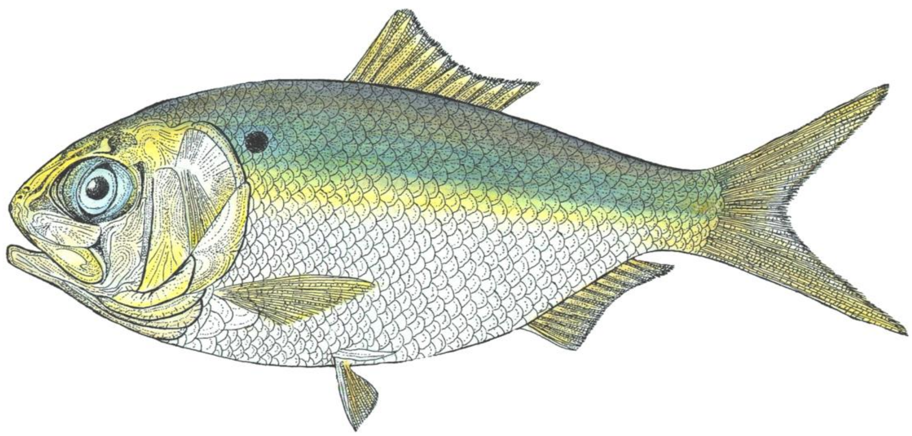
SEDAR 27 Working Document

Surplus production models of gulf menhaden, *Brevoortia patronus*



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Abstract

This working document describes production models (biomass-dynamic models) of gulf menhaden *Brevoortia patronus*, using data through 2010. Data series available for modeling included fishery-independent and fishery-dependent estimates of relative abundance and harvest data from the commercial reduction, commercial bait, recreational, and shrimp bycatch fisheries. The gulf menhaden population was analyzed with a logistic (Schaefer) surplus-production model, fit through maximum likelihood using ASPIC software, with a series of sensitivity runs made to examine effects of using various combinations data sets and other assumptions. The proposed reference run estimates that the population biomass is well above B_{MSY} and that the fishing mortality rate is below F_{MSY}. The sensitivity runs all reach the same conclusion, which implies that the conclusion is relatively robust.

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1 Introduction

This working document describes surplus-production model analyses of gulf menhaden, *Brevoortia patronus*, in the Gulf of Mexico. Data series available for modeling included fishery-independent and fishery-dependent indices of relative abundance and removals data from the reduction, bait, recreational, and shrimp bycatch fisheries. Analyses were made with the ASPIC software (Prager 1994; 2004), a flexible production-model implementation that is included in the NOAA Fisheries Toolbox (NOAA 2010).

Seventeen model configurations (Table 1) were fit, in order to make a thorough exploration of sensitivity to inclusion of each data, length of the removals series, and model shape. The proposed reference configuration used all available data sets (four abundance indices plus total removals) and a production curve of logistic (Schaefer) form. To keep this report to a reasonable size, reported results focus on the reference configuration, with other model configurations treated in less detail.

2 Data

Data were obtained from a data spreadsheet circulated to SEDAR 27 participants (SEDAR 2011b). Except for the abundance index based on reduction-fishery CPUE (described in this report in §2.3.2), data sources and processing are described in the SEDAR 27 meeting report (SEDAR 2011a). For completeness, the various data series are also described briefly in the balance of this section.

2.1 Landings data

Removals data, in thousands of tons per year, were taken from the second "Total Landings" column of SEDAR (2011b). The totals include directed take from the reduction, bait, and recreational fisheries, as well as bycatch from shrimp trawl. These data streams are tabulated starting in 1948, and data from 1948 through 2010 were used here in most model configurations (Table 1, Figure 1). The largest fraction of removals is due to the reduction fishery, with the bait fishery second and the others taking very small fractions.

Removals were reconstructed back to 1873 in SEDAR (2011a) and SEDAR (2011b), and a portion of the reconstruction was used here (in model runs 009 and 025) to examine sensitivity to data-series length. Because the reconstructed data exhibit little pattern in the earliest years, and because no abundance indices are available in those years (or, indeed, in any year before 1967), the two sensitivity runs to extended landings used landings reconstructions starting in 1920.

2.2 Juvenile abundance indices

Two juvenile abundance indices (JAIs) are tabulated in SEDAR (2011b), one from seine sampling off Texas, Louisiana, Mississippi, Alabama, and Florida (Figure 2c); the other from trawling off Texas, Louisiana, Mississippi, Alabama, and Florida (Figure 2d). Both juvenile indices were used here, with a date adjustment for better correspondence with adult indices. The year value associated with each index datum was increased by one, under the assumption that an indicator of age-zero abundance in any given year should be an indicator of age-one abundance in the following year.

Coefficients of variation (CVs) are provided for the two JAIs in SEDAR (2011b). In modeling the juvenile population, those CVs could be used directly. However, as noted above, here the juvenile index was assumed to be proportional to an unobserved adult index in the following year. Clearly, that relationship has additional variance, both through the variance in survival and the composition of the adult stock of 1- and 2-year olds. To address that added variance in an admittedly heuristic way, the tabulated CVs were doubled.

2.3 Adult abundance indices

Two adult abundance indices (AAIs) were used in modeling. The first is an existing fishery-independent index; the second, a fishery-dependent index, developed from data on the reduction fishery.

2.3.1 Fishery-independent gillnet index

An AAI is available from fishery-independent gillnet sampling off Texas, Louisiana, Mississippi, and Alabama (SEDAR 2011b). The index, which is believed to reflect gulf menhaden abundance throughout its range in the Gulf of Mexico (SEDAR 2011a), was used here as tabulated in SEDAR (2011b), along with its tabulated CVs (Figure 2a).

2.3.2 Fishery-dependent CPUE index

To make the most efficient use of data available for modeling, we developed an additional AAI from catch per unit effort (CPUE) in the reduction fishery. Reduction landings are tabulated in SEDAR (2011b), along with several measures of fishing effort. Vessel tonnage has increased over the years (SEDAR 2011a), so we chose vessel-ton-weeks (VTW) as a more stable measure of fishing effort than the others given. A nominal abundance index was computed as reduction landings divided by fishing effort in VTW.

Like most fisheries, this one has experienced fishing-power increases beyond vessel tonnage. Considerable increases would be expected, e. g, from improvements in netting materials, change from wood to steel hulls, and use of stern ramps rather than davits for launching purse boats.[1] In an attempt to reduce the effect of such factors, and thus arrive at a measure of effort whose units are consistent, a fishing-power adjustment (assumed annual increase in fishing power) γ is often applied to CPUE series derived from commercial fisheries.

Ideally, the value of γ is based on observational data, but when studies have not been made, a constant around $\gamma = 2\% \cdot \mathrm{yr}^{-1}$ is often used. That value reflects findings of increases of 1% to 4.5% per year in studied fisheries (e.g., Skjold et al. 1996; Stefansson et al. 1998; Jin et al. 2002; Hannesson 2007). In the gulf menhaden reduction fishery, the unit of effort (VTW) used already accounts for part of the fishing-power increase. Therefore, we used the lower end of the range, $\gamma = 1\% \cdot \mathrm{yr}^{-1}$, in our reference configuration (Figure 2b). We made sensitivity runs with the nominal CPUE index ($\gamma = 0$) and with a larger annual increase ($\gamma = 2\% \cdot \mathrm{yr}^{-1}$) (Figure 3).

There is no obvious way to derive the variance of the resulting abundance index. Its main components are recorded rather precisely, which argues for a small CV. Nonetheless, because of the use of spotter planes—among other biological and operational factors— substantial variance may be present in the index's relationship to actual relative abundance. Using a heuristic approach, we doubled the reported CV of the reduction landings, which was estimated as 4% by Vaughan et al. (2007). In other words, we assumed a constant 8% CV for this index.

2.4 Comparison of abundance indices

It can be seen by examining the individual indices (Figure 2) or the pairwise correlations between them (Figure 4, Table 2) that the four indices do not all tell the same story. In particular, the gillnet index—apart from the most recent year—is the most optimistic, showing a steady increase over roughly the last thirty years. In the same time period, the other three indices tend to a slow decline (Figure 2).

[1] J. W. Smith, NOAA Beaufort Lab, email of 6/21/2011.

3 Modeling

3.1 Model structure and software

Data were analyzed primarily with a logistic (Schaefer) production model (Schaefer 1954; 1957; Pella 1967; Prager 1994), as implemented by the ASPIC software, version 5.43 (Prager 2004). The software provides a continuous-time formulation of the Schaefer production model and a small-step, discrete-time formulation of the Fox and Pella–Tomlinson models. We did not attempt to estimate model shape, as in the Pella–Tomlinson model, but we did fit two configurations using the Fox model shape.

In many cases, it is difficult to estimate the year-1 biomass (either absolutely or relative to carrying capacity K) from a production model. This is especially common when the indices are not well correlated, as here. In all runs here, to avoid that difficulty, we fixed the year-1 biomass at 85% of carrying capacity ($B_1 = 0.85K$), reflecting the low exploitation levels in 1948 and before.

All runs were conditioned on catch. This reflects almost certain situation that observed catches are known more accurately and precisely than the abundance indices.

Uncertainty in model estimates was estimated through bootstrapping. Following the bootstrap, a short-term stochastic projection was made.

3.2 Combination of indices used in model runs

In total, we made 17 model runs (Table 1). Of them, 10 runs included the juvenile abundance indices (runs numbered 001 through 010), and 7 runs used only the adult abundance indices (runs 020 through 026).

Reference configuration. Of the 17 model configurations, we consider run 006 to be the reference configuration. That run uses all four abundance indices, including the reduction CPUE index with 1% fishing-power adjustment. We see no *a priori* reason to prefer a configuration that omits any of the data available.

Length of removals series. Runs 009 and 025 are sensitivity runs using the extended landings series.

Single-series models. Runs 001, 002, 020, and 021 were made with a single abundance index each. Such analyses can be useful in understanding what each abundance index says about population status and trends in the context of a production model.

Fishing power. Runs 006 (reference configuration), 007, and 008 vary only by using different values of γ, the fishing-power adjustment in the reduction CPUE index (see §2.3.2). The same is true of runs 022, 023, and 024.

Model shape. Runs 010 and 026 are sensitivity runs using the Fox model shape.

Other runs. Runs not specifically mentioned above use various combinations of indices.

3.3 Bootstrap and projection

A bootstrap (implemented in ASPIC) with 1,000 realizations was used to estimate uncertainty in model estimates and provide a set of starting values for stock projections. (The bootstrap is a nonparametric resampling technique that fits in the broad category of computer-intensive statistics.) From the bootstrap, it is possible to obtain bias-corrected confidence intervals (Efron and Gong 1983) on each model parameter and on functions of the parameters; e. g., on B_{2011}/B_{MSY}. The bootstrap has the advantage (compared, e. g., to likelihood profiling) that fewer parametric assumptions must be made.

In the bootstrapping method employed by ASPIC, estimated abundance indices and residuals from the original fit are saved. The residuals are then increased by an adjustment factor (Stine 1990), which is generally slightly more than unity and is reported in the ASPIC output file. Then, once for each bootstrap realization, the residuals are randomly added (with replacement) to the estimated values to arrive at a synthetic data set, and the model is refit. Adjustments are made in saving and applying the residuals to account for the original variance structure of the data, as specified in the input file.

Following the bootstrap, a short-term stochastic projection was made.[2] The projection began in 2011 and continued for ten year, with each year's projected removals being the actual removals observed in 2010.

Projections included two sources of stochasticity, used to generate confidence intervals. (1) The analysis included 1,000 realizations of the population projection—one realization based on each bootstrap set of parameter estimates and population states. (2) The projection incorporated additional variability by drawing each year's population value of MSY from a lognormal distribution with a nominal c.v. of 20%, bounded at ±4 standard deviations.

[2]Calculations were made with the ASPICP software (version 4.10), part of the ASPIC distribution.

4 Results

4.1 Reference configuration

The run with proposed reference configuration fit the general pattern of the abundance indices reasonably well (Figure 5). However, to fit all the indices precisely would be impossible, given the apparent noise in the data (e.g., high points in the seine JAI around 1985) and the disagreement on recent trends.

This run estimates that stock biomass has been increasing since about 1990 and that fishing mortality has been decreasing since about 1985 (Figure 6a). Terminal-year B is estimated well above B_{MSY}, and terminal F well below F_{MSY} (Table 3). Recent yields have been somewhat below the estimated MSY.

4.2 Length of removals series

Using the extended landings series has a small but noticeable effect on the model status estimates. In runs using all four indices, the additional landings allow the estimate of B_{1948} to be higher than the constrained value of $0.85\,K$ assumed in the reference configuration (Figure 6a,b). This in turn corresponds to estimates of fewer years in overfishing and no years of $B < B_{\text{MSY}}$.

When the extended landing series is used in a run with only the AAIs (no JAIs), and compared to a similar run with the standard landings series, the differences are similar, though considerably less pronounced (Figure 6c,d).

4.3 Single-series models

An attempted run (001) with the seine JAI only did not yield usable estimates. Apparently, this data set is not sufficiently informative for modeling by itself.

The run (002) with only the trawl JAI produced estimates, but we do not deem them stable enough to be considered reliable. In a bootstrap of this configuration with 1,000 trials, 980 trials initially could not converge to estimates within reasonable bounds. Thus, this configuration was not informative.

The run (020) using only the gillnet AAI fit the data quite well, except for the last year's lower value (Figure 7a). Its status estimates were not unlike those of the reference configuration, but depict a somewhat more dynamic population; i. e., one whose population level changes more rapidly (Figure 7b).

The run (021) using only the reduction AAI fit the data reasonably well. (Figure 8a). The lack of fit (overestimation) in the first decade suggests that the initial condition $B_1 = 0.85K$ was not a good match to this configuration. However, an exploratory run without that condition failed to produce stable estimates. The so-called one-way trip (steady decline) portrayed in this index rarely contains enough information to stably estimate production-model parameters.

4.4 Omission of gillnet series

As noted in §2.4, the gillnet AAI could be considered the most optimistic of the abundance indices. For that reason, its omission would be expected to produce a more pessimistic result. Results of run 005, similar to the reference configuration but without the gillnet index, bear out that speculation to some degree, with the biomass series showing a steady decline until about 2005, and a slight increase thereafter (Figure 9d.). Still, this sensitivity run indicates neither $F > F_{\mathrm{MSY}}$ nor $B < B_{\mathrm{MSY}}$ in the terminal year.

4.5 Fishing power assumption

The assumption on fishing power in the reduction fishery (see §2.3.2) is moderately influential on the resulting status estimates. When the fishing-power increase per year (γ) is assumed to have been zero, we estimated that B never went below B_{MSY} and that F never exceeded F_{MSY} (Figure 10a). When we assumed $\gamma = 1\%\,\mathrm{yr}^{-1}$ (the reference configuration), a short period of overfishing was estimated, in the 1980s (Figure 10b). When we assumed $\gamma = 2\%\,\mathrm{yr}^{-1}$, the highest value examined, the period of overfishing was longer, extending for about 20 years (Figure 10c).

4.6 Model shape assumption

The sensitivity run with Fox model shape is compared to the proposed reference configuration in Figure 11. Status estimates under the Fox model are that overfishing was briefer and that biomass was never less than B_{MSY} (Figure 11b).

4.7 Bootstrap and projection

Bootstrap confidence intervals in this analysis were unusually narrow (Table 4, Figure 12). These narrow intervals represent statistical uncertainty in the reference configuration, and do not include model uncertainty, nor other forms of uncertainty.

The projection estimates that continuing to take the current yield, i.e., Y_{2010}, would be a sustainable policy. Under that policy, stock biomass would be expected to increase.

5 Discussion

In this work, we examined uncertainty in our results in two distinct ways: by considering each data source, in turn, in a series of sensitivity runs (Table 1), and by using the bootstrap. Although the four indices of abundance do not completely agree about population trend, our results were relatively robust to choice of data sets (Table 3).

Uncertainty as estimated by the bootstrap seems unusually low in this analysis. instead of relying solely on the bootstrap, one might instead estimate uncertainty in quantities of management interest by examining the distributions of estimates from all runs in Table 3. Such a procedure would incorporate more of the uncertainty about which data sets are more reliable. Time limitations did not allow us to use that approach in this report.

We lagged both JAIs by one year (advanced the years by one) in an attempt to align them with the AAIs. We have some uncertainty about the optimal lag to use in that context, as the age structure of the fishery has shifted slightly in recent decades to older fish, and adult sampling by gillnets may favor two-year-olds, rather than one-year-olds. However, each abundance index is highly autocorrelated, so a difference of one year in lag seems unlikely to make much difference.

The status estimates can be summarized as follows: With starting biomass fixed to $0.85K$, all runs estimate initial high biomass, declining to a minimum somewhere in the late 1980s (following historically high landings in the mid-1980s), then rising to the present. The degree of biomass decline varies with data configuration. Estimates from some configurations dip below $B = B_{\text{MSY}}$; others do not. None falls below an overfished criterion set at $B = 0.5B_{\text{MSY}}$.

Fishing pressure generally follows the landings pattern. It rises from low initial values, peaks with peak landings in the 1980s, and then declines. Most, but not all, runs estimate that overfishing occurred during the 1980s, if overfishing is defined as $F > F_{\text{MSY}}$. All runs suggest that F has declined since the mid 1980s, to values well below that overfishing definition.

Because there is no reason to discard any of the available data series, We suggest a reference run using all data inputs for discussion during the SEDAR 27 Assessment Workshop in July, 2011.

6 Acknowledgments

M. H. Prager's participation in this work was supported by Omega Protein Corporation. D. S. Vaughan's participation was supported by NOAA. Analysis and graphing

of model results was accomplished with version 2.13.0 of the open-source statistics language R (R Development Core Team 2011).

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7 Tables

Table 1. Production model data configurations by run number.

Run no.	Total catch	Juvenile indices: Seine	Juvenile indices: Trawl	Adult indices: Gillnet	Adult indices: Reduction	B_1/K	Notes
1	✓	✓	–	–	–	0.85	No fit
2	✓	–	✓	–	–	0.85	Fit unstable
3	✓	✓	✓	–	–	0.85	No fit
4	✓	✓	✓	✓	–	0.85	
5	✓	✓	✓	–	1%	0.85	
6	✓	✓	✓	✓	1%	0.85	Reference config.
7	✓	✓	✓	✓	nom	0.85	
8	✓	✓	✓	✓	2%	0.85	
9	extended	✓	✓	✓	1%	0.85	
10	✓	✓	✓	✓	1%	0.85	Fox model
20	✓	–	–	✓	–	0.85	
21	✓	–	–	–	1%	0.85	
22	✓	–	–	✓	nom	0.85	
23	✓	–	–	✓	1%	0.85	
24	✓	–	–	✓	2%	0.85	
25	extended	–	–	✓	1%	0.85	
26	✓	–	–	✓	1%	0.85	Fox model

Table 2. Pairwise correlations between abundance indices of gulf menhaden.

	Adult indices		**Juvenile indices**	
	Gillnet	Reduction	Seine	Trawl
Gillnet	1.00	−0.14	−0.45	−0.02
Reduction	−0.14	1.00	0.49	0.34
Seine	−0.45	0.49	1.00	0.43
Trawl	−0.02	0.34	0.43	1.00

Table 3. Estimates from production model analyses of gulf menhaden. Runs 001–003 did not produce usable estimates and are omitted. Run 006 (ruled) is proposed reference configuration.

Run	MSY	F/F_{MSY} in 2010	B/B_{MSY} in 2011	Y_{eq} in 2011	Y at F_{MSY} in 2011
004	653	0.40	1.47	506	920
005	493	0.75	1.03	493	507
006	626	0.45	1.35	548	829
007	782	0.30	1.63	474	1215
008	599	0.61	1.07	596	640
009	618	0.47	1.33	549	813
010	661	0.35	1.68	534	1072
020	680	0.36	1.56	470	984
021	497	0.76	1.02	496	506
022	760	0.31	1.62	469	1169
023	635	0.44	1.39	537	858
024	610	0.58	1.11	603	670
025	634	0.44	1.39	538	857
026	663	0.34	1.70	528	1083

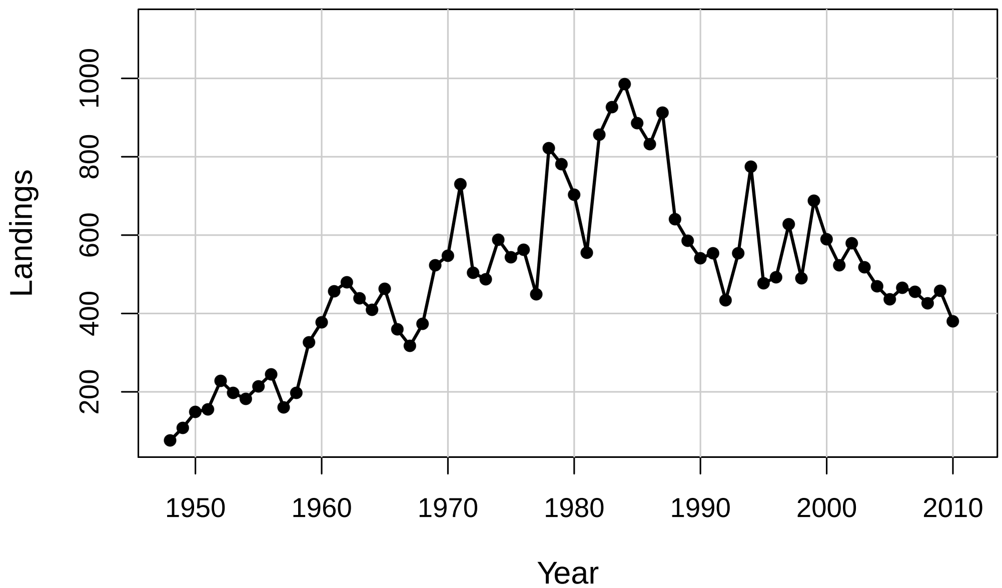
Table 4. Estimates from reference production model of gulf menhaden, with non-parametric measures of uncertainty derived from the bootstrap.

Quantity	Point estimate	80% conf. bounds Lower	80% conf. bounds Upper	Interquartile range (IQR)	Relative IQR
MSY	626	605	647	235	0.037
B_{2011}/B_{MSY}	1.35	1.26	1.44	0.102	0.075
F_{2010}/F_{MSY}	0.455	0.414	0.504	0.053	0.117
$Y_{e,2011}$	548	521	563	23.5	0.043
Y_{2011} at F_{MSY}	829	754	901	87.6	0.106

Note: Units of MSY are 1,000 t per year. Interquartile range (IQR), the difference between the 75th and 25th percentiles, is a nonparametric statistic similar in concept to the standard deviation. Relative interquartile range is the IQR divided by the point estimate and is similar in concept to a coefficient of variation.

8 Figures

Figure 1. Landings data used in production modeling of gulf menhaden. (Top) standard landings series, 1948–2010; (bottom) extended landings series, 1920–2010.



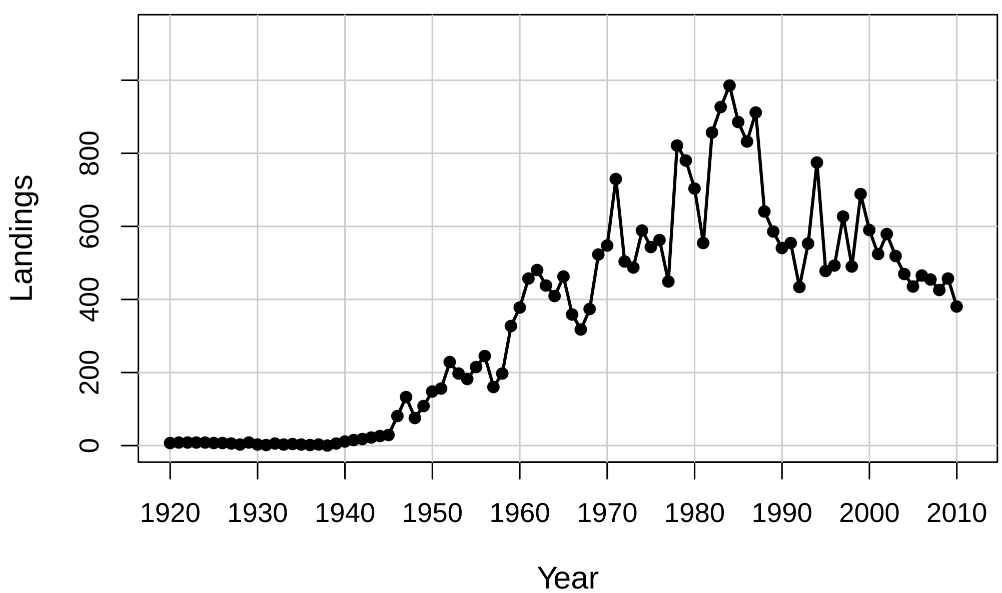


Figure 2. Abundance indices used in production modeling of gulf menhaden: (a) gill-net adult index, (b) reduction fishery adult CPUE index with 1% per year adjustment for fishing-power increase, (c) seine juvenile index, (d) trawl juvenile index. Dates of juvenile index values were increased by one year (see text).

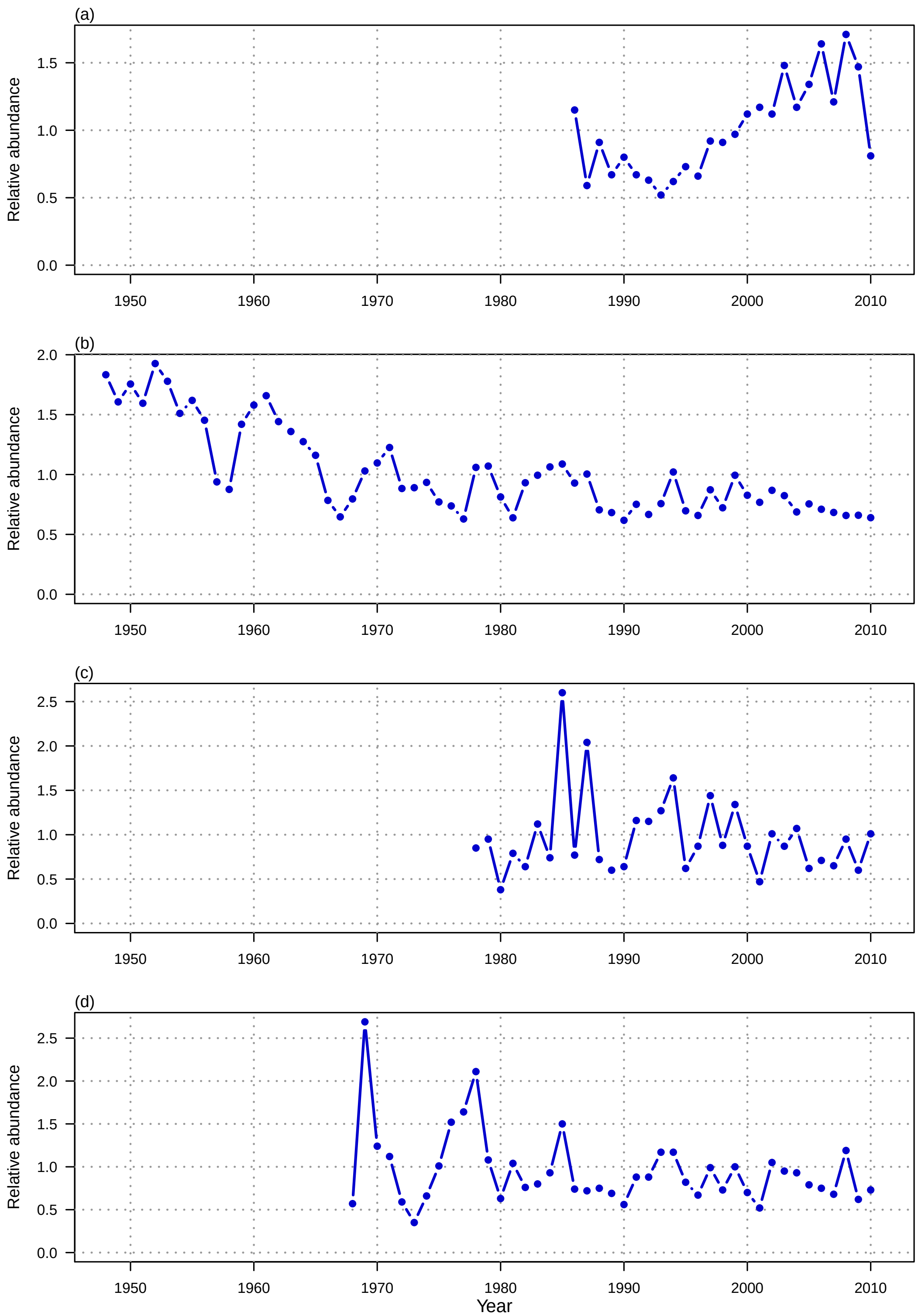


Figure 3. Effects of three assumptions about annual fishing-power increase γ on abundance index based on reduction CPUE. (a) nominal CPUE index ($\gamma = 0$), (b) index with $\gamma = 1\%$ per year, (c) index with $\gamma = 2\%$ per year.

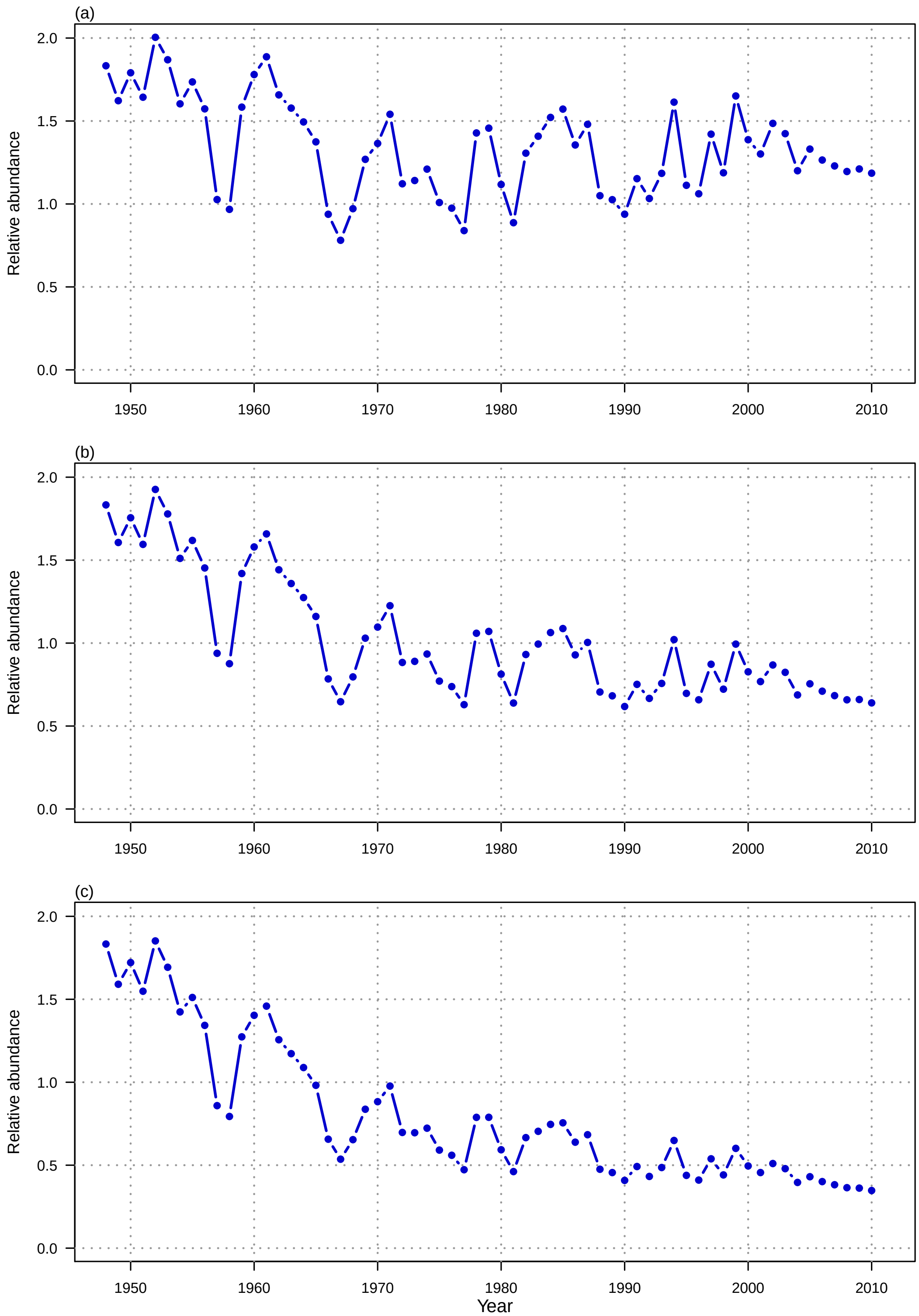


Figure 4. Pairwise correlations among abundance indices used in production modeling of gulf menhaden. U.01 is gillnet adult index; U.02, reduction-fishery adult CPUE index (adjusted $1\% \cdot \mathrm{yr}^{-1}$ *for fishing-power increase); U.03, seine juvenile index; U.04, trawl juvenile index. Dates of juvenile indices were increased by one year.*

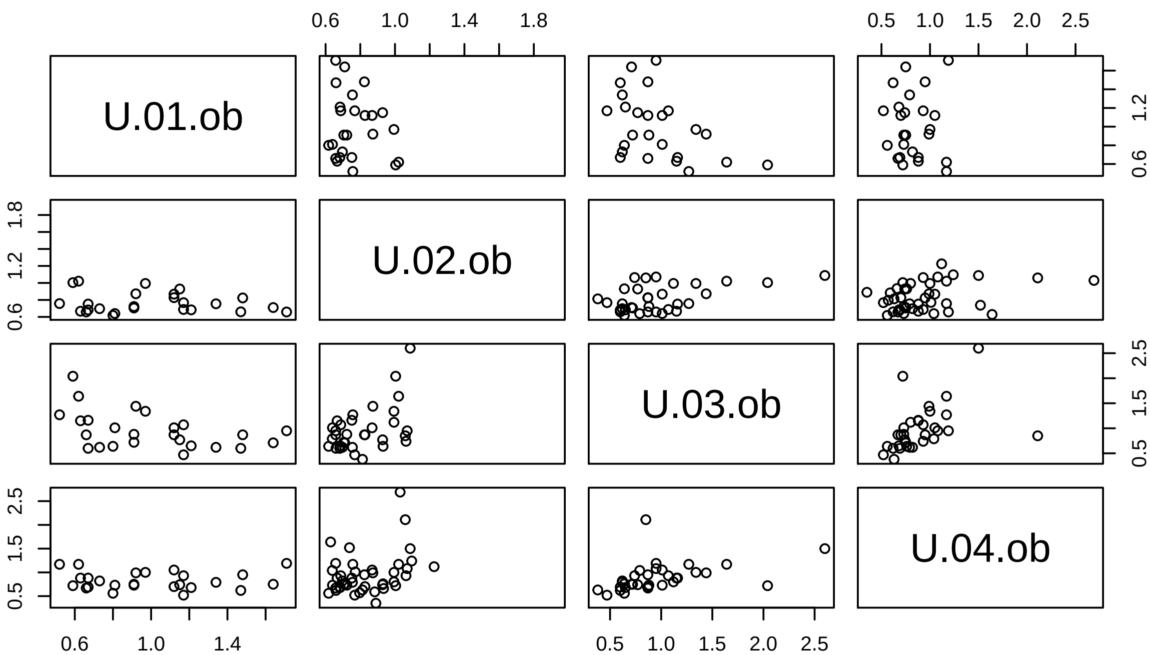


Figure 5. Fit of proposed reference configuration (run 006) to (a) gillnet adult index, (b) reduction CPUE index with 1%/yr fishing-power adjustment, (c) seine JAI, (d) trawl JAI.

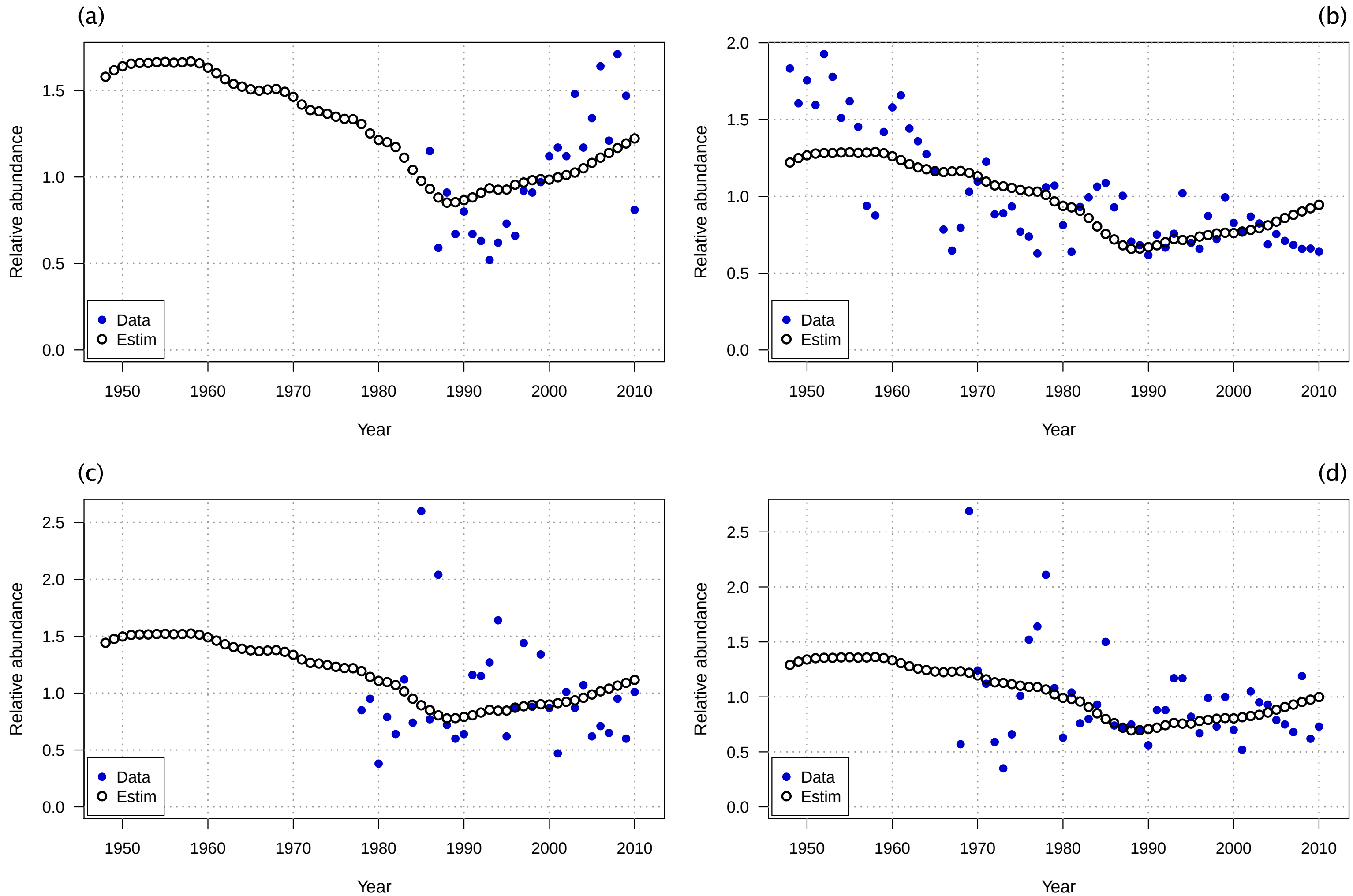


Figure 6. Stock and fishery status estimates from (a) run 006 (proposed reference configuration); (b) model run 009 (four indices, longer landings series); (c) run 023 (adult indices only, shorter landings series); and (d) run 025 (adult indices only, longer landings series).

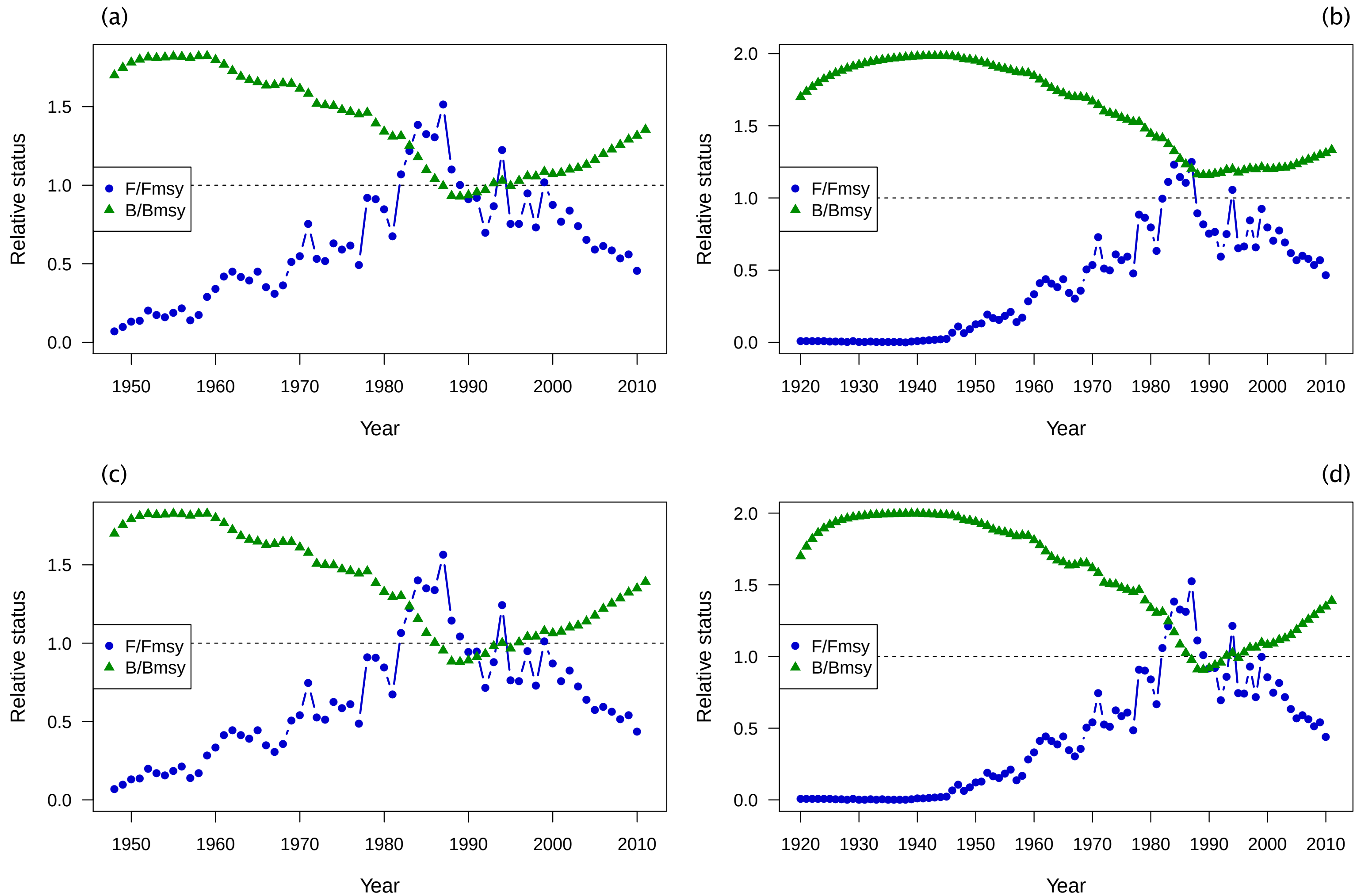


Figure 7. Model run 020: gillnet adult index and total removals. Panel (a), model fit; (b), status estimates.

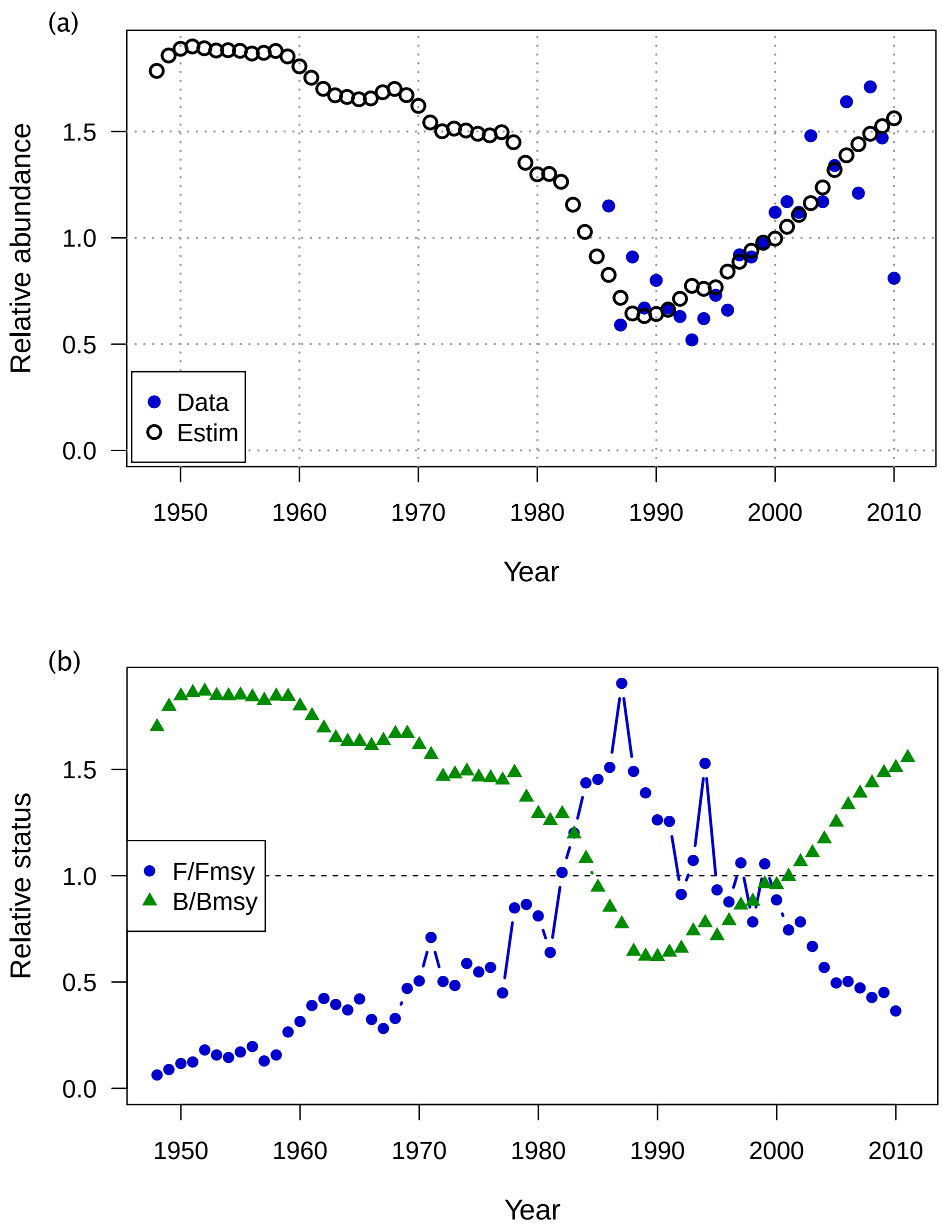


Figure 8. Model run 021: reduction-fishery adult index and total removals. Panel (a), model fit; (b), status estimates. Estimates are dependent on fixed initial condition $B_1 = 0.85K$ and are not stable without some such constraint. We do not consider them informative.

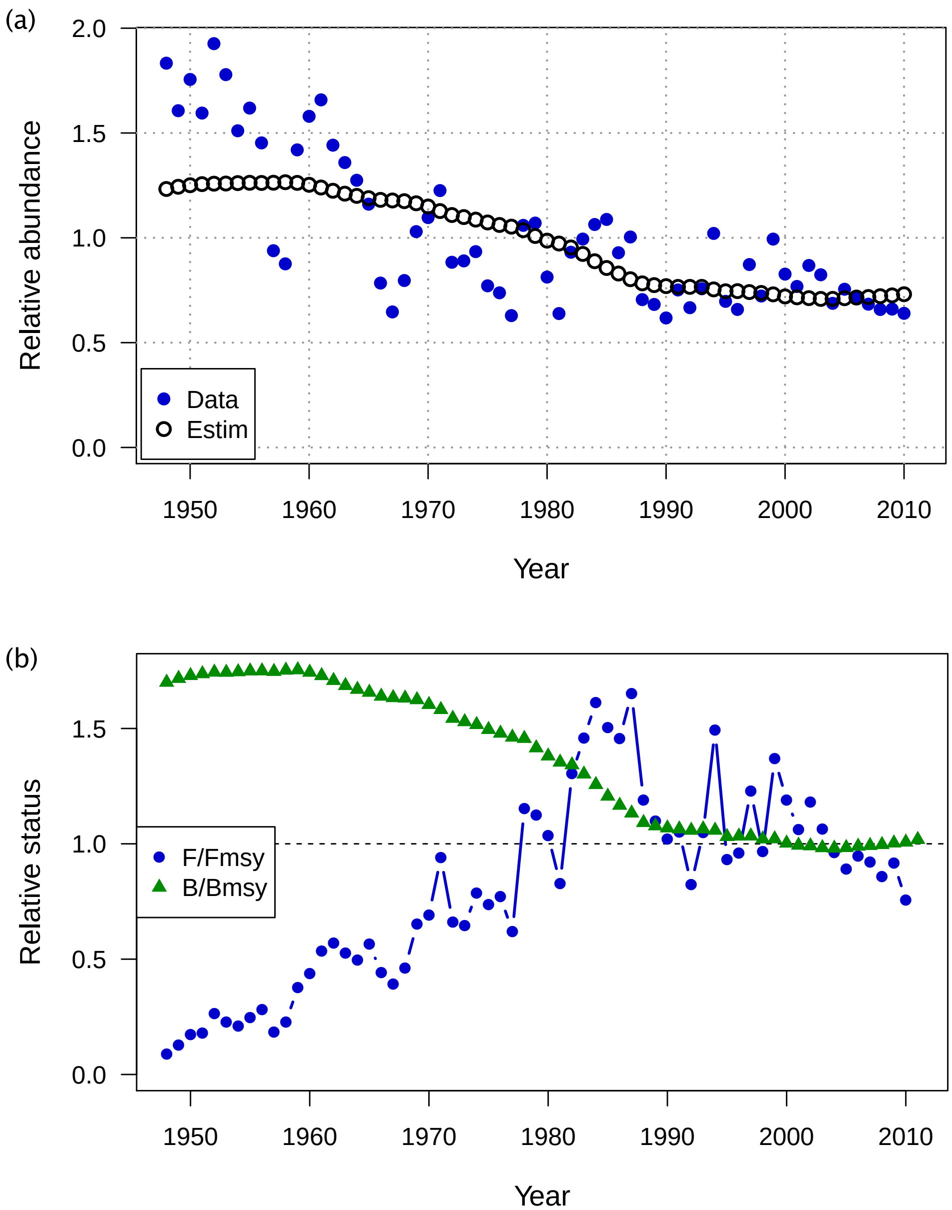


Figure 9. Model run 005: Similar to reference configuration, but without gillnet index. Panel (a), fit to reduction AAI; (b), fit to seine JAI, (c), fit to trawl JAI; (d), status estimates.

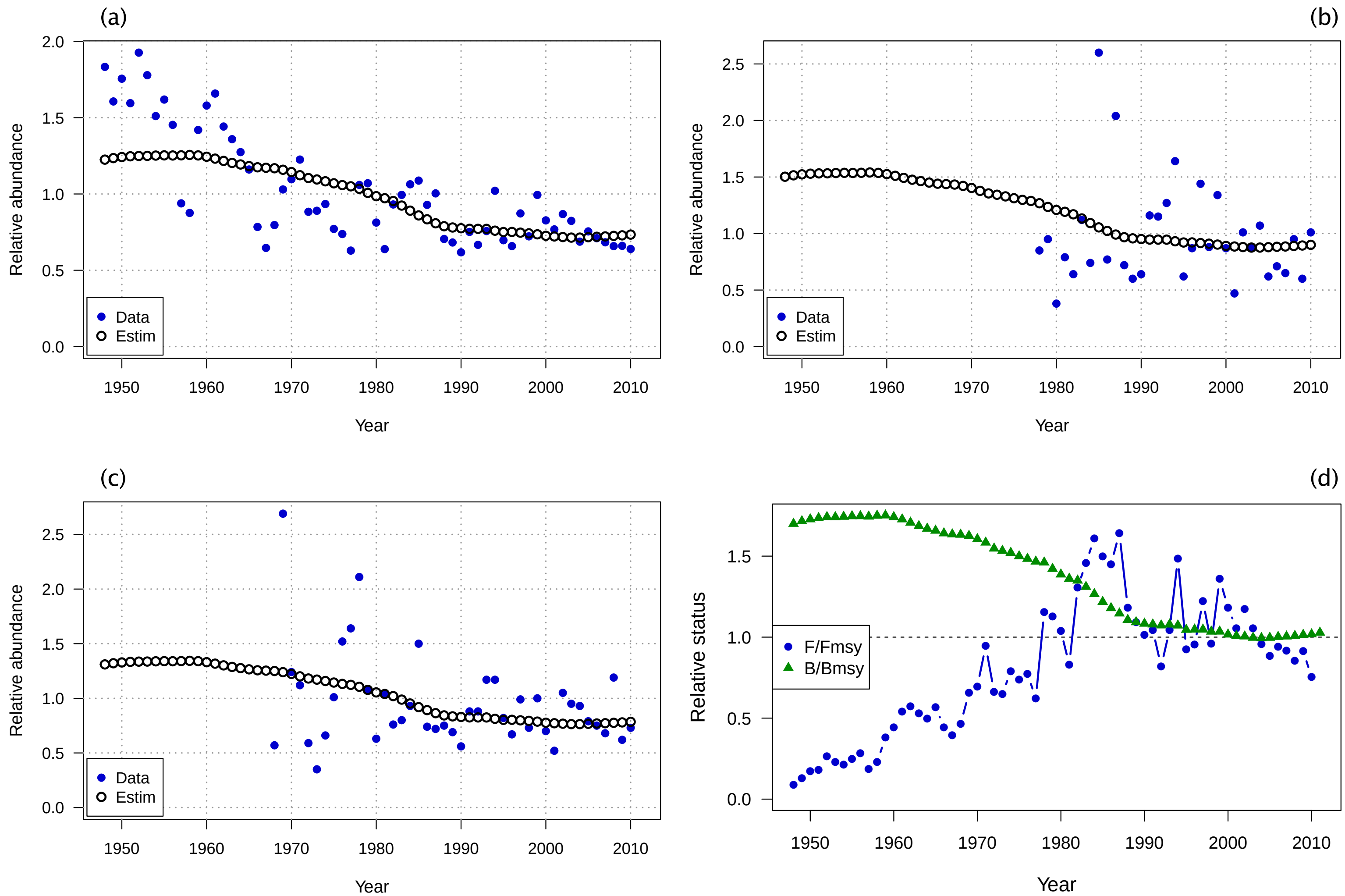


Figure 10. Effects on status estimates of assumptions about fishing-power increase in the reduction fishery. Each model uses all four indices. (a) Run 007, nominal index (increase assumed to be zero; (b) run 006, reference configuration (increase assumed to be 1% per year); (c) run 008, increase assumed to be 2% per year.)

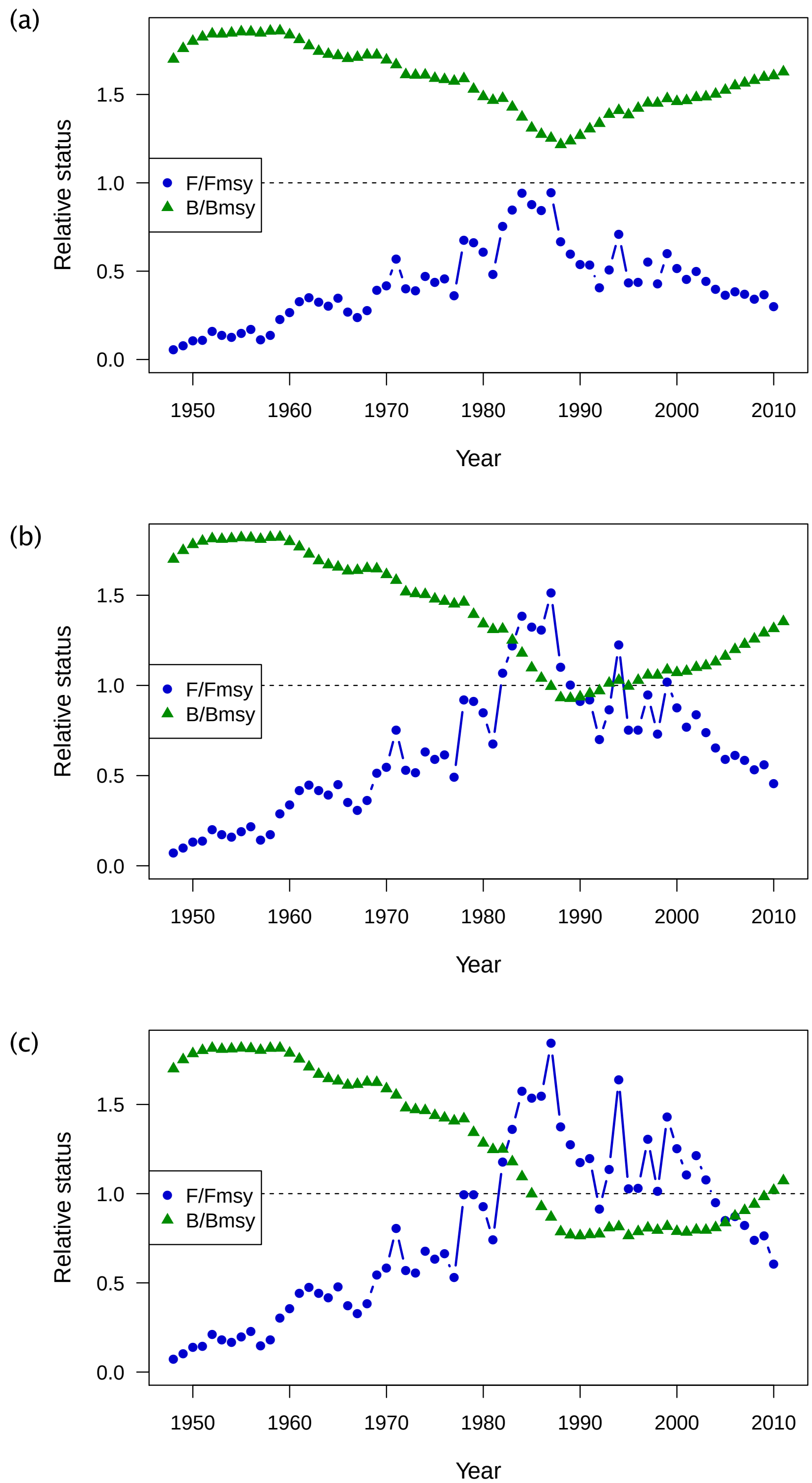


Figure 11. Sensitivity to assumption on model shape. Status estimates from (a) run 006, reference configuration with Schaefer model (symmetrical shape) and (b) run 010, same configuration but with Fox model shape.

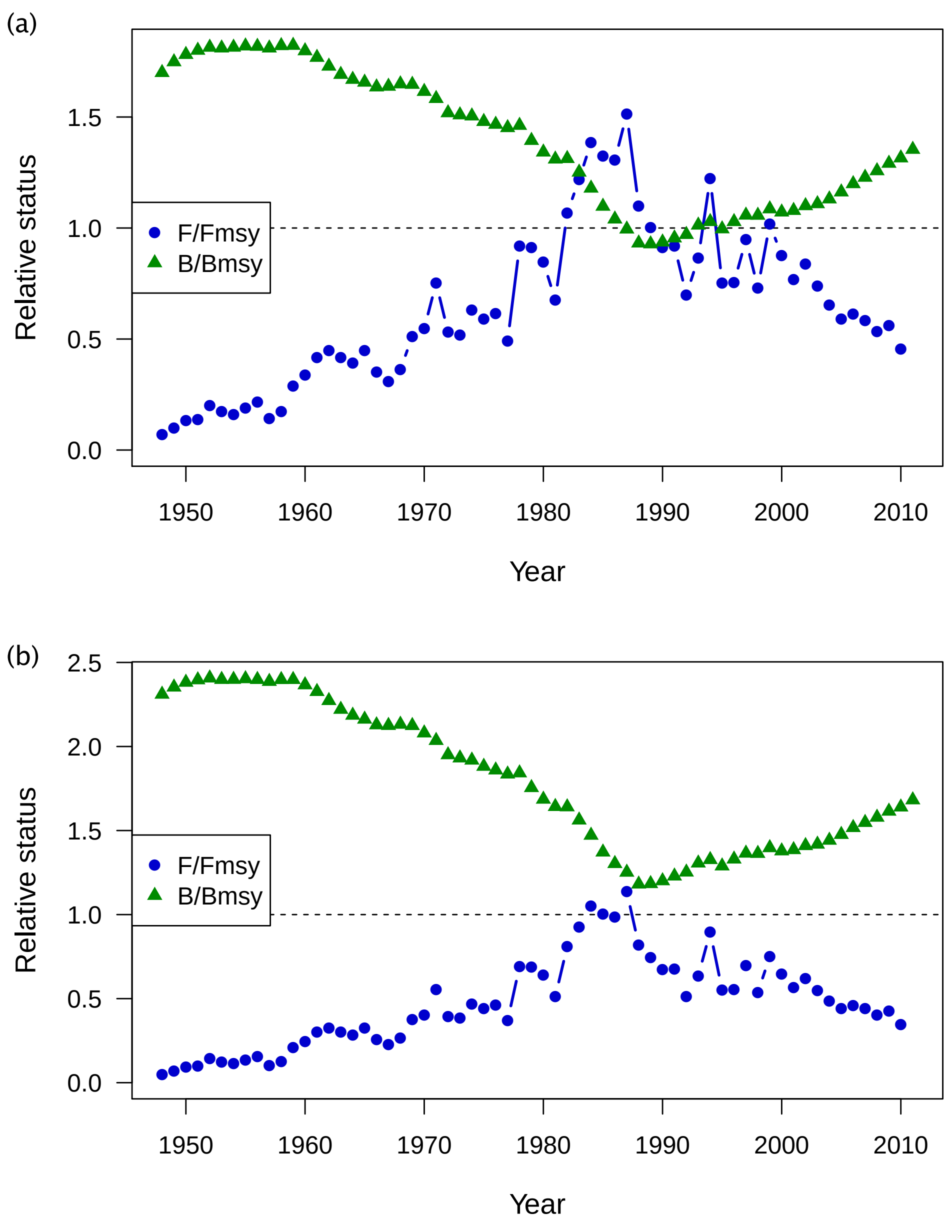
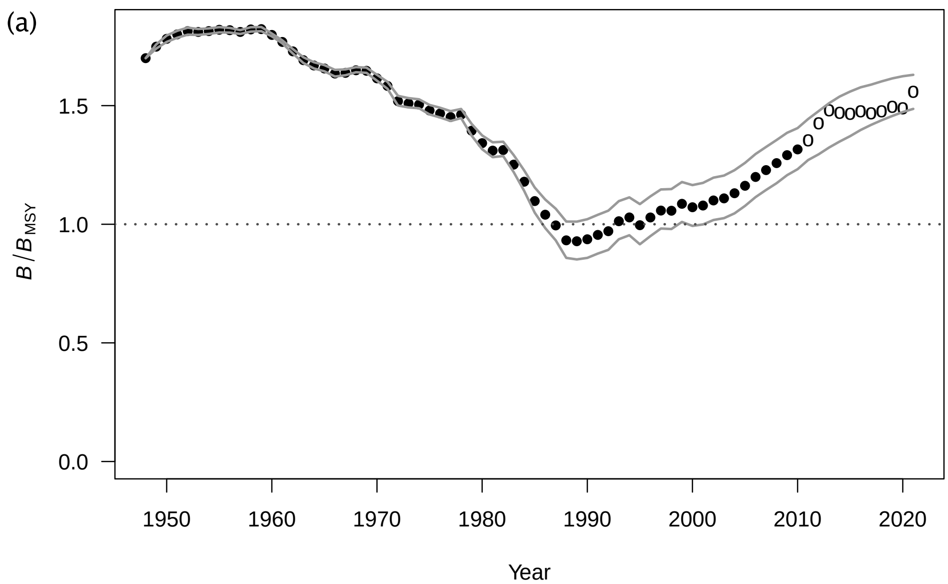
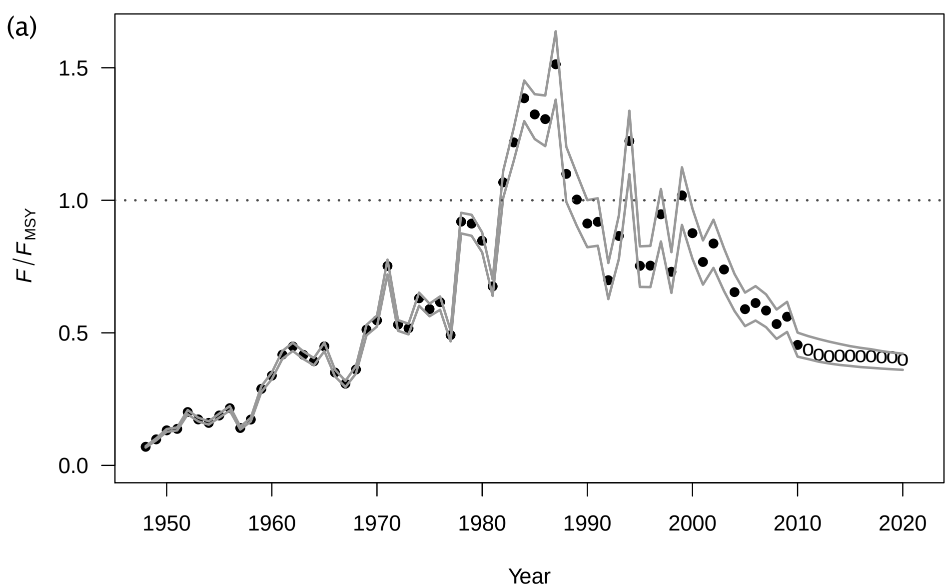


Figure 12. (a) Relative biomass B/B_{MSY} and (b) relative fishing mortality rate F/F_{MSY} of gulf menhaden during assessment period and in stochastic 10-yr projection. Projected fishing is constant at $Y_t = Y_{2010}$. Filled circles mark assessment period; open circles, projection period in which MSY varies annually with 20% CV. Gray lines mark 80% confidence interval from bootstrap.





Appendices

A Objective function and weighting used by ASPIC

This section describes the ASPIC objective function and approach to statistical weighting of data. The ASPIC optimization routine uses weighted least squares, a method equivalent to maximum likelihood estimation (Bradley 1973).

The objective function of ASPIC contains a term for each index series:

$$\sum_t w_i \, \tilde{w}_{it} \left(\log X - \log \hat{X} \right)^2 \tag{1}$$

where

t is an index of time (usually in years),

w_i is a data-series specific statistical weight,

$\tilde{w}_{it}$ is an additional weighting factor to accommodate yearly values,

X is the observed population estimate or abundance index, and

$\hat{X}$ is the model's estimated population size or abundance index value,

For maximum likelihood estimation, the product $w_i \tilde{w}_{it}$ should equal $1/\sigma^2_{it}$, i. e., the product of the two weighting factors should equal the reciprocal of the sampling variance of the annual observation (in log transformation). Since the standard deviation of the log-transformed data is closely approximated by the coefficient of variation of the untransformed data, the product of the weights can be set to the reciprocal of the squared coefficient of variation (CV) of each untransformed observation. That was done in this study.

B ASPIC input and output files

B.1 ASPIC input file—reference configuration

```
FIT                     ## Run type (FIT, BOT, or IRF)
"Gulf Menhaden Production Model 2011"
LOGISTIC  YLD  WTDSSE   ## See notes at end of this file
102                     ## Verbosity on screen (0-3); add 10 for SUM & PRN files
1000  90                ## N bootstrap trials <= 1000, user bootst. conf. intvl.
0 2000000               ## 0=no MC search, 1=search, 2=repeated srch; N trials
1d-8                    ## Convergence crit. for simplex
3d-8    8               ## Convergence crit. for restarts, N restarts
1d-4    24              ## Conv. crit. for F; N steps/yr for gen. model
6d0                     ## Maximum F when cond. on yield
0d0                     ## Stat weight for B1>K as residual (usually 0 or 1)
4                       ## Number of fisheries (data series)
1d0  1d0  1d0  1d0      ## Statistical weights for data series
0.85d0                  ## B1/K (starting guess, usually 0 to 1)
6.5d2                   ## MSY (starting guess)
1.0d4                   ## K (carrying capacity) (starting guess)
2d-4  2d-4  2d-4  2d-4  ## q (starting guesses -- 1 per data series)
0 1 1 1 1 1 1 1         ## Estimate flags (0 or 1) (B1/K,MSY,K,q1...qn)
500.0  1.0d4            ## Min and max constraints -- MSY
1.0d3  1.0d5            ## Min and max constraints -- K
3921295                 ## Random number seed (large integer)
63                      ## Number of years of data in each series
"Gillnet AAI, total yield"
CC
1948      -1.0           75.79        0.00
1949      -1.0          108.59        0.00
1950      -1.0          148.38        0.00
1951      -1.0          155.99        0.00
1952      -1.0          228.29        0.00
1953      -1.0          196.88        0.00
1954      -1.0          182.38        0.00
1955      -1.0          214.49        0.00
1956      -1.0          245.20        0.00
1957      -1.0          160.49        0.00
1958      -1.0          197.42        0.00
1959      -1.0          327.09        0.00
1960      -1.0          377.99        0.00
1961      -1.0          457.09        0.00
1962      -1.0          480.19        0.00
1963      -1.0          438.70        0.00
1964      -1.0          409.02        0.00
1965      -1.0          462.58        0.00
1966      -1.0          359.04        0.00
1967      -1.0          317.34        0.00
1968      -1.0          373.29        0.00
1969      -1.0          522.82        0.00
1970      -1.0          547.36        0.00
1971      -1.0          730.05        0.00
1972      -1.0          503.37        0.00
1973      -1.0          488.03        0.00
1974      -1.0          588.90        0.00
1975      -1.0          543.99        0.00
1976      -1.0          562.71        0.00
```

1977	-1.0	448.58	0.00
1978	-1.0	821.59	0.00
1979	-1.0	780.81	0.00
1980	-1.0	703.48	0.00
1981	-1.0	554.69	0.00
1982	-1.0	856.50	0.00
1983	-1.0	926.24	0.00
1984	-1.0	986.09	0.00
1985	-1.0	885.52	0.00
1986	1.15	831.85	197.26
1987	0.59	912.12	158.93
1988	0.91	640.59	189.37
1989	0.67	585.61	178.58
1990	0.80	540.51	179.69
1991	0.67	554.00	173.70
1992	0.63	434.05	159.98
1993	0.52	553.25	142.51
1994	0.62	775.28	137.80
1995	0.73	477.37	150.16
1996	0.66	492.32	162.84
1997	0.92	627.26	168.41
1998	0.91	490.17	169.91
1999	0.97	688.01	191.66
2000	1.12	589.93	192.44
2001	1.17	523.70	190.81
2002	1.12	579.02	220.48
2003	1.48	518.41	220.26
2004	1.17	469.40	230.05
2005	1.34	435.90	236.58
2006	1.64	465.72	261.42
2007	1.21	454.80	231.52
2008	1.71	425.68	256.45
2009	1.47	457.84	281.41
2010	0.81	380.03	177.45

"Reduction AAI 1% adj CPUE"
I1

1948	1.832924	156.25
1949	1.606294	156.25
1950	1.755469	156.25
1951	1.594983	156.25
1952	1.926202	156.25
1953	1.778432	156.25
1954	1.510607	156.25
1955	1.618786	156.25
1956	1.452804	156.25
1957	0.9384944	156.25
1958	0.875825	156.25
1959	1.419397	156.25
1960	1.579551	156.25
1961	1.658039	156.25
1962	1.441911	156.25
1963	1.358963	156.25
1964	1.274388	156.25
1965	1.16039	156.25
1966	0.784054	156.25
1967	0.6465248	156.25
1968	0.7962084	156.25
1969	1.029588	156.25
1970	1.096435	156.25

1971	1.225374	156.25
1972	0.883306	156.25
1973	0.8899094	156.25
1974	0.9340906	156.25
1975	0.7709397	156.25
1976	0.7376452	156.25
1977	0.6289297	156.25
1978	1.059336	156.25
1979	1.070289	156.25
1980	0.8127125	156.25
1981	0.6387303	156.25
1982	0.9311838	156.25
1983	0.994071	156.25
1984	1.063483	156.25
1985	1.08763	156.25
1986	0.9287132	156.25
1987	1.003969	156.25
1988	0.7051171	156.25
1989	0.6821282	156.25
1990	0.6177281	156.25
1991	0.7512791	156.25
1992	0.6666439	156.25
1993	0.7569824	156.25
1994	1.020944	156.25
1995	0.6969213	156.25
1996	0.6582972	156.25
1997	0.8725004	156.25
1998	0.7222782	156.25
1999	0.9938754	156.25
2000	0.8268593	156.25
2001	0.7679695	156.25
2002	0.8680839	156.25
2003	0.8236698	156.25
2004	0.6875068	156.25
2005	0.754664	156.25
2006	0.7101496	156.25
2007	0.6833477	156.25
2008	0.6581261	156.25
2009	0.6599717	156.25
2010	0.6396737	156.25

"Seine JAI +1yr"
I1

1948	-1.0	0.00
1949	-1.0	0.00
1950	-1.0	0.00
1951	-1.0	0.00
1952	-1.0	0.00
1953	-1.0	0.00
1954	-1.0	0.00
1955	-1.0	0.00
1956	-1.0	0.00
1957	-1.0	0.00
1958	-1.0	0.00
1959	-1.0	0.00
1960	-1.0	0.00
1961	-1.0	0.00
1962	-1.0	0.00
1963	-1.0	0.00
1964	-1.0	0.00

```
1965    -1.0             0.00
1966    -1.0             0.00
1967    -1.0             0.00
1968    -1.0             0.00
1969    -1.0             0.00
1970    -1.0             0.00
1971    -1.0             0.00
1972    -1.0             0.00
1973    -1.0             0.00
1974    -1.0             0.00
1975    -1.0             0.00
1976    -1.0             0.00
1977    -1.0             0.00
1978     0.85            1.08
1979     0.95            1.65
1980     0.38            2.14
1981     0.79            2.34
1982     0.64            4.43
1983     1.12            6.19
1984     0.74            7.22
1985     2.60            9.81
1986     0.77            6.48
1987     2.04           12.61
1988     0.72           11.25
1989     0.60           10.06
1990     0.64           11.93
1991     1.16           17.43
1992     1.15           17.21
1993     1.27           18.36
1994     1.64           19.17
1995     0.62           15.99
1996     0.87           18.30
1997     1.44           19.62
1998     0.88           21.00
1999     1.34           21.66
2000     0.87           18.19
2001     0.47           15.99
2002     1.01           20.73
2003     0.87           21.61
2004     1.07           21.45
2005     0.62           20.79
2006     0.71           21.52
2007     0.65           18.99
2008     0.95           23.70
2009     0.60           22.10
2010     1.01           22.21
"Trawl JAI +1yr"
I1
1948   -1.0                   0.00
1949   -1.0                   0.00
1950   -1.0                   0.00
1951   -1.0                   0.00
1952   -1.0                   0.00
1953   -1.0                   0.00
1954   -1.0                   0.00
1955   -1.0                   0.00
1956   -1.0                   0.00
1957   -1.0                   0.00
1958   -1.0                   0.00
```

1959	-1.0	0.00
1960	-1.0	0.00
1961	-1.0	0.00
1962	-1.0	0.00
1963	-1.0	0.00
1964	-1.0	0.00
1965	-1.0	0.00
1966	-1.0	0.00
1967	-1.0	0.00
1968	0.57	10.31
1969	2.69	10.18
1970	1.24	5.82
1971	1.12	10.95
1972	0.59	7.71
1973	0.35	9.26
1974	0.66	15.35
1975	1.01	32.35
1976	1.52	9.39
1977	1.64	6.54
1978	2.11	12.20
1979	1.08	16.04
1980	0.63	14.86
1981	1.04	8.97
1982	0.76	21.47
1983	0.80	53.43
1984	0.93	35.69
1985	1.50	40.84
1986	0.74	57.77
1987	0.72	36.94
1988	0.75	53.30
1989	0.69	47.38
1990	0.56	40.86
1991	0.88	40.57
1992	0.88	56.34
1993	1.17	60.06
1994	1.17	52.85
1995	0.82	37.18
1996	0.67	50.19
1997	0.99	49.97
1998	0.73	59.80
1999	1.00	51.06
2000	0.70	41.59
2001	0.52	53.67
2002	1.05	49.48
2003	0.95	59.34
2004	0.93	65.31
2005	0.79	67.22
2006	0.75	48.84
2007	0.68	55.63
2008	1.19	53.06
2009	0.62	55.84
2010	0.73	51.73

B.2 ASPIC output file—reference configuration

```
Gulf Menhaden Production Model 2011                                                                           Page 1
                                                                                    Saturday, 09 Jul 2011 at 17:30:08
ASPIC -- A Surplus-Production Model Including Covariates (Ver. 5.44)
                                                                                                     FIT program mode
Author:     Michael H. Prager                                                                    LOGISTIC model mode
            Prager Consulting                                                                       YLD conditioning
            mike.prager@mhprager.com                                                            WTDSSE optimization

Reference:  Prager, M. H. 1994. A suite of extensions to a nonequilibrium             ASPIC User's Manual is available
            surplus-production model.  Fishery Bulletin 92: 374-389.                           gratis from the author.

CONTROL PARAMETERS (FROM INPUT FILE)           Input file: e:\...omega protein\gm 2011\production model\gm_2011_006.inp
------------------------------------------------------------------------------------------------------------------------
Operation of ASPIC:  Fit logistic (Schaefer) model by direct optimization.
Number of years analyzed:                       63            Number of bootstrap trials:                             0
Number of data series:                           4            Bounds on MSY (min, max):       5.000E+02     1.000E+04
Objective function:                  Least squares            Bounds on K (min, max):         1.000E+03     1.000E+05
Relative conv. criterion (simplex):      1.000E-08            Monte Carlo search mode, trials:        0       2000000
Relative conv. criterion (restart):      3.000E-08            Random number seed:                             3921295
Relative conv. criterion (effort):       1.000E-04            Identical convergences required in fitting:           8
Maximum F allowed in fitting:                6.000


PROGRAM STATUS INFORMATION (NON-BOOTSTRAPPED ANALYSIS)                                                  error code   0
------------------------------------------------------------------------------------------------------------------------
Normal convergence

WARNING: Negative correlations detected between some indices.  A fundamental assumption of ASPIC is that all indices
         represent the abundance of the stock. That assumption should be checked.
Number of restarts required for convergence:      8


CORRELATION AMONG INPUT SERIES EXPRESSED AS CPUE (NUMBER OF PAIRWISE OBSERVATIONS BELOW)
------------------------------------------------------------------------------------------------------------------------
                                       |
 1  Gillnet AAI, total yield           |   1.000
                                       |      25
                                       |
 2  Reduction AAI 1% adj CPUE          |  -0.145   1.000
                                       |      25      63
                                       |
 3  Seine JAI +1yr                     |  -0.448   0.495   1.000
                                       |      25      33      33
                                       |
 4  Trawl JAI +1yr                     |  -0.018   0.344   0.434   1.000
                                       |      25      43      33      43
                                       --------------------------------------------------
                                              1       2       3       4


GOODNESS-OF-FIT AND WEIGHTING (NON-BOOTSTRAPPED ANALYSIS)
------------------------------------------------------------------------------------------------------------------------
                                                    Weighted           Weighted      Current    Inv. var.    R-squared
Loss component number and title                          SSE      N         MSE       weight       weight      in CPUE
```

Loss(-1)	SSE in yield	0.000E+00					
Loss(0)	Penalty for B1 > K	0.000E+00	1	N/A	0.000E+00	N/A	
Loss(1)	Gillnet AAI, total yield	3.585E+02	25	1.559E+01	1.000E+00	3.146E-01	0.337
Loss(2)	Reduction AAI 1% adj CPUE	5.947E+02	63	9.750E+00	1.000E+00	5.030E-01	0.470
Loss(3)	Seine JAI +1yr	8.055E+01	33	2.598E+00	1.000E+00	1.887E+00	-0.218
Loss(4)	Trawl JAI +1yr	1.391E+02	43	3.392E+00	1.000E+00	1.446E+00	0.093

TOTAL OBJECTIVE FUNCTION, MSE, RMSE:	1.17283189E+03	7.423E+00	2.725E+00
Estimated contrast index (ideal = 1.0):	0.4471	C* = (Bmax-Bmin)/K	
Estimated nearness index (ideal = 1.0):	1.0000	N* = 1 - |min(B-Bmsy)|/K	

MODEL PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	User/pgm guess	2nd guess	Estimated	User guess
B1/K	Starting relative biomass (in 1948)	8.500E-01	8.500E-01	6.708E-01	0	1
MSY	Maximum sustainable yield	6.262E+02	6.500E+02	2.400E+03	1	1
K	Maximum population size	9.124E+03	1.000E+04	2.531E+03	1	1
phi	Shape of production curve (Bmsy/K)	0.5000	0.5000	----	0	1
---------	Catchability Coefficients by Data Series ---------------					
q(1)	Gillnet AAI, total yield	2.007E-04	2.000E-04	3.137E-04	1	1
q(2)	Reduction AAI 1% adj CPUE	1.551E-04	2.000E-04	1.900E-02	1	1
q(3)	Seine JAI +1yr	1.833E-04	2.000E-04	1.900E-02	1	1
q(4)	Trawl JAI +1yr	1.640E-04	2.000E-04	1.900E-02	1	1

MANAGEMENT and DERIVED PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	Logistic formula	General formula
MSY	Maximum sustainable yield	6.262E+02	----	----
Bmsy	Stock biomass giving MSY	4.562E+03	K/2	K*n**(1/(1-n))
Fmsy	Fishing mortality rate at MSY	1.373E-01	MSY/Bmsy	MSY/Bmsy
n	Exponent in production function	2.0000	----	----
g	Fletcher's gamma	4.000E+00	----	[n**(n/(n-1))]/[n-1]
B./Bmsy	Ratio: B(2011)/Bmsy	1.354E+00	----	----
F./Fmsy	Ratio: F(2010)/Fmsy	4.545E-01	----	----
Fmsy/F.	Ratio: Fmsy/F(2010)	2.200E+00	----	----
Y.(Fmsy)	Approx. yield available at Fmsy in 2011	8.288E+02	MSY*B./Bmsy	MSY*B./Bmsy
	...as proportion of MSY	1.324E+00	----	----
Ye.	Equilibrium yield available in 2011	5.478E+02	4*MSY*(B/K-(B/K)**2)	g*MSY*(B/K-(B/K)**n)
	...as proportion of MSY	8.747E-01	----	----
---------	Fishing effort rate at MSY in units of each CE or CC series ---------			
fmsy(1)	Gillnet AAI, total yield	6.840E+02	Fmsy/q(1)	Fmsy/q(1)

ESTIMATED POPULATION TRAJECTORY (NON-BOOTSTRAPPED)

Obs	Year or ID	Estimated total F mort	Estimated starting biomass	Estimated average biomass	Observed total yield	Model total yield	Estimated surplus production	Ratio of F mort to Fmsy	Ratio of biomass to Bmsy
1	1948	0.010	7.756E+03	7.870E+03	7.579E+01	7.579E+01	2.969E+02	7.016E-02	1.700E+00
2	1949	0.013	7.977E+03	8.055E+03	1.086E+02	1.086E+02	2.591E+02	9.821E-02	1.748E+00
3	1950	0.018	8.127E+03	8.172E+03	1.484E+02	1.484E+02	2.342E+02	1.323E-01	1.781E+00
4	1951	0.019	8.213E+03	8.245E+03	1.560E+02	1.560E+02	2.180E+02	1.378E-01	1.800E+00
5	1952	0.028	8.275E+03	8.267E+03	2.283E+02	2.283E+02	2.132E+02	2.012E-01	1.814E+00
6	1953	0.024	8.260E+03	8.268E+03	1.969E+02	1.969E+02	2.129E+02	1.735E-01	1.811E+00
7	1954	0.022	8.276E+03	8.290E+03	1.824E+02	1.824E+02	2.082E+02	1.603E-01	1.814E+00
8	1955	0.026	8.302E+03	8.298E+03	2.145E+02	2.145E+02	2.064E+02	1.883E-01	1.820E+00
9	1956	0.030	8.294E+03	8.276E+03	2.452E+02	2.452E+02	2.112E+02	2.158E-01	1.818E+00
10	1957	0.019	8.260E+03	8.285E+03	1.605E+02	1.605E+02	2.092E+02	1.411E-01	1.811E+00
11	1958	0.024	8.309E+03	8.312E+03	1.974E+02	1.974E+02	2.033E+02	1.730E-01	1.821E+00
12	1959	0.040	8.314E+03	8.256E+03	3.271E+02	3.271E+02	2.156E+02	2.886E-01	1.822E+00
13	1960	0.046	8.203E+03	8.132E+03	3.780E+02	3.780E+02	2.427E+02	3.386E-01	1.798E+00
14	1961	0.057	8.068E+03	7.973E+03	4.571E+02	4.571E+02	2.761E+02	4.176E-01	1.768E+00
15	1962	0.062	7.887E+03	7.798E+03	4.802E+02	4.802E+02	3.110E+02	4.486E-01	1.729E+00
16	1963	0.057	7.717E+03	7.664E+03	4.387E+02	4.387E+02	3.367E+02	4.170E-01	1.692E+00
17	1964	0.054	7.615E+03	7.585E+03	4.090E+02	4.090E+02	3.512E+02	3.928E-01	1.669E+00
18	1965	0.062	7.558E+03	7.507E+03	4.626E+02	4.626E+02	3.653E+02	4.489E-01	1.657E+00
19	1966	0.048	7.460E+03	7.467E+03	3.590E+02	3.590E+02	3.723E+02	3.503E-01	1.635E+00
20	1967	0.042	7.474E+03	7.499E+03	3.173E+02	3.173E+02	3.667E+02	3.083E-01	1.638E+00
21	1968	0.050	7.523E+03	7.518E+03	3.733E+02	3.733E+02	3.634E+02	3.617E-01	1.649E+00
22	1969	0.070	7.513E+03	7.437E+03	5.228E+02	5.228E+02	3.774E+02	5.121E-01	1.647E+00
23	1970	0.075	7.368E+03	7.292E+03	5.474E+02	5.474E+02	4.020E+02	5.468E-01	1.615E+00
24	1971	0.103	7.222E+03	7.070E+03	7.300E+02	7.300E+02	4.369E+02	7.523E-01	1.583E+00
25	1972	0.073	6.929E+03	6.907E+03	5.034E+02	5.034E+02	4.608E+02	5.309E-01	1.519E+00
26	1973	0.071	6.887E+03	6.875E+03	4.880E+02	4.880E+02	4.653E+02	5.172E-01	1.509E+00
27	1974	0.087	6.864E+03	6.805E+03	5.889E+02	5.889E+02	4.749E+02	6.305E-01	1.505E+00
28	1975	0.081	6.750E+03	6.720E+03	5.440E+02	5.440E+02	4.862E+02	5.897E-01	1.480E+00
29	1976	0.085	6.692E+03	6.657E+03	5.627E+02	5.627E+02	4.942E+02	6.158E-01	1.467E+00
30	1977	0.067	6.624E+03	6.648E+03	4.486E+02	4.486E+02	4.954E+02	4.916E-01	1.452E+00
31	1978	0.126	6.670E+03	6.509E+03	8.216E+02	8.216E+02	5.119E+02	9.195E-01	1.462E+00
32	1979	0.125	6.361E+03	6.237E+03	7.808E+02	7.808E+02	5.417E+02	9.121E-01	1.394E+00
33	1980	0.116	6.122E+03	6.047E+03	7.035E+02	7.035E+02	5.598E+02	8.475E-01	1.342E+00
34	1981	0.093	5.978E+03	5.983E+03	5.547E+02	5.547E+02	5.655E+02	6.754E-01	1.310E+00
35	1982	0.147	5.989E+03	5.844E+03	8.565E+02	8.565E+02	5.766E+02	1.068E+00	1.313E+00
36	1983	0.167	5.709E+03	5.538E+03	9.262E+02	9.262E+02	5.973E+02	1.218E+00	1.251E+00
37	1984	0.190	5.380E+03	5.187E+03	9.861E+02	9.861E+02	6.142E+02	1.385E+00	1.179E+00
38	1985	0.182	5.008E+03	4.872E+03	8.855E+02	8.855E+02	6.232E+02	1.324E+00	1.098E+00
39	1986	0.179	4.746E+03	4.640E+03	8.319E+02	8.319E+02	6.260E+02	1.306E+00	1.040E+00
40	1987	0.208	4.540E+03	4.391E+03	9.121E+02	9.121E+02	6.252E+02	1.513E+00	9.951E-01
41	1988	0.151	4.253E+03	4.244E+03	6.406E+02	6.406E+02	6.232E+02	1.100E+00	9.322E-01
42	1989	0.138	4.235E+03	4.255E+03	5.856E+02	5.856E+02	6.234E+02	1.003E+00	9.284E-01
43	1990	0.125	4.273E+03	4.316E+03	5.405E+02	5.405E+02	6.244E+02	9.124E-01	9.366E-01
44	1991	0.126	4.357E+03	4.393E+03	5.540E+02	5.540E+02	6.254E+02	9.186E-01	9.550E-01
45	1992	0.096	4.428E+03	4.526E+03	4.341E+02	4.341E+02	6.261E+02	6.987E-01	9.707E-01
46	1993	0.119	4.620E+03	4.658E+03	5.532E+02	5.532E+02	6.260E+02	8.654E-01	1.013E+00
47	1994	0.168	4.693E+03	4.616E+03	7.753E+02	7.753E+02	6.261E+02	1.223E+00	1.029E+00
48	1995	0.103	4.544E+03	4.620E+03	4.774E+02	4.774E+02	6.261E+02	7.528E-01	9.960E-01
49	1996	0.103	4.693E+03	4.760E+03	4.923E+02	4.923E+02	6.250E+02	7.534E-01	1.029E+00
50	1997	0.130	4.825E+03	4.824E+03	6.273E+02	6.273E+02	6.242E+02	9.473E-01	1.058E+00
51	1998	0.100	4.822E+03	4.890E+03	4.902E+02	4.902E+02	6.230E+02	7.303E-01	1.057E+00
52	1999	0.140	4.955E+03	4.921E+03	6.880E+02	6.880E+02	6.223E+02	1.018E+00	1.086E+00

53	2000	0.120	4.889E+03	4.906E+03	5.899E+02	5.899E+02	6.227E+02	8.760E-01	1.072E+00
54	2001	0.105	4.922E+03	4.972E+03	5.237E+02	5.237E+02	6.212E+02	7.673E-01	1.079E+00
55	2002	0.115	5.020E+03	5.040E+03	5.790E+02	5.790E+02	6.194E+02	8.369E-01	1.100E+00
56	2003	0.101	5.060E+03	5.110E+03	5.184E+02	5.184E+02	6.172E+02	7.390E-01	1.109E+00
57	2004	0.090	5.159E+03	5.232E+03	4.694E+02	4.694E+02	6.127E+02	6.536E-01	1.131E+00
58	2005	0.081	5.302E+03	5.389E+03	4.359E+02	4.359E+02	6.056E+02	5.893E-01	1.162E+00
59	2006	0.084	5.472E+03	5.539E+03	4.657E+02	4.657E+02	5.975E+02	6.125E-01	1.199E+00
60	2007	0.080	5.603E+03	5.672E+03	4.548E+02	4.548E+02	5.891E+02	5.841E-01	1.228E+00
61	2008	0.073	5.738E+03	5.816E+03	4.257E+02	4.257E+02	5.789E+02	5.332E-01	1.258E+00
62	2009	0.077	5.891E+03	5.948E+03	4.578E+02	4.578E+02	5.684E+02	5.608E-01	1.291E+00
63	2010	0.062	6.002E+03	6.092E+03	3.800E+02	3.800E+02	5.558E+02	4.545E-01	1.315E+00
64	2011		6.177E+03						1.354E+00

RESULTS FOR DATA SERIES # 1 (NON-BOOTSTRAPPED) Gillnet AAI, total yield

Data type CC: CPUE-catch series Series weight: 1.000

Obs	Year	Observed CPUE	Estimated CPUE	Estim F	Observed yield	Model yield	Resid in log scale	Statist weight
1	1948	*	1.579E+00	0.0096	7.579E+01	7.579E+01	0.00000	0.000E+00
2	1949	*	1.617E+00	0.0135	1.086E+02	1.086E+02	0.00000	0.000E+00
3	1950	*	1.640E+00	0.0182	1.484E+02	1.484E+02	0.00000	0.000E+00
4	1951	*	1.655E+00	0.0189	1.560E+02	1.560E+02	0.00000	0.000E+00
5	1952	*	1.659E+00	0.0276	2.283E+02	2.283E+02	0.00000	0.000E+00
6	1953	*	1.659E+00	0.0238	1.969E+02	1.969E+02	0.00000	0.000E+00
7	1954	*	1.664E+00	0.0220	1.824E+02	1.824E+02	0.00000	0.000E+00
8	1955	*	1.665E+00	0.0258	2.145E+02	2.145E+02	0.00000	0.000E+00
9	1956	*	1.661E+00	0.0296	2.452E+02	2.452E+02	0.00000	0.000E+00
10	1957	*	1.663E+00	0.0194	1.605E+02	1.605E+02	0.00000	0.000E+00
11	1958	*	1.668E+00	0.0238	1.974E+02	1.974E+02	0.00000	0.000E+00
12	1959	*	1.657E+00	0.0396	3.271E+02	3.271E+02	0.00000	0.000E+00
13	1960	*	1.632E+00	0.0465	3.780E+02	3.780E+02	0.00000	0.000E+00
14	1961	*	1.600E+00	0.0573	4.571E+02	4.571E+02	0.00000	0.000E+00
15	1962	*	1.565E+00	0.0616	4.802E+02	4.802E+02	0.00000	0.000E+00
16	1963	*	1.538E+00	0.0572	4.387E+02	4.387E+02	0.00000	0.000E+00
17	1964	*	1.522E+00	0.0539	4.090E+02	4.090E+02	0.00000	0.000E+00
18	1965	*	1.507E+00	0.0616	4.626E+02	4.626E+02	0.00000	0.000E+00
19	1966	*	1.499E+00	0.0481	3.590E+02	3.590E+02	0.00000	0.000E+00
20	1967	*	1.505E+00	0.0423	3.173E+02	3.173E+02	0.00000	0.000E+00
21	1968	*	1.509E+00	0.0497	3.733E+02	3.733E+02	0.00000	0.000E+00
22	1969	*	1.493E+00	0.0703	5.228E+02	5.228E+02	0.00000	0.000E+00
23	1970	*	1.463E+00	0.0751	5.474E+02	5.474E+02	0.00000	0.000E+00
24	1971	*	1.419E+00	0.1033	7.300E+02	7.300E+02	0.00000	0.000E+00
25	1972	*	1.386E+00	0.0729	5.034E+02	5.034E+02	0.00000	0.000E+00
26	1973	*	1.380E+00	0.0710	4.880E+02	4.880E+02	0.00000	0.000E+00
27	1974	*	1.366E+00	0.0865	5.889E+02	5.889E+02	0.00000	0.000E+00
28	1975	*	1.349E+00	0.0810	5.440E+02	5.440E+02	0.00000	0.000E+00
29	1976	*	1.336E+00	0.0845	5.627E+02	5.627E+02	0.00000	0.000E+00
30	1977	*	1.334E+00	0.0675	4.486E+02	4.486E+02	0.00000	0.000E+00
31	1978	*	1.306E+00	0.1262	8.216E+02	8.216E+02	0.00000	0.000E+00
32	1979	*	1.252E+00	0.1252	7.808E+02	7.808E+02	0.00000	0.000E+00
33	1980	*	1.214E+00	0.1163	7.035E+02	7.035E+02	0.00000	0.000E+00
34	1981	*	1.201E+00	0.0927	5.547E+02	5.547E+02	0.00000	0.000E+00
35	1982	*	1.173E+00	0.1466	8.565E+02	8.565E+02	0.00000	0.000E+00

36	1983	*	1.111E+00	0.1672	9.262E+02	9.262E+02	0.00000	0.000E+00
37	1984	*	1.041E+00	0.1901	9.861E+02	9.861E+02	0.00000	0.000E+00
38	1985	*	9.779E-01	0.1817	8.855E+02	8.855E+02	0.00000	0.000E+00
39	1986	1.150E+00	9.311E-01	0.1793	8.319E+02	8.319E+02	-0.21114	1.973E+02
40	1987	5.900E-01	8.813E-01	0.2077	9.121E+02	9.121E+02	0.40132	1.589E+02
41	1988	9.100E-01	8.517E-01	0.1509	6.406E+02	6.406E+02	-0.06620	1.894E+02
42	1989	6.700E-01	8.539E-01	0.1376	5.856E+02	5.856E+02	0.24249	1.786E+02
43	1990	8.000E-01	8.662E-01	0.1252	5.405E+02	5.405E+02	0.07945	1.797E+02
44	1991	6.700E-01	8.817E-01	0.1261	5.540E+02	5.540E+02	0.27458	1.737E+02
45	1992	6.300E-01	9.083E-01	0.0959	4.341E+02	4.341E+02	0.36586	1.600E+02
46	1993	5.200E-01	9.347E-01	0.1188	5.532E+02	5.532E+02	0.58642	1.425E+02
47	1994	6.200E-01	9.265E-01	0.1679	7.753E+02	7.753E+02	0.40166	1.378E+02
48	1995	7.300E-01	9.271E-01	0.1033	4.774E+02	4.774E+02	0.23903	1.502E+02
49	1996	6.600E-01	9.553E-01	0.1034	4.923E+02	4.923E+02	0.36983	1.628E+02
50	1997	9.200E-01	9.681E-01	0.1300	6.273E+02	6.273E+02	0.05095	1.684E+02
51	1998	9.100E-01	9.814E-01	0.1002	4.902E+02	4.902E+02	0.07551	1.699E+02
52	1999	9.700E-01	9.877E-01	0.1398	6.880E+02	6.880E+02	0.01805	1.917E+02
53	2000	1.120E+00	9.846E-01	0.1202	5.899E+02	5.899E+02	-0.12883	1.924E+02
54	2001	1.170E+00	9.978E-01	0.1053	5.237E+02	5.237E+02	-0.15919	1.908E+02
55	2002	1.120E+00	1.012E+00	0.1149	5.790E+02	5.790E+02	-0.10186	2.205E+02
56	2003	1.480E+00	1.026E+00	0.1014	5.184E+02	5.184E+02	-0.36675	2.203E+02
57	2004	1.170E+00	1.050E+00	0.0897	4.694E+02	4.694E+02	-0.10822	2.301E+02
58	2005	1.340E+00	1.081E+00	0.0809	4.359E+02	4.359E+02	-0.21436	2.366E+02
59	2006	1.640E+00	1.112E+00	0.0841	4.657E+02	4.657E+02	-0.38884	2.614E+02
60	2007	1.210E+00	1.138E+00	0.0802	4.548E+02	4.548E+02	-0.06102	2.315E+02
61	2008	1.710E+00	1.167E+00	0.0732	4.257E+02	4.257E+02	-0.38182	2.564E+02
62	2009	1.470E+00	1.194E+00	0.0770	4.578E+02	4.578E+02	-0.20824	2.814E+02
63	2010	8.100E-01	1.223E+00	0.0624	3.800E+02	3.800E+02	0.41166	1.774E+02

* Asterisk indicates missing value(s).

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UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 1

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                  -1      -0.75     -0.5     -0.25      0       0.25     0.5      0.75      1
                   |    .    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |
Year   Residual   ------------------------------------------------------------------------------------
1983    0.0000                                          |
1984    0.0000                                          |
1985    0.0000                                          |
1986   -0.2111                                  ========|
1987    0.4013                                          |================
1988   -0.0662                                       ===|
1989    0.2425                                          |==========
1990    0.0794                                          |===
1991    0.2746                                          |===========
1992    0.3659                                          |===============
1993    0.5864                                          |=======================
1994    0.4017                                          |================
1995    0.2390                                          |==========
1996    0.3698                                          |===============
1997    0.0509                                          |==
1998    0.0755                                          |===
1999    0.0180                                          |=
2000   -0.1288                                     =====|
2001   -0.1592                                    ======|
2002   -0.1019                                      ====|
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2003    -0.3667                          ===============|
2004    -0.1082                                     ====|
2005    -0.2144                                =========|
2006    -0.3888                         ================|
2007    -0.0610                                       ==|
2008    -0.3818                          ===============|
2009    -0.2082                                 ========|
2010     0.4117                                         |================
                   ------------------------------------------------------------------------------------
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RESULTS FOR DATA SERIES # 2 (NON-BOOTSTRAPPED) Reduction AAI 1% adj CPUE

Data type I1: Abundance index (annual average) Series weight: 1.000

Obs	Year	Observed effort	Estimated effort	Estim F	Observed index	Model index	Resid in log index	Statist weight
1	1948	1.000E+00	1.000E+00	--	1.833E+00	1.221E+00	0.40657	1.562E+02
2	1949	1.000E+00	1.000E+00	--	1.606E+00	1.249E+00	0.25138	1.562E+02
3	1950	1.000E+00	1.000E+00	--	1.755E+00	1.267E+00	0.32576	1.562E+02
4	1951	1.000E+00	1.000E+00	--	1.595E+00	1.279E+00	0.22093	1.562E+02
5	1952	1.000E+00	1.000E+00	--	1.926E+00	1.282E+00	0.40696	1.562E+02
6	1953	1.000E+00	1.000E+00	--	1.778E+00	1.282E+00	0.32701	1.562E+02
7	1954	1.000E+00	1.000E+00	--	1.511E+00	1.286E+00	0.16123	1.562E+02
8	1955	1.000E+00	1.000E+00	--	1.619E+00	1.287E+00	0.22942	1.562E+02
9	1956	1.000E+00	1.000E+00	--	1.453E+00	1.284E+00	0.12384	1.562E+02
10	1957	1.000E+00	1.000E+00	--	9.385E-01	1.285E+00	-0.31423	1.562E+02
11	1958	1.000E+00	1.000E+00	--	8.758E-01	1.289E+00	-0.38652	1.562E+02
12	1959	1.000E+00	1.000E+00	--	1.419E+00	1.280E+00	0.10299	1.562E+02
13	1960	1.000E+00	1.000E+00	--	1.580E+00	1.261E+00	0.22502	1.562E+02
14	1961	1.000E+00	1.000E+00	--	1.658E+00	1.237E+00	0.29328	1.562E+02
15	1962	1.000E+00	1.000E+00	--	1.442E+00	1.209E+00	0.17577	1.562E+02
16	1963	1.000E+00	1.000E+00	--	1.359E+00	1.189E+00	0.13386	1.562E+02
17	1964	1.000E+00	1.000E+00	--	1.274E+00	1.176E+00	0.07996	1.562E+02
18	1965	1.000E+00	1.000E+00	--	1.160E+00	1.164E+00	-0.00336	1.562E+02
19	1966	1.000E+00	1.000E+00	--	7.841E-01	1.158E+00	-0.39008	1.562E+02
20	1967	1.000E+00	1.000E+00	--	6.465E-01	1.163E+00	-0.58722	1.562E+02
21	1968	1.000E+00	1.000E+00	--	7.962E-01	1.166E+00	-0.38145	1.562E+02
22	1969	1.000E+00	1.000E+00	--	1.030E+00	1.154E+00	-0.11364	1.562E+02
23	1970	1.000E+00	1.000E+00	--	1.096E+00	1.131E+00	-0.03100	1.562E+02
24	1971	1.000E+00	1.000E+00	--	1.225E+00	1.096E+00	0.11118	1.562E+02
25	1972	1.000E+00	1.000E+00	--	8.833E-01	1.071E+00	-0.19291	1.562E+02
26	1973	1.000E+00	1.000E+00	--	8.899E-01	1.066E+00	-0.18077	1.562E+02
27	1974	1.000E+00	1.000E+00	--	9.341E-01	1.055E+00	-0.12208	1.562E+02
28	1975	1.000E+00	1.000E+00	--	7.709E-01	1.042E+00	-0.30150	1.562E+02
29	1976	1.000E+00	1.000E+00	--	7.376E-01	1.032E+00	-0.33617	1.562E+02
30	1977	1.000E+00	1.000E+00	--	6.289E-01	1.031E+00	-0.49428	1.562E+02
31	1978	1.000E+00	1.000E+00	--	1.059E+00	1.010E+00	0.04814	1.562E+02
32	1979	1.000E+00	1.000E+00	--	1.070E+00	9.673E-01	0.10121	1.562E+02
33	1980	1.000E+00	1.000E+00	--	8.127E-01	9.379E-01	-0.14327	1.562E+02
34	1981	1.000E+00	1.000E+00	--	6.387E-01	9.280E-01	-0.37355	1.562E+02
35	1982	1.000E+00	1.000E+00	--	9.312E-01	9.063E-01	0.02708	1.562E+02
36	1983	1.000E+00	1.000E+00	--	9.941E-01	8.589E-01	0.14611	1.562E+02
37	1984	1.000E+00	1.000E+00	--	1.063E+00	8.045E-01	0.27914	1.562E+02
38	1985	1.000E+00	1.000E+00	--	1.088E+00	7.557E-01	0.36413	1.562E+02

39	1986	1.000E+00	1.000E+00	--	9.287E-01	7.196E-01	0.25516	1.562E+02
40	1987	1.000E+00	1.000E+00	--	1.004E+00	6.811E-01	0.38801	1.562E+02
41	1988	1.000E+00	1.000E+00	--	7.051E-01	6.582E-01	0.06886	1.562E+02
42	1989	1.000E+00	1.000E+00	--	6.821E-01	6.599E-01	0.03319	1.562E+02
43	1990	1.000E+00	1.000E+00	--	6.177E-01	6.694E-01	-0.08027	1.562E+02
44	1991	1.000E+00	1.000E+00	--	7.513E-01	6.814E-01	0.09765	1.562E+02
45	1992	1.000E+00	1.000E+00	--	6.666E-01	7.019E-01	-0.05159	1.562E+02
46	1993	1.000E+00	1.000E+00	--	7.570E-01	7.224E-01	0.04682	1.562E+02
47	1994	1.000E+00	1.000E+00	--	1.021E+00	7.160E-01	0.35484	1.562E+02
48	1995	1.000E+00	1.000E+00	--	6.969E-01	7.165E-01	-0.02767	1.562E+02
49	1996	1.000E+00	1.000E+00	--	6.583E-01	7.383E-01	-0.11468	1.562E+02
50	1997	1.000E+00	1.000E+00	--	8.725E-01	7.481E-01	0.15378	1.562E+02
51	1998	1.000E+00	1.000E+00	--	7.223E-01	7.584E-01	-0.04881	1.562E+02
52	1999	1.000E+00	1.000E+00	--	9.939E-01	7.633E-01	0.26401	1.562E+02
53	2000	1.000E+00	1.000E+00	--	8.269E-01	7.609E-01	0.08312	1.562E+02
54	2001	1.000E+00	1.000E+00	--	7.680E-01	7.711E-01	-0.00409	1.562E+02
55	2002	1.000E+00	1.000E+00	--	8.681E-01	7.817E-01	0.10480	1.562E+02
56	2003	1.000E+00	1.000E+00	--	8.237E-01	7.926E-01	0.03846	1.562E+02
57	2004	1.000E+00	1.000E+00	--	6.875E-01	8.114E-01	-0.16573	1.562E+02
58	2005	1.000E+00	1.000E+00	--	7.547E-01	8.358E-01	-0.10206	1.562E+02
59	2006	1.000E+00	1.000E+00	--	7.101E-01	8.591E-01	-0.19040	1.562E+02
60	2007	1.000E+00	1.000E+00	--	6.833E-01	8.797E-01	-0.25262	1.562E+02
61	2008	1.000E+00	1.000E+00	--	6.581E-01	9.021E-01	-0.31529	1.562E+02
62	2009	1.000E+00	1.000E+00	--	6.600E-01	9.225E-01	-0.33484	1.562E+02
63	2010	1.000E+00	1.000E+00	--	6.397E-01	9.448E-01	-0.39000	1.562E+02

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```
UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 2
                   -1       -0.75     -0.5      -0.25       0        0.25      0.5       0.75       1
                    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |
Year   Residual    -------------------------------------------------------------------------------------
1948     0.4066                                             |================
1949     0.2514                                             |==========
1950     0.3258                                             |=============
1951     0.2209                                             |=========
1952     0.4070                                             |================
1953     0.3270                                             |=============
1954     0.1612                                             |======
1955     0.2294                                             |=========
1956     0.1238                                             |=====
1957    -0.3142                                =============|
1958    -0.3865                              ===============|
1959     0.1030                                             |====
1960     0.2250                                             |=========
1961     0.2933                                             |============
1962     0.1758                                             |=======
1963     0.1339                                             |=====
1964     0.0800                                             |===
1965    -0.0034                                             |
1966    -0.3901                             ================|
1967    -0.5872                      =======================|
1968    -0.3814                              ===============|
1969    -0.1136                                        =====|
1970    -0.0310                                            =|
1971     0.1112                                             |====
1972    -0.1929                                     ========|
```

```
1973   -0.1808                =======|
1974   -0.1221                  =====|
1975   -0.3015           ============|
1976   -0.3362          =============|
1977   -0.4943   ====================|
1978    0.0481                       |==
1979    0.1012                       |====
1980   -0.1433                 ======|
1981   -0.3735        ===============|
1982    0.0271                       |=
1983    0.1461                       |======
1984    0.2791                       |===========
1985    0.3641                       |===============
1986    0.2552                       |==========
1987    0.3880                       |================
1988    0.0689                       |===
1989    0.0332                       |=
1990   -0.0803                    ===|
1991    0.0977                       |====
1992   -0.0516                     ==|
1993    0.0468                       |==
1994    0.3548                       |==============
1995   -0.0277                      =|
1996   -0.1147                  =====|
1997    0.1538                       |======
1998   -0.0488                     ==|
1999    0.2640                       |===========
2000    0.0831                       |===
2001   -0.0041                       |
2002    0.1048                       |====
2003    0.0385                       |==
2004   -0.1657                =======|
2005   -0.1021                   ====|
2006   -0.1904               ========|
2007   -0.2526             ==========|
2008   -0.3153          =============|
2009   -0.3348          =============|
2010   -0.3900         ================|
        ----------------------------------------------------------------------------------
```


RESULTS FOR DATA SERIES # 3 (NON-BOOTSTRAPPED) Seine JAI +1yr

Data type I1: Abundance index (annual average) Series weight: 1.000

Obs	Year	Observed effort	Estimated effort	Estim F	Observed index	Model index	Resid in log index	Statist weight
1	1948	0.000E+00	0.000E+00	--	*	1.442E+00	0.00000	0.000E+00
2	1949	0.000E+00	0.000E+00	--	*	1.476E+00	0.00000	0.000E+00
3	1950	0.000E+00	0.000E+00	--	*	1.498E+00	0.00000	0.000E+00
4	1951	0.000E+00	0.000E+00	--	*	1.511E+00	0.00000	0.000E+00
5	1952	0.000E+00	0.000E+00	--	*	1.515E+00	0.00000	0.000E+00
6	1953	0.000E+00	0.000E+00	--	*	1.515E+00	0.00000	0.000E+00
7	1954	0.000E+00	0.000E+00	--	*	1.519E+00	0.00000	0.000E+00
8	1955	0.000E+00	0.000E+00	--	*	1.521E+00	0.00000	0.000E+00

9	1956	0.000E+00	0.000E+00	--	*	1.517E+00	0.00000	0.000E+00
10	1957	0.000E+00	0.000E+00	--	*	1.518E+00	0.00000	0.000E+00
11	1958	0.000E+00	0.000E+00	--	*	1.523E+00	0.00000	0.000E+00
12	1959	0.000E+00	0.000E+00	--	*	1.513E+00	0.00000	0.000E+00
13	1960	0.000E+00	0.000E+00	--	*	1.490E+00	0.00000	0.000E+00
14	1961	0.000E+00	0.000E+00	--	*	1.461E+00	0.00000	0.000E+00
15	1962	0.000E+00	0.000E+00	--	*	1.429E+00	0.00000	0.000E+00
16	1963	0.000E+00	0.000E+00	--	*	1.405E+00	0.00000	0.000E+00
17	1964	0.000E+00	0.000E+00	--	*	1.390E+00	0.00000	0.000E+00
18	1965	0.000E+00	0.000E+00	--	*	1.376E+00	0.00000	0.000E+00
19	1966	0.000E+00	0.000E+00	--	*	1.368E+00	0.00000	0.000E+00
20	1967	0.000E+00	0.000E+00	--	*	1.374E+00	0.00000	0.000E+00
21	1968	0.000E+00	0.000E+00	--	*	1.378E+00	0.00000	0.000E+00
22	1969	0.000E+00	0.000E+00	--	*	1.363E+00	0.00000	0.000E+00
23	1970	0.000E+00	0.000E+00	--	*	1.336E+00	0.00000	0.000E+00
24	1971	0.000E+00	0.000E+00	--	*	1.296E+00	0.00000	0.000E+00
25	1972	0.000E+00	0.000E+00	--	*	1.266E+00	0.00000	0.000E+00
26	1973	0.000E+00	0.000E+00	--	*	1.260E+00	0.00000	0.000E+00
27	1974	0.000E+00	0.000E+00	--	*	1.247E+00	0.00000	0.000E+00
28	1975	0.000E+00	0.000E+00	--	*	1.232E+00	0.00000	0.000E+00
29	1976	0.000E+00	0.000E+00	--	*	1.220E+00	0.00000	0.000E+00
30	1977	0.000E+00	0.000E+00	--	*	1.218E+00	0.00000	0.000E+00
31	1978	1.000E+00	1.000E+00	--	8.500E-01	1.193E+00	-0.33893	1.080E+00
32	1979	1.000E+00	1.000E+00	--	9.500E-01	1.143E+00	-0.18493	1.650E+00
33	1980	1.000E+00	1.000E+00	--	3.800E-01	1.108E+00	-1.07039	2.140E+00
34	1981	1.000E+00	1.000E+00	--	7.900E-01	1.097E+00	-0.32791	2.340E+00
35	1982	1.000E+00	1.000E+00	--	6.400E-01	1.071E+00	-0.51482	4.430E+00
36	1983	1.000E+00	1.000E+00	--	1.120E+00	1.015E+00	0.09847	6.190E+00
37	1984	1.000E+00	1.000E+00	--	7.400E-01	9.506E-01	-0.25043	7.220E+00
38	1985	1.000E+00	1.000E+00	--	2.600E+00	8.930E-01	1.06873	9.810E+00
39	1986	1.000E+00	1.000E+00	--	7.700E-01	8.503E-01	-0.09917	6.480E+00
40	1987	1.000E+00	1.000E+00	--	2.040E+00	8.048E-01	0.93009	1.261E+01
41	1988	1.000E+00	1.000E+00	--	7.200E-01	7.778E-01	-0.07717	1.125E+01
42	1989	1.000E+00	1.000E+00	--	6.000E-01	7.797E-01	-0.26201	1.006E+01
43	1990	1.000E+00	1.000E+00	--	6.400E-01	7.910E-01	-0.21177	1.193E+01
44	1991	1.000E+00	1.000E+00	--	1.160E+00	8.052E-01	0.36514	1.743E+01
45	1992	1.000E+00	1.000E+00	--	1.150E+00	8.294E-01	0.32676	1.721E+01
46	1993	1.000E+00	1.000E+00	--	1.270E+00	8.536E-01	0.39734	1.836E+01
47	1994	1.000E+00	1.000E+00	--	1.640E+00	8.460E-01	0.66189	1.917E+01
48	1995	1.000E+00	1.000E+00	--	6.200E-01	8.466E-01	-0.31154	1.599E+01
49	1996	1.000E+00	1.000E+00	--	8.700E-01	8.724E-01	-0.00275	1.830E+01
50	1997	1.000E+00	1.000E+00	--	1.440E+00	8.840E-01	0.48790	1.962E+01
51	1998	1.000E+00	1.000E+00	--	8.800E-01	8.962E-01	-0.01821	2.100E+01
52	1999	1.000E+00	1.000E+00	--	1.340E+00	9.019E-01	0.39591	2.166E+01
53	2000	1.000E+00	1.000E+00	--	8.700E-01	8.991E-01	-0.03294	1.819E+01
54	2001	1.000E+00	1.000E+00	--	4.700E-01	9.112E-01	-0.66202	1.599E+01
55	2002	1.000E+00	1.000E+00	--	1.010E+00	9.237E-01	0.08931	2.073E+01
56	2003	1.000E+00	1.000E+00	--	8.700E-01	9.366E-01	-0.07373	2.161E+01
57	2004	1.000E+00	1.000E+00	--	1.070E+00	9.588E-01	0.10970	2.145E+01
58	2005	1.000E+00	1.000E+00	--	6.200E-01	9.876E-01	-0.46553	2.079E+01
59	2006	1.000E+00	1.000E+00	--	7.100E-01	1.015E+00	-0.35752	2.152E+01
60	2007	1.000E+00	1.000E+00	--	6.500E-01	1.040E+00	-0.46956	1.899E+01
61	2008	1.000E+00	1.000E+00	--	9.500E-01	1.066E+00	-0.11514	2.370E+01
62	2009	1.000E+00	1.000E+00	--	6.000E-01	1.090E+00	-0.59702	2.210E+01
63	2010	1.000E+00	1.000E+00	--	1.010E+00	1.116E+00	-0.10016	2.221E+01

* Asterisk indicates missing value(s).

UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 3

```
                 -2       -1.5      -1       -0.5       0        0.5       1        1.5       2
                  |    .    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |
Year   Residual  ---------------------------------------------------------------------------------
1976     0.0000                                           |
1977     0.0000                                           |
1978    -0.3389                                    =======|
1979    -0.1849                                       ====|
1980    -1.0704                      =====================|
1981    -0.3279                                    =======|
1982    -0.5148                                 ==========|
1983     0.0985                                           |==
1984    -0.2504                                      =====|
1985     1.0687                                           |=====================
1986    -0.0992                                         ==|
1987     0.9301                                           |===================
1988    -0.0772                                         ==|
1989    -0.2620                                      =====|
1990    -0.2118                                       ====|
1991     0.3651                                           |=======
1992     0.3268                                           |=======
1993     0.3973                                           |========
1994     0.6619                                           |=============
1995    -0.3115                                     ======|
1996    -0.0028                                           |
1997     0.4879                                           |==========
1998    -0.0182                                           |
1999     0.3959                                           |========
2000    -0.0329                                          =|
2001    -0.6620                              =============|
2002     0.0893                                           |==
2003    -0.0737                                          =|
2004     0.1097                                           |==
2005    -0.4655                                  =========|
2006    -0.3575                                    =======|
2007    -0.4696                                  =========|
2008    -0.1151                                         ==|
2009    -0.5970                               ============|
2010    -0.1002                                         ==|
                 ---------------------------------------------------------------------------------
```


RESULTS FOR DATA SERIES # 4 (NON-BOOTSTRAPPED) Trawl JAI +1yr

Data type I1: Abundance index (annual average) Series weight: 1.000

Obs	Year	Observed effort	Estimated effort	Estim F	Observed index	Model index	Resid in log index	Statist weight
1	1948	0.000E+00	0.000E+00	--	*	1.291E+00	0.00000	0.000E+00
2	1949	0.000E+00	0.000E+00	--	*	1.321E+00	0.00000	0.000E+00
3	1950	0.000E+00	0.000E+00	--	*	1.340E+00	0.00000	0.000E+00
4	1951	0.000E+00	0.000E+00	--	*	1.352E+00	0.00000	0.000E+00

5	1952	0.000E+00	0.000E+00	--	*	1.356E+00	0.00000	0.000E+00
6	1953	0.000E+00	0.000E+00	--	*	1.356E+00	0.00000	0.000E+00
7	1954	0.000E+00	0.000E+00	--	*	1.359E+00	0.00000	0.000E+00
8	1955	0.000E+00	0.000E+00	--	*	1.361E+00	0.00000	0.000E+00
9	1956	0.000E+00	0.000E+00	--	*	1.357E+00	0.00000	0.000E+00
10	1957	0.000E+00	0.000E+00	--	*	1.359E+00	0.00000	0.000E+00
11	1958	0.000E+00	0.000E+00	--	*	1.363E+00	0.00000	0.000E+00
12	1959	0.000E+00	0.000E+00	--	*	1.354E+00	0.00000	0.000E+00
13	1960	0.000E+00	0.000E+00	--	*	1.334E+00	0.00000	0.000E+00
14	1961	0.000E+00	0.000E+00	--	*	1.308E+00	0.00000	0.000E+00
15	1962	0.000E+00	0.000E+00	--	*	1.279E+00	0.00000	0.000E+00
16	1963	0.000E+00	0.000E+00	--	*	1.257E+00	0.00000	0.000E+00
17	1964	0.000E+00	0.000E+00	--	*	1.244E+00	0.00000	0.000E+00
18	1965	0.000E+00	0.000E+00	--	*	1.231E+00	0.00000	0.000E+00
19	1966	0.000E+00	0.000E+00	--	*	1.225E+00	0.00000	0.000E+00
20	1967	0.000E+00	0.000E+00	--	*	1.230E+00	0.00000	0.000E+00
21	1968	1.000E+00	1.000E+00	--	5.700E-01	1.233E+00	-0.77145	1.031E+01
22	1969	1.000E+00	1.000E+00	--	2.690E+00	1.220E+00	0.79096	1.018E+01
23	1970	1.000E+00	1.000E+00	--	1.240E+00	1.196E+00	0.03626	5.820E+00
24	1971	1.000E+00	1.000E+00	--	1.120E+00	1.159E+00	-0.03452	1.095E+01
25	1972	1.000E+00	1.000E+00	--	5.900E-01	1.133E+00	-0.65224	7.710E+00
26	1973	1.000E+00	1.000E+00	--	3.500E-01	1.127E+00	-1.16974	9.260E+00
27	1974	1.000E+00	1.000E+00	--	6.600E-01	1.116E+00	-0.52519	1.535E+01
28	1975	1.000E+00	1.000E+00	--	1.010E+00	1.102E+00	-0.08718	3.235E+01
29	1976	1.000E+00	1.000E+00	--	1.520E+00	1.092E+00	0.33105	9.390E+00
30	1977	1.000E+00	1.000E+00	--	1.640E+00	1.090E+00	0.40837	6.540E+00
31	1978	1.000E+00	1.000E+00	--	2.110E+00	1.067E+00	0.68141	1.220E+01
32	1979	1.000E+00	1.000E+00	--	1.080E+00	1.023E+00	0.05446	1.604E+01
33	1980	1.000E+00	1.000E+00	--	6.300E-01	9.917E-01	-0.45370	1.486E+01
34	1981	1.000E+00	1.000E+00	--	1.040E+00	9.812E-01	0.05816	8.970E+00
35	1982	1.000E+00	1.000E+00	--	7.600E-01	9.583E-01	-0.23184	2.147E+01
36	1983	1.000E+00	1.000E+00	--	8.000E-01	9.082E-01	-0.12687	5.343E+01
37	1984	1.000E+00	1.000E+00	--	9.300E-01	8.506E-01	0.08924	3.569E+01
38	1985	1.000E+00	1.000E+00	--	1.500E+00	7.990E-01	0.62982	4.084E+01
39	1986	1.000E+00	1.000E+00	--	7.400E-01	7.608E-01	-0.02777	5.777E+01
40	1987	1.000E+00	1.000E+00	--	7.200E-01	7.202E-01	-0.00023	3.694E+01
41	1988	1.000E+00	1.000E+00	--	7.500E-01	6.960E-01	0.07479	5.330E+01
42	1989	1.000E+00	1.000E+00	--	6.900E-01	6.977E-01	-0.01112	4.738E+01
43	1990	1.000E+00	1.000E+00	--	5.600E-01	7.078E-01	-0.23417	4.086E+01
44	1991	1.000E+00	1.000E+00	--	8.800E-01	7.205E-01	0.20002	4.057E+01
45	1992	1.000E+00	1.000E+00	--	8.800E-01	7.422E-01	0.17030	5.634E+01
46	1993	1.000E+00	1.000E+00	--	1.170E+00	7.638E-01	0.42646	6.006E+01
47	1994	1.000E+00	1.000E+00	--	1.170E+00	7.570E-01	0.43533	5.285E+01
48	1995	1.000E+00	1.000E+00	--	8.200E-01	7.576E-01	0.07918	3.718E+01
49	1996	1.000E+00	1.000E+00	--	6.700E-01	7.806E-01	-0.15284	5.019E+01
50	1997	1.000E+00	1.000E+00	--	9.900E-01	7.911E-01	0.22434	4.997E+01
51	1998	1.000E+00	1.000E+00	--	7.300E-01	8.019E-01	-0.09396	5.980E+01
52	1999	1.000E+00	1.000E+00	--	1.000E+00	8.070E-01	0.21437	5.106E+01
53	2000	1.000E+00	1.000E+00	--	7.000E-01	8.046E-01	-0.13922	4.159E+01
54	2001	1.000E+00	1.000E+00	--	5.200E-01	8.153E-01	-0.44979	5.367E+01
55	2002	1.000E+00	1.000E+00	--	1.050E+00	8.266E-01	0.23928	4.948E+01
56	2003	1.000E+00	1.000E+00	--	9.500E-01	8.381E-01	0.12537	5.934E+01
57	2004	1.000E+00	1.000E+00	--	9.300E-01	8.580E-01	0.08060	6.531E+01
58	2005	1.000E+00	1.000E+00	--	7.900E-01	8.837E-01	-0.11208	6.722E+01
59	2006	1.000E+00	1.000E+00	--	7.500E-01	9.084E-01	-0.19158	4.884E+01
60	2007	1.000E+00	1.000E+00	--	6.800E-01	9.302E-01	-0.31331	5.563E+01
61	2008	1.000E+00	1.000E+00	--	1.190E+00	9.538E-01	0.22124	5.306E+01
62	2009	1.000E+00	1.000E+00	--	6.200E-01	9.754E-01	-0.45310	5.584E+01

```
 63    2010    1.000E+00    1.000E+00      --    7.300E-01    9.990E-01    -0.31369    5.173E+01

* Asterisk indicates missing value(s).


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UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 4
                   -2       -1.5       -1       -0.5        0        0.5        1        1.5        2
                    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |
Year   Residual    ------------------------------------------------------------------------------------
1965     0.0000                                             |
1966     0.0000                                             |
1967     0.0000                                             |
1968    -0.7715                              ===============|
1969     0.7910                                             |================
1970     0.0363                                             |=
1971    -0.0345                                            =|
1972    -0.6522                                =============|
1973    -1.1697                      =======================|
1974    -0.5252                                  ===========|
1975    -0.0872                                           ==|
1976     0.3311                                             |=======
1977     0.4084                                             |========
1978     0.6814                                             |==============
1979     0.0545                                             |=
1980    -0.4537                                    =========|
1981     0.0582                                             |=
1982    -0.2318                                        =====|
1983    -0.1269                                          ===|
1984     0.0892                                             |==
1985     0.6298                                             |=============
1986    -0.0278                                            =|
1987    -0.0002                                             |
1988     0.0748                                             |=
1989    -0.0111                                             |
1990    -0.2342                                        =====|
1991     0.2000                                             |====
1992     0.1703                                             |===
1993     0.4265                                             |=========
1994     0.4353                                             |=========
1995     0.0792                                             |==
1996    -0.1528                                          ===|
1997     0.2243                                             |====
1998    -0.0940                                           ==|
1999     0.2144                                             |====
2000    -0.1392                                          ===|
2001    -0.4498                                    =========|
2002     0.2393                                             |=====
2003     0.1254                                             |===
2004     0.0806                                             |==
2005    -0.1121                                           ==|
2006    -0.1916                                         ====|
2007    -0.3133                                       ======|
2008     0.2212                                             |====
2009    -0.4531                                    =========|
2010    -0.3137                                       ======|
                   ------------------------------------------------------------------------------------
```

```
                Observed (O) and Estimated (*) CPUE for Data Series # 1 -- Gillnet AAI, total yield
           :
     2.00 -:
           :
           :
           :
           :
     1.75 -:
           :                                                                    O
           :          ***********                                             O
           :        **           *
           :                      **
     1.50 -:                        ******                                 O
           :                              *                                      O
           :                               ***
           :                                  ****                           O
           :                                      *
     1.25 -:                                       *
           :                                        **                         O **
           :                                          *   O              O  O  **
           :                                           *                O O  **
           :                                            *                  **
     1.00 -:                                             *            *****
           :                                              *      ***** O
           :                                               *O  **    OO
           :                                                ***
           :                                                  O                   O
     0.75 -:                                                       O
           :
           :                                                 O OO   O
           :                                               O      O
           :
     0.50 -:                                                     O
           :........................................................................................................
            :         :         :         :         :         :         :         :         :         :         :
         1940.     1950.     1960.     1970.     1980.     1990.     2000.     2010.     2020.     2030.     2040.


                Observed (O) and Estimated (*) CPUE for Data Series # 2 -- Reduction AAI 1% adj CPUE
           :
     2.00 -:
           :            O
           :
           :        O
           :             O
     1.75 -:          O
           :
           :                     O
           :         O O   O    O
           :
     1.50 -:              O
           :                O     O
           :                   O
```

```
           :                       0
           :           *********
     1.25 -:         **         **  0      0
           :        *             ***
           :                         2*****
           :                              0*             0
           :                             0  ******00    0
     1.00 -:                                      *    0   0      0    0
           :                 0                0    ***0   0                       *
           :                  0             00        *                        ***
           :                                           *             0  0 0  **
           :                          0 0           0   *                 *2*
     0.75 -:                                   00        *     0 0  *****2   0
           :                                              **00 ****2  0     0 00
           :                           0         0   0      *** 0   0           000
           :                                                  0
           :
     0.50 -:
           :........................................................................................................
            :         :         :         :         :         :         :         :         :         :         :
         1940.     1950.     1960.     1970.     1980.     1990.     2000.     2010.     2020.     2030.     2040.
```

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```
                Observed (O) and Estimated (*) CPUE for Data Series # 3 -- Seine JAI +1yr
           :
      3.6 -:
           :
           :
           :
           :
      3.0 -:
           :
           :
           :                                             0
           :
      2.4 -:
           :
           :
           :                                               0
           :
      1.8 -:
           :                                                      0
           :           *********
           :        ***         *****                                0
           :                         ********                    0     0
      1.2 -:                                 *******           00
           :                                        ***0                    0  ****
           :                                       0   **              * *2**** 0 0
           :                                      0  0   ***  ******2*2 2  0
           :                                            0 0 2*                0
      0.6 -:                                          0      00    0         0 0 0
           :                                                             0
           :                                        0
           :
           :
      0.0 -:
```

```
          :........................................................................................................
           :         :         :         :         :         :         :         :         :         :         :
        1940.     1950.     1960.     1970.     1980.     1990.     2000.     2010.     2020.     2030.     2040.
```

```
               Observed (O) and Estimated (*) CPUE for Data Series # 4 -- Trawl JAI +1yr
          :
     3.6 -:
          :
          :
          :
          :
     3.0 -:
          :
          :
          :                             O
          :
     2.4 -:
          :
          :                                      O
          :
          :
     1.8 -:
          :                                     O
          :                                    O        O
          :
          :        ***************
     1.2 -:                       *******2*                     OO             O
          :                               O*******2 O                    O
          :                                   O    ****O            O O   OO *****
          :                                           O**     OO  O*********2
          :                                  O       O   2222******O O O     OO  O
     0.6 -:                            O   O       O         O                  O
          :                                                             O
          :                                 O
          :
          :
     0.0 -:
          :........................................................................................................
           :         :         :         :         :         :         :         :         :         :         :
        1940.     1950.     1960.     1970.     1980.     1990.     2000.     2010.     2020.     2030.     2040.
```



```
                                 Time Plot of Estimated F/Fmsy and B/Bmsy (dashed line = 1.0)
          :
     2.4 -:
          :
          :
          :
          :
     2.0 -:
          :
          :           BBBBBBBBB
          :         BB         BBB
          :        B              BBB  BB
```

```
1.6 -:                          BB  BB
     :                                BBB            F
     :                                   BBBB
     :                                       BB   FF                         B
     :                                         BBB  F                     BBB
1.2 -:                                           FB         F          BBB
     :                                             B  F          B  BBB
     :------------------------------------------2---2--2---22-222222-------------------
     :                                               BBBBBB  B F
     :                                      FFF         FF F      F
0.8 -:                                                             FF
     :                               F                    F  FF F    F
     :                                  F F    F                      F F
     :                              F F  F                             F FFF
     :                      F  F   F   F   F                                F
0.4 -:                     F FF   F
     :                   FF     FF
     :            F   F
     :          FF FFF FF
     :        FF
0.0 -:
     :........................................................................................................
      :         :         :         :         :         :         :         :         :         :         :
   1940.     1950.     1960.     1970.     1980.     1990.     2000.     2010.     2020.     2030.     2040.
```

Elapsed time: 0 hours, 0 minutes, 0 seconds.