6.113	6.653	7.808	9.279	11.691	13.294	14.754	16.114

50th PERCENTILES OF NUMBERS AT AGE

	1	2	3	4	5	6	7
2000	5088.	4262.	2310.	1211.	433.	307.	165.
2001	3490.	4005.	2749.	1047.	523.	187.	212.
2002	3490.	2810.	2965.	1753.	654.	327.	254.
2003	4914.	2810.	2081.	1892.	1096.	409.	365.
2004	5309.	3957.	2081.	1327.	1182.	685.	497.
2005	5309.	4275.	2929.	1327.	830.	739.	732.
2006	5309.	4275.	3165.	1869.	830.	518.	923.
2007	4914.	4275.	3165.	2019.	1168.	518.	962.
2008	4914.	3957.	3165.	2019.	1262.	730.	1120.
2009	5309.	3957.	2929.	2019.	1262.	789.	1216.
2010	5534.	4275.	2929.	1869.	1262.	789.	1313.

AGEPRO Model 5 Results

Input File: gmc99mod5.in

Recruitment model 5 - Beverton-Holt model with Log-normal error

```
GM Cod F=Fmax SSB Target    ## Name of projection run
 2000          ## First year of projection run
 11            ## Length of planning horizon (between 1 and 25)
 1             ## Number of simulations per initial population vector (between 1 and 200)
 24680         ## Number of reps to initialize the random number generator
 0             ## lag recruitment flag
 0             ## Catch projections based on a mixture of F and Q
 0             ## Discard flag (1=true, 0=false)
 0             ## quota based management flag
 0             ## Constant harvest strategy flag (1=true, 0=false)
 0             ## F target flag Print (1=true, 0=false)
 0             ## Index flag
 1             ## threshold flag
 0             ## market category flag
 0             ## total mortality flag
 0             ## partial recruitment flag
 0             ## constant discard flag
 0             ## bounded recruitment flag
 1             ## constant natural mortality flag
 1             ## bootstrap flag
 7              1            ## number of age classes and age of recruitment
 0.2           ## constant natural mortality
 0.613  1.087  1.79  2.347  3.21  4.712  11.635 ## mean spawning weights at age
 0.9  1.563  2.024  2.764  3.957  6.524  11.635 ## mean landed weights at age
 0  0.38  0.89  0.99  1  1  1 ## fraction mature at age
 0.1667        ## fraction of total mortality that occurs before spawning
 5             ## Model number
 5894.962       6424.442       0.1          ## a b sigma stock recruitment parameters
 1000           1000          ## conversion coefficients for spawning stock biomass and recruitment
 100           ## number of bootstraps
C:\Nafo\Workshop\gmcod\gmcod2000_base.2bootN            ## name of bootstrap N's file
 1000          ## units for bootstrap
 20000000      ## thresholds
 0.0614  0.373  0.924  1  1  1  1 ## Constant partial recruitment
 0.64  0.27  0.27  0.27  0.27  0.27  0.27  0.27  0.27  0.27  0.27 ## F series
```

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PROJECTION RUN: GM Cod F=Fmax SSB Target
INPUT FILE: C:\Nafo\Workshop\gmcod\gmc99mod5.in
OUTPUT FILE: C:\Nafo\Workshop\gmcod\gmc99mod5.out
RECRUITMENT MODEL: 5
NUMBER OF SIMULATIONS: 1

Bootstrapped Population Numbers

AGE	AVG N	STD
1	5076.259	156.209
2	4457.452	1592.477
3	2356.606	634.759
4	1242.444	341.000
5	463.895	157.366
6	329.767	124.461
7	174.981	44.895

PERCENTILES OF Bootstrapped Population Numbers

Age	1%	5%	10%	25%	50%	75%	90%	95%	99%
1	4652.896	4819.785	4857.587	4955.638	5088.163	5179.793	5244.828	5330.930	5447.146
2	1665.745	2286.521	2548.306	3368.059	4262.300	5355.144	6045.256	7813.131	9363.643
3	1271.062	1323.649	1555.983	1977.917	2310.130	2657.227	3071.718	3433.747	4099.466
4	450.096	736.132	807.075	1015.968	1210.729	1470.548	1671.914	1821.812	2162.420
5	220.540	267.481	298.548	351.413	432.922	543.687	673.343	791.504	880.318
6	119.558	146.389	187.788	235.576	306.653	390.245	498.722	530.817	710.647
7	92.089	110.333	124.155	146.377	165.140	200.252	239.598	251.869	289.561

F-BASED PROJECTIONS
TIME-VARYING F

YEAR	F
2000	0.640
2001	0.270
2002	0.270
2003	0.270
2004	0.270
2005	0.270
2006	0.270
2007	0.270
2008	0.270
2009	0.270
2010	0.270

SPAWNING STOCK BIOMASS (THOUSAND MT)

YEAR	AVG SSB (000 MT)	STD
2000	11.927	1.738
2001	12.922	1.887
2002	15.798	1.903
2003	18.045	2.218
2004	20.196	2.307
2005	22.874	2.770
2006	24.734	2.880
2007	25.400	3.138
2008	26.266	2.947
2009	27.206	3.270
2010	27.941	3.787

PERCENTILES OF SPAWNING STOCK BIOMASS (000 MT)

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
2000	8.570	9.122	9.528	10.543	12.055	13.068	13.860	14.294	15.521
2001	9.361	10.082	10.452	11.432	12.685	13.899	15.144	15.938	17.875
2002	11.924	12.640	13.348	14.578	15.606	16.714	17.956	19.430	21.096
2003	13.761	14.226	15.203	16.471	17.961	19.240	20.701	22.537	23.376
2004	14.308	16.145	17.247	18.546	20.101	21.651	23.653	24.229	25.435
2005	16.195	18.133	19.393	20.863	22.779	24.596	26.077	27.698	29.994
2006	18.839	20.009	21.059	22.690	24.675	26.219	28.709	29.911	30.990
2007	19.689	20.211	21.532	23.471	25.113	26.979	29.885	31.103	33.376
2008	20.071	21.729	22.770	23.937	26.113	28.131	30.170	31.424	32.987
2009	20.144	22.523	23.412	24.616	26.539	29.199	31.529	32.621	35.433
2010	20.696	22.990	23.781	25.058	27.132	30.648	33.401	34.375	36.002

ANNUAL PROBABILITY THAT SSB EXCEEDS THRESHOLD: 20.0000000000000
THOUSAND MT

YEAR	Pr(SSB > Threshold Value)
2000	0.000
2001	0.000
2002	0.040
2003	0.170
2004	0.530
2005	0.850
2006	0.960
2007	0.980
2008	1.000
2009	1.000
2010	1.000

RECRUITMENT UNITS ARE: 1000.00000000000 FISH

BIRTH YEAR	AVG RECRUITMENT	STD
2000	3894.498	1341.750
2001	4195.905	1181.766
2002	4368.351	1553.909
2003	4741.697	1999.992
2004	4625.566	1459.561
2005	4696.778	1350.521
2006	5152.977	1897.815
2007	4871.621	1857.100
2008	4890.674	1553.266
2009	4944.081	1456.600
2010	5021.736	1519.306

PERCENTILES OF RECRUITMENT UNITS ARE: 1000.00000000000 FISH

BIRTH YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
2000	1721.381	2274.654	2460.999	2944.502	3611.293	4477.657	5654.472	6678.258	7887.828
2001	2038.727	2559.858	2844.270	3356.583	3959.904	4886.227	5643.123	6075.731	6794.713
2002	2178.429	2312.719	2672.357	3239.054	4127.168	5260.242	6217.577	6593.237	10429.539
2003	1803.968	2717.734	3021.459	3381.749	4150.249	5543.853	7053.537	8061.580	11804.019
2004	1946.213	2561.413	3038.762	3573.912	4331.775	5473.115	6431.661	7110.151	8449.123
2005	2813.871	2888.191	3126.858	3749.181	4493.711	5200.195	6660.819	7350.759	8400.892
2006	2341.073	3016.871	3189.306	3555.482	4761.030	5819.197	7985.833	8745.507	10249.675
2007	2237.004	2560.030	2956.884	3438.224	4518.885	5713.174	7704.723	7986.075	10351.371
2008	2649.421	2998.403	3200.374	3638.944	4481.195	5787.563	7378.350	8165.561	8535.129
2009	2194.844	3106.939	3200.122	3541.106	4797.147	5843.003	6833.787	7806.615	8110.790
2010	2342.836	2636.065	3276.904	3975.924	4750.426	6017.702	7298.427	7985.945	8208.968

LANDINGS FOR F-BASED PROJECTIONS

YEAR	AVG LANDINGS (000 MT)	STD
2000	7.550	1.071
2001	3.685	0.518
2002	4.473	0.538
2003	5.084	0.614
2004	5.691	0.653
2005	6.311	0.736
2006	6.711	0.804
2007	6.908	0.841
2008	7.145	0.817
2009	7.391	0.910
2010	7.566	1.006

PERCENTILES OF LANDINGS (000 MT)

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
2000	5.431	5.797	6.101	6.677	7.620	8.290	8.658	9.235	9.856
2001	2.699	2.888	3.051	3.305	3.632	3.939	4.266	4.564	5.077
2002	3.342	3.569	3.789	4.131	4.430	4.756	5.102	5.468	5.965
2003	3.836	3.998	4.287	4.602	5.076	5.449	5.776	6.350	6.483
2004	4.039	4.525	4.836	5.296	5.622	6.093	6.717	6.846	7.231
2005	4.512	5.048	5.370	5.757	6.290	6.778	7.226	7.535	8.223
2006	5.069	5.427	5.712	6.193	6.646	7.167	7.750	8.232	8.412
2007	5.321	5.546	5.814	6.356	6.838	7.296	8.121	8.378	8.988
2008	5.493	5.968	6.146	6.491	7.042	7.726	8.282	8.716	8.983
2009	5.489	6.050	6.359	6.678	7.151	8.088	8.599	8.900	9.588
2010	5.682	6.231	6.443	6.811	7.355	8.362	9.041	9.322	9.569

50th PERCENTILES OF NUMBERS AT AGE

	1	2	3	4	5	6	7
2000	5088.	4262.	2310.	1211.	433.	307.	165.
2001	3611.	4005.	2749.	1047.	523.	187.	212.
2002	3960.	2908.	2965.	1753.	654.	327.	254.
2003	4127.	3189.	2153.	1892.	1096.	409.	365.
2004	4150.	3323.	2361.	1373.	1182.	685.	497.
2005	4332.	3342.	2460.	1506.	858.	739.	732.
2006	4494.	3488.	2474.	1570.	941.	536.	923.
2007	4761.	3619.	2582.	1578.	981.	588.	917.
2008	4519.	3834.	2679.	1647.	986.	613.	973.
2009	4481.	3639.	2838.	1709.	1030.	617.	984.
2010	4797.	3609.	2694.	1811.	1068.	644.	1032.

AGEPRO Model 9 Results

Input File: gmc99mod9.in

Time-vary empirical recruitment distribution

```
GM Cod: F=Fmax   SSB Target ## Name of projection run
 2000          ## First year of projection run
 11            ## Length of planning horizon (between 1 and 25)
 1             ## Number of simulations per initial population vector (between 1 and 200)
 24680         ## Number of reps to initialize the random number generator
 0             ## lag recruitment flag
 0             ## Catch projections based on a mixture of F and Q
 0             ## Discard flag (1=true, 0=false)
 0             ## quota based management flag
 0             ## Constant harvest strategy flag (1=true, 0=false)
 0             ## F target flag Print (1=true, 0=false)
 0             ## Index flag
 1             ## threshold flag
 0             ## market category flag
 0             ## total mortality flag
 0             ## partial recruitment flag
 0             ## constant discard flag
 0             ## bounded recruitment flag
 1             ## constant natural mortality flag
 1             ## bootstrap flag
 7             1           ## number of age classes and age of recruitment
 0.2           ## constant natural mortality
 0.613  1.087  1.79  2.347  3.21  4.712  11.635 ## mean spawning weights at age
 0.9  1.563  2.024  2.764  3.957  6.524  11.635 ## mean landed weights at age
 0.04  0.38  0.89  0.99  1  1  1 ## fraction mature at age
 0.1667        ## fraction of total mortality that occurs before spawning
 9             ## Model number
 16            ## number of observed recruitments for each year in the time horizon
 3090000  2912000  1983000  2204000  3490000  3090000  2912000  1983000  2204000  3490000
3090000  2912000  1983000  2204000  3490000  3900000 ## observed recruitments for each year in
the time horizon
 3090000  2912000  1983000  2204000  3490000  3090000  2912000  1983000  2204000  3490000
3090000  2912000  1983000  2204000  3490000  3090000 ## observed recruitments for each year in
the time horizon
 3090000  2912000  1983000  2204000  3490000  3090000  2912000  1983000  2204000  3490000
3090000  2912000  1983000  2204000  3490000  3090000 ## observed recruitments for each year in
the time horizon
 3376000  3391000  5883000  5309000  8260000  3090000  2912000  1983000  2204000  3490000
3391000  5883000  5309000  8260000  3090000  2912000 ## observed recruitments for each year in
the time horizon
 3376000  3391000  5883000  5309000  8260000  3090000  2912000  1983000  2204000  3490000
3391000  5883000  5309000  8260000  3090000  2912000 ## observed recruitments for each year in
the time horizon
 3376000  3391000  5883000  5309000  8260000  3090000  2912000  1983000  2204000  3490000
3391000  5883000  5309000  8260000  3090000  2912000 ## observed recruitments for each year in
the time horizon
 3376000  3391000  5883000  5309000  8260000  3090000  2912000  1983000  2204000  3490000
3391000  5883000  5309000  8260000  3090000  2912000 ## observed recruitments for each year in
the time horizon
 5534000  7746000  4914000  7410000  9954000  21648000  3376000  3391000  5883000  5309000
8260000  3090000  2912000  1983000  2204000  3490000 ## observed recruitments for each year in
the time horizon
 5534000  7746000  4914000  7410000  9954000  21648000  3376000  3391000  5883000  5309000
8260000  3090000  2912000  1983000  2204000  3490000 ## observed recruitments for each year in
the time horizon
 5534000  7746000  4914000  7410000  9954000  21648000  3376000  3391000  5883000  5309000
8260000  3090000  2912000  1983000  2204000  3490000 ## observed recruitments for each year in
the time horizon
 5534000  7746000  4914000  7410000  9954000  21648000  3376000  3391000  5883000  5309000
8260000  3090000  2912000  1983000  2204000  3490000 ## observed recruitments for each year in
the time horizon
 100           ## number of bootstraps
C:\Nafo\Workshop\gmcod\gmcod2000_base.2bootN           ## name of bootstrap N's file
 1000          ## units for bootstrap
 20000000      ## thresholds
 0.0614  0.373  0.924  1  1  1  0 ## Constant partial recruitment
 0.64  0.27  0.27  0.27  0.27  0.27  0.27  0.27  0.27  0.27  0.27 ## F series
```

07 Sep 2000 at 10:50.58

PROJECTION RUN: GM Cod: F=Fmax SSB Target
INPUT FILE: C:\Nafo\Workshop\gmcod\gmc99mod9.in
OUTPUT FILE: C:\Nafo\Workshop\gmcod\gmc99mod9.out
RECRUITMENT MODEL: 9
NUMBER OF SIMULATIONS: 1

Bootstrapped Population Numbers

AGE	AVG N	STD
1	5076.259	156.209
2	4457.452	1592.477
3	2356.606	634.759
4	1242.444	341.000
5	463.895	157.366
6	329.767	124.461
7	174.981	44.895

PERCENTILES OF Bootstrapped Population Numbers

Age	1%	5%	10%	25%	50%	75%	90%	95%	99%
1	4652.896	4819.785	4857.587	4955.638	5088.163	5179.793	5244.828	5330.930	5447.146
2	1665.745	2286.521	2548.306	3368.059	4262.300	5355.144	6045.256	7813.131	9363.643
3	1271.062	1323.649	1555.983	1977.917	2310.130	2657.227	3071.718	3433.747	4099.466
4	450.096	736.132	807.075	1015.968	1210.729	1470.548	1671.914	1821.812	2162.420
5	220.540	267.481	298.548	351.413	432.922	543.687	673.343	791.504	880.318
6	119.558	146.389	187.788	235.576	306.653	390.245	498.722	530.817	710.647
7	92.089	110.333	124.155	146.377	165.140	200.252	239.598	251.869	289.561

F-BASED PROJECTIONS
TIME-VARYING F

YEAR	F
2000	0.640
2001	0.270
2002	0.270
2003	0.270
2004	0.270
2005	0.270
2006	0.270
2007	0.270
2008	0.270
2009	0.270
2010	0.270

SPAWNING STOCK BIOMASS (THOUSAND MT)

YEAR	AVG SSB (000 MT)	STD
2000	12.245	1.774
2001	13.857	1.983
2002	16.727	1.909
2003	18.289	1.810
2004	19.822	1.842
2005	22.497	2.338
2006	25.588	2.744
2007	27.307	3.102
2008	28.831	3.289
2009	30.403	3.438
2010	33.555	5.313

PERCENTILES OF SPAWNING STOCK BIOMASS (000 MT)

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
2000	8.831	9.364	9.836	10.793	12.363	13.403	14.202	14.690	15.977
2001	10.077	10.748	11.276	12.307	13.631	15.088	16.365	16.695	19.203
2002	13.088	13.785	14.125	15.292	16.574	17.741	19.098	19.795	21.780
2003	14.555	15.458	15.833	17.158	18.288	19.318	20.625	21.396	23.087
2004	15.808	16.978	17.391	18.338	19.765	20.942	22.175	22.965	24.755
2005	16.984	19.250	19.566	20.786	22.297	23.771	25.141	27.422	28.880
2006	19.963	21.808	22.405	23.755	24.928	26.957	29.266	31.093	33.505
2007	21.416	22.697	23.554	25.049	26.710	29.042	32.087	33.107	35.349
2008	21.833	23.931	24.894	26.230	28.538	30.859	32.885	35.361	37.025
2009	23.107	25.198	26.250	27.811	30.528	32.104	35.211	36.496	39.348
2010	24.137	26.371	27.475	29.829	32.756	36.647	40.582	43.891	48.487

ANNUAL PROBABILITY THAT SSB EXCEEDS THRESHOLD: 20.0000000000000
THOUSAND MT

YEAR	Pr(SSB > Threshold Value)
2000	0.000
2001	0.000
2002	0.050
2003	0.140
2004	0.470
2005	0.870
2006	0.990
2007	1.000
2008	1.000
2009	1.000
2010	1.000

RECRUITMENT UNITS ARE: 1000.00000000000 FISH

BIRTH YEAR	AVG RECRUITMENT	STD
2000	2744.380	613.426
2001	2736.230	555.447
2002	2762.290	541.816
2003	4222.780	1836.194
2004	4445.960	2009.916
2005	4656.140	2162.239
2006	4250.230	1900.424
2007	5641.680	4072.855
2008	6512.660	4981.173
2009	6688.360	4679.051
2010	6408.220	5063.186

PERCENTILES OF RECRUITMENT UNITS ARE: 1000.00000000000 FISH

BIRTH YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
2000	1983.000	1983.000	1983.000	2204.000	2912.000	3090.000	3490.000	3490.000	3900.000
2001	1983.000	1983.000	1983.000	2204.000	2912.000	3090.000	3490.000	3490.000	3490.000
2002	1983.000	1983.000	1983.000	2204.000	2912.000	3090.000	3490.000	3490.000	3490.000
2003	1983.000	2204.000	2204.000	3090.000	3391.000	5309.000	8260.000	8260.000	8260.000
2004	1983.000	1983.000	1983.000	3090.000	3391.000	5883.000	8260.000	8260.000	8260.000
2005	1983.000	2204.000	2204.000	2912.000	3391.000	5883.000	8260.000	8260.000	8260.000
2006	1983.000	1983.000	1983.000	2912.000	3391.000	5309.000	8260.000	8260.000	8260.000
2007	1983.000	1983.000	2204.000	3090.000	4914.000	7410.000	9954.000	9954.000	21648.000
2008	1983.000	2204.000	2912.000	3376.000	5309.000	7746.000	9954.000	21648.000	21648.000
2009	1983.000	2204.000	2912.000	3391.000	5534.000	7746.000	9954.000	21648.000	21648.000
2010	1983.000	1983.000	2204.000	3090.000	5309.000	7746.000	9954.000	21648.000	21648.000

LANDINGS FOR F-BASED PROJECTIONS

YEAR	AVG LANDINGS (000 MT)	STD
2000	6.668	0.951
2001	3.124	0.478
2002	3.672	0.467
2003	3.689	0.431
2004	3.656	0.422
2005	3.403	0.304
2006	3.326	0.544
2007	3.732	0.695
2008	4.109	0.791
2009	4.572	0.940
2010	5.005	1.329

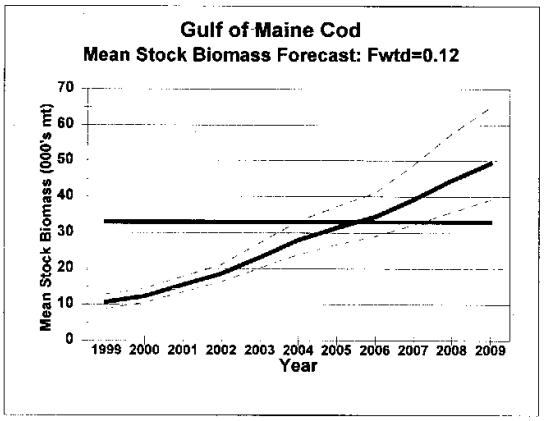
PERCENTILES OF LANDINGS (000 MT)

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
2000	4.773	5.131	5.365	5.970	6.658	7.319	7.634	8.131	8.929
2001	1.991	2.403	2.523	2.871	3.067	3.385	3.670	3.956	4.495
2002	2.583	2.974	3.042	3.423	3.651	3.848	4.192	4.432	5.070
2003	2.868	3.006	3.134	3.437	3.660	3.891	4.129	4.473	4.931
2004	2.808	3.014	3.112	3.357	3.615	3.862	4.122	4.418	4.854
2005	2.839	2.929	2.982	3.189	3.390	3.589	3.780	3.913	4.181
2006	2.351	2.608	2.736	2.928	3.224	3.614	4.162	4.307	4.677
2007	2.557	2.804	2.920	3.207	3.583	4.150	4.796	4.923	5.213
2008	2.612	2.957	3.221	3.475	3.946	4.653	5.128	5.399	5.760
2009	2.376	3.199	3.371	3.859	4.457	5.138	5.614	6.124	6.890
2010	2.615	3.288	3.599	4.113	4.738	5.562	6.804	7.026	8.770

50th PERCENTILES OF NUMBERS AT AGE

	1	2	3	4	5	6	7
2000	5088.	4262.	2310.	1211.	433.	307.	165.
2001	2912.	4005.	2749.	1047.	523.	187.	276.
2002	2912.	2345.	2965.	1753.	654.	327.	351.
2003	2912.	2345.	1736.	1892.	1096.	409.	495.
2004	3391.	2345.	1736.	1107.	1182.	685.	686.
2005	3391.	2731.	1736.	1107.	692.	739.	982.
2006	3391.	2731.	2021.	1107.	692.	433.	1264.
2007	3391.	2731.	2021.	1290.	692.	433.	1300.
2008	4914.	2731.	2021.	1290.	806.	433.	1318.
2009	5309.	3957.	2021.	1290.	806.	504.	1335.
2010	5534.	4275.	2929.	1290.	806.	504.	1446.

```
GM Cod F=Fmax SSB Target    ## Name of projection run
 2000         ## First year of projection run
 11           ## Length of planning horizon (between 1 and 25)
 1            ## Number of simulations per initial population vector (between 1 and 200)
 24680        ## Number of reps to initialize the random number generator
 0            ## lag recruitment flag
 0            ## Catch projections based on a mixture of F and Q
 0            ## Discard flag (1=true, 0=false)
 0            ## quota based management flag
 0            ## Constant harvest strategy flag (1=true, 0=false)
 0            ## F target flag Print (1=true, 0=false)
 0            ## Index flag
 1            ## threshold flag
 0            ## market category flag
 0            ## total mortality flag
 0            ## partial recruitment flag
 0            ## constant discard flag
 0            ## bounded recruitment flag
 1            ## constant natural mortality flag
 1            ## bootstrap flag
 7             1           ## number of age classes and age of recruitment
 0.2          ## constant natural mortality
 0.613  1.087  1.79  2.347  3.21  4.712  11.635 ## mean spawning weights at age
 0.9  1.563  2.024  2.764  3.957  6.524  11.635 ## mean landed weights at age
 0  0.38  0.89  0.99  1  1  1 ## fraction mature at age
 0.1667       ## fraction of total mortality that occurs before spawning
 2            ## Model number
 16           ## number of observed recruitment/SSB data points
 5534000  7746000  4914000  7410000  9954000  21648000  3376000  3391000  5883000  5309000
8260000  3090000  2912000  1983000  2204000  0 ## observed recruitment series
 22786000  18061000  13984000  15272000  14561000  14371000  17732000  26192000  22585000
20313000  13438000  10710000  12258000  14173000  12711000  0  ## the observed SSB series
 100          ## number of bootstraps
C:\Nafo\Workshop\gmcod\gmcod2000_base.2bootN            ## name of bootstrap N's file
 1000         ## units for bootstrap
 20000000     ## thresholds
 0.0614  0.373  0.924  1  1  1  1 ## Constant partial recruitment
 0.64  0.27  0.27  0.27  0.27  0.27  0.27  0.27  0.27  0.27  0.27 ## F series
```



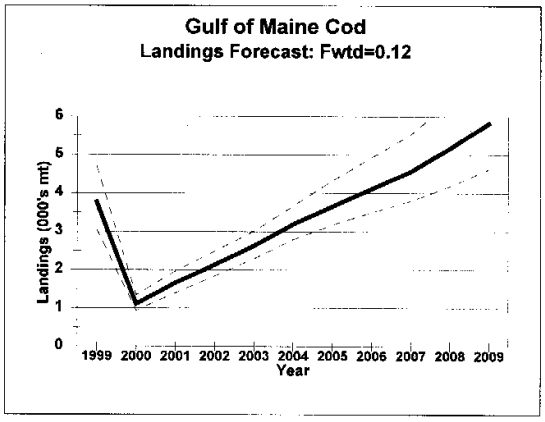


Figure 13. Medium-term forecasts of mean biomass (ages 2+) and landings for Gulf of Maine cod. Fwtd=0.12