S E D A R

Southeast Data, Assessment, and Review

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SEDAR 18

Assessment Workshop Report

Atlantic Red Drum

July 30, 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

SEDAR
The South Atlantic Fishery Management Council
4055 Faber Place #201
North Charleston, SC 29405
(843) 571-4366

Section II. Assessment Workshop Report

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1 Workshop Proceedings

1.1 Introduction

1.1.1 Workshop Time and Place

The SEDAR 18 Assessment Workshop was held June 1-5, 2009, in North Charleston, SC.

1.1.2 Terms of Reference

1. 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.
2. 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.
3. 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.
4. 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'.
5. Provide yield-per-recruit, spawner-per-recruit, and stock-recruitment evaluations, including figures and tables of complete parameters.
6. 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%).
7. 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.
8. 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.
9. 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.
10. 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.

1.1.3 Participants

Appointee	Function	Affiliation
Coordination		
Dale Theiling	Chairman	SEDAR
Rachael Lindsay	Administrative Support	SEDAR
Technical Committee Representatives		
Lee Paramore	Stock Leader and Proceedings Editor	ASMFC TC
Rapporteur		
Mike Denson	Rapporteur	ASMFC TC
Analytical Team		
Mike Murphy	Lead Analyst and Model Editor	ASMFC RD SAS
Joe Grist	Analyst	ASMFC RD SAS
Lee Paramore	Analyst	ASMFC RD SAS
Mike Denson	Analyst	ASMFC RD SAS
Carolyn Belcher	Analyst	ASMFC RD SAS
Noel Cadigan	Analyst	CIE
Consultant		
Doug Vaughan	Assessment History Consultation	SEFSC-Beaufort
Data Workgroup Leaders		
Joe Grist	Life History Data Presenter	ASMFC TC
Lee Paramore	Commercial Data Presenter	ASMFC TC
Mike Denson	Recreational Data Presenter	ASMFC TC
Mike Murphy	Indices Presenter	ASMFC RD SAS
Commission Representatives		
Robert Boyles	Commissioner	ASMFC
Nichola Meserve	Red Drum FMP Coordinator	ASMFC
Katie Drew	Stock Assessment Scientist/ Data Compiler	ASMFC
Advisory Panel Representatives		
Bill Windley	ASMFC AP Chair	Recreational, MD
Gene Dickson	ASMFC AP Member	Recreational, SC

Acronyms

AP	Advisory Panel
ASMFC TC	Atlantic States Marine Fisheries Commission Technical Committee
CIE	Center for Independent Experts
MD	Maryland
RD SAS	Red Drum Stock Assessment Subcommittee
SEFSC	Southeast Fisheries Science Center, National Marine Fisheries Service
SC	South Carolina
SEDAR	Southeast Data, Assessment, and Review

1.1.4 Workshop Documents

Research documents and working papers prepared for and by the SEDAR 18 assessment and data workshop follow. Several included working papers were prepared or updated following the assessment workshop.

SEDAR 18

Atlantic Red Drum

Workshops Document List

Document #	Title	Authors
	Documents Prepared for the Data Workshop	
SEDAR18-DW01	Red drum assessment history	Vaughan 2008
SEDAR18-DW02	Overview of red drum tagging data and recapture results by state from Virginia to Florida	S-18 DW Tagging Workgroup 2009
SEDAR18-DW03	Atlantic states red drum management overview	Meserve 2009
SEDAR18-DW04	Georgia's marine sportfish carcass recovery project	Georgia DNR
SEDAR18-DW05	Georgia's metadata for fishery independent red drum data 2002-07	Georgia DNR
SEDAR18-DW06	North Carolina biological data-surveys descriptions and background info	Paramore 2009
SEDAR18-DW07	Life-history based estimates of natural mortality for U. S. south Atlantic red drum	Vaughan 2008
SEDAR18-DW08	Reported commercial landings of red drum in Florida and estimated annual length and age composition	Murphy 2009
SEDAR18-DW09	Recreational harvest estimates and estimated catch-at-age for the recreational fishery in Florida during 1982-2007	Murphy 2009
SEDAR18-DW10	Indices of relative abundance for young-of-the-year and subadult red drum in Florida	Murphy 2009
SEDAR18-DW11	South Carolina red drum electro-fishing survey	SC DNR undated
SEDAR18-DW12	South Carolina red drum tagging data	S. Arnott 2009
SEDAR18-DW13	South Carolina tournament and fish wrack recycle program 2002-2007	McDonough undated
SEDAR18-DW14	Assessment of adult red drum in South Carolina	SC DNR undated

SEDAR18-DW15	South Carolina fishery independent survey description and protocol	SC DNR undated
SEDAR18-DW16	An estimate of rd removals from North Carolina estuarine gill net fishery occurring from both recreational users of gill nets and from regulatory and unmarketable discards	Paramore 2009
SEDAR18-DW17	Estimating the size and age composition of the b–2 fish (caught and released alive) in the recreational fishery for red drum and spotted seatrout in South Carolina	McDonough, Wenner 2009
SEDAR18-DW18	South Carolina randomly stratified trammel net survey	Arnott 2009
Documents Prepared for the Assessment Workshop		
SEDAR18-AW01	Estimating the age composition of the MRFSS estimated landings for red drum along the Atlantic coast	Murphy 2009
SEDAR18-AW02	Nonparametric growth model for the northern region Atlantic red drum stock and changes to natural mortality (M) estimates	Cadigan 2009
SEDAR18-AW03	Preliminary estimation of red drum fishing mortality rates in the southern and northern regions using the SVPA/FADAPT method employed in the last assessment and comparison of findings between short (1986-1998) and long (1982-2007) time frame runs	Murphy 2009
SEDAR18-AW04	Estimation of the length and age composition of red drum caught and released alive by anglers fishing along the mid and south Atlantic coast of the U.S. during 1982-2007	Murphy 2009
SEDAR18-AW05text SEDAR18-AW05table	References and selected abstracts on red drum hook mortality	Denson, Arnott 2009
SEDAR18-AW06	Graphical analyses of the catch age composition for red drum	Cadigan 2009
SEDAR18-AW07	Semi-separable untuned VPA for red drum	Cadigan 2009
SEDAR18-AW08	Description of the input and findings from potential base model runs for the northern and southern red drum stocks from the U.S. Atlantic coast	Murphy 2009
SEDAR18-AW09	Description of the age-structured model used to estimate population dynamics parameters for the southern and northern region red drum stocks along the Atlantic coast of the U.S.	Murphy 2009

SEDAR18-AW10	Percentage, by age class, of red drum tagged by the South Carolina marine game fish tagging program	McDonough, Arnott 2009
SEDAR18-AW11	Tagging estimates of abundance at age for the northern region red drum stock	Cadigan, Paramore 2009
SEDAR18-AW12	Continuity run of the spreadsheet virtual population analysis	Grist, Lee 2009
Documents Prepared for the Review Workshop		
SEDAR18-RW01	SEDAR 18 Atlantic red drum preliminary stock assessment report	SEDAR 18
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 DW Panel 2009
SEDAR18-RW Report	SEDAR 18 Review Workshop Report	To be prepared following Review Workshop
Final Assessment Reports		
SEDAR18-SAR01	Assessment of the red drum stock in the U.S. Atlantic	To be prepared following Review Workshop
Reference Documents		
SEDAR18-RD01	Tag-reporting levels for red drum caught by anglers in South Carolina and Georgia estuaries	Denson *et al* 2002
SEDAR18-RD02	Association of large juvenile red drum with an estuarine creek on the Atlantic coast of Florida	Adams and Tremain 2000
SEDAR18-RD03	Use of passive acoustics to determine red drum spawning in Georgia waters	Barbieri *et al* TAFS 2008
SEDAR18-RD04	Spatial and temporal patterns in modeled particle transport to estuarine habitat with comparisons to larval fish settlement patterns	Brown *et al* 2005
SEDAR18-RD05	Incidental catch and discard of red drum, in a large mesh Paralichthyidae gillnet fishery: experimental evaluation of a fisher's experience at limiting bycatch	Buckel *et al* 2006
SEDAR18-RD06	Site fidelity and movement patterns of wild subadult red drum, within a salt marsh-dominated estuarine landscape	Dresser and Kneib 2007

SEDAR18-RD07	Behavior and recruitment success in fish larvae: variation with growth rate and the batch effect	Fuiman *et al* 2005
SEDAR18-RD08	Estimating stock composition of anadromous fishes from mark–recovery data: possible application to American shad	Hoenig, Latour and Olney TAFS 2008
SEDAR18-RD09	Distribution of red drum spawning sites identified by a towed hydrophone array	Holt TAFS 2008
SEDAR18-RD10	Year-class component, growth, and movement of juvenile red drum stocked seasonally in a South Carolina estuary	Jenkins *et al* 2004
SEDAR18-RD11	Experimental investigation of spatial and temporal variation in estuarine growth of age-0 juvenile red drum	Lanier and Scharf 2007
SEDAR18-RD12	Estimates of fishing and natural mortality for subadult red drum in South Carolina waters	Latour *et al* 2001
SEDAR18-RD13	Properties of the residuals from two tag-recovery models	Latour *et al* 2002
SEDAR18-RD14	Habitat triage for exploited fishes: Can we identify essential ‘‘essential fish habitat?’’	Levin and Stunz 2005
SEDAR18-RD15	Identifying sciaenid critical spawning habitats by the use of passive acoustics	Luczkovich and Pullinger TAFS 2008
SEDAR18-RD16	Large scale patterns in fish trophodynamics of estuarine and shelf habitats of the southeast US	Marancik and Hare 2007
SEDAR18-RD17	Ecophys.fish: a simulation model of fish growth in time-varying environmental regimes	Neill *et al* 2004
SEDAR18-RD18	Population structure of rd as determined by otolith chemistry	Patterson *et al* 2004
SEDAR18-RD19	A new growth model for rd that accommodates seasonal and ontogenic changes in growth rates	Porch *et al* 2002
SEDAR18-RD20	Estimating abundance from gillnet samples with application to rd in Texas bays	Porch *et al* 2002b
SEDAR18-RD21	Icthyoplankton community structure in a shallow subtropical estuary of the Florida Atlantic coast	Reyier and Shenker 2007
SEDAR18-RD22	Role of an estuarine fisheries reserve in the production and export of ichthyoplankton	Reyier *et al* 2008
SEDAR18-RD23	Trophic plasticity and foraging performance in red drum	Ruehl and DeWitt 2007
SEDAR18-RD24	Estuarine recruitment, growth, and first-year survival of juvenile red drum in North Carolina	Stewart and Scharf TAFS 2008

SEDAR 18-RD25	Habitat-related predation on juvenile wild-caught and hatchery-reared red drum	Stunz and Minello 2001
SEDAR 18-RD26	Selection of estuarine nursery habitats by wild-caught and hatchery-reared juvenile red drum in laboratory mesocosms	Stunz *et al* 2001
SEDAR 18-RD27	Growth of newly settled red drum S*ciaenops ocellatus* in different estuarine habitat types	Stunz *et al* 2002
SEDAR 18-RD28	Multidirectional movements of sportfish species between an estuarine no-take zone and surrounding waters of the Indian River Lagoon, Florida	Tremain *et al* 2004
SEDAR 18-RD29	Marine stock enhancement in Florida: a multi-disciplinary, stakeholder-supported, accountability-based approach	Tringali *et al* 2008
SEDAR 18-RD30	Estimating improvement in spawning potential ratios for south Atlantic red drum through bag and size limit regulations	Vaughan and Carmichael 2002
SEDAR 18-RD31	Catch-and-release mortality in subadult and adult red drum captured with popular fishing hook types	Vecchio and Wenner NAJFM 2008
SEDAR 18-RD32	Using estuarine landscape structure to model distribution patterns in nekton communities and in juveniles of fishery species	Whaley *et al* 2007
SEDAR 18-RD33	Reproductive biology of red drum, S*ciaenops ocellatus,* from the neritic waters of the northern Gulf of Mexico	Wilson and Neiland 1994
SEDAR 18-RD34	An age-dependent tag return model for estimating mortality and selectivity of an estuarine-dependent fish with high rates of catch and release	Bacheler *et al* 2008
SEDAR 18-RD35	Genetic effective size in populations of hatchery-raised red drum released for stock enhancement	Gold *et al* 2008
SEDAR 18-RD36	Contributions to the biology of red drum, *Sciaenops ocellatus*, in South Carolina	Wenner 2000
SEDAR 18-RD37	Recruitment of juvenile red drum in North Carolina: spatiotemporal patterns of year-class strength and validation of a seine survey	Bacheler, Paramore, Buckel, and Scharf 2008
SEDAR 18-RD38	Hooking mortality of spotted seatrout (C*ynoscion nebulosus*), weakfish (*Cynoscion regalis*), red drum (S*ciaenops ocellatus*), and southern flounder (P*aralichthys lethostigma*) in north Carolina	Gearhart 2002
SEDAR 18-RD39	Evaluation of the estuarine hook and line recreational fishery in Neuse River, North Carolina	Brown 2007

SEDAR 18-RD40	Large circle hooks and short leaders with fixed weights reduce incidence of deep hooking in angled adult red drum	Beckwith and Brown 2005
SEDAR 18-RD41	Abiotic and biotic factors influence the habitat use of an estuarine fish	Bacheler, Paramore, Buckel, and Hightower 2008
SEDAR 18-RD42	Stock status of the northern red drum stock	Takade and Paramore 2005
SEDAR 18-RD43	Short-term hooking mortality and movement of adult red drum (S*ciaenops ocellatus*) in the Neuse River, North Carolina	Aguilar 2003
SEDAR 18-RD44	Identification of critical spawning habitat and male courtship vocalization characteristics of red drum, S*ciaenops ocellatus*, in the lower Neuse River estuary of North Carolina	Beckwith 2006
SEDAR 18-RD45	Movement and selectivity of red drum and survival of adult red drum: an analysis of 20 years of tagging data	Burdick, Hightower, Buckel, Paramore, and Pollock 2007
SEDAR 18-RD46	Age, growth, mortality, and reproductive biology of red drum in North Carolina waters	Ross, Stephens, and Vaughan 1995
SEDAR 18-RD47	North Carolina red drum fishery management plan, amendment 1	Red drum FMP advisory committee and NC DMF 2008
SEDAR 18-RD48	Status of the red drum stock of the Atlantic coast- stock assessment report for 1989	Vaughan and Helser 1990
SEDAR 18-RD49	Status of the red drum stock of the Atlantic coast- stock assessment report for 1991	Vaughan 1992
SEDAR 18-RD50	Status of the red drum stock of the Atlantic coast- stock assessment report for 1992	Vaughan 1993
SEDAR 18-RD51	Status of the red drum stock of the Atlantic coast- stock assessment report for 1995	Vaughan 1996
SEDAR 18-RD52	Assessment for Atlantic red drum for 1999- northern and southern regions	Vaughan and Carmichael 2000
SEDAR 18-RD53	Bag and size limit analysis for red drum in northern and southern regions of the U. S. Atlantic	Vaughan and Carmichael 2001
SEDAR 18-RD54	Seasonal variation in age-specific movement patterns of red drum S*ciaenops ocellatus* inferred from conventional tagging and telemetry	Bacheler, Paramore, Burdick, Buckel, Hightower in review
SEDAR 18-RD55	A combined telemetry – tag return approach to estimate fishing and natural mortality rates of an estuarine fish	Bacheler, Buckel, Hightower, Paramore and Pollock in review

SEDAR 18-RD56	Investigation into the feasibility of stocking artificially propagated red drum in Georgia	Pafford, Nicholson, and Woodward 1990
SEDAR 18-RD57	A biological and fisheries profile of red drum, S*ciaenops ocellatus*	Mercer 1984
SEDAR 18-RD58	Ultrasonic biotelemetry study of young-adult red drum in Georgia, July 1993 – September 1995	Nicholson, Jordan, and Purser 1996
SEDAR 18-RD59	Habitat use and movement of subadult red drum, *Sciaenops ocellatus*, within a salt marsh-estuarine system	Dresser 1996
SEDAR 18-RD60	Mortality, movement, and growth of red drum in Georgia	Pafford, Woodward, and Nicholson 1990
SEDAR 18-RD61	Spatial homogeneity and temporal heterogeneity of red drum microsatellites-effective population size and management implications	Chapman, Ball, Mash 2002
SEDAR 18-RD62	A modified stepping-stone model of population structure in red drum from northern Gulf of Mexico	Gold, Burridge, Turner 2001
SEDAR 18-RD63	Population structure of red drum in the northern Gulf of Mexico, as inferred from variation in nuclear-coded microsatellites	Gold, Turner 2002
SEDAR 18-RD64	An analysis of genetic population structure of red drum based on MTDNA control region sequences	Seyoum, Tringali, Bert, McElroy, Stokes 2000
SEDAR18-RD65	The 1960 salt-water angling survey, USFWS Circular 153	J. R. Clark
SEDAR18-RD66	The 1965 salt-water angling survey, USFWS Resource Publication 67	D. G. Deuel and J. R. Clark. 1968
SEDAR18-RD67	1970 salt-water angling survey, NMFS Current Fisheries Statistics Number 6200	D. G. Deuel. 1973
SEDAR18-RD68	Overview of an experimental stock enhancement program for red drum in South Carolina	Smith, Jenkins, Denson 1997

1.2 Panel Recommendations and Comments

1.2.1 Review of Working Papers

The AW Working Papers are reviewed in Sub-item**1.2.2 Review of Terms of Reference** in the context of the reviews of the appropriate Term of Reference.

1.2.2 Review of Terms of Reference

This section addresses each Workshop Term of Reference based on work conducted during and after the assessment workshop. Consensus comments and recommendations that were made by the assessment panel in response to the Assessment Workshop Terms of Reference are included.

1.2.2.1 Term 1.

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.

The last red drum assessment utilized data from 1986-1998 (Vaughan and Carmichael 2000). As with previous SEDARs, the workgroup was tasked with collecting recreational landings for years prior to the start of the MRFSS in 1981. Salt-water angling surveys were conducted in 1960, 1965, and 1970 (Clark 1962; Deuel and Clark 1968; Deuel 1973). These surveys resulted in estimates of the number of anglers, number and weight of fish caught by region for all recreational fishing, and number of days fished per year (1970 survey only). Catch data from the Middle and South Atlantic Regions were included in the proceedings section of the data workshop report. In the 1960 survey, anglers reported only total number of fish caught and fishing method. Biologists and other knowledgeable professionals estimated the average weight per species post-angler interview. In addition to limited utility of weight data from the 1960 survey, the potential for recall bias was also possible in all three surveys. As noted in SEDAR 17, the long recall period of one year could likely lead to overestimates of landings and effort described as “Recall Bias”.

The Assessment Panel concluded that these data have a high degree of uncertainty and also lack any age structures that would make them useful for a statistical catch at age analysis.

MRFSS sampling during wave 1 (Jan-Feb) did not begin until 1982 in Florida where the winter catches can be significant, occasionally more than 20% of the annual catch. Sampling during January and February in the more northern states occurred only sporadically but the catches during this time of the year are considered insignificant. The panel agreed to exclude any recreational data prior to 1982. In addition, the commercial fisheries for both regions lack any biological sampling prior to 1981. As a result, the panel agreed that all assessment data in the statistical catch at age analysis would begin with 1982.

The assessment panel evaluated the applicability and fit of the Von Bertalanffy growth models and their subsequent use in calculating natural mortality for the assessment model. Working paper **S18-AW02**, provides an alternative growth model fit using a nonparametric smooth monotone function. The solution provided by this model resulted in an overall better fit to the observed growth data, particularly for the north region. This growth model resulted in somewhat higher estimates of natural mortality (M) for younger ages based on the scaled Lorenzen method. The largest difference was for one-year old fish from the north region, where the DW Lorenzen-M estimate based on the von Bertalanffy model predicted length was 0.16 and the M estimate based on the nonparametric model was 0.20. The panel decided to adopt the better fitting model proposed in working paper **S18 AW02** and to use the natural mortality values produced from these models. Results of this analysis are provided in Section 2.1 **Life History and Growth.**

The panel discussed the potential effect of management on selectivity. A management overview by state was provided at the data workshop (**S18DW03**). For the North region (North Carolina and north), the panel chose periods based on years where regulations, particularly size limits, were most consistent. Because North Carolina is the dominant contributor to total removals in this region, consistent regulations in this state were given the primary consideration. Panel recommendations for management periods in the north region were: 1982 to 1991, 1992 to 1998, and 1999 to 2007.

In the south region (South Carolina – Florida), all states are major contributors to total annual removals, and furthermore, states have more dissimilar size limits. The assessment panel investigated the use of Shewhart Control charts (Wheeler 1999) to evaluate the effects of management on selectivity for the south region. The data used were sizes of harvested fish from the South Carolina Recreational Finfish Survey and the Georgia Carcass Recovery Program. Average annual sizes and their corresponding variances were plotted over the time series and compared to the grand mean and associated control limits for all years combined. In trying to apply key management dates as logical breaks in the time series for the lengths, it became obvious that management was not the strongest influence on the pattern of average lengths. As such, the method did not provide useful information for determining management breaks.

For the south region, the assessment panel recommended state-specific selectivity periods based on intervals when size limits were similar or unchanged within each state. These time periods were as follows:

FL commercial - 1982-1988; recreational landed 1982-1985 and 1986-2007

GA commercial/recreational landed - 1982-1985; 1986-1991; 1992-2001 and 2002-2007

SC commercial/recreational landed - 1982-1989; 1990-1993; 1994-2000 and 2001-2007

FL recreational live release – 1982-1985 and 1986-2007

GA/SC recreational live release - 1982-1991 and 1992-2007

In Florida, the commercial fishery was greatly reduced in annual landings before size limit changes were made in the mid 1980s, thus one selectivity period was chosen. The Florida recreational fisheries (landed and live release) were assigned selectivity periods that reflected the historic 12" FL minimum length limit during 1982 through most of 1985, then the 18"/27" minimum/maximum size limit mostly in force since then (the maximum size limit change evolved more slowly). The Georgia recreational landings fishery was assigned selectivity periods corresponding to stable size limits before 1986: 14" total minimum size limit and no maximum size limit from 1986 through most of 1991; the 14"/27" minimum/maximum size limits from 1992 through 2001; and the smaller maximum size limit since July 2002. The South Carolina recreational landed fishery was given selectivity periods based on historic size limits through 1989 (though there were some short minimum-size limit increases during the summers of 1987-1989, considered insignificant), then the 14" year-round minimum from 1990 to 1993 when a 27" maximum size limit was enacted. From 1994 through 2000 the minimum/maximum limits were 14"/27" TL, and these were changed to 15"/24" in 2001. The Georgia/South Carolina combined recreational live-release fishery's selectivity periods were a compromise reflecting an earlier period of relatively consistent (over time) regulations (1982-1991) followed by a period of size-limit management changes (1992-2007).

During 1996, two hurricanes and subsequent flooding occurred during the sample season for the NC red drum juvenile seine survey, which severely altered sampling in this year. During panel discussions, the exact year of this event was brought into question. It was confirmed that 1996 was the correct year and the assessment panel agreed with the recommendation from the Data Workshop, which was to omit this point from the index. This fall survey for young-of-the-year red drum was used as a beginning-of-the-following-year abundance index for age-1 fish so, in the model, the 1997 data point was omitted.

The panel discussed the most appropriate value to assign for release mortality in both the recreational hook and line fishery and the commercial gill net fishery. No recommendation was made at the Data Workshop. The group agreed to document estimates from available hook and line studies for red drum and these results are summarized in working paper **S18-AW05**. Based on this review, the panel recommended a base value of 8% release mortality, which is the mean of all studies summarized, with a release mortality of 16% to be considered as a sensitivity run. This reflects the highest overall release mortality found for hook-caught red drum captured in saltwater (Jordan and Woodward 1992). The only available data on release mortality in the commercial gill net fishery was from a study conducted in NC (Price and Gearhart 2002). The overall release mortality from the study indicated a weighted average of 3.4%. The advisory panel recommended using 5% as the best available estimate for the release mortality of red drum released from gill nets. Prior analyses provided in working paper **S18-DW16** used a conservative release mortality of 10%. New results based on 5% are provided in Section 2.2 **Release Mortality.** Because mortality associated with red drum released from gill nets makes up such a small proportion of the overall takes (~1%), the panel felt no sensitivity runs were needed.

Recreational length and age composition based on the MRFSS harvest estimates (Type A+Type B1 catches) were provided at the Assessment Workshop (working paper **S18-AW01**). Two weighting/expansion schemes were explored: 1) the standard MRFSS weighting scheme and 2) a hierarchical pooling scheme which was developed to objectively assign length samples to strata that were not represented by at least 20 lengths. With this method, additional lengths from the Georgia carcass recovery program (1999-2007) and the South Carolina sportfishing survey (1991-2007) were used to supplement MRFSS lengths where appropriate. The assessment panel reviewed the working paper and recommended that the hierarchical pooling scheme be used as input for the stock assessment. Details of the expansion methods are provided in **S18-AW01** while the inputs used for the model are outlined in Section 2.3 **Recreational Fisheries**.

The assessment panel discussed available information to characterize the size and age composition of red drum captured and released in the recreational fishery. While the MRFSS provides estimates on the number of fish released alive (B2), no corresponding data are provided on the size of these releases. Released red drum that are assumed to die are a significant portion of the total removals in both the north and south region. Potential sources of information on the size and/or age of red drum released in the recreational fishery were provided to the panel for consideration. These included: a Florida volunteer angler logbook program (2002-2007; primarily for Gulf of Mexico coast); a South Carolina B2 study described in **S18-DW17** which was a study designed to identify the B2 component of the catch from an angler group that provided detailed logs of catch; a South Carolina volunteer tagging program where size and age composition of captured and released fish were provided (1981-2007; **S18-AW10**); and tag recapture data from North Carolina where period-specific selectivity vectors by age from released red drum was estimated using an age-dependent tag return model (1983-2006; Bacheler *et al*. 2008 [**S18-RD34**]). For the north region, the assessment panel consensus was to use the period and age specific selectivity estimates from the North Carolina tagging data as direct input parameters to infer the age composition of recreational releases. The assessment panel opted to drop the Florida volunteer logbook data because available data were too sparse and the vast majority of the information was from the gulf coast of Florida. In lieu of using these data, North Carolina tagging selectivity estimates were used for Florida. Selectivity estimates for the period of 1983-1991 from North Carolina were used to describe Florida recreational releases from 1982 to 1985, while selectivity estimates from the most recent period in North Carolina (1999-2007) were used to describe Florida recreational releases from 1986 to 2007. These periods represent years where recreational regulations between Florida and North Carolina were most similar. Recreational releases from South Carolina and Georgia were combined and the length and age composition from the South Carolina volunteer tagging program was used to describe the age composition of recreational releases **(S18-AW10)**. A more detailed description of this workup is provided in Section 3.2.1.2 **Data Sources**. A working paper describing the initial workup is also provided (**S18-AW04)**.

The North Carolina tagging program also provided estimated of fishing mortality rates for the combined commercial/recreational harvest fisheries in the north region and the recreational live-release fishery. These were incorporated into the analysis as additional "observed" data to be used to compare to the model-estimated values of fishing mortality for the appropriate fisheries.

Estimates of fishing mortality (F) for North Carolina's recreational and commercial fisheries based on recaptures from tagging experiments conducted during 1983-2006 are available from Bacheler et al. (2008). A copy of this manuscript is available as a reference document **(S18-RD34**). Estimates of F were adjusted for tag loss and reporting rates and should be unbiased for the north region red drum stock components in North Carolina. It was felt that these components comprise the majority of this stock, and that the F estimates are indicative of the north stock as a whole. The assessment panel considered possible methods for the incorporation of the tagging results into the current Statistical Catch at Age (SCA) model. Working paper **S18-AW11** provides trends in estimated abundance of the north stock derived from tagging estimates of fishing mortality rates (F) and independent estimates of catch-at-age (CAA). Trends were consistent with the general understanding of stock trends for red drum in the north region. Despite consistent trends, it was found that catch-curve estimates of F from tagging abundance-at-age estimates suggested lower Fs overall than the tagging-Fs themselves, although the trends in Fs were similar. Because of these discrepancies, the panel recommended the direct use of tagging-Fs to assist in estimating the SCA. Details of this analysis are provided in Section 3 **Stock Assessment Models and Results**.

Based on the recommendations from the indices working group at the DW, the North Carolina Independent Gill Net Survey (IGNS) index was converted from an age-aggregated index to age-specific indices (for age-1 and for age-2) with PSEs by age reported. Results are provided in Section 2.4 **Indices**.

1.2.2.2 Term 2.

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.

The assessment panel discussed the most appropriate type of model based on the available data for red drum. Past assessments have been conducted primarily using Virtual Population Analysis (VPA) approaches. The panel did not recommend continuing this approach due to the potential for considerable error in the catch at age (CAA). This is primarily because of limited data characterizing the age structure of the catch early in the time series, as well as a lack of direct information on the size/age distribution of the recreational releases. A standard statistical catch at age (SCA) model has been used in spreadsheet form (Vaughan and Carmichael 2000). The panel recommended that this approach be the basis for a more comprehensive model that reflected fishery-specific differences in fishing mortality. Working paper **S18-AW08** provides information on all input data used in the base model for the north and south regions. Working paper **S18-AW09** provides the background and a model description (i.e., equations) for a standard SCA model and includes some special features for capturing some of the peculiarities of

the red drum population dynamics and its fisheries. All data inputs along with a full model description and results are provided in Section 3 **Stock Assessment Models and Results**.

Because of the recommended model change, the panel discussed the need for a continuity run. The last stock assessment for red drum was completed in 2000 by Vaughan and Carmichael. Vaughan and Carmichael applied three separate models - a Separable Virtual Population Analysis (SVPA), a Spreadsheet SCA (SprdSCA), and a virtual population analysis using F-ADAPT. At the SEDAR 18 AW, the panel agreed that a revised SCA model (**S18-AW09**) would be the most appropriate model to use in the current assessment. Under TOR 2, a continuity run of the previous model was needed. Of the three models utilized by Vaughan and Carmichael (2000), only the SprdSCA 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 both the indices and the CAA. The suggested alternative was to use the original model with updated data where needed and compare to a model run where all data were updated based on the findings of SEDAR 18 DW. The SEDAR 18 AW panel did not find the results of the continuity model worthy of consideration given the inability to reproduce all the original input data. Additionally, the working group will not be using the SprdSCA for the current assessment of red drum in favor of the SCA model. Results of this continuity run are included in working paper **SD18-AW12** and discussed briefly in Section 3.2.3 **Discussion**.

Working paper **SD18-AW03** also provides some preliminary estimation of red drum fishing mortality rates for both the south and north regions using the SVPA/FADAPT method employed in the last assessment. The last assessment for red drum (Vaughan and Carmichael 2000) included an analysis that utilized a separability model (SVPA; Pope and Shepard 1982) to estimate terminal year selectivity and fishing mortality, which were then used as initial parameters in a tuned virtual population analysis (FADAPT; Restrepo 1996). Working paper **SD18-AW03** reports on some preliminary runs using this assessment approach. These analyses were originally envisioned as continuity runs that could be compared with the Vaughan and Carmichael (2000) findings to determine the effect of using additional years of data or for comparison with another modeling technique. However, because of extensive changes made to the input data series (DW report SEDAR 18), it was deemed more appropriate to rerun the 1986-1998 analyses using the modern input data and compare this with findings for a full complement of years (1982-2007). Results are provided in the working paper (**S18-AW03**). This analysis was conducted as a preliminary attempt at a continuity run. The panel felt a true continuity run was not possible given the changes in the data inputs from Vaughan and Carmichael (2000). **SD18-AW12** provides a 'best attempt' at a continuity run in consideration of addressing TOR 2.

A semi-separable untuned VPA (**SD18-AW07**) was also provided to the assessment panel for consideration. Untuned backwards VPAs were applied to catch at age data for the north and south regions red drum stocks to provide comparisons with estimates of historic stock size from SCA assessment models. The final year (2007) abundance of age two fish was determined by specifying their age-specific fishing mortality (F), and 2007 abundances at other ages were selected with a combination of constraints on selectivity in 2007 and approximate separability of F during 2003-2007. The constraints on selectivity were similar to those used in the SCA assessment model, and were consistent with tagging information. Age compositions for the release mortality component of the recreational fishery (i.e., B2 catches) were inferred from the

harvested age compositions (i.e., A+B1 catches) and the selectivity of the B2 fishery component relative to the A+B1 component, as inferred from a tagging model.

The results show that average F for ages 1-3 in the north region was about 1.5 during 1982-1990 but declined during 1991-1994 and was relatively stable during 1995-2002 with a mean of 0.9. Total abundance (number of fish) during 1982-1997 fluctuated between 200,000 and 400,000, but increased to 660,000 in 1998 and then declined to 160,000 in 2003, the second lowest value during 1982-2003. Untuned VPA results after 2003 are more speculative because the VPA is not yet converged. Results for the south region demonstrated that the VPA was not converged in the base setup. This is because of the low levels of F during 1990-2000, and the truncated age-structure of the catches. Cohorts are never "fished-out", and the size of the plus group that survives the larger juvenile fishery is quite uncertain. The basic trend in the VPA is for stock abundance to increase during 1982-1987, and then decline after 1991.

Untuned VPAs using alternative F-constraints were similar to the base setting for the north region, but quite different for the south region, which again demonstrates the lack of convergence in the south region VPA. The alternative VPA for the south region stock, which utilized specific selectivity information obtained from tagging studies for the north region stock, seemed more reliable in that some degree of convergence was achieved. However, the scale and trends in the base and alternative VPA for the south region stock were quite different, suggesting that the assessment of this stock will be more uncertain than the north region stock.

Unfortunately, this semi-separable untuned VPA is highly sensitive to assumptions about the selectivity pattern at the oldest assessed ages (5 and 6), which is a major deficiency in using this approach to assist the stock assessments of north and south region Atlantic coast red drum. Although not considered a primary model, the panel felt the trends in F-rates and abundance from the semi-separable untuned VPA could provide some useful insight for comparison with the SCA model. Methods and results of the semi-separable untuned VPA are provided in working paper **S18-AW07**.

Working paper **S18-AW06** provides a graphical analysis of the age composition for red drum in both the north and south regions. Results included the annual catch in numbers, as well as bubble plots of both the age composition of the catch and the relative size of the catch compared to the same ages in other years. Plots showing the standardized proportions at age (*SPAY*) and the standardized proportions at year (*SPYA*) are also provided. *SPAY* plots allow for a visual tracking of cohorts while *SPYA* plots show more clearly when catches for a given year and age are above or below average. It was noted that the catch at age data used in this working paper includes the inferred deaths from the recreational B2 (catch and release) fishery component. Preliminary estimates of the age composition of this catch component were considered too unreliable to use in the assessments for both the north and south region red drum stocks. This component represents approximately 20% of the total catch for both stocks, with considerable annual variability. Hence, age composition information presented in this working paper will not be exactly the same as that used in the stock assessment model, but should be broadly indicative.

1.2.2.3 Term 3.

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.

The panel discussed estimates of stock population parameters as provided from the SCA model. Section 3.2.2 **Results** provides the results for estimates of stock abundance, recruitment, fishery selectivity, fishing mortality and also provides the relationship between the estimated female spawning stock biomass and the next year's estimated abundance of age-1 fish.

Estimates of total abundance for red drum indicate at least a two- to four-fold increase in both stocks between the early 1980s and 2007. It was noted that much of the rapid increase in population size is a result of increases in the "less available" adult portion (age 4+) of the population. In the north region, the exploited portion of the stock (ages 1-3) also showed a dramatic increase in abundance over time. The south region had more modest increases in abundance of the age 1, 2, and 3 red drum. Estimated recruitment (age-1 abundance) showed an increasing, yet highly variable, trend in the north region. The south region estimated recruitment changed little over the time series. Recruitment estimates were more precise in the north region than in the south region. The panel agreed with the trends in the population abundance and recruitment for both the north and south regions as provided by the SCA base run.

Overall selectivity estimates from the SCA model gave results that were considered logical, based on the management programs (i.e., maximum and minimum size limits) in place for each management period and region. Details are provided in Section 3.2.2.5 **Fishery Selectivity**. The panel accepted the estimated selectivity patterns for each fishery/period combination.

Fishing mortality estimates and associated measures of precision are graphed by sector (Figures 3.2.5.15 and 3.2.5.16) and detailed results are provided in Section 3.2.2.6 **Fishing Mortality**. Age 1-3 exploitation rates in the north region experienced a sharp decline around 1991. Prior to this period (1983-1990) exploitation rates averaged 0.66, while for the period of 1991-2007 exploitation rates averaged 0.19 with no obvious trend over time. In the south region, exploitation rates showed a marked decline around 1988. Exploitation rates in this region averaged 0.40 from 1982-1987, while average exploitation rates from 1988-2007 averaged 0.19. Unlike the north region, a gradual, but significant, positive trend in the exploitation rates was apparent in the south region since the time series low in 1989. Despite the gradual increase, exploitation rates still remain well below prior levels. The assessment panel agreed with the trends in fishing mortality and exploitation rates.

A stock-recruitment analysis was not conducted or used for this assessment. Section 3.2.2.7 **Stock Recruitment Parameters** does provide, however, the model-estimated recruitment's relation with the previous year's female spawning biomass. Results for the north region indicate an increasing female abundance since the early 1990s with what appears to be a variable but increasing trend in age-1 recruitment. The south region results indicate an increasing trend in female biomass over time with little change in the abundance of age-1 recruits.

1.2.2.4 Term 4.

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'.

For all observed input data derived from estimates, measures of precision were available for use in the model. Commercial landings, derived from assumed complete census data, were assigned a low coefficient of variation (CV = standard error / mean) of 0.01. CVs for the annual recreational landings and the annual recreational live-release mortality were taken as the proportional standard errors estimated from the Marine Recreational Fisheries Statistics Surveys. A summary of all data inputs and associated or assumed measures of precision are provided in Section 3.2.1.2 **Data Sources** and 3.2.1.5 **Uncertainty and Measures of Precision**.

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. In addition, visual assessments of the fits were made. Measures of overall model fit are provided in detail in Section 3.2.2.1 **Measures of Overall Model Fit**. The assessment panel reviewed and accepted the methods used to fit the model to the observed data.

The assessment panel discussed the need for various sensitivity runs to be conducted to better understand how assumptions made about data input and model configurations impacted the assessment results. Sensitivity runs requested by the assessment panel included evaluating the sensitivity of the model to: 1) assumptions about selectivity at age, particularly for the older ages, 2) the use of tag-based input data on the north red drum stock, 3) various assumptions about natural mortality, and 4) a more conservative (16% versus 8%) estimate of recreational release mortality.

Brief results for each of these sensitivity runs are provided here; detailed results can be found in Section 3.2.2.8 **Evaluation of Uncertainty**.

In the base run, selectivity of red drum age 4 and age 5 were restricted to be a proportion of the selectivity at age 3 (i.e., selectivity of age 4 was 10% of age 3 and selectivity of age 5 was 5% of age 3). This configuration was deemed justified based on analysis of tag return data and also based on observations in general life history that suggests a decreasing trend in vulnerability with age. For the sensitivity run, the model was reconfigured so selectivity was estimated for ages 1 through 5, with ages 6 and 7+ set equal to age 5. Estimates of exploitation and abundance in the north region were largely unchanged when compared to the base run. The lack of sensitivity is likely attributable to the inclusion of the observed tag-based F-at-age estimates for the combined commercial and landed recreational fisheries. Results for the south region showed high sensitivity to changes in the assumptions about selectivity. Estimates of abundance were substantially lower with no apparent increasing trend from 1982-2007.

Assessment results for the north region that excluded the tag-based data resulted in unrealistically large population estimate (>5 billion fish) with fishing mortality rates near zero.

An upper and lower natural mortality vector was estimated from available life history information and used to test the model sensitivity to this input parameter. For the north region, alternative natural mortality vectors had little impact on estimates of abundance and

exploitation for ages 1-3. Age 4^+ abundance estimates were impacted in the more recent years with about a 29% increase in estimated abundance over the base run under the low-M sensitivity. For the south region, sensitivity was higher to alternative M vectors. Total abundance was approximately double in the high-M sensitivity case as compared to the base model for both ages 1-3 and age 4+. Likewise, the low-M analysis gave lower estimates of abundance and higher estimates of exploitation for all age groups.

A single recreational release mortality estimate (16%) was investigated to compare with the base run assumption (8%). For the north region the high release mortality assumption resulted in higher estimated abundance and relatively constant exploitation rates. The same pattern was noted in the south region, although a slight increase in exploitation was apparent after 1990, a time period that has seen an increasing trend in recreational releases.

A retrospective analysis was conducted by sequentially eliminating terminal year data from the base model, beginning with 2007 through 2004. The analysis did not reveal any consistent patterns or trends in the north region. In the south region, there was a consistent tendency to revise past estimates of F downward as new years were added to the analysis.

Section 3.2.2.9 **Benchmarks / Reference Points** also provides some insight on the imprecision of the estimated benchmarks. A range of escapement rates associated with the various sensitivity runs is provided. Additionally, imprecision in the estimated base model benchmarks is graphed by profiling the model likelihood across various potential values of the benchmark. Results show static spawning potential ratio (sSPR) and escapement in 2007 for the north region are much more precisely estimated than is the south region estimates (Fig. 3.2.5.22). Under the base run analysis, both areas have only a low probability that the 2007 sSPR was below 30%; 4% in the north region and 16% in the south region.

1.2.2.5 Term 5.

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

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. In both regions, the 2005-2007 estimates of apical F were below either yield-per-recruit benchmark, $F_{0.1}$ or F_{max}. The spawning-stock-biomass analysis showed that fishing mortality in both regions during 2007 was close to the $F_{35\%}$ level but that for all recent years fishing mortalities were less than the $F_{20\%}$ level.

Benchmarks estimated for this assessment include static spawning potential ratio, escapement rates through age 3, and escapement rates through age 5 (See Section 3.2.1.6 **Benchmark and Reference Points Methods** for calculation details). Results, including tables and graphs, are provided in Section 3.2.2.9 **Benchmarks / Reference Points** and a summary is provided under Term 6 below.

A stock-recruitment analysis was not conducted or used for this assessment. Section 3.2.2.7 **Stock Recruitment Parameters** does provide, however, the model-estimated recruitment's relation with the previous year's female spawning biomass. Results for the north region indicate an increasing female abundance since the early 1990's with what appears to be a variable but increasing trend in age-1 recruitment. The south region results indicate an increasing trend in female biomass over time with little change in the abundance of age-1 recruits.

1.2.2.6 Term 6.

Provide estimates of spawning potential ratio and escapement 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%).

Amendment 2 to the ASMFC FMP for Red Drum required states to implement management measures that were designed to achieve a static spawning potential ratio (sSPR) of 40% by January 1, 2003. This assessment provides an evaluation of the effectiveness of those management measures and will provide guidance to fisheries managers for any future changes.

The 2007 estimates of sSPR estimated using the base models is 34.0% in the north region and 36.9% in the south region. An alternative estimate using a three-year average for the period of 2005-07 estimates sSPR to be 41.5% in the north region and 35.4% in the south region. Based on these reported values the current sSPR value is below the OY target set by Amendment 2 (sSPR=40%) and above the overfishing definition of 30% sSPR.

In previous assessments, a lack of information on the adult stock implied that no estimate of the magnitude, and hence status, of the adult stock could be made. Although the new model approach used here (statistical catch at age model) implicitly includes the "adult stock", it's mostly represented by a plus group (ages 7+) that will poorly represent an adult stock that includes ages 5 (or 6) to 60+ years of age in the north region and to about 40 years of age in the south region. This lack of detailed information, especially age composition, on the full range of adult stock continues to circumscribe our ability to characterize the adult stock and recommend potential benchmarks that may be used to determine status relative to an overfished state.

Given the general lack of observations about the age composition and relative abundance of the adult portions of these stocks, the panel felt it may be preferable to define a biological benchmark that is not sensitive to assumptions about the population dynamics of the adults. A useful benchmark that only requires estimates of fishing mortalities for the available immature age groups is escapement rate. The threshold and target levels for escapement would depend on the same theoretical considerations used to define the 30% threshold and 40% target for the static spawning potential ratio and on the presumed (if not measured) level of fishing on adults. Two types of escapement rate estimates may be used year-specific and yearclass-specific (see Section 3.2.1.6 **Benchmark and Reference Points Methods** for a description). These can be thought of as measures of overfishing status (year-specific escapement based on the current year's F values) and of overfished status (yearclass-specific escapement incorporating the F history leading up to the current year). The panel discussed and indicated a preference for the use of escapement rate to determine stock status.

Measures of escapement were higher than sSPR estimates because of the small amount of fishing on adults. For the north region, year-specific escapement through age 5 was 40% (2005-07 avg. = 47%); in the south region 2007 year-specific escapement through age 5 was 43% (2005-07 avg. = 42%). The 2007 cohort-specific escapement rates were 63% for the north region (2005-07 avg. = 54%) and 43% for the south region (2005-07 avg. = 46%).

A more detailed summary of the benchmark/reference point calculations is provided in Section 3.2.2.9 **Benchmarks /Reference Points**.

1.2.2.7 Term 7.

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.

Both north and south Atlantic red drum stocks have responded positively to prior management action. Estimates of population abundance indicate at least a two- to three-fold increase in both stocks between the 1980s and 2007. For the north region, an abrupt decline in age 1-3 exploitation rates occurred around 1991, simultaneous to a shift in the minimum size limit from 14 inches to 18 inches. Similarly for the south region, exploitation rates declined around 1988 just after commercial harvest was banned in both Florida and South Carolina. Since the early 1990s no apparent major shift in exploitation rates is apparent in either the north or south regions, although overall abundance has continued to increase during this time. Exploitation rates in the south region do indicate a gradual increasing trend in recent years. A growing recreational fishery, particularly with regard to recreational releases may eventually drive current sSPR values lower over time. Currently, it appears that regulations in place provide both sufficient escapement of sub-adults and protection of the adults in order to maintain sSPR above the 30% threshold and near the target of 40%.

Annual estimates of sSPR were low through the late 1980s in both regions before increasing to near-present levels by the mid 1990s. In the north region, sSPR was estimated at less than 1% for most years during 1983-1990, and then increased dramatically in 1991 to reach 32.7%. Since 1996, sSPR has been variable and ranged from 30.7% to 60.1%. In the south region, sSPR was generally below 20% before 1988 then rapidly increased to near 50% by 1989 and 1990. Since then it has fluctuated with a slow decline reaching 34-38% after 2004.

1.2.2.8 Term 8.

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.

The assessment panel reviewed the research recommendations from the data workshop report. Additional research recommendations developed at the Assessment Workshop are:

- Determine batch fecundity estimates of red drum.
- Conduct experiments using logbooks etc. to develop estimates of the B2 catch in both the North and South regions.
- Further identify the selectivity of age classes of the B2 catch in both regions.
- Determine if existing and historic recreational tagging programs can be used to evaluate better B2 selectivities.

1.2.2.9 Term 9.

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.

Separate Microsoft Excel spreadsheets (TOR9_North.xlsx and TOR9_South.xlsx) were developed for the north and south regional assessments. These contained the estimated population dynamics, model fits, observed data, parameters estimates, and benchmark findings for the base run, sensitivities, and the retrospective analysis.

1.2.2.10 Term 10.

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.

A list of tasks to be completed was developed following the AW. The assessment workshop report was completed and distributed to the review panel on July 30, 2009.

The AW report editors will provide all assessment-related content required for the summary report in the AW report. The final summary report will be prepared following the RW.

1.2.3 Report of the Independent Expert

Upon request from SEDAR and based on a recommendation of an earlier SEDAR Assessment Panel, the Center for Independent Experts (CIE) appointed Dr. Noel Cadigan to serve as a member of the SEDAR 18 Assessment Panel, to attend the assessment workshop, and to perform other responsibilities of Assessment Panel members. As a CIE contractor, Dr. Cadigan submitted a report to SEDAR via the CIE. The report is designed to relate the appointee's involvement in the assessment of Atlantic red drum, to critique the assessment workshop process, and to provide advice toward improvement. The appointed expert report also informs the Review Panel of the assessment from the vantage of an assessment scientist not otherwise associated with the assessed stock or assessment and management agencies. Dr. Cadigan's independent report is **Appendix A** to this Assessment Report.

1.2.4 Literature Cited

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.

Clark, J.R. 1962. The 1960 Salt-Water Angling Survey. U.S. Department of the Interior, Bureau of Sport Fisheries and Wildlife, Circular 153, 36 pp.

Deuel, D.G. 1973. The 1970 Salt-Water Angling Survey. U.S. Department of Commerce, National Marine Fisheries Service, Current Fishery Statistics No. 6200, 54 pp.

Deuel, D.G. and J.R. Clark. 1968. The 1965 Salt-Water Angling Survey. U.S. Department of the Interior, Bureau of Sport Fisheries and Wildlife, Resource Publication 67, 51 pp.

Jordan, S. R. and A. G. Woodward. 1992. Survival of hook-caught red drum. Proceedings of the Annual Conference of Southeastern Association of Fish and Wildlife Agencies, 46:337-344.

Lorenzen, K. 1996. The relationship between body weight and natural mortality in juvenile and adult fish: A comparison of natural ecosystems and aquaculture. J. Fish. Biol. 49:627-647.

Porch, C. E., Wilson, C. A., and Nieland, D. L. 2002. A new growth model for red drum (*Sciaenops ocellatus*) that accommodates seasonal and ontogenic changes in growth rates. Fish. Bull. 100: 149-152.

Price, A. Blake and J.L. Gearhart. 2002. Small Mesh (< 4.5-inch) Gillnet Discard Mortality of spotted seatrout (*Cynoscion nebulosus*), weakfish (*Cynoscion regalis*), southern flounder (*Paralichthys lethostigma*), and red drum (*Sciaenops ocellata*) in Roanoke Sound, Core Sound, and the Neuse River, North Carolina. North Carolina Division of Marine Fisheries, Morehead City, North Carolina.

Vaughan, D. S. 1992. Status of the red drum stock of the Atlantic coast: Stock assessment report for 1991. NOAA Technical Memorandum NMFS-SEFC-297, Beaufort Laboratory, Beaufort, North Carolina 28516, 117 p. [S18-RD49]

Vaughan, D. S. 1993. Status of the red drum stock on the Atlantic coast: Stock assessment report for 1992. NOAA Technical Memorandum NMFS-SEFC-313, Beaufort Laboratory, Beaufort, North Carolina 28516, 65 p. [S18-RD50]

Vaughan, D. S. 1996. Status of the red drum stock on the Atlantic coast: Stock assessment report for 1995. NOAA Technical Memorandum NMFS-SEFC-380, Beaufort Laboratory, Beaufort, North Carolina 28516, 50 p. [S18-RD51]

Vaughan, D. S., and J. T. Carmichael. 2000. Assessment of the Atlantic red drum stock for 1999: Northern and southern regions. NOAA Technical Memorandum NMFS-SEFC- 447, Beaufort Laboratory, Beaufort, North Carolina 28516. [S18-RD52]

Wheeler, Donald J. (1999). Understanding Variation: The Key to Managing Chaos - 2nd Edition. SPC Press, Inc.

2 Data Review and Update

Processing of data for the assessment is described in the SEDAR 18 Red Drum Data Workshop Report. This section describes additional manipulations to the data input for use in the model. In this section and throughout this report, we use the terms 'north' and 'northern' to refer to information about the northern stock of red drum inhabiting the waters from North Carolina northward. Likewise, we use the terms 'south' or 'southern' when referring to information about the southern red drum stock that inhabits waters from South Carolina southward.

2.1 Life History (Growth, Maturity and Mortality)

During the data workshop the panel chose von Beralanffy growth model to describe growth and subsequently develop M based on the Lorenzen equation to determine natural mortality.

During the AW a working paper, "Nonparametric growth model for Atlantic red drum, and changes to natural mortality (M) estimates", (**S18-AW02)** was presented in which the fit of the von Bertalanffy growth models generated in the data workshop was contrasted to a fit based on a smooth monotone function generated in R.

A standard von Bertalanffy growth curve was used to model length-at-age growth data for Atlantic red drum (see Section 2.7 in SEDAR 18 Data Workshop Report, DWR). Other approaches investigated (a 4 parameter model, and a double von Bertalanffy model) did not converge, and the standard von Bertalanffy model was considered to be sufficient. One of the uses of the growth model was to estimate instantaneous natural mortality (M) at age (see Section 2.4.12 in DWR), using the scaled Lorenzen method. However, there is evidence of model misfit, particularly for the north region Atlantic red drum stock (see Figure 2.17.1 in DWR). Model predicted growths are at the "edge" of the data distribution for ages near 6 and 13. The data suggest more rapid growth than the von Bertalanffy model for the first 5-7 years, and perhaps slower growth rates thereafter.

It is not surprising that the simple von Bertalanffy growth model may not fit the data well for a stock like red drum as juvenile red drum occur in inshore regions and grow extremely rapidly, especially during the warmer months. When they mature (50% of fish are mature at age 3 for females, and 1.5 for males), red drum move offshore and grow very little. The change in growth with age is too abrupt for the standard von Bertalanffy curve to accommodate. An alternative approach is provided by Porch et al. (2002). To better fit the red drum data a *smooth monotone* function provided in the R package *fda* (functional data analysis) was applied to the data. This is a spline-based method that uses a type of monotone link function for smooth monotone regression. Its genesis was for fitting human growth data.

A nonparametric smooth monotone growth model fit the data very well, whereas for the north region red drum stock the von Bertalanffy did not fit as well. However, this smooth monotone growth model did not result in substantial differences in estimates of natural mortality (M) at age, based on the scaled Lorenzen method. The largest difference was found at age one, where the DW Lorenzen M estimate based on the von Bertalanffy model predicted length was 0.16 and the M estimate based on the nonparametric model was 0.20.

The panel adopted the better fitting nonparametric smooth monotone growth model proposed in **S18-AW02** for both regions and used the natural mortality values produced from these models (Table 2.1.1). The panel also chose to conduct sensitivity runs using Lorenzen-calculated age-specific Ms based on the upper and lower bound of the Hoenig based M estimates.

Table 2.1.1. Estimates (est) of instantaneous natural mortality for red drum ages 1-7^{+} years in the North and South region of the Atlantic coast of the United States calculated using Lorenzen equation. Also shown are the lower and upper estimates used in the sensitivity analyses.

	Age	1	2	3	4	5	6	7+
North region	low	0.12	0.08	0.06	0.05	0.05	0.05	0.04
	est	0.20	0.13	0.10	0.09	0.08	0.08	0.07
	high	0.29	0.19	0.15	0.13	0.12	0.11	0.11
South region	low	0.14	0.10	0.08	0.08	0.07	0.07	0.06
	est	0.26	0.18	0.15	0.14	0.13	0.12	0.11
	high	0.37	0.26	0.21	0.19	0.18	0.17	0.16

2.2 Release Mortality

The assessment panel discussed in detail the release mortality rates that would be used in the model for recreational hook and line as well as commercial gill nets. The previous assessment used 10% release mortality for recreational hook and line fishing based on Vaughan 1992, 1993, 1996 and Jordan 1990 (Vaughan and Carmichael 2000). A number of studies conducted since that time are reported in the literature and are summarized in Working paper **S18-AW05** (References and selected abstracts on red drum hook mortality). Included is a table summarizing key parameters and observed mortality rates in post-hooking mortality studies of red drum. These studies suggest a range of values of release mortality under varying environmental conditions. The mean value from the various studies was ~8% and serves as an appropriate starting point for use in the analysis. In addition, panel members pointed out that the studies referenced only post-hooking mortality, usually in tanks or cages, and do not reflect predation associated with post-hooking release. Therefore they decided also to select 16% as an upper limit for release mortality. The group agreed on evaluating both 8% and 16% as part of a sensitivity analysis.

The panel identified a 5% mortality rate for fish released alive (B2) from the gill net fishery in North Carolina based on studies conducted by NCDMF. The panel considered doubling the value to 10% for a sensitivity analysis but opted not to undergo this exercise because the proportion of red drum assumed to die from gillnet releases accounts for only a very small proportion of the total removals.

North Carolina estuarine gill net discard mortality estimates were provided in the Data Workshop Report (Section 3.4). Following the Data Workshop recommendations, discard estimates were extrapolated within the management period to North Carolina commercial gill net harvest. Annual age-length keys (ALK) for the north region were used to develop a catch-at-age (CAA) matrix for the estuarine gill net discards following the same methods used to describe the commercial catch data (Table 2.2.1). Expansion before this period was not recommended due to drastic changes in gill net regulations prior to this period. The panel agreed to use these estimates as input into the model.

Table 2.2.1. North Carolina commercial gill net discard estimates in numbers at age based on estimates. Includes dead discards and assumes 5% release mortality on live discards.

Year	1	2	3	4	5	6	7	8	9	10+
1999	32,509	17,485	3,064	304	2	2	0	0	0	12
2000	19,596	10,540	1,847	183	1	1	0	0	0	7
2001	13,407	7,211	1,264	125	1	1	0	0	0	5
2002	7,288	3,920	687	68	0	0	0	0	0	3
2003	7,990	4,298	753	75	0	0	0	0	0	3
2004	10,130	341	636	108	0	2	0	1	0	12
2005	13,160	11,719	922	65	0	0	0	0	0	0
2006	8,892	5,031	1,461	129	2	0	0	0	0	0
2007	20,220	10,876	1,906	189	1	1	0	0	0	7

Estimates of landings from recreational gill nets from North Carolina were provided for the period of 2002 to 2006 in the Data Workshop working paper **S18-DW16**. Following the Data Workshop recommendations, recreational gill net landings were extrapolated out to all remaining years from 1999-2007 by applying the ratio estimated for the North Carolina commercial gill net harvest. Expansion before this period was not recommended due to drastic changes in gill net regulations prior to this period. These landings were converted to a CAA using length data from the commercial gill net fishery in North Carolina (Table 2.2.2).

Table 2.2.2. North Carolina recreational gill net landings in numbers at age for the period of 1999 to 2007.

Year	1	2	3	4	5	6	7	8	9	10+
1999	457	4,452	903	8	0	0	0	0	0	4
2000	92	2,142	1,243	29	1	0	0	0	0	3
2001	56	802	1,150	7	1	0	0	0	0	1
2002	340	2,494	198	6	1	0	1	0	0	7
2003	20	971	175	1	0	0	0	0	0	0
2004	210	417	719	10	0	0	0	0	0	0
2005	127	1,743	51	2	0	0	0	0	0	0
2006	47	1,381	456	5	0	0	0	0	0	0
2007	53	1,665	412	3	0	0	0	0	0	0

2.3 Recreational Fishery

The recreational harvest CAA was provided at the assessment workshop and details of the analysis are provided in working paper **S18-AW01**. The assessment panel recommended using a hierarchical pooling scheme that was developed to objectively assign length samples to any strata that was not represented by at least 20 lengths. In addition, this method incorporated additional lengths from the Georgia carcass recovery program (1999-2007) and the South Carolina sportfishing survey (1991-2007) to supplement MRFSS sampling where appropriate. The resulting landings (MRFSS Type A + Type B1) –at-age are provided in Table 2.3.1.

Table 2.3.1. Estimated landings (MRFSS Type A+B1) –at-age for red drum in Florida, Georgia, South Carolina, and the north region (North Carolina through Delaware) during 1982-2007. The unseen harvest (Type B1) is assumed to be distributed across ages the same as the inspected harvest (Type A).

Florida

	1	2	3	4	5	6	7	8	9	10+	Total
1982	145,344	54,714	1,544	900	1,115	340	43	14	14	373	204,400
1983	262,486	66,773	11,753	3,248	255	0	0	0	0	0	344,514
1984	417,109	90,176	22,810	5,497	1,344	673	0	5,887	0	5,887	549,382
1985	233,161	28,077	3,241	467	48	0	63	0	32	97	265,186
1986	37,551	49,127	21,682	2,005	456	0	524	0	524	1,571	113,439
1987	22,286	19,554	4,820	3,489	578	227	179	5	0	85	51,224
1988	3,531	4,829	757	311	33	22	11	12	0	36	9,544
1989	10,942	16,696	4,290	2,148	272	240	102	28	0	29	34,747
1990	10,671	20,993	7,084	3,744	615	626	272	0	23	251	44,279
1991	17,158	30,590	27,209	23,017	3,253	676	731	0	37	58	102,727
1992	32,245	32,962	20,530	15,094	1,422	795	607	366	10	95	104,125
1993	7,246	24,393	19,910	11,786	1,685	995	490	41	13	127	66,685
1994	21,713	38,202	36,320	21,696	1,519	611	753	106	6	13	120,938
1995	11,343	29,832	32,939	18,340	2,173	618	386	162	0	1,136	96,928
1996	32,317	49,634	38,378	22,754	2,626	549	560	4	0	0	146,822
1997	14,007	22,018	18,601	15,435	2,039	1,560	695	739	0	0	75,094
1998	11,695	39,378	37,988	16,190	1,980	846	360	4	0	0	108,440
1999	5,046	69,844	46,078	7,369	2,881	0	0	0	0	0	131,219
2000	4,676	99,458	70,136	13,967	6,440	0	0	0	0	0	194,677
2001	4,495	86,306	66,303	16,003	7,949	0	2	2	2	17	181,079
2002	1,215	57,527	45,217	11,457	5,223	0	0	0	0	0	120,640
2003	3,396	89,172	61,787	10,904	6,107	0	0	0	0	0	171,365
2004	2,554	72,736	57,369	30,121	1,391	0	0	0	0	0	164,171
2005	5,631	86,322	71,942	30,171	2,170	0	0	0	0	0	196,236
2006	2,537	56,600	67,088	21,135	2,380	5	0	0	5	7	149,756
2007	5,932	77,766	85,538	27,305	2,618	0	0	0	0	0	199,159

Table 2.3.1 (con't.). Estimated landings (MRFSS Type A+B1) –at-age for red drum in Florida, Georgia, South Carolina, and the north region (North Carolina through Delaware) during 1982-2007. The unseen harvest (Type B1) is assumed to be distributed across ages the same as the inspected harvest (Type A).

Georgia

	1	2	3	4	5	6	7	8	9	10+	Total
1982	25,866	3,239	638	128	10	50	46	10	19	751	30,757
1983	51,439	5,134	256	25	0	0	0	0	0	0	56,853
1984	237,256	15,739	4,665	293	0	78	78	0	0	78	258,188
1985	162,945	19,281	1,537	76	0	0	0	0	0	2	183,840
1986	72,441	28,612	2,566	370	13	0	0	0	0	13	104,015
1987	106,274	26,187	3,802	596	0	0	0	0	0	451	137,310
1988	84,998	45,773	4,800	883	24	0	0	0	0	806	137,284
1989	30,130	18,281	2,681	141	1	0	0	0	0	1	51,235
1990	45,492	20,020	6,755	1,123	27	286	286	27	27	2,571	76,612
1991	120,316	38,546	3,043	1,228	0	0	0	0	0	0	163,133
1992	60,963	21,097	2,680	342	87	95	178	166	166	99	85,875
1993	68,000	29,544	8,108	2,004	256	44	44	1	1	188	108,189
1994	96,309	38,070	4,606	275	0	0	0	0	0	0	139,260
1995	100,680	35,658	5,120	211	2	0	0	0	0	2	141,673
1996	43,516	17,897	1,511	220	4	1	1	0	0	1	63,151
1997	20,747	15,021	2,949	531	113	0	0	0	0	0	39,361
1998	14,037	11,732	1,528	303	0	0	0	0	0	0	27,600
1999	41,945	23,485	3,581	0	0	0	0	0	0	0	69,011
2000	53,312	29,444	10,218	1,455	0	0	0	0	0	0	94,429
2001	67,601	20,842	1,608	343	0	0	0	0	0	1	90,395
2002	58,445	32,518	2,073	269	0	0	0	0	0	0	93,305
2003	80,870	37,255	5,318	0	0	0	0	0	0	0	123,443
2004	40,047	81,912	11,035	409	0	0	0	0	0	0	133,402
2005	68,586	36,374	3,002	7	0	0	0	0	0	0	107,970
2006	37,033	43,681	1,341	210	0	0	0	0	0	4	82,269
2007	57,278	44,655	1,262	190	0	0	0	0	0	0	103,385

Table 2.3.1 (con't.). Estimated landings (MRFSS Type A+B1) –at-age for red drum in Florida, Georgia, South Carolina, and the north region (North Carolina through Delaware) during 1982-2007. The unseen harvest (Type B1) is assumed to be distributed across ages the same as the inspected harvest (Type A).

South Carolina

	1	2	3	4	5	6	7	8	9	10+	Total
1982	127,340	21,405	929	2,359	2,141	149	226	78	0	6,136	160,762
1983	77,182	22,444	4,186	979	12	0	0	0	0	0	104,803
1984	88,867	39,148	1,088	432	12	0	0	0	0	3	129,550
1985	369,762	124,774	30,846	4,726	0	0	0	0	0	0	530,108
1986	103,738	77,202	11,393	1,563	64	0	66	0	0	0	194,026
1987	391,860	114,970	13,552	1,610	45	0	0	0	0	6	522,044
1988	142,867	129,946	14,298	1,139	40	1	1	0	0	129	288,421
1989	59,660	51,798	13,650	2,591	94	2	0	0	0	31	127,826
1990	47,411	57,413	6,992	1,316	54	0	0	0	0	4	113,191
1991	88,404	36,305	2,420	120	49	12	4	1	1	105	127,421
1992	55,095	52,551	5,421	487	466	0	0	0	0	757	114,778
1993	48,425	61,023	10,226	2,248	171	0	0	1	0	46	122,141
1994	41,414	65,048	11,057	1,518	44	3	0	0	0	0	119,083
1995	110,033	55,633	8,460	2,569	368	0	0	0	0	8	177,072
1996	37,848	80,694	5,852	1,311	126	4	0	0	0	0	125,835
1997	112,215	12,150	4,198	3,058	152	53	9	0	0	0	131,834
1998	15,241	25,698	4,502	1,983	189	3	0	0	0	0	47,617
1999	22,236	19,441	3,585	530	34	0	0	0	0	0	45,826
2000	17,688	15,523	3,491	610	48	0	0	0	0	0	37,360
2001	38,822	16,805	4,430	953	35	0	0	0	0	1	61,046
2002	12,794	27,241	1,301	130	4	0	0	0	0	0	41,471
2003	40,913	99,119	14,406	7,500	750	7	0	0	0	0	162,695
2004	23,378	89,438	14,904	4,071	276	8	0	0	0	0	132,075
2005	49,074	71,256	18,561	2,072	59	0	0	0	0	0	141,023
2006	28,260	38,013	5,204	584	38	9	19	9	0	350	72,487
2007	42,724	45,001	490	5	0	0	0	0	0	0	88,220

Table 2.3.1 (con't.). Estimated landings (MRFSS Type A+B1) –at-age for red drum in Florida, Georgia, South Carolina, and the north region (North Carolina through Delaware) during 1982-2007. The unseen harvest (Type B1) is assumed to be distributed across ages the same as the inspected harvest (Type A).

North region

	1	2	3	4	5	6	7	8	9	10+	Total
1982	11,462	3,205	915	263	0	0	116	36	18	432	16,446
1983	82,027	27,235	3,940	1,788	0	0	480	143	101	1,168	116,882
1984	79,686	20,560	5,192	1,930	0	0	672	202	131	1,873	110,247
1985	15,445	4,807	1,514	144	0	0	21	6	4	134	22,075
1986	47,299	7,905	0	0	0	0	0	0	0	3,239	58,443
1987	48,172	10,374	974	2,899	0	0	0	0	0	867	63,286
1988	110,318	27,974	4,900	503	0	0	85	38	0	3,159	146,977
1989	27,052	41,592	5,424	0	0	0	466	155	311	381	75,381
1990	31,338	866	1,755	69	0	0	0	6	4	459	34,497
1991	47,331	9,481	289	875	0	0	0	0	0	701	58,678
1992	1,639	32,778	2,250	13	63	0	19	0	0	108	36,869
1993	4,557	43,835	14,687	40	37	0	38	0	0	729	63,923
1994	1,762	11,614	11,728	1,959	85	0	475	85	526	2,368	30,603
1995	12,439	70,790	7,611	994	880	0	0	0	0	208	92,921
1996	12,997	14,830	7,548	1,104	453	0	0	0	0	538	37,470
1997	4,919	2,888	1,787	491	208	0	65	0	0	355	10,714
1998	2,450	122,742	5,285	712	544	132	27	133	0	739	132,765
1999	5,876	54,286	18,419	158	0	0	0	0	0	24	78,764
2000	1,134	37,909	44,151	1,067	0	0	0	0	0	0	84,262
2001	1,249	8,157	17,858	2,599	126	14	2	14	0	381	30,400
2002	19,085	76,491	2,678	1,410	154	189	334	70	0	70	100,481
2003	307	26,997	13,673	365	18	0	0	0	0	0	41,360
2004	7,108	12,398	15,148	686	0	0	0	0	0	0	35,340
2005	591	54,005	1,296	0	0	0	0	0	0	0	55,892
2006	5,533	49,441	17,889	1,735	0	0	0	0	0	0	74,598
2007	2,575	88,351	44,728	524	0	0	0	0	0	0	136,178

2.3.1 South Carolina Marine Gamefish Tagging Program

A marine game fish tagging program has been conducted in South Carolina (SC) since 1974 but with high numbers of fish tagged only since 1981. It relies on volunteer anglers, who tag and release fish and report the species, length, and location to the SC Department of Natural Resources. As many as 14,000 anglers actively participated in tagging at least 1 fish during the period 1974-2004. Since then, participation has been limited to recreational anglers who have completed a training workshop, and the total number of trained taggers was limited to 225 statewide. Some anglers in the program before 2004 are still active and their releases are included in the Marine Gamefish Tagging Program Database. Further details of the tagging program are provided in the working document **S18-DW02**.

For each year since 1981, the total lengths of red drum at the time of tagging reported from anglers (extracted from marine game fish tag database) were used to estimate the number of fish tagged and released by age class (Table 2.3.2). Age length keys derived from the SC Fisheries Independent sampling was used to assign ages to reported lengths of tagged and released fish (Table 2.3.3). Ages of fish tagged by SC anglers serve as a proxy for selectivity of size classes caught by recreational anglers and effectively represent the B2 component of the recreational catch.

In 1993, the state began instructing anglers not to tag red drum less than 18” TL. This raises the possibility that the size composition of the released fish might be biased, as fish smaller than 18” would not be tagged and thus not reported. However, since this change in procedure was explained mainly to new taggers, the group agreed that any bias introduced would be minimal. The continued reporting of fish less than 18” TL provides some support for this assumption (Fig. 2.3.1). While there does appear to be a shift towards more large fish reported released after 1993, it’s difficult to distinguish between changes in angler behavior due to the change in tagging protocol, and those that are due to new regulations (1993 was also the year that SC reduced the maximum size to 27” and instituted a 5-fish bag limit).

Table 2.3.2. Red drum tagged by the SC marine game fish tagging program, by size class (TL), for each year since 1981.

TL (inch)	1981	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	Total
54																								1				1
53															1													1
52																										1		1
51															1													1
50					1										2			1	1	1		1	1					8
49												1		1			1		1			2	1					7
48											1			1	1		2	3		1	3	2	1	1			1	17
47							1							3	2	3			3	3	1	9	3					28
46					2			1		1	2			3	7		1	6		6	8	10	3	2	3		1	56
45									1		3	1	4	5	7	3	6	15	1	4	14	20	13	8	2	3	2	112
44													3	7	18	6	11	42	5	9	23	24	12	7	9	8	4	188
43								1		4	1	1	5	8	17	8	7	43	5	11	14	28	17	10	8	6	1	195
42						1		2		1	2	3	7	14	25	16	13	69	9	27	34	63	25	12	13	7	8	351
41			1			1	1		2			3	5	8	15	20	7	66	11	25	23	33	29	15	5	10	13	293
40					1		1	1	3	2	6	7	8	9	15	33	11	94	23	29	45	88	27	10	10	19	8	450
39						1		3	6		2	3	3	7	11	14	12	72	13	32	20	35	18	6	3	10	7	278
38					2	1		6	5		2	2	5	5	15	17	10	56	12	27	20	54	38	6	20	4	12	319
37	1							1	1	1	1	3	2	13	3	11	14	41	14	19	17	31	23	11	12	4	5	228
36	1	1			1	3	2	4	5	5	1	1	9	16	17	17	24	53	27	17	20	44	28	9	16	6	3	330
35	1		1			1		3	4		4	2	8	21	14	13	18	49	37	24	23	50	27	12	14	9	10	345
34	0		1			2	1	7	7	2	2	6	16	27	20	36	37	57	51	31	32	41	26	15	24	14	10	465
33	0			1	1	6	5	3	4	6	2	10	19	28	46	57	49	97	74	51	50	57	30	23	35	31	12	697
32	1	2			1	12	1	13	5	6	3	17	27	55	76	79	106	145	126	106	99	75	46	41	44	45	48	1179
31	1	2	1		4	2	3	8	9	6	4	13	68	54	94	123	161	160	119	121	82	75	52	53	56	54	36	1361
30	2	1	1	1	4	14	5	11	12	18	9	20	102	115	163	186	242	264	134	158	91	98	85	114	78	96	58	2082
29	3	3		0	2	4	10	10	14	7	10	35	90	100	147	189	277	257	139	134	100	83	110	126	91	97	52	2090
28	3	4		4	1	5	8	13	20	14	15	52	164	144	172	272	349	287	156	154	107	88	173	182	100	140	59	2686
27	7	6		1	2	6	18	11	26	20	20	70	151	131	136	202	299	230	179	179	96	104	260	201	125	156	78	2714
26	1	3	1	2	3	15	21	12	35	25	27	63	184	124	110	211	227	181	203	168	80	102	327	197	130	129	68	2649
25	2	3	1	3	6	24	17	15	39	26	29	86	237	159	131	232	332	215	208	165	84	143	282	235	126	105	81	2986
24	1	2	2	4	9	22	29	32	68	29	37	102	271	205	197	358	406	283	173	175	73	153	228	152	96	57	75	3239
23	3	4	3	5	5	20	20	22	55	21	22	96	221	167	160	351	304	199	129	136	53	108	161	129	82	53	52	2581
22	2	6	7	2	3	19	30	33	71	18	24	118	211	102	138	335	245	179	111	106	39	96	188	124	63	45	39	2354
21	2	4	6	1	3	16	17	36	72	12	21	101	153	76	95	241	148	153	82	93	19	89	118	92	53	39	30	1772
20	1	8	7	7	3	26	21	45	93	18	35	126	161	83	105	178	94	159	75	80	30	102	138	106	41	27	25	1794
19	0	3	11	5	10	18	27	33	50	16	23	86	122	61	104	157	79	139	88	75	27	104	135	66	28	35	39	1541
18	7	5	12	9	16	29	58	58	63	43	48	116	148	92	292	311	161	306	160	218	37	116	127	80	38	70	85	2705
17	6	10	11	17	31	42	67	46	55	96	133	189	182	75	171	312	323	380	240	44	37	46	53	24	33	15	22	2660
16	8	7	28	16	44	89	88	132	151	159	265	502	233	107	143	193	229	229	178	35	48	62	39	21	32	13	30	3081
15	16	21	33	22	67	74	152	149	212	180	358	863	294	108	178	180	179	163	102	33	66	30	26	8	16	10	33	3573
14	18	15	33	32	40	77	304	278	220	280	450	865	353	102	186	129	130	155	64	25	78	23	15	10	4	8	15	3909
13	20	31	14	25	46	68	247	157	118	262	382	603	302	56	107	41	71	111	43	14	40	23	10	2	3	1	8	2805
12	7	20	17	35	43	82	248	274	227	217	348	488	354	49	86	42	63	85	26	13	17	17	3	5	2	2	15	2785
11	4	23	7	11	15	33	208	112	177	186	205	349	204	49	27	19	24	49	14	9	11	3	2	2	1		8	1752
10	1	17	23	6	13	60	160	68	169	148	123	225	171	38	27	8	25	18	9	3	8	1	2				4	1327
9		2			5	30	41	30	45	65	44	49	43	9	12	2	7	2	4	1	1							392
8		1	1		1	4	16	7	24	15	16	34	24	5	6		11	3	1	1			1	1				172
7							3	3	5		7	7	6	0	2		1		1	1								36
6							2	1	1		4	5	2	1	1		2							1				20
5				1	1			1	1		2	1					1											8
Total	119	204	222	210	386	807	1832	1642	2075	1909	2693	5324	4572	2443	3303	4605	4719	5116	3051	2564	1670	2333	2903	2120	1416	1329	1057	60624

Table 2.3.3. The percentage of red drum tagged by the SC marine game fish tagging program, by age class, for each year since 1981. Major changes in regulation periods are shown below.

Year

Age	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
7+	1.3	0.1	0.5	0.0	1.5	0.6	0.2	0.9	0.9	0.5	0.6	0.3	0.8	3.0	4.1
6	0.5	0.3	0.2	0.1	0.2	0.3	0.1	0.3	0.2	0.2	0.1	0.1	0.1	0.7	0.3
5	2.6	1.3	0.6	0.5	0.9	1.5	0.5	1.1	1.0	0.8	0.1	0.2	0.7	2.1	3.2
4	7.7	5.2	1.5	2.4	2.9	4.9	2.0	3.2	3.8	2.9	0.3	0.8	5.8	17.1	18.1
3	9.3	7.9	3.6	5.2	4.4	7.9	4.2	5.0	8.4	4.5	2.4	5.0	19.1	26.7	16.3
2	22.7	22.7	34.4	27.9	28.9	28.5	19.3	24.2	28.1	20.0	17.9	32.5	34.8	32.8	29.7
1	55.9	62.5	59.3	63.5	61.0	56.2	73.4	65.0	57.3	71.2	78.1	60.8	38.6	17.6	28.2
0	0.0	0.0	0.0	0.5	0.3	0.0	0.3	0.3	0.3	0.0	0.5	0.2	0.2	0.0	0.1

1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
2.8	2.2	9.2	4.0	5.1	11.6	13.8	5.7	3.5	5.0	4.6	5.9
0.7	1.1	1.5	1.7	0.6	1.7	1.1	2.6	1.6	1.4	1.2	0.6
6.2	4.3	9.1	9.3	8.3	7.7	10.5	8.6	6.8	8.6	7.7	8.0
16.2	22.4	20.2	17.0	21.7	22.3	15.5	22.0	26.6	26.0	27.4	15.4
17.7	27.7	13.2	22.6	26.9	24.6	18.9	29.9	31.6	35.7	31.7	27.1
45.4	24.9	30.8	29.3	29.0	15.2	34.0	28.3	27.2	19.3	23.2	30.5
11.0	17.0	16.0	16.1	8.3	16.9	6.1	2.8	1.8	3.9	3.3	12.5
0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

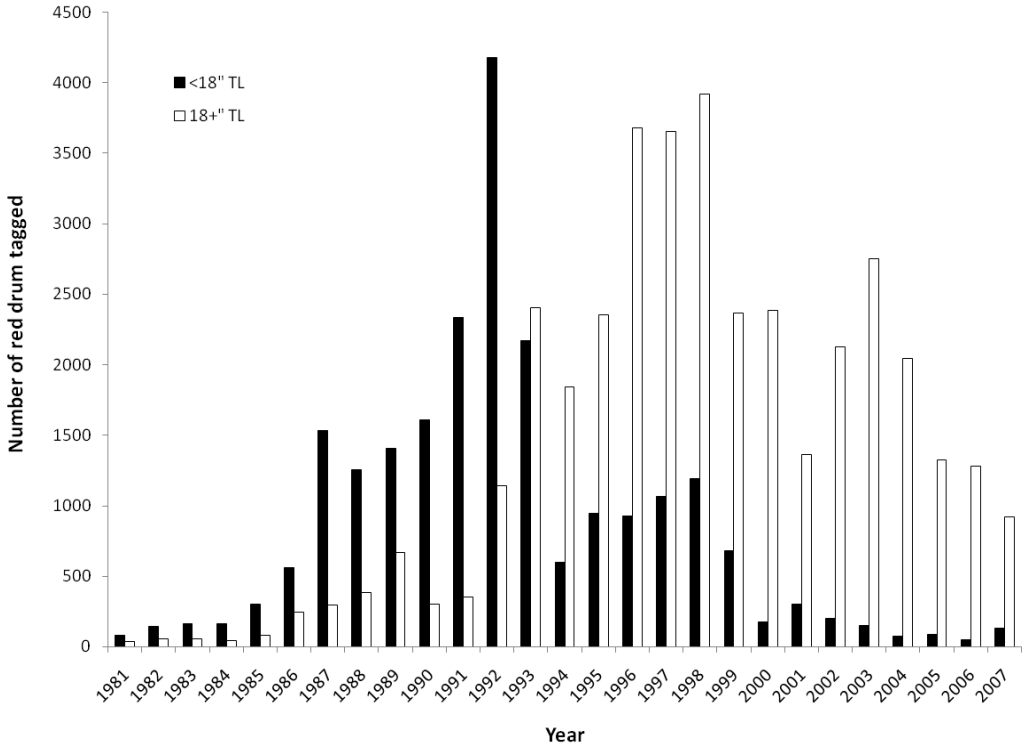


Figure 2.3.1: Numbers of red drum tagged and released by recreational anglers annually by size category.

2.4 Indices

A sub-adult index of abundance was provided by NC Division of Marine Fisheries as part of the Pamlico Sound Independent Gill Net Survey. A full description of the survey is provided in the DW report section 5.3.8. Results in the DW report were provided as an age aggregated index. The indices working group recommended that the index be aged and the associated measures of variance be provided with age group. As a result, red drum captured in this survey were aged based on the length at capture. Six-month age length keys provided good separation between fish less than age-4. Results of this analysis were made available at the AW (Table 2.4.1).

Table 2.4.1. Annual geometric mean and proportional standard error based on red drum captured in the NC Independent Gill Net Survey.

	Age-1		Age-2		Age-3	
	Mean	PSE	Mean	PSE	Mean	PSE
2001	0.54	16	0.36	16	0.06	53
2002	1.31	11	0.4	15	0.03	37
2003	0.2	22	0.59	15	0.01	93
2004	1.03	11	0.06	34	0.05	44
2005	0.65	16	0.86	11	0.01	177
2006	1.03	10	0.77	12	0.03	36
2007	0.39	15	0.76	12	0.06	32

A young-of-the-year index was estimated for the Georgia monofilament gillnet survey conducted since 2003. The index working group discussed the original estimates based on all stations occupied by this survey and suggested alternatives based on consistently occupied (year-to-year) sites or restricted to the randomly chosen sites. A re-analysis of the data provided estimates and their coefficients of variation (Table 2.4.2).

Table 2.4.2. Annual geometric mean, 95% confidence interval boundaries, and coefficient of variation (x 100) for the age-1 catch from the Georgia independent gillnet survey.

Year	Mean	95% LCL	95% UCL	CV
2003	1.59	1.06	2.11	24.55
2004	0.66	0.36	0.97	27.94
2005	1.03	0.64	1.42	25.15
2006	0.34	0.16	0.51	28.82
2007	0.95	0.43	1.47	34.79

Though the data workshop panel was aware of and discussed the tagging program information available for the north region, additional data discovery and analyses occurred after the workshop following discussion of their utility. The tagging program provided estimates of fishing mortality at age and corresponding coefficients of variation for the combined commercial/recreational landed fisheries for ages 1-4^{+} during 1983-2004 (Table 2.4.3). In addition, the north recreational live-release fishery's age-specific fishing mortality rate estimates and full F coefficients of variation were available (Table 2.4.4). Given the lack of age composition data for the live-release fishery in the north region, the estimated selectivities derived from the live-release fishery's age-specific F estimates were used as input parameters in the north model (Table 2.4.5) and the fully recruited F's were used as observed data evaluated in the model fit. The panel also decided that the Florida recreational live-release fishery age composition would be best inferred using the north regions early and late selectivites as input parameters to the south region model.

Table 2.4.3. Age-specific estimates of instantaneous fishing mortality and coefficients of variation for red drum from the north commercial/recreational harvest fisheries.

	Estimates				Coefficients of variation			
	1	2	3	4^+	1	2	3	4^+
1983	2.519	3.806	1.393	0.117	0.497	0.484	0.494	0.484
1984	1.776	2.683	0.982	0.082	0.433	0.418	0.430	0.418
1985	0.898	1.357	0.497	0.042	0.443	0.428	0.439	0.428
1986	0.825	1.246	0.456	0.038	0.260	0.235	0.255	0.235
1987	1.478	2.233	0.817	0.068	0.228	0.198	0.222	0.198
1988	1.528	2.309	0.845	0.071	0.221	0.190	0.214	0.190
1989	2.564	3.873	1.418	0.119	0.226	0.196	0.220	0.196
1990	1.987	3.002	1.099	0.092	0.254	0.228	0.249	0.228
1991	0.499	0.755	0.276	0.023	0.224	0.194	0.218	0.194
1992	0.177	0.653	0.192	0.03	0.123	0.121	0.127	0.121
1993	0.259	0.952	0.28	0.044	0.113	0.110	0.116	0.110
1994	0.121	0.446	0.131	0.021	0.117	0.114	0.120	0.114
1995	0.087	0.32	0.094	0.015	0.103	0.100	0.107	0.100
1996	0.07	0.257	0.076	0.012	0.171	0.170	0.174	0.170
1997	0.126	0.463	0.136	0.022	0.142	0.140	0.145	0.140
1998	0.165	0.606	0.178	0.028	0.097	0.094	0.102	0.094
1999	0.026	0.437	0.104	0.001	0.116	0.116	0.118	0.116
2000	0.034	0.558	0.133	0.001	0.114	0.113	0.116	0.113
2001	0.065	1.08	0.257	0.003	0.129	0.128	0.130	0.128
2002	0.071	1.168	0.278	0.003	0.208	0.208	0.209	0.208
2003	0.026	0.422	0.101	0.001	0.257	0.256	0.257	0.256
2004	0.015	0.256	0.061	0.001	0.412	0.411	0.412	0.411

Table 2.4.4. Age-specific estimates of instantaneous fishing mortality and full F coefficients of variation for red drum from the north recreational live-release fishery.

	Estimates				CV for full F	
	1	2	3	4^+	1	2
1986	0.008	0.002	0.000	0.000	0.387	
1987	0.013	0.003	0.000	0.000	0.293	
1988	0.007	0.002	0.000	0.000	0.293	
1989	0.025	0.006	0.000	0.000	0.262	
1990	0.040	0.009	0.000	0.000	0.338	
1991	0.034	0.008	0.000	0.000	0.107	
1992	0.017	0.008	0.001	0.000	0.143	
1993	0.043	0.020	0.001	0.001	0.102	
1994	0.118	0.055	0.004	0.003	0.082	
1995	0.068	0.032	0.002	0.002	0.153	
1996	0.024	0.011	0.001	0.001	0.217	
1997	0.038	0.018	0.001	0.001	0.104	
1998	0.035	0.017	0.001	0.001	0.107	
1999	0.016	0.024	0.005	0.002		0.119
2000	0.023	0.034	0.007	0.003		0.111
2001	0.027	0.040	0.008	0.004		0.129
2002	0.020	0.029	0.006	0.003		0.170
2003	0.013	0.020	0.004	0.002		0.200
2004	0.006	0.009	0.002	0.001		0.289

Table 2.4.5. Estimated selectivities used as parameters for the north recreational live-release fishery and for the early and late periods of the south region Florida live-release fishery.

Period	1	2	3	4	5	6	7^+
83-91	1.000	0.221	0.012	0.012	0.012	0.012	0.012
92-98	1.000	0.467	0.031	0.023	0.023	0.023	0.023
99-07	0.6840	1.0000	0.2070	0.0890	0.089	0.089	0.089

3 Stock Assessment Models and Results

3.1 Model One – Continuity Run

The last stock assessment for red drum was completed in 2000 by Vaughan and Carmichael. Vaughan and Carmichael applied three separate models: a Separable Virtual Population Analysis, a Spreadsheet Statistical Catch-at-Age analysis (SprdSCA), and a virtual population analysis using F-ADAPT. Of the three models utilized by Vaughan and Carmichael (2000), only the spreadsheet-based statistical catch-at-age could be reproduced by the workshop for a continuity run. However, 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 indices and the catch-at-age. The suggested alternative was to use the original model with updated data where needed and compare to a model run where all data were updated based on the findings of SEDAR 18 DW. The SEDAR 18 AW did not find the results of the continuity model worthy of consideration to examine simple model-change effects given the inability to reproduce all the original input data. Additionally, the working group agreed that a statistical catch-at-age model (SCA) (Section 3.2 **Model Two – Statistical Catch-at-Age**) would be the more appropriate model to use in the current assessment.

3.2 Model Two – Statistical Catch-at-Age

3.2.1 Methods

3.2.1.1 Overview

A standard SCA model was developed for red drum, which included special features for capturing some information from tagging programs and restricting the selectivity estimated for older fish. These analyses were defined for the period 1982-2007 and included age-specific data for red drum ages 1 through 7^+.

3.2.1.2 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.

In the SCA framework all input data can be considered as ‘tuning’ indices. The inputs included the 1982-2007 total annual kill of red drum by the northern fisheries: commercial gillnet and beach seine, other commercial gears (mostly pound nets and seines), recreational landings, and recreational live-release mortalities. Since the commercial fishery statistics are considered a complete census of the landings, the coefficients of variation (CV = standard error / mean) for each year’s landings was assumed low, at 0.01. The CV’s for the annual recreational harvest and the annual live-release mortalities were taken as the proportional standard errors estimated for the Marine Recreational Fisheries Statistics Survey’s (MRFSS) Type A+B1 catch (landings) and

Type B2 catch (live releases), respectively. The 1982-2007 southern region's total annual landings of red drum were grouped as: Florida commercial fishery, Florida recreational landings, Georgia recreational landings, South Carolina recreational landings, Florida live-release mortalities, and Georgia/South Carolina live-release mortalities. The coefficients of variation associated with these estimates were assigned or derived as explained above for the northern region.

The input data for the age compositions for the catch from the fisheries listed above were generally derived from random fish length samples taken from the catch that were then converted to ages using various age-length keys. The age data were rarely available directly for the recreational live-release fisheries but some information was available from angler-taken measurements of released fish. These were deemed sufficient for the South Carolina and Georgia live-release fisheries but not for the northern region or for the Florida live-release fishery where North Carolina tagging study results were used to infer the catch age-structure. The age composition proportions were represented as a multinomial distribution so the number of aged fish in the annual samples indicated the precision of the observed proportions. Because these ages weren't direct random samples from the catch, we used the square-root of the annual age-length key sample size as the effective sample with a minimum level of two used for the years when no age-length data were available. This minimum sample size of two was also used for the age composition data estimated for the Georgia/South Carolina live-release fishery.

Indices of abundance are used in the assessment model to 'tune' agreement between the model-predicted and observed trends in abundance. For the northern region, four indices were used to model trends in abundance. Two indices measured young-of-the-year (age 1) abundance: the North Carolina Independent Gillnet Survey (IGNS) and the North Carolina bag seine survey, though the former was for late year age-1 red drum and the latter was for the beginning-of-the-year age-1 fish. The other indices of abundance used in the northern region were the IGNS catch rates for age-2 red drum and the MRFSS total catch rate (assumed to apply to the aggregate abundance of ages 1-3), both for mid-year abundances. For the southern region, there were eight indices of abundance used. Three indices measured young-of-the-year trends: the Florida small seine survey, the Georgia monofilament gill net survey, and the South Carolina electro-shock survey. The last two surveys were compared to midyear abundance estimates, with a beginning-of-the-year time frame for the Florida survey. Other age-specific surveys included: the Florida haul seine survey used separately for ages 2 and 3 and the South Carolina trammel net survey for age 2. Finally, two pooled-age indices were used: MRFSS for ages 1-3 and the South Carolina longline survey (ages 6^+). The MRFSS survey was used to indicate mid-year abundance; the longline survey for abundance 10 months into the calendar year. Estimated annual geometric means and their coefficients of variation were used for all indices included in the assessment model.

Less conventional 'tuning' was provided by estimates of age-specific instantaneous fishing mortality rates (F) available from a long-term tag-recapture program conducted in North Carolina. In the northern region, estimates for F-at-age were available for the combined harvest fisheries (commercial and recreational A+B1). These estimates and associated coefficients of variation were used to 'tune' the model-estimated F-at-age for ages 1-4 during 1983-2004. The 1986-2004, annual fully recruited F's estimated for the live-releases were also used to compare against that fisheries fully recruited F's estimated within the model.

The temporal and age framework for these analyses for both the northern and southern stock models was 1982-2007 and ages 1-7$^+$. The assessment model was configured under the separability assumption that there was a year-specific apical F for each fishery and age-specific selectivities as portions of this fully recruited F. Selectivities were estimated for ages 1, 2, and 3 but were constrained for older ages, assuming that age 4 selectivity was 10% of age 3 selectivity and age 5 and older selectivities were 5% of that for age 3 (see section 3.2.2.8 **Evaluation of Uncertainty** for a sensitivity to relaxation of this constraint).

The selectivity blocks used for the northern region were 1982-1991, 1992-1998, and 1999-2007 for all fisheries chosen mostly to reflect changes in size limits. In the southern region, where regulatory actions were not as coincidental among the states, constant selectivity within each fishery was assumed to occur during: 1982-1988 for Florida commercial fishery; 1982-1985, 1986-2007 for the Florida recreational harvest fisheries (both harvest and live release); 1982-1985, 1986-1991, 1992-2001, and 2002-2007 for the Georgia recreational harvest fishery; 1982-1989, 1990-1993, 1994-2000, 2001-2007 for the South Carolina recreational harvest fishery; and 1982-1991, 1992-2007 for the Georgia/South Carolina pooled recreational live release fishery. Selectivities were not estimated for the Florida recreational live-release fishery. These selectivities during the two periods defined for this fishery were assumed equal to the North Carolina tagging study findings for the periods 1982-1991 and 1999-2004. During these periods there were generally similar size limit regulations in place in North Carolina that corresponded to the two Florida selectivity periods (1982-1985, 1986-2007).

Natural mortality was assumed constant over time, though varying with age for each regional stock.

3.2.1.3 Model Configuration and Equations

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

$$F_{f,y,a} = F^*_{f,y} s_{f,y,a}$$

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 be 10% and 5% of the selectivity at age age-3, respectively. These assumptions are roughly consistent with Bacheler *et al.* (2008) who showed that usually F for ages 4 and older was less than 5% of F at age 2. Selectivity was therefore estimated for ages 1-3 in each of the time periods for which the selectivity was assumed not to have changed for each fishery.

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 1982 through 2007) and an initial year's abundance at age ($N_{1982,a}$ for ages 2-7$^+$). Initial conditions were both modeled as lognormally distributed variables with:

$$N_{1982,a} = \overline{N} e^{d_a} \quad \text{and} \quad N_{y,1} = \overline{R} e^{g_y},$$

where d_a and g_y are normally distributed variables with a mean of zero and the 'barred' values are the averages. 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 beginning of the year stock abundance of chosen age groups:

$$\hat{I}_{s,y} = q_s N_y,$$

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 N_y is the beginning of the year total abundance for the age(s) included in the index.

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 where:

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

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:

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

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:

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

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 1983-2004 were included in the northern region's objective function as:

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

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 1986-2004 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 $F_{full(y)}$ and $\sigma_{full(y)}$ 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, the recruitment deviations (g_y) and the initial-year abundance deviation (d_a). These were each configured as deviation vectors, whose sum equaled zero.

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:

$$ObjFunction=\sum_{f}\left(\lambda_{TC(f)}negLL\left(\mathrm{T}_{f}\right)\right)+\sum_{f,y}\left(\lambda_{P(f,y)}negLL\left(P_{f,y}\right)\right)+\sum_{s}\left(\lambda_{s}negLL\left(I_{s}\right)\right)+$$
$$\sum_{1983}^{2004}\left(\lambda_{Ftag}negLL\left(F_{tag(y)}\right)\right)+\sum_{1986}^{2004}\left(\lambda_{Ffull}negLL\left(F_{full(y)}\right)\right).$$

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

3.2.1.4 Parameters Estimated (List all model estimated parameters.)

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 average initial abundance for ages 2-7^{+} and deviations from this average for each age, average recruitment during 1982-2007 and deviations from this for each year, and catchability coefficients for each survey. All parameters were estimated in log space. For the northern region, 168 parameters were estimated and for the southern region, 218 parameters were estimated (Table 3.2.4.1).

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 1983-2004 (northern region only), CV's for fishing mortality-at-age for the combined 'harvest' fleets during 1983-2004, fully-recruited F for recreational live-release fishery during 1983-2006 (northern region only), annual survey catch per unit effort, and CV's for annual survey catch per unit effort. There were 803 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 1,007 in the southern region (Table 3.2.4.2).

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, defined periods of constant selectivity, selectivities for ages 4-7$^+$ (relative to age-3 estimate), selectivity for all ages for Florida and northern recreational live-release fisheries, release mortality, ages selection 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.

3.2.1.5 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 3.2.2.1 Measures of Overall Model Fit). The precision of important derived values, e.g., escapement, 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.

3.2.1.6 Benchmark and Reference Points Methods

The ASMFC (2002) defines the overfishing threshold for red drum to be 30% static spawning potential ratio (sSPR). However, state compliance reports provided to the ASMFC are based on achieving a 40% static spawning potential ratio (Table 19 and 20, ASMFC (2002)) though it is defined as a management target).

The benchmarks estimated for this assessment include the static spawning potential ratio, escapement rate through age 3, and escapement rate through age 5. The static SPR is calculated as the spawning stock biomass per recruit expected under the current year's fishing regime divided by the theoretical spawning stock biomass under no fishing. This was calculated as:

$$sSPR_y = \frac{\sum_a Mat_a B_a \prod_1^a e^{-M_a - F_{y,a}}}{\sum_a Mat_a B_a \prod_1^a e^{-M_a}},$$

where Mat_a and B_a are the maturity- and weight-at-age vectors through the maximum ages (62 years in north and 38 years in south), respectively. Weights were estimated as region-specific nonparametric growth function predicted length converted to weight. A single maturity-at-age vector was used for both regions.

A more readily 'observable' metric for red drum, that is very similar to sSPR when there are low levels of fishing mortality on mature adults, is the escapement rate. The last assessment (Vaughan and Carmichael 2000) presented estimates of escapement through model-age 3. It may be more useful to encompass more of the immature portion of the stock in the escapement

estimate, so we have also used escapement estimates through age 5 here. Because there are a large number of adult age groups (ages 6-62 in the north and ages 6-38 in the south) assumed to have the same low level of fishing mortality as for age 5 in the sSPR calculation, escapement rates are always higher than the static SPR. If there was no fishing mortality on mature adults then escapement would equal static SPR levels.

Static or year-specific escapement (sEsc) was defined as:

$$sEsc_y = e^{\sum_{a=1}^{T} -F_{y,a}},$$

where T is either age 3 or age 5 depending on the defined age-span for escapement. The cohort-specific escapement (tEsc), which defines the escapement rate for the cohort completing its final 'escapement' age that year, is:

$$tEsc_y = e^{\sum_{a=1}^{T} -F_{y-T+a,a}}.$$

Yield-per-recruit and spawning-stock-biomass-per-recruit benchmarks were calculated using the overall recent fisheries selectivities estimated using the SCA analysis. These analyses required inputs for maturity-at-age, weight-at-age, fishery selectivity, and natural-mortality-at-age. For the yield-per-recruit analyses, the midpoints between predicted lengths-at-age were converted to weight to provide a calendar-year average weight. The end-of-the-year predicted weight was used in the spawning-biomass-per-recruit analysis because spawning for red drum occurs late in the calendar year. Yield and spawning biomass was calculated across a range of apical F's to determine F_{max} and $F_{0.1}$ for the yield per recruit and $F_{35\%}$ and $F_{20\%}$ for the spawning stock biomass per recruit analyses.

3.2.2 Results

3.2.2.1 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 27 external-weight combinations for the southern region and 36 external-weight combinations for the northern region using the minimum total standardized residual sum of squares (Tables 3.2.4.3, 3.2.4.4). For both regions, the 'best' model was configured with unity weights for all but the age composition information, which was down-weighted using 0.01 (Table 3.2.4.5).

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 3.2.4.6). 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.

3.2.5.1). This can be attributed to the low coefficient of variation (0.01) assumed for these data since commercial landings are theoretically collected using a complete census of the landings, though discards were not accounted for except in recent northern region gillnet fisheries The model estimated numbers of total mortalities generally falls within ±2 standard errors around the observed data except during the 1992, mid 1990's, and 2001, and 2003 for the recreational landed-fish fishery and during 1994 and 2002 for the recreational live-release fishery (Fig. 3.2.5.1). 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 0.58 (Table 3.2.4.6). 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 from 1993 onward and high for ages 5-7^+ over this time frame (Fig, 3.2.5.2). A consistent difference was the model overestimating the proportion of the catch in the older ages since 2004 for all fisheries.

The indices of abundance were fit well with the model-predicted trends following the NC juvenile abundance index quite closely since 2000 (Fig. 3.2.5.3). 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 3.2.4.6).

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. 3.2.5.4). 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. 3.2.5.5). 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 3.2.4.6)

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 0.67 (Table 3.2.4.7). The model-predicted total annual harvests or kills were nearly always within the ±2 standard error envelope around the observed data (Fig. 3.2.5.6).

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 over-estimating the proportion at age after the mid 1990's when the proportions for these older ages fell to extremely low levels (Fig. 3.2.5.7). An exception to these trends is the Georgia/South Carolina live-release fishery where the post mid-1990's age-1 proportions were overestimated and the age-4 through age-7^+ age groups were underestimated. The SDSR's, calculated using the expected standard deviation for a binomial (square root of Npq), were less than or equal to 1.3

except for the Florida recreational harvest fishery (Table 3.2.4.7). Fits to the age composition for this fishery were poor for all but ages 3 and 3 after about 1996.

The observed relative abundance indices were fit well in the southern region, especially the South Carolina trammel net survey data for age-2 abundance (Fig.3.2.5.8). 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 Florida haul-seine age-2 index, the SDSR's were 2.0 or less (Table 3.2.4.7).

3.2.2.2 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, initial age-specific abundances, annual recruitment, and survey catchability coefficients (Table 3.2.4.1). The associated asymptotic standard errors for each of these are reported in the spreadsheets required by TOR 9 (see section 1.2.2.9 Term 9). Further discussion of the parameter uncertainties are included below in the appropriate sections describing stock abundance, recruitment, and fishing mortality and in section 3.2.2.8 Evaluation of Uncertainty.

3.2.2.3 Stock Abundance and Recruitment

Estimates of total abundance for red drum indicate at least a two- to four-fold increase in both stocks between the early 1980's and 2007. In the northern region, estimated total population abundance averaged about 407,000 fish during the 1980's, increased during the 1990's and has averaged 1.83 million fish since 2000 (Table 3.2.4.8, Fig. 3.2.5.9). In the southern region, the total population was estimated at about 2.2 million fish in the 1980's and about 4.1 million fish since 2000 (Table 3.2.4.9).

Much of this rapid increase in estimated abundance comes from the increases in the 'less available' adult portion (ages 4^+) of the populations. This is logical given the large number of potential age groups in the 'plus' group, allowing for a substantial 'filling in' effect. Additionally, in the northern region the trends in abundance for the more exploited (observed) portion of the stocks, ages 1-3, also showed a dramatic increase in abundance over time. Average 1980's abundances for ages 1, 2, and 3 were about 186,000, 55,000, and 7,000 fish (Fig. 3.2.5.10). This increased to estimated averages during the 2000's of about 367,000, 327,000, and 172,000 fish, respectively. In the southern region, more modest changes in the abundance of age 1, 2, and 3 red drum occurred between the 1980's and 2000's, with a 10% increase in average abundance of age 1's, a 62% increase in age 2's, and a 119% increase in age 3's.

Estimated recruitment each year during 1982-2007 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 3.2.4.10, Fig. 3.2.5.11). The variability in recruitment has apparently increased since the mid 1990's, with abundances of large yearclasses being higher than was seen during the 1980's. 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.

3.2.2.4 Stock Biomass

The total stock biomass was not estimated in these analyses. These estimates would likely be highly uncertain because the 'plus' age group (7^+) contains a large number of ages and, given varying weight-at-age and an unknown initial age structure within this group, its biomass is unknown. Despite this uncertainty, we report the spawning stock biomass (see Section 3.2.2.7) under simplistic assumptions about equilibrium age structure within this 'plus' group.

3.2.2.5 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. 3.2.5.12). The recreational harvest fishery showed the effects of changing regulations with an older age of full recruitment in more recent years and a narrowing of the selectivity in response to minimum and maximum size limit restrictions. The live-release fisheries show a greater selection for younger ages. Of course, these were not model-estimated but were inputs derived from analyses of North Carolina tag return data.

In the southern region, the historic Florida commercial fishery and the recent recreational harvest fishery in Florida showed similar selectivities for ages 2 and 3. The early-period Florida recreational harvest fishery showed a higher selection for age 1 red drum. This almost certainly reflects the change in minimum size limit from 12" fork length to 18" total length. In other southern fisheries, the early period selectivities were as high or higher for age 1 than they were for the more recent periods (Fig. 3.2.5.13). The Georgia and South Carolina recreational harvest fisheries, each show a decline in the selectivity of age-3 fish following implementation of maximum size limits. The Georgia/South Carolina pooled live-release fishery shows unusual high selection for ages 1-3 throughout the time frame of these analyses.

3.2.2.6 Fishing Mortality

Estimates of exploitation (= predicted annual catch / estimated beginning-of-the-year abundance) showed marked declines beginning in 1991 in the northern region and beginning in 1988 in the southern region. Northern region exploitation rates for pooled ages 1-3 red drum averaged 0.66 during 1983-1990 then declined to average 0.19 from 1991-2007 (Table 3.2.4.11, Fig. 3.2.5.14). During the latter period there was no significant trend in exploitation. In the southern region, age 1-3 exploitation averaged 0.40 during the period 1982-1987 and 0.19 during 1988-2007. Since reaching a minima in 1989 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 3.2.4.12) and the southern region (Table 3.2.4.13) and for all fisheries combined within each region (Table 3.2.4.14).

The estimated asymptotic standard errors for the fully recruited F estimates were generally larger in the early years of the analyses in both regions. In the northern region the coefficients of variation (asymptotic standard error/estimate) were much higher during 1983-1988 for the commercial gillnet/beach seine fishery and during 1983-1990 for the other three fisheries (Fig. 3.2.5.15). In the southern region the estimated fully recruited F's were also generally less precise in the early years of the commercial and recreational landed fisheries (Fig. 3.2.5.16). The estimated standard errors for the southern region's live-release fisheries were more similar across the years with higher errors in the later years when the fully recruited F's were higher.

3.2.2.7 Stock-Recruitment Parameters

A stock-recruitment analysis was not conducted or used for this assessment. However, since spawning potential ratios are used by managers, with adequate levels determined using general levels suggested for other demersal-type fishes, we show the model-estimated recruitment's relation with the previous year's female spawning biomass. These calculations used the same average weights and maturity used in the calculation of static spawning potential ratio and an assumed 1:1 sex ratio. They also come with the same caveats noted above in section 3.2.2.4.

The northern stock has increased in abundance markedly since the early 1990's so there is a strong increasing trend in the spawning stock biomass (Fig. 3.2.5.17). In addition the level of recruitment, as estimated in the model, has increased 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 increased but the abundance of age-1 fish has not.

3.2.2.8 Evaluation of Uncertainty

The northern and southern region models were configured such that the selectivities of red drum age 4 and age 5 were restricted to be a proportion of the selectivity at age 3, i.e., selectivity at age 4 was 10% of that at age 3 and selectivity at age 5 was 5% of that 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, with ages 6 and 7^+ set equal to age 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. 3.2.5.18). 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 and do not show any increase over the 1982-2007 period (Fig. 3.2.5.18). In fact, abundance estimates for age-4^+ red drum average only about 427,000 fish each year compared with 1.8 million fish estimated for these ages during 2000-2007 under the 'restricted' base model configuration. While the model fits to the observed data were reasonable when selectivity was estimated independently for ages 1-5, the patterns of selectivity were erratic and age-4 selectivity was general greater than 0.20 (Fig. 3.2.5.19).

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 (>5 billion) and therefore fishing mortality rates near zero.

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. The cumulative effect of the different M's was greater on the abundance of ages 4^+, with the more recent estimates being 29% higher than the base model under the low M sensitivity and 25% lower under the high M sensitivity (Fig. 3.2.5.20).

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 and therefore the exploitation rate was lower. The total abundance of ages 1-3 in the southern region was about 102% higher in the high-M sensitivity case and -36% lower in the low-M case than in the base model (Fig. 3.2.5.20). Likewise, the estimates abundance of age 4^+ was also significantly higher (83%) under the high-M sensitivity and lower under the low M sensitivity (-34%). As would be expected, the age 1-3 pooled exploitation was lower under the low-M sensitivity than under the base model and higher under the high-M sensitivity.

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 abundances of red drum that were greater than for the base model, which largely offset the increased number killed so that exploitation remained the same between the high-release-mortality model and the base model (Fig. 3.2.5.21). In the southern region, the same effect was noted though the exploitation rates for age 1-3 red drum did increase slightly after 1990 when the number of live-release deaths increased.

The retrospective analysis was conducted using the base model configurations and sequentially eliminating data available for 2007, 2006, and then 2005. In the southern region, the short Georgia gillnet survey was dropped from the 2004 run because the survey began in 2003. For the northern region, there was no evidence of any significant difference between the runs estimates of age 1-3 abundance or exploitation (Fig. 3.2.5.22). The 2004 run did not converge properly and that may explain the observed differences.

In the southern region 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. Except for the run ending in 2004, which utilized one fewer index of abundance, the estimates of exploitation were similar. Additional investigation into this potential bias is warranted.

3.2.2.9 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 34.0% in the northern region and 36.9% 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. This is 41.5% in the northern region and 35.4% in the southern region.

Annual estimates of sSPR were low through the late 1980's in both regions before increasing to near-present levels by the mid 1990's. In the northern region, sSPR was estimated at less than 1% for most years during 1983-1990, and then increased dramatically in 1991 to reach 32.7% (Table 3.2.4.15, Fig. 3.2.5.23). Since 1996, sSPR has been variable and ranged from 30.7% to 60.1%. In the southern region, sSPR was generally below 20% before 1988 then rapidly increased to near 50% by 1989 and 1990. Since then it has fluctuated with a slow decline reaching 34-38% after 2004.

A more readily 'observable' metric for red drum, that is very similar in value to sSPR when there are low levels of fishing mortality on mature adults, is the year-specific escapement rate (sEsc). The last assessment (Vaughan and Carmichael 2000) presented estimates of sEsc through model-age 3. It may be more useful to encompass more of the immature portion of the stock in the escapement estimate to provide a measure of 'recruitment' to the spawning stock. We have used escapement estimates through age 5 here. Because there are a large number of adult age groups (ages 6-62 in the north and ages 6-38 in the south) assumed to have the same low level of fishing mortality as the age-5 group in the sSPR calculation, year-specific escapement rates are always equal to or higher than the static SPR. If there was no fishing mortality on mature adults then escapement would equal static SPR levels. For the northern region, year-specific escapement through age 5 in 2007 was about 40% (2005-07 average equals 47%); in the southern region 2007 escapement was 43% (2005-07 average equals 42%). Yearclass-specific escapement rates (tEsc), a measure of the effect of fishing mortality on a cohort through age-5, are presented in Table 3.2.4.15 (Fig. 3.2.5.23).

The range of year-specific escapement rate estimates from the sensitivity runs of the models can provide some idea of the precision of these estimates. For the higher release-mortality sensitivities, 2007 year-specific escapement was estimated at 35.1% in the northern region and 34.4% in the southern region (Table 3.2.4.16). Under the high-low natural mortality sensitivities, age 1-5 escapement in 2007 was calculated to be 39.1 and 40.9%, respectively, in the northern region and 66.1% and 25.6%, respectively, in the southern region. Under the configuration sensitivities, with selectivities estimated for ages 4 and 5, the northern region 2007 escapement was estimated at 41.4%,and 14.9% in the southern region. The associated sSPR estimates for these sensitivities are general about 6 percentage points lower than the escapement levels (Table 3.2.4.16).

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 sSPR and year-specific escapement in 2007 for the northern region is much more precisely estimated than is the southern region estimates (Fig. 3.2.5.24). In both areas, the profiles indicate that it is likely that the 2007 sSPR was below the management target of 40% sSPR; 99% chance in the northern region and 62% in the southern region. However, chances that the overfishing threshold of 30% sSPR (ASMFC 2002) was not met were small in the northern region (4% chance) and low-intermediate in the southern region (16% chance).

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 well-defined peak across fishing mortality with the F_{max} and $F_{0.1}$ benchmarks being quite similar (Table 17, Fig. 3.2.5.25). 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. The spawning-stock-biomass analysis showed that fishing mortality in both regions during 2007 was close to the $F_{35\%}$ level but that for all recent years fishing mortalities were less than the $F_{20\%}$ level.

3.2.3 Discussion

The observations from the northern region red drum fisheries and indices of abundance point to a number of changes that occurred mostly during the late 1980s and 1990s in this stock. The fisheries landings fluctuate but showed a period of depressed landings with no strong peaks from 1990 through 1997. In 1992 there was a dramatic and long-term shift away from age-1 fish in the harvest to mostly age 2 and 3. Meanwhile, the observed indices indicate that there was increasing abundance of age-1 fish during the period 1992 through at least 1997. The strongest signal of change in the fisheries dynamics comes from the tagging program results on fishing mortality, which dropped precipitously after 1989 and remained low from 1991-2007. The population model integration of these observations using the SCA suggest a stock whose abundance increased about 4-fold during the 1990's because of increased recruitment (peak in 1992 and sustained high levels during 1995-1999) and increased survival of age-1 fish. This, in turn, led to increased age-specific abundances propagating through the population over time, assisted by constrained levels of F on these older age groups. The 1986-1998 continuity run found a different population dynamic during the 1990's, with variable but stable total abundance and increasing fishing mortalities all generally above 1.0 yr^{-1} (**S18 AW-12**). The AW panel found that the continuity model was not reliable and did not endorse its use. Also, the continuity model did not include the tagging-F-estimate data (not available for Vaughan and Carmichael (2000)) and, this may explain some of the difference, in light of the sensitivity of the northern SCA analysis to the inclusion of these data. The continuity model also set age-3 selectivity equal to age-2. This would mean full selectivity of age-3 when most age-3's in the north region are over 27" and unavailable for harvest particularly since the mid to late 1990's. The tagging data and SCA would suggest age-3's are not fully selected. The semi-separable VPA was used to take advantage of the convergence properties of VPA and determine if the catch-at-age analysis alone (with some constraints, see **S18 AW-07**) was informative about the population dynamics and consistent with the SCA results. This model did appear to agree with the SCA results that indicated average age1-3 F's declined during the early 1990's but without the noticeable increase in abundance, seen in the SCA beginning in 1991, until at least 1997. On an absolute scale, the semi-separable VPA estimates of F and abundance were fairly similar to the SCA estimates prior to 1991 and during the late 1990's. Major differences occurred during the 1990's when the SCA rapidly increased abundance and the semi-separable VPA kept abundance low and during the most recent non-converged part of the VPA (after 2003).

The observations for southern region red drum show that most changes in the fishery occurred during the late 1980's early 1990's. During that time period, total harvest declined from a peak in the mid 1980's to a minima in 1989. The Florida recreational harvest and Georgia/South Carolina commercial/recreational harvest fisheries declined and the Florida commercial fishery was regulated out of existence by 1989. The observed dominant age-group in the catch changed rapidly from age-1 to ages 1 and 2 in 1986 in Florida, more slowly during 1991-1994 for the GA/SC live-release fishery, and even more slowly for the Georgia and South Carolina commercial/recreational harvest fisheries. The indices of abundance do not extend back to this period of change (earliest is 1991) and do not indicate strong long-term changes in abundance. The SCA fit to these data suggest that the drop in total catch and age-composition change in the late 1980's resulted in lower exploitation rates overall leading to an increase in age $1\text{-}4^{+}$ abundance as the stock moved toward equilibrium with lower mortality. The SCA suggests that since 1998 the number of older fish has remained stable but that recruitment and abundance

of ages 1-3 has increased, following short-term trends in some of the indices. The continuity model, which used data from 1986-1998, also indicated a drop in fishing mortality during the mid-late 1980's but from much higher levels of F and a much less pronounced increase in abundance. The semi-separable VPA for the southern region failed to converge, except when F was constrained, though even for these runs the fully converged solutions occurred prior to 1990. One conclusion from this analysis, that the southern region analysis would be less certain than that for the northern region, agreed with the findings from the SCA.

The last coast-wide assessment for red drum was conducted for the period 1986-1998 (Vaughan and Carmichael 2000). The preferred analysis, based on Red Drum Assessment group recommendations, were FADAPT VPA's (Restrepo 1996) that utilized separable-virtual-population-analysis estimates of selectivity in the terminal year. Separate regional VPA's were run under different terminal selectivity constraints: F at age 3 was defined as 70% of that for age 2 in the northern region and 83% in the southern region. These constraints resulted in selectivities that were different to those estimated in the current SCA, with the SCA-estimated overall F's at age 3 being about 40% of that at age 2 in the northern region and about 75% in the southern region during 1986-1998. Estimates of sSPR based on the FADAPT VPA for the southern region averaged 0.5% during 1988-1991 and 15.1% during 1992-1997. These compare to sSPR averages of 42% and 44%, respectively in the current SCA analysis. These large differences are strongly linked to the selectivity constraints used. For example, when the selectivity was estimated without constraints for ages 1-5 (sensitivity runs) in the southern region, the SCA estimates of sSPR were sharply lower (0.9% 1988-1991 and 2% 1992-1997) because the estimated F's-at-age were high and nearly constant through age 5 without any significant peak. There was also a difference between the estimation of sSPR with Vaughan and Carmichael (2000) assuming no fishing on ages 6^+ and the current analyses applying the age 7^+ F to all older age groups through the maximum age (max. age equals 62 years in north and 38 years in south).

Single state-specific assessments have been conducted recently for red drum, one in the northern region and one in the south. The northern region assessment conducted for North Carolina (Takade and Paramore 2007) using a spreadsheet SCA similar to Vaughan and Carmichael (2000) found period-specific average sSPR's of 2.4%, 30.4%, and 32.3% for 1986-1991, 1992-1998, and 1999-2004, respectively. They also updated Vaughan and Carmichael's (2000) FADAPT VPA for the north region, results were: period-specific average sSPR's of 1.1%, 18.4%, and 40.4% for 1986-1991, 1992-1998, and 1999-2004. Estimates for these time periods from the current analyses were higher: 6.6%, 39.8%, and 46.9%. In the southern region, an assessment in Florida (Murphy and Munyandorero 2008) found similar early and late estimates of escapement (through age 5): average values for 1982-1985, Florida 13.5% and southern region 15.0%; and for 2004-2007, Florida 41.6% and southern region 42.2%. Intermediate year estimates, however, were quite different: 1988-1992, Florida 74.1% and southern region 49.1%. This appears logical since there was a moratorium to all red drum fishing in Florida just prior to this period which likely caused escapement to spike in the early 1990's.

The red drum stocks in the northern and southern regions are likely not experiencing overfishing with regards to the 30% sSPR threshold. The precision of the benchmark estimates and the effects of sensitivities make this conclusion much less certain in the southern region than in the northern.

Given the general lack of observations about the age composition and relative abundance of the adult portions of these stocks, the panel felt it may be preferable to define a biological benchmark that is not sensitive to assumptions about the population dynamics of the adults. A useful benchmark that only requires estimates of fishing mortalities for the available immature age groups is escapement rate. The threshold and target levels for escapement would depend on the same theoretical considerations used to define the 30% threshold and 40% target for the static spawning potential ratio and on the presumed (if not measured) level of fishing on adults. As defined above, two types of escapement rate estimates may be used year-specific and yearclass-specific. These can be thought of as measures of overfishing status (year-specific escapement based on the current year's F values) and of overfished status (yearclass-specific escapement incorporating the F history leading up to the current year). The panel discussed and indicated a preference for the use of escapement rate to determine stock status.

Additional Literature Cited

Murphy, M.D. and J. Munyanorero. 2008. An assessment of the status of red drum in Florida waters through 2007. Florida Fish and Wildlife Conservation Commission Fish and Wildlife Research Institute In-House Report 2008-008. St. Petersburg.

Takade, H. and L. Paramore. 2007. Stock status of the northern red drum stock. Appendix 3. North Carolina Division of Marine Fisheries. Morehead City.

3.2.4 Tables

Table 3.2.4.1. Estimated parameters in the SCA models for 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 and age 1-3 selectivities (log_sel) for each period of assumed constant selectivity. Abundance-estimate related parameters include mean recruitment (log_R), deviations from this mean across years (log_rec_devs), mean first-year abundance for ages 2-7$^+$ (log initN), deviations from this mean (log_initN_devs), and index-of-abundance proportionality coefficients ('survey scalars' or log_q).

Northern region

Population dynamic	Parameters estimated		Number
Fishing mortality			
Comm BS&GN	1982-2007 log_F's; 3 sets of age 1-3 log_sel's		35
Comm other	1982-2007 log_F's; 3 sets of age 1-3 log_sel's		35
Rec A+B1	1982-2007 log_F's; 3 sets of age 1-3 log_sel's		35
Rec B2	1983-2007 log_F's		25
		Total	130
Abundance			
recruitment	mean log_R, 1982-2007 deviations log_rec_dev's		27
initial abundance	mean log_initN, log_initN_dev'ss for ages 2-7$^+$		7
survey scalar	log_q's for four surveys		4
		Total	38
Grand Total			168

Southern region

Population dynamic	Parameters estimated		Number
Fishing mortality			
FL comm	1982-1988 log_F's; 1 set of age 1-3 log_sel's		10
FL rec A+B1	1982-2007 log_F's; 2 sets of age 1-3 log_sel's		32
GA rec A+B1	1982-2007 log_F's; 4 sets of age 1-3 log_sel's		38
SC rec A+B1	1982-2007 log_F's; 4 sets of age 1-3 log_sel's		38
FL rec B2	1982-2007 log_F's		26
GA/SC rec B2	1982-2007 log_F's; 2 sets of age 1-3 log_sel's		32
		Total	176
Abundance			
recruitment	mean log_R, 1982-2007 deviations log_rec_dev's		27
initial abundance	mean log_initN, log_initN_dev's for ages 2-7$^+$		7
survey scalar	log_q's for four surveys		8
		Total	42
Grand Total			218

Table 3.2.4.2. 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 (82-07)	26	Comm FL (82-88)	7
Comm other (82-07)	26	Rec kept FL (82-07)	26
Rec kept (82-07)	26	Rec kept GA (82-07)	26
Rec live release (83-07)	25	Rec kept SC (82-07)	26
		Rel live release FL (82-07)	26
		Rec live release GA/SC (82-07)	26
Totals	103		137
Proportion at age		**Proportion at age**	
Comm GN & BS (82-07, ages 1-7$^+$)	182	Comm FL	49
Comm other (82-07, ages 1-7$^+$)	182	Rec kept FL (82-07, ages 1-7$^+$)	182
Rec kept (82-07, ages 1-7$^+$)	182	Rec kept GA (82-07, ages 1-7$^+$)	182
		Rec kept SC (82-07, ages 1-7$^+$)	182
		Rec live release GA/SC (82-07, ages 1-7$^+$)	182
Totals	546		777
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 (91-07, without 1997)	16	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	47		93
Tagging study estimates			
F kept at age (83-04, ages 1-4$^+$)	88		
Full F release (86-04)	19		
Totals	107		
Grand Totals	803		1,007

Table 3.2.4.3. The external hypotheses (weights) used to evaluate 'best' model fit in the northern region. The total catch fleets were the commercial gillnet and beach seine, the other commercial gears, the recreational landed (MRFSS Type A+B1) catch, and the recreational live-release. The first three of these were included in the proportion at age weights (the age composition of the live-release fishery was implied from tagging estimates). The indexes were the North Carolina independent gill net survey (IGNS) age 1 index, the IGNS age 2 index, the North Carolina juvenile abundance index, and the MRFSS total catch rate index. The tag-based F weights were used for the F-at-age estimates from the recreational landed fish and the fully recruited F's for the live-release fishery.

<u>Total Catch by fleet</u>

H_o : default

1. 1. 1. 1.

H_{a1}: B2 recreational total catch estimates are suspect

1. 1. 1. 0.1

H_{a2}: B2 recreational total catch estimates are really suspect

1. 1. 1. 0.01

<u>Proportion at age(excludes the live-release fishery)</u>

H_o: default

catch at age by fleet and year all year and all fleets 1.0

H_a: the recreational age composition data is less certain than commercial

commercial fleets are 1.0 and recreational fleet is 0.01

<u>Indexes of abundance</u>

H_o: default

1. 1. 1. 1.

H_{a1}: the MRFSS index is best due to larger spatial coverage

1. 1. 1. 10.

H_{a2}: the YOY indexes are best due to scientific design and ease of capture

10. 1. 10. 1.

<u>Tagging based F (for kept F at age and then full F B2 recreational)</u>

H_o: default

1. 1.

H_a: both less accurate than catch-at-age model

0.1 0.1

Table 3.2.4.4. The external hypotheses (weights) used to evaluate 'best' model fit in the southern region. The total catch fleets were the Florida commercial fishery, the Florida recreational landed (MRFSS Type A+B1) fishery, the Georgia recreational landed commercial fishery, the South Carolina recreational landed/commercial fishery, the Florida live-release fishery, and the Georgia/South Carolina live release fishery. All but the Florida live-release fishery (in order) were included in the proportion at age weights (the age composition of the Florida live-release fishery was implied from tagging estimates). The indexes were the young-of-the-year surveys in Florida, Georgia, and South Carolina, the Florida haul seine survey for age 2 red drum, the Florida haul seine survey for age 2, the South Carolina trammel net survey for age 2, the MRFSS total catch rate index, and the South Carolina longline survey for adults.

<u>Total Catch by fleet</u>

H_o : default

1. 1. 1. 1. 1. 1.

H_{a1}: B2 recreational total catch estimates are uncertain

1. 1. 1. 1. 0.1 0.1

H_{a2}: B2 recreational total catch estimates are really uncertain

1. 1. 1. 1. 0.01 0.01

<u>Proportion at age (excludes the Florida live-release fishery)</u>

H_o: default

catch at age by fleet and year all year and all fleets 1.0

H_{a1}: the live release recreational age composition data is less certain than other data

landed fisheries are 1.0 and recreational live release fleet is 0.1

H_{a2}: the recreational age composition data is less certain than commercial

landed fisheries are 1.0 and recreational live release fleet is 0.01

<u>Indexes of abundance</u>

H_o: default

1. 1. 1. 1. 1. 1. 1. 1.

H_{a1}: the MRFSS index is best due to larger areal coverage

1. 1. 1. 1. 1. 1. 10. 1.

H_{a2}: the YOY indexes are best due to scientific design and ease of capture

10. 10. 10. 1. 1. 1. 1. 1.

Table 3.2.4.5. Total standardized residual (observed minus model-predicted) sum of squares for the various external-weighting schemes (refer to Tables 7.1.1 and 7.1.2) used in the northern and southern regions.

Northern Region

			Total catch hypothesis		
	Indexes, H_o		H_o	H_{a1}	H_{a2}
Tag-based F, H_o	Proportion at age	H_o	5,215	5,382	5,898
		H_{a1}	**4,850**	5,029	5,568
			Total catch hypothesis		
	Indexes, H_{a1}		H_o	H_{a1}	H_{a2}
	Proportion at age	H_o	6,597	6,694	7,387
		H_{a1}	6,256	6,235	7,053
			Total catch hypothesis		
	Indexes, H_{a2}		H_o	H_{a1}	H_{a2}
	Proportion at age	H_o	5,585	5,900	6,387
		H_{a1}	5,193	14,034	6,105
			Total catch hypothesis		
	Indexes, H_o		H_o	H_{a1}	H_{a2}
Tag-based F, H_o	Proportion at age	H_o	12,598	12,673	13,923
		H_{a1}	11,066	11,095	12,326
			Total catch hypothesis		
	Indexes, H_{a1}		H_o	H_{a1}	H_{a2}
	Proportion at age	H_o	11,656	13,715	15,348
		H_{a1}	10,595	12,136	20,571
			Total catch hypothesis		
	Indexes, H_{a2}		H_o	H_{a1}	H_{a2}
	Proportion at age	H_o	15,688	15,556	16,489
		H_{a1}	14,160	13,955	15,018

Southern region

		Total catch hypothesis		
Indexes, H_o		H_o	H_{a1}	H_{a2}
Proportion at age	H_o	7,458	5,486	7,575
	H_{a1}	**6,344**	5,192	7,507
	H_{a2}	6,520	9,145	11,955
		Total catch hypothesis		
Indexes, H_{a1}		H_o	H_{a1}	H_{a2}
Proportion at age	H_o	5,710	5,449	7,825
	H_{a1}	5,325	8,107	8,589
	H_{a2}	5,352	5,303	10,167
		Total catch hypothesis		
Indexes, H_{a2}		H_o	H_{a1}	H_{a2}
Proportion at age	H_o	4,894	4,866	14,602
	H_{a1}	4,483	4,962	7,776
	H_{a2}	17,581	4,946	7,742

Table 3.2.4.6. 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 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					
Comm GN & BS	26	103,760.51	0.84	-119.32	0.178
Comm other	26	400,468.42	0.02	-119.72	0.028
Rec kept	26	349.43	249.34	81.02	2.936
Rec live release	25	2,924.90	125.88	23.24	2.229
Totals	103	507,503.26	376.08	-134.78	
Proportion at age					
Comm GN & BS	182			426.90	1.904
Comm other	182			404.59	0.622
Rec kept	182			481.63	0.582
Totals	546			1,313.12	
Indexes of Abundance					
NC IGNS age 1	7	10.72	4.98	-1.66	0.843
NC IGNS age 2	7	6.84	18.81	6.95	1.639
NC JAI age 1	16	792.48	258.97	92.35	4.023
MRFSS ages 1-3	17	211.65	312.40	120.81	4.287
Totals	47	1,021.69	595.16	218.45	
Auxiliary Observations					
F kept at age	88	4,729.47	1,001.81	353.71	3.374
Full F release	19	513.74	135.07	33.63	2.634
Totals	107	5,243.21	1,136.88	387.34	
Others Deviations					
selectivities				85.12	
Totals				85.12	
Grand Totals	803			1,869.2	

Table 3.2.4.7. 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					
Comm FL	7	307,464.92	0.00	-32.24	0.000
Rec kept FL	26	432.55	11.41	-45.82	0.663
Rec kept GA	26	156.91	7.51	-37.58	0.533
Rec kept SC	26	258.58	10.83	-36.17	0.645
Rel live release FL	26	1,744.44	0.76	-51.51	0.171
Rec live release GA/SC	26	1,453.36	0.62	-45.31	0.155
Totals	137	311,510.76	31.14	-248.62	
Proportion at age					
Comm FL	49			60.20	0.141
Rec kept FL	182			278.22	3.357
Rec kept GA	182			188.96	1.279
Rec kept SC	182			857.64	0.894
Rec live release GA/SC	182			93.42	0.410
Totals	777			1,478.44	
Indexes of Abundance					
FL small seine	10	34.98	28.13	3.56	1.672
GA gillnet	5	18.92	8.49	-2.21	1.301
SC electro-shock	8	46.47	33.78	5.80	1.906
FL haul seine age 2	11	54.32	55.42	6.33	2.245
FL haul seine age 3	11	59.31	44.25	0.74	2.006
SC trammel age 2	17	467.50	22.72	-32.32	1.147
MRFSS ages 1-3	17	6.89	13.08	-18.96	0.877
SC adults longline	14	84.99	82.36	16.44	2.407
Totals	93	773.38	288.24	-20.62	
Others Deviations					
selectivities				27.69	
Totals				27.69	
Grand Totals	1,007			1,236.87	

Table 3.2.4.8. Estimated abundance of red drum ages 1 – 7+ in the northern region during 1982-2007.

	1	2	3	4	5	6	7+	Totals
1982	91,918	23,117	4,037	4,361	3,875	3,173	201,743	332,225
1983	286,688	55,580	11,238	2,883	3,892	3,535	188,786	552,602
1984	188,171	53,796	2,752	3,197	2,347	3,391	169,207	422,861
1985	118,756	36,995	2,924	833	2,619	2,051	152,317	316,495
1986	232,054	56,696	9,176	1,636	725	2,360	140,493	443,139
1987	182,013	102,050	13,268	4,939	1,420	652	129,750	434,093
1988	263,193	53,688	9,166	4,974	4,133	1,254	116,323	452,731
1989	128,648	56,865	5,229	3,386	4,156	3,647	104,805	306,737
1990	133,369	19,224	1,963	1,355	2,730	3,603	94,935	257,180
1991	457,287	36,727	1,250	683	1,125	2,402	87,531	587,004
1992	148,008	292,604	19,466	936	612	1,029	83,013	545,668
1993	181,454	103,256	163,842	14,418	838	559	77,537	541,905
1994	248,649	116,476	43,799	110,609	12,784	762	71,676	604,755
1995	457,109	169,143	67,144	33,793	99,327	11,687	66,878	905,080
1996	351,523	326,022	98,706	52,104	30,387	90,903	72,518	1,022,164
1997	529,711	263,278	225,823	80,113	47,094	27,892	150,670	1,324,582
1998	613,885	374,114	171,792	177,237	72,123	43,126	164,902	1,617,179
1999	687,997	421,519	194,581	125,591	158,455	65,822	191,367	1,845,331
2000	162,882	523,269	221,766	166,932	113,925	145,521	237,962	1,572,258
2001	471,861	124,696	284,346	190,699	151,368	104,563	354,165	1,681,697
2002	558,325	350,905	48,804	237,089	172,348	138,680	423,536	1,929,687
2003	246,575	407,893	143,128	40,518	213,348	157,159	516,551	1,725,172
2004	269,085	194,028	249,702	124,780	36,841	196,263	624,533	1,695,232
2005	484,853	209,955	121,005	217,846	113,359	33,855	760,038	1,940,910
2006	581,072	366,026	106,257	103,169	197,232	103,918	734,779	2,192,454
2007	161,154	438,001	198,764	90,940	93,308	180,541	774,478	1,937,185

Table 3.2.4.9. Estimated abundance of red drum ages 1 – 7^+ in the southern region during 1982-2007.

	1	2	3	4	5	6	7+	Total
1982	776,030	207,480	75,409	171,819	80,826	39,493	223,061	1,574,118
1983	991,403	337,928	95,986	39,003	141,953	69,187	228,944	1,904,403
1984	1,503,840	442,104	163,095	51,694	32,352	121,752	260,268	2,575,104
1985	1,384,972	560,786	184,904	76,751	42,306	27,562	330,983	2,608,264
1986	849,466	499,601	225,529	84,749	62,639	35,990	310,939	2,068,913
1987	1,127,894	477,104	271,869	127,267	70,588	53,816	303,771	2,432,309
1988	942,593	483,563	210,994	134,681	104,463	60,141	310,353	2,246,788
1989	763,214	486,580	272,359	129,661	113,050	90,053	325,311	2,180,229
1990	885,788	494,715	332,607	196,262	110,625	98,277	367,582	2,485,855
1991	1,297,240	575,153	334,675	245,844	167,982	96,362	413,124	3,130,381
1992	943,415	801,382	357,526	229,397	208,364	145,391	449,030	3,134,504
1993	1,016,372	626,762	523,669	263,198	196,107	181,296	526,365	3,333,770
1994	1,125,776	646,990	395,175	389,440	225,032	170,544	626,248	3,579,206
1995	1,258,566	701,975	379,077	276,841	330,709	194,928	702,643	3,844,739
1996	597,605	775,755	414,156	270,111	235,557	286,804	792,419	3,372,408
1997	764,145	378,127	456,101	285,623	229,122	203,993	950,969	3,268,081
1998	671,643	483,083	228,430	331,123	243,318	198,734	1,020,222	3,176,553
1999	936,526	450,913	303,745	159,294	281,070	210,730	1,075,277	3,417,555
2000	865,660	617,768	275,119	209,464	135,045	243,250	1,133,597	3,479,903
2001	1,177,519	568,562	366,249	180,804	176,666	116,548	1,210,136	3,796,483
2002	1,060,515	747,842	320,177	242,219	152,527	152,444	1,166,893	3,842,617
2003	1,430,495	686,392	470,723	225,395	205,824	132,180	1,165,094	4,316,102
2004	1,301,134	916,102	414,584	325,677	191,189	178,205	1,144,722	4,471,614
2005	1,198,380	818,597	542,340	285,166	275,826	165,302	1,165,344	4,450,954
2006	930,451	746,398	466,386	356,549	240,258	237,749	1,168,678	4,146,470
2007	1,241,522	575,445	430,915	315,202	301,420	207,527	1,237,284	4,309,315

Table 3.2.4.10. Estimated recruitment (age-1 beginning-of-the-year abundance) and associated bounds using ± 2 asymptotic standard errors. All values were originally in log space so bounds are not symmetrical.

	Northern region			Southern region		
	-2SE	Est	+2SE	-2SE	Est	+2SE
1982	33,555	91,918	251,766	388,757	776,030	1,549,451
1983	163,233	286,688	503,486	457,522	991,403	2,148,765
1984	94,706	188,171	373,857	735,679	1,503,840	3,074,799
1985	67,439	118,756	209,110	715,003	1,384,972	2,683,353
1986	160,624	232,054	335,232	425,532	849,466	1,696,137
1987	128,509	182,013	257,780	607,691	1,127,894	2,093,897
1988	205,942	263,193	336,341	455,291	942,593	1,951,907
1989	100,101	128,648	165,328	366,596	763,214	1,589,301
1990	103,897	133,369	171,192	538,834	885,788	1,456,487
1991	401,182	457,287	521,211	834,333	1,297,240	2,017,465
1992	118,189	148,008	185,342	604,413	943,415	1,472,896
1993	148,154	181,454	222,226	661,784	1,016,372	1,561,311
1994	213,506	248,649	289,562	734,743	1,125,776	1,725,321
1995	400,875	457,109	521,203	831,407	1,258,566	1,905,635
1996	303,097	351,523	407,670	393,072	597,605	908,775
1997	435,720	529,711	643,942	504,717	764,145	1,157,192
1998	538,705	613,885	699,525	443,468	671,643	1,017,459
1999	607,441	687,997	779,189	621,808	936,526	1,410,859
2000	136,329	162,882	194,599	574,279	865,660	1,305,178
2001	410,362	471,861	542,545	779,921	1,177,519	1,778,236
2002	482,816	558,325	645,609	699,364	1,060,515	1,608,537
2003	209,713	246,575	289,900	955,932	1,430,495	2,141,159
2004	226,283	269,085	319,967	868,098	1,301,134	1,950,625
2005	419,348	484,853	560,567	795,385	1,198,380	1,805,988
2006	510,065	581,072	661,925	614,671	930,451	1,408,785
2007	120,278	161,154	215,911	790,967	1,241,522	1,949,159

Table 3.2.4.11. Predicted catch (Ca), estimated abundance (Na), 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 1982-2007.

	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^+
1982	32,441	119,072	0.27	34,911	332,225	0.11	414,672	1,058,919	0.39	430,800	1,574,118	0.27
1983	262,997	353,505	0.74	273,955	552,602	0.50	537,642	1,425,316	0.38	548,960	1,904,403	0.29
1984	182,948	244,720	0.75	192,277	422,861	0.45	967,742	2,109,038	0.46	982,233	2,575,104	0.38
1985	71,566	158,676	0.45	75,205	316,495	0.24	1,009,510	2,130,662	0.47	1,025,728	2,608,264	0.39
1986	141,446	297,925	0.47	145,090	443,139	0.33	437,403	1,574,596	0.28	449,074	2,068,913	0.22
1987	202,625	297,332	0.68	208,531	434,093	0.48	761,821	1,876,866	0.41	780,481	2,432,309	0.32
1988	230,348	326,047	0.71	235,918	452,731	0.52	477,964	1,637,150	0.29	490,493	2,246,788	0.22
1989	154,280	190,742	0.81	161,281	306,737	0.53	229,868	1,522,154	0.15	237,108	2,180,229	0.11
1990	99,933	154,556	0.65	104,644	257,180	0.41	253,646	1,713,110	0.15	260,837	2,485,855	0.10
1991	104,846	495,263	0.21	105,716	587,004	0.18	426,894	2,207,069	0.19	441,815	3,130,381	0.14
1992	123,157	460,078	0.27	124,024	545,668	0.23	323,686	2,102,323	0.15	334,157	3,134,504	0.11
1993	125,792	448,552	0.28	127,392	541,905	0.24	364,198	2,166,804	0.17	376,467	3,333,770	0.11
1994	82,074	408,924	0.20	84,716	604,755	0.14	436,676	2,167,941	0.20	458,155	3,579,206	0.13
1995	116,055	693,395	0.17	118,045	905,080	0.13	473,763	2,339,617	0.20	493,588	3,844,739	0.13
1996	101,600	776,252	0.13	103,209	1,022,16	0.10	382,770	1,787,516	0.21	405,991	3,372,408	0.12
1997	158,274	1,018,813	0.16	161,160	1,324,58	0.12	284,375	1,598,374	0.18	305,706	3,268,081	0.09
1998	265,310	1,159,792	0.23	272,069	1,617,17	0.17	226,832	1,383,156	0.16	253,054	3,176,553	0.08
1999	213,280	1,304,097	0.16	216,233	1,845,33	0.12	287,540	1,691,184	0.17	312,568	3,417,555	0.09
2000	208,078	907,917	0.23	212,078	1,572,25	0.13	338,884	1,758,547	0.19	369,242	3,479,903	0.11
2001	125,906	880,902	0.14	132,356	1,681,69	0.08	433,153	2,112,330	0.21	462,764	3,796,483	0.12
2002	236,086	958,034	0.25	248,200	1,929,68	0.13	374,186	2,128,535	0.18	397,509	3,842,617	0.10
2003	129,955	797,596	0.16	133,116	1,725,17	0.08	475,034	2,587,609	0.18	500,024	4,316,102	0.12
2004	72,905	712,815	0.10	77,351	1,695,23	0.05	534,768	2,631,821	0.20	564,612	4,471,614	0.13
2005	124,848	815,812	0.15	132,867	1,940,91	0.07	562,644	2,559,317	0.22	598,772	4,450,954	0.13
2006	178,964	1,053,355	0.17	188,375	2,192,45	0.09	468,337	2,143,236	0.22	502,908	4,146,470	0.12
2007	238,258	797,919	0.30	250,293	1,937,18	0.13	443,890	2,247,882	0.20	479,221	4,309,315	0.11

Table 3.2.4.12. Estimated age-1 to age-5 instantaneous fishing mortality for each fishery defined for the northern region during 1982-2007. 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
1982	0.056	0.203	0.067	0.007	0.003	0.074	0.217	0.088	0.009	0.004
1983	0.248	0.897	0.296	0.030	0.015	0.393	1.153	0.470	0.047	0.024
1984	0.332	1.202	0.397	0.040	0.020	0.255	0.749	0.306	0.031	0.015
1985	0.176	0.638	0.211	0.021	0.011	0.137	0.403	0.164	0.016	0.008
1986	0.138	0.499	0.165	0.016	0.008	0.179	0.526	0.215	0.021	0.011
1987	0.274	0.991	0.328	0.033	0.016	0.286	0.841	0.343	0.034	0.017
1988	0.219	0.792	0.262	0.026	0.013	0.159	0.467	0.190	0.019	0.010
1989	0.482	1.744	0.576	0.058	0.029	0.155	0.455	0.186	0.019	0.009
1990	0.471	1.704	0.563	0.056	0.028	0.156	0.459	0.187	0.019	0.009
1991	0.074	0.268	0.089	0.009	0.004	0.046	0.135	0.055	0.005	0.003
1992	0.016	0.131	0.035	0.003	0.002	0.003	0.019	0.007	0.001	0.000
1993	0.036	0.303	0.080	0.008	0.004	0.005	0.040	0.015	0.001	0.001
1994	0.019	0.162	0.043	0.004	0.002	0.005	0.033	0.012	0.001	0.001
1995	0.021	0.174	0.046	0.005	0.002	0.008	0.059	0.021	0.002	0.001
1996	0.007	0.057	0.015	0.002	0.001	0.001	0.010	0.004	0.000	0.000
1997	0.003	0.029	0.008	0.001	0.000	0.001	0.010	0.004	0.000	0.000
1998	0.024	0.205	0.054	0.005	0.003	0.005	0.037	0.013	0.001	0.001
1999	0.043	0.335	0.030	0.003	0.001	0.001	0.009	0.004	0.000	0.000
2000	0.026	0.199	0.018	0.002	0.001	0.001	0.006	0.003	0.000	0.000
2001	0.042	0.321	0.028	0.003	0.001	0.001	0.006	0.003	0.000	0.000
2002	0.014	0.108	0.010	0.001	0.000	0.001	0.007	0.003	0.000	0.000
2003	0.012	0.092	0.008	0.001	0.000	0.000	0.003	0.002	0.000	0.000
2004	0.013	0.103	0.009	0.001	0.000	0.000	0.002	0.001	0.000	0.000
2005	0.032	0.248	0.022	0.002	0.001	0.001	0.009	0.004	0.000	0.000
2006	0.019	0.143	0.013	0.001	0.001	0.001	0.008	0.004	0.000	0.000
2007	0.032	0.249	0.022	0.002	0.001	0.001	0.011	0.005	0.000	0.000

Table 3.2.4.12 (con't.). Estimated age-1 to age-5 instantaneous fishing mortality for each fishery defined for the northern region during 1982-2007. 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
1982	0.173	0.172	0.081	0.008	0.004					
1983	0.832	0.825	0.390	0.039	0.020	0.001	0.000	0.000	0.000	0.000
1984	0.837	0.831	0.393	0.039	0.020	0.002	0.001	0.000	0.000	0.000
1985	0.225	0.223	0.106	0.011	0.005	0.001	0.000	0.000	0.000	0.000
1986	0.298	0.295	0.140	0.014	0.007	0.007	0.001	0.000	0.000	0.000
1987	0.448	0.444	0.210	0.021	0.011	0.013	0.003	0.000	0.000	0.000
1988	0.946	0.938	0.444	0.044	0.022	0.009	0.002	0.000	0.000	0.000
1989	1.041	1.033	0.488	0.049	0.024	0.024	0.005	0.000	0.000	0.000
1990	0.439	0.435	0.206	0.021	0.010	0.024	0.005	0.000	0.000	0.000
1991	0.096	0.095	0.045	0.005	0.002	0.030	0.007	0.000	0.000	0.000
1992	0.122	0.290	0.158	0.016	0.008	0.020	0.009	0.001	0.000	0.000
1993	0.152	0.361	0.196	0.020	0.010	0.050	0.023	0.002	0.001	0.001
1994	0.079	0.187	0.102	0.010	0.005	0.083	0.039	0.003	0.002	0.002
1995	0.065	0.156	0.085	0.008	0.004	0.044	0.020	0.001	0.001	0.001
1996	0.069	0.165	0.090	0.009	0.004	0.012	0.005	0.000	0.000	0.000
1997	0.100	0.239	0.130	0.013	0.006	0.043	0.020	0.001	0.001	0.001
1998	0.112	0.265	0.144	0.014	0.007	0.035	0.016	0.001	0.001	0.001
1999	0.007	0.136	0.013	0.001	0.001	0.022	0.032	0.007	0.003	0.003
2000	0.013	0.234	0.022	0.002	0.001	0.028	0.041	0.008	0.004	0.004
2001	0.024	0.438	0.042	0.004	0.002	0.030	0.044	0.009	0.004	0.004
2002	0.030	0.551	0.052	0.005	0.003	0.069	0.101	0.021	0.009	0.009
2003	0.013	0.245	0.023	0.002	0.001	0.014	0.021	0.004	0.002	0.002
2004	0.011	0.202	0.019	0.002	0.001	0.023	0.034	0.007	0.003	0.003
2005	0.013	0.244	0.023	0.002	0.001	0.035	0.051	0.010	0.005	0.005
2006	0.014	0.258	0.025	0.002	0.001	0.049	0.072	0.015	0.006	0.006
2007	0.019	0.353	0.034	0.003	0.002	0.060	0.087	0.018	0.008	0.008

Table 3.2.4.13. Estimated age-1 to age-5 instantaneous fishing mortality for each fishery defined for the southern region during 1982-2007. 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 commercial fishery					Florida recreational harvest fishery				
	1	2	3	4	5	1	2	3	4	5
1982	0.032	0.069	0.078	0.008	0.004	0.074	0.279	0.268	0.213	0.021
1983	0.026	0.056	0.063	0.006	0.003	0.393	0.351	0.337	0.267	0.027
1984	0.020	0.043	0.048	0.005	0.002	0.255	0.409	0.393	0.312	0.031
1985	0.013	0.028	0.031	0.003	0.002	0.137	0.198	0.191	0.151	0.015
1986	0.012	0.025	0.028	0.003	0.001	0.179	0.035	0.149	0.177	0.018
1987	0.006	0.014	0.015	0.002	0.001	0.286	0.016	0.066	0.079	0.008
1988	0.000	0.000	0.000	0.000	0.000	0.159	0.003	0.012	0.015	0.001
1989						0.155	0.009	0.040	0.047	0.005
1990						0.156	0.011	0.045	0.054	0.005
1991						0.046	0.021	0.090	0.108	0.011
1992						0.003	0.019	0.080	0.095	0.010
1993						0.005	0.012	0.052	0.062	0.006
1994						0.005	0.023	0.099	0.117	0.012
1995						0.008	0.018	0.074	0.088	0.009
1996						0.001	0.029	0.121	0.144	0.014
1997						0.001	0.018	0.076	0.091	0.009
1998						0.005	0.033	0.138	0.165	0.016
1999						0.001	0.034	0.142	0.169	0.017
2000						0.001	0.043	0.183	0.217	0.022
2001						0.001	0.036	0.153	0.182	0.018
2002						0.001	0.026	0.110	0.131	0.013
2003						0.000	0.026	0.112	0.133	0.013
2004						0.000	0.027	0.114	0.136	0.014
2005						0.001	0.035	0.147	0.174	0.017
2006						0.001	0.027	0.115	0.137	0.014
2007						0.001	0.011	0.005	0.000	0.000

Table 3.2.4.13 (con't.). Estimated age-1 to age-5 instantaneous fishing mortality for each fishery defined for the southern region during 1982-2007. 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
1982	0.043	0.034	0.035	0.004	0.002	0.215	0.218	0.182	0.018	0.009
1983	0.060	0.048	0.049	0.005	0.002	0.104	0.106	0.089	0.009	0.004
1984	0.198	0.158	0.162	0.016	0.008	0.094	0.096	0.080	0.008	0.004
1985	0.143	0.114	0.117	0.012	0.006	0.388	0.394	0.329	0.033	0.016
1986	0.096	0.075	0.072	0.007	0.004	0.163	0.165	0.138	0.014	0.007
1987	0.116	0.091	0.087	0.009	0.004	0.407	0.414	0.346	0.035	0.017
1988	0.121	0.096	0.091	0.009	0.005	0.234	0.238	0.199	0.020	0.010
1989	0.045	0.035	0.034	0.003	0.002	0.102	0.103	0.086	0.009	0.004
1990	0.059	0.047	0.045	0.004	0.002	0.084	0.099	0.039	0.004	0.002
1991	0.095	0.075	0.071	0.007	0.004	0.070	0.083	0.032	0.003	0.002
1992	0.044	0.064	0.020	0.002	0.001	0.065	0.077	0.030	0.003	0.002
1993	0.065	0.095	0.029	0.003	0.001	0.079	0.094	0.037	0.004	0.002
1994	0.074	0.107	0.032	0.003	0.002	0.064	0.090	0.027	0.003	0.001
1995	0.067	0.098	0.030	0.003	0.001	0.081	0.114	0.034	0.003	0.002
1996	0.042	0.061	0.019	0.002	0.001	0.086	0.121	0.036	0.004	0.002
1997	0.031	0.045	0.014	0.001	0.001	0.103	0.145	0.044	0.004	0.002
1998	0.025	0.036	0.011	0.001	0.001	0.044	0.062	0.019	0.002	0.001
1999	0.052	0.076	0.023	0.002	0.001	0.033	0.047	0.014	0.001	0.001
2000	0.049	0.072	0.022	0.002	0.001	0.022	0.030	0.009	0.001	0.000
2001	0.065	0.095	0.029	0.003	0.001	0.032	0.075	0.021	0.002	0.001
2002	0.085	0.074	0.034	0.003	0.002	0.020	0.047	0.013	0.001	0.001
2003	0.061	0.053	0.024	0.002	0.001	0.042	0.098	0.028	0.003	0.001
2004	0.076	0.066	0.030	0.003	0.002	0.040	0.092	0.026	0.003	0.001
2005	0.058	0.051	0.023	0.002	0.001	0.041	0.094	0.027	0.003	0.001
2006	0.069	0.060	0.028	0.003	0.001	0.047	0.110	0.031	0.003	0.002
2007	0.064	0.056	0.025	0.003	0.001	0.036	0.084	0.024	0.002	0.001

Table 3.2.4.13 (con't.). Estimated age-1 to age-5 instantaneous fishing mortality for each fishery defined for the southern region during 1982-2007. 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
1982	0.001	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.000	0.000
1983	0.006	0.001	0.000	0.000	0.000	0.001	0.001	0.001	0.000	0.000
1984	0.004	0.001	0.000	0.000	0.000	0.001	0.001	0.001	0.000	0.000
1985	0.016	0.004	0.000	0.000	0.000	0.001	0.001	0.001	0.000	0.000
1986	0.006	0.009	0.002	0.001	0.001	0.005	0.005	0.005	0.001	0.000
1987	0.022	0.032	0.007	0.003	0.003	0.020	0.019	0.019	0.002	0.001
1988	0.014	0.020	0.004	0.002	0.002	0.029	0.028	0.028	0.003	0.001
1989	0.010	0.015	0.003	0.001	0.001	0.007	0.007	0.007	0.001	0.000
1990	0.004	0.005	0.001	0.000	0.000	0.014	0.014	0.014	0.001	0.001
1991	0.026	0.039	0.008	0.003	0.003	0.009	0.009	0.008	0.001	0.000
1992	0.012	0.017	0.004	0.002	0.002	0.009	0.007	0.008	0.001	0.000
1993	0.021	0.030	0.006	0.003	0.003	0.015	0.011	0.013	0.001	0.001
1994	0.029	0.042	0.009	0.004	0.004	0.023	0.017	0.020	0.002	0.001
1995	0.026	0.038	0.008	0.003	0.003	0.032	0.024	0.029	0.003	0.001
1996	0.024	0.035	0.007	0.003	0.003	0.017	0.012	0.015	0.001	0.001
1997	0.033	0.048	0.010	0.004	0.004	0.014	0.010	0.012	0.001	0.001
1998	0.028	0.042	0.009	0.004	0.004	0.009	0.006	0.008	0.001	0.000
1999	0.030	0.044	0.009	0.004	0.004	0.007	0.005	0.006	0.001	0.000
2000	0.033	0.048	0.010	0.004	0.004	0.013	0.010	0.012	0.001	0.001
2001	0.037	0.055	0.011	0.005	0.005	0.023	0.017	0.020	0.002	0.001
2002	0.027	0.040	0.008	0.004	0.004	0.017	0.012	0.015	0.001	0.001
2003	0.028	0.040	0.008	0.004	0.004	0.028	0.021	0.025	0.002	0.001
2004	0.037	0.054	0.011	0.005	0.005	0.023	0.017	0.020	0.002	0.001
2005	0.044	0.065	0.013	0.006	0.006	0.036	0.026	0.032	0.003	0.002
2006	0.038	0.055	0.011	0.005	0.005	0.039	0.029	0.034	0.003	0.002
2007	0.036	0.053	0.011	0.005	0.005	0.032	0.024	0.029	0.003	0.001

Table 3.2.4.14. Estimated age-1 to age-5 instantaneous fishing mortality for the northern and southern regions during 1982-2007.

	Northern region					Southern region				
	1	2	3	4	5	1	2	3	4	5
1982	0.303	0.591	0.237	0.024	0.012	0.366	0.602	0.564	0.242	0.036
1983	1.473	2.876	1.157	0.116	0.058	0.590	0.562	0.538	0.288	0.037
1984	1.427	2.782	1.096	0.110	0.055	0.572	0.708	0.685	0.341	0.046
1985	0.539	1.264	0.481	0.048	0.024	0.699	0.739	0.669	0.199	0.039
1986	0.622	1.322	0.519	0.052	0.026	0.461	0.315	0.394	0.202	0.031
1987	1.021	2.280	0.881	0.088	0.044	0.858	0.585	0.540	0.128	0.034
1988	1.332	2.199	0.896	0.090	0.045	0.557	0.385	0.335	0.048	0.019
1989	1.701	3.236	1.250	0.125	0.063	0.319	0.170	0.170	0.061	0.012
1990	1.090	2.603	0.956	0.096	0.048	0.317	0.176	0.144	0.064	0.011
1991	0.246	0.505	0.189	0.019	0.010	0.246	0.226	0.211	0.122	0.020
1992	0.160	0.450	0.200	0.020	0.010	0.133	0.184	0.141	0.103	0.014
1993	0.243	0.728	0.293	0.030	0.016	0.185	0.242	0.136	0.072	0.013
1994	0.185	0.421	0.159	0.018	0.010	0.193	0.279	0.187	0.129	0.019
1995	0.138	0.409	0.154	0.016	0.009	0.214	0.291	0.175	0.101	0.017
1996	0.089	0.237	0.109	0.011	0.006	0.170	0.259	0.199	0.154	0.021
1997	0.148	0.297	0.142	0.015	0.008	0.182	0.266	0.156	0.102	0.017
1998	0.176	0.524	0.213	0.022	0.011	0.111	0.178	0.184	0.172	0.022
1999	0.074	0.512	0.053	0.007	0.005	0.124	0.206	0.195	0.178	0.023
2000	0.067	0.480	0.051	0.008	0.006	0.118	0.204	0.235	0.226	0.028
2001	0.096	0.808	0.082	0.011	0.008	0.159	0.278	0.234	0.194	0.027
2002	0.114	0.767	0.086	0.016	0.012	0.150	0.199	0.180	0.141	0.020
2003	0.040	0.361	0.037	0.005	0.003	0.160	0.239	0.197	0.144	0.021
2004	0.048	0.342	0.036	0.006	0.005	0.177	0.257	0.203	0.148	0.022
2005	0.081	0.551	0.059	0.009	0.007	0.180	0.271	0.242	0.188	0.027
2006	0.083	0.481	0.056	0.010	0.008	0.194	0.281	0.220	0.151	0.023
2007	0.112	0.700	0.079	0.014	0.011	0.170	0.248	0.223	0.172	0.025

Table 3.2.4.15. Calculated static spawning potential ratio (sSPR), year-specific escapement (sEsc), and cohort-specific escapement (tEsc) for red drum in the northern and southern regions during 1982-2007. The escapement was defined as through age 5.

	Northern region			Southern region		
	sSPR	sEsc	tEsc	sSPR	sEsc	tEsc
1982	0.260	0.311		0.139	0.174	
1983	0.002	0.003		0.158	0.195	
1984	0.002	0.004		0.093	0.121	
1985	0.067	0.095		0.083	0.109	
1986	0.055	0.079	0.013	0.239	0.292	0.164
1987	0.008	0.013	0.008	0.119	0.155	0.143
1988	0.006	0.010	0.035	0.258	0.306	0.142
1989	0.001	0.002	0.055	0.509	0.560	0.168
1990	0.005	0.008	0.019	0.530	0.572	0.268
1991	0.327	0.379	0.010	0.399	0.456	0.305
1992	0.368	0.431	0.004	0.515	0.562	0.455
1993	0.214	0.270	0.011	0.479	0.524	0.528
1994	0.390	0.453	0.160	0.392	0.445	0.520
1995	0.424	0.484	0.362	0.402	0.452	0.522
1996	0.582	0.637	0.343	0.392	0.445	0.511
1997	0.480	0.543	0.433	0.432	0.484	0.462
1998	0.326	0.388	0.482	0.450	0.511	0.442
1999	0.481	0.521	0.580	0.421	0.481	0.457
2000	0.496	0.542	0.542	0.375	0.440	0.461
2001	0.326	0.366	0.477	0.347	0.407	0.471
2002	0.307	0.370	0.466	0.441	0.499	0.465
2003	0.606	0.640	0.520	0.407	0.464	0.450
2004	0.601	0.646	0.379	0.384	0.443	0.451
2005	0.442	0.493	0.401	0.338	0.400	0.477
2006	0.464	0.528	0.589	0.358	0.416	0.462
2007	0.340	0.400	0.630	0.369	0.430	0.430

Table 3.2.4.16. 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		
sSPR	2005	2006	2007
Base	0.442	0.464	0.340
RM 0.16	0.380	0.381	0.273
M low	0.446	0.468	0.349
M high	0.438	0.460	0.330
Sel 1-5	0.429	0.454	0.362
sEsc	2005	2006	2007
Base	0.493	0.528	0.400
RM 0.16	0.450	0.472	0.351
M low	0.496	0.533	0.409
M high	0.489	0.524	0.391
Sel 1-5	0.470	0.509	0.414

	Southern region		
sSPR	2005	2006	2007
Base	0.338	0.358	0.369
RM 0.16	0.249	0.267	0.280
M low	0.178	0.192	0.201
M high	0.583	0.616	0.612
Sel 1-5	0.107	0.114	0.123
sEsc	2005	2006	2007
Base	0.400	0.416	0.430
RM 0.16	0.314	0.331	0.344
M low	0.233	0.244	0.256
M high	0.635	0.663	0.661
Sel 1-5	0.131	0.139	0.149

Table 3.2.4.17. 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 ($F_{0.1}$), sSPR equal to 20% ($F_{20\%}$), and sSPR equal to 35% ($F_{35\%}$).

	Northern region		
Benchmark	full F	Y/R	sSPR
F_{2007}	0.700	2.184	0.340
F_{max}	1.126	2.343	0.189
$F_{0.1}$	1.049	2.339	0.212
$F_{20\%}$	1.087	2.342	0.200
$F_{35\%}$	0.706	2.189	0.350

	Southern region		
Benchmark	full F	Y/R	sSPR
F_{2007}	0.350	1.354	0.369
F_{max}	0.618	1.504	0.188
$F_{0.1}$	0.584	1.502	0.206
$F_{20\%}$	0.595	1.503	0.200
$F_{35\%}$	0.386	1.398	0.350

3.2.5 Figures

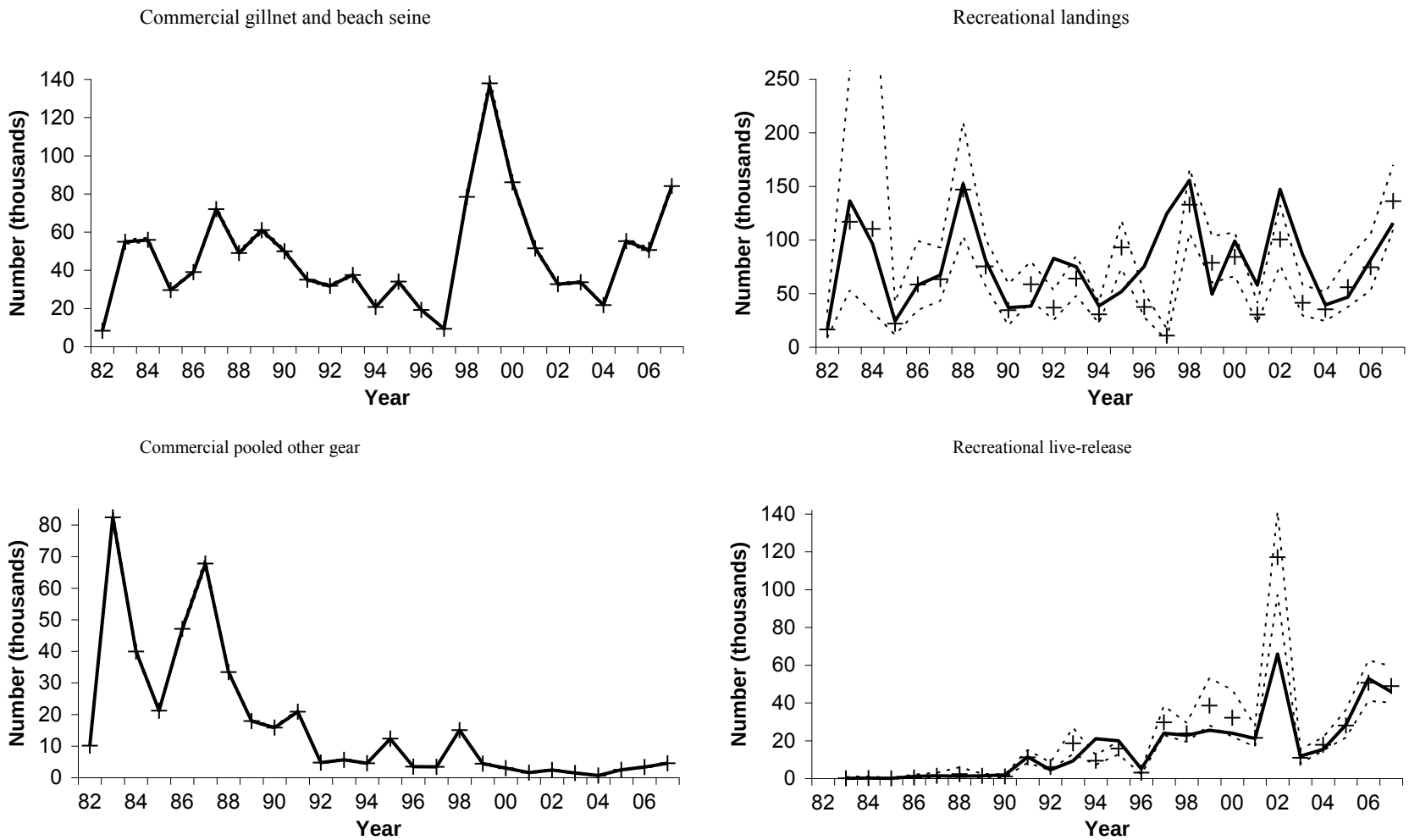


Figure 3.2.5.1. Observed (+) total annual harvest number, showing ± two standard errors (dashed lines), and the associated model estimates for the four northern fisheries.

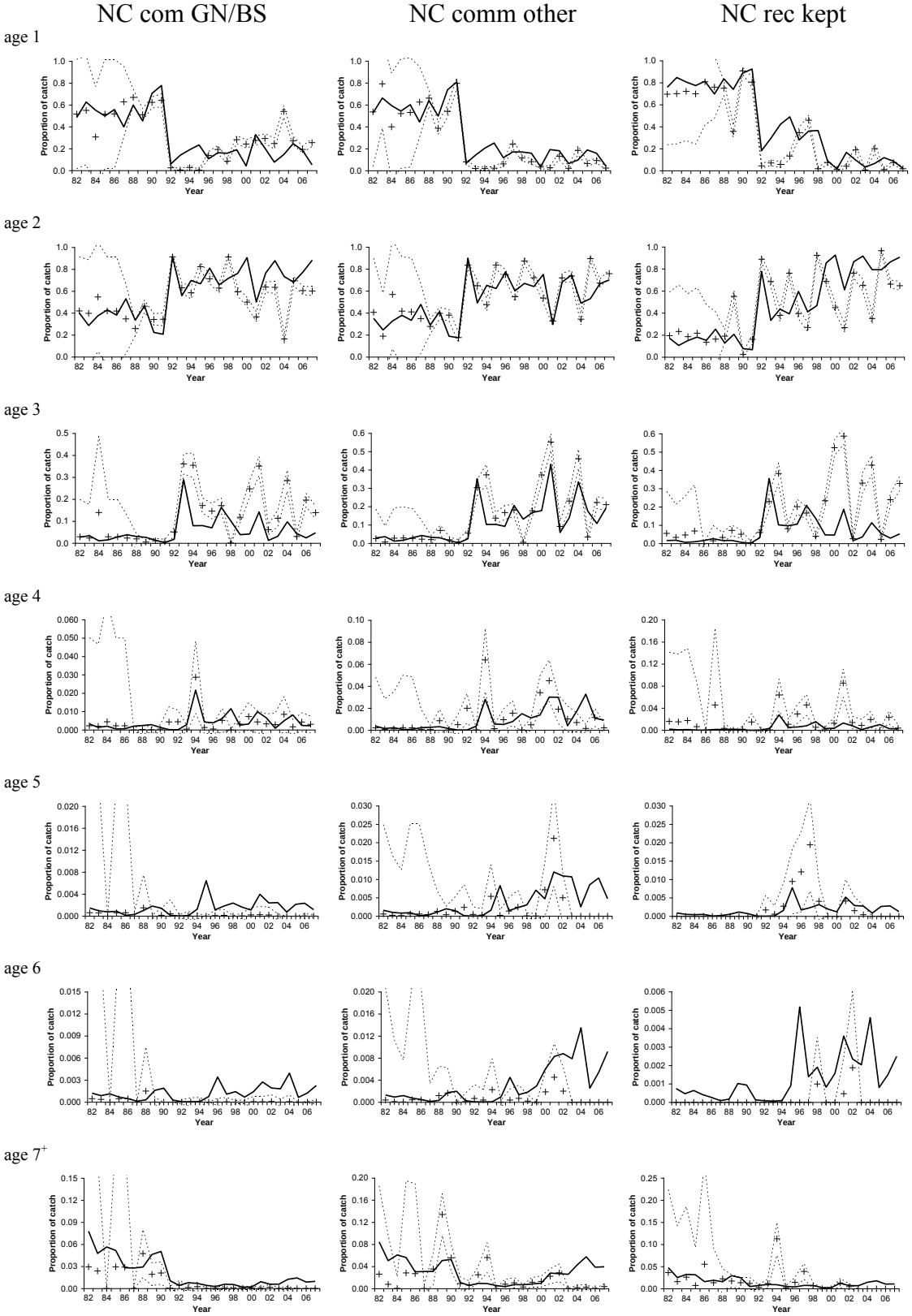
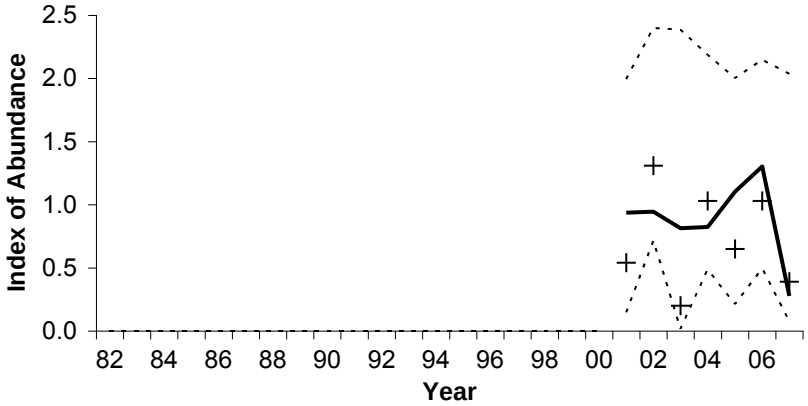
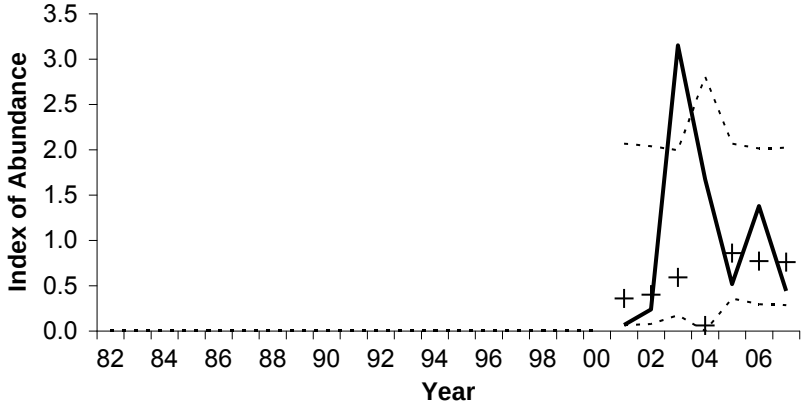


Figure 3.2.5.2. Observed (+) and predicted proportions at age in the landings for the northern commercial gillnet/beach seine fishery, the northern other commercial fishery, and the northern recreational landed fishery during 1982-2007. Each column of graphs shows ages 1 (top row) through ages 7+ (bottom row) for each fishery. Dashed lines show ± 2 standard errors around the observed data.

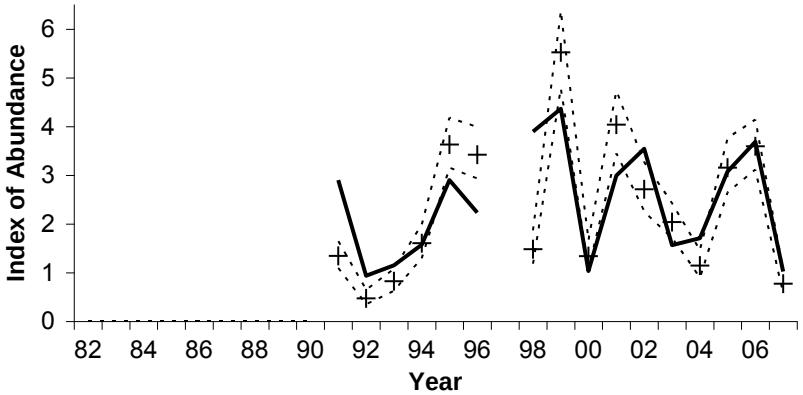
NC independent gillnet survey – age 1



NC independent gillnet survey – age 2



NC juvenile abundance index – age 1



MRFSS total catch rate – ages 1-3

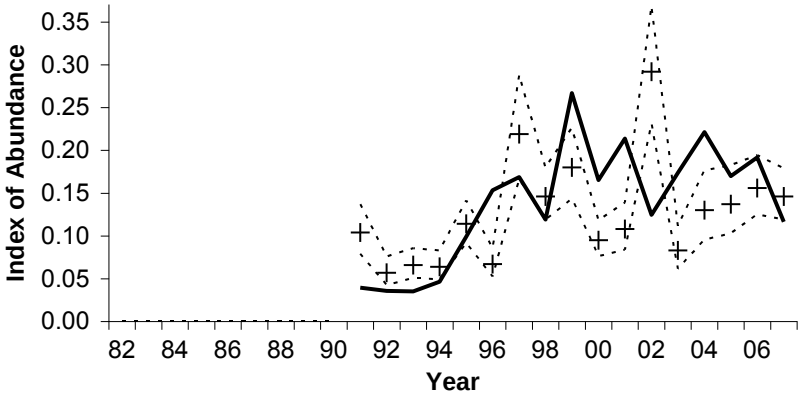


Figure 3.2.5.3. Observed (+) indexes of abundance for red drum, showing ± two standard errors (dashed lines), and the associated model estimates for the four northern indexes.

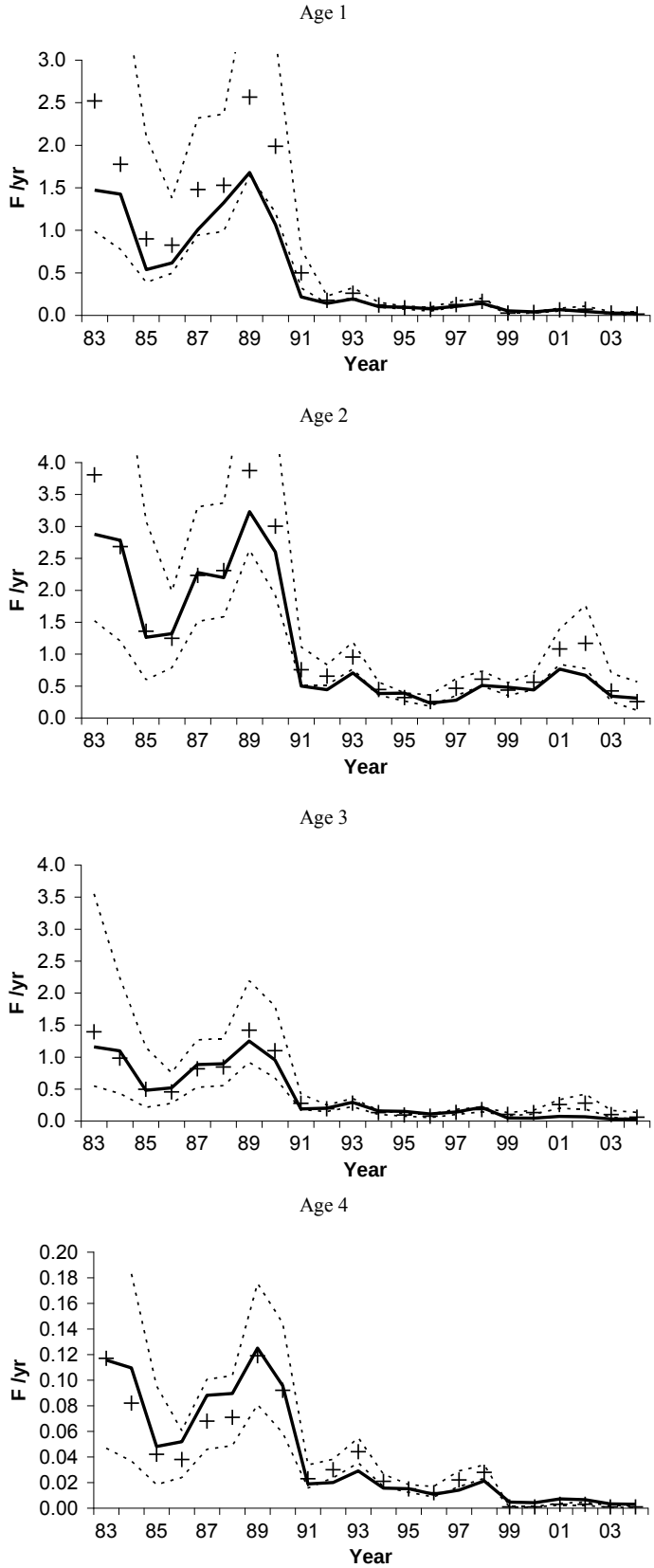


Figure 3.2.5.4. Observed (+) estimates of tag-based estimates of F-at-age for red drum, showing ± two standard errors (dashed lines), and the associated model estimates (solid line) for the northern stock.

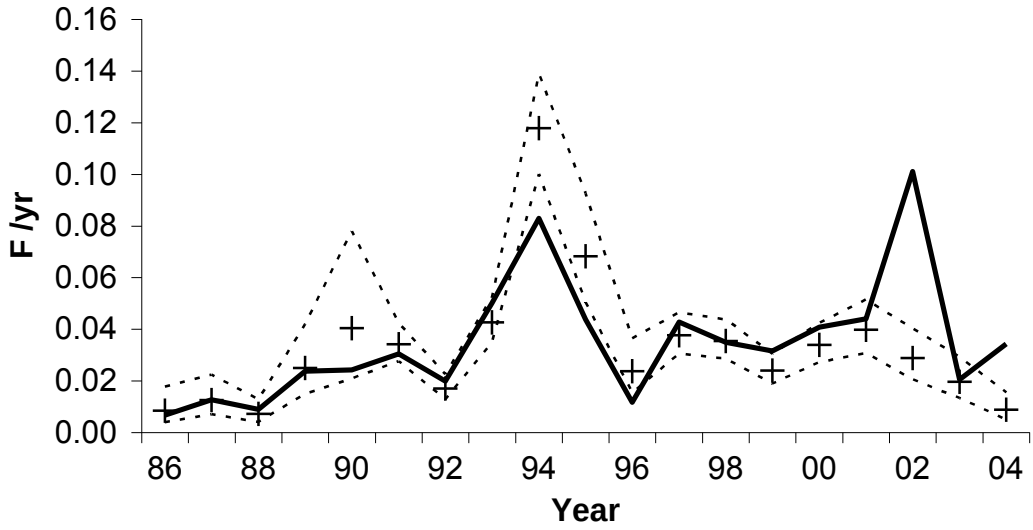


Figure 3.2.5.5. Observed (+) estimates of tag-based estimates of fully recruited F for red drum live releases from the recreational fishery, showing ± two standard errors (dashed lines), and the associated model estimates (solid line) for the northern stock.

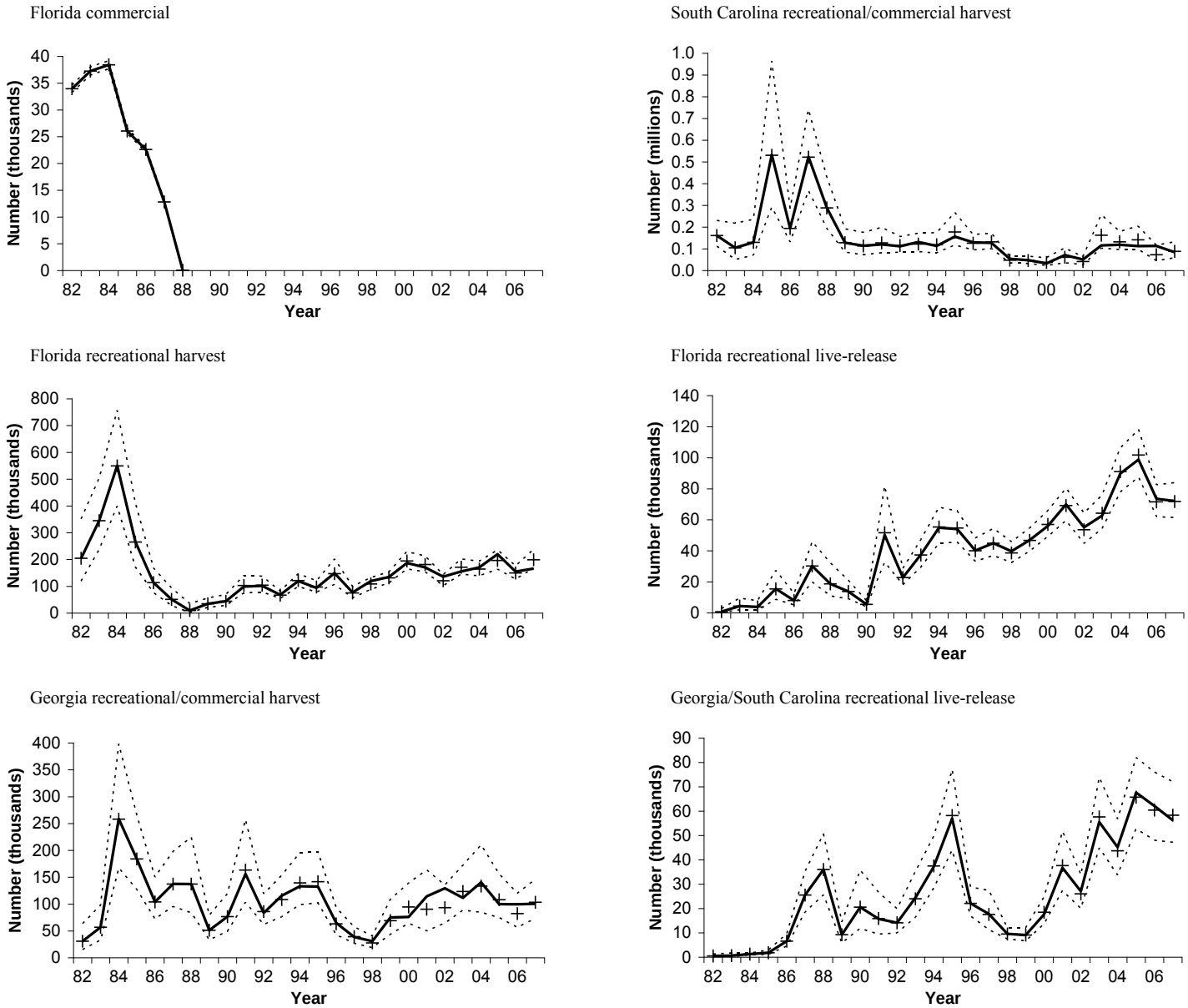


Figure 3.2.5.6. Observed (+) total annual harvest number, showing ± two standard errors (dashed lines), and the associated model estimates for the six southern fisheries.

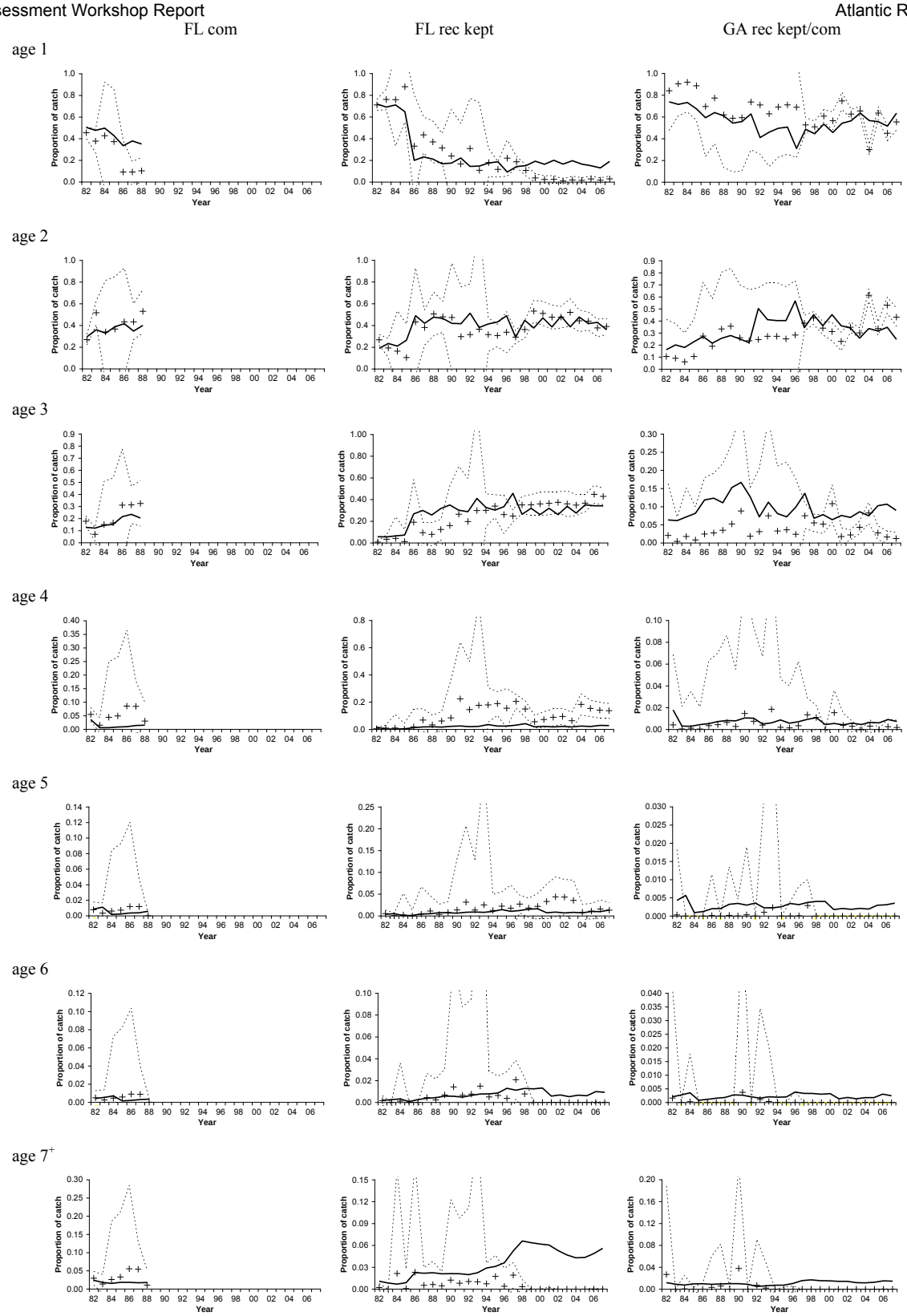


Figure 3.2.5.7. Observed (+) and predicted proportions at age in the landings for the Florida commercial, Florida kept recreational and Georgia kept recreation/commercial fisheries in the southern region during 1982-2007 Dashed lines show ± 2 standard errors around the observed data.

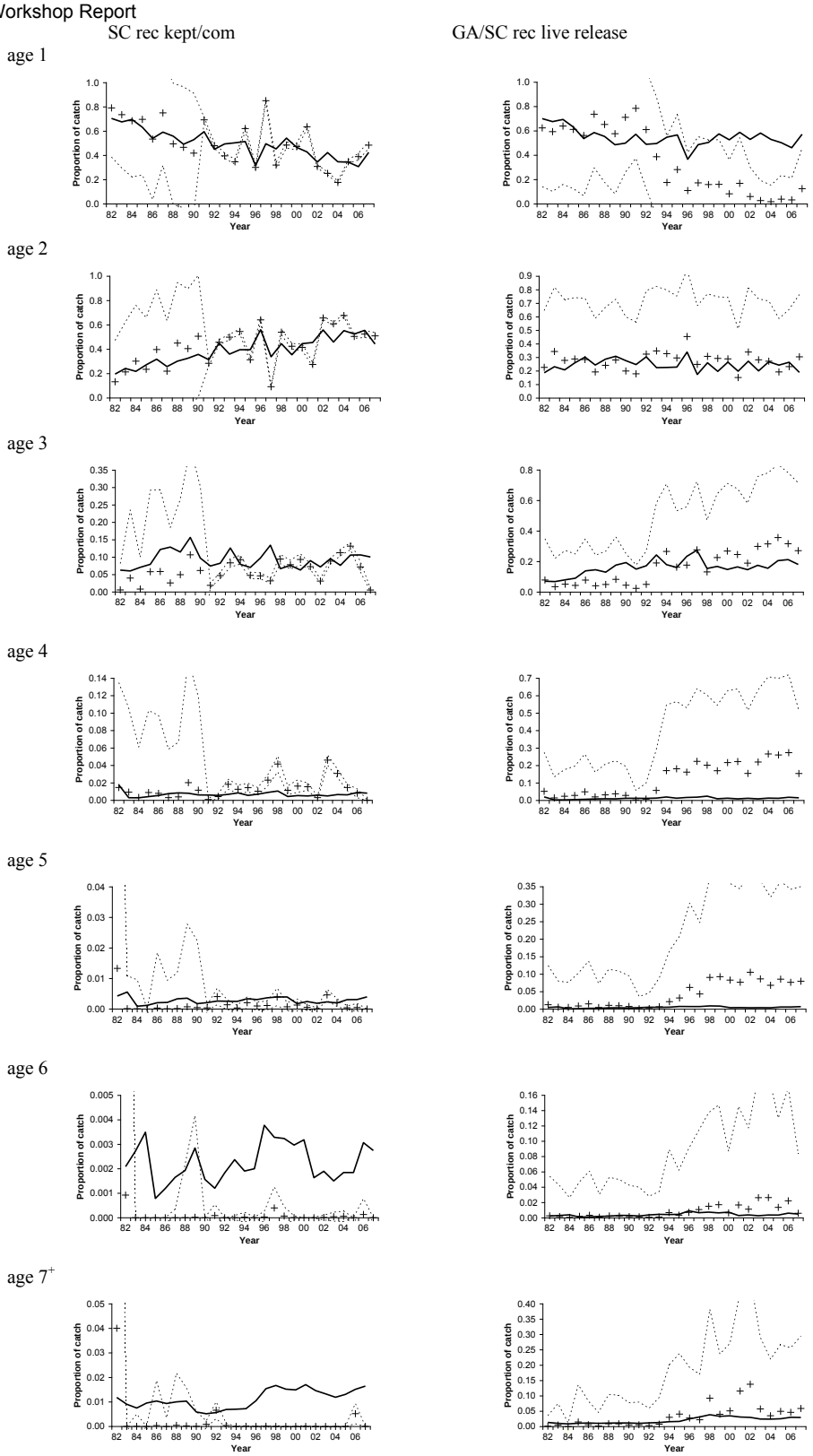


Figure 3.2.5.7 (con't). Observed (+) and predicted proportions at age in the landings for the South Carolina recreationally kept fishery and the Georgia/South Carolina live-release fishery in the southern region during 1982-2007. Dashed lines show ± 2 standard errors around the observed data.

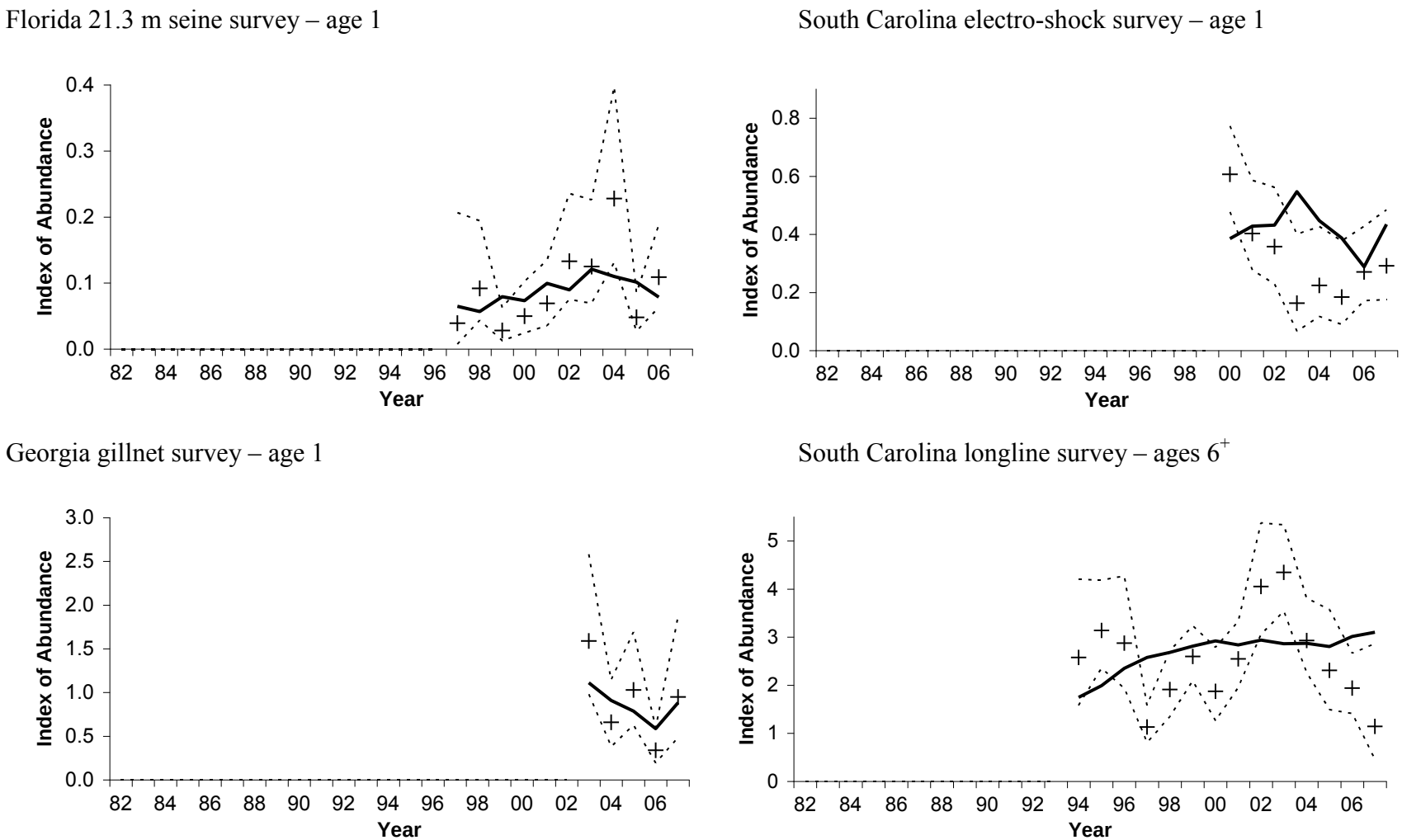
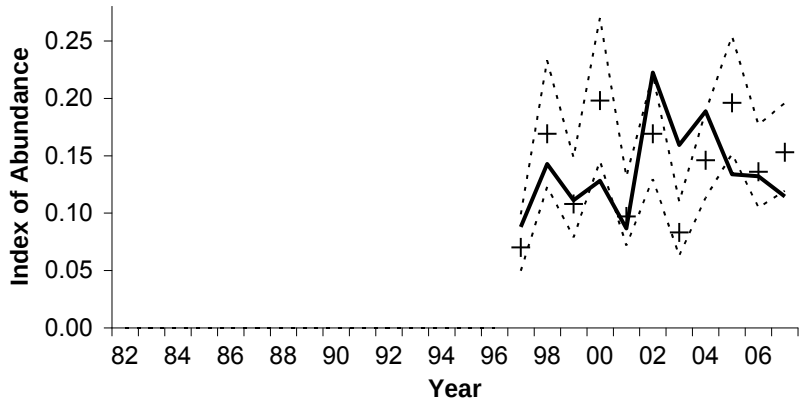
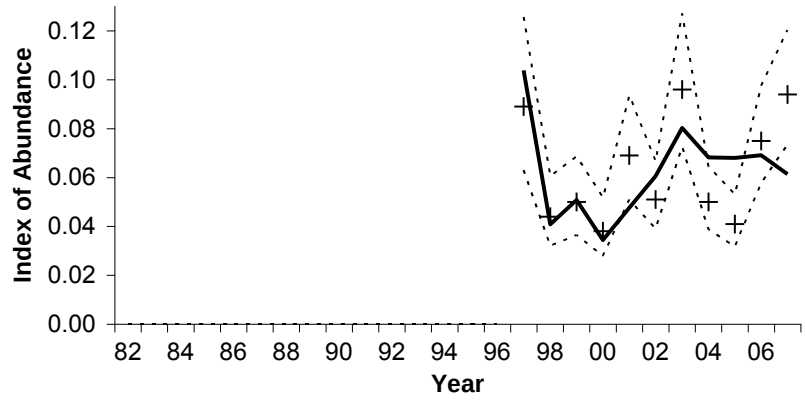


Figure 3.2.5.8. Observed (+) indexes of abundance for red drum, showing ± two standard errors (dashed lines), and the associated model estimates for the eight southern indices.

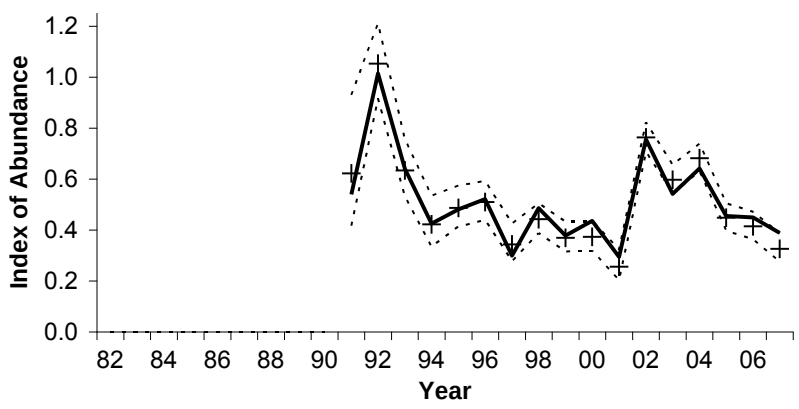
Florida 183-m haul seine – ages 2



Florida 183-m haul seine – ages 3



South Carolina trammel net survey – age 2



MRFSS total catch rates – ages 1-3

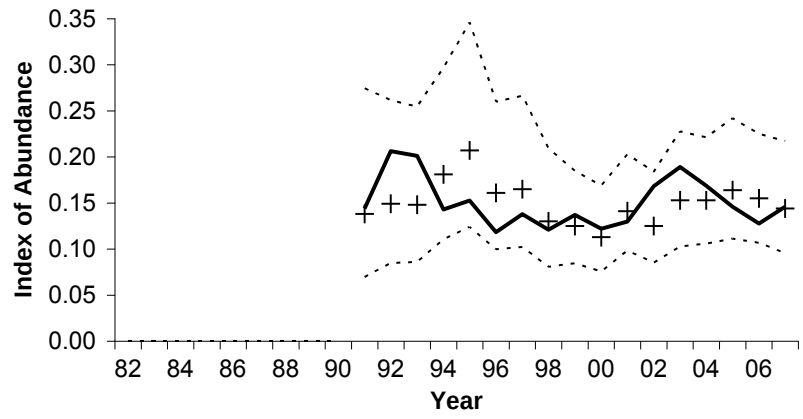
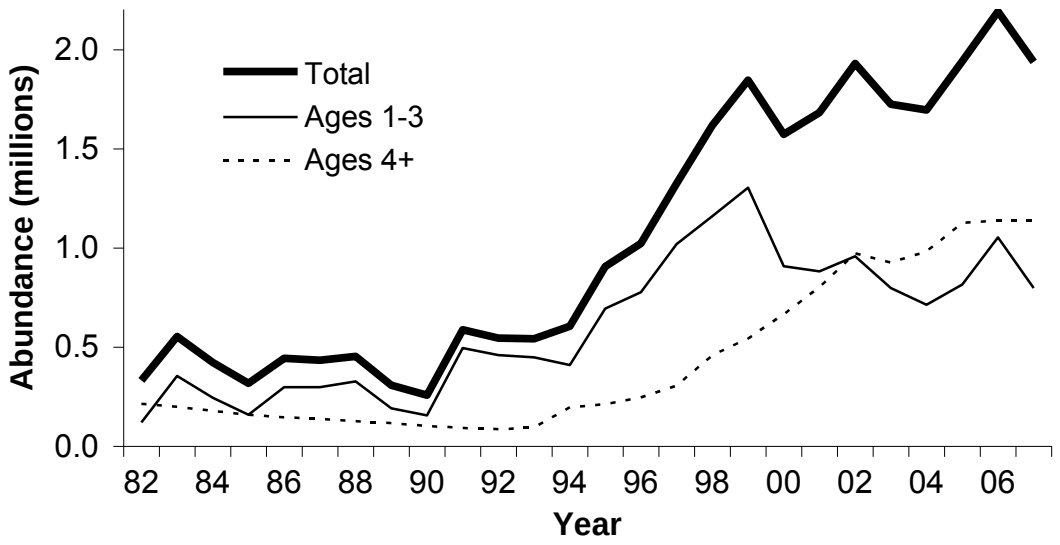


Figure 3.2.5.8 (con't). Observed (+) indexes of abundance for red drum, showing ± two standard errors (dashed lines), and the associated model estimates for the eight southern indexes.

Northern region



Southern region

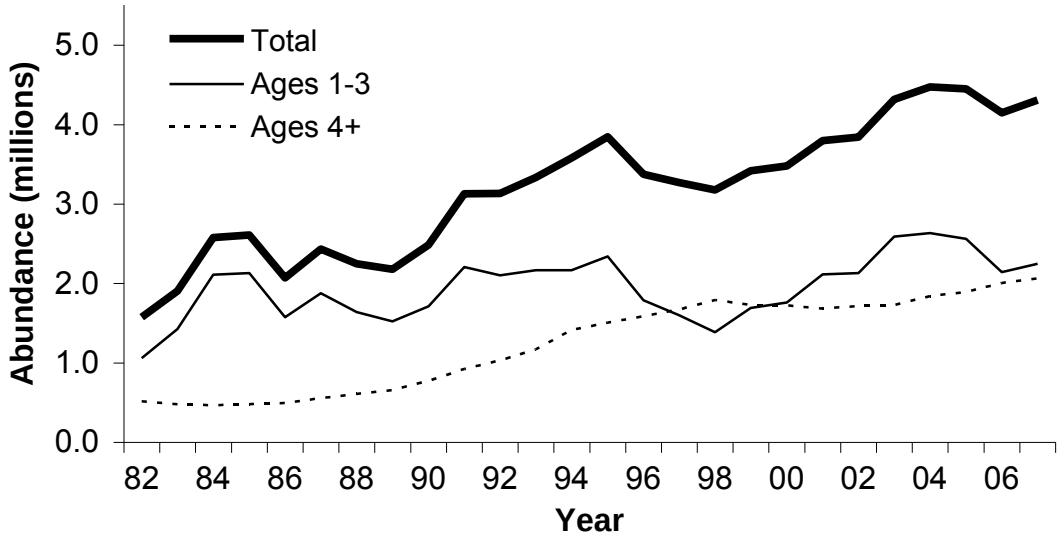
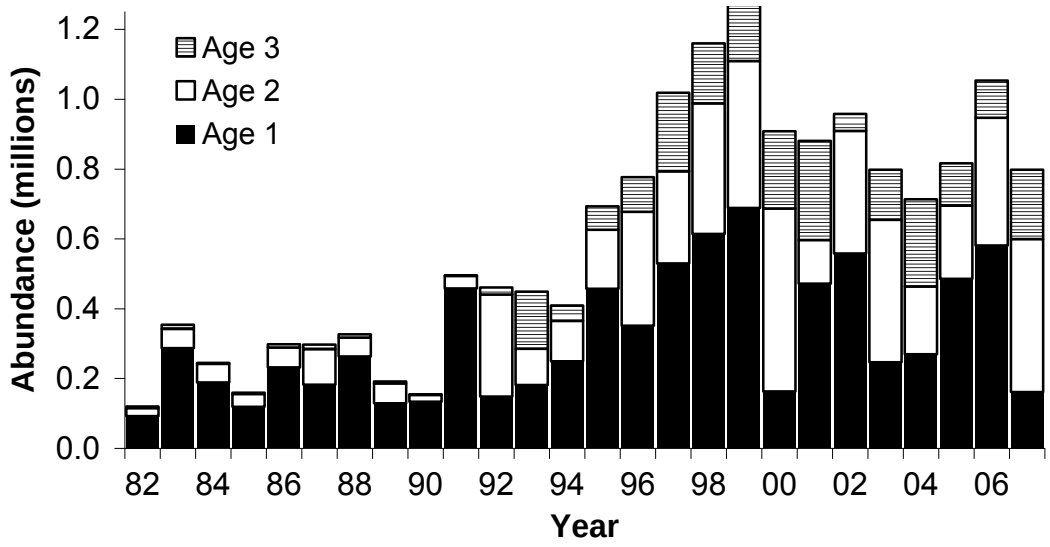


Figure 3.2.5.9. Estimated beginning-of-the-year abundance for red drum in the northern and southern stock areas during 1982-2007.

Northern region



Southern region

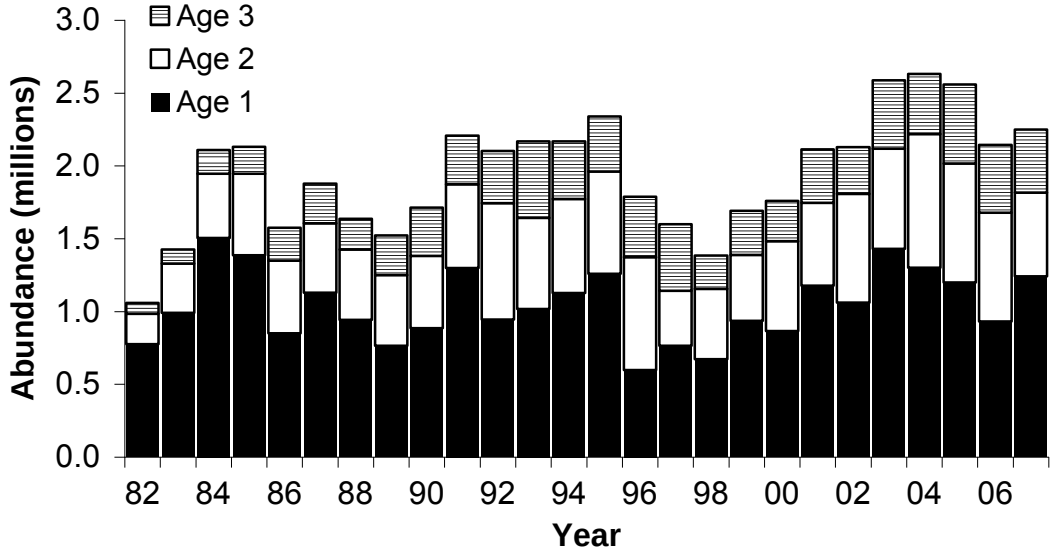
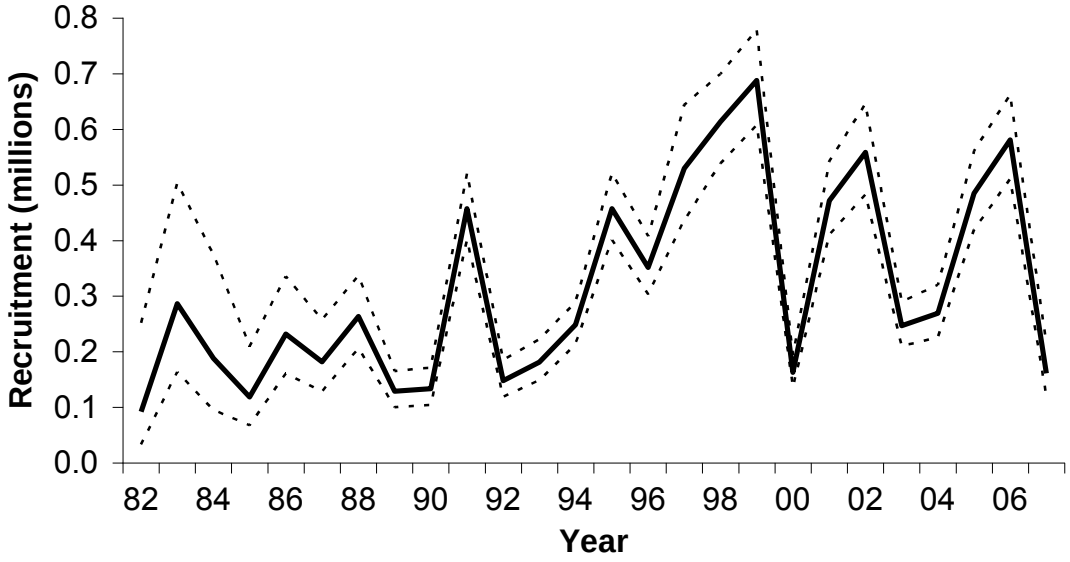


Figure 3.2.5.10. Estimates of abundance of red drum ages 1-3 in the northern and southern stock areas during 1982-2007

Northern region



Southern region

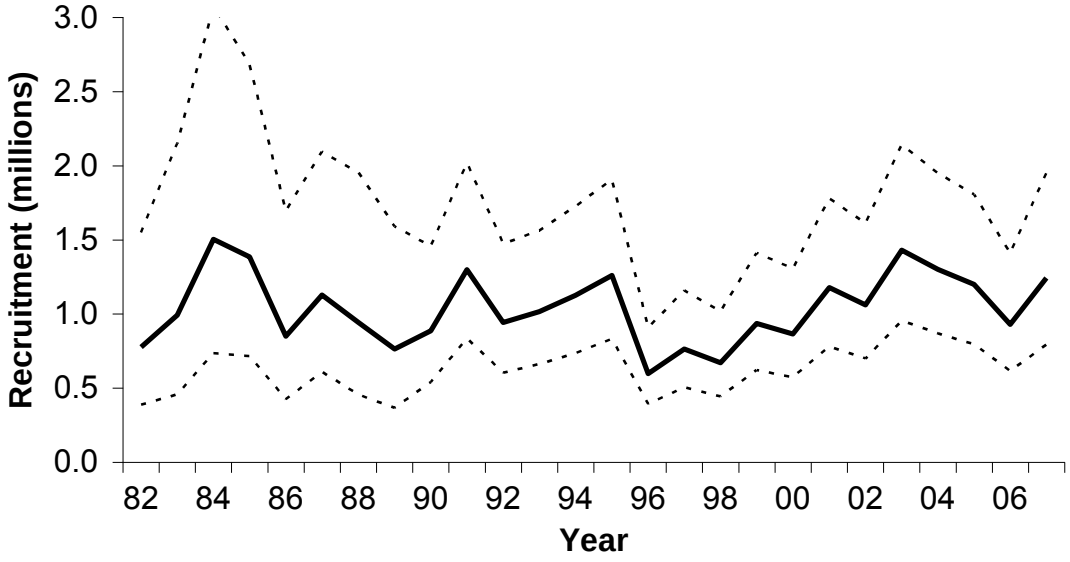


Figure 3.2.5.11. Estimated recruitment (age-1 abundance, solid line) and ± two standard errors (dashed lines) for the northern and southern regions during 1982-2007

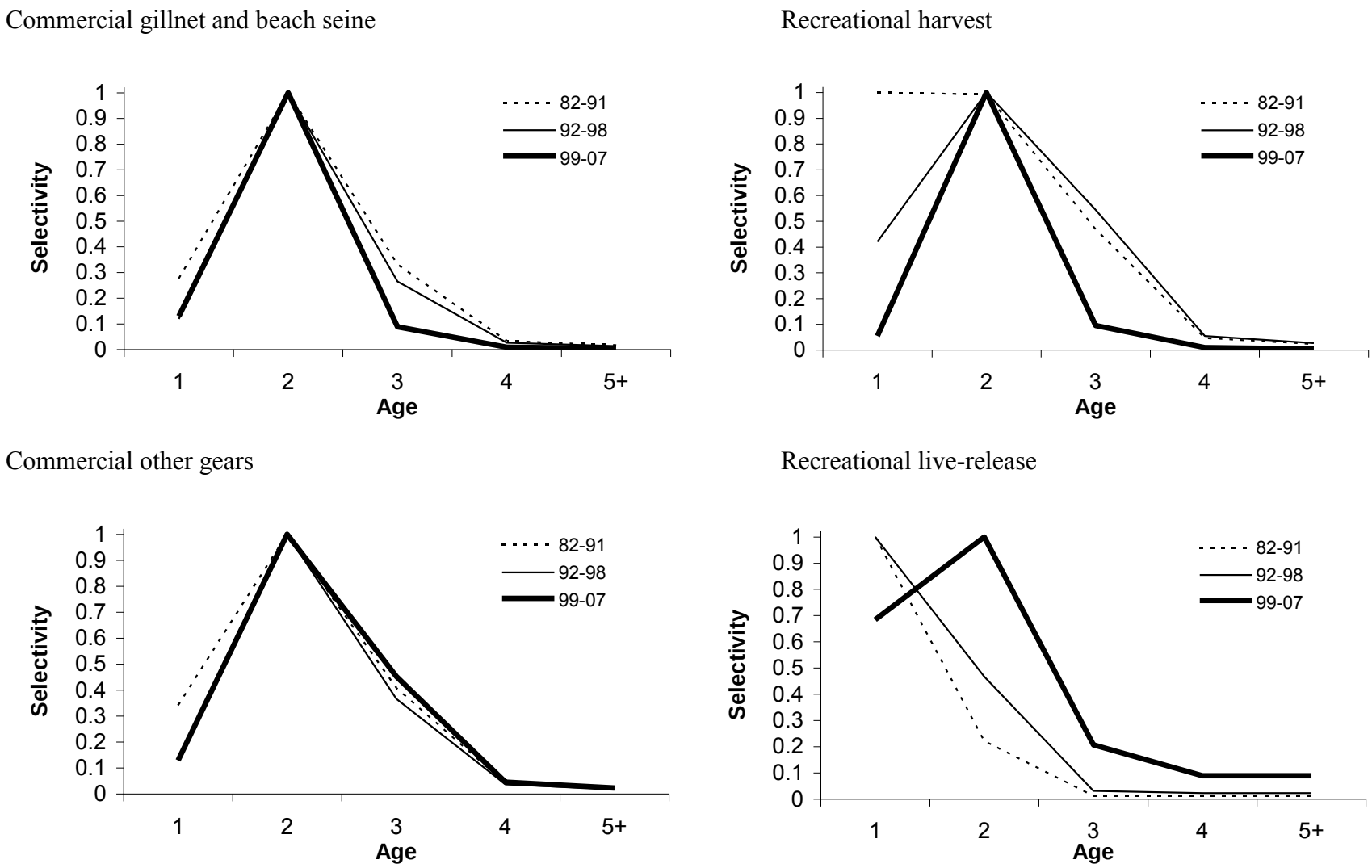


Figure 3.2.5.12. Estimated selectivities for three of the four northern fisheries modeled separately and the tag-based input selectivity data for the recreational live-release fishery. Under the separability assumption, this age-effect for distributing fishing mortality across ages was estimated for each of the indicated periods of years.

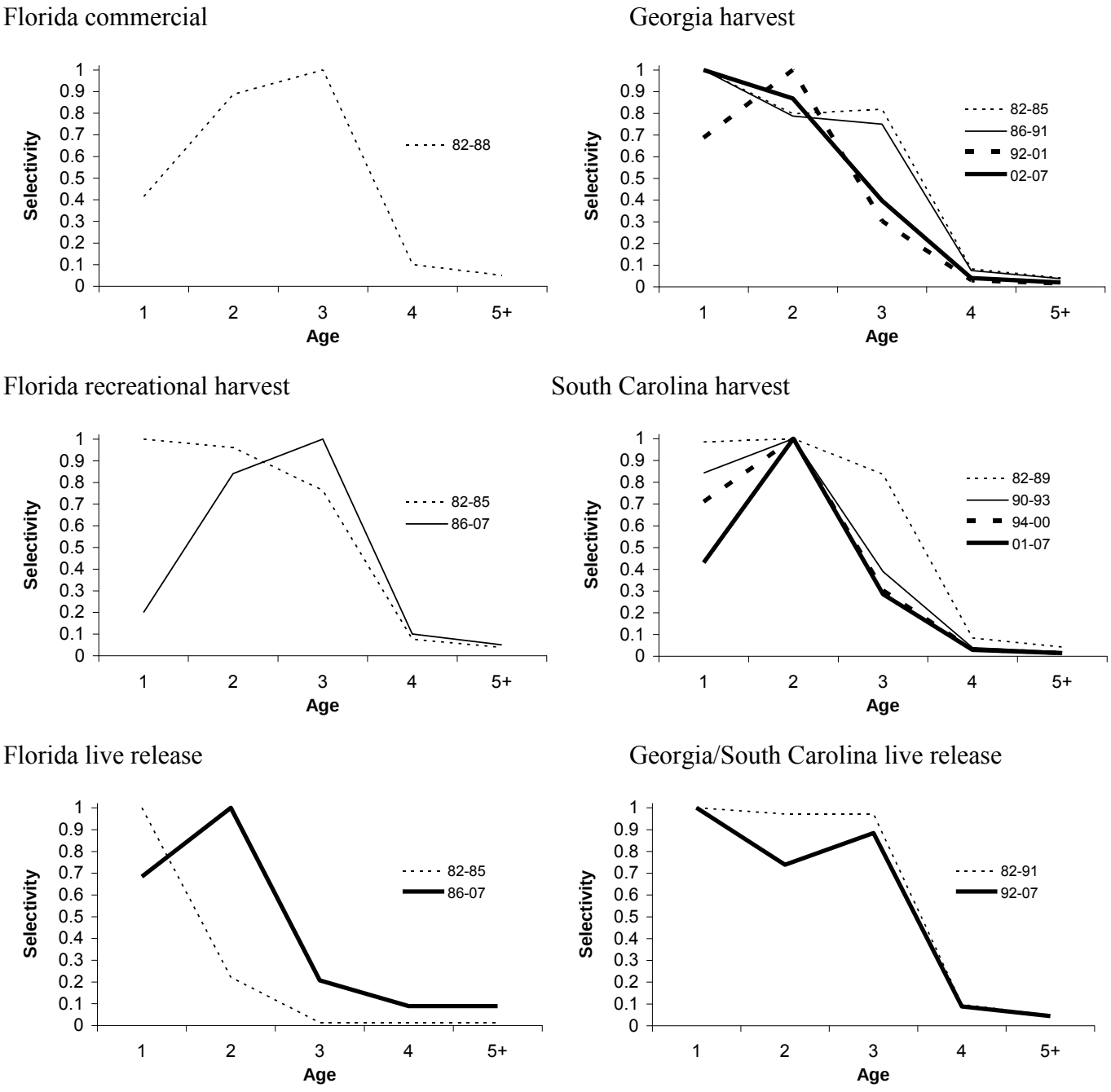
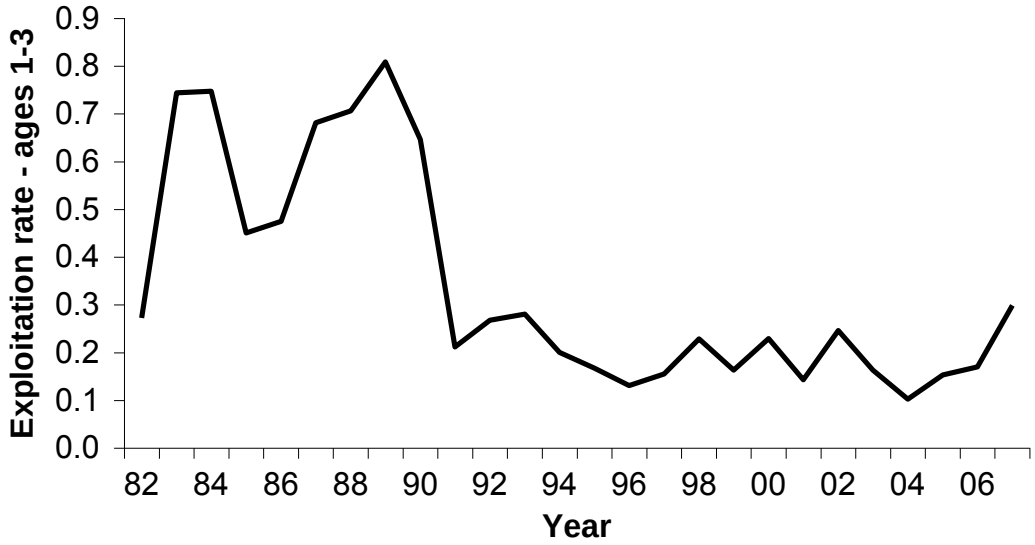


Figure 3.2.5.13. Estimated selectivities for five of the six southern fisheries modeled separately and the tag-based input selectivity data for the Florida recreational live-release fishery. Under the separability assumption, this age-effect for distributing fishing mortality across ages was estimated for each of the indicated periods of years.

Northern region



Southern region

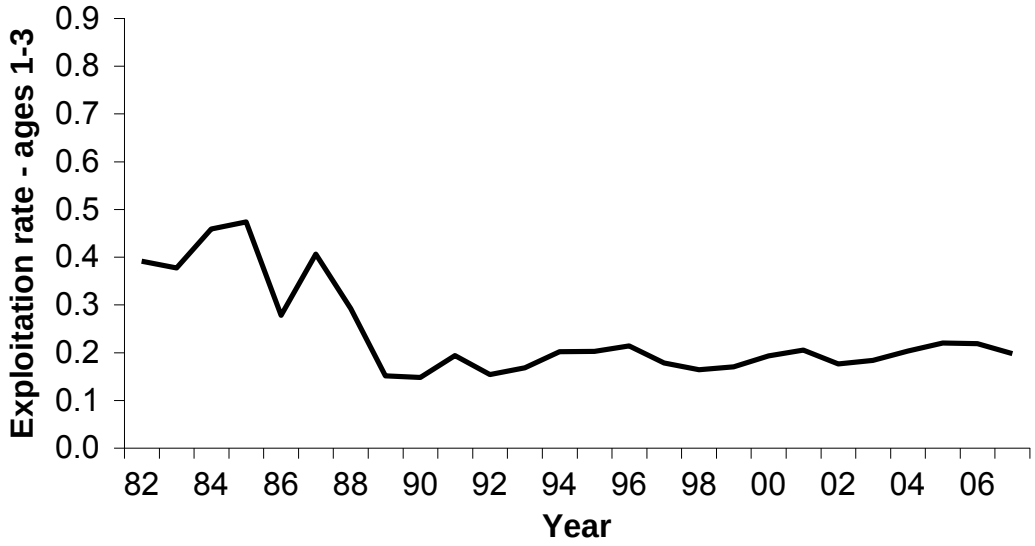


Figure 3.2.5.14. Estimated annual exploitation rate for red drum ages 1-3 in the northern and southern regions during 1982-2007.

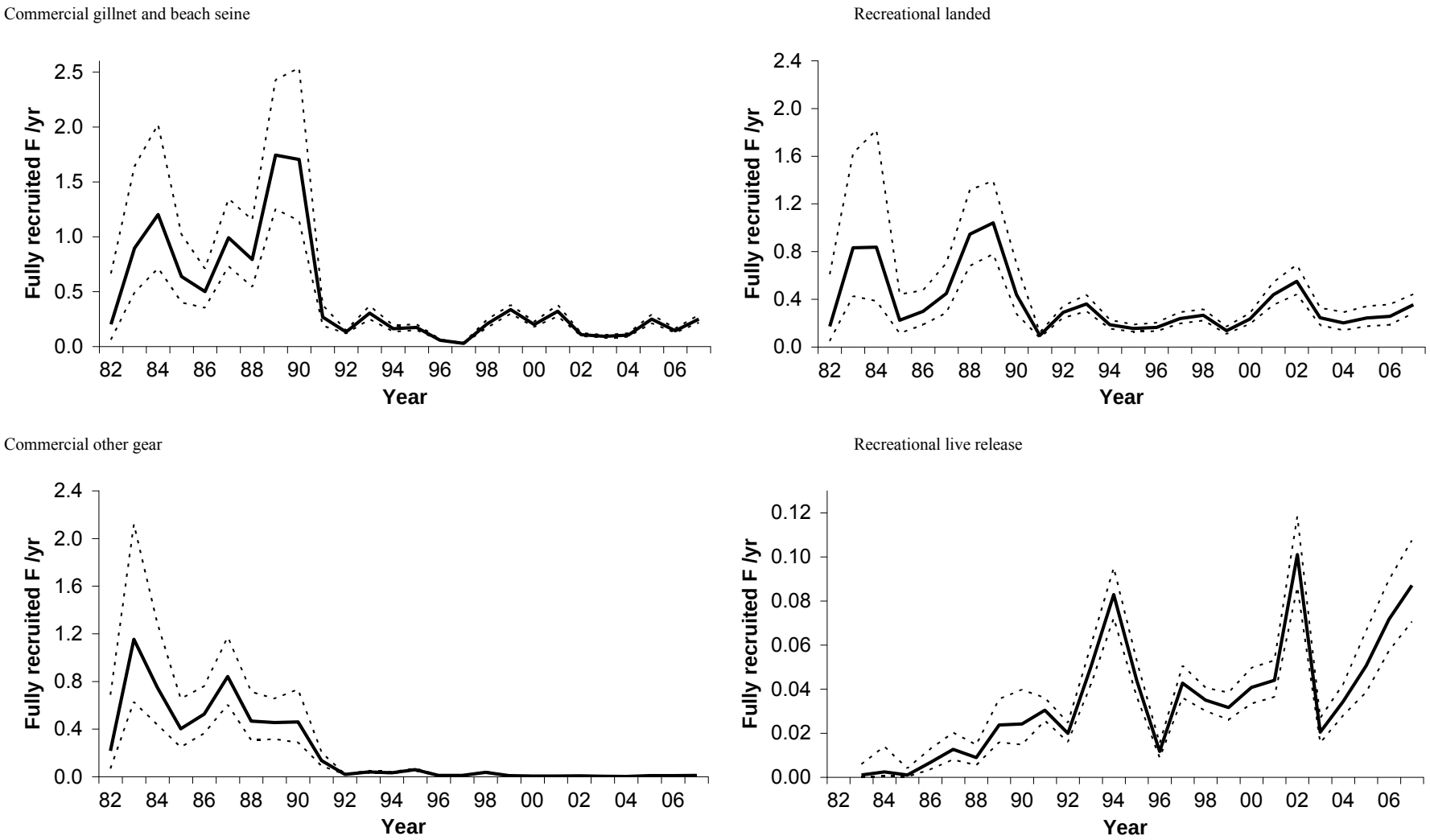


Figure 3.2.5.15. Estimated fully recruited instantaneous fishing mortality (solid line) and ± two standard errors (dashed lines) for the four northern region fisheries during 1982-2007.

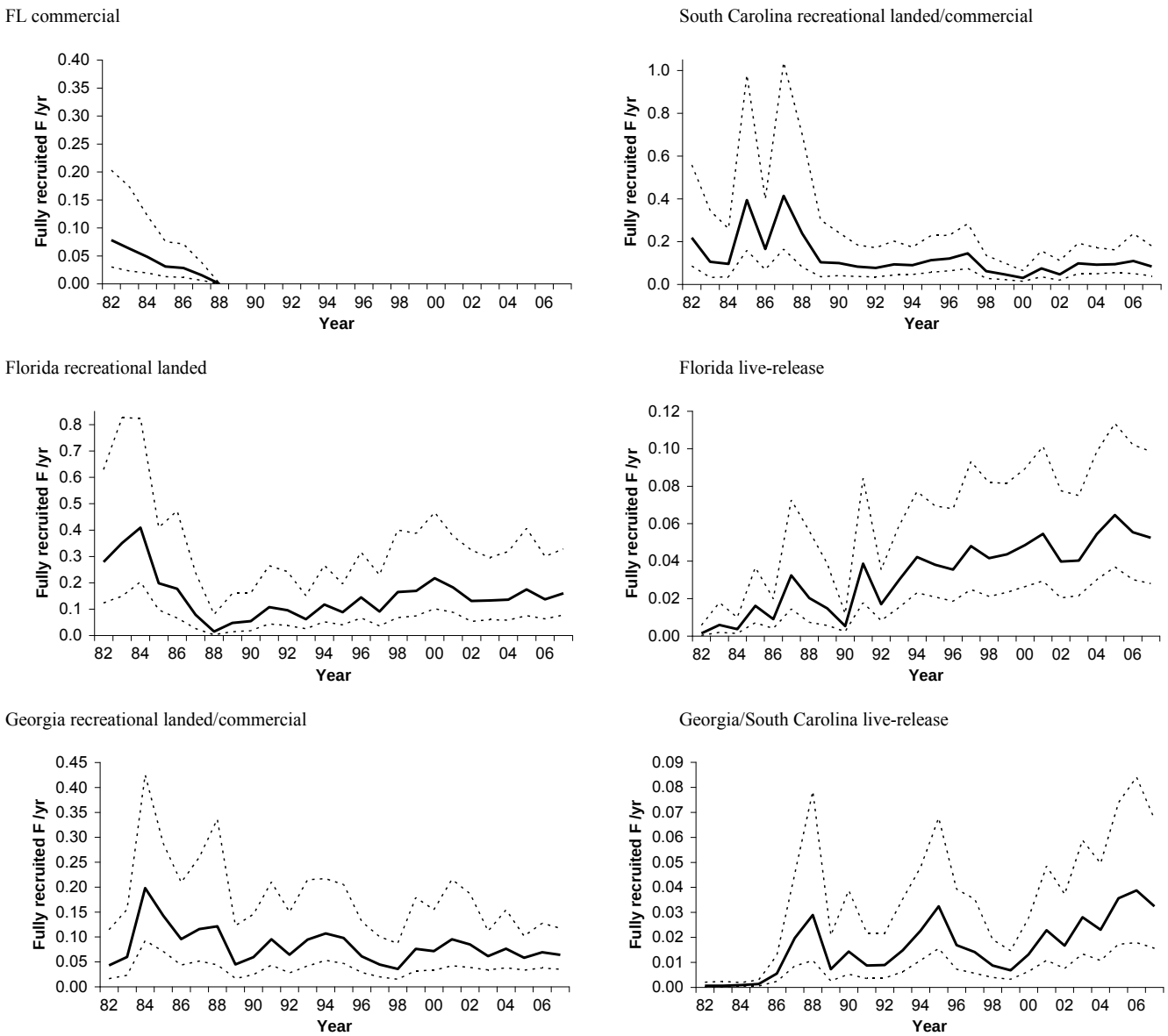


Figure 3.2.5.16. Estimated fully recruited instantaneous fishing mortality (solid line) and ± two standard errors (dashed lines) for the six southern region fisheries during 1982-2007.

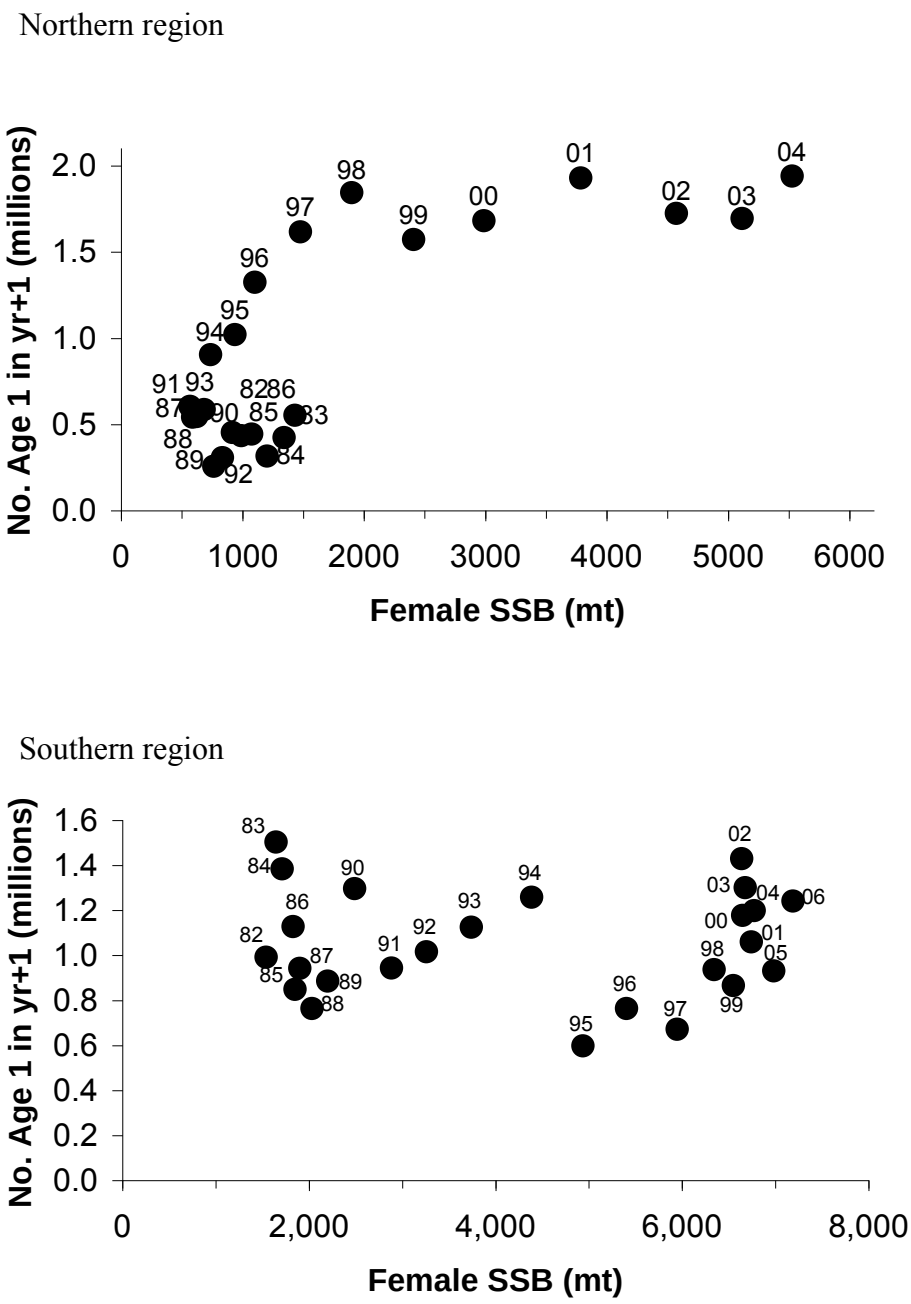


Figure 3.2.5.17. Estimated female spawning stock biomass (mt) of red drum during 1982-2006 and the next year's estimated abundance of age-1 fish.

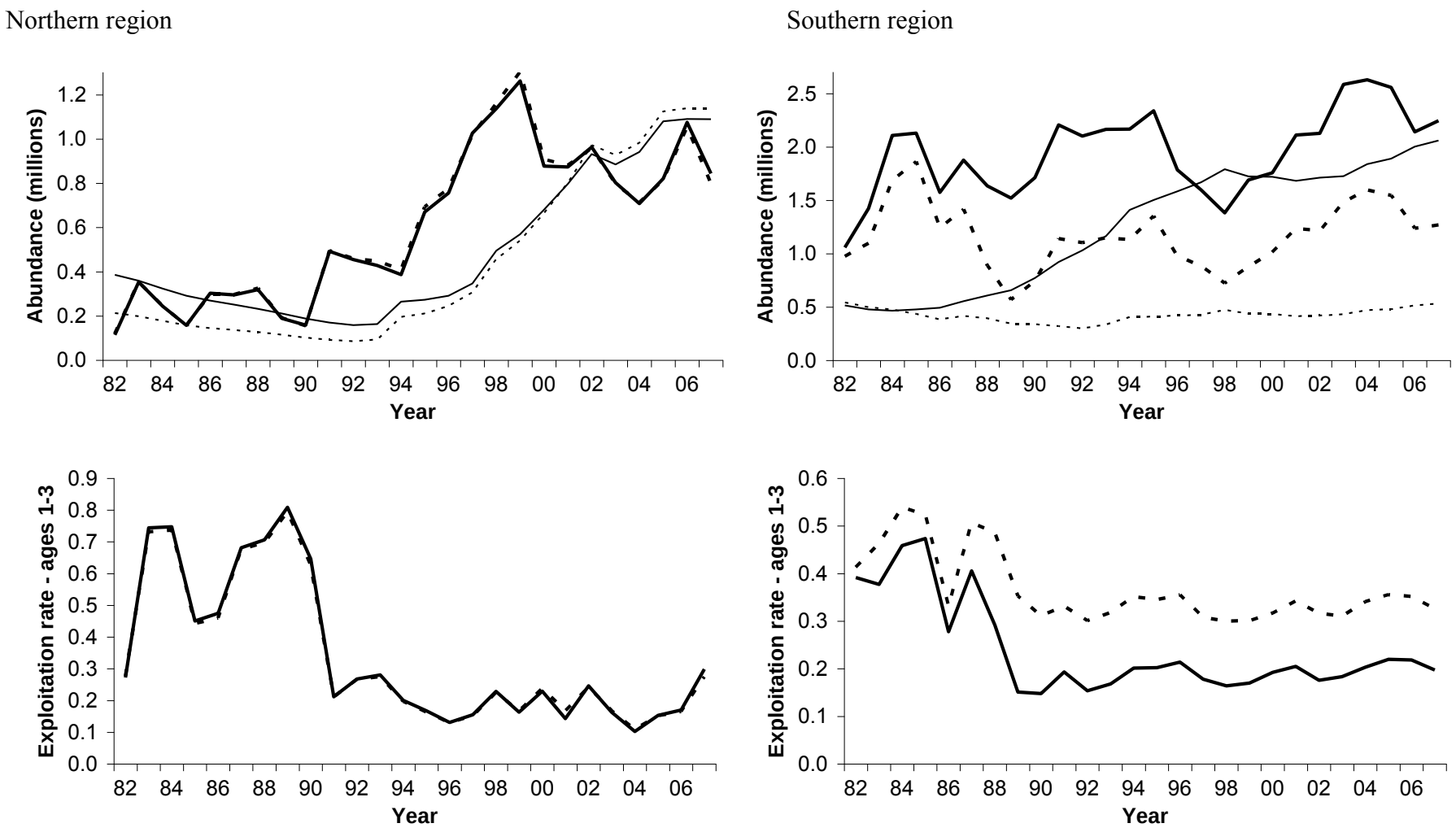


Figure 3.2.5.18. Estimates of abundance and age 1-3 exploitation when the selectivities of ages 1-5 were estimated (dashed lines) in the models instead of the restricted configuration used in the base model runs (solid lines). The abundance panels show the estimates for the pooled ages 1-3 (heavier lines) and for ages 4^+ (lighter lines).

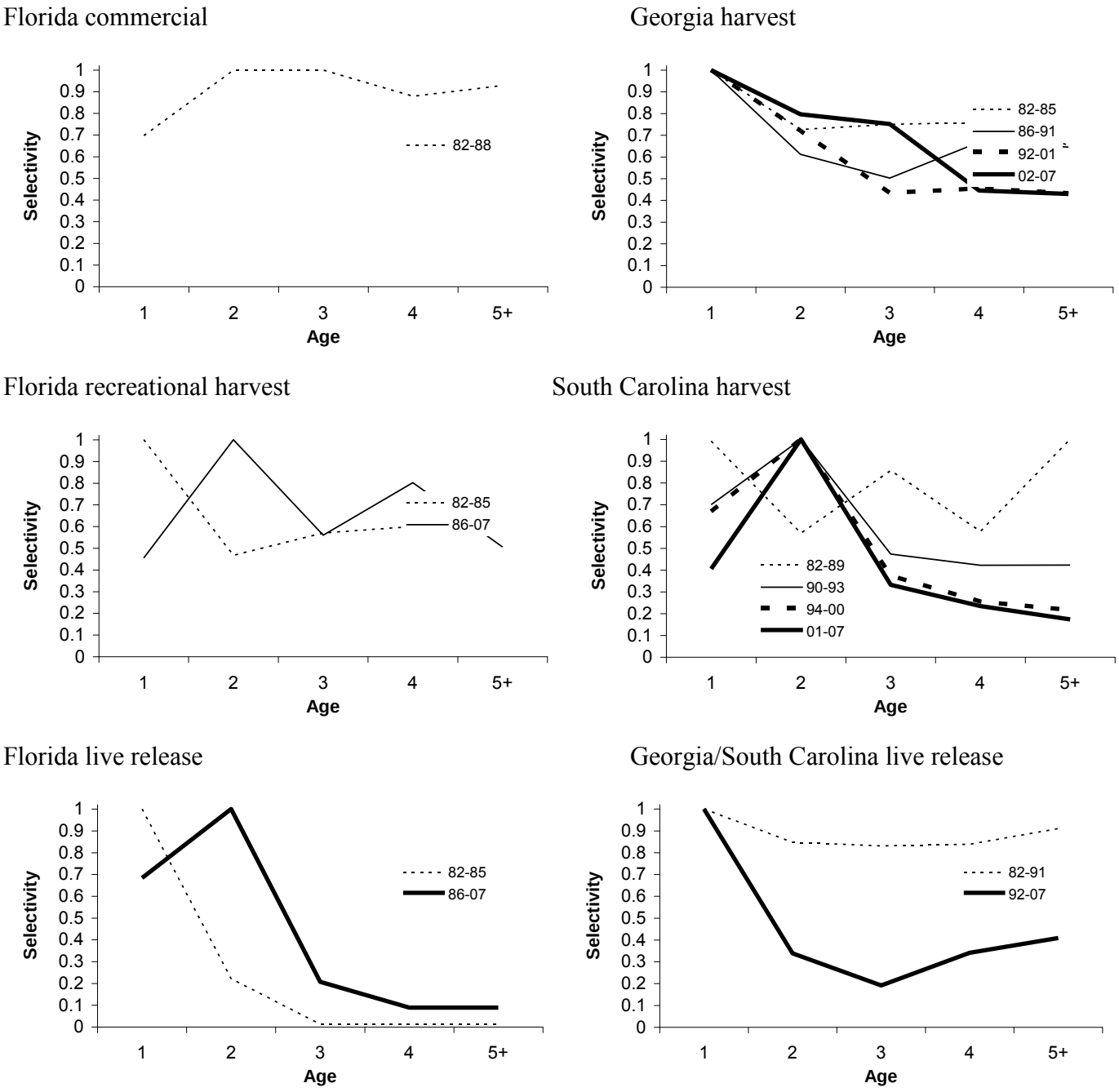


Figure 3.2.5.19. Estimated selectivities for five of the six southern fisheries modeled separately and the tag-based input selectivity data for the Florida recreational live-release fishery. Under the separability assumption, this age-effect for distributing fishing mortality across ages was estimated for each of the indicated periods of years.

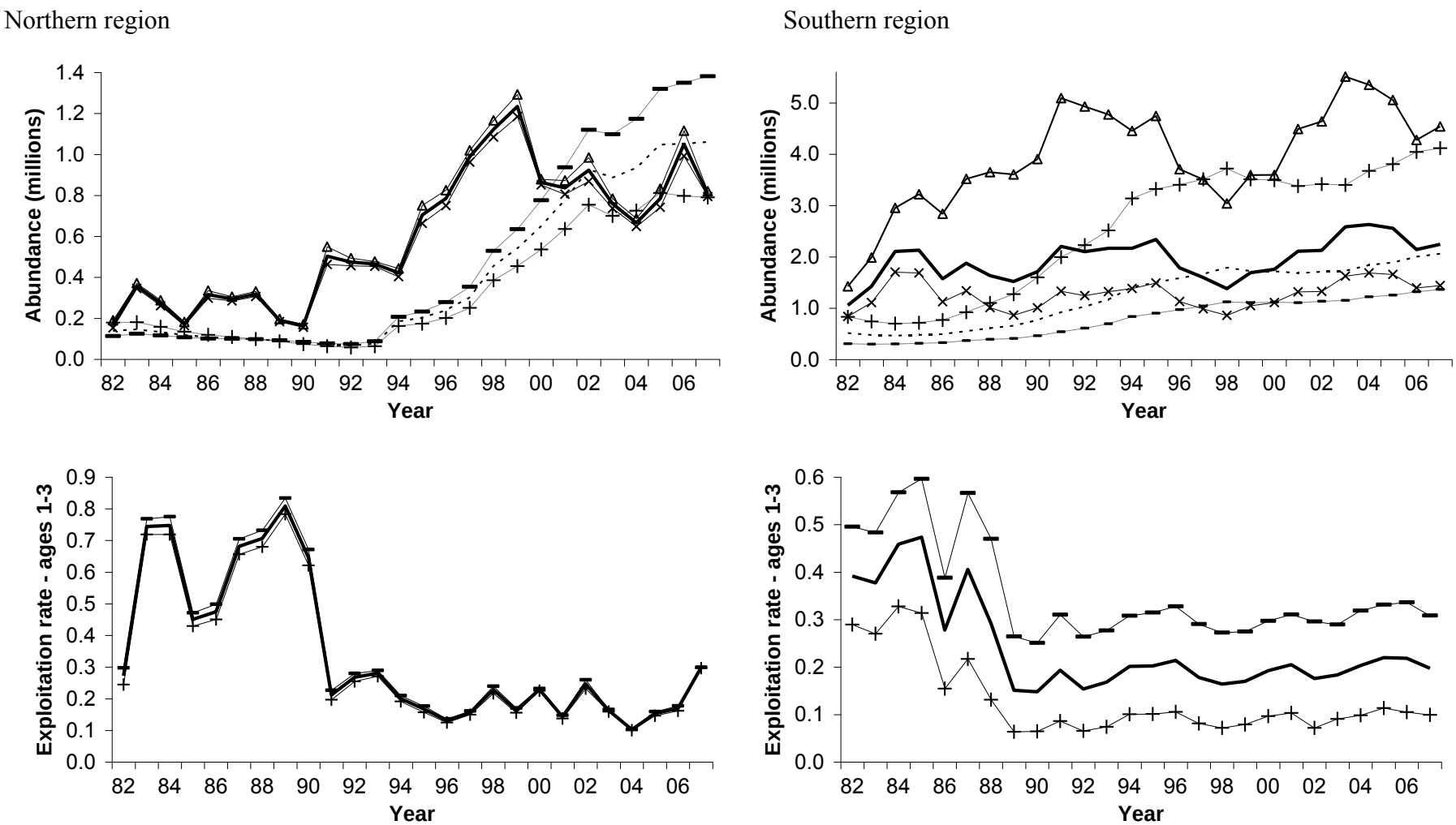


Figure 3.2.5.20. Estimates of abundance and age 1-3 exploitation using the high M (+'s or triangle), low M (-'s or X's), and base model M's (lines without symbols). The abundance panels show the estimates for the pooled ages 1-3 (heavier lines) and for ages 4^+ (dashed lines)

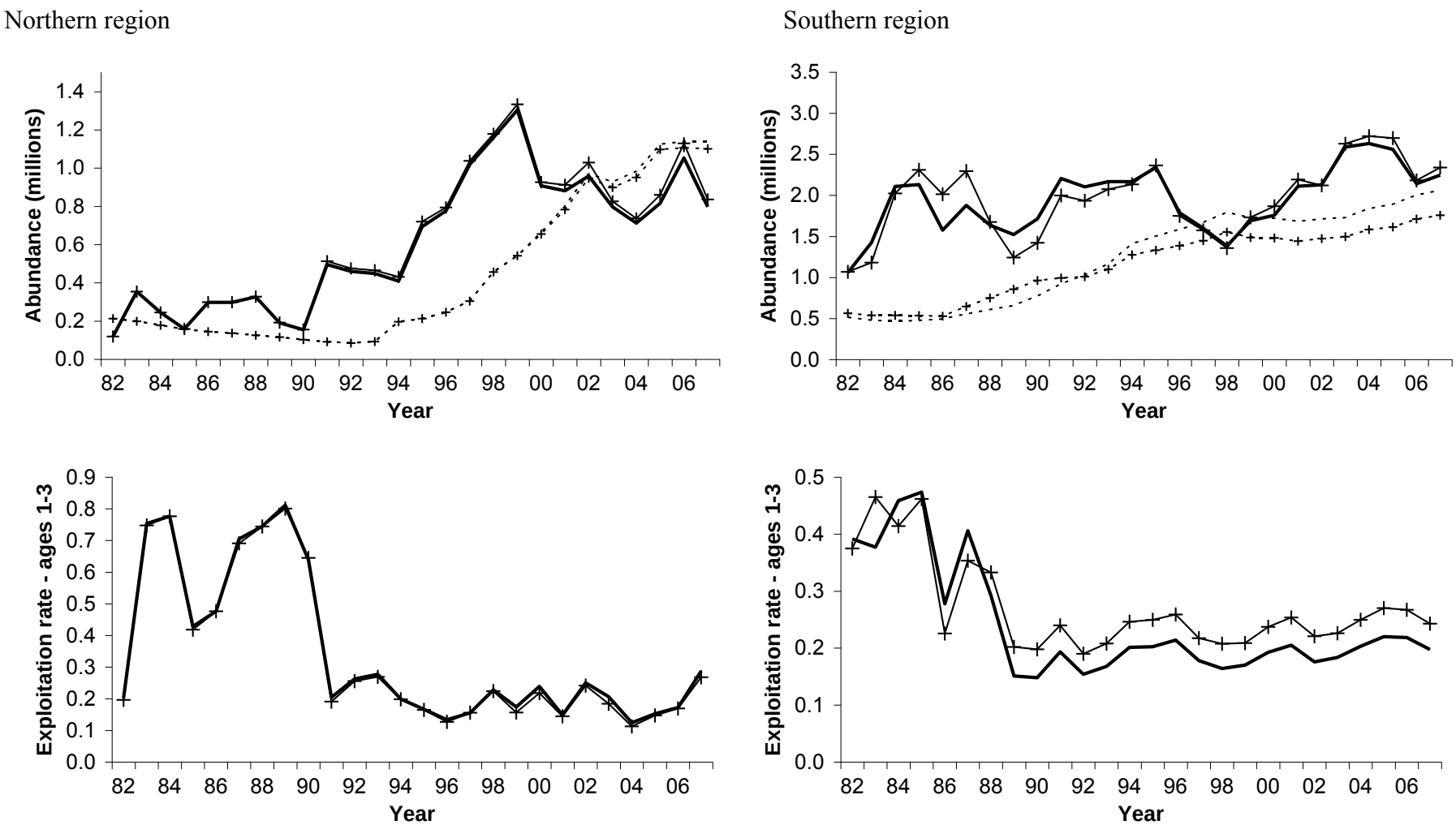


Figure 3.2.5.21. Estimates of abundance and age 1-3 exploitation when the hooking mortality was 0.16 (lines with the + symbols), double the base level of 0.08 (solid lines). The abundance panels show the estimates for the pooled ages 1-3 (heavier lines) and for ages 4^+ (lighter lines).

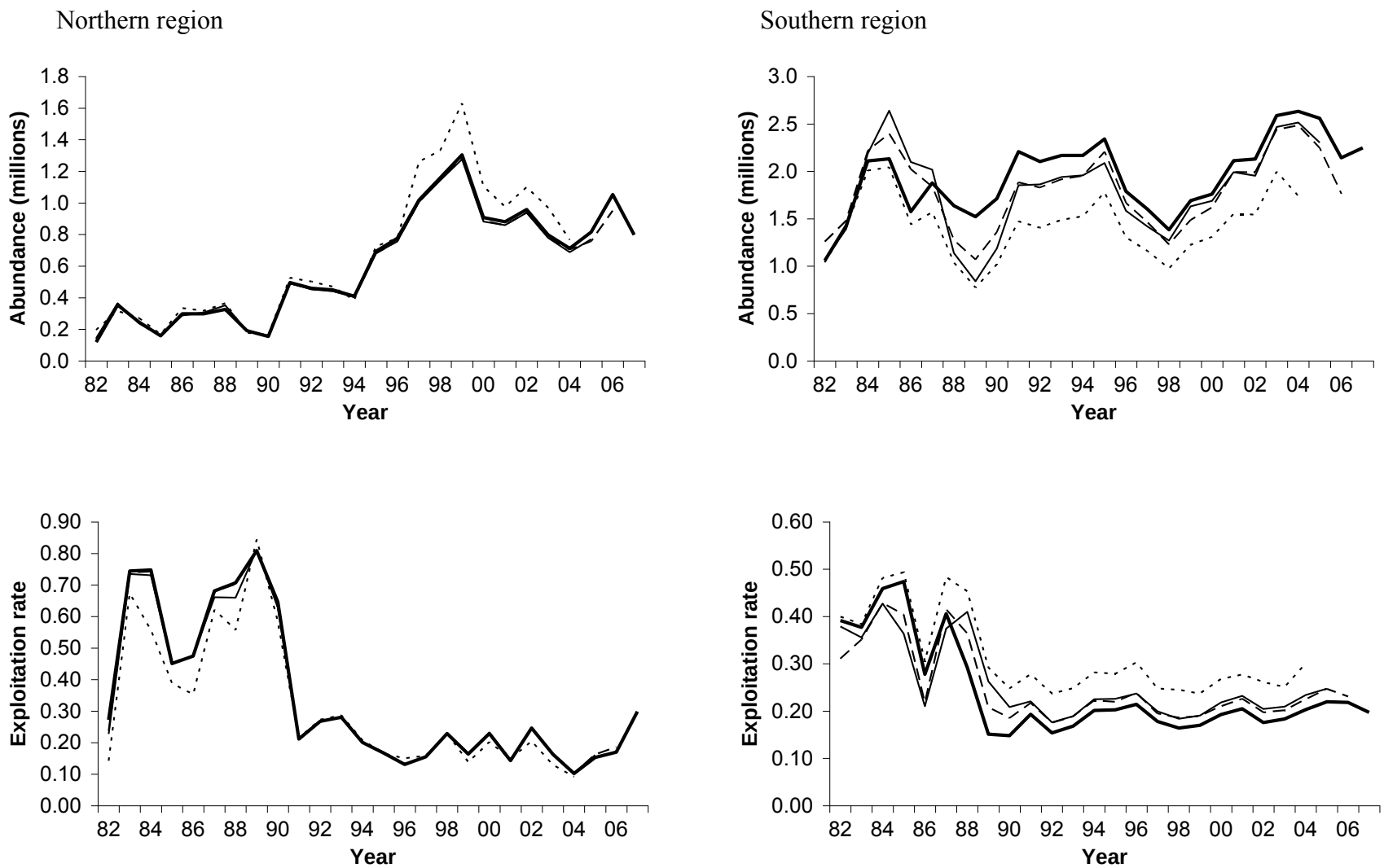


Figure 3.2.5.22. Estimates of age 1-3 abundance (top) and exploitation rate (bottom) using sequentially fewer years in the analysis, with the ending year changing from 2007 to 2006, to 2005, and to 2004 .

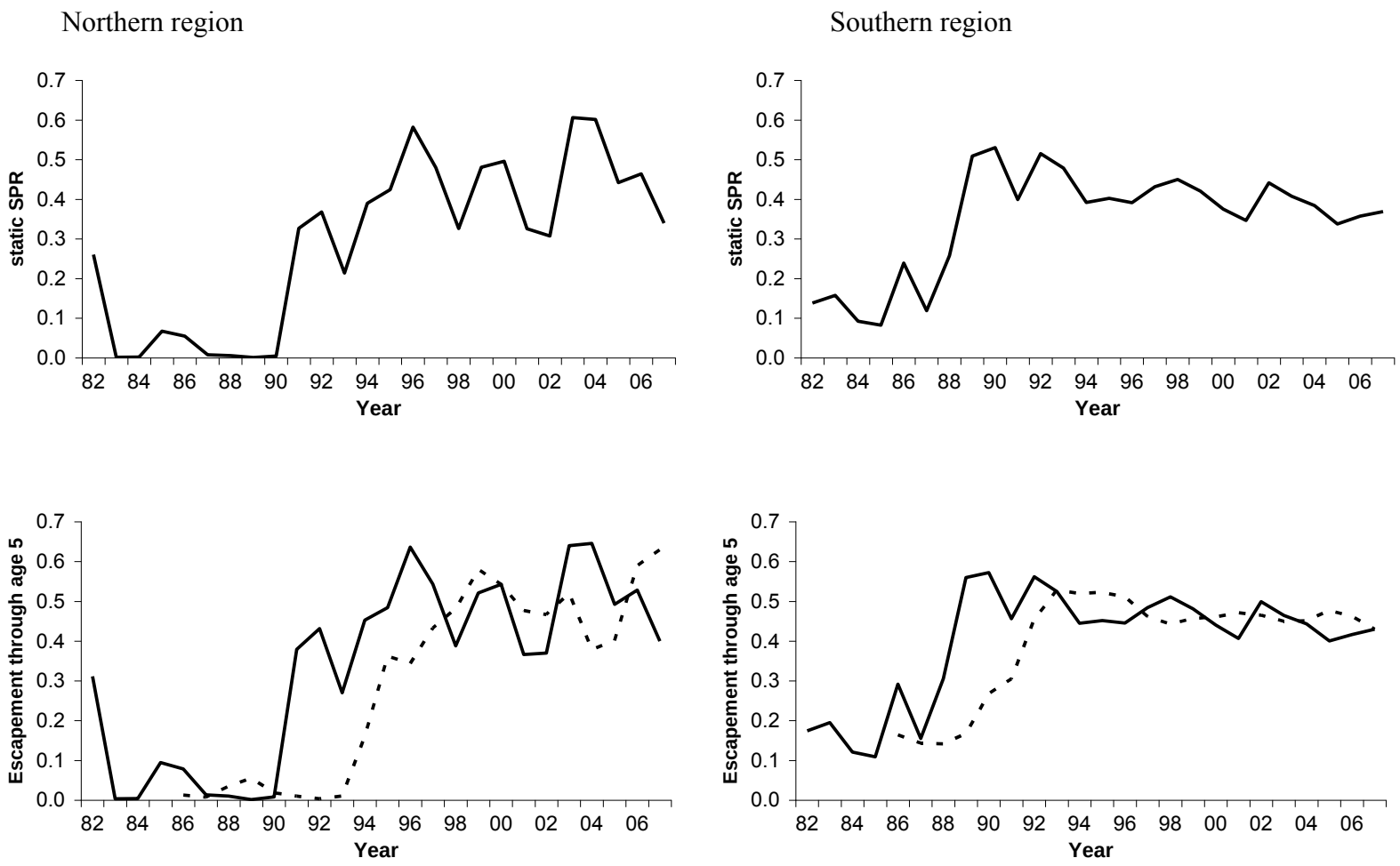


Figure 3.2.5.23. Northern and southern region estimates of static spawning potential ratio during 1982-2007 (top) and escapement rates (bottom) showing year-specific (heavy line) and year class-specific (dashed line) estimates.

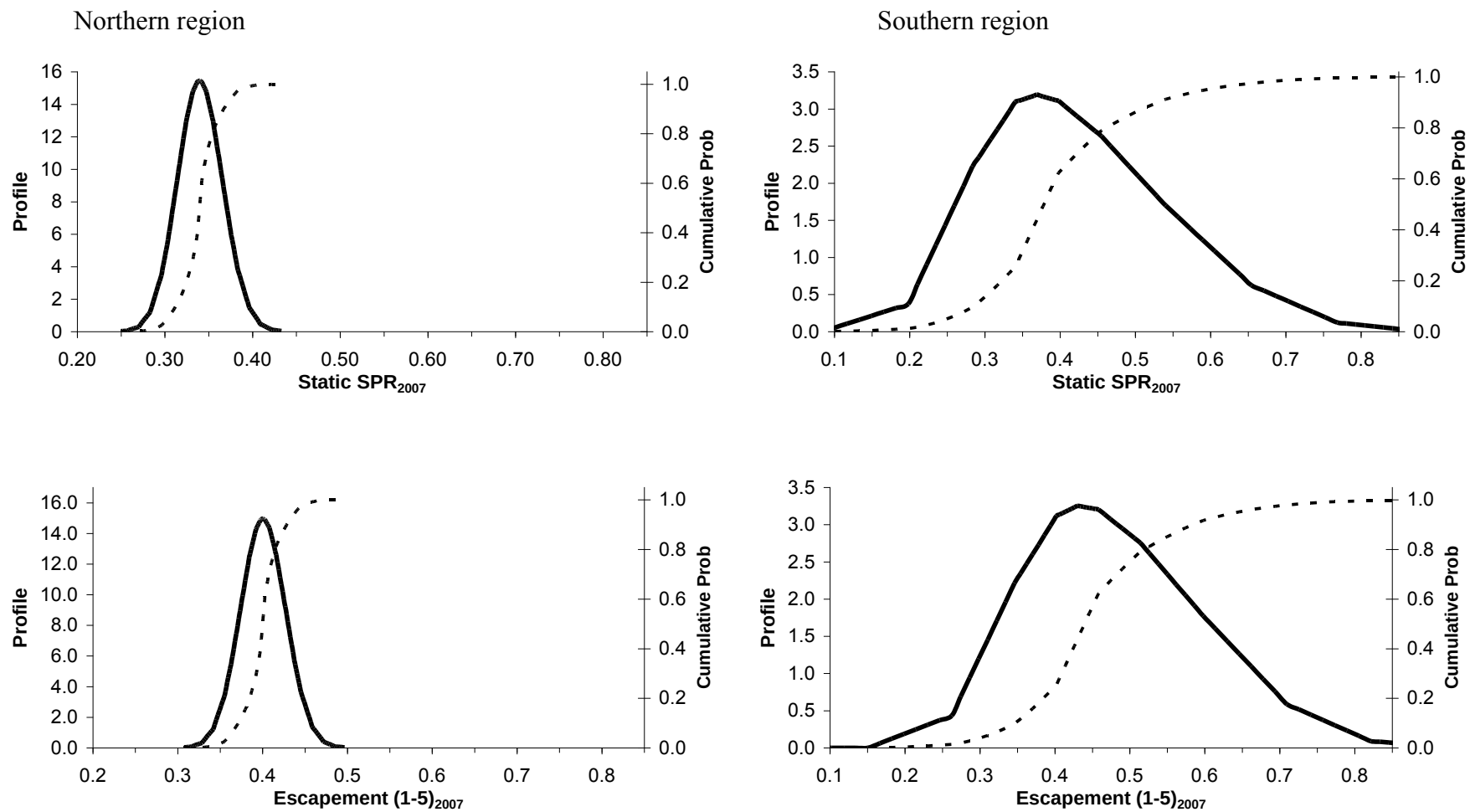
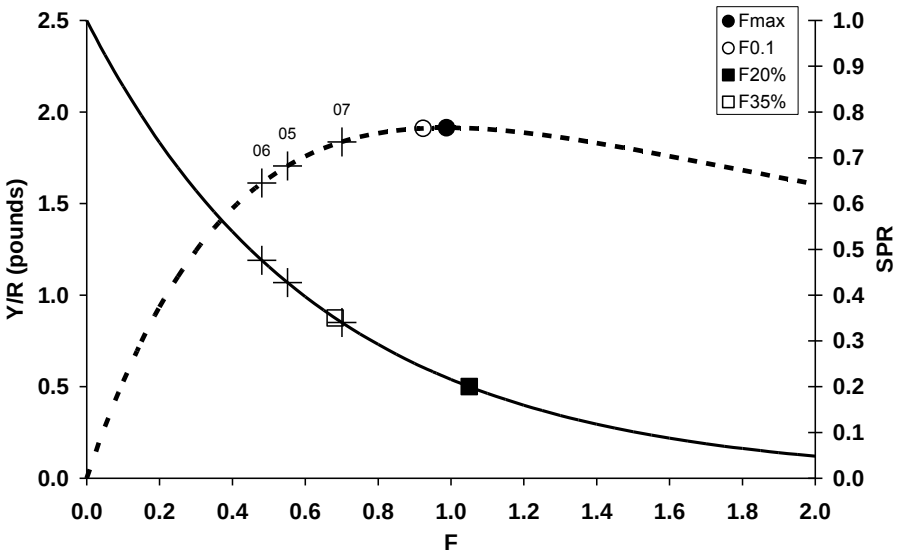


Figure 3.22.5.24. Northern and southern region likelihood profiles (solid line) and cumulative probability distribution (dashed lines) for the base model estimates of static spawning potential ratio in 2007 and age 1-5 escapement in 2007.

Northern region



Southern Region

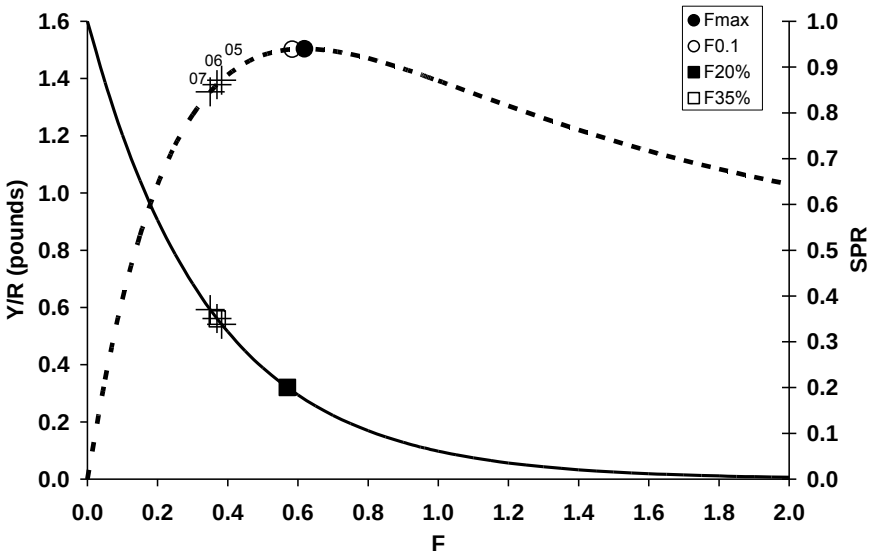


Figure 2.3.5.25. Equilibrium yield-per-recruit (dashed line) and spawning-stock-biomass-per-recruit (of spawning potential ratio, SPR, solid line) expected for red drum across a range of instantaneous fishing mortalities in the northern and southern. As indicated in legend, the YPR benchmarks Fmax and $F_{0.1}$ 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 A Report of the Independent Expert

CIE Independent Report
Stock Assessment Workshop
Atlantic Red Drum
June 1-5, 2009
North Charleston, South Carolina

Dr. Noel Cadigan
Fisheries and Oceans Canada,
Northwest Atlantic Fisheries Center
St. John's, NL, Canada

Executive Summary

The Assessment Workshop (AW) report was not completed by the time this CIE report was required, and analyses were still being conducted by the lead analyst. Rapporteur notes were not available either. I cannot report in detail on Summary of Findings for each ToR, and Conclusions and Recommendations in accordance with the ToRs. However:

- There was consensus on the baseline assessment model (i.e. statistical catch at age, SCCA) and configuration for the northern region red drum stock.
- There was consensus on the baseline assessment model for the southern region red drum stock (i.e. SCCA), although a precise configuration for this model was not be determined.

Little progress was made at the AW on draft text for the Assessment Workshop Report or the Summary Report. Most of this will occur outside plenary, and, in my experience, such reports do not get the same level of review as those developed in plenary. However, I recognize that there was too much analysis required at SEDAR 18 AW to allow for drafts to be completed. Part of the problem was the length of time since the last full assessment of the northern and southern red drum stocks. I provide a few recommendations that may speed up future assessments.

To assist the AW I provided analyses and working papers:

1. **S18-AW02**. Nonparametric growth model for Atlantic red drum, and changes to natural mortality (M) estimates.
2. **S18-AW06**. Graphical analyses of the catch age composition for red rum.
3. **S18-AW07**. Semi-separable untuned VPA for red drum.
4. **S18-AW11**. Tagging estimates of abundance at age for the northern region red drum stock.

Background

SEDAR 18 involves a compilation of data at a **data workshop (DW)**, a benchmark assessment of the stock at an **assessment workshop (AW)**, and an assessment review for Atlantic red drum. The goal of SEDAR assessment workshops is to conduct quantitative population analysis to determine stock status, evaluate management benchmarks, and project future stock conditions. The lead assessment agency and SEDAR partner for SEDAR 18 is the Atlantic States Marine Fisheries Commission.

Red drum is an important recreational fishery resource and contributes to commercial fisheries within its range on the Atlantic coast of the US. The most recent assessments of red drum in Atlantic waters are those done in 2000 for the Atlantic stock and in 2005 for both Florida coasts. Considerable additional life history and fishery data have been collected since these assessments. Significant changes in stock status have been documented due to management efforts and population abundance.

The SEDAR 18 Assessment Panel was composed of one CIE-appointed panelist, five panelists appointed by the Atlantic States Marine Fisheries Commission from Atlantic coastal states, and one panelist appointed by the SEFSC director. The workshop was chaired by the SEDAR coordinator. Commission staff, Commission members, and Commission advisory panel members attended as observers.

The **Terms of Reference** (**ToRs**) for the AW are described later in this report. The AW was tasked with preparing an Assessment Workshop Report which summarized the primary assessment findings, and a first draft of the Summary Report.

The specific goals of the AW were to:

- Review post-DW data changes and analyses suggested by the DW.
- Summarize data used in each assessment model, and justify deviations from DW recommendations.
- Develop population assessment models compatible with relevant data.
- Recommend a model configuration deemed useful for advice relative to static SPR levels.
- Document input data, assumptions, equations, and model code in a working paper.
- Include a continuity case run to determine the effect, if there is a model change.
- Provide estimates of stock population parameters.
- Characterize scientific uncertainty in the assessment and estimated values.
- Provide measures of model performance, reliability, and ‘goodness of fit’.

- Provide recruitment evaluations and estimates of SPR and escapement.
- Evaluate the impacts of management actions on the stock.
- Discuss workshop research recommendations.
- Prepare a spreadsheet containing model parameter estimates and relevant population information with data findings.
- Complete the AW Report and Summary Report draft, and
- Develop a post AW task list.

Role of reviewer

The CIE appointed expert was tasked with participating on the Assessment Panel, rather than the Review Panel. This included participating in discussions of technical details of the methods used for the SEDAR assessment, and assisting in decisions related to model configuration. The appointee was tasked with impartially and independently contributing fresh information to improve the assessment being undertaken, and determining if the best available science was utilized for fisheries management decisions.

During the AW, the appointee and six other assessment panel members discussed technical details of the methods used in the SEDAR assessment, and assisted in decisions related to model configuration. The CIE expert was tasked with impartially critiquing the assessment being undertaken to advise the analytic team on ways to improve the model and to interpret and present its results. The CIE expert assisted in the determination that the best available information and science were utilized in the assessment and, to the extent determined by the lead analyst, contributed to the written assessment workshop report (see below).

The CIE expert was asked to read all documents in preparation for the assessment workshop. This included 18 documents prepared by the DW, and 68 other background documents. During the review meeting, I participated in panel discussions on assessment methods, data, validity, results, recommendations, and conclusions, according to the ToRs.

To assist the AW, I provided analyses and working papers (WP's). The WP's were provided so that relevant sections could be included in the AW report. The WP's I provided were:

1. **S18-AW02**. Nonparametric growth model for Atlantic red drum, and changes to natural mortality (M) estimates.
2. **S18-AW06**. Graphical analyses of the catch age composition for red rum.
3. **S18-AW07**. Semi-separable untuned VPA for red drum.
4. **S18-AW11**. Tagging estimates of abundance at age for the northern region red drum stock.

The Abstract or Summaries are provided in **Appendix 3**.

Summary of AW findings

- There was consensus (see Tor2) on the baseline assessment model (i.e. statistical catch at age, **SCCA**) and configuration for the northern region red drum stock.
- There was consensus (see Tor2) on the baseline assessment model for the southern region red drum stock (i.e. SCCA), although a precise configuration for this model was not be determined. Issues to be resolved involved treatment of age-composition information for recreational release mortalities and the weighting of data components.

The AW report was not completed by the time this CIE report was required, and analyses were still being conducted by the lead analyst. Rapporteur notes were not available either. This reflects the large amount of work that was required to assess the two red drum stocks (northern and southern) since the last full assessment was conducted nine years ago (2000). Substantial progress was made at the AW, and I anticipate that useful conclusions and recommendations will be forthcoming in the next several weeks regarding all AW ToR's; however, currently I cannot report on Summary of Findings for each AW ToR, and Conclusions and Recommendations in accordance with the ToR's for this report.

Based on my own notes, in this section I describe the assessment activities completed during the assessment workshop, and give my independent views on each ToR.

In the next section (Summary of conclusions and recommendations), I provide recommendations to improve the assessment and the assessment process.

ToR 1: 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.

The chair asked for changes in assessment inputs indices to be described.

There were no changes to tuning indices since the DW. I felt that the DW report provided a reasonable description of the tuning indices, including their strengths and weaknesses. However, there was some confusion among AW participants about the tuning indices. Some states had provided alternative analyses (i.e. arithmetic or geometric mean), and it was not clear which ones were being used in the statistical catch at age (SCCA) stock assessment model. The lead assessment scientist asked that participants check the indices to make sure the right ones were used, but confirmations were not reported to the meeting. There was also some uncertainty about how to interpret the measures of uncertainty provided for the tuning indices.

Final catch and catch age data were also adjusted since the DW, and this continued after the AW. I did not get the sense that the adjustments were substantial, but the adjustments did not get much peer-review.

A substantial fraction of the catch for both red drum stocks involved mortality inferred from catch and release fisheries. There is little quantitative information on the mortality rates for releases or their age compositions. These issues were considered in some detail at the AW, and I feel this took too much of the meeting's time and detracted from establishing base models and report writing. The issue of mortality rates for releases should have been resolved at the DW.

Sampling information for the various red drum fisheries was poor in some cases. This required some subjective decisions to be made regarding how to infer age compositions. As a result, the catch-at-age seemed rather noisy.

ToR 2: 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.

Population assessment models were developed for the northern and southern red drum stocks. The AW concluded that SCCA would be used as the basic assessment model for both stocks. Models would cover 1982-2007 and ages 1-7+.

<u>Basic SCCA configuration for the southern stock.</u>

The SCCA will be based on eight indices of abundance:

Source:	FL	GA	SC	FL	SC	FL	MRFSS	SC
Ages:	1	1	1	2	2	3	1-3	7+

Total catch and age-compositions are used for seven "fleets": Three fleets for each state's (FL,GA,SC) recreational harvest. Three fleets for each state's recreational release mortalities. One fleet for FL commercial harvest. Commercial landings from GA and SC are added to their recreational harvest.

Age selectivities are estimated for time periods corresponding to important changes in management regulations:

1. FL commercial harvest: 1982-1986.

2. FL recreational harvest: 1) 1982-1985, 2) 1986-2007.
3. GA recreational+commercial harvest: 1) 1982-1985, 2) 1986-1991, 3) 1992-2001, 4) 2002-2007.
4. SC recreational+commercial harvest: 1) 1982-1989, 2) 1990-1993, 3) 1994-2000, 4) 2001-2007.
5. *FL, GA, and SC recreational release mortalities still to be resolved*.

Selectivities for ages 4 and 5+ are assumed to be 10% and 5% of selectivity at age 3. Selectivity is estimated for ages 1-3 in each of time period.

Data components will be weighted by standard errors where available, and additional external weighting would be by default (i.e. 1) except for recreational release "fleets". *Data weighting is still to be resolved*.

Basic SCCA configuration for the northern stock.

The SCCA will be based on four indices of abundance:

Source:	NC GN	NC GN	NC JA	MRFSS
Ages:	1	2	1	1-3

And tagging estimates of fishing mortality at ages 1-3. *The specifics (i.e. fit function, weighting) of including tagging-F's were not resolved during the meeting*.

Total catch and age-compositions are used for four "fleets": 1) Commercial (beach seine, gill net), 2) commercial (other), 3) recreational harvest, and 4) recreational release mortalities.

Age selectivities for each fleet are estimated for three time periods corresponding to important changes in management regulations: 1) 1982-1991, 2) 1992-1998, 3) 1999-2007. Selectivity for recreational release mortalities are inferred from tagging estimates.

Selectivities for ages 4 and 5+ are assumed to be 10% and 5% of selectivity at age 3. Selectivity is estimated for ages 1-3 in each of time period.

Data components will be weighted by standard errors and additional external weighting would be by default (i.e. 1).

Workshop activities

Initial models were not fully compatible with the data because they required age compositions for the catch and release mortality component, and reliable information was not available for all years and regions. At the AW, these problems were resolved by using tagging estimates of the age-selectivity of the

catch and release fishery for the northern stock where the age compositions were not available. Only the total mortality estimates for releases (i.e. all ages) were used in the SCCA. For the southern stock, age compositions were available for some states and these were used in the SCCA. Tagging estimates of selectivity for the northern stock were incorporated into the southern stock SCCA where appropriate. The details of this are somewhat complicated, but I felt by the end of the AW meeting that substantial progress was made in resolving the catch and release mortality issue.

Tagging information was also used to provide absolute estimates of stock size for ages 1-3 for the northern region, to be used when estimating the SCCA. This provided important information to scale the population abundance estimates from SCCA. Otherwise, a much greater range in stock size estimates occurred. The tagging estimates of abundance (see S18 AW11) were derived from harvested catch at age and tagging estimates of the fishing mortality for the harvested catch (Fharvest). After the meeting, some problems were discovered with the tagging estimates of abundance. Until these problems are resolved, it was decided that the best approach was to include tagging estimates of Fharvest directly into fitting the SCCA. In addition, the tagging estimates of Frelease could be used the same way. Using external estimates of F will also provide useful information to scale the population model. It was felt that using the tagging estimates of F directly was statistically more appropriate in the SCCA context where there is non-ignorable measurement error in the catch.

A draft document describing the SCCA was provided during the workshop. This seemed reasonably complete, although I did not have the opportunity at the workshop to go through it in detail, and some specifics will have to be updated for the RW. This included how tagging selectivities and fishing mortalities were incorporated into the model. Computer code was provided, although I did not look at this in much detail.

A working paper was provided after the AW with the output from the SCCA's for both stocks. More output would help. Suggestions are provided in the next section.

The chosen assessment model differed from that used previously (Vaughan and Carmichael 2000), which is expected because of the long time period between assessments. Vaughan and Carmichael (2000) applied three separate models: a Separable Virtual Population Analysis (SVPA), a Spreadsheet Virtual Population Analysis (SprdVPA), and a virtual population analysis using F-ADAPT. The AW agreed that a SCCA was the most appropriate model to use in the current assessment. Only the SprdVPA could be reproduced for the continuity run. Also, treatments of assessment input data (i.e. age composition of catches, M's) changed, and the tuning indices used in Vaughan and Carmichael (2000) could not be located.

The AW decided to apply the continuity model to the original catch at age data and natural mortality values, and the data derived for the SEDAR 18 AW. However, the indices were updated for both runs of the model. This analysis measured the impact of some of the changes in the assessment inputs on the 2000 assessment.

It was not possible to do a true continuity run of applying the previous and proposed assessment models to data for the current assessment period. I am not sure why this was, but I recall there were several issues that had to be resolved. Because of the length of time since the last assessment, and because the model in Vaughan and Carmichael (2000) was not being considered for the current assessment, it did not seem useful to devote much of the AW's time to conducting a true continuity model run.

ToR 3: 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.

Estimates of stock-recruitment relationships were not provided because good estimates of spawning stock size were not available.

The SCCA produced age-specific estimates of fishing mortality (both harvest and catch and release), abundance, and selectivity. The F's were decomposed by broad gear/fleet types: beach seine/gill net and others for the northern region stock; state and commercial for southern region stock; recreational harvested, and recreational released.

Measures of precision were not provided.

ToR 4: 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'.

The assessment incorporated standard errors for input values.

Measures of precision for estimated quantities were not provided to the AW. Some preliminary runs gave indefinite Hessians (not provided) and "linearized" standard errors could not be produced.

Measures of model performance (i.e. parameter gradients, etc) were not provided.

Goodness of fit was evaluated using time series plots of observed and predicted values.

Untuned VPA's were provided to partially evaluate uncertainty in the modelling approach.

Uncertainty from model assumptions and configuration, and model reliability, will be assessed using some sensitivity analyses. These will be conducted after the AW.

ToR 5: Provide yield-per-recruit, spawner-per-recruit, and stock-recruitment evaluations, including figures and tables of complete parameters.

Stock-recruitment and spawner-per-recruit evaluations were not provided because of the difficulty in estimating spawning stock size.

Yield-per-recruit estimates were not included in the preliminary models presented at AW, and I do not think there are plans to do so.

ToR 6: Provide estimates of spawning potential ratio and escapement 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%).

Such estimates were not provided to the AW, although I am confident that this information will be provided to the RW for the baseline assessment models.

ToR 7: 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.

No results were presented for this ToR.

ToR 8: 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 was adequately addressed at the AW. Every participant was given an opportunity to provide recommendations for future research and data collection. Recommendations were recorded and I expect that they will appear in the workshop report.

ToR 9: 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.

The assessment lead provided spreadsheets for some preliminary model runs considered at the meeting and shortly after. This included basic output from the SCCA, and some graphs. They were not clearly documented, and did not include any results for spawning potential ratio and escapement.

The DW spreadsheet was available, and it was updated as required. It contained most of the data summaries provided to the AW, although it did not include some raw data that were included as graphics in the DW report.

ToR 10: 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.

The Assessment Workshop Report and a first draft of the Summary Report were not completed at the AW. A list of tasks to be completed following the workshop was developed.

Summary of conclusions and recommendations

ToR 1: 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.

The DW should produce a comparison graph of tuning indices, and if possible provide measures of uncertainty on these graphs. This could involve several panels on a single page, each with age-specific indices (± 2 standard error). The idea is a one-page summary of the tuning indices.

Of course it is desirable to have as complete information on commercial landings as possible; however, I realize that these data are probably acquired on an almost continual basis, and updates will always produce some differences. It seems desirable to decide on a cut-off date before the AW to compile landings statistics to be considered as “official” for the assessment. Making minor changes to landings during or after the AW may create unnecessary workload and detract from other important assessment initiatives.

It would be desirable to develop a more automatic (and perhaps statistically efficient) way to infer age compositions of commercial catches when sampling is

too sparse. Subjectively assigning ‘neighboring’ samples is prone to error, and rarely gets good peer review. An objective way of delineating a ‘neighbor’ would be useful. This also has the benefit of being repeatable. If the computer program used to create the catch at age is saved, and a standardized database of sampling information exists, then catch at age can be replicated at any time by simply re-running the program. For example, I have used a kernel density estimation procedure to estimate the length composition of a fishery for any time, location, and gear. All historic length samples are used, with kernel weights assigned according to the ‘distance’ between the prediction point and the samples. The kernel weights, and most importantly how they decline with distance (i.e. the size of the neighborhood), could be decided using some objective criteria, such as cross-validation on independent data. This may also provide a way to quantify the uncertainty in catch age compositions.

For the important catch and release fishery component there was almost no sampling information, and the above procedure could not be used. Essentially, the neighborhoods would be empty. Additional data are required. Utilizing tagging information, like with the northern red drum stock, seems like a good approach. There are several ways to do this which I will not describe.

ToR 2: 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.

Most of the tuning indices for the southern stock are state-specific, and cover only a portion of the stock range. If there are spatio-temporal variations in abundance in the stock then these indices will legitimately give different trends. I don’t see how the SCCA index could sort this out. For some reason the preliminary model runs fitted the South Carolina index at age 2 very well, but not the MRFSS index. This latter index covers the largest portion of the stock and is as long as the South Carolina index; however, the MRFSS is age-aggregated. All things being equal, I would be more comfortable if the MRFSS index was fit best. I can rationalize mis-fit with the state indices as local variability. Some rationale for the MRFSS mis-fit should be provided.

In a preliminary run, the fit to the South Carolina YOY index was very poor, and the average predicted was greater than the averaged observed. These averages should be approximately equal, and identically equal on a log scale.

It seemed that the southern region SCCA was not converged in the sense that the overall scale of stock size estimates was not well determined by the tuning indices. A similar pattern occurred (so I understand) for the northern stock, but the tagging estimates of F provide substantial information to fix the scale, and also to provide trend information. Clearly there is a need to analyze tagging datasets for the southern stock with the specific objective of providing as much information as possible to improve the stock assessment.

A true continuity run will be valuable if the next assessment of the stock is conducted within a shorter time frame (i.e. 5 years).

As part of the output from the SCCA's for both stocks, provide

1. Total fit to each index/catch/age composition (i.e. more detail to Table 3 in S18-AW08).
2. Residual plots. Plotting observed vs. predicted for indices is good and should be retained, but this does not give you direct information about the individual point contributions to the total fit. Standardized residuals, (log(obis)-log(prod))/std.dev, that directly contribute to the objective function are useful. Likewise for catch and age compositions.
3. Provide estimated selectivities in addition to estimated age-compositions.
4. Provide plots of numbers-at-age, and F-at-age.

It would be useful for the assessment team to create a graphics 'can' for the SCCA, so that the assessment lead spends as little time as possible producing plots during a meeting. R is a good package for this. It can also create html tables of output to be included directly into a report. There is a lot of R code freely available to do useful graphics (e.g. SPAY plots, see S18-AW06).

ToR 3: 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.

Like most stock assessment models, reliable measures of precision were not provided. The SCCA did not estimate variances for its various inputs. These were derived from the CV's of tuning indices or age-composition data, and I am not sure what was done for the catch data. However, these CV's are only part of the error (the measurement error) and do not account for any process error. This was not quantified.

Precision should be defined more precisely. Otherwise, one has to accept a possibly wide variety of measures of precision that are not all compatible (e.g. Survey design-based, model-based, subjective Bayesian).

In a highly parameterized model like the SCCA, it is well known that variances (e.g. process error) are difficult to estimate reliably.

Considerable research would need to occur to establish that measures of precision are reliable (i.e. they are what the claim to be). There is much that can be written about this. Briefly, the best models I have seen for quantifying uncertain are state-space models in which high dimensional parameters (basically those with year subscripts) are treated as random effects. The information about parameters with year subscripts does not grow as data are accumulated, and asymptotic inference procedures such as Hessian based standard errors may not be reliable. Small sample size procedures seem necessary. If the high dimension parameters are treated as random then they can be predicted using empirical Bayes. Marginal likelihood approaches also can provide more accurate results for random effect models. ADMB seems to handle random effects very nicely. This is currently an area that requires much more development for stock assessment models in general.

ToR 4: 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'.

A statistical state-space model in which high dimensional parameters are treated as random effects (see Tor3) may be a good approach to characterize uncertainty in model estimates. At the least, this approach could provide a realistic alternative model to the SCCA.

For the results of both assessments to be considered robust and reliable, I think the assessment models should be applied to simulated data from a realistic range of operating models producing noisy data. However, this standard is rarely applied in stock assessments I am familiar with, and it is unfair to say that best practice requires such simulations.

Sensitivity analyses will be used to characterize uncertainty by the AW. This is a subjective way to characterize uncertainty, and prone to mis-interpretation. It is subjective because it involves choosing perturbations to model inputs or assumptions. It is prone to mis-interpretation because of the temptation to interpret the range of model outputs as an interval for what happened in the population. A sensitivity analyses does not provide an interval with desirable statistical properties for important assessment quantities. Sensitivity analyses usually focus on the impact of model mis-specification, which is a component of uncertainty.

Sensitivity analyses are important when “building” a stock assessment model. Ideally, a good stock assessment model produces intervals for parameters, and that those intervals contain the parameter estimates obtained from most sensitivity analyses. A more objective approach to sensitivity analyses would be useful. Cadigan and Farrell (2002, 2004) outlined an objective approach that is fairly simple to use, even for models that are time consuming to optimize. The approach is particularly easy to use if the assessment software gives derivatives automatically. Sensitivity should be routinely assessed with respect to perturbations to catch, M, likelihood weights, and selectivity assumptions. This should save the AW and RW much time in doing re-runs

Cadigan, N. G. and Farrell, P. J. 2002. Generalized local influence with applications to fish stock cohort analysis. Appl. Statist. 51: 1-15.

Cadigan, N. G. and Farrell, P. J. 2004. Local Influence Diagnostics for the Retrospective Problem in Sequential Population Analysis . ICES Journal of Marine Science. 62: 256-265.

ToR 5: Provide yield-per-recruit, spawner-per-recruit, and stock-recruitment evaluations, including figures and tables of complete parameters.

I have no recommendations for this ToR.

ToR 6: Provide estimates of spawning potential ratio and escapement 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%).

I have no recommendations for this ToR.

ToR 7: 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.

I have no recommendations for this ToR.

ToR 8: 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.

I have embedded research recommendations in my comments for ToR's 1-4.

ToR 9: 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.

A goal should be to automate this process, so that every SCCA model run generates this spreadsheet. I would also add the configuration file. This is a good way to archive runs, so that they can be reproduced years from now. In assessments I have conducted I also archived my stock assessment model code, so that I can rerun models from 10 years ago with almost the same ease as 10 years ago.

ToR 10: 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.

Little progress was made at the AW on drafts of the Assessment Workshop Report or the Summary Report. Most of this will occur outside plenary, and in my experience such reports do not get the same level of review as those developed in plenary. However, I recognize that there was too much analysis required at SEDAR 18 AW to allow for this ToR to be completed.

Critique of the SEDAR assessment process

The timeframe since the last full assessment was too long for the two red drum stocks to be assessed within the normal SEDAR process timeframe of a one week meeting. This process is rigorous in terms of the expectations of the DW, AW, and RW, and the documentation and format expected. However, the objectives of the AW were not met during the AW meeting plenary. Much work continued after the meeting, and the peer review of these analyses will likely be deficient in some areas.

If the next assessment is within 5 years then I would anticipate more progress could be made in plenary at the AW, particularly with drafts of the Assessment Workshop Report and the Summary Report. However, it is important to schedule sufficient time at the AW to complete or make substantial progress on the entire set of ToR's. This did not occur in SEDAR18 AW.

Stock-recruit relationships for these stocks are not used. Estimates of mature stock size were not attempted at the AW, and it seems likely to me that any such estimates would be highly uncertain given the life-cycle of red drum and the

nature of the fishery. Mature fish essentially escape into a refuge (they are not fished much) and it will always be difficult to estimate the size of this portion of the stock. The references to stock-recruit relationships in the ToR's should be removed.

Rapporteur notes should be compiled and made available at the meeting. Ideally notes are compiled each night and made available to participants the next day for review. This should be a daily business item of the meeting.

Appendix 1: Bibliography of materials provided for appointee's involvement

1) SEDAR (Southeast Data, Assessment, and Review) Stock Assessment Program.
2) Tasks, Responsibilities, and Supplemental Instructions for SEDAR Assessment Workshop Participants.
3) SEDAR Workshop Panelist Guidelines.
4) FTP Site for SEDAR 18 Data & Document Compilation.
5) SEDAR 18 Atlantic Red Drum Workshops Document List, and 86 reference documents.
6) SEDAR 18 Assessment Workshop Daily Schedule and Tasks.
7) SEDAR 18 - Atlantic Red Drum Stock Assessment Modified Project Schedule.
8) SEDAR 18 Participants List. Atlantic Red Drum Assessment Workshop. June 1-5, 2009. Charleston, SC.
9) SEDAR 18. Atlantic Red DrumWorkshop Terms of Reference.
10) Summary: SEDAR 18 Pre-Assessment Workshop Conference Call

Appendix 2: A copy of the CIE Statement of Work

Attachment A: Statement of Work for Dr. Noel Cadigan

External Independent Resource Assessment Panel Membership by the Center for Independent Experts

SEDAR 18 Stock Assessment Workshop
Atlantic Red Drum
June 1-5, 2009
North Charleston, South Carolina

Scope of Work and CIE Process: The National Marine Fisheries Service's (NMFS) Office of Science and Technology coordinates and manages a contract to provide external expertise through the Center for Independent Experts (CIE) to conduct impartial and independent peer reviews of NMFS scientific projects and to participate in resource assessments involving NMFS. The Statement of Work (SoW) described herein was established by the NMFS Contracting Officer's Technical Representative (COTR) and CIE based on the resource assessment requirements submitted by NMFS Project Contact. CIE appointees are selected by the CIE Coordination Team and Steering Committee to conduct the peer review of NMFS science and to participate in resources assessments with project specific Terms of Reference (ToRs). The CIE appointee shall produce a CIE independent report of the appointee's involvement with specific format and content requirements (**Annex 1**). This SoW describes the CIE appointee's work tasks and deliverables related to the following NMFS resource assessment project.

Project Description: South East Data, Assessment, and Review (SEDAR) is a process for fisheries stock assessment development and review conducted by the South Atlantic, Gulf of Mexico, and Caribbean Fishery Management Councils; NOAA Fisheries Southeast Fisheries Science Center (SEFSC) and Southeast Regional Office (SERO); and the Atlantic and Gulf States Marine Fisheries Commissions. SEDAR is organized around three workshops: data, assessment, and review. Input data are compiled during the data workshop, population models are developed during the assessment workshop, and an independent peer review of the data, assessment models, and results is provided by the review workshop. SEDAR documents include working papers prepared for each workshop, supporting reference documents, and a SEDAR stock assessment report. The SEDAR stock assessment report consists of a data report produced by the data workshop, a stock assessment report produced by the assessment workshop, and a peer review panel report prepared by the review workshop.

SEDAR is a public process conducted by the Fishery Management Councils and Commission in the Southeast US. All workshops, including the assessment workshop, are open to the public and noticed in the Federal Register. All documents prepared for SEDAR are freely distributed to the public upon request and posted to the publicly accessible SEDAR website. Verbal public comment during SEDAR workshops is taken on an 'as needed' basis; the workshop chair is allowed discretion to recognize the public and solicit comment as appropriate during panel deliberations. Written comments are accepted in accordance with existing Council or Commission operating procedures. The names of all participants, including those on the assessment panel, are revealed.

SEDAR 18 will be a compilation of data, a benchmark assessment of the stock, and an assessment review for Atlantic red drum. The CIE appointed expert will participate on the Assessment Panel, rather than the Review Panel. Request for three CIE appointments to the SEDAR 18 Review Panel have been made separately. SEDAR assessments typically involve an assessment panel composed of assessment analysts named by the lead SEDAR partner, fishery scientists, and fishery managers. The lead assessment agency and SEDAR partner for SEDAR 18 is the Atlantic States Marine Fisheries Commission. Red drum is an

important recreational fishery resource and contributes to commercial fisheries within its range on the Atlantic coast of the US. The most recent assessments of red drum in Atlantic waters are those done in 2000 for the Atlantic stock and in 2005 for both Florida coasts. Considerable additional life history and fishery data have been collected since these assessments. Significant changes in stock status have been documented due to management efforts and population abundance.

The SEDAR 18 Assessment Panel will be composed of one CIE-appointed panelist, five panelists appointed by the Atlantic States Marine Fisheries Commission from Atlantic coastal states, and one panelist appointed by the SEFSC director. The workshop will be chaired by the SEDAR coordinator. Commission staff, Commission members, and Commission advisory panel members are scheduled to attend as observers. Members of the public may attend SEDAR assessment workshops.

The Terms of Reference (ToRs) of the assessment are attached in **Annex 2**. The tentative agenda of the assessment workshop is attached in **Annex 3,** and the Assessment Workshop Report outline appears as **Annex 4**.

Requirements for CIE Appointee: The CIE appointed expert shall participate as a panel member in the SEDAR fishery resource assessment of Atlantic red drum in accordance with the SoW and ToRs herein. The appointee will participate in discussions of technical details of the methods used for the SEDAR assessment, and assist in decisions related to model configuration during the workshop. It is anticipated the independent analyst will impartially and independently contribute fresh information to improve the assessment being undertaken and to determine if the best available science is utilized for fisheries management decisions.

The CIE assessment panel appointee should have expertise, background, and experience in stock assessment, statistics, fisheries science, and marine biology sufficient to complete the primary task of participation in discussions of technical details of the methods used for this SEDAR assessment, and to assist in decisions related to model configuration during the workshop, in accordance with the SoW and ToRs herein.

The CIE appointee's duties shall not exceed a maximum of 14 work days to complete all work tasks of the assessment described herein. They will comprise several days prior to the SEDAR assessment workshop for document review, five days at the workshop, and several days following the workshop to contribute to the assessment workshop report as a panelist and to ensure final assessment comments and document edits are provided to the lead analyst.

Location of Assessment Workshop: The CIE appointee shall participate during the assessment workshop scheduled in North Charleston, South Carolina during June 1-5, 2009.

Statement of Tasks: The CIE appointed expert shall complete the following tasks in accordance with the SoW and Schedule of Milestones and Deliverables herein.

Prior to the Assessment Workshop: Upon completion of the CIE appointee selection by the CIE Steering committee, the CIE shall provide the CIE appointee information (name, affiliation, and contact details) to the COTR, who forwards this information to the NMFS Project Contact no later than the date specified in the Schedule of Milestones and Deliverables. The CIE is responsible for providing the SoW and ToRs to the CIE appointee. The NMFS Project Contact is responsible for providing the CIE appointee with the background documents, reports, and information concerning other pertinent workshop arrangements. Any changes to the SoW or ToRs must be made through the COTR prior to the commencement of the assessment workshop.

Foreign National Security Clearance: The assessment workshop will not be held at a government facility, so foreign national security clearance is not necessary.

Pre- Assessment Workshop Background Documents: Two weeks before the assessment workshop, the NMFS Project Contact will send by electronic mail or make available at an FTP site to the CIE appointee all necessary background information and reports for the assessment workshop. In the case where the documents need to be mailed, the NMFS Project Contact will consult with the CIE on where to send documents. The CIE appointee shall read all documents in preparation for the assessment workshop.

The SEDAR 18 Documents List is displayed as Annex 5. Working papers and reference documents are available at the SEDAR website (http://www.sefsc.noaa.gov/sedar/). The report of the data workshop is in preparation. This list of pre-assessment documents may be updated up to two weeks before the assessment workshop. Any delays in submission of pre-assessment documents will result in delays with the CIE appointee's participation, including a SoW modification to the schedule of milestones and deliverables. Furthermore, the CIE appointee is responsible only for the pre-assessment documents that are delivered to the appointee in accordance to the SoW scheduled deadlines specified herein.

Assessment Workshop: The CIE appointee shall participate in the fishery resource assessment in accordance with the SoW and ToRs. **Modifications to the SoW and ToRs can not be made during the assessment workshop, and any SoW or ToRs modifications prior to the assessment workshop shall be approved by the COTR and CIE Lead Coordinator.** The CIE appointee shall actively participate in a professional and respectful manner as a member of the assessment workshop panel, and the appointee's tasks shall be focused on the ToRs as specified in the contract SoW. The NMFS Project Contact is responsible for any facility arrangements (e.g., conference room for the assessment workshop or teleconference arrangements). The CIE Lead Coordinator can contact the Project Contact to confirm any assessment workshop arrangements, including the meeting facility arrangements.

It is anticipated significant progress will have been realized by the analytic team in model development prior to the assessment workshop, and the model to-date will have been provided to the CIE appointee. During the assessment workshop the appointee will serve with six other assessment panel members in discussing technical details of the methods used in the SEDAR assessment, and assist in decisions related to model configuration. Other panel members comprise the analytic team of five ASMFC appointed analysts and one NMFS analyst as consultant. The CIE independent analyst will impartially critique the assessment being undertaken to advise the analytic team on ways to improve the model and to interpret and present its results. The CIE expert will assist in the determination that the best available information and science are utilized in the assessment and, to the extent determined by the lead analyst, will contribute to the written assessment workshop report.

The Project Contact is the SEDAR Coordinator assigned to SEDAR 18 for Atlantic red drum and serves as workshop chairman, and not as an assessment panel member. A state senior scientist appointed by the Atlantic States Marine Fisheries Commission serves as lead analyst. Guidelines for the conduct of a SEDAR assessment workshop appear as Annex 6.

Contract Deliverables - Independent CIE Reports: The CIE appointed expert shall complete an independent report in accordance with the SoW and with the required format and content described in Annex 1. The independent report shall address each ToR as described in Annex 2.

Other Tasks – Contribution to the Assessment Workshop Report: The CIE appointed expert will assist the Chair of the assessment workshop and the lead analyst with contributions to the Assessment Workshop Report. The CIE appointee is not required to reach a consensus with other assessment panel members, and should instead provide a statement of the appointee's critique of the resource assessment model and recommendations on its improvement.

Specific Tasks for the CIE Appointed Expert: The following chronological list of tasks shall be completed by the CIE appointee in a timely manner as specified in the **Schedule of Milestones and Deliverables**.

1) Conduct necessary pre-assessment workshop preparations, including the review of background material and reports provided by the NMFS Project Contact in advance of the assessment workshop;
2) Participate during the assessment workshop at the location and on the dates called for in the SoW; impartially critique the assessment and model to-date; independently relate opinions, advice, and recommendations to the assessment panel; and contribute to the assessment workshop report as directed by the chairman and lead analyst.
3) No later than June 19, 2009, the CIE appointee shall submit an independent report addressed to the "Center for Independent Experts," and sent to Mr. Manoj Shivlani, CIE Lead Coordinator, via email to shivlanim@bellsouth.net, and CIE Regional Coordinator, via email David Sampson david-sampson@oregonstate.edu. The CIE report shall be written using the format and content requirements specified in Annex 1, and address each ToR in Annex 2;
4) The CIE appointee shall address changes as required by the CIE in accordance with the schedule of milestones and deliverables.

Schedule of Milestones and Deliverables: CIE shall complete the tasks and deliverables described in this SoW in accordance with the following schedule.

April 27, 2009	CIE sends appointed expert's contact information to the COTR, who then sends this to the NMFS Project Contact.
May 15, 2009	NMFS Project Contact sends the CIE expert the pre- assessment workshop documents.
June 1-5, 2009	The CIE appointed expert participates in the resource assessment workshop.
June 19, 2009	CIE appointee submits draft CIE independent report to the CIE Lead Coordinator and CIE Regional Coordinator.
July 2, 2009	CIE submits CIE independent report to the COTR.
July 10, 2009	The COTR distributes the final CIE report to the NMFS Project Contact and regional Center Director.

Modifications to the Statement of Work: Requests to modify this SoW must be made through the Contracting Officer's Technical Representative (COTR) who submits the modification for approval to the Contracting Officer at least 15 working days prior to making any permanent substitutions. The Contracting Officer will notify the CIE within 10 working days after receipt of all required information of the decision on substitutions. The COTR can approve changes to the milestone dates, list of pre-assessment workshop documents, and Terms of Reference (ToR) of the SoW as long as the role and ability of the CIE appointed expert to complete the SoW deliverable in accordance with the ToRs and deliverable schedule are not adversely impacted. The SoW and ToRs cannot be changed once the assessment workshop has begun.

Acceptance of Deliverables: Upon review and acceptance of the CIE independent report by the CIE Lead Coordinator, Regional Coordinator, and Steering Committee, the report shall be sent to the COTR for final approval as a contract deliverable based on compliance with the SoW. As specified in the Schedule of Milestones and Deliverables, the CIE shall send via e-mail the contract deliverable (the CIE independent report) to the COTR (William Michaels, via William.Michaels@noaa.gov).

Applicable Performance Standards: The contract is successfully completed when the COTR provides final approval of the contract deliverables. The acceptance of the contract deliverables shall be based on three performance standards: (1) the CIE report shall have the format and content in accordance with

Annex 1, (2) the CIE report shall address each ToR as specified in Annex 2, (3) the CIE report shall be delivered in a timely manner as specified in the schedule of milestones and deliverables.

Distribution of Approved Deliverables: Upon notification of acceptance by the COTR, the CIE Lead Coordinator shall send via e-mail the final CIE report in *.PDF format to the COTR. The COTR will distribute the approved CIE report to the NMFS Project Contact and regional Center Director.

Key Personnel:

William Michaels, Contracting Officer's Technical Representative (COTR)
NMFS Office of Science and Technology
1315 East West Hwy, SSMC3, F/ST4, Silver Spring, MD 20910
William.Michaels@noaa.gov Phone: 301-713-2363 ext 136

Manoj Shivlani, CIE Lead Coordinator
Northern Taiga Ventures, Inc.
10600 SW 131st Court, Miami, FL 33186
shivlanim@bellsouth.net Phone: 305-383-4229

Dale Theiling, SEDAR 18 Coordinator, NMFS Project Contact
South Atlantic Fishery Management Council
4055 Faber Place, Suite 201
North Charleston, SC 29405
Dale.Theiling@SAFMC.net Phone: 843-571-4366

Annex 1: Format and Contents of CIE Independent Report

1. The CIE independent report shall be prefaced with an Executive Summary providing a concise summary of the findings and recommendations.

2. The main body of the appointed expert's report shall consist of a Background, Description of the Individual Appointee's Role in the Assessment Activities, Summary of Findings for each ToR, and Conclusions and Recommendations in accordance with the ToRs.

   a. Appointee should describe in Appointee's own words the assessment activities completed during the assessment workshop, including providing a detailed summary of findings, conclusions, and recommendations.

   b. Appointee should discuss Appointee's independent views on each ToR even if these were consistent with those of other panelists, and especially where there were divergent views.

   c. Appointee should elaborate on any points raised in the assessment workshop report that the appointee feels might require further clarification.

   d. Appointee shall provide a critique of the SEDAR assessment process, including suggestions for improvements of both process and products.

   e. The CIE independent report shall be a stand-alone document for others to understand the proceedings and findings of the meeting, regardless of whether or not they read the summary report. The CIE independent report shall be an independent appraisal of each ToR and shall not simply repeat the contents of the assessment workshop report.

3. The appointee report shall include separate appendices as follows:

   Appendix 1: Bibliography of materials provided for appointee's involvement
   Appendix 2: A copy of the CIE Statement of Work
   Appendix 3: Panel Membership or other pertinent information from the assessment workshop report.

Annex 2: Terms of Reference for the Assessment Workshop

SEDAR 18
Atlantic Red Drum

1. 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.

2. 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.

3. 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.

4. 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'.

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

6. Provide estimates of spawning potential ratio and escapement 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%).

7. 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.

8. 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.

9. 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.

10. 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.

These Terms of Reference may be modified prior to the Assessment Workshop. If so, final terms of reference will be provided to the panelists with the workshop briefing materials.

Annex 3: Tentative Agenda

SEDAR 18 Assessment Workshop Daily Schedule and Tasks

Workshop Location and Duration

Hilton Garden Inn, 5265 International Boulevard, North Charleston, SC 29418
Monday June 1 beginning at 1:00pm until Friday June 5, adjournment at 1:00pm

General Daily Schedule

Mornings (Tuesday-Friday) Session I - 8:00- 9:30 Session II - 10:00-11:30
Afternoons (Monday-Thursday) Session I - 1:00- 3:00 Session II - 3:30-5:30

This schedule is provides the general sequence of events. Session times will be followed to the extent possible. Timing of plenary sessions, work sessions, and topical discussions will be driven by progress.

Workshop Goals

In response to the Assessment Workshop Terms of Reference the panel will:

- review post-DW data changes and analyses suggested by the DW,
- summarize data used in each assessment model, and justify deviations from DW recs,
- develop population assessment models compatible with data,
- recommend configuration deemed useful for advice relative to static SPR levels,
- document input data, assumptions, equations, and model code in a working paper,
- include a continuity case run to determine the effect, if there is a model change,
- provide estimates of stock population parameters,
- characterize scientific uncertainty in the assessment and estimated values,
- provide measures of model performance, reliability, and 'goodness of fit',
- provide recruitment evaluations and estimates of SPR and escapement,
- evaluate the impacts of management actions on the stock,
- discuss workshop research recommendations,
- prepare a spreadsheet containing model parameter estimates and relevant population information with data findings,
- complete the AW Report and Summary Report draft, and
- develop a post AW task list.

Working Levels

The following tasks will be completed by the panel during plenary sessions:

- hold topical discussions,
- identify tasks to be accomplished and confirm individual and small group assignments,
- receive reports on individual and small group efforts and discuss progress and issues, and
- adopt findings and recommendations as workshop products.

During work sessions individuals and small groups will:

- perform agreed to tasks;
- develop, compile, and qualify data to be fit to the proposed models; and
- draft Assessment Workshop report components and replies to Terms of Reference (ToR).

Daily Overview

Monday	Topical Discussions:	Introductions
June 1		Review and resolve data issues.
		Analysts present initial models.
	Milestones:	Final data decisions
		Identify individual roles and tasks.
	Homework:	Review materials and Data Section text.
Tuesday	Topical Discussions:	Approve continuity runs and base configuration
June 2		Identify sensitivity runs.
	Milestones:	Base configuration is concluded.
		Sensitivity/Uncertainty run lists are developed.
	Homework:	Finish base and continuity runs.
		Prepare sensitivity runs.
Wednesday	Topical Discussions:	Evaluate sensitivities
June 3		Compare models and select preferred run
		Projection and benchmark methods
	Milestones:	The preferred model is determined.
		Consensus is reached on stock status.
	Homework:	Final preferred runs.
Thursday	Topical Discussions:	Compare and contrast models;
June 4		SFA parameters and status determination
	Milestones:	Consensus text is drafted
	Homework:	Make final runs. Draft report components text
Friday	Topical Discussions:	Review results and conclusions in draft reports
June 5		Discuss DW research recs and offer new ones.
	Milestones:	AW report is drafted and reviewed.
		All data and report component files are on server.
		Adjournment
	Homework:	Drive safely.
		Comply with post-AW SEDAR Project Schedule

Annex 4: Assessment Workshop Report

The extent of the written contribution to the Assessment Workshop Report by the CIE appointed expert will be determined by the Assessment Workshop Chairman and the lead assessment analyst, but will be limited to matters of the appointee's: (1) participation at the assessment workshop; (2) critique of the assessment and model to-date; and (3) independent opinions, advice, and recommendations toward improvement of the assessment and model.

The Assessment workshop Report is Section III of the final Stock Assessment Report. Its outline follows.

III. Assessment Workshop Report [Assessment Workshop Panel]

1. Workshop Proceedings
   - 1.1 Introduction **[SEDAR]**
     - 1.1.1 Workshop Time and Place
     - 1.1.2 Terms of Reference
     - 1.1.3 List of Participants
     - 1.1.4 List of Assessment Workshop Working Papers
   - 1.2 Panel Recommendations and Comments (Offer consensus comments and recommendations. Address each Assessment Workshop Term of Reference.) **[AW Panel]**
     - 1.2.1 Review of Working Papers
     - 1.2.2 Review of Terms of Reference (Terms of Reference are detailed in Annex 2.)
2. Data Review and Update **[Lead Analyst and Data Compiler]**
   - 2.1 Tabulated Input Data as Used in Assessment Modeling
   - 2.2 Deviations from the Data Workshop
   - 2.3 Resolution of Issues Raised by the Data Workshop
   - 2.4 Additional Data Analyses - if any
3. Stock Assessment Models and Results (This may be finalized after the Assessment Workshop.) **[Analyst for each model]**
   - 3.1 Model One - typically the 'continuity case'. (Repeat this item for each model.)
     - 3.1.1 Methods
       - 3.1.1.1 Overview
       - 3.1.1.2 Data Sources (State sources and tabulate all data used in the model even if duplicated from Data Workshop report.)
       - 3.1.1.3 Model Configuration and Equations (Describe the configuration, explicitly state assumptions, and list equations. If a standard accepted model, such as NFT, ICCAT, ICES, or FAO, this equations requirement may be accommodated by citation of program documentation.)
       - 3.1.1.4 Parameters Estimated (List all model estimated parameters.)
       - 3.1.1.5 Uncertainty and Measures of Precision (Describe the methods used to evaluate sources of error including process, observation, and any other error.)
       - 3.1.1.6 Benchmark and Reference Points Methods
     - 3.1.2 Results
       - 3.1.2.1 Measures of Overall Model Fit
       - 3.1.2.2 Parameter Estimates and Associated Measures of Uncertainty (Provide a table of all model parameters and their values. Include SE, CV, or other appropriate measures of variation.)
       - 3.1.2.3 Stock Abundance and Recruitment
       - 3.1.2.4 Stock Biomass (Include total and spawning stock biomass.)
       - 3.1.2.5 Fishery Selectivity
       - 3.1.2.6 Fishing Mortality
       - 3.1.2.7 Stock-Recruitment Parameters
       - 3.1.2.8 Evaluation of Uncertainty (This is broader than paragraph 3.1.2.2. Include evaluation of assumptions, model configurations, etc. This may include retrospective analyses and sensitivities.)

3.1.2.9 Benchmarks / Reference Points (Provide the management parameters.)
3.1.3 Discussion
3.1.4 Tables (For recommended content refer to SEDAR Guidelines Section 8.3.)
3.1.5 Figures (For recommended content refer to SEDAR Guidelines Section 8.3.)
3.1.6 References
3.2 Model Two (or more as needed)

4. Submitted Comment - any submitted, written comment or opinion statements **[Assessment Workshop participants or observers]**

Annex 5

SEDAR 18
Atlantic Red Drum
Workshops Document List (3-5-09)

Document #	Title	Authors
Documents Prepared for the Data Workshop		
SEDAR18-DW01	Red drum assessment history	Vaughan 2008
SEDAR18-DW02	Overview of Red Drum Tagging Data and Recapture Results by state from Virginia to Florida	S-18 DW Tagging Workgroup 2009
SEDAR18-DW03	Atlantic States Red Drum Management Overview	Meserve 2009
SEDAR18-DW04	Georgia's Marine Sportfish Carcass Recovery Project	Georgia DNR
SEDAR18-DW05	Georgia's Metadata for Fishery Independent RD Data 2002-07	Georgia DNR
SEDAR18-DW06	NC Biological Data-Surveys Descriptions and Background Info	Paramore 2009
SEDAR18-DW07	Life-History Based Estimates of Natural Mortality for U.S. South Atlantic Red Drum	Vaughan 2008
SEDAR18-DW08	Reported commercial landings of red drum in Florida and estimated annual length and age composition	Murphy 2009
SEDAR18-DW09	Recreational harvest estimates and estimated catch-at-age for the recreational fishery in Florida during 1982-2007	Murphy 2009
SEDAR18-DW10	Indices of relative abundance for young-of-the-year and subadult red drum in Florida	Murphy 2009
SEDAR18-DW11	SC Red drum electro-fishing survey	SC DNR undated
SEDAR18-DW12	SC Red Drum Tagging Data	S. Arnott 2009
SEDAR18-DW13	SC Tournament and Fish Wrack Recycle Program 2002-2007	McDonough undated
SEDAR18-DW14	Assessment of Adult Red Drum in South Carolina	SC DNR undated
SEDAR18-DW15	South Carolina Fishery Independent Survey Description and Protocol	SC DNR undated
SEDAR18-DW16	An Estimate of RD Removals from NC Estuarine Gill Net Fishery Occurring from both Rec Users of Gill Nets and from Regulatory and Unmarketable Discards.	Paramore 2009
SEDAR18-DW17	Estimating the size and age composition of the B–2 fish (caught and released alive) in the recreational fishery for red drum in South Carolina	SC DNR undated
SEDAR18-DW18	South Carolina randomly stratified trammel net survey	Arnott 2009
Documents Prepared for the Assessment Workshop		
SEDAR18-AW01	None submitted	
Documents Prepared for the Review Workshop		
SEDAR18-RW01	SEDAR 18 Atlantic Red Drum Document for Peer Review	To be prepared following Assessment Workshop
Workshop Reports		

	SEDAR 18 Data Workshop Report	To be prepared following Data Workshop
	SEDAR 18 Assessment Workshop Report	To be prepared following Assessment Workshop
	SEDAR 18 Review Workshop Report	To be prepared following Review Workshop
Final Assessment Reports		
SEDAR18-SAR01	Assessment of the red drum stock in the US Atlantic	To be prepared following Review Workshop
Reference Documents		
SEDAR18-RD01	Tag-reporting levels for RD caught by anglers in SC and Georgia estuaries	Denson *et al* 2002
SEDAR18-RD02	Association of large juvenile RD with an estuarine creek on the Atlantic coast of Florida	Adams & Tremain 2000
SEDAR18-RD03	Use of passive acoustics to determine RD spawning in Georgia waters	Barbieri *et al* TAFS 2008
SEDAR18-RD04	Spatial and temporal patterns in modeled particle transport to estuarine habitat with comparisons to larval fish settlement patterns	Brown *et al* 2005
SEDAR18-RD05	Incidental catch and discard of RD, in a large mesh Paralichthyidae gillnet fishery: experimental evaluation of a fisher's experience at limiting bycatch	Buckel *et al* 2006
SEDAR18-RD06	Site fidelity and movement patterns of wild subadult RD, within a salt marsh-dominated estuarine landscape	Dresser & Kneib 2007
SEDAR18-RD07	Behavior and recruitment success in fish larvae: variation with growth rate and the batch effect	Fuiman *et al* 2005
SEDAR18-RD08	Estimating stock composition of anadromous fishes from mark–recovery data: possible application to American shad	Hoenic , Latour & Olney TAFS 2008
SEDAR18-RD09	Distribution of RD spawning sites Identified by a towed hydrophone array	Holt TAFS 2008
SEDAR18-RD10	Year-class component, growth, and movement of juvenile RD stocked seasonally in a SC estuary	Jenkins *et al* 2004
SEDAR18-RD11	Experimental investigation of spatial and temporal variation in estuarine growth of age-0 juvenile RD	Lanier & Scharf 2007
SEDAR18-RD12	Estimates of fishing and natural mortality for subadult RD in SC Waters	Latour *et al* 2001
SEDAR18-RD13	Properties of the residuals from two tag-recovery models	Latour *et al* 2002
SEDAR18-RD14	Habitat triage for exploited fishes: Can we identify essential ''Essential Fish Habitat?''	Levin & Stunz 2005
SEDAR18-RD15	Identifying Sciaenid critical spawning habitats by the use of passive acoustics	Luczkovich & Pullinger TAFS 2008
SEDAR18-RD16	Large scale patterns in fish trophodynamics of estuarine and shelf habitats of the SE US	Marancik & Hare 2007
SEDAR18-RD17	Ecophys.Fish: A simulation model of fish growth in time-varying environmental regimes	Neill *et al* 2004
SEDAR18-RD18	Population structure of RD as determined by otolith chemistry	Patterson *et al* 2004

SEDAR18-RD19	A new growth model for RD that accommodates seasonal and ontogenic changes in growth rates	Porch *et al* 2002
SEDAR18-RD20	Estimating abundance from gillnet samples with application to RD in Texas bays	Porch *et al* 2002b
SEDAR18-RD21	Icthyoplankton community structure in a shallow subtropical estuary of the Florida Atlantic coast	Reyier & Shenker 2007
SEDAR18-RD22	Role of an estuarine fisheries reserve in the production and export of ichthyoplankton	Reyier *et al* 2008
SEDAR18-RD23	Trophic plasticity and foraging performance in RD	Ruehl & DeWitt 2007
SEDAR18-RD24	Estuarine recruitment, growth, and first-year survival of juvenile RD in NC	Stewart & Scharf TAFS 2008
SEDAR 18-RD25	Habitat-related predation on juvenile wild-caught and hatchery-reared RD	Stunz & Minello 2001
SEDAR 18-RD26	Selection of estuarine nursery habitats by wild-caught and hatchery-reared juvenile red drum in laboratory mesocosms	Stunz *et al* 2001
SEDAR 18-RD27	Growth of newly settled red drum *Sciaenops ocellatus* in different estuarine habitat types	Stunz *et al* 2002
SEDAR 18-RD28	Multidirectional movements of sportfish species between an estuarine no-take zone and surrounding waters of the Indian River Lagoon, Florida	Tremain *et al* 2004
SEDAR 18-RD29	Marine stock enhancement in Florida: A multi-disciplinary, stakeholder-supported, accountability-based approach	Tringali *et al* 2008
SEDAR 18-RD30	Estimating improvement in spawning potential ratios for South Atlantic RD through bag and size limit regulations	Vaughan & Carmichael 2002
SEDAR 18-RD31	Catch-and-release mortality in subadult and adult red drum captured with popular fishing hook types	Vecchio & Wenner NAJFM 2008
SEDAR 18-RD32	Using estuarine landscape structure to model distribution patterns in nekton communities and in juveniles of fishery species	Whaley *et al* 2007
SEDAR 18-RD33	Reproductive biology of red drum, *Sciaenops ocellatus*, from the neritic waters of the northern Gulf of Mexico	Wilson and Neiland 1994
SEDAR 18-RD34	An age-dependent tag return model for estimating mortality and selectivity of an estuarine-dependent fish with high rates of catch and release	Bacheler *et al* 2008
SEDAR 18-RD35	Genetic effective size in populations of hatchery-raised red drum released for stock enhancement	Gold *et al* 2008
SEDAR 18-RD36	Contributions to the biology of red drum, *Sciaenops ocellatus*, in South Carolina	Wenner 2000
SEDAR 18-RD37	Recruitment of juvenile red drum in North Carolina: spatiotemporal patterns of year-class strength and validation of a seine survey	Bacheler, Paramore, Buckel, and Scharf 2008
SEDAR 18-RD38	Hooking Mortality of spotted seatrout (*Cynoscion nebulosus*), weakfish (*Cynoscion regalis*), red drum (*Sciaenops ocellatus*), and southern flounder (*Paralichthys lethostigma*) in North Carolina	Gearhart 2002
SEDAR 18-RD39	Evaluation of the estuarine hook and line recreational fishery in Neuse River, North Carolina	Brown 2007
SEDAR 18-RD40	Large circle hooks and short leaders with fixed weights reduce incidence of deep hooking in angled adult red drum	Beckwith and Brown 2005
SEDAR 18-RD41	Abiotic and biotic factors influence the habitat use of	Bacheler, Paramore,

	an estuarine fish	Buckel, and Hightower 2008
SEDAR 18-RD42	Stock Status of the northern red drum stock	Takade and Paramore 2005
SEDAR 18-RD43	Short-term hooking mortality and movement of adult red drum (*Sciaenops ocellatus*) in the Neuse River, North Carolina.	Aguilar 2003
SEDAR 18-RD44	Identification of critical spawning habitat and male courtship vocalization characteristics of red drum, *Sciaenops ocellatus*, in the lower Neuse River estuary of North Carolina	Beckwith 2006
SEDAR 18-RD45	Movement and selectivity of red drum and survival of adult red drum: an analysis of 20 years of tagging data	Burdick, Hightower, Buckel, Paramore, and Pollock 2007
SEDAR 18-RD46	Age, growth, mortality, and reproductive biology of red drums in North Carolina waters	Ross, Stephens, and Vaughan 1995
SEDAR 18-RD47	North Carolina red drum fishery management plan, amendment 1	Red drum fishery management plan advisory committee and NC DMF 2008
SEDAR 18-RD48	Status of the red drum stock of the Atlantic coast-stock assessment report for 1989	Vaughan and Helser 1990
SEDAR 18-RD49	Status of the red drum stock of the Atlantic coast-stock assessment report for 1991	Vaughan 1992
SEDAR 18-RD50	Status of the red drum stock of the Atlantic coast-stock assessment report for 1992	Vaughan 1993
SEDAR 18-RD51	Status of the red drum stock of the Atlantic coast-stock assessment report for 1995	Vaughan 1996
SEDAR 18-RD52	Assessment for Atlantic red drum for 1999-northern and southern regions	Vaughan and Carmichael 2000
SEDAR 18-RD53	Bag and size limit analysis for red drum in northern and southern regions of the U. S. Atlantic	Vaughan and Carmichael 2001
SEDAR 18-RD54	Seasonal variation in age-specific movement patterns of red drum *Sciaenops ocellatus* inferred from conventional tagging and telemetry	Bacheler, Paramore, Burdick, Buckel, Hightower in review
SEDAR 18-RD55	A combined telemetry – tag return approach to estimate fishing and natural mortality rates of an estuarine fish	Bacheler, Buckel, Hightower, Paramore and Pollock in review
SEDAR 18-RD56	Investigation into the Feasibility of Stocking Artificially Propagated Red Drum in Georgia	Pafford, Nicholson, and Woodward 1990
SEDAR 18-RD57	A Biological and Fisheries Profile of Red Drum, *Sciaenops ocellatus*	Mercer 1984
SEDAR 18-RD58	Ultrasonic Biotelemetry Study of Young-Adult Red Drum in Georgia, July 1993 – September 1995	Nicholson, Jordan, and Purser 1996
SEDAR 18-RD59	Habitat Use and Movement of Subadult Red Drum, *Sciaenops ocellatus*, within a Salt Marsh-Estuarine System	Dresser 1996
SEDAR 18-RD60	Mortality, Movement, and Growth of Red Drum in Georgia	Pafford, Woodward, and Nicholson 1990
SEDAR 18-RD61	Spatial Homogeneity & Temporal Heterogeneity of Red Drum Microsatellites-Effective Pop Size & Management Implications	Chapman, Ball, Mash 2002
SEDAR 18-RD62	A modified stepping-stone model of population structure in Red Drum from Northern GOM	Gold, Burridge, Turner 2001
SEDAR 18-RD63	Population structure of red drum in the Northern Gulf	Gold, Turner 2002

	of Mexico, as inferred from variation in nuclear-coded microsatellites	
SEDAR 18-RD64	An analysis of genetic population structure of red drum based on mtDNA control region sequences	Seyoum, Tringali, Bert, McElroy, Stokes 2000
SEDAR18-RD65	The 1960 Salt-Water Angling Survey, USFWS Circular 153	J. R. Clark
SEDAR18-RD66	The 1965 Salt-Water Angling Survey, USFWS Resource Publication 67	D. G. Deuel and J. R. Clark. 1968
SEDAR18-RD67	1970 Salt-Water Angling Survey, NMFS Current Fisheries Statistics Number 6200	D. G. Deuel. 1973
SEDAR18-RD68	Overview of an experimental stock enhancement program for red drum in South Carolina	Smith, Jenkins, Denson 1997

Annex 6

SEDAR Assessment Workshop Guidelines
(from SEDAR Guidelines, version 17, October 2007)

Tasks, Responsibilities, and Supplemental Instructions for SEDAR Assessment Workshop Participants

SEDAR Overview

SouthEast Data, Assessment, and Review (**SEDAR**) is a cooperative Fishery Management Council process initiated in 2002 to improve the quality and reliability of fishery stock assessments in the South Atlantic, Gulf of Mexico, and US Caribbean. SEDAR is managed by the Caribbean, Gulf of Mexico, and South Atlantic Regional Fishery Management Councils in coordination with NOAA Fisheries and the Atlantic and Gulf States Marine Fisheries Commissions. Oversight is provided by a Steering Committee composed of representatives of these partner agencies.

SEDAR is organized around three workshops. First is the Data Workshop, during which fisheries, monitoring, and life history data are reviewed and compiled. Second is the Assessment workshop, during which assessment models are developed and population parameters are estimated using the information provided from the Data Workshop. Third and final is the Review Workshop, during which independent experts review the input data, assessment methods, and assessment products. The charge to each SEDAR Workshop is specified in Terms of Reference that are approved by the appropriate Council. The completed assessment, including the reports of all 3 workshops and all supporting documentation, is then forwarded to the Council SSC for certification as 'appropriate for management' and development of specific management recommendations.

Assessment workshop participants include the workshop panel, appointed observers, and other observers. Workshop panels are composed of include NOAA Fisheries stock assessment scientists, Commission/State/university/independent assessment scientists, Council advisory panel (commercial, recreational, and/or NGO) representatives, and Council technical committee representatives, such as members of the Scientific & Statistical Committee. Council or senior agency representatives may participate as official observers, but cannot serve as panel members. Members of the public who attend are noted as observers. The SEDAR coordinator will typically serve as the workshop Chair. As with all SEDAR workshops, stock assessment workshop panelists are to be appointed from each Councils' SEDAR Advisory Panel.

SEDAR workshops are open, transparent, public processes administered according to the rules and regulations governing Federal Fishery Management Council operations and other applicable Federal laws. All workshops are recorded. The names and affiliations of workshop panel participants and workshop observers will be disclosed. SEDAR workshop reports and submitted working papers are public documents that become part of the official SEDAR Administrative Record and will be posted on the SEDAR website. The public is given opportunities to comment during SEDAR Workshops and may submit written comments to the associated Councils, Commissions or other agencies in accordance with Council guidelines.

Assessment Workshop Goal

The goal of SEDAR assessment workshops is to conduct quantitative population analysis to determine stock status, evaluate management benchmarks, and project future stock conditions.

Pre-Workshop Preparation

Panelists should review the findings of the data workshop, including any submitted working papers and reference documents. Those with analytical capabilities may wish to conduct their own model runs.

Working Papers

Initial analyses, data summaries, and program documentation should be submitted in advance as SEDAR Working Papers. Deadlines for submission will be provided on the schedule for each project. Working papers and all other documentation will be distributed electronically via email and the SEDAR website (http://www.sefsc.noaa.gov/sedar/). Papers should be submitted as word documents or .pdf files. Authors may follow any format of their choosing, but are encouraged to review instruction in the SEDAR workshop guidelines pertaining to content and formatting. Working papers are numbered sequentially by SEDAR

cycle and workshop. Please contact the SEDAR Coordinator to obtain document numbers. Working papers shall not contain confidential information.

SEDAR Agendas

Establishing strict agendas for SEDAR workshops is not usually practical, as no one can foresee all the issues that will develop or predict the amount of discussion that will be generated for any particular item. Therefore, workshop agendas provide a general listing of meeting times and are constructed around daily milestones and tasks. Evening working sessions are likely. Only the starting and ending time of the workshop are certain, to enable appropriate travel planning; all other events during the workshop may change as necessary to meet the tasks outlined in the Terms of Reference.

Consensus

SEDAR workshops strive to achieve group consensus on many potentially complex and controversial issues, and it is recognized that consensus may not always equate to unanimous consent for each issue. For SEDAR purposes, consensus is taken to mean that all workshop panelists consent to the range and treatment of recommendations included in the report.

Nature of Discussions

Those criticizing the work and recommendations of others are expected to do so constructively and to offer reasonable solutions to go along with any criticisms. Recommendations for sensitivity and exploratory analyses along with ranges for critical parameters should all be considered when evaluating uncertain information.

Materials Distribution

SEDAR workshops are 'paperless' to the extent possible. Materials such as datasets and working papers that are received within submission deadlines will be distributed by SEDAR staff via email and website posting, and hard copies or cds will be mailed upon request. Paper copies of the agenda and Terms of Reference will be provided at the workshop. Working papers that are distributed in advance by SEDAR staff and made available on the website will not be provided in print copy at the workshop, but will be available by cd and posted to the workshop network. Those who submit working papers after the submission deadline are responsible for providing both print and electronic copies for distribution at the workshop. **Please contact the SEDAR Coordinator for the appropriate number of copies.**

Confidentiality

SEDAR is a Council process and therefore it is an open and public process. All working papers are available to distribution to the general public, all data summaries are available to distribution to the general public, but not all workshop participants have clearance to view confidential data. Therefore, no confidential data should be included in any SEDAR documentation. This includes working papers, reference documents, workshop presentations, and SEDAR assessment reports. Under no circumstances should confidential data be stored on publicly accessible locations of SEDAR workshop networks. **Authors and data submitters are responsible for ensuring that submitted papers and datasets do not contain confidential data.**

Administrative Record and Public Comment

SEDAR is a public Council process. All submitted documents and official correspondence become part of the official administrative record. All SEDAR workshops are announced in the Federal Register. All workshop discussion sessions are recorded. All working papers and final documents will be publicly posted on the SEDAR website. The names and affiliations of all workshop participants and observers will be listed in the workshop reports. The general public is welcome to view all workshop proceedings and will be given the opportunity to comment during plenary sessions as necessary. Written public comments will be accepted in accordance with each Council's Standard Operating Procedures.

Meeting Attendance and Sign-in Forms

Sign in forms will be posted in the meeting space during each day of the workshop. All appointed participants are expected to sign in each day that they attend. Failure to sign-in could result in denial of reimbursement requests. SEDAR workshops seldom 'end early' and it is never known when a critical issue may be discussed; therefore, participants are strongly encouraged to stay for the entire workshop.

Network and IT

A wireless network is available at each SEDAR workshop to provide internet and file server access. IT staff will be available during each workshop to aid each participant in securing network access.

What to Bring

Workshop participants should come prepared to conduct analyses and prepare report text. Ideally they should bring a laptop computer with word processing and networking capabilities. Participants should bring

electronic copies of any documents they want considered during the workshop. Participants should bring copies of any relevant research documents which are not already provided in the project document list.

Assessment Workshop Roles and Responsibilities

Workshop Chair: (SEDAR Coordinator) Responsible for conducting the workshop, scheduling workshop sessions, and ensuring the Terms of Reference are addressed.

Workshop Rapporteur: (Council Appointee, 1 per stock) Responsible for taking notes during plenary sessions to ensure that discussion items are reflected in the workshop report, assists chair in ensuring Terms of Reference and Council requirements are addressed. May be asked by appointing Council to assist in presenting workshop findings to the SSC and other Council bodies.

Stock Leader (Council Appointee, 1 per stock) Prepares and edits the proceedings section of the assessment workshop report. Responsible for compiling segments drafted by workshop participants and completing and submitting report in accordance with project deadlines. Represents the assessment panel at the Review Workshop and subsequent Council meetings. Rapporteur and Editor roles may be filled by one individual at Council's discretion.

Lead Analyst: (SEFSC/Assessment Agency, 1 per stock) Leader of the assessment team, responsible for preparing population models and making presentations to the assessment panel. Also responsible for presenting the assessment to the Review Panel and the SSC and Council.

Analytical Team: Core group of assessment analysts responsible for conducting model runs, presenting results, and conducting further analyses during the Review Workshop.

Data Presenters: Responsible for presenting overviews of data sources, including the results of any post-DW analyses and compilations. May be filled by the same individuals as other workshop roles, or may be filled by data workshop workgroup leaders.

SEDAR Workshop Panelist Code of Conduct

- SEDAR workshop panel decisions shall be based on science. Discussions and deliberations shall not consider possible future management actions, agency financial concerns, or social and economic consequences.
- SEDAR workshop decisions are based on consensus. Panels are expected to reach conclusions that all participants can accept, which may include agreeing to acknowledge multiple possibilities.
- Personal attacks will not be tolerated. Advancement in science is based on disagreement and healthy, spirited discourse is encouraged. However, professionalism must be upheld and those who descend into personal attacks will be asked to leave.
- SEDAR workshop panelists are expected to support their discussions with appropriate text and analytical contributions. Each panelist is individually responsible for ensuring that their points and recommendations are addressed in workshop reports; they should not rely on others to address their concerns.
- Panelists are expected to provide constructive suggestions and alternative solutions; criticisms should be followed with recommendations and solutions.

Appendix 3: Panel Membership or other pertinent information from the assessment workshop report.

WP AW02

Nonparametric growth model for Atlantic red drum, and changes to natural mortality (M) estimates.

Noel Cadigan
CIE expert
Fisheries and Oceans Canada

Abstract

There is evidence of misfit in the von Bertalanffy growth model for the northern region Atlantic red drum stock provided by the SEDAR 18 Data Workshop (DW). We used a nonparametric smooth monotone growth model which fit both the southern and northern region data very well. This growth model resulted in somewhat higher estimates of natural mortality (M) for younger ages based on the scaled Lorenzen method. The largest difference was for one-year old fish from the northern region, where the DW Lorenzen M estimate based on the von Bertalanffy model predicted length was 0.16 and the M estimate based on the nonparametric model was 0.20.

WP AW06

Graphical analyses of the catch age composition for red drum.

Noel Cadigan
Fisheries and Oceans Canada
CIE expert

Summary

It is first important to note that the catch at age data used in this working paper includes the inferred deaths from the recreational B2 (catch and release) fishery component. Preliminary estimates of the age composition of this catch component were considered too unreliable to use in the assessments for both the northern and southern region red drum stocks. This component represents approximately 20% of the total catch for both stocks, with considerable annual variability. A figure for this has been prepared for the AW report. Hence, age composition information presented in this working paper will not be exactly the same as that used in the stock assessment model, but should be broadly indicative.

The size and age structure of total catch is important information in most stock assessments. A simple graphical display is shown in Figure 1 for the northern red drum stock. The top panel shows the total annual catch, the middle panel shows the annual age composition, and the bottom panel shows the relative size of catch compared to the same ages in other years. The areas of the bubbles are proportional to size. Computational details are given in the Appendix. Figure 1 demonstrates that the total catch for the northern red drum stock has considerable inter-annual variability. It is composed of primarily ages 1-3. Age 1 fish were caught more frequently prior to 1992. The distribution of catch at older ages has considerable inter-annual variability, perhaps due to their infrequent occurrence and sampling error.

Standardized proportions at year (SPAY; see Appendix) can show cohort patterns more clearly. These are shown in the top panel of Figure 2. They give the trends in the middle panel of Figure 1. Strong cohorts are not evident in the catches. Exceptions are the 1990 cohort which was relatively strong at ages 1-5 and 7. The 1996 and, to a lesser extent, the 1997 cohorts can be tracked for several ages. Standardized proportions at year (SPYA) shown in the bottom panel of Figure 2 give the trends relative to the average for the proportions in the bottom panel of Figure 1. They show more clearly when catches are above or below average. For example, they show that catches in 2007 at ages 1, 6, and 9 were average in the time series, whereas catches at other ages were all above average.

SPAY plots are provided by the FLEDA component of the FLR (Fisheries Library in R) package for the R statistical software. FLEDA provides exploratory analysis of stock assessment data.

Catches for the southern region red drum stock (top panel Figure 3) were highest in 1984-5 and 1987. Catches since 2000 have been slightly higher than in the 1990's. Overall, catches for this stock show less inter-annual variability compared to the northern region stock (Figure 1). Ages 1-4 dominate the catches (middle panel, Figure 3). The SPAY and SPYA plots show three periods of fairly consistent age compositions:

1. 1982-1990. Catches at age one are more prevalent.
2. 1991-1999/2000. Catches at ages 6-9 are more prevalent.
3. 2000/2001-2007. Catches at ages 2-5 are more prevalent.

This suggests potential changes in fishery selectivity.

WP AW07

Semi-separable untuned VPA for red drum.

Noel Cadigan
Fisheries and Oceans Canada

CIE expert

Summary

Untuned backwards VPA's were applied to catch at age data for the northern and southern regions red drum stocks to provide comparisons with estimates of historic stock size from statistical catch at age (SCCA) assessment models. The final year (2007) abundance of age two fish was determined by specifying their fishing mortality (F), and 2007 abundances at other ages were selected with a combination of constraints on selectivity in 2007 and approximate separability of F during 2003-2007. The constraints on selectivity were similar to those used in the SCCA assessment model, and were consistent with tagging information. Age compositions for the release mortality component of the recreational fishery (i.e. B2 catches) were inferred from the harvested age compositions (i.e. A+B1 catches) and the selectivity of the B2 fishery component relative to the A+B1 component, as inferred from a tagging model.

The results show that average F for ages 1-3 in the **northern region** was about 1.5 during 1982-1990 but declined during 1991-1994 and was relatively stable during 1995-2002 with a mean of 0.9. Total abundance during 1982-1997 fluctuated between 200 000 and 400 000, but increased to 660 000 in 1998 and then declined to 160 000 in 2003, the second lowest value during 1982-2003. Untuned VPA results after 2003 are more speculative because the VPA is not yet converged.

Results for the **southern region** demonstrated that the VPA was not converged in the base setup. This is because of the low levels of F during 1990-2000, and the truncated age-structure of the catches. Cohorts are never "fished-out", and the size of the plus group that survives the larger juvenile fishery is quite uncertain. The basic trend in the VPA is for stock abundance to increase during 1982-1987, and then decline after 1991.

Untuned VPA's using alternative F-constraints were similar to the base setting for the NR, but quite different for the SR, which again demonstrates the lack of convergence in the SR VPA. The alternative VPA for the SR stock, which utilized specific selectivity information obtained from tagging studies for the NR stock, seemed more reliable in that some degree of convergence was achieved. However, the scale and trends in the base and alternative VPA for the SR stock were quite different, suggesting that the assessment of this stock will be more uncertain than the NR stock.

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Tagging estimates of abundance at age for the northern region red drum stock.

Noel Cadigan
CIE Expert
Fisheries and Oceans Canada

Lee Paramore
North Carolina Division of Marine Fisheries

Abstract

Trends in estimates of abundance derived from tagging estimates of fishing mortality rates (F) and independent estimates of catch-at-age were consistent with the general understanding of stock trends for northern red drum. However, we found that catch-curve estimates of F from tagging abundance-at-age estimates suggested lower F's overall than the tagging-F's themselves, although the trends in F's were similar. Until these discrepancies are resolved, it seems more prudent to use the tagging-F's to assist in estimating a SCCA. Tagging-F's and their standard errors can be treated as direct inputs and fitted to SCCA model estimates of F. Fitting to *log(F)* may be reasonable but requires some investigation. Tagging-F's should only be compared with the appropriate F component in the SCCA.