APPENDIX 2. Woods Hole Version of ADAPT/VPA Fisheries Assessment Compilation Toolbox (FACT)

NAFO Sci. Coun. Studies, 36: 163–199

Appendix 2: Woods Hole Version of ADAPT/VPA Fisheries Assessment Compilation Toolbox (FACT)

Outlines and Data Sets

by

R.K. Mayo
National Marine Fisheries Service, Northeast Fisheries Science Center
Woods Hole, Massachusetts 02543 USA

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.

ADAPT is an age-structured, adaptable framework for estimating historical stock sizes of an exploited population. It is not a rigidly defined model in the mathematical sense, but rather a flexible set of modular tools designed to integrate data that may contain useful information on population size. The statistical basis of the ADAPTive approach is to minimize the discrepancy between observation of state variables and their predicted values. The observed state variables are usually (but are not limited to) age-specific indices of population size, e.g. from commercial catch-effort data, research surveys, mark-recapture experiments, etc. The predicted values are a function of a vector of estimated population size (age-specific) and catchability parameters.

This document shows how to run Adapt/VPA using a sample input file to complete a VPA. A description of the various files containing the VPA results is given. Details on the completion of a set of bootstrap analyses are also provided, and a description of the various files containing the bootstrap 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 ADAPT module.

ADAPT

This module is the VPA implementation using the ADAPT approach towards minimizing sums of squares in a specified objective function. In ADAPT, there is a calibration block and an estimation block.

The calibration block is the set of indices × ages which are used to 'calibrate' the VPA terminal populations. A value of q is estimated for each index in the calibration block.

The estimation block is the set of ages for which you are estimating a terminal population stock size. In ADAPT, these are considered as survivors at the end (31 December) of the terminal year of the catch at age matrix, or at the beginning (1 January) of the year following the terminal year.

Input

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

The ADAPT module requires the following input:

Catch-at-age
Mean catch weights-at-age
Mean stock weights-at-age
Tuning indices
Natural mortality
Maturation ogive

There are also several initialization specifications to be set before the VPA can run.

All of these data are in a single example file: **gmcod2000_base.inp**

This file can be imported directly into the ADAPT module using the File dialog box.

The VPA will run using all of the data as the default. You may also wish to change the indices depending on trends in the residuals.

Diagnostics

1. In addition to the residuals, one can look for a retrospective pattern in the estimates of F, stock size-at-age, and SSB. The retrospective may be selected from the Diagnostics dialog box.

2. The final formulation of the VPA may be run through a bootstrap procedure in which a normalized residual is drawn at random from the pool, and subtracted from an observed normalized survey index. This is done for each index in the calibration block. Generally, between 500 and 1 000 bootstrap runs are performed. This may take time, so 100 is recommended for the workshop.

Output

After the VPA has run successfully, formatted output will be written by default to a file based on the name of the input file, in this case: **gmcod2000_base.2.** This file should be brought into a word processor for viewing and printing. If a Retrospective Analysis has been selected, the results will be appended to the end of this file.

An ASCII 'Flat File' may also be output as an option. This file contains VPA results and residuals selected by the user. This file should be brought into a spreadsheet for further analysis, tabulation, and plotting.

After the Bootstrap procedure has run successfully, formatted output containing a summary of all bootstrapped variables will be written to a file based on the name of the input file, in this case: **gmcod2000_base.2boot**. This file should also be brought into a word processor for viewing and printing.

The Bootstrap procedure also produces 6 'data files' in free format containing all of the bootstrap results, in this case:

gmcod2000_base.2bootF	Fully recruited F in terminal year of the VPA
gmcod2000_base.2bootN	Estimated stock sizes at age at the end of the terminal year
gmcod2000_base.2bootSSB	Spawning Stock Biomass in all years of the VPA
gmcod2000_base.2bootMB	Mean Stock Biomass in the terminal year of the VPA
gmcod2000_base.2bootJB	Beginning-year Biomass in the terminal year of the VPA
gmcod2000_base.2bootBWF	Biomass-weighted F in the terminal year of the VPA

These files may be brought into a spreadsheet for further analysis, tabulation, and plotting. The file, **gmcod2000_base.2bootN** is used as input for the forward projection program, AGEPRO. The file, **gmcod2000_base.2bootSSB,** may also be required, depending on the recruitment generation model selected in AGEPRO.

The following sections are taken from the on-line HELP available in FACT.

VPA Introduction

Virtual Population Analysis (VPA) Method

ADAPT is an age-structured, adaptable framework of estimating historical stock sizes of an exploited population. It is not a rigidly defined model in the mathematical sense, but rather a flexible set of modular tools designed to integrate data that may contain useful information on population size.

The statistical basis of the ADAPTive approach is to minimize the discrepancy between observation of state variables and their predicted values. The observed state variables are usually (but are not limited to) age-specific indices of population size, e.g. from commercial catch-effort data, research surveys, mark-recapture experiments, etc. The predicted values are a function of a vector of estimated population size (age-specific) and catchability parameters. Sequential population analysis equations (Gulland's (MS 1965) VPA) and nonlinear least squares objective functions are employed to minimize the discrepancies.

The appellation ADAPT was introduced by Gavaris (MS 1988). However, the foundation of the method was developed over the preceding decade under an umbrella of research generally referred to as VPA tuning. Although not generally recognized, Parks (1976) was the first to tune a VPA using auxiliary data and a least squares objective function. He tuned VPA back-calculated fishing mortality rates (Fs) to Fs derived independently from tagging experiments. Gray (MS 1977) suggested a least squares approach to estimate mortality rates (both F and M) using a commercial catch-per-unit-effort (CPUE) index of abundance as auxiliary data.

Doubleday (1981) used age-specific research survey indices of abundance as auxiliary data to estimate survivors in the terminal year for each cohort. This appears to have been the first attempt to utilize multiple indices of abundance in a least squares tuning procedure.

Parrack (1986) expanded upon Doubleday's work by integrating indices of abundance from widely diverse sources into the least squares objective function. His formulation allowed indices from commercial fisheries, research surveys, larval surveys, etc. Indices could be either age-specific or represent several age-classes. Indices could be expressed in either population number or biomass. Indices were related to population size either linearly or through a power function. Variance estimates were made assuming linearity at the optimal solution. He also recognized that not all indices are of equal value in measuring population abundance. Some indices will always be inherently more variable than others, and some may be biased. He introduced detailed examination of residuals and correlation statistics as an acceptance/rejection filter that each index needed to pass through in order to be used in the final tuning. The tuning procedure described by Parrack (1986) is the kernel of the method today known as ADAPT, both in terms of the objective function employed and in terms of the underlying philosophy.

The ADAPTive framework developed by Gavaris (MS 1988) generalized Parrack's procedure in several ways:

1. The adaptive aspects of the method were greatly enhanced through the use of a modular model structure and implementation in the APL programming language. This made it possible to modify the objective function significantly, as needed to rectify problems, even during the course of an assessment working group meeting.
2. A Marquardt algorithm (Bard 1974) was used for optimization of the least squares objective function. This allowed the simultaneous estimation of age-specific population sizes in the terminal year and catchabilities (Parrack estimated only the full F in the terminal year F vector). Additionally, the use of numerical derivatives in the Marquardt algorithm greatly enhanced the adaptive philosophy by making objective function modifications easy to implement.
3. The more complete statistical model allowed for improved diagnostics. In addition to residual analysis, availability of the full variance-covariance matrix (assuming linearization at the optimal solution) provided variance estimates of all parameters, correlation among parameter estimates, and in general a better sense of which parameters were estimable from the available information.

The integration of many diverse sources of information focused attention on objective procedures to account for differences in the quality of information. Collie (1988) suggested that all indices of abundance should be included in the least squares objective function rather than employing Parrack's acceptance/rejective criteria. He recommended weighting the indices by the inverse of their variances. Vaughn *et al*. (1989) used Monte Carlo simulation to investigate the effect of weighting on the Fs estimated for bluefin tuna. They found that the F estimates were unbiased only when the indices were weighted. Conser and Powers (1990) developed a more general weighting procedure that allowed for two-way effects, i.e. index and year. Gavaris and Van Eeckhaute (MS 1991) employed a similar weighting procedure using an analysis of variance approach. Gassuikov (1990) suggested an alternative approach to weighting in ADAPT using the moving check procedure of Vapnik (1982).

The approach shows how to get started using Adapt/VPA using a sample input file to demonstrate a run. The book **Getting Started with Adapt/VPA**, includes a documented input file and output file.

The *Explanation of the sample output file* provides links to explain the mathematical methods for the given results.

Input File

Output File

Demonstration with Sample program

Adapt/VPA Model Overview

ADAPT is an age-structured. adaptable framework of estimating historical stock sizes of an exploited population. It is not a rigidly defined model in the mathematical sense. but rather a flexible set of modular tools designed to integrate all available data that may contain useful information on population size.

The statistical basis of the ADAPTive approach is to minimize the discrepancy between observation of state variables and their predicted values. The observed state variables are usually (but are not limited to) age-specific indices of population size. e.g. from commercial catch-effort data, research surveys, mark-recapture experiments, etc. The predicted values are a function of a vector of estimated population size (age- specific) and catchability parameters; and standard population dynamics equations (usua1ly Gulland's (MS 1965) VPA). Non-linear least squares objective functions are employed to minimize the discrepancies.

Model Overview

Adapt VPA model uses the application of a statistical technique, non-linear least squares, to determine the most appropriate estimate of the population matrix. Gavaris (1988) initially describes the Adapt objective function in general terms, as a minimization of the difference between observation of variables and the values of those variables predicted as functions of the population matrix (i.e. as function of the catch-at-age). That is,

$$min \sum_{k}^{K} W_k (\theta_k - \hat{\theta}_k)^2$$

where θ_k is the k_{th} observation.

$\hat{\theta} = f(\Pi, \Omega)$ (user defined)

Π is the population matrix.

Ω are the other parameters which may be required.

W_k = weight for observed variable set k.

K is the number of observations.

In this implementation of ADAPT the error in the catch at age is assumed to be negligible relative to error in the indices of abundance. This appears to be reasonable. This above objective function has been used almost exclusively in the CAFSAC and NAFO assessments that have employed ADAPT (Gavaris, pers. comm.)

Residual Sum or Squares

The objective function employed in this ADAPT Version has the following form.

$$RSS = \sum_{k=1}^{K} \sum_{j=1}^{Y+1} \left[\frac{ln\, I(k,j)}{\bar{I}(k)} - ln\, \hat{I}(k,j) \right]^2 \bullet W(k,j)$$

where k is a general pointer that specifies a particular combination of age group index type, and tuning type. For example $k = 1$ might specify the age 5 survey index from an autumn survey tuned to Jan. 1 abundance in year $T + 1$.

K is the number of indices used, as selected by the user (**Available indices** tab).

j is the year and ranges from the first year to the terminal year plus one.

I(k, j) is the observed survey index with index number k in year j .

$\hat{I}(k,j)$ is the predicted index with index number k in year j .This is calculated differently depending on the user's choice of tuning units (**Weight, Number**) and tuning date (**Jan l** and **Mean**) in the indices tab of the user's interface. See **indices options**.

$W(k,j)$ is the weight associated with the observed indices at index number k in year j.

$\bar{I}(k)$ is the average over years for an index and is defined by the equation:

$$\bar{I}(k) = \frac{1}{Y+1} \sum_{j=1}^{Y+1} I(k,j)$$

When the index value is 0, that year is not included into the equation.

The Fitting Procedure

The fitting procedure for terminal year + 1 population numbers (N) and catchabilities (q) in ADAPT/VPA uses the Marquardt algorithm. The algorithm uses initial guesses for stock size in year, $y + 1$ and catchabilities to calculate fishing mortality (F) and population numbers using cohort equations. An iterative procedure is applied where q and N parameters are adjusted to minimize the objective function. Trial values for the parameters are adjusted at each calculation of the residual sum of squares (RSS) and compared to the previous RSS. The procedure is then repeated until the RSS is zero or effectively stops decreasing. For this ADAPT /VPA the successive RSS values are recalculated until the difference between consecutive RSS values is 0.00001 or 200 iterations have been performed. The parameters with the lowest RSS value are considered the "best fit" and are considered the most correct estimate.

One assumption in the ADAPT model is that the error in the indices is greater than the error in the catch-at-age. Since the statistical procedure does not deal with error in both variables, the model assumes error in the catch-at-age matrix, only in the survey indices. In addition, the model does not assume separability (F is represented as a fraction of catch to total stock size rather than assuming that F is a function of an age specific and year specific exploitation pattern.)

Statistical Weighting

The weights associated with each observation are not limited to the $1/\sigma^2$ type weights from research surveys, but include such weighting in addition to other weighting factors. Weighting in addition to log transformation fails to stabilize variance among the observations. Three types of weighting contribute multiplicatively to the weight assigned to each observation.

$$W(k,j) = \omega(k,j) \bullet \chi(k) \bullet \delta(j)$$

where $\omega(k,j)$ are the $1/\sigma^2$ type weights from research surveys, multiplicative models using catch-effort data, or other exogenous information. See Omega weights.

$\chi(k)$ are weights designed to stabilize the variance across the various indices of abundance. See Chi weights.

$\delta(j)$ are weights designed to stabilize the variance across years to counteract the convergence properties of VPA. This process known as down-weighting allows the user to systematically assign linear, quadratic or tricubic weights to a weighting function. See Downweighting.

The raw weights calculated by the above equation are normalized prior to use in the objective function, such that

$$\sum_k \sum_j W(k,j) = 1$$

For any given assessment, all of these weights, some subset of them, or none of them may be employed depending on the available data and the structure of the heteroscedasticity.

Omega weights – Inverse Variance Weights from Exogenous data $(\omega(k,j))$

These weights are the type suggested by Gavaris (1988). Their use is intended to discount the effect of less reliable observations on the parameter estimates and to better satisfy the usual regression assumption of homogeneity of variance among all observations. When all observed indices of abundance are based on research surveys that have been carried out in a consistent manner, these weights alone may be sufficient to stabilize variance, both across years and across indices. However, when indices of abundance are derived from different data sources (e.g. research surveys and catch-effort data), it is unlikely that variances computed from the respective data sources will stabilize the variance across indices.

Omega weights are user-defined weights where each index is individually weighted. A value of 1 has no effect on the weighting. See Statistical weighting and VPA screen.

Chi weights – Inverse Variance weights from iterative re-weighting – $X(k)$

$X(k)$ are weights designed to stabilize the variance across the various indices of abundance.
Chi weights are set to 1 during the initial VPA run and are activated by **Re-weighted VPA** of the **Run VPA** menu selection. The **Re-weighting VPA** option can only be enabled after an initial **VPA run**. The output is appended to the VPA output file.

By invoking re-weighting, the chi weights are calculated for each index and are used to re-weight the indices in the final residuals sum of squares (RSS) solution. The calculating procedure for weighting is as follows:

$$\chi(k) = \frac{\dfrac{\dfrac{1}{MSR(k)}}{\sum_{k=1}^{K} \dfrac{1}{MSR(k)}}}{\sum_{k=1}^{K} \left[\dfrac{\dfrac{1}{MSR(k)}}{\sum_{k=1}^{K} \dfrac{1}{MSR(k)}} \right]}$$

where *k* is the index of indices and *K* is the number of indices used, as selected by the user (**Available indices tab**).

MSR is the mean square residual and is defined by the following equation:

$$MSR(k) = \frac{\sum_{j}^{Y+1} Res(k,j)^2}{K_{Total} - [K + A_n]}$$

k is the index of indices, K_{Total} is the total number of non-zero indices and *K* is the number of catchabilities (*q*) estimated.
A_n is the number of ages the user enters into the **Ages to estimate** text box.
Res is the residual or the difference between the observed survey index *I(k, j)* and the predicted index $\hat{I}(k,j)$. $\hat{I}(k)$ is the average over years for an index.

$$Res(k,j) = \frac{ln\, I(k,j)}{\hat{I}(k)} - ln\, \hat{I}(k,j)$$

See Residual Sum of Squares (RSS).

Down-weighting to counterbalance VPA convergence – $\delta(j)$

Assuming that error in the catch-at-age estimates is negligible relative to error in the indices of abundance (Gavaris 1988), the residuals from any VPA-based tuning method will tend to be smaller in the more recent years. In earlier years, where the VPA has converged, the differences between observed and predicted indices will not be affected greatly by various choices of the parameters in the terminal year. In contrast, the residuals from more recent years can be reduced appreciably by the tuning process. ADAPT/VPA has options to apply linear, quadratic or tricubic weightings to the down-weighting function.

The following expression is used to calculate the down-weighting value.

$$\delta(j) = \left(1 - \left(\frac{Y + 1 - j}{Y_{DW}} \right)^{DW} \right)^{DW}$$

for years $j=1$ to $Y+1$.

Y_{DW} is the number of years to down-weight (and DW specifies the type of down-weighting in which there are several options.

a) None or uniform = 0
b) Linear = 1
c) Biquadratic = 2
d) Tricubic = 3

References

BARD, J. 1974. Nonlinear parameter estimation. Academic Press, New York, NY, 341 p.

COLLIE, J.S. 1988. Evaluation of virtual population analysis tuning procedures as applied to Atlantic bluefin tuna. *ICCAT, Coll. Vol. Sci. Pap*., **28**: 203–220.

CONSER, R. J. and J. E. POWERS. 1990. Extension of the ADAPT VPA tuning method designed to facilitate assessment work on tuna and swordfish stocks. *ICCAT, Coll. Vol. Sci. Pap*., **32**: 461–467.

DOUBLEDAY, W. G. 1981. A method for estimating the abundance of survivors of an exploited fish population using commercial catch-at-age and research vessel abundance indices. *Can. Spec. Pub. Fish. and Aquat. Sci*., **58**: 164–178.

GASSOIKOV, P. S. 1990. Practical use of adaptive framework for stock assessment. *NAFO SCR Doc*., No. 48, Serial No. N1765, 11 p.

GAVARIS, S. MS 1988. An adaptive framework for the estimation of population size. *DFO, CAFSAC Res. Doc*., No. 29: 12 p.

GAVARIS, S. and L. VAN EECKHAUTE. MS 1991. Assessment of haddock on eastern Georges Bank. *DFO, CAFSAC Res. Doc*., No. 42: 30 p.

GRAY, D. F. MS 1977. An iterative derivation of fishing and natural mortality from catch and effort data giving measurements of goodness of fit. *ICES C. M. Doc*., No. F:33, 13 p.

GULLAND, J. A. MS 1965. Estimation of mortality rates. Annex to Arctic Fisheries Working Group Report. *ICES C.M., Gadoid Fish. Comm*., Doc. 3, 9 p. (mimeo).

PARKS, W. W. 1976. Cohort analysis, equilibrium yield-per-recruit analysis and predicted effects of minimum size limit regulation in the Atlantic bluefin tuna fisheries system. *Int. Comm. Conserv. Atlantic Tunas*, *Coll. Vol. Sci. Pap*., **5**: 313–331.

PARRACK, M. L. 1986. A method of analyzing catches and abundance indices from the fishery. *Int. Comm. Conserv. Atlantic Tunas*, *Coll. Vol. Sci. Pap*., **24**: 209–221.

VAPNIK, V. 1982. Estimation of discrepancies based on empirical data. Springer. New York.

VAUGHN, D. S., S. C. TURNER and J. M. HOENIG. 1989. Preliminary investigation of the effects of weighting CPUE indices on estimates of fishing mortality from the CAL VPA Program. *Int. Comm. Conserv. Atlantic Tunas*, *Coll. Vol. Sci. Pap*., **30**(2): 283–301.

ADAPT/VPA Input Data
File: gmcod2000_base.inp

```
                                    Second FACT INPUT FILE
1
GoM Cod 2000 Base Run
0.0001 0.053 0.421 1 1 1
2 3 4 5 6
3000 3000 500 500 500
1
1982
0.01*21
FLAT
1*18
1000000
0
1
0
1*19
1,7 1,6 2,6 4,6
0.1667
0.1667
4 5 6
Backward
None or Uniform
 1982
Catch at Age
 30           1380          1633          1143          633           69            230
 0.001        866           2357          1058          638           422           155
 4            446           1240          1500          437           194           136
 0.001        407           1445          991           630           128           136
 0.001        84            2164          813           250           177           95
 2            216           595           1109          277           66            79
 0.001        160           1443          953           406           43            30
 0.001        337           1583          1454          449           81            56
 0.001        205           3425          2064          430           157           99
 0.001        344           934           4161          851           143           79
 0.001        313           530           484           2018          202           84
 0.001        76            1487          641           129           457           36
 0.001        29            1016          1135          288           72            86
 0.001        218           880           1153          194           12            34
 0.001        65            584           1738          347           45            10
 0.001        53            438           435           832           68            8
 0.001        94            390           542           165           193           10
 0.001        0.001         178           192           90            27            36
Weight at Age
 0.9          1.156         1.664         2.764         4.77          6.739         11.33
 0.9          1.164         1.66          2.475         3.778         5.962         9.755
 0.9          1.159         1.67          2.721         3.677         5.898         10.176
 0.9          1.26          1.746         2.84          4.466         5.525         9.721
 0.9          1.304         1.837         2.923         4.619         6.067         10.295
 0.9          1.313         1.684         3.283         4.831         6.824         10.241
 0.9          1.268         1.881         2.426         5.166         6.767         11.233
 0.9          1.247         1.776         2.993         3.864         4.872         12.2
 0.9          1.071         1.692         2.271         4.265         7.645         13.747
 0.9          1.13          1.568         2.512         4.136         7.309         11.449
 0.9          1.533         1.922         2.714         3.061         5             10.614
 0.9          1.293         1.889         2.513         4.356         6.174         11.063
 0.9          1.45          1.943         3.151         3.444         6.132         10.018
 0.9          1.652         1.921         2.775         5.142         8.29          12.969
 0.9          1.687         2.136         2.376         3.648         7.376         11.647
 0.9          1.733         2.233         3.007         3.193         4.649         12.479
 0.9          1.277         2.089         2.979         4.191         4.211         10.262
 0.9          1.277         1.774         2.704         4.02          5.727         7.901
```

Biomass Weights

0.791	0.965	1.364	2.364	4.267	5.67	11.33
0.793	1.024	1.385	2.029	3.231	5.333	9.755
0.761	1.021	1.394	2.125	3.017	4.72	10.176
0.748	1.065	1.423	2.178	3.486	4.507	9.721
0.745	1.083	1.521	2.259	3.622	5.205	10.295
0.758	1.087	1.482	2.456	3.758	5.614	10.241
0.765	1.068	1.572	2.021	4.118	5.718	11.233
0.825	1.059	1.501	2.373	3.062	5.017	12.2
0.803	0.982	1.453	2.008	3.573	5.435	13.747
0.69	1.008	1.296	2.062	3.065	5.583	11.449
0.751	1.175	1.474	2.063	2.773	4.548	10.614
0.709	1.079	1.702	2.198	3.438	4.347	11.063
0.664	1.142	1.585	2.44	2.942	5.168	10.018
0.657	1.219	1.669	2.322	4.025	5.343	12.969
0.649	1.232	1.878	2.136	3.182	6.159	11.647
0.756	1.249	1.941	2.534	2.754	4.118	12.479
0.756	1.072	1.903	2.579	3.55	3.667	10.262
0.756	1.072	1.505	2.377	3.461	4.899	7.901
0.741	1.072	1.521	2.091	3.076	4.67	7.901

SSB Weights

0.791	0.965	1.364	2.364	4.267	5.67	11.33
0.793	1.024	1.385	2.029	3.231	5.333	9.755
0.761	1.021	1.394	2.125	3.017	4.72	10.176
0.748	1.065	1.423	2.178	3.486	4.507	9.721
0.745	1.083	1.521	2.259	3.622	5.205	10.295
0.758	1.087	1.482	2.456	3.758	5.614	10.241
0.765	1.068	1.572	2.021	4.118	5.718	11.233
0.825	1.059	1.501	2.373	3.062	5.017	12.2
0.803	0.982	1.453	2.008	3.573	5.435	13.747
0.69	1.008	1.296	2.062	3.065	5.583	11.449
0.751	1.175	1.474	2.063	2.773	4.548	10.614
0.709	1.079	1.702	2.198	3.438	4.347	11.063
0.664	1.142	1.585	2.44	2.942	5.168	10.018
0.657	1.219	1.669	2.322	4.025	5.343	12.969
0.649	1.232	1.878	2.136	3.182	6.159	11.647
0.756	1.249	1.941	2.534	2.754	4.118	12.479
0.756	1.072	1.903	2.579	3.55	3.667	10.262
0.756	1.072	1.505	2.377	3.461	4.899	7.901
0.741	1.072	1.521	2.091	3.076	4.67	7.901

Indices

WHSpr	WHSpr	WHSpr	WHSpr	WHSpr	WHAut	WHAut	WHAut	WHAut	WHAut
2	3	4	5	6	2	3	4	5	6
1-Jan	1-Jan	1-Jan	1-Jan	1-Jan	1-Jan	1-Jan	1-Jan	1-Jan	1-Jan
number	number	number	number	number	number	number	number	number	number
1.019	0.516	0.694	0.864	0.117	0.619	0.382	0.549	0.474	0.089
0.978	0.833	0.641	0.357	0.181	0.7	3.142	2.473	1.167	0.248
1.033	1.147	0.741	0.19	0.053	1.66	0.977	0.852	0.139	0.264
0.238	0.622	0.665	0.677	0.095	0.384	0.421	0.565	0.399	0.22
0.33	0.647	0.387	0.074	0.046	0.378	0.91	0.763	0.209	0.218
0.638	0.486	0.3	0.128	0.011	0.301	0.49	0.654	0.333	0.086
1.053	0.633	0.355	0.217	0.087	0.599	1.324	0.6	0.257	0.061
0.649	0.79	0.632	0.09	0.077	1.951	2.245	0.96	0.528	0.11
0.19	1.327	0.627	0.167	0.032	0.416	2.391	1.356	0.294	0.174
0.209	0.355	1.477	0.268	0.024	0.029	0.367	1.643	0.623	0.278
0.23	0.24	0.28	1.31	0.22	0.142	0.142	0.221	0.632	0.079
0.5	0.8	0.33	0.09	0.48	0.29	0.45	0.14	0.04	0.33
0.316	0.387	0.213	0.095	0.047	0.198	0.569	0.363	0.032	0
0.18	1.12	0.37	0.15	0.03	0.21	0.88	0.83	0.09	0.05
0.02	0.59	1.33	0.4	0.06	0.07	0.28	1.23	0.33	0.08
0.132	0.399	0.264	0.876	0.242	0.12	0.38	0.19	0.54	0.06
0.224	0.33	0.517	0.142	0.421	0.297	0.086	0.16	0.182	0.149
0.344	0.713	0.344	0.315	0.134	0.097	0.32	0.115	0.192	0.039
0.725	0.438	0.457	0.107	0.101	0.431	0.363	0.59	0.243	0.132

Indices

MASpr	MASpr	MASpr	MAAut	MAAut	MAAut	CM_CPE	CM_CPE	CM_CPE	CM_CPE	CM_CPE
2	3	4	1	2	3	2	3	4	5	6
1-Jan	1-Jan	1-Jan	1-Jan	1-Jan	1-Jan	mean	mean	mean	mean	mean
number	number	number	number	number	number	number	number	number	number	number
7.06	3.418	1.147	2.018	5.652	7.29	0.07432	0.07382	0.04502	0.02168	0.00265
18.572	5.331	0.501	4.667	2.346	1.005	0.04767	0.10991	0.04215	0.02094	0.01231
5.408	2.271	0.865	1.308	0.651	0.1	0.03313	0.04478	0.04418	0.01179	0.00552
3.822	2.794	0.692	12.296	0.344	0.022	0.01372	0.04226	0.02894	0.01793	0.00361
3.222	0.887	0.426	2.832	0.419	0.018	0.00409	0.06877	0.02257	0.00661	0.00428
6.997	2.268	0.257	2.478	1.15	0.833	0.00738	0.01861	0.02599	0.00572	0.00177
11.356	2.511	1.37	389.584	2.386	0.02	0.01455	0.0492	0.02418	0.00932	0.00147
25.26	6.58	0.458	4.571	20.49	0.679	0.01698	0.0637	0.03966	0.01059	0.00231
6.89	17.77	2.64	2.971	2.7	0.35	0.01098	0.15953	0.07816	0.01219	0.0051
3.56	2.54	5.03	9.37	9.13	1.74	0.01943	0.04044	0.13551	0.0217	0.00394
6.35	3.58	0.65	4.65	4.2	0.81	0.01494	0.01733	0.0138	0.05147	0.00519
7.76	3.6	1.45	24.3	2.01	0.11	0.00267	0.04997	0.02324	0.00407	0.01395
5.67	2.46	0.52	49.92	3.32	0.61	0	0	0	0	0
1.36	3.89	1.2	33.49	14.13	6.37	0	0	0	0	0
0.97	2.11	0.81	2.56	0.64	0.54	0	0	0	0	0
1	1.34	0.2	7.59	0.15	0.02	0	0	0	0	0
1.17	0.89	1.17	2.02	0.02	0	0	0	0	0	0
3.55	3.31	1.32	2.7	1.05	0.01	0	0	0	0	0
7.34	4.03	2.3	6.63	0.84	0.14	0	0	0	0	0

Maturity Matrix

0.07	0.26	0.61	0.88	0.97	1	1
0.07	0.26	0.61	0.88	0.97	1	1
0.07	0.26	0.61	0.88	0.97	1	1
0.04	0.48	0.95	1	1	1	1
0.04	0.48	0.95	1	1	1	1
0.04	0.48	0.95	1	1	1	1
0.04	0.48	0.95	1	1	1	1
0.04	0.48	0.95	1	1	1	1
0.11	0.28	0.56	0.81	0.93	0.98	1
0.11	0.28	0.56	0.81	0.93	0.98	1
0.11	0.28	0.56	0.81	0.93	0.98	1
0.11	0.28	0.56	0.81	0.93	0.98	1
0.04	0.38	0.89	0.99	1	1	1
0.04	0.38	0.89	0.99	1	1	1
0.04	0.38	0.89	0.99	1	1	1
0.04	0.38	0.89	0.99	1	1	1
0.04	0.38	0.89	0.99	1	1	1
0.04	0.38	0.89	0.99	1	1	1

M Matrix

0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2

ADAPT/VPA Output
File: gmcod2000_base.2

```
Fisheries Assessment Toolbox GoM Cod 2000 Base Run Run Number 1 8/25/20009:15:13 AM

FACT Version 1.3.6
GoM Cod 2000 Base Run  1982 - 2000
Input Parameters and Options Selected
---------------------------------------
Natural mortality is a matrix below
Oldest age (not in the plus group) is 6
For all years prior to the terminal year (18), backcalculated
stock sizes for the following ages used to estimate
total mortality (Z) for age  6 : 4 5 6
This method for estimating F on the oldest age is generally used when a
flat-topped partial recruitment curve is thought to be characteristic of the stock.
F for age 7 + is then calculated from the following
ratios of F[age 7 +] to F[age 6 ]
          1982              1
          1983              1
          1984              1
          1985              1
          1986              1
          1987              1
          1988              1
          1989              1
          1990              1
          1991              1
          1992              1
          1993              1
          1994              1
          1995              1
          1996              1
          1997              1
          1998              1
          1999              1
Stock size of the 7 + group is then calculated using
the following method:  CATCH EQUATION
 Partial recruitment estimate for 2000
 1            0.0001
 2            0.053
 3            0.421
 4            1
 5            1
 6            1
Objective function is Sum w*(LOG(OBS)-LOG(PRED))**2
 Indices normalized (by dividing by mean observed value)
before tuning to VPA stock sizes
Down-weighting is None or Uniform
Biomass estimates (other than SSB) reflect mean stock sizes.
SSB calculated as in the NEFSC projection program
(see note below SSB table for description of the algorithm).
Initial estimates of parameters for the Marquardt algorithm
and lower and upper bounds on the parameter estimates:
Par.          Initial Est   Lower Bnd     Upper Bnd
N  2          3.00E+03      0.00E+00      1.00E+06
N  3          3.00E+03      0.00E+00      1.00E+06
N  4          5.00E+02      0.00E+00      1.00E+06
N  5          5.00E+02      0.00E+00      1.00E+06
N  6          5.00E+02      0.00E+00      1.00E+06
q WHSpr2      1.00E-02      0.00E+00      1.00E+00
q WHSpr3      1.00E-02      0.00E+00      1.00E+00
q WHSpr4      1.00E-02      0.00E+00      1.00E+00
q WHSpr5      1.00E-02      0.00E+00      1.00E+00
q WHSpr6      1.00E-02      0.00E+00      1.00E+00
q WHAut2      1.00E-02      0.00E+00      1.00E+00
q WHAut3      1.00E-02      0.00E+00      1.00E+00
q WHAut4      1.00E-02      0.00E+00      1.00E+00
q WHAut5      1.00E-02      0.00E+00      1.00E+00
q WHAut6      1.00E-02      0.00E+00      1.00E+00
q MASpr2      1.00E-02      0.00E+00      1.00E+00
q MASpr3      1.00E-02      0.00E+00      1.00E+00
q MASpr4      1.00E-02      0.00E+00      1.00E+00
q MAAut1      1.00E-02      0.00E+00      1.00E+00
q MAAut2      1.00E-02      0.00E+00      1.00E+00
q MAAut3      1.00E-02      0.00E+00      1.00E+00
```

```
q CM_CPE2     1.00E-02      0.00E+00      1.00E+00
q CM_CPE3     1.00E-02      0.00E+00      1.00E+00
q CM_CPE4     1.00E-02      0.00E+00      1.00E+00
q CM_CPE5     1.00E-02      0.00E+00      1.00E+00
q CM_CPE6     1.00E-02      0.00E+00      1.00E+00
The following indices of abundance are available
 1            WHSpr2
 2            WHSpr3
 3            WHSpr4
 4            WHSpr5
 5            WHSpr6
 6            WHAut2
 7            WHAut3
 8            WHAut4
 9            WHAut5
 10           WHAut6
 11           MASpr2
 12           MASpr3
 13           MASpr4
 14           MAAut1
 15           MAAut2
 16           MAAut3
 17           CM_CPE2
 18           CM_CPE3
 19           CM_CPE4
 20           CM_CPE5
 21           CM_CPE6
 The Indices that will be used in this run are:
 1            WHSpr2
 2            WHSpr3
 3            WHSpr4
 4            WHSpr5
 5            WHSpr6
 6            WHAut2
 7            WHAut3
 8            WHAut4
 9            WHAut5
 10           WHAut6
 11           MASpr2
 12           MASpr3
 13           MASpr4
 14           MAAut1
 15           MAAut2
 16           MAAut3
 17           CM_CPE2
 18           CM_CPE3
 19           CM_CPE4
 20           CM_CPE5
 21           CM_CPE6
Obs Indices (before transformation) by index and year; with Index means
```

	1982	1983	1984	1985	1986	1987	1988
WHSpr2	1.02	0.98	1.03	0.24	0.33	0.64	1.05
WHSpr3	0.52	0.83	1.15	0.62	0.65	0.49	0.63
WHSpr4	0.69	0.64	0.74	0.67	0.39	0.30	0.36
WHSpr5	0.86	0.36	0.19	0.68	0.07	0.13	0.22
WHSpr6	0.12	0.18	0.05	0.10	0.05	0.01	0.09
WHAut2	0.62	0.70	1.66	0.38	0.38	0.30	0.60
WHAut3	0.38	3.14	0.98	0.42	0.91	0.49	1.32
WHAut4	0.55	2.47	0.85	0.57	0.76	0.65	0.60
WHAut5	0.47	1.17	0.14	0.40	0.21	0.33	0.26
WHAut6	0.09	0.25	0.26	0.22	0.22	0.09	0.06
MASpr2	7.06	18.57	5.41	3.82	3.22	7.00	11.36
MASpr3	3.42	5.33	2.27	2.79	0.89	2.27	2.51
MASpr4	1.15	0.50	0.87	0.69	0.43	0.26	1.37
MAAut1	2.02	4.67	1.31	12.30	2.83	2.48	389.58
MAAut2	5.65	2.35	0.65	0.34	0.42	1.15	2.39
MAAut3	7.29	1.01	0.10	0.02	0.02	0.83	0.02
CM_CPE2	0.07	0.05	0.03	0.01	0.00	0.01	0.01
CM_CPE3	0.07	0.11	0.04	0.04	0.07	0.02	0.05
CM_CPE4	0.05	0.04	0.04	0.03	0.02	0.03	0.02
CM_CPE5	0.02	0.02	0.01	0.02	0.01	0.01	0.01

CM_CPE6	0.00	0.01	0.01	0.00	0.00	0.00	0.00

	1989	1990	1991	1992	1993	1994	1995
WHSpr2	0.65	0.19	0.21	0.23	0.50	0.32	0.18
WHSpr3	0.79	1.33	0.36	0.24	0.80	0.39	1.12
WHSpr4	0.63	0.63	1.48	0.28	0.33	0.21	0.37
WHSpr5	0.09	0.17	0.27	1.31	0.09	0.10	0.15
WHSpr6	0.08	0.03	0.02	0.22	0.48	0.05	0.03
WHAut2	1.95	0.42	0.03	0.14	0.29	0.20	0.21
WHAut3	2.25	2.39	0.37	0.14	0.45	0.57	0.88
WHAut4	0.96	1.36	1.64	0.22	0.14	0.36	0.83
WHAut5	0.53	0.29	0.62	0.63	0.04	0.03	0.09
WHAut6	0.11	0.17	0.28	0.08	0.33	0.00	0.05
MASpr2	25.26	6.89	3.56	6.35	7.76	5.67	1.36
MASpr3	6.58	17.77	2.54	3.58	3.60	2.46	3.89
MASpr4	0.46	2.64	5.03	0.65	1.45	0.52	1.20
MAAut1	4.57	2.97	9.37	4.65	24.30	49.92	33.49
MAAut2	20.49	2.70	9.13	4.20	2.01	3.32	14.13
MAAut3	0.68	0.35	1.74	0.81	0.11	0.61	6.37
CM_CPE2	0.02	0.01	0.02	0.01	0.00	0.00	0.00
CM_CPE3	0.06	0.16	0.04	0.02	0.05	0.00	0.00
CM_CPE4	0.04	0.08	0.14	0.01	0.02	0.00	0.00
CM_CPE5	0.01	0.01	0.02	0.05	0.00	0.00	0.00
CM_CPE6	0.00	0.01	0.00	0.01	0.01	0.00	0.00

	1996	1997	1998	1999	2000	Average
WHSpr2	0.02	0.13	0.22	0.34	0.73	0.474
WHSpr3	0.59	0.40	0.33	0.71	0.44	0.651
WHSpr4	1.33	0.26	0.52	0.34	0.46	0.559
WHSpr5	0.40	0.88	0.14	0.32	0.11	0.343
WHSpr6	0.06	0.24	0.42	0.13	0.10	0.129
WHAut2	0.07	0.12	0.30	0.10	0.43	0.468
WHAut3	0.28	0.38	0.09	0.32	0.36	0.848
WHAut4	1.23	0.19	0.16	0.12	0.59	0.750
WHAut5	0.33	0.54	0.18	0.19	0.24	0.353
WHAut6	0.08	0.06	0.15	0.04	0.13	0.148
MASpr2	0.97	1.00	1.17	3.55	7.34	6.701
MASpr3	2.11	1.34	0.89	3.31	4.03	3.767
MASpr4	0.81	0.20	1.17	1.32	2.30	1.211
MAAut1	2.56	7.59	2.02	2.70	6.63	29.787
MAAut2	0.64	0.15	0.02	1.05	0.84	3.770
MAAut3	0.54	0.02	0.00	0.01	0.14	1.148
CM_CPE2	0.00	0.00	0.00	0.00	0.00	0.022
CM_CPE3	0.00	0.00	0.00	0.00	0.00	0.062
CM_CPE4	0.00	0.00	0.00	0.00	0.00	0.044
CM_CPE5	0.00	0.00	0.00	0.00	0.00	0.016
CM_CPE6	0.00	0.00	0.00	0.00	0.00	0.005

Catch at age (thousands) - D:\NAFO\SeptWS\gmcod\gmcod2000_base.2

	1982	1983	1984	1985	1986	1987	1988
1	30	00	04	00	00	02	00
2	1380	866	446	407	84	216	160
3	1633	2357	1240	1445	2164	595	1443
4	1143	1058	1500	991	813	1109	953
5	633	638	437	630	250	277	406
6	69	422	194	128	177	66	43
7	230	155	136	136	95	79	30
1+	5118	5496	3957	3737	3583	2344	3035

	1989	1990	1991	1992	1993	1994	1995
1	00	00	00	00	00	00	00
2	337	205	344	313	76	29	218
3	1583	3425	934	530	1487	1016	880
4	1454	2064	4161	484	641	1135	1153
5	449	430	851	2018	129	288	194
6	81	157	143	202	457	72	12
7	56	99	79	84	36	86	34
1+	3960	6380	6512	3631	2826	2626	2491

	1996	1997	1998	1999
1	00	00	00	00
2	65	53	94	00
3	584	438	390	178
4	1738	435	542	192
5	347	832	165	90
6	45	68	193	27
7	10	08	10	36
1+	2789	1834	1394	523

CAA Summary for ages 4 - 7

1982	1983	1984	1985	1986	1987	1988
2075	2273	2267	1885	1335	1531	1432

1989	1990	1991	1992	1993	1994	1995
2040	2750	5234	2788	1263	1581	1393

1996	1997	1998	1999
2140	1343	910	345

Weight at age (mid year) in kg - D:\NAFO\SeptWS\gmcod\gmcod2000_base.2

	1982	1983	1984	1985	1986	1987	1988
1	0.900	0.900	0.900	0.900	0.900	0.900	0.900
2	1.156	1.164	1.159	1.260	1.304	1.313	1.268
3	1.664	1.660	1.670	1.746	1.837	1.684	1.881
4	2.764	2.475	2.721	2.840	2.923	3.283	2.426
5	4.770	3.778	3.677	4.466	4.619	4.831	5.166
6	6.739	5.962	5.898	5.525	6.067	6.824	6.767
7	11.330	9.755	10.176	9.721	10.295	10.241	11.233

	1989	1990	1991	1992	1993	1994	1995
1	0.900	0.900	0.900	0.900	0.900	0.900	0.900
2	1.247	1.071	1.130	1.533	1.293	1.450	1.652
3	1.776	1.692	1.568	1.922	1.889	1.943	1.921
4	2.993	2.271	2.512	2.714	2.513	3.151	2.775
5	3.864	4.265	4.136	3.061	4.356	3.444	5.142
6	4.872	7.645	7.309	5.000	6.174	6.132	8.290
7	12.200	13.747	11.449	10.614	11.063	10.018	12.969

	1996	1997	1998	1999
1	0.900	0.900	0.900	0.900
2	1.687	1.733	1.277	1.277
3	2.136	2.233	2.089	1.774
4	2.376	3.007	2.979	2.704
5	3.648	3.193	4.191	4.020
6	7.376	4.649	4.211	5.727
7	11.647	12.479	10.262	7.901

January 1 Biomass Weights - D:\NAFO\SeptWS\gmcod\gmcod2000_base.2

	1982	1983	1984	1985	1986	1987	1988
1	0.791	0.793	0.761	0.748	0.745	0.758	0.765
2	0.965	1.024	1.021	1.065	1.083	1.087	1.068
3	1.364	1.385	1.394	1.423	1.521	1.482	1.572
4	2.364	2.029	2.125	2.178	2.259	2.456	2.021
5	4.267	3.231	3.017	3.486	3.622	3.758	4.118
6	5.670	5.333	4.720	4.507	5.205	5.614	5.718
7	11.330	9.755	10.176	9.721	10.295	10.241	11.233

	1989	1990	1991	1992	1993	1994	1995
1	0.825	0.803	0.690	0.751	0.709	0.664	0.657
2	1.059	0.982	1.008	1.175	1.079	1.142	1.219
3	1.501	1.453	1.296	1.474	1.702	1.585	1.669
4	2.373	2.008	2.062	2.063	2.198	2.440	2.322
5	3.062	3.573	3.065	2.773	3.438	2.942	4.025
6	5.017	5.435	5.583	4.548	4.347	5.168	5.343
7	12.200	13.747	11.449	10.614	11.063	10.018	12.969

	1996	1997	1998	1999
1	0.649	0.756	0.756	0.756
2	1.232	1.249	1.072	1.072
3	1.878	1.941	1.903	1.505
4	2.136	2.534	2.579	2.377
5	3.182	2.754	3.550	3.461
6	6.159	4.118	3.667	4.899
7	11.647	12.479	10.262	7.901

SSB Weights - D:\NAFO\SeptWS\gmcod\gmcod2000_base.2

	1982	1983	1984	1985	1986	1987	1988
1	0.791	0.793	0.761	0.748	0.745	0.758	0.765
2	0.965	1.024	1.021	1.065	1.083	1.087	1.068
3	1.364	1.385	1.394	1.423	1.521	1.482	1.572
4	2.364	2.029	2.125	2.178	2.259	2.456	2.021
5	4.267	3.231	3.017	3.486	3.622	3.758	4.118
6	5.670	5.333	4.720	4.507	5.205	5.614	5.718
7	11.330	9.755	10.176	9.721	10.295	10.241	11.233

	1989	1990	1991	1992	1993	1994	1995
1	0.825	0.803	0.690	0.751	0.709	0.664	0.657
2	1.059	0.982	1.008	1.175	1.079	1.142	1.219
3	1.501	1.453	1.296	1.474	1.702	1.585	1.669
4	2.373	2.008	2.062	2.063	2.198	2.440	2.322
5	3.062	3.573	3.065	2.773	3.438	2.942	4.025
6	5.017	5.435	5.583	4.548	4.347	5.168	5.343
7	12.200	13.747	11.449	10.614	11.063	10.018	12.969

	1996	1997	1998	1999
1	0.649	0.756	0.756	0.756
2	1.232	1.249	1.072	1.072
3	1.878	1.941	1.903	1.505
4	2.136	2.534	2.579	2.377
5	3.182	2.754	3.550	3.461
6	6.159	4.118	3.667	4.899
7	11.647	12.479	10.262	7.901

Computed (Rivard)from midyear weights: Jan 1 Weights - D:\NAFO\SeptWS\gmcod\gmcod2000_base.2

	1982	1983	1984	1985	1986	1987	1988
1	0.791	0.793	0.761	0.748	0.745	0.758	0.765
2	0.965	1.024	1.021	1.065	1.083	1.087	1.068
3	1.364	1.385	1.394	1.423	1.521	1.482	1.572
4	2.364	2.029	2.125	2.178	2.259	2.456	2.021
5	4.267	3.231	3.017	3.486	3.622	3.758	4.118
6	5.670	5.333	4.720	4.507	5.205	5.614	5.718
7	11.330	9.755	10.176	9.721	10.295	10.241	11.233

	1989	1990	1991	1992	1993	1994	1995
1	0.825	0.803	0.690	0.751	0.709	0.664	0.657
2	1.059	0.982	1.008	1.175	1.079	1.142	1.219
3	1.501	1.453	1.296	1.474	1.702	1.585	1.669
4	2.373	2.008	2.062	2.063	2.198	2.440	2.322
5	3.062	3.573	3.065	2.773	3.438	2.942	4.025
6	5.017	5.435	5.583	4.548	4.347	5.168	5.343
7	12.200	13.747	11.449	10.614	11.063	10.018	12.969

	1996	1997	1998	1999	2000
1	0.649	0.756	0.756	0.756	0.741
2	1.232	1.249	1.072	1.072	1.072
3	1.878	1.941	1.903	1.505	1.521
4	2.136	2.534	2.579	2.377	2.091
5	3.182	2.754	3.550	3.461	3.076
6	6.159	4.118	3.667	4.899	4.670
7	11.647	12.479	10.262	7.901	7.901

Percent Mature (females)- D:\NAFO\SeptWS\gmcod\gmcod2000_base.2

	1982	1983	1984	1985	1986	1987	1988
1	07	07	07	04	04	04	04
2	26	26	26	48	48	48	48
3	61	61	61	95	95	95	95
4	88	88	88	100	100	100	100
5	97	97	97	100	100	100	100
6	100	100	100	100	100	100	100
7	100	100	100	100	100	100	100

	1989	1990	1991	1992	1993	1994	1995
1	04	11	11	11	11	04	04
2	48	28	28	28	28	38	38
3	95	56	56	56	56	89	89
4	100	81	81	81	81	99	99
5	100	93	93	93	93	100	100
6	100	98	98	98	98	100	100
7	100	100	100	100	100	100	100

	1996	1997	1998	1999
1	04	04	04	04
2	38	38	38	38
3	89	89	89	89
4	99	99	99	99
5	100	100	100	100
6	100	100	100	100
7	100	100	100	100

Natural Mortality D:\NAFO\SeptWS\gmcod\gmcod2000_base.2

	1982	1983	1984	1985	1986	1987	1988
1	.200	.200	.200	.200	.200	.200	.200
2	.200	.200	.200	.200	.200	.200	.200
3	.200	.200	.200	.200	.200	.200	.200
4	.200	.200	.200	.200	.200	.200	.200
5	.200	.200	.200	.200	.200	.200	.200
6	.200	.200	.200	.200	.200	.200	.200
7	.200	.200	.200	.200	.200	.200	.200

	1989	1990	1991	1992	1993	1994	1995
1	.200	.200	.200	.200	.200	.200	.200
2	.200	.200	.200	.200	.200	.200	.200
3	.200	.200	.200	.200	.200	.200	.200
4	.200	.200	.200	.200	.200	.200	.200
5	.200	.200	.200	.200	.200	.200	.200
6	.200	.200	.200	.200	.200	.200	.200
7	.200	.200	.200	.200	.200	.200	.200

	1996	1997	1998	1999
1	.200	.200	.200	.200
2	.200	.200	.200	.200
3	.200	.200	.200	.200
4	.200	.200	.200	.200
5	.200	.200	.200	.200
6	.200	.200	.200	.200
7	.200	.200	.200	.200

Sex Ratio (Percent Female) - D:\NAFO\SeptWS\gmcod\gmcod2000_base.2

	1982	1983	1984	1985	1986	1987	1988
1	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2	0.5	0.5	0.5	0.5	0.5	0.5	0.5
3	0.5	0.5	0.5	0.5	0.5	0.5	0.5
4	0.5	0.5	0.5	0.5	0.5	0.5	0.5
5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
6	0.5	0.5	0.5	0.5	0.5	0.5	0.5
7	0.5	0.5	0.5	0.5	0.5	0.5	0.5

	1989	1990	1991	1992	1993	1994	1995
1	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2	0.5	0.5	0.5	0.5	0.5	0.5	0.5
3	0.5	0.5	0.5	0.5	0.5	0.5	0.5
4	0.5	0.5	0.5	0.5	0.5	0.5	0.5
5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
6	0.5	0.5	0.5	0.5	0.5	0.5	0.5
7	0.5	0.5	0.5	0.5	0.5	0.5	0.5

	1996	1997	1998	1999
1	0.5	0.5	0.5	0.5
2	0.5	0.5	0.5	0.5
3	0.5	0.5	0.5	0.5
4	0.5	0.5	0.5	0.5
5	0.5	0.5	0.5	0.5
6	0.5	0.5	0.5	0.5
7	0.5	0.5	0.5	0.5

pF is 0.1667
pM is 0.1667

```
Residual Sum of Squares from Marquardt Algorithm
Number 1
RSS            4757.4636160016
Lambda        1.00E-02

Number 2
RSS            3659.71341037588
Lambda        1.00E-03

Number 3
RSS            2871.24006283006
Lambda        1.00E-01

Number 4
RSS            2338.80230082771
Lambda        1.00E-02

Number 5
RSS            2110.59689632427
Lambda        1.00E+00

Number 6
RSS            1700.06987407547
Lambda        1.00E-01

Number 7
RSS            1546.94190193848
Lambda        1.00E+01

Number 8
RSS            1278.82209227215
Lambda        1.00E+00

Number 9
RSS            1173.18264217126
Lambda        1.00E+02

Number 10
RSS            992.137735859582
Lambda        1.00E+01

Number 11
RSS            917.73038579856
Lambda        1.00E+00

Number 12
RSS            792.489781270954
Lambda        1.00E+02

Number 13
RSS            286.055030653559
Lambda        1.00E+01

Number 14
RSS            246.596438368479
Lambda        1.00E+00

Number 15
RSS            242.849135995446
Lambda        1.00E+02

Number 16
RSS            242.798374032756
Lambda        1.00E+01

Number 17
RSS            242.798341477608
Lambda        1.00E+00

Number 18
RSS            242.798341241649
Lambda        1.00E+02
```

```
RESULTS
-------
Approximate Statistics Assuming Linearity Near Solution
Sum of Squares:  242.798341241649
Mean Square Residuals: 0.72261

                   PAR. EST. STD. ERR. T-STATISTIC
                                                 C.V.
N  2               4.39E+03  1.73E+03  2.54E+00  0.39
N  3               2.24E+03  6.58E+02  3.41E+00  0.29
N  4               1.16E+03  3.31E+02  3.51E+00  0.28
N  5               4.55E+02  1.65E+02  2.75E+00  0.36
N  6               3.03E+02  1.23E+02  2.46E+00  0.41
q WHSpr2           1.67E-04  3.31E-05  5.03E+00  0.20
q WHSpr3           2.71E-04  5.36E-05  5.06E+00  0.20
q WHSpr4           4.66E-04  9.21E-05  5.06E+00  0.20
q WHSpr5           9.92E-04  1.97E-04  5.03E+00  0.20
q WHSpr6           3.36E-03  6.72E-04  5.00E+00  0.20
q WHAut2           1.45E-04  2.89E-05  5.03E+00  0.20
q WHAut3           1.99E-04  3.93E-05  5.06E+00  0.20
q WHAut4           3.90E-04  7.71E-05  5.06E+00  0.20
q WHAut5           1.06E-03  2.11E-04  5.03E+00  0.20
q WHAut6           4.12E-03  8.49E-04  4.86E+00  0.21
q MASpr2           1.61E-04  3.19E-05  5.03E+00  0.20
q MASpr3           2.32E-04  4.58E-05  5.06E+00  0.20
q MASpr4           3.94E-04  7.79E-05  5.06E+00  0.20
q MAAut1           4.53E-05  9.25E-06  4.89E+00  0.20
q MAAut2           8.89E-05  1.77E-05  5.03E+00  0.20
q MAAut3           6.08E-05  1.23E-05  4.93E+00  0.20
q CM_CPE2          1.42E-04  3.51E-05  4.05E+00  0.25
q CM_CPE3          2.75E-04  6.78E-05  4.05E+00  0.25
q CM_CPE4          6.16E-04  1.52E-04  4.05E+00  0.25
q CM_CPE5          1.64E-03  4.04E-04  4.05E+00  0.25
q CM_CPE6          5.21E-03  1.28E-03  4.05E+00  0.25

Catchability Estimates in Original Units

              Estimate      Std.Err.      C.V.
              --------      --------      ------
q WHSpr2      7.89E-05      1.57E-05      0.20
q WHSpr3      1.77E-04      3.49E-05      0.20
q WHSpr4      2.61E-04      5.15E-05      0.20
q WHSpr5      3.40E-04      6.77E-05      0.20
q WHSpr6      4.34E-04      8.69E-05      0.20
q WHAut2      6.80E-05      1.35E-05      0.20
q WHAut3      1.69E-04      3.34E-05      0.20
q WHAut4      2.93E-04      5.78E-05      0.20
q WHAut5      3.75E-04      7.46E-05      0.20
q WHAut6      6.11E-04      1.26E-04      0.21
q MASpr2      1.08E-03      2.14E-04      0.20
q MASpr3      8.74E-04      1.73E-04      0.20
q MASpr4      4.77E-04      9.43E-05      0.20
q MAAut1      1.35E-03      2.76E-04      0.20
q MAAut2      3.35E-04      6.67E-05      0.20
q MAAut3      6.98E-05      1.41E-05      0.20
q CM_CPE2     3.08E-06      7.60E-07      0.25
q CM_CPE3     1.69E-05      4.17E-06      0.25
q CM_CPE4     2.69E-05      6.63E-06      0.25
q CM_CPE5     2.65E-05      6.53E-06      0.25
q CM_CPE6     2.69E-05      6.64E-06      0.25
```

CORRELATION BETWEEN PARAMETERS ESTIMATED

1	0.05	0.04	0.03	0.02	-0.11	-0.01	-0.01	-0.01	-0.01	-0.11	-0.01	-0.01	-0.01	-0.01	-0.11	-0.01	-0.01	-0.12	-0.11	-0.01	0	0	0	0	0
0.05	1	0.05	0.04	0.03	-0.09	-0.09	-0.01	-0.01	-0.01	-0.09	-0.09	-0.01	-0.01	-0.01	-0.09	-0.09	-0.01	-0.09	-0.09	-0.09	0	0	0	0	0
0.04	0.05	1	0.05	0.04	-0.08	-0.07	-0.08	-0.01	-0.01	-0.08	-0.07	-0.08	-0.01	-0.01	-0.08	-0.07	-0.08	-0.08	-0.08	-0.07	0	0	0	0	0
0.03	0.04	0.05	1	0	-0.06	-0.06	-0.08	-0.12	-0.05	-0.06	-0.06	-0.08	-0.12	-0.05	-0.06	-0.06	-0.08	-0.06	-0.06	-0.01	0	0	0	0	0
0.02	0.03	0.04	0	1	-0.05	-0.05	-0.06	-0.12	-0.2	-0.05	-0.05	-0.06	-0.12	-0.2	-0.05	-0.05	-0.06	-0.05	-0.05	-0.05	0	0	0	0	0
-0.11	-0.09	-0.08	-0.06	-0.05	1	0.02	0.01	0.01	0.01	0.03	0.02	0.01	0.01	0.01	0.03	0.02	0.01	0.03	0.03	0.01	0	0	0	0	0
-0.01	-0.09	-0.07	-0.06	-0.05	0.02	1	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.02	0.02	0.01	0.02	0.02	0.01	0	0	0	0	0
-0.01	-0.01	-0.08	-0.08	-0.06	0.01	0.01	1	0.02	0.02	0.01	0.01	0.02	0.02	0.02	0.01	0.01	0.02	0.01	0.01	0.01	0	0	0	0	0
-0.01	-0.01	-0.01	-0.12	-0.12	0.01	0.01	0.02	1	0.03	0.01	0.01	0.02	0.03	0.03	0.01	0.01	0.02	0.01	0.01	0.01	0	0	0	0	0
-0.01	-0.01	-0.01	-0.05	-0.2	0.01	0.01	0.02	0.03	1	0.01	0.01	0.02	0.03	0.04	0.01	0.01	0.02	0.01	0.01	0.01	0	0	0	0	0
-0.11	-0.09	-0.08	-0.06	-0.05	0.03	0.02	0.01	0.01	0.01	1	0.02	0.01	0.01	0.01	0.03	0.02	0.01	0.03	0.03	0.01	0	0	0	0	0
-0.01	-0.09	-0.07	-0.06	-0.05	0.02	0.02	0.01	0.01	0.01	0.02	1	0.01	0.01	0.01	0.02	0.02	0.01	0.02	0.02	0.01	0	0	0	0	0
-0.01	-0.01	-0.08	-0.08	-0.06	0.01	0.01	0.02	0.02	0.02	0.01	0.01	1	0.02	0.02	0.01	0.01	0.02	0.01	0.01	0.01	0	0	0	0	0
-0.01	-0.01	-0.01	-0.12	-0.12	0.01	0.01	0.02	0.03	0.03	0.01	0.01	0.02	1	0.03	0.01	0.01	0.02	0.01	0.01	0.01	0	0	0	0	0
-0.01	-0.01	-0.01	-0.05	-0.2	0.01	0.01	0.02	0.03	0.04	0.01	0.01	0.02	0.03	1	0.01	0.01	0.02	0.01	0.01	0.01	0	0	0	0	0
-0.11	-0.09	-0.08	-0.06	-0.05	0.03	0.02	0.01	0.01	0.01	0.03	0.02	0.01	0.01	0.01	1	0.02	0.01	0.03	0.03	0.01	0	0	0	0	0
-0.01	-0.09	-0.07	-0.06	-0.05	0.02	0.02	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.02	1	0.01	0.02	0.02	0.01	0	0	0	0	0
-0.01	-0.01	-0.08	-0.08	-0.06	0.01	0.01	0.02	0.02	0.02	0.01	0.01	0.02	0.02	0.02	0.01	0.01	1	0.01	0.01	0.01	0	0	0	0	0
-0.12	-0.09	-0.08	-0.06	-0.05	0.03	0.02	0.01	0.01	0.01	0.03	0.02	0.01	0.01	0.01	0.03	0.02	0.01	1	0.03	0.02	0	0	0	0	0
-0.11	-0.09	-0.08	-0.06	-0.05	0.03	0.02	0.01	0.01	0.01	0.03	0.02	0.01	0.01	0.01	0.03	0.02	0.01	0.03	1	0.01	0	0	0	0	0
-0.01	-0.09	-0.07	-0.01	-0.05	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	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	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	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	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	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	1

```
CORRELATION BETWEEN PARAMETERS ESTIMATED (SYMBOLIC FORM)
N 2
                          *  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .
N 3
                          .  *  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .
N 4
                          .  .  *  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .
N 5
                          .  .  .  *  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .
N 6
                          .  .  .  .  *  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .
WHSpr
                          .  .  .  .  .  *  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .
WHSpr
                          .  .  .  .  .  .  *  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .
WHSpr
                          .  .  .  .  .  .  .  *  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .
WHSpr
                          .  .  .  .  .  .  .  .  *  .  .  .  .  .  .  .  .  .  .  .  .  .  .
WHSpr
                          .  .  .  .  .  .  .  .  .  *  .  .  .  .  .  .  .  .  .  .  .  .  .
WHAut
                          .  .  .  .  .  .  .  .  .  .  *  .  .  .  .  .  .  .  .  .  .  .  .
WHAut
                          .  .  .  .  .  .  .  .  .  .  .  *  .  .  .  .  .  .  .  .  .  .  .
WHAut
                          .  .  .  .  .  .  .  .  .  .  .  .  *  .  .  .  .  .  .  .  .  .  .
WHAut
                          .  .  .  .  .  .  .  .  .  .  .  .  .  *  .  .  .  .  .  .  .  .  .
WHAut
                          .  .  .  .  .  .  .  .  .  .  .  .  .  .  *  .  .  .  .  .  .  .  .
MASpr
                          .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  *  .  .  .  .  .  .  .
MASpr
                          .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  *  .  .  .  .  .  .
MASpr
                          .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  *  .  .  .  .  .
MAAut
                          .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  *  .  .  .  .
MAAut
                          .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  *  .  .  .
MAAut
                          .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  *  .  .
CM_CPE
                          .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  *  .
CM_CPE
                          .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  *
CM_CPE
                          .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .
CM_CPE
                          .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .
CM_CPE
                          .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .

SYMBOLS:  = LARGE NEGATIVE CORRELATION    whenever -1 <= R <  -L
          - MODERATE NEGATIVE CORRELATION whenever -L <= R <  -M
          . SMALL CORRELATION             whenever -M <= R <= +M
          + MODERATE POSITIVE CORRELATION whenever +M <  R <= +L
          * LARGE POSITIVE CORRELATION    whenever +L <  R <= +1
```

Where R is the estimated correlation, M is, 0.25 and L is 0.5

Partial variance (and proportion of total) by index

Index	Partial Variance	Proportion
WHSpr 2	0.571	0.04
WHSpr 3	0.182	0.013
WHSpr 4	0.15	0.01
WHSpr 5	0.27	0.019
WHSpr 6	0.929	0.065
WHAut 2	0.633	0.044
WHAut 3	0.261	0.018
WHAut 4	0.295	0.02
WHAut 5	0.355	0.025
WHAut 6	0.312	0.022
MASpr 2	0.321	0.022
MASpr 3	0.293	0.02
MASpr 4	0.602	0.042
MAAut 1	1.827	0.127
MAAut 2	2.165	0.15
MAAut 3	4.004	0.278
CM_CPE 2	0.981	0.068
CM_CPE 3	0.163	0.011
CM_CPE 4	0.041	0.003
CM_CPE 5	0.028	0.002
CM_CPE 6	0.01	0.001

Standardized residuals by index and year; with row/column/grand means

	1982	1983	1984	1985	1986	1987	1988
WHSpr2	0.410	1.063	1.248	-0.874	0.045	0.337	0.580
WHSpr3	-0.462	-0.323	0.788	0.075	-0.323	-0.184	-0.336
WHSpr4	-0.002	0.204	-0.044	0.548	0.070	-0.644	-0.508
WHSpr5	0.499	-0.107	-0.322	0.743	-0.756	-0.101	0.023
WHSpr6	0.569	-0.748	-1.282	0.072	-1.209	-1.750	1.011
WHAut2	-0.001	0.845	1.981	-0.136	0.380	-0.371	0.092
WHAut3	-0.763	1.292	0.652	-0.331	0.131	-0.121	0.585
WHAut4	-0.414	1.657	-0.016	0.221	0.732	0.137	-0.026
WHAut5	-0.322	1.172	-0.804	0.006	0.352	0.910	0.108
WHAut6	-0.155	-0.779	0.205	0.659	0.219	0.267	0.192
MASpr2	-0.386	1.453	0.122	-0.681	-0.347	0.082	0.305
MASpr3	-0.119	-0.020	-0.290	-0.039	-1.833	-0.253	-0.596
MASpr4	-0.122	-0.796	-0.573	-0.115	-0.528	-1.537	0.370
MAAut1	-1.665	-0.552	-2.444	0.728	-1.483	-1.987	3.049
MAAut2	0.724	0.391	-0.997	-2.142	-1.375	-0.671	-0.159
MAAut3	3.745	0.990	-0.990	-2.764	-3.444	1.542	-3.308
CM_CPE2	1.364	1.558	1.197	-0.258	-1.175	-0.955	-0.514
CM_CPE3	0.417	0.464	0.135	0.140	0.281	-1.020	-0.244
CM_CPE4	-0.086	0.232	-0.136	0.242	0.049	-0.233	-0.506
CM_CPE5	-0.419	0.175	0.082	0.146	0.093	0.055	0.083
CM_CPE6	-0.170	-0.053	-0.089	0.208	-0.059	0.031	0.031
Col Avg	0.126	0.387	-0.075	-0.169	-0.485	-0.308	0.011

	1989	1990	1991	1992	1993	1994	1995
WHSpr2	-0.904	-0.163	-0.056	-0.591	0.449	-0.599	-0.036
WHSpr3	-0.444	-0.749	-0.038	-0.432	0.252	-0.541	0.183
WHSpr4	-0.083	-0.572	-0.482	0.268	0.137	-0.826	-0.358
WHSpr5	-1.379	-0.595	-0.621	0.210	0.009	-0.240	0.366
WHSpr6	0.241	-1.622	-1.897	0.532	0.366	0.116	1.480
WHAut2	0.567	0.935	-2.204	-0.982	-0.017	-0.974	0.321
WHAut3	0.837	-0.003	0.054	-0.996	-0.372	-0.035	-0.048
WHAut4	0.273	0.199	-0.493	-0.147	-1.008	-0.335	0.456
WHAut5	0.588	-0.044	0.258	-0.762	-1.059	-1.634	-0.349
WHAut6	0.259	-0.032	0.583	-1.075	-0.477	0.000	1.680
MASpr2	0.331	0.989	0.207	0.240	0.602	-0.276	-0.729
MASpr3	0.168	0.422	0.396	0.867	0.140	-0.247	-0.233
MASpr4	-1.172	0.408	0.249	0.548	1.168	-0.487	0.315
MAAut1	0.005	-0.507	0.197	-0.502	0.936	3.008	2.508
MAAut2	1.456	1.258	2.686	1.125	0.384	0.466	3.396
MAAut3	0.470	-1.224	2.924	2.092	-0.990	1.086	3.320

CM_CPE2	-1.246	0.463	1.164	0.167	-1.764	0.000	0.000
CM_CPE3	-0.359	-0.195	0.648	-0.453	0.186	0.000	0.000
CM_CPE4	-0.049	0.228	-0.092	0.027	0.321	0.000	0.000
CM_CPE5	-0.317	-0.092	0.165	0.127	-0.097	0.000	0.000
CM_CPE6	0.005	0.075	-0.191	0.113	0.098	0.000	0.000
Col Avg	-0.036	-0.039	0.165	0.018	-0.035	-0.101	0.767

	1996	1997	1998	1999	2000
WHSpr2	-2.651	-0.040	0.368	0.546	0.868
WHSpr3	0.777	0.194	0.367	1.078	0.119
WHSpr4	0.394	0.158	0.618	0.637	0.485
WHSpr5	0.933	0.704	0.271	0.798	-0.434
WHSpr6	0.519	1.794	1.027	1.093	-0.312
WHAut2	-1.002	0.023	0.875	-0.767	0.432
WHAut3	-0.047	0.189	-1.163	0.189	-0.049
WHAut4	0.166	-0.365	-0.898	-0.788	0.649
WHAut5	0.593	0.021	0.449	0.101	0.416
WHAut6	0.456	-0.248	-0.596	-0.761	-0.398
MASpr2	-1.158	-0.731	-0.761	0.219	0.519
MASpr3	0.395	-0.262	-0.347	1.003	0.849
MASpr4	-0.900	-0.879	0.868	1.508	1.675
MAAut1	-0.126	0.938	-0.945	-1.159	0.000
MAAut2	-0.275	-1.591	-4.176	0.158	-0.660
MAAut3	1.765	-2.235	0.000	-2.849	-0.130
CM_CPE2	0.000	0.000	0.000	0.000	0.000
CM_CPE3	0.000	0.000	0.000	0.000	0.000
CM_CPE4	0.000	0.000	0.000	0.000	0.000
CM_CPE5	0.000	0.000	0.000	0.000	0.000
CM_CPE6	0.000	0.000	0.000	0.000	0.000
Col Avg	-0.010	-0.146	-0.270	0.063	0.252

Percent of total sum of squares by index and year; with row/column sums

	1982	1983	1984	1985	1986	1987	1988
WHSpr2	0.050	0.336	0.463	0.227	0.001	0.034	0.100
WHSpr3	0.064	0.031	0.185	0.002	0.031	0.010	0.034
WHSpr4	0.000	0.012	0.001	0.090	0.001	0.123	0.077
WHSpr5	0.074	0.003	0.031	0.164	0.170	0.003	0.000
WHSpr6	0.096	0.166	0.489	0.002	0.435	0.912	0.304
WHAut2	0.000	0.213	1.168	0.005	0.043	0.041	0.003
WHAut3	0.173	0.497	0.127	0.033	0.005	0.004	0.102
WHAut4	0.051	0.817	0.000	0.014	0.159	0.006	0.000
WHAut5	0.031	0.409	0.193	0.000	0.037	0.246	0.003
WHAut6	0.007	0.181	0.012	0.129	0.014	0.021	0.011
MASpr2	0.044	0.629	0.004	0.138	0.036	0.002	0.028
MASpr3	0.004	0.000	0.025	0.000	1.000	0.019	0.106
MASpr4	0.004	0.189	0.098	0.004	0.083	0.703	0.041
MAAut1	0.825	0.091	1.778	0.158	0.654	1.175	2.766
MAAut2	0.156	0.046	0.296	1.366	0.563	0.134	0.008
MAAut3	4.175	0.292	0.292	2.274	3.531	0.708	3.257
CM_CPE2	0.554	0.723	0.427	0.020	0.411	0.271	0.079
CM_CPE3	0.052	0.064	0.005	0.006	0.024	0.310	0.018
CM_CPE4	0.002	0.016	0.005	0.017	0.001	0.016	0.076
CM_CPE5	0.052	0.009	0.002	0.006	0.003	0.001	0.002
CM_CPE6	0.009	0.001	0.002	0.013	0.001	0.000	0.000
++	6.424	4.723	5.603	4.668	7.203	4.740	7.013

	1989	1990	1991	1992	1993	1994	1995
WHSpr2	0.243	0.008	0.001	0.104	0.060	0.107	0.000
WHSpr3	0.059	0.167	0.000	0.055	0.019	0.087	0.010
WHSpr4	0.002	0.097	0.069	0.021	0.006	0.203	0.038
WHSpr5	0.566	0.105	0.115	0.013	0.000	0.017	0.040
WHSpr6	0.017	0.783	1.071	0.084	0.040	0.004	0.652
WHAut2	0.096	0.260	1.445	0.287	0.000	0.282	0.031
WHAut3	0.209	0.000	0.001	0.295	0.041	0.000	0.001
WHAut4	0.022	0.012	0.072	0.006	0.302	0.033	0.062
WHAut5	0.103	0.001	0.020	0.173	0.334	0.795	0.036
WHAut6	0.020	0.000	0.101	0.344	0.068	0.000	0.840

MASpr2	0.033	0.291	0.013	0.017	0.108	0.023	0.158
MASpr3	0.008	0.053	0.047	0.223	0.006	0.018	0.016
MASpr4	0.409	0.050	0.018	0.089	0.406	0.071	0.030
MAAut1	0.000	0.076	0.012	0.075	0.260	2.693	1.872
MAAut2	0.631	0.471	2.147	0.377	0.044	0.065	3.432
MAAut3	0.066	0.446	2.544	1.302	0.292	0.351	3.281
CM_CPE2	0.462	0.064	0.403	0.008	0.927	0.000	0.000
CM_CPE3	0.038	0.011	0.125	0.061	0.010	0.000	0.000
CM_CPE4	0.001	0.015	0.002	0.000	0.031	0.000	0.000
CM_CPE5	0.030	0.003	0.008	0.005	0.003	0.000	0.000
CM_CPE6	0.000	0.002	0.011	0.004	0.003	0.000	0.000
++	3.015	2.916	8.226	3.545	2.958	4.750	10.499

	1996	1997	1998	1999	2000	++
WHSpr2	2.092	0.000	0.040	0.089	0.224	4.181
WHSpr3	0.179	0.011	0.040	0.346	0.004	1.334
WHSpr4	0.046	0.007	0.114	0.121	0.070	1.099
WHSpr5	0.259	0.148	0.022	0.189	0.056	1.976
WHSpr6	0.080	0.958	0.314	0.355	0.029	6.793
WHAut2	0.299	0.000	0.228	0.175	0.056	4.632
WHAut3	0.001	0.011	0.402	0.011	0.001	1.912
WHAut4	0.008	0.040	0.240	0.185	0.125	2.156
WHAut5	0.105	0.000	0.060	0.003	0.052	2.599
WHAut6	0.062	0.018	0.106	0.172	0.047	2.154
MASpr2	0.399	0.159	0.172	0.014	0.080	2.348
MASpr3	0.046	0.020	0.036	0.300	0.214	2.143
MASpr4	0.241	0.230	0.224	0.677	0.835	4.401
MAAut1	0.005	0.262	0.266	0.400	0.000	13.367
MAAut2	0.023	0.753	5.189	0.007	0.130	15.837
MAAut3	0.927	1.487	0.000	2.415	0.005	27.645
CM_CPE2	0.000	0.000	0.000	0.000	0.000	4.348
CM_CPE3	0.000	0.000	0.000	0.000	0.000	0.724
CM_CPE4	0.000	0.000	0.000	0.000	0.000	0.184
CM_CPE5	0.000	0.000	0.000	0.000	0.000	0.124
CM_CPE6	0.000	0.000	0.000	0.000	0.000	0.045
++	4.772	4.105	7.453	5.460	1.928	100.000

STOCK NUMBERS (Jan 1) in thousands - D:\NAFO\SeptWS\gmcod\gmcod2000_base.2

	1982	1983	1984	1985	1986	1987	1988
1	6162	5534	7746	4914	7410	9954	21647
2	9108	5018	4530	6339	4023	6067	8148
3	4328	6208	3325	3306	4821	3218	4772
4	2666	2066	2950	1600	1399	1989	2096
5	1661	1149	734	1058	413	410	625
6	166	787	363	206	296	112	85
7	547	284	250	214	156	132	58
1+	24639	21046	19900	17636	18519	21882	37431

	1989	1990	1991	1992	1993	1994	1995
1	3375	3391	5879	5283	8137	2870	2947
2	17723	2763	2776	4813	4325	6662	2350
3	6526	14206	2077	1962	3657	3472	5428
4	2601	3911	8531	855	1126	1649	1924
5	854	814	1334	3220	262	342	323
6	145	293	277	322	810	98	20
7	98	182	151	131	63	114	55
1+	31322	25559	21025	16587	18382	15208	13046

	1996	1997	1998	1999	2000
1	2113	2536	3345	5363	00
2	2413	1730	2076	2738	4391
3	1727	1917	1369	1615	2242
4	3648	885	1173	768	1161
5	532	1414	331	470	455
6	89	121	405	122	303
7	19	14	21	162	175
1+	10541	8617	8719	11236	8727

FISHING MORTALITY - D:\NAFO\SeptWS\gmcod\gmcod2000_base.2

	1982	1983	1984	1985	1986	1987	1988
1	0.01	0.00	0.00	0.00	0.00	0.00	0.00
2	0.18	0.21	0.12	0.07	0.02	0.04	0.02
3	0.54	0.54	0.53	0.66	0.69	0.23	0.41
4	0.64	0.83	0.83	1.15	1.03	0.96	0.70
5	0.55	0.95	1.07	1.07	1.10	1.37	1.26
6	0.61	0.90	0.89	1.16	1.08	1.05	0.82
7	0.61	0.90	0.89	1.16	1.08	1.05	0.82

	1989	1990	1991	1992	1993	1994	1995
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.02	0.09	0.15	0.07	0.02	0.00	0.11
3	0.31	0.31	0.69	0.35	0.60	0.39	0.20
4	0.96	0.88	0.77	0.98	0.99	1.43	1.09
5	0.87	0.88	1.22	1.18	0.78	2.66	1.09
6	0.97	0.90	0.84	1.18	0.98	1.67	1.13
7	0.97	0.90	0.84	1.18	0.98	1.67	1.13

	1996	1997	1998	1999
1	0.00	0.00	0.00	0.00
2	0.03	0.03	0.05	0.00
3	0.47	0.29	0.38	0.13
4	0.75	0.78	0.71	0.32
5	1.28	1.05	0.80	0.24
6	0.82	0.97	0.75	0.28
7	0.82	0.97	0.75	0.28

1,7
1,6
2,6
4,6
Average F for 1,7 1,6 2,6 4,6

	1982	1983	1984	1985	1986	1987	1988
1,7	0.45	0.62	0.62	0.76	0.71	0.67	0.58
1,6	0.42	0.57	0.57	0.69	0.65	0.61	0.54
2,6	0.51	0.69	0.69	0.82	0.78	0.73	0.64
4,6	0.60	0.89	0.93	1.13	1.07	1.13	0.93

	1989	1990	1991	1992	1993	1994	1995
1,7	0.59	0.56	0.65	0.71	0.62	1.12	0.68
1,6	0.52	0.51	0.61	0.63	0.56	1.03	0.60
2,6	0.63	0.61	0.73	0.75	0.67	1.23	0.72
4,6	0.93	0.88	0.95	1.11	0.92	1.92	1.10

	1996	1997	1998	1999
1,7	0.59	0.58	0.49	0.18
1,6	0.56	0.52	0.45	0.16
2,6	0.67	0.63	0.54	0.19
4,6	0.95	0.93	0.75	0.28

Average F weighted by N for 1,7 1,6 2,6 4,6

	1982	1983	1984	1985	1986	1987	1988
1,7	0.29	0.39	0.30	0.35	0.31	0.17	0.12
1,6	0.28	0.38	0.30	0.34	0.31	0.16	0.12
2,6	0.38	0.52	0.49	0.47	0.51	0.30	0.28
4,6	0.61	0.88	0.88	1.12	1.05	1.03	0.83

	1989	1990	1991	1992	1993	1994	1995
1,7	0.19	0.36	0.50	0.38	0.24	0.33	0.30
1,6	0.19	0.36	0.49	0.37	0.24	0.32	0.29
2,6	0.21	0.41	0.69	0.54	0.43	0.39	0.38
4,6	0.94	0.88	0.83	1.14	0.96	1.64	1.09

	1996	1997	1998	1999
1,7	0.42	0.34	0.23	0.06
1,6	0.41	0.34	0.23	0.05
2,6	0.52	0.48	0.38	0.11
4,6	0.82	0.95	0.74	0.29

Average F for weighted by Catch for 1,7 1,6 2,6 4,6

	1982	1983	1984	1985	1986	1987	1988
1,7	0.47	0.63	0.69	0.83	0.81	0.74	0.60
1,6	0.46	0.62	0.68	0.82	0.80	0.73	0.60
2,6	0.46	0.62	0.68	0.82	0.80	0.73	0.60
4,6	0.61	0.88	0.88	1.13	1.05	1.04	0.87

	1989	1990	1991	1992	1993	1994	1995
1,7	0.61	0.55	0.79	0.94	0.75	1.16	0.69
1,6	0.61	0.54	0.79	0.93	0.74	1.14	0.68
2,6	0.61	0.54	0.79	0.93	0.74	1.14	0.68
4,6	0.94	0.88	0.85	1.14	0.96	1.68	1.09

	1996	1997	1998	1999
1,7	0.74	0.77	0.59	0.24
1,6	0.74	0.77	0.59	0.23
2,6	0.74	0.77	0.59	0.23
4,6	0.84	0.96	0.74	0.29

Biomass Weighted F

1982	1983	1984	1985	1986	1987	1988
0.40	0.53	0.45	0.50	0.45	0.30	0.20

1989	1990	1991	1992	1993	1994	1995
0.27	0.44	0.63	0.50	0.38	0.40	0.37

1996	1997	1998	1999
0.48	0.43	0.36	0.11

BACKCALCULATED PARTIAL RECRUITMENT

	1982	1983	1984	1985	1986	1987	1988
1	0.01	0.00	0.00	0.00	0.00	0.00	0.00
2	0.29	0.22	0.11	0.06	0.02	0.03	0.02
3	0.84	0.57	0.50	0.57	0.62	0.17	0.32
4	1.00	0.88	0.77	0.99	0.93	0.70	0.55
5	0.85	1.00	1.00	0.92	1.00	1.00	1.00
6	0.96	0.94	0.83	1.00	0.98	0.76	0.65
7	0.96	0.94	0.83	1.00	0.98	0.76	0.65

	1989	1990	1991	1992	1993	1994	1995
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.02	0.10	0.12	0.06	0.02	0.00	0.10
3	0.32	0.34	0.56	0.30	0.60	0.15	0.18
4	1.00	0.97	0.63	0.83	1.00	0.54	0.96
5	0.90	0.98	1.00	1.00	0.79	1.00	0.97
6	1.00	1.00	0.69	1.00	0.98	0.63	1.00
7	1.00	1.00	0.69	1.00	0.98	0.63	1.00

	1996	1997	1998	1999
1	0.00	0.00	0.00	0.00
2	0.02	0.03	0.06	0.00
3	0.37	0.28	0.47	0.40
4	0.59	0.75	0.89	1.00
5	1.00	1.00	1.00	0.74
6	0.64	0.92	0.94	0.87
7	0.64	0.92	0.94	0.87

MEAN BIOMASS (using catch mean weights at age)

	1982	1983	1984	1985	1986	1987	1988
1	5013	4514	6317	4008	6044	8119	17658
2	8746	4788	4504	6987	4701	7081	9266
3	5090	7269	3938	3872	5877	4407	6729
4	4981	3186	5021	2490	2355	3869	3355
5	5582	2577	1528	2672	1067	997	1696
6	766	2849	1303	621	1014	437	360
7	4243	1685	1551	1137	905	770	410
1+	34422	26868	24161	21786	21963	25680	39473

	1989	1990	1991	1992	1993	1994	1995
1	2753	2766	4795	4309	6638	2341	2404
2	19827	2575	2650	6452	5021	8735	3341
3	9071	18829	2159	2894	4762	5095	8605
4	4604	5442	13693	1362	1654	2563	3004
5	2025	2125	2947	5346	728	389	933
6	416	1358	1258	875	2941	273	90
7	708	1515	1072	757	408	517	392
1+	39403	34609	28574	21994	22152	19912	18768

	1996	1997	1998	1999	
1	1724	2068	2728	4374	
2	3636	2673	2344	3169	
3	2690	3382	2171	2440	
4	5601	1695	2289	1616	
5	1013	2577	878	1529	
6	411	333	1102	554	
7	142	103	137	1013	
1+	15217	12831	11650	14696	00

Summaries for ages 1,7 1,6 2,6 4,6

	1982	1983	1984	1985	1986	1987	1988
1,7	34422	26868	24161	21786	21963	25680	39473
1,6	30179	25183	22610	20650	21057	24910	39063
2,6	25166	20670	16293	16642	15013	16791	21405
4,6	11330	8613	7851	5783	4435	5303	5411

	1989	1990	1991	1992	1993	1994	1995
1,7	39403	34609	28574	21994	22152	19912	18768
1,6	38695	33094	27502	21238	21744	19395	18377
2,6	35942	30329	22707	16929	15106	17054	15973
4,6	7045	8925	17898	7583	5323	3224	4027

	1996	1997	1998	1999
1,7	15217	12831	11649	14696
1,6	15075	12728	11512	13683
2,6	13351	10659	8784	9309
4,6	7025	4605	4269	3700

Catch BIOMASS (using catch mean weights)

	1982	1983	1984	1985	1986	1987	1988
1	27	00	04	00	00	02	00
2	1603	1013	519	514	110	284	203
3	2746	3955	2093	2555	4027	1008	2737
4	3198	2659	4144	2872	2421	3704	2343
5	3052	2452	1638	2868	1178	1370	2144
6	471	2557	1163	722	1095	459	295
7	2606	1512	1384	1322	978	809	337
1+	13703	14149	10944	10853	9808	7636	8060

	1989	1990	1991	1992	1993	1994	1995
1	00	00	00	00	00	00	00
2	421	220	390	481	99	42	361
3	2831	5835	1484	1026	2842	1990	1699
4	4428	4763	10604	1337	1640	3665	3262
5	1763	1864	3596	6307	570	1033	1017
6	402	1220	1062	1031	2872	454	102
7	683	1361	905	892	398	862	441
1+	10527	15263	18040	11074	8420	8047	6882

	1996	1997	1998	1999
1	00	00	00	00
2	110	92	120	00
3	1259	984	821	317
4	4188	1327	1637	523
5	1294	2707	702	364
6	337	322	824	156
7	117	100	103	284
1+	7305	5532	4207	1644

Summaries for ages 1,7 1,6 2,6 4,6

	1982	1983	1984	1985	1986	1987	1988
1,7	13703	14149	10944	10853	9808	7636	8060
1,6	11097	12637	9560	9531	8830	6827	7723
2,6	11070	12637	9556	9531	8830	6825	7723
4,6	6721	7669	6945	6462	4693	5534	4782

	1989	1990	1991	1992	1993	1994	1995
1,7	10527	15262	18040	11074	8420	8047	6882
1,6	9844	13902	17135	10183	8022	7185	6441
2,6	9844	13902	17135	10183	8022	7185	6441
4,6	6592	7847	15261	8675	5082	5153	4381

	1996	1997	1998	1999
1,7	7304	5532	4207	1644
1,6	7188	5432	4104	1359
2,6	7188	5432	4104	1359
4,6	5819	4356	3162	1042

Jan 1 BIOMASS (using Jan 1 mean weights)

	1982	1983	1984	1985	1986	1987	1988
1	4874	4388	5895	3675	5520	7545	16560
2	8789	5138	4626	6751	4357	6595	8702
3	5904	8598	4635	4704	7333	4769	7501
4	6303	4192	6269	3485	3160	4886	4236
5	7088	3711	2215	3688	1497	1540	2575
6	942	4198	1714	927	1542	630	485
7	6202	2775	2549	2082	1605	1350	655
1+	40102	33001	27903	25313	25015	27313	40714

	1989	1990	1991	1992	1993	1994	1995
1	2785	2723	4056	3967	5769	1906	1936
2	18769	2714	2798	5655	4667	7608	2865
3	9796	20641	2692	2891	6225	5504	9060
4	6172	7853	17592	1765	2476	4023	4467
5	2614	2908	4090	8929	902	1007	1300
6	725	1591	1548	1467	3522	507	105
7	1198	2496	1727	1394	694	1142	707
1+	42059	40925	34502	26068	24255	21697	20439

	1996	1997	1998	1999
1	1372	1917	2529	4054
2	2972	2161	2225	2936
3	3243	3720	2605	2430
4	7792	2244	3025	1825
5	1692	3895	1176	1626
6	547	500	1485	597
7	227	175	212	1276
1+	17845	14611	13257	14744

Summaries for ages 1,7 1,6 2,6 4,6

	1982	1983	1984	1985	1986	1987	1988
1,7	40102	33001	27903	25313	25015	27313	40714
1,6	33900	30226	25354	23230	23409	25964	40059
2,6	29026	25838	19459	19555	17889	18418	23499
4,6	14333	12102	10198	8100	6199	7055	7296

	1989	1990	1991	1992	1993	1994	1995
1,7	42059	40925	34502	26068	24255	21697	20439
1,6	40861	38429	32776	24674	23561	20555	19732
2,6	38076	35706	28720	20707	17792	18649	17796
4,6	9511	12352	23230	12160	6900	5537	5872

	1996	1997	1998	1999
1,7	17845	14611	13257	14744
1,6	17618	14436	13044	13468
2,6	16247	12519	10516	9413
4,6	10031	6638	5686	4048

SSB AT THE START OF THE SPAWNING SEASON -MALES AND FEMALES (MT) (using SSB mean weights)

	1982	1983	1984	1985	1986	1987	1988
1	330	297	399	142	214	292	641
2	2144	1247	1141	3096	2015	3041	4025
3	3184	4633	2503	3872	6011	4218	6440
4	4820	3105	4650	2781	2575	4029	3647
5	6071	2971	1738	2983	1205	1184	2017
6	823	3496	1429	739	1245	511	409
7	5415	2311	2125	1659	1297	1096	552
1+	22786	18061	13984	15272	14561	14370	17732

	1989	1990	1991	1992	1993	1994	1995
1	108	290	432	422	614	74	75
2	8683	725	739	1513	1260	2794	1034
3	8545	10617	1300	1476	3052	4439	7546
4	5085	5317	12113	1174	1644	3035	3569
5	2187	2260	3002	6598	712	625	1048
6	597	1298	1275	1142	2837	371	84
7	987	2078	1451	1108	570	836	567
1+	26191	22585	20311	13432	10690	12175	13924

	1996	1997	1998	1999
1	53	74	98	157
2	1087	790	811	1079
3	2582	3051	2105	2047
4	6587	1885	2571	1655
5	1322	3162	995	1511
6	462	411	1268	551
7	191	144	181	1178
1+	12285	9517	8029	8179

ADAPT/VPA Bootstrap Output
File: gmcod2000_base.2boot

The number of bootstraps: 100
Bootstrap Output Variable: N hat

	NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
N 2	4391	4457	1592	0.36
N 3	2242	2357	635	0.28
N 4	1161	1242	341	0.29
N 5	455	464	157	0.35
N 6	303	330	124	0.41

	BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE	LOWER 80%CI	UPPER 80%CI
N 2	67	159	1.52	4324	0.368318	2564	6190
N 3	115	63	5.11	2127	0.298377	1308	2919
N 4	82	34	7.03	1079	0.315954	684	1553
N 5	09	16	2.01	446	0.353130	325	792
N 6	27	12	8.76	277	0.449921	164	492

Bootstrap Output Variable: Q_unscaled

	NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
q WHSpr2	0.0000789	0.0000813	0.0000154	0.19
q WHSpr3	0.0001766	0.0001758	0.0000355	0.20
q WHSpr4	0.0002607	0.0002616	0.0000476	0.18
q WHSpr5	0.0003404	0.0003363	0.0000643	0.19
q WHSpr6	0.0004341	0.0004445	0.0000898	0.21
q WHAut2	0.0000680	0.0000686	0.0000138	0.20
q WHAut3	0.0001688	0.0001705	0.0000328	0.19
q WHAut4	0.0002927	0.0003097	0.0000618	0.21
q WHAut5	0.0003750	0.0003840	0.0000754	0.20
q WHAut6	0.0006108	0.0006193	0.0001095	0.18
q MASpr2	0.0010758	0.0011056	0.0001972	0.18
q MASpr3	0.0008737	0.0008904	0.0001683	0.19
q MASpr4	0.0004771	0.0004840	0.0001001	0.21
q MAAut1	0.0013482	0.0013375	0.0002738	0.20
q MAAut2	0.0003353	0.0003417	0.0000617	0.18
q MAAut3	0.0000698	0.0000697	0.0000123	0.18
q CM_CPE2	0.0000031	0.0000030	0.0000006	0.21
q CM_CPE3	0.0000169	0.0000173	0.0000038	0.23
q CM_CPE4	0.0000269	0.0000277	0.0000065	0.24
q CM_CPE5	0.0000265	0.0000270	0.0000059	0.22
q CM_CPE6	0.0000269	0.0000274	0.0000067	0.25

	BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE	LOWER 80%CI	UPPER 80%CI
q WHSpr2	0.00000232	0.000001536	2.941	0.000076626	0.20	0.0000579	0.0000968
q WHSpr3	-0.00000080	0.000003546	-0.456	0.000177375	0.20	0.0001354	0.0002199
q WHSpr4	0.00000083	0.000004762	0.318	0.000259914	0.18	0.0002074	0.0003273
q WHSpr5	-0.00000408	0.000006428	-1.199	0.000344453	0.19	0.0002739	0.0004425
q WHSpr6	0.00001038	0.000008975	2.392	0.000423735	0.21	0.0003295	0.0005553
q WHAut2	0.00000057	0.000001382	0.832	0.000067432	0.20	0.0000521	0.0000924
q WHAut3	0.00000172	0.000003282	1.019	0.000167090	0.20	0.0001354	0.0002222
q WHAut4	0.00001702	0.000006180	5.815	0.000275701	0.22	0.0002214	0.0003767
q WHAut5	0.00000900	0.000007539	2.401	0.000366042	0.21	0.0003135	0.0005427
q WHAut6	0.00000857	0.000010947	1.403	0.000602192	0.18	0.0004777	0.0007961
q MASpr2	0.00002980	0.000019721	2.770	0.001046014	0.19	0.0007848	0.0013173
q MASpr3	0.00001664	0.000016827	1.904	0.000857091	0.20	0.0006550	0.0010604
q MASpr4	0.00000690	0.000010014	1.447	0.000470175	0.21	0.0004004	0.0006712
q MAAut1	-0.00001065	0.000027381	-0.790	0.001358838	0.20	0.0011042	0.0018513
q MAAut2	0.00000648	0.000006168	1.933	0.000328775	0.19	0.0002602	0.0004070
q MAAut3	-0.00000012	0.000001227	-0.166	0.000069885	0.18	0.0000572	0.0000895
q CM_CPE2	-0.00000010	0.000000065	-3.180	0.000003179	0.20	0.0000027	0.0000050
q CM_CPE3	0.00000038	0.000000382	2.253	0.000016543	0.23	0.0000112	0.0000207
q CM_CPE4	0.00000086	0.000000646	3.218	0.000026007	0.25	0.0000189	0.0000378
q CM_CPE5	0.00000054	0.000000594	2.029	0.000025924	0.23	0.0000196	0.0000331
q CM_CPE6	0.00000043	0.000000666	1.614	0.000026502	0.25	0.0000205	0.0000347

Bootstrap Output Variable: N t1

	NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
Age 1	5068.4	5076.3	156.2	0.0308
Age 2	4390.5	4457.5	1592.5	0.3627
Age 3	2242.0	2356.6	634.8	0.2831
Age 4	1160.9	1242.4	341.0	0.2937
Age 5	454.8	463.9	157.4	0.3460
Age 6	303.2	329.8	124.5	0.4105
Age 7	175.3	175.0	44.9	0.2562

	BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE	LOWER 80%CI	UPPER 80%CI
Age 1	7.84	15.62	0.155	5060.58	0.03	4814.2	5218.5
Age 2	66.90	159.25	1.524	4323.64	0.37	2564.2	6190.5
Age 3	114.62	63.48	5.112	2127.37	0.30	1308.0	2919.5
Age 4	81.59	34.10	7.028	1079.27	0.32	683.8	1552.6
Age 5	9.13	15.74	2.008	445.63	0.35	325.4	791.5
Age 6	26.57	12.45	8.763	276.63	0.45	164.4	492.4
Age 7	-0.28	4.49	-0.158	175.53	0.26	138.6	254.4

Bootstrap Output Variable: F t

	NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
Age 1	0.0000	0.0000	0.0000	0.40
Age 2	0.0000	0.0000	0.0000	0.28
Age 3	0.1299	0.1308	0.0379	0.29
Age 4	0.3235	0.3427	0.0903	0.28
Age 5	0.2379	0.2473	0.0870	0.37
Age 6	0.2807	0.2950	0.0649	0.23
Age 7	0.2807	0.2950	0.0649	0.23

	BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE	LOWER 80%CI	UPPER 80%CI
Age 1	0.0000000	0.0000000	11.102	0.0000002	0.45	0.0000	0.0000
Age 2	0.0000000	0.0000000	2.061	0.0000004	0.28	0.0000	0.0000
Age 3	0.0009154	0.0037909	0.705	0.1290096	0.29	0.0971	0.1965
Age 4	0.0191060	0.0090312	5.905	0.3044409	0.30	0.1845	0.4237
Age 5	0.0093784	0.0086969	3.942	0.2285263	0.38	0.1513	0.3723
Age 6	0.0142422	0.0064933	5.073	0.2664836	0.24	0.1895	0.3396
Age 7	0.0142422	0.0064933	5.073	0.2664836	0.24	0.1895	0.3396

Bootstrap Output Variable: F full t

NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
0.2807	0.2950	0.0649	0.23

BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE	LOWER 80%CI	UPPER 80%CI
0.01424	0.00649	5.07	0.26648	0.24	0.1895	0.3396

Bootstrap Output Variable: PR t

	NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
Age 1	0.0000	0.0000	0.0000	0.48
Age 2	0.0000	0.0000	0.0000	0.34
Age 3	0.4016	0.3855	0.1484	0.37
Age 4	1.0000	0.9549	0.1022	0.10
Age 5	0.7353	0.7079	0.2237	0.30
Age 6	0.8677	0.8314	0.0943	0.11
Age 7	0.8677	0.8314	0.0943	0.11

	ESTIMATE	STD ERROR	BIAS	FOR BIAS	STIMATE	80%CI	UPPER 80%CI
Age 1	0.00000	0.000000	6.73	0.00000059	0.52	0.0000	0.0000
Age 2	0.00000	0.000000	-3.27	0.00000129	0.33	0.0000	0.0000
Age 3	-0.01611	0.014837	-4.01	0.41767448	0.36	0.3019	0.8742
Age 4	-0.04505	0.010215	-4.51	1.04505144	0.10	0.5386	1.0000
Age 5	-0.02739	0.022370	-3.73	0.76269571	0.29	0.5098	1.0000
Age 6	-0.03622	0.009426	-4.17	0.90387357	0.10	0.7693	0.9848
Age 7	-0.03622	0.009426	-4.17	0.90387357	0.10	0.7693	0.9848

Bootstrap Output Variable: PR mean

	NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
Age 1	0.0000	0.0000	0.0000	0.23
Age 2	0.0014	0.0013	0.0002	0.16
Age 3	0.3748	0.3612	0.0410	0.11
Age 4	0.8735	0.8494	0.0338	0.04
Age 5	0.9026	0.8759	0.0934	0.10
Age 6	0.9071	0.8834	0.0587	0.06
Age 7	0.9071	0.8834	0.0587	0.06

	BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE	LOWER 80%CI	UPPER 80%CI
Age 1	0.00000	0.0000000	-0.50	0.0000005	0.23	0.0000	0.0000
Age 2	-0.00004	0.0000218	-2.99	0.0014208	0.15	0.0012	0.0019
Age 3	-0.01356	0.0041020	-3.62	0.3883452	0.11	0.3506	0.4868
Age 4	-0.02408	0.0033759	-2.76	0.8975813	0.04	0.8604	0.8902
Age 5	-0.02667	0.0093355	-2.95	0.9292533	0.10	0.7988	0.9885
Age 6	-0.02367	0.0058667	-2.61	0.9307563	0.06	0.8411	0.9614
Age 7	-0.02367	0.0058667	-2.61	0.9307563	0.06	0.8411	0.9614

Bootstrap Output Variable: Mean Biomass

NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
14696.3238	15227.0049	2167.2455	0.15

BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE	LOWER 80%CI	UPPER 80%CI
530.6811	216.7246	3.61	14165.6427	0.15	10937.6621	16395.9087

Bootstrap Output Variable: SSB f mean

NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
3605.2593	4297.8627	670.4795	0.19

BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE	LOWER 80%CI	UPPER 80%CI
692.603	67.048	19.21	2912.656	0.23	2947.5296	3711.4627

Bootstrap Output Variable: SSB spawn t

NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
8178.8261	8495.8262	1257.3919	0.15

BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE	LOWER 80%CI	UPPER 80%CI
317.00	125.74	3.88	7861.83	0.16	6032.3126	9442.0787

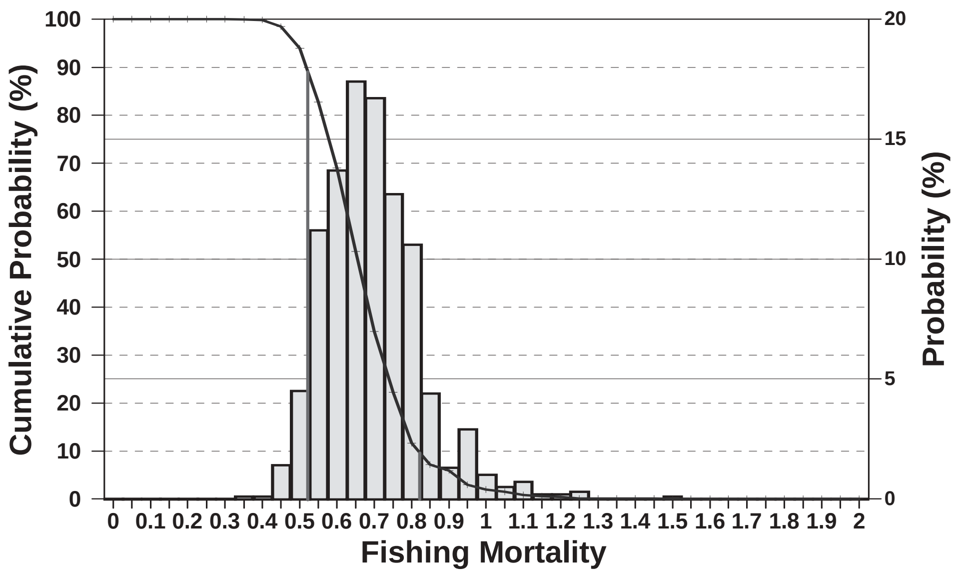
Bootstrap Output Variable: Jan 1 biomass

NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
14743.7195	15242.0697	2036.2864	0.14

BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE	LOWER 80%CI	UPPER 80%CI
498.35	203.63	3.38	14245.37	0.14	11483.96	16397.45

Gulf of Maine Cod

Precision of 1998 F Estimate



Precision of 1998 SSB Estimate