S E D A R

Southeast Data, Assessment, and Review

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SEDAR 18

Review Workshop Report

Atlantic Red Drum

October 7, 2009

SEDAR is a Cooperative Initiative of:

The Caribbean Fishery Management Council
The Gulf of Mexico Fishery Management Council
The South Atlantic Fishery Management Council
NOAA Fisheries Southeast Regional Office
NOAA Fisheries Southeast Fisheries Science Center
The Atlantic States Marine Fisheries Commission
The Gulf States Marine Fisheries Commission

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Section V. Review Workshop Report

Table of Contents and One-way Links

1 Introduction

1.1 Workshop Time and Place

The SEDAR 18 Review Workshop was held at the Doubletree Buckhead Inn in Atlanta, Georgia on August 24 through 28, 2009.

1.2 Terms of Reference

The SEDAR 18 Terms of Reference (ToR) were approved by the South Atlantic State-Federal Fisheries Management Board on October 23, 2008. ToR#6 was modified May 18, 2009.

SEDAR 18 Terms of Reference

1. Evaluate the adequacy, appropriateness, and application of data used in the assessment*.
2. Evaluate the adequacy, appropriateness, and application of methods used to assess the stock*.
3. Recommend appropriate estimates of stock abundance, biomass, and exploitation*.
4. Evaluate the methods used to estimate population benchmarks and management parameters (e.g., static spawning potential ratio); provide estimated values for management benchmarks, and declarations of stock status*. Evaluate the population metric used by managers to determine the stock status and, if appropriate, recommend alternative measures.
5. Evaluate the adequacy, appropriateness, and application of methods used to characterize uncertainty in estimated parameters. Provide measures of uncertainty for estimated parameters*. Ensure that the implications of uncertainty in technical conclusions are clearly stated.
6. Ensure that stock assessment results are clearly and accurately presented in the Stock Assessment Report and that reported results are consistent with Review Panel recommendations**.
7. Evaluate the SEDAR Process. Identify any Terms of Reference which were inadequately addressed by the Data or Assessment Workshops; identify any additional information or assistance which will improve Review Workshops; suggest improvements or identify aspects requiring clarification.
8. Review the research recommendations provided by the Data and Assessment workshops and make any additional recommendations warranted. Clearly indicate the research and monitoring needs that may appreciably improve the reliability of future assessments. Recommend an appropriate interval for the next assessment.
9. Prepare a Peer Review Consensus Summary summarizing the Panel's evaluation of the stock assessment and addressing each Term of Reference. Develop a list of tasks

to be completed following the workshop. Complete and submit the Consensus Report within 3 weeks of workshop conclusion.

* The review panel may request additional sensitivity analyses, evaluation of alternative assumptions, and correction of errors identified in the assessments provided by the assessment workshop panel; the review panel may not request a new assessment. Additional details regarding the latitude given the review panel to deviate from assessments provided by the assessment workshop panel are provided in the *SEDAR Guidelines* and the *SEDAR Review Panel Overview and Instructions*.

** The panel shall ensure that corrected estimates are provided by addenda to the assessment report in the event corrections are made in the assessment, alternative model configurations are recommended, or additional analyses are prepared as a result of review panel findings regarding the TORs above.

1.3 List of Participants

SEDAR 18 Review Workshop

Appointee	Function	Affiliation
Independent Review Panel		
Dr. Robert O'Boyle	Chair and Reviewer	Consultant
Dr. Matthew Cieri	Independent Reviewer	ASMFC- ME DNR
Dr. Dr. Kevin Stokes	Independent Reviewer	CIE
Dr. Norm Hall	Independent Reviewer	CIE
Dr. Jamie Gibson	Independent Reviewer	CIE
Rapporteur		
Dr. Mike Denson	Rapporteur	ASMFC RD SAS
Presenters and Analytical Team		
Mike Murphy	Lead Analyst	ASMFC RD SAS
Lee Paramore	Stock Leader	ASMFC-TC
Joe Grist	Presenter and Asst-Rapporteur	ASMFC RD SAS
Appointed Observers		
Robert Boyles	Commissioner	ASMFC
Nichola Meserve	Red Drum FMP Coordinator	ASMFC
Coordination		
Dale Theiling	Coordinator	SEDAR
Rachael Lindsay	Administrative Support	SEDAR
Patrick Gilles	Information Technology Support	SEFSC-Miami

Acronyms
SEDAR 18 Review Workshop Participants List

ASMFC TC	Atlantic States Marine Fisheries Commission Technical Committee
CIE	Center for Independent Experts
ME DNR	Maine Department of Natural Resources
NMFS	National Marine Fisheries Service
RD SAS	Red Drum Stock Assessment Subcommittee
SEFSC	Southeast Fisheries Science Center, National Marine Fisheries Service
SEDAR	Southeast Data, Assessment, and Review

1.4 List of Review Workshop Working Papers & Documents

SEDAR 18
Atlantic Red Drum
Review Workshop Document List

Document #	Title	Authors
Documents Prepared for the Review Workshop		
SEDAR18-RW01	Application of the statistical catch-at-age models for red drum to the data for the time period used in the previous assessment, 1986-1998.	Murphy 2009
SEDAR18-RW02	Standardized proportion-at-age residuals between the observed data and model predicted estimates for each fishery and for the total harvest in the northern and southern regions during 1982-2007.	Murphy 2009
Workshop Reports		
SEDAR18-DW Report	SEDAR 18 Data Workshop Report	SEDAR 18 DW Panel 2009
SEDAR18-AW Report	SEDAR 18 Assessment Workshop Report	SEDAR 18 AW Panel 2009

2 Review Panel Report

In the sections below, reference is made to the data used and model structure of the 2009 northern and southern red drum stock assessments, the details of which can be found in Appendix A. The computer programming code (ADMB) and input files for the northern and southern red drum stock assessments are provided in Appendices B and C, respectively, allowing an understanding of how the models and data are used to derive estimates of stock abundance, biomass, and exploitation.

The Review Workshop provided a comprehensive and in-depth evaluation of each assessment, which resulted in a number of modifications to the assessment formulations developed during the Assessment Workshop. The Review Panel determined that these assessment model modifications and associated re-runs did not constitute a new assessment.

In addressing each term of reference, some repetition of the issues discussed at the Review Workshop will be noticed. This was necessary to address each term of reference independently. As well, for some terms of reference (e.g. stock status and reference points), it was relatively straightforward to provide the Review Panel's response separately for each stock assessment. For most however, the issues were sufficiently similar for each assessment that it was more informative to provide the Review Panel's response combined for both assessments.

2.1 Statements addressing each Term of Reference

2.1.1 Term of Reference 1

Evaluate adequacy, appropriateness, and application of data used in assessment

The Review Panel examined all input parameters and data used in the assessment of northern and southern stocks of red drum. The Panel's response to this term of reference is organized by data type, including stock units, landings and removals, proportion of the catch-at-age, survey data, tagging data, and biological data, for each of the two stock assessments combined.

2.1.1.1 The Stock Units

The Assessment Team presented information relating to genetic studies, habitat utilization, life history characteristics, as well as tagging information, to support the current stock definitions. The Review Panel suggested that, in the case of Atlantic red drum, genetic studies, while valuable for defining evolutionarily significant units, were less useful in defining stock unit boundaries, because, in cases where genetic divergence is recent, or where a low level of straying exists between populations, or if sampling occurs during periods when populations are mixed, no apparent population structuring may be detected using these methods, even when this exists.

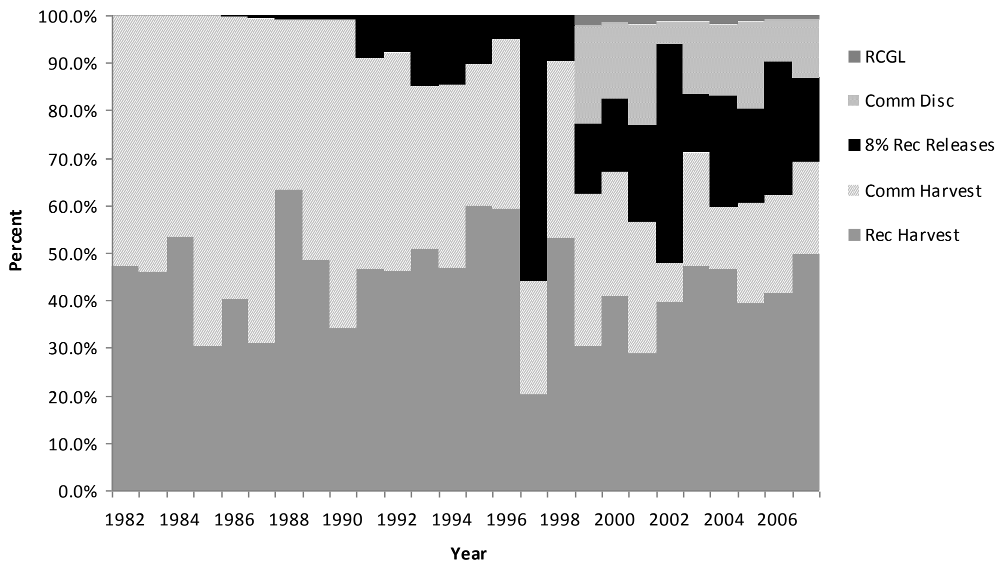
In defining the stock units for red drum, the Assessment Team considered possible interactions between the Atlantic and Gulf of Mexico populations and possible interactions between northern and southern components of the Atlantic population. The Review Panel agreed that some interaction and migration between the southern Atlantic component and the Gulf of Mexico component probably existed, but it was likely small when compared to the overall cohesiveness of the southern Atlantic stock.

The Assessment Team recommended a wider geographic context than the current state-based management. It further recommended the continued application of sub-division of the Atlantic red drum population into two regions separated at the border of North Carolina and South Carolina. The Review Panel accepted this recommendation, noting that the proposed stock structure for red rum is consistent with fishery management arrangements, but also noting that there is likely some mixing between these proposed stocks. Special mention was made of the distribution of suitable red drum habitat. The split between the north and south red drum stocks at the North-South Carolina border is consistent with a lack of suitable habitat for red drum in this area. The Review Panel, however, noted that localized population dynamics within the northern and southern components may be very important. The tagging information shows little movement even within a stock, and is suggestive of population structure at a finer spatial scale than the proposed stock units. Exploitation at levels appropriate for the overall stocks could lead to overfishing of localized, lower-productivity populations.

2.1.1.2 Landings and Removals

The Assessment Team presented state-specific landings and discards from the commercial and recreational fishery. The Review Panel generally agreed with the Assessment Team's treatment of the landings information for the northern and southern stocks. The Review Panel noted the influence of recent management changes on state landings and the associated red drum age composition. Recreational landings and removals due to live release mortality have increased for both stocks, whereas commercial removals have relatively declined. This implies increasing uncertainty in the estimation of total stock removals as those for the recreational fisheries are based upon surveys of recreational landings as well as estimates of live release morality. While these uncertainties require further examination (section 2.1.8.3), the Review Panel generally agreed that the Assessment Team had made pragmatic and appropriate decisions in the treatment of these data. The Review Panel had issue with the estimation of the commercial discards for the northern stock for 1999 – 2007 only, based upon data collected during 2004 – 2006, despite commercial discards being known to occur prior to 1999. To avoid potential bias in the most recent years of the population analysis, the Review Panel recommended that the 2004 – 2006 average commercial discard / kept ratio be applied to the entire time series used in the assessment, and not just for 1999 – 2007 (figure 2.1.1.1).

a) Commercial discards as initially determined by Assessment Team



b) Commercial discards as revised at Review Workshop

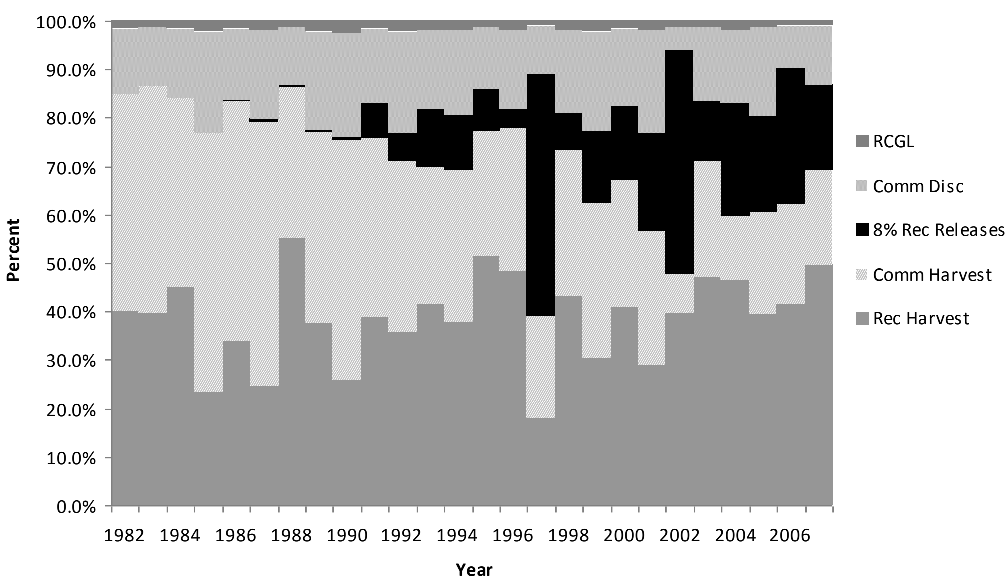


Figure. 2.1.1.1. Percent by weight of annual removals of each fishery type for the northern assessment a) as initially determined by the Assessment Team and b) with commercial discard estimates as revised at the Review Workshop (figure produced as reply to Review Panel post-review request for clarification of material presented at Review Workshop)

2.1.1.3 Proportion-at-age

Detailed information on the sampling of commercial and recreational fishery catch for both stocks was presented to the Review Panel, which noted and accepted the pragmatic decisions made in analyzing these data. After much discussion, the Review Panel agreed with the treatment of the proportion-at-age data for 1989 to the present. However sampling prior to 1989 was not adequate to characterize annual age/size composition of removals for the age-based assessment models (see section 2.1.2). The Review Panel therefore recommended that the assessments for both stocks start in 1989.

The Review Panel noted that the age composition of the live release removals for both stocks was based upon size frequencies from North Carolina tagging programs. This is a weakness in the assessments which needs to be addressed in the longer-term (section 2.1.8.3).

The Review Panel noted that the small amounts of catch above age five made sampling of these removals difficult. It speculated that this sampling could be based upon collections of otoliths alone without resort to a first phase sampling of size frequencies. Certainly, the Review Panel considered that following year-classes through the catch-at-age beyond age 4 was very difficult and generated uncertainty in the estimated size of the two stocks at the older age groups.

2.1.1.4 Surveys

Both stock assessments used a number of fishery dependent and independent surveys to monitor trends in stock abundance, including recreational surveys in the north and south, and gill net surveys, as well as fishery-independent surveys using trammel nets and electro–fishing, in the south. The Review Panel noted that the Assessment Team spent considerable effort examining and analyzing the surveys during SEDAR – 18. The Review Panel had been concerned that these surveys did not fully cover the spatial range of both stocks but, for the north, the presentation on the survey program at the Review Workshop indicated that this was not the case, although no single survey covered the stock's full range. In the south, however, the surveys have been more localized and the time series for each survey is generally shorter. Detailed examination suggested that there was not a great deal of agreement amongst the abundance trends in the southern surveys. This may be due to the dynamics of localized populations or to movement. Overall, the northern surveys appeared to be relatively more informative of stock trends than those of the southern stock.

The Assessment Team noted that surveys for both stocks predominantly sampled age 1 – 3 red drum with only one survey in the south (adult longline) and none in the north sampling older age groups. This hampers assessment of abundance of older age groups.

Notwithstanding the issues with the survey program for both stocks, the Review Panel accepted the suite of surveys used in both assessments as chosen by the Assessment Team.

The Review Panel pointed out that the Assessment Team had used the geometric mean to provide the annual indices of survey abundance. These data are additionally log transformed in the assessment model. For stratified-random designed surveys, the arithmetic mean is the statistic of choice. Thus, the Review Panel recommended the arithmetic mean as the indicator of annual abundance to be used in the assessment models. This was accepted by the Assessment Team and revisions of survey indices were made at the Review Workshop.

2.1.1.5 Tagging Information

For the northern stock, there has been an extensive tagging program which provides the assessment with externally derived estimates of fishing mortality. The North Carolina tagging program in particular represents a relatively long time-series of tag releases and recaptures. The

Review Panel considered these data valuable to include in the assessment model and supported the Assessment Team's treatment of these data. It noted, however, that without these data, the results of the northern assessment are very different, indicating inconsistency in the interpretation of stock dynamics between the tagging and non-tagging (i.e. removals and survey data) information (see sections 2.1.5.2 and A3.2.2.8). The Review Panel considered that in the longer-term, incorporation of the tagging analysis directly into the stock assessment model should be explored (section 2.1.8.3). The Review Panel also noted that the estimates of natural mortality used in the tagging model differed from those used in the two assessment models; it suggested that this issue be explored further after the Review Workshop.

Other concerns with the northern tagging data raised by the Review Panel included the amount of information available by fish disposition (released or not), lack of a priori design of the program, and the tag reporting rate. Many of the more recent tagging data were for fish that had been subsequently released and were thus not available for more thorough biological sampling and aging. The lack of a tagging program sampling design implied that some areas may have been over-sampled while others under-sampled. Additionally, the Review Panel noted that some of the fishing mortality estimates from the external tagging analysis seemed very high (e.g. fishing mortality of 3.873 for age 2 fish in 1989, the equivalent of a 98% exploitation rate).

The Review Panel noted that, although tagging data were available for the southern stock, they were not included in the assessment model and encouraged their development for future red drum assessments.

2.1.1.6 Biological Data

The Review Panel examined the biological characteristics of both stocks, including natural mortality, growth, maturity and other relevant information. In general, the Review Panel supported the analyses undertaken by the Assessment Team. In particular, it supported the use of an age-dependent natural mortality, which is an improvement over assuming a constant natural mortality for all age groups. The Review Panel expressed reservations, however, with the low natural mortality rates, particularly for older fish that do not appear in more recent fishery-dependent or fishery-independent sampling. The Review Panel thus supported the use of sensitivity analysis by the Assessment Team to examine the effects of uncertainty in natural mortality on estimates of population size.

The Review Panel expressed concern about the use of the same maturity schedule (derived for the northern stock) for both northern and southern stocks, given the differences in individual growth between these stocks. Notwithstanding this concern, given the lack of information on maturity-at-age or size for the southern stock, the Review Panel supported the use of the northern maturity schedule for both stocks. The Review Panel recommends that maturity at size and age be investigated for the southern stock of Red Drum (section 2.1.8.3).

2.1.2 Term of Reference 2

Evaluate the adequacy, appropriateness, and application of methods used to assess stock

The Assessment Team used a statistical catch-at-age model (SCA), implemented using AD-Model Builder (ADMB), to assess the status of both northern and southern red drum. As formulated, abundance-at-age in the first year, as well as age 1 abundance in all years is estimated within the model. Abundance-at-age for other age classes is estimated by projecting the population forward from these starting abundances using an exponential decay function including both natural and fishing mortality. Fishing mortality was modeled assuming separability. That is, for a given fishery during a given time period, fishing mortality is composed of two components - a fully recruited fishing mortality allowed to vary from year to year, and a selectivity pattern that determines how fishing mortality varies among age classes. The model for northern red drum was fit to the commercial landings, commercial proportions-at-age, annual estimates of fishing mortality from an external analysis of tagging data, and a set of abundance indices from surveys. The model for southern red drum was fit to commercial landings, commercial proportions-at-age and a set of survey indices. Log-normal error structures were used for all model components except the proportions-at-age for which a multinomial likelihood was used. Parameters estimated in the model were the starting abundances by age, the age 1 abundances for each year, fully recruited fishing mortality for each year, the selectivity parameters, and catchability coefficients for the surveys. In the final versions of the model, 134 parameters were estimated for the northern stock and 157 parameters were estimated for the southern stock (table A3.2.4.1). The difference in the number of parameters is due to differences in the number of fisheries and indices for the two stocks.

The Review Panel considered that the use of a SCA model was appropriate given the types of data available for these stocks and endorsed the use of ADMB for its implementation. Limited data were available for reconstructing the catch-at-age for some fisheries, leading to uncertainty in the reconstructed catch-at-age. SCA models, which do not require the assumption that catch-at-age is known without error, are appropriate for these types of data. The modeling framework is also very flexible in that model assumptions and alternatives, as well as the influence of various datasets on the model output, can be easily evaluated. The Review Panel considered that the error structures assumed for fitting the model were appropriate. Overall, the Review Panel supported the decision to use an SCA model for the northern and southern red drum assessments.

Before the Review Workshop, the Assessment Team provided continuity runs which compared the results of the current assessments with those of 2000. Of the three models utilized by Vaughan and Carmichael (2000), only the spreadsheet SCA could be reproduced for the continuity run. A true continuity run (i.e. original model run appended with the more recent data) was not possible due to changes in the methodologies used to calculate the indices and the catch-at-age, as well as the lack of availability of the tagging results in the earlier assessment. Given these differences, the Assessment Workshop did not consider that the continuity model results were comparable, a conclusion supported by the Review Panel (see section 2.2.1 for further pre-workshop discussion on the continuity analysis).

Notwithstanding the endorsement of the SCA approach, the Review Panel identified issues with the implementation of the two models. In the weeks before the Review Workshop, the Review Panel reviewed the data input files and model code and found that one of the survey input vectors was not in the correct order and that the model code used to correct abundance for natural mortality occurring prior to the survey was not correctly implemented. The Assessment Team addressed these concerns prior to the Review Workshop, allowing the review to proceed with consistent descriptions of the data inputs, model formulation and model results (see section 2.2.1 for more details). Additionally, the Review Panel noticed that the model components for the initial abundances-at-age and age 1 recruitments were over-parameterized (one more parameter than was needed was being estimated in each case). This was discussed at the Review Workshop and the assessment models modified.

The Assessment Team identified a number of hypotheses in relation to the data sets included in the two assessments and used the total standardized residual sum of squares as a criterion for choosing the most appropriate formulation. The Review Panel agreed with this approach. For both stocks, the selected model was a configuration with unity weights for all but the recreational age composition information, which was down-weighted (0.01 for northern stock and 0.1 for southern stock).

As indicated by the Assessment Team, relatively little data were available for reconstructing catch-at-age for the years before 1989. The reconstruction had "borrowed" data across fisheries. The Review Panel suggested that starting the model in 1989 would address this concern. As a result, the earlier years were dropped from the model for the final model runs (see section 2.1.1.3).

Although the Review Panel endorsed the use of a SCA model for this assessment, as pointed out by the Assessment Team, the fits of the models for both the northern and southern stocks were not fully satisfactory. In the case of the northern model, the fit and associated abundance time series were largely determined by the tagging results. When the tagging component was not included in the model, abundance estimates converged at potentially implausibly high values, indicating high sensitivity to the inclusion and weighting of the tagging data (section 2.1.5 and section A3.2.2.8). Although the Review Panel would have preferred to have the tagging analysis embedded in the SCA model (see Quinn and Deriso, 1999 for a discussion of methods) in order that uncertainty in the tagging analysis is carried forward through the full assessment, the Review Panel agreed that for the current northern assessment, the tagging results should be included as inputs to the assessment. The Review Panel noted that in the earlier years, some of the fishing mortality rates obtained from the tagging model appeared very high.

In the case of the southern model, standard errors on some model parameters were relatively large, but perhaps not unrealistically so given the input data.

The Assessment Team choose to model the fishery selectivities by estimating the age-specific selectivities for ages 1 to 3 as separate parameters, and assumed that the selectivity for age 4 and age 5 were 0.1 and 0.05 that of age 3 and that the selectivities for ages 6 and older were the same as for age 5. The Review Panel agreed with the Assessment Team that, given the observed pattern in the catch-at-age (potentially bi-modal), this approach was preferable over the use of a parametric selectivity curve (as is commonly used). However, the Review Panel suggested that rather than assuming values of the scalars for age 4 and age 5 selectivities, that these quantities be estimated in the model. This suggestion was carried forward for the final model runs. The Review Panel noted that a small penalty was being used (the 'selectivity deviate constraint') which had the effect of pulling the selectivity parameter estimates toward a common value. Removing this penalty resulted in lack of convergence, and thus the Review Panel endorsed its use.

The Assessment Team reported standard errors for estimated model parameters based on asymptotic approximations which is standard output produced by ABMB. The Review Panel suggested use of the "sdreport_variable" declaration, easily implemented within ADMB, as a method for obtaining standard errors for derived quantities (e.g. total abundance) as well as for the estimated parameters. This approach was used for the final model runs. The Review Panel also demonstrated post-convergence MCMC methods available within ADMB as a method for exploring the parameter space to determine how well model parameters were being estimated. These analyses indicated that the older-age-class, first-year (1989) abundances were not being well estimated, particularly by the southern model. Additionally, the initial size of the age 7^+ group in the north appeared very large relative to the abundance of younger age groups (it was roughly five times larger in size than would be expected if the population was at equilibrium given the age 6 abundance estimate and assuming no fishing mortality; table A3.2.4.7). These observations led to explorations of the model formulation in attempts to alleviate these issues.

2.1.3 Term of Reference 3
Recommend appropriate estimates of stock abundance, biomass, and exploitation

2.1.3.1 Northern Stock

The base case model of the northern stock assessment has a number of characteristics which deserve mention. The model appears to be anchored by the tagging information as indicated by the sensitivity analyses which show that the central tendency of the average 2005 – 2007 static SPR (sSPR) estimates is stable over a range of input data and model assumptions. The model appears to describe age 1 - 3 abundance relatively well and annual trends in fishing mortality and exploitation are consistent with management interventions. On the other hand, as noted in working paper SEDAR 18 – RW02, there are persistent age-specific trends in lack of model fit to the proportions-at-age data with the model under-fitting the age 1 – 4 data and over-fitting the age 5^+ data (see also section A3.2.2.1). While the Review Panel accepted the inclusion of the tagging data, it is worrisome that without these data, considerably higher sSPR is estimated (section A3.2.2.8). Indeed, the model-based estimates of fishing mortality and the direct estimates of fishing mortality from the tagging data are very similar. This is indicative of an inconsistency between the tagging and non-tagging information. Age 4 – 7 abundance is not well estimated to the point of not being informative. Specifically, the age 7^+ abundance estimates are overly large in comparison to the abundance of the younger age groups (noted above under section 2.1.2). Finally, the sensitivity analyses indicate that use of an assumed higher natural mortality produced better model fit (section A3.2.2.8).

Notwithstanding the issues with the northern assessment model, the Review Panel considered that the model was informative of the age 1 – 3 abundance and exploitation rates, but not those of the older age groups. The model was also informative of annual trends in sSPR and the 2005 – 2007 average sSPR.

Recruitment (age 1 abundance) has fluctuated widely and without apparent trend since 1989 (figure A3.2.5.9). Abundance of age 1 – 3 red drum increased during 1990 – 2000 after which it fluctuated widely (figures A3.2.5.7 and A3.2.5.8). The initial increase in abundance of these age groups can be explained by the reduction in exploitation rates in the early part of the time series with relative stability since then (figure A3.2.5.12). The trends in sSPR indicate low sSPR in the early part of the time series with increases during 1990 – 1997 and wide fluctuations thereafter (figure A3.2.5.21).

2.1.3.2 Southern Stock

The base case model of the southern stock assessment also has a number of characteristics which deserve mention. The sensitivity analyses show that the central tendency of the 2005 – 2007 average sSPR estimates is stable over a range of input data and model assumptions, except for those relating to fishery selectivity. The model appears to describe age 1 - 3 trends relatively well and annual trends in fishing mortality and exploitation are consistent with management interventions. On the other hand, as with the northern model, there are persistent age-specific trends in lack of model fit to the proportions-at-age data with the model under-fitting the age 1 – 4 data and over-fitting the age 5^+ data (section A3.2.2.1). Age 4 – 7 abundance is not well estimated to the point of not being informative. The model's fit to the age 6^+ data is poor. As noted above, the model results are highly sensitive to assumptions on fishery selectivity and, during the Review Workshop, explorations of different model start conditions indicated possible convergence of the model to local minima. The 95% confidence intervals on the average 2005 – 07 sSPR were very large (0.2 – 0.8), indicating high uncertainty on current stock status in relation to the overfishing benchmark. Given these uncertainties, the Review Panel considered that the model was informative only about the relative, not absolute, trends in age 1 – 3 abundance and exploitation but not those of the older age groups. The model was also considered to be informative of relative trends in annual sSPR and the three-year average sSPR, this result being highly conditional on the estimated fishery selectivity pattern. These results allow for only general statements on stock status. It is important to keep this in mind when interpreting the tables and figures on the southern stock trends in Appendix A.

The relative trend in recruitment (age 1 abundance) has fluctuated without apparent trend since 1989 (figure A3.2.5.9). The relative trend in abundance of age 1 - 3 red drum increased during 1989 – 1992, declined during 1992 – 1998 and has fluctuated thereafter (figures A3.2.5.7 and A3.2.5.8). As with the northern stock, the initial increase in abundance of these age groups can be explained by the reduction in exploitation rates in the early part of the time series. There appears to have been a slight increase in exploitation rates since 1990 (figure A3.2.5.12). This is reflected in the long-term decline in the relative trend of sSPR (figure A3.2.5.21) since 1990.

The Review Panel referred to the sensitivity analyses and retrospective analysis for the southern stock to guide its statements on current stock status. The Review Panel emphasizes that further explorations of the data and model of the southern stock are required to understand the basis for the retrospective pattern in sSPR and the uncertainty in population parameters, which lead to uncertainty in the determination of SPR and less robust advice to management.

2.1.4 Term of Reference 4

Evaluate methods used to estimate population benchmarks and management parameters (e.g., static spawning potential ratio): provide estimated values for management benchmarks, and declarations of stock status; evaluate the population metric used by managers to determine the stock status and, if appropriate, recommend alternative measures.

2.1.4.1 Background

As described in section 2.1.3, the Review Panel partially accepted base case assessments for both the north and south regions, noting a number of weaknesses in each. A weakness in both assessments is estimation of large abundance for ages 7^+, even though there are no fishery dependent or independent data that directly support these estimates (table A3.2.4.7). For both stocks, age 4-6 abundances are also poorly estimated. Overall, the Review Panel agreed that the age 4-7^+ estimates are not well estimated, to the point of being uninformative. For stocks with maximum ages of about 40 and 60 years, the lack of information on abundance-at-age 4^+ creates a problem for the definition of appropriate indicators and benchmarks, whether for the state of the stock ("overfished") or for the pressure on it ("overfishing").

The Review Panel considered the use of static SPR (sSPR) and escapement (sESC) as described in the Assessment Workshop report (section 3.2.2.9). Noting the difficulties with estimation of age 4^+ abundance and, for the south region, the sensitivity of sSPR to the estimated selectivity pattern, the Review Panel accepted the use of sSPR as an indicator of fishing pressure (exploitation or fishing mortality). Appropriate overfishing benchmarks were discussed in the context of the uncertainty relating to age 7^+ abundance. Although red drum is long-lived, the maturity schedule and productivity are sufficiently similar to other marine fish species that the Review Panel agreed to accept commonly used default threshold and target overfishing benchmarks of 30% sSPR and 40% sSPR, which is the *status quo* for red drum. However, the Review Panel did not consider annual changes in sSPR to be informative and preferred to adopt a running mean of estimated annual sSPR as the indicator to compare to the management benchmarks (herein referred to as the average sSPR). A running mean of three years was adopted as a practical measure that balanced estimation problems, a likely assessment schedule and management needs.

Static SPR is calculated using given values of natural mortality, maturity and weight-at-age combined with estimated fishing mortalities-at-age. In effect, sSPR is a translation of the estimated fishing mortalities-at-age into a standardized scale for which the implications of commonly used benchmarks (e.g. 30% sSPR and 40% sSPR) have been investigated. Escapement is another form of translation of the fishing mortality-at-age estimates to provide an indicator of fishing pressure. However, unlike sSPR, there are no commonly accepted benchmarks that might be applied to the escapement indicator. In order to provide management guidance based on sESC, it would be necessary to define such benchmarks. The Review Panel did not see the utility of using escapement rate (sESC) as an indicator of fishing pressure.

Because of the high uncertainty in the age 4 $–7^+$ dynamics , the Review Panel did not see value in attempting to estimate indicators and benchmarks of stock biomass which would be used to measure the overfished status of each stock. The Review Panel therefore concentrated efforts on investigating the behavior of sSPR for the north and south stocks as a basis for declarations of stock status.

Although not used to determine stock status, updates of the yield-per-recruit analyses were undertaken for completeness (section A3.2.2.9; table A3.2.4.25).

2.1.4.2 Northern stock

As described in section 2.1.3.1, the fishing mortality-at-age estimates for the northern stock are anchored by the tagging data; they are therefore tightly estimated and not highly sensitive to the model’s assumptions (sections 2.1.5.2 and A3.2.2.8). As sSPR is a translation of fishing mortality-at-age, it too is tightly estimated. The Review Panel agreed that the base case model is sufficient to allow a determination of stock status using the estimated three-year running average of sSPR.

The distribution of $sSPR_{2007}$ (estimated annual sSPR averaged over 2005-2007) is centered at about 45% with the lower 95% confidence limit at or above 40% sSPR (figures 2.1.4.1 and A3.2.5.23).

The three-year average sSPR has been above the threshold (30%) since 1994 and with the exception of one year (2002) has been at or above the target (40%) since 1996 (Figure A3.2.5.22). Fishing pressure appears to be stable. The indicator of fishing pressure, average sSPR, is therefore above the threshold overfishing benchmark with high probability and thus the stock is likely not subject to overfishing. The average sSPR is also likely above the target benchmark.

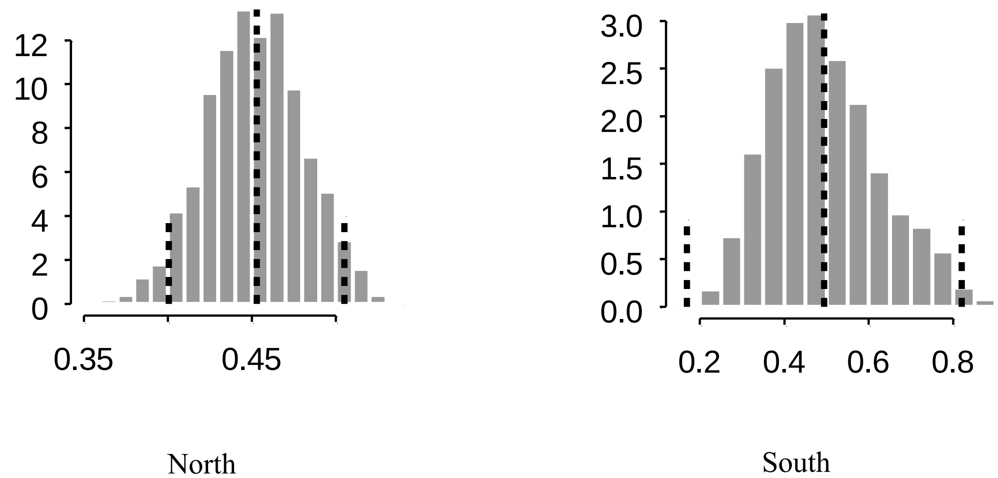


Figure 2.1.4.1. Posterior distributions of average (2005-2007) sSPR from MCMC analyses of the base case assessment models (North: left panel; South: right panel). For comparison, the vertical lines show the asymptotic estimates of the mean +/- 2 s.e. from the baseline assessment runs

2.1.4.3 Southern stock

The estimates of annual and average sSPR from the southern stock assessment are highly sensitive to the model inputs and assumptions (sections 2.1.3.2 and A3.2.2.8). As noted in section 2.1.3.2, the Review Panel accepted the base case as indicative of relative trends in sSPR, conditional on the estimated selectivity pattern. The Panel therefore agrees that the base case model and associated sensitivity runs are sufficient to allow a determination of overfishing status using the estimated three-year running average of sSPR.

The distribution of $sSPR_{2007}$ (estimated annual sSPR averaged over 2005-2007) is very wide, ranging from about 20% to 80% (figures 2.1.4.1 and A3.2.5.23). However, the majority of the probability is above 30% sSPR. Retrospective analyses of the average sSPR (section A3.2.2.8) suggest that whilst more work is needed to make definitive statements about sSPR, it is likely that the average sSPR in 2007 is above 30%. Thus, the indicator of fishing pressure, average sSPR, is uncertain but likely above the accepted threshold benchmark. The stock is therefore likely not subject to overfishing at this time. Due to the uncertainties, it is not possible to determine status in relation to the fishing pressure target benchmark of 40% sSPR.

Relative trends in average sSPR (slowly trending downwards since 1991) are apparent (figures A3.2.5.22). Fishing pressure, therefore, appears to be slowly increasing.

2.1.5 Term of Reference 5

Evaluate adequacy, appropriateness, and application of methods used to characterize uncertainty in estimated parameters: Provide measures of uncertainty for estimated parameters; Ensure that the implications of uncertainty in technical conclusions are clearly stated

2.1.5.1 Adequacy, appropriateness, and application of methods used to characterize uncertainty in estimated parameters

The SCA models that were developed to integrate the information present within the different sets of catch, proportion-at-age, survey, and tagging data available for the northern and southern stocks of Atlantic Red Drum are complex, requiring estimation of a large number of parameters. As complexity grows and additional datasets are incorporated into such models, the potential for contradictory signals from the different datasets increases. Such signals can lead to tensions among different model components when fitting, residual patterns that indicate structural inadequacy of the model, and difficulty in interpreting model results.

The decision by the Assessment Team to implement the SCA models for the northern and southern stocks using ADMB facilitated exploration of the uncertainty of estimates of parameters and derived variables using well-tested features of this software (section 2.1.2) as well as estimates of the asymptotic standard errors of parameters and exploration of conditional profile likelihoods for selected indicator variables.

The Assessment Team applied two approaches to characterize the uncertainty of the estimated parameters and derived variables output by the model that were brought forward for review. These included use of the post-convergence facility of ADMB to calculate estimates of the asymptotic standard errors of the parameters and conditional profile likelihoods of sSPR and escapement. Time series of parameter estimates ± 2SEs and observed data were plotted to display the extent to which the estimates matched the corresponding observations. The Assessment Team also reported the estimates of the non-weighted total standardized residual sum of squares that resulted when the objective function was calculated as a weighted sum of the negative log-likelihoods (NLLs) of the different components, i.e. catches, catch proportions-at-age, survey indices, and, in the case of the northern region, tagging data sets, to which the model was fitted. Through these weights, the Assessment Team had explored 36 and 27 alternative hypotheses relating to the precision of the different sets of input data used for the northern and southern stocks, respectively. The Assessment Team had selected the weights to be employed for the base case model of the northern stock as those that had produced the smallest total standardized residual sum of squares. For the southern stock, while this was the intent, during the Review Workshop, it was noted that the chosen model did not exhibit the smallest total standardized residual sum of squares although it was consistent with the weights employed for the northern stock assessment model. As a consequence of the discussion at the Review Workshop, modifications were made to the southern base case model, which employed the weights of the initial model. While it can be argued that the resultant model has not been optimally fit, a wide range of sensitivity analyses provided clear indications of the southern stock's model behaviour.

A retrospective analysis was undertaken for the selected base case model for each region (section A3.2.2.8).

During the Review Workshop, the Assessment Team produced plots of time series with observed and predicted data ± 2 asymptotic SEs, and tables of the residuals and of the NLLs for the different components that resulted when the sensitivities of the model outputs to various forms of structural uncertainty were explored (section A3.2.2.8). The Review Panel drew the attention of the Assessment Team to an option within ADMB that enables calculation of estimates of the asymptotic standard deviations of derived variables. Additionally, the use of ADMB's post-convergence MCMC utility to produce estimates of the true marginal distributions of the posterior probability distributions of both parameters and derived variables was discussed at the Review Workshop. An exploration of the output produced from the base case models by the Review Panel using this tool (1) supported the characterization of uncertainty obtained using the approaches that had been adopted by the Assessment Team, and (2) assisted the Review Panel in interpreting the sources of uncertainty and model fit for each stock.

2.1.5.2 Sources of uncertainty in models of the northern and southern stocks of Atlantic Red Drum

The Review Panel agreed with the Assessment Team's conclusion that model structure was a major source of the uncertainty of estimates of stock status indicators, and that these estimates were likely to be sensitive to the values of the scalars used to determine the selectivities of age 4 and 5^+ fish relative to that of age 3 fish, and to the levels of natural mortality and of mortality after release (section A3.2.2.8). The Assessment Team had explored the sensitivity of values of sSPR and escapement through age 5 to model (structural) uncertainty for each stock by comparing the estimates produced by different sensitivity runs with those obtained using the base case models. It had also employed these sensitivity runs to explore the sensitivity of model output to considerably greater mortality of released fish, less or greater natural mortality, and to the estimation of selectivities for ages 1 to 5 rather than to only age 3 with that for ages 4 and 5 (and older) set to 0.10 and 0.05, respectively, of age 3 selectivity (tables A3.2.4.13 and A3.2.4.14). In addition to these, sensitivity runs in which a range of scalars for the age 4 and 5^+ selectivities were assumed (tables A3.2.4.15 – A3.2.4.22) were also examined during the Review Workshop. As discussed in section 2.1.2, the Review Panel recommended estimating the age 4 and 5 selectivity scalars, an approach that was adopted for the base case model for each stock.

As noted above, the sensitivity of the new base case models to lower and higher values of natural mortality and to a higher level of mortality of released fish (i.e. 16 % rather than 8%) were explored using sensitivity runs. In addition, the Review Panel also requested a sensitivity run for the northern stock that excluded tagging data to determine the extent to which the available catch, proportions-at-age and survey data contributed information on stock status and hence allowed the value of the tagging program to be assessed (table A3.2.4.13). There was insufficient time during the Review Workshop to consider the implications of uncertainty in the input data derived from analysis of tagging data conducted externally to the SCA model. Tables comparing the results of the selectivity runs, plots, and tables of residuals were examined (section A3.2.2.8).

The Review Panel endorsed the Assessment Team's finding that estimates of northern stock abundance were highly sensitive to the inclusion or exclusion of the externally-determined tag-based input data. From the results of the sensitivity and other exploratory model runs, the information content of the tagging data had a dominant influence on the values of parameters that were estimated when the model for the northern stock was fitted. The importance of the tagging data to the assessment of the northern stock highlighted a future need to integrate the tagging analysis within the SCA model (section 2.1.8.3). Such integration would ensure that assumptions used when analyzing the tagging data would be consistent with those of the assessment model and that the uncertainties associated with the tagging data would be carried forward fully into the estimates of the SCA.

Tables of residuals revealed patterns that indicated that proportions-at-age were poorly estimated by the base case model for both red drum stocks (tables A3.2.4.4 and A3.2.4.6)

A retrospective analysis conducted by the Assessment Team using the base case model demonstrated that the time series of predicted values of the three-year average sSPR for the northern stock were almost identical for runs using data until 2002, 2004, 2006, and 2007, noting that model runs terminating in 2003 and 2005 failed to produce a positive-definite Hessian matrix (figure A3.2.5.20). The Review Panel recognized, however, that this analysis was not a true retrospective run as the tagging data, which had been analyzed independently to produce estimates of fishing mortality that were input to the assessment model, were not affected by dropping years of data in the various runs of the retrospective analysis. The influence of these tagging data was sufficient to ensure that similar trajectories of the three-year average sSPR were predicted for each of the runs considered in the retrospective analysis.

A retrospective analysis employing the base case model for the southern stock produced a very clear and disturbing retrospective pattern (figure A3.2.5.20). The time series of estimates of exploitation rate (and by inference the three-year average of sSPR) had very similar trends but varied markedly in magnitude, with the values for 2003 being considerably lower than those for other years (this pattern may be the result of a convergence issue, although this was not fully explored at the meeting). The Review Panel explored whether the pattern produced by the retrospective analysis could be a consequence of the short Georgia survey index being progressively reduced and ultimately dropped from the analysis when truncation of this short time series to a terminal year of 2003 left insufficient data for the index to be retained. Repeating the retrospective analysis without this index failed to alter the retrospective pattern. The Review Panel also explored whether a reduction of the number of parameters providing the information used by the model to initialize the vector of numbers-at-age in 1989 from seven to three could resolve the retrospective pattern. Again, the pattern of predicted values produced by the residual analysis continued to display characteristics similar to the retrospective pattern produced for the base case model. The model run terminating in 2006 failed to produce a positive-definite Hessian matrix.

The retrospective pattern of the base case model for the southern stock demonstrates that, although trends in relative values appear to be unaffected, estimates of the three-year average sSPR are highly sensitive to the input data.

Failure of the models for both the northern and southern stocks to produce a positive-definite Hessian matrix for all runs undertaken in the respective retrospective analyses indicates that the base case models are not robust and may exhibit convergence problems.

2.1.5.3 Measures of uncertainty for estimated parameters and implications of uncertainty in technical conclusions

After examining the appropriateness of alternative indicators of stock status and the ability of the models to produce reliable estimates of these variables, the Review Panel agreed with the Assessment Team's conclusion that it was appropriate to consider only a stock status indicator relating to overfishing. Thus, the three-year average of the sSPR for 2007 was the only indicator considered by the Review Panel when assessing stock status (section 2.1.4.1). Likelihood profiles and cumulative probability plots of the three-year average sSPR for 2007 were produced using the base case models for each of the two stocks (figures 2.1.4.1 and A3.2.5.23).

The uncertainty of the technical conclusions was considered by the Review Panel when responding to each of the terms of reference.

2.1.6 Term of Reference 6

Ensure that stock assessment results are clearly and accurately presented in the Stock Assessment Report and that reported results are consistent with Review Panel recommendations

Following the Review Workshop, the chair of the Review Panel worked with the SEDAR coordinator to ensure that Appendices A, B and C were consistent with the discussions and conclusions of the workshop.

2.1.7 Term of Reference 7

Evaluate the SEDAR Process: identify any Terms of Reference which were inadequately addressed by the Data or Assessment Workshops; identify any additional information or assistance which will improve Review Workshops; suggest improvements or identify aspects requiring clarification

2.1.7.1 Terms of Reference of Data Workshop (9 – 13 February 2009)

Characterize stock structure and develop a unit stock definition. Provide a map of species and stock distribution(s)

- Stock structure was characterized although it would have been useful to have a more consistent synthesis of spatial descriptions of habitat and red drum distribution as these appear to be influential in determining the split between the northern and southern stock units.

Tabulate available life history information (e.g. age, growth, natural mortality, reproductive characteristics, discard mortality rates); provide appropriate models to describe natural mortality, growth, maturation, and fecundity by age, sex, or length as applicable; and provide appropriate relations between length and weight and between various length measures; evaluate the adequacy of available life-history information for input into stock assessments and recommend life history information for use in population modeling

- The life history information used by the Assessment Team was presented in tabular form at the Review Workshop. While the adequacy of the available life history information was considered, better documentation on what data were specifically used in the assessment models would have been useful.

Evaluate all available tag/recapture data for use in estimating mortality rates, both natural and fishing, within appropriate strata (e.g., age, size classes, areas); estimate tag/recapture-based selectivity vectors for fishery units, by length or age.

- It was noted at the Review Workshop that tagging data for the southern stock exists but were not considered in its assessment. Given the impact of the tagging data on the northern stock assessment, more exploration of the tagging data for the southern stock could have benefited its assessment.

- The evaluation of the tagging data did not appear to be documented in either the Data Workshop or Assessment Workshop reports. This hindered the Review Panel’s ability to fully understand the impact of these data on the northern assessment. Specifically, while a description of the analysis of the North Carolina tagging data was presented in working paper S18-RD34, the Data Workshop reported that these tagging data were not discussed. It was advised, however, that the data were being re-analysed to provide estimates of selectivity, survival and exploitation, but that the adequacy of the results for use in the assessment models would need to be determined at the Assessment Workshop. While this analysis was not described in detail in the Assessment Workshop report, the results of the analysis were accepted for use and reported.

Consider relevant fishery dependent and independent data sources to develop measures of population abundance; document all programs used to develop indices; address program objectives, methods, coverage, sampling intensity, and other relevant characteristics; provide maps of survey coverage; develop relative abundance indices by appropriate strata (e.g., age, size, area, and fishery); provide measures of precision; evaluate the degree to which available indices represent fishery and population conditions; evaluate stock enhancement effects on indices

- A synopsis of the spatial coverage of each stock by each survey would have been useful. While survey coverage maps were provided at the Review Workshop, having a more synoptic overview of survey coverage would have assisted the discussion.

- It would have been useful to have a chart indicating the timing during the year of each survey. This would clarify when each survey samples each stock in relation to its life history and fisheries.

Characterize catch for each fishery unit (e.g., commercial hook and line, recreational, commercial gill net), including both landings and discard removals, in pounds and number; discuss the adequacy of available data for accurately characterizing harvest and discard by species and fishery unit; for estimated catch provide measures of precision; provide all available data on the length and age distributions of the catch, both harvest and discard; provide figures of the amount of fishery effort and harvest; also, provide a timeline of all fishery regulations relevant to the above fishery units, such as size limits, caps, and gear restrictions.

- While this term of reference were addressed thoroughly, it would have been useful to have synopses of the percentage catch for each stock that is based upon assumption rather than direct observation. This would have provided further insight of the model fits to these data.
- A timeline of fishery regulations in relation to each stock's catch and stock status history would have aided in a more informed interpretation of model fit issues.

Provide recommendations for future research in areas such as sampling, fishery monitoring, and stock assessment; evaluate sampling intensity by sector (fleet), area, and season.

- Both parts of this term of reference were addressed at the Data Workshop.

Develop a spreadsheet of potential assessment model input data that incorporates the decisions and recommendations of the Data Workshop. Review and approve the contents of the input spreadsheet within 6 weeks prior to the Assessment Workshop

- A Data workbook was prepared and used at the Assessment Workshop; it was reported at the Review Workshop as being very valuable.
- A review of the input spreadsheet was reported as being done at the Review Workshop.

Prepare complete documentation of workshop actions and decisions (Section II. of the SEDAR assessment report); prepare a list of tasks to be completed following the workshop, including deadlines and personnel assignments

- This term of reference was addressed. Specifically, the complete set of documents provided to the Review Panel proved very valuable.

2.1.7.2 Terms of Reference of Assessment Workshop (1 – 5 June 2009)

Review any changes in data following the data workshop, any completed analyses suggested by the data workshop; summarize data as used in each assessment model; provide justification for any deviations from Data Workshop recommendations.

- This term of reference was addressed.

Develop population assessment models that are compatible with available data and recommend which model and configuration is deemed most reliable or useful for providing advice relative to current management metric (static SPR levels); document all input data, assumptions, and equations; document model code in an AW working paper; if chosen assessment model differs from that used previously (Vaughan and Carmichael 2000) include a continuity case run of that model to determine, as best as possible, the effect of changing assessment models.

- This term of reference was addressed.

Provide estimates of stock population parameters (fishing mortality, abundance, biomass, selectivity, stock-recruitment relationship, discard removals, etc.) by age and other relevant categorizations (i.e., fleet or sector); include representative measures of precision for parameter estimates.

- This term of reference was addressed.

Characterize scientific uncertainty in the assessment and estimated values, considering components such as input data sources, data assumptions, modeling approach, and model configuration; provide appropriate measures of model performance, reliability, and goodness of fit.

- This term of reference was addressed.

Provide yield-per-recruit, spawner-per-recruit, and stock-recruitment evaluations, including figures and tables of complete parameters.

- This term of reference was addressed.

Provide estimates of spawning potential ratio consistent with the goal of Amendment 2 to the Interstate FMP for Red Drum (i.e., to achieve and maintain optimum yield for the Atlantic coast red drum fishery as the amount of harvest that can be taken while maintaining the Static Spawning Potential Ratio at or above 40%).

- This term of reference was addressed.

Evaluate the impacts of past and current management actions on the stock, with emphasis on determining progress toward stated management goals and identifying possible unintended fishery or population effects.

- This term of reference was addressed.

Consider the data workshop research recommendations; provide additional recommendations for future research and data collection (field and assessment); be as specific as possible in describing sampling design and sampling intensity.

- This term of reference was addressed.

Prepare an accessible, documented, labeled, and formatted spreadsheet containing all model parameter estimates and all relevant population information resulting from model estimates and any projection and simulation exercises. Include all data included in assessment report tables, all data that support assessment workshop figures, and those tables required for the summary report.

- This term of reference was addressed.

Complete the Assessment Workshop Report (Section III of the SEDAR Stock Assessment Report), prepare a first draft of the Summary Report, and develop a list of tasks to be completed following the workshop.

- This term of reference was addressed.

2.1.7.3 Identification of additional information and suggested improvements / clarification.

In relation to additional information, the Review Panel considers that, in general, preparations for the SEDAR Review Workshop were comprehensive. Modest additional information needs are noted above in relation to the Data Workshop terms of reference. In addition to these, the Review Panel recommends that future SEDAR data workshops be tasked with compiling the data into a form ready for incorporation into the assessment models. This would allow a greater degree of interaction and feedback between the data preparation and assessment formulation processes.

In relation to the SEDAR process, the Review Panel considers it to be an effective peer review. Of special note was the work of the red drum Assessment Team both prior to and during the Review Workshop. The response of the Assessment Team to the requests of the Review Panel was very professional and effective. Without this degree of cooperation, the Review Workshop would not have been the success that it was.

It would help to have more external peer review in Data and Assessment Workshops to sort out detailed technical issues well in advance of the Review Workshop but this would depend upon budgets and policy on use of CIE experts (i.e. implications for independence rating).

It would have assisted the Review Panel’s understanding of SEDAR to have a diagram of the overall process and where each workshop fits.

On Review Workshop preparations, the Review Panel commends the efforts to establish a well functioning wireless network in the meeting room. IT support was always prompt and effective. The file exchange system (WinSCP) was a particularly good software application for the review.

2.1.8 Term of Reference 8

Review the research recommendations provided by the Data and Assessment workshops and make any additional recommendations warranted; clearly indicate the research and monitoring needs that may appreciably improve the reliability of future assessments; recommend an appropriate interval for the next assessment

2.1.8.1 Recommendations of Data Workshop (9 – 13 February 2009)

Life History Work Group

The ASMFC-approved multi-state sampling program of adult Atlantic red drum from Florida to Virginia represents a unique opportunity to obtain critical comprehensive data. Specifically relevant to the genetic population structure evaluation is the concurrent aging of the fish which will allow for the determination if any detected genetic structure is the result of differential age composition of the reproductive stock, particularly in light of the proposed temporal genetic heterogeneity (Chapman et al. 2002) and suspected age structure differences from the GoM. The combined age-specific life history and genetic knowledge will allow for greater interpretive capabilities of the genetic data as well as provide the needed life history information necessary for an accurate estimate of effective population sizes for Atlantic red drum

- The Review Panel considers this project low priority for leading to improvements to the assessment of red drum stock status. The Review Panel considers that further investigation into population structure is important. However, genetic analyses are only one of the tools available to address this question and may be of limited utility if there are low levels of gene flow among populations or if population divergence has been recent. It was not clear to the Review Panel how knowledge of the effective population size would be expected to improve the assessment.

Updated maturity schedules and fecundity information for adult Atlantic red drum from Florida to Virginia is lacking; just as there are suspected age structure differences between the Atlantic and GoM stocks, maturity schedules and fecundity estimates are also suspected to be different in the Atlantic stock.

- The Review Panel supports research to better characterize maturity schedules of red drum for the northern and southern stocks, given the observed differences in growth in these resources. This study would require a specially designed sampling plan given the potential bias due to age- and possible maturity-dependent processes.

Further study is needed to determine discard mortality estimates for the Atlantic coast, both for recreational and commercial gears. Additionally, discard estimates should examine the impact of slot-size limit management and explore regulatory discard impacts due to high-grading.

- The Review Panel recommends the establishment of programs to provide on-going estimates of commercial discard and recreational live release mortality using appropriate statistical methods. While specifically targeted studies are useful, it is through time series of these data that patterns emerge and insight is gained on both mortality rates and influential processes.

Dedicated northern and southern region larval and juvenile recruitment indices, as well as a Virginia adult recruitment index are recommended to provide more informative trends for future assessment processes

- The Review Panel does not support the establishment of larval surveys to provide indices of spawning biomass. Larval surveys can only provide general indications of spawning biomass. There are more direct sampling approaches to assess spawning biomass. Further, the Review Panel recommends evaluation of the broader survey program needs (see section 2.1.8.3).

Continued cooperation between state ageing labs, such as the October 2008 red drum ageing workshop, to provide consistent age verification between labs; additionally, otolith microchemistry should be approached to look at state differences between regions for stock differentiation

- On-going cooperation between state ageing labs should be standard best practice; the Review Panel notes its concern if this is not occurring. It is thus highly supportive of this recommendation.
- In relation to the recommendation on otolith microchemistry, the Review Panel considers that this project would be of value if the life stage linkage between estuarine and offshore red drum were incorporated into the study. There is uncertainty on the origins of offshore adult red drum in relation to the early life history stages in the estuarine habitat which could be resolved by this study.

Identification of juvenile and adult habitat requirements and loss rates would provide more informative information for future management planning

- As this recommendation does not directly pertain to improvements in the stock assessment but rather to management, the Review Panel defers comment.

Commercial Work Group

Continued and expanded observer coverage for the NC and VA gill net fisheries (5-10% coverage)

- The Review Panel notes that observer coverage in the NC fishery during 2004-06 was adequate but didn't provide an indication of annual variability in discard rates. The Panel thus supports expanded observer coverage in State and Federal fisheries as appropriate to allow better on-going characterization of discards in directed and non-directed fisheries. As noted earlier, while specifically targeted studies are useful, it is through time series of these data that patterns emerge and insight is gained on both mortality rates and influential processes. Specifically, it is important that this program identify the main factors that cause both high vulnerability of red drum to fishing gear (e.g. salinity, temperature) and high post – release mortality (e.g. hook type).

Expand observer coverage to include other gears of concern (i.e. haul seine, pound net, trawls).

- As with the previous recommendation, the Review Panel supports expanded observer coverage in State and Federal fisheries as appropriate to allow better on-going characterization of discards in directed and non-directed fisheries.

Expand biostatistical sampling (ages and lengths) to better cover all statistical strata (gears/states - principally NC and VA) – more ages proportional to lengths, preferably otoliths

- The Review Panel recommends that this project only be undertaken based upon a statistical analysis which would specify the details of a sampling program required to comprehensively characterize the age/size composition of removals.

Recreational Work Group

Have experts in survey design and implementation review historical data

- Sampling design is fundamental to any survey activity but it is unclear what is being proposed. Thus, the Review Panel cannot comment on this recommendation.

The recreational statistics workgroup supports ongoing efforts to improve recreational and for-hire data collection through the Marine Recreational Information Program (MRIP)

- The Review Panel supports this recommendation to the degree that it informs the stock assessment of red drum.

We support inclusion of volunteer logbook data for length

- The Review Panel supports this recommendation to the degree it informs stock assessment of red drum. Further, the statistical methods used to analyze the collected data require careful consideration given that there does not currently appear to be an experimental design for the volunteer program.

Indices Work Group

Adult sampling with the goal of small population estimates or density estimates through tag-recapture methods to evaluate trends in abundance over time. Secondarily, this would help with delineate the stock distribution and mixing rates.

- This recommendation is unclear. Thus, the Review Panel cannot comment.

Suggests a workshop on adaptive sampling techniques as applied to wildlife populations as well as other techniques that can be applied to aggregated species.

- See the Review Panel's recommendation on surveys (section 2.1.8.3). There, the need for the study of the broader survey program needs is identified.

Encourage that States continue on with current surveys, and with current methodologies. If sampling methodologies change, the workgroup suggests some consistency exist between the original and new methodologies.

- As with the previous recommendation, see the Review Panel's recommendation on surveys (section 2.1.8.3). There, the need for the study of the broader survey program needs is identified.

Age structure established for surveys internally rather through external age-length keys

- Best practice is that survey-specific age/length keys are developed and applied to that survey's size frequency information to provide age-based estimates of abundance. Thus, the Review Panel endorses this recommendation.

2.1.8.2 Recommendations of Assessment Workshop (1 – 5 June 2009)

Determine batch fecundity estimates of red drum

- The Review Panel does not support this recommendation as it will not significantly improve the red drum stock assessments. While more precise estimates of fecundity could be provided, it is unclear how these would be used given the uncertainties in the estimation of age 4^+ female abundance.

Conduct experiments using logbooks etc. to develop estimates of the B2 catch in both the North and South regions

- See the Review Panel's response to the Data Workshop's recommendation on volunteer logbook data (section 2.1.8.1), where the need for careful consideration of the statistical analyses to be employed on these datasets was noted.

Further identify the selectivity of age classes of the B2 catch in both regions

- Assuming that adequate size frequency information is collected for the B2 catch, the Review Panel supports explorations of assessment model formulations that fit modeled size frequencies to the observations (see section 2.1.8.3).

Determine if existing and historic recreational tagging programs can be used to evaluate better B2 selectivities

- See previous recommendation.

2.1.8.3 Recommendations of Review Workshop (24 – 28 August 2009)

The Review Panel considered the needs of the two red drum assessments that were additional to those noted in the Data and Assessment workshops. These covered issues spanning input data, assessment model and benchmarks.

- The Review Panel recommends study of the broader survey program to better identify gaps in current activities and potential expansion / refocusing of current surveys. At present, it is difficult to discern where improvements to the overall survey program could be made. This study could be undertaken through simulation work to evaluate how proposed new survey activities would better inform stock assessment and management.
- The Review Panel notes the gap in synoptic indices of adult abundance and age composition which are critical to improvements in the red drum stock assessments. It recommends that a survey to provide indices of abundance for ages 4 and older be established but in the context of the previous recommendation. During the Review Workshop, mention was made of apparent gaps in the size frequencies (i.e., red drum present in these distributions at smaller sizes and again at larger sizes but with few observations in between). The Review Panel recommends development of testable hypotheses on the biological basis of this apparent missing size frequency information. Survey activity could then be designed to challenge these hypotheses.
- The Review Panel recommends that a comprehensive analysis of existing tagging data for use in the assessment models be undertaken and, based upon this, there be consideration of additional tagging activities (based upon a statistical design for both the northern and southern stocks to provide age-based estimates of population abundance and fishing mortality). This activity could also provide estimates of movement which can confound estimation of stock parameters. It would be worthwhile to consider State- Space methods as has been recently employed to estimate fishing mortality and migration rates of some New England groundfish stocks (Miller and Andersen, 2008).
- Further on the tagging data, the Review Panel strongly recommends integration of the tagging analysis into the assessment models, thereby ensuring that parameters and error estimates derived in the model are appropriately treated throughout the analysis. This would ensure that the tagging data are appropriately weighted in the assessment model and are not afforded undue weighting compared to other information.

- The Review Panel recommends exploration of iterative re-weighting to better define weightings for the contribution of each data set. The contribution of the survey indices to the negative log-likelihood calculated by the assessment model should be modified to allow for both the variance associated with sampling, i.e. related to the CVs calculated for the surveys, and an additional variance component due to "fluctuations in ... the fraction of the population present in the sites being surveyed" (Punt et al., 2002). An example is presented by DeOliveira et al. (2007), who cite Butterworth et al. (1993). Essentially, the inclusion of this additional variance provides an iterative re-weighting of the survey indices and avoids the need for including an arbitrary, subjective, external weighting, such as that currently employed in the assessment model. A similar approach may need to be adopted for other components of the objective function if the observations are derived from samples that are not fully representative.
- The effective sample size that is currently employed when calculating the negative log-likelihood of the proportion-at-age data, i.e., the square root of the number of fish in the age-length key for the year or two if no age-length key was available for the year, should be compared with the value that is currently calculated in the ADMB implementation of the model using the method described by McAllister and Ianelli (1997, Appendix 2, Equation 2.5). Such a comparison might indicate whether the effective sample size currently used is appropriate.
- The Review Panel recommends exploration of assessment model formulations that fit modeled size frequencies, based upon age-based population dynamics to the size frequency observations. This would facilitate use of size frequency data when data for age / length keys are too sparse to reliably derive age composition.
- The Review Panel recommends exploration of imposing constraints on the size of the age 4^+ abundance to determine whether or not model fits are improved.
- Possible inconsistencies among the various data sets that contribute to the objective function of the assessment model should be explored by plotting the likelihood profiles for each component across the ranges of feasible values for the parameters that represent the major axes of uncertainty. By examining the resulting plots, it is possible to identify the values of the parameters that minimize the negative log-likelihood of the different components, and thereby identify those parameters that most influence the values of the parameter estimates. Identification of inconsistencies among the data sets provides a focus for re-assessing the extent to which inconsistent data sets are representative of the variables that they are intended to measure.
- Convergence of the assessment models for the base, sensitivity and retrospective runs should be confirmed by "jittering" the initial parameter values and re-fitting the model a number of times, e.g. 100, then comparing the resulting parameter estimates and values of the objective function (e.g., Methot, 2007). Exploration of the consequences of "jittering" may also reveal whether the model converges to a region of parameter space in which the Hessian is positive definite, noting that, in several of the retrospective runs, the Hessian was found to be non-positive definite.
- Highly-correlated parameters indicate that the parameter estimates to which the model has converged are likely not to be unique, and that the model may be over-parameterized. In

future stock assessments, the Review Panel recommends that the parameter correlation matrix should be explored.

- The Review Panel recommends exploration of use of estimates of fishing mortality directly from the tagging data (i.e. northern stock) as the basis for stock assessment and guidance for fisheries management. Current stock assessments are undertaken every five years or so and involve the collection and synthesis of a wide array of data. The tagging program, as long as it is designed appropriately, can directly provide estimates of fishing mortality at a higher frequency than the current statistical catch-at-age (SCA) formulations. It also has the benefit of having wide fishery visibility and support. Through a simulation exercise, such as Management Strategy Evaluation (MSE), the efficacy of using the tagging-derived fishing mortality estimates between applications of the SCA assessment could be explored. The use of the tagging information directly to inform management decision rules could also be investigated.

2.1.8.4 Recommend an appropriate interval for the next assessment

Key issues which influence the appropriate interval until the next red drum assessments are significant advances on the research agenda and the nature of management actions. It is evident that until progress on many of the research recommendations outlined in this report is made, future assessments will suffer many of the same uncertainties that have influenced the current assessments. It would be inappropriate to undertake assessments before the key ones are addressed. If management requires more immediate assessment input, then consideration should be given to more immediate addressing of the tagging-related recommendations as these may provide improvements in the relatively short-term. The last Review Panel recommendation on MSE-style simulations is of particular note in this regard. This approach would allow evaluation of the assessment approach (e.g. SCA, tagging analysis) in the context of the management tools in use.

Under these conditions, it is likely that the next assessment should not be undertaken within at least five years.

2.1.9 Term of Reference 9

Prepare a Peer Review Consensus Summary summarizing the Panel's evaluation of the stock assessment and addressing each Term of Reference; develop a list of tasks to be completed following the workshop; complete and submit the Consensus Report within three weeks of workshop conclusion

Regarding the tasks to be completed following the workshop, each section of the Review Panel's report was assigned to a panelist for drafting. These were compiled by the chair and then edited by the chair and Review Panel. The final report was then circulated to the Review Panel for approval. As well, the Assessment Team was provided with a list of tables and charts to be prepared for the report. It also updated the assessments based upon the discussions at the Review Workshop.

Regarding the timing of the submission of the Review Panel report, at the Review Workshop, it was agreed to delay its submission by one week to give the Assessment Team time to make identified modifications to the northern and southern assessments. The Review Panel consensus drafts were due to the Chair and SEDAR by 18 September, with the Consensus Report by the Chair due to SEDAR by 2 October. The Center for Independent Experts was consulted and agreed to this change.

2.2 Summary Results of Analytical Requests

2.2.1 Pre-Review Workshop

Prior to the Review Workshop, the SEDAR Coordinator arranged for a series of teleconferences to acquaint the Review Panel chair with the Assessment Team and assessment as well as to provide the Review Panel with an opportunity to discuss issues that may have arisen during its pre-workshop review of the documentation.

The first teleconference was held 13:30 – 14:30 EST on 12 August 2009. Besides the SEDAR coordinator (D. Theiling) and Review Workshop chair (R. O'Boyle), the lead red drum assessment analyst (M. Murphy) and members of the Assessment Team (J. Grist, L. Paramore, M. Denson) were in attendance. M. Murphy provided an overview of the assessment data inputs, model and its sensitivities and apparent stock status. Following this, the chair asked a number of questions on the data and the model which clarified his understanding of the assessment. It was agreed that all pre-Review Workshop communications on issues from the Review Panel would be routed to the Assessment Team through the SEDAR Coordinator. The latter also noted that M. Denson had been appointed as the RW rapporteur with J. Grist providing backup. The SEDAR coordinator encouraged the chair to communicate his reporting requirements to the rapporteurs prior to the Review Workshop, which he did. It was subsequently indicated that N. Meserve of the ASFMC would serve as rapporteur on Thursday and Friday at the Review Workshop.

The second teleconference was held during 13:30 – 14:00 on 13 August 2009. Besides the SEDAR Coordinator (D. Theiling) and Review Workshop chair (R. O'Boyle), it was attended by the Review Panel, including M. Cieri, N. Hall and J. Gibson. Due to a scheduling conflict, K. Stokes, could not attend. In preparation for this call, the chair prepared a list of issues and potential presentations by the Assessment Team, organized by Review Workshop terms of reference, based upon his review of the data workshop and assessment workshop reports and the discussion with the Assessment Team on 12 August. In addition, he provided an outline of a draft agenda which indicated the time to be allotted to discussion on each terms of reference. At the teleconference, a number of additional issues were raised and the initial list of issues updated.

An issue raised by the Review Panel was the need to undertake a continuity check of the current with the previous (2000) assessment. The Assessment Workshop report noted that the 2000 assessment was based upon three models (Separable VPA, Spreadsheet Statistical Catch-at-Age Analysis or SprdSCA and F-ADAPT) with only the SprdSCA being able to be duplicated as a continuity check, this due to changes in methodologies used to calculate indices and the catch-at-age. The SEDAR 18 Assessment Workshop had not found the results of the continuity model worthy of consideration given the inability to reproduce the original data. In lieu of this, the Review Panel requested that a continuity check be undertaken by applying the current assessment's SCA formulation to the data for the time period used in the 2000 assessment. This was done and communicated to the Review Panel prior to the Review Workshop (working paper SEDAR 18 – RW01). The analysis showed little difference between the time-shortened and full-time period model estimates of red drum abundance and exploitation in the northern region. The full-time-period model showed a slightly more rapid increase in abundance during 1994-1998 and a resultant greater depression in the exploitation rates for those years. With these lower exploitation rates, the calculated sSPR was slightly higher for the full-time-period analysis than for the time-shortened analysis. On the other hand, the southern region time-shortened and full-time-period analyses showed much more significant differences. The time-shortened model estimated lower abundances and no increasing trend in abundance during 1986-1998. It also estimated higher exploitation rates than did the full-time-period analysis. Both models showed a decline in exploitation rates between 1987 and 1989 but the time-shortened model's rates were higher and showed a slow rebound in the level of exploitation after 1990. Given the overall higher exploitation, sSPR levels were considerably less for the time-shortened analysis than for the full-time-period model. It was felt that some of the differences between the 1986-1998 and 1982-2007 SCA models in the southern region could lie in the contrast added when the high levels of harvest prior to 1986 were included. This was discussed further at the Review Workshop.

The Review Panel also suggested that the residuals between the observed and predicted proportions-at-age from each fishery in each stock be tabulated to better illustrate model fit to these data. Working paper SEDAR 18 – RW 02 was subsequently prepared and distributed to the Review Panel prior to the Review Workshop. For both stocks, it appeared that the model was overestimating (negative value for observed proportion minus model-predicted proportion) the proportions for ages 5-7^+. It was speculated that the fishing mortality for these ages could have been held artificially high by the selectivity constraints forcing 5% of the age 3 fishing mortality onto these age groups. Less consistently, the model underestimated proportion-at-age 4 and sometimes age 3, possibly reflecting a balance to the misfits at the older ages. Again, this was further discussed at the Review Workshop.

Regarding process, it was clarified on the teleconference that the rapporteur's notes, while valuable to the Review Panel, would not be included in the Review Workshop report.

The initial list of issues and draft agenda was updated by the Review Panel chair and communicated to the Assessment Team through the SEDAR Coordinator, emphasizing that the intent was to give the Assessment Team as much heads up as possible to allow efficient preparation for the Review Workshop.

The full Review Panel convened an additional teleconference during 20:00 – 22:00 EST on 20 August 2009 to further refine the list of issues and finalize the Review Workshop agenda. In preparation for this call, the Review Panel explored further the issues that it had encountered during its review of the documentation. The Review Panel identified possible errors in the model code at this time that required correction before the assessment results could be reviewed. The model code used to correct abundance for natural mortality occurring prior to the survey did not appear be correctly implemented. The length of time between the start of the year and the time of the survey was input in months, whereas the code was written as if the input was in years. The Assessment Team acknowledged this error, corrected it and reran the assessment prior to the Review Workshop. The Review Panel also found inconsistencies between the survey values reported in the workshop reports and the data input files:

- Data for the North Carolina Juvenile Abundance Index from 1991 to 2007 are presented on page 114 of the Data Workshop Report, but the values did not match those in the data file used by ADMB
- Data for the South Carolina Electro-shock Survey are presented on page 111 of the Data Workshop Report, but the values did not match those in the data file used by ADMB
- Data for the South Carolina Trammel Net Survey are presented on page 120 of the Data Workshop Report, but the values did not match those in the data file used by ADMB

As with the survey index timing issues, these inconsistencies were resolved by the Assessment Team prior to the Review Workshop, resulting in a change to one of the data input vectors.

During the teleconference, the list of issues drafted as a consequence of the first two teleconferences was discussed and changes made. The main issues related to

- Data Inputs: stock structure, fishery removals, fishery catch of size to age conversion process and aging error, survey indices, tagging and growth
- Assessment model: fishery selectivity and influence on size of plus group, size of plus group, model selection criteria, retrospective analysis and the continuity check
- Biological Reference Points: Cryptic biomass (accumulation of biomass in the plus group for which there is little empirical support as opposed to modeled population dynamics), biological basis of reference points, maturity schedule, and overfished and overfishing reference points

This list was communicated to the Assessment Team and served as a guide to the discussions at the Review Workshop.

The Review Workshop agenda was also discussed and updated. Specifically, timing of consideration of the presentations on the data and models was moved so that these would be completed by Tuesday evening. This required the addition of evening sessions. Time was allotted to drafting and reruns on Wednesday with the intent being finalization of discussion on stock status by Thursday.

One final item discussed prior to the workshop is the suite of stock status indices to be reported to the interested management agencies (e.g. ASMFC). The Review Panel chair proposed (via the SEDAR Coordinator) that the suite of indices include 1) trends in catch and fishing mortality (proxy for effort), 2) trends in spawning biomass, exploited biomass, total biomass and recruitment, 3) trends in the indicators most relevant to the biological reference points (in this case, perhaps escapement biomass) and 4) profiles of the probability of overfishing and being overfished in the current year. Responses from D. Vaughan and N. Meserve generally corroborated this suite. This was further discussed and modified at the Review Workshop.

In general, in preparation for the Review Workshop, the Review Panel spent considerable time reviewing the assessment documentation including running model code and developing a list of major issues for consideration at the Review Workshop. The Assessment Team led by M. Murphy was highly responsive to the requests from the Review Panel and was proactive in addressing many of the issues prior to the meeting. This allowed the Review Workshop to focus on substantive issues rather than being side-tracked by data and coding updates. The Review Panel was impressed by the professionalism of M. Murphy and his Assessment Team in working with the Review Panel to resolve these issues and wished to put this on record.

2.2.2 During Review Workshop

At the Review Workshop, the Review Panel considered the full spectrum of data and model issues for both the northern and southern Red Drum assessments. These resulted in a number of modifications to the assessment formulations as developed by the Assessment Team. It is important to note that the Review Panel determined that these assessment model modifications did not constitute a new assessment.

Provided in this section is an overview of the analyses conducted during the workshop, all of which have been referenced in section 2.1. The details of the assessment model modifications and associated analyses / re-runs are provided in Appendix A and the ADMB model code and data in Appendix B and C.

The Review Panel heard comprehensive presentations by the Assessment Team on the biology and data inputs of the northern and southern red drum stock assessments. Regarding landings and removals (section 2.1.1.2), the main modification recommended by the Review Panel was the application of the 2004 – 2006 average commercial discard / kept ratio to the entire time series of commercial information for the northern stock.

As noted in section 2.1.1.3, the Review Panel considered that the level of sampling prior to 1989 for both stocks was inadequate to characterize annual proportions-at-age in the removals. Thus, both assessments started in 1989. This is a major modification to both assessments as the 1980s was previously noted to be a period of high exploitation.

Regarding surveys, as noted in section 2.1.1.4, the Review Panel heard presentations by the Assessment Team on the spatial coverage and abundance trends of each survey used in the assessments. While the Review Panel accepted the suite of surveys used in each assessment, it noted the Assessment Team's use of the geometric mean to provide annual indices of abundance and recommended instead use of the arithmetic mean. This was accepted by the Assessment Team and necessitated re-calculation of each survey series at the Review Workshop.

Regarding tagging (section 2.1.1.5) and biological data (2.1.1.6), other than recommendations on future work, the Review Panel concurred with the treatment of these data by the Assessment Team and did not recommend any modifications during the Review Workshop.

Regarding the assessment models, 134 and 157 parameters were estimated by the northern and southern stock assessment models respectively. During the Review Workshop, it was noted that each initial model had one more parameter than was required for both first-year abundance-at-age and for the age one abundance in each year. The models were modified to address this. The main modification to the two assessment models involved the estimated age – specific fishery selectivity. The initial models had assumed age 4 and 5^+ fishery-specific selectivity as 10% and 5% of the estimated age 3 selectivity. While the Review Panel acknowledged the rationale in assuming age 4^+ fishery selectivities were fractions of that of younger age groups, it recommended that these fractions be determined within the two assessment models through use of estimated constants for ages 4 and 5^+. This modification was employed in the two base case models.

As noted in section 2.1.2, the Review Panel suggested use of the "sdreport_variable" declaration (straightforward implementation within ADMB) for obtaining standard errors on derived model output (e.g. total abundance). This approach was implemented for the final model runs. The Review Panel also demonstrated post-convergence MCMC methods available within ADMB as a method for exploring the parameter space to determine how well model parameters were being estimated (see figure 2.1.4.1).

During the Review Workshop, considerable time was spent considerable time examining the sensitivities of the two base case models to their key assumptions, these being those on natural mortality (low to high), live release mortality (0.16 versus 0.08), fishery selectivity (constants versus estimated) and, in the case of the northern assessment, use (or not) of the tagging data, the results of which are reported in sections 2.1.5 and A3.2.2.8. Additionally, retrospective analyses of the two base case assessments to determine how the modifications made changed these from patterns observed in the initial Assessment Workshop formulations were also considered. These were influential in the Review Panel's comments on the status of the southern stock (section 2.1.4.3).

An issue that arose during the explorations of assessment model behaviour was lack of convergence in some of the retrospective analyses. Explorations at the Review Workshop failed to resolve this issue. The explorations led the Review Panel to make recommendations on further investigation of the causes for lack of convergence (section 2.1.8.3). Another issue was the apparent inconsistency within the northern model of the 1989 age 7^+ abundance compared to that of younger age groups. Attempts at the Review Workshop to resolve this inconsistency were not successful, again prompting the Review Panel to recommend further exploration.

Regarding status benchmarks (section 2.1.4), the Review Panel accepted the use of the static spawning potential ratio (sSPR) as an indicator of fishing pressure and 30% sSPR and 40% sSPR as benchmarks of overfishing and target fishing mortality respectively. It did not, however, consider annual changes in sSPR informative and preferred to adopt a three-year running mean of estimated annual sSPR as the indicator to compare to the benchmarks to guide management. The Review Panel did not endorse the use of a benchmark based on escapement as this is another translation of fishing mortality but without commonly recognized benchmarks. Subsequent to the Review Workshop, and as agreed, the yield-per-recruit and spawning-stock-biomass-per-recruit analyses were updated and are reported in section A3.2.2.9.

Finally, the trends in age 1 – 3 abundance, annual sSPR and three-year average sSPR were produced by the Assessment Team using the northern and southern models as modified by the Review Workshop (section 2.1.3). As noted earlier, the Assessment Team also updated the tables and figures of trends for each stock (Appendix A).

Overall, the Review Workshop represented an in-depth and thorough review of the 2009 northern and southern red drum stock assessments.

2.3 References

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3 Submitted Comments

None were received.

Appendix A. Revised Stock Assessment Analysis of the Northern and Southern Region Atlantic Red Drum

Purpose

This appendix describes the data input, model specification and model output details for the northern and southern stock assessment base and sensitivity runs as agreed to at the Review Workshop held in Atlantic, Georgia on 24-28 August 2009. The organization of the text, tables, and figures is similar to that for Section 3.2 in the Assessment Workshop Report.

This appendix is the final assessment and is the subject of the final review. Significant revisions were involved. These revisions affected data, data use, analytic approaches, assessment outputs, and interpretation of results. While there were essential differences between the analyses and accompanying discussion reported in the initial AW Report and those presented in this appendix, the Review Panel determined the replacement model run and analyses did not constitute a new assessment. To gain a full understanding of the assessment and its review through time, the reader should read the original AW Report (SAR Section III), the RW Report (SAR Section V), and the RW Report appendix (SAR Section V, Appendix A).

Although Appendix A resulted from requests by the SEDAR 18 Review Panel and its preparation benefited from the assessment review, it remains a product of the Atlantic Red Drum Assessment Panel and is independent of the Review Panel Report to which it is appended.

A3.2 Model Two – Revised Statistical Catch-at-Age

A3.2.1 Methods

A3.2.1.1 Overview

A standard SCA model was revised at the request of the Review Workshop Panel to reduce the number of parameters used to describe recruitment and the initial population age structure, solve for parameters that relate age-4 and age-5 selectivities to that estimated for age 3, and include only those data available for 1989-2007. Also, errors found in the original model coding (intra-annual decrement of abundance) and input data (northern Juvenile Abundance Index data) were corrected.

A3.2.1.2 Data Sources

The observed data used in the analyses for the southern and northern stock of red drum included the total annual harvest (landings plus release mortalities) attributed to each fishery, the estimated age-proportions in these annual harvests, indices of abundance, and tagging derived fishing mortality-at-age. For all observed data derived from estimates, measures of precision were available for use in the model.

The data inputs included the 1989-2007 total annual kill of red drum by the northern fisheries for the four fishery fleets used in the original analysis. For the southern region total annual landings were also the same as originally used but excluded the Florida commercial fishery which ended before the initial year used in the revised analysis.

The input data for the age compositions for the catch was confined to the shortened 1989-2007 time frame but were otherwise the same as originally used. All input data on relative abundance is the same except for corrections to the JAI index used for age-1 red drum in the northern region. The chronological order for these data was incorrect in the original and the time frame was off by one year. Tag-based estimates of instantaneous fishing mortality (F) in the northern region were truncated to include only the shortened time frame. The separability assumption was applied within the same periods described for the original model, as available under the shortened 1989-2007 time frame. Natural mortality was assumed constant over time, though varying with age for each regional stock.

A3.2.1.3 Model Configuration and Equations

The population dynamics model was based on annual fleet- and age-specific separable fishing mortalities:

$$F_{f,y,a} = F^*_{f,y} s_{f,y,a} \qquad \text{for a} = 1, 2, 3$$
$$F_{f,y,a} = F^*_{f,y} s_{f,y,3}\, c_a \qquad \text{for a} = 4, 5$$
$$F_{f,y,a} = F^*_{f,y} s_{f,y,5} \qquad \text{for a} = 6, 7+$$

where $F_{f,y,a}$ is the instantaneous fishing mortality caused by fleet *f* in year *y* on age *a* fish, F* is the apical fishing mortality for fleet *f* in year *y*, and *s* is the selectivity, a bounded number ranging from zero and one. Given red drum's inherent reduced vulnerability after age 3 due to their movement from estuarine waters to nearshore waters and more recently to enacted maximum size limits, the selectivity for ages 4 and 5 fish were restricted to be a proportion of the selectivity at age-3. The parameters c_a, for *a* equal to 4 and 5, were bounded numbers between zero and one. The fishing mortality for ages 6 and 7^+ were set equal to that estimated for age 5

The abundance of the different age groups in the population are modeled forward in time beginning with estimates for a series of recruits ($N_{y,1}$ in 1989 through 2007) and an initial year's abundance at age ($N_{1989,a}$ for ages 2-7^+). Initial conditions were both modeled as bounded variables on the log scale. From these starting abundances older ages are sequentially modeled as:

$$N_{y+1,a+1} = N_{y,a} e^{-\sum_f F_{f,y,a} - M_a},$$

where M_a is the age-specific instantaneous natural mortality rate. A 'plus' group abundance included survivors from both the previous year's plus group and that year's next-to-oldest age group

$$N_{y+1,A} = N_{y,A-1} e^{-\sum_f F_{f,y,A-1} - M_{A-1}} + N_{y,A} e^{-\sum_f F_{f,y,A} - M_A},$$

where *A* is age 7^+.

The observation model for these analyses involves total catch, the proportion of the fleet- and year-specific catch in each age group, and indices of abundance. The fleet- and year-specific predicted catch at age, $C_{f,y,a}$, was calculated using the Baranov catch equation:

$$\hat{C}_{f,y,a} = N_{y,a}\frac{F_{f,y,a}}{\sum_f F_{f,y,a} + M_a}\left(1 - e^{-\sum_f F_{f,y,a} - M_a}\right),$$

with the annual total catch for each fleet determined by summing across ages and the proportion at age in the catch determined from the age-specific catch relative to this annual total. The observed catch has an assumed lognormal error, ε_{fya}, from the true catch and the model estimates the true catch.

Indices of abundance were assumed linearly related to the stock abundance of chosen age groups expected at the time of the relative abundance survey:

$$\hat{I}_{s,y} = q_s \sum_a N_{y,a} e^{\left(\sum_f F_{f,y,a} + M_a\right)\frac{m}{12}},$$

where $I_{s,y}$ is the predicted index of relative abundance for the age(s) caught by survey s in year y, q_s is the proportionality constant for survey s, and the summation of N_y is the total abundance in year y across the age(s) included in the index and decremented for the within-year mortality through month m.

The objective function used to confront the observation model predictions with the observed data contained abbreviated lognormal negative log likelihoods for fleet- and year-specific total catch and annual indices of abundance:

$$negLL\left(\mathrm{T}_f\right) = \sum_y \left(0.5\frac{\left(\ln\left(\overset{o}{T}_{f,y} + 1.e^{-6}\right) - \ln\left(\sum_a \hat{C}_{f,y,a} + 1.e^{-6}\right)\right)^2}{\sigma^2_{f,y}} + \ln\left(\sigma_{f,y}\right)\right),$$

where $T_{f,y}$ is the observed total number killed each year y by fleet f and $\sigma_{f,y}$ is the standard error of the total catch within each fleet each year. The variance was estimated from the reported coefficient of variations using $\sigma^2=\ln(CV^2+1)$. The CV's were available for the recreational fisheries as the proportional standard error (PSE) and were assumed low (0.01) for the commercial fisheries. Likewise, the negative log likelihoods for the indices of abundance were:

$$negLL\left(\mathrm{I}_s\right) = \sum_y \left(0.5\frac{\left(\ln\left(\overset{o}{I}_{s,y} + 1.e^{-6}\right) - \ln\left(q_s \sum_a \hat{N}_{y,a} + 1.e^{-6}\right)\right)^2}{\sigma^2_{s,y}} + \ln\left(\sigma_{s,y}\right)\right),$$

where $I_{s,y}$ is the observed index for the age(s) in the survey in year y, and $\sigma_{s,y}$ is the standard error of the survey index in year y, estimated from the original data or from a standardization procedure, e.g. delta lognormal method (Lo *et al*. 1992). Of course, in the case of multi-age indices, estimated abundances across these ages would be compared to the index value.

For the catch proportion at age, a multinomial negative log likelihood was used:

$$negLL\left(P_{f,y}\right) = -\sum_a \left(n_{f,y} \left(\overset{o}{P}_{f,y,a} + 1.e^{-6} \right) \ln\left(\frac{\hat{C}_{f,y,a}}{\sum_a \hat{C}_{f,y,a}} + 1.e^{-6} \right) \right),$$

where $P_{f,y,a}$ is the observed proportion at age a in the total catch for fleet f in year y and $n_{f,y}$ is the sample size for aged fish. These components were not included for the fleets where the selectivity estimates based on tagging were used (northern live-release recreational fishery and the southern region's Florida recreational live-release fishery).

There were additional observed data derived from a long-term tag-recapture study conducted in the northern region that was utilized in these northern region analyses. The estimated fishing mortality rates at age and their standard errors for the pooled harvest (kept) fisheries in the north during 1989-2004 were included in the northern region's objective function as:

$$negLL\left(\mathrm{F}_{tag(y)}\right) = \sum_y \left(0.5 \frac{\left(\ln\left(F_{tag(y,a)}\right) - \ln\left(\sum_f \hat{F}_{f,y,a} \right) \right)^2}{\sigma^2_{tag(y,a)}} + \ln\left(\sigma_{tag(y,a)}\right) \right),$$

where $F_{tag(y,a)}$ and $\sigma_{tag(y,a)}$ are the observed fishing mortality and its estimated standard deviation for year y and age a. The estimated F's at age were only tallied for the recreational kept and commercial fisheries. Likewise, F-at-age estimates for the recreational live-release fishery were available for the period 1989-2004 from the tagging program. However, since the selectivity vectors from this program were used as input parameters because of the lack of observations for the catch-at-age for this fishery, only the information from its fully-recruited F's were used in the northern region's analysis:

$$negLL\left(\mathrm{F}_{full(y)}\right) = \sum_y \left(0.5 \frac{\left(\ln\left(F_{full(y)}\right) - \ln\left(\hat{F}_{full(y)} \right) \right)^2}{\sigma^2_{full(y)}} + \ln\left(\sigma_{full(y)}\right) \right),$$

where $\mathrm{F}_{\mathrm{full(y)}}$ and $\sigma_{\mathrm{full(y)}}$ represent the fully recruited F's for the recreational live-release fishery and its standard deviation.

The final components of the objective function include the sum of squares for the log of the unstandardized (to unity) selectivitities for each fleet-specific selectivity period and ages 1 through 3. These values were configured as a deviation vector, whose sum equaled zero. This added stability to the solution search routine.

The resulting objective function included input weights (λ's) for the different likelihoods that reflected the relative perceived levels of accuracy associated with the estimation equations for the predicted values was:

$$ObjFunction = \sum_{f}\left(\lambda_{TC(f)}\, negLL(\mathrm{T}_f)\right) + \sum_{f,y}\left(\lambda_{P(f,y)}\, negLL(P_{f,y})\right) + \sum_{s}\left(\lambda_s\, negLL(I_s)\right) + \sum_{y=1989}^{2004}\left(\lambda_{Ftag}\, negLL(F_{tag(y)})\right) + \sum_{y=1989}^{2004}\left(\lambda_{Ffull}\, negLL(F_{full(y)})\right) + 5.\sum_{fsel}\sum_{a=1}^{3} sel\_dev^2 .$$

The F_{tag} and F_{full} negative log-likelihoods were not part of the southern region analyses.

A3.2.1.4 Parameters Estimated

Parameters were estimated for: age 1-3 selectivity during each block of years within a fishery where selectivity was assumed constant, the fully recruited instantaneous fishing mortality (also referred to as apical F) for each fishery each year, the age-4 and age-5 selectivity constraints, the initial abundance for ages 2-7^+, the recruitment during 1989-2007, and catchability coefficients for each survey. All parameters except for the selectivity constraints were estimated in log space. For the northern region, 134 parameters were estimated and for the southern region, 157 parameters were estimated (Table A3.2.4.1).

The observed data for these analyses included: total annual kill by fleet, coefficients of variation (CV) for total annual kill by fleet, proportion at age each year, effective number of ages sampled each year for each fleet, fishing mortality-at-age for the combined 'harvest' fleets during 1989-2004 (northern region only), CV's for fishing mortality-at-age for the combined 'harvest' fleets during 1989-2004, fully-recruited F for recreational live-release fishery during 1989-2004 (northern region only), annual survey catch per unit effort, and CV's for annual survey catch per unit effort. There were 601 observations (data points), not including estimates of coefficients of variation for many of the data points or aged sample-size observations, in the northern region and 762 in the southern region (Table A3.2.4.2).

There were a number of input parameters (part of model structure) that were assumed to be known and without error, though several were analyzed through sensitivity analyses. These input parameters included: natural mortality at age, selectivity for all ages for Florida and northern recreational live-release fisheries, release mortality, ages included for each survey, survey time of year, and external weights for likelihoods from fleet-specific total catch, fleet- and year-specific proportion at age, each index, the total kept-fishery estimates of F-at-age, and the fully recruited F for the live release fishery.

A3.2.1.5 Uncertainty and Measures of Precision

Estimated coefficients of variation (or proportional standard errors) were used as measures of the precision for observed data. For the proportion-at-age data, the samples size and proportion indicated the precision of the observed data. For the model-estimated parameters, asymptotic standard errors were estimated during the model fitting process (see Section A3.2.2.1 Measures of Overall Model Fit). The precision of important derived values, e.g., average static spawning potential, was explored by describing their likelihood profiles. The implied precision from likelihood profiles is probably too great (i.e., narrow) given that there were no errors associated with input parameters, e.g., M at age, and the standard deviations of the standardized residuals often departed significantly from 1.0. This would suggest that there was additional 'process error' that was not included in the model. For these reasons, the precision of the estimated parameters and derived values is almost certainly too great, i.e., confidence bands are too narrow.

A3.2.2 Results

A3.2.2.1 Measures of Overall Model Fit

The fit of the model-predicted estimates to the observed data were measured in terms of the residual sum of squares, the negative log likelihood, and the standard deviation of the standardized residuals. Standardized residuals were defined as the difference between the observation and the model prediction divided by the observations input standard error. In addition, visual assessments of the fits were made. The choice of the 'best' overall model fit was determined for the original statistical catch at age model (see Section 3.2.2.1 Measures of Overall Model Fit). For the northern region, the model was configured with unity weights for all but the recreational-kept fisheries' age composition information, which was down-weighted using 0.01. In the southern region though it was not the 'best' (lowest residual sum of squares) of the schemes investigated, the model was configured with unity weights for all but the GA/SC recreational live-release fisheries' age composition information which was down-weighted using 0.1.

Northern stock

The northern model's fit to the observed data was reasonable given the estimated or assumed coefficients of variation for the observed data. For the total-catch component of the objective function, the commercial fisheries' fits were much better than for the recreational fisheries (Table A3.2.4.3). The small residual sum of squares (RSS) and negative log likelihoods, along with the standard deviation of the standardized residuals (SDSR) being much smaller than 1.0, reflect the near perfect match between the observed and predicted commercial landings (Fig. A3.2.5.1). The model estimated numbers of total mortalities generally falls within ±2 standard errors around the observed data (Fig. A3.2.5.1). The SDSR's for the recreational fishery harvest or total kill was greater than 2.0 showing excessive dispersion of these residuals (the expected standard deviation is one if the residuals were perfectly standardized by the CV's used) and potentially bias the estimated standard errors for population size and fishing mortalities.

The predicted proportion-at-age for the fishery harvest or kill, though down-weighted for the recreational kept fishery, fit this fishery's observed proportion-at-age well, with an SDSR of 0.17 (Table A3.2.4.3). Likewise, the 'other' commercial fishery's age composition was fit well. The predicted age composition of the landings for the main commercial fishery in the northern region, gillnets and beach seines, followed the general trends in the observed data but were often offset somewhat, e.g., they were low for age-3, 4, and 5 and high for ages 2 and 7^+ (Table A3.2.4.4).

The indices of abundance were fit well (Fig. A3.2.5.2). The lack of fit to the occasional peaks displayed in this index and the MRFSS total-catch rate index resulted in high standard deviations for the standardized residuals for these indices (Table A3.2.4.3).

Auxiliary data on observed fishing mortality rates were used in the northern model. In general, the fits were close for the age 1-4 fishing mortality rates for the combined commercial and recreational landings fisheries. The model estimates almost always fell within the ± 2 standard-error-range, though it underestimated the strong peaks in some observed age-1 and age-2 fishing mortalities (Fig. A3.2.5.3). The fit to the fully-recruited F for the recreational live-release fishery was also good, though some peak observed F's were not matched and the model interpreted the large 2002 landings as resulting in a much higher F than suggested by the tagging data (Fig.

A3.2.5.4). The generally high SDSR for these data can probably be attributed to what may be overly narrow observed standard errors for the tag-based estimates (Table A3.2.4.3)

Southern stock

The southern model's fit to the data was especially good for the catch-associated data and less so for the indices of abundance. The annual total catch was predicted well for all fisheries, with low RSS's and standard deviations for the standardized residuals of less than 0.14 (Table A3.2.4.5). The model-predicted total annual harvests or kills were always within the ±2 standard error envelope around the observed data (Fig. A3.2.5.5).

The proportion-at-age estimated by the model fit within the error bounds for most of the age-1 to age-3 observations. The fit to older ages was generally poorer with the model under-estimating the proportion at age for ages 4, 5, and 6 (Table A3.2.4.6). The SDSR's, calculated using the expected standard deviation for a binomial (square root of *Npq*), were less than or equal to 1.05 (Table A3.2.4.5).

The observed relative abundance indices were fit well in the southern region (Fig. A3.2.5.6). The model fits to the age-1 surveys generally showed less variability than did the observed data. The single adult red drum index was not fit well, with the model showing a stable trend in recent years and the observed data showing a strong declining trend since 2003. Except for this survey and the Georgia gillnet age-1 index, the SDSR's were 2.0 or less (Table A3.2.4.5).

A3.2.2.2 Parameter Estimates and Associated Measures of Uncertainty

The parameters estimated in the SCA include annual fully recruited estimates of F by fishery, period-specific age 1-3 selectivities, age-4 and -5 selectivity constraints, initial age-specific abundances, annual recruitment, and survey catchability coefficients (Table A3.2.4.1). Further discussion of the parameter uncertainties is included below in the appropriate sections describing stock abundance, recruitment, and fishing mortality and in section A3.2.2.8 Evaluation of Uncertainty.

A3.2.2.3 Stock Abundance and Recruitment

Estimates of total abundance for red drum indicate a decline in the northern region and about a 50% increase through 1991 in the southern region followed by stable abundance through 2007. In the northern region, estimated total population abundance was over 5 million fish (mostly 7^+) through 1992 declining to just over 3 million fish by 2007 (Table A3.2.4.7, Fig. A3.2.5.7). In the southern region, the total population was estimated at about 6-7 million fish after 1990 (Table A3.2.4.7).

Much of this rapid decrease in estimated abundance in the northern region comes from the decreases in the 'less available' adult portion (ages 7^+) of the population, and may be an artifact of the assessment model. The abundance of ages 1-3 are shown in Figure A3.2.5.8.

Estimated recruitment each year during 1989-2007 was more precise in the northern region than in the southern region. In the northern region, the estimated ± 2-standard-error bounds for recruitment were relatively larger during the years where recruitment abruptly peaked (Table A3.2.4.8, Fig. A3.2.5.9). In the southern region, the precision of the estimates was greater (smaller standard errors) during the mid 1990's than either earlier or later. Annual estimated southern region recruitment is much greater than northern region recruitment and the year-to-year trend has been relatively stable.

A3.2.2.4 Total Stock Biomass

The total stock biomass was not estimated in these analyses.

A3.2.2.5 Fishery Selectivity

Selectivities generally followed logical changes over the selectivity periods chosen for the analysis (based on management actions). In the northern region, commercial fisheries selectivities consistently peaked at age 2 (Fig. A3.2.5.10). In other southern fisheries, selectivities for ages 2 and 3 were more similar than for the northern region (Fig. A3.2.5.11).

A3.2.2.6 Fishing Mortality

Estimates of exploitation (= predicted annual catch / estimated beginning-of-the-year abundance) showed marked declines beginning during 1989-1992 in the northern region and 1989-1990 in the southern region. Northern region exploitation rates remained somewhat stable since the mid 1990's before increasing after 2004 (Table A3.2.4.9, Fig. A3.2.5.12). Since reaching a minima in 1992 in the southern region there has been a slow but statistically significant increasing trend in age 1-3 exploitation. Estimates of F's for ages 1-5 are given for each fishery in the northern region (Table A3.2.4.10) and the southern region (Table A3.2.4.11) and for all fisheries combined within each region (Table A3.2.4.12).

The estimated asymptotic standard errors for the fully recruited F estimates were generally larger in the early years of the analyses in the northern region and in the later years in the southern region. In the northern region the coefficients of variation (asymptotic standard error/estimate) were higher during 1989-1990 for the commercial and similar across years for the recreational fisheries (Fig. A3.2.5.13). In the southern region the estimated fully recruited F's were generally less precise in the later years for the commercial and recreational landed fisheries (Fig. A3.2.5.14).

A3.2.2.7 Stock-Recruitment Parameters

The northern stock has decreased in abundance markedly since the early 1990's so there is a strong decreasing trend in the spawning stock biomass (Fig. A3.2.5.15). In addition the level of recruitment, as estimated in the model, has decreased or become more variable about that same time, leading to an apparent relationship between spawning biomass and recruitment. In the southern region, abundance of older ages and therefore spawning biomass has been stable recently along with the abundance of age-1 fish.

A3.2.2.8 Evaluation of Uncertainty

A number of sensitivity runs were made to investigate the effects of different model configurations. The included changes to selectivity estimates, use of tag-based estimates of F (northern region), and changes to the input values for the instantaneous natural mortality and live-release fisheries' release mortality rate. Diagnostics requested by the Review Workshop Panel are provided in Table A3.2.4.13 (northern region) and Table A3.2.4.14 (southern region).

The northern and southern region models were configured in the revised model such that the selectivities of red drum age 4 and age 5 were estimated as a proportion (between 0.0 and 1.0) of the selectivity at age 3. This configuration was considered justified by evidence from tag return and general life history observations that red drum become less available to fisherman as they rapidly grow and move to less heavily fished nearshore habitats. To determine the sensitivity of these analyses to this configuration, the model was reconfigured so selectivity was estimated for ages 1 through 5.

This configuration of the northern region assessment provided estimates of exploitation and abundance that were only slightly different from the base model runs (Fig. A3.2.5.16). This lack of sensitivity was probably due to the information about declining selectivity-with-age contained in the observed tag-based F-at-age estimates for the combined commercial and landed recreational fisheries.

The southern region's analysis was highly sensitive to this configuration change. Without restrictions to selectivity, the estimates of abundance for red drum are much lower than the levels estimated in the base model (Fig. A3.2.5.16). Exploitation rates estimated for ages 1-3 were about four times higher when selectivity was estimated for ages 1 through 5. While the model fits to the observed data were reasonable when selectivity was estimated independently for ages 1-5, the patterns of selectivity were often erratic and age-4 selectivity was general greater than 0.20.

The review panel requested additional sensitivity runs involving the use of various selectivity constraints. The requested diagnostics for these sensitivities are given in Table A3.2.4.15 through Table A3.2.4.22.

The other model reconfiguration investigated was how the use of the tag-based data for the northern region model changed the estimated population dynamics. In all cases studied where the tag-based data were dropped from the model, the analysis converged on unrealistically large population estimates (>100 million) and therefore fishing mortality rates less than 0.05 with static spawning potential ratio\s exceeding 85%.

The input information on natural mortality at age and hooking mortality were uncertain so the 'best' estimates were used in the base model runs and alternatives were relegated to sensitivity runs.

For the instantaneous natural mortality rate, an upper and lower age-specific vector was estimated from the available life history information (see section 2.0 **Data Review and Update**). In the northern region, these alternative natural mortalities had only a minor effect on the estimates of abundance or exploitation for ages 1-3 (Figs. A3.2.5.17 and A3.2.5.18). The cumulative effect of the different M's was greater on the abundance of ages 4^{+}, with the abundance estimates being about 30% lower than the base model under the high M sensitivity and 25% higher, in recent years, under the low M sensitivity.

The southern region analysis was more sensitive to the alternative M-vectors than was the northern region analysis. In general, at the higher levels of M, the population size was estimated to be larger for all age groups and therefore the exploitation rate was lower (Fig. A3.2.5.17 and A3.2.5.18).

A single alternative hooking mortality value of 0.16 was investigated and compared to the base level of 0.08. In the northern region, the high-release-mortality model estimated age 1-3 abundances of red drum that were greater than for the base model, which largely offset the increased number killed so that age 1-3 exploitation remained about the same between the high-release-mortality model and the base model (Fig. A3.2.5.19). The trend in the age 4^{+} abundance changed dramatically from a declining trend over high abundances under the base model to a slowly increasing trend over very low abundance in the high release mortality model. In the southern region, the sensitivity run (high release mortality) showed higher abundances for all age groups and lower age 1-3 exploitation rates.

The retrospective analysis was conducted using the base model configurations and sequentially eliminating data available for 2007, 2006, 2005, 2004, 2003, and then 2002. In the southern region, the short Georgia gillnet survey was dropped from the 2004, 2003, and 2002 runs because the survey began in 2003. For the northern region, there was no strong evidence of any significant difference between the base and retrospective runs estimates of age 1-3 abundance or exploitation (Fig. A3.2.5.20).

In the southern region, the retrospective pattern was much more apparent. There was a consistent revision of past F's downward and past estimates of abundance upward as additional years of data were included in the analysis. There was no indication of a convergence between the different retrospective runs. This pattern greatly eroded the capacity of this model to estimate absolute levels of abundance, F, or static spawning potential.

A3.2.2.9 Benchmarks / Reference Points

The 2007 estimates of static spawning potential ratio (sSPR: the calculated female spawning stock biomass per recruit under the current year's age-specific fishing mortality rates divided by the same biomass per recruit expected under no fishing), as estimated using the base models, were 29.2% in the northern region and 50.7% in the southern region. The estimates of fishing mortality are generally less precise in the last year so a potentially better measure of the current sSPR may be the average for the last three years in the stock assessment. For the current assessment, this is 2005-2007. This is 45.3% in the northern region and 49.5% in the southern region.

Annual estimates of sSPR were low in 1989 and 1990 in the northern region before increasing to near-present levels by the mid 1990's. In the northern region, sSPR was estimated at less than 2% during 1989 and 1990, and then increased dramatically in 1991 to reach 21.6% (Table A3.2.4. 23, Fig. A3.2.5.21). Since then, sSPR has been variable but appears to have peaked during 1993-1994 at just about 70%. Since then it has fluctuated with a slow decline reaching 44-54% after 2004. Three-year running averages of these annual sSPR values are shown in Figure A3.2.5.22.

The sensitivity runs indicate that the likely bounds of the true 2005-2007 average sSPR (three-year sSPR average for 2007) were about 43-48% in the northern region and 0-65% in the southern region. Discounting the sensitivity where selectivity was estimated for ages 1-5 in the southern region, these three-year average sSPR's range from 37-65% (Table A3.2.4.24).

Another means of capturing the imprecision of the estimated benchmarks is to profile the model objective function total across various potential values of the benchmark. These profiles will under-estimate the imprecision (show too narrow a spread for the estimates) because the uncertainty for some model inputs (e.g., natural mortality at age, selectivity for Florida and northern region live-release recreational fisheries) is ignored. Regardless, these profiles show that the estimated 2007 three-year average sSPR for the northern region is much more precisely estimated than is the southern region estimate (Fig. A3.2.5.23). In both areas, the profiles indicate that it was more likely that the three-year sSPR was above the management target of 40% sSPR than below it: 98% chance in the northern region and 87% in the southern region.

Overall, the southern region estimates for sSPR were highly uncertain given the very low sSPR estimates under the selectivity-for-ages-1-5 sensitivity, the strong retrospective pattern, and the wide likelihood profile. While most of these and other sensitivity runs indicated that the 2007 sSPR was above the 30% overfishing threshold, many indicated that 2007 sSPR was below the 40% sSPR target.

The yield-per-recruit and spawning-stock-biomass-per-recruit analyses show that recent (2005-2007) fishing mortality rates were at or below many of the commonly used biological benchmarks. Yield-per-recruit showed a broad region near peak-levels across fishing mortality, with F_{max} being offset more from $F_{0.1}$ in the northern region than in the south (Table A3.2.4.25, Fig. A3.2.5.24). Both benchmarks were at higher apical F's (fully recruited F) in the northern region reflecting the more narrowly focused selectivity for the major fisheries there. In both regions, the 2005-2007 estimates of apical F were below either yield-per-recruit benchmark, except for 2007 in the northern region where apical F was just above $F_{0.1}$. The spawning-stock-biomass analysis showed that fishing mortality in both regions during 2005-2007 was less than the $F_{20\%}$ levels.

3.2.3 Discussion

The revised assessments for the northern and southern regions utilized shorter time-series of data (beginning in 1989) than did the initial assessment runs (1982 beginning) and estimated the relative selectivities for ages 4 and 5 rather than defining them within the model configuration. A consistent difference between the initial and revised runs was the tendency for estimates defining the northern region's population dynamics to be much more precisely estimated than those for the southern region, This was especially apparent in the sensitivity runs and the retrospective pattern analysis where the resultant southern region exploitation and population sizes varied significantly. Another difference observed between revised and initial assessment runs was the change in the trajectory of the age 4^+ abundance in the northern region. The initial assessment showed a significant increase after 1989 whereas the revised run showed a consistent decrease. As discussed in the Assessment report's Section 3.2.3, there is little confidence in the estimated population dynamics of adult red drum (about age 4^+) because relatively few are directly observed in the fisheries catches or surveys of abundance. Though some of the comments made in the AW Report Section 3.2.3 Discussion are no longer valid given the findings of the revised model, there is still a good argument to be made for biological benchmarks like escapement, that don't directly rely on information drawn from the adult red drum population. Of course, setting appropriate levels of escapement requires some assumptions about the levels of new recruits to the adult stock needed to sustain the population.

3.2.4 Tables

Table A3.2.4.1. Estimated parameters in the SCA models for 1989-2007 red drum population dynamics in the northern region and southern region. Parameters in each region include those that describe fishing mortality: annual fully recruited F's (log_F) for each fishery, age 1-3 selectivities (log_sel) for each fishery during each period of assumed constant selectivity, and constraints on selectivity for ages 4 and 5 relative to age 3. Abundance-estimate related parameters include recruitment (log_R) for each year, first-year abundance for ages 2-7^+ (log initN), and index-of-abundance proportionality coefficients ('survey scalars' or log_q).

Northern region

Population dynamic	Parameters estimated	Number
Fishing mortality		
Comm BS&GN	1989-2007 log_F's; 3 sets of age 1-3 log_sel's	28
Comm other	1989-2007 log_F's; 3 sets of age 1-3 log_sel's	28
Rec landed	1989-2007 log_F's; 3 sets of age 1-3 log_sel's	28
Rec live-release	1989-2007 log_F's	19
Sel constraints	Sel 4 and Sel 5 relative to Sel 3	2
	Total	105
Abundance		
recruitment	1989-2007 log_rec's	19
initial abundance	log_initN for ages 2-7^+	6
survey scalar	log_q's for four indices	4
	Total	29
Grand Total		134

Southern region

Population dynamic	Parameters estimated	Number
Fishing mortality		
FL rec landed	1989-2007 log_F's; 1 sets of age 1-3 log_sel's	22
GA rec landed	1989-2007 log_F's; 3 sets of age 1-3 log_sel's	28
SC rec landed	1989-2007 log_F's; 3 sets of age 1-3 log_sel's	28
FL rec live release	1989-2007 log_F's	19
GA/SC rec live rel	1989-2007 log_F's; 2 sets of age 1-3 log_sel's	25
Sel constraints	Sel 4 and Sel 5 relative to Sel 3	2
	Total	124
Abundance		
recruitment	1989-2007 log_rec's	19
initial abundance	log_initN for ages 2-7^+	6
survey scalar	log_q's for eight indices	8
	Total	33
Grand Total		157

Table A3.2.4.2. Short description and number of observations used in the SCA for each region. Not included but also used were coefficients of variation for most data (excluding the commercial total catch) and the observed number of aged fish used in the estimation of proportion at age.

Northern region			**Southern region**	
Components	Number		Components	Number
Total Catch			**Total Catch**	
Comm GN & BS (89-07)	19		Rec kept FL (89-07)	26
Comm other (89-07)	19		Rec kept GA (89-07)	26
Rec kept (89-07)	19		Rec kept SC (89-07)	26
Rec live release (89-07)	19		Rel live release FL (89-07)	26
			Rec live release GA/SC (89-07)	26
Totals	76			137
Proportion at age			**Proportion at age**	
Comm GN & BS (89-07, ages $1\text{-}7^{+}$)	133		Rec kept FL (89-07, ages $1\text{-}7^{+}$)	133
Comm other (89-07, ages $1\text{-}7^{+}$)	133		Rec kept GA (89-07, ages $1\text{-}7^{+}$)	133
Rec kept (89-07, ages $1\text{-}7^{+}$)	133		Rec kept SC (89-07, ages $1\text{-}7^{+}$)	133
			Rec live release GA/SC (89-07, ages $1\text{-}7^{+}$)	133
Totals	399			532
Indexes of Abundance			**Indexes of Abundance**	
NC IGNS age 1 (01-07)	7		FL small seine (97-06)	10
NC IGNS age 2 (01-07)	7		GA gillnet (03-07)	5
NC JAI age 1 (92-07, without 1997)	15		SC electro-shock (00-07)	8
MRFSS ages 1-3 (91-07)	17		FL haul seine age 2 (97-07)	11
			FL haul seine age 3 (97-07)	11
			SC trammel age 2 (91-07)	17
			MRFSS ages 1-3 (91-07)	17
			SC adults longline (94-07)	14
Totals	46			93
Tagging study estimates				
F kept at age (89-04, ages $1\text{-}4^{+}$)	64			
Full F release (89-04)	16			
Totals	80			
Grand Totals	601			762

Table A3.2.4.3. Likelihood components of the **northern** red drum assessment model showing the fisheries included in the total catch and proportion-at-age components, in indexes of abundance, the tag-based fishing mortality estimates, and the minimized deviations for estimating the initial age structure, annual recruitment, and selectivity. Shown are the sample size (N), the standardized total sum of squares (TSS, observation differenced with a logical mean, e.g. across-year quantity divide by the observed standard deviation), the standardized residual sum of squares (RSS), and the standard deviation of the standardized residuals (SDSR). The standard deviation used to 'standardize' the proportion-at-age residuals was calculated as defined for a multinomial, sqrt(*Npq*).

Components		N	TSS	RSS	NegLL	SDSR
Total kill						
Comm GN & BS		19	72,024.02	0.54	-87.23	0.165
Comm other		19	152,627.50	0.01	-87.49	0.027
Rec kept		19	300.05	154.98	42.21	2.732
Rec live release		19	1,149.66	124.92	25.80	2.554
	Totals	76	226,101.23	280.45	-106.71	
Proportion at age						
Comm GN & BS		133			501.07	0.681
Comm other		133			364.20	0.099
Rec kept		133			4.33	0.167
	Totals	399			869.60	
Indexes of Abundance						
NC IGNS age 1		7	100.28	12.97	-5.10	1.359
NC IGNS age 2		7	102.75	28.49	4.07	2.017
NC JAI age 1		16	258.56	238.90	94.73	3.861
MRFSS ages 1-3		17	212.14	146.27	37.75	2.933
	Totals	47	673.73	426.62	131.45	
Auxiliary Observations						
F kept at age		64	3,248.35	3,248.35	280.70	3.533
Full F release		16	354.87	354.87	37.42	2.911
	Totals	80	3,603.22	3,603.22	318.12	
Others Deviations						
selectivities					75.41	
	Totals				75.41	
	Grand Totals	802			1,287.87	

Table A3.2.4.4. Standardized residuals for the model fit to the observed proportion-at-age data in the **northern** region. Positive (green) residuals indicate the model under-estimated the observed data and negative (red) residuals indicate the model over-estimated the observed data. Shaded numbers are greater than two standard errors from zero residual. For the 'All Fisheries' table the underlined values indicate ages that represented less than 1% of the annual catch.

Commercial gillnet and beach seine

	1	2	3	4	5	6	7+
1989	0.284	-0.452	0.750	0.038	0.318	**-3.912**	**-3.158**
1990	-1.149	0.745	1.329	0.267	0.422	**-2.050**	**-3.424**
1991	-1.693	0.866	1.573	0.339	1.059	0.467	-1.065
1992	-0.764	-1.243	**2.855**	0.704	1.087	-0.014	-0.828
1993	0.982	-1.375	-0.683	**3.171**	0.533	0.121	-0.848
1994	-0.617	-0.175	0.169	**2.903**	**4.353**	0.040	-0.619
1995	-0.286	-1.186	1.677	1.448	0.609	-0.095	-0.486
1996	1.495	-1.361	-0.893	1.286	0.489	-0.437	-0.471
1997	-0.302	0.413	-0.573	1.354	1.142	-0.156	-0.298
1998	-1.128	-0.494	**2.546**	0.008	0.429	-0.199	-0.201
1999	1.190	-1.982	0.850	0.073	0.008	-0.031	-0.004
2000	1.395	**-2.768**	1.607	0.126	0.102	0.233	-0.003
2001	0.210	-1.211	1.519	-0.339	0.072	0.168	-0.104
2002	0.323	-0.661	0.447	-0.103	0.043	0.131	0.014
2003	1.458	**-2.335**	0.929	0.063	-0.020	-0.363	-0.040
2004	1.065	-1.889	0.911	0.142	-0.010	-0.276	-0.077
2005	0.977	-1.239	0.203	-0.061	-0.008	-0.039	-0.039
2006	0.299	-1.297	1.318	0.105	-0.010	-0.076	-0.037
2007	1.276	-1.962	0.732	-0.042	0.001	-0.236	-0.032

Commercial pooled other gear

	1	2	3	4	5	6	7+
1989	-0.747	0.458	-0.350	-0.006	0.049	**6.255**	**4.415**
1990	-1.230	1.438	-0.044	-0.065	0.588	-1.938	0.073
1991	0.065	-0.073	0.001	0.137	1.132	0.608	-0.395
1992	-0.517	0.308	0.215	0.564	0.229	**3.955**	-0.196
1993	-0.427	-0.624	1.407	-0.039	0.149	**2.319**	0.847
1994	-1.313	-0.691	1.940	1.555	**2.542**	**13.017**	**2.401**
1995	-0.789	0.614	0.514	-0.122	0.077	0.012	-0.310
1996	0.005	0.008	-0.171	0.376	0.270	0.287	0.157
1997	0.290	0.905	-1.559	0.224	0.488	0.524	0.225
1998	-1.565	1.918	-0.868	-0.518	0.002	0.151	-0.002
1999	-0.358	-0.199	0.406	0.153	-0.003	-0.054	0.433
2000	0.074	-1.164	0.762	1.581	1.447	1.496	0.478
2001	**-2.045**	0.438	0.628	0.366	**4.216**	**3.712**	0.760
2002	-1.861	0.960	0.173	-0.487	0.914	1.471	1.066
2003	-0.132	-1.327	1.728	0.485	-0.044	-0.250	-0.156
2004	-1.043	1.254	-0.545	-0.120	-0.010	-0.253	-0.152
2005	-1.119	1.138	-0.202	-0.913	-0.014	-0.023	-0.013
2006	-0.669	0.767	-0.447	0.596	-0.035	-0.044	-0.110
2007	-0.544	0.948	-0.514	-0.869	-0.007	-0.153	0.051

Table A3.2.4.4 (con't). Standardized residuals for the model fit to the observed proportion-at-age data in the **northern** region. Positive (green) residuals indicate the model under-estimated the observed data and negative (red) residuals indicate the model over-estimated the observed data. Shaded numbers are greater than two standard errors from zero residual. For the 'All Fisheries' table the underlined values indicate ages that represented less than 1% of the annual catch.

Recreational landings

	1	2	3	4	5	6	7+
1989	**-5.142**	**3.991**	0.012	-0.391	-0.045	-0.337	-0.803
1990	0.849	-0.825	0.523	0.033	-0.015	-0.167	-0.849
1991	-1.370	0.796	0.002	0.949	-0.001	-0.018	0.110
1992	**-2.879**	1.749	0.461	0.010	0.346	-0.004	-0.213
1993	-0.902	-0.330	1.173	-0.048	0.115	-0.001	0.192
1994	**-3.974**	-1.586	**3.261**	**3.623**	0.555	-0.002	**4.771**
1995	-1.164	0.597	0.125	0.388	1.898	-0.010	-0.120
1996	**3.944**	**-3.935**	0.657	1.686	**2.430**	-0.040	0.474
1997	**2.181**	-1.845	-0.950	**2.325**	**3.917**	-0.049	1.582
1998	**-4.459**	**3.282**	-0.182	-0.075	0.813	0.811	0.200
1999	0.278	**-2.498**	**2.856**	0.093	-0.004	-0.012	-0.009
2000	-0.071	**-5.097**	**6.303**	0.659	-0.002	-0.019	-0.030
2001	-1.711	**-4.143**	**5.520**	**4.497**	0.816	0.366	0.493
2002	0.732	-0.785	0.113	0.501	0.285	1.518	0.157
2003	-0.053	-1.418	**2.057**	0.401	0.076	-0.122	-0.026
2004	-0.363	-0.853	1.489	0.763	-0.004	-0.251	-0.082
2005	-0.416	0.226	0.087	-0.157	-0.003	-0.012	-0.024
2006	-0.064	-0.866	1.172	1.098	-0.008	-0.027	-0.023
2007	-0.109	-1.163	1.795	0.005	-0.002	-0.089	-0.024

All fisheries

	1	2	3	4	5	6	7+
1989	-1.337	1.009	0.283	-0.128	<u>0.056</u>	<u>-0.914</u>	-1.256
1990	-0.809	0.353	0.830	0.240	<u>0.202</u>	<u>-0.813</u>	**-2.165**
1991	-1.023	0.444	0.504	0.642	<u>0.365</u>	<u>0.091</u>	-0.355
1992	-0.725	-0.361	1.536	<u>0.640</u>	<u>0.616</u>	<u>0.114</u>	-0.468
1993	0.349	-0.833	0.575	<u>**2.047**</u>	<u>0.246</u>	<u>0.077</u>	-0.078
1994	-1.418	-0.754	1.694	**3.892**	<u>1.748</u>	<u>0.509</u>	**3.235**
1995	-0.882	0.295	0.462	<u>0.829</u>	**2.150**	<u>-0.035</u>	-0.284
1996	1.975	-1.817	0.083	<u>1.656</u>	<u>**2.577**</u>	<u>-0.089</u>	0.226
1997	0.996	-0.870	-0.491	<u>1.957</u>	<u>**3.320**</u>	<u>0.164</u>	0.841
1998	-1.829	0.905	0.806	-0.051	<u>0.874</u>	<u>1.555</u>	0.074
1999	0.963	-1.514	1.356	<u>0.114</u>	<u>0.001</u>	<u>-0.027</u>	<u>0.003</u>
2000	0.854	**-2.544**	**3.254**	<u>0.403</u>	<u>0.074</u>	<u>0.109</u>	-0.010
2001	-0.160	-1.497	**2.583**	**0.975**	<u>0.643</u>	<u>0.721</u>	**0.174**
2002	**0.384**	-0.461	0.182	0.256	0.375	<u>**3.772**</u>	<u>0.173</u>
2003	0.783	-1.949	2.330	0.298	**0.063**	<u>-0.177</u>	-0.043
2004	0.171	-1.259	**1.882**	0.610	-0.007	<u>-0.267</u>	-0.108
2005	0.348	-0.338	0.172	<u>-0.157</u>	<u>-0.005</u>	<u>-0.018</u>	<u>-0.038</u>
2006	0.090	-1.111	1.675	<u>0.789</u>	<u>-0.012</u>	<u>-0.039</u>	<u>-0.039</u>
2007	0.517	-1.579	**2.106**	-0.042	<u>-0.002</u>	<u>-0.125</u>	-0.034

Table A3.2.4.5. Likelihood components of the **southern** red drum assessment model showing the fisheries included in the total catch and proportion-at-age components, in indexes of abundance, and the minimized deviations for estimating the initial age structure, annual recruitment, and selectivity. Shown are the sample size (N), the standardized total sum of squares (TSS, observation differenced with a logical mean, e.g. across years quantity divide by the observed standard deviation), the standardized residual sum of squares (RSS), and the standard deviation of the standardized residuals (SDSR). The standard deviation used to 'standardize' the proportion-at-age residuals was calculated as defined for a multinomial, sqrt(Npq).

Components	N	TSS	RSS	NegLL	SDSR
Total kill					
Rec kept FL	19	285.90	0.16	-41.87	0.091
Rec kept GA	19	99.24	0.20	-30.89	0.102
Rec kept SC	19	115.90	0.36	-31.29	0.138
Rel live release FL	19	571.13	0.02	-43.80	0.028
Rec live release GA/SC	19	453.11	0.01	-35.51	0.027
Totals	95	1,525.27	0.75	-183.36	
Proportion at age					
Rec kept FL	133			221.09	1.050
Rec kept GA	133			178.78	0.810
Rec kept SC	133			818.69	0.177
Rec live release GA/SC	133			7.37	0.366
Totals	532			1,225.93	
Indexes of Abundance					
FL small seine	10	33.93	23.96	1.47	1.543
GA gillnet	5	30.85	21.63	5.99	2.071
SC electro-shock	8	33.52	22.32	-0.87	1.554
FL haul seine age 2	11	54.32	32.04	-5.36	1.707
FL haul seine age 3	11	59.31	29.45	-6.66	1.636
SC trammel age 2	17	255.87	64.61	1.33	1.883
MRFSS ages 1-3	17	7.00	11.47	-19.76	0.821
SC adults longline	14	84.99	85.92	18.22	2.455
Totals	93	559.81	291.40	-5.65	
Others Deviations					
selectivities				27.84	
Totals				27.84	
Grand Totals	1,007			1,064.80	

Table A.3.2.4.6. Standardized residuals for the model fit to the observed proportion-at-age data in the **southern** region. Positive (green) residuals indicate the model under-estimated the observed data and negative (red) residuals indicate the model over-estimated the observed data. Shaded numbers are greater than two standard errors from zero residual. For the 'All Fisheries' table the underlined values indicate ages that represented less than 1% of the annual catch.

Florida recreational harvest

	1	2	3	4	5	6	7+
1989	0.838	-0.145	-0.452	-0.038	-0.547	-1.541	-0.921
1990	-0.541	0.897	-1.169	1.142	1.044	0.970	-0.407
1991	-0.762	-1.609	0.537	**3.528**	**2.505**	0.947	-0.513
1992	1.651	-1.490	-1.292	**2.106**	1.044	1.144	0.324
1993	0.131	0.124	-1.612	1.882	1.962	**2.218**	0.437
1994	0.743	-0.026	-1.196	0.646	0.839	0.661	-0.046
1995	-0.406	-0.124	-0.301	1.143	1.488	0.639	1.019
1996	1.067	-1.138	**-2.021**	**4.532**	**8.550**	0.038	-0.878
1997	0.265	0.410	**-7.169**	**9.766**	**14.280**	**10.163**	0.557
1998	-0.047	-0.910	**2.611**	1.119	**9.312**	**3.158**	-1.634
1999	-0.907	1.897	**-2.745**	-0.615	**11.025**	-1.012	-1.997
2000	-0.715	0.597	1.580	**-3.519**	**18.238**	-1.464	**-2.054**
2001	-1.631	1.580	-0.408	1.664	**23.977**	-0.663	-1.976
2002	-0.900	-0.633	**4.192**	1.567	**24.235**	-0.936	-1.580
2003	-0.924	1.830	**-3.564**	0.872	**19.650**	-0.555	-1.467
2004	-1.046	0.381	1.322	**4.539**	**4.155**	-0.841	-1.580
2005	-1.004	0.402	0.324	**6.657**	**4.755**	-0.644	-1.608
2006	-0.828	-0.400	**2.873**	**4.717**	**8.241**	-1.394	-1.560
2007	-1.317	0.584	1.540	**4.581**	**6.558**	-0.770	-1.624

Georgia recreational/commercial harvest

	1	2	3	4	5	6	7+
1989	0.239	0.344	-0.725	**-2.186**	**-3.799**	**-4.344**	-0.649
1990	-0.508	0.466	-0.720	0.384	0.012	0.341	**3.817**
1991	1.131	-0.522	**-2.077**	-0.848	-0.077	-0.102	-0.629
1992	1.673	-1.366	-1.780	-0.496	0.491	0.602	0.598
1993	1.398	-0.758	**-2.556**	-0.751	1.220	0.137	-0.014
1994	1.713	-0.474	**-3.368**	**-4.102**	-0.413	-0.150	-0.319
1995	0.859	-0.070	-1.907	**-2.853**	-0.586	-0.344	-0.298
1996	**2.394**	-1.616	**-2.575**	**-2.586**	-0.553	-0.698	-0.450
1997	-0.640	1.465	**-2.039**	-1.073	1.262	-0.488	-0.511
1998	0.347	0.117	-0.657	**-2.484**	-0.357	-0.382	-0.607
1999	0.112	0.707	**-2.112**	-1.488	-0.451	-0.282	-0.557
2000	0.679	-0.693	0.484	-1.564	-0.242	-0.438	-0.615
2001	0.322	0.343	-1.918	-0.945	-0.284	-0.145	-0.435
2002	1.558	-1.349	-0.860	-1.186	-0.154	-0.208	-0.352
2003	0.979	-0.222	-1.830	-1.061	-0.240	-0.330	-1.468
2004	-1.798	**2.258**	0.301	**-2.081**	-0.180	-0.449	-1.422
2005	0.804	-0.250	-1.192	-1.304	-0.393	-0.337	-1.417
2006	-0.081	0.970	-1.602	-1.438	-0.243	-0.809	-1.494
2007	-0.583	1.482	-1.514	-1.196	-0.228	-0.372	-1.322

Table A.3.2.4.6 (con't.). Standardized residuals for the model fit to the observed proportion-at-age data in the **southern** region. Positive (green) residuals indicate the model under-estimated the observed data and negative (red) residuals indicate the model over-estimated the observed data. Shaded numbers are greater than two standard errors from zero residual. For the 'All Fisheries' table the underlined values indicate ages that represented less than 1% of the annual catch.

South Carolina recreational/commercial harvest

	1	2	3	4	5	6	7+
1989	-0.999	0.479	1.667	0.586	-1.387	-4.488	-1.026
1990	**-2.334**	**2.585**	0.255	0.554	0.209	-1.870	-1.310
1991	0.590	-0.417	-0.473	-0.536	0.206	0.017	-0.682
1992	0.275	0.020	-0.905	-0.395	**2.451**	-0.066	**2.169**
1993	-0.089	0.847	-1.608	-0.595	0.734	-0.207	-0.832
1994	-0.756	1.310	-0.406	-1.968	-0.106	-0.232	-0.936
1995	0.439	-0.116	-0.655	-0.953	0.816	-0.605	-0.865
1996	-0.301	0.824	-0.754	-1.084	0.172	-1.131	-1.265
1997	**2.127**	-1.728	-1.825	0.234	0.392	-0.345	-1.513
1998	-0.797	0.447	0.890	0.985	**2.207**	-0.548	-1.712
1999	-0.629	0.931	-0.353	-0.140	0.091	-0.493	-1.652
2000	0.331	-0.534	0.625	-0.646	0.623	-0.740	-1.748
2001	1.123	-1.066	-0.465	-0.089	0.016	-0.377	-1.904
2002	0.475	-0.179	-0.497	-1.122	-0.114	-0.487	-1.422
2003	-0.817	1.156	-1.203	**2.391**	**2.617**	-0.321	-1.685
2004	-1.282	1.205	0.801	-0.186	1.109	-0.424	-1.593
2005	-0.004	-0.309	0.949	-0.334	-0.184	-0.382	-1.606
2006	0.878	-0.709	-0.465	-1.121	0.067	-0.693	0.848
2007	0.371	0.659	**-2.068**	-1.636	-0.279	-0.456	-1.618

Georgia/South Carolina recreational live-release

	1	2	3	4	5	6	7+
1989	0.128	-0.267	0.093	0.610	1.886	**-7.461**	1.526
1990	0.408	-0.016	-1.640	1.425	**4.630**	**-2.056**	-0.556
1991	0.925	-1.652	-0.823	-0.198	0.029	0.144	0.004
1992	1.097	-0.668	**-2.008**	-0.196	0.043	0.070	-0.051
1993	0.390	0.858	-1.774	0.005	0.172	0.082	0.081
1994	-0.696	0.991	-0.467	0.850	0.543	0.698	0.686
1995	-0.811	1.012	-0.806	1.298	0.813	0.231	0.966
1996	-0.787	0.877	-0.804	1.127	1.636	0.482	0.546
1997	-1.276	1.046	-0.443	**2.152**	1.146	0.996	0.360
1998	-0.921	-0.862	-0.551	1.408	**2.441**	1.513	**2.237**
1999	-1.357	1.003	-0.639	1.678	**2.487**	1.789	0.821
2000	-1.323	-0.822	0.731	1.803	**2.246**	0.527	1.093
2001	-1.933	-0.438	0.516	**2.400**	**2.067**	1.808	**2.960**
2002	-1.517	-1.105	0.449	1.349	**2.861**	1.139	**3.576**
2003	-1.847	0.765	-0.183	**2.387**	**2.337**	**2.853**	1.369
2004	-1.984	-0.246	1.489	**2.384**	1.842	**2.831**	0.744
2005	-1.954	-1.309	1.645	**2.762**	**2.292**	1.450	1.145
2006	-1.647	-1.393	0.999	**2.799**	**2.067**	**2.289**	1.040
2007	-1.891	1.398	0.668	1.377	**2.152**	0.585	1.420

Table A.3.2.4.6 (con't.). Standardized residuals for the model fit to the observed proportion-at-age data in the **southern** region. Positive (green) residuals indicate the model under-estimated the observed data and negative (red) residuals indicate the model over-estimated the observed data. Shaded numbers are greater than two standard errors from zero residual. For the 'All Fisheries' table the underlined values indicate ages that represented less than 1% of the annual catch.

All Fisheries

	1	2	3	4	5	6	7+
1989	-0.512	0.422	0.504	-0.082	-0.445	-2.421	-0.783
1990	-1.619	1.919	-0.519	0.804	0.361	0.233	1.707
1991	0.708	-1.102	-0.405	1.937	0.952	0.676	-0.794
1992	1.468	-1.246	-1.445	1.559	0.714	1.204	0.840
1993	0.691	0.146	-1.789	0.714	0.804	1.359	0.056
1994	0.616	0.325	-1.471	-0.392	0.543	0.740	0.149
1995	0.252	-0.021	-0.788	0.483	0.914	0.333	1.015
1996	0.927	-0.645	-1.038	0.855	1.161	-0.095	-0.751
1997	1.160	-0.591	**-2.139**	**2.161**	1.254	**2.396**	-0.008
1998	-0.325	-0.592	0.954	0.583	1.703	1.585	-1.172
1999	-0.844	1.900	-1.277	-0.211	1.541	-0.240	**-2.092**
2000	-0.399	0.096	0.717	-1.098	**2.661**	-0.651	**-2.087**
2001	-1.155	0.948	-0.403	1.256	**3.339**	0.429	0.277
2002	-0.054	-1.136	0.934	0.557	**3.301**	0.034	1.113
2003	-0.906	1.306	-1.318	**1.522**	**2.647**	1.067	-0.072
2004	**-2.037**	1.426	0.740	**1.397**	1.093	0.735	-0.846
2005	-0.848	-0.081	0.361	**2.610**	1.642	0.489	-0.323
2006	-0.847	-0.305	0.571	**2.542**	**2.189**	0.951	0.108
2007	-1.414	1.134	-0.047	1.496	1.805	-0.022	-0.146

Table A3.2.4.7. Estimated beginning-of-the-year abundance of red drum ages 1 – 7^+ in the **northern** and **southern** regions during 1989-2007.

Northern	1	2	3	4	5	6	7^+	Totals
1989	126,360	47,100	19,495	14,457	35,614	64,623	5,571,045	5,878,695
1990	129,913	19,327	3,406	3,536	11,981	32,824	5,245,749	5,446,735
1991	325,426	35,287	2,570	912	3,001	11,045	4,915,181	5,293,422
1992	267,912	170,786	16,255	1,554	813	2,768	4,589,556	5,049,643
1993	153,194	181,333	85,882	10,837	1,394	750	4,279,071	4,712,461
1994	300,296	93,697	68,664	50,306	9,636	1,285	3,984,606	4,508,490
1995	325,276	203,747	53,581	50,624	45,334	8,878	3,709,184	4,396,625
1996	162,919	226,016	123,909	39,271	45,634	41,797	3,462,369	4,101,914
1997	463,875	122,274	158,749	98,730	35,604	42,107	3,265,487	4,186,827
1998	805,476	332,545	67,183	120,109	89,172	32,828	3,079,962	4,527,275
1999	526,829	544,080	168,925	45,534	107,788	82,237	2,899,243	4,374,636
2000	122,868	406,897	304,603	144,399	41,383	99,249	2,772,128	3,891,527
2001	290,489	94,244	214,213	259,015	131,105	38,074	2,667,465	3,694,605
2002	468,789	215,163	33,669	174,391	234,493	120,588	2,513,164	3,760,256
2003	83,915	334,437	68,687	27,042	156,876	214,290	2,429,922	3,315,167
2004	467,406	66,196	211,363	59,794	24,620	144,559	2,459,119	3,433,057
2005	431,431	362,228	34,859	180,483	54,347	22,673	2,420,571	3,506,591
2006	505,295	334,604	214,066	30,028	164,003	50,006	2,270,475	3,568,477
2007	192,825	384,172	183,739	182,547	27,215	150,553	2,151,126	3,272,177

Southern	1	2	3	4	5	6	7^+	Total
1989	801,345	437,369	107,584	120,696	1,086,033	1,245,351	880,516	4,678,893
1990	1,706,380	511,078	286,861	78,497	99,601	951,367	1,888,809	5,522,593
1991	2,452,544	1,175,498	368,222	219,629	65,778	87,355	2,532,825	6,901,852
1992	1,835,114	1,680,573	830,644	275,862	182,722	57,600	2,339,988	7,202,501
1993	1,454,805	1,308,101	1,261,106	661,772	234,038	160,241	2,144,569	7,224,632
1994	1,282,817	1,011,956	967,162	1,011,608	562,544	205,123	2,059,441	7,100,650
1995	1,730,071	848,509	694,724	738,386	846,455	492,347	2,020,199	7,370,692
1996	787,768	1,114,212	565,721	523,437	615,304	740,827	2,239,057	6,586,327
1997	1,324,526	525,420	752,166	419,777	434,139	538,629	2,654,665	6,649,322
1998	888,355	898,024	367,816	585,927	353,470	380,026	2,846,949	6,320,568
1999	1,267,246	632,429	653,179	282,994	491,511	309,494	2,879,207	6,516,060
2000	925,348	880,394	445,784	491,045	235,649	430,113	2,843,997	6,252,330
2001	1,961,418	620,056	580,781	313,008	400,163	205,974	2,915,805	6,997,205
2002	1,248,159	1,343,437	411,390	414,437	256,376	349,838	2,782,486	6,806,124
2003	1,538,121	879,837	955,663	315,897	347,430	224,453	2,794,586	7,055,987
2004	1,489,962	1,008,202	539,157	686,463	259,291	303,804	2,691,287	6,978,165
2005	1,525,795	974,481	621,484	386,669	563,000	226,476	2,666,194	6,964,099
2006	1,159,575	996,625	592,002	433,235	314,277	491,424	2,573,915	6,561,053
2007	1,920,497	788,187	661,527	432,940	357,559	274,713	2,729,219	7,164,642

Table A3.2.4.8. Estimated recruitment (age-1 beginning-of-the-year abundance) and associated bounds using ± 1.96 asymptotic standard errors. All values were originally in log space so bounds are not symmetrical.

	Northern region				Southern region		
	-1.96SE	Est	+1.96SE		-1.96SE	Est	+1.96SE
1989	98,428	126,360	163,084		285,826	801,345	2,294,212
1990	102,712	129,913	165,234		761,413	1,706,380	3,888,523
1991	282,852	325,426	375,564		1,128,399	2,452,544	5,419,640
1992	227,821	267,912	315,838		822,679	1,835,114	4,164,305
1993	119,328	153,194	197,493		668,022	1,454,805	3,216,486
1994	256,884	300,296	352,504		626,728	1,282,817	2,666,721
1995	270,379	325,276	392,457		863,855	1,730,071	3,516,652
1996	131,357	162,919	202,951		377,318	787,768	1,669,743
1997	384,548	463,875	561,292		627,215	1,324,526	2,842,572
1998	723,879	805,476	897,884		412,784	888,355	1,941,478
1999	465,473	526,829	598,227		618,875	1,267,246	2,631,225
2000	101,491	122,868	149,369		453,556	925,348	1,915,865
2001	242,738	290,489	348,684		942,650	1,961,418	4,141,216
2002	399,548	468,789	551,929		614,689	1,248,159	2,570,420
2003	64,477	83,915	109,899		796,599	1,538,121	3,009,607
2004	393,406	467,406	557,334		781,541	1,489,962	2,876,659
2005	366,649	431,431	509,489		787,854	1,525,795	2,994,896
2006	429,717	505,295	596,256		583,308	1,159,575	2,339,763
2007	148,407	192,825	252,115		945,010	1,920,497	3,959,071

Table A3.2.4.9. Predicted catch (C_a), estimated abundance (N_a), and calculated exploitation rate ($\mu = C_a/N_a$) for ages 1 through 3 and 1 through 7^+ in the **northern** and **southern** regions during 1989-2007.

	Northern region							Southern region					
	C_a 1-3	N_a 1-3	μ 1-3	C_a 1-7^+	N_a 1-7+	μ 1-7^+		C_a 1-3	N_a 1-3	μ 1-3	C_a 1-7^+	N_a 1-7+	μ 1-7^+
1989	152,188	192,955	0.79	162,145	5,878,695	0.03		223,995	1,346,299	0.17	236,929	4,678,893	0.05
1990	98,087	152,645	0.64	104,790	5,446,735	0.02		254,403	2,504,318	0.10	260,360	5,522,593	0.05
1991	123,324	363,283	0.34	126,999	5,293,422	0.02		451,456	3,996,265	0.11	467,300	6,901,852	0.07
1992	115,146	454,953	0.25	118,030	5,049,643	0.02		336,192	4,346,331	0.08	345,541	7,202,501	0.05
1993	161,805	420,410	0.38	168,163	4,712,461	0.04		343,085	4,024,013	0.09	361,289	7,224,632	0.05
1994	89,672	462,657	0.19	97,846	4,508,490	0.02		428,161	3,261,934	0.13	472,352	7,100,650	0.07
1995	113,406	582,605	0.19	118,522	4,396,625	0.03		489,707	3,273,304	0.15	528,707	7,370,692	0.07
1996	68,928	512,844	0.13	70,684	4,101,914	0.02		362,707	2,467,701	0.15	395,641	6,586,327	0.06
1997	120,334	744,898	0.16	125,242	4,186,827	0.03		285,606	2,602,112	0.11	308,618	6,649,322	0.05
1998	276,446	1,205,205	0.23	281,502	4,527,275	0.06		202,798	2,154,196	0.09	231,650	6,320,568	0.04
1999	221,775	1,239,834	0.18	229,555	4,374,636	0.05		278,184	2,552,854	0.11	301,262	6,516,060	0.05
2000	178,150	834,369	0.21	188,376	3,891,527	0.05		353,454	2,251,526	0.16	397,378	6,252,330	0.06
2001	98,521	598,946	0.16	110,748	3,694,605	0.03		402,925	3,162,254	0.13	434,458	6,997,205	0.06
2002	188,188	717,621	0.26	218,617	3,760,256	0.06		318,562	3,002,987	0.11	341,910	6,806,124	0.05
2003	93,463	487,038	0.19	98,325	3,315,167	0.03		566,346	3,373,621	0.17	596,100	7,055,987	0.08
2004	58,974	744,964	0.08	65,294	3,433,057	0.02		526,360	3,037,321	0.17	578,953	6,978,165	0.08
2005	133,769	828,518	0.16	142,573	3,506,591	0.04		560,460	3,121,760	0.18	603,410	6,964,099	0.09
2006	162,605	1,053,965	0.15	176,164	3,568,477	0.05		392,009	2,748,202	0.14	426,992	6,561,053	0.07
2007	249,095	760,736	0.33	267,501	3,272,177	0.08		474,747	3,370,211	0.14	512,204	7,164,642	0.07

Table A3.2.4.10. Estimated age-1 to age-5 instantaneous fishing mortality for each fishery defined for the **northern** region during 1989-2007. Estimates showing zero are fishing mortalities that round to less than 0.001, those left blank indicate no harvest (F=0). F's for ages 6 and 7^{+} are defined as equal to F at age 5.

	Commercial Gillnet and Beach Seine					Commercial 'other' gear fishery				
	1	2	3	4	5	1	2	3	4	5
1989	0.528	1.154	0.794	0.048	0.001	0.157	0.363	0.197	0.012	0.000
1990	0.497	1.087	0.748	0.045	0.001	0.159	0.368	0.199	0.012	0.000
1991	0.116	0.253	0.174	0.011	0.000	0.069	0.159	0.086	0.005	0.000
1992	0.093	0.072	0.132	0.008	0.000	0.003	0.031	0.013	0.001	0.000
1993	0.121	0.094	0.171	0.010	0.000	0.004	0.036	0.015	0.001	0.000
1994	0.052	0.041	0.074	0.004	0.000	0.004	0.036	0.015	0.001	0.000
1995	0.072	0.056	0.102	0.006	0.000	0.006	0.058	0.024	0.001	0.000
1996	0.042	0.033	0.060	0.004	0.000	0.002	0.014	0.006	0.000	0.000
1997	0.014	0.011	0.020	0.001	0.000	0.002	0.017	0.007	0.000	0.000
1998	0.083	0.064	0.117	0.007	0.000	0.005	0.044	0.018	0.001	0.000
1999	0.031	0.284	0.034	0.002	0.000	0.001	0.008	0.004	0.000	0.000
2000	0.027	0.247	0.030	0.002	0.000	0.001	0.006	0.003	0.000	0.000
2001	0.050	0.461	0.056	0.003	0.000	0.001	0.008	0.004	0.000	0.000
2002	0.020	0.185	0.022	0.001	0.000	0.002	0.012	0.006	0.000	0.000
2003	0.013	0.118	0.014	0.001	0.000	0.001	0.005	0.002	0.000	0.000
2004	0.020	0.184	0.022	0.001	0.000	0.000	0.003	0.002	0.000	0.000
2005	0.018	0.168	0.020	0.001	0.000	0.001	0.007	0.004	0.000	0.000
2006	0.017	0.156	0.019	0.001	0.000	0.001	0.008	0.004	0.000	0.000
2007	0.032	0.298	0.036	0.002	0.000	0.002	0.013	0.007	0.000	0.000

Table A3.2.4.10 (con't.). Estimated age-1 to age-5 instantaneous fishing mortality for each fishery defined for the **northern** region during 1989-2007. Estimates showing zero are fishing mortalities that round to less than 0.001, those left blank indicate no harvest (F=0). F's for ages 6 and 7^+ are defined as equal to F at age 5.

	Recreational harvest					Recreational live-release				
	1	2	3	4	5	1	2	3	4	5
1989	0.976	0.976	0.616	0.037	0.001	0.017	0.004	0.000	0.000	0.000
1990	0.429	0.429	0.271	0.016	0.000	0.019	0.004	0.000	0.000	0.000
1991	0.225	0.225	0.142	0.009	0.000	0.035	0.008	0.000	0.000	0.000
1992	0.077	0.447	0.160	0.010	0.000	0.017	0.008	0.001	0.000	0.000
1993	0.119	0.689	0.248	0.015	0.000	0.048	0.022	0.001	0.001	0.001
1994	0.055	0.316	0.114	0.007	0.000	0.077	0.036	0.002	0.002	0.002
1995	0.040	0.232	0.083	0.005	0.000	0.046	0.021	0.001	0.001	0.001
1996	0.029	0.170	0.061	0.004	0.000	0.014	0.006	0.000	0.000	0.000
1997	0.073	0.420	0.151	0.009	0.000	0.045	0.021	0.001	0.001	0.001
1998	0.073	0.424	0.152	0.009	0.000	0.031	0.015	0.001	0.001	0.001
1999	0.007	0.130	0.012	0.001	0.000	0.019	0.028	0.006	0.002	0.002
2000	0.012	0.221	0.021	0.001	0.000	0.025	0.037	0.008	0.003	0.003
2001	0.022	0.390	0.037	0.002	0.000	0.027	0.040	0.008	0.004	0.004
2002	0.039	0.702	0.067	0.004	0.000	0.077	0.113	0.023	0.010	0.010
2003	0.010	0.186	0.018	0.001	0.000	0.013	0.019	0.004	0.002	0.002
2004	0.017	0.298	0.028	0.002	0.000	0.018	0.026	0.005	0.002	0.002
2005	0.010	0.185	0.018	0.001	0.000	0.025	0.036	0.007	0.003	0.003
2006	0.014	0.243	0.023	0.001	0.000	0.042	0.062	0.013	0.006	0.006
2007	0.027	0.485	0.046	0.003	0.000	0.055	0.080	0.017	0.007	0.007

Table A3.2.4.11. Estimated age-1 to age-5 instantaneous fishing mortality for each fishery defined for the **southern** region during 1989-2007. Estimates showing zero are fishing mortalities that round to less than 0.001, those left blank indicate no harvest (F=0). F's for ages 6 and 7^+ are defined as equal to F at age 5.

	Florida recreational harvest fishery				
	1	2	3	4	5
1989	0.012	0.048	0.064	0.020	0.001
1990	0.009	0.037	0.050	0.016	0.000
1991	0.013	0.051	0.068	0.021	0.001
1992	0.009	0.036	0.047	0.015	0.000
1993	0.005	0.021	0.028	0.009	0.000
1994	0.011	0.046	0.061	0.019	0.000
1995	0.011	0.045	0.060	0.019	0.000
1996	0.018	0.074	0.098	0.031	0.001
1997	0.010	0.042	0.055	0.017	0.000
1998	0.016	0.066	0.087	0.027	0.001
1999	0.019	0.077	0.103	0.032	0.001
2000	0.029	0.118	0.157	0.049	0.001
2001	0.026	0.105	0.139	0.044	0.001
2002	0.015	0.059	0.078	0.024	0.001
2003	0.019	0.077	0.103	0.032	0.001
2004	0.021	0.083	0.110	0.035	0.001
2005	0.025	0.100	0.133	0.042	0.001
2006	0.019	0.077	0.102	0.032	0.001
2007	0.025	0.099	0.131	0.041	0.001

Table A3.2.4.11 (con't.). Estimated age-1 to age-5 instantaneous fishing mortality for each fishery defined for the **southern** region during 1989-2007. Estimates showing zero are fishing mortalities that round to less than 0.001, those left blank indicate no harvest (F=0). F's for ages 6 and 7^+ are defined as equal to F at age 5.

	Georgia commercial/recreational harvest fishery					South Carolina commercial/recreational harvest fishery				
	1	2	3	4	5	1	2	3	4	5
1989	0.044	0.046	0.043	0.013	0.000	0.117	0.127	0.048	0.015	0.000
1990	0.035	0.037	0.034	0.011	0.000	0.056	0.061	0.023	0.007	0.000
1991	0.048	0.050	0.047	0.015	0.000	0.039	0.043	0.016	0.005	0.000
1992	0.027	0.024	0.011	0.003	0.000	0.033	0.036	0.014	0.004	0.000
1993	0.040	0.035	0.016	0.005	0.000	0.041	0.045	0.017	0.005	0.000
1994	0.062	0.054	0.024	0.008	0.000	0.050	0.058	0.015	0.005	0.000
1995	0.061	0.053	0.024	0.007	0.000	0.072	0.083	0.022	0.007	0.000
1996	0.037	0.032	0.014	0.005	0.000	0.065	0.075	0.020	0.006	0.000
1997	0.022	0.019	0.009	0.003	0.000	0.071	0.082	0.022	0.007	0.000
1998	0.017	0.015	0.007	0.002	0.000	0.026	0.031	0.008	0.003	0.000
1999	0.038	0.033	0.015	0.005	0.000	0.024	0.028	0.008	0.002	0.000
2000	0.058	0.050	0.023	0.007	0.000	0.021	0.024	0.007	0.002	0.000
2001	0.038	0.033	0.015	0.005	0.000	0.018	0.046	0.011	0.004	0.000
2002	0.039	0.043	0.014	0.004	0.000	0.010	0.025	0.006	0.002	0.000
2003	0.053	0.059	0.019	0.006	0.000	0.049	0.123	0.030	0.010	0.000
2004	0.060	0.066	0.021	0.007	0.000	0.038	0.094	0.023	0.007	0.000
2005	0.046	0.050	0.016	0.005	0.000	0.038	0.094	0.023	0.007	0.000
2006	0.038	0.042	0.013	0.004	0.000	0.020	0.050	0.012	0.004	0.000
2007	0.040	0.044	0.014	0.004	0.000	0.024	0.059	0.015	0.005	0.000

Table A3.2.4.11 (con't.). Estimated age-1 to age-5 instantaneous fishing mortality for each fishery defined for the **southern** region during 1989-2007. Estimates showing zero are fishing mortalities that round to less than 0.001, those left blank indicate no harvest (F=0). F's for ages 6 and 7^+ are defined as equal to F at age 5.

	Florida recreational live-release fishery					Georgia/South Carolina recreational live-release fishery				
	1	2	3	4	5	1	2	3	4	5
1989	0.009	0.013	0.003	0.001	0.001	0.008	0.008	0.008	0.002	0.000
1990	0.002	0.003	0.001	0.000	0.000	0.010	0.010	0.009	0.003	0.000
1991	0.013	0.019	0.004	0.002	0.002	0.005	0.005	0.005	0.001	0.000
1992	0.005	0.008	0.002	0.001	0.001	0.003	0.004	0.004	0.001	0.000
1993	0.010	0.015	0.003	0.001	0.001	0.006	0.006	0.007	0.002	0.000
1994	0.018	0.027	0.006	0.002	0.002	0.011	0.012	0.014	0.004	0.000
1995	0.018	0.026	0.005	0.002	0.002	0.019	0.019	0.022	0.007	0.000
1996	0.015	0.022	0.005	0.002	0.002	0.009	0.009	0.011	0.003	0.000
1997	0.018	0.027	0.006	0.002	0.002	0.007	0.007	0.008	0.003	0.000
1998	0.016	0.023	0.005	0.002	0.002	0.004	0.005	0.005	0.002	0.000
1999	0.019	0.027	0.006	0.002	0.002	0.004	0.004	0.004	0.001	0.000
2000	0.024	0.034	0.007	0.003	0.003	0.009	0.009	0.010	0.003	0.000
2001	0.023	0.034	0.007	0.003	0.003	0.013	0.013	0.015	0.005	0.000
2002	0.016	0.024	0.005	0.002	0.002	0.009	0.009	0.011	0.003	0.000
2003	0.022	0.032	0.007	0.003	0.003	0.019	0.019	0.022	0.007	0.000
2004	0.030	0.045	0.009	0.004	0.004	0.015	0.016	0.018	0.006	0.000
2005	0.034	0.050	0.010	0.004	0.004	0.023	0.024	0.028	0.009	0.000
2006	0.026	0.037	0.008	0.003	0.003	0.023	0.024	0.028	0.009	0.000
2007	0.023	0.033	0.007	0.003	0.003	0.019	0.019	0.022	0.007	0.000

Table A3.2.4.12. Estimated age-1 to age-5 instantaneous fishing mortality for the **northern** and **southern** regions during 1989-2007.

	Northern region					Southern region				
	1	2	3	4	5	1	2	3	4	5
1989	1.678	2.497	1.607	0.098	0.002	0.190	0.242	0.165	0.052	0.002
1990	1.103	1.888	1.218	0.074	0.001	0.113	0.148	0.117	0.037	0.001
1991	0.445	0.645	0.403	0.025	0.001	0.118	0.167	0.139	0.044	0.003
1992	0.190	0.557	0.305	0.019	0.001	0.079	0.107	0.077	0.024	0.001
1993	0.292	0.841	0.435	0.027	0.001	0.103	0.122	0.070	0.022	0.002
1994	0.188	0.429	0.205	0.014	0.002	0.153	0.196	0.120	0.038	0.003
1995	0.164	0.367	0.211	0.014	0.001	0.180	0.225	0.133	0.042	0.003
1996	0.087	0.223	0.127	0.008	0.000	0.145	0.213	0.148	0.047	0.003
1997	0.133	0.469	0.179	0.012	0.001	0.129	0.177	0.100	0.032	0.003
1998	0.192	0.547	0.289	0.018	0.001	0.080	0.138	0.112	0.036	0.003
1999	0.058	0.450	0.057	0.006	0.003	0.104	0.170	0.135	0.043	0.003
2000	0.065	0.512	0.062	0.007	0.003	0.140	0.236	0.204	0.065	0.005
2001	0.100	0.899	0.106	0.009	0.004	0.118	0.230	0.187	0.060	0.004
2002	0.138	1.012	0.119	0.016	0.010	0.090	0.161	0.114	0.036	0.003
2003	0.037	0.329	0.039	0.004	0.002	0.162	0.310	0.181	0.057	0.004
2004	0.055	0.511	0.058	0.006	0.002	0.165	0.304	0.182	0.058	0.005
2005	0.054	0.396	0.049	0.006	0.003	0.166	0.318	0.211	0.067	0.006
2006	0.074	0.469	0.059	0.008	0.006	0.126	0.230	0.163	0.052	0.005
2007	0.116	0.877	0.106	0.013	0.007	0.130	0.254	0.189	0.060	0.004

Table A3.2.4.13. Review panel requested diagnostics for the northern region base model run and sensitivity runs for low and high M-at-age vectors, for higher release mortality for live release fisheries of 0.16, for a configuration where age 1-5 selectivities are estimated, and when tag-based F estimates were not used. Shown are the negative log likelihoods by data category, abundance estimates in the first and last year and the age 7+ to age 6 abundance ratios, and static spawning potential ratios for 2007 and for the 2005-07 average.

		Base	Sensitivity Run				
negLL		Run	Low M	High M	RelM 0.16	Sel 1-5	w/o Tagging
Total kill		-106.7	-102.8	-109.5	284.8	-109.9	-246.9
Proportion at age		869.6	870.9	867.6	966.9	861.8	802.7
Indexes of Abundance		131.5	131.4	132.2	195.2	124.0	106.4
Tagging		318.1	324.7	313.3	536.8	24.9	
Selectivity deviations		75.4	75.9	74.7	77.4	330.1	22.5
Total Obj. Function		1,287.9	1,300.1	1,278.3	2,061.1	1,230.9	684.7
Abundance	Age	Base	Low M	High M	RelM 0.16	Sel 1-5	w/o Tagging
First-Year	1	126,360	132,926	121,405	117,362	132,840	862,707
	2	47,100	48,251	46,447	49,358	46,487	424,415
	3	19,495	17,954	19,079	20,865	20,314	229,157
	4	14,457	14,164	13,749	2,133	1,997	159,066
	5	35,614	42,757	42,029	144	160	90,026
	6	64,623	54,188	66,489	226	6,787	159,324
	7^+	5,571,045	4,261,104	5,309,664	15,545	6,355,530	8,886,110
	7^+/6 ratio	86	79	80	69	936	56
Last-Year	1	192,825	227,723	168,183	350,401	186,881	1,140,366
	2	384,172	403,682	370,658	546,056	380,445	2,557,181
	3	183,739	184,899	187,257	387,618	187,464	2,042,448
	4	182,547	179,199	191,220	267,415	169,524	1,903,180
	5	27,215	25,488	29,671	37,547	26,134	292,317
	6	150,553	139,870	166,802	328,250	138,702	1,347,202
	7^+	2,151,126	1,030,731	3,211,018	917,313	2,296,682	11,272,813
	7^+/6 ratio	14	7	19	3	17	8
Benchmark		Base	Low M	High M	RelM 0.16	Sel 1-5	w/o Tagging
sSPR 2007		0.292	0.289	0.298	0.391	0.277	0.851
sSPR 2005-07 Average		0.453	0.454	0.456	0.481	0.429	0.897

Table A3.2.4.14. Review panel requested diagnostics for the **southern** region base model run and sensitivity runs for low and high M-at-age vectors, for higher release mortality for live release fisheries of 0.16, for a configuration where age 1-5 selectivities are estimated, & when tag-based F estimates were not used. Shown are the negative log likelihoods by data category, abundance estimates in the first & last year & the age 7^+ to age 6 abundance ratios, & static spawning potential ratios for 2007 & for the 2005-07 average.

		Base	Sensitivity Run			
negLL		Run	Low M	High M	RelM 0.16	Sel 1-5
Total kill		-183.4	-183.0	-183.6	-183.5	-173.1
Proportion at age		1,225.9	1,229.6	1,223.1	1,225.7	1,236.7
Indexes of Abundance		-5.6	-9.1	-2.2	-5.4	-17.0
Selectivity deviations		27.9	27.7	27.9	28.6	38.3
Total Obj. Function		1,064.8	1,065.2	1,065.2	1,065.4	1,084.9
Abundance	Age	Base	Low M	High M	RelM 0.16	Sel 1-5
First-Year	1	801,346	522,955	1,393,199	1,085,791	301,955
	2	437,370	297,936	730,144	599,118	149,591
	3	107,584	70,968	183,508	152,796	20,744
	4	120,696	79,404	205,259	178,441	8,799
	5	1,086,033	1,077,785	1,390,854	1,630,114	1,600
	6	1,245,352	1,236,993	1,596,101	1,869,777	3,001
	7^+	880,517	871,632	1,128,886	1,322,348	2,136
	7^+/6 ratio	0.71	0.70	0.71	0.71	0.71
Last-Year	1	1,920,498	1,280,837	3,231,066	2,665,617	864,749
	2	788,188	552,030	1,266,931	1,102,977	270,952
	3	661,527	451,673	1,084,438	956,104	115,122
	4	432,940	283,638	732,672	653,588	25,882
	5	357,559	237,225	600,137	556,110	4,865
	6	274,714	194,620	437,164	429,436	742
	7^+	2,729,221	3,381,144	2,885,214	4,111,357	583
	7^+/6 ratio	9.93	17.37	6.60	9.57	0.78
Benchmark		Base	Low M	High M	RelM 0.16	Sel 1-5
sSPR 2007		0.507	0.382	0.654	0.554	0.001
sSPR 2005-07 Average		0.495	0.367	0.645	0.535	0.001

Table A3.2.4.15. Selectivity Constraints North. Review panel requested diagnostics for the northern region base model run and sensitivity runs for using different constraints on the selectivities for age 4 and age 5. Sensitivity-run headings indicate the constraint, showing proportion of age-3 selectivity assigned to age 4 & age 5. Shown are negative log likelihoods by data category, abundance estimates in first & last year & age 7^{+} to age 6 abundance ratios, & static spawning potential ratios for 2007 & for 2005-07 average.

		Base	Sensitivity Run				
negLL		Run	0.05,0.025	0.20,0.10	0.20,0.20	0.20,0.40	1.00,1.00
Total kill		-106.7	-95.8	-9.1	-102.9	-101.8	-12.4
Proportion at age		869.6	863.5	923.5	906.7	934.5	1,135.6
Indexes of Abundance		131.5	133.2	183.1	133.9	134.3	221.2
Tagging		318.1	336.4	967.5	610.0	608.0	2,329.4
Selectivity deviations		75.4	71.7	33.8	87.4	88.2	63.7
Total Obj. Function		1,287.9	1,309.1	2,098.8	1,635.1	1,663.2	3,737.4
Abundance	Age	Base	0.05,0.025	0.20,0.10	0.20,0.20	0.20,0.40	1.00,1.00
First-Year	1	126,360	131,662	136,270	135,043	135,027	162,435
	2	47,100	46,560	60,507	49,131	48,754	60,730
	3	19,495	18,208	23,522	21,856	20,895	14,039
	4	14,457	10,296	4,157	3,425	2,391	1,736
	5	35,614	1,036	378	233	142	133
	6	64,623	1,632	595	367	223	209
	7^{+}	5,571,045	129,624	48,861	29,163	17,717	10,559
	7^{+}/6 ratio	86	79	82	79	79	51
Last-Year	1	192,825	207,843	274,591	217,664	214,588	302,437
	2	384,172	409,724	706,256	430,659	426,139	521,957
	3	183,739	206,951	459,877	232,236	233,924	281,185
	4	182,547	210,534	432,393	246,717	249,970	329,324
	5	27,215	31,174	69,832	34,405	34,483	51,572
	6	150,553	175,760	370,472	195,611	195,828	207,709
	7^{+}	2,151,126	676,232	1,320,329	708,115	662,360	1,141,293
	7^{+}/6 ratio	14	4	4	4	3	5
Benchmark		Base	0.05,0.025	0.20,0.10	0.20,0.20	0.20,0.40	1.00,1.00
sSPR 2007		0.292	0.294	0.518	0.297	0.269	0.310
sSPR 2005-07		0.453	0.457	0.653	0.467	0.439	0.439

Table A3.2.4.16. Selectivity Constraints North. Standardized residuals for the model fit to the pooled observed proportion-at-age data in the northern region under various selectivity constraints. Positive (green) residuals indicate the model under-estimated the observed data and negative (red) residuals indicate the model over-estimated the observed data. Shaded numbers are greater than two standard errors from zero residual. The underlined values indicate ages that represented less than 1% of the annual catch. See Table A3.2.4.4 for base residuals.

Sel_4 = 0.05 Sel_3, Sel_5 = 0.025 Sel_3

	1	2	3	4	5	6	7+
1989	-1.540	1.068	0.324	0.021	0.066	-0.230	-0.604
1990	-0.837	0.304	0.849	0.271	-0.685	-0.271	-1.466
1991	-1.120	0.497	0.518	0.640	0.312	-0.608	-0.094
1992	-0.752	-0.375	1.573	0.638	0.624	-0.100	-0.308
1993	0.303	-0.775	0.468	**2.050**	0.225	-0.011	0.112
1994	-1.121	-0.941	1.553	**3.922**	1.593	0.101	**3.622**
1995	-0.928	0.502	0.185	0.842	1.390	-0.469	-0.196
1996	1.996	-1.806	0.000	1.644	1.905	**-2.047**	0.313
1997	1.020	-0.802	-0.670	**2.040**	**2.873**	-1.767	0.867
1998	-1.732	0.910	0.754	-0.001	0.111	-0.456	-0.008
1999	0.936	-1.477	1.316	0.116	-0.237	-0.514	-0.030
2000	0.866	**-2.542**	**3.221**	0.405	-0.046	-0.810	-0.087
2001	-0.227	-1.298	**2.410**	**1.068**	-0.592	-0.766	-0.176
2002	**0.360**	-0.376	0.159	0.287	-0.928	-0.706	-0.055
2003	0.804	-1.945	2.343	0.299	-0.471	**-2.171**	-0.245
2004	0.231	-1.020	**1.566**	0.608	-0.229	**-3.894**	-0.900
2005	0.347	-0.290	0.154	-0.152	-0.199	-0.222	-0.377
2006	0.085	-0.997	1.558	0.784	-0.594	-0.558	-0.377
2007	0.519	-1.497	**2.035**	-0.041	<u>-0.107</u>	<u>-1.805</u>	-0.416

Sel_4 = 0.2 Sel_3, Sel_5 = 0.1 Sel_3

	1	2	3	4	5	6	7+
1989	-1.373	0.814	0.409	0.044	0.042	-0.028	-0.232
1990	-0.714	0.271	0.772	-0.102	-0.216	-0.031	-0.561
1991	-1.099	0.467	0.549	0.501	-0.023	-0.089	-0.005
1992	-1.264	-0.106	**2.115**	0.526	0.257	-0.102	-0.092
1993	0.576	-1.356	1.574	1.692	0.037	-0.061	0.181
1994	-1.638	-0.621	**2.225**	**2.737**	0.509	-0.068	**2.638**
1995	-1.276	0.524	0.950	-0.047	-0.315	-0.307	-0.102
1996	1.960	-1.953	0.979	1.171	-0.158	-1.164	0.213
1997	0.485	-0.870	0.638	1.249	1.128	-1.080	0.495
1998	-1.502	0.641	1.251	-0.524	-0.618	-0.309	-0.196
1999	-1.361	0.589	1.071	-0.107	-0.842	-0.599	-0.233
2000	0.642	**-2.121**	**4.016**	-0.135	-0.306	-0.648	-0.296
2001	-0.015	-0.565	**1.832**	-0.289	-1.798	-0.595	-0.677
2002	-1.092	1.163	-0.027	-1.343	**-2.103**	-1.154	-0.514
2003	0.584	-1.259	**2.697**	-0.018	**-3.097**	**-2.096**	-0.953
2004	-0.870	0.176	**2.045**	0.094	-0.768	**-4.134**	-1.945
2005	-1.037	1.214	0.006	-1.272	-0.690	-0.456	-1.780
2006	-1.032	0.259	1.549	0.561	-1.737	-0.495	-1.379
2007	0.306	-0.706	**2.075**	-0.900	<u>-0.321</u>	<u>-1.697</u>	-1.478

Table A3.2.4.17. Selectivity Constraints North. Standardized residuals for the model fit to the pooled observed proportion-at-age data in the northern region under various selectivity constraints. Positive (green) residuals indicate the model under-estimated the observed data and negative (red) residuals indicate the model over-estimated the observed data. Shaded numbers are greater than two standard errors from zero residual. The underlined values indicate ages that represented less than 1% of the annual catch. See Table A3.2.4.4 for base residuals.

$Sel_4 = 0.2\ Sel_3$, $Sel_5 = 0.2\ Sel_3$

	1	2	3	4	5	6	7^+
1989	-1.545	0.930	0.426	0.126	0.046	-0.037	-0.249
1990	-0.765	0.216	0.833	-0.162	-0.505	-0.042	-0.645
1991	-1.078	0.447	0.501	0.677	-0.219	-0.141	0.048
1992	-0.707	-0.471	1.621	0.683	0.305	-0.277	-0.109
1993	0.240	-1.099	1.169	**2.114**	0.040	-0.073	0.106
1994	-1.492	-0.913	**2.198**	**3.469**	0.315	-0.074	**2.580**
1995	-1.162	0.414	0.834	0.448	-1.462	-0.501	-0.123
1996	1.875	**-2.105**	1.046	1.527	-0.696	**-2.343**	0.166
1997	0.849	-1.051	0.417	1.641	0.576	-1.872	0.252
1998	-1.747	0.901	1.034	-0.619	-1.624	-0.772	-0.394
1999	0.847	-1.432	1.461	0.076	-0.757	-0.484	-0.137
2000	0.834	**-2.610**	**3.504**	0.285	-0.312	-0.907	-0.290
2001	-0.301	-1.386	**3.254**	**0.164**	**-2.797**	-1.013	-1.248
2002	0.381	-0.186	0.260	-0.120	**-3.059**	-1.409	-0.700
2003	0.781	-1.763	**2.315**	0.290	-1.431	-1.843	-0.676
2004	0.041	-1.049	**2.574**	0.405	-0.632	**-3.813**	**-2.670**
2005	0.360	-0.180	0.215	-0.402	-0.490	-0.193	-1.039
2006	0.097	-1.013	1.847	0.823	-1.553	-0.501	-1.086
2007	0.505	-1.410	**2.248**	-0.370	<u>-0.279</u>	<u>-1.634</u>	-1.223

$Sel_4 = 0.2\ Sel_3$, $Sel_5 = 0.4\ Sel_3$

	1	2	3	4	5	6	7^+
1989	-1.564	0.962	0.459	0.188	0.021	-0.024	-0.272
1990	-0.778	0.226	0.827	-0.144	-0.376	-0.021	-0.402
1991	-1.084	0.470	0.498	0.681	-0.324	-0.091	0.060
1992	-0.702	-0.482	1.611	0.687	0.122	-0.274	-0.056
1993	0.235	-1.117	1.165	**2.127**	-0.034	-0.076	0.065
1994	-1.485	-0.926	**2.202**	**3.500**	-0.222	-0.090	1.764
1995	-1.095	0.457	0.846	0.479	**-2.144**	-0.501	-0.093
1996	1.904	**-2.072**	1.087	1.556	-1.462	**-2.343**	0.062
1997	0.934	-1.031	0.478	1.683	-0.422	-1.893	-0.097
1998	-1.633	0.971	1.037	-0.577	-1.891	-0.825	-0.549
1999	0.845	-1.421	1.459	0.079	-0.761	-0.480	-0.175
2000	0.836	**-2.616**	**3.497**	0.295	-0.346	-0.932	-0.367
2001	-0.233	-1.245	**3.303**	**0.285**	**-2.963**	-1.046	-1.627
2002	0.430	0.015	0.262	-0.099	**-3.204**	-1.577	-0.969
2003	0.788	-1.641	**2.299**	0.294	**-1.473**	-1.842	-0.835
2004	0.208	-0.839	**2.630**	0.430	-0.615	**-3.744**	**-3.207**
2005	0.384	-0.064	0.216	-0.389	-0.502	-0.193	-1.282
2006	0.132	-0.881	1.843	0.829	-1.592	-0.520	-1.345
2007	0.520	-1.258	**2.240**	-0.364	<u>-0.287</u>	<u>-1.693</u>	-1.527

Table A3.2.4.18. Selectivity Constraints North. Standardized residuals for the model fit to the pooled observed proportion-at-age data in the northern region under various selectivity constraints. Positive (green) residuals indicate the model under-estimated the observed data and negative (red) residuals indicate the model over-estimated the observed data. Shaded numbers are greater than two standard errors from zero residual. The underlined values indicate ages that represented less than 1% of the annual catch. See Table A3.2.4.4 for base residuals.

Sel_4 = 1.0 Sel_3, Sel_5 = 1.0 Sel_3

	1	2	3	4	5	6	7+
1989	-1.616	0.608	0.976	0.059	0.006	-0.009	0.003
1990	0.029	-0.360	0.833	-0.447	-0.065	-0.006	-0.033
1991	-0.817	0.288	0.488	0.216	-0.158	-0.020	0.042
1992	-0.678	-0.455	1.721	0.259	-0.053	-0.101	-0.012
1993	-0.286	-0.758	1.554	0.821	-0.114	-0.092	0.039
1994	-1.088	-1.059	**2.768**	0.258	-0.243	-0.092	0.772
1995	-1.546	0.971	0.975	-0.692	-1.273	-0.222	-0.052
1996	1.997	**-2.007**	1.682	0.000	-0.785	-0.951	0.006
1997	1.248	-0.772	0.741	-0.547	-0.832	-0.898	-0.225
1998	-1.427	1.168	1.142	-1.903	-1.017	-0.510	-0.367
1999	-1.225	0.605	1.349	-0.391	-1.048	-0.458	-0.287
2000	0.882	**-2.191**	**3.674**	-0.497	-0.330	-0.609	-0.310
2001	-0.487	0.409	**2.552**	**-2.630**	-1.868	-0.642	-1.158
2002	0.643	0.576	0.323	**-2.741**	-1.770	-0.731	-0.620
2003	0.627	0.088	**2.171**	-0.097	**-4.240**	**-2.062**	-1.275
2004	0.334	0.086	**3.379**	-0.902	-0.369	**-4.286**	**-2.408**
2005	-0.031	1.579	0.179	-1.430	-0.939	-0.205	**-2.612**
2006	-0.437	0.649	1.838	0.223	-1.269	-0.683	**-2.224**
2007	0.275	0.062	**2.374**	-1.530	-0.277	-0.995	**-2.221**

Table A3.2.4.19. Selectivity Constraints South Review panel requested diagnostics for the **southern** region base model run and sensitivity runs for using different constraints on the selectivities for age 4 and age 5. Sensitivity-run headings indicate the constraint, showing the proportion of age-3 selectivity assigned to age 4 and age 5. Shown are the negative log likelihoods by data category, abundance estimates in the first and last year and the age 7^+ to age 6 abundance ratios, and static spawning potential ratios for 2007 and for the 2005-07 average.

		Base	Sensitivity Run				
negLL		Run	0.05,0.025	0.20,0.10	0.20,0.20	0.20,0.40	1.00,1.00
Total kill		-183.4	-183.4	-183.6	-181.3	-176.6	-173.9
Proportion at age		1,225.9	1,225.9	1,267.7	1,256.0	1,257.8	1,259.6
Indexes of Abundance		-5.6	-5.6	-5.2	5.4	10.6	4.5
Selectivity deviations		27.9	27.4	24.9	25.8	28.2	27.8
Total Obj. Function		1,064.8	1,106.3	1,105.0	1,117.7	1,118.4	1,075.2
Abundance	Age	Base	0.05,0.025	0.20,0.10	0.20,0.20	0.20,0.40	1.00,1.00
First-Year	1	801,346	1,354,410	462,295	367,532	359,708	329,646
	2	437,370	876,887	269,593	202,322	177,937	156,334
	3	107,584	221,546	51,206	26,984	20,009	19,146
	4	120,696	1,639,399	94,644	39,533	22,024	9,248
	5	1,086,033	760,134	48,996	8,341	2,830	1,953
	6	1,245,352	873,322	56,558	9,557	3,234	2,243
	7^+	880,517	618,401	40,214	6,755	2,282	1,593
	7^+/6 ratio	0.7	0.7	0.7	0.7	0.7	0.7
Last-Year	1	1,920,498	2,633,921	1,044,060	908,871	887,521	879,441
	2	788,188	1,125,648	368,633	300,252	287,278	281,833
	3	661,527	1,021,816	222,508	152,798	138,691	133,000
	4	432,940	725,429	94,297	40,318	27,910	26,933
	5	357,559	636,748	64,177	21,425	12,794	5,101
	6	274,714	492,680	48,429	14,683	7,020	1,055
	7^+	2,729,221	4,379,559	352,401	59,006	13,334	753
	7^+/6 ratio	9.9	8.9	7.3	4.0	1.9	0.7
Benchmark		Base	0.05,0.025	0.20,0.10	0.20,0.20	0.20,0.40	1.00,1.00
sSPR 2007		0.507	0.634	0.120	0.024	0.007	0.001
sSPR 2005-07 Average		0.495	0.625	0.113	0.022	0.006	0.001

Table A3.2.4.20. Selectivity Constraints South. Standardized residuals for the model fit to the pooled observed proportion-at-age data in the southern region under various selectivity constraints. Positive (green) residuals indicate the model under-estimated the observed data and negative (red) residuals indicate the model over-estimated the observed data. Shaded numbers are greater than two standard errors from zero residual. The underlined values indicate ages that represented less than 1% of the annual catch. See Table A3.2.4.6 for base residuals.

Sel_4 = 0.05 Sel_3, Sel_5 = 0.025 Sel_3

	1	2	3	4	5	6	7^+
1989	-0.187	0.148	0.421	-0.171	-0.513	**-2.335**	-0.354
1990	-1.045	1.683	-1.116	0.987	-0.603	-0.112	0.519
1991	0.927	-1.050	-0.908	**2.201**	0.861	-1.599	-0.534
1992	1.571	-1.213	-1.684	1.857	0.539	0.868	-0.189
1993	0.709	0.081	**-2.082**	1.888	0.628	0.727	-0.451
1994	0.515	0.187	-1.946	**2.291**	0.137	0.001	-0.672
1995	0.193	-0.156	-1.026	**2.280**	0.369	-0.758	-0.338
1996	0.973	-0.760	-1.338	**2.714**	0.598	**-2.161**	-1.522
1997	1.263	-0.609	**-2.434**	**3.196**	0.895	0.726	-1.317
1998	-0.391	-0.801	0.582	**3.558**	1.202	-0.178	**-2.825**
1999	-0.810	1.977	-1.487	1.202	0.963	-1.290	**-2.855**
2000	-0.424	-0.008	0.343	1.752	**2.286**	**-2.353**	**-3.251**
2001	-1.152	0.993	-0.648	**2.482**	**2.825**	-0.337	-1.929
2002	-0.043	-1.201	0.714	1.942	**2.994**	-0.943	-1.135
2003	-0.865	1.355	-1.559	**2.219**	**2.328**	0.364	-1.365
2004	**-2.128**	1.306	0.326	**3.413**	0.845	-0.209	-1.840
2005	-0.809	-0.078	0.035	**3.568**	1.091	-0.242	-1.720
2006	-0.846	-0.300	0.196	**3.841**	1.802	-0.791	-1.688
2007	-1.439	1.151	-0.366	**2.890**	1.399	-0.919	-1.858

Sel_4 = 0.2 Sel_3, Sel_5 = 0.1 Sel_3

	1	2	3	4	5	6	7^+
1989	-0.036	-0.077	0.528	-0.184	-0.621	-1.565	-0.261
1990	-0.935	1.533	-0.850	0.865	-0.629	-0.217	0.243
1991	0.718	-0.874	-0.610	1.898	0.675	-0.979	-0.431
1992	1.456	-1.203	-1.307	1.608	0.046	0.219	-0.268
1993	0.484	0.211	-1.544	1.482	0.272	-0.206	-0.389
1994	0.081	0.656	-1.095	1.201	-0.711	-0.757	-0.706
1995	-0.296	0.208	-0.130	1.861	-0.795	-1.509	-0.504
1996	0.727	-0.539	-0.476	**2.352**	-0.387	**-3.916**	-1.666
1997	1.107	-0.580	-1.678	**3.059**	0.428	-0.728	-1.681
1998	-0.359	-0.384	1.053	**2.623**	0.584	-1.119	**-3.083**
1999	-0.840	**2.210**	-0.885	0.756	-0.123	-1.507	**-2.805**
2000	-0.434	0.320	0.978	0.753	1.647	**-3.220**	**-3.114**
2001	-1.190	1.180	0.039	**2.172**	1.838	-1.042	**-2.293**
2002	-0.304	-0.788	1.125	1.600	**2.642**	-1.642	-1.413
2003	-1.177	1.623	-0.821	**2.010**	1.892	-0.291	-1.540
2004	**-2.432**	1.698	1.153	**2.835**	0.392	-0.881	-1.851
2005	-1.175	0.150	1.011	**3.437**	0.105	-0.898	-1.872
2006	-1.131	-0.135	1.092	**3.703**	1.387	-1.930	-1.791
2007	-1.675	1.363	0.396	**2.604**	1.013	-1.068	-1.864

Table A3.2.4.21. Selectivity Constraints South. Standardized residuals for the model fit to the pooled observed proportion-at-age data in the southern region under various selectivity constraints. Positive (green) residuals indicate the model under-estimated the observed data and negative (red) residuals indicate the model over-estimated the observed data. Shaded numbers are greater than two standard errors from zero residual. The underlined values indicate ages that represented less than 1% of the annual catch. See Table A3.2.4.6 for base residuals.

Sel_4 = 0.2 Sel_3, Sel_5 = 0.2 Sel_3

	1	2	3	4	5	6	7^+
1989	0.024	-0.386	0.683	0.048	-0.323	-0.783	-0.257
1990	-0.925	1.335	-0.768	0.920	-1.096	0.194	0.848
1991	0.588	-0.875	-0.499	1.960	0.608	-1.210	-0.282
1992	1.381	-1.198	-1.265	1.672	-0.406	0.091	-0.260
1993	0.298	0.206	-1.453	1.706	0.097	-0.470	-0.427
1994	-0.371	0.797	-0.774	1.572	-1.084	-0.873	-1.010
1995	-0.675	0.289	0.178	**2.252**	-1.276	-1.259	-0.443
1996	0.506	-0.581	-0.374	**2.647**	-0.341	**-3.672**	**-2.044**
1997	0.980	-0.617	-1.912	**3.245**	0.444	-0.185	-1.816
1998	-0.429	-0.468	0.731	**2.928**	0.612	-0.692	**-3.075**
1999	-0.750	**2.151**	-1.554	0.872	-0.746	-1.039	**-2.596**
2000	-0.371	0.227	0.589	0.881	1.121	**-3.283**	**-2.693**
2001	-1.200	1.194	-0.331	**2.258**	0.884	-1.230	-1.732
2002	-0.508	-0.601	1.021	1.724	**2.415**	**-2.013**	-0.803
2003	-1.339	1.726	-1.019	**2.021**	1.623	-0.427	-1.429
2004	**-2.606**	1.713	1.161	**3.034**	-0.016	-1.008	-1.847
2005	-1.374	0.220	1.058	**3.507**	-0.486	-1.088	-1.682
2006	-1.334	-0.070	1.049	**3.844**	1.206	-1.906	-1.400
2007	-1.831	1.389	0.240	**2.716**	0.895	-0.966	-1.628

Sel_4 = 0.2 Sel_3, Sel_5 = 0.4 Sel_3

	1	2	3	4	5	6	7^+
1989	-0.270	-0.227	0.809	0.306	-0.191	-0.523	-0.324
1990	-1.079	1.332	-0.548	0.973	-1.262	0.345	1.866
1991	0.587	-0.938	-0.494	**2.058**	0.472	-1.020	-0.016
1992	1.415	-1.175	-1.384	1.719	-0.832	0.094	0.250
1993	0.219	0.289	-1.474	1.766	-0.288	-0.554	-0.114
1994	-0.509	0.861	-0.631	1.698	-1.822	-1.035	-0.810
1995	-0.595	0.224	0.162	**2.381**	**-2.219**	-1.232	0.185
1996	0.411	-0.443	-0.512	**2.709**	-0.764	**-3.688**	-1.840
1997	0.892	-0.650	-1.924	**3.347**	-0.017	-0.020	-1.318
1998	-0.552	-0.486	0.551	**3.217**	0.312	-0.791	**-2.081**
1999	-0.700	**2.149**	-1.864	0.955	-1.446	-0.840	-1.983
2000	-0.314	0.241	0.250	0.962	0.260	**-3.044**	-1.734
2001	-1.163	1.277	-0.605	**2.312**	-0.616	-1.200	-0.356
2002	-0.561	-0.509	0.906	1.770	1.604	**-2.250**	0.509
2003	-1.376	1.793	-1.134	**2.049**	0.857	-0.612	-1.007
2004	**-2.653**	1.730	1.101	**3.153**	-0.666	-1.136	-1.500
2005	-1.421	0.261	1.010	**3.578**	-1.385	-1.146	-0.947
2006	-1.414	-0.057	0.965	**3.957**	0.656	-1.741	-0.334
2007	-1.907	1.406	0.115	**2.812**	0.515	-0.905	-0.754

Table A3.2.4.22. Selectivity Constraints South. Standardized residuals for the model fit to the pooled observed proportion-at-age data in the southern region under various selectivity constraints. Positive (green) residuals indicate the model under-estimated the observed data and negative (red) residuals indicate the model over-estimated the observed data. Shaded numbers are greater than two standard errors from zero residual. The underlined values indicate ages that represented less than 1% of the annual catch. See Table A3.2.4.6 for base residuals.

Sel_4 = 1.0 Sel_3, Sel_5 = 1.0 Sel_3

	1	2	3	4	5	6	7^+
1989	-0.312	-0.017	0.838	-0.058	-0.399	-1.640	-0.809
1990	-1.458	1.482	-0.175	0.510	-0.325	0.804	**2.936**
1991	0.328	-0.840	-0.065	1.251	0.605	0.052	0.378
1992	1.482	-1.425	-1.085	0.920	-0.106	0.623	1.804
1993	0.306	0.411	-1.569	0.513	0.064	0.453	0.785
1994	-0.209	1.006	-0.464	-1.016	-1.597	-0.342	0.940
1995	-0.350	0.140	0.033	1.007	-1.634	-0.844	1.944
1996	0.211	-0.263	-0.537	1.311	-0.265	**-2.049**	0.357
1997	0.809	-0.747	-1.682	**2.100**	0.577	1.487	1.337
1998	-0.634	-0.227	0.942	0.684	0.464	0.712	1.189
1999	-0.697	1.994	-1.445	-0.418	-1.036	-0.866	0.029
2000	-0.328	0.484	0.524	-1.327	0.866	**-2.455**	0.306
2001	-1.174	1.175	-0.455	0.765	1.113	-0.580	**2.523**
2002	-0.485	-0.457	1.022	0.155	**2.194**	-1.125	**2.963**
2003	-1.359	1.798	-0.997	**0.743**	0.941	-0.040	1.213
2004	**-2.579**	1.842	1.355	**0.876**	-0.261	-0.740	0.453
2005	-1.520	0.209	1.216	**2.252**	-0.379	-0.426	1.231
2006	-1.460	-0.139	1.183	**2.470**	1.464	-0.140	1.975
2007	-1.941	1.380	0.365	1.356	0.979	-0.302	1.656

Table A3.2.4.23. Calculated three-year average (average of previous two years and current year) static spawning potential ratio (3yr SPR), static spawning potential ratio (sSPR), year-specific escapement (sEsc), and cohort-specific escapement (tEsc) for red drum in the **northern** and **southern** regions during 1989-2007. The escapement was defined as through age 5.

	Northern region				Southern region			
	3yr SPR	sSPR	sEsc	tEsc	3yr SPR	sSPR	sEsc	tEsc
1989		0.003	0.003			0.510	0.551	
1990		0.014	0.014			0.652	0.686	
1991	0.078	0.216	0.219		0.590	0.608	0.654	
1992	0.189	0.339	0.342		0.667	0.740	0.769	
1993	0.251	0.198	0.203	0.019	0.687	0.713	0.744	0.605
1994	0.319	0.420	0.433	0.125	0.678	0.581	0.625	0.682
1995	0.359	0.460	0.469	0.234	0.612	0.540	0.584	0.714
1996	0.505	0.636	0.640	0.286	0.559	0.556	0.603	0.694
1997	0.513	0.444	0.452	0.390	0.574	0.625	0.667	0.617
1998	0.475	0.345	0.351	0.499	0.618	0.673	0.719	0.570
1999	0.443	0.541	0.564	0.556	0.637	0.613	0.664	0.588
2000	0.461	0.496	0.523	0.426	0.595	0.500	0.560	0.618
2001	0.449	0.309	0.327	0.474	0.546	0.526	0.585	0.624
2002	0.346	0.235	0.274	0.485	0.558	0.649	0.695	0.597
2003	0.396	0.645	0.663	0.500	0.548	0.470	0.520	0.567
2004	0.464	0.512	0.532	0.336	0.528	0.465	0.522	0.578
2005	0.576	0.571	0.602	0.314	0.458	0.438	0.499	0.592
2006	0.526	0.495	0.540	0.585	0.481	0.539	0.595	0.520
2007	0.453	0.292	0.327	0.542	0.495	0.507	0.564	0.480

Table A3.2.4.24. The calculated static spawning potential ratios (sSPR) and year-specific escapement rate through age 5 (sEsc) for the northern and southern regions during 2005-2007 for the base data, using a release mortality of 0.16 (RM 0.16), using the low natural mortality-at-age vector (M low), the high vector (M high), and a model configured to estimate selectivities through age 5.

	Northern region					**Southern region**		
sSPR	2005	2006	2007		**sSPR**	2005	2006	2007
Base	0.571	0.495	0.292		Base	0.438	0.539	0.507
Sel 1-5	0.529	0.481	0.277		Sel 1-5	<0.001	0.001	0.001
M low	0.571	0.499	0.298		M low	0.306	0.414	0.382
M high	0.578	0.495	0.289		M high	0.601	0.681	0.654
RM 0.16	0.506	0.547	0.391		RM 0.16	0.482	0.568	0.554
sEsc	2005	2006	2007		**sEsc**	2005	2006	2007
Base	0.602	0.540	0.327		Base	0.464	0.563	0.529
Sel 1-5	0.557	0.524	0.310		Sel 1-5	0.001	0.008	0.006
M low	0.598	0.541	0.329		M low	0.328	0.436	0.401
M high	0.611	0.544	0.328		M high	0.625	0.702	0.674
RM 0.16	0.643	0.677	0.539		RM 0.16	0.516	0.599	0.583

Table A3.2.4.25. Yield-per-recruit (lbs) and spawning stock biomass per recruit (defined as sSPR) benchmarks estimated using the recent selectivity vectors estimated by the SCA analysis. The apical fishing mortality, yield-per-recruit (Y/R) and static SPR (sSPR) are shown for the 2007 estimate of F (F_{2007}), maximum yield per recruit (F_{max}), yield per recruit where the slope is 10% of that at the origin ($F_{0.1}$), and sSPR equal to 20% ($F_{20\%}$) or 35% ($F_{35\%}$).

Northern region			
Benchmark	full F	Y/R	sSPR
F_{2007}	0.877	1.585	0.292
F_{max}	1.250	1.651	0.174
$F_{0.1}$	0.865	1.581	0.0.297
$F_{20\%}$	1.149	1.647	0.200
$F_{35\%}$	0.748	1.518	0.350
Southern region			
Benchmark	full F	Y/R	sSPR
F_{2007}	0.254	0.986	0.507
F_{max}	0.747	1.389	0.137
$F_{0.1}$	0.517	1.329	0.252
$F_{20\%}$	0.604	1.368	0.200
$F_{35\%}$	0.393	1.221	0.350

3.2.5 Figures

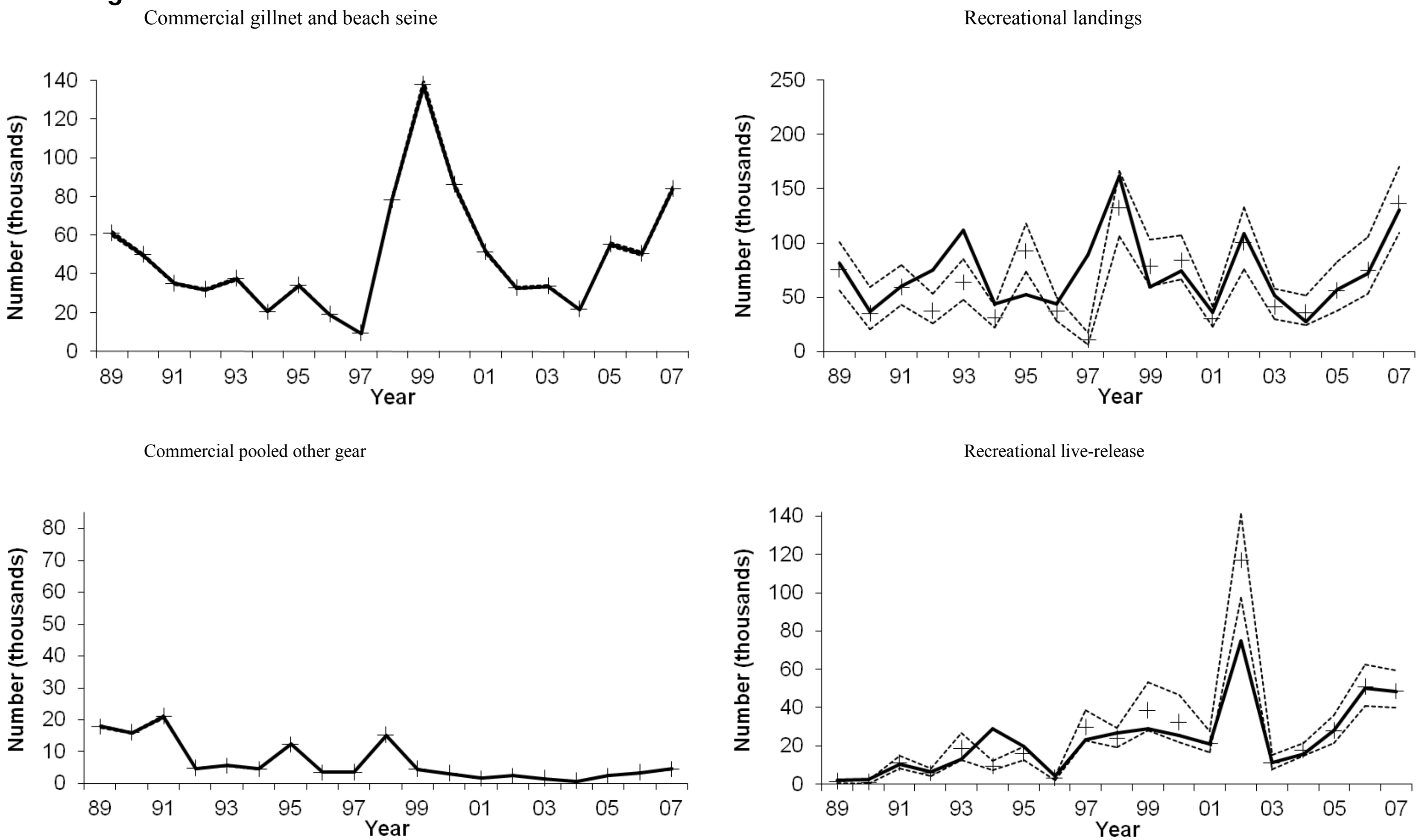
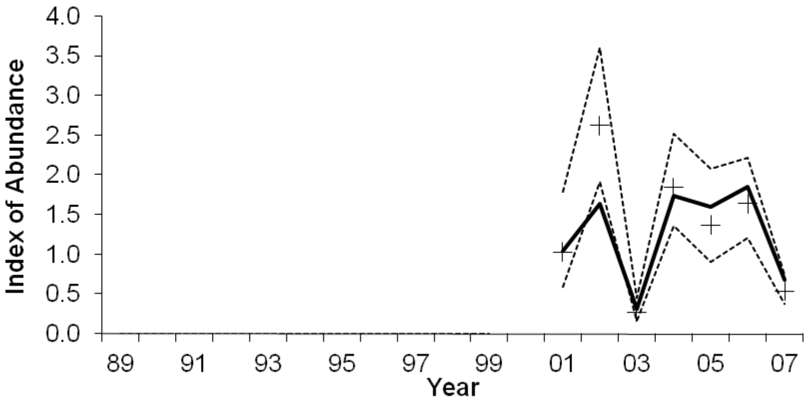
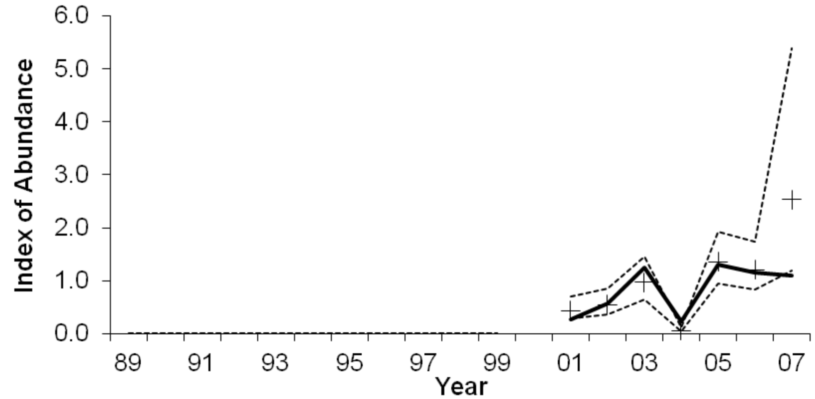


Figure A3.2.5.1. Observed (+) total annual harvest number, showing ± two standard errors (dashed lines), and the associated model estimates for the four **northern** fisheries.

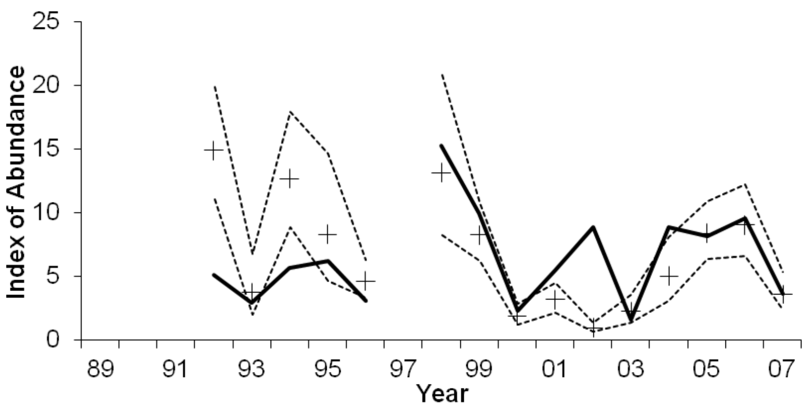
NC independent gillnet survey – age 1



NC independent gillnet survey – age 2



NC juvenile abundance index – age 1



MRFSS total catch rate – ages 1-3

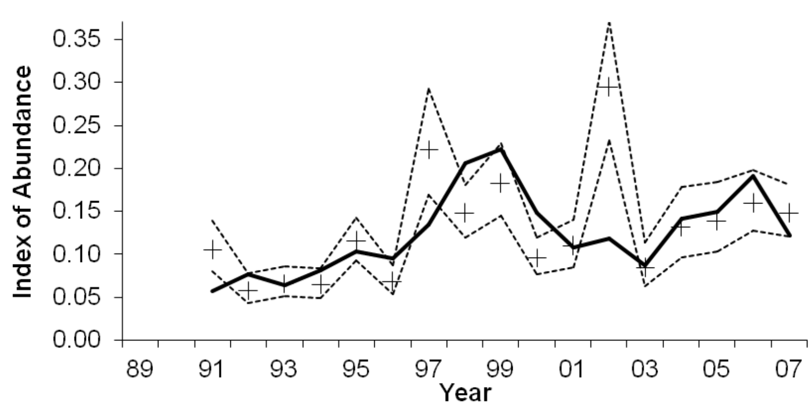


Figure A3.2.5.2. Observed (+) indexes of abundance for red drum, showing ± two standard errors (dashed lines), and the associated model estimates for the four northern indexes.

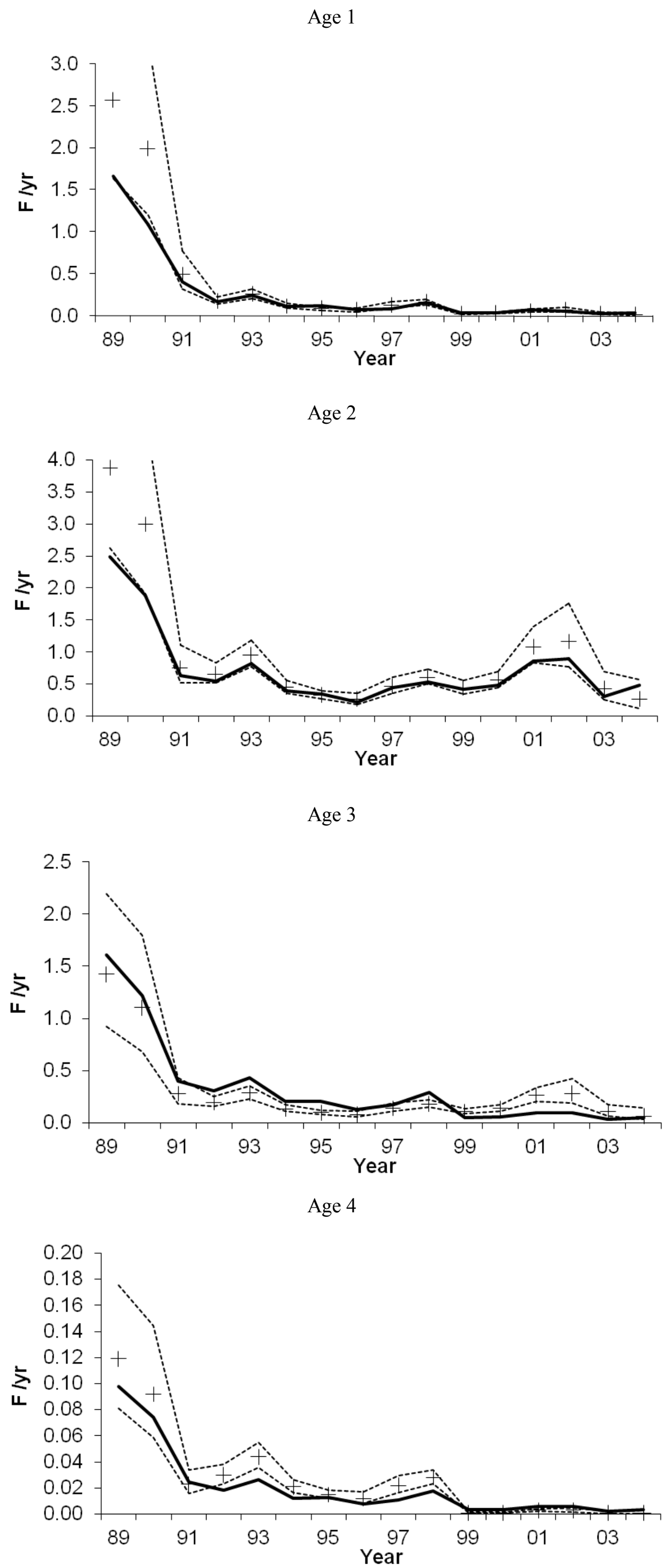


Figure A3.2.5.3. Observed (+) estimates of tag-based estimates of F-at-age for red drum, showing ± two standard errors (dashed lines), and the associated model estimates (solid line) for the **northern** stock.

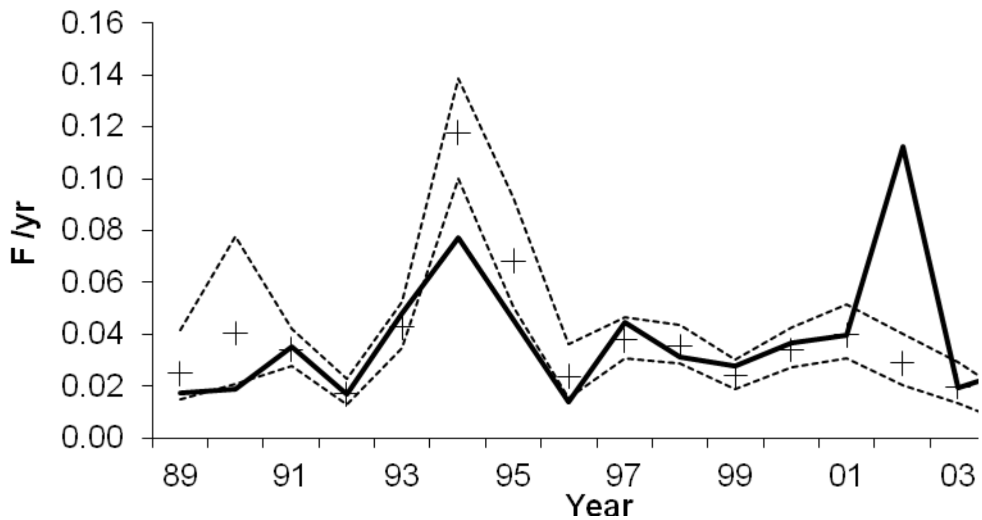


Figure A3.2.5.4. Observed (+) estimates of tag-based estimates of fully recruited F for red drum live releases from the recreational fishery, showing ± two standard errors (dashed lines), and the associated model estimates (solid line) for the northern stock.

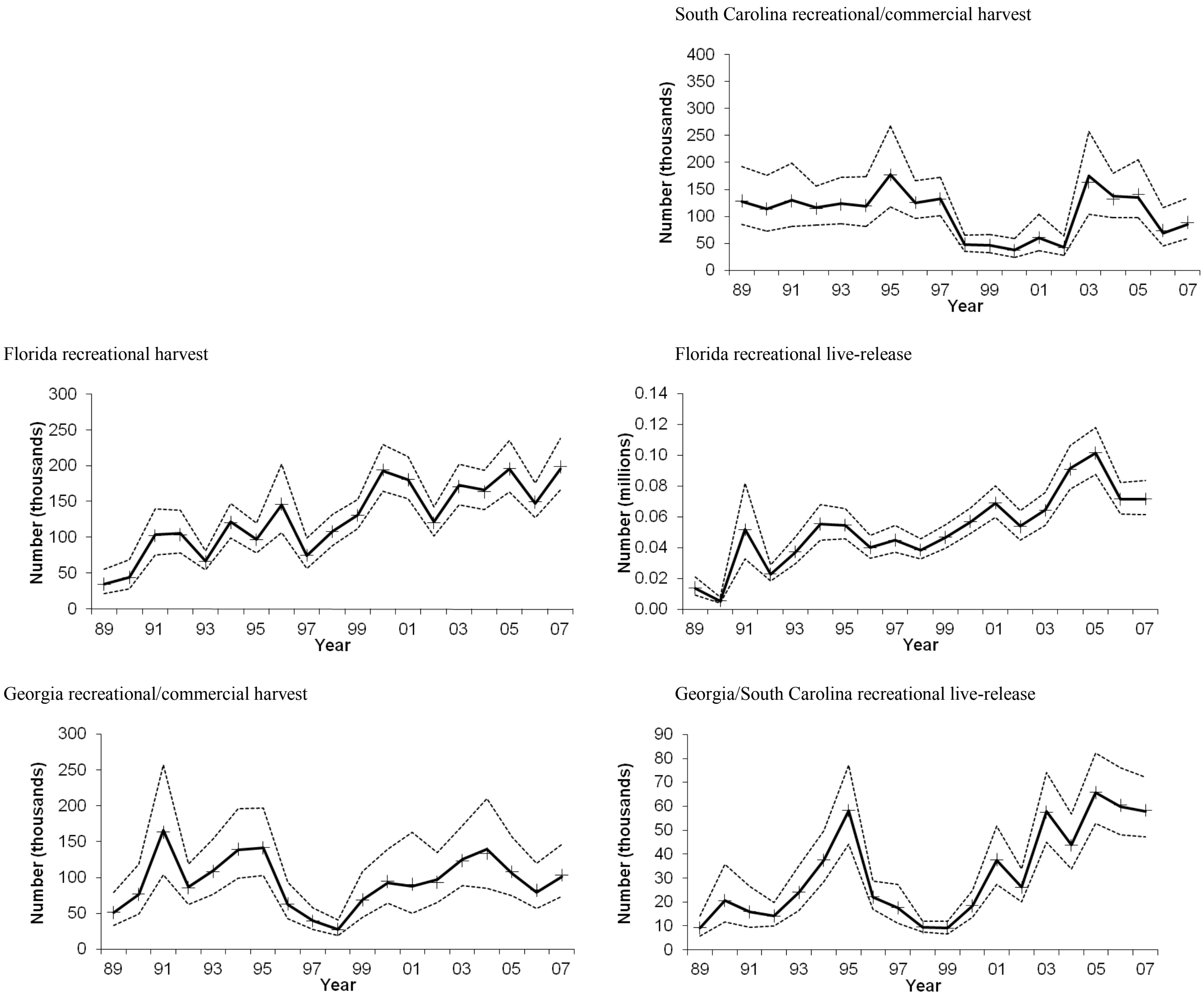


Figure A3.2.5.5. Observed (+) total annual harvest number, showing ± two standard errors (dashed lines), and the associated model estimates for the six **southern** fisheries.

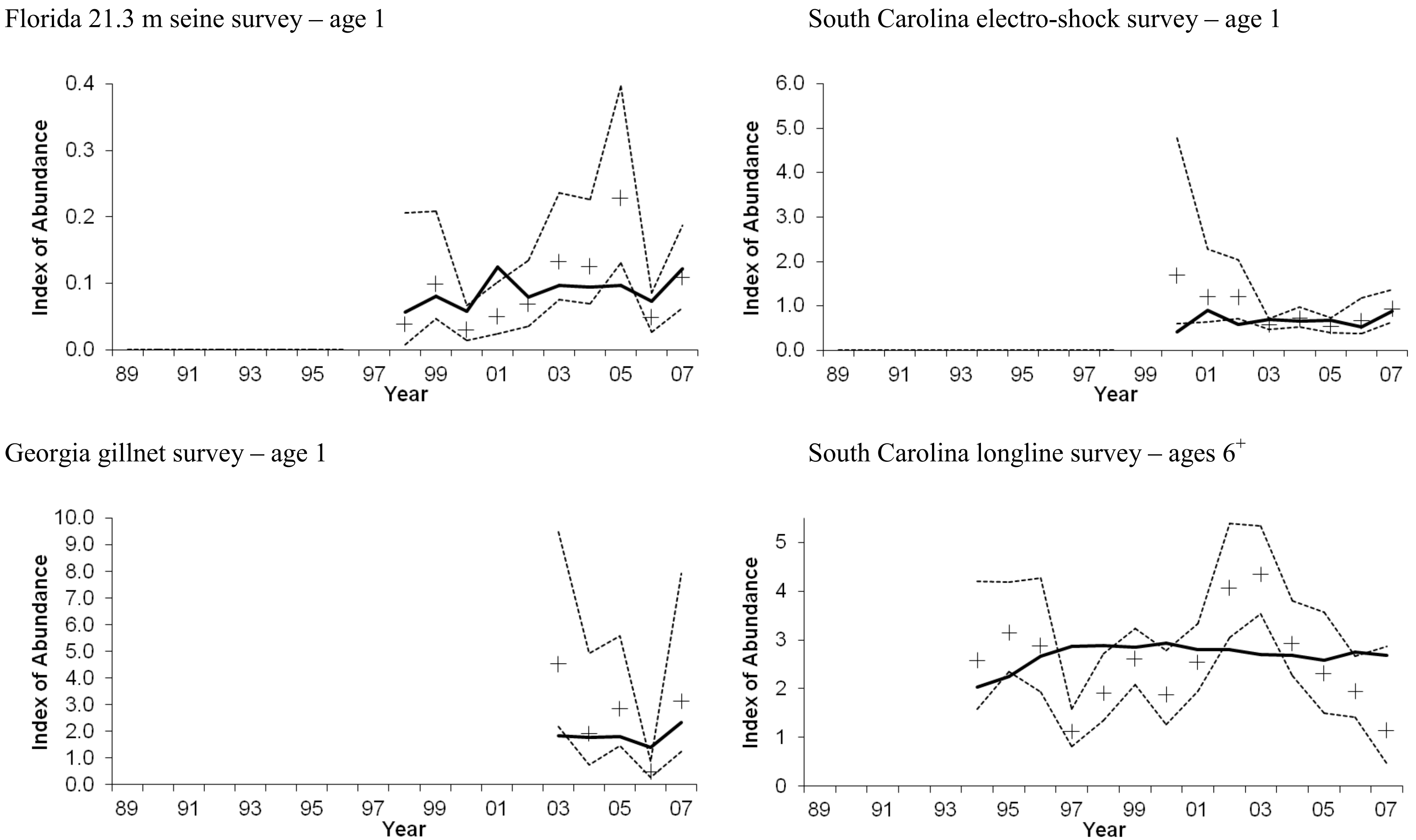


Figure A3.2.5.6. Observed (+) indexes of abundance for red drum, showing ± two standard errors (dashed lines), and the associated model estimates for the eight **southern** indices.

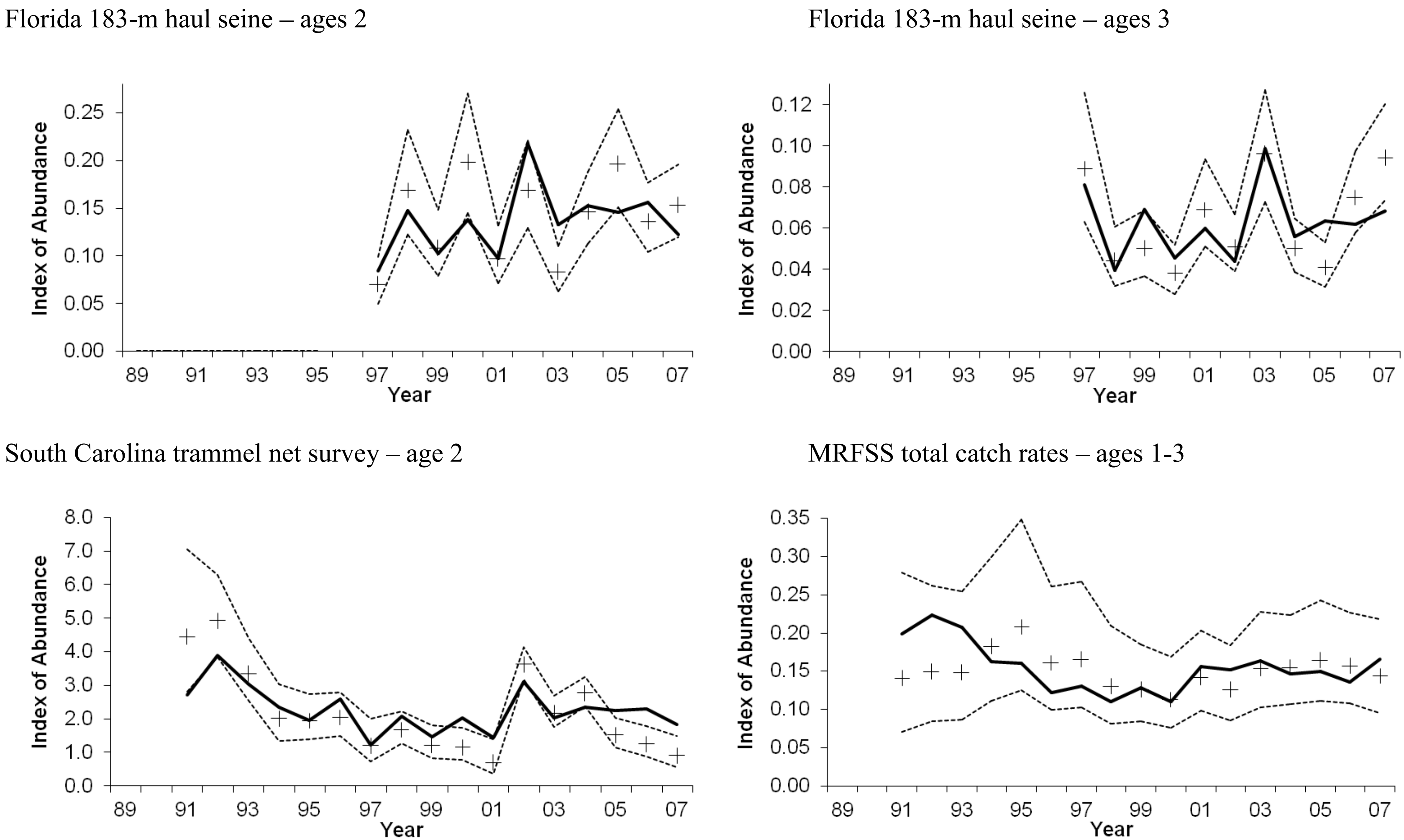
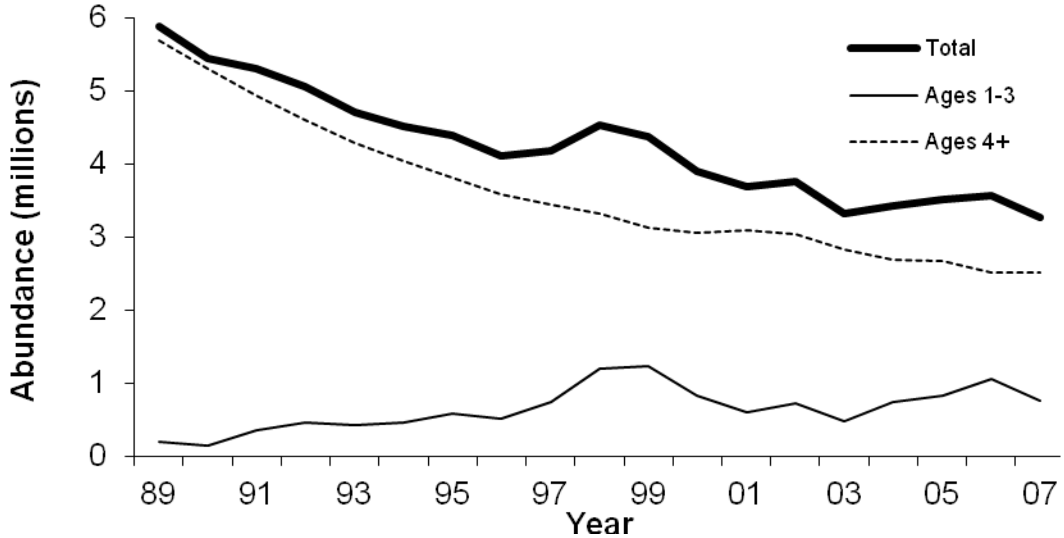


Figure A3.2.5.6 (con't). Observed (+) indexes of abundance for red drum, showing ± two standard errors (dashed lines), and the associated model estimates for the eight **southern** indexes.

Northern region



Southern region

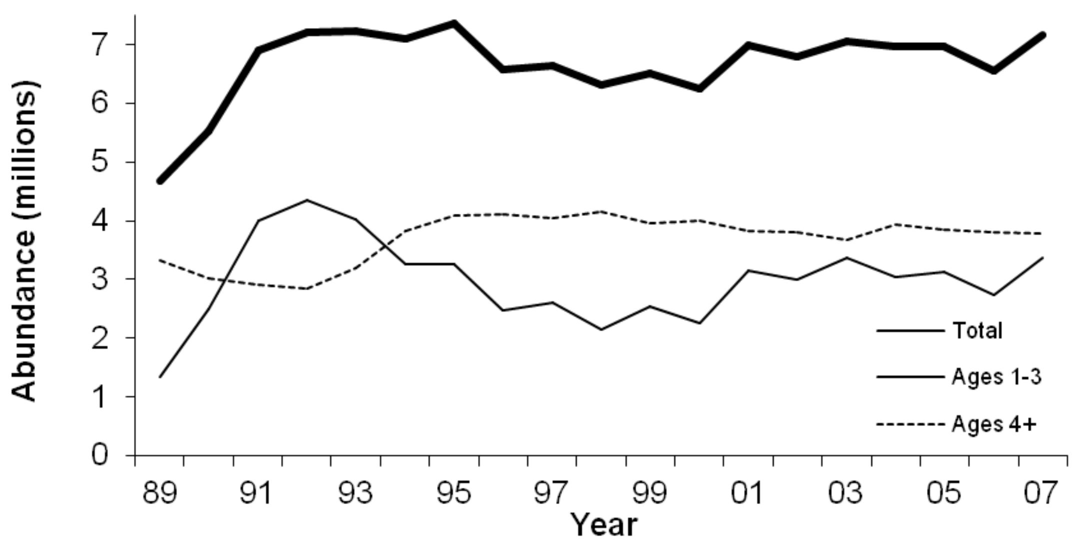
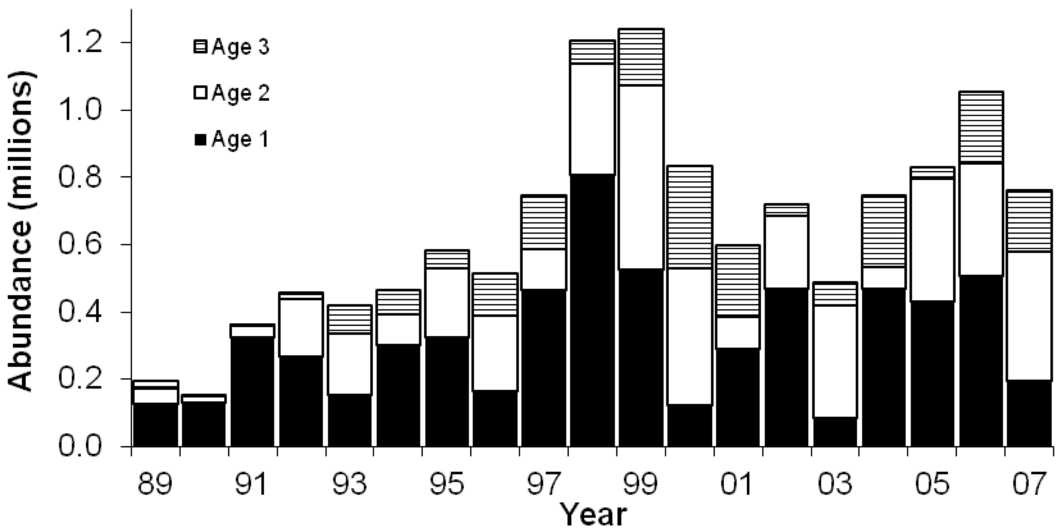


Figure A3.2.5.7. Estimated beginning-of-the-year abundance for red drum in the **northern** and **southern** stock areas during 1989-2007.

Northern region



Southern region

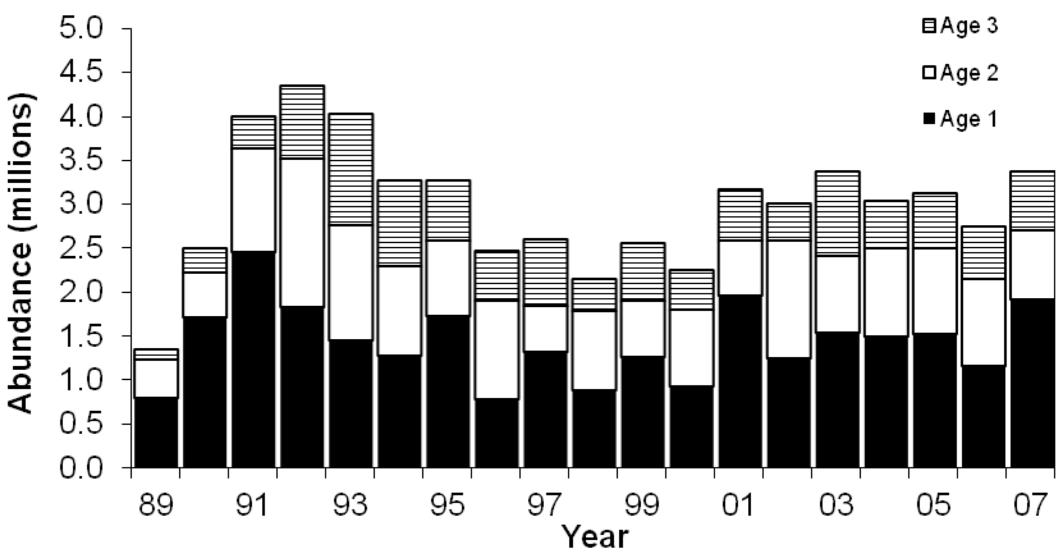
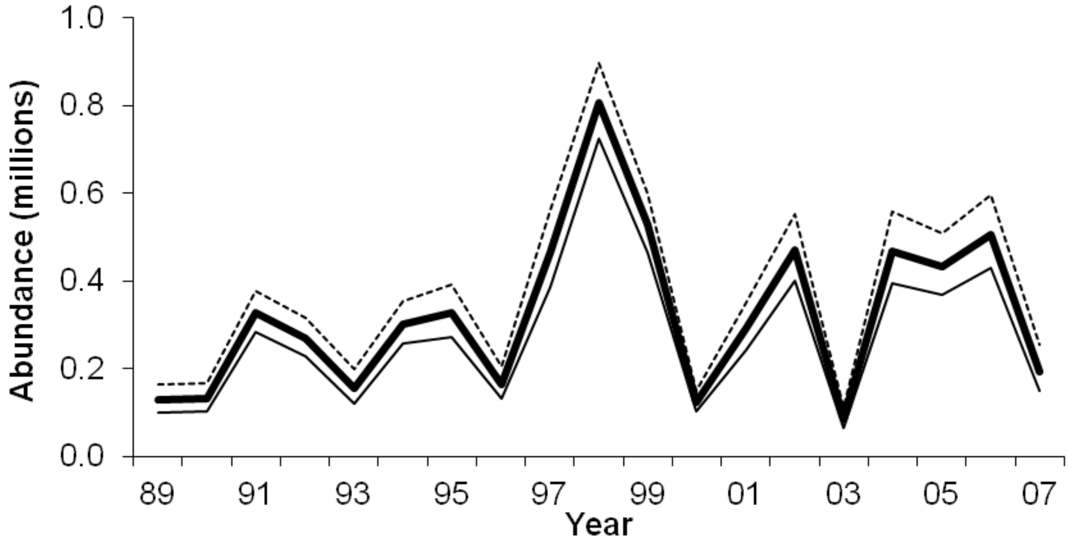


Figure A3.2.5.8. Estimates of abundance of red drum ages 1-3 in the **northern** and **southern** stock areas during 1989-2007

Northern region



Southern region

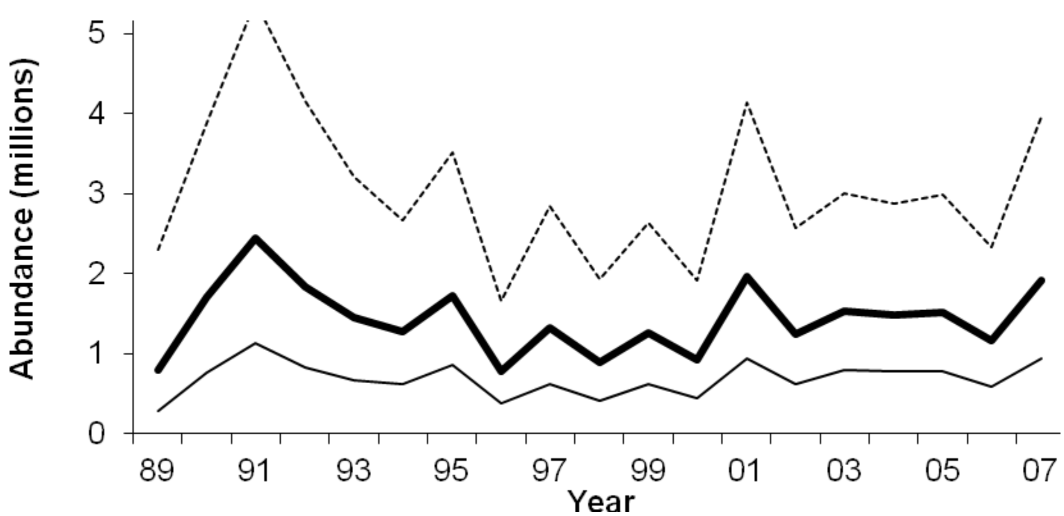


Figure A3.2.5.9. Estimated recruitment (age-1 abundance, heavy solid line) and ± 1.96 standard errors for the **northern** and **southern** regions during 1989-2007

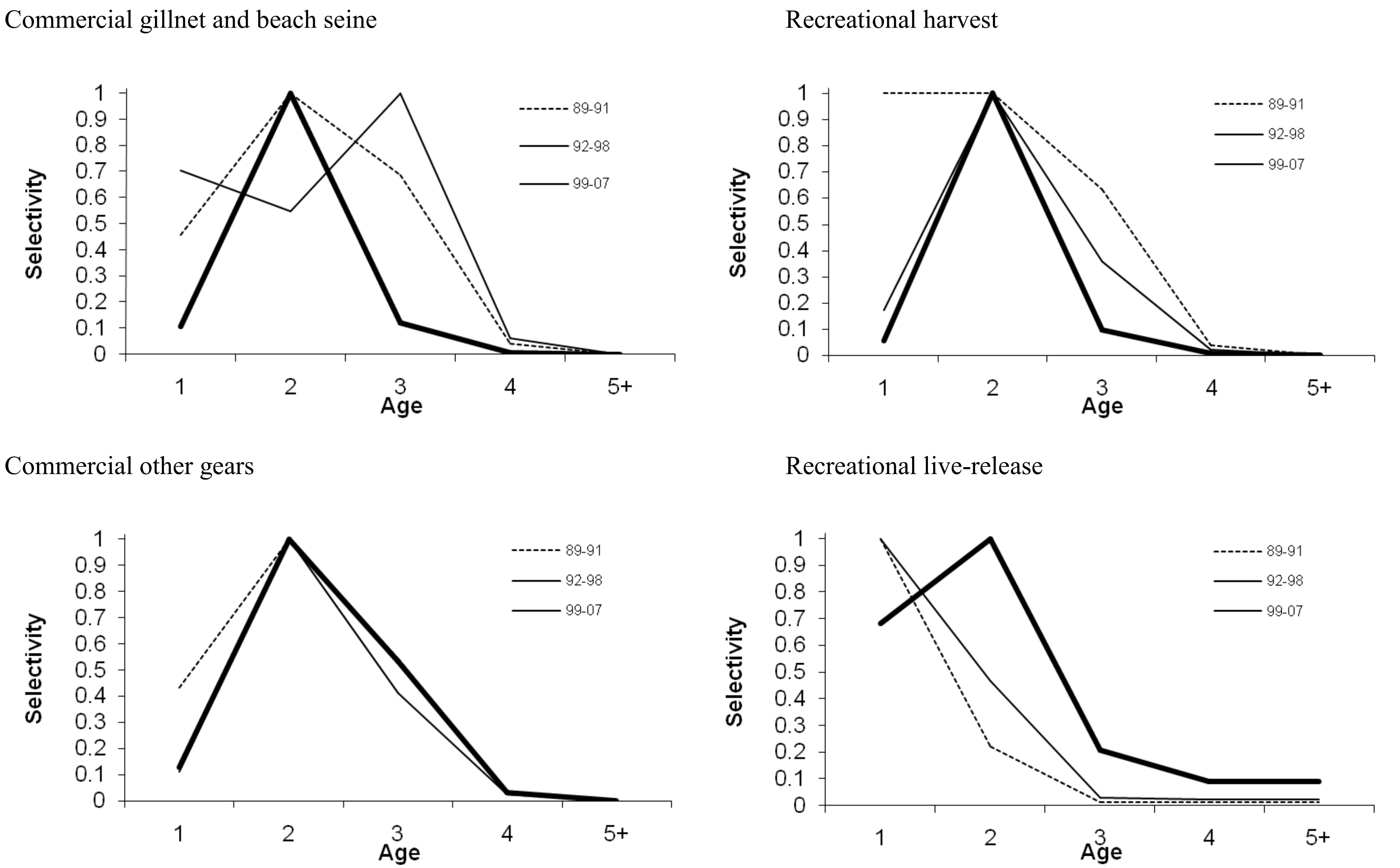


Figure A3.2.5.10. Estimated selectivities for three of the four **northern** fisheries modeled separately and the tag-based input selectivity data for the recreational live-release fishery. Under the separability assumption, this age-effect for distributing fishing mortality across ages was estimated for each of the indicated periods of years.

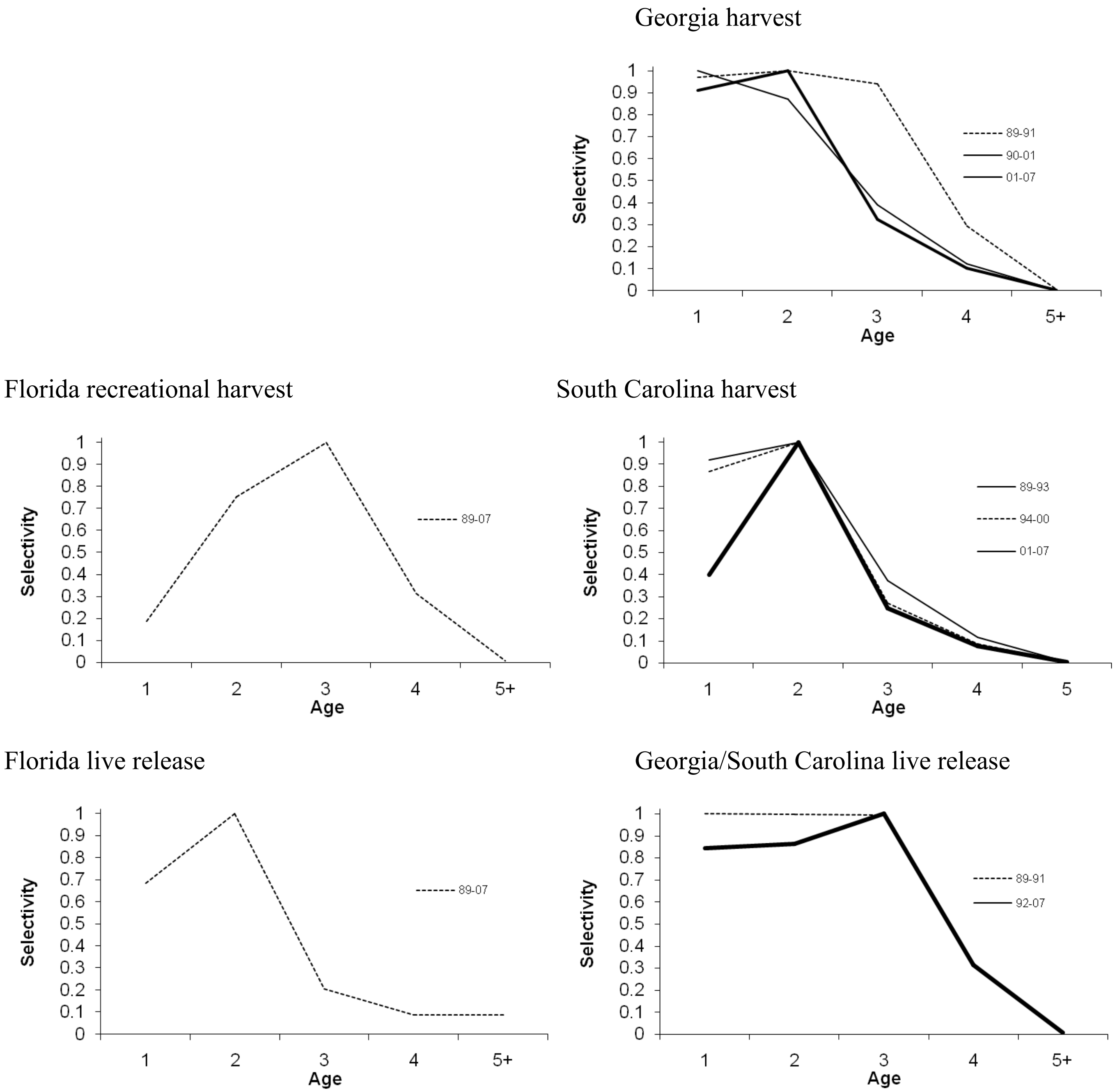
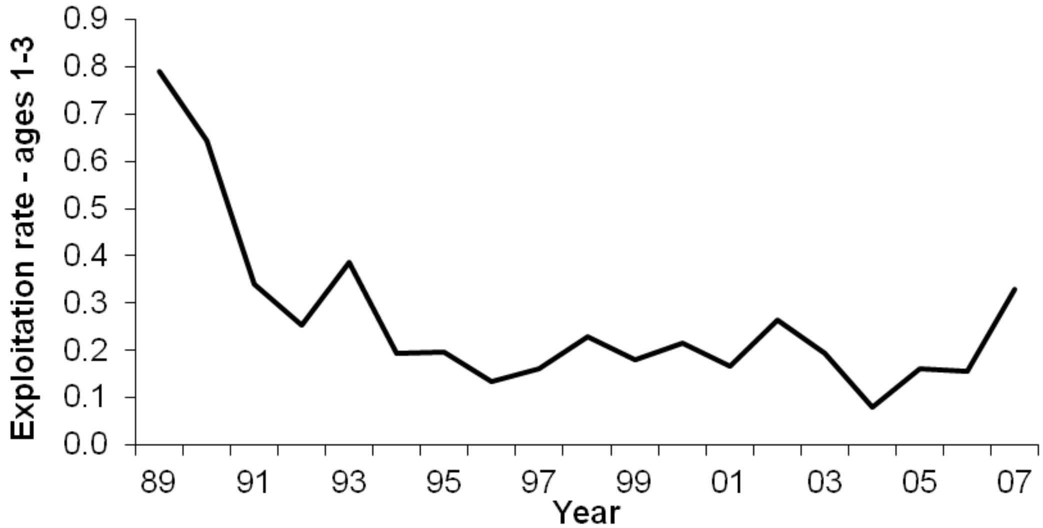


Figure A3.2.5.11. Estimated selectivities for five of the five **southern** fisheries modeled separately and the tag-based input selectivity data for the Florida recreational live-release fishery. Under the separability assumption, this age-effect for distributing fishing mortality across ages was estimated for each of the indicated periods of years.

Northern region



Southern region

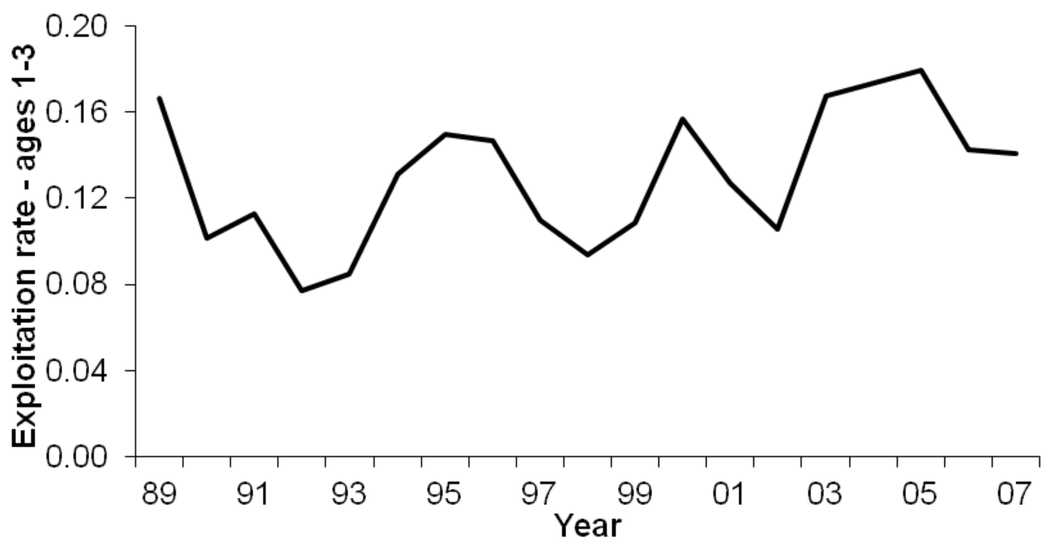


Figure A3.2.5.12. Estimated annual exploitation rate for red drum ages 1-3 in the **northern** and **southern** regions during 1989-2007.

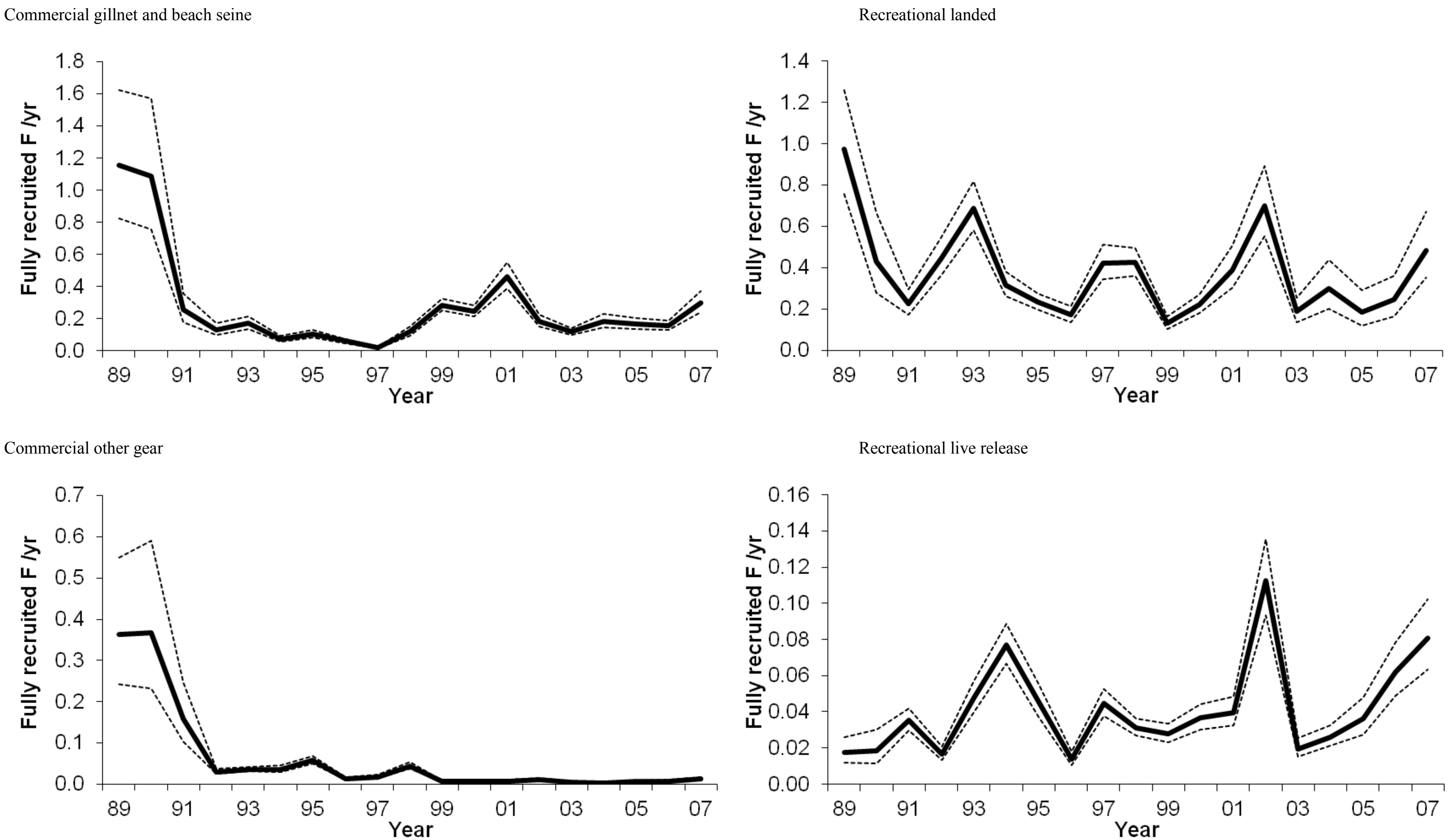


Figure A3.2.5.13. Estimated fully recruited instantaneous fishing mortality (solid line) and ± 1.96 standard errors (dashed lines) for the four **northern** region fisheries during 1989-2007.

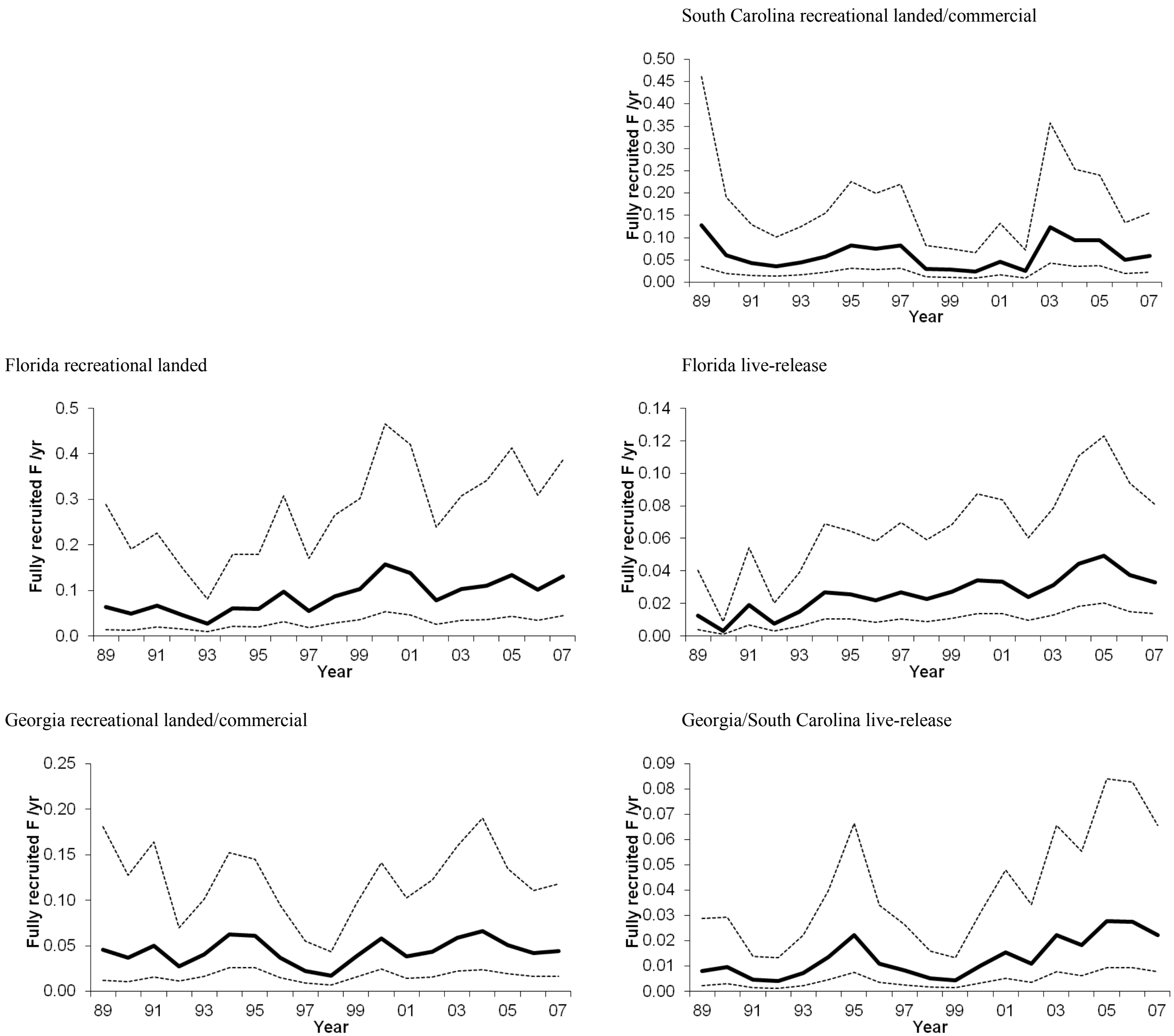
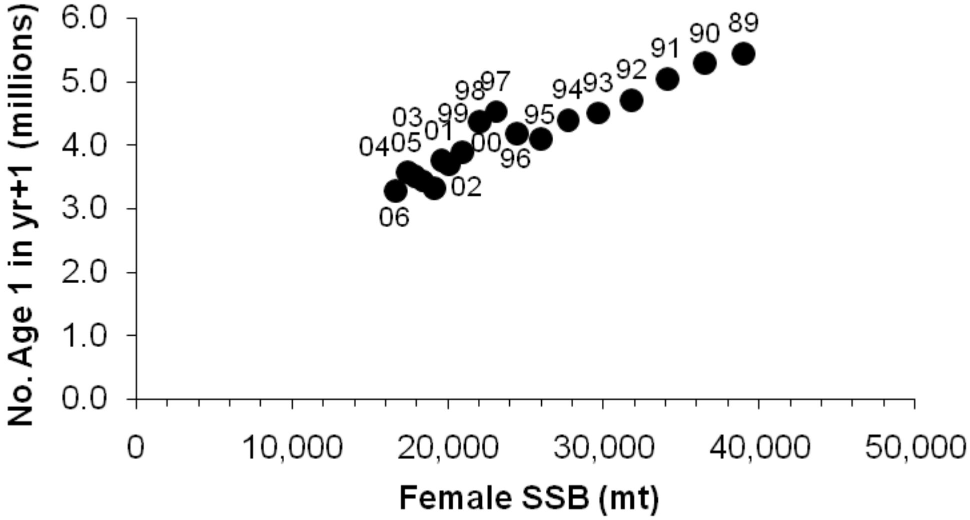


Figure A3.2.5.14. Estimated fully recruited instantaneous fishing mortality (solid line) and ± 1.96 standard errors (dashed lines) for the six **southern** region fisheries during 1989-2007.

Northern region



Southern region

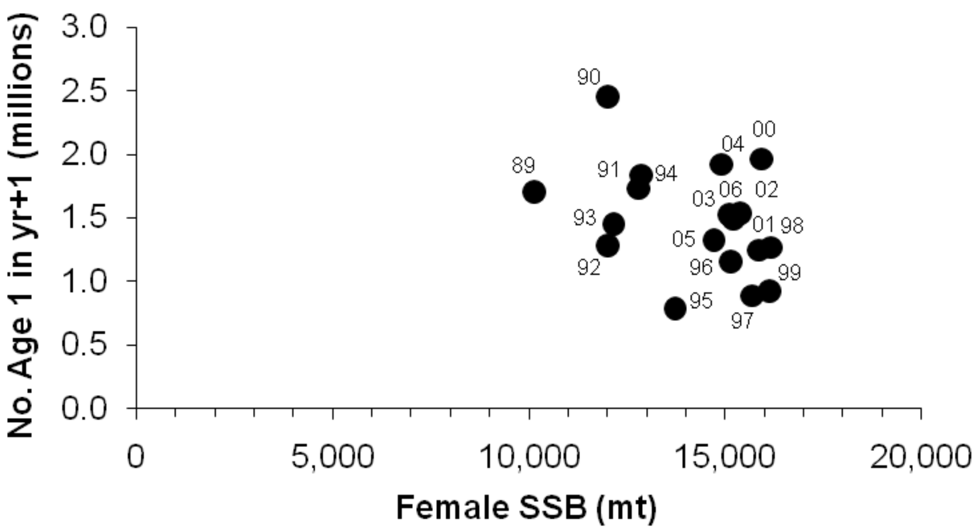


Figure A3.2.5.15. Estimated female spawning stock biomass (mt) of red drum during 1989-2006 and the next year's estimated abundance of age-1 fish.

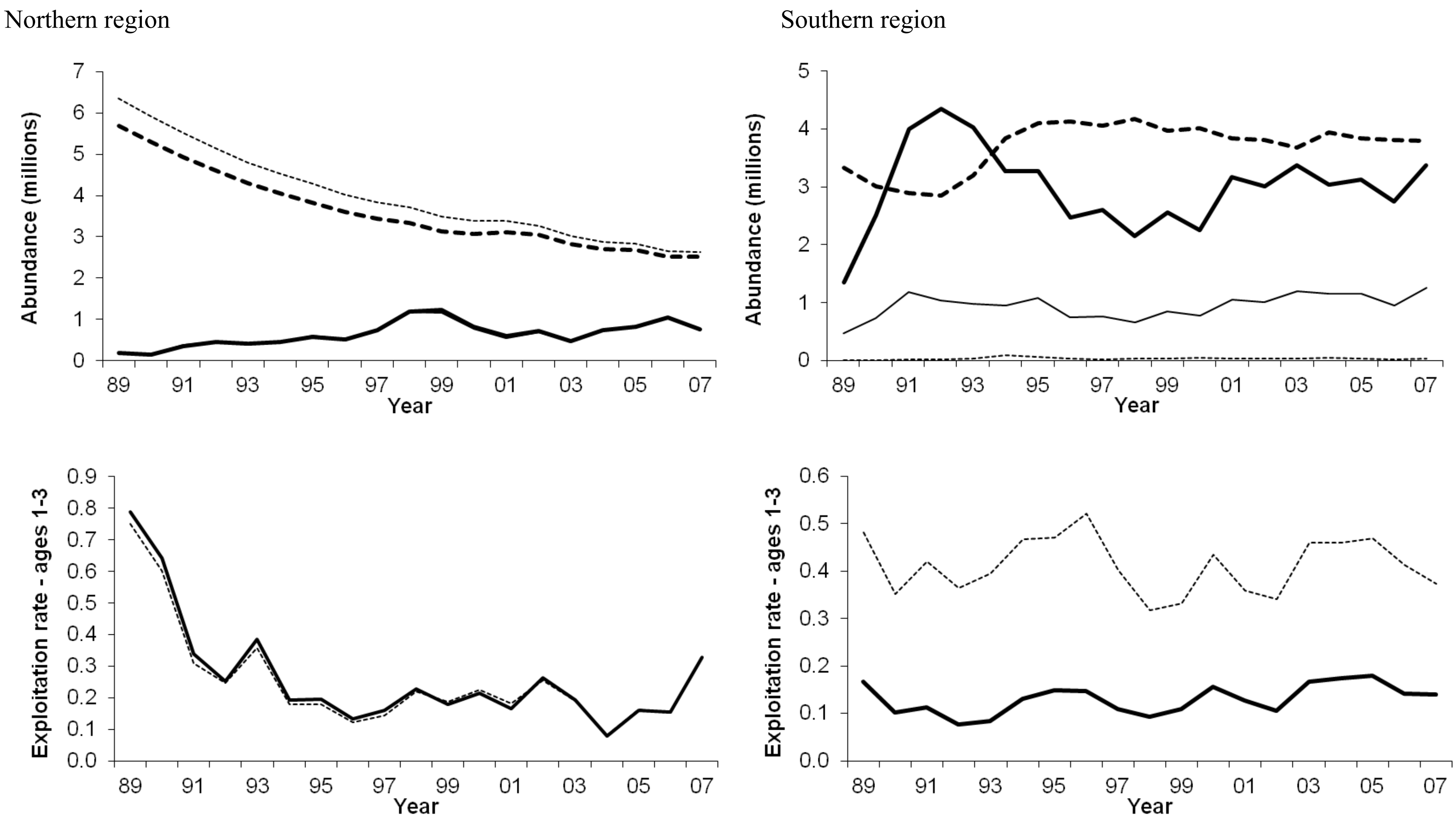


Figure A3.2.5.16. Estimates of abundance and age 1-3 exploitation when the selectivities of ages 1-5 were estimated (lighter lines) in the models instead of the restricted configuration used in the base model runs (heavy lines). The abundance panels show the estimates for the pooled ages 1-3 (solid lines) and for ages 4^+ (dashed lines).

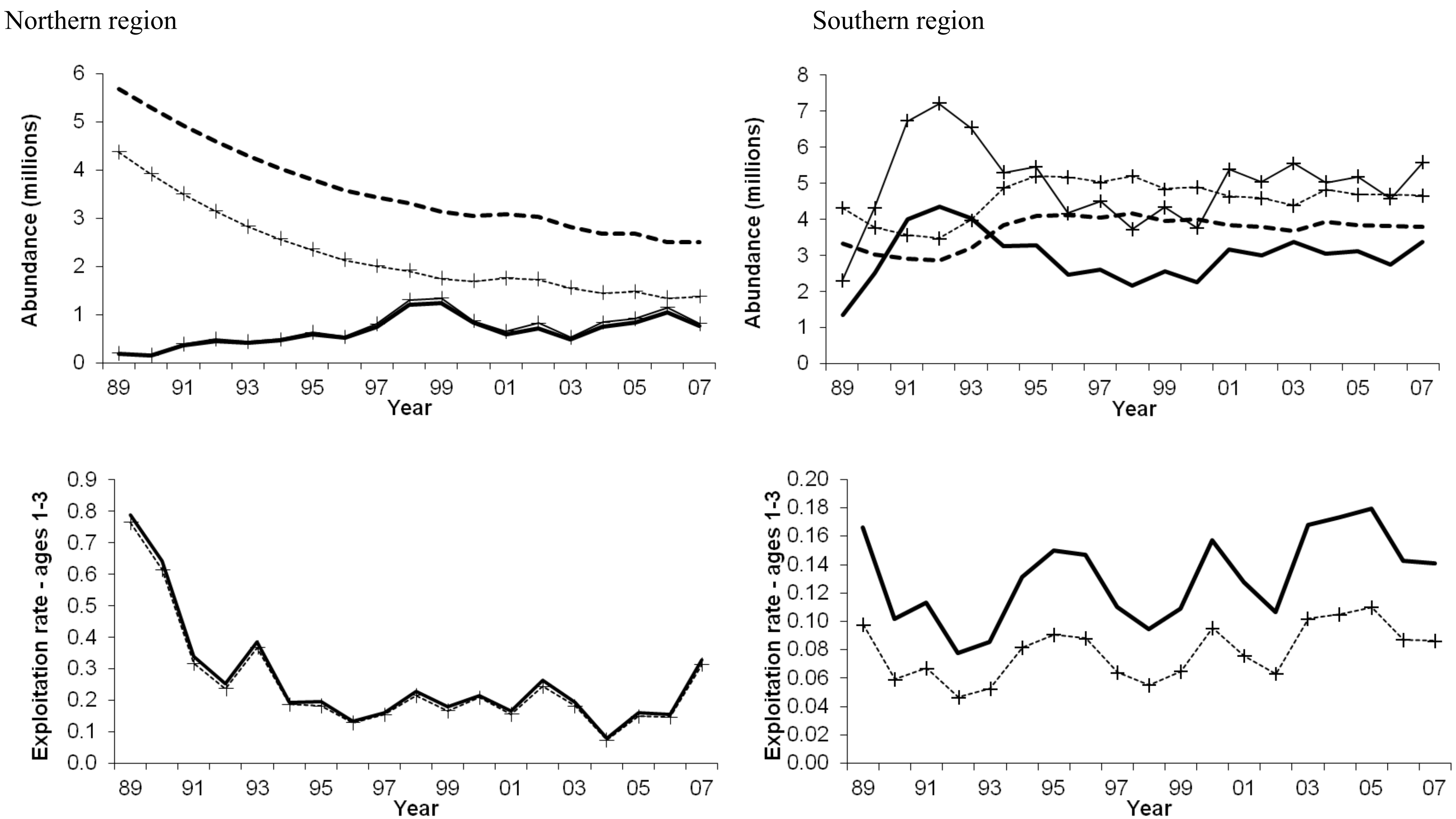


Figure A3.2.5.17. Estimates of abundance and age 1-3 exploitation using the **high** M (+'s) and base model M's (lines without symbols). The abundance panels show the estimates for the pooled ages 1-3 (heavier solid lines) and for ages 4^+ (heavy dashed lines)

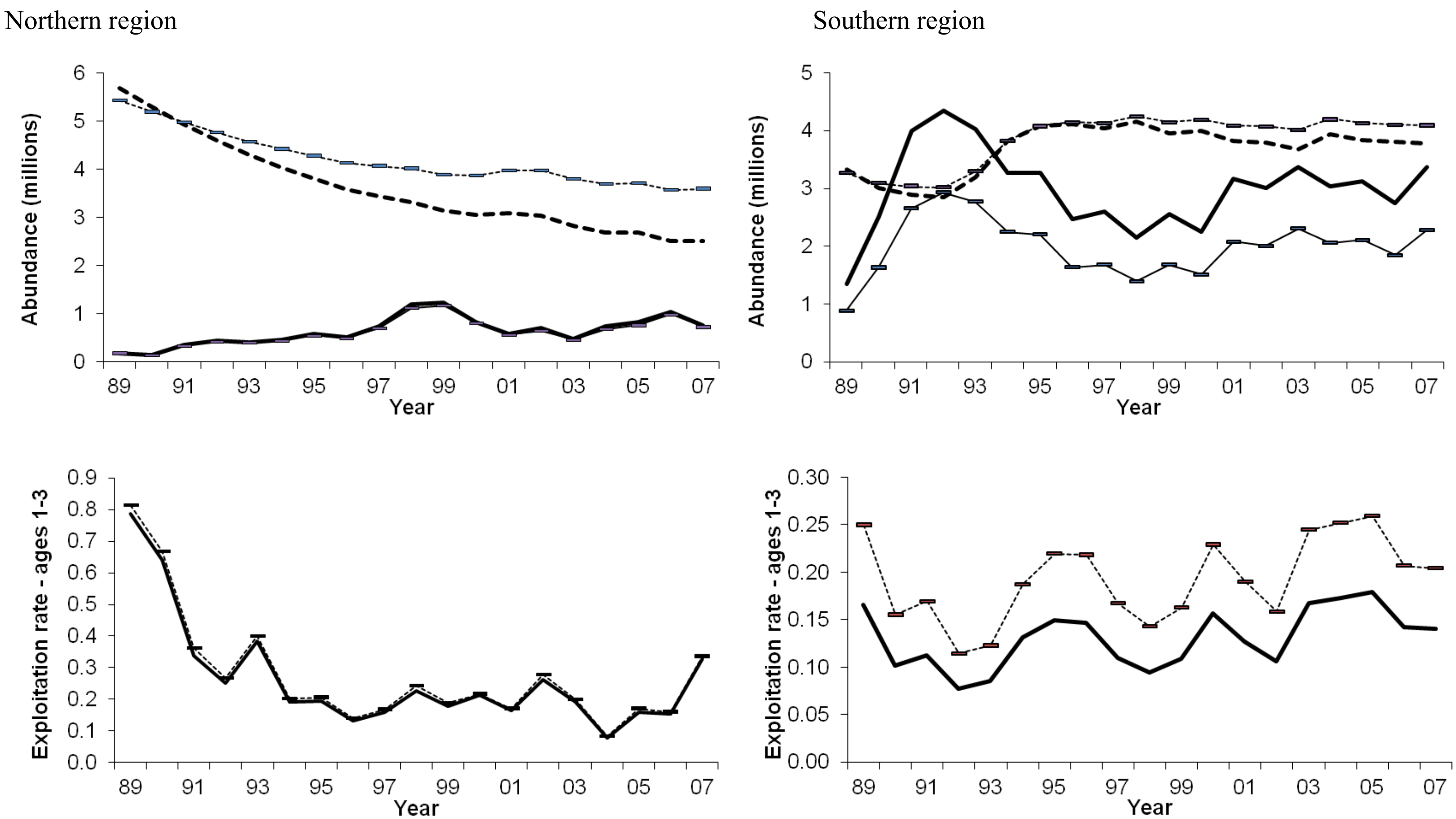


Figure A3.2.5.18. Estimates of abundance and age 1-3 exploitation using the **low** M (-‘s) and base model M’s (lines without symbols). The abundance panels show the estimates for the pooled ages 1-3 (heavier solid lines) and for ages 4^+ (heavier dashed lines)

Northern region

Southern region

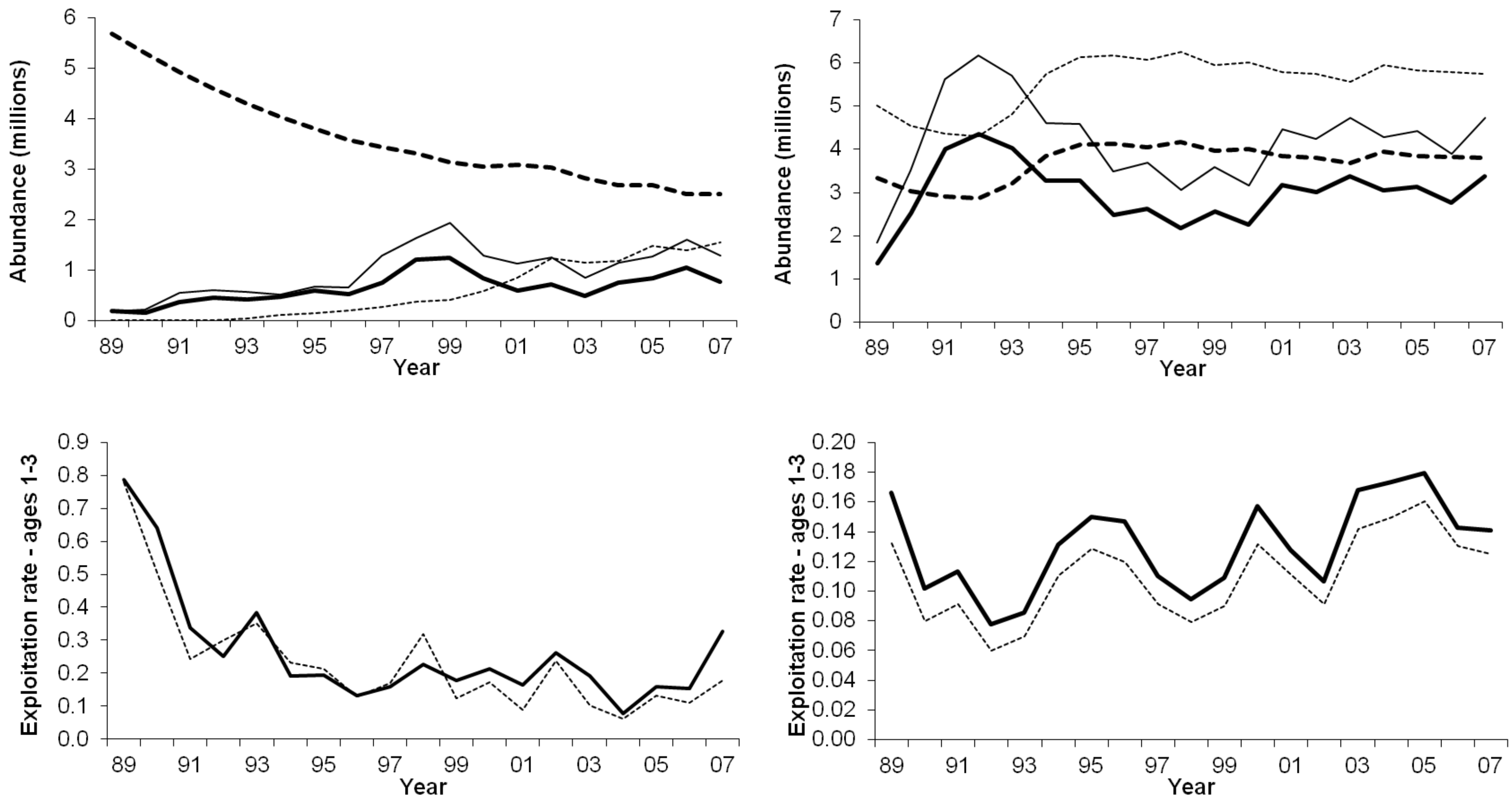


Figure A3.2.5.19. Estimates of abundance and age 1-3 exploitation when the hooking mortality was 0.16 (lighter lines), double the base level of 0.08 (heavier lines). The abundance panels show the estimates for the pooled ages 1-3 (heavier solid lines) and for ages 4^+ (heavier dashed lines).

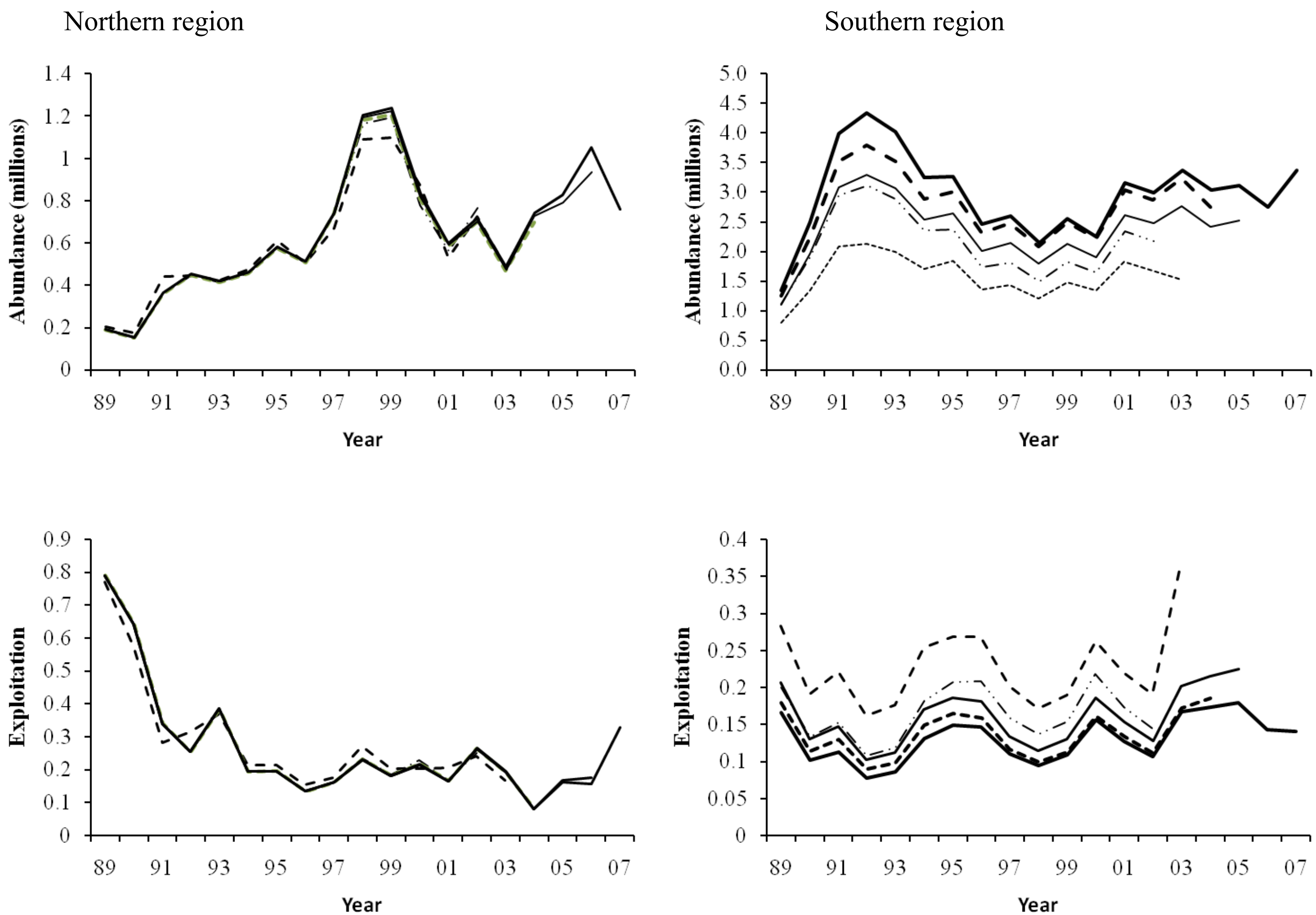


Figure A3.2.5.20. Estimates of age 1-3 abundance (top) and exploitation rate (bottom) using sequentially fewer years in the analysis, with the ending year changing from 2007 to 2006, to 2005, to 2004, to 2003, and to 2002. The 2003 and 2005 northern and the 2006 southern runs were not shown because their solutions did not produce positive definite Hessian matrices.

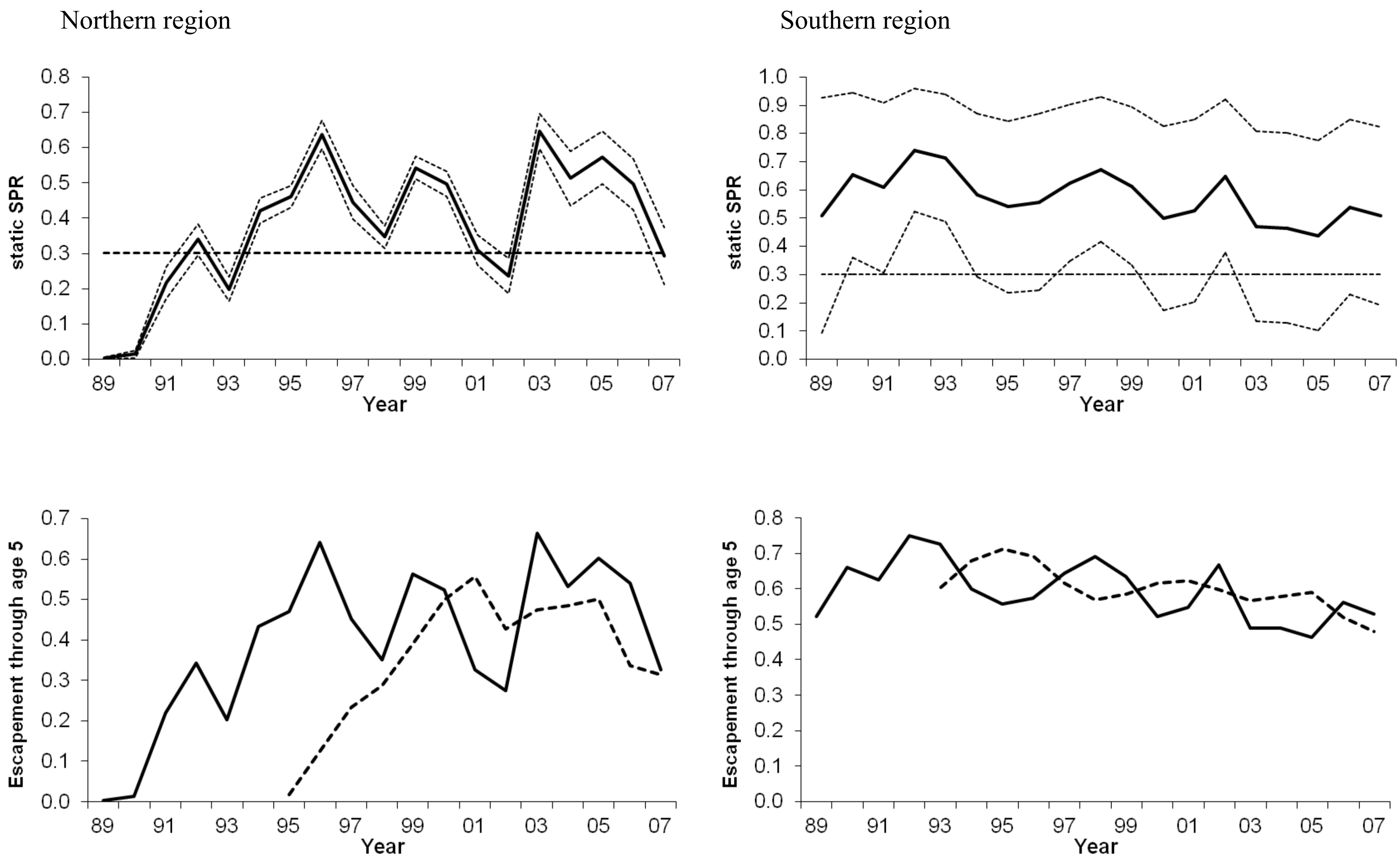
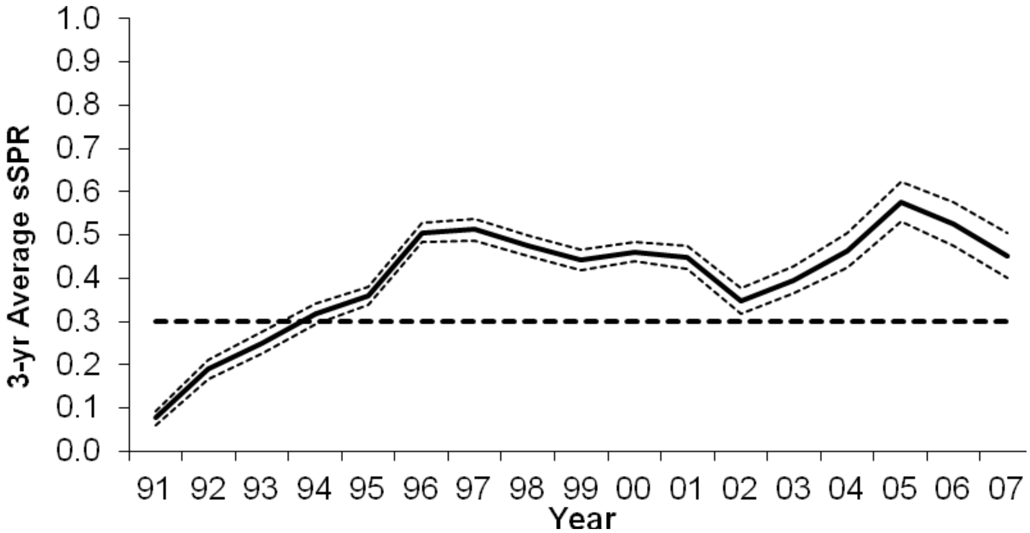


Figure A3.2.5.21. Northern and **southern** region estimates of static spawning potential ratio with ± 1.96 standard errors (dashed lines) during 1989-2007 (top) and escapement rates (bottom) showing year-specific (heavy line) and year class-specific (dashed line) estimates.

Northern region



Southern region

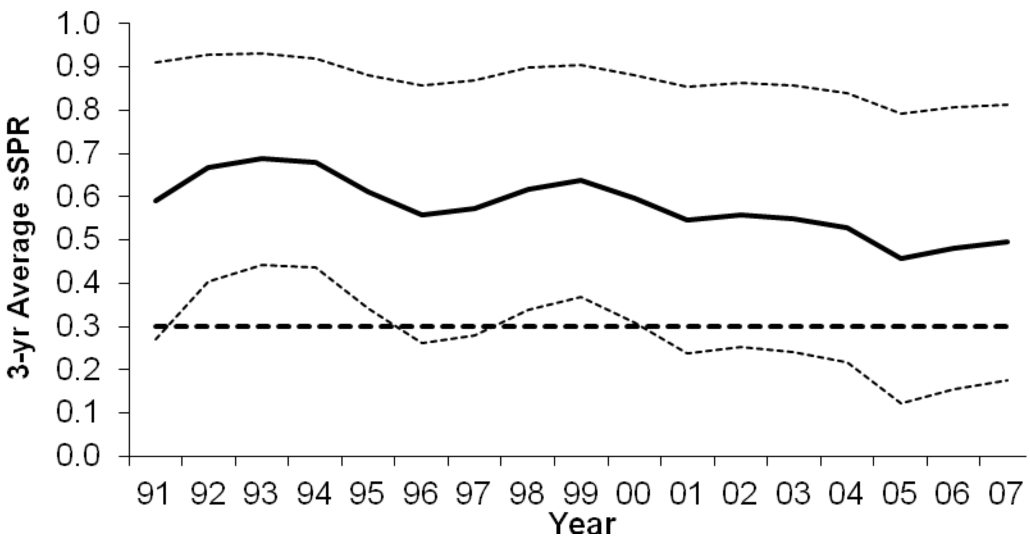
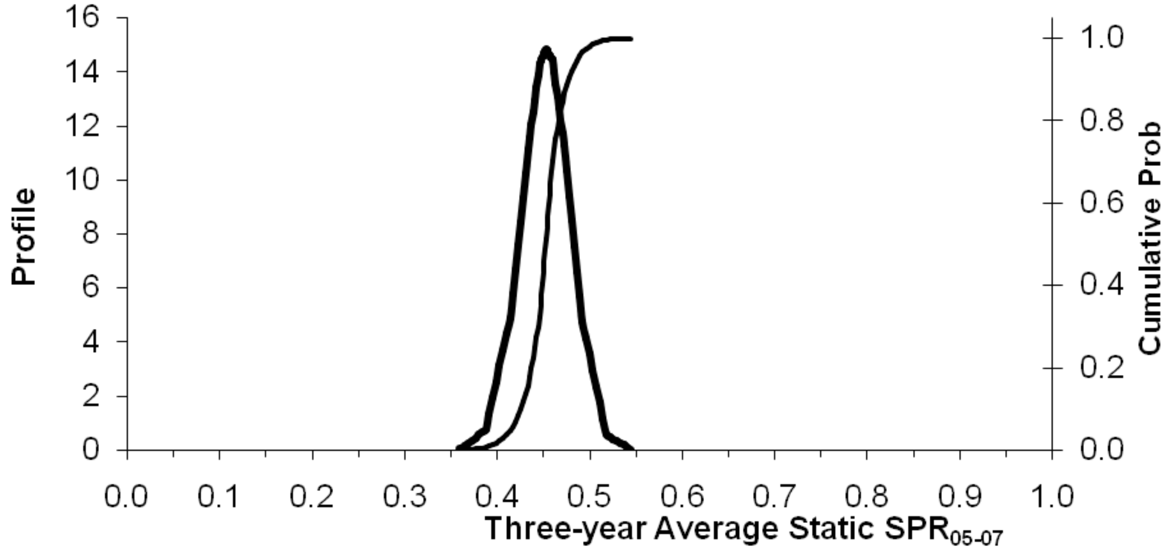


Figure A3.2.5.22. **Northern** and **southern** region estimates of three-year average static spawning potential ratio with ± 1.96 standard errors (dashed lines) during 1991-2007. Three-year averages include current and previous two year's sSPR estimates. The heavy dashed line shows the 30% overfishing threshold.

Northern region



Southern region

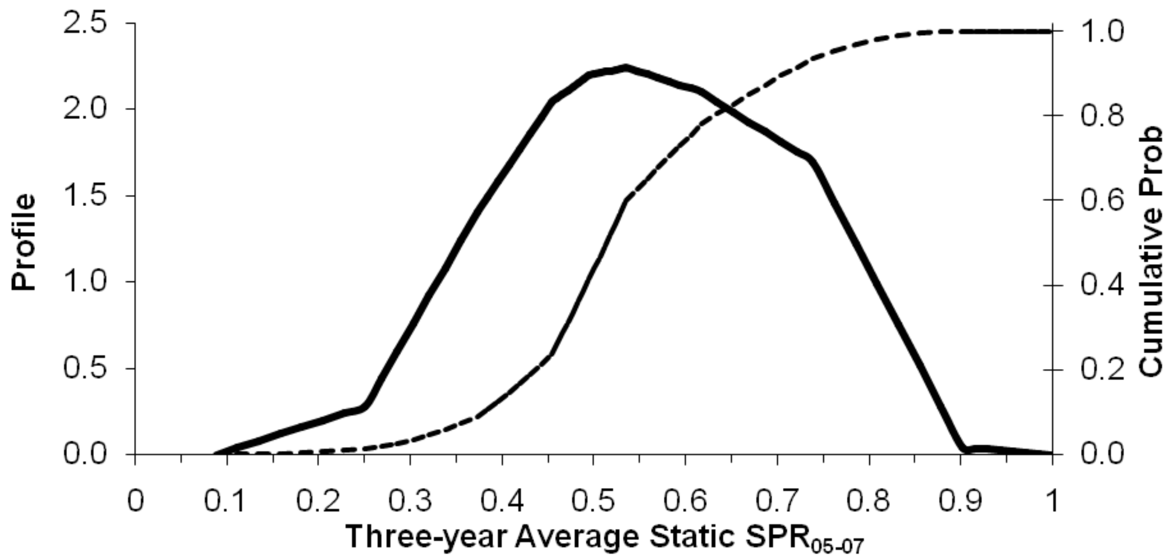
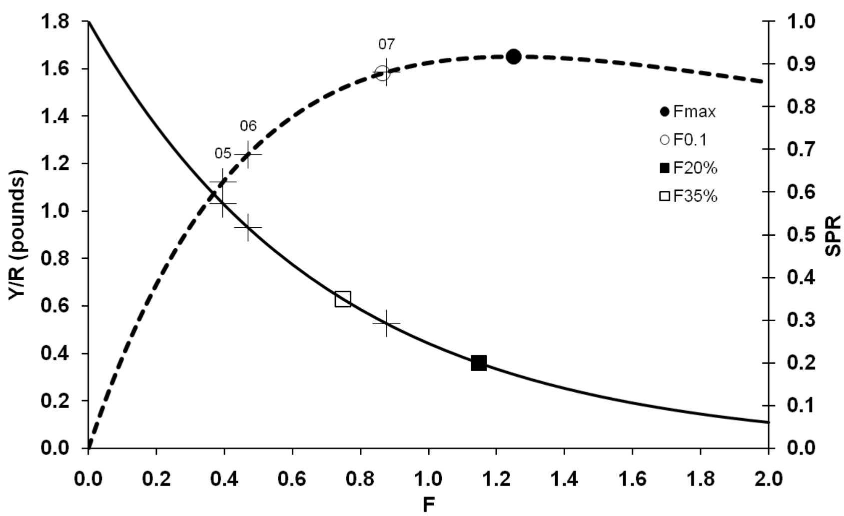


Figure A3.2.5.23. Northern and **southern** region likelihood profiles (solid line) and cumulative probability distribution (dashed lines) for the base model estimates of three-year-average static spawning potential ratio in 2007 (2005-2007 average).

Northern region



Southern Region

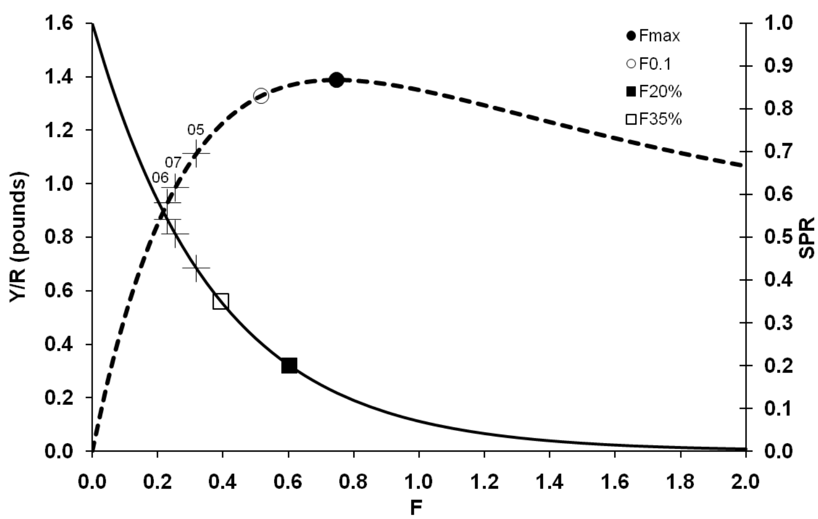


Figure A3.2.5.24. Equilibrium yield-per-recruit (dashed line) and spawning-stock-biomass-per-recruit (of spawning potential ratio, SPR, solid line) expected for red drum across a range of instantaneous fishing mortalities in the northern and southern. As indicated in legend, the YPR benchmarks F_{max} and $F_{0.1}$ are shown as are the SPR benchmarks for SPR=35% ($F_{35\%}$, hidden under pluses in southern region graph) and 20% ($F_{20\%}$). Also shown as '+'s' are the equilibrium values given fishing mortalities estimated for 2005, 2006, and 2007.

3.2.6 References

Atlantic States Marine Fisheries Commission Red Drum Plan Development Team, 2002.

Amendment 2 to the interstate fishery management plan for red drum. Fisheries Management Report No. 38.

Bacheler, N.M., Hightower, J.E., Paramore, L.M., Buckel, J.A., Pollock, K.H., 2008. Age-dependent tag return model to estimate mortality and selectivity of an estuarine-dependent fish with high rates of catch and release. Trans. Am. Fish. Soc. 137, 1422-1432.

Lo, N.C., L.D. Jacobson, and J.L. Squire. 1992. Indices of relative abundance from fish spotter data based on delta-lognormal models. Can. J. Fish. Aquat. Sci. 49:2515-2526.

Vaughan, D.S. and J.T. Carmichael, 2000. Assessment of Atlantic red drum for 1999: northern and southern regions. NOAA Tech. Memo. NMFS-SEFSC-447.

Appendix B. ADMB code and input data for northern region Atlantic red drum stock assessment

Description

This appendix presents the AD Model Builder model code and input data used to implement the age-structured assessment for the northern region described in Appendix A.

Model code

```
DATA_SECTION   ///////////////////////////////////////////////////////////////////////////
   // !!USER_CODE ad_comm::change_datafile_name("n_base.dat");

 //////////// general dimensions and structural inputs ////////////
 // how many groups with separate fishing characteristics, fisheries?
 init_int nfleets

 // global first and last age used in the assesment
 init_int firstyr
 init_int lastyr

 // first and last years of catch data for each fishery
 init_ivector first_fyr(1,nfleets)
 init_ivector last_fyr(1,nfleets)

 // first and last age used in the assessment - last assumed plus group
 init_int firstage
 init_int lastage

 // last age that selectivity is estimated
 init_int last_sel_age

 // instantaneous natural mortality from firstage through lastage
 init_vector M(firstage,lastage)

 // selectivity blocks defined sequentially by fleet by year
 init_imatrix yr_sel_block(1,nfleets,first_fyr,last_fyr)

  //////////// observed data /////////////
```

```
// total landed catch for each fleet each year and its CV
init_matrix obs_tot_catch(1,nfleets,first_fyr,last_fyr)
init_matrix tot_catch_CVs(1,nfleets,first_fyr,last_fyr)

// observed selectivity for northern live-release fishery over two
// defined time period
init_matrix B2_select(1,3,firstage,lastage)

// additional non-landed catch that is subject to the hook-and-line
// release mortality (rel_mort)
init_matrix tot_B2catch(1,nfleets,first_fyr,last_fyr)
init_number rel_mort

// observed proportion at age for all 'observed' landings and  sampled live-releases
// and number of fish sampled for age each year associated with these observed proportions
init_3darray obs_prop_at_age(1,nfleets,first_fyr,last_fyr,firstage,lastage)
init_matrix agedN(1,nfleets,first_fyr,last_fyr)

init_matrix kept_Fatage(1989,2004,1,4)  // northern tagging total F-at-age for all kept fisheries, rec
and comm
init_matrix kept_F_CVs(1989,2004,1,4)   // tagging total F-at-age CV's for kept fisheries

init_vector fullF_B2rec(1989,2004)     // fully recruited F for live-release fishery
init_vector fullF_CVs(1989,2004)       // CV for fully recruited F for live-release fishery

// number of indices used for relative abundance
init_int n_ndx
// first and last year for each index
init_ivector first_syr(1,n_ndx)
init_ivector last_syr(1,n_ndx)
// first and last age included in index
init_ivector first_sage(1,n_ndx)
init_ivector last_sage(1,n_ndx)
// midpoint month for the survey
init_vector survey_month(1,n_ndx)
// relative abundance by index for each year available
// and coefficient of variation
init_matrix survey_ndx(1,n_ndx,first_syr,last_syr)
init_matrix survey_CVs(1,n_ndx,first_syr,last_syr)

// temporary penalty for keeping early-solution-search-F up
init_number F_brake
```

```
// the weights set associated with the total catches, proportion at age, indices, tagFs
init_ivector wt_choice(1,4)

 // matrix showing three columns - for weight (lbs), proportion mature, and natural mortality
 // for every age in the fishes life
 init_matrix wt_mat_M62(1,62,1,3)




// file names for the different weighting schemes referred to in wt_choice variable
   // total catch weights
!!USER_CODE ad_comm::change_datafile_name("n0_TC.wts");
    init_matrix totcatch_wt(1,3,1,nfleets)

   // PAA wts
!!USER_CODE ad_comm::change_datafile_name("n0_PAA.wts");
     init_3darray PAA_wt(1,2,1,nfleets-1,firstyr,lastyr)

   // Index wts
!!USER_CODE ad_comm::change_datafile_name("n0_Ndx.wts");
    init_matrix indx_wt(1,3,1,n_ndx)

   // TagF wts
!!USER_CODE ad_comm::change_datafile_name("n0_tagF.wts");
    init_matrix tagF_wt(1,2,1,2)
  ///////////////////////////////////////////////////////////////////////////////////////

 // various statistics and manipulations of the input data
    ivector nselblocks(1,nfleets)
    int k
    number tot
    vector ave_obstC(1,nfleets)
    vector ave_obsNdx(1,n_ndx)
    matrix ave_obsPAA(1,nfleets,firstage,lastage)
    vector ave_obsFkept(1,4)
    number ave_obsFrelease
    matrix stdevPAA(1,nfleets,firstage,lastage)
LOCAL_CALCS
   for(ifleet=1;ifleet<=nfleets;ifleet++)
     {
     // how many 'selectivity blocks' are there for each fishery?
```

```
      nselblocks(ifleet) = yr_sel_block(ifleet,last_fyr(ifleet));
      }
       // special calculation for the norther rec live-release fisheries -- fleet=4 -- to calculate total
kill
      for (iyr=first_fyr(4);iyr<=last_fyr(4);iyr++)
        {
        obs_tot_catch(4,iyr) = tot_B2catch(4,iyr) * (rel_mort);
        }

     // calculate various mean observed values to use in the total sum of squares [TSS = sum of squares
     //  for (mean-observed)/stdev(observed)], though this did not appear to be very helpful for
     //  'goodness of fit' evaluation where residual sum of squares [RSS = sum of squares for (observed-
predicted)
     //   /stdev(observed)] was confounded by multidimensionaity of problem.

        // total catch
       for(ifleet=1;ifleet<=nfleets;ifleet++)
         {
         k = 0;
         tot=0;
        for (iyr=first_fyr(ifleet);iyr<=last_fyr(ifleet);iyr++)
           {
           k++;
           tot += log(obs_tot_catch(ifleet,iyr)+1e-6);
           }
         ave_obstC(ifleet) = tot/double(k);
        }

      // indices
    for (indx=1;indx<=n_ndx;indx++)
     {
       k = 0;
       tot=0;
      for(iyr=first_syr(indx);iyr<=last_syr(indx);iyr++)
       {
         if(survey_ndx(indx,iyr)>0)
           {
            k++;
            tot += log(survey_ndx(indx,iyr)+1.e-6);
            }
       }
      ave_obsNdx(indx) = tot/double(k);
     }
```

```
    //PAA -- this is a strech for 0.0-1.0 bound number      ---- remember fleet 4 doesn't count
for (ifleet=1;ifleet<=nfleets-1;ifleet++)
 {
  for (iage=firstage;iage<=lastage;iage++)
    {
     k = 0;
     tot=0;
    for (iyr=first_fyr(ifleet);iyr<=last_fyr(ifleet);iyr++)
      {
      k++;
      tot += obs_prop_at_age(ifleet,iyr,iage)+1.e-6;
      }
  ave_obsPAA(ifleet,iage) = tot/double(k);
    }
 }

 // what is the standard deviation of observed PAA across years for each fleet and age?
   for (ifleet=1;ifleet<=nfleets-1;ifleet++)
    {
     for (iage=firstage;iage<=lastage;iage++)
       {
        k = 0;
        tot=0;
        for (iyr=first_fyr(ifleet);iyr<=last_fyr(ifleet);iyr++)
          {
          k++;
          tot += square( obs_prop_at_age(ifleet,iyr,iage)-ave_obsPAA(ifleet,iage) );
          }
        stdevPAA(ifleet,iage) = sqrt( tot/(double(k)-1)  );
        }
     }


    // kept F-at-age
    for (iage=1;iage<=4;iage++)
      {
       k = 0;
       tot=0;
       for (iyr=1989;iyr<=2004;iyr++)
         {
         k++;
```

```
          tot += log(kept_Fatage(iyr,iage)+1.e-6);
          }
       ave_obsFkept(iage) = tot/double(k);
        }

   // Fully recruited Frelease

       k = 0;
       tot=0;
      for (iyr=1989;iyr<=2004;iyr++)
        {
        k++;
        tot += log(fullF_B2rec(iyr));
        }
       ave_obsFrelease = tot/double(k);
 END_CALCS


   // initialize various counters and temporary integers
   int sel_count
   int ifleet
   int iyr
   int iage
   int indx
   int i
   int j

   int ndx_n
   int PAA_n
   int PAA_n2
   int tC_n
   int kept_n
   int fullF_n



PARAMETER_SECTION  ///////////////////////////////////////////////////////////////////////////////
  // NOTE: for convenience number of selectivities is hardwired -- does not include fleet=4, north live-
release fishery
  //       when tag-based selectivity used is used


      init_bounded_number sel04(0.,1.,5)
```

```
    init_bounded_number sel05(0.,1.,5)

//----in get_selectivity function
//Parameter: selectivities
 init_bounded_dev_vector fill_log_sel(1,27,-5,5,5)
   3darray log_sel(1,nfleets,1,nselblocks,firstage,lastage)
   matrix max_log_sel(1,nfleets,1,nselblocks)

//----in get_mortality_rates function----
//Parameter: fully recruited F's
 init_bounded_matrix log_Fmult(1,nfleets,first_fyr,last_fyr,-15,2,4)
   3darray log_Ffleet(1,nfleets,first_fyr,last_fyr,firstage,lastage)
   matrix Z(firstyr,lastyr,firstage,lastage)
   matrix tot_F(firstyr,lastyr,firstage,lastage)

//----in get_number_at_age function
//Parameters: median initial abundance ages 2-7+ and deviations from this for each age
//  init_bounded_number log_initN(8,25,1)
//  init_bounded_dev_vector log_initN_devs(firstage+1,lastage,-10,10,2)
    init_bounded_vector log_initN(firstage+1,lastage,2,16,1)



     matrix log_N(firstyr,lastyr,firstage,lastage)

 //Parameters: median recruitment by year and deviations from this for each year
// init_bounded_number log_R(8,25,1)
// init_bounded_dev_vector log_recruit_devs(firstyr,lastyr,-10,10,3)
//     vector log_recruits(firstyr,lastyr)
        init_bounded_vector log_recruits(firstyr,lastyr,5,18,2)

//----in calculate_catch function
     3darray C(1,nfleets,first_fyr,last_fyr,firstage,lastage)
     matrix pred_catch(1,nfleets,first_fyr,last_fyr)

//---- evaluate the objective function
          // indices
  //Parameter: catchability coefficient for each index
  matrix EffN(1,nfleets,first_fyr,last_fyr)
  matrix resid_ndx(1,n_ndx,first_syr,last_syr)
  matrix residmean_ndx(1,n_ndx,first_syr,last_syr)
         matrix resid_ndx2(1,n_ndx,first_syr,last_syr)
```

```
       matrix residmean_ndx2(1,n_ndx,first_syr,last_syr)
matrix pred_ndx(1,n_ndx,first_syr,last_syr)
vector stdev_ndx(1,n_ndx)
vector neglogLL_ndx(1,n_ndx)
number ndx_f
        // PAA
3darray resid_PAA(1,nfleets,first_fyr,last_fyr,firstage,lastage)
3darray residmean_PAA(1,nfleets,first_fyr,last_fyr,firstage,lastage)
       // fake residuals
       3darray resid_PAA2(1,nfleets,first_fyr,last_fyr,firstage,lastage)
       3darray residmean_PAA2(1,nfleets,first_fyr,last_fyr,firstage,lastage)
vector stdev_PAA(1,nfleets-1)
matrix neglogLL_PAA(1,nfleets,first_fyr,last_fyr)
number PAA_f
        // total catch
matrix resid_tC(1,nfleets,first_fyr,last_fyr)
matrix residmean_tC(1,nfleets,first_fyr,last_fyr)
     matrix resid_tC2(1,nfleets,first_fyr,last_fyr)
     matrix residmean_tC2(1,nfleets,first_fyr,last_fyr)
vector stdev_tC(1,nfleets)
vector neglogLL_tC(1,nfleets)
           vector numerat(1,n_ndx)
           vector denomin(1,n_ndx)
           init_bounded_vector log_q_MLE(1,n_ndx,-18,-5,4)
number tC_f
        //  kept F at age
matrix pred_kept_Fatage(1989,2004,1,4)
matrix resid_kept(1989,2004,1,4)
matrix residmean_Fkept(1989,2004,1,4)
  matrix resid_kept2(1989,2004,1,4)
  matrix residmean_Fkept2(1989,2004,1,4)
number stdev_kept
vector neglogLL_kept(1989,2004)
number kept_f
        //  fullF B2
vector resid_fullF_B2(1989,2004)
vector residmean_Frelease(1989,2004)
    vector resid_fullF_B22(1989,2004)
    vector residmean_Frelease2(1989,2004)
number stdev_fullF
number neglogLL_fullF
number fullF_f
```

```
    // define some intermediate calculation
    number temp
    number temp2
    number avg_F
    number F_brake_penalty

       // Benchmark stuff
       // including spawning stock biomass under fishing and under no fishing,
       // spawning potential ratio, and various escapement estimates
       vector SSB_F(firstyr,lastyr)
       vector SSB_F0(firstyr,lastyr)
         number F_survival
         number F0_survival
       vector escapement13(firstyr,lastyr)
       vector escapement15(firstyr,lastyr)
          //transitional
          vector tEsc15(firstyr+4,lastyr)
          vector tEsc13(firstyr+2,lastyr)

    objective_function_value f

      sdreport_vector log_total_abundance(firstyr,lastyr)
      sdreport_vector log_N1(firstyr,lastyr)
      sdreport_vector log_N2(firstyr,lastyr)
      sdreport_vector log_N3(firstyr,lastyr)
      sdreport_vector expl13(firstyr,lastyr)
      sdreport_vector static_SPR(firstyr,lastyr)
      sdreport_vector three_yrSPR(firstyr+2,lastyr)

      likeprof_number three_yrSPR2007



PROCEDURE_SECTION ///////////////////////////////////////////////////////////////////////////
 get_selectivities();
 get_mortality_rates();
 get_numbers_at_age();
 calculate_catch();
 evaluate_the_objective_function();

   // static spawning potential ratio, and various escapement rate estimates
```

```
// calculate spawning stock biomass per recruit with current year's fishing and without any F
  for(iyr=firstyr;iyr<=lastyr;iyr++)
    {
   F_survival = mfexp( -1. * (wt_mat_M62(1,3)+tot_F(iyr,1)) );
   F0_survival = mfexp(-1. * wt_mat_M62(1,3));
     SSB_F(iyr) = wt_mat_M62(1,2)*wt_mat_M62(1,1)*F_survival;
     SSB_F0(iyr) = wt_mat_M62(1,2)*wt_mat_M62(1,1)*F0_survival;

     for(iage=firstage+1;iage<=lastage;iage++)
       {

     F_survival *= mfexp( -1.* (wt_mat_M62(iage,3)+tot_F(iyr,iage)) );
     F0_survival *= mfexp(-1.* wt_mat_M62(iage,3));
         SSB_F(iyr) += wt_mat_M62(iage,2)*wt_mat_M62(iage,1)*F_survival;
       SSB_F0(iyr) += wt_mat_M62(iage,2)*wt_mat_M62(iage,1)*F0_survival;
       }
     for(iage=lastage+1;iage<=62;iage++)
       {
     F_survival *= mfexp( -1.* (wt_mat_M62(iage,3)+tot_F(iyr,lastage)) );
     F0_survival *= mfexp(-1.* wt_mat_M62(iage,3));
         SSB_F(iyr) += wt_mat_M62(iage,2)*wt_mat_M62(iage,1)*F_survival;
       SSB_F0(iyr) += wt_mat_M62(iage,2)*wt_mat_M62(iage,1)*F0_survival;
       }
       // static SPR and static (year-specific) escapement rates
       static_SPR(iyr) = SSB_F(iyr)/SSB_F0(iyr);
       escapement13(iyr) = mfexp(-1.* tot_F(iyr,1)-tot_F(iyr,2)-tot_F(iyr,3));
       escapement15(iyr) = mfexp(-1.* tot_F(iyr,1)-tot_F(iyr,2)-tot_F(iyr,3)-tot_F(iyr,4)-
tot_F(iyr,5));

        // transitional (yearclass-specific) escapement rates
         if(iyr>1992)
           {
            tEsc15(iyr) = mfexp( -1.* tot_F(iyr-4,1)-tot_F(iyr-3,2)-tot_F(iyr-2,3)-tot_F(iyr-1,4)-
tot_F(iyr,5) );
           }
         if(iyr>1990)
           {
            tEsc13(iyr) = mfexp( -1.* tot_F(iyr-2,1)-tot_F(iyr-1,2)-tot_F(iyr,3) );
           }
  }

  log_total_abundance=log(rowsum(mfexp(log_N)));
```

```
      for(iyr=firstyr;iyr<=lastyr;iyr++)
         {
          log_N1(iyr) = log_N(iyr,1);
          log_N2(iyr) = log_N(iyr,2);
          log_N3(iyr) = log_N(iyr,3);
          // catch across fleets
            temp=0.;
            for(ifleet=1;ifleet<=nfleets;ifleet++)
              {
              temp += C(ifleet,iyr,1)+C(ifleet,iyr,2)+C(ifleet,iyr,3);
              }
          expl13(iyr) = temp/( mfexp(log_N1(iyr))+mfexp(log_N2(iyr))+mfexp(log_N3(iyr)) );
            if(iyr>1990)
             {
             three_yrSPR(iyr) = ( static_SPR(iyr-2)+static_SPR(iyr-1)+static_SPR(iyr) )/3.;
             }
          }

          three_yrSPR2007 = ( static_SPR(2007-2)+static_SPR(2007-1)+static_SPR(2007) )/3.;

    ///////////////////////// Begin Population Dynamics Model ///////////////////////////////
FUNCTION get_selectivities

 //----selectivity is not described parametrically but assumed constant above some maximum age
 //----the following simply fills out the array of candidate selectivities to be evaluated
 //----in the end it is standardized to the largest selectivity

  sel_count=0;  //remember first age is one;
  for (ifleet=1;ifleet<=nfleets-1;ifleet++)
        {
         for (i=1;i<=yr_sel_block(ifleet,last_fyr(ifleet));i++)
          {

             // fill log_sel matrix using bounded vector
             for (iage=firstage;iage<=last_sel_age;iage++)
              {
              sel_count++;
              log_sel(ifleet,i,iage) = fill_log_sel(sel_count);
              }
              max_log_sel(ifleet,i) = max(log_sel(ifleet,i));

             // standardize relative to this maximum
```

```
            for (iage=firstage;iage<=last_sel_age;iage++)
             {
             log_sel(ifleet,i,iage) =  log_sel(ifleet,i,iage)-max_log_sel(ifleet,i);
             }
              // Special: for red drum, we assume that the selectivity drops after last estimated age
              log_sel(ifleet,i,last_sel_age+1) = log_sel(ifleet,i,last_sel_age)+log(sel04);
              log_sel(ifleet,i,last_sel_age+2) = log_sel(ifleet,i,last_sel_age)+log(sel05);

            // selectivity for older ages is set equal to oldest-aged selectivity
            for (iage=last_sel_age+3;iage<=lastage;iage++)
             {
             log_sel(ifleet,i,iage) = log_sel(ifleet,i,last_sel_age+2);
             }
         }
       }

         // Special: for the northern live-release fishery selectivites are 'observed data'
         ifleet = 4;
         for (i=1;i<=yr_sel_block(ifleet,last_fyr(ifleet));i++)
          {
             for (iage=firstage;iage<=lastage;iage++)
              {
              log_sel(ifleet,i,iage) = log(B2_select(i,iage));
              }
          }


FUNCTION get_mortality_rates

  //----age-specific fishing mortalities is derived using estimated selectivities and year-specific F----

  for (ifleet=1;ifleet<=nfleets;ifleet++)
   {
   // fill out the fleet-, year-, age-specific F's
   for (iyr=first_fyr(ifleet);iyr<=last_fyr(ifleet);iyr++)
     {
     for (iage=firstage;iage<=lastage;iage++)
      {
      log_Ffleet(ifleet,iyr,iage)=log_Fmult(ifleet,iyr)+log_sel(ifleet,yr_sel_block(ifleet,iyr),iage);
      }
     }
   }
```

```
  // --- calculate instantaneous total mortality for convenience later
  // allow for variable M with age

       // calculate the total fishing mortality across all fisheries each year
       //remember not all years have all fleets operating -- sum available F's
       tot_F=0.0;
      for (ifleet=1;ifleet<=nfleets;ifleet++)
        {
        for (iyr=first_fyr(ifleet);iyr<=last_fyr(ifleet);iyr++)
         {
         for (iage=firstage;iage<=lastage;iage++)
           {
          tot_F(iyr,iage) += mfexp(log_Ffleet(ifleet,iyr,iage));
           }
         }
       }

     // calculate Z's
    for (iyr=firstyr;iyr<=lastyr;iyr++)
      {
        Z(iyr) = M;
         for (iage=firstage;iage<=lastage;iage++)
           {
            Z(iyr,iage) += tot_F(iyr,iage);
           }
      }


FUNCTION get_numbers_at_age

    // This fills parameter estimates for initial N's or top row and
    // numbers-at-age-1 (recruits) or left column in N-at-age matrix

   // initial year's abundance for ages-2 to 7+
   //   for (iage=firstage+1;iage<=lastage;iage++)
   //   {
   //   if (active(log_initN_devs))
   //     {
   //     log_N(firstyr,iage)=log_initN+log_initN_devs(iage);
   //       }
   //     else
```

```
//       {
//     log_N(firstyr,iage)=log_initN;
//       }
//  }

    // initial year's abundance for ages-2 to 7+
 for (iage=firstage+1;iage<=lastage;iage++)
  {
     log_N(firstyr,iage)=log_initN(iage);
  }




 // all year's recruitment or beginning-of-the-year abundance of age-1
 // for (iyr=firstyr;iyr<lastyr;iyr++)
 //  {
 //  if (active(log_recruit_devs))
  //   {
  //      log_recruits(iyr) = log_R + log_recruit_devs(iyr);
  //      log_N(iyr,firstage) = log_recruits(iyr);
  //      }
  //    else
  //      {
  //      log_recruits(iyr) = log_R;
  //      log_N(iyr,firstage) =log_recruits(iyr);
  //      }

  for (iyr=firstyr;iyr<=lastyr;iyr++)
  {
      log_N(iyr,firstage) = log_recruits(iyr);
  }


  //----from these starting values project abundances forward in time and age----
  for (iyr=firstyr;iyr<lastyr;iyr++)
  {
    for (iage=firstage;iage<lastage;iage++)
     {
     log_N(iyr+1,iage+1)=log_N(iyr,iage)-Z(iyr,iage);
     }
```

```
   //----oldest age is a plus group so, in addition to the cohort survivors for last year
   //    need to add the last year's plus-group survivors
     log_N(iyr+1,lastage)=log( mfexp(log_N(iyr,lastage)-Z(iyr,lastage))+mfexp(log_N(iyr+1,lastage))  );
     }
   //----define recruitment in the final year, this is only informed if there is a yoy index to fit----
     // if (active(log_recruit_devs))
   //     {
   //          log_recruits(lastyr) = log_R + log_recruit_devs(lastyr);
   //          log_N(lastyr,firstage) = log_recruits(lastyr);
   //          }
   //        else
   //          {
   //          log_recruits(lastyr) = log_R;
   //          log_N(lastyr,firstage) =log_recruits(lastyr);
   //          }
  //////////////////////////////// END POPULATION DYNAMICS MODEL
///////////////////////////////////////////////


FUNCTION calculate_catch

   /////// for convenience need to calculate some terms to be used to calculate predicted proportion at
age
   //----Use catch equation to calculate fleet-specific catch-at-age matrices----
   //    and total kill each year for each fleet
     pred_catch = 0.0;
     for (ifleet=1;ifleet<=nfleets;ifleet++)
       {
       for (iyr=first_fyr(ifleet);iyr<=last_fyr(ifleet);iyr++)
         {
         for (iage=firstage;iage<=lastage;iage++)
           {
           C(ifleet,iyr,iage) = (mfexp(log_Ffleet(ifleet,iyr,iage))/Z(iyr,iage))
                                * mfexp( log_N(iyr,iage) ) * ( 1.-mfexp(-1.*Z(iyr,iage)) );
           pred_catch(ifleet,iyr) +=  C(ifleet,iyr,iage);
           }
          }
        }


  ///////////////////////////////  OBSERVATION MODEL ///////////////////////////////////
FUNCTION evaluate_the_objective_function
```

```
 // Estimate effective sample size -- ignore fleet-4; northern rec live-release
 // useful in determining the 'goodness of fit' for the multinomial prediction of proportion at age in kill
    for (ifleet=1;ifleet<=nfleets;ifleet++)
      {
      for (iyr=first_fyr(ifleet);iyr<=last_fyr(ifleet);iyr++)
        {
        temp = 0.;
        temp2 = 0.;
         for (iage=firstage;iage<=lastage;iage++)
           {
          temp  += C(ifleet,iyr,iage)/(pred_catch(ifleet,iyr)+1.e-13)*( 1-C(ifleet,iyr,iage)

/(pred_catch(ifleet,iyr)+1.e-13) );
          temp2 += square( obs_prop_at_age(ifleet,iyr,iage)-C(ifleet,iyr,iage)
                                                                             /(pred_catch(ifleet,iyr)+1.e-13) );
           }
     EffN(ifleet,iyr) = temp/temp2;
        }
       }

                  // in the last phase a small penalty for a small F is added to objective
                  // function, in earlier phases a much larger penalty keeps solution away
                  // from infinitesimally small Fs
 F_brake_penalty = 0.;
 avg_F=sum(tot_F)/double(size_count(tot_F));
 if(last_phase())
  {
    F_brake_penalty += 1.e-6*square(log(avg_F/.2));
  }
  else
  {
    F_brake_penalty += F_brake*square(log(avg_F/.2));
  }

  ///////////// minimally 'regularize' the selectivities ///////////
   f += 5.*norm2(fill_log_sel);

// ----negative log Likelihood estimation for indices-----------------------------------------
   ndx_f = 0;
   neglogLL_ndx = 0;
```

```
    for (indx=1;indx<=n_ndx;indx++)
     {
      ndx_n = 0;
      for(iyr=first_syr(indx);iyr<=last_syr(indx);iyr++)
       {
         if(survey_ndx(indx,iyr)>0)
           {
            // for aggregate indices, sum appropriate N estimates
            temp=0;
            for(iage=first_sage(indx);iage<=last_sage(indx);iage++)
            {
            temp += mfexp( log_N(iyr,iage)-Z(iyr,iage)*(survey_month(indx)/12.) );
            }

         ndx_n++;
         pred_ndx(indx,iyr) = mfexp(log_q_MLE(indx))*temp;
          // standardized residual
        resid_ndx(indx,iyr) = (   log(survey_ndx(indx,iyr)+1.e-6) - ( log_q_MLE(indx) + log(temp+1.e-6) )
)/
                                   sqrt(log(pow(survey_CVs(indx,iyr),2)+1));
          // standardized residual from average -- for total sum of squares (dubious)
        residmean_ndx(indx,iyr) = (   log(survey_ndx(indx,iyr)+1.e-6) -  ave_obsNdx(indx)   )/
                                   sqrt(log(pow(survey_CVs(indx,iyr),2)+1));


                // squared residuals//////////////////
        resid_ndx2(indx,iyr) = square(    (   log(survey_ndx(indx,iyr)+1.e-6) - ( log_q_MLE(indx) +
log(temp+1.e-6) )   )/
                                   sqrt(log(pow(survey_CVs(indx,iyr),2)+1))    );
        residmean_ndx2(indx,iyr) = square(  (   log(survey_ndx(indx,iyr)+1.e-6) -  ave_obsNdx(indx)   )/
                                   sqrt(log(pow(survey_CVs(indx,iyr),2)+1))  );
               ///////////////////////////////////


          // negative log-likelihood for the lognormal distribution
        neglogLL_ndx (indx) +=  0.5*square( resid_ndx(indx,iyr) ) +
log(sqrt(log(pow(survey_CVs(indx,iyr),2)+1)));
            }
       }
      stdev_ndx(indx) = sqrt(  sum(resid_ndx2(indx))/double(ndx_n));
      ndx_f += neglogLL_ndx(indx)*indx_wt(wt_choice(3),indx);
     }


//---Likelihood estimation for catch proportions-at-age ------------------------
  PAA_f = 0;
```

```
  neglogLL_PAA=0;
  PAA_n = 0;
  for (ifleet=1;ifleet<=nfleets-1;ifleet++)  // these were not observed for fleet=4, north rec live-
release fishery
   {
     PAA_n2=0;
    for (iyr=first_fyr(ifleet);iyr<=last_fyr(ifleet);iyr++)
      {
      for (iage=firstage;iage<=lastage;iage++)
        {
        PAA_n++;   // just overall number of observations counter
        PAA_n2++;
         // 'residual' in multinomial sense
        resid_PAA(ifleet,iyr,iage) = (obs_prop_at_age(ifleet,iyr,iage)+1.e-6)*log(
(C(ifleet,iyr,iage)/pred_catch(ifleet,iyr)+1.e-6)  );
        residmean_PAA(ifleet,iyr,iage) = (obs_prop_at_age(ifleet,iyr,iage)+1.e-6)*log(
ave_obsPAA(ifleet,iage)+1.e-6  );


               // squared residuals//////////////////
        resid_PAA2(ifleet,iyr,iage) = square( ( (obs_prop_at_age(ifleet,iyr,iage)+1.e-6) -
(C(ifleet,iyr,iage)/pred_catch(ifleet,iyr)+1.e-6) ) /
                                   sqrt(  agedN(ifleet,iyr)*(obs_prop_at_age(ifleet,iyr,iage)+1.e-6)*(1-
(obs_prop_at_age(ifleet,iyr,iage)+1.e-6)) ) );
        residmean_PAA2(ifleet,iyr,iage) = square( ( (obs_prop_at_age(ifleet,iyr,iage)+1.e-6) -
(ave_obsPAA(ifleet,iage)+1.e-6))/
                                    sqrt(  agedN(ifleet,iyr)*(obs_prop_at_age(ifleet,iyr,iage)+1.e-6)*(1-
(obs_prop_at_age(ifleet,iyr,iage)+1.e-6)) ) );
               ///////////////////////////////////


           // negative log-likelihood for the multinomial distribution
        neglogLL_PAA(ifleet,iyr) -= resid_PAA(ifleet,iyr,iage)*agedN(ifleet,iyr);
        }
        PAA_f +=  PAA_wt(wt_choice(2),ifleet,iyr) * neglogLL_PAA(ifleet,iyr);
      }
     stdev_PAA(ifleet) = sqrt(  sum(resid_PAA2(ifleet))/double(PAA_n2));
   }


// ----total catch kill ----------------------------------------
      tC_f = 0;
      neglogLL_tC = 0;
      tC_n=0;
      for(ifleet=1;ifleet<=nfleets;ifleet++)
       {
       for(iyr=first_fyr(ifleet);iyr<=last_fyr(ifleet);iyr++)
         {
```

```
        tC_n++;  //just an overall total number of observations
           // standardized residual
        resid_tC(ifleet,iyr) = (  log(obs_tot_catch(ifleet,iyr)+1.e-6) - log(pred_catch(ifleet,iyr)+1.e-
6)  )/
                                             sqrt(log(pow(tot_catch_CVs(ifleet,iyr),2)+1));
           // standardized residual from average
        residmean_tC(ifleet,iyr) = (  log(obs_tot_catch(ifleet,iyr)+1.e-6) - ave_obstC(ifleet)  )/
                                             sqrt(log(pow(tot_catch_CVs(ifleet,iyr),2)+1));


               // squared residuals///////////////////
        resid_tC2(ifleet,iyr) = square (    (  log(obs_tot_catch(ifleet,iyr)+1.e-6) -
log(pred_catch(ifleet,iyr)+1.e-6)  )/
                                             sqrt(log(pow(tot_catch_CVs(ifleet,iyr),2)+1))    );
        residmean_tC2(ifleet,iyr) = square(    (  log(obs_tot_catch(ifleet,iyr)+1.e-6) -
ave_obstC(ifleet)  )/
                                             sqrt(log(pow(tot_catch_CVs(ifleet,iyr),2)+1))    );
              ///////////////////////////////////


              // negative log-likelihood for the lognormal distribution
       neglogLL_tC (ifleet) +=  0.5*square( resid_tC(ifleet,iyr) ) +
log(sqrt(log(pow(tot_catch_CVs(ifleet,iyr),2)+1)));
        }


      tC_f += neglogLL_tC(ifleet)*totcatch_wt(wt_choice(1),ifleet);
      }


// tagging information on the catch at age for the kept fisheries
     // first need sum for the pooled predicted F-at-age for the kept fleets
      pred_kept_Fatage=0.0;
      for (ifleet=1;ifleet<=3;ifleet++)
        {
        for (iyr=1989;iyr<=2004;iyr++)
         {
         for (iage=1;iage<=4;iage++)
           {
          pred_kept_Fatage(iyr,iage) += mfexp(log_Ffleet(ifleet,iyr,iage));
           }
         }
       }


        kept_f = 0;
        kept_n=0;
        neglogLL_kept=0;
```

```
     for (iyr=1989;iyr<=2004;iyr++)
      {
      for (iage=1;iage<=4;iage++)
        {
        kept_n++;
            // standardized residual
        resid_kept(iyr,iage) = (  log(kept_Fatage(iyr,iage)) - log(pred_kept_Fatage(iyr,iage))  ) /
                                          sqrt(log(pow(kept_F_CVs(iyr,iage),2)+1));
            // standardized residual from average
        residmean_Fkept(iyr,iage) = (  log(kept_Fatage(iyr,iage)) - ave_obsFkept(iage)  ) /
                                          sqrt(log(pow(kept_F_CVs(iyr,iage),2)+1));

                // squared residuals//////////////////
        resid_kept2(iyr,iage) = square(    (  log(kept_Fatage(iyr,iage)) - log(pred_kept_Fatage(iyr,iage))
) /
                                          sqrt(log(pow(kept_F_CVs(iyr,iage),2)+1))   );
        residmean_Fkept2(iyr,iage) = square(    (  log(kept_Fatage(iyr,iage)) - ave_obsFkept(iage)  ) /
                                          sqrt(log(pow(kept_F_CVs(iyr,iage),2)+1))    );
               ///////////////////////////////////

               // negative log-likelihood for the lognormal distribution
        neglogLL_kept(iyr) +=  0.5*square( resid_kept(iyr,iage) ) +
log(sqrt(log(pow(kept_F_CVs(iyr,iage),2)+1)));
        }
        kept_f += neglogLL_kept(iyr)*tagF_wt(wt_choice(4),1);
      }
      stdev_kept = sqrt(sum(resid_kept2)/double(kept_n));



 // tagging information on the full F for live release fishery
         fullF_f = 0;
         neglogLL_fullF=0;
         fullF_n=0;
     for (iyr=1989;iyr<=2004;iyr++)
      {
       fullF_n++;
             // standardized residual
        resid_fullF_B2(iyr) = (  log(fullF_B2rec(iyr)) - log_Fmult(4,iyr)  ) /
                                          sqrt(log(pow(fullF_CVs(iyr),2)+1));
             // standardized residual from average
        residmean_Frelease(iyr) = (  log(fullF_B2rec(iyr)) - ave_obsFrelease  ) /
                                          sqrt(log(pow(fullF_CVs(iyr),2)+1));
```

```
            // squared residuals//////////////////
        resid_fullF_B22(iyr) = square(    (  log(fullF_B2rec(iyr)) - log_Fmult(4,iyr)  ) /
                                          sqrt(log(pow(fullF_CVs(iyr),2)+1))    );
        residmean_Frelease2(iyr) = square(    (  log(fullF_B2rec(iyr)) - ave_obsFrelease  ) /
                                          sqrt(log(pow(fullF_CVs(iyr),2)+1))    );
           ///////////////////////////////////

            // negative log-likelihood for the lognormal distribution
        neglogLL_fullF +=  0.5*square( resid_fullF_B2(iyr) ) + log(sqrt(log(pow(fullF_CVs(iyr),2)+1)));
       }
      fullF_f = neglogLL_fullF*tagF_wt(wt_choice(4),2);



      // full weighted estimate of sum of likelihoods
   f += ndx_f + PAA_f + tC_f + F_brake_penalty + kept_f + fullF_f;



REPORT_SECTION
  report << "ALL INPUT DATA" << endl;
  report << nfleets << endl;
  report << endl;
  report << firstyr << "  " << lastyr << endl;
  report << endl;
  report << firstage << "  " << lastage << endl;
  report << endl;
  report << first_fyr << last_fyr << endl;
  report << endl;
  report << last_sel_age << endl;
  report << endl;
  report << M << endl;
  report << endl;
  report << yr_sel_block << endl;
  report << endl;
  report << obs_tot_catch << endl;
  report << endl;
  report << obs_prop_at_age << endl;
  report << endl;
  report << endl;
  report << n_ndx << endl;
  report << endl;
```

```
  report << first_syr << endl;
  report << endl;
  report << last_syr << endl;
  report << endl;
  report << survey_ndx << endl;
  report << endl;
  report << "unwted_obj fnctn fit " <<
sum(neglogLL_ndx)+sum(neglogLL_PAA)+sum(neglogLL_tC)+sum(neglogLL_kept)+neglogLL_fullF
                                      +F_brake_penalty+norm2(fill_log_sel)<< endl;
  report << endl;
  report << "Objective function total = " << setw(15) << setprecision(5) << f << endl;
  report << "   Index part            = " << setw(15) << setprecision(5) << ndx_f << setw(15) <<
setprecision(5) << double(ndx_n) << endl;
  report << "   PAA part              = " << setw(15) << setprecision(5) << PAA_f << setw(15) <<
setprecision(5) << double(PAA_n) << endl;
  report << "   total catch part      = " << setw(15) << setprecision(5) << tC_f << setw(15) <<
setprecision(5) << double(tC_n) << endl;
  report << "   Fkept part             = " << setw(15) << setprecision(5) << kept_f << setw(15) <<
setprecision(5) << double(kept_n) <<
            " Ffull rel  " << setw(15) << setprecision(5) << fullF_f << setw(15) << setprecision(5) <<
double(fullF_n) << endl;


  report << "   F brake penalty       ="  << F_brake_penalty << // " initN devs = " <<
norm2(log_initN_devs) <<
            " log selectivity devs = " << 5.*norm2(fill_log_sel) << endl; //" log recruit devs = " <<
norm2(log_recruit_devs) << endl;
  report << "Look at fits - predicted" << endl;
  report << " indices " << endl;
    for(indx=1;indx<=n_ndx;indx++)
      {
      for(iyr=first_syr(indx);iyr<=last_syr(indx);iyr++)
        {
        report << setw(5) << setprecision(0) << indx
               << setw(5) << setprecision(0) << iyr
               << setw(10) << setprecision(5) << pred_ndx(indx,iyr) << endl;
             //if(indx==2 && iyr==last_syr(indx)) { report << endl; };
         }
      }
  report << endl;
  report << endl;
  report << " proportion at age " << endl;
      for(ifleet=1;ifleet<=nfleets;ifleet++)
        {
        for(iyr=first_fyr(ifleet);iyr<=last_fyr(ifleet);iyr++)
          {
```

```
        report << setw(5) << setprecision(0) << ifleet
               << setw(5) << setprecision(0) << iyr
               << setw(10) << setprecision(5) << C(ifleet,iyr)/pred_catch(ifleet,iyr) << endl;
        }
      }
report << endl;
report << endl;
report << " total catch " << endl;
  for(ifleet=1;ifleet<=nfleets;ifleet++)
    {
    for(iyr=first_fyr(ifleet);iyr<=last_fyr(ifleet);iyr++)
      {
         report << setw(5) << setprecision(0) << ifleet
                << setw(10) << setprecision(0) << iyr
                << setw(15) << setprecision(0) << pred_catch(ifleet,iyr) << endl;
      }
    }
report << endl;
report << endl;
report << "Predicted population dynamics" << endl;
report << "Abundance" << endl;
    for(iyr=firstyr;iyr<=lastyr;iyr++)
      {
       report << setw(5) << setprecision(0) << iyr
              << setw(15) << setprecision(9) << mfexp(log_N(iyr)) << endl;
       }
report << endl;
report << "F at age by fleet" << endl;
   for(ifleet=1;ifleet<=nfleets;ifleet++)
     {
     for(iyr=first_fyr(ifleet);iyr<=last_fyr(ifleet);iyr++)
      {
       report << setw(5) << setprecision(0) << ifleet
              << setw(5) << setprecision(0) << iyr
              << setw(10) << setprecision(5) << mfexp(log_Ffleet(ifleet,iyr))
              << setw(10) << setprecision(5) << EffN(ifleet,iyr) << endl;
       }
     }
report << endl;

  report << "northern kept fishery F at ages 1-4" << endl;   //space keeper for now
    for(iage=1;iage<=4;iage++)
```

```
    {
   for (iyr=1989;iyr<=2004;iyr++)
     {
     report << setw(5) << setprecision(0) << iyr
            << setw(5) << setprecision(0) << iage
            << setw(15) << setprecision(5) << kept_Fatage(iyr,iage)
            << setw(15) << setprecision(5) << pred_kept_Fatage(iyr,iage) << endl;
     }
    }
  report << "Release kill fully recruited F" << endl;
    for(iyr=1989;iyr<=2004;iyr++)
    {
     report << setw(5) << setprecision(0) << iyr
            << setw(15) << setprecision(5) << fullF_B2rec(iyr)
            << setw(15) << setprecision(5) << mfexp(log_Fmult(4,iyr)) << endl;
    }


report << endl;
report << "Check bounded values" << endl;
report << "fill_log_sels" << endl;
report << setw(5) << setprecision(0) << fill_log_sel << endl;
report << endl;
report << "log_Fmult" << endl;
report << setw(5) << setprecision(0) << log_Fmult << endl;
report << endl;
report << "log_initN" << endl;
report << setw(5) << setprecision(0) << log_initN << endl;
report << endl;
report << "log_recruits" << endl;
report << setw(5) << setprecision(0) << log_recruits << endl;
report << endl;
report << "log_q_MLE" << endl;
report << setw(5) << setprecision(0) << log_q_MLE << endl;
report << endl;
report << "selectivities" << endl;
     for (ifleet=1;ifleet<=nfleets;ifleet++)
           {
            for (i=1;i<=yr_sel_block(ifleet,last_fyr(ifleet));i++)
             {
                report << setw(5) << setprecision(0) << ifleet
                       << setw(5) << setprecision(0) << i
```

```
                      << setw(10) << setprecision(5) << mfexp(log_sel(ifleet,i)) << endl;
          }
        }
report << endl;
report << "weighting scheme for this run" << endl;
report << "TC wt" << setw(10) << setprecision(5) << totcatch_wt(wt_choice(1)) << endl;
report << "PAA wt" << endl;
report << setw(10) << setprecision(5) << PAA_wt(wt_choice(2)) << endl;
report << "Index wt" << setw(10) << setprecision(5) << indx_wt(wt_choice(3)) << endl;
report << "tagF wt" << setw(10) << setprecision(5) << indx_wt(wt_choice(4)) << endl;
report << "Fbrake" << setw(10) << setprecision(5) << F_brake << endl;
report << endl;
report << endl;
        for (iyr=firstyr;iyr<=lastyr;iyr++)
         {
          report << setw(5) << setprecision(0) << iyr;
         for (iage=firstage;iage<=lastage;iage++)
           {
            report << setw(10) << setprecision(5) << tot_F(iyr,iage);
           }
          report << endl;
          }
report << endl;

report << "total catch fit" << endl;
  for(ifleet=1;ifleet<=nfleets;ifleet++)
   {
   stdev_tC(ifleet) = std_dev(resid_tC(ifleet));
     report << "neg_logL = " << neglogLL_tC(ifleet) << "   SDSR =  " << stdev_tC(ifleet) << endl;
   for(iyr=first_fyr(ifleet);iyr<=last_fyr(ifleet);iyr++)
    {
     report << setw(5) << setprecision(0) << ifleet
            << setw(5) << setprecision(0) << iyr
            << setw(15) << setprecision(5) << resid_tC2(ifleet,iyr)
            << setw(15) << setprecision(5) << residmean_tC2(ifleet,iyr) << endl;
    }
   }

report << "index fit" << endl;
  for(indx=1;indx<=n_ndx;indx++)
   {
     stdev_ndx(indx) = std_dev(resid_ndx(indx));
```

```
      report << "neg_logL = " << neglogLL_ndx(indx) << "    SDSR = " << stdev_ndx(indx) << endl;
    for(iyr=first_syr(indx);iyr<=last_syr(indx);iyr++)
     {
      report << setw(5) << setprecision(0) << indx
             << setw(5) << setprecision(0) << iyr
             << setw(15) << setprecision(5) << resid_ndx2(indx,iyr)
             << setw(15) << setprecision(5) << residmean_ndx2(indx,iyr) << endl;
                     //  if(indx==2 && iyr==last_syr(indx)) { report << endl; };
     }
    }
  report << endl;

  report << "Proportion at age" << endl;
for (ifleet=1;ifleet<=nfleets-1;ifleet++)
 {
    report << "neg_logL = " << sum(neglogLL_PAA(ifleet)) << "    SDSR = " << stdev_PAA(ifleet) << endl;
  for (iyr=first_fyr(ifleet);iyr<=last_fyr(ifleet);iyr++)
    {
    report << setw(5) << setprecision(0) << ifleet
             << setw(5) << setprecision(0) << iyr
             << setw(15) << setprecision(5) << sum(resid_PAA2(ifleet,iyr))
             << setw(15) << setprecision(5) << sum(residmean_PAA2(ifleet,iyr)) << endl;
    }
  }

  report << "F kept at age fit" << endl;
      report << "neg_logL = " << sum(neglogLL_kept) << "    SDSR = " << stdev_kept << endl;
    for (iyr=1989;iyr<=2004;iyr++)
     {
      report << setw(5) << setprecision(0) << iyr
             << setw(15) << setprecision(5) << sum(resid_kept2(iyr))
             << setw(15) << setprecision(5) << sum(residmean_Fkept2(iyr)) << endl;
     }

  report << "F release" << endl;
      report << "neg_logL = " << neglogLL_fullF << "    SDSR = " << std_dev(resid_fullF_B2) << endl;
    for (iyr=1989;iyr<=2004;iyr++)
     {
      report << setw(5) << setprecision(0) << iyr
             << setw(15) << setprecision(5) << resid_fullF_B22(iyr)
             << setw(15) << setprecision(5) << residmean_Frelease2(iyr) << endl;
    }
```

```
 report << " static SPR     " << setw(15) << setprecision(5) << static_SPR << endl;
report << " escapement 1-3 " << setw(15) << setprecision(5) << escapement13 << endl;
report << " escapement 1-5 " << setw(15) << setprecision(5) << escapement15 << endl;
report << " t Esc 1-3 " << setw(15) << setprecision(5) << tEsc13 << endl;
report << " t Esc 1-5 " << setw(15) << setprecision(5) << tEsc15 << endl;

report << "selectivity constraint (4 and 5) =" << sel04
        << "   " << sel05 << endl;
```

```
RUNTIME_SECTION
  convergence_criteria 1.0e-7
  maximum_function_evaluations 10000
```

Input data

```
#Northern Region 1989-2007
#
# Defining two regional commercial fisheries - gillnet+beachseine and other gear less lines
# adding comm line gear to regional rec A+B1 fishery, and added a rec released-alive fishery
#
#fleets (1=VAMDNCcomGNBS, 2=VAMDNCcomSE, 3=NCVAMDrecAB1, 4=NCVAMDrecB2)
4
# global first and last years used in assessment
1989 2007
#
# first and last year for each fishing fleet
 1989 1989 1989 1989
 2007 2007 2007 2007
#
#firstage lastage (same for all fleets)
 1 7
#
#last age selectivity estimated for
3
#natural mortality - Lorenzen scaled to Hoenig method -using nonparameteric growth
#   1    2    3    4    5    6    7
 0.20 0.13 0.10 0.09 0.08 0.08 0.07
#
#selectivity block -- only fleet1-3 used, fleet4(rec) uses tag-based input for selevtivity
#89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07
  1  1  1  2  2  2  2  2  2  2  3  3  3  3  3  3  3  3  3
  1  1  1  2  2  2  2  2  2  2  3  3  3  3  3  3  3  3  3
```

```
  1  1  1  2  2  2  2  2  2  2  3  3  3  3  3  3  3  3  3
  1  1  1  2  2  2  2  2  2  2  3  3  3  3  3  3  3  3  3
#
# total kill by fleet in numbers, except only A+B1 for fleet3 (rec) (1=VAMDNCcomGNBS, 2=VAMDNCcomSE, 3=NCVAMDrecAB1, 4=NCVAMDrecB2)
#1989    1990    1991    1992    1993    1994    1995    1996    1997    1998    1999    2000    2001    2002    2003    2004    2005    2006
2007
60989   49914   35102   31823   37551   20723   34082   19195   9299    78437   137880  86069   51500   32678   33681   21790   55287   50590
84072
17901   15866   20887   4736    5655    4568    12315   3505    3430    15034   4441    3025    1634    2422    1457    701     2455    3332
4571
75381   34497   58678   36869   63923   30603   92921   37470   10714   132765  78764   84262   30400   100481  41360   35340   55892   74598
136178
0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0
0
# CV's for total kill by fleet in numbers (assumed for commercial fleets, from MRFSS AB1 north region for fleet 3 and B2 for fleet 4))
#1989    1990    1991    1992    1993    1994    1995    1996    1997    1998    1999    2000    2001    2002    2003    2004    2005    2006
2007
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    0.01    0.01    0.01    0.01    0.01
0.01
0.01    0.01    0.01    0.01    0.01    0.01    0.01    0.01    0.01    0.01    0.01    0.01    0.01    0.01    0.01    0.01    0.01    0.01
0.01
0.1448  0.2741  0.1552  0.1851  0.1446  0.1590  0.1200  0.1485  0.2387  0.1129  0.1367  0.1203  0.1519  0.1394  0.1708  0.1884  0.2009
0.1737  0.1109
0.3003  0.3621  0.1488  0.1672  0.1841  0.1338  0.1109  0.1702  0.1298  0.1041  0.1605  0.1891  0.1265  0.0935  0.1704  0.0973  0.1300
0.1058  0.0982
#
#input B2 selectivity for rec northern region by age (columns through last_sel_age) and select period (rows)
1.000   0.221   0.012   0.012   0.012   0.012   0.012
1.000   0.467   0.031   0.023   0.023   0.023   0.023
0.6840  1.0000  0.2070  0.0890  0.089   0.089   0.089
# total release by fleet
#1989    1990    1991    1992    1993    1994    1995    1996    1997    1998    1999    2000    2001    2002    2003    2004    2005    2006
2007
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       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       0       0       0       0
0
17522   13385   140347  75915   232761  118372  198152  38175   371869  298735  482682  402443  268973  1464952 137762  223283  350290
633277  610962
#release mortality
 0.08
#
#proportion catch at age (age columns, year rows) by fleet -- corrected both coms LP 6/15 email; fleet 1 with discard -8/25
#Age      1               2               3               4               5               6               7+
# VAMDNCcomGNBS
0.53532641      0.25506212      0.19125250      0.01174369      0.00105295      0.00000658      0.00001273
0.54997111      0.27865103      0.15184156      0.01232150      0.00103996      0.00004544      0.00000468
0.53784406      0.29116599      0.15630788      0.01212885      0.00225448      0.00012662      0.00000516
0.53346258      0.11710446      0.32076407      0.02500651      0.00230494      0.00000702      0.00000786
0.53634137      0.10894496      0.23925858      0.11382647      0.00113475      0.00002393      0.00001488
0.53386572      0.11729449      0.22677101      0.11199137      0.00924675      0.00001067      0.00001353
0.53572492      0.10890644      0.29441983      0.05949493      0.00140140      0.00000525      0.00000525
0.53656341      0.14708777      0.26285039      0.05212642      0.00115173      0.00003075      0.00001273
0.53978786      0.16026654      0.23778351      0.05938571      0.00248020      0.00004542      0.00001734
```

0.53471131	0.13347076	0.32004514	0.01063573	0.00101827	0.00000566	0.00000822
0.28352941	0.59444343	0.11823362	0.00322766	0.00003904	0.00001148	0.00051537
0.24332885	0.50081775	0.24747056	0.00734254	0.00022719	0.00006917	0.00074394
0.27623290	0.36751078	0.35111438	0.00439388	0.00026898	0.00006316	0.00041593
0.29365313	0.63878228	0.06225820	0.00330664	0.00022201	0.00009042	0.00168731
0.24762352	0.63575886	0.11363328	0.00287185	0.00001155	0.00001155	0.00009237
0.54029409	0.16533763	0.28514835	0.00852235	0.00000000	0.00007343	0.00062414
0.27305599	0.69439955	0.03083340	0.00171287	0.00000000	0.00000000	0.00000000
0.19341339	0.60574644	0.19648556	0.00431903	0.00002965	0.00000198	0.00000395
0.25559565	0.60169066	0.13947429	0.00306286	0.00001171	0.00001171	0.00015312

VAMDNCcomSE

0.38723625	0.39767719	0.07029334	0.00858626	0.00042456	0.00167591	0.13410649
0.54169188	0.38132784	0.01963268	0.00022689	0.00136767	0.00000000	0.05575304
0.79755253	0.17721155	0.00840718	0.00502707	0.00240821	0.00014363	0.00924982
0.08083282	0.83618050	0.05547226	0.01997593	0.00048567	0.00069683	0.00635598
0.02040564	0.64960303	0.30380351	0.00024756	0.00031829	0.00040670	0.02521528
0.02128079	0.47735085	0.37359606	0.06390805	0.00540777	0.00227696	0.05617953
0.02385728	0.83707541	0.13732146	0.00142104	0.00023549	0.00001624	0.00007308
0.06216301	0.75043506	0.16797421	0.00955696	0.00139788	0.00039940	0.00807349
0.24128280	0.54822157	0.18125364	0.01548105	0.00247813	0.00069971	0.01058309
0.11592159	0.87452026	0.00596636	0.00026606	0.00009977	0.00021285	0.00301311
0.08336148	0.72181315	0.17809453	0.00490891	0.00006755	0.00000000	0.01175437
0.03405296	0.53651602	0.37312791	0.03415215	0.00720733	0.00188448	0.01305915
0.02698898	0.32766218	0.55220318	0.04504284	0.02117503	0.00452876	0.02239902
0.13293151	0.72001816	0.09218511	0.01903150	0.00503654	0.00202287	0.02877431
0.02195992	0.73716717	0.23064782	0.01022509	0.00000000	0.00000000	0.00000000
0.18555524	0.34427633	0.46131887	0.00699401	0.00000000	0.00000000	0.00185555
0.06594436	0.89519775	0.03458108	0.00154780	0.00000000	0.00000000	0.00272901
0.09303163	0.67276874	0.22267571	0.01152392	0.00000000	0.00000000	0.00000000
0.02419549	0.75876704	0.21113080	0.00216578	0.00000000	0.00000000	0.00374089

#NCVAMDrec (just A+B1 proportions)

0.358876000	0.551751000	0.071952000	0.000000000	0.000000000	0.000000000	0.017421000
0.908423000	0.025114000	0.050877000	0.001991000	0.000000000	0.000000000	0.013595000
0.806628000	0.161583000	0.004921000	0.014918000	0.000000000	0.000000000	0.011950000
0.044449000	0.889033000	0.061028000	0.000343000	0.001716000	0.000000000	0.003431000
0.071285000	0.685741000	0.229765000	0.000627000	0.000574000	0.000000000	0.012008000
0.057572000	0.379518000	0.383244000	0.064008000	0.002770000	0.000000000	0.112888000
0.133864000	0.761833000	0.081905000	0.010695000	0.009466000	0.000000000	0.002237000
0.346870000	0.395779000	0.201431000	0.029463000	0.012091000	0.000000000	0.014366000
0.459152000	0.269600000	0.166783000	0.045867000	0.019456000	0.000000000	0.039142000
0.018456000	0.924506000	0.039808000	0.005366000	0.004096000	0.000997000	0.006771000
0.074608000	0.689224000	0.233853000	0.002012000	0.000000000	0.000000000	0.000303000
0.013461000	0.449898000	0.523974000	0.012666000	0.000000000	0.000000000	0.000001000
0.041071000	0.268319000	0.587449000	0.085487000	0.004154000	0.000470000	0.013050000
0.189933000	0.761250000	0.026655000	0.014030000	0.001532000	0.001879000	0.004721000
0.007417000	0.652730000	0.330581000	0.008831000	0.000440000	0.000000000	0.000000000
0.201126000	0.350817000	0.428649000	0.019408000	0.000000000	0.000000000	0.000000000
0.010577000	0.966242000	0.023181000	0.000000000	0.000000000	0.000000000	0.000000000
0.074168000	0.662770000	0.239804000	0.023258000	0.000000000	0.000000000	0.000000000

```
0.018908000     0.648792000     0.328451000     0.003848000     0.000000000     0.000000000     0.000001000
#NCVAMD B2 only -- calculated within program this is just initializing matrix
0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000
0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000
0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000
0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000
0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000
0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000
0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000
0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000
0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000
0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000
0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000
0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000
0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000
0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000
0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000
0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000
0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000
0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000
0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000
#
#number of ages that went into catch at age calcs by fleet and year (1=VAMDNCcomGNBS, 2=VAMDNCcomSE, 3=NCVAMDrecAB1, 4=NCVAMDrecB2) sqrt alkN with 2 minimum
#1989  1990  1991  1992  1993  1994  1995  1996  1997  1998  1999  2000  2001  2002  2003  2004  2005  2006  2007
18  19  16  21  21  17  22  20  22  25  25  23  22  21  17  19  22  26  24
18  19  16  21  21  17  22  20  22  25  25  23  22  21  17  19  22  26  24
18  19  16  21  21  17  22  20  22  25  25  23  22  21  17  19  22  26  24
2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
# North region information on F at age for age 1-4+, 1989-2004 total harvest)
#estimates
2.564   3.873   1.418   0.119
1.987   3.002   1.099   0.092
0.499   0.755   0.276   0.023
0.177   0.653   0.192   0.030
0.259   0.952   0.280   0.044
0.121   0.446   0.131   0.021
0.087   0.320   0.094   0.015
0.070   0.257   0.076   0.012
0.126   0.463   0.136   0.022
0.165   0.606   0.178   0.028
0.026   0.437   0.104   0.001
0.034   0.558   0.133   0.001
0.065   1.080   0.257   0.003
0.071   1.168   0.278   0.003
0.026   0.422   0.101   0.001
0.015   0.256   0.061   0.001
```

```
#CV's
0.226   0.196   0.220   0.196
0.254   0.228   0.249   0.228
0.224   0.194   0.218   0.194
0.123   0.121   0.127   0.121
0.113   0.110   0.116   0.110
0.117   0.114   0.120   0.114
0.103   0.100   0.107   0.100
0.171   0.170   0.174   0.170
0.142   0.140   0.145   0.140
0.097   0.094   0.102   0.094
0.116   0.116   0.118   0.116
0.114   0.113   0.116   0.113
0.129   0.128   0.130   0.128
0.208   0.208   0.209   0.208
0.257   0.256   0.257   0.256
0.412   0.411   0.412   0.411
#
#North region information for release rec fishery,1989-2004
#fully recruited F estimate
0.0250
0.0404
0.0342
0.0170
0.0427
0.1178
0.0683
0.0237
0.0377
0.0354
0.0240
0.0340
0.0398
0.0288
0.0197
0.0088
# CV (corrected)
0.2622
0.3376
0.1073
0.1432
0.1015
0.0818
0.1534
0.2168
0.1045
0.1068
0.1191
0.1111
```

```
0.1287
0.1696
0.2000
0.2887
# number of indices
# 1)NCIGNS1 2)NCIGNS2 3)NC JAI 4) MRFSS
  4
# first year of surveys forllowed by last year of surveys
  2001 2001 1992 1991
  2007 2007 2007 2007
# indices ages (indices in order by row showing begin, end ages)
 1 2 1 1
 1 2 1 3
#
# middle of survey (months)
 9  6  0  6
#
#observed index values across years (columns)
# 1)NCIGNS1 2)NCIGNS2 3)NC JAI 4) MRFSS
#1982   1983   1984   1985   1986   1987   1988   1989   1990   1991   1992   1993   1994   1995   1996   1997   1998   1999
2000    2001   2002   2003   2004   2005   2006   2007

1.03    2.63   0.27   1.85   1.37   1.64   0.53

0.44    0.55   0.97   0.06   1.36   1.21   2.54
                                                                      14.848 3.716  12.650 8.290  4.613  -999   13.127 8.234
1.878   3.179  0.975  2.258  5.008  8.375  9.017  3.592
                                                               0.105  0.058  0.066  0.064  0.115  0.068  0.222  0.147  0.182
0.096   0.109  0.294  0.084  0.131  0.138  0.159  0.147


# estimated CV's for the index values
#1982   1983   1984   1985   1986   1987   1988   1989   1990   1991   1992   1993   1994   1995   1996   1997   1998   1999
2000    2001   2002   2003   2004   2005   2006   2007

0.2816  0.1597  0.2593  0.1568  0.2117  0.1524  0.1698

0.2273  0.2182  0.2062  0.3333  0.1765  0.1818  0.3898
                                                                      0.1468  0.3054  0.1753  0.2909  0.1570  -999   0.2342
0.1361  0.2213  0.1809  0.1922  0.2334  0.2458  0.1349  0.1558  0.2038
                                                               0.139  0.146  0.131  0.131  0.108  0.123  0.138  0.104  0.114
0.11    0.126  0.117  0.149  0.154  0.145  0.11   0.102
#Fbrake level
 20.
# choice of weighting scheme
# TC, PAA, Ndx, tagF
   1.  2.   1.   1.
#
# weight, maturity, and natural mortality at age through age 62
0.864973405     0.00    0.1954623
3.349192056     0.00    0.1293428
8.374519205     0.01    0.09780164
12.87254557     0.58    0.085783
16.23206009     0.99    0.07992542
19.10192225     1.00    0.0760537
```

21.52350705	1.00	0.07333485
23.26076249	1.00	0.07161907
24.40688279	1.00	0.07057607
25.21164374	1.00	0.06988122
25.84398236	1.00	0.06935523
26.39275495	1.00	0.0689122
26.90604188	1.00	0.06850856
27.41259354	1.00	0.0681199
27.9307121	1.00	0.06773201
28.4713612	1.00	0.06733708
29.04019395	1.00	0.06693204
29.6375295	1.00	0.06651768
30.25911724	1.00	0.06609792
30.89671045	1.00	0.06567888
31.53919302	1.00	0.06526786
32.1743315	1.00	0.06487219
32.79002767	1.00	0.06449822
33.37603747	1.00	0.06415069
33.92494963	1.00	0.0638323
34.43250184	1.00	0.06354385
34.8974287	1.00	0.06328443
35.32107458	1.00	0.06305194
35.70667741	1.00	0.06284347
36.05877382	1.00	0.06265572
36.38211385	1.00	0.06248533
36.68199478	1.00	0.06232907
36.96332748	1.00	0.06218399
37.23078519	1.00	0.06204744
37.48831689	1.00	0.0619171
37.73995462	1.00	0.0617909
37.98896732	1.00	0.06166708
38.23849556	1.00	0.06154406
38.49126414	1.00	0.06142051
38.74966712	1.00	0.06129532
39.01547619	1.00	0.06116761
39.2904003	1.00	0.06103678
39.57503106	1.00	0.06090256
39.86949138	1.00	0.06076502
40.17294008	1.00	0.06062465
40.48354721	1.00	0.06048238
40.79856563	1.00	0.06033958
41.1139136	1.00	0.06019802
41.4251298	1.00	0.06005975
41.72677231	1.00	0.059927
42.01350039	1.00	0.05980193
42.28039018	1.00	0.05968655
42.52316015	1.00	0.0595824
42.73890564	1.00	0.05949051
42.92603471	1.00	0.05941128

```
43.08459987     1.00    0.05934452
43.21591391     1.00    0.05928947
43.32235499     1.00    0.059245
43.40706135     1.00    0.05920971
43.47341589     1.00    0.05918213
43.52483293     1.00    0.05916081
43.564341       1.00    0.05914441
```

Weight options files

```
#File: n0_TC.wts
#weights
#total catch by fleet
# Ha:default
#fleet1 fleet2 fleet3 fleet4
   1.     1.     1.     1.
# Ha:B2 rec total catch estimates are suspect
#fleet1 fleet2 fleet3 fleet4
   1.   1.     1.     0.1
# Ha:B2 rec total catch estimates are really suspect
#fleet1 fleet2 fleet3 fleet4 fleet5 fleet6
1.     1.     1.     0.01
```

```
#File: n0_PAA.wts
#PAA weights
#Ha:default
#catch at age by fleet and year (excluding the B2 release fleet4)
#1982  1983    1984    1985    1986    1987    1988    1989    1990    1991    1992    1993    1994    1995    1996    1997    1998    1999
2000    2001    2002    2003    2004    2005    2006    2007
1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1
1       1       1       1       1       1       1       1
1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1
1       1       1       1       1       1       1       1
1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1
1       1       1       1       1       1       1       1
#Ha:the AB1 age compostion data is less uncertain than commercial age comp
#catch at age by fleet and year
#1982   1983    1984    1985    1986    1987    1988    1989    1990    1991    1992    1993    1994    1995    1996    1997    1998    1999
2000    2001    2002    2003    2004    2005    2006    2007
1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1
1       1       1       1       1       1       1       1
1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1
1       1       1       1       1       1       1       1
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    0.01    0.01    0.01    0.01    0.01
0.01    0.01    0.01    0.01    0.01    0.01    0.01    0.01
```

```
#File: n0_Ndx.wts
#weights
#Ha:default
# index weight
 1. 1. 1. 1.
#Ha:the MRFSS index is best due to areal coverage
```

```
# index weight
 1. 1. 1. 10.
#Ha:the yoy indexes are best due to scientific design and ease of capture
# index weight
 10. 1. 10. 1.

#File: n0_tagF.wts
#weights
#tagging based F (showing for keptF at age and then fullF B2rec)
# Ha: default
   1.   1.
# Ha: both less accurate
   0.1   0.1
```

Appendix C. ADMB code and input data for southern region Atlantic red drum stock assessment

Description

This appendix presents the AD Model Builder model code and input data used to implement the age-structured assessment for the southern region described in Appendix A.

Model code

```
DATA_SECTION ///////////////////////////////////////////////////////////////////
    !!USER_CODE ad_comm::change_datafile_name("so_base.dat");

        // all commented out sections in response to reviewer findings - MDM 8/21

 //////////// general dimensions and structural inputs ////////////
 // how many groups with separate fishing characteristics, fisheries?
 init_int nfleets

 // global first and last age used in the assesment
 init_int firstyr
 init_int lastyr


 // first and last years of catch data for each fishery
 init_ivector first_fyr(1,nfleets)
 init_ivector last_fyr(1,nfleets)

 // first and last age used in the assessment - last assumed plus group
 init_int firstage
 init_int lastage

 // last age that selectivity is estimated
 init_int last_sel_age

 // instantaneous natural mortality from firstage through lastage
 init_vector M(firstage,lastage)

 // selectivity blocks defined sequentially by fleet by year
```

```
init_imatrix yr_sel_block(1,nfleets,first_fyr,last_fyr)

//////////// observed data /////////////
// total landed catch for each fleet each year and its CV
init_matrix obs_tot_catch(1,nfleets,first_fyr,last_fyr)
init_matrix tot_catch_CVs(1,nfleets,first_fyr,last_fyr)

// observed selectivity for Florida live-release fishery over two
// defined time period
init_matrix B2_select(1,1,firstage,lastage)

// additional non-landed catch that is subject to the hook-and-line
// release mortality (rel_mort)
init_matrix tot_B2catch(1,nfleets,first_fyr,last_fyr)
init_number rel_mort

// observed proportion at age for all 'observed' landings and  sampled live-releases
// and number of fish sampled for age each year associated with these observed proportions
init_3darray obs_prop_at_age(1,nfleets,first_fyr,last_fyr,firstage,lastage)
init_matrix agedN(1,nfleets,first_fyr,last_fyr)

// number of indices used for relative abundance
init_int n_ndx
// first and last year for each index
init_ivector first_syr(1,n_ndx)
init_ivector last_syr(1,n_ndx)
// first and last age included in index
init_ivector first_sage(1,n_ndx)
init_ivector last_sage(1,n_ndx)
// midpoint month for the survey
init_vector survey_month(1,n_ndx)
// relative abundance by index for each year available
// and coefficient of variation
init_matrix survey_ndx(1,n_ndx,first_syr,last_syr)
init_matrix survey_CVs(1,n_ndx,first_syr,last_syr)

// temporary penalty for keeping early-solution-search-F up
init_number F_brake

// the weights set associated with the total catches, proportion at age and indices
init_ivector wt_choice(1,3)
```

```
 // matrix showing three columns - for weight (lbs), proportion mature, and natural mortality
 // for every age in the fishes life
 init_matrix wt_mat_M38(1,38,1,3)

// file for the different weighting schemes referred to in wt_choice variable
   // total catch weights
!!USER_CODE ad_comm::change_datafile_name("s0_TC.wts");
    init_matrix totcatch_wt(1,3,1,nfleets)

   // PAA wts
!!USER_CODE ad_comm::change_datafile_name("s0_PAA.wts");
     init_3darray PAA_wt(1,3,1,nfleets,firstyr,lastyr)

   // Index wts
!!USER_CODE ad_comm::change_datafile_name("s0_Ndx.wts");
    init_matrix indx_wt(1,3,1,n_ndx)
  ////////////////////////////////////////////////////////////////////////////////////

 // various statistics and manipulations of the input data
    ivector nselblocks(1,nfleets)
    int k
    number tot
    vector ave_obstC(1,nfleets)
    vector ave_obsNdx(1,n_ndx)
    matrix ave_obsPAA(1,nfleets,firstage,lastage)
    matrix stdevPAA(1,nfleets,firstage,lastage)
LOCAL_CALCS
   for(ifleet=1;ifleet<=nfleets;ifleet++)
     {
   // how many 'selectivity blocks' are there for each fishery?
     nselblocks(ifleet) = yr_sel_block(ifleet,last_fyr(ifleet));
     }

  // special calculation for the B2 rec live-release fisheries -- fleet=5-6 -- to calculate total kill
   for(ifleet=4;ifleet<=nfleets;ifleet++)
     {
     for (iyr=first_fyr(ifleet);iyr<=last_fyr(ifleet);iyr++)
       {
       obs_tot_catch(ifleet,iyr) = tot_B2catch(ifleet,iyr) * (rel_mort);
       }
     }
```

```
  // calculate various mean observed values to use in the total sum of squares [TSS = sum of squares
  //  for (mean-observed)/stdev(observed)], though this did not appear to be very helpful for
  //  'goodness of fit' evaluation where residual sum of squares [RSS = sum of squares for (observed-
predicted)
  //   /stdev(observed)] was confounded by multidimensionaity of problem.

   // total catch
     for(ifleet=1;ifleet<=nfleets;ifleet++)
        {
        k = 0;
        tot=0;
       for (iyr=first_fyr(ifleet);iyr<=last_fyr(ifleet);iyr++)
          {
          k++;
          tot += log(obs_tot_catch(ifleet,iyr)+1e-6);
          }
        ave_obstC(ifleet) = tot/double(k);
       }

     // indices
   for (indx=1;indx<=n_ndx;indx++)
    {
      k = 0;
      tot=0;
     for(iyr=first_syr(indx);iyr<=last_syr(indx);iyr++)
      {
        if(survey_ndx(indx,iyr)>0)
          {
           k++;
           tot += log(survey_ndx(indx,iyr)+1.e-6);
           }
      }
     ave_obsNdx(indx) = tot/double(k);
    }
      //PAA -- this is a strech for 0.0-1.0 bound number      ---- remember fleet 5 doesn't count
 for (ifleet=1;ifleet<=nfleets;ifleet++)
  {
   for (iage=firstage;iage<=lastage;iage++)
     {
      k = 0;
      tot=0;
     for (iyr=first_fyr(ifleet);iyr<=last_fyr(ifleet);iyr++)
```

```
        {
        k++;
        tot += obs_prop_at_age(ifleet,iyr,iage)+1.e-6;
        }
    ave_obsPAA(ifleet,iage) = tot/double(k);
      }
   }

   // what is the standard deviation of observed PAA across years for each fleet and age?
     for (ifleet=1;ifleet<=nfleets;ifleet++)
      {
       for (iage=firstage;iage<=lastage;iage++)
         {
          k = 0;
          tot=0;
          for (iyr=first_fyr(ifleet);iyr<=last_fyr(ifleet);iyr++)
            {
            k++;
            tot += square( obs_prop_at_age(ifleet,iyr,iage)-ave_obsPAA(ifleet,iage) );
            }
          stdevPAA(ifleet,iage) = sqrt( tot/(double(k)-1)  );
          }
       }
 END_CALCS


    // initialize various counters and temporary integers
    int sel_count
    int ifleet
    int iyr
    int iage
    int indx
    int i
    int j

    int PAA_n
    int PAA_n2
    int tC_n
    int ndx_n


PARAMETER_SECTION  ////////////////////////////////////////////////////////////////////////////////
```

```
      init_bounded_number sel04(0.,1.,5)
      init_bounded_number sel05(0.,1.,5)


  // NOTE: for convenience number of selectivities is hardwired -- does not include fleet=5, FL live-
release fishery
  //       when tag-based selectivity used is used
  //----in get_selectivity function
  //Parameter: selectivities
   init_bounded_dev_vector fill_log_sel(1,30,-5,5,5)
     3darray log_sel(1,nfleets,1,nselblocks,firstage,lastage)
     matrix max_log_sel(1,nfleets,1,nselblocks)

  //----in get_mortality_rates function----
  //Parameter: fully recruited F's
   init_bounded_matrix log_Fmult(1,nfleets,first_fyr,last_fyr,-15,2,3)
     3darray log_Ffleet(1,nfleets,first_fyr,last_fyr,firstage,lastage)
     matrix Z(firstyr,lastyr,firstage,lastage)
     matrix tot_F(firstyr,lastyr,firstage,lastage)

  //----in get_number_at_age function
  //Parameters: median initial abundance ages 2-7+ and deviations from this for each age
 //   init_bounded_number log_initN(8,15,1)
 //   init_bounded_dev_vector log_initN_devs(firstage+1,lastage,-10,10,2)
     init_bounded_vector log_initN(firstage+1,lastage,2,15,1)



       matrix log_N(firstyr,lastyr,firstage,lastage)

  //Parameters: median recruitment by year and deviations from this for each year
  //  init_bounded_number log_R(4,19,1)
  // init_bounded_dev_vector log_recruit_devs(firstyr,lastyr,-10,10,3)
  //     vector log_recruits(firstyr,lastyr)
        init_bounded_vector log_recruits(firstyr,lastyr,5,18,2)

  //----in calculate_catch function
       3darray C(1,nfleets,first_fyr,last_fyr,firstage,lastage)
       matrix pred_catch(1,nfleets,first_fyr,last_fyr)

  //---- in evaluate the objective function
```

```
        // indices
//Parameter: catchability coefficient for each index
init_bounded_vector log_q_ndx(1,n_ndx,-19,-4,4)
   matrix EffN(1,nfleets,first_fyr,last_fyr)
   matrix resid_ndx(1,n_ndx,first_syr,last_syr)
   matrix residmean_ndx(1,n_ndx,first_syr,last_syr)
      matrix resid_ndx2(1,n_ndx,first_syr,last_syr)
      matrix residmean_ndx2(1,n_ndx,first_syr,last_syr)
   matrix pred_ndx(1,n_ndx,first_syr,last_syr)
   vector stdev_ndx(1,n_ndx)
   vector neglogLL_ndx(1,n_ndx)
   number ndx_f
        // PAA
   3darray resid_PAA(1,nfleets,first_fyr,last_fyr,firstage,lastage)
       // fake residuals
      3darray resid_PAA2(1,nfleets,first_fyr,last_fyr,firstage,lastage)
      3darray residmean_PAA2(1,nfleets,first_fyr,last_fyr,firstage,lastage)
   vector stdev_PAA(1,nfleets)
   matrix neglogLL_PAA(1,nfleets,first_fyr,last_fyr)
   number PAA_f
        // total catch
   matrix resid_tC(1,nfleets,first_fyr,last_fyr)
   matrix residmean_tC(1,nfleets,first_fyr,last_fyr)
     matrix resid_tC2(1,nfleets,first_fyr,last_fyr)
     matrix residmean_tC2(1,nfleets,first_fyr,last_fyr)
   vector stdev_tC(1,nfleets)
   vector neglogLL_tC(1,nfleets)

  // define some intermediate calculation
  number temp
  number temp2
  number tC_f
  number avg_F
  number F_brake_penalty

// Benchmark stuff
  // including spawning stock biomass under fishing and under no fishing,
  // spawning potential ratio, and various escapement estimates
    vector SSB_F(firstyr,lastyr)
    vector SSB_F0(firstyr,lastyr)
      number F_survival
      number F0_survival
```

```
        vector escapement13(firstyr,lastyr)
        vector escapement15(firstyr,lastyr)
           //transitional
           vector tEsc15(firstyr+4,lastyr)
           vector tEsc13(firstyr+2,lastyr)

    objective_function_value f

      sdreport_vector log_total_abundance(firstyr,lastyr)
      sdreport_vector log_N1(firstyr,lastyr)
      sdreport_vector log_N2(firstyr,lastyr)
      sdreport_vector log_N3(firstyr,lastyr)
      sdreport_vector expl13(firstyr,lastyr)
      sdreport_vector static_SPR(firstyr,lastyr)
      sdreport_vector three_yrSPR(firstyr+2,lastyr)

      likeprof_number three_yrSPR2007

PROCEDURE_SECTION ///////////////////////////////////////////////////////////////////////////
 get_selectivities();
 get_mortality_rates();
 get_numbers_at_age();
 calculate_catch();
 evaluate_the_objective_function();


   // static spawning potential ratio, and various escapement rate estimates
     // calculate spawning stock biomass per recruit with current year's fishing and without any F
     for(iyr=firstyr;iyr<=lastyr;iyr++)
       {
        F_survival = mfexp( -1. * (wt_mat_M38(1,3)+tot_F(iyr,1)) );
        F0_survival = mfexp(-1. * wt_mat_M38(1,3));
          SSB_F(iyr) = wt_mat_M38(1,2)*wt_mat_M38(1,1)*F_survival;
          SSB_F0(iyr) = wt_mat_M38(1,2)*wt_mat_M38(1,1)*F0_survival;

        for(iage=firstage+1;iage<=lastage;iage++)
          {

          F_survival *= mfexp( -1.* (wt_mat_M38(iage,3)+tot_F(iyr,iage)) );
          F0_survival *= mfexp(-1.* wt_mat_M38(iage,3));
            SSB_F(iyr) += wt_mat_M38(iage,2)*wt_mat_M38(iage,1)*F_survival;
            SSB_F0(iyr) += wt_mat_M38(iage,2)*wt_mat_M38(iage,1)*F0_survival;
```

```
          }
        for(iage=lastage+1;iage<=38;iage++)
          {
          F_survival *= mfexp( -1.* (wt_mat_M38(iage,3)+tot_F(iyr,lastage)) );
          F0_survival *= mfexp(-1.* wt_mat_M38(iage,3));
            SSB_F(iyr) += wt_mat_M38(iage,2)*wt_mat_M38(iage,1)*F_survival;
            SSB_F0(iyr) += wt_mat_M38(iage,2)*wt_mat_M38(iage,1)*F0_survival;
          }

          // static SPR and static (year-specific) escapement rates
          static_SPR(iyr) = SSB_F(iyr)/SSB_F0(iyr);
          escapement13(iyr) = mfexp(-1.* tot_F(iyr,1)-tot_F(iyr,2)-tot_F(iyr,3));
          escapement15(iyr) = mfexp(-1.* tot_F(iyr,1)-tot_F(iyr,2)-tot_F(iyr,3)-tot_F(iyr,4)-
tot_F(iyr,5));

           // transitional (yearclass-specific) escapement rates
            if(iyr>1992)
              {
               tEsc15(iyr) = mfexp( -1.* tot_F(iyr-4,1)-tot_F(iyr-3,2)-tot_F(iyr-2,3)-tot_F(iyr-1,4)-
tot_F(iyr,5) );
              }
            if(iyr>1990)
              {
               tEsc13(iyr) = mfexp( -1.* tot_F(iyr-2,1)-tot_F(iyr-1,2)-tot_F(iyr,3) );
              }
       }

       log_total_abundance=log(rowsum(mfexp(log_N)));

       for(iyr=firstyr;iyr<=lastyr;iyr++)
         {
          log_N1(iyr) = log_N(iyr,1);
          log_N2(iyr) = log_N(iyr,2);
          log_N3(iyr) = log_N(iyr,3);
          // catch across fleets
            temp=0.;
            for(ifleet=1;ifleet<=nfleets;ifleet++)
              {
              temp += C(ifleet,iyr,1)+C(ifleet,iyr,2)+C(ifleet,iyr,3);
              }
          expl13(iyr) = temp/( mfexp(log_N1(iyr))+mfexp(log_N2(iyr))+mfexp(log_N3(iyr)) );
            if(iyr>1990)
             {
```

```
            three_yrSPR(iyr) = ( static_SPR(iyr-2)+static_SPR(iyr-1)+static_SPR(iyr) )/3.;
            }
         }

         three_yrSPR2007 = ( static_SPR(2007-2)+static_SPR(2007-1)+static_SPR(2007) )/3.;


    //////////////////////// Begin Population Dynamics Model ///////////////////////////////
FUNCTION get_selectivities

 //----selectivity is not described parametrically but assumed constant above some maximum age
 //----the following simply fills out the array of candidate selectivities to be evaluated
 //----in the end it is standardized to the largest selectivity

  sel_count=0;  //remember first age is one;
  for (ifleet=1;ifleet<=nfleets;ifleet++)
        {
         for (i=1;i<=yr_sel_block(ifleet,last_fyr(ifleet));i++)
          {

         // Special: for the Florida live-release fishery selectivites are 'observed data'
         if(ifleet==4)
           {
            for (iage=firstage;iage<=lastage;iage++)
               {
               log_sel(ifleet,i,iage) = log(B2_select(i,iage));
               }
           }
         else
           {
              max_log_sel(ifleet,i)= -99.;
              // fill log_sel matrix using bounded vector
             for (iage=firstage;iage<=last_sel_age;iage++)
              {
              sel_count++;
              log_sel(ifleet,i,iage) = fill_log_sel(sel_count);
              // retain maximum selectivity within fleet and block of year
              if(log_sel(ifleet,i,iage)>max_log_sel(ifleet,i))
{max_log_sel(ifleet,i)=log_sel(ifleet,i,iage);}
              }

             // standardize relative to this maximum
```

```
            for (iage=firstage;iage<=last_sel_age;iage++)
             {
             log_sel(ifleet,i,iage) =  log_sel(ifleet,i,iage)-max_log_sel(ifleet,i);
             }
              // Special: for red drum, we assume that the selectivity drops after last estimated age
              log_sel(ifleet,i,last_sel_age+1) = log_sel(ifleet,i,last_sel_age)+log(sel04);
              log_sel(ifleet,i,last_sel_age+2) = log_sel(ifleet,i,last_sel_age)+log(sel05);

            // selectivity for older ages is set equal to oldest-aged selectivity
            for (iage=last_sel_age+3;iage<=lastage;iage++)
             {
             log_sel(ifleet,i,iage) = log_sel(ifleet,i,last_sel_age+2);
             }
          }
        }
      }


FUNCTION get_mortality_rates

  //----age-specific fishing mortalities are derived using estimated selectivities and year-specific F's--
--
  for (ifleet=1;ifleet<=nfleets;ifleet++)
   {
   // fill out the fleet-, year-, age-specific F's
   for (iyr=first_fyr(ifleet);iyr<=last_fyr(ifleet);iyr++)
     {
     for (iage=firstage;iage<=lastage;iage++)
      {
      log_Ffleet(ifleet,iyr,iage) = log_Fmult(ifleet,iyr)+log_sel(ifleet,yr_sel_block(ifleet,iyr),iage);
      }
     }
   }

  // --- calculate instantaneous total mortality for convenience later
  //     allow for variable M with age

       // calculate the total fishing mortality across all fisheries each year
       // remember not all fleets operate all year -- sum available F's
       tot_F=0.0;
      for (ifleet=1;ifleet<=nfleets;ifleet++)
        {
```

```
        for (iyr=first_fyr(ifleet);iyr<=last_fyr(ifleet);iyr++)
         {
         for (iage=firstage;iage<=lastage;iage++)
           {
          tot_F(iyr,iage) += mfexp(log_Ffleet(ifleet,iyr,iage));
           }
         }
       }

     // calculate Z's
    for (iyr=firstyr;iyr<=lastyr;iyr++)
      {
        Z(iyr) = M;
         for (iage=firstage;iage<=lastage;iage++)
           {
            Z(iyr,iage) += tot_F(iyr,iage);
           }
      }

FUNCTION get_numbers_at_age

   // This fills parameter estimates for initial N's or top row and
   // numbers-at-age-1 (recruits) or left column in N-at-age matrix

    // initial year's abundance for ages-2 to 7+
//    for (iage=firstage+1;iage<=lastage;iage++)
//     {
//      if (active(log_initN_devs))
//        {
 //       log_N(firstyr,iage)=log_initN+log_initN_devs(iage);
 //         }
 //       else
 //         {
 //       log_N(firstyr,iage)=log_initN;
 //         }
 //    }

       // initial year's abundance for ages-2 to 7+
    for (iage=firstage+1;iage<=lastage;iage++)
     {
        log_N(firstyr,iage)=log_initN(iage);
     }
```

```
    // all year's recruitment or beginning-of-the-year abundance of age-1
  //  for (iyr=firstyr;iyr<lastyr;iyr++)
  //   {
  //    if (active(log_recruit_devs))
  //      {
  //        log_recruits(iyr) = log_R + log_recruit_devs(iyr);
  //        log_N(iyr,firstage) = log_recruits(iyr);
  //        }
  //      else
  //        {
  //        log_recruits(iyr) = log_R;
  //        log_N(iyr,firstage) =log_recruits(iyr);
  //        }

     for (iyr=firstyr;iyr<=lastyr;iyr++)
     {
          log_N(iyr,firstage) = log_recruits(iyr);
     }


    //----from these starting values project abundances forward in time and age----
     for (iyr=firstyr;iyr<lastyr;iyr++)
     {
       for (iage=firstage;iage<lastage;iage++)
        {
        log_N(iyr+1,iage+1)=log_N(iyr,iage)-Z(iyr,iage);
        }

   //----oldest age is a plus group so, in addition to the cohort survivors for last year
   //    need to add the previous year's plus-group survivors
     log_N(iyr+1,lastage)=log( mfexp(log_N(iyr,lastage)-Z(iyr,lastage))+mfexp(log_N(iyr+1,lastage))  );
     }
   //----define recruitment in the final year, this is only informed if there is a yoy index to fit----
//      if (active(log_recruit_devs))
//        {
 //         log_recruits(lastyr) = log_R + log_recruit_devs(lastyr);
```

```
 //         log_N(lastyr,firstage) = log_recruits(lastyr);
 //         }
 //       else
 //         {
 //         log_recruits(lastyr) = log_R;
 //         log_N(lastyr,firstage) =log_recruits(lastyr);
 //         }
 // //////////////////////////////// END POPULATION DYNAMICS MODEL
///////////////////////////////////////////////


FUNCTION calculate_catch


   /////// for convenience need to calculate some terms to be used to calculate predicted proportion at
age
   //----Use catch equation to calculate fleet-specific catch-at-age matrices----
   //    and total kill each year for each fleet
     pred_catch = 0.0;
     for (ifleet=1;ifleet<=nfleets;ifleet++)
       {
       for (iyr=first_fyr(ifleet);iyr<=last_fyr(ifleet);iyr++)
         {
         for (iage=firstage;iage<=lastage;iage++)
           {
           C(ifleet,iyr,iage) = (mfexp(log_Ffleet(ifleet,iyr,iage))/Z(iyr,iage))
                                * mfexp( log_N(iyr,iage) ) * ( 1.-mfexp(-1.*Z(iyr,iage)) );
           pred_catch(ifleet,iyr) +=  C(ifleet,iyr,iage);
           }
          }
        }



  ///////////////////////////////  OBSERVATION MODEL ///////////////////////////////////
FUNCTION evaluate_the_objective_function



 // Estimate effective sample size -- ignore fleet-5; FL rec live-release
 // useful in determining the 'goodness of fit' for the multinomial prediction of proportion at age in
kill


    for (ifleet=1;ifleet<=nfleets;ifleet++)
      {
      for (iyr=first_fyr(ifleet);iyr<=last_fyr(ifleet);iyr++)
```

```
        {
        temp = 0.;
        temp2 = 0.;
         for (iage=firstage;iage<=lastage;iage++)
           {
          temp  += C(ifleet,iyr,iage)/(pred_catch(ifleet,iyr)+1.e-13)*( 1-C(ifleet,iyr,iage)
/(pred_catch(ifleet,iyr)+1.e-13) );
          temp2 += square( obs_prop_at_age(ifleet,iyr,iage)-C(ifleet,iyr,iage)
                                                                          /(pred_catch(ifleet,iyr)+1.e-
13) );
           }
     EffN(ifleet,iyr) = temp/temp2;
        }
       }

                  // in the last phase a small penalty for a small F is added to objective
                  // function, in earlier phases a much larger penalty keeps solution away
                  // from infinitesimally small Fs
 F_brake_penalty = 0.;
 avg_F=sum(tot_F)/double(size_count(tot_F));
 if(last_phase())
  {
    F_brake_penalty += 1.e-6*square(log(avg_F/.2));
  }
  else
  {
    F_brake_penalty += F_brake * square(log(avg_F/.2));
  }

       ///////////// minimally 'regularize' the selectivities ///////////
       f += 5. *norm2(fill_log_sel);

 // ----negative log Likelihood estimation for indices-----------------------------------------
   ndx_f = 0;
   neglogLL_ndx = 0;
   ndx_n = 0;
    for (indx=1;indx<=n_ndx;indx++)
     {
      for(iyr=first_syr(indx);iyr<=last_syr(indx);iyr++)
       {
         if(survey_ndx(indx,iyr)>0)
           {
```

```
            // for aggregate indices, sum appropriate N estimates
            temp=0;
            for(iage=first_sage(indx);iage<=last_sage(indx);iage++)
            {
            temp += mfexp( log_N(iyr,iage)-Z(iyr,iage)*(survey_month(indx)/12.) );
            }
        ndx_n++; // how many index data points
        pred_ndx(indx,iyr) = mfexp(log_q_ndx(indx))*temp;
          // standardized residual
        resid_ndx(indx,iyr) = (   log(survey_ndx(indx,iyr)+1.e-6) - ( log_q_ndx(indx) + log(temp+1.e-6) )
)/
                                    sqrt(log(pow(survey_CVs(indx,iyr),2)+1));
          // standardized residual from average -- for total sum of squares (dubious)
        residmean_ndx(indx,iyr) = (   log(survey_ndx(indx,iyr)+1.e-6) -  ave_obsNdx(indx)   )/
                                    sqrt(log(pow(survey_CVs(indx,iyr),2)+1));


                // squared residuals//////////////////
        resid_ndx2(indx,iyr) = square(  ( log(survey_ndx(indx,iyr)+1.e-6) - ( log_q_ndx(indx) +
log(temp+1.e-6) ) )/
                                    sqrt(log(pow(survey_CVs(indx,iyr),2)+1))    );
        residmean_ndx2(indx,iyr) = square(  ( log(survey_ndx(indx,iyr)+1.e-6) -  ave_obsNdx(indx) )/
                                    sqrt(log(pow(survey_CVs(indx,iyr),2)+1))   );
               //////////////////////////////////


         // negative log-likelihood for the lognormal distribution
        neglogLL_ndx (indx) +=  0.5*square( resid_ndx(indx,iyr) ) +
log(sqrt(log(pow(survey_CVs(indx,iyr),2)+1)));
            }
        }
      ndx_f += neglogLL_ndx(indx)*indx_wt(wt_choice(3),indx);
     }


//---Likelihood estimation for catch proportions-at-age ------------------------
  PAA_f = 0;
  neglogLL_PAA = 0;
  PAA_n2=0;
  for (ifleet=1;ifleet<=nfleets;ifleet++)
   {
     PAA_n = 0;
    for (iyr=first_fyr(ifleet);iyr<=last_fyr(ifleet);iyr++)
      {
        // these were not observed for fleet=5; Florida rec live-release fishery
        if(ifleet==4) {PAA_f +=0;}
```

```
                else
                 {
      for (iage=firstage;iage<=lastage;iage++)
        {
        PAA_n2++;
        PAA_n++;
         // 'residual' in multinomial sense
        resid_PAA(ifleet,iyr,iage) = (obs_prop_at_age(ifleet,iyr,iage)+1.e-6)*log(
(C(ifleet,iyr,iage)/pred_catch(ifleet,iyr)+1.e-6)  );


                // squared residuals//////////////////
        resid_PAA2(ifleet,iyr,iage) = square( ( (obs_prop_at_age(ifleet,iyr,iage)+1.e-6) -
(C(ifleet,iyr,iage)/pred_catch(ifleet,iyr)+1.e-6) ) /
                                                 sqrt(
agedN(ifleet,iyr)*(obs_prop_at_age(ifleet,iyr,iage)+1.e-6)*(1-(obs_prop_at_age(ifleet,iyr,iage)+1.e-6)) )
);
        residmean_PAA2(ifleet,iyr,iage) = square( ( (obs_prop_at_age(ifleet,iyr,iage)+1.e-6) -
(ave_obsPAA(ifleet,iage)+1.e-6))/
                                                 sqrt(
agedN(ifleet,iyr)*(obs_prop_at_age(ifleet,iyr,iage)+1.e-6)*(1-(obs_prop_at_age(ifleet,iyr,iage)+1.e-6)) )
);
               ///////////////////////////////////


           // negative log-likelihood for the multinomial distribution
        neglogLL_PAA(ifleet,iyr) -= resid_PAA(ifleet,iyr,iage)*agedN(ifleet,iyr);
        }
                 PAA_f +=  PAA_wt(wt_choice(2),ifleet,iyr) * neglogLL_PAA(ifleet,iyr);
                 }
      }


         // dubious standard deviation for standardzed residuals -- rather, use effective sample size
        if(ifleet==4) { stdev_PAA(ifleet)=0;}
                else
                 {
                  stdev_PAA(ifleet) = sqrt(  sum(resid_PAA2(ifleet))/double(PAA_n));
                 }
   }



// ----total catch kill -----------------------------------------
      tC_f = 0;
      tC_n = 0;
      neglogLL_tC = 0;
      for(ifleet=1;ifleet<=nfleets;ifleet++)
       {
```

```
      for(iyr=first_fyr(ifleet);iyr<=last_fyr(ifleet);iyr++)
        {
        tC_n++;
            // standardized residual
        resid_tC(ifleet,iyr) = (  log(obs_tot_catch(ifleet,iyr)+1.e-6) - log(pred_catch(ifleet,iyr)+1.e-
6)  )/
                                             sqrt(log(pow(tot_catch_CVs(ifleet,iyr),2)+1));
            // standardized residual from average
        residmean_tC(ifleet,iyr) = (  log(obs_tot_catch(ifleet,iyr)+1.e-6) - ave_obstC(ifleet)  )/
                                             sqrt(log(pow(tot_catch_CVs(ifleet,iyr),2)+1));

               // squared residuals//////////////////
        resid_tC2(ifleet,iyr) = square (  ( log(obs_tot_catch(ifleet,iyr)+1.e-6) -
log(pred_catch(ifleet,iyr)+1.e-6) )/
                                             sqrt(log(pow(tot_catch_CVs(ifleet,iyr),2)+1))   );
        residmean_tC2(ifleet,iyr) = square(   ( log(obs_tot_catch(ifleet,iyr)+1.e-6) - ave_obstC(ifleet)
)/
                                             sqrt(log(pow(tot_catch_CVs(ifleet,iyr),2)+1))  );
              ///////////////////////////////////

              // negative log-likelihood for the lognormal distribution
       neglogLL_tC (ifleet) +=  0.5*square( resid_tC(ifleet,iyr) ) +
log(sqrt(log(pow(tot_catch_CVs(ifleet,iyr),2)+1)));
        }
      tC_f += neglogLL_tC(ifleet)*totcatch_wt(wt_choice(1),ifleet);
      }

      /////////////////////////// End of Observation Model ////////////////////////////////

   // objective function sum of likelihoods -- F_brake is near zero and could be dropped in last phase
   f += ndx_f + PAA_f + tC_f + F_brake_penalty;




REPORT_SECTION
  report << " Dump ALL INPUT DATA to verify correct read" << endl;
  report << nfleets << endl;
  report << endl;
  report << firstyr << "  " << lastyr << endl;
  report << endl;
  report << firstage << "  " << lastage << endl;
  report << endl;
  report << first_fyr << last_fyr << endl;
```

```
  report << endl;
  report << last_sel_age << endl;
  report << endl;
  report << M << endl;
  report << endl;
  report << yr_sel_block << endl;
  report << endl;
  report << obs_tot_catch << endl;
  report << endl;
  report << obs_prop_at_age << endl;
  report << endl;
  report << n_ndx << endl;
  report << endl;
  report << first_syr << endl;
  report << endl;
  report << last_syr << endl;
  report << endl;
  report << survey_ndx << endl;
  report << endl;
  report << endl;
  report << "unwted_obj fnctn fit " <<
sum(neglogLL_ndx)+sum(neglogLL_PAA)+sum(neglogLL_tC)+F_brake_penalty
                                     +norm2(fill_log_sel)<< endl;
  report << endl;
  report << "Objective function total = " << setw(15) << setprecision(5) << f << endl;
  report << "   Index part (wted)     = " << setw(15) << setprecision(5) << ndx_f << setw(15) <<
setprecision(5) << double(ndx_n) << endl;
  report << "   PAA part  (wted)      = " << setw(15) << setprecision(5) << PAA_f << setw(15) <<
setprecision(5) << double(PAA_n2) << endl;
  report << "   total catchpart (wted)= " << setw(15) << setprecision(5) << tC_f << setw(15) <<
setprecision(5) << double(tC_n) << endl;
  report << "   F brake penalty       ="  << F_brake_penalty << // " initN devs = " <<
norm2(log_initN_devs) <<
            " log selectivity devs = " << 5.*norm2(fill_log_sel) << endl; //" log recruit devs = " <<
norm2(log_recruit_devs) << endl;
  report << "Look at fits - predicted" << endl;
  report << " indices " << endl;
    for(indx=1;indx<=n_ndx;indx++)
      {
      for(iyr=first_syr(indx);iyr<=last_syr(indx);iyr++)
        {
        report << setw(5) << setprecision(0) << indx
               << setw(5) << setprecision(0) << iyr
               << setw(10) << setprecision(5) << pred_ndx(indx,iyr) << endl;
```

```
       }
     }
 report << endl;
 report << " proportion at age " << endl;
     for(ifleet=1;ifleet<=nfleets;ifleet++)
       {
       for(iyr=first_fyr(ifleet);iyr<=last_fyr(ifleet);iyr++)
         {
         report << setw(5) << setprecision(0) << ifleet
                << setw(5) << setprecision(0) << iyr
                << setw(10) << setprecision(5) << C(ifleet,iyr)/pred_catch(ifleet,iyr) << endl;
         }
       }
 report << endl;
 report << " total catch " << endl;
   for(ifleet=1;ifleet<=nfleets;ifleet++)
     {
     for(iyr=first_fyr(ifleet);iyr<=last_fyr(ifleet);iyr++)
       {
          report << setw(5) << setprecision(0) << ifleet
                 << setw(10) << setprecision(0) << iyr
                 << setw(15) << setprecision(0) << pred_catch(ifleet,iyr) << endl;
       }
     }
 report << endl;
 report << "Predicted population dynamics" << endl;
 report << "Abundance" << endl;
     for(iyr=firstyr;iyr<=lastyr;iyr++)
       {
        report << setw(5) << setprecision(0) << iyr
               << setw(15) << setprecision(9) << mfexp(log_N(iyr)) << endl;
        }
 report << endl;
 report << "F at age by fleet" << endl;
    for(ifleet=1;ifleet<=nfleets;ifleet++)
      {
      for(iyr=first_fyr(ifleet);iyr<=last_fyr(ifleet);iyr++)
       {
        report << setw(5) << setprecision(0) << ifleet
               << setw(5) << setprecision(0) << iyr
               << setw(10) << setprecision(5) << mfexp(log_Ffleet(ifleet,iyr))
               << setw(10) << setprecision(5) << EffN(ifleet,iyr) << endl;
```

```
      }
    }
report << endl;
report << "Check bounded values" << endl;
report << "fill_log_sels" << endl;
report << setw(5) << setprecision(0) << fill_log_sel << endl;
report << endl;
report << "log_Fmult" << endl;
report << setw(5) << setprecision(0) << log_Fmult << endl;
report << endl;
report << "log_initN" << endl;
report << setw(5) << setprecision(0) << log_initN << endl;
report << endl;
report << "log_recruits" << endl;
report << setw(5) << setprecision(0) << log_recruits << endl;
report << endl;
report << "log_q_ndx" << endl;
report << setw(5) << setprecision(0) << log_q_ndx << endl;
report << endl;
report << "selectivities" << endl;
     for (ifleet=1;ifleet<=nfleets;ifleet++)
           {
            for (i=1;i<=yr_sel_block(ifleet,last_fyr(ifleet));i++)
             {
                report << setw(5) << setprecision(0) << ifleet
                       << setw(5) << setprecision(0) << i
                       << setw(10) << setprecision(5) << mfexp(log_sel(ifleet,i)) << endl;
            }
          }
 report << endl;
 report << "weighting scheme for this run" << endl;
 report << "TC wt" << setw(10) << setprecision(5) << totcatch_wt(wt_choice(1)) << endl;
 report << "PAA wt" << endl;
 report << setw(10) << setprecision(5) << PAA_wt(wt_choice(2)) << endl;
 report << "Index wt" << setw(10) << setprecision(5) << indx_wt(wt_choice(3)) << endl;
 report << "Fbrake" << setw(10) << setprecision(5) << F_brake << endl;

 report << endl;
 report << "Total F estimates by year and age" << endl;
         for (iyr=firstyr;iyr<=lastyr;iyr++)
          {
           report << setw(5) << setprecision(0) << iyr;
```

```
          for (iage=firstage;iage<=lastage;iage++)
           {
            report << setw(10) << setprecision(5) << tot_F(iyr,iage);
           }
          report << endl;
          }
 report << endl;

 report << "total catch fit" << endl;
   for(ifleet=1;ifleet<=nfleets;ifleet++)
    {
      stdev_tC(ifleet) = std_dev(resid_tC(ifleet));
      report << "neg_logL = " << neglogLL_tC(ifleet) << "   SDSR =  " << stdev_tC(ifleet) << endl;
    for(iyr=first_fyr(ifleet);iyr<=last_fyr(ifleet);iyr++)
     {
      report << setw(5) << setprecision(0) << ifleet
             << setw(5) << setprecision(0) << iyr
             << setw(15) << setprecision(5) << resid_tC2(ifleet,iyr)
             << setw(15) << setprecision(5) << residmean_tC2(ifleet,iyr) << endl;
     }
    }

 report << "index fit" << endl;
   for(indx=1;indx<=n_ndx;indx++)
    {
      stdev_ndx(indx) = std_dev(resid_ndx(indx));
      report << "neg_logL = " << neglogLL_ndx(indx) << "    SDSR = " << stdev_ndx(indx) << endl;
    for(iyr=first_syr(indx);iyr<=last_syr(indx);iyr++)
     {
      report << setw(5) << setprecision(0) << indx
             << setw(5) << setprecision(0) << iyr
             << setw(15) << setprecision(5) << resid_ndx2(indx,iyr)
             << setw(15) << setprecision(5) << residmean_ndx2(indx,iyr) << endl;
     }
    }

 report << "Proportion at age" << endl;
for (ifleet=1;ifleet<=nfleets;ifleet++)
 {
   report << "neg_logL = " << sum(neglogLL_PAA(ifleet)) << "    SDSR = " << stdev_PAA(ifleet) << endl;
 for (iyr=first_fyr(ifleet);iyr<=last_fyr(ifleet);iyr++)
   {
```

```
      report << setw(5) << setprecision(0) << ifleet
                << setw(5) << setprecision(0) << iyr
                << setw(15) << setprecision(5) << sum(resid_PAA2(ifleet,iyr))
                << setw(15) << setprecision(5) << sum(residmean_PAA2(ifleet,iyr)) << endl;
      }
    }
        report << " static SPR     " << setw(15) << setprecision(5) << static_SPR << endl;
        report << " escapement 1-3 " << setw(15) << setprecision(5) << escapement13 << endl;
        report << " escapement 1-5 " << setw(15) << setprecision(5) << escapement15 << endl;
        report << " t Esc 1-3 " << setw(15) << setprecision(5) << tEsc13 << endl;
        report << " t Esc 1-5 " << setw(15) << setprecision(5) << tEsc15 << endl;

        report << "sel constraint estimates (4 and 5)=" << sel04 << "   " << sel05 << endl;
```

Input data

```
#Southern Region 1989-2007
#
# Defining 7 fleets with each state's (FL,GA,SC) having A+B1 rec, only FL com, and FLrec B2 fishery then combined GASC B2
# DECISION: added small com landings from GA SC to their A+B1 rec fisheries
#
#fleets
5
# global first and last years used in assessment
1989 2007
#
# first and last year for each fishing fleet
1989 1989 1989 1989 1989
2007 2007 2007 2007 2007
#
#firstage lastage (same for all fleets)
1 7
#
#last age selectivity estimated for
 3
#natural mortality (from nonparametric VBG curve)
#   1    2    3    4    5    6    7
 0.26 0.18 0.15 0.14 0.13 0.12 0.11
#
#selectivity block by fleet (each row is a fleet;1=FLrec,2=Garec/com,3=SCrec/com,..4)FL live rel,5)B2 fleets FL,GA/SC)
#89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07
 1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1
 1  1  1  2  2  2  2  2  2  2  2  2  2  3  3  3  3  3  3
 1  1  1  1  1  2  2  2  2  2  2  2  3  3  3  3  3  3  3
 1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1
```

```
 1  1  1  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
#
# total kill by fleet in numbers (A+B1 for recs)
#1989    1990    1991    1992    1993    1994    1995    1996    1997    1998    1999    2000    2001    2002    2003    2004    2005    2006
2007
34747   44279   102727  104125  66685   120938  96928   146822  75094   108440  131219  194677  181079  120640  171365  164171  196236
149756  199159
51235   76612   163133  85875   108189  139260  141673  63151   39361   27600   69011   94429   90395   93305   123443  133402  107970  82269
103385
127826  113191  127421  114778  122141  119083  177072  125835  131834  47617   45826   37360   61046   41471   162695  132075  141023  72487
88220
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       0       0       0       0       0       0       0       0       0       0       0
0
#
# CV's for landings or releases depending on fishery (FL com assumed 0.01
#1989    1990    1991    1992    1993    1994    1995    1996    1997    1998    1999    2000    2001    2002    2003    2004    2005    2006
2007
0.243   0.227   0.157   0.141   0.103   0.099   0.107   0.161   0.141   0.102   0.078   0.083   0.081   0.086   0.083   0.084   0.091   0.082
0.090
0.220   0.224   0.231   0.164   0.176   0.172   0.165   0.198   0.191   0.195   0.231   0.196   0.303   0.187   0.168   0.230   0.186   0.190
0.175
0.207   0.222   0.225   0.156   0.173   0.191   0.208   0.138   0.134   0.157   0.181   0.232   0.269   0.215   0.231   0.154   0.187   0.239
0.208
0.213   0.183   0.233   0.115   0.118   0.104   0.091   0.093   0.097   0.087   0.08    0.073   0.075   0.091   0.084   0.078   0.075   0.072
0.078
0.228   0.282   0.264   0.174   0.193   0.141   0.141   0.133   0.226   0.121   0.149   0.150   0.160   0.132   0.125   0.131   0.111   0.115
0.106
#
#input B2 selectivity for rec northern region by age (columns through last_sel_age) and year (rows)
0.684   1.000   0.207   0.089   0.089   0.089   0.089
# total release by fleet (B2's -- SC 1984 zero is averaged across adjacent years)
#1989    1990    1991    1992    1993    1994    1995    1996    1997    1998    1999    2000    2001    2002    2003    2004    2005    2006
2007
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       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       0       0       0       0
0
172303  68667   645772  284798  465657  691811  683706  500278  560345  482040  583157  712492  863580  670215  803039  1137540 1271042
893781  897091
115003  256955  198077  176347  299961  468735  727458  276123  219315  118645  113392  230359  470258  325547  719907  546486  822107
755500  728744
#
#release mortality
 0.08
#
#proportion catch at age (age columns, year rows) by fleet
#Age      1               2               3               4               5               6               7               8               9
10+
# FLrec (AB1 prop at age)
0.31491021      0.48049246      0.12347638      0.06181182      0.00783740      0.00689753      0.00457420
0.24098580      0.47409672      0.15999462      0.08454883      0.01388023      0.01414645      0.01234736
0.16702276      0.29777916      0.26486572      0.22405532      0.03166977      0.00657599      0.00803128
0.30967310      0.31656060      0.19716913      0.14495885      0.01365739      0.00763239      0.01034854
0.10866745      0.36579754      0.29856153      0.17673439      0.02526153      0.01491402      0.01006354
```

0.17953596	0.31587891	0.30031710	0.17939555	0.01256366	0.00505562	0.00725322
0.11702704	0.30777011	0.33983358	0.18920826	0.02241453	0.00637073	0.01737576
0.22010868	0.33805670	0.26139372	0.15497726	0.01788476	0.00373733	0.00384154
0.18653179	0.29320276	0.24769939	0.20553831	0.02714874	0.02077304	0.01910598
0.10784524	0.36313031	0.35031347	0.14930099	0.01825740	0.00779767	0.00335492
0.03845467	0.53227078	0.35115582	0.05616096	0.02195777	0.00000000	0.00000000
0.02401761	0.51088664	0.36026963	0.07174471	0.03308141	0.00000000	0.00000000
0.02482402	0.47662003	0.36615689	0.08837673	0.04389968	0.00000000	0.00012265
0.01007436	0.47685025	0.37480700	0.09497156	0.04329683	0.00000000	0.00000000
0.01981715	0.52036051	0.36055582	0.06363114	0.03563539	0.00000000	0.00000000
0.01555853	0.44304880	0.34944481	0.18347572	0.00847214	0.00000000	0.00000000
0.02869365	0.43988907	0.36660982	0.15375091	0.01105655	0.00000000	0.00000000
0.01693788	0.37794664	0.44798483	0.14113257	0.01589195	0.00003032	0.00007581
0.02978489	0.39047265	0.42949546	0.13710285	0.01314415	0.00000000	0.00000000
#GArec/com (AB1 prop at age)						
0.58807613	0.35680267	0.05231875	0.00275960	0.00002142	0.00000000	0.00002142
0.59379797	0.26131516	0.08816583	0.01466469	0.00034733	0.00372683	0.03798219
0.73753163	0.23628607	0.01865553	0.00752677	0.00000000	0.00000000	0.00000000
0.70990141	0.24566672	0.03121396	0.00398124	0.00101811	0.00110938	0.00710918
0.62853250	0.27307518	0.07494238	0.01852342	0.00236331	0.00040910	0.00215410
0.69157626	0.27337695	0.03307431	0.00197248	0.00000000	0.00000000	0.00000000
0.71064814	0.25169231	0.03613704	0.00149097	0.00001578	0.00000000	0.00001578
0.68907944	0.28339394	0.02392936	0.00348294	0.00006533	0.00001633	0.00003266
0.52709418	0.38161973	0.07491347	0.01349308	0.00287954	0.00000000	0.00000000
0.50857638	0.42506809	0.05537142	0.01098411	0.00000000	0.00000000	0.00000000
0.60780851	0.34030628	0.05188521	0.00000000	0.00000000	0.00000000	0.00000000
0.56457193	0.31181173	0.10821051	0.01540583	0.00000000	0.00000000	0.00000000
0.74783700	0.23056974	0.01778527	0.00379655	0.00000000	0.00000000	0.00001144
0.62638628	0.34851337	0.02221689	0.00288346	0.00000000	0.00000000	0.00000000
0.65512016	0.30180315	0.04307670	0.00000000	0.00000000	0.00000000	0.00000000
0.30019432	0.61402208	0.08271649	0.00306711	0.00000000	0.00000000	0.00000000
0.63523497	0.33689193	0.02780420	0.00006890	0.00000000	0.00000000	0.00000000
0.45014750	0.53095416	0.01629958	0.00254976	0.00000000	0.00000109	0.00004792
0.55402776	0.43192821	0.01220683	0.00183720	0.00000000	0.00000000	0.00000000
#SCrec/com (AB1 prop at age)						
0.46673155	0.40522280	0.10678364	0.02026848	0.00073466	0.00001726	0.00024161
0.41886135	0.50722428	0.06177473	0.01162317	0.00047980	0.00000000	0.00003667
0.69379537	0.28492226	0.01899512	0.00093946	0.00038801	0.00009213	0.00086765
0.48001112	0.45784774	0.04723312	0.00424613	0.00406233	0.00000000	0.00659956
0.39646715	0.49961103	0.08372224	0.01840634	0.00140248	0.00000381	0.00038695
0.34777466	0.54623850	0.09285186	0.01274663	0.00036686	0.00002148	0.00000000
0.62140162	0.31418236	0.04777840	0.01450957	0.00207994	0.00000039	0.00004773
0.30077812	0.64126531	0.04650402	0.01041973	0.00100249	0.00003033	0.00000000
0.85118386	0.09215811	0.03184139	0.02319292	0.00115356	0.00040086	0.00006930
0.32008089	0.53968954	0.09455215	0.04164577	0.00396179	0.00006884	0.00000103
0.48523039	0.42423492	0.07823522	0.01156125	0.00073562	0.00000260	0.00000000
0.47343670	0.41549695	0.09345039	0.01632059	0.00129537	0.00000000	0.00000000
0.63593933	0.27528619	0.07257250	0.01561033	0.00057439	0.00000036	0.00001690
0.30850326	0.65687384	0.03138038	0.00313999	0.00009259	0.00000995	0.00000000

```
0.25146987	0.60923356	0.08854771	0.04609571	0.00460995	0.00004319	0.00000000
0.17700903	0.67717688	0.11284406	0.03082222	0.00208840	0.00005941	0.00000000
0.34798908	0.50528206	0.13161702	0.01469452	0.00041732	0.00000000	0.00000000
0.38985967	0.52441218	0.07179190	0.00805968	0.00052236	0.00013059	0.00522361
0.48428648	0.51009810	0.00555809	0.00005733	0.00000000	0.00000000	0.00000000
#
# FLrec B2 age comp -- replaced by NC selectivity-based estimates
0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
#SC rec+GArec B2 age comp
0.57656953	0.28111028	0.08379944	0.03754222	0.00985708	0.00228353	0.00883757
0.71166677	0.20015928	0.04490851	0.02861340	0.00771494	0.00167849	0.00525781
0.78573592	0.17899055	0.02412844	0.00290153	0.00118827	0.00148533	0.00557000
0.61077378	0.32486203	0.05032028	0.00812315	0.00197644	0.00075131	0.00319309
0.38803167	0.34818939	0.19059958	0.05764308	0.00678737	0.00109361	0.00765529
0.17593282	0.32820075	0.26674962	0.17065048	0.02135410	0.00682225	0.03029063
0.28264395	0.29654444	0.16343297	0.18125057	0.03210796	0.00344994	0.04060000
0.10979195	0.45442694	0.17678472	0.16191921	0.06208160	0.00704642	0.02794915
0.17340378	0.24925145	0.27697305	0.22385249	0.04343180	0.01082930	0.02225922
0.15959003	0.30814581	0.13213125	0.20187088	0.09069977	0.01515136	0.09241188
0.16065846	0.29308053	0.22628033	0.16997654	0.09273685	0.01721775	0.04010745
0.08335014	0.28991161	0.26876571	0.21687327	0.08311522	0.00648803	0.05110862
0.16925367	0.15206610	0.24624962	0.22281958	0.07683213	0.01688954	0.11589008
0.06085357	0.34027738	0.18944133	0.15471936	0.10545862	0.01132624	0.13792460
0.02785600	0.28280930	0.29927904	0.21984056	0.08646740	0.02630834	0.05743969
0.01870044	0.27219603	0.31565140	0.26644652	0.06815821	0.02640779	0.03518406
0.03949210	0.19312508	0.35730393	0.26038392	0.08556977	0.01374777	0.04967044
0.03337321	0.23233154	0.31690157	0.27383913	0.07665807	0.02224871	0.04633637
0.12530176	0.30476423	0.27110751	0.15399790	0.07972887	0.00604072	0.05905853
# assumed ages sampled by fleet and year( 1=FLcom,2=FLrec,3=Garec/com,4=SCrec/com,5=B2FL, 6=B2GA/SC) -- sqrt alkN or 2
#1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
2007
```

```
7       2       2       2       1       6       9       5       16      12      10      9       9       10      8       10      12      12
13
2       2       2       2       2       2       2       2       15      19      17      12      11      22      23      19      17      15
13
2       2       43      47      46      46      48      49      47      44      42      36      59      65      72      72      67      35
36
2       2       2       2       2       2       2       2       2       2       2       2       2       2       2       2       2       2
2
2       2       2       2       2       2       2       2       2       2       2       2       2       2       2       2       2       2
2
# number of indices
# YOY's: 1)FL 2)GA 3)SC; subadult: 4)FL hs 2 5)FL hs 3 6)SC tn 2 7) MRFSS 8) SC adults
  8
# first year of surveys forllowed by last year of surveys
  1998 2003 2000 1997 1997 1991 1991 1994
  2007 2007 2007 2007 2007 2007 2007 2007
# indices ages (indices in order by row showing begin, end ages)
 1  1  1  2  3  2  1 6
 1  1  1  2  3  2  3 7
#
# middle of survey (months)
  0  6  6  6   6   0  6   10
#
#observed index values across years (columns)
# YOY's: 1)FL 2)GA 3)SC; subadult: 4)FL hs 2 5)FL hs 3 6)SC tn 2 7) MRFSS 8)SC adult --FLyoy pushed
# 91-07 MRFSS am, FL yoy am, GA yoy, sc trammel, FL haul seine ok,
#1990   1991    1992    1993    1994    1995    1996    1997    1998    1999    2000    2001    2002    2003    2004    2005    2006    2007
                                                                0.039   0.099   0.030   0.050   0.069   0.133   0.125   0.228   0.048   0.109
                                                                                                        4.54    1.91    2.85    0.48    3.14
                                                                                1.68    1.20    1.20    0.57    0.71    0.54    0.66    0.93
                                                        0.07    0.169   0.108   0.198   0.097   0.169   0.083   0.146   0.196   0.136   0.153
                                                        0.089   0.044   0.05    0.038   0.069   0.051   0.096   0.05    0.041   0.075   0.094
        4.46    4.93    3.35    2.02    1.95    2.05    1.21    1.68    1.22    1.16    0.71    3.63    2.18    2.78    1.53    1.26    0.91
        0.140   0.149   0.148   0.182   0.208   0.161   0.165   0.130   0.125   0.113   0.141   0.125   0.153   0.154   0.164   0.156   0.144
                                2.577   3.138   2.875   1.131   1.913   2.600   1.875   2.548   4.055   4.347   2.931   2.310   1.941   1.143
# estimated CV's for the index values
#1990   1991    1992    1993    1994    1995    1996    1997    1998    1999    2000    2001    2002    2003    2004    2005    2006    2007
                                                                1.001   0.387   0.419   0.369   0.344   0.292   0.303   0.283   0.292   0.276
                                                                                                        0.3814  0.5038  0.3471  0.301
0.4891
                                                                                0.5591  0.3291  0.2651  0.1033  0.1604  0.1513  0.2917
0.1951
                                                        0.174   0.161   0.159   0.156   0.153   0.134   0.141   0.128   0.13    0.132   0.124
                                                        0.174   0.161   0.159   0.156   0.153   0.134   0.141   0.128   0.13    0.132   0.124
        0.233   0.124   0.139   0.206   0.171   0.156   0.255   0.143   0.196   0.206   0.347   0.066   0.107   0.081   0.145   0.176   0.248
        0.354   0.287   0.276   0.251   0.261   0.243   0.243   0.241   0.197   0.203   0.183   0.194   0.201   0.186   0.196   0.188   0.208
                                0.248   0.145   0.200   0.169   0.177   0.110   0.200   0.134   0.142   0.103   0.131   0.221   0.160   0.484
#Fbrake level, eliminates low F/high N bias in early phases of solution
 2000.
# choice of weighting scheme
# TC, PAA, Ndx
   1.   2.   1.
# weight, maturity, and M  at age through age 38
```

0.745867914	0.00	0.2638464
2.267529707	0.00	0.1840338
4.37580732	0.01	0.1519453
6.760009123	0.58	0.1374477
9.173469286	0.99	0.1284954
11.45526322	1.00	0.1211395
13.51699411	1.00	0.1147478
15.32201767	1.00	0.1098573
16.86679767	1.00	0.1066331
18.16689012	1.00	0.1046954
19.24738101	1.00	0.1035679
20.13681845	1.00	0.1029001
20.86362728	1.00	0.1024811
21.45417678	1.00	0.1021946
21.93189338	1.00	0.1019771
22.31699989	1.00	0.1017924
22.62660715	1.00	0.1016172
22.87498464	1.00	0.101433
23.07390545	1.00	0.1012223
23.23300492	1.00	0.1009657
23.36012044	1.00	0.1006416
23.46159685	1.00	0.1002297
23.54255179	1.00	0.09971932
23.60710128	1.00	0.0991217
23.65854837	1.00	0.09848023
23.69953899	1.00	0.0978663
23.73218976	1.00	0.09735495
23.75819204	1.00	0.09699182
23.77889616	1.00	0.09677546
23.79537947	1.00	0.09666848
23.80850107	1.00	0.09662475
23.81894567	1.00	0.0966099
23.82725888	1.00	0.09660567
23.83387529	1.00	0.09660463
23.839141	1.00	0.09660441
23.84333162	1.00	0.09660437
23.84666655	1.00	0.09660436
23.84932046	1.00	0.09660436

Weight options files

```
#Fule: s0_TC.wts
#weights
#total catch by fleet
# Ha:default
#fleet1 fleet2 fleet3 fleet4 fleet5 fleet6
   1.     1.     1.     1.     1.     1.
# Ha:B2 rec total catch estimates are suspect
```

```
#fleet1 fleet2 fleet3 fleet4 fleet5 fleet6

   1.     1.     1.     1.     0.1    0.1

# Ha:B2 rec total catch estimates are really suspect

#fleet1 fleet2 fleet3 fleet4 fleet5 fleet6

   1.     1.     1.     1.     0.01    0.01


#File: s0_PAA.wts

#weights

#Ha:default

#catch at age by fleet and year

#1982   1983    1984    1985    1986    1987    1988    1989    1990    1991    1992    1993    1994    1995    1996    1997    1998    1999
2000    2001    2002    2003    2004    2005    2006    2007

1       1       1       1       1       1       1       0       0       0       0       0       0       0       0       0       0       0
0       0       0       0       0       0       0       0

1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1
1       1       1       1       1       1       1       1

1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1
1       1       1       1       1       1       1       1

1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1
1       1       1       1       1       1       1       1

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       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1
1       1       1       1       1       1       1       1

#Ha:the B2 age compostion data is very uncertain

#catch at age by fleet and year

#1982   1983    1984    1985    1986    1987    1988    1989    1990    1991    1992    1993    1994    1995    1996    1997    1998    1999
2000    2001    2002    2003    2004    2005    2006    2007

1       1       1       1       1       1       1       0       0       0       0       0       0       0       0       0       0       0
0       0       0       0       0       0       0       0

1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1
1       1       1       1       1       1       1       1

1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1
1       1       1       1       1       1       1       1

1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1
1       1       1       1       1       1       1       1

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

0.1     0.1     0.1     0.1     0.1     0.1     0.1     0.1     0.1     0.1     0.1     0.1     0.1     0.1     0.1     0.1     0.1     0.1
0.1     0.1     0.1     0.1     0.1     0.1     0.1     0.1

#Ha:the B2 age compostion data is very,very uncertain

#catch at age by fleet and year

#1982   1983    1984    1985    1986    1987    1988    1989    1990    1991    1992    1993    1994    1995    1996    1997    1998    1999
2000    2001    2002    2003    2004    2005    2006    2007

1       1       1       1       1       1       1       0       0       0       0       0       0       0       0       0       0       0
0       0       0       0       0       0       0       0

1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1
1       1       1       1       1       1       1       1

1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1
1       1       1       1       1       1       1       1

1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1
1       1       1       1       1       1       1       1

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

0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001


#File: s0_Ndx.wts

#weights
```

```
#Ha:default
# index weight
 1. 1. 1. 1. 1. 1. 1. 1.
#Ha:the MRFSS index is best due to areal coverage
# index weight
 1. 1. 1. 1. 1. 1. 10. 1.
#Ha:the yoy indexes are best due to scientifically design and ease of capture
# index weight
 10. 10. 10. 1. 1. 1. 1. 1.
```