S E D A R

Southeast Data, Assessment, and Review

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SEDAR 18

Stock Assessment Report

Atlantic Red Drum

October 16, 2009

SEDAR is a Cooperative Initiative of:

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

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Stock Assessment Report

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Section I. Introduction

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1 SEDAR Process Description

SEDAR (Southeast Data, Assessment and Review) was initially developed by the Southeast Fisheries Science Center and the South Atlantic Fishery Management Council to improve the quality and reliability of stock assessments and to ensure a robust and independent peer review of stock assessment products. SEDAR was expanded in 2003 to address the assessment needs of all three Fishery Management Council in the Southeast Region (South Atlantic, Gulf of Mexico, and Caribbean) and to provide a platform for assessments developed through the Atlantic and Gulf States Marine Fisheries Commissions and state agencies within the southeast.

SEDAR strives to improve the quality of assessment advice provided for managing fisheries resources in the Southeast US by increasing and expanding participation in the assessment process, ensuring the assessment process is transparent and open, and providing a robust and independent review of assessment products. SEDAR is overseen by a Steering Committee composed of NOAA Fisheries representatives: Southeast Fisheries Science Center Director and the Southeast Regional Administrator; Regional Council representatives: the Executive Directors and Chairs of the South Atlantic, Gulf of Mexico, and Caribbean Fishery Management Councils; and Interstate Commissions: the Executive Directors of the Atlantic States and Gulf States Marine Fisheries Commissions.

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.

SEDAR workshops are organized by SEDAR staff and the lead SEDAR cooperator. Data and Assessment Workshops are chaired by the SEDAR coordinator. Participants are drawn from state and federal agencies, non-government organizations, Council members, Council advisors, and the fishing industry with a goal of including a broad range of disciplines and perspectives. All participants are expected to contribute to the process by preparing working papers, contributing, providing assessment analyses, and completing the workshop report.

SEDAR Review Workshop Panels consist of a chair, a reviewer appointed by the lead SEDAR cooperator, and 3 reviewers appointed by the Center for Independent Experts (CIE), an independent organization that provides independent, expert reviews of stock assessments and related work. The Review Workshop Chair is appointed by the SEFSC director and is usually selected from a NOAA Fisheries regional science center. Participating councils may appoint representatives of their SSC, Advisory, and other panels as observers to the review workshop.

SEDAR 18 was charged with assessing red drum in the US Atlantic. This task was accomplished through workshops held between February and August 2009.

2 Management Overview

This overview is first presented as working paper **S18-DW03**. The outline is modified here to meet SEDAR standards. The working paper provides the current management unit and area definitions, a management and regulatory history, and the current management criteria for Atlantic coast red drum.

2.1 Management Unit and Area Definitions

The management unit is defined as the red drum (*Sciaenops ocellatus)* resource throughout the range of the species within U.S. waters of the northwest Atlantic Ocean from the estuaries eastward to the offshore boundaries of the Exclusive Economic Zone. The selection of this management unit is based on the biological distribution of the species along the Atlantic coast and historical patterns which have identified fisheries for red drum extending north through New Jersey.

The management area is the entire Atlantic coast distribution of the resource from Florida through New Jersey. (Fig. 2.1) The management area is divided into a southern region which includes the waters of the Atlantic coast of Florida north to the North Carolina/South Carolina border. The northern region extends from the North Carolina/South Carolina border north through New Jersey (ASMFC 2002).

Figure 2.1. The management area is composed of two regions for assessment purposes. The southern region is waters of the Atlantic coast of Florida north to the NC/SC state line and the northern region extends from the NC/SC state line north through New Jersey.

2.2 Regulatory History

2.2.1 Atlantic States Marine Fisheries Commission

Interjurisdictional management of Atlantic coast red drum began in 1984 when the Atlantic States Marine Fisheries Commission (ASMFC) adopted the Fishery Management Plan (FMP) for Red Drum (ASMFC 1984). The interstate FMP provided recommended management measures to achieve its objectives for the states from Maryland through Florida. The ASMFC updated the interstate FMP in 1991 with Amendment 1 for consistency with measures recommended in the federal FMP for state waters. In 1994, the Atlantic Coastal Fisheries Cooperative Management Act provided the ASMFC with a means to enforce state adoption of required elements of fishery management plans. Subsequently, the ASFMC adopted Amendment 2 in June 2002 (ASMFC 2002), which required management measures to achieve its objectives in all states from New Jersey through Florida.

2.2.2 South Atlantic Fishery Management Council

In 1990, the South Atlantic Fishery Management Council (Council) adopted an FMP for red drum in federal waters (3-200 nautical miles offshore; SAFMC 1990). The Council adopted new definitions of the plan's management criteria in 1998. In 1999, the Council recommended that management authority for red drum be transferred to the states through the Commission's Interstate Fishery Management Program process. The final rule to fulfill this recommendation became effective November 5, 2008 (73 FR 58059).

2.2.3 Regulatory History per Jurisdiction

Table 1 provides a regulatory history for the ASMFC, the SAFMC, and each state in the management area. Actions are grouped by the responsible state or agency.

2.3 Current Management Criteria and Stock Benchmarks

2.3.1 Definition of Overfishing

Overfishing for red drum is defined as a fishing mortality rate (F) in excess of the fishing mortality rate at 30% Static Spawning Potential Ratio (SPR) or F30% SPR. The target fishing mortality rate is the fishing mortality rate at 40% Static Spawning Potential Ratio (SPR) or F40% SPR (ASMFC 2002).

2.4 References

Atlantic States Marine Fisheries Commission (ASMFC). 1984. Fishery Management Plan for Red Drum. Washington (DC): ASMFC. Fishery Management Report No. 5. 107 pp.

ASMFC. 1994. Fishery Management Plan for Red Drum - Amendment #1. Washington (DC): ASMFC. Fishery Management Report No. 19. 123 pp.

ASMFC. 2002. Amendment 2 to the Interstate Fishery Management Plan for Red Drum. Washington (DC): ASMFC. Fishery Management Report No. 38. 142 pp.

Fisheries of the Caribbean, Gulf of Mexico, and South Atlantic; Atlantic Coastal Fisheries Cooperative Management Act Provisions; Atlantic Coast Red Drum Fishery off the Atlantic States; Transfer of Management Authority, 73 Fed. Reg. 58059 (2008) (to be codified at 50 CFR Parts 622 and 697)

SAFMC (South Atlantic Fishery Management Council). 1990. The Atlantic Coast Red Drum Fishery Management Plan. Charleston (SC): SAFMC. 106pp.

Table 1. Regulatory history of red drum by jurisdiction

State/ Agency	Regulatory Description	Action	Effective Date
ASMFC	Recommends measures for Maryland-Florida to attain OY: 14" TL minimum size limit with comparable mesh size regulations in directed fisheries (defined as containing at least 60% red drum by weight), possession limit of 2 fish > 32" TL, prohibition of purse seining.	Original FMP	October 1984
ASMFC	Recommends that all Atlantic coast states implement measures to present the development of northern markets.	ISFMP Policy Board request	1988
ASMFC	Adopts the Federal FMP and recommends complimentary management measures for states (New Jersey - Florida) to achieve OY, starting with an interim 10% SSBR. Recommended measures are either, 1) 18-27" TL and 5 fish, including one >27", and 2) 14-27" TL and 5 fish.	Amendment 1	October 1991
ASMFC	Defined the goal of OY as the harvest associated with a 40% static SPR. Overfishing is defined as the fishing mortality rate that exceeds F30% SPR, and the target as F40% SPR. States are required to implement recreational regulations that achieve F30%SPR, and to maintain any existing (or more conservative) commercial regulations. Maximum size limit set at 27" TL.	Amendment 2	January 1, 2003
SAFMC	Defined optimum yield as the harvest amount that can be taken while maintaining SSBR at or above 30% and overfishing as the fishing mortality rate that will, if continued, reduce SSBR below 30%. Recommended that states implement measures necessary to achieve at least 30% escapement (estimated as necessary to achieve 30% SSBR). Prohibited the harvest of red drum in the EEZ.	Original FMP	November 9, 1990
SAFMC	Defined OY as the harvest associated with a 40% static, MSY as 30% static SPR, overfishing at less than 30% static SPR, and threshold overfishing at 10% static SPR.	Amendment 1	October 1998
New Jersey	18" minimum size limit, possession limit of 1 fish greater than 27" TL.		May 15, 1994
New Jersey	18" minimum size limit, 27" maximum size limit, 1 fish creel limit.	N. J. A. C. 7:25-18.1	November 1, 2002

Table 1. continued

Delaware	18" TL minimum size limit, 27" TL maximum size limit, 5 fish possession limit with 1 fish allowed > 27" TL.	Tidal Finfish Regulation 11	June 11, 1994
Delaware	20" TL minimum size limit, 27" TL maximum size limit, 5 fish possession limit.	Tidal Finfish Regulation 11	March 10, 2003
PRFC	14" TL minimum size limit.	Reg. III, Sec. 11(a)(13)	July 1, 1990
PRFC	18" TL minimum size limit, possession limit of 1 fish >27" TL.	Reg. III, Sec. 11(a)(13)	July 1, 1993
PRFC	18" TL minimum size limit, 27" TL maximum size limit, 5 fish possession limit with 1 fish allowed > 27" TL.	Order 96-2	January 1, 1996
PRFC	18" TL minimum size limit, 25" TL maximum size limit, 5 fish possession limit.	Order 2003-04	January 1, 2003
Maryland	14" TL minimum size limit, possession limit of 2 fish > 32" TL.	Md. Code Ann. Nat. Res. Section 4-734(12)	1991
Maryland	18" TL minimum size limit, 5 fish possession limit with 1 fish allowed > 27" TL (Chesapeake Bay Red Drum Fishery Management Plan incorporated into regulation)	COMAR 08.02.01.01, COMAR 08.02.05.16, 21:18 Md. R. 1257	September 12, 1994
Maryland	18" TL minimum size limit, 27" TL recreational maximum size limit, 25" TL commercial maximum size limit, 1 fish recreational possession limit, 5 fish commercial possession limit.	COMAR 08.02.05.16, emergency provision 30:13 Md. R. 850, amendment 30:16 Md. R. 1073	June 9, 2003 (emergency provision; permanent August 18, 2003)
Virginia	Possession limit of 2 fish > 32" TL.	Code of Virginia § 28.2-304	July 1, 1960
Virginia	14" TL minimum size limit, possession limit of 2 fish > 32" TL.	VR450-01-0037	June 1, 1986
Virginia	18" TL minimum size limit, 27" TL maximum size limit, 5 fish possession limit, with 1 fish allowed > 27" TL.	VR450-01-0037 as amended	March 1, 1992
Virginia	18" TL minimum size limit, 26" TL maximum size limit, 3 fish possession limit.	4 VAC 20-280-10 et seq. amended	January 1, 2003

Table 1. continued

North Carolina	14" TL minimum size limit, possession limit of 2 fish > 32" TL.	Rule NCAC 3B .0105	1-Feb-76
North Carolina	14" TL minimum size limit, 32" maximum size limit, 1 fish allowed >32" TL, 5 fish recreational possession limit, 300,000 pound commercial cap.	Rule NCAC 3B .0105 (Commercial Cap under Proclamation M-1-89/90)	January 1, 1990
North Carolina	18" TL minimum size limit, 32" maximum size limit, 1 fish allowed >32" TL, 5 fish recreational possession limit, 250,000 pound commercial cap.	Rule NCAC 3M .0501 (Commercial Cap under Proclamation FF-11-91)	August 26, 1991
North Carolina	18" TL minimum size limit, 27" maximum size limit, 1 fish allowed >27" TL (no sale >27" TL), 5 fish recreational possession limit, 250,000 pound commercial cap.	Rule NCAC 3M .0501 (Commercial Cap under Proclamation FF-8-92)	April 1, 1992
North Carolina	18" TL minimum size limit, 27" maximum size limit, 1 fish recreational possession limit, 100 pound daily commercial trip limit, 250,000 pound commercial cap.	Rule 3M .0501 & 3J .0103	October 22, 1998
North Carolina	18" TL minimum size limit, 27" maximum size limit, 1 fish recreational possession limit, 5 fish commercial trip limit (due to cap overages in 1999 and 2000), 250,000 pound commercial cap.	Proclamation FF-32-00	July 22, 2000
North Carolina	18" TL minimum size limit, 27" maximum size limit, 1 fish recreational possession limit, 5 fish commercial trip limit, the total weight of red drum can not exceed 50% total marketable catch (excluding menhaden), 250,000 pound commercial cap.	Proclamation FF-33-2001	March 31, 2001
North Carolina	Establishes authority for Director to adjust commercial trip limit as needed to avoid annual cap overages. Shifts commercial season to be monitored from September 1 through August 31.	Rule 3M .0501	May 1, 2001
North Carolina	18" TL minimum size limit, 27" maximum size limit, 1 fish recreational possession limit, 7 fish commercial trip limit, total weight of red drum can not exceed 50% total marketable catch (excluding menhaden), 250,000 pound commercial cap.	Proclamation FF-47-2001	September 6, 2001

Table 1. continued

South Carolina	14" TL minimum size limit from June 1 to September 1, possession limit of 1 fish > 32" TL	Amendment to Section 50-17-55, SC Code of Laws	June 9, 1986
South Carolina	14" TL minimum size limit from June 1 to September 1, possession limit of 1 fish > 32" TL, 20 fish possession limit, gamefish status (prohibiting the sale of native fish, except maricultured fish).	Amendment adding Section 50-17-56 to SC Code of Laws	June 30, 1987
South Carolina	14" TL minimum size limit from June 1-October 1, possession limit of 1 fish > 32" TL, 20 fish possession limit, gamefish status.	Amendment to Section 50-17-55, SC Code of Laws	April 5, 1988
South Carolina	14" TL minimum size limit, 32" TL maximum size limit, possession limit of 1 fish >32" TL, 20 fish possession limit, gamefish status.	Amendment to Section 50-17-510, SC Code of Laws	June 6, 1990
South Carolina	14" TL minimum size limit, 32" TL maximum size limit, possession limit of 1 fish >32" TL, 5 fish possession limit, gamefish status.	Amendment to Section 50-17-520, SC Code of Laws	April 29, 1991
South Carolina	14" TL minimum size limit, 27" TL maximum size limit, 5 fish possession limit, gamefish status.	Amendment to Section 50-17-510, SC Code of Laws	June 11, 1993
South Carolina	15" TL minimum size limit, 24" TL maximum size limit, 2 fish possession limit.	Amendment to Section 50-5-1705 and -1710, SC Code of Laws	August 31, 2001
South Carolina	15" TL minimum size limit, 23" TL maximum size limit, 3 fish possession limit.	Amendment to Section 50-5-1705 and -1710, SC Code of Laws	June 15, 2007
GA	14" TL minimum size limit, possession limit of 2 fish > 32" TL.	Game and Fish Law. 27-4-10 and -11	1986
GA	14" TL minimum size limit, possession limit of 2 fish > 32" TL, 10 fish daily possession limit.	"Saltwater Finfishing Rule" O.C.G.A. 27-4-130.1	September 13, 1989
GA	14" TL minimum size limit, possession limit of 1 fish > 27" TL, 5 fish daily possession limit.	Board of Natural Resources Action	August 19, 1991
GA	14" TL minimum size limit, 27" TL maximum size limit, 5 fish daily possession limit.	O.C.G.A 27-4-130.1	August 15, 1993
GA	14" TL minimum size limit, 23" TL maximum size limit, 5 fish daily possession limit.	O.C.G.A 27-4-130.1(b) and DNR Rule 391-2-4-.04	July 1, 2002

Table 1. continued

Florida	Prohibition on red drum harvest by out-of-state citizens or for industrial purposes		Before 1925
Florida	12" FL minimum size limit		1925
Florida	15" FL minimum size limit		1953
Florida	12" FL minimum size limit		1955
Florida	Length definition changed to TL		1971
Florida	Length definition changed back to FL		1973
Florida	18" TL minimum size limit, possession limit of 1 fish >32" TL, protected species designation.	CH 46-22, F.A.C.	September 12, 1985
Florida	Prohibition of harvest in state waters and any sale of native fish.	Emergency Rule, CH 46ER86-3, F.A.C.	November 7, 1986
Florida	Emergency rule lifted, 18" TL minimum size limit, possession limit of 1 fish >32" TL, March-April closure, must be landed whole, snatch hooking and use of treble hooks while fishing with natural bait prohibited.	CH 46-22, F.A.C.	February 12, 1987
Florida	Prohibition of harvest in state waters and any possession, transportation, buying, selling or exchanging of native fish	Emergency Rule, CH 46ER87-1, F.A.C, and CH 46-22, F.A.C	May 1, 1987
Florida	Temporary season opening, 18" TL minimum size limit, 27" TL maximum size limit, commercial possession limit of 5 fish, recreational possession limit of 1 fish, use of treble hooks while fishing with natural bait prohibited, "restricted species" designation, must be landed whole.	CH 46-22, F.A.C.	October 1, 1987
Florida	Statewide harvest closure resumes, sale of native redfish allowed until January 5, 1988.	CH 46-22, F.A.C.	January 1, 1988
Florida	Fishery reopens with prohibition on sale of native red drum, 18" minimum size limit, 27" maximum size limit, March-May closed season, 1 fish possession limit.	CH 46-22, F.A.C.	January 1, 1989
Florida	"Protected species" designation, gigging and spearing prohibited. Above rules continued indefinitely.	CH 46-22, F.A.C.	June 3, 1991
Florida	Prohibition on sale of native red drum, 18" minimum size limit, 27" maximum size limit, no closed season, 1 fish possession limit, must be landed whole.	CH 46-22, F.A.C.	1-Jan-96
Florida	Tournament exemptions to exceed bag limit defined	CH 68B-22, F.A.C.	March 17, 2004
Florida	Definition of total length clarified	CH 68B-22, F.A.C.	July 1, 2006

Table 2 provides a timeline of major regulatory changes (size limits, creel limits, commercial quotas, etc.) for red drum in the state waters of the management unit. Note that federal waters were closed to the harvest or possession of red drum on November 9, 1990. All lengths are total length (TL) unless reported as fork length (FL).

Table 2. Chronology of red drum size and creel restrictions and commercial quotas by state of jurisdiction

	1925	~	1953	~	1955	~	1960	~	1976	~	1985	1986	1987
New Jersey													
Delaware													
Maryland													
Potomac River													
Virginia							Only 2 fish > 32"					14" min., only 2 fish > 32"	
North Carolina									14" min., only 2 fish > 32"				
South Carolina												14" min. June -August, only 2 fish > 32"	No sale, 14" min. June-August, only 1 fish > 32", 20 fish limit
GA												14" min., only 2 fish > 32"	
Florida	12" FL min.		15" FL min.		12" FL min.						18" min., only 1 fish > 32"	Nov-Dec: Fishery Closed	Jan-Feb: 18" min., only 1 fish > 32". March-Sept: closed. Oct-Dec: 18" min., 27" max., 5 fish com., 1 fish rec.

Table 2. continued

	1988	1989	1990	1991	1992	1993	1994	~
New Jersey							18" min., only 1 > 27"	
Delaware							18" min., only 1 > 27", 5 fish	
Maryland				14" min., only 2 fish >32"			18" min., only 1 > 27", 5 fish	
Potomac River			14" min.			18" min., only 1 > 27"		
Virginia					18" min., only 1 fish > 27", 5 fish			
North Carolina			14" min., only 1 fish > 32", 5 fish rec., 300,000 lb com. cap	18" min., only 1 fish > 32", 5 fish rec., 250,000 lb com. cap	18" min., only 1 fish > 27", 5 fish rec., 250,000 lb com. cap			
South Carolina	No sale, 14" min. June-September, only 1 fish > 32", 20 fish limit		No sale, 14" min, only 1 fish > 32", 20 fish limit	No sale, 14" min, only 1 fish > 32", 5 fish limit		No sale, 14" min, 27" max., 5 fish limit		
GA		14" min., only 2 fish > 32", 10 fish limit		14" min., only 1 fish > 27", 5 fish limit		14" min., 27" max., 5 fish limit		
Florida	Fishery Closed	No sale, 18" min., 27" max., 1 fish, closed March-May						

Table 2. continued

	1996	~	1998	~	2000	2001	2002	2003	~	2007
New Jersey										
Delaware								20" min., 27" max., 5 fish		
Maryland										
Potomac River	18" min., only 1 > 27", 5 fish							18" min., 25" max., 5 fish		
Virginia								18" min., only 1 fish > 26", 3 fish		
North Carolina			18" min., 27" max., 1 fish rec., 250,000 lb com. cap, 100 lb daily limit com.		18" min., 27" max., 1 fish rec., 250,000 lb com. cap, 5 fish com.	18" min., 27" max., 1 fish rec., 250,000 lb com. cap, 5 fish com. (up to 7 in Sept), 50% bycatch rule				
South Carolina						No sale, 15" min, 24" max., 2 fish limit				No sale, 15" min, 23" max., 3 fish limit
GA							14" min., 23" max., 5 fish			
Florida	No sale, 18" min., 27" max., 1 fish									

3 Assessment History

This overview is first presented as working paper **S18-DW01**. The outline is modified to meet SEDAR standards.

3.1 Previous Assessments

The most recently completed assessment of the status of the Atlantic stock was documented in **Vaughan and Carmichael (2000)**. This assessment of red drum was conducted using recreational and commercial data from 1986 through 1998, and updates data and analyses from the 1989, 1991, 1992 and 1995 stock assessments on Atlantic coast red drum **(Vaughan and Helser, 1990; Vaughan 1992; 1993; 1996)**. Using available length-frequency distributions and age-length keys, recreational and commercial catches were converted to catch in numbers at age. Separable and tuned virtual population analyses were conducted on the catch in numbers at age to obtain estimates of fishing mortality rates and population size (including recruitment to age 1). In turn, these estimates of fishing mortality rates combined with estimates of growth (length and weight), sex ratios, sexual maturity and fecundity were used to estimate yield per recruit, escapement to age 4, and static (or equilibrium) spawning potential ratio (static SPR, based on both female biomass and egg production).

Three virtual analysis approaches (separable, spreadsheet, and FADAPT) were applied to catch matrices for two time periods (early: 1986-1991, and late: 1992-1998) and two regions (Northern: North Carolina and north, and Southern: South Carolina through east coast of Florida). Additional catch matrices were developed based on different treatments for the catch and-release recreationally-caught red drum (B2-type). These approaches included assuming 0% mortality (BASE0) versus 10% mortality for B2 fish. For the 10% mortality on B2 fish, sizes were assumed the same as caught fish (BASE1), or positive difference in size distribution between the early period and the later period (DELTA), or intermediate (PROP). Hence, a total of 8 catch matrices were developed (2 regions, and 4 B2 assumptions for 1986-1998) to which the three VPA approaches were applied. The question of when offshore emigration or reduced availability begins (during or after age 3) was to be a source of bias that tended to result in overestimates of fishing mortality. Additionally, the continued assumption **(Vaughan and Helser, 1990; Vaughan 1992; 1993; 1996)** of no fishing mortality on adults (ages 6 and older), causes a bias that results in underestimates of fishing mortality for adult ages (0 versus some positive value). Because of emigration and the effect of the slot limit for the later period, a range in relative exploitations of age 3 to age 2 red drum was considered. Tuning indices were developed from the MRFSS, and state indices for use in the spreadsheet and FADAPT VPAs.

The SAFMC Red Drum Assessment Group favored the FADAPT approach with catch matrix based on DELTA and a selectivity for age 3 relative to age 2 of 0.70 for the northern region and 0.87 for the southern region. In the northern region, estimates of static SPR increased from about 1.3% for the period 1987-1991 to approximately 18% (15% and 20%) for the period 1992-1998. For the southern region, estimates of static SPR increased from about 0.5% for the period 1988-1991 to approximately 15% for the period 1992-1998. Population models used in this assessment (specifically yield per recruit and static spawning potential ratio) are based on equilibrium assumptions: because no direct estimates are available as to the current status of the adult stock, model results imply potential longer term, equilibrium effects. Because current status of the adult stock was unknown, a specific rebuilding schedule could not be determined. However, the duration of a rebuilding schedule should reflect, in part, a measure of the generation time of the fish species under consideration. For a long-lived, but relatively early spawning, species as red drum, mean generation time would be on the order of 15 to 20 years based on age-specific egg production. Maximum age is 50 to 60 years for the northern region, and about 40 years for the southern region. The ASMFC Red Drum Board's first phase recovery goal of increasing %SPR to at least 10% appeared to have been met.

Based on the joint Red Drum Technical Committee's (SAFMC/ASMFC) selection of the most appropriate catch matrix (incorporating an assumption on size of recreationally-released fish), selectivity of age 3 relative to age 2, and virtual population analysis (FADAPT), a bag and size limit analysis was conducted **(Vaughan and Carmichael 2001)**. Given gear- and age-specific estimates of fishing mortality (F) for the 1992-1998 period, analyses were made of potential gains in escapement through age 4 and static spawning potential ratio (SPR) from further reductions in fishing mortality due to changes in slot and bag limits. Savings from bag limits were calculated given a particular slot size for the recreational fishery, with no savings for the commercial fisheries in the northern region due to their being managed primarily through a quota. Relative changes in catch-at-age estimates were used to adjust age-specific F and hence calculated escapement through age 4 and static SPR. Adjustment was made with the recreational savings to account for release mortality (10%, as in the stock assessment). Alternate runs for the northern region commercial fishery considered 25% release mortality for lengths outside the slot (instead of 0% for the base run), and 0% vs. 10% gain or loss across legal sizes in F. These results were summarized for ranges of bag limits with increasing minimum size limit (for fixed maximum size), and with decreasing maximum size limit (for fixed minimum size limit). For the southern region, a bag limit of one-fish per angler trip would be required to attain the stated target of 40% static SPR if the current slot limit were not changed. However, for the northern region, a bag limit of one-fish per angler trip appears to be insufficient to attain the stated target of 40% static SPR while maintaining the current slot limit. A peer-reviewed version of these analyses as applied to the Southern Region was prepared **(Vaughan and Carmichael 2002)**.

3.2 References

Vaughan, D. S., and T. E. Helser. 1990. Status of the red drum stocks of the Atlantic coast: Stock assessment report for 1989. **NOAA Technical Memorandum NMFS-SEFC-263**, Beaufort Laboratory, Beaufort, North Carolina 28516, 117 p.

Vaughan, D. S. 1992. Status of the red drum stock of the Atlantic coast: Stock assessment report for 1991. **NOAA Tech Memorandum NMFS-SEFC-297**, Beaufort Laboratory, Beaufort, NC 28516, 117 p.

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.

Vaughan, D. S. 1996. Status of the red drum stock on the Atlantic coast: Stock assessment report for 1995. **NOAA Tech Memorandum NMFS-SEFC-380**, Beaufort Laboratory, Beaufort, NC 28516, 50 p.

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.

Vaughan, D. S., and J. T. Carmichael. 2001. Bag and size limit analyses for the red drum in northern and southern regions of the U.S. Atlantic. **NOAA Technical Memorandum NMFS-SEFC-454**, Beaufort Laboratory, Beaufort, North Carolina 28516.

Vaughan, D. S., and J. T. Carmichael. 2002. Estimating improvement in spawning potential ratios for South Atlantic red drum through bag and size limit regulations. **North Am. J. Fish. Manage.** 22:895-906.

4 Regional Map

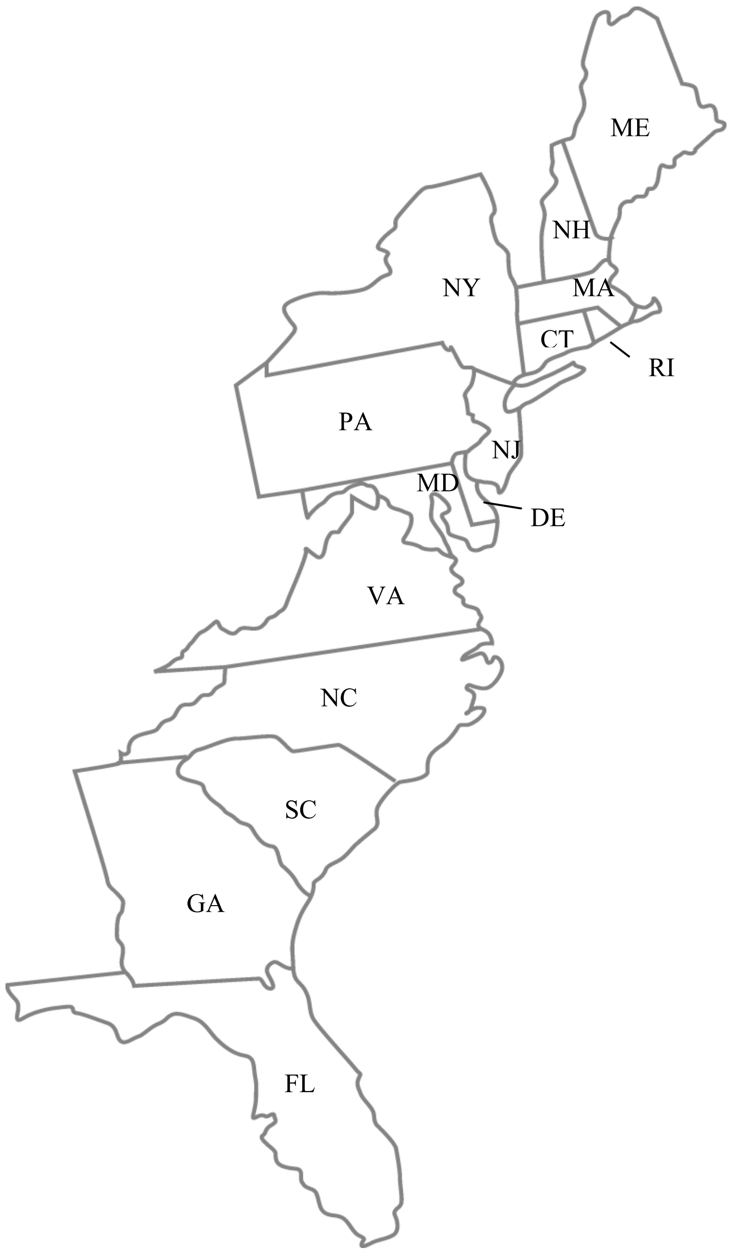


Figure 1. East coast states of the United States. ASMFC member states are Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Delaware, Maryland, Virginia, North Carolina, South Carolina, GA, and Florida. The Atlantic red drum management area is US waters of the northwest Atlantic Ocean from the estuaries to the seaward boundary of the exclusive economic zone from New Jersey through Florida.

Atlantic Red Drum

Assessment Summary Report

SEDAR 18

Atlantic Red Drum Stock Assessment Report

Section I, Chapter 5

October 16, 2009

5 Assessment Summary Report

Sources of Information

This Assessment Summary Report provides a broad but concise view of the salient aspects of the stock assessment. It recapitulates: (a) the information available to and prepared by the Data Workshop (DW); (b) the application of those data, development and execution of one or more assessment models, and identification of the most reliable model configuration as the base run by the Assessment Workshop (AW); and (c) the findings and advice determined during the Review Workshop (RW).

All contents of the Assessment Summary Report are derived from the SEDAR 18 Atlantic Red Drum Stock Assessment Report (SAR). The source of information is identified in the paragraph title as being one or more SAR components:

- Introduction: SAR Section I - Introduction,
- DW: SAR Section II - Data Workshop Report,
- AW: SAR Section III - Assessment Workshop Report,
- (Section IV is Research Recommendations)
- RW: SAR Section V - Review Workshop Report, and
- RW Appendix A: SAR Section V Appendix A – Appendix A of the Review Workshop Report.

SAR copies are available on the SEDAR website (www.sefsc.gov/sedar) or through the SEDAR program office at the South Atlantic Fishery Management Council (4055 Faber Place Drive, Suite 201, North Charleston, SC 29405). Readers are advised that the Council or Commission receiving a SEDAR assessment may request additional sensitivity analyses or projection scenarios following receipt of this report and that the results of such further analyses are not included in the SEDAR report and not reflected in this summary.

Significant Assessment Modifications (AW, RW, RW Appendix A)

The reader's attention is directed to Appendix A of the RW Report. Appendix A presents responses by the Assessment Team (AT) to requests from the Review Panel (RP) formulated during the review process, both before and during the RW. Significant revisions were involved. These revisions affected data, data use, analytic approaches, assessment outputs, and interpretation of results. While there were essential differences between the analyses and accompanying discussion reported in the initial AW Report and those presented in the RW Report, Appendix A, the RP determined that the replacement model run and analyses did not constitute a new assessment. Furthermore, the reader should be aware that results summarized in this Assessment Summary Report relate to the revised analysis of the final assessment in the RW Report, Appendix A and not to that initially presented in the AW Report. To gain a full understanding of the assessment and its review through time, the reader should read the original AW Report (SAR Section III), the RW Report (SAR Section V), and the RW Report appendix (SAR Section V, Appendix A).

Stock Status and Determination Criteria (Introduction, RW, RW Appendix A)

Amendment 2 to the ASMFC Interstate Fishery Management Plan for Red Drum defines overfishing for red drum as a fishing mortality rate (F) in excess of the fishing mortality rate at 30% Static Spawning Potential Ratio (sSPR), or F30% sSPR. The target F is F40% sSPR. Based on these definitions and the recommended 3-year average annual sSPR as an indicator of stock status, overfishing was not occurring in either the southern or the northern stock component (Table 5.1, Figure 5.1). Northern stock 3-year average sSPR, ending 2007, is estimated at 45.3% with a range among sensitivities of 43-48%. Although only relative estimates of sSPR are considered informative for the south, all estimates derived from the models were above the overfishing benchmark. The southern 3-year average sSPR is estimated at 49.5%; discounting the sensitivity where selectivity was estimated for ages 1-5, the range is 37 to 65%.

Yield-per-recruit and spawning-stock-biomass-per-recruit analyses were evaluated against common biological benchmarks. Results suggest that recent (2005-2007) fishing mortality rates were at or below both Fmax and F0.1 benchmarks based on yield per recruit, and the F35% and F20% benchmarks based on SPR analyses (Table 5.2, Figure 5.2).

Table 5.1. (RW Appendix A Table A3.2.4.24 modified). The calculated annual and 3-year average (average of previous two and current years) 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. Three-year average sSPR data are from RW Appendix A Table A3.2.4.23.

Northern region				**Southern region**			
sSPR	2005	2006	2007	**sSPR**	2005	2006	2007
Base	0.571	0.495	0.292	Base	0.438	0.539	0.507
3-yr avg	0.576	0.526	0.453	3-yr avg	0.458	0.481	0.495
Sel 1-5	0.529	0.481	0.277	Sel 1-5	<0.001	0.001	0.001
M low	0.571	0.499	0.298	M low	0.306	0.414	0.382
M high	0.578	0.495	0.289	M high	0.601	0.681	0.654
RM 0.16	0.506	0.547	0.391	RM 0.16	0.482	0.568	0.554
sEsc	2005	2006	2007	**sEsc**	2005	2006	2007
Base	0.602	0.540	0.327	Base	0.464	0.563	0.529
Sel 1-5	0.557	0.524	0.310	Sel 1-5	0.001	0.008	0.006
M low	0.598	0.541	0.329	M low	0.328	0.436	0.401
M high	0.611	0.544	0.328	M high	0.625	0.702	0.674
RM 0.16	0.643	0.677	0.539	RM 0.16	0.516	0.599	0.583

Table 5.2 (Appendix A Table A3.2.4.25.) Yield-per-recruit (lbs) and spawning stock biomass per recruit (defined as sSPR) benchmarks estimated using the recent selectivity vectors estimated by the SCA analysis. The apical fishing mortality, yield-per-recruit (Y/R) and static SPR (sSPR) are shown for the 2007 estimate of F (F_{2007}), maximum yield per recruit (F_{max}), yield per recruit where the slope is 10% of that at the origin ($F_{0.1}$), and sSPR equal to 20% ($F_{20\%}$) or 35% ($F_{35\%}$).

Northern region			
Benchmark	full F	Y/R	sSPR
F_{2007}	0.877	1.585	0.292
F_{max}	1.250	1.651	0.174
$F_{0.1}$	0.865	1.581	0.297
$F_{20\%}$	1.149	1.647	0.200
$F_{35\%}$	0.748	1.518	0.350
Southern region			
Benchmark	full F	Y/R	sSPR
F_{2007}	0.254	0.986	0.507
F_{max}	0.747	1.389	0.137
$F_{0.1}$	0.517	1.329	0.252
$F_{20\%}$	0.604	1.368	0.200
$F_{35\%}$	0.393	1.221	0.350

Northern region

Southern region

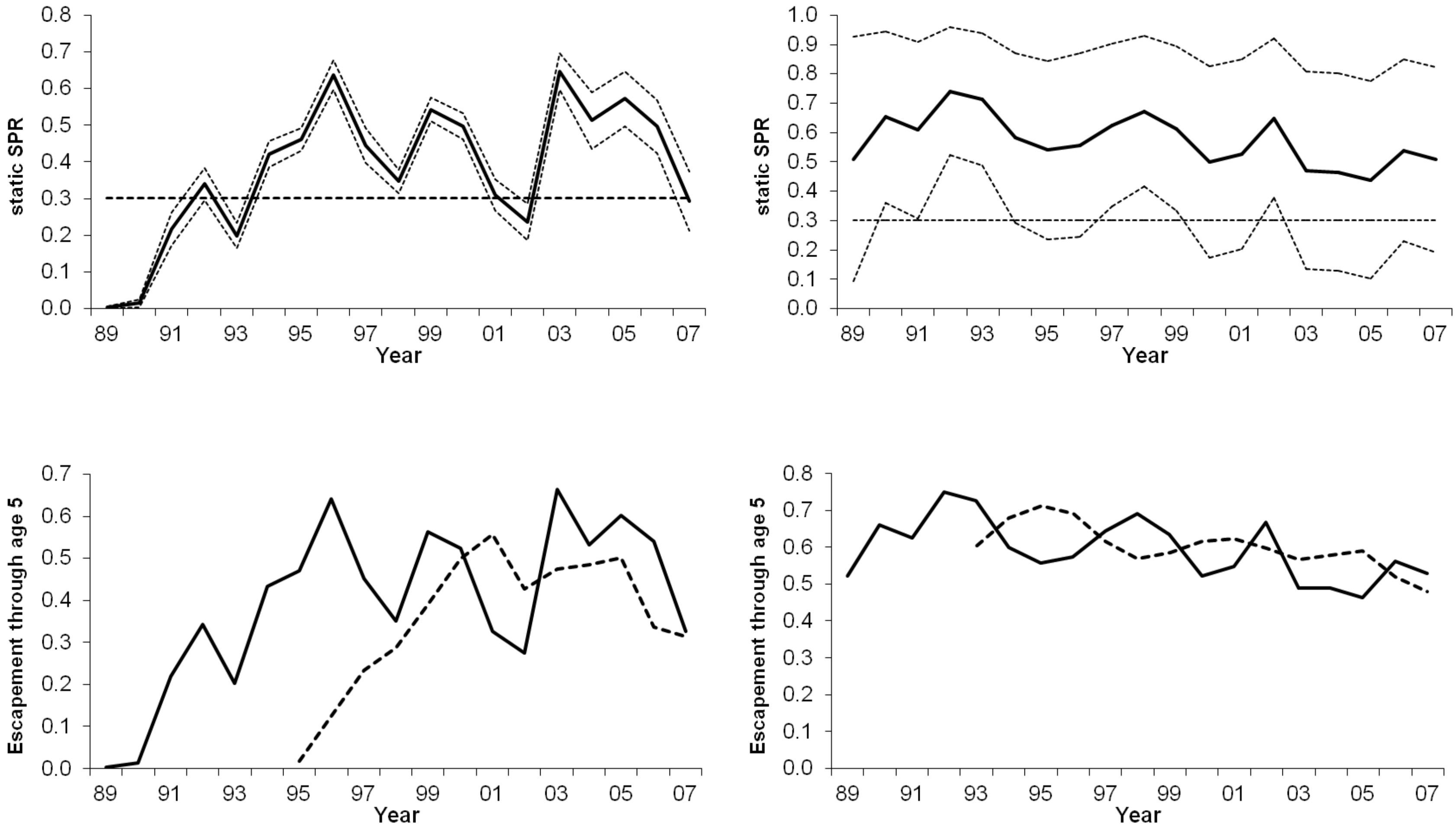
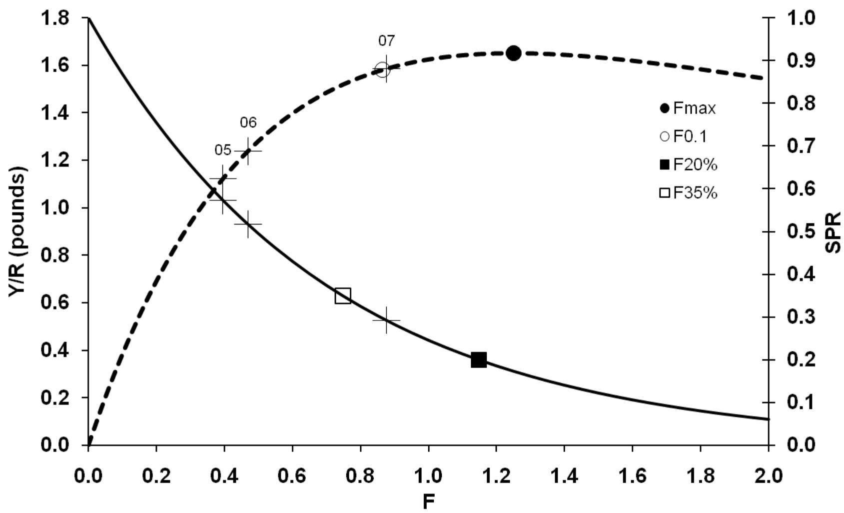


Figure 5.1. (RW Appendix A Figure A3.2.5.21.) **Northern** and **southern** region estimates of static spawning potential ratio with ± 1.96 standard errors (dashed lines) during 1989-2007 (top) and escapement rates (bottom) showing year-specific (heavy line) and year class-specific (dashed line) estimates.

Northern region



Southern Region

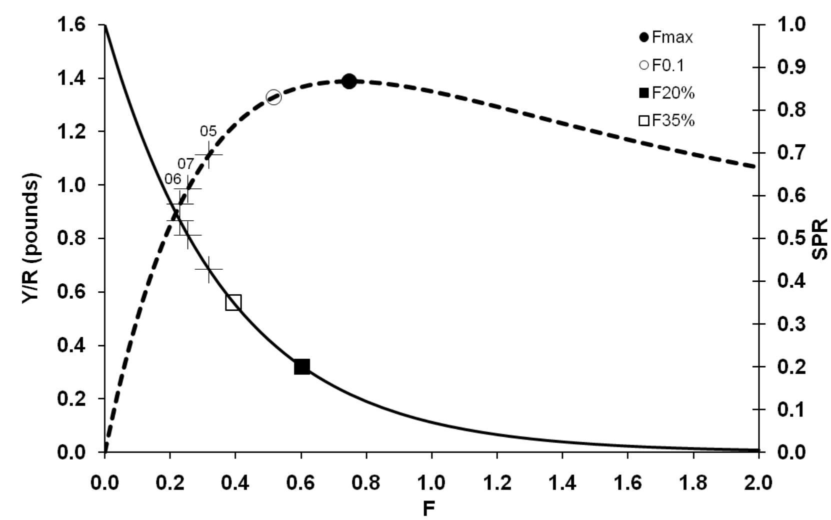


Figure 5.2. (RW appendix A3.2.5.24.) Equilibrium yield-per-recruit (dashed line) and spawning-stock-biomass-per-recruit (of spawning potential ratio, SPR, solid line) expected for red drum across a range of instantaneous fishing mortalities in the northern and southern. As indicated in legend, the YPR benchmarks F_{max} and $F_{0.1}$ are shown as are the SPR benchmarks for SPR=35% ($F_{35\%}$, hidden under pluses in southern region graph) and 20% ($F_{20\%}$). Also shown as '+'s' are the equilibrium values given fishing mortalities estimated for 2005, 2006, and 2007.

Species Distribution (DW)

The red drum, *Sciaenops ocellatus*, inhabits nearshore and estuarine waters of the U.S. Atlantic coast from Massachusetts to Florida and of the Gulf of Mexico (GoM) from Florida to northern Mexico.

Stock Identification and Management Unit (DW, AW, RW)

The stock under assessment is the red drum stock of the Atlantic Ocean. This assessment follows previous efforts in dividing the stock into two units - a northern region composed of Virginia and North Carolina, and a southern region composed of South Carolina, Georgia, and east Florida.

Stock Life History (DW, AW, RW Appendix A)

Separate growth models and estimates of natural mortality were provided for the two regions/stocks, based on observed differences in the life history characteristics over the two areas. The oldest fish aged in the north region was 62 years, with numerous fish aged in their 50s. The oldest fish aged in the south region was 38 years.

Several methods for determining an age-constant *M* based on life history characteristics were explored and results are summarized in Table 5.3. In addition, age-specific natural morality is estimated similar to several previous SEDARs, based on the Lorenzen (1996) approach scaled to fixed M estimates based on the Hoenig (1983) approach (Table 5.4). For assessment modeling purposes, January 1 was chosen as the birth date of all red drum across the management unit. For life history analyses, a standard biological birth date of September 1 was agreed to. Table 5.5 shows north and south fractional and integer ages.

Three variations of the von Bertalanffy growth model were explored, with the single von Bertalanffy growth models by region recommended as appropriate for the assessment. Models by region show similar growth patterns but have visually different L_{infs} (Figure 5.3).

Known reproductive features were compiled (Table 5.6). Depending on area, male red drum mature at age 1 to 4 and females at age 3 to 6. Male size at maturity is determined to be from 511mm to 713mm and female size at 792mm to 900mm. (Table 5.7).

There is little evidence of significant migration by red drum. Tag return data suggest movement into VA waters from NC waters in late May, followed by return to NC waters in the fall for overwintering. Also, some red drum have been observed over-wintering in Chesapeake Bay tributaries near power plants. Less movement is indicated for fish from the southern stock, with 85.3 % of GA-tagged fish recaptured within state waters, and 96.4% of tagged sub-adults in SC recaptured within 30 miles of the tagging site.

Equations for length-length and weight-length conversions for available data were determined using the simple linear regression model and the power function. Details were presented in tabular form in the DW report. Coefficients of determination (r^2) ranged from 0.91 to 0.99 for these length and weight regressions. The DW recommended use of the conversion equations based on northern and southern regions.

Assessment Methods (AW, RW Appendix A)

This assessment is based on a standard statistical Catch-at-Age (SCA) model developed through ADMB software. The configuration includes features for capturing some information from tagging programs and restricting the selectivity estimated for older fish. Analyses were defined for 1982-2007 and include age-specific data for red drum ages 1 through 7^+.

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

Assessment Data (DW, AW, RW Appendix A)

Data incorporated in the initial (1982-2007) and final (1989-2007) analyses are summarized in Table 5.8 and Table 5.9. Northern assessment harvest data were commercial seine/gill net and other gear combined landings, and MRFSS recreational landings and live release mortality rates. Proportion-at-age information was derived from commercial beach seine/gillnet, commercial other gear, and recreational harvest data. Indices of abundance sources were NC gillnet surveys, NC juvenile age-1 abundance index, and angler total age 1-3 catch rate. Tagging data were used to estimate F for total age-1-4^+ harvest and fully recruited F for recreational live-release. Southern harvest data were FL, GA, and SC commercial and recreational harvest, and FL, GA, and SC recreational live-release mortality rates. Proportion-at-age information was derived from FL, GA, and SC commercial and recreational harvest, and SC and GA recreational live-release mortality data. Indices of abundance surveys considered were FL small seine young-of-the-year and haul seine; GA gillnet; and SC electro-shocking, trammel net, and longline.

Release (Discard) Mortality (DW, AW)

Release mortality for recreational fisheries is assumed to be 8%, based on the mean of a range of studies examined by the Data Workshop. A sensitivity run including 16% release mortality was recommended to reflect potential delayed mortality. Although survival of released fish is high, overall removals through discard mortality are significant due to high encounter and discard rates.

Release mortality for commercial gill net fisheries is assumed to be 5%, but overall is not a large component of mortality.

Catch Trends (DW, AW)

Commercial

For modeling, northern assessment harvest data were reduced to: (1) commercial seine/gill net and (2) other gear combined. Southern harvest data were FL, GA, and SC commercial harvest combined.

Commercial landings are highly variable and exhibit little trend over time (Table 5.10, Table 5.11, and Figure 5.4). Commercial landings are predominantly from NC through the time series, and exclusively from NC since 1987 when the sale of native-caught red drum had become prohibited in FL, SC and GA. Interestingly, sporadic records indicate commercial harvest in FL as early as 1889. The dominant gear across the Atlantic range is gill nets, although in the early period of 1950-1962 beach seines dominated.

Overall, red drum commercial landings averaged 249,000 pounds (whole weight) annually between 1950 and 2007.

Recreational - Headboat Landings

The DW Recreational Workgroup concluded headboat data were insufficient to characterize catch or the effect of the headboat fishery and would not be useful in the assessment. Red drum encounters in the headboat fishery are patchy and inconsistent, ranging from 1 to 451 fish per year resulting in annual total harvest estimates of 6 to 3,228 pounds. From 1981-2007, the Southeast Region Headboat Survey sampled landing by all headboats operating in the SE U.S. EEZ. Data available were catch and total weight.

Recreational – Marine Recreational Fishing Statistics Survey

Trends in estimated landings [MRFSS Type A+B1] are highly variable during the initial and final assessment periods with extreme swings apparent annually and across ages. Some variability may be explained by regulatory changes effected by states (Table 5.12).

Fishing Mortality Trends (RW Appendix A)

Northern region estimated exploitation rates of age 1-3 fish declined considerably from 0.8 to about 0.3 between 1989 and 1992. Mortality continued to slowly drop to a low of around 0.1 in 2004, but has since increased to a 2005-2007 average of 0.2. Since reaching a minimum in 1992, in the southern region there has been a slow but statistically significant increasing trend in age 1-3 exploitation, but it has remained below 0.2 during 1989-2007 (Table 5.13, Figure 5.5).

Stock Abundance and Biomass Trends (RW Appendix A)

Estimates of total abundance for red drum indicate a decline in the northern region and about a 50% increase through 1991 in the southern region followed by stable abundance through 2007. In the northern region, estimated total population abundance was over 5 million fish (mostly 7^+) through 1992 declining to just over 3 million fish by 2007 (Table 5.14, Figure 5.6). In the southern region, the total population was estimated at about 6-7 million fish after 1990.

Much of this rapid decrease in estimated abundance in the northern region comes from the decreases in the ‘less available’ adult portion (ages 7^+) of the population, and may be an artifact of the assessment model. The abundance of ages 1-3 are shown in Figure 5.7.

The total stock biomass was not estimated in these analyses.

Scientific Uncertainty (RW Appendix A)

Observed Data

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

Parameter Estimates

The parameters estimated in the SCA include annual fully recruited estimates of F by fishery, period-specific age 1-3 selectivities, age-4 and -5 selectivity constraints, initial age-specific abundances, annual recruitment, and survey catchability coefficients.

Recruitment

Estimated recruitment each year during 1989-2007 was more precise in the northern region than in the southern region. In the northern region, the estimated ± 2-standard-error bounds for recruitment were relatively larger during the years where recruitment abruptly peaked (Table 5.15, Figure 5.8). 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.

Fishing Mortality

The estimated asymptotic standard errors for the fully recruited F estimates were generally larger in the early years of the analyses in the northern region and in the later years in the southern region. In the northern region the coefficients of variation (asymptotic standard error/estimate) were higher during 1989-1990 for the commercial and similar across years for the recreational fisheries (Figure 5.9). In the southern region, the estimated fully recruited F’s were generally less precise in the later years for the commercial and recreational landed fisheries (Figure 5.10).

Sensitivity Runs

Sensitivity runs were made to investigate the effects of changes to selectivity estimates, use of tag-based estimates of F (northern region), and changes to the input values for the instantaneous natural mortality and live-release fisheries’ release mortality rate.

The revised models were configured such that the selectivities of age 4 and age 5 were estimated as a proportion (between 0.0 and 1.0) of the selectivity at age 3. To determine the sensitivity of these analyses to this configuration, the model was reconfigured so that selectivity was estimated for ages 1 through 5. This configuration for the north provided estimates of exploitation and abundance that were only slightly different from the base model runs; the south was highly sensitive. Without restrictions to selectivity, the estimates of abundance are much lower than base model estimates. Exploitation rates estimated for ages 1-3 were about four times higher when selectivity was estimated for ages 1-5.

The review panel requested additional sensitivity runs involving the use of various selectivity constraints. The requested diagnostics are given in RW Appendix A.

Where the northern tag-based data were dropped from the model, the analysis converged on unrealistically large population estimates, low fishing mortality rates, and high sSPRs.

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. 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 southern region analysis was more sensitive. In general, at the higher levels of M, the population size was estimated to be larger for all age groups and therefore the exploitation rate was lower.

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

Retrospective analyses were conducted using the base model configurations and sequentially eliminating data available for 2007, 2006, 2005, 2004, 2003 then 2002. The southern region short Georgia gillnet survey was dropped from the 2004, 2003, and 2002 runs because the survey began in 2003. For the northern region, there was no strong evidence of significant difference between the base and retrospective runs estimates of age 1-3 abundance or exploitation. In the southern region, the retrospective pattern was much more apparent. There was a consistent revision of past F's downward and past estimates of abundance upward as additional years of data were included. There was no indication of a convergence between the different retrospective runs. This pattern greatly eroded the capacity of this model to estimate absolute levels of abundance, F, or static spawning potential.

Special Comments

None were submitted.

Tables

See the **Stock Status and Determination Criteria** paragraph above for Table 5.1 and Table 5.2.

Table 5.3 (DW Table 2.16.2.) US Atlantic red drum age-constant natural mortality rates. *M*: Natural mortality, k: Von Bertalanffy growth parameter, T: average water temperature (°C), L_∞: Von Bertalanffy asymptotic length (mm), Maximum age: t_{max} = **62** in north region, t_{max} = **38** in south region; and average water temperature = **19**° C (Williams et al. 1973 as used in Ross et al. 1995).

Life History	Parameters	North Region	South Region
Approach		L_∞ = 118.67 cm, k =0.19	L_∞ = 104.15 cm, k= 0.23
Alverson & Carney	k, t_{max}	0.006	0.026
Hoenig	t_{max}	0.067	0.109
Jensen	K	0.287	0.343
Pauly	k, L_∞, T°C	0.345	0.401
Rule of thumb	t_{max}	0.048	0.079

Table 5.4 (DW Table 2.16.3.) US Atlantic red drum age-varying natural mortality rates for subadult (ages 1-5, including average across ages) and average over adult ages (6+) ages. Age-varying estimates are based on the Lorenzen (1996) approach for two regions (North and South. Age-specific estimates of natural mortality have been scaled to cumulative survival of 1.5% at maximum observed age. A range of age-varying M is also provided based on scaling to a range in Hoenig M's (giving alternate cumulative survival).

Age Grouping	Northern Region	Southern Region
Subadult Ages:		
1	0.16 (0.10, 0.24)	0.24 (0.13, 0.33)
2	0.13 (0.07, 0.19)	0.19 (0.10, 0.25)
3	0.11 (0.06, 0.16)	0.16 (0.08, 0.21)
4	0.09 (0.06, 0.14)	0.14 (0.08, 0.19)
5	0.09 (0.05, 0.13)	0.13 (0.07, 0.17)
Average 1-5	0.12 (0.07, 0.17)	0.17 (0.09, 0.23)
Ages 6+	0.06 (0.04, 0.09)	0.10 (0.06, 0.14)

Table 5.5. Fractional and integer ages determined for red drum by region

Region	Fractional Age (biological birth date Sept 1)	Integer Age (assessment model birth date Jan 1)	Sample Size
Northern	0.65 to 62.1	0 to 62	8,671
Southern	0.33 to 38.2	0 to 38	26,042

Table 5.6. Known red drum reproductive features

Reproductive Feature	Findings
Spawning season	NC: Aug/Sept. GA: Aug/mid – Oct. Atlantic FL/Sept - Oct
Spawning location	nearshore adjacent to channels and passes; nearshore continental shelves
Spawning frequency	N Gulf of Mexico: 2-4 days
Sex ratio	1:1
Mean fecundity	N Gulf of Mexico: 1.54 mil ova

Table 5.7. Sexual maturity at size and age by state

	NC		SC		Atlantic FL	
Maturity	**male**	**female**	**male**	**female**	**male**	**female**
50% size (mm)	-	-	713	792	511	825-900
50% age (years)	1-2	3	3.6	4.3	1-3	-
100% age (years)	3	4	4	5	-	6

Table 5.8 Data employed for the initial (1982-2007) and final (1989-2007) northern assessment, statistical catch-at-age model – ages 1-7$^+$.

Observed data:	Initial Base Run	Final Base Run
• Total annual harvest in numbers		
– Commercial beach seine/gillnet	1982-2007	1989-2007
– Commercial other gear	1982-2007	1989-2007
– Recreational harvest	1982-2007	1989-2007
– Recreational live-release deaths	1983-2007	1989-2007
• Proportion-at-age for ages 1-7$^+$		
– Commercial beach seine/gillnet	1982-2007	1989-2007
– Commercial other gear	1982-2007	1989-2007
– Recreational harvest	1982-2007	1989-2007
• Indices of abundance		
– NC gillnet survey-age 1	2001-2007	2001-2007
– NC gillnet survey-age 2	2001-2007	2001-2007
– NC juvenile abundance index-age 1	1992-2007	1992-2007 (corrected)
– Angler total catch rate, ages 1-3	1991-2007	1991-2007
• Tagging-estimated F estimates		
– F for total harvest, ages 1-4$^+$	1983-2004	1989-2004
– Fully recruited F for rec live-release	1986-2004	1989-2004

Table 5.9 Data employed for the initial (1982-2007) and final (1989-2007) southern assessment, statistical catch-at-age model – ages 1-7$^+$.

Observed data:	Initial Base Run	Final Base Run
• Total annual harvest in numbers		
– Florida commercial	1982-1988	not used
– FL recreational harvest	1982-2007	1989-2007
– GA rec/com harvest	1982-2007	1989-2007
– South Carolina rec/com harvest	1982-2007	1989-2007
– FL recreational live-release deaths	1982-2007	1989-2007
– SC/GA rec live-release deaths	1982-2007	1989-2007
• Proportion-at-age for ages 1-7$^+$		
– Florida commercial	1982-1988	not used
– FL recreational harvest	1982-2007	1989-2007
– GA rec/com harvest	1982-2007	1989-2007
– South Carolina rec/com harvest	1982-2007	1989-2007
– SC/GA rec live-release deaths	1982-2007	1989-2007
• Indices of abundance		
– FL small seine yoy survey – age 1	1997-2006	1997-2006
– GA gillnet survey – age 1	2003-2007	2003-2007
– SC electro-shocking survey - age 1	2000-2007	2000-2007
– FL haul seine survey – age 2 & age 3	1997-2007	1997-2007
– SC trammel net survey – age 2	1991-2007	1991-2007
– Angler total catch rate, ages 1-3	1991-2007	1991-2007
– SC longline survey, ages 6+	1994-2007	1994-2007

Table 5.10 (DW Table 3.2.) Red drum commercial landings (pounds, whole weight) by region for the US Atlantic coast. Northern region includes states from Massachusetts to NC. Southern region includes landings from SC, GA, and east coast FL.

Calendar	US Atlantic Coast		
Year	**North**	**South**	**Total**
1950	385,100	242,700	627,800
1951	262,500	275,500	538,000
1952	271,100	216,600	487,700
1953	306,300	196,000	502,300
1954	310,200	169,800	480,000
1955	173,100	169,400	342,500
1956	51,100	164,900	216,000
1957	162,900	108,600	271,500
1958	44,400	102,500	146,900
1959	38,500	131,200	169,700
1960	108,900	133,600	242,500
1961	101,700	116,400	218,100
1962	73,800	149,300	223,100
1963	73,900	134,200	208,100
1964	106,100	130,500	236,600
1965	167,500	146,300	313,800
1966	38,500	155,900	194,400
1967	13,900	153,800	167,700
1968	12,600	172,500	185,100
1969	5,000	122,400	127,400
1970	7,600	149,400	157,000
1971	17,900	87,700	105,600
1972	48,819	133,000	181,819
1973	77,364	170,800	248,164
1974	158,137	142,700	300,837
1975	234,036	105,700	339,736
1976	186,859	115,900	302,759
1977	20,137	109,300	129,437
1978	24,174	109,353	133,527
1979	128,517	95,402	223,919
1980	243,623	196,300	439,923
1981	93,620	259,443	353,063
1982	54,261	141,649	195,910
1983	261,671	108,564	370,235
1984	285,620	136,796	422,416
1985	153,776	95,982	249,758
1986	255,476	92,438	347,914
1987	252,257	62,247	314,504
1988	232,371	3,565	235,936
1989	283,556	3,963	287,519
1990	184,726	2,763	187,489
1991	128,349	1,629	129,978
1992	131,591	1,759	133,350
1993	246,857	2,533	249,390
1994	152,445	2,129	154,574
1995	251,789	2,578	254,367
1996	116,077	2,271	118,348
1997	56,619	1,426	58,045
1998	301,754	672	302,426
1999	386,304	1,115	387,419
2000	285,098	707	285,805
2001	155,733	128	155,861
2002	90,751	379	91,130
2003	98,802	559	99,361
2004	54,913	357	55,270
2005	130,528	138	130,666
2006	176,771	444	177,215
2007	256,992	119	257,111

Year	North	South	Total

Table 5.11. (DW Table 3.3.**)** Red drum commercial landings (pounds, whole weight) by gear for the US Atlantic coast (see text for gear descriptions). Landings included MA to FL.

Calendar Year	US Atlantic Coast							
	Beach Seine	Gill Nets	Hook-n-Line	Other Gears	Pound Net	Seines	Trawls	Total
1950	257,600	129,500	112,800	0	103,300	0	24,600	627,800
1951	273,900	94,800	85,300	0	54,500	0	29,500	538,000
1952	277,300	91,700	52,500	0	28,000	0	38,200	487,700
1953	326,500	103,800	32,400	0	9,100	0	30,500	502,300
1954	212,100	103,600	49,600	0	85,200	0	29,500	480,000
1955	128,100	69,400	92,900	0	43,600	0	8,500	342,500
1956	43,100	62,300	102,100	0	7,300	0	1,200	216,000
1957	157,700	40,900	59,300	0	13,200	0	400	271,500
1958	48,900	21,600	55,100	0	19,700	0	1,600	146,900
1959	29,500	49,400	77,100	0	12,200	0	1,500	169,700
1960	105,700	47,500	67,200	0	12,300	0	9,800	242,500
1961	113,400	72,900	23,600	0	2,900	0	5,300	218,100
1962	18,200	96,600	40,100	0	6,400	58,900	2,900	223,100
1963	13,200	90,500	32,400	0	800	69,700	1,500	208,100
1964	49,200	69,900	30,300	0	2,000	84,400	800	236,600
1965	59,600	83,500	41,200	0	71,500	58,000	0	313,800
1966	38,600	86,800	39,100	100	1,300	21,700	6,800	194,400
1967	23,900	100,300	36,000	0	2,000	4,900	600	167,700
1968	29,100	112,800	31,800	0	2,300	7,500	1,600	185,100
1969	9,500	86,200	28,100	0	2,400	1,200	0	127,400
1970	10,400	115,900	26,100	0	600	2,400	1,600	157,000
1971	10,400	73,900	11,500	100	3,700	3,100	2,900	105,600
1972	20,151	100,119	29,000	200	21,193	5,551	5,605	181,819
1973	24,333	153,749	26,300	138	11,664	21,100	10,880	248,164
1974	42,526	115,893	35,800	0	37,946	65,321	3,351	300,837
1975	46,965	92,548	23,638	0	33,809	66,740	76,036	339,736
1976	27,548	132,043	27,700	100	26,630	76,700	12,038	302,759
1977	12,118	79,697	24,300	0	301	11,759	1,262	129,437
1978	800	91,299	17,278	3,875	1,346	4,200	14,729	133,527
1979	500	128,631	27,370	337	9,741	43,200	14,140	223,919
1980	16,409	239,196	29,880	145	29,984	71,382	52,927	439,923
1981	1,012	246,126	41,368	6	36,357	11,102	17,092	353,063
1982	1,542	135,687	28,445	557	4,081	6,947	18,651	195,910
1983	16,754	222,477	26,206	198	36,247	21,065	47,288	370,235
1984	20,555	274,062	29,950	1,082	6,919	20,421	69,427	422,416
1985	4,023	156,857	23,515	904	3,227	13,738	47,494	249,758
1986	7,590	180,521	19,681	214	9,440	71,085	59,383	347,914

Table 5.11 (continued).

Calendar Year	US Atlantic Coast							
	Beach Seine	Gill Nets	Hook-n-Line	Other Gears	Pound Net	Seines	Trawls	Total
1987	9,130	168,041	17,705	2,026	60,832	35,567	21,203	314,504
1988	12,042	134,747	5,215	431	26,378	23,972	33,151	235,936
1989	15,898	142,572	8,123	100	40,354	56,110	24,362	287,519
1990	27,269	97,977	3,549	153	25,796	18,234	14,511	187,489
1991	13,987	78,606	2,254	154	19,734	4,348	10,895	129,978
1992	2,220	106,313	2,065	0	13,351	6,341	3,060	133,350
1993	10,443	204,504	5,592	31	11,617	10,748	6,455	249,390
1994	2,125	114,588	4,429	122	9,874	16,385	7,051	154,574
1995	6,208	181,283	5,669	130	21,285	38,630	1,162	254,367
1996	4,639	91,896	4,268	400	6,290	9,555	1,300	118,348
1997	2,824	37,452	3,301	204	4,343	9,688	233	58,045
1998	5,931	249,059	5,005	505	4,181	37,618	127	302,426
1999	4,355	358,605	4,607	167	13,627	4,014	2,044	387,419
2000	19,690	246,812	3,770	49	10,338	2,990	2,156	285,805
2001	2,424	141,753	1,617	23	8,638	981	425	155,861
2002	769	76,731	1,321	524	9,427	2,029	329	91,130
2003	979	87,589	928	94	3,786	1,365	4,620	99,361
2004	610	50,600	622	12	2,023	1,306	97	55,270
2005	1,661	117,755	489	533	9,540	638	50	130,666
2006	1,843	159,384	956	5,273	7,304	2,263	192	177,215
2007	1,031	233,584	644	6,731	11,374	3,105	642	257,111

Table 5.12 (AW Table 2.3.1.) Estimated landings (MRFSS Type A+B1) –at-age for red drum in FL, GA, SC, and the north region (NC 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 5.12 (continued).

Goergia

	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 5.12 (continued).

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 5.12 (continued).

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

Table 5.13 (Appendix A Table A3.2.4.9.) Predicted catch (C_a), estimated abundance (N_a), and calculated exploitation rate ($\mu = C_a/N_a$) for ages 1 through 3 and 1 through 7^+ in the **northern** and **southern** regions during 1989-2007.

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

Table 5.14 (RW Appendix A Table A3.2.4.7.) Estimated beginning-of-the-year abundance of red drum ages 1 – 7^+ in the **northern** and **southern** regions during 1989-2007.

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

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

Table 5.15. (Table A3.2.4.8.) Estimated recruitment (age-1 beginning-of-the-year abundance) and associated bounds using ± 1.96 asymptotic standard errors. All values were originally in log space so bounds are not symmetrical.

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

Figures

See the **Stock Status and Determination Criteria** paragraph for Figure 5.1 and Figure 5.2.

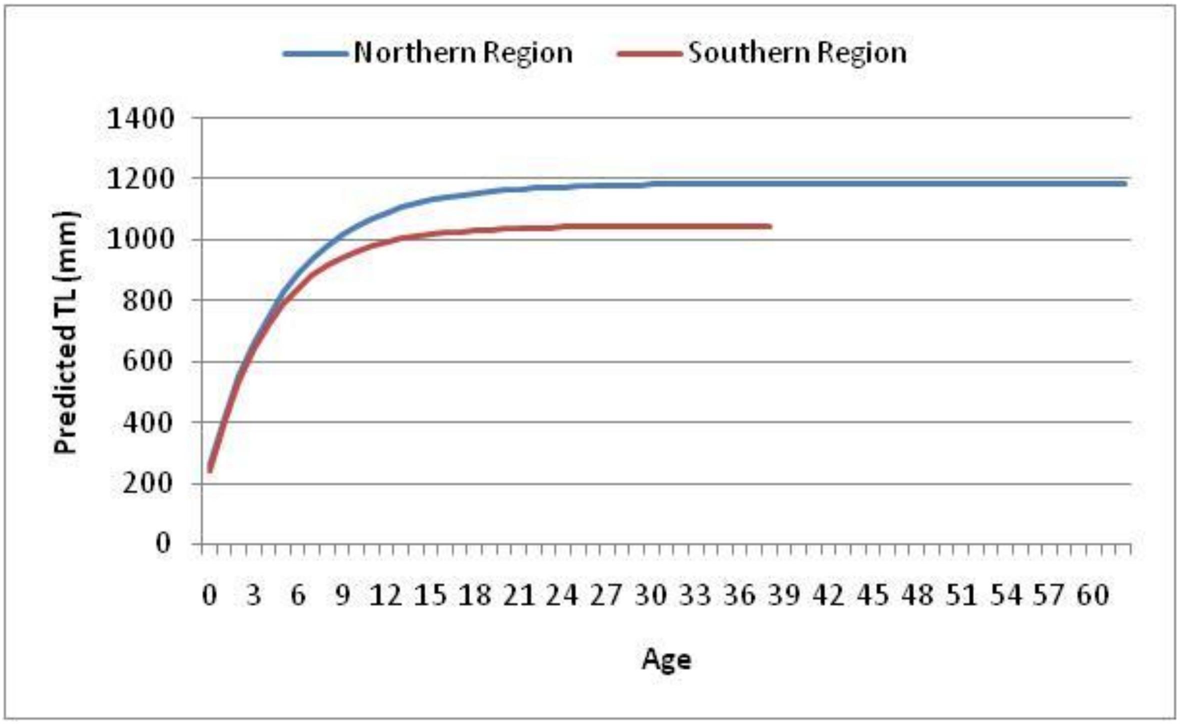


Figure 5.3 (DW Figure 2.17.3.). Comparison of predicted total lengths from von Bertalanffy models by region.

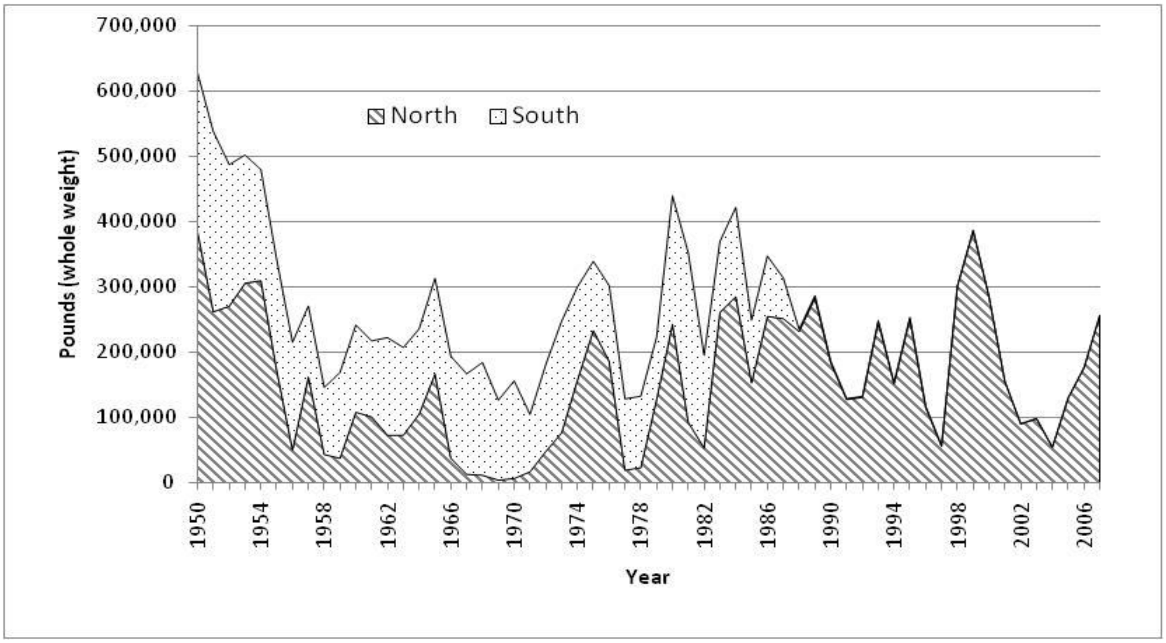
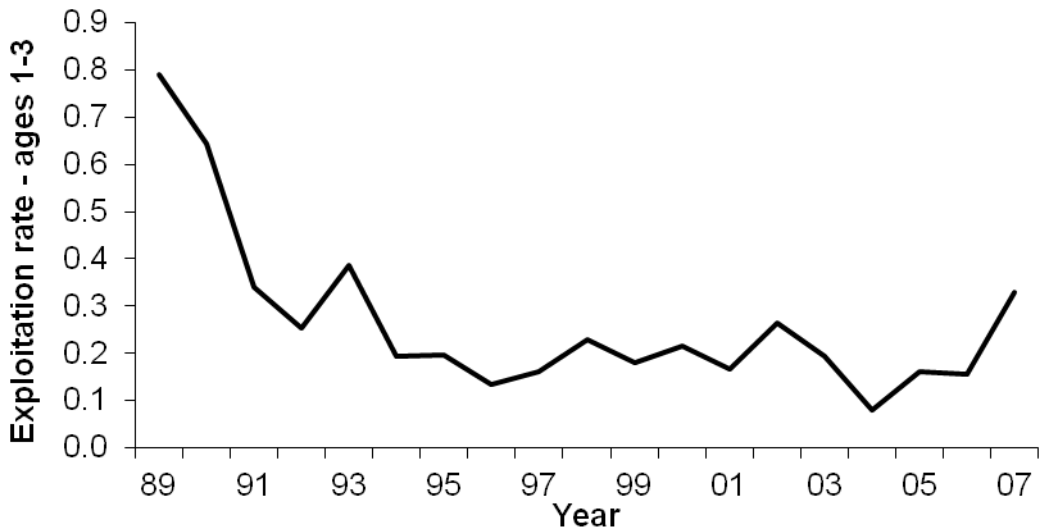


Figure 5.4 (DW Figure 3.2). Red drum commercial landings in pounds (whole weight) by region from the US Atlantic coast, 1950-2007.

Northern region



Southern region

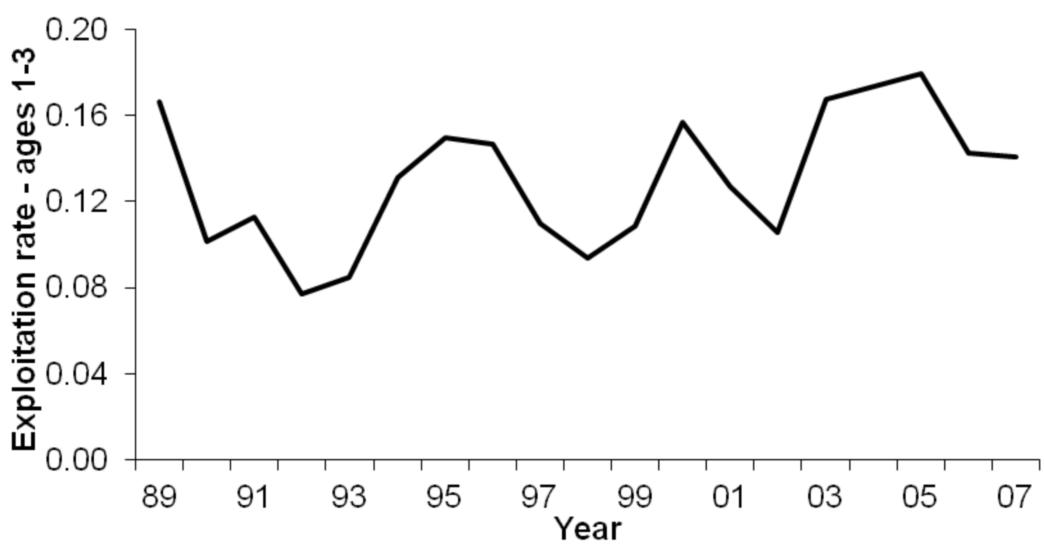
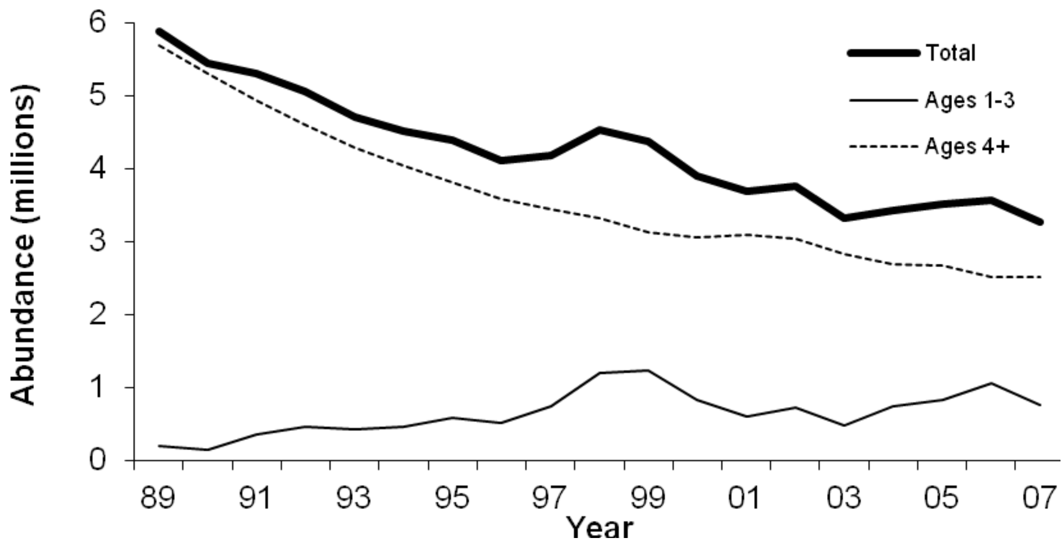


Figure 5.5 (RW Appendix Figure A3.2.5.12.). Estimated annual exploitation rate for red drum ages 1-3 in the northern and southern regions during 1989-2007.

Northern region



Southern region

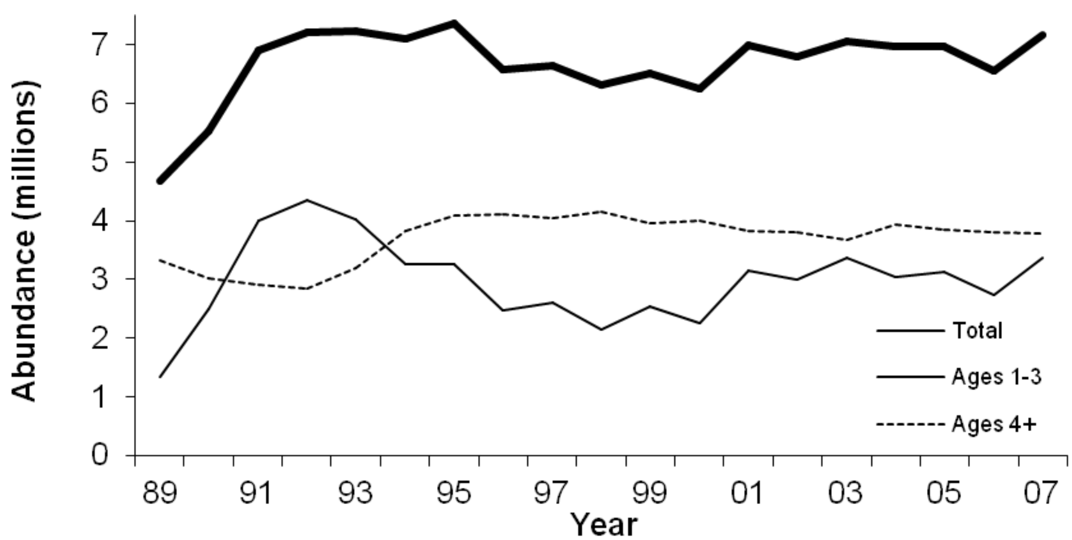
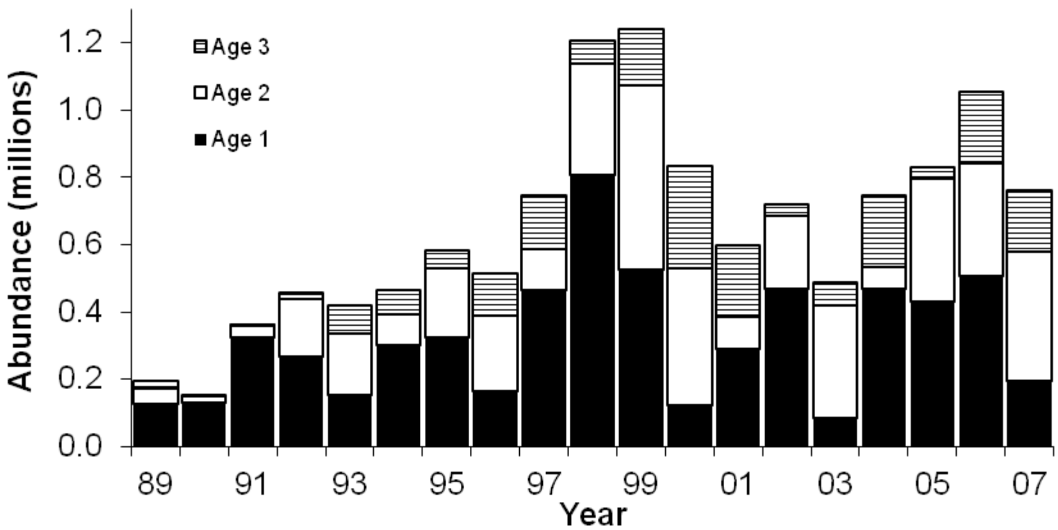


Figure 5.6 **(**Figure A3.2.5.7.). Estimated beginning-of-the-year abundance for red drum in the northern and southern stock areas during 1989-2007.

Northern region



Southern region

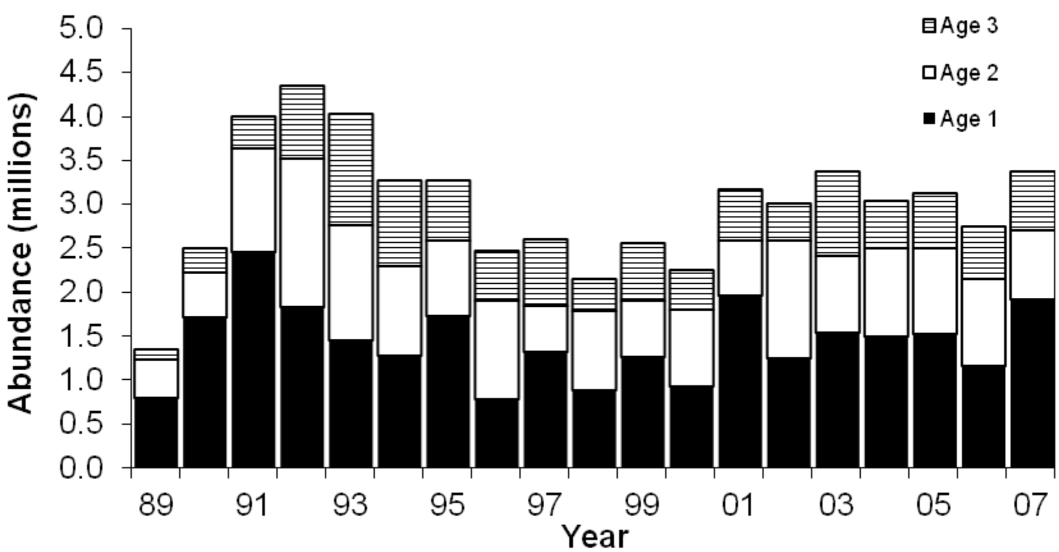
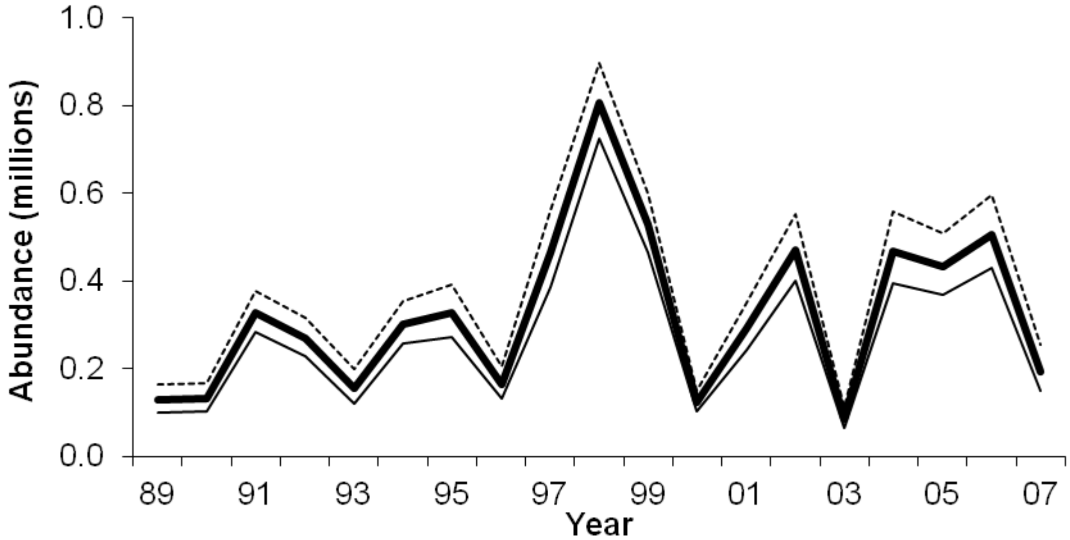


Figure 5.7 (Figure A3.2.5.8.). Estimates of abundance of red drum ages 1-3 in the northern and southern stock areas during 1989-2007

Northern region



Southern region

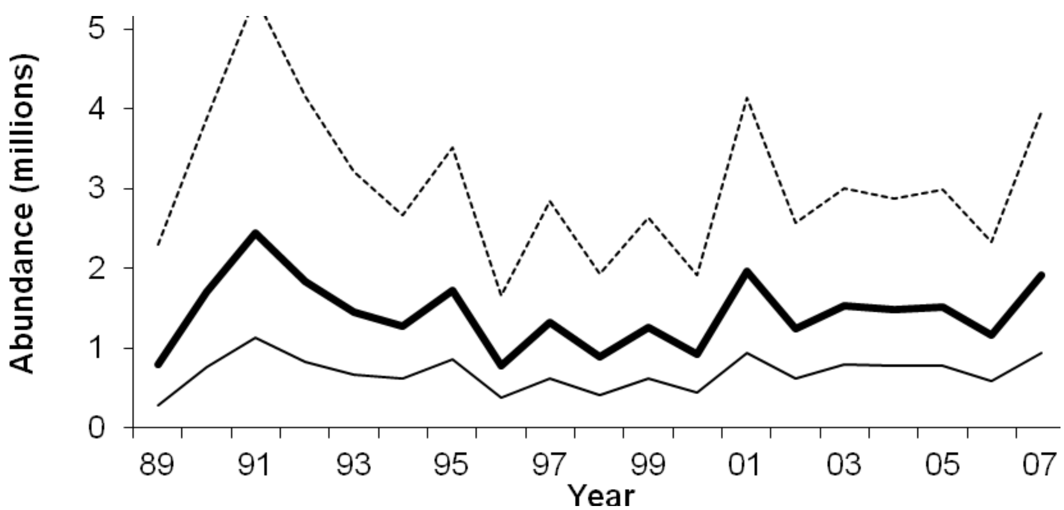


Figure 5.8 (Figure A3.2.5.9.). Estimated recruitment (age-1 abundance, heavy solid line) and ± 1.96 standard errors for the northern and southern regions during 1989-2007

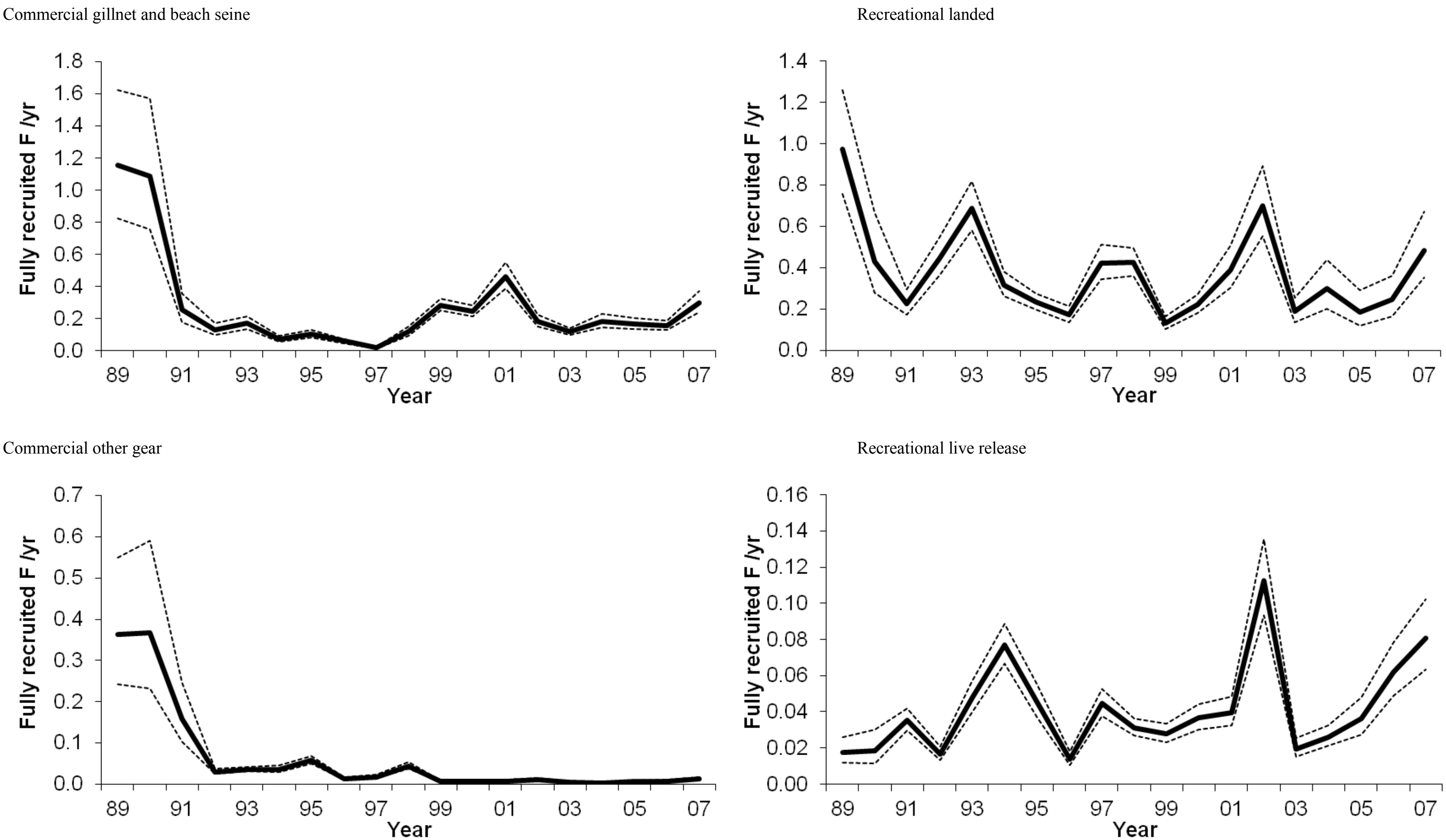
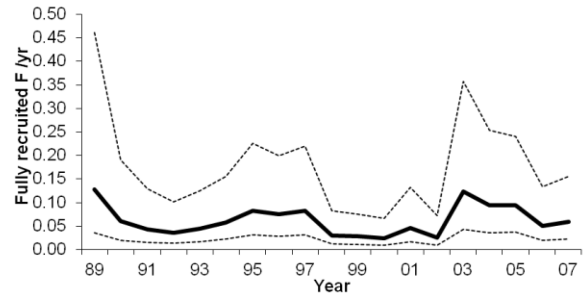
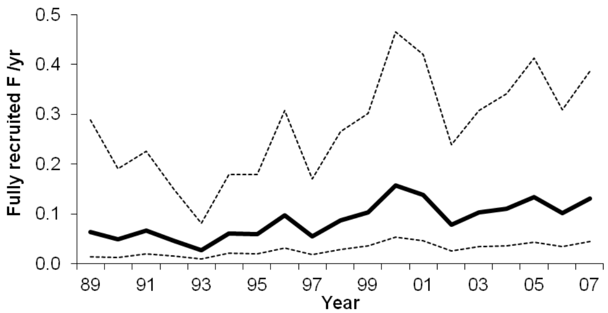


Figure 5.9 (Figure A3.2.5.13). Estimated fully recruited instantaneous fishing mortality (solid line) and ± 1.96 standard errors (dashed lines) for the four **northern** region fisheries during 1989-2007.

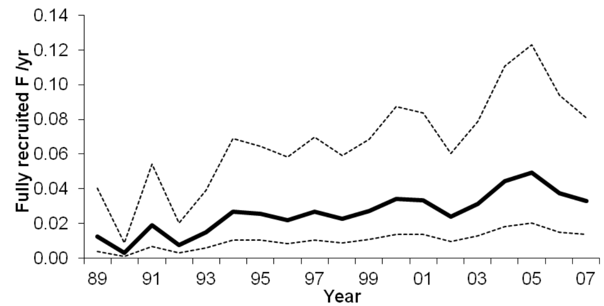
South Carolina recreational landed/commercial



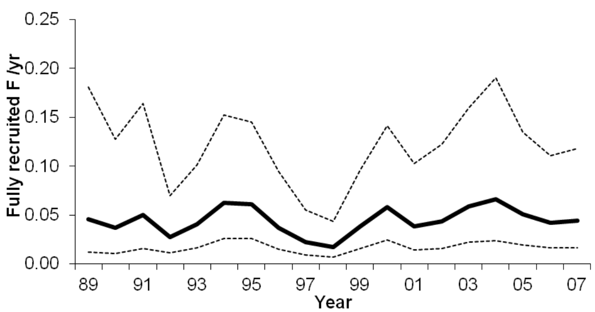
Florida recreational landed



Florida live-release



Georgia recreational landed/commercial



Georgia/South Carolina live-release

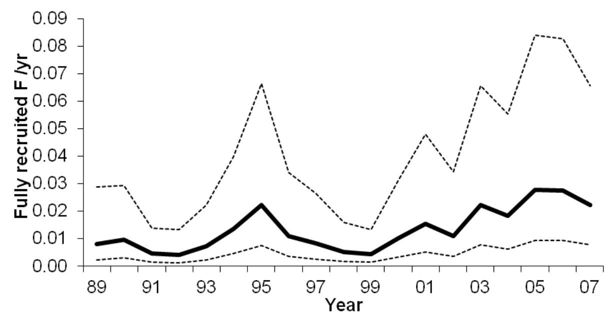


Figure 5.10. (Figure A3.2.5.14.) Estimated fully recruited instantaneous fishing mortality (solid line) and ± 1.96 standard errors (dashed lines) for the six **southern** region fisheries during 1989-2007.

6 Data for NMFS Species Information System

6.1 Atlantic Red Drum: Southern Stock - SEDAR 18

Data Elements:	Workshop Data:
Assessment Year	2009
Assessment Month	September
Last Data Year	2007
Assessment Model	Simple statistical catch-at-age model in AD Model Builder code
Model Version	Revised at SEDAR 18 Review Workshop, Atlanta, GA, 24-28 August 2009
Lead Lab	ASMFC Red drum Technical committee
Point of Contact	Michael D. Murphy
Update Type	Benchmark: Assessments that are substantially different from the previous assessment (new/updated model, inclusion of new data source)
Review Type	Accept: (with revisions and caveats) Assessment was accepted by the scientific review committee and is available for use as advice to management
Life History	2: Basic demographic parameters such as age, growth, and maturity rates provide information on productivity and natural mortality.
Frequency	1: Infrequent-the most recent assessment was conducted more than three years ago.
Level	4: Size, stage, or age structured models such as cohort analysis and untuned and tuned VPA analyses, age-structured production models, CAGEAN, stock synthesis, size or age-structured Bayesian models, modified DeLury methods, and size or age-based mark-recapture models;
Catch	2: Catch size composition provides a measure of the sizes of fish being impacted by the fishery, and when tracked over time can provide an index of recruitment to the fishery and total mortality rates.
Abundance	2: Precise, frequent surveys with age composition will provide more accurate tracking of changes in stock abundance and the associated age composition data will enable better estimation of historical and current levels of recruitment
Citation	Atlantic Red Drum Stock Assessment Report, SEDAR 18, 2009 http://www.sefsc.noaa.gov/sedar/
Minimum F Estimate	<1%
Maximum F Estimate	64.5%

Data Elements:	Workshop Data:
Best F Estimate	49.5%
F Unit	Dimensionless, calculated as a spawning stock biomass ratio so biomass/biomass units
F Year	2005-2007 average
F Basis	3-year average static spawning potential ratio (sSPR)
Flimit	sSPR threshold is defined as 30% and **this is a lower limit**.
Flimit Basis	$F_{30\%}$
Fmsy	Not available, though YPR-based F_{max} gave sSPR's of 13.7%.
Fmsy Basis	Not available
Ftarget	sSPR of 40%
Ftarget Basis	$F_{40\%}$
F/Flimit	Not applicable
F/Fmsy	Not applicable
F/Ftarget	Not applicable
Minimum B Estimate	Not Available
Maximum B Estimate	Not Available
Best B Estimate	Not Available
B Unit	Not Available
B Year	Not Available
B Basis	Not Available
Blimit	Not Available
Blimit Basis	Not Available
Bmsy	Not Available
Bmsy Basis	Not Available
MSY	Not Available
Stock Level to Bmsy	Not Available
B/Blimit	Not Available
B/Bmsy	Not Available
Comments	In general, the assessment analysis was not considered adequate to estimate biomass.

6.2 Atlantic Red Drum: Northern Stock - SEDAR 18

Data Elements:	Workshop Data:
Assessment Year	2009
Assessment Month	September
Last Data Year	2007
Assessment Model	Simple statistical catch-at-age model in AD Model Builder code
Model Version	Revised at SEDAR 18 Review Workshop, Atlanta, GA, 24-28 August 2009
Lead Lab	ASMFC Red drum Technical committee
Point of Contact	Michael D. Murphy
Update Type	Benchmark: Assessments that are substantially different from the previous assessment (new/updated model, inclusion of new data source)
Review Type	Accept: (with revisions and caveats) Assessment was accepted by the scientific review committee and is available for use as advice to management
Life History	2: Basic demographic parameters such as age, growth, and maturity rates provide information on productivity and natural mortality.
Frequency	1: Infrequent-the most recent assessment was conducted more than three years ago.
Level	4: Size, stage, or age structured models such as cohort analysis and untuned and tuned VPA analyses, age-structured production models, CAGEAN, stock synthesis, size or age-structured Bayesian models, modified DeLury methods, and size or age-based mark-recapture models;
Catch	2: Catch size composition provides a measure of the sizes of fish being impacted by the fishery, and when tracked over time can provide an index of recruitment to the fishery and total mortality rates.
Abundance	2: Precise, frequent surveys with age composition will provide more accurate tracking of changes in stock abundance and the associated age composition data will enable better estimation of historical and current levels of recruitment
Citation	Atlantic Red Drum Stock Assessment Report, SEDAR 18, 2009 http://www.sefsc.noaa.gov/sedar/
Minimum F Estimate	42.9%
Maximum F Estimate	48.1%
Best F Estimate	45.3%

Data Elements:	Workshop Data:
F Unit	Dimensionless, calculated as a spawning stock biomass ratio so biomass/biomass units
F Year	2005-2007 average
F Basis	3-year average static spawning potential ratio (sSPR)
Flimit	sSPR threshold is defined as 30% and **this is a lower limit**.
Flimit Basis	$F_{30\%}$
Fmsy	Not available, though YPR-based F_{max} gave sSPR's of 17.4%
Fmsy Basis	Not available
Ftarget	sSPR of 40%
Ftarget Basis	$F_{40\%}$
F/Flimit	Not applicable
F/Fmsy	Not applicable
F/Ftarget	Not applicable
Minimum B Estimate	Not Available
Maximum B Estimate	Not Available
Best B Estimate	Not Available
B Unit	Not Available
B Year	Not Available
B Basis	Not Available
Blimit	Not Available
Blimit Basis	Not Available
Bmsy	Not Available
Bmsy Basis	Not Available
MSY	Not Available
Stock Level to Bmsy	Not Available
B/Blimit	Not Available
B/Bmsy	Not Available
Comments	In general, the assessment analysis was not considered adequate to estimate biomass, especially in the Southern region.

7 SEDAR Abbreviations

ABC	Allowable Biological Catch
ACCSP	Atlantic Coastal Cooperative Statistics Program
ADMB	AD Model Builder software program
ALS	Accumulated Landings System; SEFSC fisheries data collection program
ASMFC	Atlantic States Marine Fisheries Commission
AT	Assessment Team
B	stock biomass level
BAC	SAFMC SSC Bioassessment sub-Committee
B_{MSY}	value of B capable of producing MSY on a continuing basis
CFMC	Caribbean Fishery Management Council
CIE	Center for Independent Experts
CPUE	catch per unit of effort
GMFMC	Gulf of Mexico Fishery Management Council
F	fishing mortality (instantaneous)
FSAP	GMFMC Finfish Assessment Panel
F_{MSY}	fishing mortality to produce MSY under equilibrium conditions
F_{OY}	fishing mortality rate to produce Optimum Yield under equilibrium
F_{XX}% SPR	fishing mortality rate that will result in retaining XX% of the maximum spawning production under equilibrium conditions
F_{MAX}	fishing mortality that maximizes the average weight yield per fish recruited to the fishery
F_0,	a fishing mortality close to, but slightly less than, Fmax
FWRI	(State of) Florida Fisheries and Wildlife Research Institute
GLM	general linear model
M	natural mortality (instantaneous)
MRFSS	Marine Recreational Fisheries Statistics Survey; combines a telephone survey of households to estimate number of trips with creel surveys to estimate catch and effort per trip
MSY	maximum sustainable yield
NMFS	National Marine Fisheries Service
NOAA	National Oceanographic and Atmospheric Administration
OY	optimum yield
RP	Review Panel
RVC	Reef Visual Census—a diver-operated survey of reef-fish numbers
SAFMC	South Atlantic Fishery Management Council
SAS	Statistical Analysis Software, SAS corporation.
SEDAR	Southeast Data, Assessment and Review
SEFSC	NOAA Fisheries Southeast Fisheries Science Center
SERO	NOAA Fisheries Southeast Regional Office
SFA	Sustainable Fisheries Act of 1996
SPR	spawning potential ratio, stock biomass relative to an unfished state of the stock
SSB	Spawning Stock Biomass
SSC	Science and Statistics Committee
Z	total mortality, the sum of M and F

S E D A R

Southeast Data, Assessment, and Review

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SEDAR 18
Data Workshop Report

Atlantic Red Drum

April 24, 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. Data Workshop Report

Contents: Page Numbers and One-way Links

1. Introduction

1.1 Workshop Time and Place

The SEDAR 18 Data Workshop was held February 9-13, 2009, in Charleston, SC.

1.2 Terms of Reference

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

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

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

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

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

6. Provide recommendations for future research in areas such as sampling, fishery monitoring, and stock assessment. Evaluate sampling intensity by sector (fleet), area, and season.
7. Develop a spreadsheet of potential assessment model input data that incorporates the decisions and recommendations of the Data Workshop. Review and approve the contents of the input spreadsheet within 6 weeks prior to the Assessment Workshop.
8. Prepare complete documentation of workshop actions and decisions (Section II. of the SEDAR assessment report); prepare a list of tasks to be completed following the workshop, including deadlines and personnel assignments.

1.3 Participants

Scheduled to Attend

Appointee	Function	Affiliation
Coordination		
Dale Theiling	Chairman and Chief Editor	SEDAR
Rachael Lindsay	Administrative Support	SEDAR
Data Management		
Pat Campfield	Data Compiler	ASMFC
Consultant		
Doug Vaughan	Assessment History Consultation	SEFSC-Beaufort
Life History Workgroup		
Joe Grist	Leader and Editor	VMRC
Alicia Nelson	Rapporteur	VMRC
Stephanie McInerny	Data Provider	NC DMF
Mike Denson	Data Provider	SC DNR
Eric Robillard	Data Provider	GA DNR
Commercial Statistics Workgroup		
Lee Paramore	Leader and Editor	NC DMF
Stephanie McInerny	Rapporteur	NC DMF
Joe Grist	Data Provider	VMRC
Gabe Gaddis	Data Provider	GA DNR
Julie DeFilippi	Data Provider	ACCSP
Doug Vaughan	Data Provider	SEFSC/TIP & Logbook
Recreational Statistics Workgroup		
Mike Denson	Leader and Editor	SC DNR
Beverly Sauls	Rapporteur	FL FWCC
Joe Grist	Data Provider	VMRC
Stephanie McInerny	Data Provider	NC DMF
Gabe Gaddis	Data Provider	GA DNR
Tom Sminkey	Data Provider	MRFSS
Indices Workgroup		
Mike Murphy	Leader and Editor	FL FWCC
Carolyn Belcher	Rapporteur	GA DNR
Joe Grist	Data Provider	VMRC
Lee Paramore	Data Provider	NC DMF
Erin Levesque	Data Provider	SC DNR/SEAMAP

Julie DeFilippi	Data Provider	ACCSP

Analytical Team Representatives (all duplicates from workgroups)

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

Commission Representatives

Robert Boyles	Commissioner	ASMFC
Spud Woodward	Commissioner	ASMFC
Nichola Meserve	Red Drum FMP Coordinator	ASMFC

Advisory Panel Representatives

Bill Windley	ASMFC AP Chair	Recreational, MD
Tom Powers	ASMFC AP Vice Chair	Recreational, VA

Official Observer

Kathy Knowlton		GA DNR

Acronyms used in SEDAR 18 Participants List

ACCSP	Atlantic Coastal Cooperative Statistics Program
ASMFC TC	Atlantic States Marine Fisheries Commission Technical Committee
CIE	Center for Independent Experts
FL FWCC	Florida Fish and Wildlife Conservation Commission
FMP	Fishery Management Plan
GA DNR	Georgia Department of Natural Resources
IT	Information Technology
ME DNR	Maine Department of Natural Resources
MRFSS	Marine Recreational Fisheries Statistics System
MRIP	Marine Recreational Information Program
NC DMF	North Carolina Division of Marine Fisheries
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
RD SAS	Red Drum Stock Assessment Subcommittee
SEFSC	Southeast Fisheries Science Center, National Marine Fisheries Service
SC DNR	South Carolina Department of Natural Resources
SEDAR	Southeast Data, Assessment, and Review
TBN	To be named
TIP	Trip Interview Program, National Marine Fisheries Service
VMRC	Virginia Marine Resources Commission

1.4 Workshop Documents

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 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	SC DNR undated

	Carolina	
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	Dresser & Kneib

	subadult RD, within a salt marsh-dominated estuarine landscape	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-	Stunz & Minello

	caught and hatchery-reared RD	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	Brown 2007

	Carolina	
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 (*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 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

2. Life History

2.1 Overview

The life history working group (LHG) reviewed information on stock structure and description, age, mortality, growth, reproduction, movement and migrations, and habitat, among others. Within the life history working group, there was a Tagging Subgroup made of members of the LHG along with members from some of the other working group.

2.1.1 Life History Group Membership

Joe Grist (Leader)	VMRC
Tonya Darden	SC DNR
Mike Denson	SC DNR
Stephanie McInerny	NC DMF
Chris Mcdonough	SC DNR
Alicia Nelson	VMRC
Eric Robillard	GA DNR
Doug Vaughan	SEFSC-Beaufort
Kirby Wolfe	GA DNR

2.1.2 Tagging Subgroup Membership

Joe Grist (Leader)	VMRC
Carolyn Belcher	GA DNR
Mike Denson	SC DNR
Jon Lucy	VIMS
Mike Murphy	FL FWC
Alicia Nelson	VMRC
Lee Paramore	NC DMF
Steve Arnott	SC DNR

2.1.3 Issues

Some of the key issues discussed by the Life History Group include the difference between total length and fork length including how each state had measured the fish, the possible split between a northern region (Virginia and North Carolina) and a southern region (South Carolina, Georgia, and Florida), and the different maximum ages for each region. It was decided that the maximum age for the northern region would be 62, and the southern region would be 38. For ageing data, there was also discussion on the age determination at the January 1 birthday being age 0 or age 1.

2.2 Review of Working Papers

S18-DW 02

Working paper S18-DW 02 provides overviews of the red drum tagging effort for each state from Virginia through Florida. It includes information on history and procedures of each state's tagging program(s), tag type usage, and recapture details. The paper provided the Life History Group important information regarding movements and migration of red drum populations through tagging and recapture information.

S18-DW 04

The Life History Workgroup reviewed the document S18-DW 04 and determined that it contained a useful narrative describing the GADNR carcass program and associated metadata, and the data provided by this program was useful age at length information. However, the workgroup feels this document is better served as a reference document and not a working paper.

S18-DW 07

The report S18-DW 07 described a variety of life history approaches for calculating natural mortality, both fixed and age-varying. This report, as amended and updated, was then used as the basis for Section 2.4 for Life History of the S18 DW Report. For these reasons, it was considered useful.

S18-DW08

This document provided in-depth detail into commercial data sources for Florida age and length samples as well as methods for calculating catch at age information. Florida age and length data for use in life history calculations were provided separately from this document and included commercial, recreational, and fishery-independent samples. Since, data from this document were provided subsequently to the life history workgroup, there was no need to pull data directly from S18-DW08.

S18-DW13

This analysis presents data from biological sampling of recreational fishing tournaments, and a carcass recovery program designed to supplement fishery independent collections, of recreationally important finfish. The utility of this type of program is the use of the angling public to provide fishery directed samples of fish species in the same habitats and environments where fishery independent sampling occurs. However, the carcass recovery programs, along with sampling at fishing tournaments are of limited utility for species such as red drum due to the size and bag limit restrictions which generally only give good information on fish that were harvested, not the general population. The best utility of this data set, for the red drum stock assessment, would be to use it as a check on the size frequency distributions of other fishery dependent sampling programs such as the

South Carolina creel census survey and the Marine Recreational Fishery Statistics Survey.

S18-DW16
This paper reviewed red drum removals and other harvest from estuarine gill net fisheries (commercial and recreational) in North Carolina. Both fisheries used the same gear types for large and small mesh gill nets, the main difference being the size of the net allowed for recreational users, which was significantly smaller than commercially used nets. These data represent the only commercial discard data presently available for both numbers and weights of red drum harvested, released alive, and direct net mortalities. The range of mortality rates (approximately 22% to 54%) represent a much higher reported rate than that for hook and line fisheries. The data presented for in this paper will be useful in the assessment for determining the level of discard mortalities in other fisheries or states (Virginia) where gill nets are used to harvest red drum.

2.3 Stock Definition and Description

The red drum, *Sciaenops ocellatus,* inhabits nearshore and estuarine waters of the U.S. Atlantic coast from Massachusetts to Florida and of the Gulf of Mexico (GoM) from Florida to northern Mexico (Lux & Mahoney 1969, in Mercer, 1984). The current distribution of red drum in the Atlantic Ocean, as indicated by commercial and recreational landings, extends from southern Florida to Chesapeake Bay (SAFMC 1990; Ross et al. 1995). Recent stock assessments (Vaughan 1993, 1996; Vaughan and Carmichael 2000) have divided this distribution into a northern region (Virginia and North Carolina) and a southern region (South Carolina, Georgia, and the eastern coast of Florida).

Seyoum *et al*.'s (2000) initial mitochondrial genetic work on red drum indicated a weak subdivision of red drum into GoM and Atlantic components with a genetic transition occurring around the southern Florida peninsula between Sarasota Bay and Mosquito Lagoon, supporting the separate management of these populations. Although little work has been conducted on the genetic structure of red drum along the southeast Atlantic coast, large-scale analyses have been conducted on red drum in the GoM (Gold et al. 2001, Gold & Turner 2002). Based on mitochondrial and microsatellite data, estuaries within the GoM showed temporal, but not spatial, stability in allele frequencies. Further analyses of spatial patterns indicated that the variability was not able to be partitioned into discrete geographic subpopulations, instead showing a pattern of isolation by distance. The proposed model of population structure fits well with gene flow predicted by life-history and due to their estuarine-dependent recruitment, a stepping stone model where gene flow primarily occurred among adjacent estuaries was described with geographic neighborhoods limited to 700-900 km. Additionally, the degree of genetic divergence detected was similar between the two markers, indicating the occurrence of sex-biased gene flow, due to female mediated dispersal and/or male philopatry.

Recommendation: Since gene flow could not be definitively defined geographically, a wider geographic context than the current state-based management would likely be appropriate.

Only two papers have addressed red drum population structure within the Atlantic (mitochondrial sequence data, Seyoum *et al*. 2000; microsatellite data, Chapman et al. 2002), both indicating little to no level of spatial structuring among estuaries. However, the Atlantic spatial scale of both projects were limited and likely confounded by low sample sizes. Additionally, an estuarine-collapsed analysis indicated temporal heterogeneity in the SC evaluation and was interpreted as a potential temporal instability of the reproductive pool (Chapman et al. 2002). SC DNR is currently in the process of re-evaluating the population structure based on subadults from Wassaw Sound, GA to Murrell's Inlet, SC with substantially higher samples sizes. Even if the lack of spatial structuring is verified with these analyses, these data would not preclude the possibility of coast-wide structure as the maximum distance among collection localities is 250 km which is substantially smaller than the geographic neighborhood limit found in GoM red drum. Therefore, the data currently available for Atlantic red drum is insufficient in respect to spatial distribution to determine the genetic population structure.

Recommendation: Therefore, based on life history differences noted during the 2000 Red Drum Assessment, the LHG recommends continuing the application of the division of the Atlantic red drum population into two regions, Northern defined as North Carolina and north and Southern defined as South Carolina and south.

Chapman et al. (2002) estimated a variance effective population size (*Ne*) of Atlantic red drum utilizing the temporal method of Waples (1989) which was an order of magnitude lower than estimates of female *Ne* in the GoM (Turner et al. 1999). However, due to red drum overlapping generations, an estimate of *Ne* requires a modification based on age-specific life history information (Jorde & Ryman 1995). At that time, the only correction factor available for red drum was based on GoM fish (Turner et al. 1999); however the appropriateness of those data for Atlantic red drum is unlikely based on suspected age-structure differences resulting from differential commercial fishery impacts during the 1980s. Therefore, determination of age-specific survival and birth rates are needed to determine accurate estimates of *Ne* for Atlantic red drum.

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

2.4 Natural Mortality

2.4.1 Life-History Based Approaches

In stock assessments, natural mortality (*M*) is one of the most difficult parameters to determine. Methods that relate life history traits with natural mortality were reviewed in Vetter (1987). Many new methods have been developed since then. A variety of methods have been explored during past SEDAR data workshops, and the results of some of these methods are summarized in this section. Often *M* is related to the parameters from the von Bertalanffy growth equation (k, L_∞), or as an inverse function of size at age, so consideration of growth of red drum is relevant to this section (*Section 2.7*).

Because the US south Atlantic population has been split into two regions/stocks for recent assessments (Vaughan 1996, Vaughan and Carmichael 2000), separate estimates are provided for these two regions/stocks. The two stocks/regions along the Atlantic coast are split at the North Carolina-South Carolina state border. Subsequently, two forms of the von Bertalanffy growth equation have been considered for red drum (both for the South Atlantic and Gulf of Mexico). These forms include the standard 3-parameter von Bertalanffy growth curve, and the "linear" 4-parameter von Bertalanffy growth curve (developed by Geaghan at LSU and referenced in Hoese et al. 1991). The latter form is referred to as "linear" because the expression for L_∞ is modeled as a linear equation ($L_\infty = b_0 + b_1$*Age). If b_1 is not significantly different from 0, that is the confidence interval includes 0, then this model reduces to the standard von Bertalanffy growth curve.

During the course of the SEDAR 18 Data Workshop, length at age data were re-analyzed using these growth models (*Section 2.7*). The fits to the "linear" form failed to converge within 1000 iterations. Based on the final iteration, the confidence intervals about parameter, b_1 included 0, and therefore, b_1 was not significantly different from 0. It was concluded that the preferred growth model should be based on the standard 3-parameter von Bertalanffy growth equation.

A preliminary version of this section was developed prior to the SEDAR 18 Data Workshop as *S18-DW07*.

2.4.1.1 Age-Constant M Approaches

In this section, we describe several methods for determining an age-constant *M* based on life history characteristics, notably maximum age (t_{max}), von Bertalanffy growth parameters (k, L_∞), and average water temperature (T^oC). Results from the following approaches are summarized in table 2.16.2.

Source	Equation
Alverson and Carney (1975)	$M = 3k/(exp(0.38*t_{max}*k)-1)$
Hoenig (1983; F ~ 0)	$M = exp(1.46 – 1.01*ln(t_{max}))$
Jensen (1996)	$M = 1.5*k$
Pauly (1980)	$M = exp(-0.0152+0.6543*ln(k)-$
$0.279*ln(L_{\infty},cm)$	
	$+0.4634*ln(T^{o}C))$
"Rule of thumb" (Hewitt & Hoenig 2005)	$M = 3/t_{max}$

Average water temperature ($T^{o}C$) used here was $19^{o}C$, from Williams et al. (1973; as referenced in Ross et al. 1995). Quinn and Deriso (1999) have converted Pauly's equation from base 10 to natural logarithms as presented above. The "rule of thumb" method has a long history in fisheries science, but it is difficult to pin down its source. I have referenced Hewitt and Hoenig (2005), who recently compare this approach to that of Hoenig (1983). Note that the Hoenig (1983) method provides an estimate of *Z*. It is only when fishing mortality can be assumed small (*F* ~ 0) that this becomes an estimate of *M*, otherwise it is an upper bound on *M*. It is believed that with sufficient age sampling over a long period of time, finding a red drum closely approximate true maximum age is obtained, and thus useful for determining *M*.

During the course of the SEDAR 18 Data Workshop, the Life History Working Group discussed the following topics with recommendations:

1) **What is maximum age of red drum in the US south Atlantic? Should we consider different values for the North and South regions?**
The group recommended that separate estimates of natural mortality be developed for the two regions based on differences in growth and maximum age observed. The oldest fish aged in the north region was 62 years, with numerous fish aged in their 50s. Meanwhile the oldest fish aged in the south region was 38 years.

2) **What is average water temperature for use in Pauly approach?**
We used the value from Williams et al. (1973) as provided in Ross et al. (1995) for this exercise. Because the Pauly method tends to give unreasonably high M, this method was not favored, so time was not spent to update temperature information.

3) **Which of the age-constant *M* approaches makes the most sense?**
Because some of these approaches will yield unrealistic estimates (either too large or too small), the Hoenig method was favored in consideration of previous SEDARs (e.g., S10, S15, and S17). We provide estimates of constant M of 0.067 for the north region and 0.11 for the south region, with suggested ranges of (0.04, 0.10) and (0.06, 0.15), respectively.

2.4.1.2 Age-Varying M Approaches

Several approaches have been developed to provide age-varying estimates of *M* (Peterson and Wroblewski 1984, Boudreau and Dickie 1989, Lorenzen 1996). All use an inverse relationship between size and natural mortality (*M*). To apply these methods, weight at age is calculated for the middle of the calendar year (July 1). Because biological year begins on September 1, or 2 months later, the fraction, 1/6, is subtracted from each age in the von Bertalanffy growth (length) equation to calculate corresponding length on July 1, and converted to weight using region-specific weight-length relationships for ages 1 and older.
The method of Peterson and Wroblewski (1984) recently was used to describe natural mortality for young-of-year Atlantic menhaden (Heimbuch et al. 2007), but requires dry weight as its independent variable, which is not readily available for red drum, and was not pursued further. The method of Boudreau and Dickie (1989) has been applied in several assessments, notably for red drum in Vaughan and Carmichael (2000). However, the method of Lorenzen (1996) has gained favor in recent years, especially in the SEDAR arena (e.g., S10, S15, and S17). When applying the method of Lorenzen (1996), estimates of age-varying *M* are scaled such that cumulative survival from age 1 through the maximum age is equal to 1.5%. This cumulative survival value comes from the fixed *M* method of Hoenig (1983) as described in Hewitt and Hoenig (2005). When scaled, the resulting M from Boudreau and Dickie (1989) and Lorenzen (1996) provide very similar results (*S18DW07*).

Unscaled and scaled estimates of *M* based on the approaches of Lorenzen (1996) were developed from von Bertalanffy growth parameters using the standard form of the 3-parameter von Bertalanffy growth equation applied to ages 1 through maximum age separately for each region (Figures 2.17.4 and 2.17.5). Additionally, a range in Hoenig-based estimates of *M* was used to rescale the Lorenzen estimates of M so as to provide a range of age-varying *M* for use by the SEDAR 18 Assessment Workshop.

The Hoenig-based estimate of *M* for the north region is 0.067, which produces a scaling to 1.5% survival from age 1 through age 62, and the *M* for the south region is 0.11, also producing a scaling to 1.5% survival from age 1 through age 38. Corresponding percentages can be developed to scale *M* ranging from *M* = 0.04 to 0.10 (or 8.4% and 0.2% survival, respectively) for the north region and *M* = 0.06 to 0.15 (or 10.2% and 0.3% survival, respectively) for the south region. Age-varying estimates of M are presented for subadult ages 1-5 (separately and averaged) and averaged over all adult (6+) ages, with range in parentheses (Table 2.16.3).

During the course of the SEDAR 18 Data Workshop, the Life History Working Group discussed these additional topics with recommendations:

4) **Does it make more sense to use age-varying estimates of *M*, recognizing higher natural mortality for the youngest ages?**
The group concurred that it is important to characterize declining natural mortality with older fish, especially distinguishing between natural mortality for the subadults (ages 1-5) and adults (ages 6+).

5) **To scale or not to scale: should the cumulative natural mortality over ages (1 through maximum age) be scaled to the equivalent mortality from a constant age approach (e.g., to Hoenig estimates as in recent SEDARs)?**
The group favored using the method of Lorenzen (1996; based on the equation described as ocean data only in Table 1), and scaled to fixed M estimates from Hoenig (1983) as used in other recent SEDARs (S10, S15, and S17).

6) **Should we average age-specific natural mortality over subadult ages (1-5) and adult ages (6+) as was done in Vaughan and Carmichael (2000)? How should we deal with age 0 (Sept – Dec of year hatched), or do we need to?**
The group suggested presenting both separate estimates for ages 1-5 and an averaged value for use by Assessment Workshop Panel, but to simply average ages 6+, since estimates are relatively constant for ages 6 and older. As for age 0 fish (Sept – Dec of first year of life), this question is moot since they are not landed, and hence not modeled.

7) **Can we recommend a range of natural mortality for use in the stock assessment sensitivity runs?**
In SEDAR 17, alternate scaling based on a range of estimates around Hoenig's was used. Hence, we have developed a range in M based on the Hoenig-based approach to re-scale the Lorenzen age-varying M to reflect different cumulative survival from age 1 through the maximum age for each stock/region.

2.5 Discard Mortality

Red drum are harvested primarily by recreational fishing gear (hook-and-line) in the southeastern United States. There is very limited information on the discard size frequencies and mortality of red drum in either commercial or recreational fisheries. There is some data available from the Marine Recreational Fisheries Statistics Survey (MRFSS) for most east coast states, but the reported percent standard error (PSE) on fish released alive (B2's) is high (> 20%) and the number of fish actually measured for lengths is low, making it difficult to extrapolate size frequency distributions. The lack of size data on discarded or released red drum has precluded estimates of discard mortality using size. In the previous stock assessment, Vaughan and Carmichael (2000) used a 10% mortality rate for sub-adult discards and assumed a 0% rate on adults due to the maximum size limit.

The data on discard length frequency that was available included Florida (MRFSS derived length frequencies) (SEDAR18-DW09) and South Carolina (Cooperative Angler Research Guide Surveys). In Florida, post release mortality had previously been estimated at 5% (Murphy 2005). Length distributions of B2 fish were determined from a volunteer angler log book program from 2002 to 2007 on Florida's Atlantic coast, and from a Gulf coast scientific hook-and-line survey from 2004 to 2007 designed to approximate angler catch and release behavior. The utility of this data set is limited by spatial and temporal gaps making it difficult to adapt to larger length data sets from previous years. The South Carolina Guide Survey data included lengths and number of all red drum released by anglers and were collected by professional fishing guides in 2007 and 2008. This study was specifically designed to collect length frequency data every month of the year in order to establish the size distribution of B2 fish. Carcass recovery programs (which occur in both South Carolina and Georgia), shore based creel surveys, and sampling at fishing tournaments are of limited utility due to the size and bag limit restrictions which generally only give good information on fish that were harvested. The information gained in the Guide Survey data provides monthly size frequency distributions of both sub-adult and adult B2 fish in South Carolina. Previous assessments assumed a 0% discard mortality for adult red drum because these large fish were above legal size and limited data existed on them. It's been demonstrated the hooking mortality does occur on adult red drum (Vecchio & Wenner 2007), so a better estimate of adult discard mortality is needed.

The North Carolina discard data were collected through both a large and small mesh gill net fishery that had commercial and recreational components. Discards from the estuarine gill net fishery represented 22% to 54% of the total annual commercial harvest (all gears combined) between 2004 and 2006. In 2004 and 2005, dead discards from the gill net fishery represented between 46% and 51% of the total commercial removals (harvest + dead discards) by number. For this same period, recreational release mortality accounted for 39% of the total recreational removals (harvest + release mortality) by number. Discard mortality represented a large portion of the overall annual removals from the red drum population in both recreational and commercial fisheries. The current North Carolina red drum stock assessment (Takade and Paramore 2007) failed to account for between 14% and 18% of all annual removals from the population in 2004 and 2005.

The greatest factor likely to influence discard mortality is hooking mortality. Available mortality rates on discards that are attributable to hooking mortality can range from 2% to 15% depending on hook type and hook placement (Anguilar et al. 2002; Gearhart SD18-RD38; Vecchio & Wenner 2007). Overall hook utilization patterns in South Carolina have shown the majority of anglers use either J-hooks (47.5%), non-offset circle hooks (34.4%), and offset circle hooks (4.7%) (Vecchio & Wenner 2007). J-hooks have been shown to have much higher incidences of deep hooking in the gut which generally results in extensive damage and mortalities (Aguilar et al. 2002; Gearhart SD18-RD38; Vecchio & Wenner 2007). Higher gut hooking rates with J-hooks in North Carolina resulted in hooking mortality estimates approaching 15% (Aguilar et al. 2002). Overall hooking mortality of sub-adult fish in South Carolina was 2% for non-offset circle hooks while adult mortality was 1.9% for non-offset circle hooks and 3.3% for J-hooks. Using the total catch estimate for red drum in South Carolina from the MRFSS in 2005 (498,537 fish), the sub-adult mortality rates (since most of the fish caught throughout the year are sub-adults), and the assumption of 7% mortality for fish caught on J-hooks (which constitute 47.5% of the hooks used to fish for red drum: Vecchio 2006), 16,576 fish died after J-hook capture and release. Under an assumption of 2% mortality for non-offset circle hooks (34.4% of hooks used: Vecchio 2006), 3,429 fish captured by this hook type died after release. If 10% mortality is assumed for all other hook types (18.1% of hooks used: Vecchio 2006), then the estimate of post release mortality is 9,023 fish. These estimates indicate, that during 2005, approximately 29,000 red drum were killed as a result of catch-and-release fishing in South Carolina. If all South Carolina anglers used non-offset circle hooks when fishing for red drum, only 9,971 fish would have died during catch-and-release events translating into a 66% reduction in mortality.

2.6 Age

2.6.1. Age Information by State

Virginia:

The Old Dominion University Center for Quantitative Fisheries Ecology Laboratory (CQFE) processes and ages hard parts collected by the Virginia Biological Sampling Program (BSP). CQFE also assists in the processing of fish, from both the recreational and commercial sectors. Currently, the BSP collects otoliths from multiple species including red drum, *Sciaenops ocellatus*. The goal of otolith collection is to correspond to the frequency distribution in lengths from past seasons, according to 1-inch length bins. The age sampling is designed to achieve a CV of 0.2 (Quinn & Deriso 1999) at each length interval. Fish are then randomly selected from each length interval (bin) to process. The sampling design does not provide targets for cobia, sheepshead, red drum, or black drum, as very few specimens have been collected on an annual basis. CQFE produces an annual report for all samples processed.

North Carolina:

Red drum (*Sciaenops ocellatus*) otoliths were collected from commercial, recreational, and North Carolina Division of Marine Fisheries (NCDMF) catches. Otoliths were removed from fish caught throughout state estuarine and coastal waters. The majority of fish sampled were from Pamlico Sound, its tributaries, and the coastal waters of the Outer Banks from Oregon Inlet to Cape Lookout. Fork length (FL) and total length (TL) in millimeters (mm) were recorded for most fish. When possible, whole weight to the nearest 0.1 kilogram (kg) or pound (later converted to kilograms), and sex were obtained.

Otoliths (sagittae) were excised from all fish and stored dry. Dorso-ventral sections of the left sagitta were made through the core to the nucleus perpendicular to the anterior-posterior plane with a Hilquist thin-sectioning machine as described by Cowan et al. (1995). Sections were mounted on slides with ultra-violet curing glue. All sections were read from a high resolution monitor coupled to a video camera mounted on a microscope. Age determination for red drum was based on the presence of annuli but had to be adjusted because the first annulus is not formed until 19-21 months after the hatching date. Additionally, a September 1 birthdate was used because this is the midpoint of the peak spawning season. Ages were incremented one year on this date. The system was calibrated with an ocular micrometer before each reading session. Validation of this technique is presented in Ross and Stevens (1991). Otolith sections were read independently by two readers.

South Carolina:

Red drum otoliths were collected from fishery independent gear surveys from 1990 to 2007. Since red drum otoliths are large and dense, they must be sectioned in order to count the rings. Prior to sectioning, the core was marked on the proximal surface with a soft lead pencil and the bone was embedded in epoxide resin7 in a silicon mold. A low speed, Isomet saw7 equipped with two 10.2-cm (4-in) diameter diamond-coated blades separated by a ~0.5-mm thick spacer made the section of the sagittae. The resulting sections were mounted on glass sides and viewed under appropriate magnification.

Georgia:

Red drum (*Sciaenops ocellatus*) otoliths were collected from recreational and Georgia Department Natural Resources catches. Otoliths were removed from fish caught throughout state estuarine and coastal waters. The majority of fish sampled were from Wassaw and Altamaha Sound, its tributaries. Total length (TL) in millimeters (mm) were recorded for most fish. When possible, whole weight to the nearest 0.1 kilogram (kg) and sex were obtained. The right or left otolith was randomly selected for analysis. The otolith was mounted with hot glue to a piece of laminate with its distal surface upwards. The laminate was secured into a chuck to a Buehler Isomet saw equipped with two Norton diamond wafering blades separated with a 0.4 mm spacer that was positioned to straddle the focus of the otolith. Otoliths were examined using a Leica MZ-8 dissecting microscope with transmitted light and dark-field polarization at between 1.6 and 2 times magnification. All samples were aged in chronological order by collection date, without knowledge of previously estimated ages or the specimen lengths. Two readers independently read the sectioned otoliths. Age determination for red drum was based on the presence of annuli but had to be adjusted because the first annulus is not formed until 19-21 months after the hatching date. Ages were incremented one year for year class grouping.

Florida:

The age and length data from Florida contained samples taken from a variety of sources, including commercial or recreational landings, scientific surveys and research studies, and tagging study mortalities. These are delineated in the dataset as: scientific, commercial, or recreational. All ages were determined from thin-sections of sagitta, using typical methodology developed for red drum beginning in the early 1980's. In general, these techniques have a high degree of agreement (>95%) among otolith section readers. To avoid the confusion due to different age-anniversary use, all fish are assigned to a yearclass using the year of their fall hatch date.

2.6.2. Aging Workshop

A Croaker and Red Drum Aging Workshop was held at the South Carolina Department of Natural Resources, Marine Resources Center in Charleston, South Carolina on October 8, 2008. Participants were presented an overview of red drum otolith processing and reading conducted by SC DNR staff at the facility in Charleston. Participants from each state briefly described their otolith processing methods. Minor differences in cutting and polishing were noted but it was determined all produce easily readable otoliths. The group discussed reliability of scale aging. Scales appear to be accurate through Age 4 and are not reliable thereafter; otoliths should be used for Age 4 fish and older. The issue of determining 'birth date' and proper assignment of correct year-class was discussed at length. For assessment modeling purposes, the decision was made to use January 1 as the birth date of all drum, regardless of differences between hatch dates among regions. For life history analyses (e.g., natural mortality estimation), a standard biological birth date of September 1 will be used.

2.6.3. Regional Age Analysis

The Data Workshop Panel decided that North Carolina and Virginia should be combined to represent the Northern region and that South Carolina, Georgia, and Florida should be combined to represent the Southern region based on differences in age structures present in data from each state and similarities in management of red drum between states. Fractional ages were calculated using a September 1 birth date. Fractional ages for the northern region ranged from 0.65 to 62.1 while integer ages ranged from 0 to 62 years (n=8,671). Fractional ages for the southern region ranged from 0.33 to 38.2 while integer ages ranged from 0 to 38 (n=26,042).

2.7 Growth

Three variations of the von Bertalanffy growth model were run for each state and by region (i.e. northern, southern) using nonlinear least squares regression, specifically, SAS's NLIN procedure (Marquardt method). Starting parameter values used for all models were t0 = 0.0, K = 0.3, and L∞ = 990. A single, or regular, von Bertalanffy model, a 4 parameter model, and a double von Bertalanffy model were calculated using fractional age and total length in millimeters. All growth models were inversely weighted by integer age. Previous aging studies and assessments for red drum found that the 4 parameter and double von Bertalanffy growth models fit better than the standard von Bertalanffy (S18-RD46). However, in most cases, the 4 parameter and double von Bertalanffy models calculated using data by state and region provided for this SEDAR did not converge. The 4 parameter model did converge for North Carolina data but the extra parameter (b1) was not significantly different from zero suggesting that the regular von Bertalanffy model should be used. Unweighted models were also run by state and region to determine whether this would help the 4 parameter model converge. Again, in most cases, the 4 parameter model did not converge. In those cases where the 4 parameter model did converge, b1 was not significantly different than zero. Regular von Bertalanffy growth models were presented to the Workshop Panel and it was decided that growth models by region were sufficient. Growth model parameters for the northern region were Linf = 1186.7, K = 0.19, and t0 = -1.30 (Figure 1) and parameters for the southern region were Linf = 1041.5, K = 0.23, and t0 = -1.14 (Figure 2). Models by region were plotted together and showed similar growth patterns but visually different Linfs (Figure 3). This is most likely the result of smaller observed lengths and lower maximum ages from the southern region.

Recommendation: Use weighted regular von Bertalanffy growth models by northern and southern regions.

2.8 Reproduction

Much of the reproductive data is based on histological data as well as observations using hydroacoustic receivers. Most of the hydroacoustic data seems to be supported by the histological data (Lowerre-Barbieri 2008). Due to a limited amount of data from the Atlantic coastal region it was necessary to use both Gulf of Mexico and Atlantic coast data.

2.8.1 Spawning Seasonality

Spawning season on the Gulf and Atlantic coasts of Florida peaks between September and October (Murphy & Taylor, 1990). The northern Gulf of Mexico appears to have a spawning season between mid-August to September. Along the coast of North Carolina spawning peaked between August and September based on GSI (Ross et. al., 1995). Along the Georgia coast based on hydroacoustic data red drum appear to congregate and spawn between August and mid-October (Lowerre-Barbieri et al. 2008)

2.8.2 Sexual Maturity

Interpolated lengths of 50% maturity for male red drum were 529 mm for Florida's Gulf coast and 511 mm for the Atlantic coast of Florida and were mature between ages 1 and 3 (Murphy and Taylor 1990). Fifty percent of females were mature between 825 mm and 900 mm and all females were mature at age 6 in Florida (Murphy and Taylor 1990). In North Carolina, females were mature at 4 years while males were mature at 3 years (Ross et. al. 1995). Fifty percent of males were mature between 1 and 2 years of age while females were didn't mature until 3 years old (Ross et. al. 1995). The size of 50% maturity for females in SC was 792 mm TL and 713 mm TL for males. The age of 50% maturity for females was 4.3 years (52 months), while for males it was determined to be 3.5 years (43 months) (Wenner 2000). In South Carolina, all males were mature at 4 years and all females were mature at 5 years (Wenner 2000).

2.8.3 Sex ratio

The sex ratio in North Carolina was 1:1 (349 males:373 females) (Ross et. al.. 1995). In the northern Gulf of Mexico, the sex ratio for spawning adults was also 1:1 (Wilson and Nieland 1994)

2.8.4 Spawning Frequencies

Wilson and Nieland (1994) estimated spawning frequencies for Northern Gulf of Mexico red drum from between 2 and 4 days.

2.8.5 Spawning Location

Spawning most likely occurs in the nearshore areas adjacent to channels and passes and may also occur over nearshore continental shelves (Lowerre-Barbieri et. al. 2008; Murphy and Taylor 1990). Spawning locations in South Carolina were also associated with passes and channels (Wenner 2000).

2.8.6 Batch Fecundity

Batch fecundity estimates vs. fork length, gonad-free body weight, age in year, and BW were generated by Wilson and Nieland (1994) for red drum from the northern Gulf of Mexico from 1986 to 1992. The mean batch fecundity was 1.54 million ova. Fish ranged from 3-33 years of age, had a fork length range of 697-1005 mm, and a batch fecundity range of 0.16-3.27 (ova x 10^6).

2.9 Movements and Migrations

Tagging information provided the best insight into the movement and migration of red drum along the Atlantic coast. Each state, from Florida to Virginia, has participated in some form of tagging program. Volunteer angler programs are or have been active in each state in which trained volunteers participate by tagging fish and reporting tagged fish when recaptured. Other programs include agency staff tagging and cooperative projects with local commercial harvesters. Almost every program relies heavily on angler returns for recapture information.

Despite differences in state-to-state programs, there is evidence of adult drum movement between Virginia and North Carolina. Data suggest red drum movement into Virginia waters from North Carolina in late May. The fish appear to stay in the area during August through September when they ultimately move during fall months to North Carolina waters where the fish appear to overwinter.

Programs in the southern states (Florida, Georgia, and South Carolina) provided evidence of limited movement as well. For example, of 1,780 fish tagged in Georgia, 85.3 % were recaptured within state waters (11.0 % were recaptured in South Carolina, and 3.7 % were recaptured in Florida). In South Carolina, fish tagged in the SC Department of Natural Resources sub-adult tagging program were primarily recaptured within 30 miles (96.4 %) (S18-DW02).

An interesting pattern of movement, or lack of movement, was observed from fish over-wintering in the area of power plants. The most productive of these areas was the Elizabeth River Hot Ditch area, in Virginia. Rather than migrating out of the Chesapeake Bay during fall to North Carolina waters (considered the usual pattern for sub-adult red drum), fish in this area were observed over-wintering in bay tributaries in the area of power plants. The cycling of river water through the plants resulted in discharges of warmed water sufficient to maintain adjacent areas at temperatures generally suitable for the fish (as well as forage the fish could use-crabs, finger mullet, mummichogs, etc.). Similar patterns were also observed, to a lesser degree, at another nearby power plant (S18-DW02).

2.10 Meristics and Conversion Factors

Equations to make length-length and weight-length conversions were determined using the simple linear regression model and the power function, respectively (Table 2.16.1). All weights are shown in grams and all lengths in millimeters. No standard lengths were provided for the northern regions, so conversions between total or fork length and standard length for the southern region were used for the northern region. Coefficients of determination (r^2) ranged from 0.91 to 0.99 for these linear (length) and nonlinear (weight) regressions.

Recommendation: Use the conversion equations based on northern and southern regions.

2.11 Habitat

The following is quoted from the SAFMC "HABITAT PLAN FOR THE SOUTH ATLANTIC REGION: ESSENTIAL FISH HABITAT REQUIREMENTS FOR FISHERY MANAGEMENT PLANS OF THE SOUTH ATLANTIC FISHERY MANAGEMENT COUNCIL," (SAFMC 1998).

> **Essential Fish Habitat and Environmental Requirements**
> For red drum, essential fish habitat includes all the following habitats to a depth of 50 meters offshore: tidal freshwater; estuarine emergent vegetated wetlands (flooded saltmarshes, brackish marsh, and tidal creeks); estuarine scrub/shrub (mangrove fringe); submerged rooted vascular plants (sea grasses); oyster reefs and shell banks; unconsolidated bottom (soft sediments); ocean high salinity surf zones; and artificial reefs. The area covered includes Virginia through the Florida Keys.
> Red drum are distributed along the Atlantic coast, in the ocean and estuarine areas in relation to their stage of maturity. Juvenile red drum utilize the shallow backwaters of estuaries as nursery areas and remain there until they move to deeper water portions of the estuary associated with river mouths, oyster bars and front beaches. Estuarine wetlands are especially important to larval red drum. The types of estuarine systems vary along the Atlantic and subsequently, the preferred juvenile habitat also varies with distribution. Young red drum are found in quiet, shallow, protected waters with grassy or slightly muddy bottoms. Shallow bay bottoms or oyster reef substrates are preferred by subadult and adult red drum. Red drum utilize the oceanic system which is the area of the Atlantic ocean from the beachfront seaward. Large red drum are thought to migrate along the Atlantic coast and are subjected to man's alterations of the natural system. Nearshore and offshore bar and bank areas such as Gaskins and Joiner Banks in South Carolina have been identified as areas where concentrations of red drum could be located. Nearshore artificial reefs along the Atlantic are also known to attract red drum as they make their spring and fall migrations. In the fall and spring red drum concentrate around inlets, shoals, capes, and from the surfzone to several miles offshore, moving among these areas.

Description, Distribution and Use of Essential Fish Habitat
The distribution of red drum between estuarine habitat and oceanic waters is dependant mainly on stage of development and temporal and environmental factors. Red drum are euryhaline. Adult and subadult red drum are most often found in diluted/concentrated seawater of 20 to 40 ppt and rarely above 50 ppt, while juveniles range into the freshest parts of estuaries. Eggs and newly hatched larvae require salinities above 25 ppt. Spawning occurs in or near passes of inlets (e.g. "Grillage" at the mouth of Charleston Harbor) with larvae being transported into the upper estuarine areas of low salinity. As larvae develop into juveniles and sub-adults, they utilize progressively higher salinity estuarine and beachfront surf zones. Red drum move out of estuarine areas as adults and occupy the high salinity surf zone nearshore and offshore coastal waters. In North Carolina and Virginia, large adults move into estuaries during summer months.
Red drum are eurythermal, occuring over a temperature range of 2°-33°C, although they usually move into deeper water at extremes. Larger juveniles and adults are more susceptible to the effects of winter cold waves than small fish. High red drum mortality during freezes occurs and has the ability to decimate large portions of juvenile year classes. Thermal optimum is dependent on salinity, a characteristic of euryhaline fish.

2.12 Adequacy of Data for Assessment Analyses

Adequacy of the data presented in this report has been discussed in each individual section. Please refer to each section for information on the adequacy of data for assessment analysis.

2.13 Life History Research Recommendations

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

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

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

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

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

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

2.14 Tasks for Completion following Data Workshop

All tasks given during the data workshop were completed prior to finalizing this report.

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2.16 Tables

Table 2.16.1. Conversion table for SEDAR 18 red drum age data.

Red Drum Conversions										
Length-Length										
Data Source	Dep. Variable	Ind. Variable	a	b	r^2	n	a SE	b SE	Ind Range	Units
Northern Region	TL	FL	1.085	-22.9	0.99	6887	0.0005	0.283	152-1300	mm
	FL	TL	0.919	22.1	0.99	6887	0.0006	0.319	149-1255	mm
	TL	SL	1.174	18.909	0.99	1684	0.0022	0.966	221-1243	mm
	FL	SL	1.048	49.347	0.91	1686	0.0081	3.517	215-1167	mm
Southern Region	TL	FL	1.057	-4.472	0.95	3227	0.0043	2.452	221-1243	mm
	FL	TL	0.899	31.636	0.95	3227	0.0036	2.192	215-1167	mm
	TL	SL	1.174	18.909	0.99	1684	0.0022	0.966	221-1243	mm
	FL	SL	1.048	49.347	0.91	1686	0.0081	3.517	215-1167	mm
Weight-Length										
Data Source	Dep. Variable	Ind. Variable	a	b	r^2	n	Len SE	Wt SE	Length Range	Units
Northern Region	Whole Wt	TL	0.00002	2.92	0.98	6316	1.03	1.01	152-1300	mm, g
Southern Region	Whole Wt	TL	0.00010	2.94	0.99	3549	1.04	1.01	221-1243	mm, g

Table 2.16.2. US South Atlantic red drum age-constant natural mortality rates. *M*: Natural mortality, k: Von Bertalanffy growth parameter, T: average water temperature (°C), L_∞: Von Bertalanffy asymptotic length (mm), Maximum age: t_{max} = **62** in north region, t_{max} = **38** in south region; and average water temperature = **19**° C (Williams et al. 1973 as used in Ross et al. 1995).

Life History	Parameters	North Region	South Region
Approach		L_∞ = 118.67 cm, k =0.19	L_∞ = 104.15 cm, k= 0.23
Alverson & Carney	k, t_{max}	0.006	0.026
Hoenig	t_{max}	0.067	0.109
Jensen	K	0.287	0.343
Pauly	k, L_∞, T^oC	0.345	0.401
Rule of thumb	t_{max}	0.048	0.079

Table 2.16.3. US South Atlantic red drum age-varying natural mortality rates for subadult (ages 1-5, including average across ages) and average over adult ages (6+) ages. Age-varying estimates are based on the Lorenzen (1996) approach for two regions (North and South. Age-specific estimates of natural mortality have been scaled to cumulative survival of 1.5% at maximum observed age. A range of age-varying M is also provided based on scaling to a range in Hoenig M's (giving alternate cumulative survival).

Age Grouping	Northern Region	Southern Region
Subadult Ages:		
1	0.16 (0.10, 0.24)	0.24 (0.13, 0.33)
2	0.13 (0.07, 0.19)	0.19 (0.10, 0.25)
3	0.11 (0.06, 0.16)	0.16 (0.08, 0.21)
4	0.09 (0.06, 0.14)	0.14 (0.08, 0.19)
5	0.09 (0.05, 0.13)	0.13 (0.07, 0.17)
Average 1-5	0.12 (0.07, 0.17)	0.17 (0.09, 0.23)
Ages 6+	0.06 (0.04, 0.09)	0.10 (0.06, 0.14)

2.17 Figures

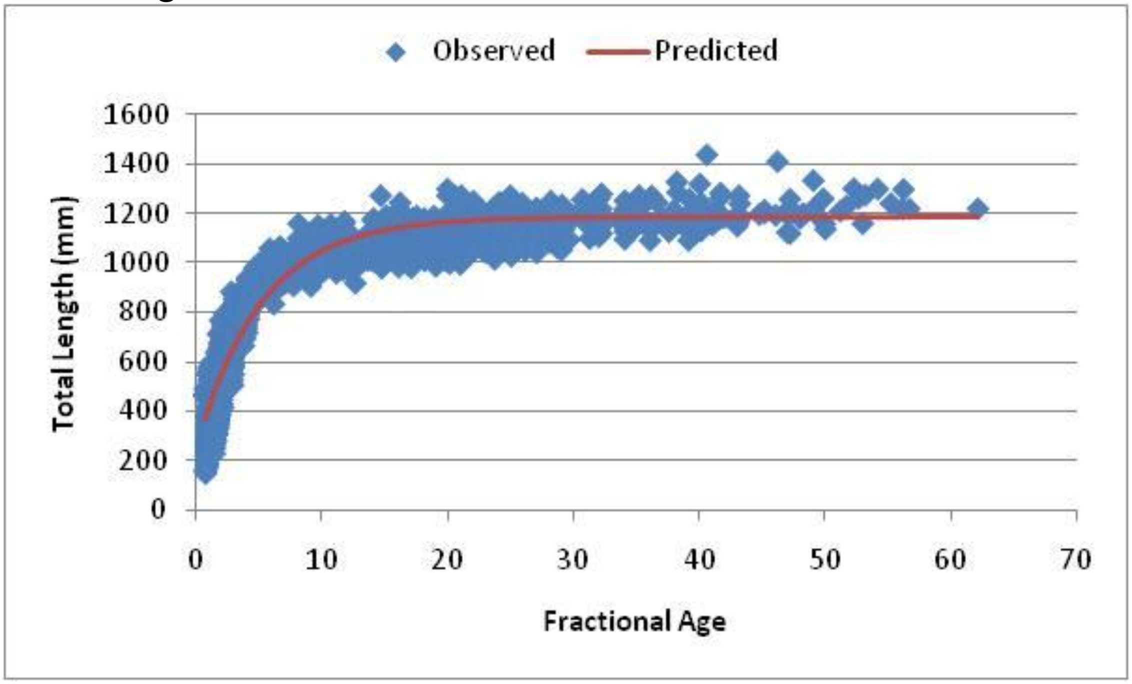

Figure 2.17.1. Observed and predicted total lengths from the regular von Bertalanffy growth model for the northern region (NC/VA).

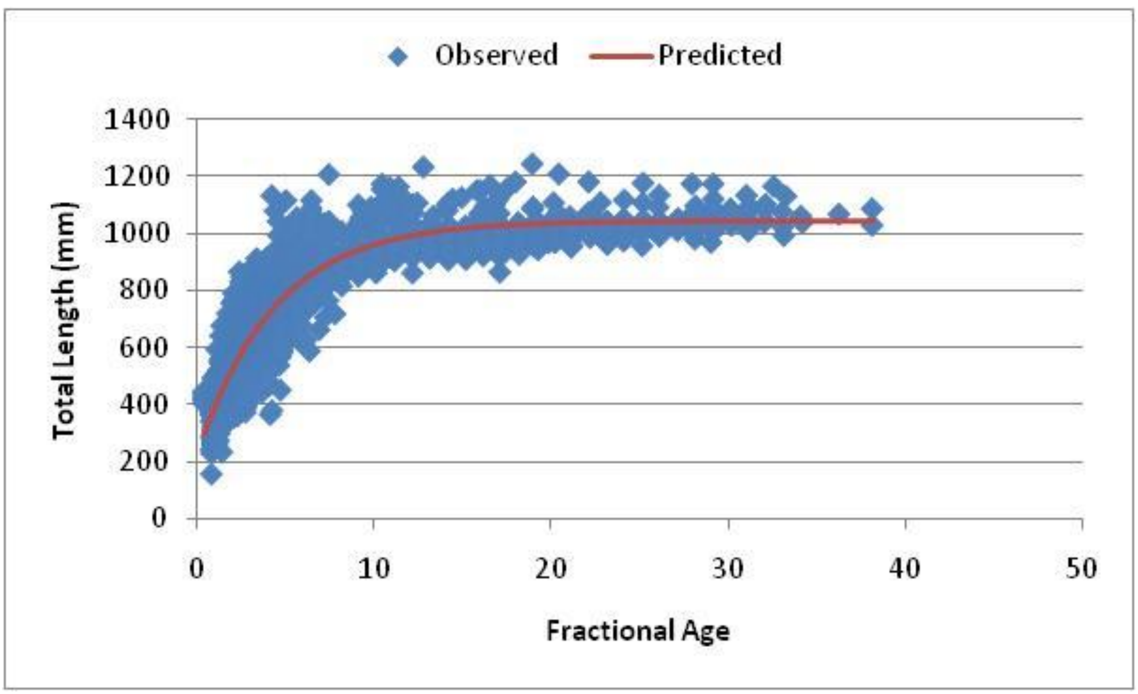

Figure 2.17.2. Observed and predicted total lengths from the regular von Bertalanffy growth model for the southern region (SC/GA/FL).

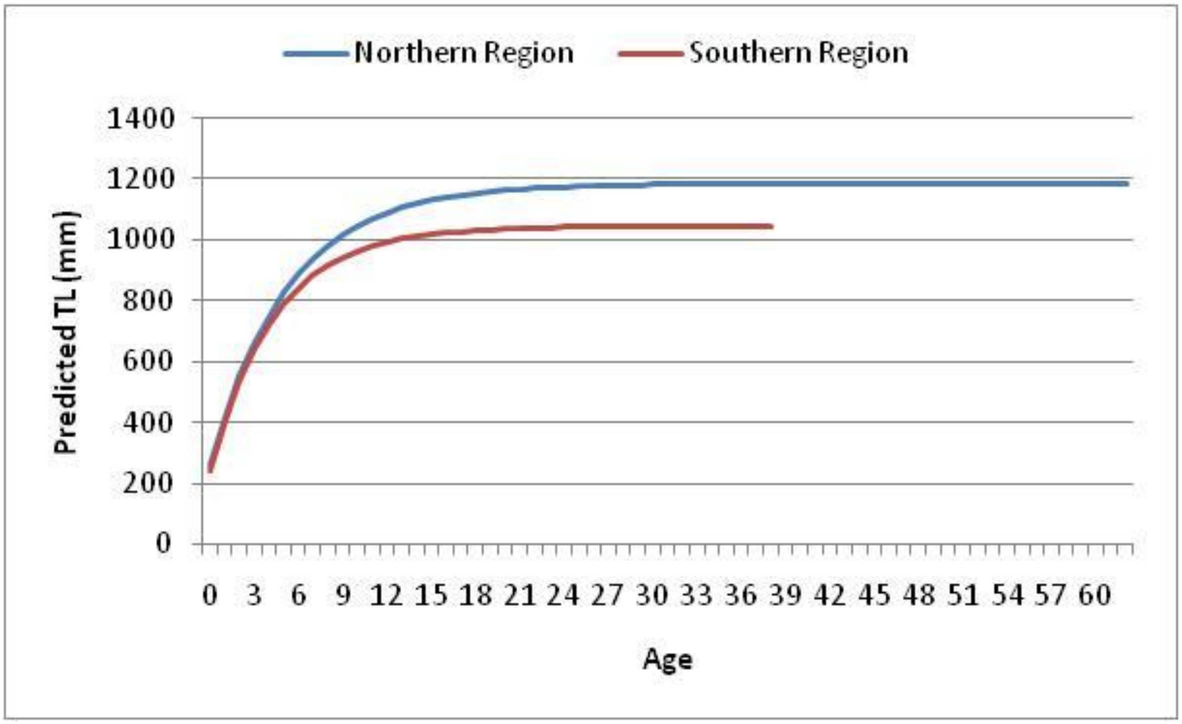

Figure 2.17.3. Comparison of predicted total lengths from von Bertalanffy models by region.

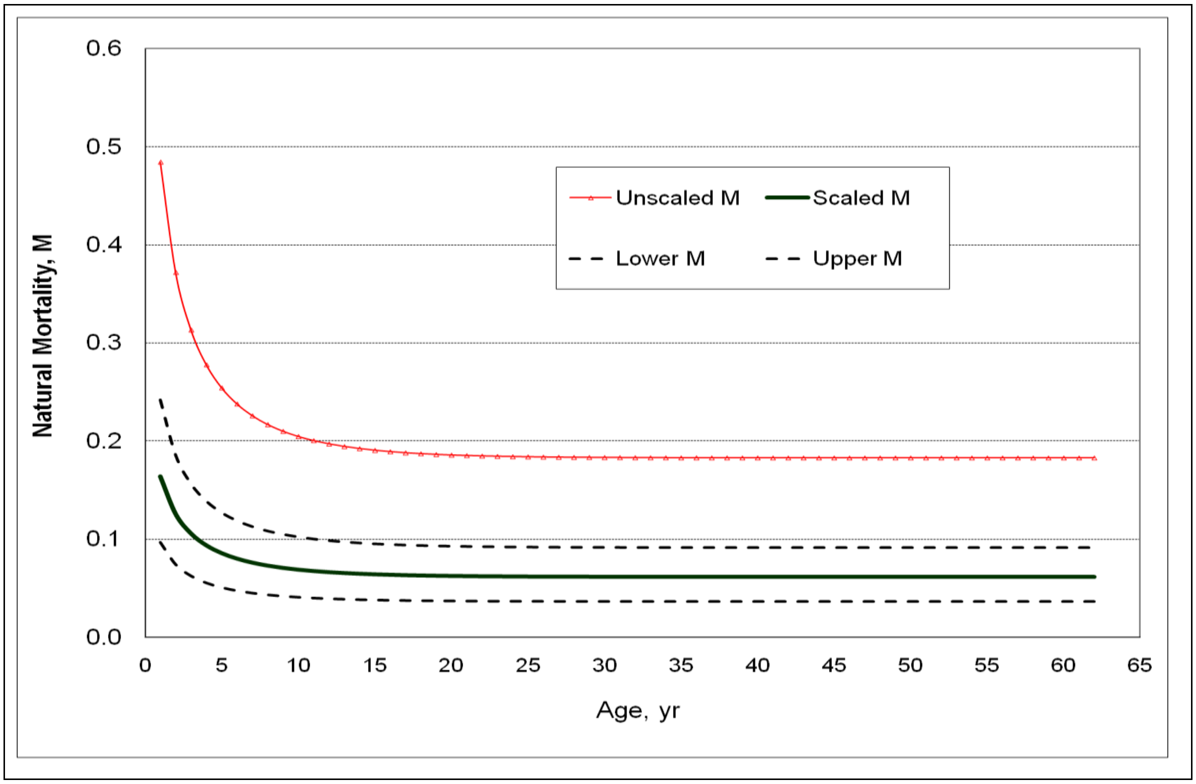

Figure 2.17.4 Comparison of unscaled and scaled estimates of age-varying *M* from the methods of Lorenzen (1996) based on growth predicted by the von Bertalanffy growth equation as applied to age and length data from the North Region. Scaled estimates assume a cumulative survival through maximum age equivalent to a constant Hoenig *M* (0.067). Also includes lower and upper range when scaled to range in Hoenig *M* (0.04, 0.10).

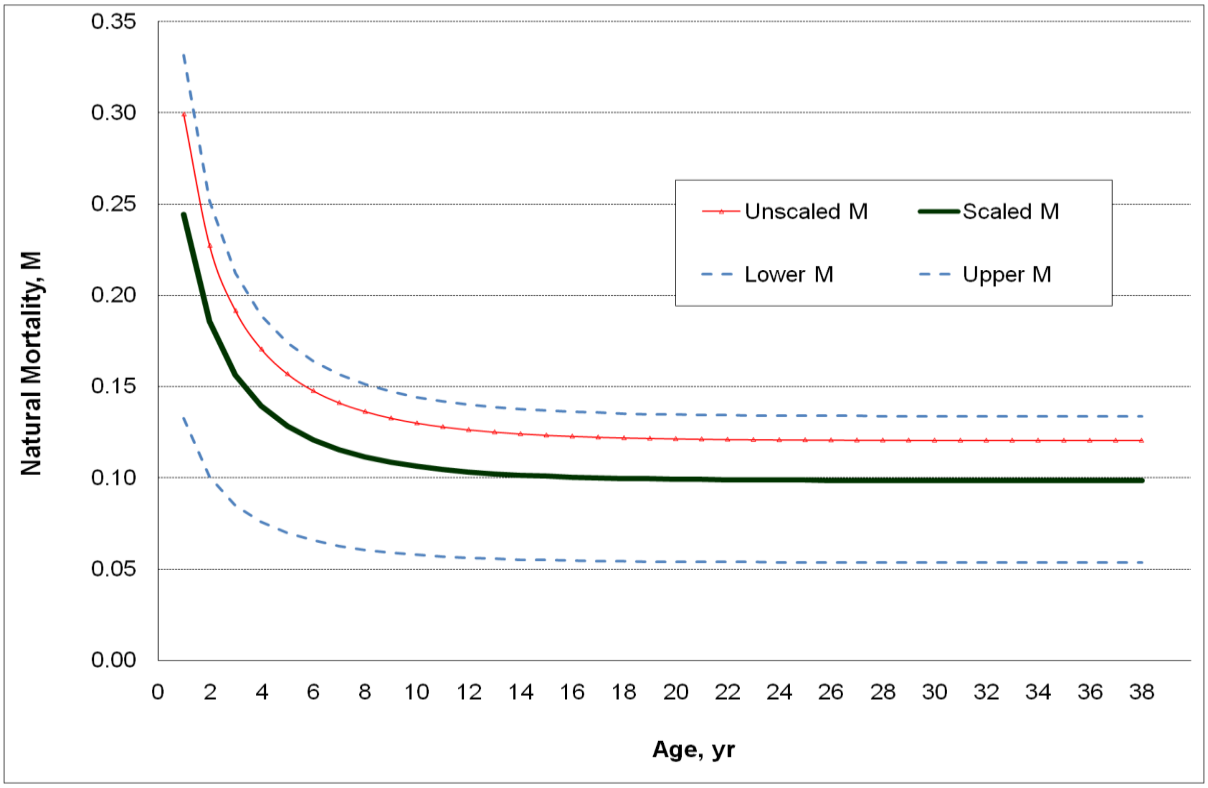

Figure 2.17.5 Comparison of unscaled and scaled estimates of age-varying *M* from the methods of Lorenzen (1996) based on growth predicted by the von Bertalanffy growth equation as applied to age and length data from the South Region. Scaled estimates assume a cumulative survival through maximum age equivalent to a constant Hoenig *M* (0.11). Also includes lower and upper range when scaled to range in Hoenig *M* (0.06, 0.15).

3. Commercial Fisheries

3.1 Overview

Commercial landings of red drum are available from all states located on the east coast of the United States from Florida to Massachusetts. Historical commercial landings data for red drum were explored to address several issues. These issues included: (1) geographic stock boundaries, (2) historical perspective of landings data (duration of data for stock assessment), (3) grouping of commercial gears for pooling landings, (4) final presentation of landings by gear in pounds (whole weight) and in numbers based on state and federal data, (5) estimates of discards in numbers from commercial gill net fishery where available, (6) length and age compositions sampled from commercial fisheries, and (7) research needs.

3.1.1 Group Membership

Lee Paramore (Leader) ....NCDMF
Stephanie McInerny...............NCDMF
Julie Defilippi.........................ACCSP
Doug Vaughan ....SEFSC
Joe Grist ....VMRC
Karl Brenkert ....SCDNR

3.2 Review of Working Papers

S18-DW08

Title: Reported commercial landings of red drum in Florida and estimated annual length and age composition.

Author: Murphy, M.D.

Abstract (written by group):

Commercial landings were obtained from the National Marine Fisheries Service and the Florida Fish and Wildlife Conservation Commission from 1950 to 1988. Annual commercial harvest of red drum in Florida was sporadically available between 1889 and the late 1920s and during the 1940s but only consistently since 1950. No commercial landings have been reported for Florida since 1988 when the sale of native-caught red drum was prohibited. From 1950 to 1988, the dominant commercial fishing gear used to capture red drum had consistently been gill nets. Biostatistics data were opportunistically collected during a red drum life history study conducted during the period 1981-1983 and during supplemental sampling of commercial gears in 1987 and 1988 while conducting tagging operations. An age length key comprised of all commercially-caught, aged, and measured red drum during 1981-1988 was applied to annual length frequencies to estimate the age composition of the commercial landings each year. The number of red drum landed from each age group during 1981-1988 was estimated by applying age-length keys to estimated length frequencies to generate year-specific landings age frequencies.

Discussion:

This document provided in-depth detail of commercial data sources for Florida age and length samples as well as methods for calculating catch at age information. The commercial workgroup found this document very useful and have decided to use the catch at age data for Florida provided in S18-DW08 as input into the assessment model.

S18-DW16

Title: An Estimate of Red Drum Removals from the North Carolina Estuarine Gill Net Fishery Occurring from both Recreational Users of Gill Nets and from Regulatory and Unmarketable Discards.

Author: Lee Paramore

Abstract (written by group)

This paper reviewed red drum removals (other than harvest) from estuarine gill net fisheries (commercial and recreational) in North Carolina and also provides an estimate for red drum harvested through the use of 'recreational' gill nets. Both the commercial and recreational fisheries used the same gear types for large and small mesh gill nets, the main difference being that the amount of net allowed for recreational users is significantly less than that of commercial nets. Survey estimates of recreational harvest of red drum were available for the period of 2002 to 2006. Recreational landings of red drum with gill nets ranged from 4,245 lbs in 2003 to 9,893 lbs in 2002. Total red drum removals (commercial and recreational) associated with unmarketable or regulatory discards were estimated for all gill nets combined for the period of 2004 to 2006. These data represent the only commercial discard data presently available and were estimated for both numbers and weight. Estimated discard mortalities in the estuarine gill net fishery were between 20,142 lbs in 2005 and 68,997 lbs in 2006. This represents approximately 22% to 54% of the total annual commercial harvest in pounds for North Carolina.

Discussion:

The Workshop Panel accepted estimates of discards from the North Carolina estuarine gill net fishery and recommended that extrapolation may be possible within the management period using a ratio with commercial estuarine gill net landings. The Workshop Panel also accepted discard estimates of recreational landings from gill nets for the period of 2002 to 2007 and recommended that extrapolation may be possible within the management period using a ratio with commercial estuarine gill net landings.

3.3 Commercial Landings and Catch Trends

Decision 1. Because red drum landings rarely occur south of Martin County, the Dade/Monroe County line was recommended as the southern boundary for red drum landings along the US Atlantic coast. This avoids landings from the Gulf coast being counted towards the Atlantic stock.

Decision 2. Data were available for all states back to 1950. The Commercial Workgroup recommended that estimates of commercial landings be extended back to 1950 for potential use in assessments. Historical landings back to 1887 are available for some states and can be use to provide a historical perspective (i.e. North Carolina and Florida).

Decision 3. The Commercial Workgroup recommended that landings by fishing gear be reduced to six categories: gill nets, haul seines, pound nets, beach seines, trawls, and hook and line. The small percentage (typically less than 1%) from miscellaneous other gears can be pooled with gill nets.

3.3.1 Atlantic Coastal Cooperative Statistics Program (ACCSP) Warehouse

Historical commercial landings (1950 to present) for the Atlantic coast are maintained in the Atlantic Coastal Cooperative Statistics Program (ACCSP) Data Warehouse. The Data Warehouse was queried on 09 February 2009 for all red drum landings (monthly summaries by state and gear category) from 1950 to 2007 for Florida (east coast), Georgia, South Carolina, Virginia, Maryland, Delaware, New Jersey, New York, Rhode Island, and Massachusetts (ACCSP 2009). The gear categories were decided upon by the working group based on knowledge of the fisheries and reporting tendencies. The specific ACCSP gears included in each category can be found in Table 3.1. Commercial landings of red drum from the North Carolina Trip Ticket Program (NCTTP) and those in the ACCSP data warehouse for North Carolina did not match when broken down by gear; therefore commercial landings data provided by the NCTTP were preferred. Florida landings of red drum in numbers and pounds were also provided by the Florida Fish and Wildlife Conservation Commission (FWC) for 1950 to 1988 (SEDAR18-DW08). These data from Florida were preferred to those from the ACCSP data warehouse. A description of how landings data have been collected by the state of Virginia is provided below:

Virginia – The National Marine Fisheries Service (NMFS) collected landings data for Virginia from 1929 through the present. From 1973 to 1992, Virginia implemented a voluntary monthly inshore dealer reporting system. However, it was discovered that better inshore harvest data were required so the Virginia Marine Resources Commission (VMRC) implemented a Mandatory Reporting Program (MRP) that began January 1, 1993. The program currently is a complete census of all commercial inshore and offshore harvest in a daily format. Data collected are species type, date of harvest, species (unit and amount), gear type, gear (amount and length), area fished, dealer, vessel (name and number), hours fished (man and gear), crew amount, and county landed.

In 2001, several fields listed above (gear length, man hours, vessel information: name and number, and crew amounts) were added to come in compliance with the Atlantic Coastal Cooperative Statistical Program (ACCSP) identified critical data elements. Also data collection gaps in the NMFS offshore collection program were identified and all offshore harvest that was not a federally permitted species or sold to a federally permitted dealer was added to the MRP. The MRP reports are collected on daily trip tickets annually distributed to all commercially licensed harvesters and aquaculture product owners. All harvesters and product owners must report everything harvested and retained on the daily tickets. The daily tickets are put in monthly folders and submitted to VMRC. The monthly folders are provided by the VMRC and due by the 5th of the following month.

Decision 4. Due to discrepancies in landings data by gear reported from the North Carolina Trip Ticket Program and data queried from the ACCSP warehouse, it was decided to use landings data provided directly from North Carolina. Florida also directly provided landings through working paper S18-DW08. ACCSP provided all other commercial landings data and no discrepancies were found.

3.3.2 Commercial Landings Developed from State Databases

North Carolina – The National Marine Fisheries Service, prior to 1978, collected commercial landings data for North Carolina. Port agents would conduct monthly surveys of the state's major commercial seafood dealers to determine the commercial landings for the state. Starting in 1978, the North Carolina Division of Marine Fisheries entered into a cooperative program with the National Marine Fisheries Service to maintain the monthly surveys of North Carolina's major commercial seafood dealers and to obtain data from more dealers. The North Carolina Division of Marine Fisheries Trip Ticket Program (NCTTP) began on 1 January 1994. The NCTTP was initiated due to a decrease in cooperation in reporting under the voluntary NMFS/North Carolina Cooperative Statistics Program in place prior to 1994, as well as an increase in demand for complete and accurate trip-level commercial harvest statistics by fisheries managers. The detailed data obtained through the NCTTP allows for the calculation of effort (i.e. trips, licenses, participants, vessels) in a given fishery that was not available prior to 1994 and provides a much more detailed record of North Carolina's seafood harvest. Annual landings of red drum were calculated for the SEDAR 18 Data Workshop for North Carolina and reported in pounds (whole weight) broken down by month and gear categories developed by the Commercial Workgroup. The annual landings are reported on an annual basis of January through December. Data used to calculate the annual landings for North Carolina from 1950 to 2007 included landings from the NCTTP (1994 to 2007), landings from NMFS (1978 to 1993), and landings from historical data (prior to 1978). Prior to 1972, monthly landings were not recorded for North Carolina.

Florida – Commercial harvest information was obtained from the FWC's Marine Fisheries Information System data and from the Fisheries Statistics Division of the National Marine Fisheries Service (NMFS) for the years 1950 to 1988. Earlier records came from various publications of Fisheries Statistics of the United States. No commercial landings have been reported for Florida since 1988 when the sale of native-caught red drum was prohibited. These data include annual landings tallied from monthly dealer reports collected by the NMFS during the period 1950 to 1985 and trip-specific commercial landings reported within the FWC trip ticket program during the period 1986 to 1988. Florida trip tickets examined included edited batches 1 – 981.

Prior to 1986, landings of red drum were reported to the NMFS through monthly dealer reports made by major fish wholesalers in Florida. Since 1986, information on what is landed and by who in Florida's commercial fisheries comes from the FWC's Marine Resources Information System, commonly known as the trip-ticket program. Wholesale dealers are required to use trip tickets to report their purchase of saltwater products from commercial fishers. Conversely, commercial fishers must have Saltwater Products Licenses to sell saltwater products to licensed wholesale dealers. In addition, red drum became a "restricted species" in late 1987 so only fishers who had Restricted Species Endorsements on their Saltwater Products License qualified to sell red drum (though commercial fishing effectively ended beginning in 1988). Each trip ticket includes the Saltwater Products License number, the wholesale dealer license number, the date of the sale, the gear used, trip duration (time away from the dock), area fished, depth fished, number of traps or number of sets where applicable, species landed, quantity landed, and price paid per pound. During the early years of the program some data field were deleted from the records, e.g. Saltwater Products License number for much of 1986, or were not collected, e.g., gear used was not a data field until about 1991. Annual commercial harvest of red drum in Florida was sporadically available between 1889 and the late 1920's and during the 1940's but consistently since 1950. There was a clear increase in landings between the historic period and the early 1980's; landings averaged 0.07 million pounds during 1927 to 1940 and 0.13 million pounds during 1975 to 1984 (Table 1, Fig. 1). During the mid-1980's the commercial fisheries faced tightening restrictions resulting in declining landings prior to being prohibited after 1987.

3.3.3 Coastwide Landings in Pounds

Commercial landings in pounds (whole weight) were summarized by state (Figure 3.1), region (Table 3.1 and Figure 3.2), and gear (Table 3.2 and Figure 3.3). The Northern region, responsible for 62% of the total red drum landings from 1950 to 2007, included coastal Atlantic US States from North Carolina to Massachusetts. The Southern region, responsible for only 38% of the total landings, included South Carolina, Georgia, and east coast Florida. Landings of red drum were predominantly from North Carolina; however, Florida reported a large portion of the landings from 1950 to 1988 before the sale of native-caught red drum in Florida was prohibited (Figure 3.1). The dominant gear harvesting red drum was gill nets, however, beach seines appeared to dominate the landings from 1950 to 1962 (Figure 3.3). The decline in beach seine landings and the increase in gill net landings over the years from 1950 to 2007 may suggest a shift in gear preference by fishermen harvesting red drum. Pound nets, seines, and trawls were also on the decline during this time period. Overall, red drum commercial landings averaged 249,000 pounds (whole weight) between 1950 and 2007.

3.3.4 Coastwide Landings in Numbers

Conversion of commercial landings in weight to numbers is based on mean weights obtained from dependent commercial sampling by North Carolina and Virginia for the northern region and Florida for the southern region. All sampled lengths were converted to weights using the weight-length relationship given by the Life History Workgroup. When length samples were inadequate (n<20) by gear and year, a weighted average was obtained by pooling across gears within a year. Further pooling across years was necessary in some cases. In these situations, pooling was limited to periods of constant size regulations. For hook and line gears, mean weights and length frequency distributions from the MRFSS were used when sampling was inadequate for a given year. During the early 1980's, pooling was required across both gear and year to obtain an adequate sample size in both North Carolina and Virginia (Table 3.4 and Table 3.6). Since the late 1980's, sampling was adequate for the majority of the landings (i.e. gill nets from North Carolina). Mean weights from Florida for the period of 1981 to 1988 are provided in Table 3.8 with details of the analysis provided in working paper S18-DW08. Landings in numbers were reported for North Carolina (Table 3.5), Virginia and all states north (Table 3.7), and Florida (Table 3.9).

Decision 5. It was agreed by the Workshop Panel that landings, mean weights, and conversions of lengths to ages for the commercial catch would be done annually with one inch size bins due to the limited length data by gear for many years.

Decision 6. The Workshop Panel recommended that length bins contain a minimum of 20 lengths per bin to describe commercial gears for any given year. When adequate lengths are not available, lengths will be substituted from other sampled gears within the same year. Collapsing lengths across years within a management period will occur if no appropriate gear is available for substitution.

Decision 7. Because no biological sampling data is available for SC or GA, mean weights and length distributions will be needed to describe limited commercial landings from these states. Hook and line gear will be described by state specific MRFSS sampling. For the period of 1981 to 1985, it was recommended to use available length and mean weight data from Florida during a period when these states had similar size regulations. Remaining years (1986-1988) will be described with commercial length data from North Carolina.

3.4 Commercial Discards and Discard Trends

The only available data on commercial discards for red drum were provided in the working paper S18-DW16. This working paper provided details from an observer program conducted in North Carolina from 2001 to 2006. Observer coverage was deemed adequate for the years of 2004 to 2006 because these years had expanded coverage by season and area making statewide estimates possible. Discard estimates were calculated by area and season for both large and small mesh gill nets. CPUE was defined as the number (or weight) of dead red drum observed per trip. In addition, a 10% release mortality was added for all red drum released alive. Extrapolation by area and season was then made by multiplying the CPUE by the number trips made for both large and small mesh gill nets from the NC Trip Ticket Program. Estimated discard mortalities from estuarine gill nets ranged from 20,142 lbs in 2004 to 68,997 lbs in 2006. This represented between 22% and 54% of the commercial harvest (all gears combined) for these years (Table 3.10). By number, dead red drum discards represented between 86% and 103% of the annual commercial harvest (Table 3.11). Length frequency distributions, weighted by area and season where samples were adequate, were calculated for 2004 to 2006 (Figure 3.4). The length distribution for dead discards was bimodal with the majority of the fish being sub-legal (<18 inches TL). The second, smaller mode was for legal size fish (~24 inches TL). These two modes represented primarily age-1 and age-2 red drum.

Decision 8. The Workshop Panel accepted estimates of discards from the North Carolina estuarine gill net fishery from 2004 to 2006 and recommended that extrapolation may be possible within the management period using a ratio with commercial estuarine gill net landings.

Decision 9. The Workshop Panel accepted discard estimates of recreational landings from gill nets for the period of 2002 to 2007 and recommended that extrapolation may be possible within the management period using a ratio with commercial estuarine gill net landings.

3.5 Commercial Effort

Trip level commercial data were available from North Carolina (1994 to 2007) and Virginia (1993 to 2007), however, catch effort data from the red drum commercial fishery were confounded by trip limits put into place in 1992 for Virginia and in 1998 for North Carolina (S18-DW03). Trip level information was also available in Florida but only for the years 1986 to 1988. After 1988, the sale of native caught red drum in Florida became prohibited.

3.6 Biological Sampling

3.6.1 Sampling Methods

Virginia - In 1989 a biological sampling program (BSP) was initiated, with the intention of establishing a long-term database with biological data (lengths, weights, sex and age composition) from the commercial finfish fishery in Virginia. Sampled species were chosen if there was a current or upcoming management plan, either for Virginia, the Chesapeake Bay or interstate or federal, or if the species was managed by regulation. Species were ranked, by commercial landings in Virginia, and the ranking was used as a second criterion for sampling. Red drum have been sampled (for length and weight) since the program's inception. Since 1998 VMRC has been in a cooperative agreement with Old Dominion University Center for Quantitative Fisheries Ecology Laboratory (CQFE). All ageing of finfish collected by the BSP are processed by CQFE.

Field sampling at fish processing houses or dealers involved multi-stage random sampling. Targets were set per species based on mandatory reporting of harvest data by harvesters from the previous years. A three year moving average of landings by gear and by month (or other temporal segment) provided a preliminary goal for the amount of length and weight samples to be collected. Real time landings were used to adjust the preliminary targets. Targets for aging samples were tracked and collection updates were done weekly. The goal of otolith collection was to correspond to the frequency distribution in lengths from past seasons, according to 1-inch length bins. Methods for processing and aging of otoliths are provided in the Life History Section.

Subsamples of a catch or batch were processed for sex information (gender and gonadal maturity or spawning condition index). Such subsamples were indexed by visual inspection of the gonads. Females were indexed as gonadal stage I-V with males as I-IV. Stage I represents an immature or resting stage of gonadal development and stages IV (males) and V (females) represent spent fish. Fish that cannot be accurately categorized, in terms of spawning condition, were not assigned a gonadal maturity stage.

Ancillary data, for fish sampled at dealers, were also collected and included: species grade or market category, harvest area, gear type used, and total catch by species market category. This information allowed for the expansion of sample size to the total harvest reported for a species. Market category and species grade are not typical for red drum.

North Carolina - Commercial length frequency data were obtained by the NCDMF commercial fisheries dependent sampling program. Red drum lengths were collected at local fish houses by gear, market grade (not typical for red drum), and area fished. Individual fish were measured (mm, FL) and total weight (0.1 kg) of all fish measured in aggregate was obtained. Subsequent to sampling a portion of the catch, the total weight of the catch by species and market grade was obtained for each trip, either by using the trip ticket weights or some other reliable estimate. Length frequencies obtained from a sample were then expanded to the total catch using the total weights from the trip ticket. All expanded catches were then combined to describe a given commercial gear for a specified time period. Major commercial gears for North Carolina are gill net, long haul seine, and pound net. Commercial samples were taken throughout the year and from all areas where red drum were landed. Dependent length frequency data for red drum in North Carolina began in the early 1980's. Data adequate to describe the major fisheries is available beginning in the late 1980's.

South Carolina – No biological sampling data were provided for South Carolina commercial landings. South Carolina had landings for the period of 1981 to 1987, primarily from gill nets, hook and line, and trawls. Annual landings (all gears combined) ranged from 808 lbs in 1981 to 14,689 lbs in 1987. After 1987, commercial sale of red drum in South Carolina was prohibited.

Georgia - No biological sampling data were provided for Georgia commercial landings. During the 1980's, landings were primarily from hook and line, gill nets, and trawls. Since 1989, landings were almost exclusively from hook and line. Overall, landings have been low ranging from 19 lbs in 2008 to 4,565 lbs in 1987.

Florida – Commercial length frequency data from Florida were obtained from the Florida FWC and are summarized in the working paper S18-DW08. In summary, biostatistics data were opportunistically collected during a red drum life history study conducted during the period 1981to 1983 (Murphy and Taylor 1990) and during supplemental sampling of commercial gears in 1987 and 1988 while conducting tagging operations (Table 3.8). Generally, individual fish lengths, gear type, and date were recorded at the very least, with more in depth sample processing for sex, weight, and aging parts for life history research and for mortalities observed during tagging operations.

3.6.2 Sampling Intensity Length/Age/Weight

Sampling intensity to describe the commercial harvest was evaluated based on the number of lengths collected by gear and year for each of the states providing commercial length data. A minimum threshold of 20 lengths was set by the Data Workshop Panel to describe a gear by year.

Virginia – Landings in Virginia were small relative to North Carolina and since 1981 have typically accountted for less than less than 5% of the coastwide total (Figure 3.1). As a result of the low landings, commercial sampling for lengths from Virginia was relatively poor throughout the time series of 1981 to 2007 (Table 3.13).

North Carolina - Since the late 1980's North Carolina has been the major commercial harvester of red drum typically accounting for >90% of the coast wide annual landings (Figure 3.1). Length sampling in North Carolina was relatively poor for most gears from 1981 through 1988. Since 1989, greater than 70% of the harvest has been represented by adequate length sampling ($n \geq 20$). For most years, particularly since 1992, this total exceeded 95% (Table 3.12).

Available age and weight data were combined from both North Carolina and Virginia for the development of annual age length keys and length-weight conversions (see Life History Section 2.10 for details). A single length-weight conversion was calculated for the entire period (n=6,316 individuals). Annual age-length keys using 1-inch length bins were developed for each year where data were available. This included every year from 1988 to 2007. Annual age length keys had sample sizes ranging from 175 to 687 fish per year. A pooled key (across all years) was used for years 1981 to 1988. The pooled key was also used to fill any wholes by size bin in the annual keys.

Florida – The adequacy of length, age, and weight data for Florida are described in working paper S18-DW08. In summary, Florida was a major contributor to commercial landings from 1981to 1987 (Figure 3.1). Length, age, and weight data were sampled for major commercial gears (gill net, hook and line, seine, and trammel net) from 1981to 1983. Additional trammel net lengths were obtained in 1987 and 1988. Mean weight by gear and year was obtained from either fish that were directly weighed for whole weight or from all red drum measured (and then converted to weight). Sampling for length data only exceeded the minimum threshold ($n \geq 20$) from 1981 to 1983 for gill nets and trammel nets and in 1982 for hook and line and seines. Where sampling was deemed inadequate for either lengths or mean weights, extrapolations and interpolations by gear and year were required. Annual age length keys for Florida were not generated due to low sample sizes. Age data (n=593 individuals) for Florida were pooled across gears and years for the period of 1981to 1988. Missing data (age 10 and age 12 fish) were filled with age-length data from angler catches.

South Carolina and Georgia – No biological sampling of red drum occurred for either South Carolina or Georgia. Biological length data from Florida will be used to describe commercial landings from 1981 to 1985 during a time when size limits were similar between the states. All hook and line landings for the entire time series will be described from state specific recreationally sampled fish in the MRFSS survey. Additional commercial landings after 1985 will be described using available length data from North Carolina. While data are limited from South Carolina and Georgia, the overall contribution of these states is low for the southern region (South Carolina and south) where Florida accounted for >90% of the landings from 1981 to 1985. Annual age-length keys for the south region are described in the Life History (Section 2.0) and will be used to derive the age composition for commercially captured red drum in these two states.

3.6.3 Length/Age Distributions

Length distributions for the northern region were derived from commercial length data provided from North Carolina and Virginia. All length distributions were described annually in one inch length bins with the length bin provided representing the floor (i.e. 15 inches = 15.0 to 15.99). As previously described, a minimum of 20 lengths by year and gear were required to represent a gear. Collapsing occurred first across gears within a year and secondly across years within a uniform management period (i.e. constant size limit). An annual age length key representing the northern region (North Carolina and north) was developed using all available age data from North Carolina and Virginia (see Life History Section for details). Any 'holes' in the age-length key were filled using a pooled (across all years) key.

Length and age distributions for the northern region are presented by major gear in Table 3.14 and Table 3.15 respectively. For the length distributions, all gears showed a notable shift towards larger fish, particularly after 1991 when both North Carolina and Virginia implemented a minimum size limit change from 14 to 18 inches total length. Likewise, the harvest of larger red drum has declined as harvest and sale of federally harvested adult red drum became illegal after 1992 in North Carolina. Similar to shifts in the length distributions, a notable shift in the age distribution from age-1 to age-2 fish was noted in 1992. Current commercial harvest of red drum within the existing slot limits is primarily on age-2 and to a lesser extent age-3 fish.

Length and age distributions for Florida are fully described in working paper SEDAR18-DW08.

The length and age distribution for South Carolina and Georgia will be derived as previously described in Section 3.6.2.

3.6.4 Adequacy for Characterizing Catch

Available length data by gear for the northern region are available in Table 3.12 for North Carolina and Table 3.13 for Virginia. Based on the minimum criteria of 20 lengths per year by gear, sampling was particularly poor prior to 1989. Previous assessments modeled the red drum population using virtual population analysis and utilized available length data from 1986 forward (Vaughan and Carmichael 2000). Since 1989, commercial sampling has been adequate to describe the vast majority of landings with length substitutions limited to minor gears.

Age data from all sources (commercial, recreational, and independent) for the northern region were combined to generate annual age length keys. Weighted length frequency distributions by gear and year were then applied to the annual age length keys. Since 1988, annual age length keys have typically had sample sizes exceeding 300 fish. A pooled key (across years) was used to fill holes where the sample size in a single length bin was less than 10 fish.

Available length, weight, and age data for Florida are fully described in working paper SEDAR18-DW08. Commercial landings occurred in Florida from 1981 to 1988,

however most length data for the major gears was only available for 1981 to 1983. Pooling using data from 1981 to 1983 was required to provide length and age distributions by gear for the entire period.
No data exists from either SC or GA to describe their commercial landings. Gear specific length and age distributions for these states will be developed using the assumptions described in Section 3.6.2.

3.6.5 Alternatives for Characterizing Discard Length/Age

Currently, the only available data to describe commercial discards are from the North Carolina estuarine gill net fishery for the period of 2004 to 2006. All available data and analysis are described in the working paper S18-DW16. The North Carolina estuarine gill net fishery is presumed to be the primary culprit of commercial red drum discards in North Carolina. The commercial working group has suggested that methods should be investigated to extrapolate discard estimates out for the entire regulatory period. For North Carolina, the current period of 1999 to 2007 has consistent regulations dealing with commercial size and trip limits, as well as regulations relative to the use of commercial gill nets. Prior to this period, extrapolation becomes more difficult due to decreased regulation in the gill net fishery and no trip limits in the commercial red drum fishery.

3.7 Commercial Workgroup Catch-at-Age/Length – directed and discard

3.8 Comments on Adequacy of Data for Assessment Analysis

3.9 Commercial Workgroup Research Recommendations

- Continued and expanded observer coverage for the NC and VA gill net fisheries (5-10% coverage).
- Expand observer coverage to include other gears of concern (i.e. haul seine, pound net, trawls).
- Expand biostatistical sampling (ages and lengths) to better cover all statistical strata (gears/states - principally NC and VA) – more ages proportional to lengths, preferably otoliths.

3.10 Tasks for Completion following Data Workshop

Complete workup of age and length distributions for South Carolina and Georgia (Lee Paramore; by May 1, 2009)

3.11 Literature Cited

Atlantic Coastal Cooperative Statistics Program. 2009. (1950-2007) Annual landings by state and custom gear category; generated by Julie Defilippi; using ACCSP Data Warehouse, Washington, D.C: accessed February 9-13, 2009.

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.

3.12 Tables

Table 3.1. ACCSP gears included in each of the SEDAR 18 gear categories.

SEDAR18 CATEGORY	ACCSP		
	GEAR_CODE	GEAR_NAME	CATEGORY_NAME
Beach Seine	20	Other Seines	Other Seines
Beach Seine	76	Stop Net	Other Fixed Nets
Gill Nets	132	Pots and Traps, Blue Crab	Pots and Traps
Gill Nets	138	Pots and Traps, Eel	Pots and Traps
Gill Nets	139	Pots and Traps, Fish	Pots and Traps
Gill Nets	162	Pots and Traps, Lobster Offshore	Pots & Traps, Lobster
Gill Nets	180	Pots and Traps, Other	Pots & Traps, Other
Gill Nets	200	Gill Nets	Gill Nets
Gill Nets	201	Gill Nets, Floating Drift	Gill Nets
Gill Nets	204	Gill Nets, Sink Anchor	Gill Nets
Gill Nets	205	Gill Nets, Runaround	Gill Nets
Gill Nets	206	Gill Nets, Stake	Gill Nets
Gill Nets	207	Gill Nets, Other	Gill Nets
Gill Nets	210	Trammel Nets	Trammel Nets
Hook and Line	300	Hook and Line	Hook and Line
Hook and Line	301	Hook and Line, Manual	Hook and Line
Hook and Line	303	Electric/Hydraulic, Bandit Reels	Hook and Line
Hook and Line	320	Troll Lines	Troll Lines
Hook and Line	660	Spears	Spears
Hook and Line	700	Hand Line	Hand Line
Hook and Line	701	Troll and Hand Lines CMB	Hand Line
Other	0	Not Coded	Not Coded
Other	60	Fyke Nets	Fyke Nets
Other	73	Floating Traps (Shallow)	Other Fixed Nets
Other	74	Bag Nets	Other Fixed Nets
Other	400	Long Lines	Long Lines
Other	401	Long Lines, Vertical	Long Lines
Other	403	Long Lines, Bottom	Long Lines
Other	404	Long Lines, Surface, Midwater	Long Lines
Other	405	Long Lines, Trot	Long Lines
Other	500	Dredge	Dredge
Other	503	Dredge, Clam	Dredge
Other	511	Dredge, New Bedford	Dredge

Table 3.1. (cont.)

Other	551	Cast Nets	Dip Nets
Other	602	Patent Tongs	Tongs
Other	622	Rakes, Oyster	Rakes, Oyster
Other	800	Other Gears	Other Gears
Other	801	Unspecified Gear	Other Gears
Other	802	Combined Gears	Other Gears
Pound Net	50	Pound Nets	Pound Nets
Seine	10	Haul Seines	Haul Seines
Seine	22	Common Seine	Other Seines
Trawls	91	Otter Trawl Bottom, Crab	Otter Trawls
Trawls	92	Otter Trawl Bottom, Fish	Otter Trawls
Trawls	94	Otter Trawl Bottom, Scallop	Otter Trawls
Trawls	95	Otter Trawl Bottom, Shrimp	Otter Trawls
Trawls	96	Otter Trawl Bottom, Other	Otter Trawls
Trawls	97	Otter Trawl Midwater	Otter Trawls
Trawls	110	Other Trawls	Other Trawls

Table 3.2. Red drum commercial landings (pounds, whole weight) by region for the US Atlantic coast. Northern region includes states from Massachusetts to North Carolina. Southern region includes landings from South Carolina, Georgia, and east coast Florida.

Calendar	US Atlantic Coast		
Year	North	South	Total
1950	385,100	242,700	627,800
1951	262,500	275,500	538,000
1952	271,100	216,600	487,700
1953	306,300	196,000	502,300
1954	310,200	169,800	480,000
1955	173,100	169,400	342,500
1956	51,100	164,900	216,000
1957	162,900	108,600	271,500
1958	44,400	102,500	146,900
1959	38,500	131,200	169,700
1960	108,900	133,600	242,500
1961	101,700	116,400	218,100
1962	73,800	149,300	223,100
1963	73,900	134,200	208,100
1964	106,100	130,500	236,600
1965	167,500	146,300	313,800
1966	38,500	155,900	194,400

Table 3.2 (cont.)

1967	13,900	153,800	167,700
1968	12,600	172,500	185,100
1969	5,000	122,400	127,400
1970	7,600	149,400	157,000
1971	17,900	87,700	105,600
1972	48,819	133,000	181,819
1973	77,364	170,800	248,164
1974	158,137	142,700	300,837
1975	234,036	105,700	339,736
1976	186,859	115,900	302,759
1977	20,137	109,300	129,437
1978	24,174	109,353	133,527
1979	128,517	95,402	223,919
1980	243,623	196,300	439,923
1981	93,620	259,443	353,063
1982	54,261	141,649	195,910
1983	261,671	108,564	370,235
1984	285,620	136,796	422,416
1985	153,776	95,982	249,758
1986	255,476	92,438	347,914
1987	252,257	62,247	314,504
1988	232,371	3,565	235,936
1989	283,556	3,963	287,519
1990	184,726	2,763	187,489
1991	128,349	1,629	129,978
1992	131,591	1,759	133,350
1993	246,857	2,533	249,390
1994	152,445	2,129	154,574
1995	251,789	2,578	254,367
1996	116,077	2,271	118,348
1997	56,619	1,426	58,045
1998	301,754	672	302,426
1999	386,304	1,115	387,419
2000	285,098	707	285,805
2001	155,733	128	155,861
2002	90,751	379	91,130
2003	98,802	559	99,361
2004	54,913	357	55,270
2005	130,528	138	130,666
2006	176,771	444	177,215
2007	256,992	119	257,111

Table 3.3. Red drum commercial landings (pounds, whole weight) by gear for the US Atlantic coast (see text for gear descriptions). Landings included from Massachusetts to Florida.

Calendar	US Atlantic Coast							
Year	Beach Seine	Gill Nets	Hook-n-Line	Other Gears	Pound Net	Seines	Trawls	Total
1950	257,600	129,500	112,800	0	103,300	0	24,600	627,800
1951	273,900	94,800	85,300	0	54,500	0	29,500	538,000
1952	277,300	91,700	52,500	0	28,000	0	38,200	487,700
1953	326,500	103,800	32,400	0	9,100	0	30,500	502,300
1954	212,100	103,600	49,600	0	85,200	0	29,500	480,000
1955	128,100	69,400	92,900	0	43,600	0	8,500	342,500
1956	43,100	62,300	102,100	0	7,300	0	1,200	216,000
1957	157,700	40,900	59,300	0	13,200	0	400	271,500
1958	48,900	21,600	55,100	0	19,700	0	1,600	146,900
1959	29,500	49,400	77,100	0	12,200	0	1,500	169,700
1960	105,700	47,500	67,200	0	12,300	0	9,800	242,500
1961	113,400	72,900	23,600	0	2,900	0	5,300	218,100
1962	18,200	96,600	40,100	0	6,400	58,900	2,900	223,100
1963	13,200	90,500	32,400	0	800	69,700	1,500	208,100
1964	49,200	69,900	30,300	0	2,000	84,400	800	236,600
1965	59,600	83,500	41,200	0	71,500	58,000	0	313,800
1966	38,600	86,800	39,100	100	1,300	21,700	6,800	194,400
1967	23,900	100,300	36,000	0	2,000	4,900	600	167,700
1968	29,100	112,800	31,800	0	2,300	7,500	1,600	185,100
1969	9,500	86,200	28,100	0	2,400	1,200	0	127,400
1970	10,400	115,900	26,100	0	600	2,400	1,600	157,000
1971	10,400	73,900	11,500	100	3,700	3,100	2,900	105,600
1972	20,151	100,119	29,000	200	21,193	5,551	5,605	181,819
1973	24,333	153,749	26,300	138	11,664	21,100	10,880	248,164
1974	42,526	115,893	35,800	0	37,946	65,321	3,351	300,837
1975	46,965	92,548	23,638	0	33,809	66,740	76,036	339,736
1976	27,548	132,043	27,700	100	26,630	76,700	12,038	302,759
1977	12,118	79,697	24,300	0	301	11,759	1,262	129,437
1978	800	91,299	17,278	3,875	1,346	4,200	14,729	133,527
1979	500	128,631	27,370	337	9,741	43,200	14,140	223,919
1980	16,409	239,196	29,880	145	29,984	71,382	52,927	439,923
1981	1,012	246,126	41,368	6	36,357	11,102	17,092	353,063
1982	1,542	135,687	28,445	557	4,081	6,947	18,651	195,910
1983	16,754	222,477	26,206	198	36,247	21,065	47,288	370,235
1984	20,555	274,062	29,950	1,082	6,919	20,421	69,427	422,416
1985	4,023	156,857	23,515	904	3,227	13,738	47,494	249,758
1986	7,590	180,521	19,681	214	9,440	71,085	59,383	347,914
1987	9,130	168,041	17,705	2,026	60,832	35,567	21,203	314,504

Table 3.3. (cont.)

Calendar Year	Beach Seine	Gill Nets	Hook-n-Line	US Atlantic Coast Other Gears	Pound Net	Seines	Trawls	Total
1988	12,042	134,747	5,215	431	26,378	23,972	33,151	235,936
1989	15,898	142,572	8,123	100	40,354	56,110	24,362	287,519
1990	27,269	97,977	3,549	153	25,796	18,234	14,511	187,489
1991	13,987	78,606	2,254	154	19,734	4,348	10,895	129,978
1992	2,220	106,313	2,065	0	13,351	6,341	3,060	133,350
1993	10,443	204,504	5,592	31	11,617	10,748	6,455	249,390
1994	2,125	114,588	4,429	122	9,874	16,385	7,051	154,574
1995	6,208	181,283	5,669	130	21,285	38,630	1,162	254,367
1996	4,639	91,896	4,268	400	6,290	9,555	1,300	118,348
1997	2,824	37,452	3,301	204	4,343	9,688	233	58,045
1998	5,931	249,059	5,005	505	4,181	37,618	127	302,426
1999	4,355	358,605	4,607	167	13,627	4,014	2,044	387,419
2000	19,690	246,812	3,770	49	10,338	2,990	2,156	285,805
2001	2,424	141,753	1,617	23	8,638	981	425	155,861
2002	769	76,731	1,321	524	9,427	2,029	329	91,130
2003	979	87,589	928	94	3,786	1,365	4,620	99,361
2004	610	50,600	622	12	2,023	1,306	97	55,270
2005	1,661	117,755	489	533	9,540	638	50	130,666
2006	1,843	159,384	956	5,273	7,304	2,263	192	177,215
2007	1,031	233,584	644	6,731	11,374	3,105	642	257,111

Table 3.4. North Carolina mean weights (in pounds) by gear based on length data provided from state and weight-length relationship. Shaded numbers represent values that were obtained by pooling across gears within a year. Shaded with underline represent further pooling across years within a management period.

Year	Beach Seine	Gill net	Haul Seine	Poundnet	Trawl	Lines*	Other
1981	3.05	3.05	3.05	3.05	3.05	2.01	3.05
1982	3.05	3.05	3.05	3.05	3.05	2.16	3.05
1983	3.05	3.05	0.49	3.05	3.05	1.63	3.05
1984	3.4	3.4	3.4	2.16	3.4	14.7	3.4
1985	3.05	3.05	3.05	3.05	3.05	3.71	3.05
1986	3.05	3.05	3.05	3.05	3.05	11.32	3.05
1987	1.8	1.8	1.8	1.8	1.8	2.39	1.8
1988	2.95	2.95	2.92	2.95	2.95	3.68	2.95
1989	7.31	2.46	12.85	7.31	7.31	3.31	7.31
1990	3.39	2.34	3.62	6.39	3.39	2.76	3.39
1991	2.87	2.7	2.87	6.58	2.87	2.74	2.87
1992	4.87	3.39	5.8	6.71	4.87	4.57	.
1993	5.76	5.64	6.07	5.76	5.76	4.87	5.76
1994	6.19	5.62	7.43	6.19	6.19	6.95	6.19
1995	5.4	5.51	5.28	5.59	5.4	5.06	5.4
1996	5.84	4.98	5.01	5.84	6.44	5.09	5.84
1997	4.29	4.3	4.29	4.29	4.29	4.16	4.29
1998	3.1	3.25	2.87	3.1	3.1	5.43	3.1
1999	6.62	4.57	4.71	5.73	4.71	5.29	4.71
2000	5.87	5.19	4.05	5.26	5.26	5.72	5.26
2001	5.27	5.21	5.27	5.86	5.27	6.48	5.27
2002	4.38	4.28	4.71	4.9	4.38	3.72	4.38
2003	4.49	4.55	4.49	4.49	.	4.83	4.49
2004	4.56	5.58	5.38	5.38	5.38	4.47	5.38
2005	4.55	4.36	4.55	6.38	4.55	5.04	4.55
2006	5.1	4.86	4.89	6.45	4.96	4.69	4.96
2007	4.86	4.81	4.16	5.49	4.86	5.44	4.86

*Mean weights for underlined values acquired from MRFSS sampling.

Table 3.5. Estimated commercial landings (numbers) of red drum from North Carolina during 1981to 2007 by major gear category.

Year	Beach Seine	Gillnet	Haul Seine	Poundnet	Trawl	Lines*	Other	Total
1981	162	9,488	3,640	11,888	5,284	.	169	30,630
1982	349	7,956	2,278	1,109	5,534	12	-	17,236
1983	2,930	41,093	42,582	6,245	14,873	139	32	107,894
1984	5,246	50,613	6,006	3,157	19,140	53	4	84,218
1985	1,085	28,481	4,504	927	14,923	32	98	50,051
1986	1,918	36,697	23,296	2,407	17,259	23	-	81,601
1987	3,357	68,394	19,648	33,296	10,601	2,563	-	137,858
1988	3,845	45,159	8,210	8,230	8,373	751	-	74,566
1989	1,833	56,655	4,367	5,247	3,251	1,015	-	72,367
1990	8,044	41,871	5,037	3,928	4,117	245	-	63,242
1991	1,864	25,109	1,515	1,197	3,495	191	43	33,414
1992	409	31,073	1,093	1,838	474	42	-	34,928
1993	1,478	35,587	1,771	1,559	1,064	618	-	42,078
1994	343	20,369	2,185	851	256	333	20	24,356
1995	1,150	32,791	7,178	3,510	91	613	23	45,355
1996	794	18,307	1,897	853	141	410	8	22,411
1997	658	8,580	2,214	327	36	383	31	12,230
1998	1,913	76,021	12,432	438	24	783	1	91,612
1999	658	77,459	392	1,664	148	465	12	80,799
2000	3,354	46,437	430	891	177	497	9	51,796
2001	460	26,909	94	923	26	143	4	28,560
2002	175	17,166	236	1,128	12	90	24	18,831
2003	218	18,843	238	547	-	46	14	19,906
2004	134	9,024	187	346	13	41	-	9,745
2005	365	26,825	130	1,448	6	53	6	28,833
2006	361	32,556	394	1,033	17	81	18	34,460
2007	212	47,905	530	1,668	49	27	6	50,396

Table 3.6. Virginia mean weights (in pounds) by gear based on length data provided from state and weight-length relationship. Shaded numbers represent values that were obtained by pooling across gears within a year. Shaded with underline represent further pooling across years within a management period. Virginia mean weights were applied to all commercial landings from Virginia and north.

Year	Seines*	Gill net	Pound net	Trawls	Lines**	Other
1981	.	.	1.42	1.42	.	.
1982	.	.	1.42	1.42	.	.
1983	1.42	1.42	1.42	1.42	1.63	.
1984	.	.	1.42	1.42	14.7	1.42
1985	1.42	.	1.42	1.42	3.7	.
1986	1.42	1.42	1.42	1.42	.	.
1987	1.42	1.42	1.42	1.42	.	.
1988	1.42	1.42	1.42	1.42	3.68	.
1989	1.36	1.28	1.36	1.36	3.31	.
1990	.	.	1.42	1.42	2.76	1.42
1991	1.43	1.33	2.03	1.42	2.74	1.42
1992	2.86	2.86	2.86	2.86	4.57	.
1993	7.82	7.82	7.82	7.82	4.87	7.82
1994	9.5	11.1	11.1	11.1	6.95	.
1995	4	3.96	3.96	3.96	5.06	3.96
1996	7.81	7.81	7.81	7.81	5.09	7.81
1997	9.09	9.09	9.09	9.09	4.16	9.09
1998	3.96	3.96	3.4	3.96	5.44	3.96
1999	3.93	8.26	7.95	8.26	5.29	8.26
2000	4.45	9.81	9.81	9.81	5.72	.
2001	15.64	15.64	15.21	15.64	6.48	.
2002	5.01	10.08	11.06	10.08	3.72	10.08
2003	5.56	5.56	5.56	5.56	4.83	5.56
2004	5.24	5.24	5.24	5.24	4.47	5.24
2005	4.08	2.59	4.08	4.08	5.05	4.08
2006	4.31	4.31	4.31	4.31	4.69	4.31
2007	5.77	5.09	5.49	5.09	3.81	5.09

*Beach and Haul Seines were combined for Virginia.
** Mean weights for underlined values acquired from MRFSS sampling.

Table 3.7. Estimated commercial landings (numbers) of red drum for all states from Virginia and north during 1981-2007 by major gear category.

Year	Seines	Gillnet	Poundnet	Trawls	Lines	Other	Total
1981	.	.	70	70	.	.	140
1982	.	.	493	704	.	.	1,197
1983	5,141	10,915	12,113	1,197	61	.	29,428
1984	.	.	70	1,549	14	70	1,704
1985	70	.	282	282	54	.	688
1986	915	423	1,479	1,690	.	.	4,507
1987	775	211	634	211	.	.	1,831
1988	493	70	1,479	5,493	380	.	7,916
1989	1,838	2,500	1,471	441	272	.	6,522
1990	.	.	488	390	72	44	995
1991	6,041	8,129	5,842	573	55	21	20,661
1992	80	342	357	263	25	.	1,067
1993	246	485	337	35	20	4	1,128
1994	16	10	415	490	2	.	933
1995	183	142	420	169	6	2	922
1996	6	93	167	50	10	28	354
1997	21	62	323	0	87	7	500
1998	489	503	831	6	20	127	1,976
1999	551	559	514	163	196	13	1,997
2000	280	592	576	125	38	.	1,611
2001	31	99	212	18	87	.	448
2002	183	324	353	27	163	42	1,091
2003	54	333	239	831	30	5	1,492
2004	57	47	30	5	18	2	160
2005	11	307	74	5	17	124	539
2006	78	270	149	26	29	1,203	1,753
2007	156	621	404	80	99	1,317	2,677

Table 3.8. Florida estimated observed mean weights (pounds) from all red drum measured for length (and converted to weight) or directly weighed for whole weight. The 'Used' mean weights were those actually applied to the estimated gear-specific landings to calculate the numbers of landed red drum by gear. Differences between the observed and 'Used' were due to inadequate sampling or sampling that was known or judged to be biased relative to the commercial landings.

	Gill Net			Hook and Line			Seine			Trammel Net		
Year	N	Obs	Used	N	Obs	Used	N	Obs	Used	N	Obs	Used
1981	649	2.808	2.808	8	19.148	3.98	0		4.759	90	7.154	7.154
1982	1,149	3.731	3.731	80	11.898	6.55	51	4.277	4.277	377	9.416	9.416
1983	108	2.448	2.448	0		5.265	15	6.397	4.277	276	7.213	7.213
1984	0		2.996	0		5.265	0		4.277	0		5.483
1985	0		2.996	0		5.265	0		4.277	0		5.483
1986	0		2.996	0		5.265	0		4.277	0		5.483
1987	0		2.996	0		5.265	0		4.277	14	3.754	3.754
1988	0		2.996	0		5.265	0		4.277	10	4.645	4.645

Table 3.9. Estimated commercial landings (numbers) of red drum for the Atlantic coast of Florida during 1981-1988 by collapsed gear category.

Year	Gill Net	Hook&Line	Seine	Trammel Net	Totals
1981	76,614	10,323	109	229	87,276
1982	29,488	4,230	112	102	33,931
1983	32,310	4,714	121	104	37,248
1984	31,308	5,469	635	1,018	38,431
1985	21,248	4,029	144	629	26,050
1986	19,304	3,205	100	0	22,609
1987	10,547	1,782	464	0	12,793
1988	44	29	0	0	73

Table 3.10. Summary of all estimated mortalities in pounds associated with the estuarine gill net fishery in North Carolina.

	Estuarine Gill Net Dead Discards (lb)			Estuarine Gill Net Mortality from Releases (lb)			RCGL Mortalities (lb)*	Total Discard Mortality (lb)	Combined Commercial Harvest (lb)	% of Commercial Landings
Year	Small Mesh	Large Mesh	Combined	Small Mesh	Large Mesh	Combined	Large Mesh	All		
2004	3,042	12,393	15,435	1,005	2,613	3,618	1,089	20,142	54,086	37%
2005	4,807	54,143	58,950	2,222	6,229	8,451	1,596	68,997	128,770	54%
2006	5,570	27,106	32,676	1,268	3,001	4,269	882	37,827	169,206	22%

*no estimates for RCGL releases or for RCGL small mesh gill nets

Table 3.11. Summary of all estimated mortalities in numbers associated with the estuarine gill net fishery in North Carolina during 2004 and 2005.

	Estuarine Gill Net Dead Discards (number)			Estuarine Gill Net Mortality from Releases (number)			RCGL Mortalities (number)*	Total Discard Mortality (number)	Combined Commercial Harvest** (number)	% of Commercial Landings
Year	Small Mesh	Large Mesh	Combined	Small Mesh	Large Mesh	Combined	Large Mesh	All		
2004	1,112	7,138	8,250	729	1,630	2,359	626	11,235	10,900	103%
2005	3,066	17,925	20,991	1,503	2,844	4,347	528	25,866	30,000	86%

*no estimates for RCGL releases or for RCGL small mesh gill nets
**all gears combined (number generated from stock assessment catch at age analysis)

Table 3.12. Red drum lengths sampled from the commercial fishery in North Carolina and the percent of total harvest that a gear contributed to the overall annual commercial landings. Areas shaded in gray are where less than 20 lengths were acquired in a year. % adequate column represents the percentage of landings that had adequate sampling based on a minimum of 20 lengths by gear and year.

	Beach Seine		Gill Nets		Long Haul		Trawls		Pound Net		Rod-n-Reel*		Others		All
Year	# meas	% Harv	# meas	% Harv	# meas	% Harv	# meas	% Harv	# meas	% Harv	# meas	% Harv	# meas	% Harv	% adequate
1983	1	4%	0	56%	40	10%	0	21%	15	9%	rec A+B1	0%	0	0%	19%
1984	0	6%	14	61%	4	7%	7	23%	26	2%	rec A+B1	0%	0	0%	3%
1985	0	2%	0	57%	2	9%	4	30%	1	2%	rec A+B1	0%	0	0%	0%
1986	0	2%	0	45%	12	29%	5	21%	0	3%	rec A+B1	0%	0	0%	0%
1987	0	2%	0	49%	20	14%	0	8%	2	24%	rec A+B1	2%	0	0%	17%
1988	0	5%	14	60%	29	11%	1	11%	1	11%	rec A+B1	1%	0	0%	12%
1989	0	5%	60	51%	44	20%	8	9%	11	14%	rec A+B1	1%	0	0%	72%
1990	0	15%	398	53%	47	10%	2	8%	69	14%	rec A+B1	0%	0	0%	77%
1991	18	6%	121	71%	10	5%	0	10%	34	8%	rec A+B1	1%	0	0%	79%
1992	6	2%	231	82%	94	5%	1	2%	55	10%	rec A+B1	0%	0	0%	97%
1993	3	4%	546	84%	41	5%	5	3%	8	4%	rec A+B1	1%	0	0%	90%
1994	9	1%	84	81%	42	11%	1	1%	6	4%	rec A+B1	2%	0	0%	94%
1995	0	3%	324	73%	96	15%	1	0%	75	8%	rec A+B1	1%	0	0%	97%
1996	0	4%	31	80%	58	8%	24	1%	7	4%	rec A+B1	2%	0	0%	91%
1997	7	5%	249	70%	7	18%	0	0%	9	3%	rec A+B1	3%	0	0%	73%
1998	0	2%	737	84%	340	12%	0	0%	5	0%	rec A+B1	1%	0	0%	97%
1999	35	1%	903	95%	16	0%	0	0%	54	3%	rec A+B1	1%	0	0%	99%
2000	69	7%	602	89%	23	1%	19	0%	12	2%	rec A+B1	1%	0	0%	98%
2001	1	2%	381	94%	2	0%	2	0%	33	4%	rec A+B1	1%	0	0%	98%
2002	1	1%	393	90%	35	1%	0	0%	38	7%	rec A+B1	0%	0	0%	99%
2003	8	1%	356	95%	18	1%	0	0%	2	3%	rec A+B1	0%	0	0%	95%
2004	57	1%	259	93%	6	2%	0	0%	6	3%	rec A+B1	0%	0	0%	95%
2005	7	1%	730	91%	2	0%	0	0%	72	7%	rec A+B1	0%	0	0%	98%
2006	40	1%	1164	94%	25	1%	0	0%	60	4%	rec A+B1	0%	0	0%	100%
2007	12	0%	1334	95%	22	1%	62	0%	126	4%	rec A+B1	0%	0	0%	100%

*MRFSS data used to represent rod-n-reel length distribution from commercial catch.

Table 3.13. Red drum lengths sampled from the commercial fishery in Virginia and the percent of total harvest that a gear contributed to the overall annual commercial landings. Areas shaded in gray are where less than 20 lengths were acquired in a year. % adequate column represents the percentage of landings that had adequate sampling based on a minimum of 20 lengths by gear and year.

	Seines		Gillnets		Rod-n-Reel		Pound		Trawl		Other		
Year	# meas	% Harv	# meas	% Harv	# meas	% Harv	# meas	% Harv	# meas	% Harv	# meas	% Harv	% Adequate
1981	0	0%	0	0%	rec A+B1	0%	0	50%	0	50%	0	0%	0%
1982	0	0%	0	0%	rec A+B1	0%	0	41%	0	59%	0	0%	0%
1983	0	18%	0	37%	rec A+B1	0%	0	41%	0	4%	0	0%	0%
1984	0	0%	0	0%	rec A+B1	8%	0	4%	0	85%	0	4%	8%
1985	0	9%	0	0%	rec A+B1	18%	0	36%	0	36%	0	0%	18%
1986	0	24%	0	11%	rec A+B1	0%	0	39%	0	26%	0	0%	0%
1987	0	42%	0	12%	rec A+B1	0%	0	35%	0	12%	0	0%	0%
1988	0	18%	0	3%	rec A+B1	0%	0	53%	0	28%	0	0%	0%
1989	0	30%	31	39%	rec A+B1	2%	13	24%	0	4%	0	0%	2%
1990	0	0%	0	0%	rec A+B1	14%		45%	0	37%	0	4%	14%
1991	197	35%	412	43%	rec A+B1	0%	58	20%	0	2%	0	0%	98%
1992	5	10%	18	27%	rec A+B1	0%	3	33%	0	30%	0	0%	0%
1993	5	22%	13	44%	rec A+B1	1%	9	30%	0	2%	0	0%	1%
1994	49	4%	1	2%	rec A+B1	0%	5	93%	0	1%	0	0%	4%
1995	23	24%	0	19%	rec A+B1	1%	0	56%	0	0%	0	0%	26%
1996	1	2%	1	33%	rec A+B1	2%	6	63%	0	0%	0	0%	2%
1997		5%	3	14%	rec A+B1	9%	1	73%	0	0%	0	0%	9%
1998	5	30%	11	25%	rec A+B1	2%	36	43%	0	0%	0	0%	45%
1999	25	18%	11	34%	rec A+B1	8%	58	30%	0	9%	0	1%	56%
2000	19	11%	19	45%	rec A+B1	2%	35	42%	0	0%	0	0%	44%
2001	2	9%	0	29%	rec A+B2	8%	27	48%	0	5%	0	0%	57%
2002	27	12%	8	41%	rec A+B3	7%	59	34%	0	1%	0	5%	53%
2003	0	10%	2	54%	rec A+B4	3%	23	30%	0	2%	0	0%	33%
2004	1	38%	0	31%	rec A+B5	10%	5	20%	0	0%	0	0%	10%
2005	1	7%	26	35%	rec A+B6	13%	8	41%	0	3%	0	0%	48%
2006	15	16%	14	56%	rec A+B7	6%	4	22%	0	0%	0	0%	6%
2007	27	13%	7	44%	32	5%	57	31%	0	5%	0	2%	5%

*MRFSS data used to represent rod-n-reel length distribution from commercial catch with exception of 2007.

Table 3.14. Length frequencies for commercial red drum landings for the northern region (North Carolina and North) during 1981 to 2007.
Beach Seines

Length	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
6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	9	54	54	-	20	35	361	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	532
9	13	78	78	-	29	51	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	249
10	35	210	210	-	78	138	166	605	-	-	-	5	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	1,448
11	32	190	190	-	70	125	993	18	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,643
12	35	206	206	448	76	135	414	1,068	-	274	5	-	-	-	-	-	1	1	-	-	-	0	-	-	-	-	-	2,867
13	17	98	98	50	36	64	-	748	16	192	109	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	1,432
14	39	232	232	99	86	152	135	107	264	1,125	180	-	8	1	-	-	2	-	-	-	-	-	-	-	0	12	-	2,674
15	52	312	312	199	115	204	8	71	136	2,269	104	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	3,783
16	41	245	245	671	91	160	-	516	320	993	38	5	-	3	-	3	7	1	-	-	-	-	-	-	0	-	0	3,341
17	56	333	333	149	123	218	324	-	328	1,317	278	81	2	-	1	-	13	47	-	-	-	2	4	6	11	24	2	3,652
18	55	325	325	2,064	120	213	-	18	152	881	578	25	45	4	9	17	98	576	-	133	42	25	30	21	63	24	15	5,856
19	27	161	161	-	60	105	15	-	24	314	349	9	58	14	6	13	148	668	-	66	20	33	26	14	37	-	16	2,345
20	6	38	38	-	14	25	8	36	112	41	65	11	52	25	26	10	148	409	-	100	23	17	19	8	25	18	17	1,292
21	29	175	175	448	65	115	926	-	-	30	82	23	170	68	78	60	51	143	-	-	35	18	20	4	33	24	23	2,795
22	1	9	9	-	3	6	8	36	16	-	16	73	99	25	237	43	4	39	49	232	47	17	28	16	37	18	34	1,103
23	11	66	66	-	24	43	-	374	40	-	-	55	244	20	298	146	1	24	99	432	75	15	30	16	34	114	39	2,266
24	4	24	24	99	9	16	-	53	88	41	-	52	333	25	287	179	10	3	164	1,162	83	20	30	27	52	36	30	2,852
25	4	22	22	174	8	14	-	-	-	101	16	30	161	31	131	142	48	2	132	664	69	14	16	10	41	48	18	1,921
26	3	20	20	373	7	13	-	-	-	30	-	12	229	29	69	103	74	1	99	399	42	9	11	8	20	24	11	1,605
27	3	21	21	472	8	14	-	-	-	-	-	9	49	68	3	79	41	0	16	166	20	2	-	2	8	6	5	1,014
28	2	12	12	-	4	8	-	-	48	20	16	2	9	7	3	-	8	-	-	-	2	1	2	-	1	-	1	160
29	1	4	4	-	2	3	-	-	8	30	-	2	3	15	0	-	-	-	99	-	1	-	1	-	1	-	0	175
30	0	1	1	-	0	1	-	-	-	10	-	1	-	1	-	-	-	-	-	-	-	0	-	-	-	12	0	28
31	0	1	1	-	0	1	-	-	8	-	-	1	-	-	0	-	1	-	-	-	-	0	-	-	-	-	-	14
32	0	1	1	-	0	1	-	-	8	-	-	9	-	-	0	-	-	-	-	-	-	-	-	-	-	-	0	21
33	0	2	2	-	1	1	-	-	-	-	11	0	1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	22
34	0	2	2	-	1	1	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7
35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
36	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
37	0	1	1	-	0	1	-	18	-	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	21
38	1	5	5	-	2	4	-	18	-	41	-	0	3	-	-	-	1	-	-	-	-	-	-	-	-	-	-	80
39	0	2	2	-	1	1	-	-	16	-	-	-	1	1	-	-	-	0	-	-	-	-	-	-	-	-	-	25
40+	13	80	80	-	30	52	-	160	224	334	16	3	10	4	-	-	-	-	-	-	-	-	-	-	-	-	-	1,007
Total	**493**	**2,930**	**2,930**	**5,247**	**1,085**	**1,918**	**3,357**	**3,845**	**1,833**	**8,044**	**1,864**	**409**	**1,478**	**343**	**1,150**	**794**	**658**	**1,913**	**658**	**3,354**	**460**	**175**	**218**	**134**	**365**	**361**	**212**	**46,230**

Table 3.14 (cont.). Length frequencies for commercial red drum landings for the northern region (North Carolina and North) during 1981 to 2007.

Gill Nets

Length	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
6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	530	767	767	-	521	672	7,361	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10,619
9	767	1,151	1,151	-	755	975	1	0	-	-	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4,820
10	2,075	3,069	3,069	-	2,042	2,636	3,376	7,109	-	-	99	13	-	-	-	0	0	-	-	-	-	3	-	-	-	-	-	23,492
11	1,880	3,361	3,361	-	1,850	2,411	20,255	214	-	-	493	-	-	-	-	1	0	-	-	-	-	13	-	0	-	8	-	33,847
12	2,031	4,005	4,005	4,318	1,999	2,620	8,456	12,551	323	-	697	-	-	-	-	1	1	37	-	-	-	17	-	0	-	16	-	41,078
13	973	2,962	2,962	480	957	1,295	31	8,791	323	883	1,810	26	-	-	-	1	31	-	150	-	-	10	-	0	-	16	-	21,700
14	2,291	5,986	5,986	960	2,255	3,011	2,813	1,272	17,181	8,923	3,634	39	48	51	12	2	16	27	87	-	-	3	-	1	36	-	-	54,633
15	3,079	6,845	6,845	1,919	3,031	4,001	201	852	12,759	14,022	2,692	66	-	0	6	4	3	108	5	15	-	3	13	0	-	-	-	56,469
16	2,420	4,849	4,849	6,476	2,382	3,124	27	6,072	10,629	7,943	1,296	869	-	254	6	594	77	45	5	30	-	3	13	35	76	27	39	52,140
17	3,285	5,141	5,141	1,439	3,233	4,184	6,603	3	6,610	5,785	5,011	14,911	48	-	45	3	167	1,009	1,177	628	3	251	430	276	904	480	546	67,314
18	3,209	4,695	4,695	19,909	3,159	4,075	3	210	7,554	1,961	8,796	4,531	1,287	305	286	2,368	1,276	14,782	6,038	4,569	2,625	2,603	2,662	970	5,290	2,923	3,610	114,391
19	1,588	2,302	2,302	-	1,563	2,016	307	0	-	883	5,822	1,561	1,663	1,115	222	1,776	1,948	27,240	5,846	3,864	1,242	3,159	1,775	765	3,051	3,001	3,773	78,783
20	378	552	552	-	372	480	154	418	944	-	969	1,494	1,454	1,976	550	594	1,970	21,534	7,117	1,794	1,449	1,572	1,461	314	2,066	2,268	3,993	56,427
21	1,729	2,455	2,455	4,318	1,702	2,193	18,862	-	-	-	1,371	2,168	2,425	5,016	2,761	1,186	676	7,543	9,923	2,391	2,139	1,958	1,735	174	2,672	3,157	5,296	86,305
22	87	123	123	-	85	110	153	418	-	-	317	1,454	2,753	1,216	3,415	4	40	2,204	16,457	3,986	2,691	1,983	2,583	347	2,850	4,134	7,664	55,197
23	648	920	920	-	638	822	-	4,390	944	-	-	567	6,513	963	10,330	3,548	11	1,569	13,290	6,891	4,485	1,549	2,870	933	2,529	5,300	8,857	79,490
24	238	338	338	960	234	302	-	627	944	294	-	497	7,097	1,064	7,936	2,958	123	159	10,938	9,574	4,761	1,970	2,882	1,072	3,598	5,202	6,709	70,815
25	216	307	307	1,679	213	274	-	-	-	196	-	319	4,595	1,420	4,126	3,551	649	186	4,471	6,938	4,009	1,350	1,565	1,520	2,565	3,237	4,099	47,791
26	194	276	276	3,598	191	247	-	-	-	-	-	1,029	6,585	1,825	2,950	1,778	976	50	1,920	4,155	2,215	768	1,017	1,588	997	1,735	2,647	37,019
27	205	291	291	4,558	202	260	-	-	-	-	-	1,313	1,293	4,561	131	4	541	12	294	1,341	1,111	180	-	657	428	996	1,048	19,716
28	119	169	169	-	117	151	-	-	-	-	-	-	203	558	144	2	114	-	10	513	145	3	157	311	36	195	205	3,319
29	43	61	61	-	42	55	-	-	-	196	-	390	42	0	13	2	1	-	5	92	69	10	-	104	36	88	34	1,344
30	11	15	15	-	11	14	-	-	-	98	-	26	-	1	-	2	2	-	5	92	3	3	13	1	-	43	-	354
31	11	15	15	-	11	14	-	-	-	-	-	-	-	2	-	3	9	-	222	7	10	7	-	-	-	-	-	325
32	11	15	15	-	11	14	-	-	-	-	-	-	-	1	-	3	2	-	-	30	10	7	-	-	-	-	-	117
33	22	31	31	-	21	28	-	-	-	-	211	-	24	1	-	3	2	-	5	37	3	13	-	-	-	-	-	432
34	22	46	46	-	21	28	0	0	-	-	-	-	-	0	-	1	1	-	-	7	13	-	-	-	-	-	-	187
35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	-	-	7	-	-	-	-	-	-	-	8
36	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-	2	1	-	-	15	13	7	-	-	-	-	-	38
37	11	15	15	-	11	14	-	209	-	-	-	-	-	-	-	0	0	-	-	-	-	7	-	-	-	-	-	282
38	54	77	77	-	53	69	-	209	-	-	-	-	-	-	-	1	0	-	-	7	3	-	-	-	-	-	-	550
39	22	31	31	-	21	28	-	-	-	-	-	-	-	-	-	1	0	9	-	7	-	-	-	-	-	-	-	150
40+	789	1,136	1,136	-	776	1,001	0	1,882	944	686	-	142	42	51	-	8	5	9	54	37	10	40	-	1	-	-	5	8,754
Total	**28,937**	**52,008**	**52,008**	**50,613**	**28,481**	**37,120**	**68,604**	**45,230**	**59,156**	**41,870**	**33,238**	**31,414**	**36,073**	**20,379**	**32,933**	**18,400**	**8,641**	**76,524**	**78,019**	**47,029**	**27,009**	**17,489**	**19,176**	**9,071**	**27,133**	**32,826**	**48,526**	**1,027,905**

Table 3.14 (cont.). Length frequencies for commercial red drum landings for the northern region (North Carolina and North) during 1981 to 2007.

Haul Seine

Length	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
6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	203	786	178	-	83	428	2,116	1	-	-	31	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3,824
9	294	1,158	12,122	-	120	623	4	3	-	-	61	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	14,387
10	796	3,111	23,222	-	324	1,681	978	1,394	-	-	61	28	-	-	-	0	6	-	-	-	-	7	-	-	-	-	-	31,608
11	721	3,092	6,798	-	297	1,571	5,864	31	279	-	613	-	-	-	-	0	0	-	-	-	-	14	-	0	-	2	-	19,283
12	779	3,517	1,039	512	323	1,729	2,503	2,501	209	535	1,135	-	-	-	-	0	2	-	-	-	-	-	-	0	-	5	-	14,790
13	373	2,176	745	57	162	916	112	1,746	353	159	1,449	6	-	-	-	0	8	-	23	-	-	-	-	0	-	5	-	8,288
14	879	4,658	1,457	114	374	2,073	987	164	1,133	198	1,685	9	68	-	16	0	6	26	44	-	-	-	-	1	0	-	-	13,895
15	1,181	5,696	1,164	228	495	2,686	220	112	645	1,349	1,457	15	-	0	8	0	3	105	22	7	-	-	2	1	-	-	-	15,395
16	929	4,227	665	769	386	2,067	100	1,167	292	59	698	12	-	0	8	0	23	53	22	14	-	-	2	2	1	-	-	11,496
17	1,260	5,058	224	171	514	2,684	1,928	21	135	1,031	245	6	-	-	27	0	44	609	72	29	1	-	2	7	4	-	-	14,075
18	1,231	4,787	65	2,363	500	2,595	10	47	93	1,031	61	9	-	1	48	0	331	5,731	72	121	10	5	22	30	27	12	74	19,276
19	609	2,359	22	-	248	1,283	91	2	186	178	-	2	9	-	22	0	499	4,215	93	89	4	39	97	26	17	60	121	10,270
20	145	564	7	-	59	306	45	82	186	79	-	28	9	-	208	30	499	1,449	32	38	5	85	54	12	9	14	163	4,108
21	663	2,544	-	512	269	1,392	5,419	-	-	59	29	65	873	182	378	301	171	521	47	21	7	95	34	6	12	70	27	13,700
22	33	127	-	-	13	70	44	82	186	-	-	321	52	425	2,341	392	14	118	123	75	10	37	15	13	13	102	72	4,678
23	249	954	-	-	101	522	-	858	372	-	-	248	44	303	1,472	603	5	29	89	28	15	34	8	24	12	113	101	6,184
24	91	350	-	114	37	191	-	82	-	-	-	223	616	516	1,898	573	33	15	169	50	17	24	19	29	19	21	37	5,124
25	83	318	-	199	34	174	-	-	-	59	-	111	63	305	776	1	165	35	93	81	16	21	8	33	15	16	27	2,633
26	75	286	-	427	30	157	-	-	-	40	-	18	64	215	152	0	249	-	34	20	11	18	4	33	7	14	37	1,890
27	79	302	-	541	32	165	-	-	-	-	-	-	36	63	6	0	137	-	3	27	6	20	-	15	3	16	21	1,472
28	46	175	-	-	19	96	-	-	557	20	-	-	44	1	-	0	29	-	2	14	3	5	-	7	0	16	-	1,032
29	17	63	-	-	7	35	-	-	93	-	-	1	35	0	-	0	0	-	2	11	0	-	22	3	0	2	-	291
30	4	16	-	-	2	9	-	-	-	-	-	10	-	2	-	0	1	-	-	11	1	5	2	1	-	5	-	67
31	4	16	-	-	2	9	-	-	93	-	-	6	-	3	-	0	2	-	1	4	3	5	-	-	-	-	-	146
32	4	16	-	-	2	9	-	-	93	-	-	44	-	1	-	0	1	-	-	14	3	-	-	-	-	-	-	187
33	8	32	-	-	3	17	-	-	-	-	-	1	-	2	-	0	1	-	-	18	1	-	-	-	-	-	-	83
34	8	39	7	-	3	19	1	1	-	-	-	2	-	0	-	0	0	-	-	4	4	-	-	-	-	-	-	89
35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	-	-	4	-	-	-	-	-	-	-	4
36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	-	-	7	4	7	-	-	-	-	-	18
37	4	16	-	-	2	9	-	41	-	-	-	-	-	-	-	0	0	-	-	-	-	-	-	-	-	-	-	71
38	21	80	-	-	8	44	-	41	-	20	-	1	-	-	-	0	2	-	-	4	1	-	-	-	-	-	-	221
39	8	32	-	-	3	17	-	-	186	-	-	-	9	30	-	0	0	9	-	4	-	-	-	-	-	-	-	298
40+	303	1,168	7	-	123	636	1	328	1,115	218	31	8	95	152	-	1	2	9	-	18	3	-	-	1	0	-	6	4,223
Total	**11,102**	**47,722**	**47,723**	**6,006**	**4,574**	**24,211**	**20,423**	**8,703**	**6,205**	**5,037**	**7,556**	**1,173**	**2,017**	**2,201**	**7,361**	**1,904**	**2,235**	**12,922**	**944**	**711**	**125**	**419**	**291**	**244**	**141**	**472**	**686**	**223,106**

Table 3.14 (cont.). Length frequencies for commercial red drum landings for the northern region (North Carolina and North) during 1981 to 2007.

Trawl

Length	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
6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	664	274	274	2	273	318	1,141	8	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2,956
9	962	401	401	9	397	467	1	31	-	2	3	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	2,675
10	2,601	1,080	1,080	17	1,073	1,256	525	1,380	-	4	7	10	-	-	-	0	0	-	-	-	-	0	-	-	-	-	-	9,035
11	2,362	1,042	1,042	98	987	1,228	3,151	386	43	25	39	-	-	-	-	0	0	-	-	-	-	1	-	0	-	1	-	10,405
12	2,556	1,167	1,167	159	1,076	1,385	1,329	2,890	50	40	58	-	-	-	-	0	0	0	-	-	-	2	-	0	-	2	-	11,881
13	1,233	673	673	680	542	825	31	2,424	68	131	85	20	-	-	-	1	0	-	1	-	-	1	-	0	-	2	-	7,391
14	2,895	1,477	1,477	1,299	1,252	1,789	481	1,608	629	469	139	30	6	0	15	1	0	0	4	-	-	0	-	0	-	-	-	13,573
15	3,881	1,854	1,854	2,174	1,652	2,219	72	1,399	352	571	335	51	-	9	7	2	0	1	1	3	-	0	-	0	-	-	-	16,436
16	3,045	1,399	1,399	5,669	1,285	1,662	27	1,835	638	570	73	54	-	11	7	2	0	1	1	6	-	0	-	0	1	-	1	17,687
17	4,120	1,741	1,741	295	1,706	2,033	1,031	239	592	722	334	32	1	-	24	2	1	2	9	4	1	-	-	1	0	-	-	14,629
18	4,022	1,665	1,665	10,273	1,658	1,935	3	108	270	561	1,241	20	33	30	58	6	5	8	13	19	1	3	-	2	2	4	5	23,612
19	1,991	821	821	7	820	954	48	23	43	484	517	-	43	11	2	5	8	9	17	13	1	5	-	2	2	6	13	6,667
20	474	196	196	2	195	228	24	85	199	1	206	30	37	19	2	4	8	6	9	7	-	2	-	1	-	-	15	1,946
21	2,166	889	889	-	892	1,031	2,924	-	-	-	103	30	123	51	1	13	3	2	10	21	2	3	-	0	0	1	11	9,164
22	108	44	44	-	45	52	24	78	28	-	-	-	74	18	8	10	0	1	23	25	3	2	-	1	0	3	16	608
23	812	333	333	-	334	387	-	814	71	-	-	35	179	15	17	28	0	1	49	37	3	0	-	2	0	3	19	3,472
24	298	122	122	-	123	142	-	116	156	37	-	100	241	28	21	35	1	0	75	49	6	2	-	2	2	7	17	1,701
25	271	111	111	-	111	129	-	-	-	185	308	135	123	67	66	30	3	0	47	34	5	2	-	2	2	6	16	1,766
26	244	100	100	-	100	116	-	-	-	37	-	74	174	84	27	21	4	0	20	20	5	4	-	2	1	4	9	1,147
27	257	105	105	-	106	122	-	-	-	-	-	43	39	104	2	16	2	0	4	11	4	2	-	1	1	1	5	931
28	149	61	61	-	61	71	-	-	85	37	308	43	9	23	1	1	0	-	6	8	1	1	-	0	0	1	0	931
29	54	22	22	-	22	26	-	-	14	37	-	-	4	20	1	1	0	-	1	5	-	1	-	0	0	1	0	232
30	13	6	6	-	6	6	-	-	-	-	-	20	-	45	-	1	0	-	1	5	1	0	-	0	-	2	1	113
31	13	6	6	-	6	6	-	-	14	-	-	-	-	71	1	1	0	-	1	2	2	1	-	-	-	-	-	130
32	13	6	6	-	6	6	-	-	14	-	-	4	-	45	1	1	0	-	-	7	2	1	-	-	-	-	0	111
33	27	11	11	-	11	13	-	-	-	-	-	-	1	46	-	2	0	-	1	8	1	1	-	-	-	-	-	133
34	27	13	13	2	12	15	0	8	-	1	1	-	-	9	-	1	0	-	-	2	2	-	-	-	-	-	-	105
35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	-	-	2	-	-	-	-	-	-	-	2
36	-	-	-	-	-	-	-	-	-	-	-	-	1	9	-	1	0	-	-	3	2	1	-	-	-	-	-	17
37	13	6	6	-	6	6	-	39	-	-	-	-	-	-	-	0	0	-	-	-	-	1	-	-	-	-	-	76
38	68	28	28	-	28	32	-	39	-	111	-	-	2	-	-	0	0	-	-	2	1	-	-	-	-	-	-	339
39	27	11	11	-	11	13	-	-	28	-	-	-	1	0	-	0	0	0	-	2	-	-	-	-	-	-	-	105
40+	989	407	407	2	407	473	0	357	397	483	309	4	9	30	-	4	0	0	16	8	2	3	-	0	0	-	1	4,308
Total	**36,357**	**16,070**	**16,070**	**20,689**	**15,204**	**18,949**	**10,812**	**13,866**	**3,692**	**4,507**	**4,069**	**737**	**1,100**	**746**	**260**	**191**	**37**	**31**	**311**	**302**	**45**	**39**	**-**	**18**	**12**	**42**	**128**	**164,282**

Table 3.14 (cont.). Length frequencies for commercial red drum landings for the northern region (North Carolina and North) during 1981 to 2007.

Pound Net

Length	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
6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	304	131	131	0	17	46	3,584	2	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4,218
9	441	234	234	0	26	72	4	8	-	3	101	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	1,123
10	1,194	584	584	1	70	189	1,650	1,312	-	5	101	37	-	-	-	1	2	-	-	-	-	-	-	-	-	-	-	5,728
11	1,087	1,172	1,172	4	78	250	9,894	132	69	31	-	-	-	-	-	1	2	-	-	-	-	12	-	0	-	5	-	13,910
12	1,178	1,682	1,682	277	94	321	4,171	2,438	167	184	104	-	-	-	-	2	3	0	-	-	-	32	-	0	-	9	-	12,344
13	573	1,965	1,965	40	72	295	92	1,814	179	165	171	27	-	-	-	2	5	-	3	-	-	18	-	0	-	9	-	7,395
14	1,342	3,527	3,527	77	144	561	1,502	599	1,291	671	821	41	9	2	37	4	8	46	1	-	-	6	-	1	2	1	-	14,219
15	1,793	3,407	3,407	136	162	591	218	487	757	1,219	1,376	69	-	8	18	7	15	231	-	-	-	6	10	0	-	-	-	13,918
16	1,404	2,090	2,090	413	114	393	82	1,296	1,150	548	1,233	77	-	16	18	5	14	69	-	-	-	6	10	2	9	1	1	11,041
17	1,892	1,237	1,237	93	118	338	3,238	64	973	664	1,589	377	2	-	58	6	18	103	27	28	8	13	21	12	46	16	17	12,195
18	1,846	846	846	1,243	106	286	8	57	435	437	875	140	48	32	136	11	70	201	147	115	92	176	76	46	284	106	131	8,794
19	913	394	394	0	52	138	152	6	69	155	425	39	74	36	19	8	89	199	158	67	41	253	65	35	175	120	169	4,246
20	218	99	99	0	13	34	75	78	321	20	42	93	55	63	79	6	86	163	164	33	45	135	49	16	101	66	169	2,320
21	994	373	373	269	55	144	9,182	-	-	15	52	143	191	169	238	45	41	56	208	73	71	130	51	8	132	99	199	13,314
22	50	19	19	-	3	7	75	76	46	-	10	328	130	61	724	8	17	32	370	122	95	123	90	20	146	138	293	3,000
23	373	140	140	-	21	54	-	800	115	-	-	247	294	50	927	119	17	75	364	203	151	104	106	38	135	181	352	5,006
24	137	51	51	60	8	20	-	114	252	20	-	235	363	70	894	194	24	24	357	272	166	141	160	48	208	179	289	4,338
25	124	47	47	105	7	18	-	-	-	49	10	136	233	114	529	235	51	47	193	198	146	95	82	54	163	119	230	3,031
26	112	42	42	224	6	16	-	-	-	15	-	56	329	124	230	164	57	0	93	86	92	72	47	55	80	67	137	2,147
27	118	44	44	284	7	17	-	-	-	-	-	40	89	213	10	154	33	0	11	92	57	22	-	24	31	35	70	1,393
28	68	26	26	-	4	10	-	-	137	10	10	8	35	33	9	4	12	-	8	59	20	13	4	11	5	13	9	534
29	25	9	9	-	1	4	-	-	23	15	-	10	16	45	1	3	6	-	17	52	2	18	3	4	3	7	2	276
30	6	2	2	-	0	1	-	-	-	5	-	31	-	39	-	4	8	-	9	34	8	8	10	1	-	11	3	184
31	6	2	2	-	0	1	-	-	23	-	-	5	-	60	1	5	10	-	13	-	24	8	-	-	-	-	-	160
32	6	2	2	-	0	1	-	-	23	-	-	41	-	38	1	5	9	-	-	1	24	12	-	-	-	-	1	166
33	12	5	5	-	1	2	-	-	-	-	7	1	1	44	-	5	11	-	-	16	8	18	-	-	-	-	-	136
34	13	22	22	0	1	4	1	2	-	1	101	2	-	8	-	2	4	-	-	-	31	-	-	-	-	-	-	212
35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	1	-	-	-	-	-	-	-	-	-	-	1
36	-	-	-	-	-	-	-	-	-	-	-	-	1	8	-	3	6	-	-	16	31	6	-	-	-	-	-	71
37	6	2	2	-	0	1	-	38	-	-	-	1	-	-	-	1	1	-	-	-	-	6	-	-	-	-	-	59
38	31	12	12	-	2	5	-	38	-	20	-	1	4	-	-	1	2	-	-	-	8	-	-	-	-	-	-	134
39	12	5	5	-	1	2	-	-	46	-	-	-	1	2	-	1	2	23	-	-	-	-	-	-	-	-	-	99
40+	454	187	187	0	26	68	1	345	642	164	10	12	23	32	-	14	26	-	35	-	16	48	-	0	2	-	-	2,292
Total	**16,731**	**18,358**	**18,358**	**3,227**	**1,209**	**3,885**	**33,929**	**9,709**	**6,717**	**4,417**	**7,039**	**2,195**	**1,896**	**1,266**	**3,930**	**1,021**	**650**	**1,268**	**2,179**	**1,467**	**1,135**	**1,481**	**786**	**377**	**1,522**	**1,182**	**2,072**	**148,005**

Table 3.14 (cont.). Length frequencies for commercial red drum landings for the northern region (North Carolina and North) during 1981 to 2007.

Lines (hook and lines)

Length	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
6	-	-	-	-	-	-	-	20	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20
7	-	-	-	-	-	1	145	-	-	-	-	-	-	-	9	-	-	-	-	-	-	-	-	-	-	-	-	154
8	-	-	-	1	-	3	9	-	-	-	-	-	-	-	7	-	62	0	-	-	-	-	-	-	-	-	-	83
9	-	-	-	-	-	-	7	-	4	-	-	-	-	-	7	-	62	0	-	-	-	-	-	-	-	-	-	80
10	-	-	-	0	-	-	-	-	4	9	4	-	0	-	-	-	31	0	-	-	-	-	-	-	-	-	-	49
11	-	-	25	-	-	2	26	-	13	-	0	-	-	0	2	-	-	-	-	-	-	-	-	-	-	-	-	68
12	-	-	14	3	-	1	19	-	13	16	6	1	-	9	-	-	-	-	-	-	-	-	-	-	-	-	0	83
13	-	67	58	1	6	1	75	-	57	55	8	2	1	2	-	8	-	-	-	-	-	1	-	-	-	-	-	343
14	-	67	55	-	-	1	266	131	157	69	6	-	16	1	9	18	5	0	13	-	-	0	-	1	-	1	-	818
15	-	33	42	-	-	0	559	39	100	53	19	2	3	-	0	33	12	0	5	-	-	4	-	-	-	5	-	909
16	-	-	-	20	9	2	736	277	142	47	25	2	35	13	5	8	-	-	9	14	9	5	-	1	-	4	3	1,366
17	-	-	-	1	19	3	264	-	286	30	18	5	42	20	5	35	34	0	10	0	2	2	-	-	-	-	0	775
18	-	-	-	-	9	2	118	131	88	13	91	8	61	8	43	43	22	10	34	27	23	74	7	7	1	3	4	828
19	-	7	-	-	19	1	89	131	42	-	29	4	2	18	33	42	36	25	55	37	1	81	14	9	4	13	32	723
20	-	-	1	-	-	1	75	131	14	0	17	4	28	10	27	18	-	27	44	19	2	40	5	9	5	21	34	532
21	-	-	-	-	-	-	-	-	14	-	6	2	19	27	59	12	22	84	54	38	9	2	6	7	7	8	15	391
22	-	-	-	-	-	-	9	-	9	1	3	5	95	12	47	-	5	165	47	38	19	5	9	5	17	12	6	509
23	-	-	-	-	-	-	30	-	83	-	4	10	150	19	120	23	-	175	79	36	28	4	7	1	4	12	6	789
24	-	-	-	-	-	-	-	-	131	1	4	4	77	30	126	38	31	187	102	77	19	11	8	8	22	8	10	893
25	-	-	-	-	9	-	42	-	43	-	-	9	25	50	71	18	35	72	72	85	27	6	9	3	3	4	4	590
26	-	-	3	-	-	-	-	131	23	0	0	6	24	22	12	54	-	25	71	93	17	8	8	4	1	10	9	520
27	-	26	-	-	9	-	2	131	34	10	1	2	42	33	11	22	-	15	25	49	19	0	1	3	5	2	2	445
28	-	-	-	-	5	-	-	-	8	1	0	2	16	9	8	23	93	3	34	17	44	1	1	1	-	2	0	268
29	-	-	-	-	-	-	-	-	4	7	-	-	-	6	0	9	6	-	0	5	9	-	1	-	-	3	-	49
30	-	-	-	10	-	-	-	-	-	-	-	-	-	6	1	-	-	-	7	0	-	0	-	-	-	-	-	24
31	-	-	-	-	-	-	-	-	-	-	0	-	-	6	7	8	-	2	-	-	1	-	-	0	-	1	-	25
32	-	-	-	-	-	-	-	-	-	0	4	-	-	7	2	2	-	-	-	-	-	2	0	-	-	-	-	17
33	-	-	-	-	-	-	-	-	-	-	-	-	-	15	0	-	12	2	-	-	-	1	-	-	-	-	-	29
34	-	-	-	10	-	-	87	-	-	-	-	-	-	-	8	1	-	2	-	-	-	-	-	-	-	-	-	108
35	-	-	-	-	-	-	-	-	-	-	-	-	0	-	-	-	-	0	-	-	1	-	-	-	-	-	-	1
36	-	-	-	-	-	-	-	-	-	-	-	0	-	1	-	-	2	-	-	-	-	-	-	-	-	-	-	3
37	-	-	-	10	-	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	21
38	-	-	-	-	-	-	-	-	18	1	-	-	0	1	-	-	-	1	-	-	-	-	-	-	-	-	-	21
39	-	-	-	-	-	1	-	-	-	2	-	-	-	2	-	-	-	1	-	-	-	-	-	-	-	-	-	6
40+	-	-	3	10	-	7	4	-	1	3	0	0	2	10	1	4	1	5	0	-	2	-	-	-	-	-	-	53
Total	**-**	**201**	**201**	**66**	**86**	**24**	**2,562**	**1,131**	**1,287**	**317**	**246**	**67**	**638**	**335**	**619**	**419**	**470**	**803**	**662**	**536**	**230**	**253**	**76**	**59**	**70**	**109**	**126**	**11,594**

Table 3.15. Estimated age frequencies of red drum harvested from all major commercial gear categories for the northern region combined (North Carolina and north) for the period of 1981 to 2007.

Gear	Year	age1	age2	age3	age4	age5	age6	age7	age8	age9	age10	Total
Beach Seine	1981	84	68	5	0	0	0	0	0	0	5	162
	1982	180	147	10	1	0	0	0	0	0	10	349
	1983	1,515	1,232	87	7	2	1	2	2	1	82	2,931
	1984	1,614	2,875	735	23	-	-	-	-	-	-	5,247
	1985	561	456	32	3	1	1	1	1	0	30	1,085
	1986	992	807	57	4	1	1	1	1	1	54	1,918
	1987	2,111	1,166	80	-	-	-	-	-	-	-	3,357
	1988	2,573	999	77	1	6	6	9	4	3	167	3,845
	1989	647	849	87	9	0	2	0	1	2	235	1,833
	1990	4,547	2,988	132	3	7	-	4	6	-	358	8,044
	1991	1,118	693	27	9	1	-	-	-	-	16	1,864
	1992	9	370	19	8	0	0	0	-	0	3	409
	1993	12	946	504	1	1	1	1	1	0	12	1,479
	1994	7	186	132	13	0	0	-	0	0	4	343
	1995	3	970	176	1	-	-	-	-	-	-	1,150
	1996	23	576	192	4	-	-	-	-	-	-	794
	1997	132	412	111	3	0	0	0	0	-	0	658
	1998	179	1,733	1	-	-	-	-	-	-	0	1,913
	1999	3	401	234	20	-	-	-	-	-	-	658
	2000	27	1,735	1,565	27	-	-	-	-	-	-	3,354
	2001	12	179	268	1	-	-	-	-	-	-	460
	2002	19	142	14	0	-	-	-	-	-	-	176
	2003	4	183	31	0	-	-	-	-	-	-	218
	2004	28	56	50	0	-	-	-	-	-	-	134
	2005	21	330	13	1	-	-	-	-	-	-	365
	2006	21	236	102	3	-	-	-	-	-	-	361
	2007	5	164	42	1	-	-	-	-	-	-	212
Gill Net	1981	4,905	3,990	281	22	6	4	6	6	3	265	9,487
	1982	4,113	3,346	236	18	5	4	5	5	3	223	7,956
	1983	28,755	20,655	1,218	103	30	19	25	26	13	1,165	52,008
	1984	15,570	27,731	7,086	226	-	-	-	-	-	-	50,613
	1985	14,723	11,978	844	66	18	13	17	18	9	797	28,481
	1986	19,261	15,564	1,087	85	23	17	22	23	12	1,027	37,120
	1987	43,148	23,829	1,626	0	0	-	-	-	-	0	68,604
	1988	30,271	11,750	908	10	69	69	111	45	31	1,967	45,230
	1989	30,541	27,424	247	-	-	-	-	-	-	944	59,156
	1990	26,600	14,135	428	22	-	-	-	-	-	686	41,870
	1991	21,437	11,408	233	145	14	-	-	-	-	-	33,238
	1992	812	28,715	1,611	135	-	-	-	-	10	132	31,414
	1993	197	22,771	13,044	16	2	1	0	2	0	39	36,073
	1994	565	11,958	7,223	582	0	1	0	2	1	48	20,379
	1995	122	27,088	5,677	45	-	-	-	-	-	-	32,933
	1996	2,637	13,127	2,619	7	2	1	1	0	0	8	18,400
	1997	1,665	5,439	1,485	45	1	0	0	0	0	5	8,641
	1998	6,600	69,800	105	1	0	1	0	1	1	15	76,524
	1999	6,124	59,623	12,100	113	4	-	-	0	0	54	78,019
	2000	1,228	28,688	16,644	393	18	5	4	2	2	46	47,029
	2001	751	10,735	15,401	93	12	3	3	1	0	12	27,009
	2002	1,949	14,318	1,136	34	6	3	3	1	1	40	17,489
	2003	326	15,961	2,868	21	-	-	-	-	-	-	19,176
	2004	1,405	2,788	4,809	68	-	-	-	-	-	1	9,071
	2005	1,788	24,600	718	28	-	-	-	-	-	-	27,133
	2006	825	23,997	7,921	82	-	-	-	-	-	-	32,826
	2007	1,210	37,880	9,366	65	-	-	-	-	-	5	48,526

Table 3.15 (cont.). Estimated age frequencies of red drum harvested from all major commercial gear categories for the northern region combined (North Carolina and north) for the period of 1981 to 2007.

Gear	Year	age1	age2	age3	age4	age5	age6	age7	age8	age9	age10	Total
Haul Seine	1981	1,882	1,531	108	8	2	2	2	2	1	102	3,640
	1982	1,177	958	68	5	1	1	1	1	1	64	2,278
	1983	45,100	2,608	1	4	3	0	-	0	-	7	47,723
	1984	1,848	3,291	841	27	-	-	-	-	-	-	6,006
	1985	2,377	1,916	133	11	3	2	3	3	1	126	4,575
	1986	12,673	10,080	690	54	15	11	14	15	7	653	24,211
	1987	12,887	7,066	467	1	0	-	-	-	-	1	20,423
	1988	5,887	2,238	167	2	14	13	22	9	6	344	8,703
	1989	2,180	1,866	745	109	4	20	5	15	20	1,240	6,205
	1990	2,706	2,018	75	0	4	-	2	5	-	228	5,037
	1991	7,269	253	3	-	-	-	-	-	-	31	7,556
	1992	58	1,035	34	34	1	1	0	0	0	9	1,173
	1993	55	1,389	470	-	0	1	2	1	1	98	2,017
	1994	9	1,270	722	18	1	5	2	8	5	162	2,201
	1995	59	6,371	929	2	-	-	-	-	-	-	7,361
	1996	28	1,725	150	1	0	-	-	-	-	1	1,904
	1997	448	1,392	379	12	1	0	1	0	0	3	2,235
	1998	1,444	11,446	14	-	0	1	0	1	1	15	12,922
	1999	128	695	119	1	-	-	-	-	-	-	944
	2000	46	418	177	34	8	2	2	1	1	22	711
	2001	3	39	66	8	4	1	1	0	0	4	125
	2002	38	324	46	5	4	1	1	-	-	0	419
	2003	6	248	32	5	-	-	-	-	-	-	291
	2004	47	83	113	2	-	-	-	-	-	1	244
	2005	9	127	5	0	-	-	-	-	-	0	141
	2006	19	359	91	3	-	-	-	-	-	-	472
	2007	20	568	91	1	-	-	-	-	-	6	686
Hook and Line	1981	-	-	-	-	-	-	-	-	-	-	-
	1982	7	3	1	0	-	-	-	-	-	-	12
	1983	146	50	2	-	-	-	-	-	-	3	201
	1984	16	11	8	8	6	2	3	1	1	11	66
	1985	23	47	16	1	-	-	-	-	-	-	86
	1986	10	6	-	-	-	0	0	0	0	7	24
	1987	1,332	1,114	31	49	30	2	-	2	-	4	2,562
	1988	338	594	186	7	2	2	2	1	1	1	1,131
	1989	466	693	109	1	2	2	4	2	1	8	1,287
	1990	201	91	18	0	0	-	0	0	0	6	317
	1991	160	79	4	3	-	0	-	-	-	0	246
	1992	5	56	5	0	-	-	-	-	-	-	67
	1993	39	442	155	0	0	0	0	0	-	2	638
	1994	32	150	115	24	2	1	0	1	0	11	335
	1995	51	468	86	10	3	0	-	0	-	1	619
	1996	130	186	90	9	0	0	-	-	-	4	419
	1997	225	122	105	16	2	0	0	-	-	1	470
	1998	9	726	55	4	1	0	0	0	0	6	803
	1999	52	438	166	5	-	-	-	-	-	0	662
	2000	13	270	243	9	-	-	-	-	-	-	536
	2001	10	69	143	6	0	-	-	-	-	2	230
	2002	53	185	9	2	1	1	1	0	0	0	253
	2003	1	59	16	1	-	-	-	-	-	-	76
	2004	12	28	19	0	-	-	-	-	-	-	59
	2005	0	65	5	0	-	-	-	-	-	-	70
	2006	6	78	24	1	-	-	-	-	-	-	109
	2007	4	105	17	0	-	-	-	-	-	-	126

Table 3.15 (cont.). Estimated age frequencies of red drum harvested from all major commercial gear categories for the northern region combined (North Carolina and north) for the period of 1981 to 2007.

Gear	Year	age1	age2	age3	age4	age5	age6	age7	age8	age9	age10	Total
Pound Net	1981	6,194	5,021	352	27	7	6	7	7	4	333	11,958
	1982	912	619	33	3	1	1	1	1	0	32	1,602
	1983	11,564	6,369	186	24	10	3	4	4	2	192	18,358
	1984	666	1,121	281	9	-	-	-	-	-	0	2,076
	1985	673	477	28	2	1	0	1	1	0	26	1,209
	1986	2,262	1,469	72	7	2	1	1	2	1	69	3,885
	1987	21,371	11,764	792	1	0	-	-	-	-	1	33,929
	1988	6,526	2,594	166	3	13	13	20	8	6	361	9,709
	1989	2,842	2,911	250	27	1	5	1	4	5	673	6,717
	1990	4,553	2,870	122	3	7	-	3	5	-	330	7,893
	1991	8,139	2,734	49	93	50	3	-	3	-	24	11,096
	1992	204	2,474	137	53	1	2	1	0	1	16	2,889
	1993	13	1,144	710	1	1	1	1	1	0	25	1,896
	1994	33	530	527	128	11	2	1	1	0	33	1,266
	1995	131	3,296	622	5	-	-	-	-	-	-	4,054
	1996	39	571	294	18	3	1	1	0	0	15	941
	1997	139	322	125	25	6	2	2	1	1	28	650
	1998	250	864	16	-	0	2	1	2	2	13	1,151
	1999	171	1,859	444	12	0	-	-	0	0	34	2,520
	2000	33	777	598	44	10	2	3	-	-	0	1,467
	2001	30	417	668	56	28	6	6	1	1	19	1,233
	2002	216	1,178	155	35	6	3	3	1	1	53	1,649
	2003	6	163	68	2	-	-	-	-	-	-	239
	2004	67	124	182	3	-	-	-	-	-	0	377
	2005	131	1,894	74	3	-	-	-	-	-	2	2,104
	2006	59	1,046	380	7	-	-	-	-	-	-	1,492
	2007	52	1,736	526	6	-	-	-	-	-	-	2,320
Trawl	1981	2,867	2,315	162	13	3	3	3	3	2	153	5,523
	1982	3,346	2,545	164	13	4	3	3	3	2	156	6,239
	1983	8,512	6,625	441	35	10	7	9	9	5	418	16,070
	1984	13,403	18,269	0	1	1	-	-	-	-	2	31,676
	1985	7,908	6,363	442	35	9	7	9	9	5	418	15,204
	1986	10,085	7,780	511	41	11	8	10	11	6	485	18,949
	1987	6,811	3,749	252	0	0	-	-	-	-	0	10,812
	1988	9,384	3,872	169	6	15	13	21	9	6	372	13,866
	1989	1,444	1,650	155	17	1	3	1	2	3	417	3,692
	1990	1,101	1,060	97	1	11	-	5	5	-	294	2,574
	1991	1,044	618	119	9	0	-	-	-	-	135	1,926
	1992	115	394	87	8	-	0	-	-	-	3	607
	1993	9	697	382	1	1	0	1	0	0	10	1,100
	1994	23	220	335	122	12	3	1	1	0	30	746
	1995	52	154	50	1	-	-	-	-	-	-	257
	1996	15	133	48	4	1	0	0	0	0	4	206
	1997	7	23	6	0	-	-	-	-	-	-	37
	1998	4	27	0	-	-	-	-	-	-	0	32
	1999	17	197	58	3	0	-	-	0	-	16	291
	2000	10	152	107	16	4	1	1	0	0	10	302
	2001	1	9	23	5	2	1	1	0	-	2	42
	2002	6	19	6	2	1	0	0	0	-	3	36
	2003	18	588	217	8	-	-	-	-	-	-	831
	2004	4	6	8	0	-	-	-	-	-	0	18
	2005	1	8	1	-	-	-	-	-	-	0	10
	2006	5	21	12	1	-	-	-	-	-	-	38
	2007	2	85	28	1	-	-	-	-	-	1	117

Table 3.15 (cont.). Estimated age frequencies of red drum harvested from all major commercial gear categories for the northern region combined (North Carolina and north) for the period of 1981 to 2007.

Gear	Year	age1	age2	age3	age4	age5	age6	age7	age8	age9	age10	Total
Other	1981	-	-	-	-	-	-	-	-	-	-	-
	1982	-	-	-	-	-	-	-	-	-	-	-
	1983	16	13	1	0	-	-	-	-	-	1	32
	1984	50	24	1	0	-	-	-	-	-	0	74
	1985	51	41	3	0	0	-	0	0	-	3	98
	1986	-	-	-	-	-	-	-	-	-	-	-
	1987	-	-	-	-	-	-	-	-	-	-	-
	1988	-	-	-	-	-	-	-	-	-	-	-
	1989	-	-	-	-	-	-	-	-	-	-	-
	1990	33	11	-	-	-	-	-	-	-	0	44
	1991	46	17	1	0	-	-	-	-	-	0	64
	1992	-	-	-	-	-	-	-	-	-	-	-
	1993	-	2	2	-	-	-	-	-	-	0	4
	1994	0	11	8	1	-	-	-	-	-	0	20
	1995	1	20	4	-	-	-	-	-	-	-	25
	1996	6	17	7	2	1	0	0	0	-	2	36
	1997	8	22	7	1	0	-	-	-	-	1	38
	1998	35	84	4	-	-	0	0	0	0	4	128
	1999	2	17	4	0	-	-	-	-	-	1	25
	2000	0	6	3	0	-	-	-	-	-	-	9
	2001	0	2	3	-	-	-	-	-	-	-	4
	2002	9	39	8	3	1	0	0	0	0	5	65
	2003	0	16	3	-	-	-	-	-	-	-	20
	2004	1	1	1	-	-	-	-	-	-	-	2
	2005	21	105	1	-	-	-	-	-	-	4	130
	2006	221	738	235	27	-	-	-	-	-	-	1,221
	2007	32	975	303	2	-	-	-	-	-	11	1,323

Table 3.16. Estimated age frequencies of red drum harvested for all major commercial gears combined for the northern region (North Carolina and north) during 1981-2007.

Year	age1	age2	age3	age4	age5	age6	age7	age8	age9	age10	Total
1981	15,930	12,925	907	71	19	14	18	19	10	857	30,770
1982	9,735	7,617	511	41	11	8	10	11	6	484	18,434
1983	95,609	37,552	1,935	173	54	31	39	41	21	1,867	137,322
1984	33,166	53,321	8,951	295	6	2	3	1	1	13	95,758
1985	26,315	21,279	1,497	116	31	23	30	31	16	1,400	50,738
1986	45,282	35,706	2,417	191	52	38	49	51	26	2,295	86,107
1987	87,659	48,688	3,247	50	30	2	-	2	-	7	139,686
1988	54,979	22,047	1,673	29	118	115	185	74	52	3,211	82,483
1989	38,120	35,392	1,592	163	8	32	11	24	31	3,517	78,890
1990	39,742	23,173	871	28	29	-	14	22	0	1,902	65,781
1991	39,213	15,803	436	259	65	3	-	3	-	207	55,989
1992	1,204	33,045	1,892	237	3	4	1	0	11	163	36,559
1993	325	27,392	15,266	19	4	4	5	4	3	186	43,206
1994	669	14,325	9,061	887	25	11	5	12	7	287	25,290
1995	419	38,367	7,544	64	3	0	-	0	-	1	46,398
1996	2,878	16,333	3,400	44	7	2	2	1	1	34	22,700
1997	2,625	7,731	2,218	101	10	3	3	1	1	38	12,730
1998	8,521	84,681	196	5	2	4	1	4	5	53	93,471
1999	6,497	63,230	13,125	155	4	-	0	0	0	106	83,117
2000	1,358	32,046	19,338	523	39	11	10	3	3	77	53,408
2001	807	11,449	16,571	168	47	10	11	2	1	38	29,103
2002	2,291	16,204	1,373	80	18	8	9	2	1	101	20,087
2003	362	17,218	3,235	36	-	-	-	-	-	-	20,851
2004	1,563	3,086	5,182	73	-	-	-	-	-	2	9,905
2005	1,971	27,127	816	32	-	-	-	-	-	7	29,954
2006	1,156	26,475	8,765	123	-	-	-	-	-	-	36,519
2007	1,326	41,513	10,373	75	-	-	-	-	-	22	53,310

Table 3.17. Estimated age frequencies of dead red drum discards resulting from the North Carolina estuarine gill net fishery from 2004 to 2006.

Year	age1	age2	age3	age4	age5	age6	age7	age8	age9	age10+	Total
2004	10,130	341	636	108	-	2	0	1	0	12	11,229
2005	13,160	11,719	922	65	-	-	-	-	-	-	25,866
2006	8,892	5,031	1,461	129	2	0	-	-	-	-	15,514

3.13 Figures

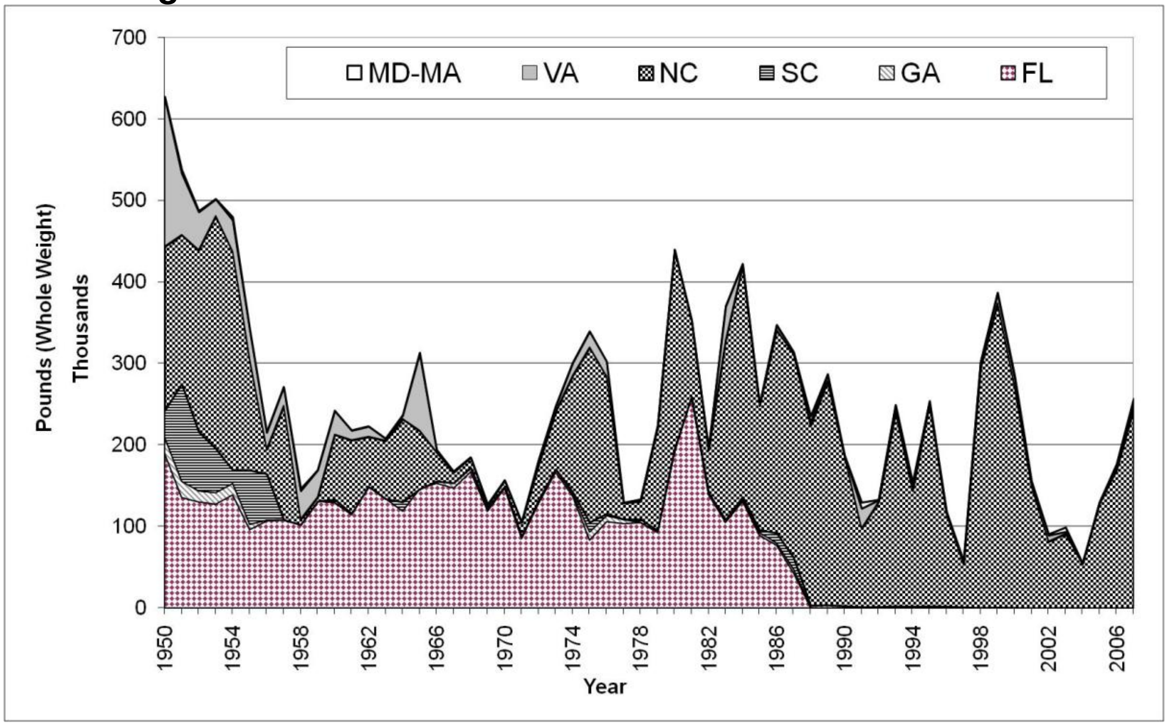

Figure 3.1. Red drum commercial landings in pounds (whole weight) by state from the US Atlantic coast, 1950-2007 (see text for data sources). MD-MA includes state landings from Maryland to Massachusetts excluding Virginia. Virginia landings were reported separately.

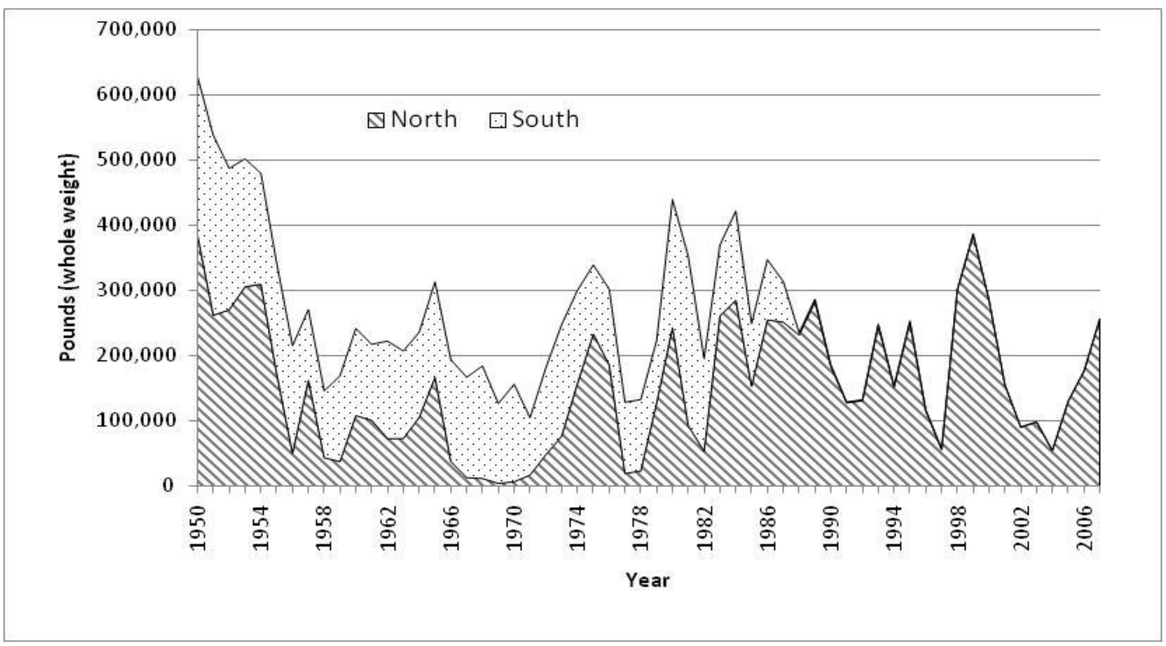

Figure 3.2. Red drum commercial landings in pounds (whole weight) by region from the US Atlantic coast, 1950-2007. Northern region includes states from Massachusetts to North Carolina. Southern region includes landings from South Carolina, Georgia, and Florida.

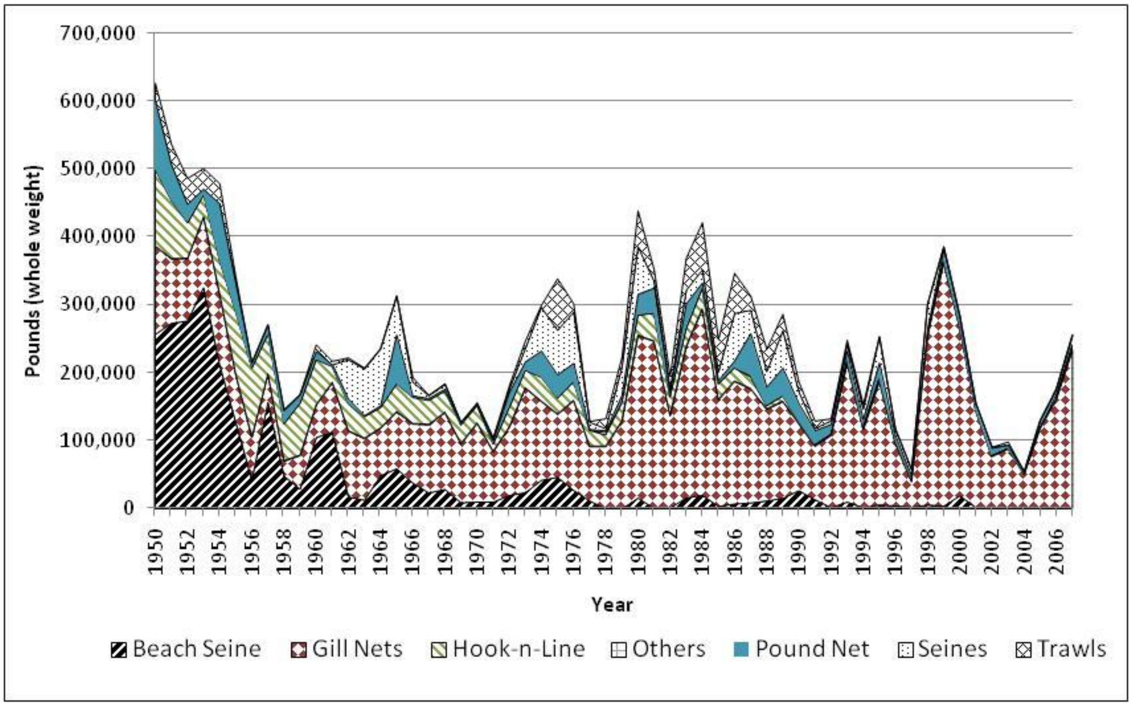

Figure 3.3. Red drum commercial landings in pounds (whole weight) by gear from the US Atlantic coast, 1950-2007 (see text for gear descriptions).

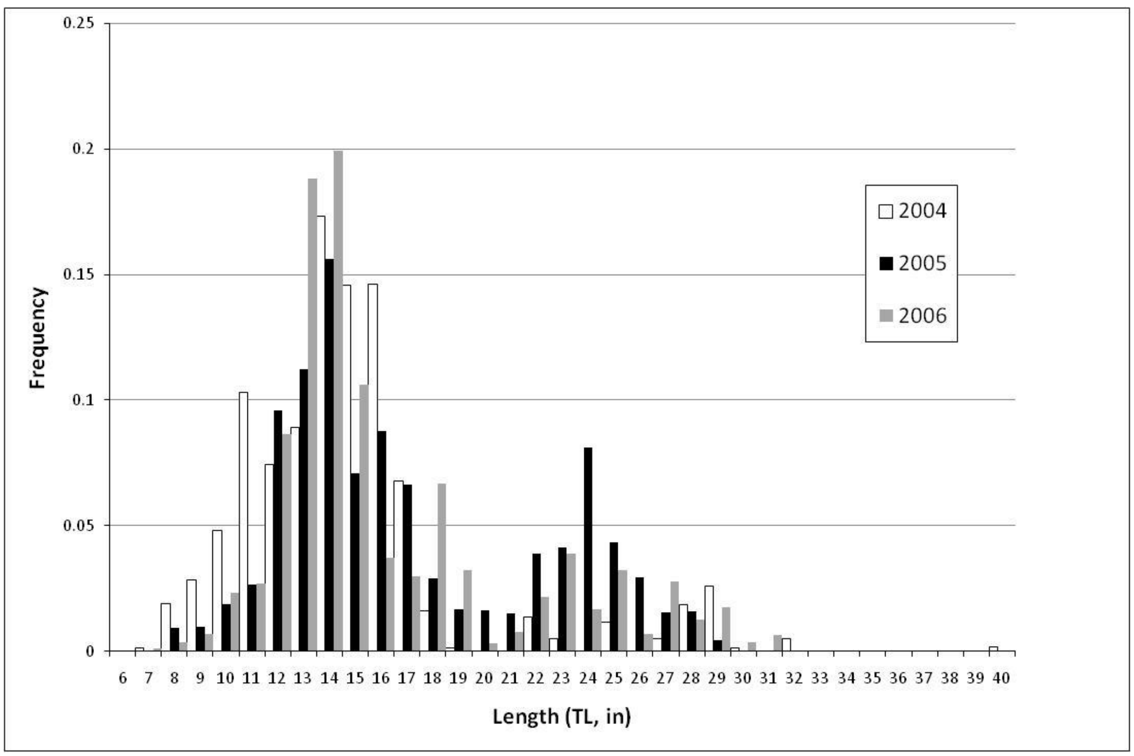

Figure 3.4. Red drum length frequency distribution that resulted from release mortality of the estuarine gill net fishery in North Carolina from 2004 to 2006.

4. Recreational Fishery Statistics

4.1 Overview

4.1.1 Group Membership

Chair	Mike Denson	SCDNR
Members	Tom Sminkey	NMFS Silver Spring
	Kathy Knowlton	GADNR
	Steve Arnott	SCDNR
	Chris McDonough	SCDNR
	Mike Murphy	FWC

4.1.2 Issues

None

4.2 Review of Working Papers

SEDAR18-DW09 "Recreational harvest estimates and estimated catch-at-age for the recreational fishery in Florida during 1982-2007."

The recreational fishery workgroup reviewed this document and determined that it provides background information on estimated red drum landings in Florida using MRFSS angler interview information. The survey covers the period Mar 1981 through 2007. It mentions significant changes in survey design that took place from 2004 onwards and references conversion factors to overcome this (also discussed during the work group sessions). It also makes assumptions used for back-dating total catch estimates to 1950. Estimated number of red drum killed by anglers in FL = 5% of live releases. In addition it gives extensive details of length-at-age keys (and assumptions), lengths of landed fish and ages of landed fish. Eleven tables of data and 1 figure are included.

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."

The MRFSS (Marine Recreational Statistical Survey) conducted by the National Marine Fisheries Service) and the state's recreational survey provides data on the number, length and weight of harvested fish, but there are no weight data for the B-2 fish. There are methods available to assign fishes of a given length to a specific age group or cohort. The length composition can be used to estimate the age structure. If you have an estimate of the catch and release mortality by length (age) of the fish, then you can assign the losses from fishing into year classes by weight. As the year class progresses through time, its abundance decreases; the rate of loss is the mortality rate. Combined age length keys from South

Carolina's fishery independent surveys (trammel net, electroshock boat, long line surveys) covering the same time period will be applied the annual size frequency distributions during the SEDAR process to derive age distribution for this data set.

4. 3 Recreational Surveys

4.3.1 Headboat Fishery

4.3.1.1 Headboat Landings

Historical accounts of headboat fishing in the South Atlantic for offshore snapper-grouper species date back to the years immediately following World War II. The headboat fishery is a readily identifiable segment of the recreational fishery, and is responsible for a significant percent of the recreational catch for some species. Presently, the number of vessels in the headboat fleet fluctuates slightly from year to year as boats enter or leave the fishery, nonetheless, the relative size of the fleet is known, making it accessible to the Southeast Region Headboat Survey. From 1981-present the Survey included all headboats operating in the southeastern U.S. EEZ. The South Atlantic headboat sampling occurred from 1981-2007. The data available were catch and total weight. The number of samples was very patchy and ranges from 1-451 fish per year (Table 4.3.1.1). Red drum occur primarily inshore and therefore are less likely to be encountered on headboats, making these data of questionable use.

4.3.1.2 Headboat Discards

No data available

4.3.1.3 Headboat Catch-at-Age/Length - directed and discard

4.3.1.4 Headboat Effort

Not adequate

4.3.1.5 Headboat Sampling Intensity Length/Age/Weight

Total headboat weights ranged from 6-3228 lbs total harvest (See Table 4.3.1.1).

4.3.1.6 Headboat Length – Age Distributions

No length composition was generated from the headboat fishery.

4.3.1.7 Headboat Adequacy for Characterizing Catch

The workgroup concluded that the data are insufficient to draw conclusions about red drum and the effect of the headboat fishery and will not be useful in the assessment (Table 4.3.1.1).

4.3.1.8 Comments on Adequacy of Headboat Data for Assessment Analyses

The workgroup concluded that the data are insufficient to draw conclusions about red drum and the effect of the headboat fishery and will not be useful in the assessment

4.3.2 General Recreational Landings (MRFSS)

MRFSS description and data collection

4.3.2.1 MRFSS Intoduction

(Text taken from Diaz and Phares, 2004 and modified for Atlantic Coast.)

The Marine Recreational Fishery Statistics Survey (MRFSS) was established to create a reliable database for estimating catch and effort by the marine recreational fishery (http://www.st.nmfs.gov/st1/recreational/survey/overview.html). In the traditional MRFSS methodology, data are collected by a telephone survey of households in coastal counties and by interviewing anglers at fishing access sites. MRFSS acknowledged that the estimation of effort for the charterboat sector is difficult due to the low incidence of this type of fishing trips by households contacted in the telephone survey. To reduce the effect of small sample sizes on charterboat effort estimation, data from a 5-year period are combined for estimates using the traditional MRFSS method. Pooling data across years provides a larger data set to produce more reliable estimates of effort. However, this approach tends to mask trends in the fishery, annual weather patterns, etc. To improve the effort estimation procedure for the charterboat mode, MRFSS started testing a new survey protocol named For Hire Survey (FHS) in 1995 (http://www.st.nmfs.gov/st1/ recreational/pubs/charter_method.pdf). To implement the new FHS, charterboat directories were created by NMFS and participating state agencies and are maintained by the NMFS' Contractor. Approximately 10% of the charterboats in the directory are randomly contacted by phone and asked relevant information regarding their fishing activities (e.g., number of trips and anglers, area of fishing, etc.). MRFSS concluded that the FHS produced significantly 'more efficient, precise, and credible charter angler effort estimates than the traditional MRFSS method'. The FHS was officially adopted as the new charterboat method in the Gulf of Mexico in 2000 and expanded to the Atlantic Coast in 2004. This document provides conversion factors to adjust effort estimates obtained by MRFSS until 2004 along the Atlantic Coast to the FHS effort levels 2004-2007. The adjusted effort levels were applied to landings' CPUEs to produce adjusted historical Spanish mackerel landings from the Mid-Atlantic US.

4.3.2.2 MRFSS Methods

From 2004 to 2007, the NMFS estimated charterboat effort using both the MRFSS (old) and FHS (new) protocols. Thus, differences in effort estimates for each stratum between both methodologies can be directly compared only for that period of time. Each stratum is defined by a unique combination of state, year, wave, and fishing-area, where wave corresponds to bimonthly periods starting in January. The MRFSS defined fishing areas for most states as: a) Inshore waters, b) < 3 miles, and c) > 3 miles. For the period 1986-2003, charterboat effort was estimated using only the MRFSS protocol. To calibrate MRFSS charterboat effort estimates (1986-2003) to FHS levels, conversion factors (ratios) between FHS and MRFSS charterboat effort were estimated using 2004-2007 data and applied to the 1986-2003 MRFSS effort estimates. To estimate the conversion factors, a ratio of FHS/MRFSS effort estimates was calculated for each stratum using only the estimates from the period 2004-2007. A generalized linear model (GLM procedure, SAS Inst.) was used to identify significant factors and to estimate predicted ratios. The factors included in the model were year, wave, fishing area, state and the interaction terms. In the event that a factor was found non-significant ($P > 0.05$), it was removed and the regression re-run until all (highest order) model terms were significant (Hocking 1976, Draper and Smith 1981). In the Mid-Atlantic region the significant strata were state and wave only, and Delaware and Maryland were not significantly different in the model so they were pooled for the purpose of conversion factor computation. In the South Atlantic region the significant factors were water body, wave and state and GA and SC clustered together. The predicted ratios are used as the conversion factors, which were then applied to the original cell-level effort estimates by stratum. The adjusted effort estimates were multiplied by the catch per trip by species to generate the adjusted Charter mode catch and landings estimates, then summed with the MRFSS private boat and shore catch statistics to produce the revised annual landings in numbers of fish. Weight landings were then produced using the average weight per fish landed by stratum then summing to produce annual state landings and annual coast or stock landings in pounds of fish.

From 1981 to 1985, the MRFSS considered charterboats and headboats as part of single fishing mode (party-charter). Thus, the conversion factors estimated with 2004-2007 charterboat data (used to calibrate 1986-2003 charterboat effort estimates) cannot be used to calibrate the 1981-1985 estimates. To calibrate the 1981-1985 combined charterboat and headboat catch estimates, conversion factors will be estimated using 1986-1990 catch estimates, by species, instead of 2004-2007 to minimize possible effects of changes in the fishery over time. To do so, headboat (NMFS Headboat Survey) and original (MRFSS) charterboat catch estimates were combined (summed) into one estimate for each year and wave. These estimates were then modeled against the MRFSS-only catch estimates to produce a time series factor for conversion of the PC estimates from the 1981-1985 period to a revised time series of annual Charter Boat only catch estimates for 1981-1985.

4.3.2.3 MRFSS Party-Charter Mode Red Drum Landings Estimation for 1981-1985

The annual landings of red drum in the mid-Atlantic region are extremely rare north of VA, particularly in the 1981-85 period. The SEHB survey does not include VA so we do not have any independent head boat landings for north of NC, which do use for adjustment of the 1981-85 Party-Charter (PC) MRFSS estimates, but based on landings during the same period from headboats in the South Atlantic region (very low annual totals with 3 of 5 years having recorded landings of 1 fish or less for the region from head boats), it is unlikely that a significant component of the PC landings (MRFSS) came from head boats in VA during 1981-85. Further, those annual PC landings are small enough relative to the total annual landings that any adjustment due to survey methodology compensation was considered insignificant. Therefore, the group decided that, due to the lack of detailed landings by mode for this time period, the MRFSS Party-Charter red drum landings estimates would be sufficient for this assessment without any additional adjustments.

4.3.2.4 MRFSS LSMEAN Ratios - Mid Atlantic Region

Significant factors are Wave and State, with DE and MD clustering together (Table 4.3.2.4).

4.3.2.5 MRFSS LSMEAN Ratios - South Atlantic Region

Significant factors are Water body, Wave, and State with SC and GA clustering together (Table 4.3.2.5).

4.3.2.6 MRFSS General Recreational Discards and Discard Trends

The access-point recreational fisheries surveys (angler intercept) ask anglers about any fish that was caught and then either landed with its body incomplete (gutted, filleted, etc), or not landed at all (released alive). Those that were released alive were designated as discards and the raw reported data were expanded to the estimated totals following the same procedures as the landed fish. No size data were available for this class of catch.

4.3.2.7 MRFSS Biological Sampling

4.3.2.7.1 Sampling Methods

The only biological data collected during the routine MRFSS/FHS surveys are length of fish and weight of landed fish. Both are collected opportunistically but field interviewers are instructed to measure and weigh up to fifteen fish of each available species from each angler interviewed. The individual fish are to be selected from the total landed catch at random to avoid any size-bias in the resultant sample. Fish are measured to the nearest mm fork length (center-line total length in non-forked fish) and weighed to the nearest 1/8 or ½ kg, depending on scale precision. Annual sample sizes of fish measured are included on the length-frequency worksheet.

4.3.2.7.2 Sampling Intensity Length/Age/Weight

See biological sampling section for length and weight sampling. No age samples are taken from MRFSS/FHS surveys.

4.3.2.7.3 Length – Age Distributions

None by surveys

4.3.2.7.4 Adequacy for Characterizing Catch

The samples of length and weight from the MRFSS/FHS surveys are stratified by year, wave, state, mode of fishing, and area fished (= cell) for purposes of estimating mean weight per fish and length frequency (weighted by catch). These cell samples are used to expand the cell catches in number to total kg and pounds landed, then are summed across cells to produce the annual statistics. Similarly, the length frequencies are expanded to counts per length group per cell, and then summed across cells to produce a single annual frequency distribution. If a cell is empty of sample, then a mode or state-level mean is substituted for mean weight. If the length frequency is absent from a cell but a catch number is estimated, then the cell is considered similar to the overall size-frequency distribution.

4.3.2.7.5 Alternatives for Characterizing Discards

None

4.3.2.8 MRFSS General Recreational Catch-at-Age/Length - Directed and Discard

None

4.3.2.9 MRFSS General Recreational Effort

Effort estimates by year, state, wave, fishing mode and area fished are available through the MRFSS for the entire time series. Recent years have an increased sample size for the Coastal Household Telephone Survey (2006 & 2007) in several states in which red drum are caught, thereby improving the precision of the effort estimates. Improvements in effort estimates were also achieved in the charterboat mode based on the 2004 implementation of the For-Hire Survey (FHS). As previously stated in Section 4.3.1, the MRFSS concluded that the FHS produced significantly 'more efficient, precise, and credible charter angler effort estimates than the traditional MRFSS method'.

4.3.2.9.1 Historical Data

As with previous SEDARs, the workgroup was tasked with collecting recreational landings for years prior to the start of the MRFSS in 1981. The U.S. Fish and Wildlife Service conducted salt-water angling surveys 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 are included in Table 4.3.2.9.1. 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 is 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. SEDAR 17 assessment workshop authors reduced estimates to 75% of the reported values for the assessment model base run, and 50%, 100%, and125% for the sensitivity runs. As noted in SEDAR 17, should the historical catch estimates be utilized during the assessment, percent standard error (PSE) estimates will need to be derived from a linear interpolation of tabled values provided in the U.S. Fish and Wildlife Service salt-water angling survey reports.

4.3.2.10 MRFSS Comments on Adequacy of General Recreational Data for Assessment Analyses

The MRFSS provides the longest running, uninterrupted recreational and charter fishing catch data in the south and mid Atlantic. For those states catching significant numbers of red drum, most estimates of annual total catch (and often annual harvest estimates) have PSE's <20, indicating acceptable levels of precision.

4.3.3 South Carolina Finfish Survey (SFS)

4.3.3.1 SC-SFS Description and Sampling design

The collection of inshore finfish intercept data in South Carolina was conducted through a non-random intercept survey at public boat landings and piers in the following areas: 1) Georgetown/Murrells Inlet, 2) Metropolitan Charleston, and 3) Beaufort/Hilton Head. The survey focuses on known productive sample sites and was conducted during January-December using a questionnaire and interview procedures similar to those of the MRFSS.

4.3.3.2 SC-SFS Background

Implemented in 1989, the State Finfish Survey (SFS) was designed to address specific gaps within the MRFSS data, as identified by SCDNR staff. These gaps included the lack of length data from species of concern to the SCDNR and the lack of seasonal and area-specific catch frequencies. Another concern was the lack of catch and effort data from private boat anglers, which make up a majority of the angling trips in South Carolina coastal waters. These data gaps were initially addressed by interviewing inshore anglers who were targeting the red drum at specific sample locations. Since 2002, more emphasis has been placed on acquiring length data from all finfish retained by anglers, canvassing at additional sampling locations, and interviewing all private fishing boats within each area of the coast. Broadening the scope of the survey may decrease some of the bias associated with the previous SFS protocol, which could potentially allow for better catch estimates and length frequency data.

4.3.3.3 SC-SFS Protocols

Sampling is conducted at public and selected private (with owner's permission) boat landings from January through December using a questionnaire and interview protocols similar to those of the MRFSS. However, the SFS questionnaire focuses on vessel surveys rather than individual angler surveys and primarily targets private boats. Interviews are obtained from cooperative anglers at each sampling site. If an angler is unwilling to participate, they can decline to be interviewed. Assigned Creel Clerks interview as many anglers as time allows at any given site.
The sampling schedule is determined by "needs assessments" of the SCDNR Marine Resources Division and creel clerks. Individual creel clerks are assigned to a sampling region and will determine their daily sampling schedules based on local conditions (i.e. weather, landing closures, or events), additional job duties, and research and management initiatives. Attempts are made to assess all sampling sites equally, and individual creel clerks randomly rotate between all sampling locations within their region. Creel clerks will remain at boat landings with fishing activity. If boat landings have little or no fishing activity, creel clerks move to alternative sampling locations in close proximity.

4.3.3.4 SC-SFS Landings

Red drum catch data by trip are available from 1991-2007 (~14,000 records). Strata include fishing mode (~95% private boat mode), area fished, number of anglers, number of hours fished, and total number of released and harvested fish by species. The dataset is available in the SEDAR 18 Data Workbook, file name: South Carolina State Creel Survey Data.

4.3.3.5 SC-SFS Biological Sampling

Over 8,000 red drum lengths (total length in mm) are available, with an average of ~470 per year. Length frequency per year can be generated.

4.3.3.6 SC-SFS Comments on Adequacy for Characterizing Catch

Length data from the SFS could be particularly helpful if there are gaps in the MRFSS length data for SC. However, since there are only biased estimates from directed sampling in non-random locations, estimates of total catch and harvest that are equivalent to MRFSS cannot be produced. A review of SC annual sample size obtained through the MRFSS indicates there is no year in which fewer than 20 red drum lengths were obtained. An additional comparison of catch estimates vs. presence/absence of length data for cell combinations of year, by wave, by fishing mode indicates that the length data are relatively complete (cell n=20). Since 1991 (when SC data start) there were only two waves in the MRFSS data (Wave 3 in 2003 and Wave 2 in 2005) in which there were catch estimates but no length data. Neither of these waves occurs during peak red drum harvest season, and thus limited length data should have minimal effect (Data workbook files: *red_drum_length_smpl-sz.xls; and red_drum_length_smpl-sz_chking.xls)*

4.3.4 South Carolina Captains' Logbook - Description and sampling design

4.3.4.1 SC Logbook Landings

Trip level red drum catch data are available from 1994-2007 (~30,000 records) with an average of >2,000 records per year. Strata include area fished, number of anglers, pounds landed and number released. Dataset available in SEDAR 18 Data Workbook, file name: SC Captains' Log.

4.3.4.2 SC Logbook Biological Sampling

Length data are only available from 2007-2008, thereby not overlapping significantly with the date range for the current red drum assessment. Over 3,500 red drum lengths (total length in inches and converted to mm) are available by area fished. Length frequency per year can be generated. Dataset available in SEDAR 18 Data Workbook, file name: SC B2 RD lengths with locations.

4.3.4.3 SC Logbook Comments on Adequacy for Characterizing Catch

Since the logbook is a census, estimates of total catch and harvest could be produced in additional to SC data generated through the MRFSS.

4.4 Recreational Workgroup Research Recommendations

4.4.1 Review of Historical Data

Have experts in survey design and implementation review historical data.

4.4.2 Marine Recreational Information Program (MRIP)

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

4.4.3 Volunteer Logbook

We support inclusion of volunteer logbook data for length.

4.5 Tasks for Completion following Data Workshop

4.6 Literature Cited

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.

4.12 Tables

Table 4.3.1.1. South Atlantic estimated head boat landings of red drum from 1981-2007.

Year	Number	wt_kg	lbs
81	1	2.5	6
83	52	272	600
84	64	320	705
85	1	4.536	10
86	14	91.401	202
87	1	9.7	21
89	17	219.282	483
90	4	17.27	38
91	451	1464.14	3228
92	21	119.49	263
93	8	25.92	57
94	9	19.95	44
95	5	13.76	30
96	18	57.47	127
97	50	210.54	464
98	15	59.87	132
99	64	224.35	495
00	35	136.08	300
01	20	50.15	111
02	53	148.85	328
03	30	182.75	403
04	17	85.99	190
05	34	128.81	284
06	18	38.11	84
07	19	42.764	94

Table 4.3.2.4. Predicted ratios and standard errors (in parenthesis) of FHS/MRFSS charterboat effort estimates (to be applied to 1986-2003) for the Mid-Atlantic states. Significant factors included state and wave.

	Wave				
	2	3	4	5	6
DE / MD	1.294 (0.52)	1.599 (0.54)	1.930 (0.54)	0.861 (0.52)	1.171 (0.56)
NJ	1.289 (0.36)	1.179 (0.34)	1.644 (0.34)	0.809 (0.34)	1.115 (0.36)
NY	1.187 (0.48)	2.048 (0.54)	2.665 (0.48)	1.210 (0.51)	0.617 (0.48)
VA	0.770 (0.25)	0.680 (0.21)	0.761 (0.21)	0.324 (0.22)	0.313 (0.22)

Table 4.3.2.5. Predicted ratios and standard errors (in parenthesis) between FHS and MRFSS charterboat effort estimates (to be applied to 1986-2003) for the South Atlantic states (note header for specific state application).

EAST FLORIDA

	Wave					
Area	1	2	3	4	5	6
INSHORE	2.051 (0.73)	3.357 (0.73)	1.919 (0.73)	3.302 (0.73)	0.887 (0.73)	1.281 (0.82)
OCEAN	0.671 (0.12)	0.980 (0.12)	0.805 (0.12)	1.036 (0.12)	0.520 (0.12)	0.616 (0.14)

NORTH CAROLINA

	Wave				
Area	2	3	4	5	6
INSHORE	12.182 (3.68)	13.291(3.68)	7.966(4.25)	0.973 (4.25)	6.134 (5.20)
OCEAN	1.660 (0.45)	1.947 (0.45)	1.116 (0.48)	1.075 (0.48)	0.684 (0.52)

SOUTH CAROLINA, GEORGIA

	Wave				
Area	2	3	4	5	6
INSHORE	2.083 (1.56)	4.881 (1.56)	2.887 (1.56)	1.252 (1.56)	0.618 (1.80)
OCEAN	1.018 (0.54)	1.708 (0.52)	2.812 (0.52)	0.940 (0.54)	0.652 (0.74)

Table 4.3.2.9.1. Estimated red drum captured from saltwater anglers surveyed in 1960, 1965 and 1970 by species, region and principal fishing area. *See discussion of bias in SEDAR 17 Vermilion Snapper Stock Assessment Report under Section III. Assessment Workshop Report, 2.3.1[S17 VS SAR 2]

Number Red Drum Caught (x1,000)
(by species, region, principal area and method fishing)

Year	Region	Ocean	Sounds, Rivers, Bays	Boat - Still	Boat - Motion	Shore - Still	Shore - Motion	Annual Total
1960	Mid Atl	-	-	260	196	0	0	456
	South Atl	-	-	3968	199	181	179	4527
Year	Region	Ocean	Sounds, Rivers, Bays	Private/Rented	Party/ Charter	Bridge, Pier, Jetty	Beach, Bank	Annual Total
1965	Mid Atl	24	172	7	35	126	28	196
	South Atl	2436	1663	1497	235	1965	402	4099
1970	Mid Atl	51	46	46	0	0	51	97
	South Atl	1032	3851	3839	276	287	481	4883

Number US Saltwater Anglers (x1,000)				
	Mid Atl		South Atl	
Year	Annual Total	Target Red Drum	Annual Total	Target Red Drum
1960	1344	35	1024	157
1965	1375	68	1720	151
1970	1767	8	1808	164

Estimated TOTAL Weight (lbs) (x1,000)		
Year	Mid Atl	South Atl
1960	11400	27160
1965	1281	15171
1970	83	13358

Where: Mid Atl - Atlantic Coast from NJ to Cape Hatteras, NC
South Atl - Atlantic Coast from Cape Hatteras, NC to Southern FL including the Keys

4.13 Figures

None

5. Indicators of Population Abundance

5.1 Overview

Several red drum indices of abundance were considered for use in the assessment model. These indices are listed in Table 5.1.1, with pros and cons of each included. The possible indices come from fishery-dependent and –independent data. Nine fishery-independent sources and 4 fishery-dependent sources were considered by the workgroup.

The Indices workgroup representatives were Carolyn Belcher (GADNR), Mike Murphy (FFWCC) leader, Julie DeFelipi (ASMFC), Erin Levesque (SCDNR), Steve Arnott (SCDNR), Carl Brenkhert (SCDNR), Lee Paramore (NCDMF), and Joe Grist (VMRC). Several issues were discussed by the group, including how to reconcile different trends in the two southern region young-of-the-year indices.

5.2 Review of Working Papers

S 18-DW02 – History of red drum tagging in North Carolina

Abstract *(written by group)*

The various tagging programs conducted by the North Carolina Division of Marine Fisheries are described along with summaries of year-, gear-, and life-stage-specific sample sizes and recovery matrices for age groups $1\text{-}4^{+}$. Tagging operations have been conducted in North Carolina since 1983. Eleven different tag types have been applied to fish captured during commercial fishing operations, volunteer angling trips, a variety of scientific sampling activities, by commercial fishers, and volunteer anglers.

Group discussion – The group did not discuss this paper at the data workshop but reviewed and approved the following text. The opportunistic feature to much of the sampling described make it unlikely an index of abundance could be developed from any catch rate data. The life history group at the workshop is investigation additional analysis of these tag/recapture data to estimate selectivity and possibly survival and exploitation rates. If the latter are estimable then they could be incorporated as an index to the trend in annual survival or exploitation estimates generated from the stock assessment model. The final decision on this awaits completion of the tagging data analysis prior to the assessment workshop.

S 18-DW05 -- Metadata for the Georgia Department of Natural Resources Division's Fishery Independent Red Drum Data 2002 – 2007 *(2007 Adult Red Drum Sacrifice also included)

Abstract
A description of three of Georgia's red drum surveys is given. The first entitled Fall 02 Adult Sacrifice targeted large adult red drum in 2002 for length and age estimates. Two hundred and thirty four fish were caught using hook and line and longline with lengths and ages recorded. The second survey entitled Fall 07 Adult Sacrifice also targeted adult red drum for age-length with hook and line and longline gear. Finally, the Summer Gillnet Survey targets young of the year red drum to produce indices of relative abundance.

Group discussion- The group reviewed the longline survey and summer gillnet survey for their use as index of red drum abundance. The longline survey was described as a stratified random survey where stations were selected at random from time and space strata within the universe of 120 possible grids. Given the short time series and small number of red drum encountered, the WG decided not to consider this survey for this assessment. The summer gillnet survey was described as a stratified random survey of 415 potential stations in the Wassaw region and 357 stations in the Altamaha region. These stations were assigned to area-specific strata that were further divided into one of two density strata based on the historically measured or perceived red drum density levels. Sampling was random within these strata. The group was concerned that the changes in the program over time, especially the reassignment of strata between the high and low density strata, could mask the changes in red drum abundance over time. This "hybrid random stratified and fixed station" design implied a very complex sampling probability scheme. The group suggested that a subset of stations consistently occupied over time be used to construct the indices, essentially a fixed station design.

S 18 DW06 -- SEDAR 18-Red Drum. NC Biological Data Survey Descriptions and Background Information: NC Red Drum Juvenile Seine Survey, NC Independent Gill Net Survey, NC Age and Growth Data, NC Commercial Dependent Sampling, NC Commercial Gillnet Observer Program.

Abstract *(written by group)*
This document briefly describes the design and results from several fisheries data collection programs being conducted in North Carolina. Two surveys for fish abundance are included: the North Carolina juvenile seine survey and the North Carolina independent gillnet survey.

Group discussion – The juvenile seine survey was a fixed station survey that appears to have been consistently sampled over time and could be used as a measure of young-of-the-year red drum abundance. The 1996 estimate of relative abundance is considered an anomaly that should be dropped from the data because of the high level of hurricane activity that year. The group suggested that the index be constructed using a geometric mean of the catch, average log(catch+1). The gillnet survey used a stratified random design to sample the Pamlico Sound and adjacent river areas. The group decided that only the Pamlico sound stations were consistently sampled over time and should be used in the index creation. Again, because of the skew in the distribution of the observed data, the group suggested that the geometric mean be estimated for the index. The index was disaggregated to age-specific estimates by applying an age-length key to the measured lengths of sampled red drum to estimate the age composition of the sample catch each year. The group discussed the need to include some additional level of uncertainty (variance) to the final estimates that reflected this age-specific estimation process but needed to investigate this further.

S 18 DW 9 -- Recreational harvest estimates and estimated catch-at-age for the recreational fishery in Florida during 1982-2007.

Abstract *(written by group)*
The MRFSS-adjusted catch estimates for Florida's Atlantic red drum fishery are given for 1982-2007. Details are provided about the number of angler-interviews conducted each year and the available biostatistics information on landed or released red drum. The analysis provided estimated annual length frequencies for the landed and for the released-alive portions of the recreational catch, age-length keys, and resultant catch-at-age estimates for red drum.

Group discussion – The group did not discuss this paper at the data workshop but reviewed and approved the following text. There was no information presented in this paper that was directly pertinent to the development of indices of abundance for red drum.

S 18 DW-10 -- Indices of relative abundance for young-of-the-year and subadult red drum in Florida.

Abstract *(written by group)*
This document described the Florida fishery-independent monitoring program's small seine survey for young-of-the-year fishes and the large seine survey of larger-size fish. Sampling intensity, catch characteristics, and estimates of annual relative abundance are given. Diagnostic of the estimation procedures are attached as an Appendix.

Group discussion – The group accepted the survey design as adequate for measuring red drum abundance changes over time. The estimates presented were arithmetic means and delta lognormal standardized means for the full dataset and a species-association subset. The group agreed that the standardization procedure was appropriate but chose the use of the entire dataset over the subset because both surveys were conducted completely within areas of red drum habitat, i.e., there were no areas that could be considered outside the universe of where red drum could occur. The large seine survey disaggregated the standardized estimate into age-specific indices and needed to consider the increased variance associated with the age-assignment process.

S 18 DW-11 -- Electric Survey: Materials and Methods.

Abstract *(written by group)*
This document was a section out of a larger report. It described in detail an electro-fishing survey of fresh and brackish coastal South Carolina waters. It provides characteristics of the sampled fish, lengths and ages, over time. Geometric mean estimates of abundance are presented for the overall catch rates for red drum and the

early-age-one estimated catch rates. Cohort-specific estimates of instantaneous total mortality are also provided.

Group discussion – The group agreed that this stratified random transect survey design was appropriate. Some discussion questioned what age was best represented by the age-specific index provided. It appeared that the sizes of fish included in the age-specific index were late age-0 fish that could be used to back-cast the changes in age-0 relative abundance. As with the other age-disaggregated indices above, there was some discussion of inflating the variance of the age-specific index values.

S 18 DW-12 – Study on mortality using SC tagged red drum.

Abstract *(written by group)*
The data file names and necessary metadata needed to understand and use the data collected from various South Carolina tagging events are presented. Also included are summary tables of the numbers tagged and numbers recovered during inshore sampling programs by gear type, sample design, and tag type. A tag/recovery matrix is given for the adult red drum program.

Group discussion – The group did not discuss this paper at the data workshop but reviewed and approved the following text. There was no obvious information relating to trend in abundance in this report. Analysis of these data could possibly produce trends in exploitation or survival that could be useful (see above S 18 DW02).

S 18 DW 14 – Assessment of adult red drum in South Carolina waters

Abstract *(written by group)*
The sampling design is described for a bottom longline survey of adult red drum in South Carolina. The average catch rates per 1 mile of longline gear show an increasing trend during 1997-2005 before dropping substantially in 2006 and 2007. Yearclasses have been identified for a subsample of the fish captured.

Group discussion – The group discussed this program with South Carolina scientists, with a special thanks to Glenn Ulrich for his historic perspective on the survey. It appeared that the bottom longline catch rates would be a useful index of adult red drum abundance. The geographic scope of the sampling program was discussed and the group decided that the Charleston Harbor samples should be used in the index because of the consistency in sampling there over time and the relatively high success rate at encountering adult red drum. Questions were raised about what ages of adult red drum are best represented by the longline catch rates. Some size 'cutoffs' in the age sampling done from these fish may have affected the age composition of the samples. The group decided to use the annual geometric mean catch rates as indices of abundance for ages 8-10, the most encountered ages.

S 18 DW 15 – South Carolina independent survey description and protocol

Abstract *(written by group)*
The sampling design and protocol was given for stopnet sampling, trammel net sampling from 1991 through 2007, and an electrofishing survey during 2001-2007.

Group discussion – The group did not discuss this paper at the data workshop but reviewed and approved the following text. Two surveys described briefly in this document were more thoroughly covered in other data workshop working papers (electro-fishing S 18-DW11; trammel net S 18-DW 18). These were more pertinent to our discussion of the use of these surveys to generate indices of abundance.

S 18 DW 18 – South Carolina randomly stratified trammel net survey

Abstract *(written by group)*
The South Carolina trammel net survey has been conducted since 1991 in seven strata within the four major estuarine systems. The majority of fish caught are age-1 (11-16 months old, or beginning of model-age2). In general, the influence of the number of stocked fish caught on the catch rate was negligible. There was a general decline across the 1992-2000, followed by a sharp rise in 2001. CPUE then underwent a second period of decline, but catch rates in 2007 and 2008 (partial) show an increasing trend and are close to the long-term mean for the whole time series.

Group discussion –This paper was the basis for the group's decision to accept the South Carolina trammel net survey for use as an index of model-age-2 beginning-of-the-year relative abundance.

5.3 Fishery-Independent Surveys

5.3.1 Survey One – Florida young-of-the-year index (S18 DW 10)

5.3.1.1 Methods, Gears, and Coverage

The FWC's Fishery Independent Monitoring (FIM) program uses a stratified, random design to collect information on animal populations (Fisheries-Independent Monitoring Program Staff. 2008). Strata are primarily defined by depth, shore type (overhanging or not), and bottom vegetation (sea grass or not). This program also supplies length, weight, sex and material for the determination of age while monitoring abundance of young-of-the-year (biological-age-0; model-age 1) and larger fishes. Annual Atlantic coast young-of-the-year (red drum smaller than or equal to 40 mm standard length) indices were estimated from collections of red drum made using 21.3-m (3.1mm bar mesh) center-bag seines. Sets used to develop these indices were made from September through March during the periods 1997-2007 in the northern Indian River Lagoon and during 2001-2007 in the St. Johns River/Nassau Sound region (Fig. 5.3.1.1). Though data were available since 1990 few or no red drum were captured during these "start-up" years; the survey changed from seasonal sampling (spring and fall) to year round in 1996, and consistent sampling zones have been randomly surveyed since 1997.

5.3.1.2 Sampling Intensity

At least 100 sets were made each year after 1997. Up to 20 red drum-per-size-class captured during 21.3-m bag seine sampling were measured for standard length (SL) and all were counted within each size class. When more than 20 red drum were encountered then length frequencies of the 20 fish were expanded to the total number caught to estimate the sample catch length frequency. All red drum used in the analysis from the young-of-the-year survey, 21.3-m bag seines, were less than or equal to 40 mm SL and were assumed to be age 1 (defined as beginning the first January 1st after fall hatching season).

5.3.1.3 Size/Age data

All red drum considered for this index were clearly age 0 based on the sizes of fish considered, less than or equal to 40 mm SL.

5.3.1.4 Catch Rates

The complete fishery-independent dataset was used to develop the relative abundance estimates. Standardized annual catch rates for red drum were estimated using a delta lognormal model (dual Generalized Linear Models, Lo et al. 1992). All factors used in the analyses were simplified categorical effects: bayzone (region within sampled estuary), bottom sediment type (sand, mud), month, shore type (overhanging vegetation, structure, other), bottom vegetation (seagrass, none), salinity (low,<8ppt; medium,8-33ppt; high,>33ppt), and temperature (low,<15degreesC; medium,16-25degreesC; high,>25 degrees C). Only main effects were used in the model.

The indices generated for young-of-the-year red drum indicate strong year-classes occurred periodically but the strongest of these occurred during the fall/winter of 2004 (January 1, 2005). A string of three consecutive, above-average year classes occurred during the period 2003-2005 (Table 5.3.1.1, Fig. 5.3.1.2). Weak year-classes have occurred recently; young-of-the-year were at low levels of abundance in 2000 and possibly again in 2006.

5.3.1.5 Uncertainty and Measures of Precision

The standardization process provided estimates of the asymptotic standard errors for the year-specific least squares mean for the binomial (presence/absence) component and the lognormal (positive catches) component. Model diagnostics for the positive-catch analysis showed a slight positive skew to the residuals and this will lead to slight under-estimation of the CV's of the annual index values. A final combined annual index value and its CV was estimated using a Monte Carlo simulation of the individual component distributions. The analysis contained comparisons between the trends in the empirical average catch rates (arithmetic), the standardized full dataset catch rates, and the species-association subset dataset (Stephens and McCall 2004). The group decided that because the survey included estuarine stations that were all potential habitat for juvenile red drum, the standardized full dataset index should be used. After the data workshop, during development of the index standardization diagnostics, the analysis (S 18 DW-10) was revised to include only those data collected since fall 1997. Estimates of coefficients of variation exceeded 100% for the original 1993-1996 index estimates and sampling design changes that occurred prior to 1997 justified dropping these early data from the analysis.

Another level of uncertainty not addressed results from the potential highly variable natural mortality rates experienced by such small red drum. The group was concerned that the year-class signals from fish this small could be modified by extreme levels of natural mortality early in the fish's first year of life, i.e., the 'critical period' could occur in older fish.

5.3.1.6 Comments on Adequacy for assessment

This index was deemed adequate for use in the assessment. The group decided that the delta lognormal standardization for the entire dataset was more useful than the species-association subset analysis. The survey area was conducted within the general habitat of young-of-the-year red drum. With multiple young-of-the-year indices in the southern red drum region, the group decided that, beside the year-specific estimates of precision, the survey weights should be made using the relative areal extent of each survey.

5.3.2 Survey Two – South Carolina electric survey (young-of-the-year index)

5.3.2.1 Methods, Gears, and Coverage

Prior to actual field sampling in May 2001, we erected six strata in estuarine systems along the South Carolina coast (Figure 5.3.2.1). These included the lower and upper Edisto Rivers, the Combahee River, The upper Ashley River, the upper Cooper River and the North Santee River. Winyah Bay replaced the North Santee stratum in November 2003. The Upper Edisto stratum was freshwater; the others had salinities that were generally less than 10 ppt.

5.3.2.2 Sampling Intensity – Time Series –

May 2001-present

5.3.2.3 Size/Age

Data generally age-1 though there is a high proportion of age-2 fish after the first year.

5.3.2.4 Catch Rates – Number and Biomass

Age 1 red drum generally accounted for the greatest percentage of the total fish caught during each year. To obtain an index of recruitment for a year class during a sampling year (the 2000 year class would be first fully recruited to the survey in 2001), the percent contribution of the newly recruited year class was multiplied by that year's annual mean catch per sample (Table 5.3.2.1 and Figure 5.3.2.2).

5.3.2.5 Uncertainty and Measures of Precision

The South Carolina electric survey sample size (number of sets) was fairly large and this is reflected in the low coefficients of variation, ranging 7-9 during 2001-2008. Proportional standard error (%) values for the annual arithmetic mean indices ranged between 8.5 and 13.5. Values for the $\log_e$ transformed data varied between 5.9 and 7.5. There was good agreement in annual trends between the juvenile indices of the SC electric survey and the SC trammel net survey (5.3.6).

5.3.2.6 Comments on Adequacy for assessment

The group agreed that catch rates for this survey would be useful as indices of abundance for young-of-the-year red drum, though there was work needed to look at the variance associated with the age composition split.

5.3.3 Survey Three – Georgia survey (model age-1)

5.3.3.1 Methods, Gears, and Coverage

From June through August, gill net surveys are conducted in Wassaw Sound and the Altamaha Sound Region (Figure 5.3.3.1). In Wassaw, stations are selected and sampled each month from a pool of 415 total stations using a hybrid random stratified and fixed station design. In the Altamaha Region, stations are selected and sampled each month from a pool of 357 total stations using a similar hybrid random stratified and fixed station design. In a given survey month, each selected station is sampled one time. All sampling occurs during the last three hours of ebb tide and only during daylight hours. Station pools in both survey areas were determined by initial surveys, which identified locations that could be effectively sampled with survey gear.

Survey gear is a single panel gillnet. The net is 300ft long by 9ft deep. The panel has 2.5in stretch mesh. The net has a 0.5in diameter float rope and a 75lb lead line. A 25lb anchor chain is attached to each end of the lead line, and a large orange bullet float is attached to each end of the float line.

A sampling event consists of a single net set. The net is deployed by boat starting at the bank following a semicircular path and ending back on the same bank. Net deployment is done against the tidal current. Immediately after deployment, the net is actively fished by making two to three passes with the boat in the area enclosed by the net. After the last pass is made, the net is retrieved starting with the end that was first set out. As the net is retrieved, catch is removed and put back into the water, inside a holding pen tied to the boat. After the net is fully retrieved, all catch is processed for information and released. All catch is identified to species and counted. All finfish specimens are measured, centerline in millimeters. In addition to catch information, temporal, spatial, weather, hydrographic and physio-chemical data are collected during each sampling event.

5.3.3.2 Sampling Intensity

A minimum of 36 stations are sampled in each sound system during each month of the sampling season (June – August). Time series covers from 2003-2007. Under the WG suggested approach (see Comments on Adequacy for Assessment) 13 fixed stations were sampled a minimum of two times within a sampling year and were represented in at least 4 of the 5 years. The number of sites visited by month and year are outlined in Table 5.3.3.1.

5.3.3.3 Size/Age

The majority of fish sampled are age-1 individuals.

5.3.3.4 Catch Rates – Number and Biomass

Two approaches were suggested for producing CPUE estimates for Georgia's age-1 red drum. First, a traditional CPUE was calculated based on the geometric means. Because of the high number of zeros in the raw data, it was also suggested that the trend in percent positive sets be examined. The use of this proportion as a measure of abundance was discussed in Bannerot and Austin (1983).

The catch rates calculated under both approaches suggested by the WG showed an oscillating trend between years, with a slight downward trend exhibited over the five years (Table 5.3.3.2). 2006 exhibited the lowest catch rate, with 2003 exhibiting the highest.

5.3.3.5 Uncertainty and Measures of Precision

Annual CPUEs and their associated 95% confidence limits / CVs were provided (Table 5.3.3.2) for the WG suggested approaches.

5.3.3.6 Comments on Adequacy for assessment

Issues were identified by the group associated with sampling units changing among strata (i.e., numbers of sampling units within strata varied across months and years). The WG recommended that GA look for sampling sites that could be considered index sites over the sampling period, and use those sites as a proxied fixed-station approach. The group agreed to the adequacy of the Georgia survey as a measure of the abundance of age-1 red drum.

5.3.4 Survey Four – North Carolina young-of-the-year index (S18 DW 6)

5.3.4.1 Methods, Gears, and Coverage

A red drum seine survey was conducted at 21 fixed sampling sites throughout coastal North Carolina (Figure 5.3.4.1) during September through November for each year from 1991 through 2007. Each of these sites was sampled in approximately two week intervals for a total of six samples with an 18.3 m (60 ft) x 1.8 m (6 ft) beach seine with 3.2 mm (1/8 in) mesh in the 1.8 m x 1.8 m bag. One “quarter sweep” pull was made at each location. This was done by stationing one end of the net onshore and stretching it perpendicularly as far out as water depth allowed. The deep end was brought ashore in the direction of the tide or current, resulting in the sweep of a quarter circle quadrant. All species were counted and identified; red drum were counted and measured to the nearest mm FL. Salinity (ppt), water temperature (^{o}C), tidal state or water level, and presence of aquatic vegetation were recorded. Locations of fixed stations were determined in 1990 based on previous catch rates and practicality for beach seining (Ross and Stevens 1992). The juvenile index, or CPUE, is the arithmetic mean catch/seine haul of young-of-the-year (YOY) individuals.

5.3.4.2 Sampling Intensity – time series-

Under the sampling design, complete survey coverage occurred at 120 seine sets per year. Only in 1994 and 1999 did the number of seine sets fall below 100.

5.3.4.3 Size/Age data

The size distribution of red drum caught during this survey indicated most fish were age-0. Size cutoff for age-0 was 100mm.

5.3.4.4 Catch Rates – Number and Biomass

Catch rates were variable early in the survey with apparent strong year classes in 1991, 1993, and 1997 (Table 5.3.4.1). During 1999-2001 there was a consistent series of low annual catch rates followed by an increase through 2005 before another drop in 2006.

5.3.4.5 Uncertainty and Measures of Precision

The estimated standard errors for the arithmetic mean catch rates were largest for the peak catch rates during the 1990's and lower since then especially for the years of lower catch rates. Hurricanes during this year caused extreme high and low water conditions and may have altered survey results. For this reason it was recommended that the 1996 data point be deleted from the index. The proportional standard errors (PSE is the same as CV of the mean) indicate that the estimated arithmetic mean catch rates were at least as precise as other indices for young-of-the-year red drum in the southern region, ranging from 13 to 31.

5.3.4.6 Comments on Adequacy for assessment

The group agreed that catch rates for this survey would be useful as an index of abundance for young-of-the-year red drum and agreed with the recommendation that 1996 data point not be used.

5.3.5 Survey Five – Florida subadult survey (S18 DW 10)

5.3.5.1 Methods, Gears, and Coverage.

This survey is a stratified random sampling, much like survey 5.3.1 above, except with 183-m seine sampling gear. This survey has operated in the southern and northern Indian River Lagoon since 1997 and in the St Johns/Nassau Sound area since 2001 (Fig. 5.3.1.1).

5.3.5.2 Sampling Intensity – time series

The calendar year sampling intensity ranged from 360 sets in 1997 to over 600 samples per year after 2002 (Table 5.3.5.1). Annual random samples of aging parts were taken from between about 60 and 150 fish each year.

5.3.5.3 Size/Age data

Estimated annual length frequencies for red drum caught in the 183-m haul seine showed a wide size range was captured by the gear. Most captured red drum were between 14 and 24 inches TL, also with a secondary mode at 5 or 6 inches. During 2004 there was an abundant group of red drum between 4 and 12 inches long. The ages of red drum captured in haul-seine sets was mostly model-age 2 and 3 years olds, with occasional high numbers of age-1 or age-4 fish.

5.3.5.4 Catch Rates – Number and Biomass

Indices generated for sub-adult red drum show relatively little change during the period 1997-2007 except for a slight increase after 2003 (Fig. 5.3.5.1). Age-specific indices seemed to show some correspondence year-to-year, with consistent abundant or rare year classes of red drum passing through model age 2 one year and model-age 3 the next. There was less correspondence seen between these relative abundance indices and that seen in the young-of-the-year (model-age 1) index.

5.3.5.5 Uncertainty and Measures of Precision

The estimated CV's for the pooled index ranged 12-17%. Age-specific partitioning uncertainty still needs to be incorporated into the final age-specific indices (variance summation). Model diagnostics for the positive-catch analysis showed a slight positive skew to the residuals (Fig. 5.3.5.2) and this will lead to slight under-estimation of the true CV's of the annual index values.

5.3.5.6 Comments on Adequacy for assessment

The group agreed that catch rates for this survey would be useful for age-specific indices of abundance for model ages 2 and 3. The group also recommended using the delta lognormal standardization for the entire dataset.

5.3.6 Survey Six – South Carolina trammel net survey (age-1 index) (S18-DW18)

5.3.6.1 Methods, Gears, and Coverage

The SC trammel net survey has been conducted since 1991 (Wenner 2000) and is an ongoing program. It uses a stratified random sampling design and has long-term data sets for seven strata within four major SC estuary systems (Figure 5.3.2.1). Sites in each stratum are selected at random on a monthly basis (without replacement) and sampled primarily during early-, mid- and late-ebb tide. The trammel nets are 184 m long by 2.1 m deep with 177 mm outer mesh and 63 mm inner mesh. Nets are set close to shore (<2 m depth) by a fast moving boat and, before retrieval, the water surface is vigorously disturbed along the full length to chase fish into the mesh. The strata include Ace Basin (AB), Ashley River (AR), Charleston Harbor (CH), Lower Wando River (LW), McBanks (MB), Cape Romain Harbor (RH) and Winyah Bay (WB). AB is in the Ace Basin estuary system (AB); AR, LW and CH are in the Charleston Harbor system (CH); MB and RH are in the Cape Romain system (CR); WB is in the Winyah Bay system (WB).

The catch data presented are for age-1 red drum. For fish that settle in the estuaries in the fall of year Y, full recruitment to the trammel gear occurs in July of year Y+1. Indices of abundance for each year class were calculated using catch data from Jul-Dec of year Y+1 and Jan-Mar of year Y+2, when the Y year class is easily discernable due to non-overlapping size distributions. For the purposes of this report we refer to these fish as age-1, although the actual data straddle the calendar year (i.e. the age-1 to age-2 transition).

In some years of the survey, cultured red drum have been released into areas covered by the trammel net survey as part of an experimental stocking program. For the 1989-1993 year classes, stocked fish were identified in the trammel catches by external tags (Smith et al. 1997). The data extracted from the trammel database excluded these fish, so no correction factor has been applied for them. In other years when stocking occurred, the percentage contribution of stocked fish was determined by matching microsatellite genotypes of fin-clipped trammel-caught fish against the parental brood stock. This was performed on fish caught in the stratum that was stocked, as well as neighboring strata in the same estuarine system. To calculate catch rates of just the wild red drum component, the catch of each set was adjusted according to the percentage contribution of stocked fish (Table 5.3.6.1). Genotype data are not yet available for the 2007 year class, so no adjustment has been made for it.

5.3.6.2 Sampling Intensity – time series

The number of July-March trammel sets that were analyzed for the 1989-2007 year classes was 8,773 (Table 5.3.6.2). Only data from random sets made during daylight hours and during early-, mid- and late-ebb tide are included, since catches are affected by tide. The number of strata increased from 2 to 7 over the time series. Mean sampling intensity also increased from *ca* 15 sets per stratum initially to about *ca* 90-100 sets per stratum from the mid-1990s onwards. The 1989 year class was only sampled during Jan-Mar 1991 (no Jul-Dec 1990 data available). There was a reduced number of sets used assessing for the 2007 year class because data from some of the latter months are not yet available.

5.3.6.3 Size/Age data

Assuming a birth date of Sept 1, the red drum cohort considered in the analysis was 11-19 months old in the July-March trammel sets. Mean total length (TL) of each year class across all the months sampled varied between 350.9 mm and 391.5 mm and showed evidence of density-dependent growth. On average, mean cohort TL increased from 268 mm in July to 419 mm in March. Table 5.3.6.3 shows the total catch for each year class and stratum.

5.3.6.4 Catch Rates – Number and Biomass

The catch number in each trammel set was $\log_e$-transformed (Ln[Catch+1]. To examine whether different strata showed similar year class trends in catch per unit effort (CPUE), data were initially explored at the stratum level. CPUE was calculated as the least squares means catch ($\log_e$-transformed, wild fish only) per trammel set using a general linear model (GLM) with year class, month of capture and tide (early-, mid- or late-ebb) as fixed factors. The output from these models showed that although absolute catch rates differed between strata, the overall trends in relative year class strength were consistent.

To calculate a South Carolina-wide CPUE, least squares means were derived using a GLM that included the $\log_e$-transformed catch data from all strata, with stratum added as a model factor. Two runs were performed, first using catches of all fish (wild + stocked) (Table 5.3.6.4), and secondly using catches of just the wild fish (i.e. catches adjusted for stocked fish contributions) (Table 5.3.6.5).

In general, the influence of stocked fish on the SC-wide CPUE was negligible (Figure 5.3.6.1). There was a general decline in CPUE across the 1990-1999 year classes, followed by a sharp rise for the 2000 year class. CPUE then underwent a second period of decline, but the 2006 and 2007 year classes show an increasing trend and are close to the long-term mean for the whole time series.

5.3.6.5 Uncertainty and Measures of Precision

There is less confidence in the earlier years of the survey because fewer estuarine systems and strata were covered, fewer trammels were set, and the 1989 year class was only sampled over three months (rather than 9). Values for the 2007 year class are preliminary because neither the most recent trammel data nor the percentage contribution of stocked fish to the AR, LW and CH strata are available yet. Evidence from previous years suggests that the effect of stocking is probably negligible to the SC-wide values.

Coefficients of variation were above 20 early in the time series and generally less than 15 after this.

5.3.6.6 Comments on Adequacy for assessment

The randomized stratified design of the trammel net survey is a statistically robust sampling protocol. There is good agreement in CPUE trends across strata, as well as with indices from the South Carolina red drum electroshock survey, which covers lower salinity areas of the trammel survey estuary systems (SC DNR 2009).

5.3.7 Survey Seven – South Carolina stopnet survey

The Indices Workgroup mistakenly assumed that this survey had been used during the last assessment. This survey was discontinued in the mid-1990's and was replaced by the trammel net survey discussed in a previous section. Given that this survey was not included in the previous assessment and that no new data has been added to the time series, the WG did not consider this survey for utility as an index of abundance.

5.3.8 Survey Eight – North Carolina Sub-Adult Survey

5.3.8.1 Methods, Gears, and Coverage

The Division's independent gill net study (Program 915) started as the presence and absence of disease sampling in 1998 on the Neuse, Pamlico and Pungo River systems (River Independent Gill Net Survey (RIGNS). Sampling in Pamlico Sound (The Pamlico Sound Independent Gill Net Survey (PSIGNS)) was initiated in May of 2001. Sampling in the RIGNS was dropped after 2000 and resumed in 2003 to present. The PSIGNS has sampled continuously since 2001. A primary objective of both the PSIGNS and the RIGNS is to provide independent relative abundance indices for key estuarine species including red drum. Sampling locations for the IGNS were selected using a stratified random sampling design based on area and water depth (Figure 5.3.8.1). The Sound was divided into eight areas: Hyde County 1 – 4 and Dare County 1 – 4. The Neuse River was divided into four areas (Upper, Upper-Middle, Middle-Lower, Lower) and the Pamlico River was divided into four areas (Upper, Middle, Lower and Pungo River). A one minute by one minute grid (i.e., one square nautical mile) was overlaid over all areas and each grid was classified as either shallow (< 6 ft), deep (≥ 6ft) or both based on bathymetric maps. Each area was sampled twice a month. For each random grid selected, both a shallow and deep sample were collected. Each sample (both shallow and deep) consisted of eight 30 yard segments of 3, 3½, 4, 4½, 5, 5½, 6, 6½ inch stretched mesh gill net, for a total of 240 yards per sample. Nets were typically deployed within an hour of sunset and retrieved the next morning, so all soak times were approximately 12 h. This sampling design results in a total of approximately 64 gill net samples (32 deep and 32 shallow samples) being collected per month across both the Rivers and Sound. Physical and environmental conditions, including surface and bottom water temperature (^{o}C), salinity (ppt), dissolved oxygen (mg/L), bottom composition, as well as, a qualitative assessment of sediment size, were recorded upon retrieval of the nets on each sampling trip. All attached submerged aquatic vegetation (SAV) in the immediate sample area was identified to species and density of coverage was estimated visually when possible. Additional habitat data recorded included distance from shore, presence or absence of sea grass or shell, and substrate type. Each collection of fish per mesh size (30-yard net) was sorted into individual species groups. All species groups were enumerated and an aggregate weight (nearest 0.01 kilogram (kg)) was obtained for most species, including damaged (partially eaten or decayed) fish. The condition of each individual was recorded as live, dead, spoiled, or parts. Individuals were measured to the nearest millimeter for either fork or total length according to the morphology of the species.

5.3.8.2 Sampling Intensity –

Sets in the Pamlico Sound were made over a part of the year in 2001 (237 sets), and thereafter was sampled at 320 sets per year.

5.3.8.3 Size/Age data

A large range of sizes were caught (range 220-1260 mm TL), but most were sizes associated with young age-1 or age-2 fish (mean of 400 mm TL).

5.3.8.4 Catch Rates – Number and Biomass

The weighted mean CPUE showed an increase from 2003 through 2007 (Table 5.3.8.1 and Figure 5.3.8.2).

5.3.8.5 Uncertainty and Measures of Precision

Standard errors and proportional standard errors were presented for the annual estimates of CPUE (Table 5.3.8.1). The proportional standard errors indicate the precision of this index is slightly less than the southern region’s Florida subadult survey and similar to the South Carolina trammel net survey.

5.3.8.6 Comments on Adequacy for assessment

The group agreed that catch rates for this survey would be useful as indices of abundance for young-of-the-year red drum, though there was work needed to look at the variance associated with the age composition split.

5.3.9 Survey Nine – South Carolina Adult Longline Survey

5.3.9.1 Methods, Gears, and Coverage (Include a map of the survey area.)

The data from the South Carolina Adult Red Drum Survey have been amended to include 1-mile long sets using a cable mainline. A cable mainline was used during the project exclusively in 1994, the first year of the study. Following discussion that sharks may be deterred by the cable (sharks were also a target species), in 1995 a monofilament mainline was also used. Both gear types were used until 1997. In 1998, the survey switched to monofilament mainline for all sets, since it was concluded that while the cable gear decreased the catch of sharks, red drum catches were unaffected by the gear. Both gear are now included in these updated data upon agreement by the Indices Sub-committee.

Since most catches of red drum occur in the fall, when they are most available to the gear, only sets made August through December have been included. Until 2007, most sampling occurred in the Charleston Harbor, using fixed stations, with occasional trips north and south, so these data only include samples from Charleston Harbor (Figure 5.3.2.1). In 2007, sampling was changed in order to cover more of the coast of South Carolina, geographically and temporally, and stations were chosen randomly from a predetermined list of sites. The new sampling utilized gear with a mainline 1/3-mile long; these sets are not represented in the data since only one season would be available. Furthermore, due to the change in sampling, only a few (n=7) 1-mile long sets were made in 2007. These sets were utilized primarily to obtain red drum for broodstock. The sets were made in areas previously sampled with the fixed station design. Samples in 2005 and 2006 were also lower than previous years (n=29, n=51 respectively), because the vessel used for the survey broke down both years during the sampling season.

5.3.9.2 Sampling Intensity – time series

Sampling intensity ranged from 29 sets in 2005 to a maximum of 115 sets in 1998 (Table 5.3.9.1) . Approximately 95 – 100 sets were made per year provided there were no equipment issues. As mentioned in 2007, only 7 1-mile long sets were made due to change in sampling protocol.

5.3.9.3 Size/Age data

Most age samples were taken only for fish 950 mm TL or less. However, the age distribution for these, even though biased low for aveage size, indicated that it was likely that a majority of the fish captured in the longline sampled were biological-age 9 or older.

5.3.9.4 Catch Rates – Number and Biomass

Catch per unit effort by year for 1994 through 2007 are given (Table 5.3.9.1).

5.3.9.5 Uncertainty and Measures of Precision

Standard errors and variances were presented for the annual estimates of CPUE (Table 5.3.9.1). Apparent coefficients of variation was releatively low, <10, for most years.

5.3.9.6 Comments on Adequacy for assessment

The WG recommended using this survey but only for those index stations in the Charleston Harbor area.

5.4 Fishery-Dependent Indices

5.4.1 Survey One - MRFSS total catch rates

The access-point angler intercept survey (APAIS) is conducted at either public or private marine/brackish-water fishing access points (boat ramps, piers, beaches, jetties, bridges, marinas, etc.) to collect catch data from individual angler, including species identification, total number of each species, and length and weight measurements of individual fishes, as well as some angler-specific information about the fishing trip and the angler's fishing behavior. The sampling universe, called the master site register, is a dynamic list of identified access-point sites for marine recreational fishing in each state, including sites in tidal brackish waters where anglers who fished in saltwater can be intercepted. In general, the estimated fishing pressure for each site by mode, month and weekday/ weekend/holiday (KOD) is determined and used as a weight in the sampling site selection process. The targeted angler trips to sample are specified by year, wave, state, and mode within a subregion (mid-Atlantic, NY south through VA; south Atlantic, NC south through FL [Miami-Dade County]). Within the targeted population, sampling is stratified by month-KOD (within the sampling wave) to assure a representative temporal distribution of samples.

This primary sampling unit is site-day with the ultimate sampling unit of individual angler-trip. Estimated catch rates for the entire 1981-2007 period were restricted to those interviews where there was no grouped catch, contributors equaled 1. Beginning in 1991, MRFSS created a 'Type-6' record that allows for all interviews within a fishing trip to be linked together. Using these linked data, catch rates for 1991-2007 were also estimated on a trip basis. The number of interviews by state across waves and collapsed fishing modes (Tables 1, 2) show the shift in interviews toward the private/rental boat mode and away from shore fishing in 1986 across all states and periodic increases in interviews (1992 and 1999) in Florida. Also, interviews during the Jan-Feb wave were periodic in North Carolina, infrequent in Georgia and South Carolina, and consistent in Florida.

5.4.1.1 Methods of Estimation

Total catches reported from MRFSS angler interview date were analyzed for different subsets of the data depending on what was assumed to retermine a directed red drum fishing trip and whether trip-specific or interview-specific catches were analyzed.

The effort definitions used to subset the MRFSS interview data were either all data where the angler reported targeting or catching red drum or all data predicted to be a red drum trip based on ana analysis of the species caught in association with red drum (Stephens and MacCall 2004). Two responses were modeled for each of these subsets: the total catch made by anglers fishing alone and total catch made by all anglers fishing on the same trip. The former was calculated for the period 1982-2007 while the latter was valid only for the period 1991-2007. A number of explanatory variables measured by the MRFSS were also grouped if specific levels occurred inconsistently in the data over time. For example, counties were grouped into logical watersheds to create a more consistent 'bay' variable; ocean waters (area_x in state and federal) were combined; and all boat trips (partyboat, charter boat, and private/rental) or shore fishing modes were combined. The final generalized linear models tested the significance of the explanatory variables wave, mode of fishing, bay, and area fished. The response variable used was total number of fish per angler-hour. Standardized annual catch rates for red drum were estimated using a delta lognormal model (dual Generalized Linear Models, Lo et al. 1992). The distribution of back-transformed least-square means estimates for each year was generated through Monte Carlo simulation using the annual least squares means and the estimated asymptotic standard errors.

5.4.1.2 Sampling Intensity

In the southern region, the number of interviews made and the number of interviews of targeted red drum anglers was greatest in Florida was increased significantly after 1991, especially in Florida.

5.4.1.3 Size/Age data

Most of the red drum caught by anglers during 1991-2007 were released. Though there is little historic information about the sizes of these released fish, recent information indicates that they are a mixture of legal sized fish, mostly model ages 2 and 3, and undersized fish, model age 1.

5.4.1.4 Catch Rates – number and biomass

Standardized catch rates for fishing-trip-aggregated data beginning in 1991show a variable but long tern increase in the northern region with particularly high levels during 1997-1999 and in 2002 (Table 5.4.1.4.1 and Fig. 5.4.1.4.1). In the southern region catch rates reached a peak in 1995 then declined through 2001. Since then there has beeen a general increase in catch rate.

5.4.1.5 Uncertainty and Measures of Precision

The distribution of the total catch rates were generated using a Monte Carlo simulation using of the estimated annual least square means and their assymtotic standard errors, backtransforming into the arithmetic scale. Generally less precision is seen in the higher catch rate estimates.

5.4.1.6 Comments on Adequacy for Assessment

The MRFSS index was calculated using aggregated total catch and effort or individual total catches pre interview of trip. The group decided that the individual trip aggregated data should be used to develop an index of abundance using the 1991-2007 data. These should be standardized using the delta lognormal approach. The species-association subsetting approach gave low numbers of valid observations, especially in the northern region, but this might be due to the changing fauna associated with red drum in the northern region. The group decided that the observations chosen for the index should be those angler intercepts that had caught a red drum or indicated they were targeting red drum.

5.4.2 Survey Two – North Carolina Trip Ticket

The North Carolina trip ticket program was considered for developing an index of abundance of red drum in the northern region. Many issues were brought forth supporting this decision: changes in regulations over time, including trip limits and bycatch restrictions; difficulty in determining a targeted trip within the diverse number of gears used in North Carolina, that trip tickets do not document trips where no fish were caught, and potential changes in catchability.

5.4.3 Survey Three – North Carolina Citation Program

An increasing trend in numbers of fish submitted for citation has been observed since the program began; however, the trend is confounded by a change in popularity of the program. The Indices subgroup does not recommend the use of this data for calculating an index of abundance.

5.4.4 Survey Four – Virginia Citation Program

Anglers only receive one Citation plaque per species regardless of how many Citation fish they register throughout the year. Virginia tracks an angler’s heaviest entry for a species and the plaque acknowledges their heaviest catch of the year. Virginia also tracks the number of releases and this number will also be included on the Citation plaque. Due to space limitations, release lengths are not included. The Virginia program was not recommended for use as an index of abundance.

5.5 Consensus Recommendations and Survey Evaluations

The DW recommended that 1 fishery-dependent index derived from the general recreational survey (MRFSS) be used in the assessment. In addition, the DW recommended use of 8 fishery-independent datasets. YOY indices were calculated from data collected through Florida's seine survey, South Carolina's electroshock fishing survey, and North Carolina's seine survey. Sub-adult indices were calculated for multiple surveys and covered ages from late age 1 to age 3. These surveys include gillnet surveys from NC (ages 1 and 2) and GA (age 1), a trammel net survey from SC (ages 1 and 2), and a haul seine survey from FL (ages 1-3). An adult index was calculated from data collected by SC to be used for age 9 and older.

5.6 Indices Workgroup Research Recommendations

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

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

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

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

5.7 Tasks for Completion following Data Workshop

- State representatives review sections related to their surveys to ensure survey is accurately represented by 2/20/09.

- State representatives provide the necessary data diagnostics, figures, tables and literature cited needed to supplement their survey sections 2/20/09.

- Georgia representatives examine the feasibility of applying a positive catch analysis to their age-1 survey. Produce necessary estimates of catch and associated variance if applicable.

- Provide all necessary documents to C. Belcher for collation into the master document by 2/27/09.

- Proof final WG document for submittal to FTP site by 3/13/09

- Upload final datasets to FTP site by 3/27/09

5.8 Literature Cited

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5.9 Tables

Table 5.1.1. List of proposed indices of abundance for red drum indicating some of the pros and cons for their inclusion in the red drum assessment. Those highlighted were recommended for use in the assessment.

Florida young-of-the-year survey

pros – consistent stratified random sampling design since 1997 in Indian River Lagoon.
- at least 100 sets made each year.

cons – utilized only fish less than or equal to 40 mm standard length that may not reflect final year-class strength, i.e., susceptible to highly variable natural mortality rates.
- areal coverage is small part of entire southern stock distribution.
- St. Johns River/Nassau Sound sampling started in 2001.

South Carolina electric survey

pros – six strata sampled randomly

cons – limited to low salinity areas where electro-shocking is effective

Georgia survey

pros – consistent sampling methodology for 13 fixed stations

cons – thirteen fixed stations monitored during the summer between 2003 and 2007
- complex hybrid random stratified survey with underlying complex probability model

North Carolina young-of-the-year index

pros – consistently sampled methodology for 21 fixed stations chosen based on historic relative abundance work
- age composition all are young-of the-year based on survey time (September-November) and sizes of fish (<100 mm)

cons – possible changes in fixed station hasbitats during extreme climatic events

Table 5.1.1. continued.

Florida subadult survey

pros – stratified random survey with large numbers of sets made each year

- complete time series from 1997 through 2007

cons – postential for bias with addition of St Johns.Nassua Sound area survey in 2001

- potential underestimate of CV without accounting for aging error.
- limited correspondence with young-of-the-year indices in these areas

South Carolina trammel net survey

pros – stratified random sampling design ranging throughout most major South Carolina estuaries.

cons - later age 1 survey that corresponds only somewhat with electric survey for this age group

-complications in disentangling wild stock from hatchery fish in these areas.

South Carolina stop net survey

pros – prior to mid-1990's major indicator of relative abundance in South Carolina

cons – discontinued after mid 1990's

- not used as an index of abundance in the last assessment

North Carolina subadult survey

pros – stratified random survey design using gill nets of various mesh sizes

- continuous sampling in Pamlico Sound since 2001

cons – started as a disease sampling survey and dropped in river areas during 2001 and 2002

South Carolina Adult Longline Survey

pros – only available survey of adult relative abundance in southern region

- apparent CVs for mean catch rate is often low
- long time series, since 1994.

cons – potential sampling complications since this was modified from a shark survey

- some potential difficulty in determining adult contribution to the total catch rate since some selectivity in sampling for age.

Table 5.1.1. continued.

MRFSS total catch rate

pros - extensive areal and temporal coverage

cons – potentially total catch rates are affected by angler choices about where and when to fish, i.e., no strict survey design.

inability to consistently determine to total catch per trip prior to 1991

North Carolina trip ticket

pros – large number of observations

cons – changes in regulations bias this landings-only index, catchability changes

-difficulty in determining which trips are targeting red drum

North Carolina citation program

pros – potential coverage of little known adult relative abundance

cons – changes in popularity of red drum fishing and angler-defined trophy sizes

Virginia citation program

pros – potential coverage of little known adult relative abundance

cons – only one citation recorded regardless of the number of trophy fish registered

Table 5.3.1.1. Estimated catch rates for young-of-the-year red drum (less than or equal to 40-mm standard length) and captured during September-March; January year shown, by 21.3-m seines deployed during the Florida Fish and Wildlife Conservation Commission's fishery-independent monitoring on the Atlantic coast. The overall sample sizes (N all), number of sets catching young-of-the-year red drum (N pos), standardized median, mean and its coefficient of variation (CV) are given. Standardization used a delta lognormal approach with the median and CV's estimated using a Monte Carlo simulation.

	N (all)	N (pos)	Median	Mean	CV
1998	140	7	0.030	0.039	100.13
1999	204	32	0.092	0.099	38.67
2000	252	26	0.028	0.030	41.91
2001	238	36	0.050	0.053	36.91
2002	458	47	0.069	0.072	34.36
2003	464	69	0.133	0.136	29.19
2004	465	63	0.125	0.130	30.31
2005	518	103	0.228	0.237	28.27
2006	632	57	0.048	0.050	29.22
2007	588	71	0.109	0.112	27.61

Table 5.3.2.1. Annual arithmetic and transformed geometric (ln[x + 1]) CPUE (catch per transect station) for red drum in the electric survey. Mean = arithmetic mean; sd = standard deviation; Gmean = mean of ln([number + 1]; Gsd = their standard deviation; CV= coefficient of variation for the back transform of the geometric mean; present = number of stations with red drum; samples = total number of stations.

Year	Mean	SD	Gmean	Gsd	CV	Present	Samples
2001	1.99	3.00	0.72	0.82	8.53	117	233
2002	2.14	3.64	0.72	0.85	6.56	203	403
2003	2.34	4.51	0.70	0.91	7.08	165	372
2004	2.10	5.50	0.60	0.86	7.26	162	379
2005	1.97	4.44	0.62	0.83	7.26	171	363
2006	1.52	3.55	0.52	0.76	7.48	156	381
2007	1.31	2.25	0.54	0.70	7.50	157	361
2008	2.19	4.75	0.69	0.08	6.77	160	323

Table 5.3.3.1. Number of gillnet sites sampled in Georgia during 2003 – 2007 sampling seasons by year and month.

	Year				
Month	2003	2004	2005	2006	2007
June	6	10	12	9	7
July	9	12	11	10	9
August	9	12	10	8	5
Total Sites	24	34	33	27	21

Table 5.3.3.2. Annual arithmetic and geometric mean CPUEs and percent positive sets for age-1 red drum captured during Georgia's gillnet survey (2003-2007).

Geometric Mean

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

Arithmetic Mean

Year	Mean	95% LCL	95% UCL	CV
2003	4.54	1.08	8.01	38.14
2004	1.91	-0.01	3.84	50.38
2005	2.85	0.87	4.83	34.71
2006	0.48	0.19	0.77	30.10
2007	3.14	0.07	6.22	48.91

Percent Positive Sets

Year	Mean	95% LCL	95% UCL
2003	58.33%	56.26%	60.40%
2004	41.18%	39.74%	42.62%
2005	42.42%	40.93%	43.92%
2006	33.33%	31.66%	35.01%
2007	38.10%	35.78%	40.41%

Table 5.3.4.1. Annual arithmetic mean or geometric mean CPUE for YOY red drum captured during the North Carolina seine survey 1991 - 2007. The coefficient of variation (CV) is for the observations and the proportional standard error (PSE) is equal to the other CV's reported in this report.

Arithmetic scale(mean)

Year	N	CPUE	lci	uci	SE	STDEV	CV	MIN	MAX	SUM	PSE
1991	105	14.85	10.58	19.12	2.18	22.33	150.4	0	122	1,559	15
1992	116	3.72	1.49	5.94	1.13	12.22	329.0	0	125	431	31
1993	117	12.65	8.30	17.00	2.22	23.98	189.6	0	130	1,480	18
1994	93	8.29	3.56	13.02	2.41	23.26	280.5	0	180	771	29
1995	119	4.61	3.19	6.03	0.72	7.90	171.2	0	44	549	16
1996	104	2.63	1.71	3.56	0.47	4.81	182.5	0	32	274	18
1997	126	13.13	7.10	19.15	3.07	34.50	262.9	0	236	1,654	23
1998	124	8.23	6.04	10.43	1.12	12.48	151.6	0	85	1,021	14
1999	98	1.88	1.06	2.69	0.42	4.11	219.0	0	29	184	22
2000	123	3.18	2.05	4.31	0.57	6.38	200.6	0	38	391	18
2001	122	0.98	0.61	1.34	0.19	2.07	212.3	0	11	119	19
2002	120	2.26	1.23	3.29	0.53	5.78	255.7	0	39	271	23
2003	120	5.01	2.60	7.42	1.23	13.49	269.3	0	113	601	25
2004	120	8.38	6.16	10.59	1.13	12.38	147.8	0	75	1,005	13
2005	120	9.02	6.26	11.77	1.40	15.39	170.6	0	80	1,082	16
2006	120	3.59	2.16	5.03	0.73	8.02	223.2	0	63	431	20
2007	119	5.46	2.48	8.44	1.52	16.59	303.7	0	149	650	28

Logarithmic scale (geometric mean)

North Carolina juvenile red drum seine index (age-0) with geometric mean

Year	E(YST)	SE OF E(YST)	PSE	Geo Mean	LCI of GEO MEAN	UCI of GEO MEAN	# Samples
1991	1.875	0.135	7	5.523	3.978	7.548	105
1992	0.851	0.091	11	1.342	0.953	1.809	116
1993	1.617	0.128	8	4.040	2.905	5.505	117
1994	1.312	0.122	9	2.714	1.911	3.737	93
1995	1.112	0.097	9	2.039	1.503	2.690	119
1996	0.765	0.092	12	1.149	0.790	1.581	104
1997	1.424	0.125	9	3.156	2.234	4.340	126
1998	1.525	0.109	7	3.595	2.698	4.710	124
1999	0.574	0.086	15	0.776	0.496	1.107	98
2000	0.853	0.087	10	1.346	0.970	1.794	123
2001	0.389	0.060	15	0.476	0.309	0.663	122
2002	0.602	0.082	14	0.826	0.551	1.150	120
2003	0.958	0.102	11	1.606	1.126	2.194	120
2004	1.533	0.109	7	3.631	2.724	4.760	120
2005	1.486	0.114	8	3.421	2.521	4.551	120
2006	0.859	0.092	11	1.361	0.964	1.838	120
2007	0.911	0.104	11	1.486	1.018	2.062	119

Table 5.3.5.1. Estimated catch rates for subadult red drum captured by 183-m seines deployed during the Florida Fish and Wildlife Conservation Commission's fishery-independent monitoring on the Atlantic coast. The overall sample sizes (N all), number of sets catching red drum (N pos), standardized median, mean and its coefficient of variation (CV)are given. Standardization used a delta lognormal approach with the median and CV's estimated using a Monte Carlo simulation. Age-specific rates, apportioned from overall catch rate using sampled age composition data each year, are given for model-age 2 and 3 fish.

	N (all)	N (pos)	Median	Mean	CV	mod-age 2	mod-age 3
1997	364	73	0.245	0.249	17.47	0.070	0.089
1998	434	91	0.276	0.281	16.12	0.169	0.044
1999	420	100	0.244	0.248	15.87	0.108	0.050
2000	420	106	0.292	0.294	15.64	0.198	0.038
2001	531	96	0.221	0.223	15.25	0.097	0.069
2002	589	129	0.274	0.275	13.35	0.169	0.051
2003	613	112	0.238	0.240	14.08	0.083	0.096
2004	614	137	0.276	0.280	12.84	0.146	0.050
2005	610	140	0.299	0.300	13.01	0.196	0.041
2006	611	114	0.270	0.274	13.23	0.136	0.075
2007	613	144	0.312	0.315	12.36	0.153	0.094

Table 5.3.6.1. Percent contribution of stocked red drum to the age-1 trammel net catches for each year classes and stratum. Blanks indicate no stocking. Stratum names are Ace Basin (AB), Ashley River (AR), Charleston Harbor (CH), Lower Wando River (LW), McBanks (MB), Cape Romain Harbor (RH) and Winyah Bay (WB).

	Ace Basin	Charleston Harbor			Cape Romain		Winyah Bay
Year Class	**AB**	**AR**	**CH**	**LW**	**MB**	**RH**	**WB**
1990		**	**	**			
1991		**	**	**			
1992		**	**	**			
1993		**	**	**			
1994							
1995							
1996							
1997							
1998							
1999		90.0%	31.0%	15.0%			
2000		35.6%	6.7%	13.5%			
2001		29.0%	1.6%	2.0%			
2002		0.0%	0.0%	0.0%			
2003							
2004							
2005	13.6%	3.1%	3.2%	0.0%			35.3%
2006		0.0%	0.0%	1.0%			
2007		*	*	*			*

* Contribution from stocked fish not yet determined from DNA samples.
** Stocking occurred, but stocked fish are not represented in catch data presented in Table 3.

Table 5.3.6.2. Number of trammel sets used for assessing the 1989-2007 year classes of age-1 red drum in South Carolina. Trammel sets cover the months July-March during daylight hours and mid- to late-ebb tide. (Strata names as in Table 1).

	Ace Basin	Charleston Harbor			Cape Romain		Winyah Bay		
Year Class	**AB**	**AR**	**CH**	**LW**	**MB**	**RH**	**WB**	**Total**	**Mean**
1989			10	21				31	15.5
1990			36	54				90	45.0
1991		49	36	71				156	52.0
1992	16	70	40	70				196	49.0
1993	84	82	60	78				304	76.0
1994	86	81	84	83				334	83.5
1995	89	98	88	84				359	89.8
1996	107	106	89	85	103	96		586	97.7
1997	102	107	91	90	95	102		587	97.8
1998	103	108	87	89	95	108		590	98.3
1999	91	106	88	90	82	98		555	92.5
2000	103	108	89	88	92	104		584	97.3
2001	102	108	87	87	91	87	45	607	86.7
2002	91	107	87	85	99	101	86	656	93.7
2003	104	106	88	90	101	99	87	675	96.4
2004	92	108	90	90	102	92	99	673	96.1
2005	86	107	86	90	91	102	83	645	92.1
2006	102	106	88	90	97	91	100	674	96.3
2007	74	79	60	65	75	70	48	471	67.3
Total	**1432**	**1636**	**1384**	**1500**	**1123**	**1150**	**548**	**8773**	

Table 5.3.6.3. Total catches of age-1 red drum (wild + stocked) in the July-March trammel sets (Stratum named as in Table 1).

	Ace Basin	Charleston Harbor			Cape Romain		Winyah Bay		
Year Class	**AB**	**AR**	**CH**	**LW**	**MB**	**RH**	**WB**	**Total**	**Mean**
1990			225	231				456	228.0
1991		45	183	285				513	171.0
1992	10	28	124	132				294	73.5
1993	126	66	201	115				508	127.0
1994	166	79	147	180				572	143.0
1995	145	18	69	91				323	80.8
1996	210	57	113	259	163	106		908	151.3
1997	109	43	85	72	113	131		553	92.2
1998	96	32	108	71	95	151		553	92.2
1999	59	118	30	42	60	42		351	58.5
2000	411	151	226	155	777	354		2074	345.7
2001	106	73	238	272	246	207	28	1170	167.1
2002	164	73	347	277	302	285	201	1649	235.6
2003	187	17	46	57	172	167	186	832	118.9
2004	111	47	85	134	157	86	67	687	98.1
2005	132	33	42	125	39	29	73	473	67.6
2006	179	35	129	103	197	223	95	961	137.3
2007	108	79	59	171	212	165	120	914	130.6
Total	**2319**	**994**	**2457**	**2772**	**2533**	**1946**	**770**	**13791**	**1970.1**

Table 5.3.6.4. CPUE of all age-1 red drum (i.e. wild + stocked fish) in the SC trammel net survey during July-March. (Stratum named as in Table 1).

	Ace Basin	Charleston Harbor			Cape Romain		Winyah Bay		
Year Class	**AB**	**AR**	**CH**	**LW**	**MB**	**RH**	**WB**	**Mean**	**SE**
1990			0.496	0.428				0.462	0.034
1991		0.152	0.563	0.255				0.323	0.124
1992	0.089	0.100	0.244	0.194				0.157	0.037
1993	0.186	0.151	0.329	0.175				0.210	0.040
1994	0.220	0.132	0.260	0.194				0.202	0.027
1995	0.191	0.044	0.161	0.170				0.141	0.033
1996	0.231	0.108	0.222	0.176	0.188	0.137		0.177	0.020
1997	0.101	0.083	0.151	0.098	0.178	0.166		0.130	0.016
1998	0.128	0.069	0.177	0.107	0.155	0.196		0.139	0.019
1999	0.100	0.138	0.086	0.072	0.139	0.099		0.105	0.011
2000	0.348	0.150	0.351	0.220	0.410	0.430		0.318	0.045
2001	0.166	0.128	0.322	0.271	0.314	0.307	0.114	0.232	0.035
2002	0.244	0.115	0.324	0.327	0.312	0.335	0.266	0.275	0.029
2003	0.184	0.039	0.104	0.076	0.262	0.244	0.250	0.165	0.035
2004	0.168	0.080	0.166	0.190	0.219	0.166	0.129	0.160	0.017
2005	0.193	0.065	0.089	0.209	0.102	0.074	0.174	0.129	0.023
2006	0.183	0.063	0.239	0.150	0.272	0.320	0.141	0.195	0.033
2007	0.219	0.135	0.175	0.251	0.310	0.309	0.260	0.237	0.025

Table 5.3.6.5. Catch per unit effort (CPUE) of wild age-1 red drum (i.e. excluding stocked fish) in the SC trammel net survey during July-March. (Stratum named as in Table 1)

	Ace Basin	Charleston Harbor			Cape Romain		Winyah Bay			
Year Class	AB	AR	CH	LW	MB	RH	WB	Mean	SE	CV
1990			0.496	0.428				0.462	0.034	7.36
1991		0.152	0.563	0.255				0.323	0.124	38.39
1992	0.089	0.1	0.244	0.194				0.157	0.037	23.57
1993	0.186	0.151	0.329	0.175				0.21	0.04	19.05
1994	0.22	0.132	0.26	0.194				0.202	0.027	13.37
1995	0.191	0.044	0.161	0.17				0.141	0.033	23.40
1996	0.231	0.108	0.222	0.176	0.188	0.137		0.177	0.02	11.30
1997	0.101	0.083	0.151	0.098	0.178	0.166		0.13	0.016	12.31
1998	0.128	0.069	0.177	0.107	0.155	0.196		0.139	0.019	13.67
1999	0.1	0.033	0.067	0.066	0.139	0.099		0.084	0.015	17.86
2000	0.348	0.12	0.339	0.204	0.41	0.43		0.308	0.05	16.23
2001	0.166	0.105	0.32	0.269	0.314	0.307	0.114	0.228	0.036	15.79
2002	0.244	0.115	0.324	0.327	0.312	0.335	0.266	0.275	0.029	10.55
2003	0.184	0.039	0.104	0.076	0.262	0.244	0.25	0.165	0.035	21.21
2004	0.168	0.08	0.166	0.19	0.219	0.166	0.129	0.16	0.017	10.63
2005	0.18	0.063	0.087	0.209	0.102	0.074	0.133	0.121	0.021	17.36
2006	0.183	0.063	0.239	0.15	0.272	0.32	0.141	0.195	0.033	16.92
2007	0.219	*	*	*	0.31	0.309		0.279	0.03	10.75

* Contribution from stocked fish not yet determined.

Table 5.3.8.1. North Carolina IGNS CPUE (arithmetic) for red drum during 2001-2007 (age aggregated). Note that the 2001 survey for for only part of the year.

Year	Number of Red Drum	# Sets	Weighted CPUE	SE	PSE	Mean Size (mm)	Min (mm)	Max (mm)
2001*	324	237	1.56	0.312	20	436	232	1,155
2002	907	320	3.22	0.419	13	406	228	1,194
2003	295	320	1.25	0.225	18	484	334	1,206
2004	525	320	1.99	0.299	15	388	250	1,200
2005	658	305	2.76	0.414	15	437	250	1,227
2006	730	320	2.91	0.349	12	422	240	1,257
2007	928	320	3.19	1.021	32	438	217	1,172

Table 5.3.9.1. Catch per unit effort (CPUE) of adult red drum in longline survey in Charleston Harbor, SC 1994 – 2007, August through December.

Year	# sets	Mean	Variance	CV
1994	71	2.58	28.9	15.78
1995	94	3.14	19.58	6.63
1996	112	2.88	36.89	11.44
1997	107	1.13	3.93	3.25
1998	115	1.91	13.24	6.03
1999	105	2.6	8.55	3.13
2000	96	1.88	13.46	7.46
2001	93	2.55	10.88	4.59
2002	91	4.05	30.14	8.18
2003	101	4.35	20.23	4.60
2004	87	2.93	12.86	5.04
2005	29	2.31	7.58	11.32
2006	51	1.94	4.94	4.99
2007	7	1.14	2.14	26.82

Table 5.4.1.4.1. Standardized total catch rates per angler-hour for anglers catching or targeting red drum during a fishing trip made in the northern or southern regions during 1991-2007. Estimated distribution of catch rates are shown given median, interquartiles, and extent of 95% confidence intervals. The number of observations made each year, N, and number with positive catches for red drum are given.

Northern region

	Mean	Median	2.5th	25th	75th	97.5th	N	Positives
1991	0.105	0.104	0.077	0.094	0.116	0.142	398	165
1992	0.058	0.057	0.041	0.051	0.064	0.078	333	98
1993	0.066	0.066	0.050	0.060	0.072	0.085	626	190
1994	0.064	0.064	0.050	0.058	0.070	0.083	728	191
1995	0.115	0.114	0.093	0.106	0.122	0.141	1,047	435
1996	0.068	0.067	0.051	0.062	0.074	0.088	637	171
1997	0.222	0.219	0.167	0.199	0.242	0.288	514	294
1998	0.147	0.146	0.117	0.136	0.158	0.180	897	461
1999	0.182	0.180	0.140	0.166	0.196	0.229	742	420
2000	0.096	0.095	0.075	0.088	0.103	0.121	772	295
2001	0.109	0.108	0.084	0.099	0.118	0.142	637	239
2002	0.294	0.292	0.230	0.269	0.316	0.371	990	671
2003	0.084	0.083	0.060	0.075	0.093	0.113	363	131
2004	0.131	0.130	0.098	0.117	0.144	0.171	443	252
2005	0.138	0.137	0.103	0.124	0.152	0.181	423	246
2006	0.159	0.156	0.124	0.145	0.172	0.198	642	373
2007	0.147	0.146	0.119	0.136	0.157	0.180	853	419

Southern Region

	Mean	Median	2.5th	25th	75th	97.5th	N	Positives
1991	0.140	0.138	0.105	0.126	0.153	0.184	354	212
1992	0.149	0.149	0.120	0.138	0.158	0.181	697	432
1993	0.148	0.148	0.120	0.137	0.158	0.181	643	363
1994	0.182	0.181	0.150	0.170	0.193	0.218	895	481
1995	0.208	0.207	0.171	0.193	0.222	0.252	941	567
1996	0.161	0.161	0.135	0.151	0.171	0.191	984	558
1997	0.165	0.165	0.138	0.154	0.175	0.197	898	528
1998	0.130	0.130	0.108	0.122	0.137	0.153	1,069	569
1999	0.125	0.125	0.108	0.119	0.131	0.144	1,614	779
2000	0.113	0.113	0.098	0.108	0.118	0.129	1,868	859
2001	0.141	0.141	0.123	0.134	0.148	0.161	2,001	940
2002	0.125	0.125	0.109	0.119	0.131	0.144	1,814	873
2003	0.153	0.153	0.132	0.146	0.160	0.176	1,598	817
2004	0.154	0.153	0.134	0.147	0.160	0.176	1,837	981
2005	0.164	0.164	0.142	0.157	0.172	0.188	1,952	1,061
2006	0.156	0.155	0.136	0.148	0.162	0.177	1,894	999
2007	0.144	0.144	0.123	0.137	0.150	0.163	1,714	846

5.10 Figures

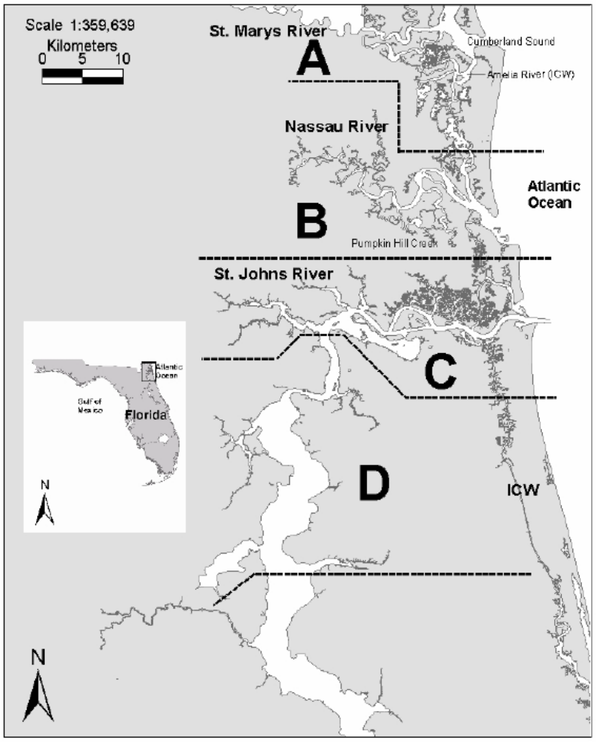


Figure JX05-01. Map of northeast Florida sampling area. Zones are labeled A-D.

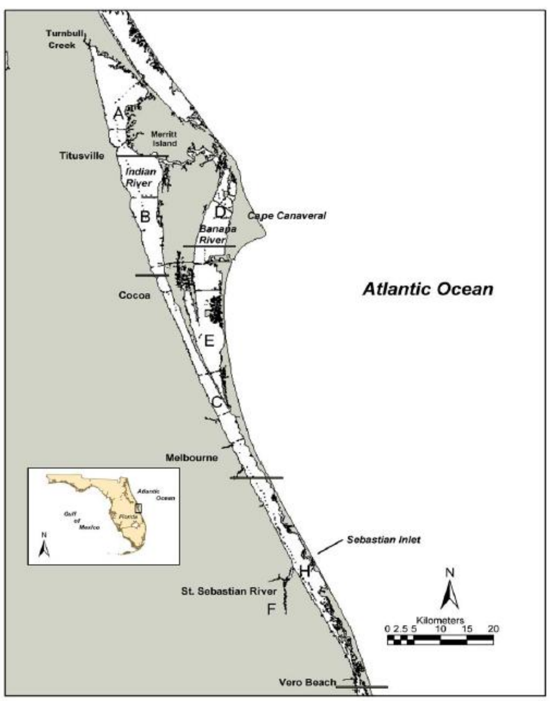


Figure IR05-01. Map of the Northern Indian River Lagoon sampling area. Zones are labeled A-F and H.

Figure 5.3.1.1 Caption is on following page.

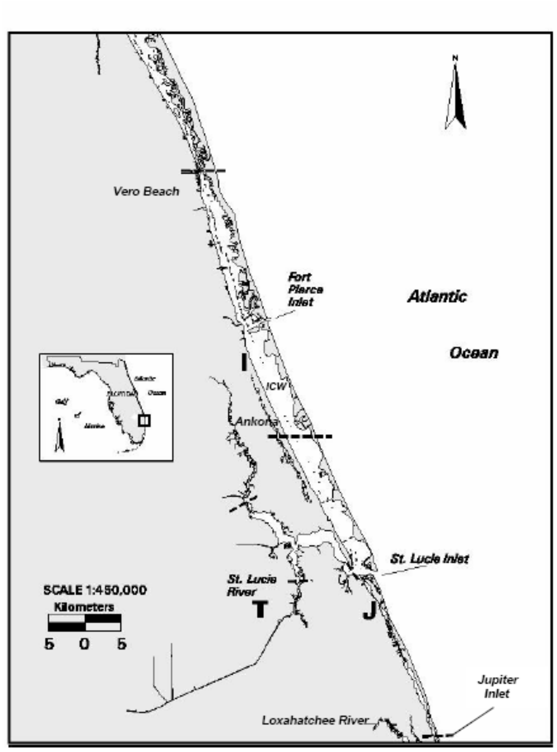


Figure TQ05-01. Map of southern Indian River Lagoon sampling area. Zones are I, J, and T.

Figure 5.3.1.1. Areas encompassing the Florida Fish and Wildlife Conservation Commission's Fishery Independent Monitoring Program's stratified random surveys for marine organisms along the Atlantic coast. Only the northeast (left) and northern Indian River Lagoon (center) areas are sampled using 21.3 m seines that effectively catch young-of-the-year red drum. In all three areas, including the southern Indian River Lagoon, 183 m seines that are used. This gear is effective in capturing subadult red drum.

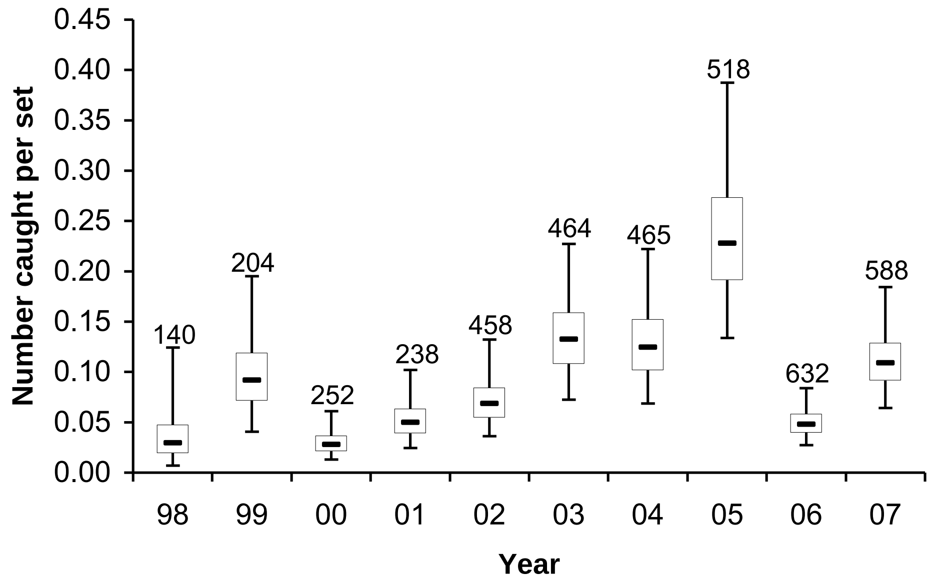


Figure 5.3.1.2. Distribution of a delta lognormal standardization for fall 1997 (fall 1997 through spring 1998 is labeled 1998) through spring 2007 data on the abundance for young-of-the-year red drum on the Atlantic coast of Florida. The dash shows the median, the box the inter-quartile range and the whiskers the 95% confidence interval. The number of sets made are given for each year.

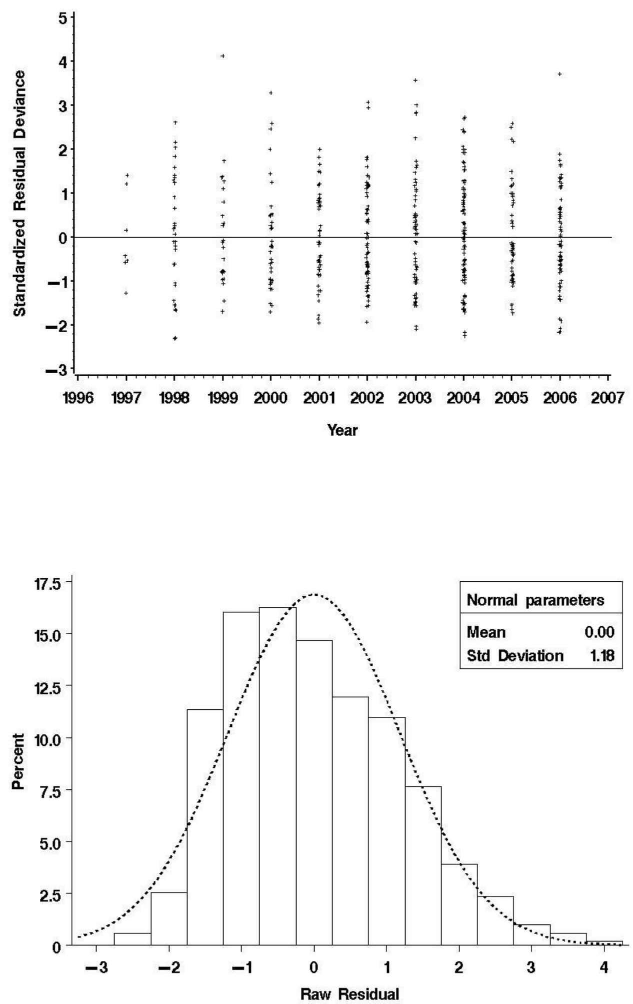


Figure 5.3.1.3. Diagnostics for fit to final lognormal standardization models for positive catch observations for young-of-the-year red drum from Florida's fisheries-independent monitoring dataset. Residual-plot year represent the fall spawning year and should range 1998-2007 to be consistent with the assumed January 1 year at beginning of age 1. By agreement, age 1 is assumed to begin on the first January 1st of the fish's life, at about 2-4 months of true age.

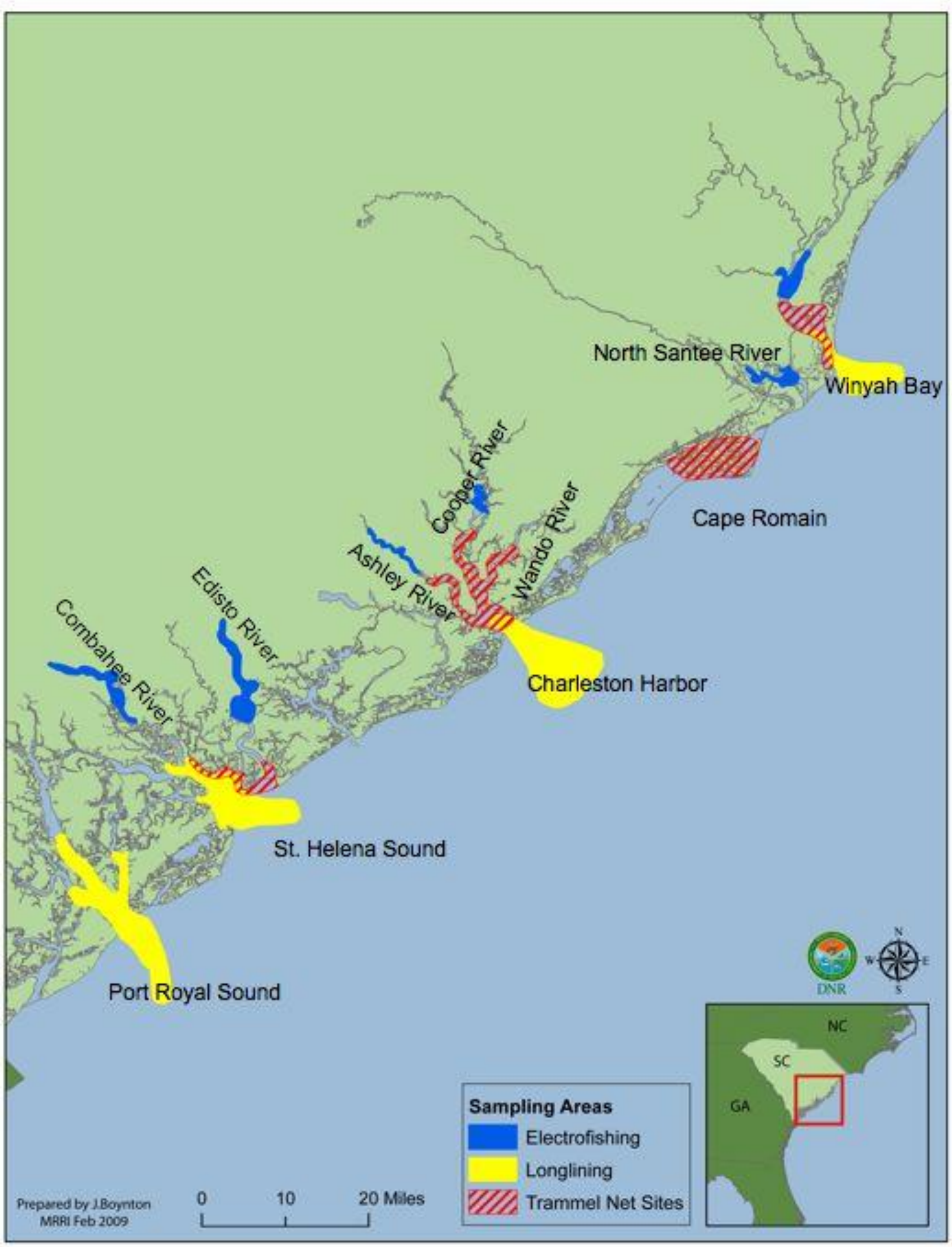


Figure 5.3.2.1. South Carolina fishery-independent sampling areas.

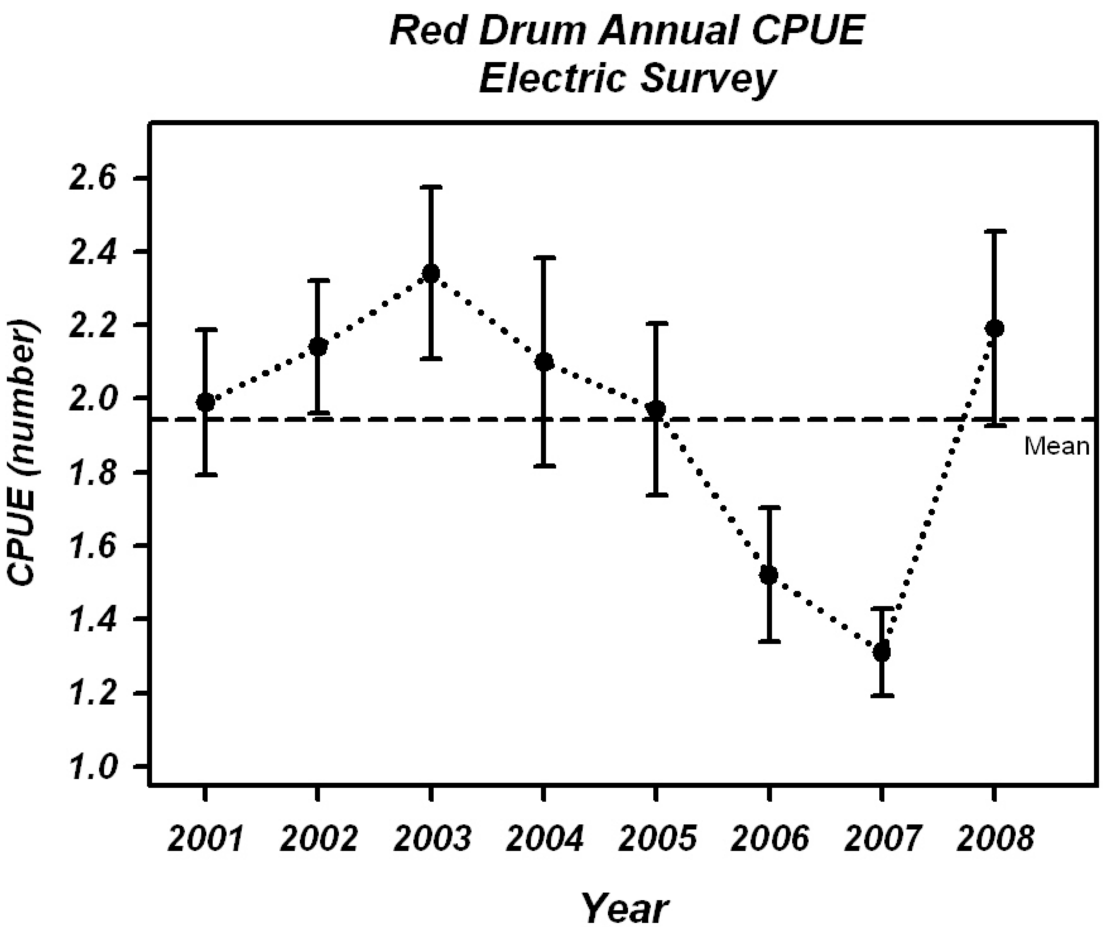


Figure 5.3.2.2. Annual mean catch per transect in numbers for red drum; filled circle = mean; vertical bars = +/- one standard error of the mean; dashed line = mean for period as a reference.

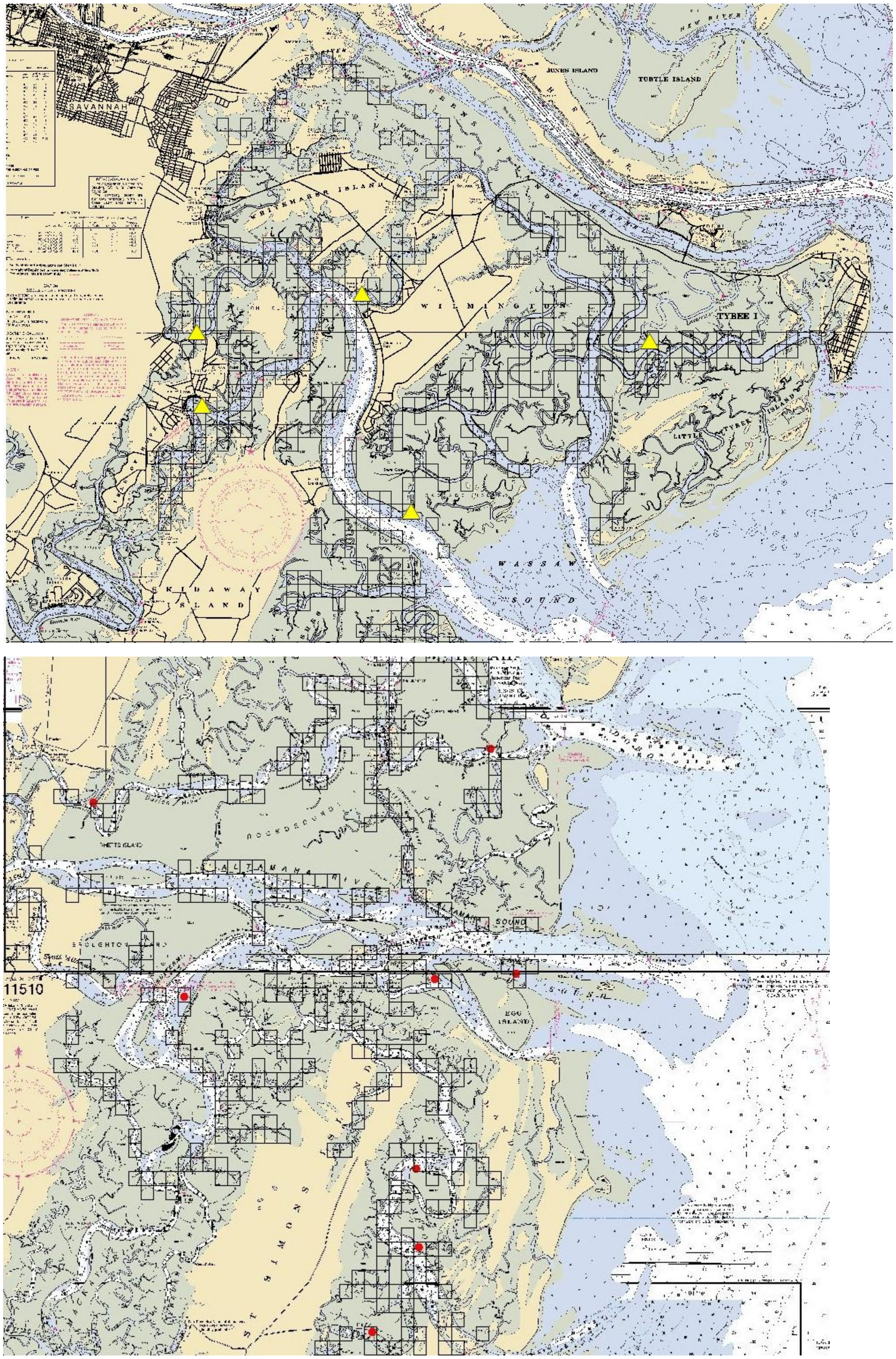


Figure 5.3.3.1. Fixed stations used in the WG suggested analysis for calculating an index of abundance for age-1 red drum in Georgia's sampled estuaries. Wassaw (top) and Altamaha (bottom) sounds are the only areas sampled.

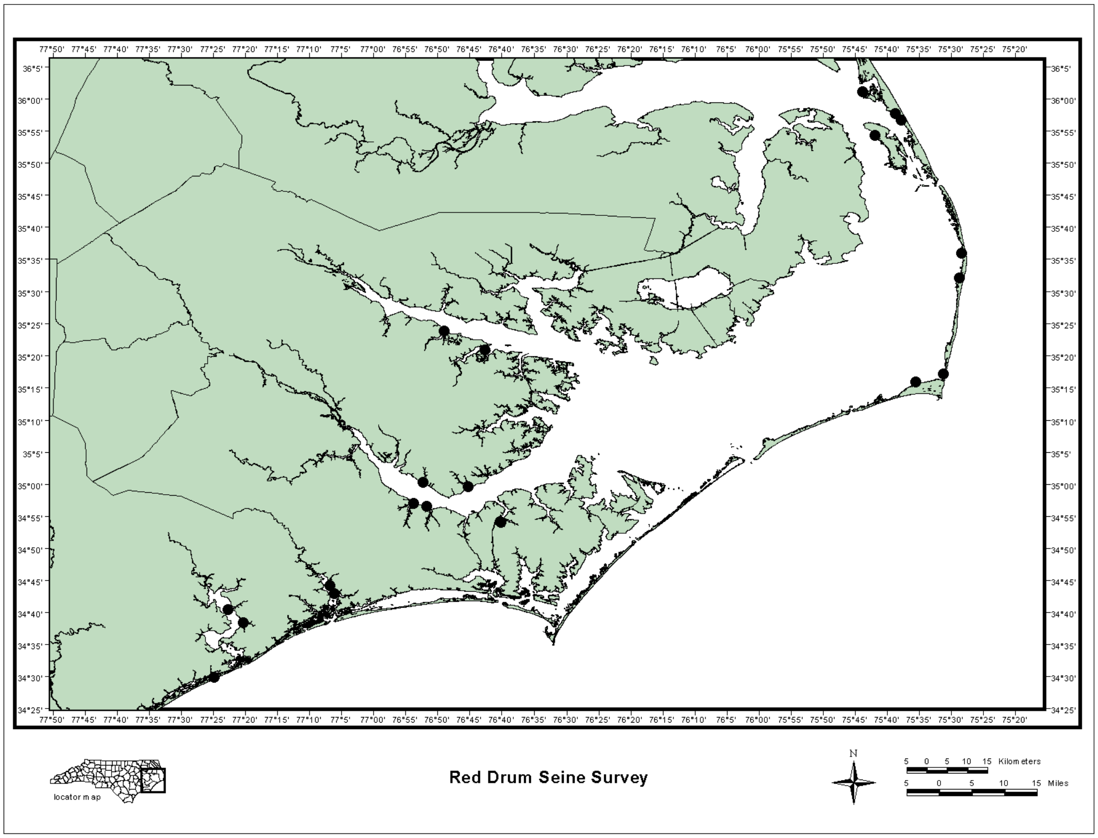


Figure 5.3.4.1. Sampling sites of the juvenile red drum survey in North Carolina.

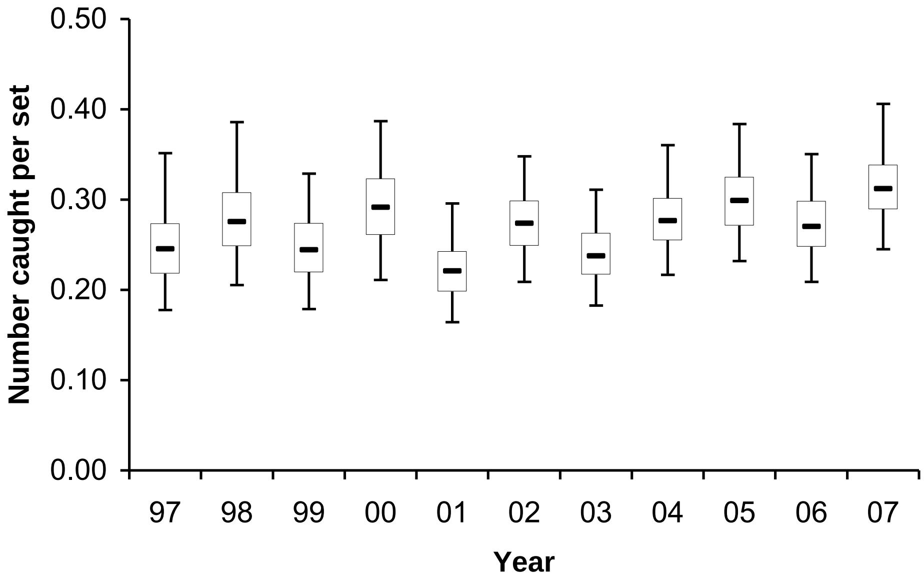


Figure 5.3.5.1. Distribution of a delta lognormal standardization for fall 1997 through spring 2007 data on the abundance for young-of-the-year red drum on the Atlantic coast of Florida. The dash shows the median, the box the inter-quartile range and the whiskers the 95% confidence interval. The number of sets made are given for each year.

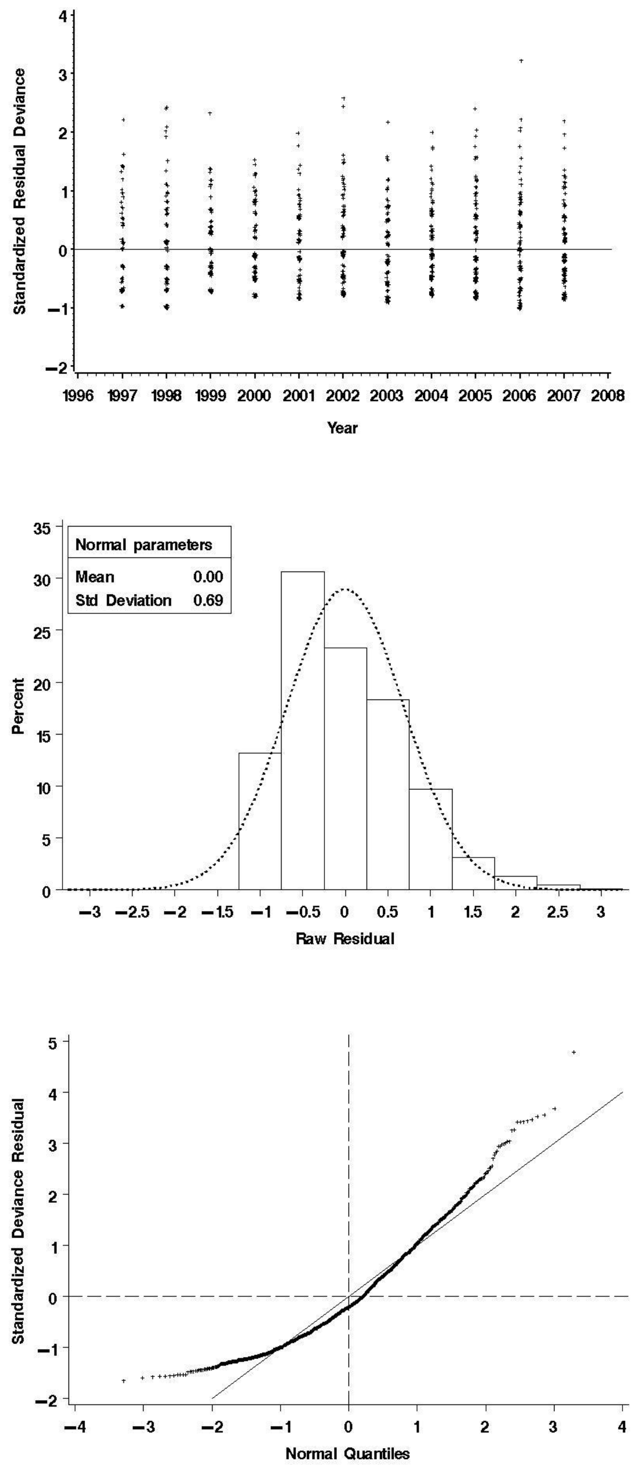


Figure 5.3.5.2. Diagnostics for fit to final lognormal standardization models for positive catch observations for subadult red drum from Florida's fisheries-independent monitoring dataset.

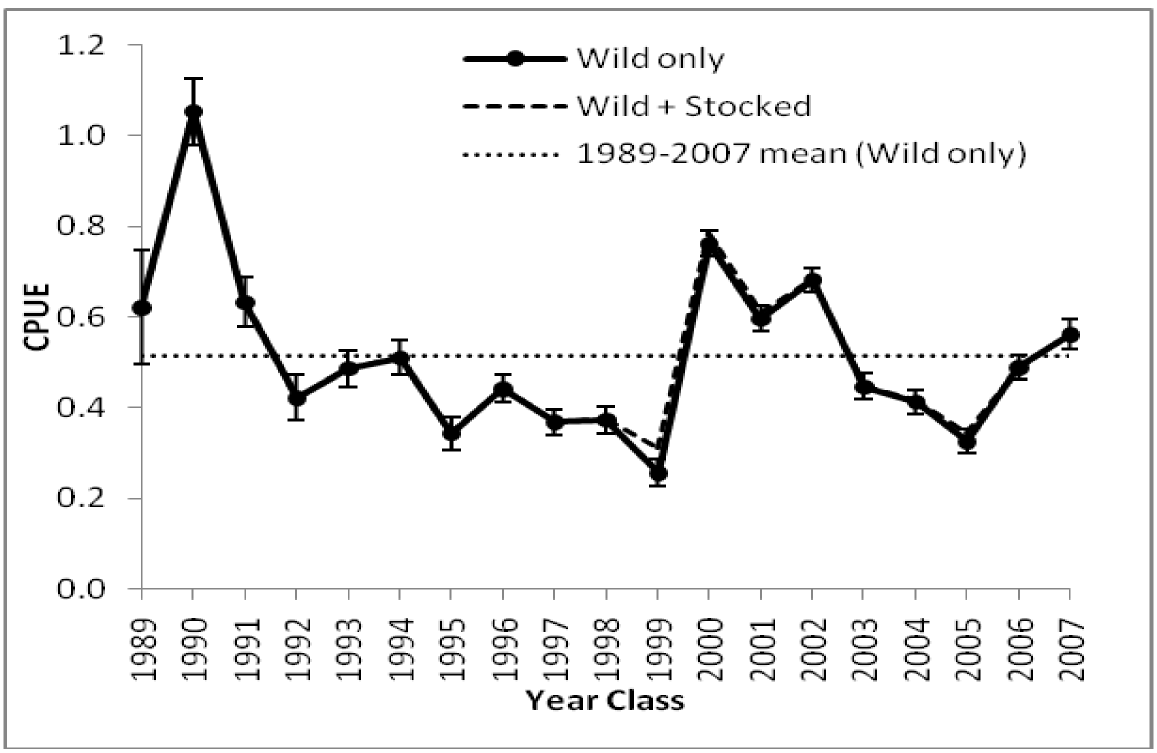


Figure 5.3.6.1. Least squares means SC-wide CPUE (ln[Catch+1] per trammel set) calculated for age-1 red drum across all strata, both before and after adjusting for stocked fish contributions. Error bars represent 1 SE.

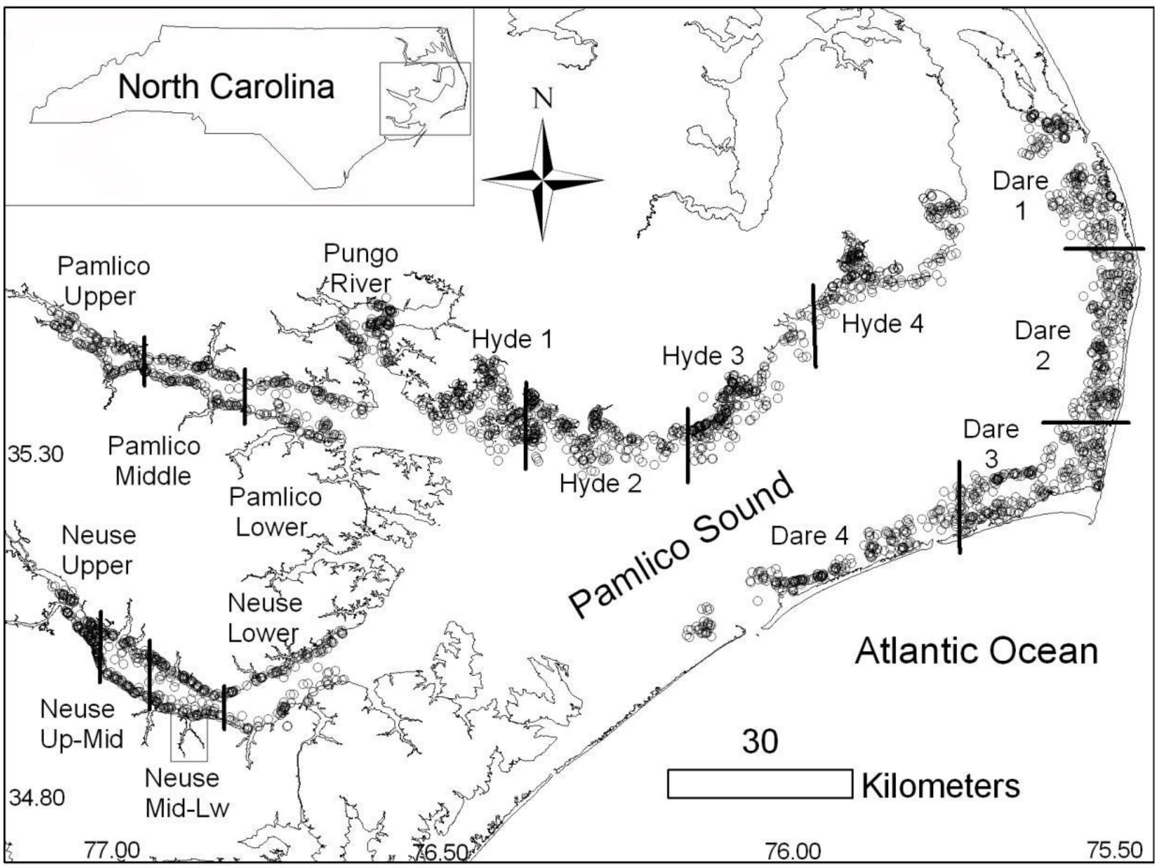


Figure 5.3.8.1. Map of Pamlico Sound and associated rivers showing the sample strata and locations of individual samples taken in the NCDMF independent gill net survey from 2001 to 2006.

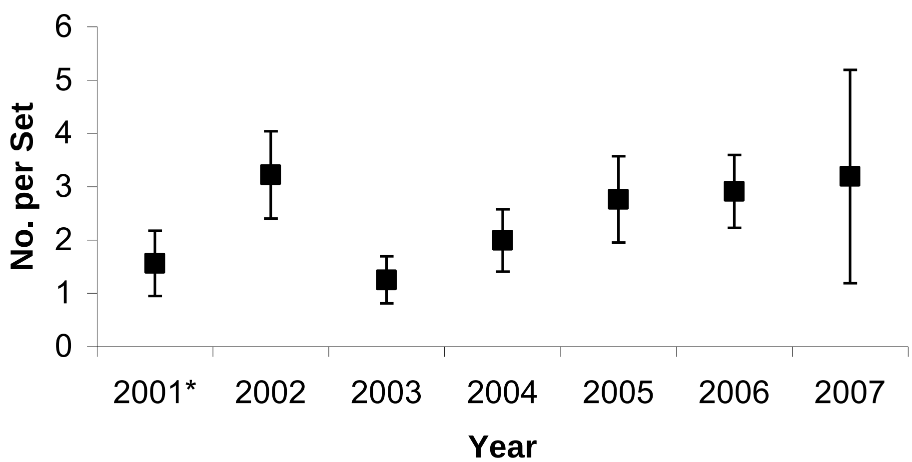
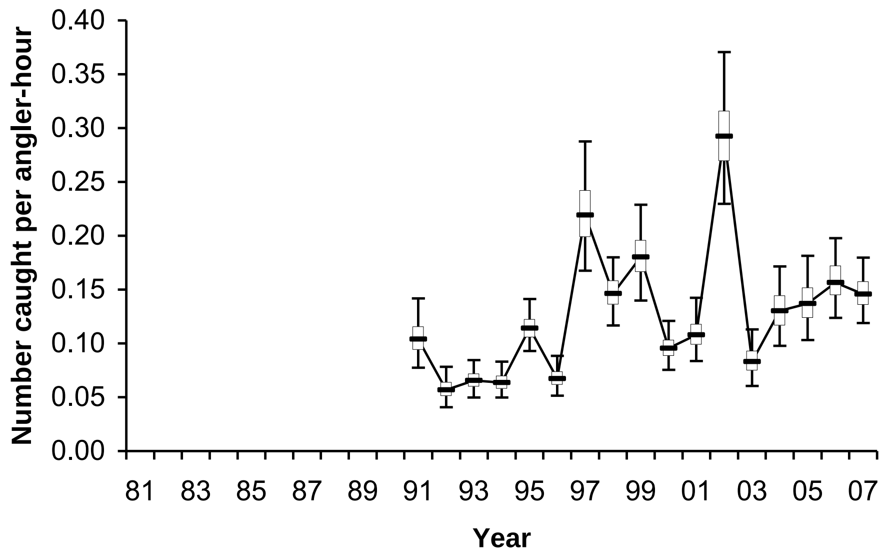


Figure 5.3.8.2. Annual average number of red drum caught per set during the North Carolina independent gill net survey. Error bars are +/- 1.96 the standard error; samples made during 2001 are for only part of the year

North Region



South Region

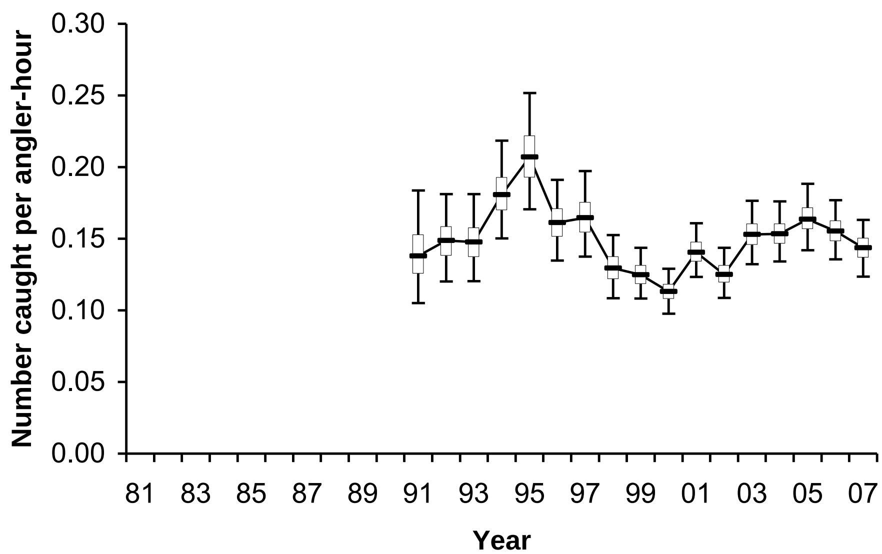


Figure 5.4.1.4.1. Standardized total catch rates per angler-hour for anglers catching or targeting red drum during a fishing trip made in the northern or southern regions. The dash shows the median, the box the inter-quartile range and the whiskers the 95% confidence interval. The number of sets made is given for each year.

6. Submitted Comment

No comments were submitted.

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

Contents: Page Numbers and One-way Links

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

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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

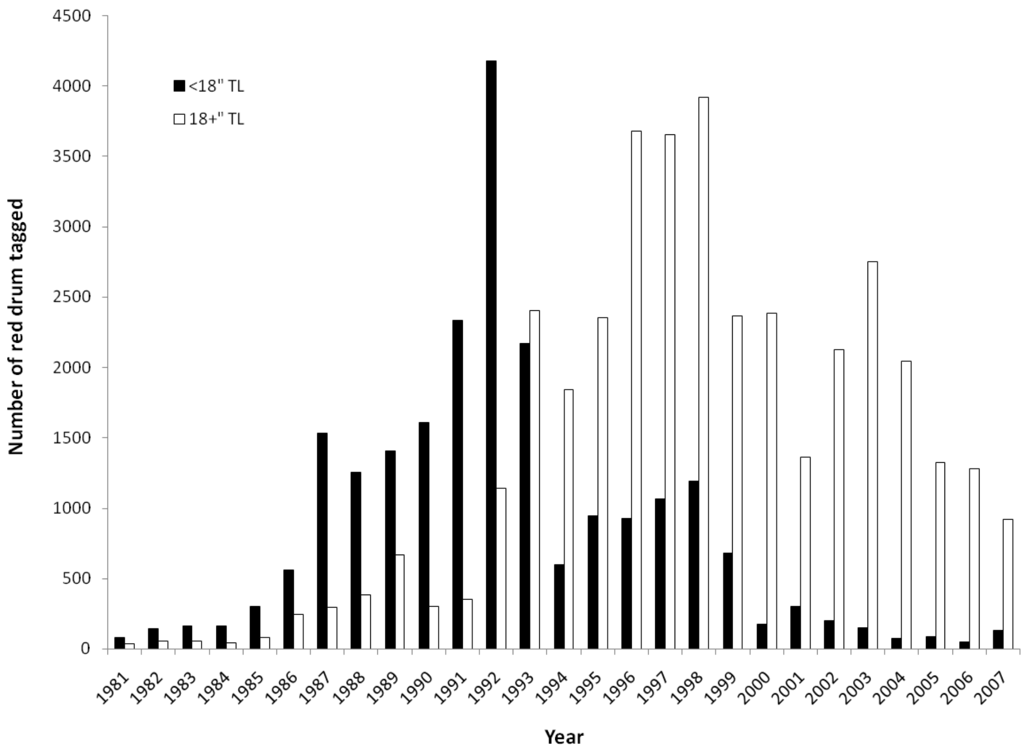


Figure 2.3.1: Numbers of red drum tagged and released by recreational anglers annually by size category.

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 $1\text{-}4^+$ 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:

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

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:

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

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:

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

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

There were additional observed data derived from a long-term tag-recapture study conducted in the northern region that was utilized in these northern region analyses. The estimated fishing mortality rates at age and their standard errors for the pooled harvest (kept) fisheries in the north during 1983-2004 were included in the northern region's objective function as:

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

where $F_{tag(y,a)}$ and $\sigma_{tag(y,a)}$ are the observed fishing mortality and its estimated standard deviation for year y and age a. The estimated F's at age were only tallied for the recreational kept and commercial fisheries. Likewise, F-at-age estimates for the recreational live-release fishery were available for the period 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

Components		Number
Total Catch		
Comm GN & BS (82-07)		26
Comm other (82-07)		26
Rec kept (82-07)		26
Rec live release (83-07)		25
	Totals	103
Proportion at age		
Comm GN & BS (82-07, ages 1-7$^+$)		182
Comm other (82-07, ages 1-7$^+$)		182
Rec kept (82-07, ages 1-7$^+$)		182
	Totals	546
Indexes of Abundance		
NC IGNS age 1 (01-07)		7
NC IGNS age 2 (01-07)		7
NC JAI age 1 (91-07, without 1997)		16
MRFSS ages 1-3 (91-07)		17
	Totals	47
Tagging study estimates		
F kept at age (83-04, ages 1-4$^+$)		88
Full F release (86-04)		19
	Totals	107
	Grand Totals	803

Southern region

Components	Number
Total Catch	
Comm FL (82-88)	7
Rec kept FL (82-07)	26
Rec kept GA (82-07)	26
Rec kept SC (82-07)	26
Rel live release FL (82-07)	26
Rec live release GA/SC (82-07)	26
	137
Proportion at age	
Comm FL	49
Rec kept FL (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
	777
Indexes of Abundance	
FL small seine (97-06)	10
GA gillnet (03-07)	5
SC electro-shock (00-07)	8
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
	93
Grand Totals	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.

Total Catch by fleet

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

Proportion at age (excludes the Florida live-release fishery)

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

Indexes of abundance

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

Tag-based F, H_o

Indexes, H_o

Proportion at age	Total catch hypothesis H_o	H_{a1}	H_{a2}
H_o	5,215	5,382	5,898
H_{a1}	**4,850**	5,029	5,568

Indexes, H_{a1}

Proportion at age	Total catch hypothesis H_o	H_{a1}	H_{a2}
H_o	6,597	6,694	7,387
H_{a1}	6,256	6,235	7,053

Indexes, H_{a2}

Proportion at age	Total catch hypothesis H_o	H_{a1}	H_{a2}
H_o	5,585	5,900	6,387
H_{a1}	5,193	14,034	6,105

Tag-based F, H_o

Indexes, H_o

Proportion at age	Total catch hypothesis H_o	H_{a1}	H_{a2}
H_o	12,598	12,673	13,923
H_{a1}	11,066	11,095	12,326

Indexes, H_{a1}

Proportion at age	Total catch hypothesis H_o	H_{a1}	H_{a2}
H_o	11,656	13,715	15,348
H_{a1}	10,595	12,136	20,571

Indexes, H_{a2}

Proportion at age	Total catch hypothesis H_o	H_{a1}	H_{a2}
H_o	15,688	15,556	16,489
H_{a1}	14,160	13,955	15,018

Southern region

Indexes, H_o

Proportion at age	Total catch hypothesis H_o	H_{a1}	H_{a2}
H_o	7,458	5,486	7,575
H_{a1}	**6,344**	5,192	7,507
H_{a2}	6,520	9,145	11,955

Indexes, H_{a1}

Proportion at age	Total catch hypothesis H_o	H_{a1}	H_{a2}
H_o	5,710	5,449	7,825
H_{a1}	5,325	8,107	8,589
H_{a2}	5,352	5,303	10,167

Indexes, H_{a2}

Proportion at age	Total catch hypothesis H_o	H_{a1}	H_{a2}
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			Southern region		
sSPR	2005	2006	2007	2005	2006	2007
Base	0.442	0.464	0.340	0.338	0.358	0.369
RM 0.16	0.380	0.381	0.273	0.249	0.267	0.280
M low	0.446	0.468	0.349	0.178	0.192	0.201
M high	0.438	0.460	0.330	0.583	0.616	0.612
Sel 1-5	0.429	0.454	0.362	0.107	0.114	0.123
sEsc	2005	2006	2007	2005	2006	2007
Base	0.493	0.528	0.400	0.400	0.416	0.430
RM 0.16	0.450	0.472	0.351	0.314	0.331	0.344
M low	0.496	0.533	0.409	0.233	0.244	0.256
M high	0.489	0.524	0.391	0.635	0.663	0.661
Sel 1-5	0.470	0.509	0.414	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

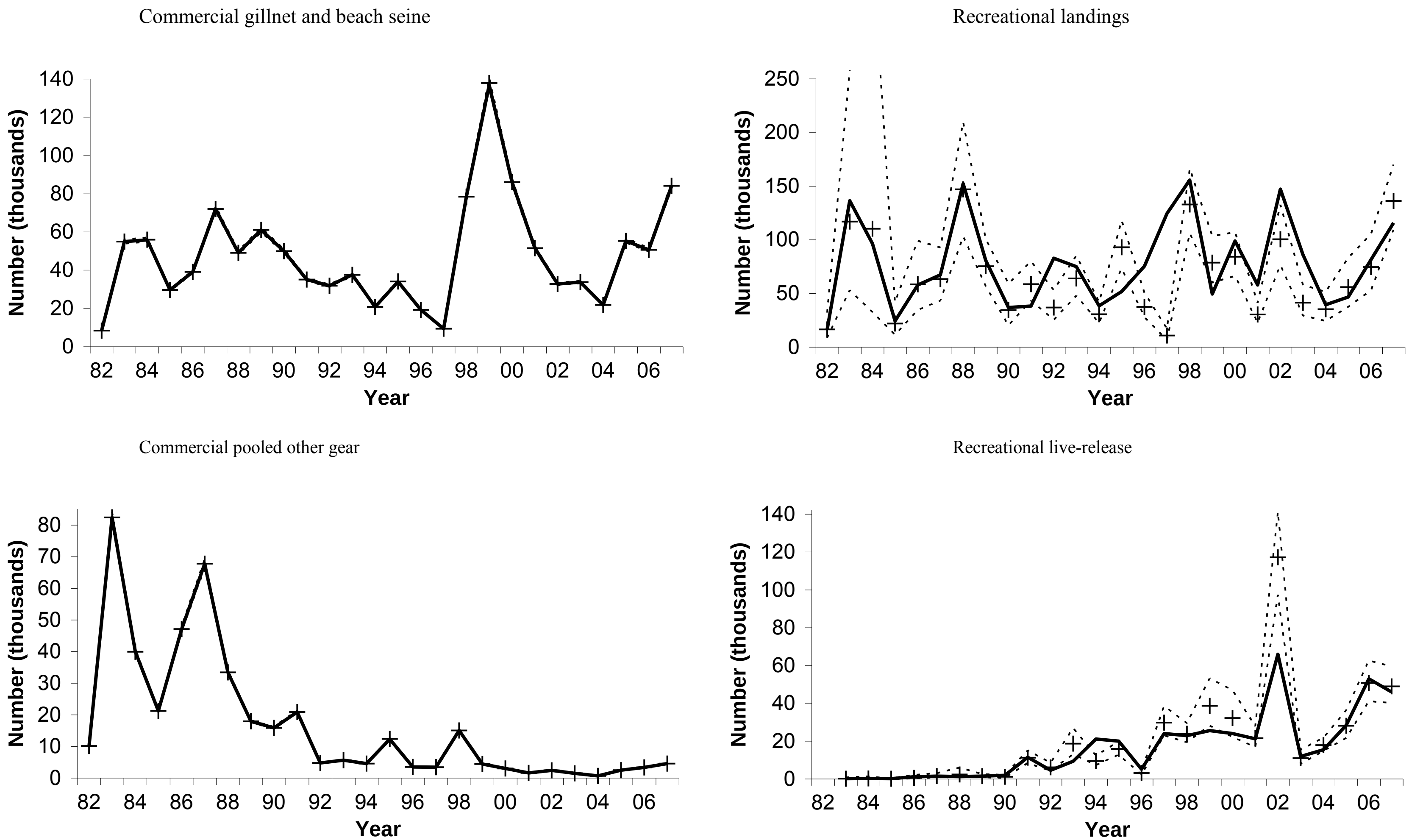


Figure 3.2.5.1. Observed (+) total annual harvest number, showing ± two standard errors (dashed lines), and the associated model estimates for the four northern fisheries.

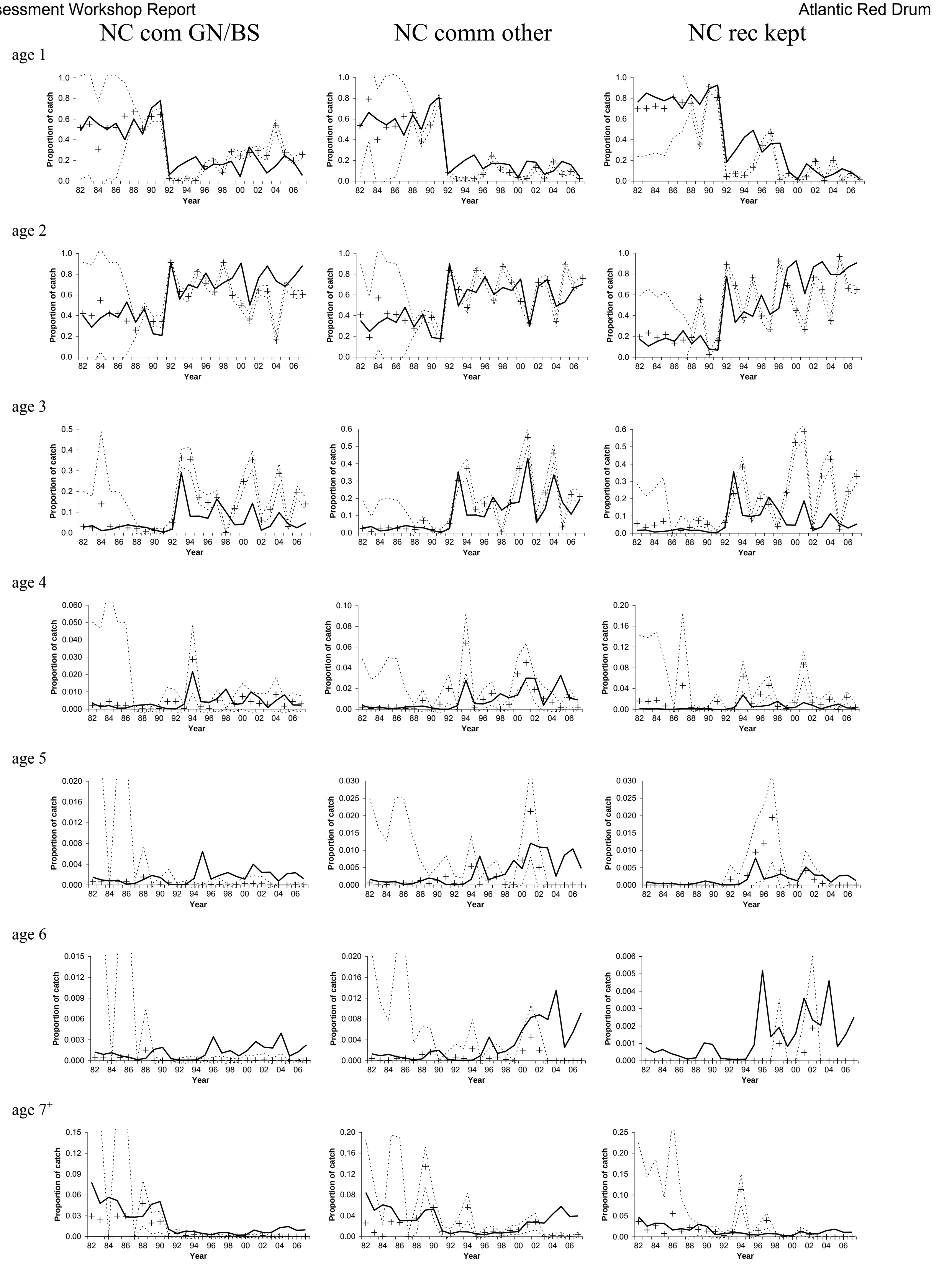


Figure 3.2.5.2. Observed (+) and predicted proportions at age in the landings for the northern commercial gillnet/beach seine fishery, the northern other commercial fishery, and the northern recreational landed fishery during 1982-2007. Each column of graphs shows ages 1 (top row) through ages 7+ (bottom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

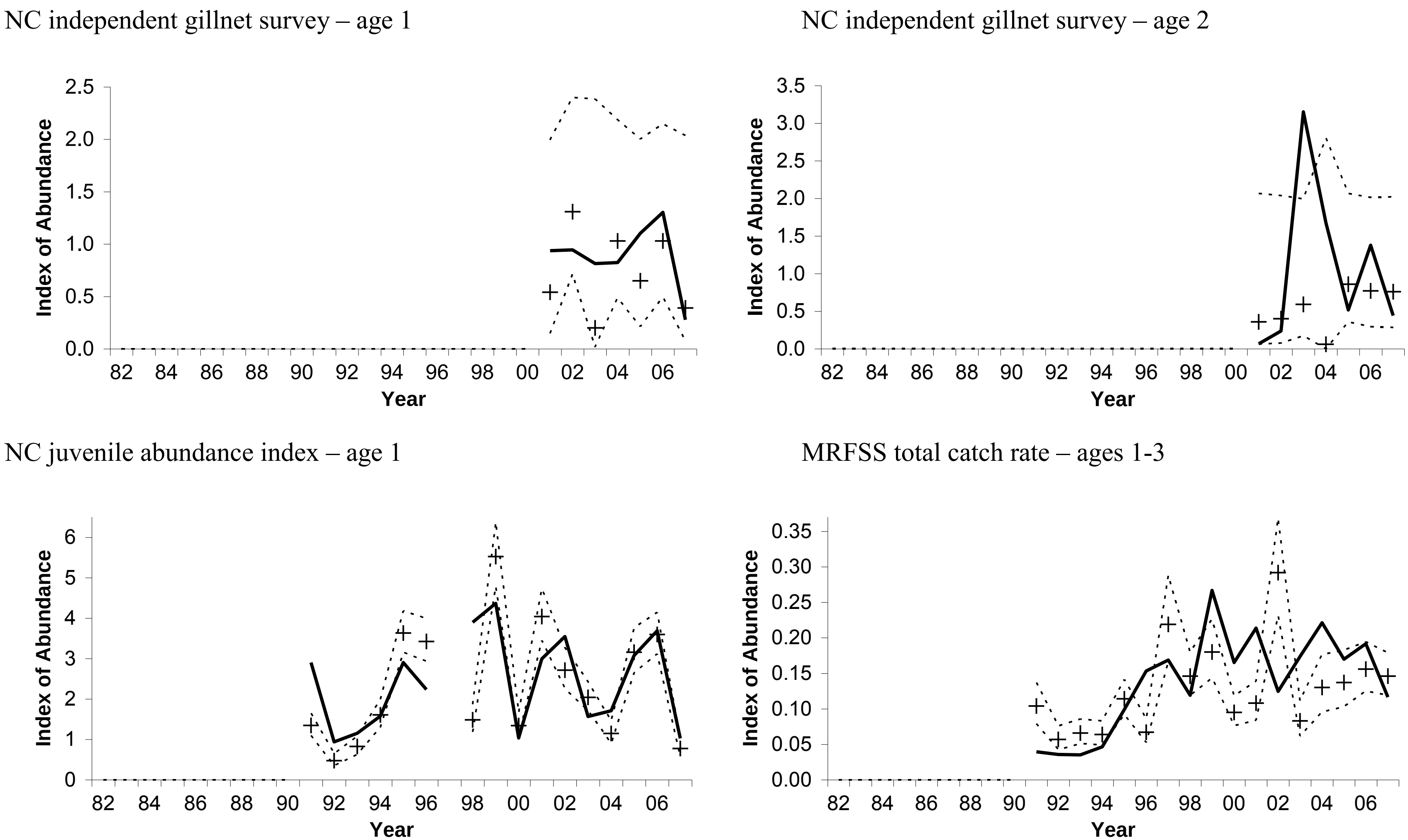


Figure 3.2.5.3. Observed (+) indexes of abundance for red drum, showing ± two standard errors (dashed lines), and the associated model estimates for the four northern indexes.

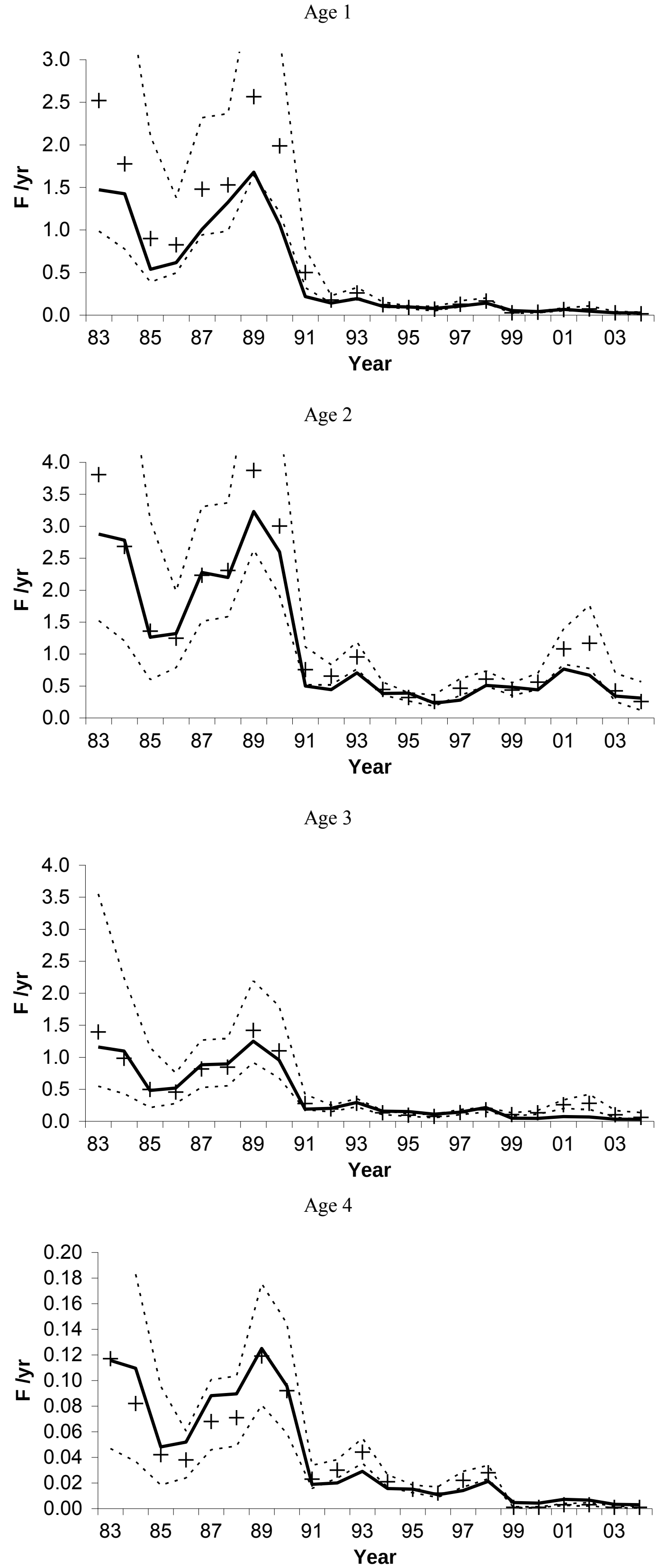


Figure 3.2.5.4. Observed (+) estimates of tag-based estimates of F-at-age for red drum, showing ± two standard errors (dashed lines), and the associated model estimates (solid line) for the northern stock.

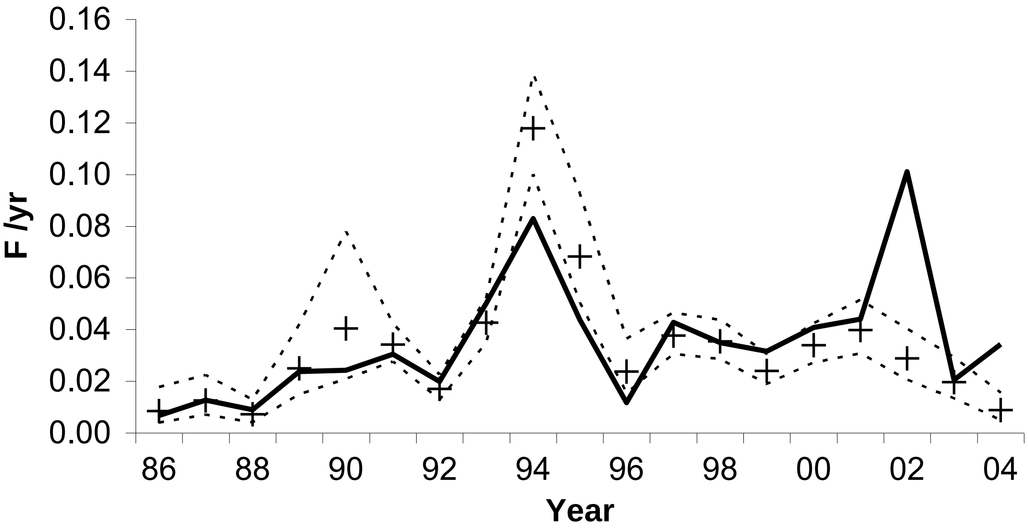


Figure 3.2.5.5. Observed (+) estimates of tag-based estimates of fully recruited F for red drum live releases from the recreational fishery, showing ± two standard errors (dashed lines), and the associated model estimates (solid line) for the northern stock.

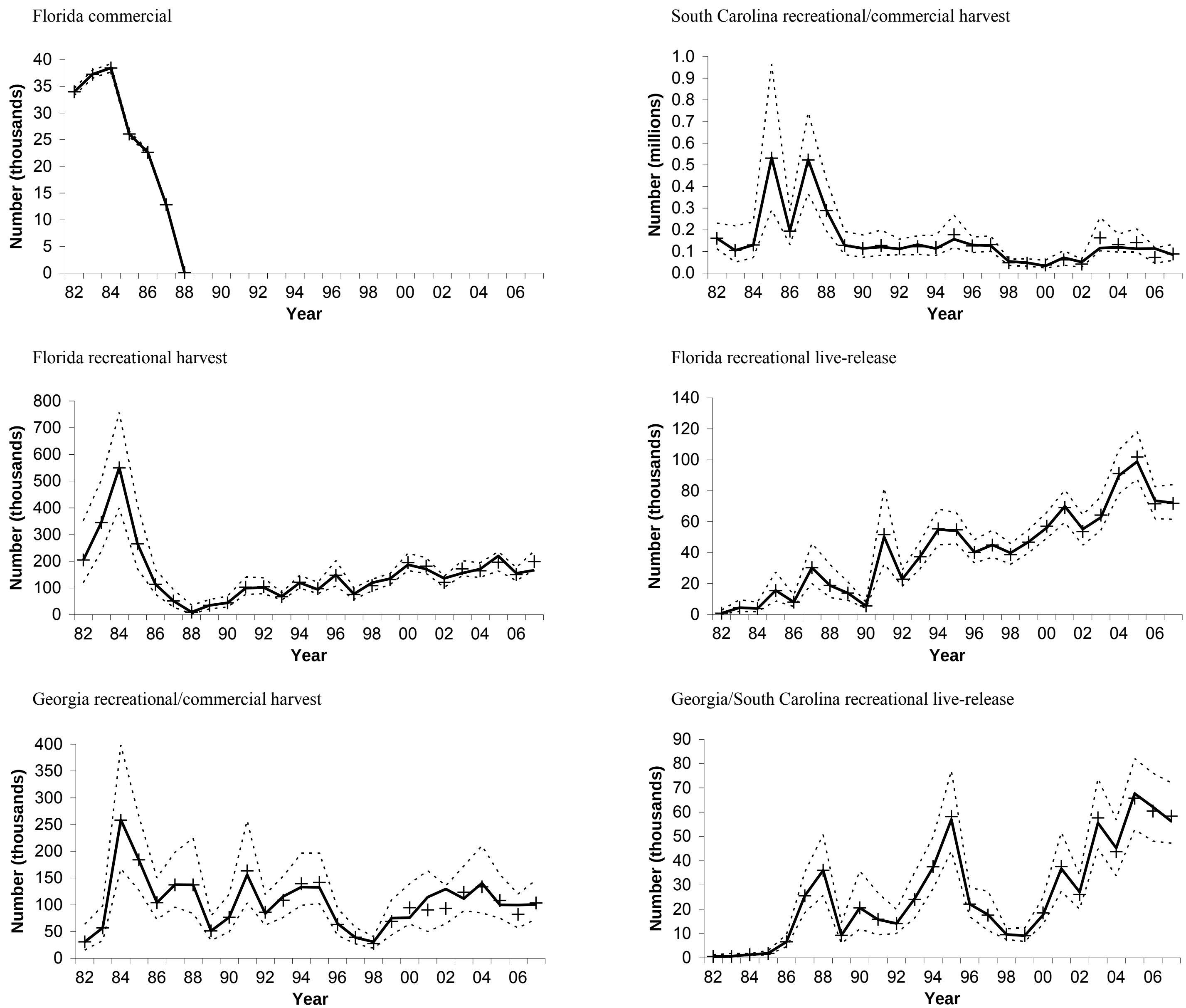


Figure 3.2.5.6. Observed (+) total annual harvest number, showing ± two standard errors (dashed lines), and the associated model estimates for the six southern fisheries.

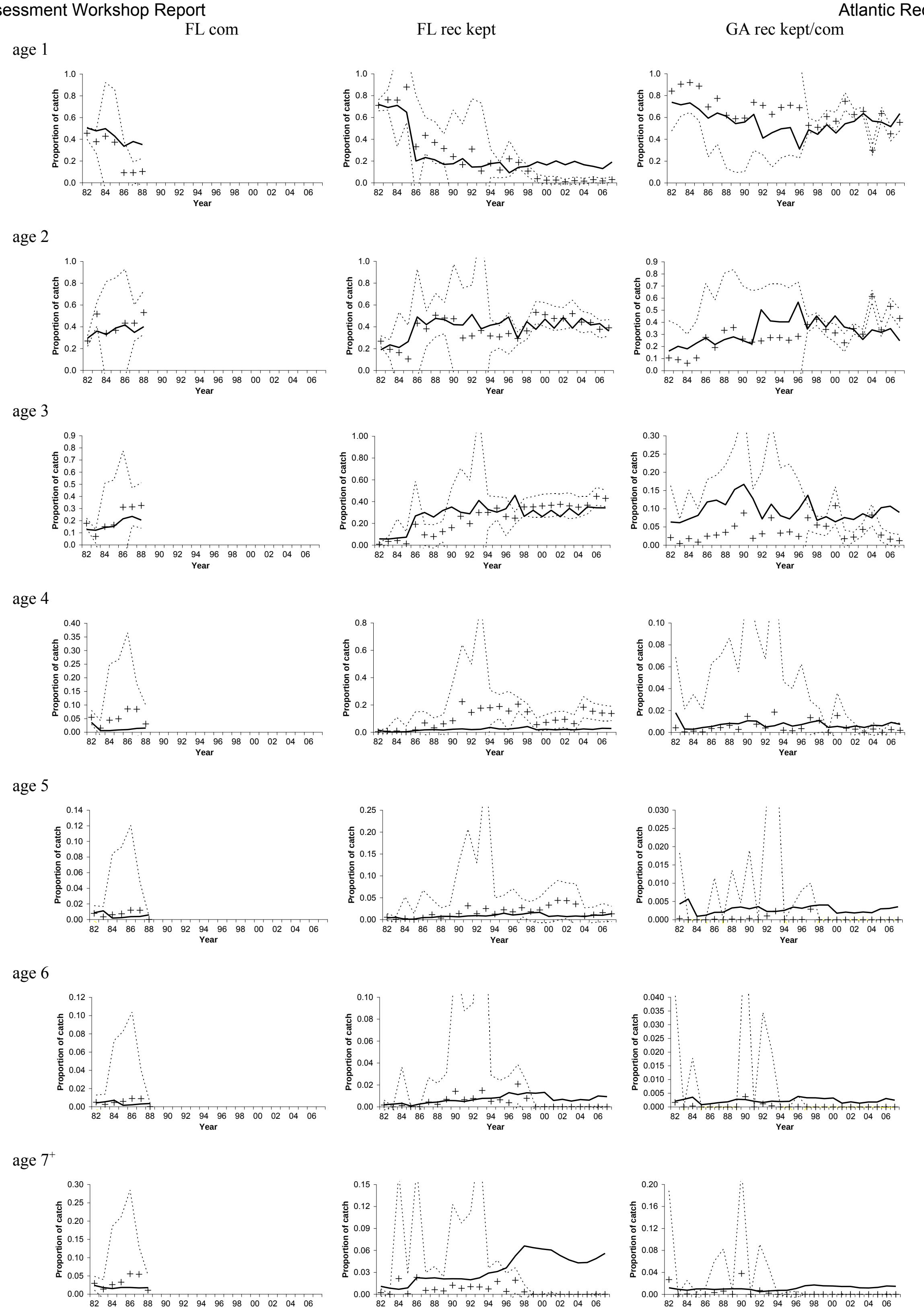


Figure 3.2.5.7. Observed (+) and predicted proportions at age in the landings for the Florida commercial, Florida kept recreational and Georgia kept recreation/commercial fisheries in the southern region during 1982-2007 Dashed lines show ± 2 standard errors around the observed data.

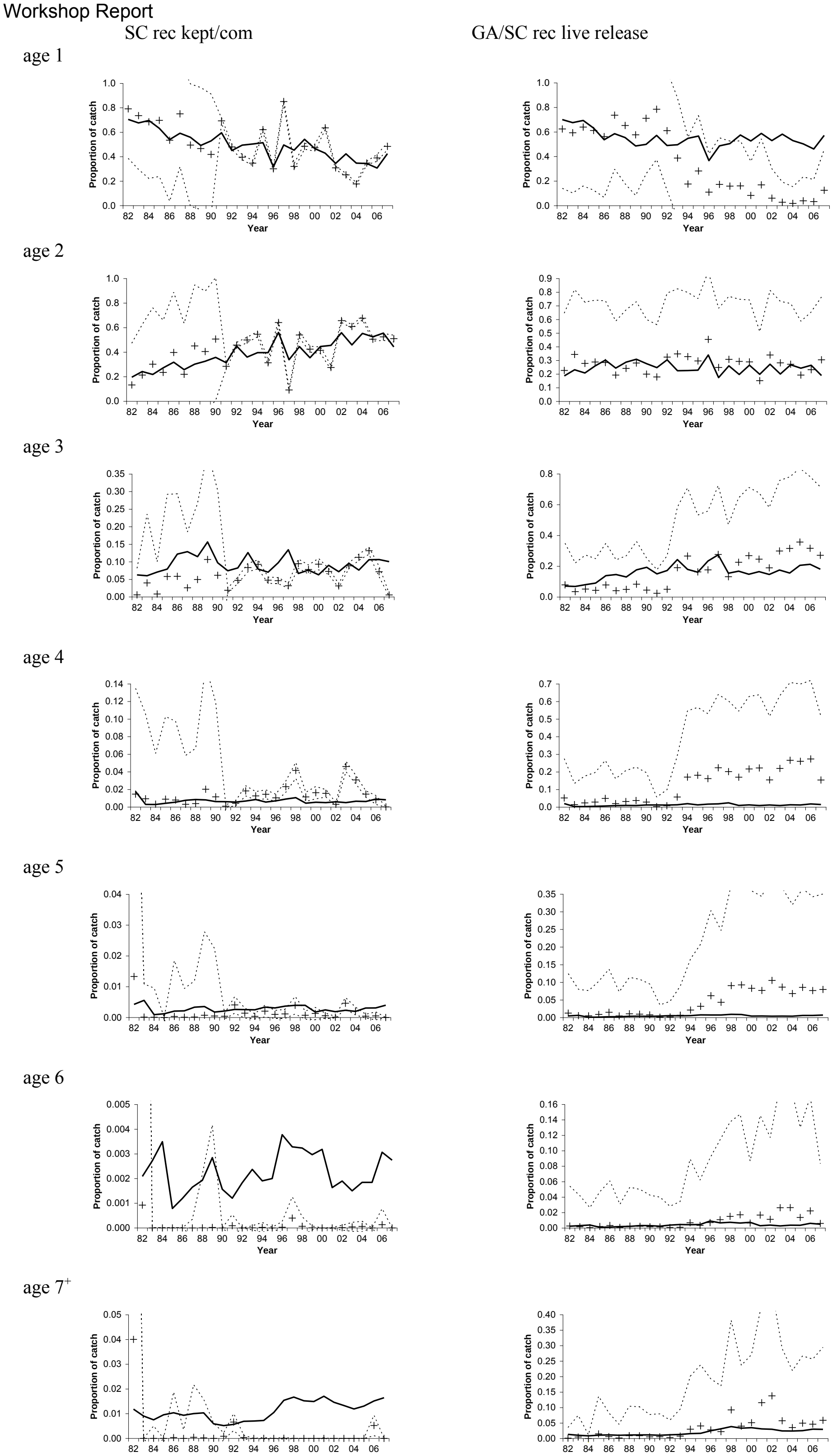


Figure 3.2.5.7 (con't). Observed (+) and predicted proportions at age in the landings for the South Carolina recreationally kept fishery and the Georgia/South Carolina live-release fishery in the southern region during 1982-2007. Dashed lines show ± 2 standard errors around the observed data.

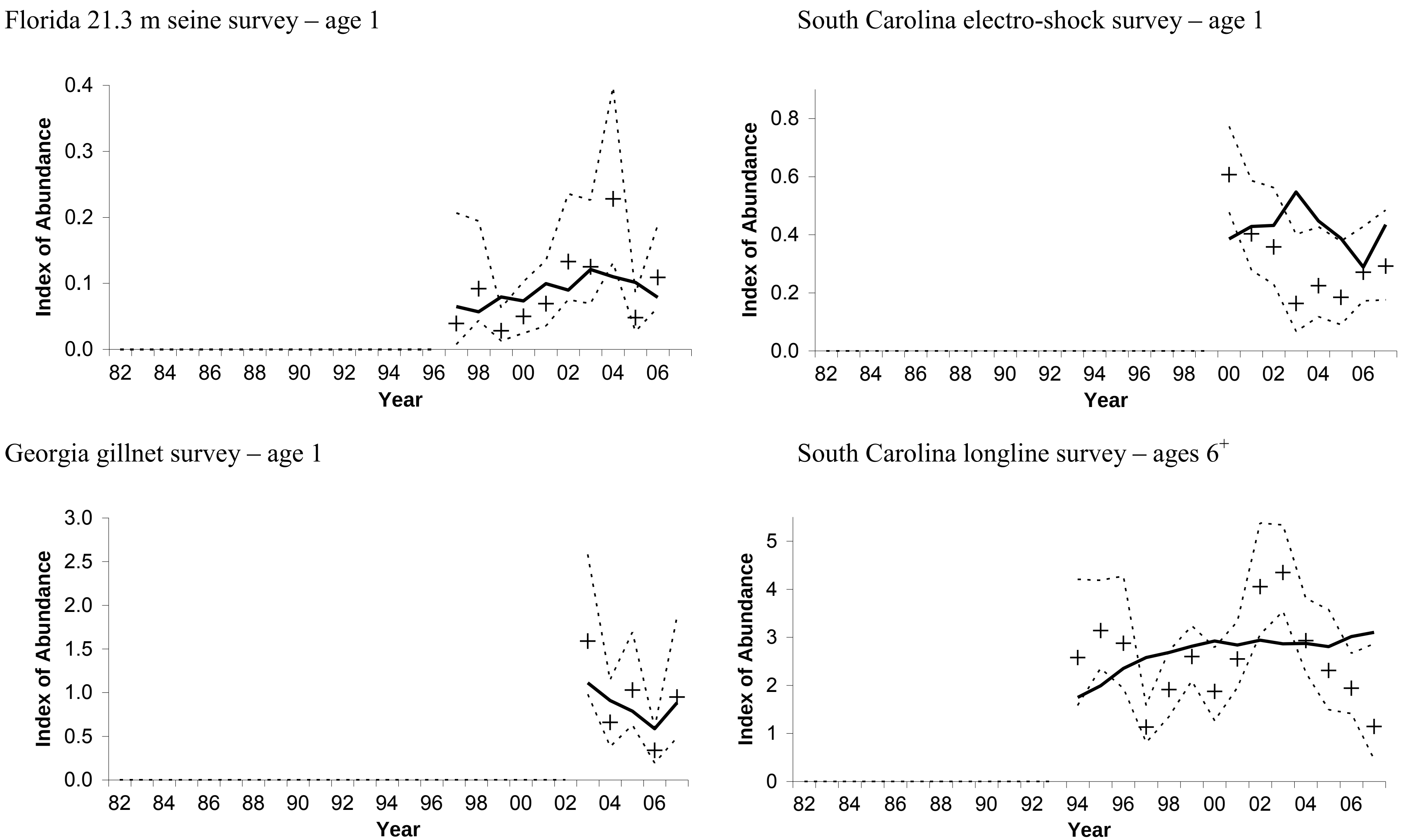
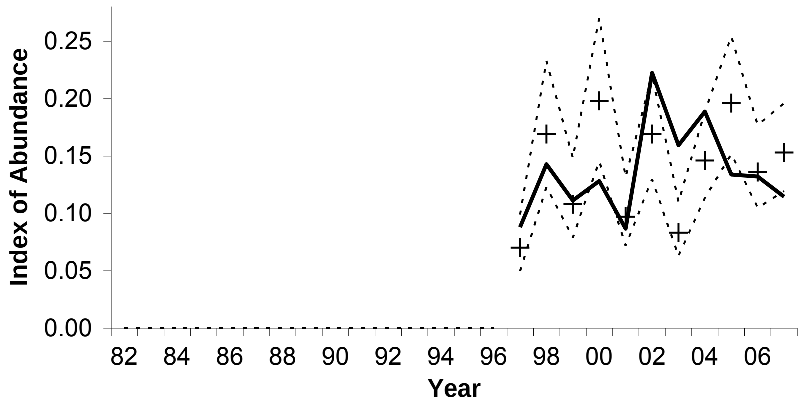
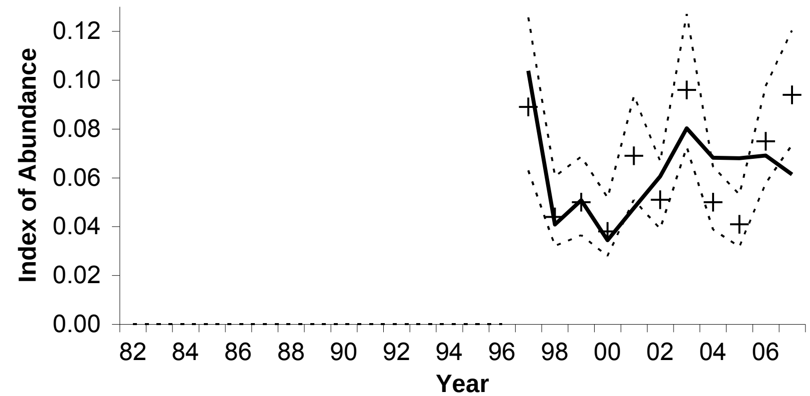


Figure 3.2.5.8. Observed (+) indexes of abundance for red drum, showing ± two standard errors (dashed lines), and the associated model estimates for the eight southern indices.

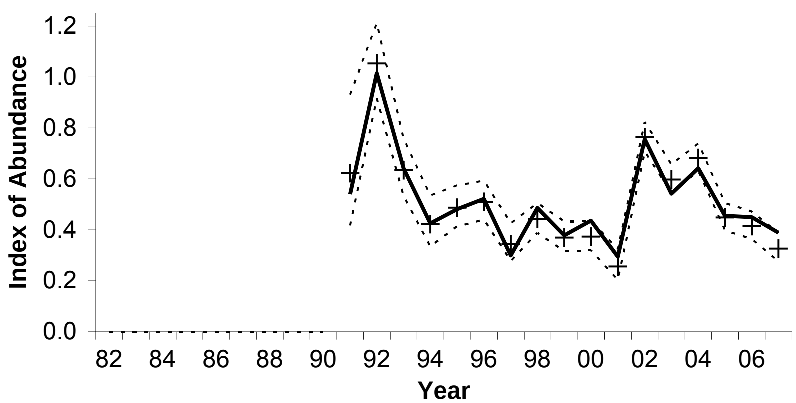
Florida 183-m haul seine – ages 2



Florida 183-m haul seine – ages 3



South Carolina trammel net survey – age 2



MRFSS total catch rates – ages 1-3

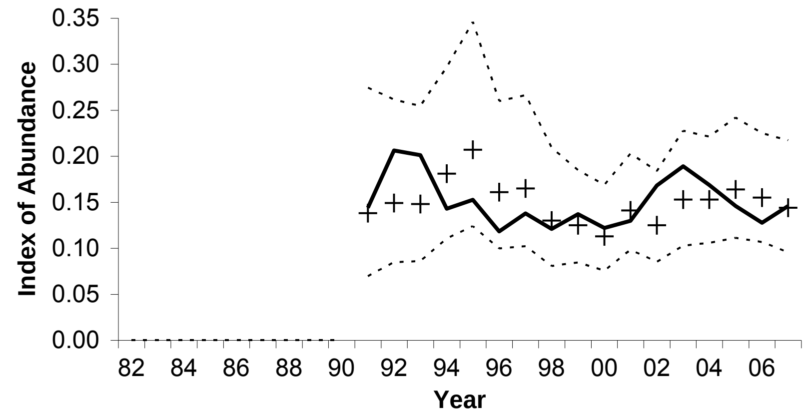
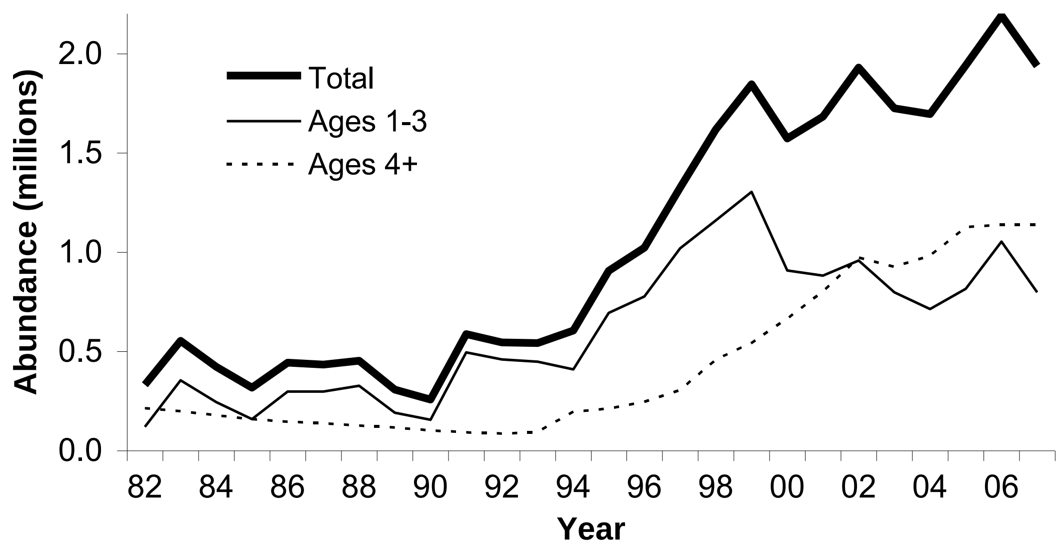


Figure 3.2.5.8 (con't). Observed (+) indexes of abundance for red drum, showing ± two standard errors (dashed lines), and the associated model estimates for the eight southern indexes.

Northern region



Southern region

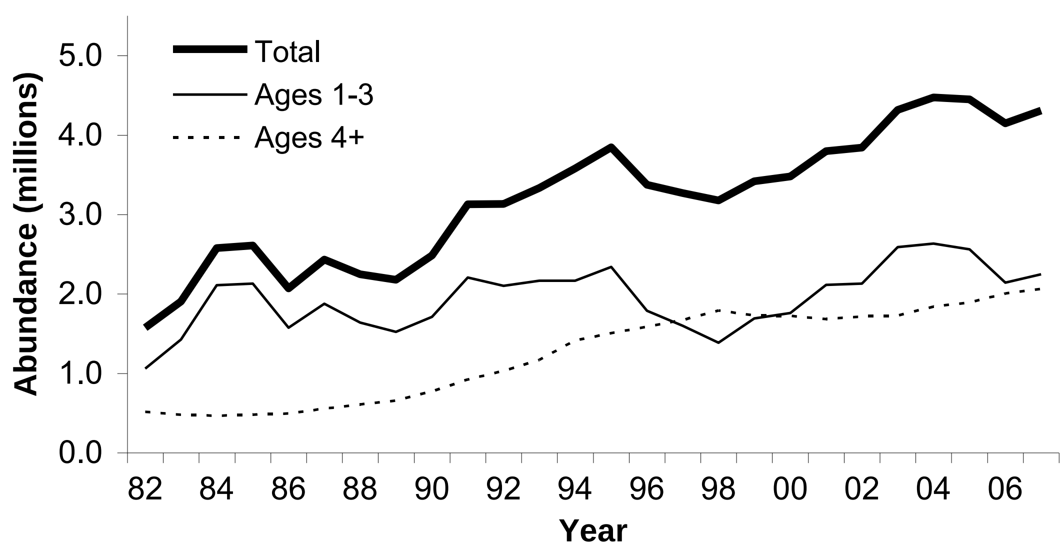
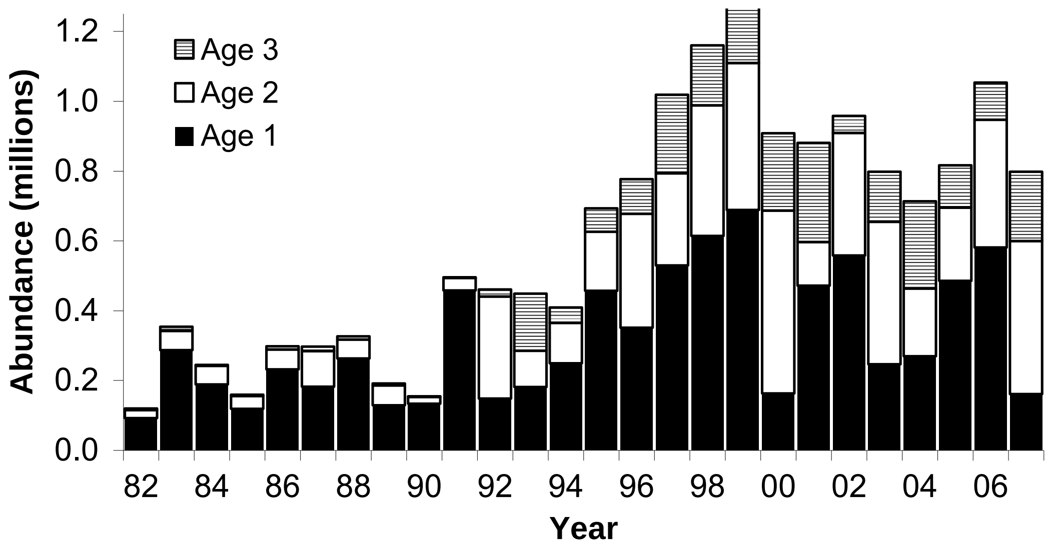


Figure 3.2.5.9. Estimated beginning-of-the-year abundance for red drum in the northern and southern stock areas during 1982-2007.

Northern region



Southern region

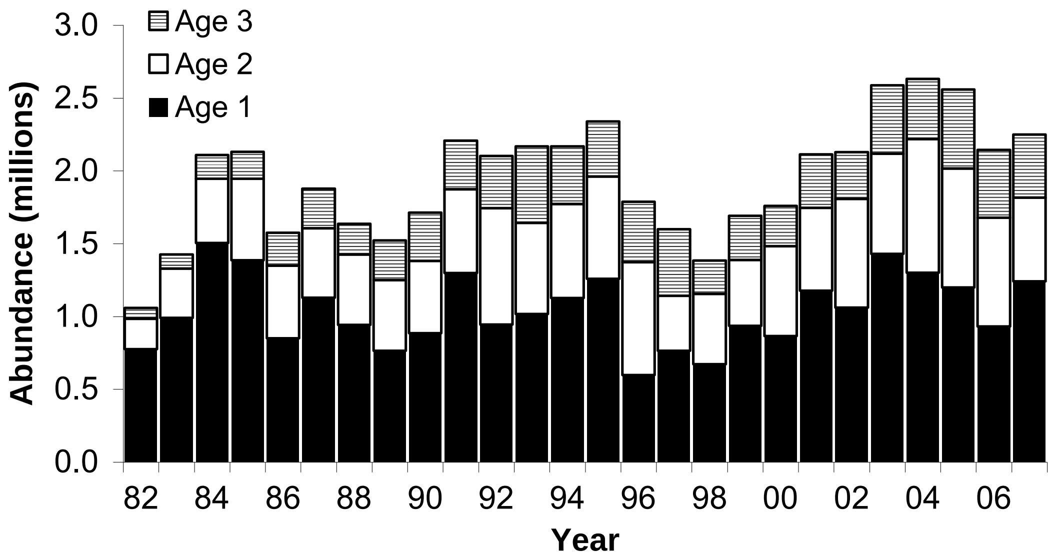
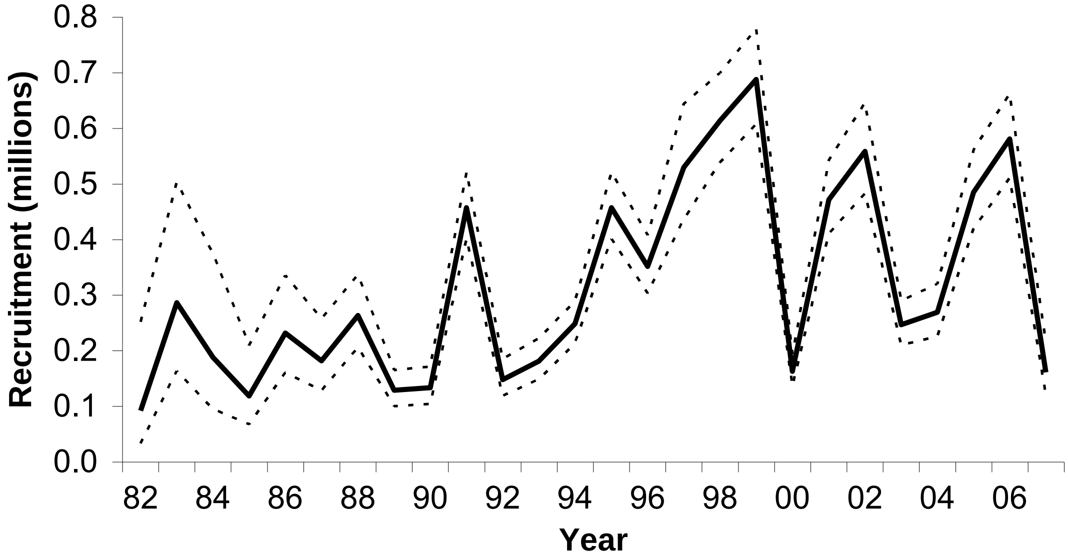


Figure 3.2.5.10. Estimates of abundance of red drum ages 1-3 in the northern and southern stock areas during 1982-2007

Northern region



Southern region

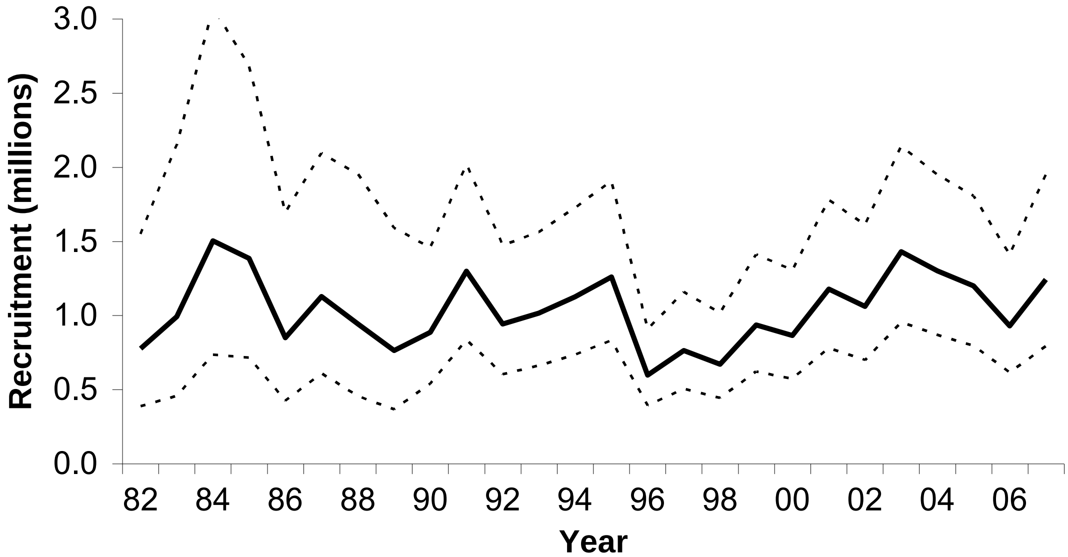


Figure 3.2.5.11. Estimated recruitment (age-1 abundance, solid line) and ± two standard errors (dashed lines) for the northern and southern regions during 1982-2007

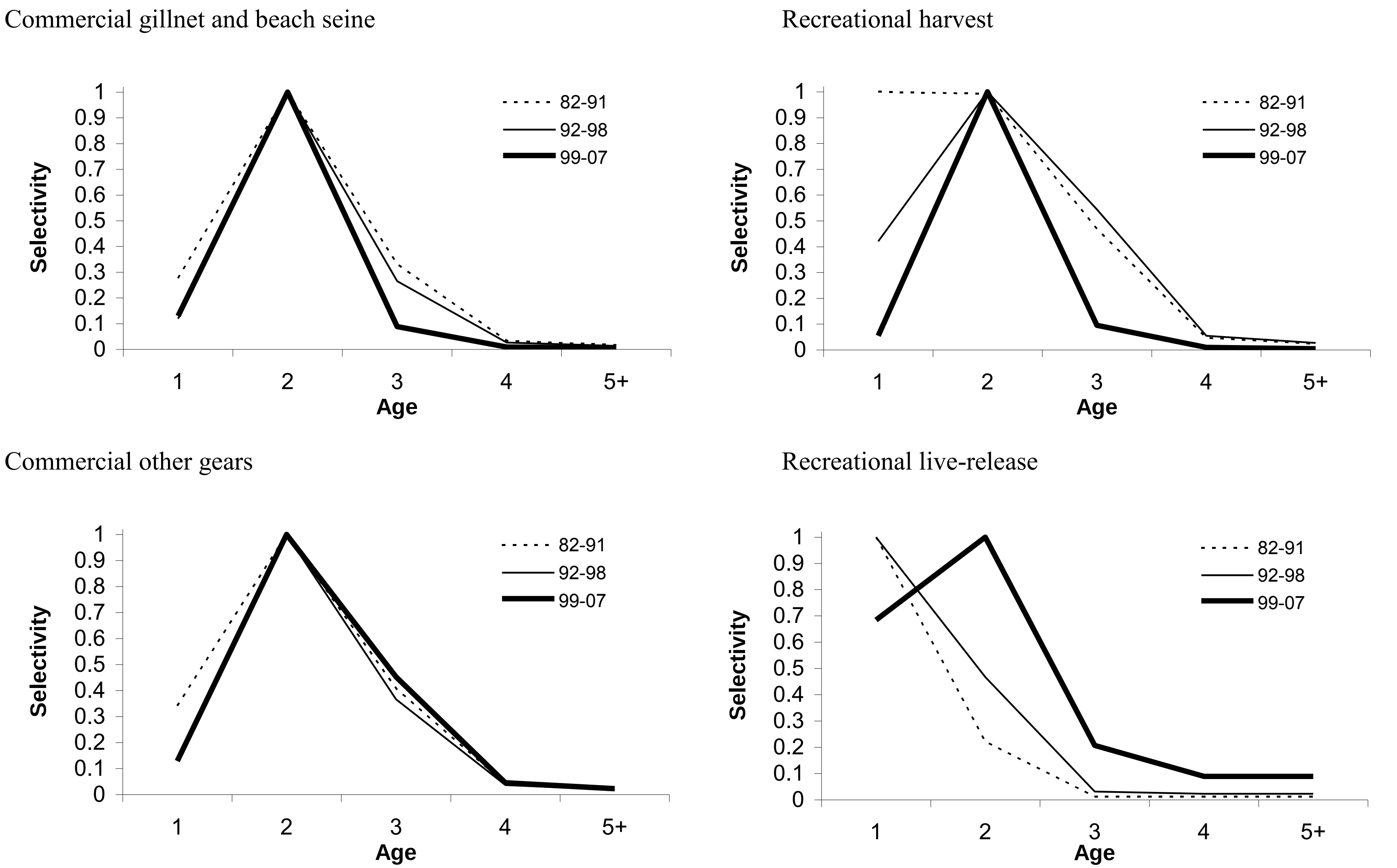


Figure 3.2.5.12. Estimated selectivities for three of the four northern fisheries modeled separately and the tag-based input selectivity data for the recreational live-release fishery. Under the separability assumption, this age-effect for distributing fishing mortality across ages was estimated for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

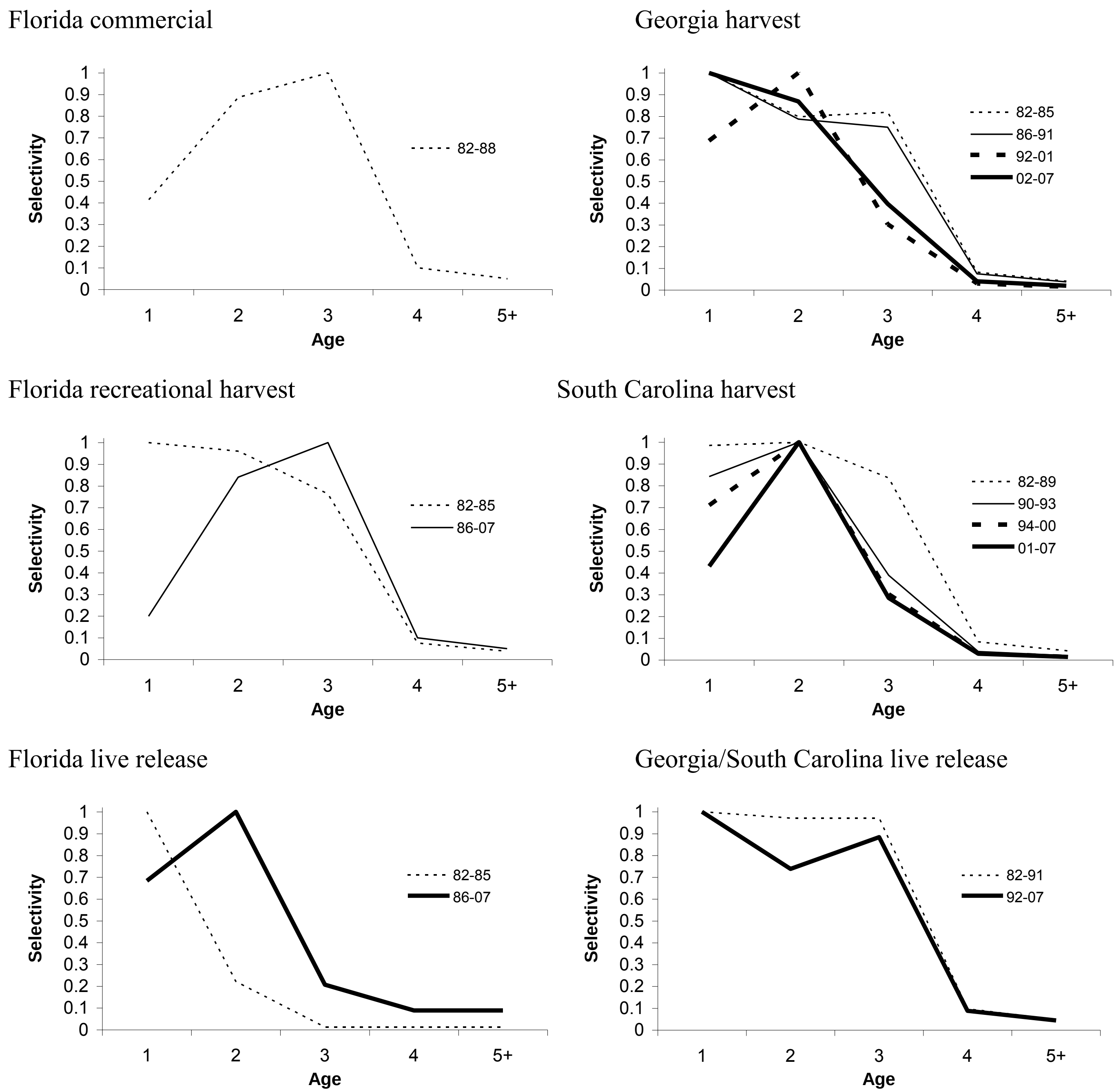
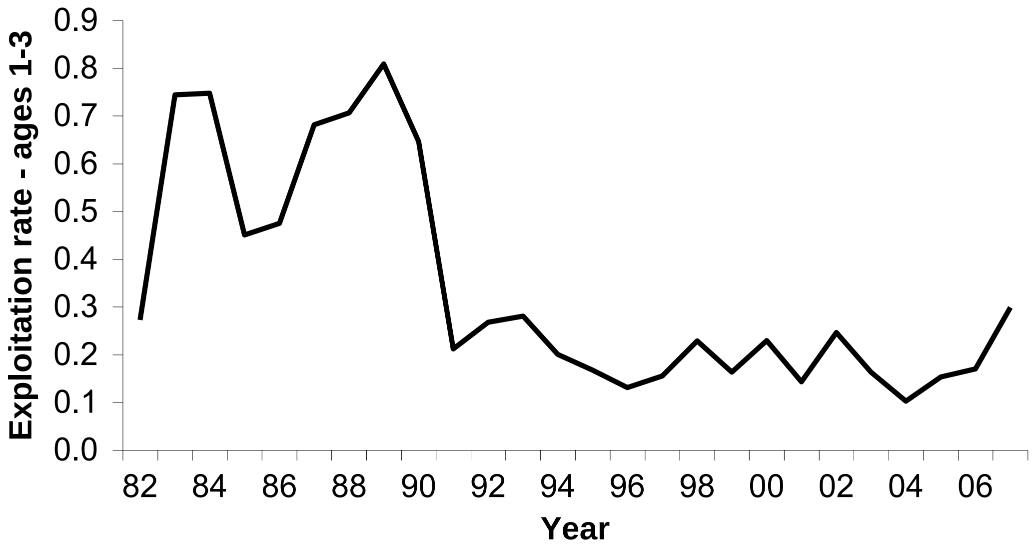


Figure 3.2.5.13. Estimated selectivities for five of the six southern fisheries modeled separately and the tag-based input selectivity data for the Florida recreational live-release fishery. Under the separability assumption, this age-effect for distributing fishing mortality across ages was estimated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

Northern region



Southern region

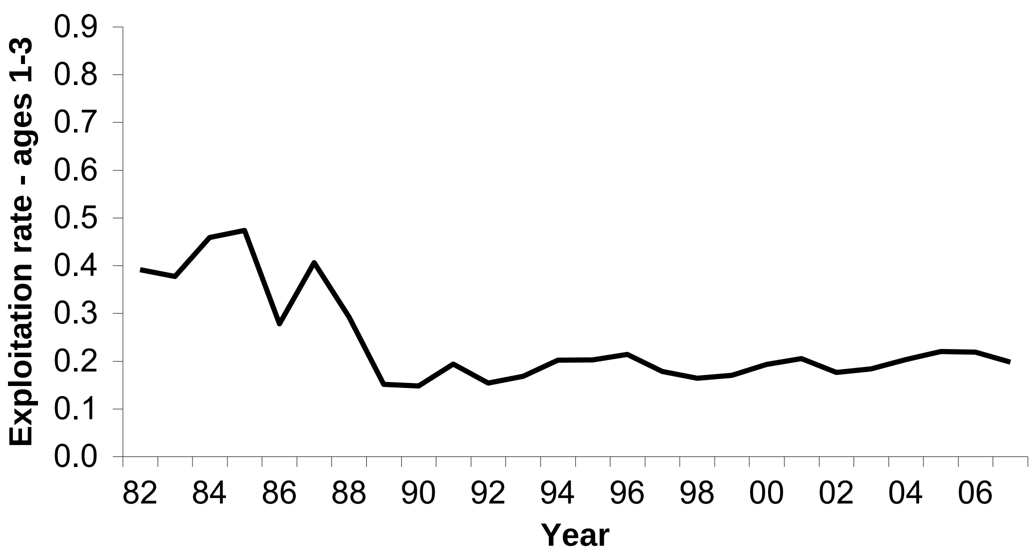


Figure 3.2.5.14. Estimated annual exploitation rate for red drum ages 1-3 in the northern and southern regions during 1982-2007.

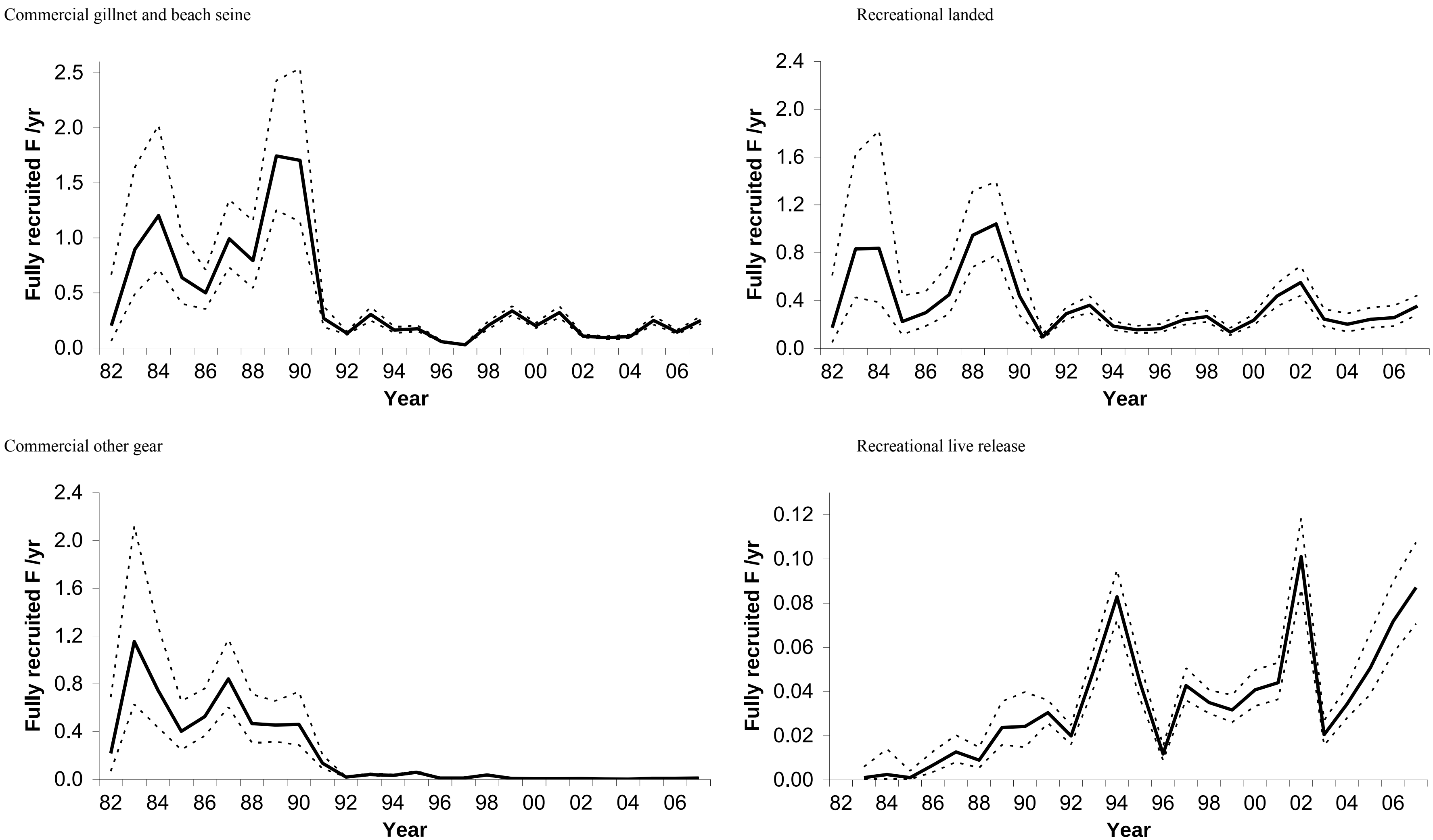


Figure 3.2.5.15. Estimated fully recruited instantaneous fishing mortality (solid line) and ± two standard errors (dashed lines) for the four northern region fisheries during 1982-2007.

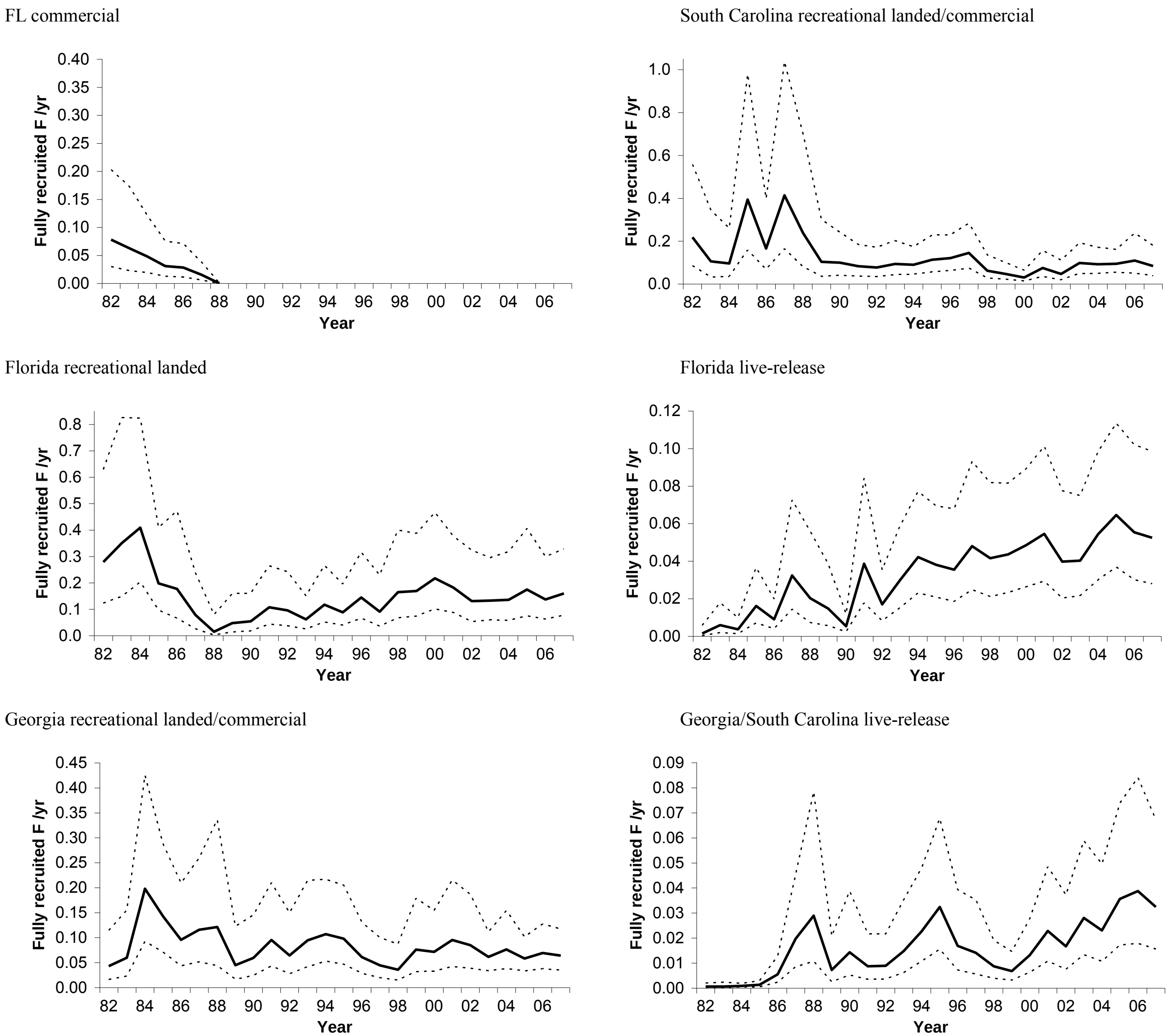
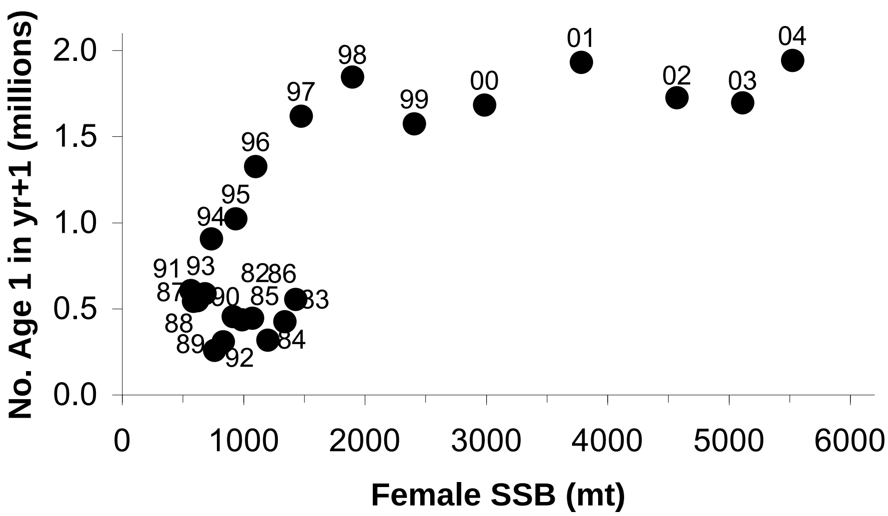


Figure 3.2.5.16. Estimated fully recruited instantaneous fishing mortality (solid line) and ± two standard errors (dashed lines) for the six southern region fisheries during 1982-2007.

Northern region



Southern region

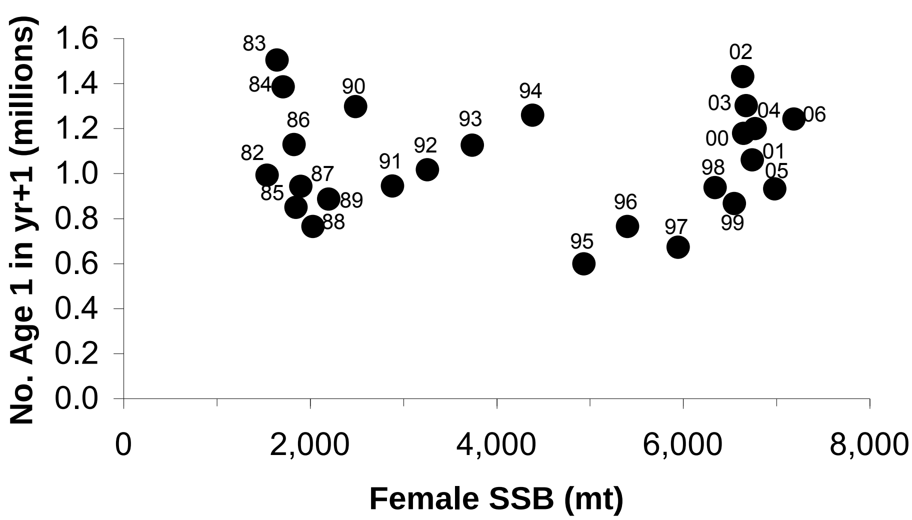


Figure 3.2.5.17. Estimated female spawning stock biomass (mt) of red drum during 1982-2006 and the next year's estimated abundance of age-1 fish.

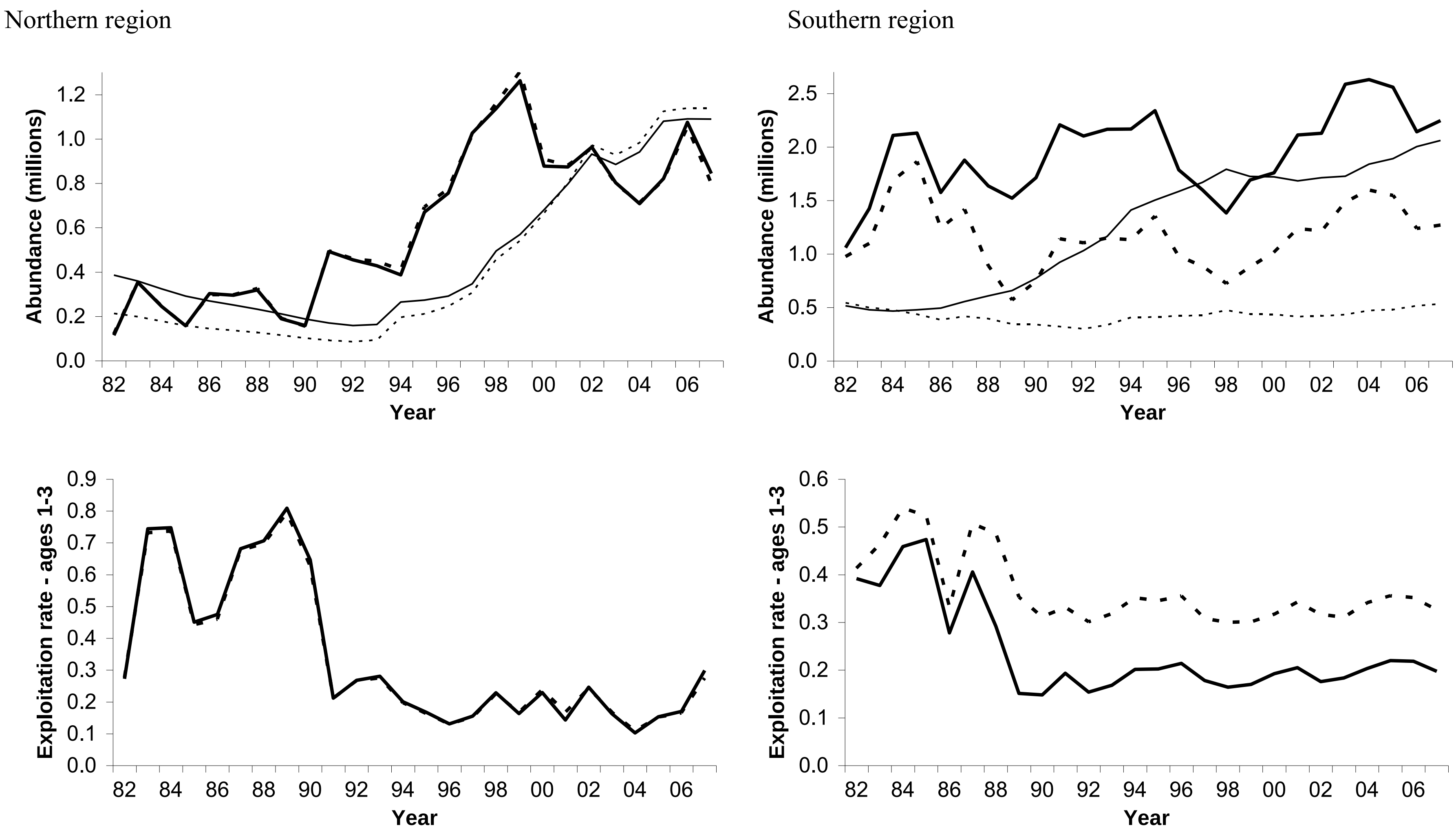


Figure 3.2.5.18. Estimates of abundance and age 1-3 exploitation when the selectivities of ages 1-5 were estimated (dashed lines) in the models instead of the restricted configuration used in the base model runs (solid lines). The abundance panels show the estimates for the pooled ages 1-3 (heavier lines)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

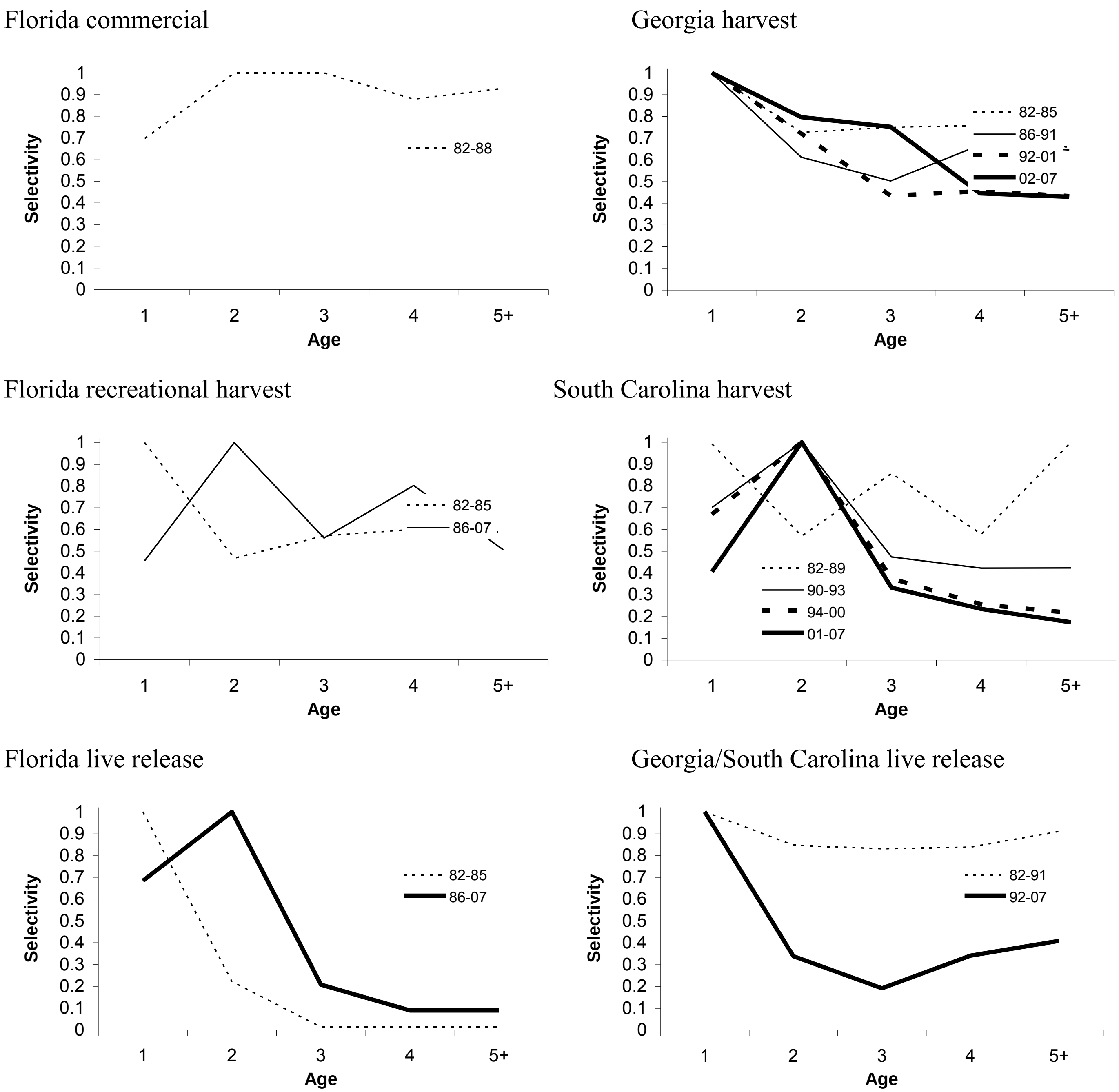


Figure 3.2.5.19. Estimated selectivities for five of the six southern fisheries modeled separately and the tag-based input selectivity data for the Florida recreational live-release fishery. Under the separability assumption, this age-effect for distributing fishing mortality across ages was estimated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

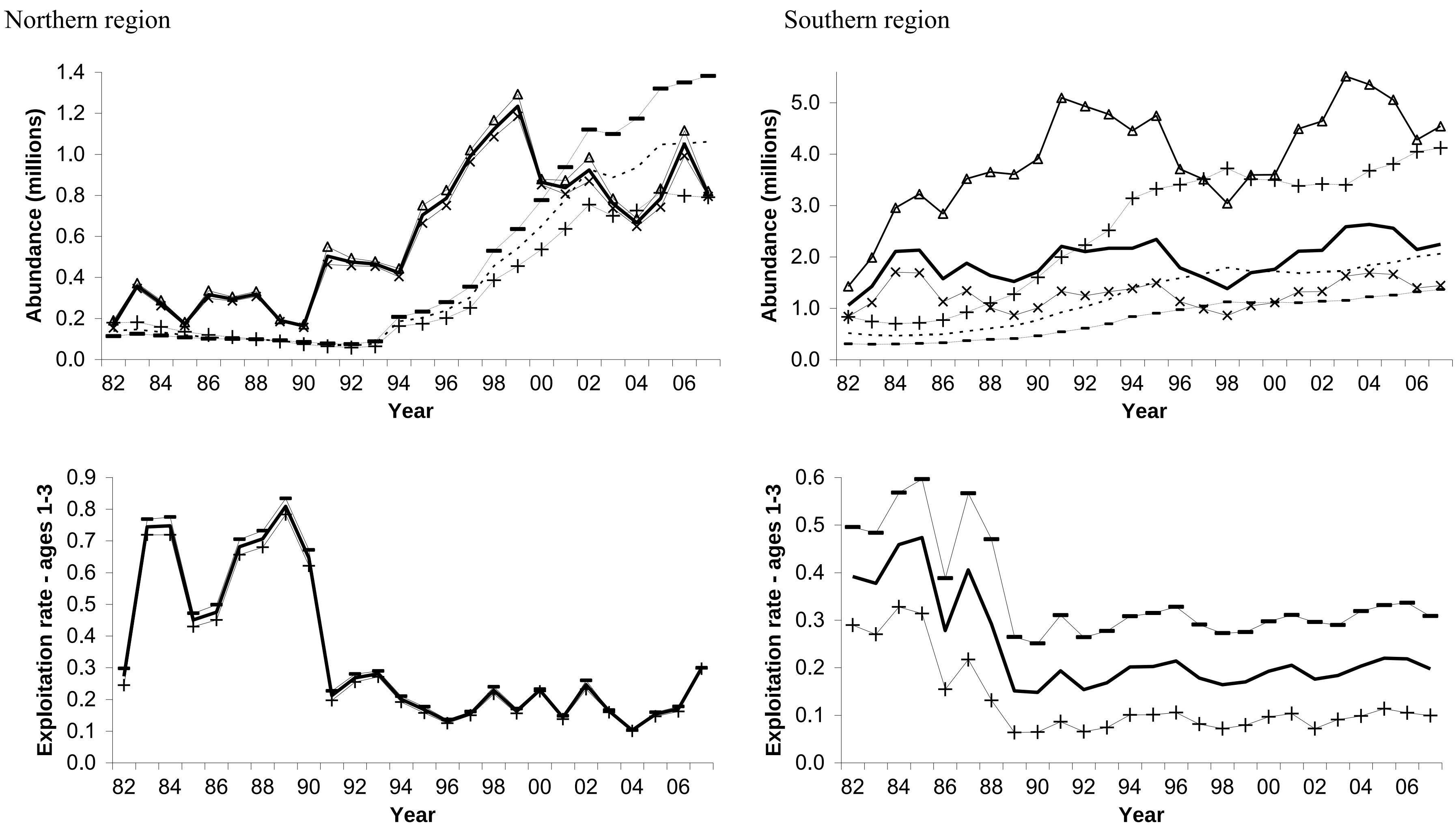


Figure 3.2.5.20. Estimates of abundance and age 1-3 exploitation using the high M (+'s or triangle), low M (-'s or X's), and base model M's (lines without symbols). The abundance panels show the estimates for the pooled ages 1-3 (heavier lines) and for ages 4^+ (dashed lines)

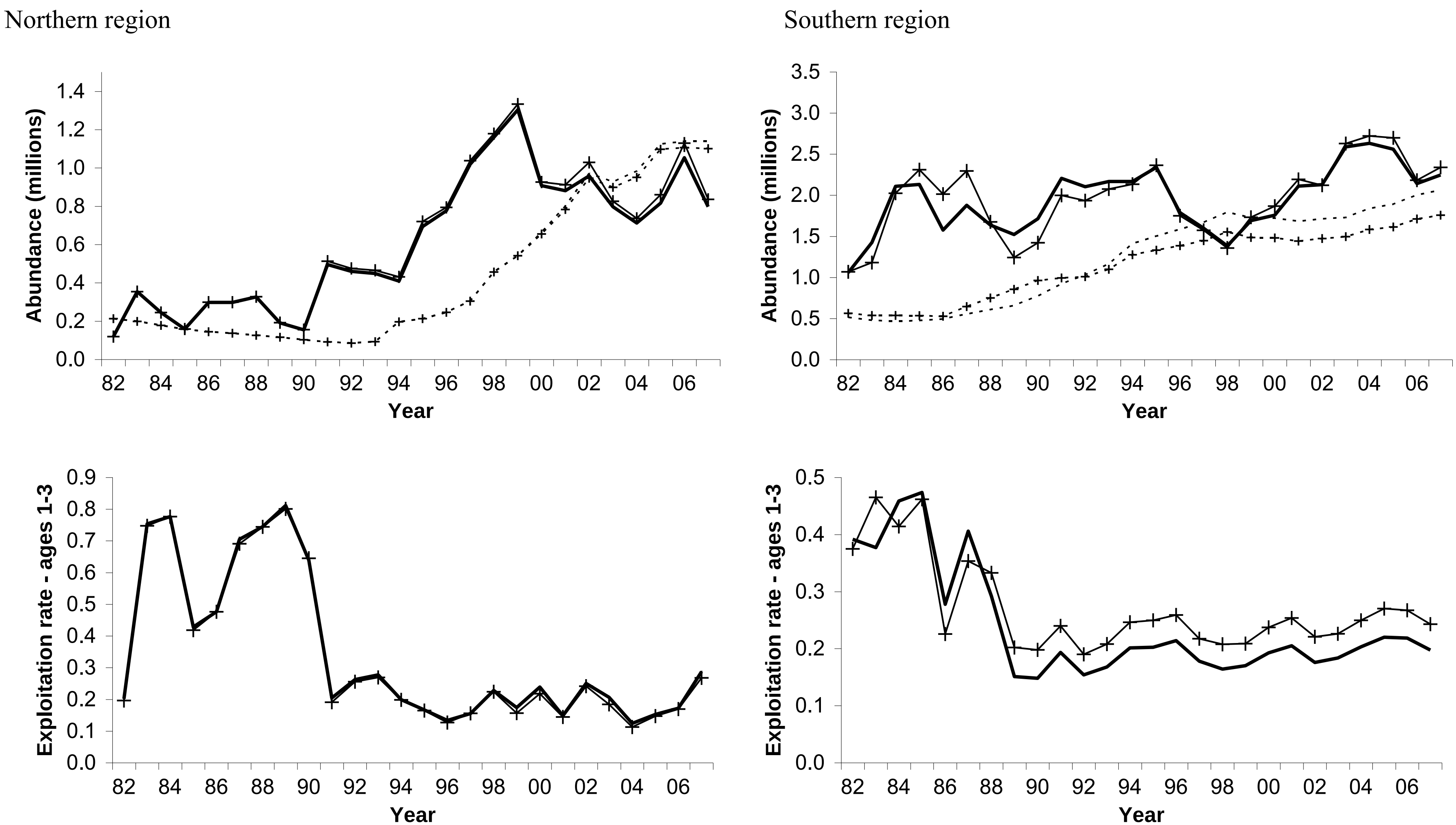


Figure 3.2.5.21. Estimates of abundance and age 1-3 exploitation when the hooking mortality was 0.16 (lines with the + symbols), double the base level of 0.08 (solid lines). The abundance panels show the estimates for the pooled ages 1-3 (heavier lines) and for ages 4^+ (lighter lines).

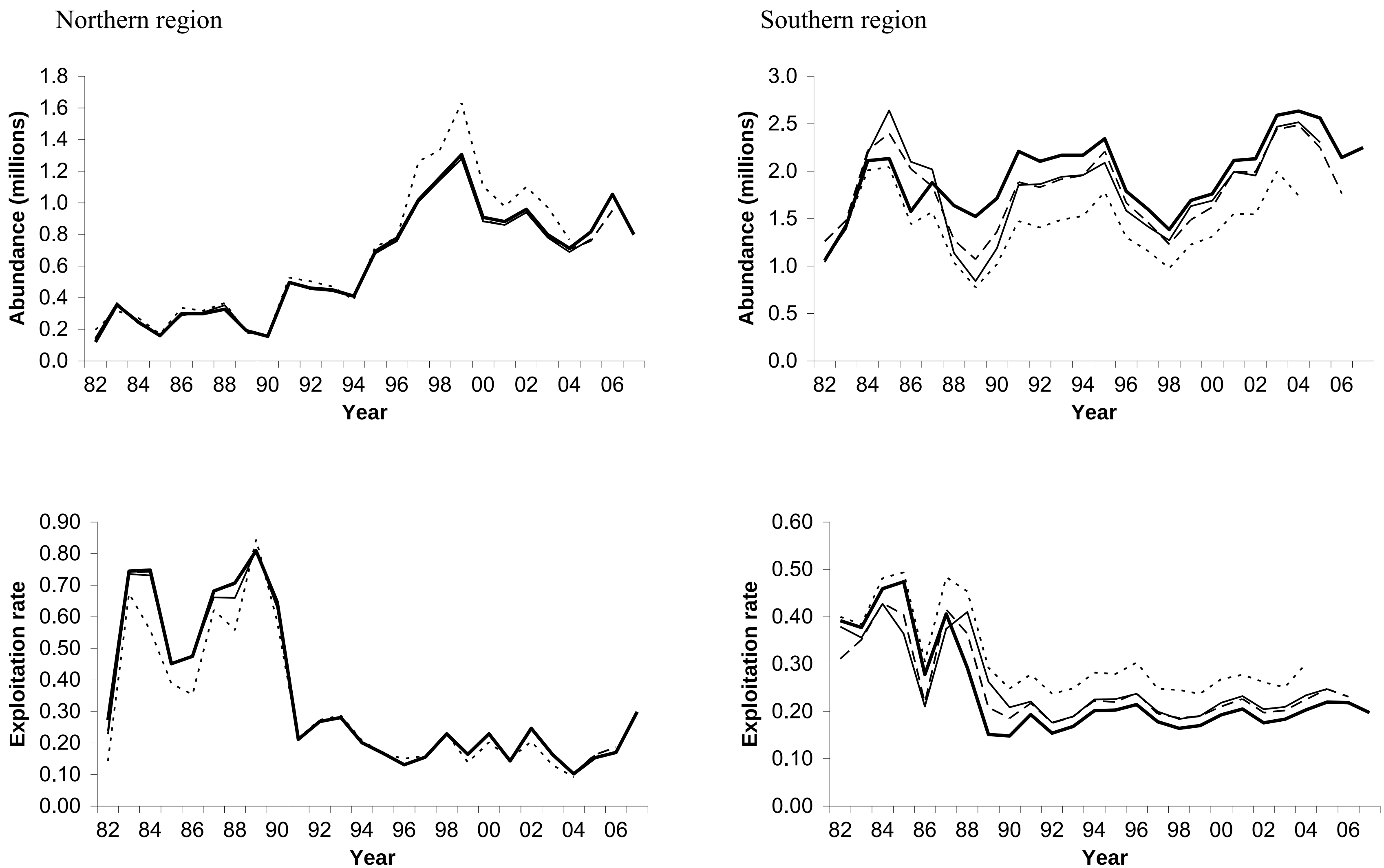


Figure 3.2.5.22. Estimates of age 1-3 abundance (top) and exploitation rate (bottom) using sequentially fewer years in the analysis, with the ending year changing from 2007 to 2006, to 2005, and to 2004 .

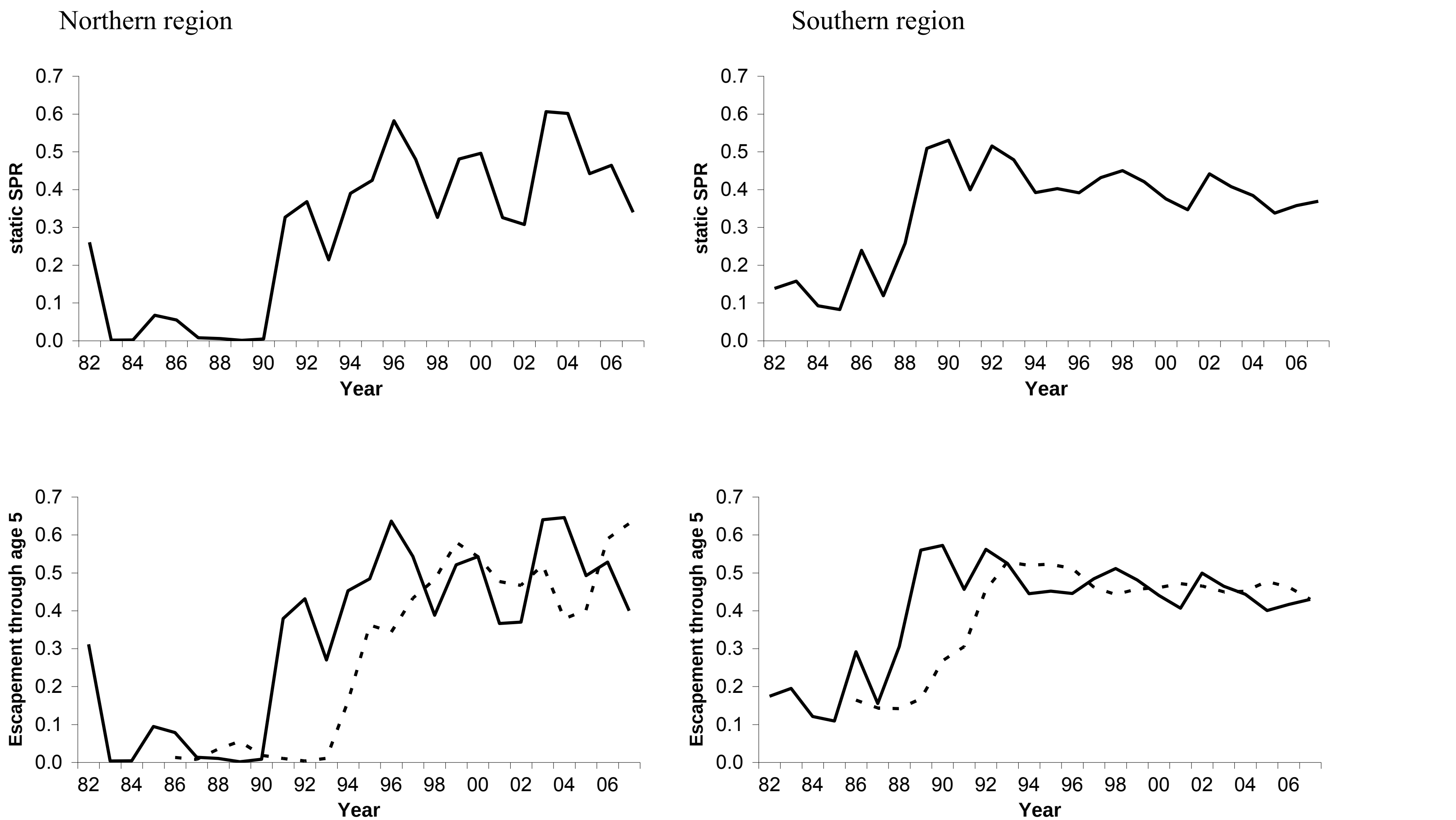


Figure 3.2.5.23. Northern and southern region estimates of static spawning potential ratio during 1982-2007 (top) and escapement rates (bottom) showing year-specific (heavy line) and year class-specific (dashed line) estimates.

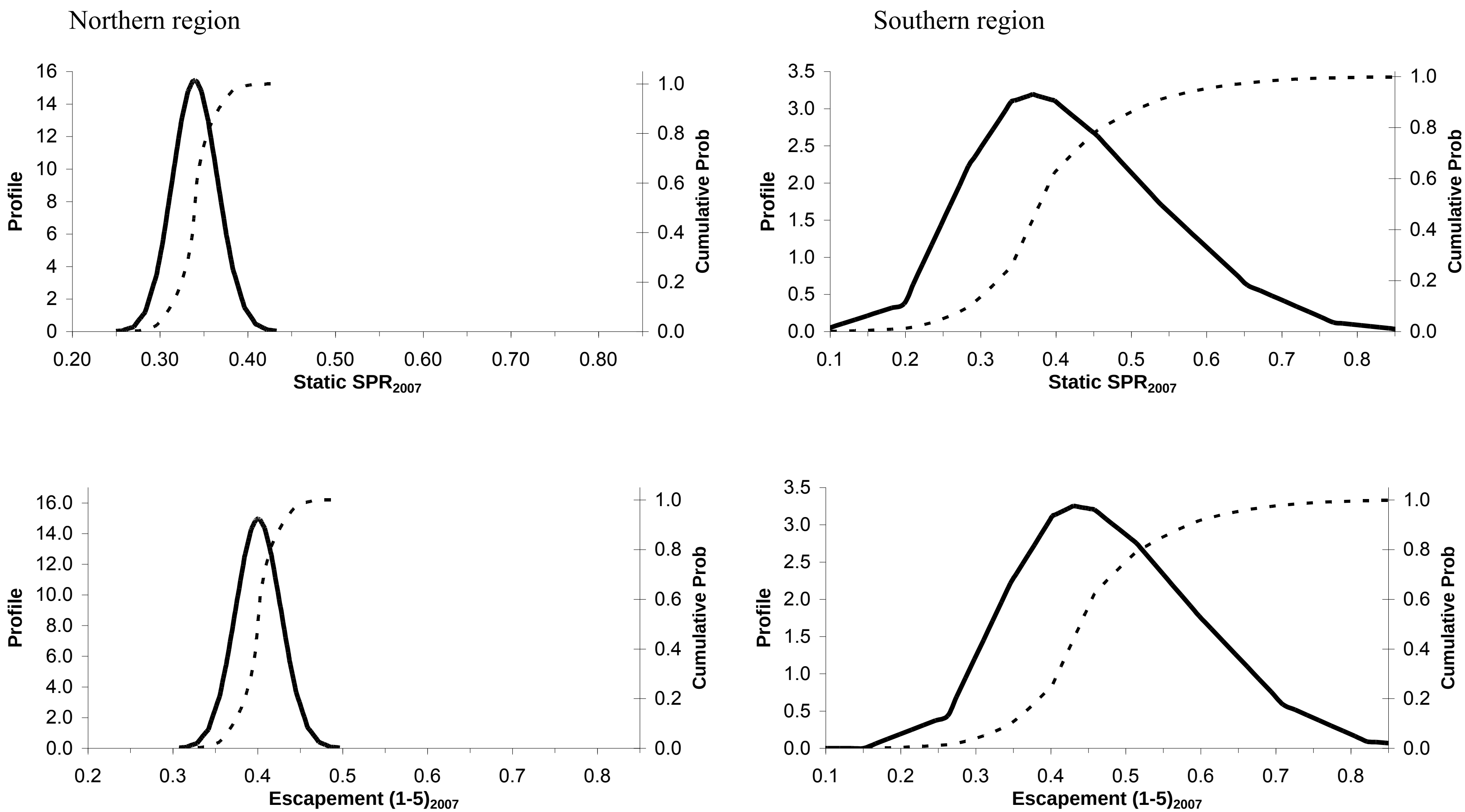
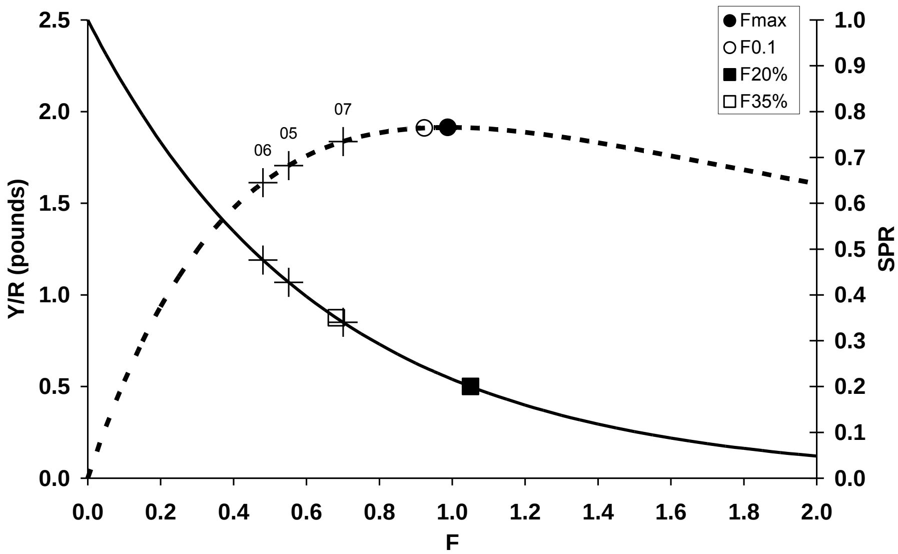


Figure 3.22.5.24. Northern and southern region likelihood profiles (solid line) and cumulative probability distribution (dashed lines) for the base model estimates of static spawning potential ratio in 2007 and age 1-5 escapement in 2007.

Northern region



Southern Region

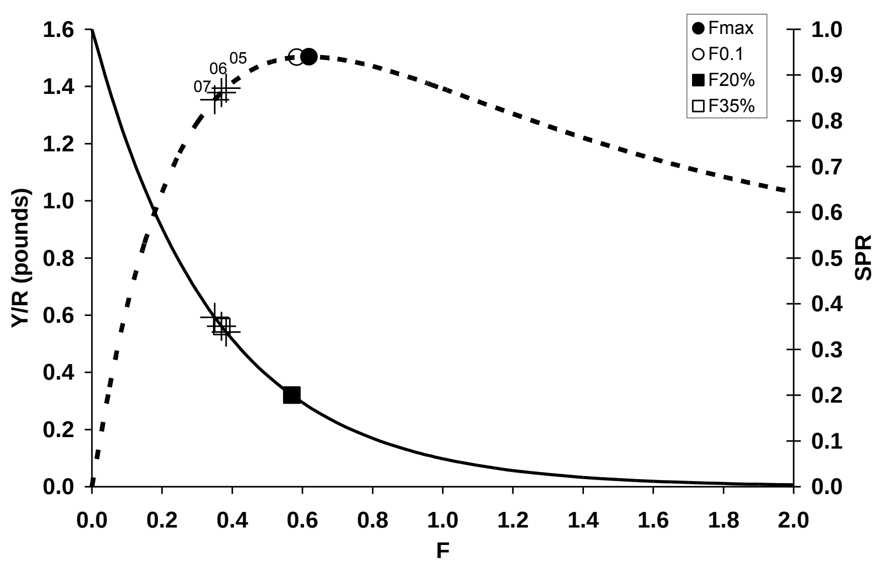


Figure 2.3.5.25. Equilibrium yield-per-recruit (dashed line) and spawning-stock-biomass-per-recruit (of spawning potential ratio, SPR, solid line) expected for red drum across a range of instantaneous fishing mortalities in the northern and southern. As indicated in legend, the YPR benchmarks Fmax and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

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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.

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Appendix A Report of the Independent Expert

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

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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.

<u>Prior to the Assessment Workshop</u>: 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.

<u>Foreign National Security Clearance</u>: 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

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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 June 1	Topical Discussions:	Introductions 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 June 2	Topical Discussions:	Approve continuity runs and base configuration Identify sensitivity runs.
	Milestones:	Base configuration is concluded. Sensitivity/Uncertainty run lists are developed.
	Homework:	Finish base and continuity runs. Prepare sensitivity runs.
Wednesday June 3	Topical Discussions:	Evaluate sensitivities 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 June 4	Topical Discussions:	Compare and contrast models; SFA parameters and status determination
	Milestones:	Consensus text is drafted
	Homework:	Make final runs. Draft report components text
Friday June 5	Topical Discussions:	Review results and conclusions in draft reports 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.

WP AW11

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.

S E D A R

Southeast Data, Assessment, and Review

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SEDAR 18

Workshop Research Recommendations

Atlantic Red Drum

October 16, 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
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(843) 571-4366

Section IV. Research Recommendations

Contents: Page Numbers and One-way Links

1. Data Workshop

1.1 Recommendations of the Life History Work Group

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

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

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

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

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

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

1.2 Recommendations of the Commercial Work Group

- Continued and expanded observer coverage for the NC and VA gill net fisheries (5-10% coverage).
- Expand observer coverage to include other gears of concern (i.e. haul seine, pound net, trawls).
- Expand biostatistical sampling (ages and lengths) to better cover all statistical strata (gears/states - principally NC and VA) – more ages proportional to lengths, preferably otoliths.

1.3 Recommendations of the Recreational Work Group

1.3.1 Review of Historical Data

Have experts in survey design and implementation review historical data.

1.3.2 Marine Recreational Information Program (MRIP)

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

1.3.3 Volunteer Logbook

We support inclusion of volunteer logbook data for length.

1.4 Recommendations of the Indices Work Group

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

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

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

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

2. Assessment Workshop

2.1 Recommendations of the Assessment Panel

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.

3. Review Workshop

In reply to RW Term of Reference 8 the Review Panel reviewed the research recommendation of the Data Workshop and the Assessment Workshop and provided research recommendations of its own.

3.1 Review of Data Workshop Recommendations

3.1.1 Life History Workgroup

3.1.1.1 The ASMFC-approved multi-state sampling program of adult Atlantic red drum from Florida to Virginia

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

3.1.1.2 Updated adult maturity schedules and fecundity information from Florida to Virginia

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

3.1.1.3 Further study to determine discard mortality estimates for recreational and commercial gears; impact of slot-size limit management; regulatory discard impacts due to high-grading

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

3.1.1.4 Dedicated northern and southern region larval and juvenile recruitment indices; Virginia adult recruitment index

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

3.1.1.5 Continued cooperation between state ageing labs to provide consistent age verification; otolith microchemistry should be approached for stock differentiation

On-going cooperation between state ageing labs should be standard best practice; the Review Panel notes its concern if this is not occurring. It is thus highly supportive of this recommendation.

In relation to the recommendation on otolith microchemistry, the Review Panel considers that this project would be of value if the life stage linkage between estuarine and offshore red drum were incorporated into the study. There is uncertainty on the origins of offshore adult red drum in relation to the early life history stages in the estuarine habitat which could be resolved by this study.

3.1.1.6 Identification of juvenile and adult habitat requirements and loss rates

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

3.1.2 Commercial Work Group

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

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

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

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

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

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

3.1.3 Recreational Work Group

3.1.3.1 Have experts in survey design and implementation review historical data

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

3.1.3.2 Improve recreational and for-hire data collection through the Marine Recreational Information Program (MRIP)

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

3.1.3.3 Inclusion of volunteer logbook data for length

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

3.1.4 Indices Work Group

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

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

3.1.4.2 Workshop on adaptive sampling techniques as applied to wildlife populations and other techniques that can be applied to aggregated species.

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

3.1.4.3 Encourage States continue current surveys with current methodologies. If sampling methodologies change, maintain consistency between original and new methodologies.

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

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

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

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

3.2.1 Determine batch fecundity estimates of red drum

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

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

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

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

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

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

See previous recommendation.

3.3 Recommendations of Review Workshop

3.3.1 Needs of Current Assessments

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

3.3.1.1 Current Surveys

The Review Panel recommends study of the broader survey program to better identify gaps in current activities and potential expansion / refocusing of current surveys. At present, it is difficult to discern where improvements to the overall survey program could be made. This study could be undertaken through simulation work to evaluate how proposed new survey activities would better inform stock assessment and management.

3.3.1.2 Adult Survey

The Review Panel notes the gap in synoptic indices of adult abundance and age composition which are critical to improvements in the red drum stock assessments. It recommends that a survey to provide indices of abundance for ages 4 and older be established but in the context of the previous recommendation. During the Review Workshop, mention was made of apparent gaps in the size frequencies (i.e., red drum present in these distributions at smaller sizes and again at larger sizes but with few observations in between). The Review Panel recommends development of testable hypotheses on the biological basis of this apparent missing size frequency information. Survey activity could then be designed to challenge these hypotheses.

3.3.1.3 Existing Tagging Data

The Review Panel recommends that a comprehensive analysis of existing tagging data for use in the assessment models be undertaken and, based upon this, there be consideration of additional tagging activities (based upon a statistical design for both the northern and southern stocks to provide age-based estimates of population abundance and fishing mortality). This activity could also provide estimates of movement which can confound estimation of stock parameters. It would be worthwhile to consider State- Space methods as has been recently employed to estimate fishing mortality and migration rates of some New England groundfish stocks (Miller and Andersen, 2008).

3.3.1.4 Tagging Data Model Integration

Further on the tagging data, the Review Panel strongly recommends integration of the tagging analysis into the assessment models, thereby ensuring that parameters and error estimates derived in the model are appropriately treated throughout the analysis. This would ensure that the tagging data are appropriately weighted in the assessment model and are not afforded undue weighting compared to other information.

3.3.1.5 Data Set Weighting

The Review Panel recommends exploration of iterative re-weighting to better define weightings for the contribution of each data set. The contribution of the survey indices to the negative log-likelihood calculated by the assessment model should be modified to allow for both the variance associated with sampling, i.e. related to the CVs calculated for the surveys, and an additional variance component due to "fluctuations in ... the fraction of the population present in the sites being surveyed" (Punt et al., 2002). An example is presented by DeOliveira et al. (2007), who cite Butterworth et al. (1993). Essentially, the inclusion of this additional variance provides an iterative re-weighting of the survey indices and avoids the need for including an arbitrary, subjective, external weighting, such as that currently employed in the assessment model. A similar approach may need to be adopted for other components of the objective function if the observations are derived from samples that are not fully representative.

3.3.1.6 Proportion-at-Age Sample Size

The effective sample size that is currently employed when calculating the negative log-likelihood of the proportion-at-age data, i.e., the square root of the number of fish in the age-length key for the year or two if no age-length key was available for the year, should be compared with the value that is currently calculated in the ADMB implementation of the model using the method described by McAllister and Ianelli (1997, Appendix 2, Equation 2.5). Such a comparison might indicate whether the effective sample size currently used is appropriate.

3.3.1.7 Size Frequency

The Review Panel recommends exploration of assessment model formulations that fit modeled size frequencies, based upon age-based population dynamics to the size frequency observations. This would facilitate use of size frequency data when data for age / length keys are too sparse to reliably derive age composition.

3.3.1.8 Effects of Age 4+ Abundance Constraints

The Review Panel recommends exploration of imposing constraints on the size of the age 4^+ abundance to determine whether or not model fits are improved.

3.3.1.9 Effects of Data Inconsistency on Uncertainty

Possible inconsistencies among the various data sets that contribute to the objective function of the assessment model should be explored by plotting the likelihood profiles for each component across the ranges of feasible values for the parameters that represent the major axes of uncertainty. By examining the resulting plots, it is possible to identify the values of the parameters that minimize the negative log-likelihood of the different components, and thereby identify those parameters that most influence the values of the parameter estimates. Identification of inconsistencies among the data sets provides a focus for re-assessing the extent to which inconsistent data sets are representative of the variables that they are intended to measure.

3.3.1.10 Confirmation of Convergence

Convergence of the assessment models for the base, sensitivity and retrospective runs should be confirmed by "jittering" the initial parameter values and re-fitting the model a number of times, e.g. 100, then comparing the resulting parameter estimates and values of the objective function (e.g., Methot, 2007). Exploration of the consequences of "jittering" may also reveal whether the model converges to a region of parameter space in which the Hessian is positive definite, noting that, in several of the retrospective runs, the Hessian was found to be non-positive definite.

3.3.1.11 Over-Parameterization

Highly-correlated parameters indicate that the parameter estimates to which the model has converged are likely not to be unique, and that the model may be over-parameterized. In future stock assessments, the Review Panel recommends that the parameter correlation matrix should be explored.

3.3.1.12 Fishing Mortality Estimates Based on Tagging Data

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

3.3.2 Recommend an appropriate interval for the next assessment

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

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

S E D A R

Southeast Data, Assessment, and Review

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SEDAR 18

Review Workshop Report

Atlantic Red Drum

October 7, 2009

SEDAR is a Cooperative Initiative of:

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

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

Section V. Review Workshop Report

Table of Contents and One-way Links

1 Introduction

1.1 Workshop Time and Place

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

1.2 Terms of Reference

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

SEDAR 18 Terms of Reference

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

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

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

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

1.3 List of Participants

SEDAR 18 Review Workshop

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

Acronyms
SEDAR 18 Review Workshop Participants List

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

1.4 List of Review Workshop Working Papers & Documents

SEDAR 18
Atlantic Red Drum
Review Workshop Document List

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

2 Review Panel Report

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

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

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

2.1 Statements addressing each Term of Reference

2.1.1 Term of Reference 1

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

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

2.1.1.1 The Stock Units

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

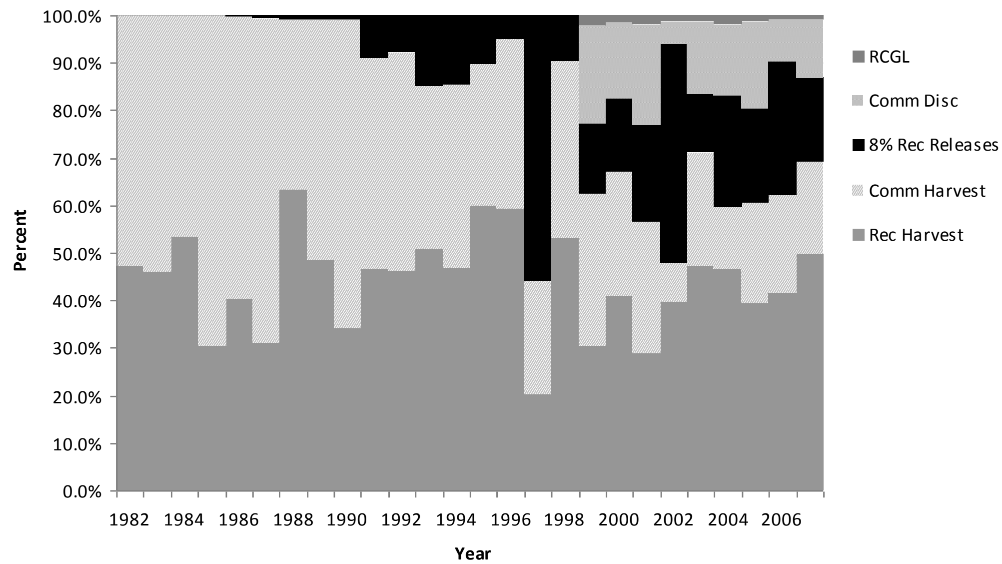
In defining the stock units for red drum, the Assessment Team considered possible interactions between the Atlantic and Gulf of Mexico populations and possible interactions between northern and southern components of the Atlantic population. The Review Panel agreed that some interaction and migration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

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

2.1.1.2 Landings and Removals

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

a) Commercial discards as initially determined by Assessment Team



b) Commercial discards as revised at Review Workshop

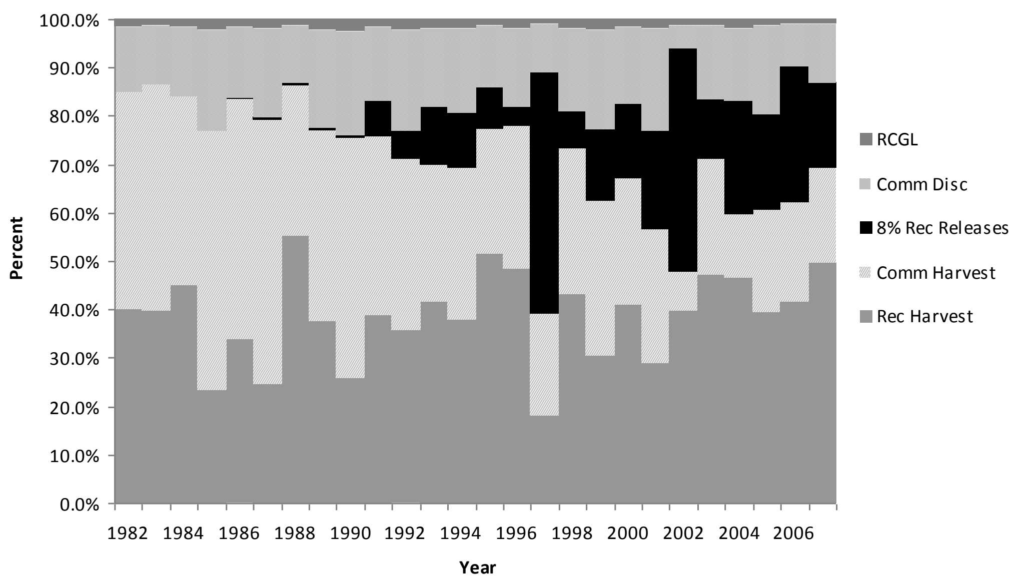


Figure. 2.1.1.1. Percent by weight of annual removals of each fishery type for the northern assessment a) as initially determined by the Assessment Team and b) with commercial discard estimates as revised at the Review Workshop (figure produced as reply to Review Panel post-review request for clarification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

2.1.1.3 Proportion-at-age

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

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

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

2.1.1.4 Surveys

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

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

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

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

2.1.1.5 Tagging Information

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

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

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

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

2.1.1.6 Biological Data

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

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

2.1.2 Term of Reference 2

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

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

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

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

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

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

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

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

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

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

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

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

2.1.3.1 Northern Stock

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

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

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

2.1.3.2 Southern Stock

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

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

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

2.1.4 Term of Reference 4

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

2.1.4.1 Background

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

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

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

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

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

2.1.4.2 Northern stock

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

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

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

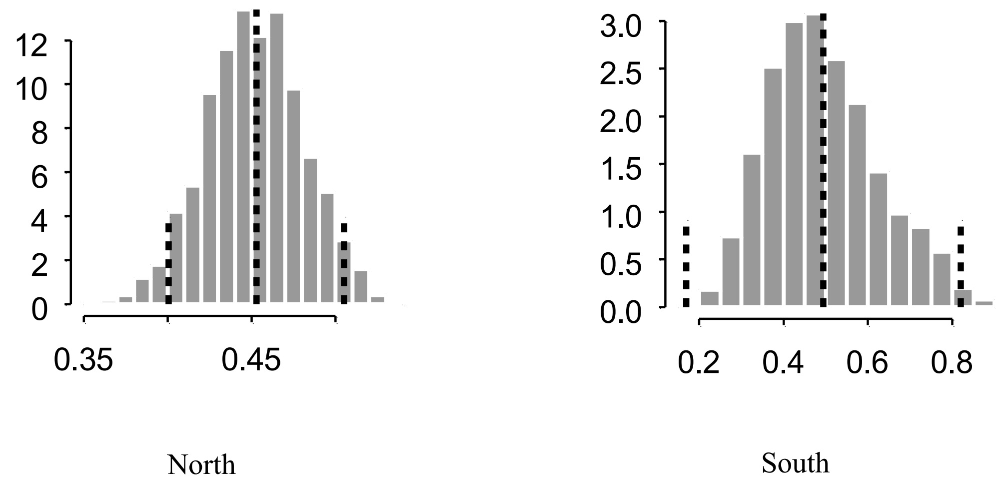


Figure 2.1.4.1. Posterior distributions of average (2005-2007) sSPR from MCMC analyses of the base case assessment models (North: left panel; South: right panel). For comparison, the vertical lines show the asymptotic estimates of the mean +/- 2 s.e. from the baseline assessment runs

2.1.4.3 Southern stock

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

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

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

2.1.5 Term of Reference 5

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

2.1.6 Term of Reference 6

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

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

2.1.7 Term of Reference 7

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

- This term of reference was addressed.

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

- This term of reference was addressed.

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

- This term of reference was addressed.

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

- This term of reference was addressed.

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

- This term of reference was addressed.

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

- This term of reference was addressed.

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

- This term of reference was addressed.

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

- This term of reference was addressed.

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

- This term of reference was addressed.

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

- This term of reference was addressed.

2.1.7.3 Identification of additional information and suggested improvements / clarification.

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

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

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

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

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

2.1.8 Term of Reference 8

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

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

Life History Work Group

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

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

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

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

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

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

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

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

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

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

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

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

Commercial Work Group

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

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

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

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

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

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

Recreational Work Group

Have experts in survey design and implementation review historical data

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

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

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

We support inclusion of volunteer logbook data for length

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

Indices Work Group

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

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

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

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

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

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

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

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

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

Determine batch fecundity estimates of red drum

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

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

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

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

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

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

- See previous recommendation.

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

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

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

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

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

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

2.1.8.4 Recommend an appropriate interval for the next assessment

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

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

2.1.9 Term of Reference 9

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

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

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

2.2 Summary Results of Analytical Requests

2.2.1 Pre-Review Workshop

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

2.2.2 During Review Workshop

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

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

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

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

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

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

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

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

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

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

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

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

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

2.3 References

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3 Submitted Comments

None were received.

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

Purpose

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

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

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

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

A3.2.1 Methods

A3.2.1.1 Overview

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

A3.2.1.2 Data Sources

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

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

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

A3.2.1.3 Model Configuration and Equations

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

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

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

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

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

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

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

where *A* is age 7^+.

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

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

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

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

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

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

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

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

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

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

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 1989-2004 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 1989-2004 from the tagging program. However, since the selectivity vectors from this program were used as input parameters because of the lack of observations for the catch-at-age for this fishery, only the information from its fully-recruited F's were used in the northern region's analysis:

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

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

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

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

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

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

A3.2.1.4 Parameters Estimated

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

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

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

A3.2.1.5 Uncertainty and Measures of Precision

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

A3.2.2 Results

A3.2.2.1 Measures of Overall Model Fit

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

Northern stock

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

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

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

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

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

Southern stock

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

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

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

A3.2.2.2 Parameter Estimates and Associated Measures of Uncertainty

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

A3.2.2.3 Stock Abundance and Recruitment

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

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

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

A3.2.2.4 Total Stock Biomass

The total stock biomass was not estimated in these analyses.

A3.2.2.5 Fishery Selectivity

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

A3.2.2.6 Fishing Mortality

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

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

A3.2.2.7 Stock-Recruitment Parameters

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

A3.2.2.8 Evaluation of Uncertainty

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

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

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

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

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

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

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

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

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

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

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

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

A3.2.2.9 Benchmarks / Reference Points

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

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

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

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

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

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

3.2.3 Discussion

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

3.2.4 Tables

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

Northern region

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

Southern region

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

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

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

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

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

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

Commercial gillnet and beach seine

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

Commercial pooled other gear

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

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

Recreational landings

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

All fisheries

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

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

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

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

Florida recreational harvest

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

Georgia recreational/commercial harvest

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

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

South Carolina recreational/commercial harvest

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

Georgia/South Carolina recreational live-release

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

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

All Fisheries

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Sel_4 = 0.05 Sel_3, Sel_5 = 0.025 Sel_3

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

Sel_4 = 0.2 Sel_3, Sel_5 = 0.1 Sel_3

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

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

Sel_4 = 0.2 Sel_3, Sel_5 = 0.2 Sel_3

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

Sel_4 = 0.2 Sel_3, Sel_5 = 0.4 Sel_3

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

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

Sel_4 = 1.0 Sel_3, Sel_5 = 1.0 Sel_3

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

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

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

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

Sel_4 = 0.05 Sel_3, Sel_5 = 0.025 Sel_3

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

Sel_4 = 0.2 Sel_3, Sel_5 = 0.1 Sel_3

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

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

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

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

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

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

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

Sel_4 = 1.0 Sel_3, Sel_5 = 1.0 Sel_3

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

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

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

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

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

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

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

3.2.5 Figures

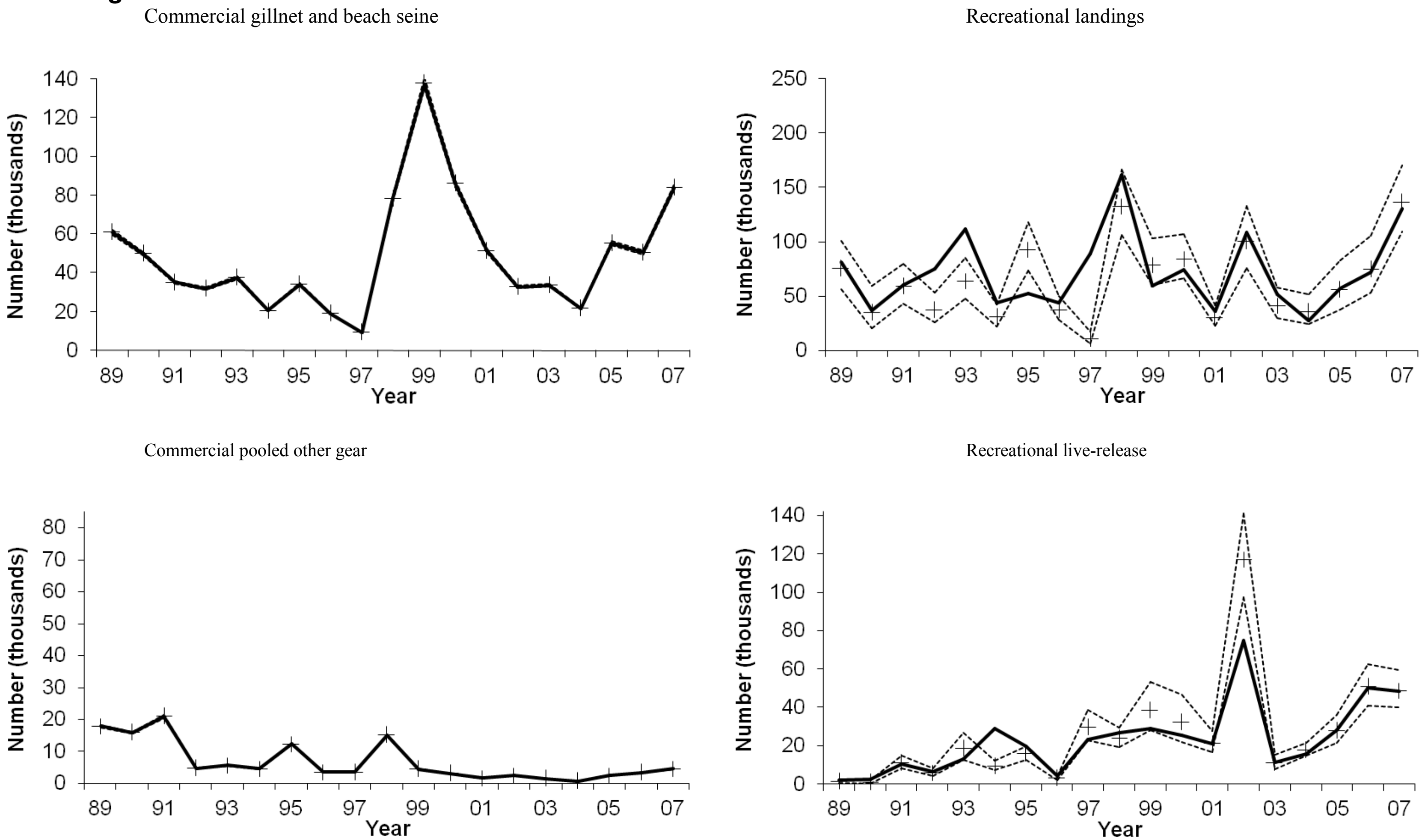


Figure A3.2.5.1. Observed (+) total annual harvest number, showing ± two standard errors (dashed lines), and the associated model estimates for the four **northern** fisheries.

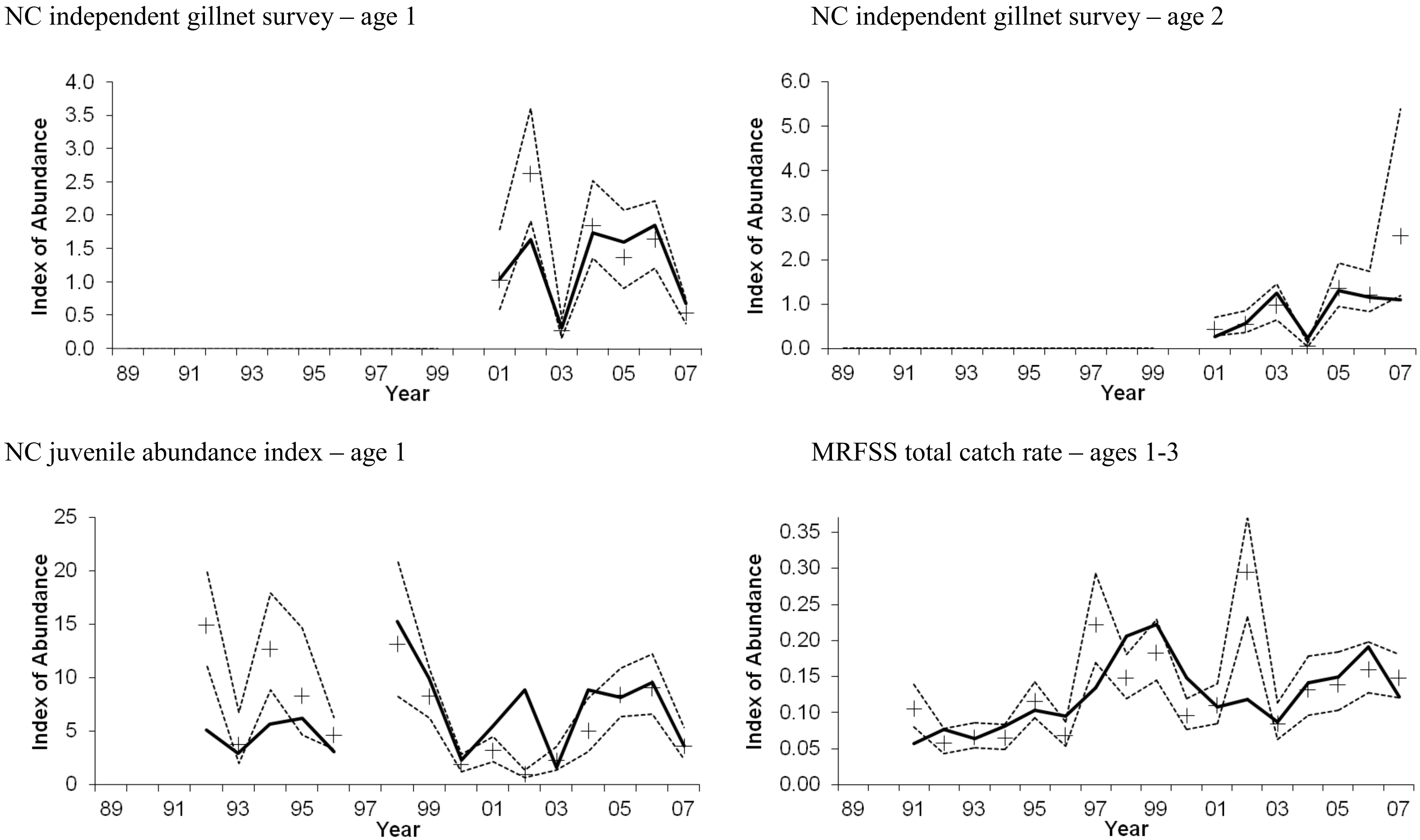


Figure A3.2.5.2. Observed (+) indexes of abundance for red drum, showing ± two standard errors (dashed lines), and the associated model estimates for the four northern indexes.

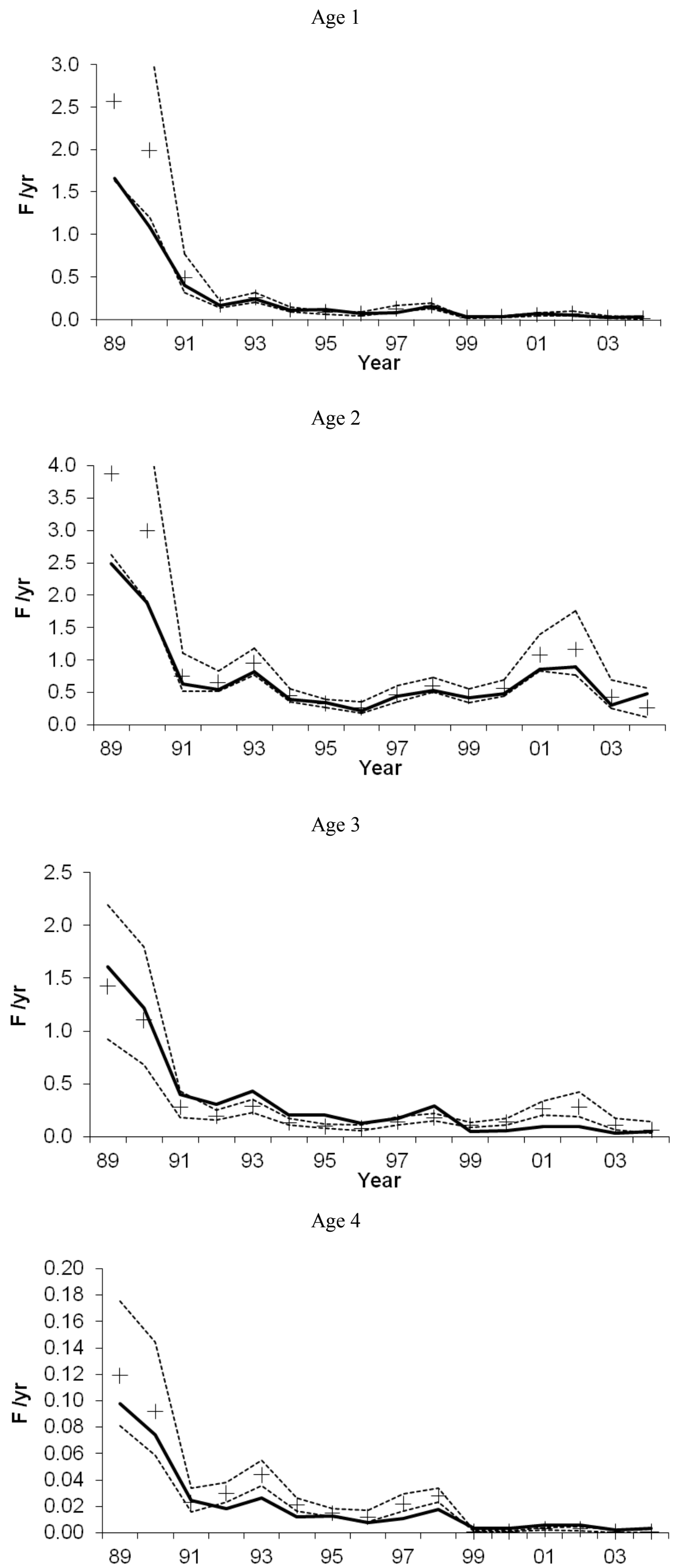


Figure A3.2.5.3. Observed (+) estimates of tag-based estimates of F-at-age for red drum, showing ± two standard errors (dashed lines), and the associated model estimates (solid line) for the **northern** stock.

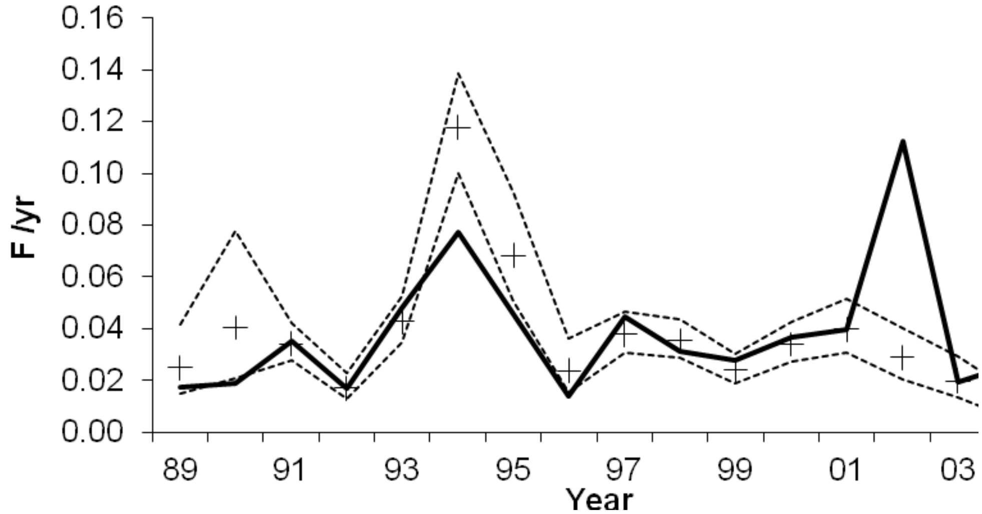


Figure A3.2.5.4. Observed (+) estimates of tag-based estimates of fully recruited F for red drum live releases from the recreational fishery, showing ± two standard errors (dashed lines), and the associated model estimates (solid line) for the northern stock.

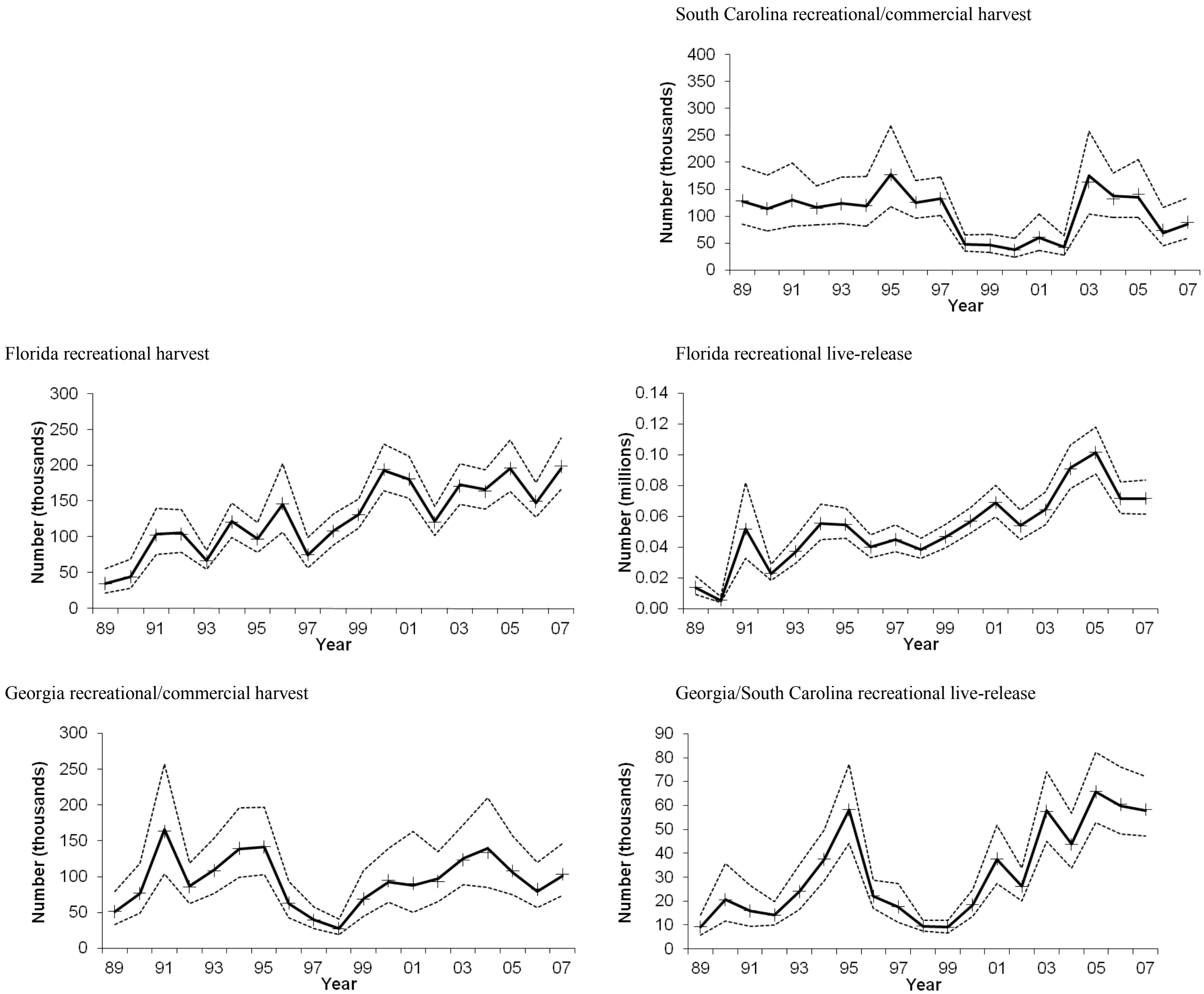


Figure A3.2.5.5. Observed (+) total annual harvest number, showing ± two standard errors (dashed lines), and the associated model estimates for the six **southern** fisheries.

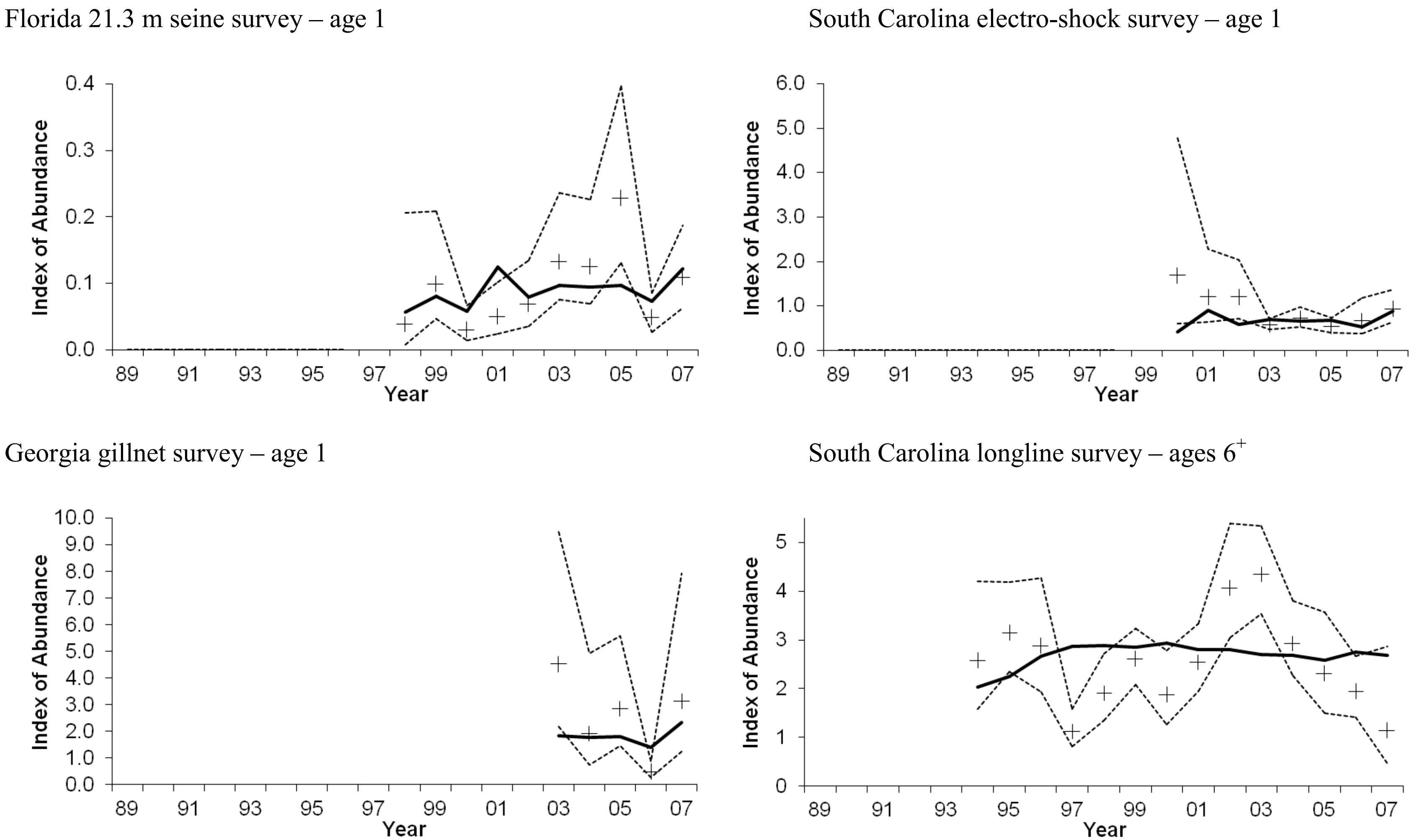
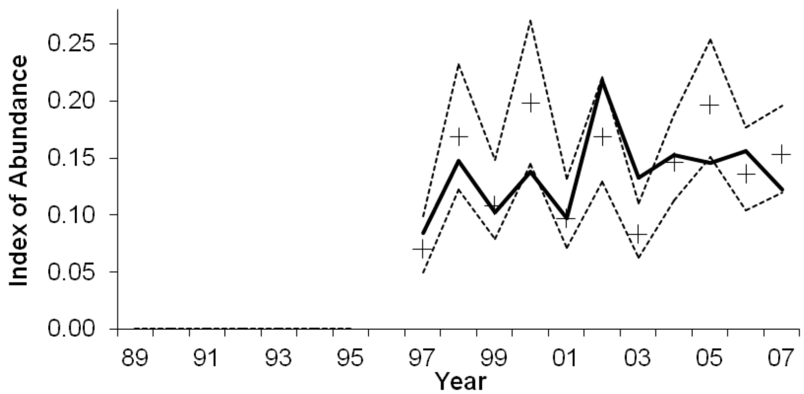
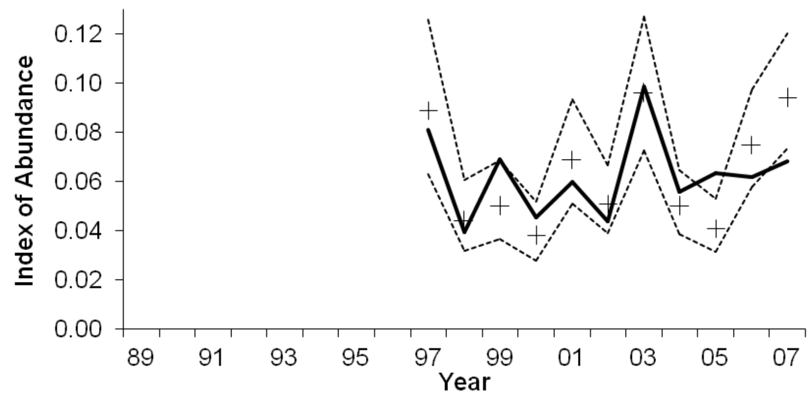


Figure A3.2.5.6. Observed (+) indexes of abundance for red drum, showing ± two standard errors (dashed lines), and the associated model estimates for the eight **southern** indices.

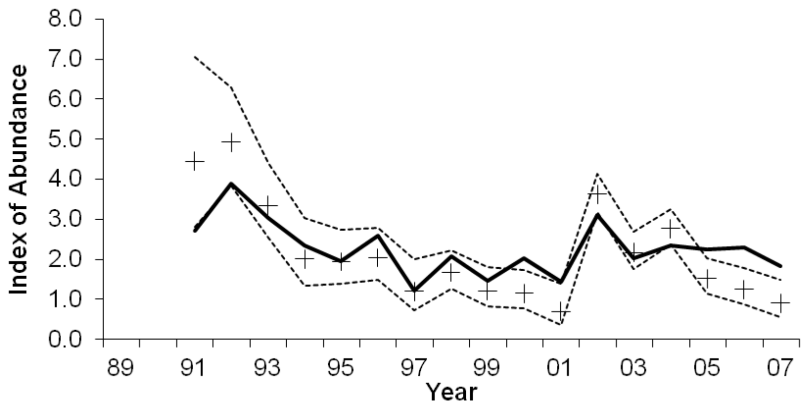
Florida 183-m haul seine – ages 2



Florida 183-m haul seine – ages 3



South Carolina trammel net survey – age 2



MRFSS total catch rates – ages 1-3

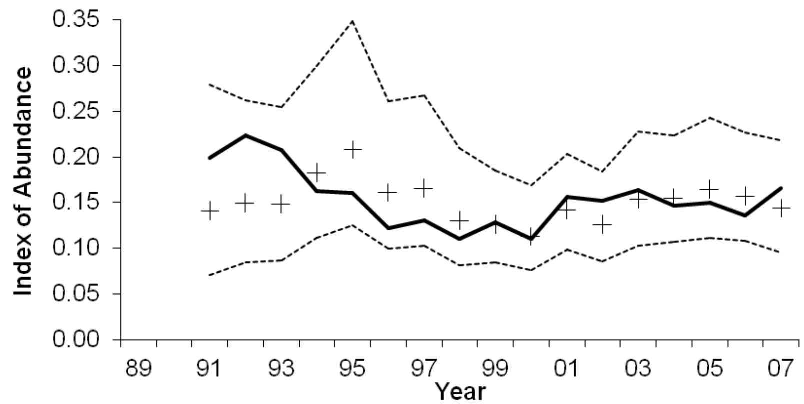
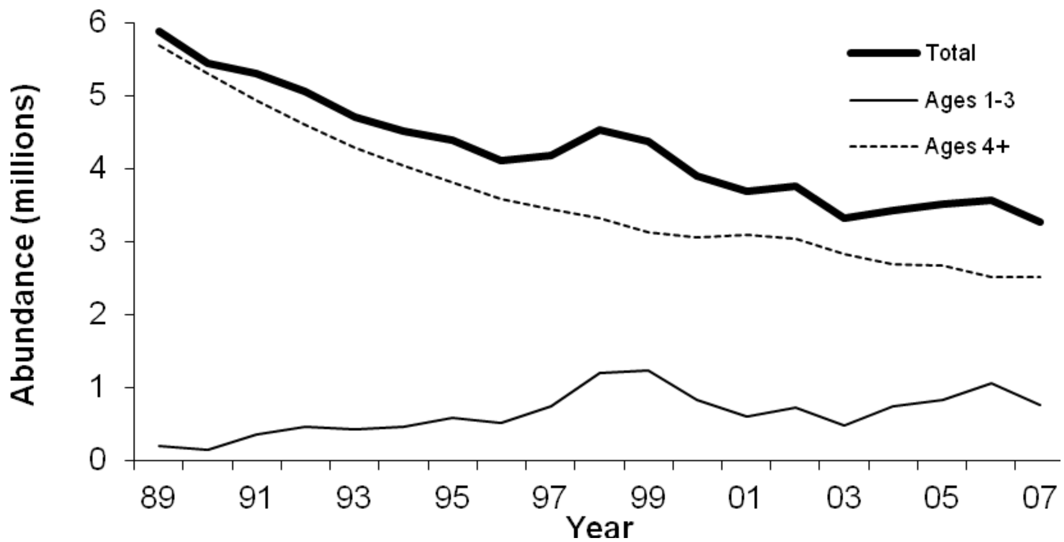


Figure A3.2.5.6 (con't). Observed (+) indexes of abundance for red drum, showing ± two standard errors (dashed lines), and the associated model estimates for the eight **southern** indexes.

Northern region



Southern region

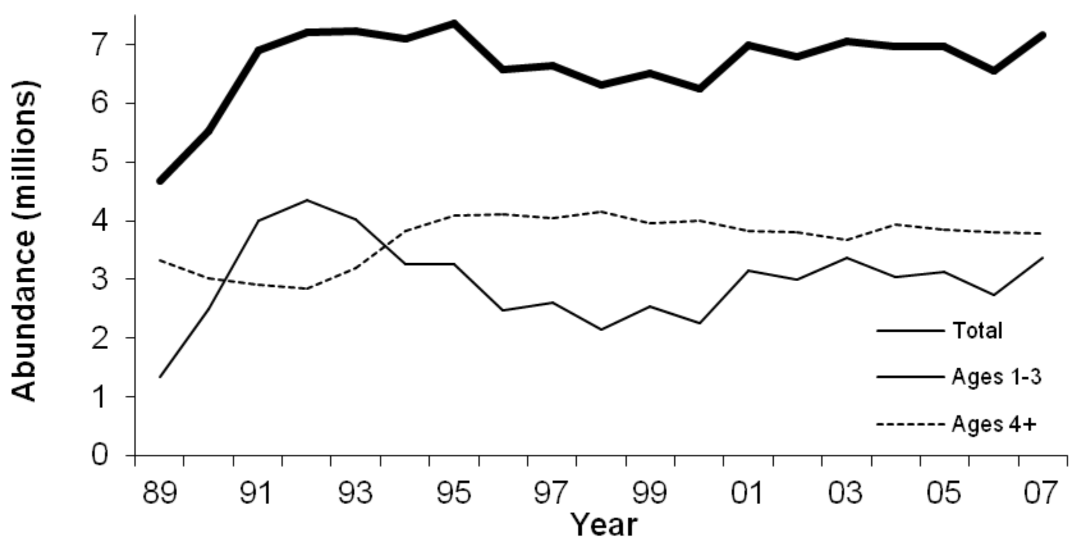
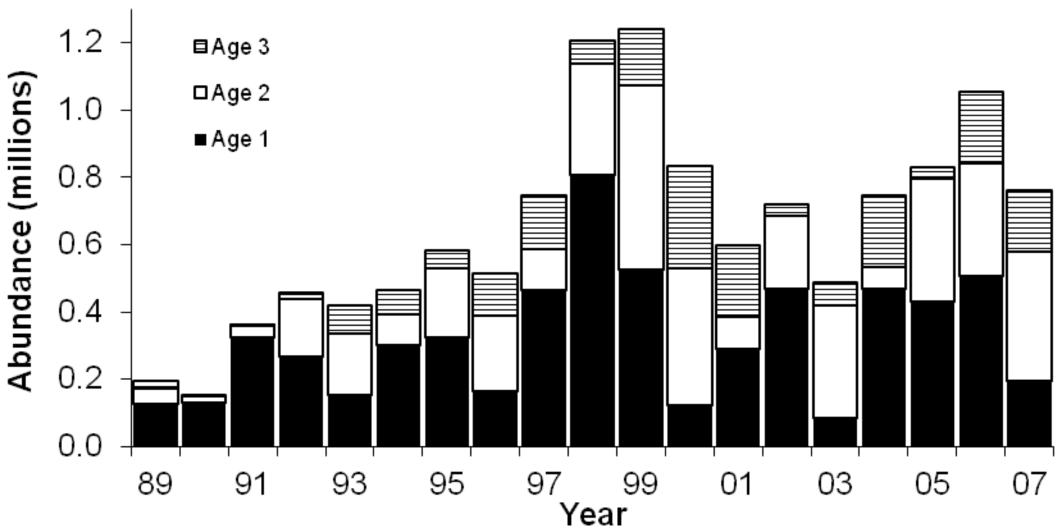


Figure A3.2.5.7. Estimated beginning-of-the-year abundance for red drum in the **northern** and **southern** stock areas during 1989-2007.

Northern region



Southern region

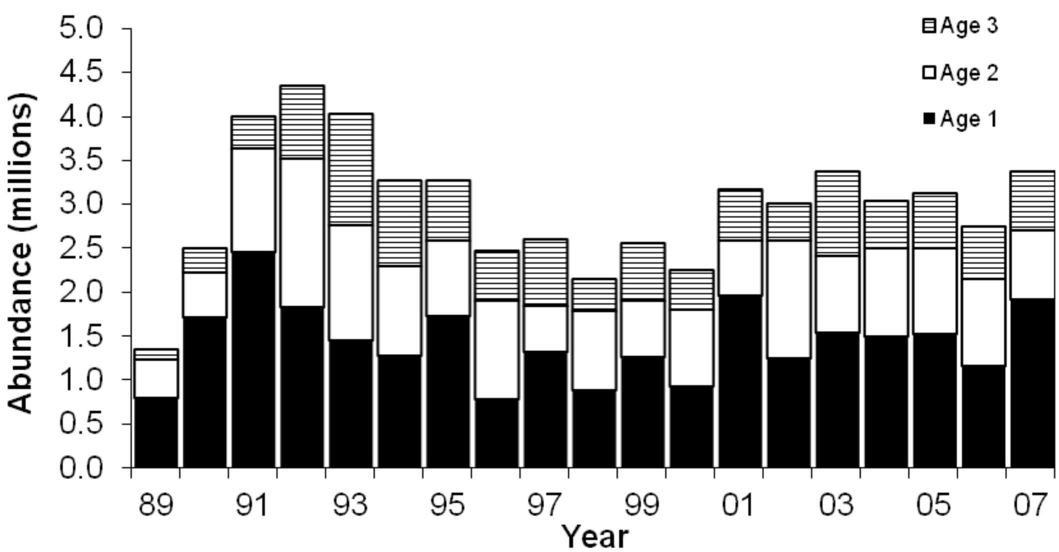
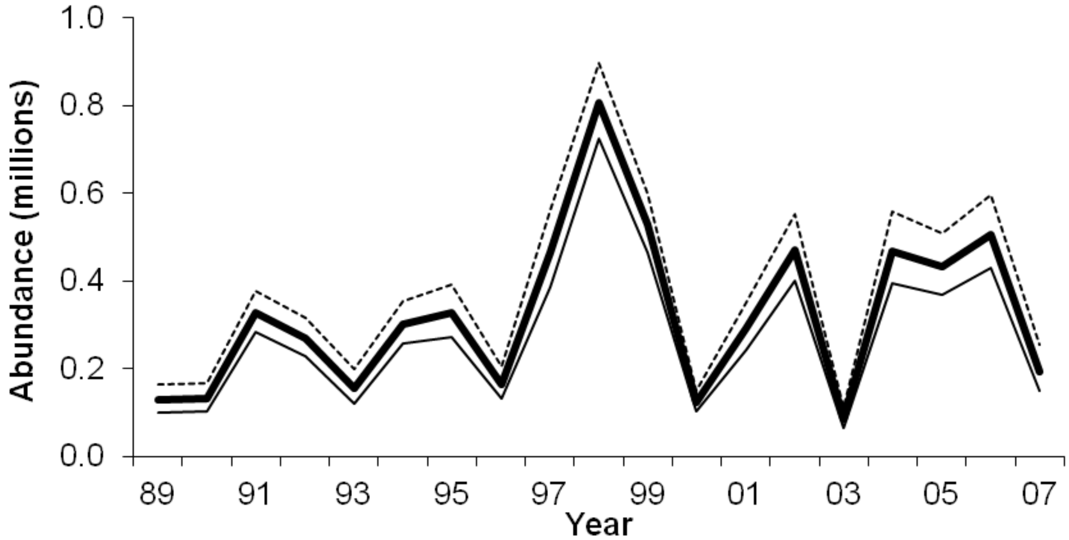


Figure A3.2.5.8. Estimates of abundance of red drum ages 1-3 in the **northern** and **southern** stock areas during 1989-2007

Northern region



Southern region

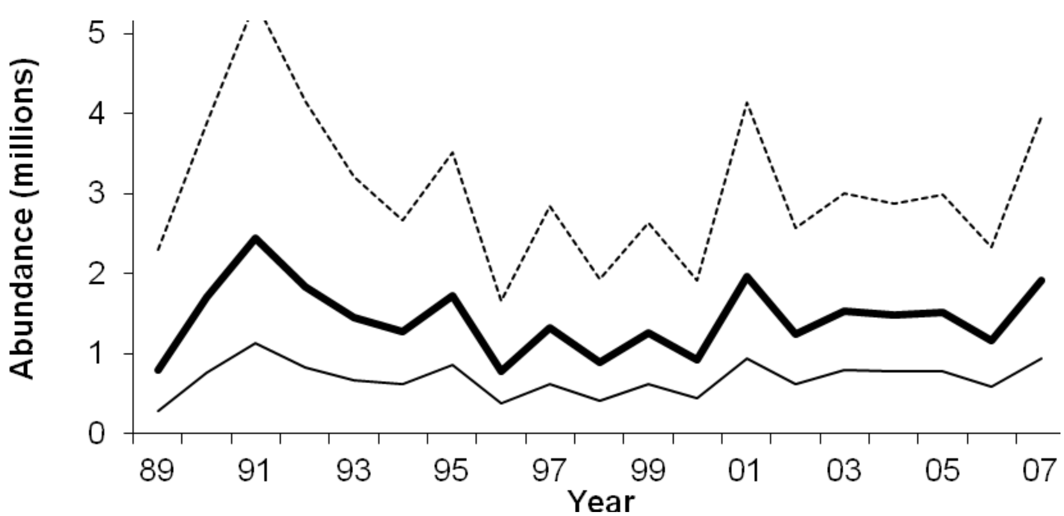
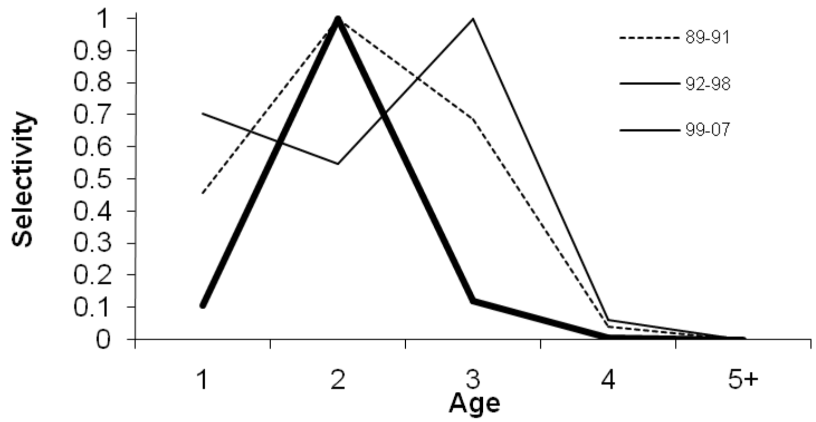
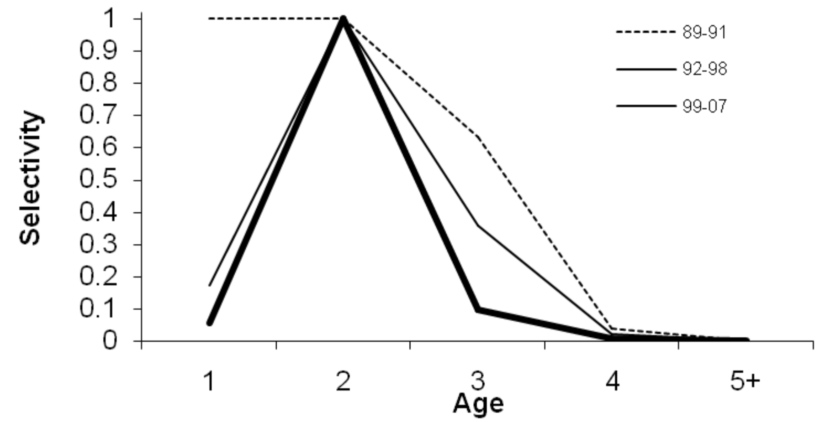


Figure A3.2.5.9. Estimated recruitment (age-1 abundance, heavy solid line) and ± 1.96 standard errors for the **northern** and **southern** regions during 1989-2007

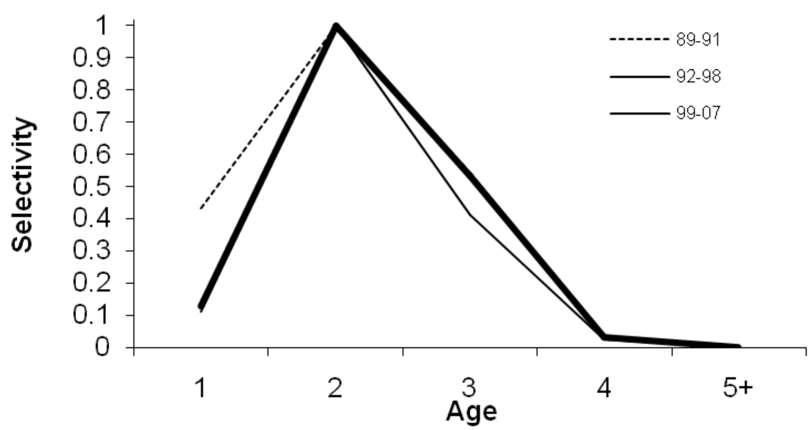
Commercial gillnet and beach seine



Recreational harvest



Commercial other gears



Recreational live-release

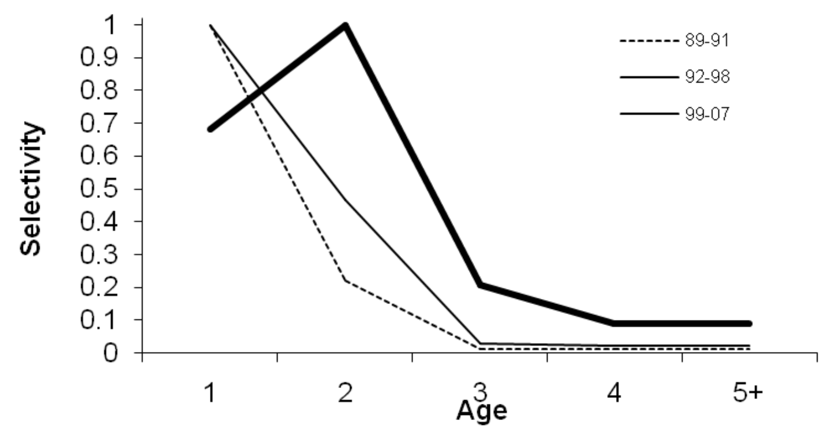
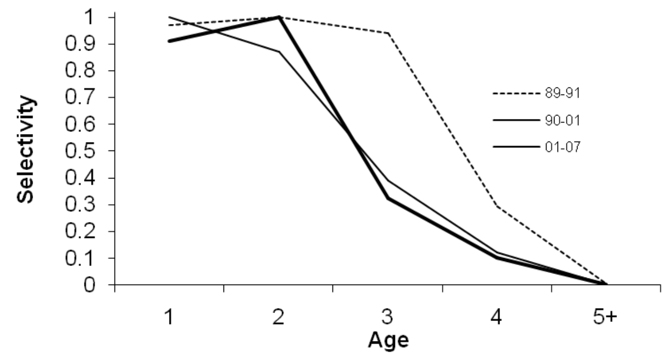
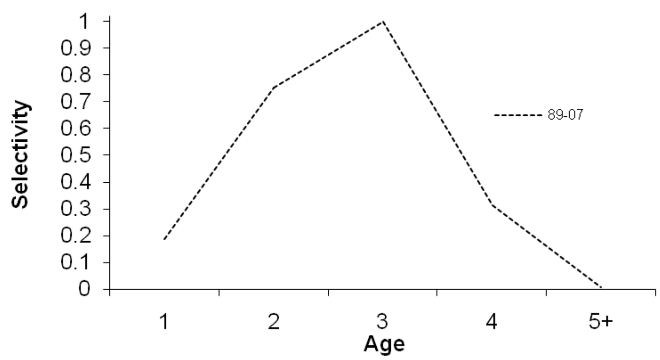


Figure A3.2.5.10. Estimated selectivities for three of the four **northern** fisheries modeled separately and the tag-based input selectivity data for the recreational live-release fishery. Under the separability assumption, this age-effect for distributing fishing mortality across ages was estimated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

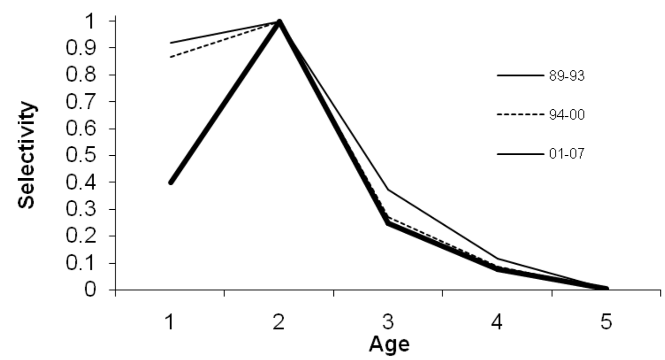
Georgia harvest



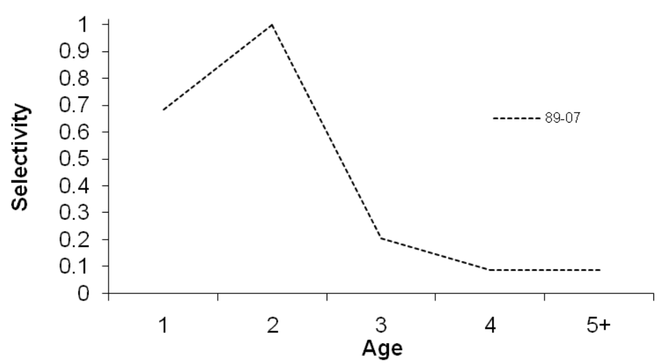
Florida recreational harvest



South Carolina harvest



Florida live release



Georgia/South Carolina live release

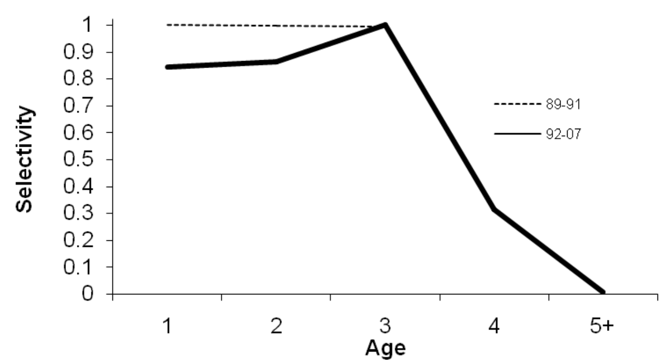
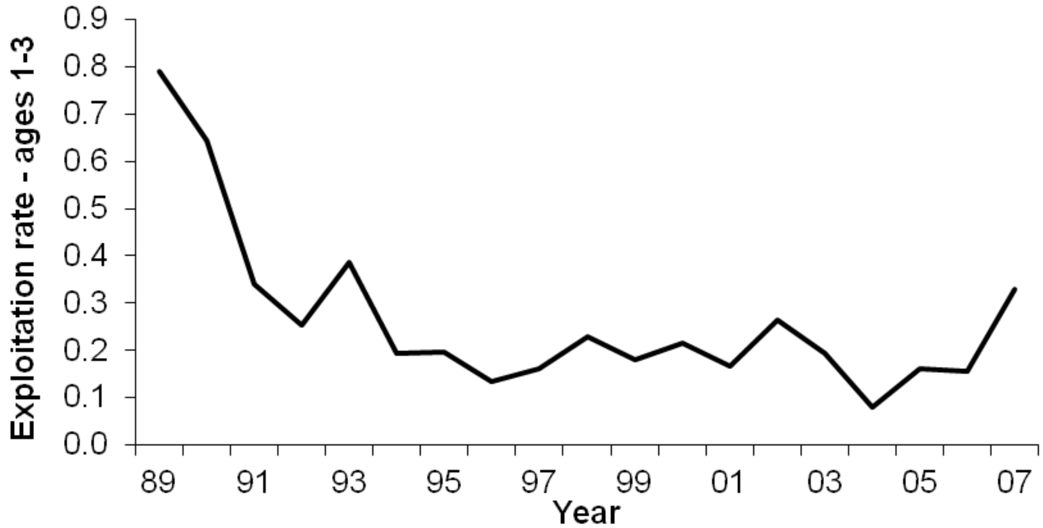


Figure A3.2.5.11. Estimated selectivities for five of the five **southern** fisheries modeled separately and the tag-based input selectivity data for the Florida recreational live-release fishery. Under the separability assumption, this age-effect for distributing fishing mortality across ages was estimated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

Northern region



Southern region

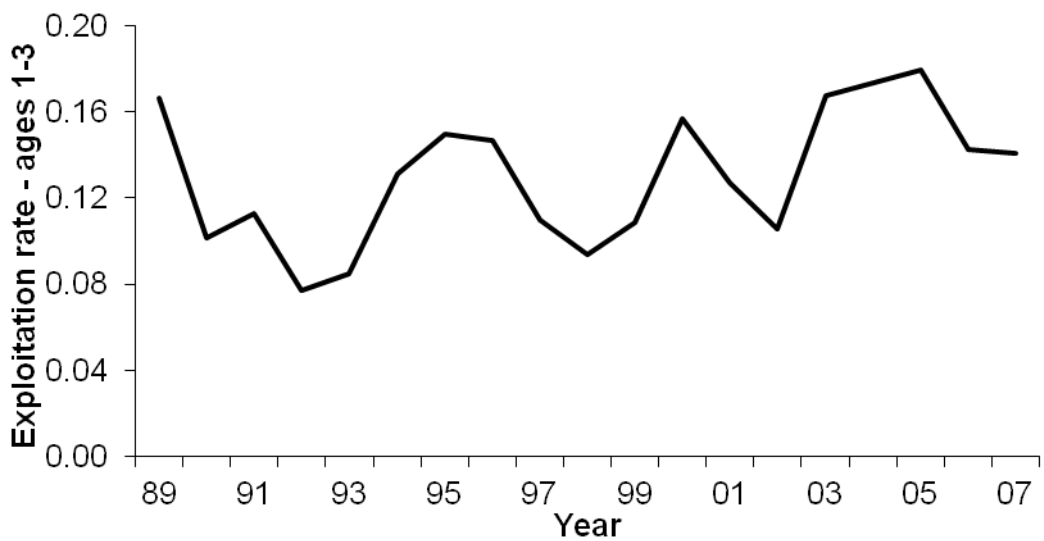


Figure A3.2.5.12. Estimated annual exploitation rate for red drum ages 1-3 in the **northern** and **southern** regions during 1989-2007.

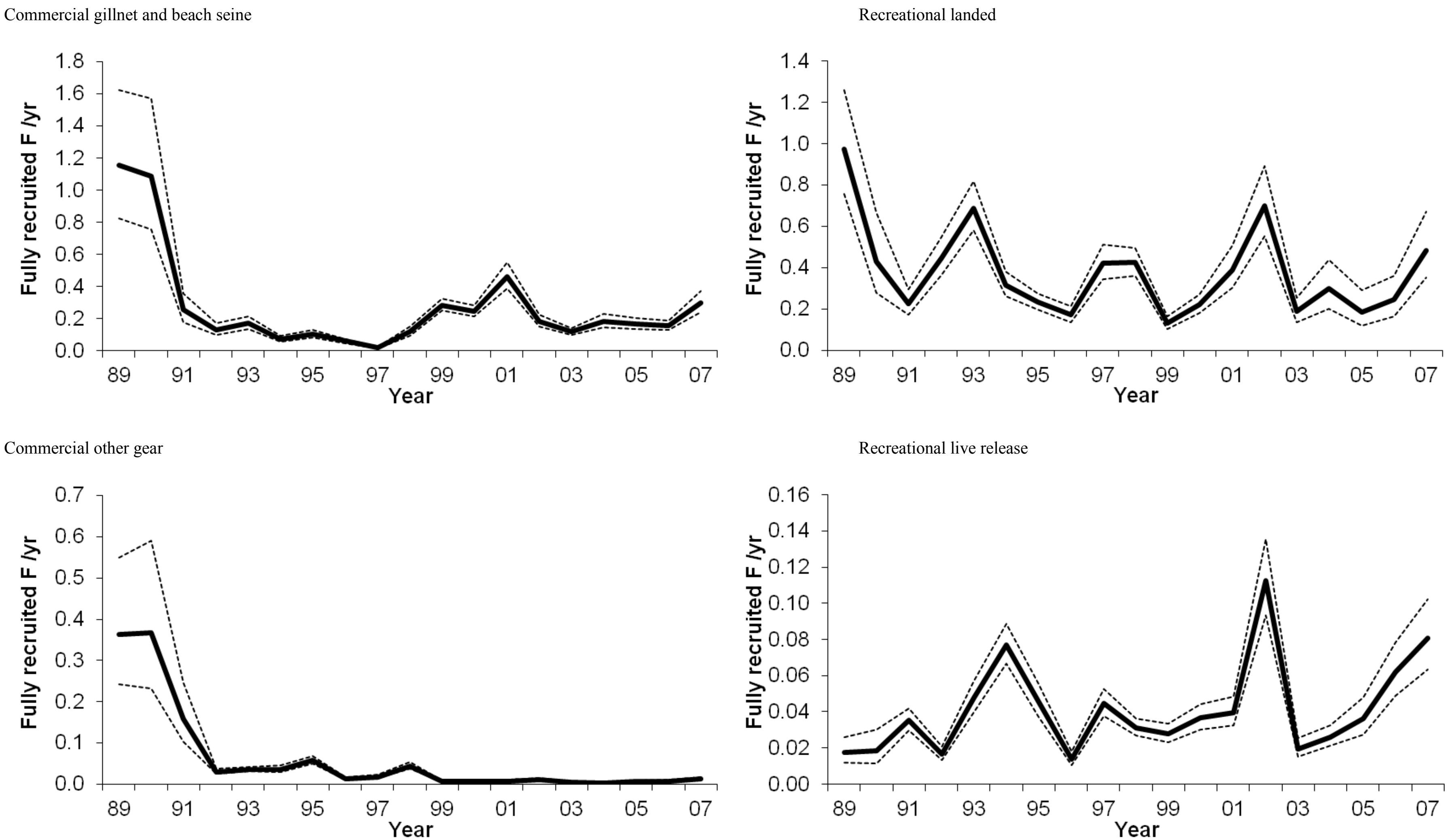


Figure A3.2.5.13. Estimated fully recruited instantaneous fishing mortality (solid line) and ± 1.96 standard errors (dashed lines) for the four **northern** region fisheries during 1989-2007.

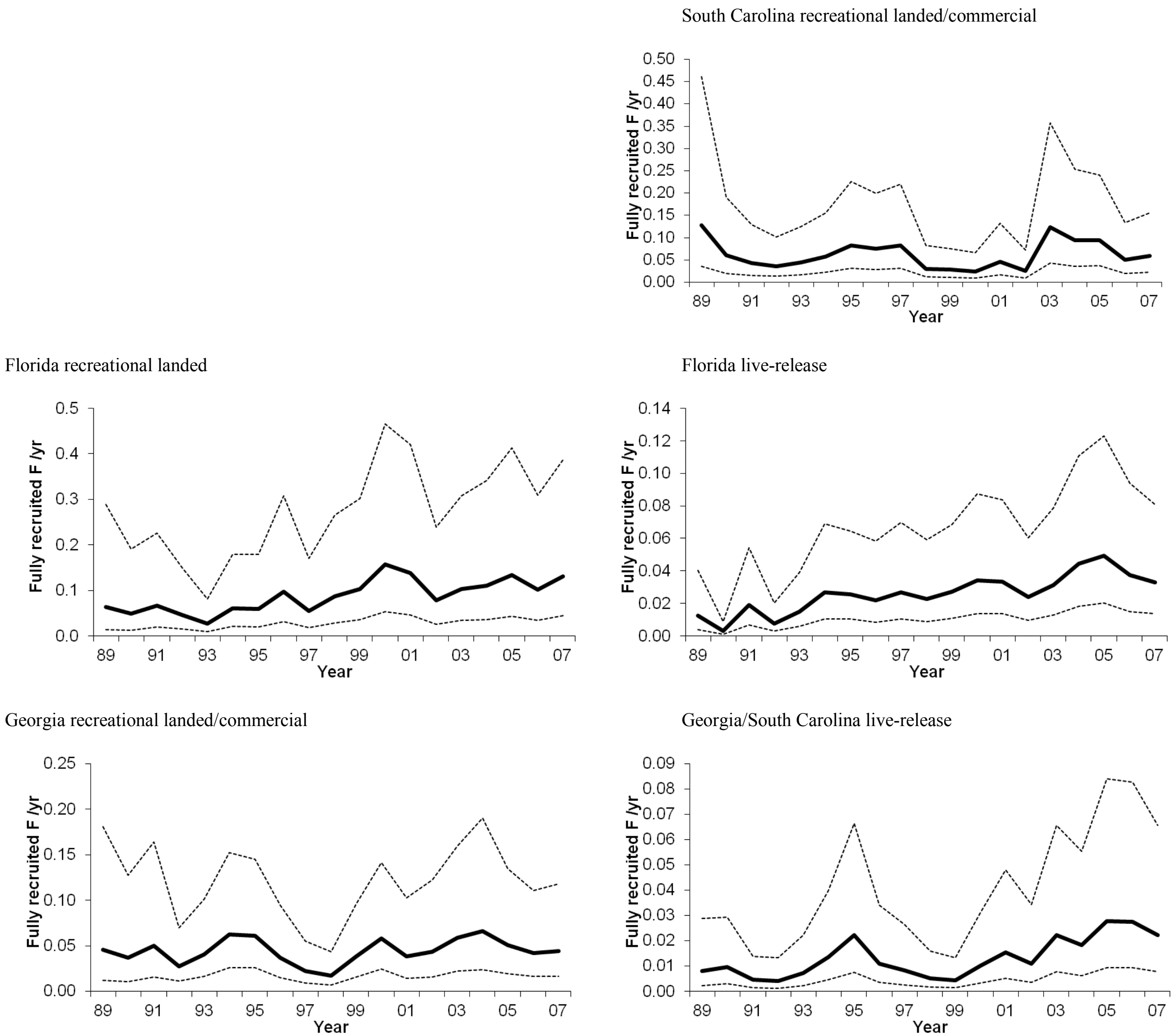
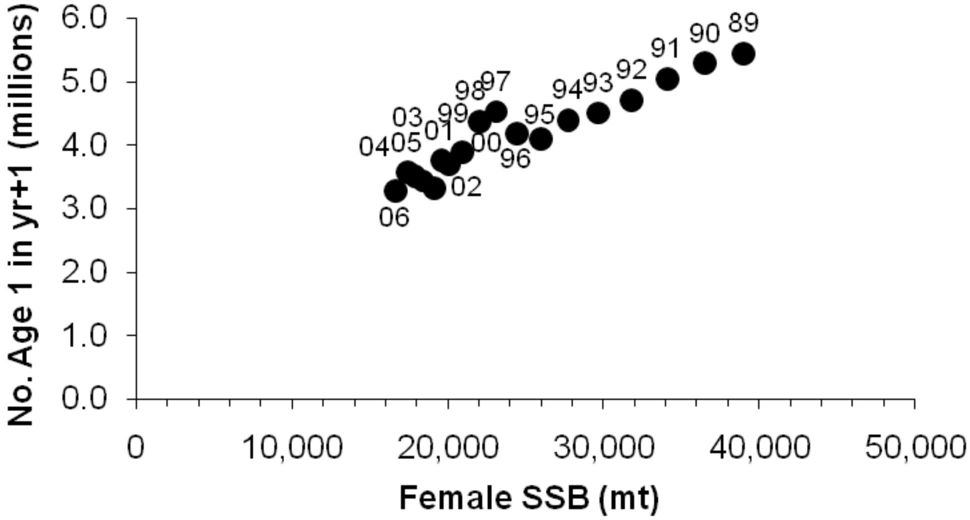


Figure A3.2.5.14. Estimated fully recruited instantaneous fishing mortality (solid line) and ± 1.96 standard errors (dashed lines) for the six **southern** region fisheries during 1989-2007.

Northern region



Southern region

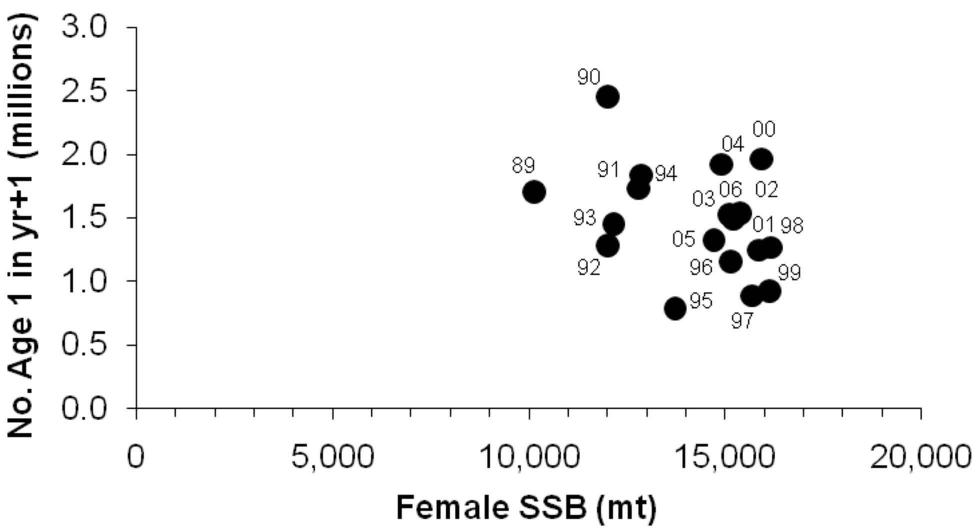


Figure A3.2.5.15. Estimated female spawning stock biomass (mt) of red drum during 1989-2006 and the next year's estimated abundance of age-1 fish.

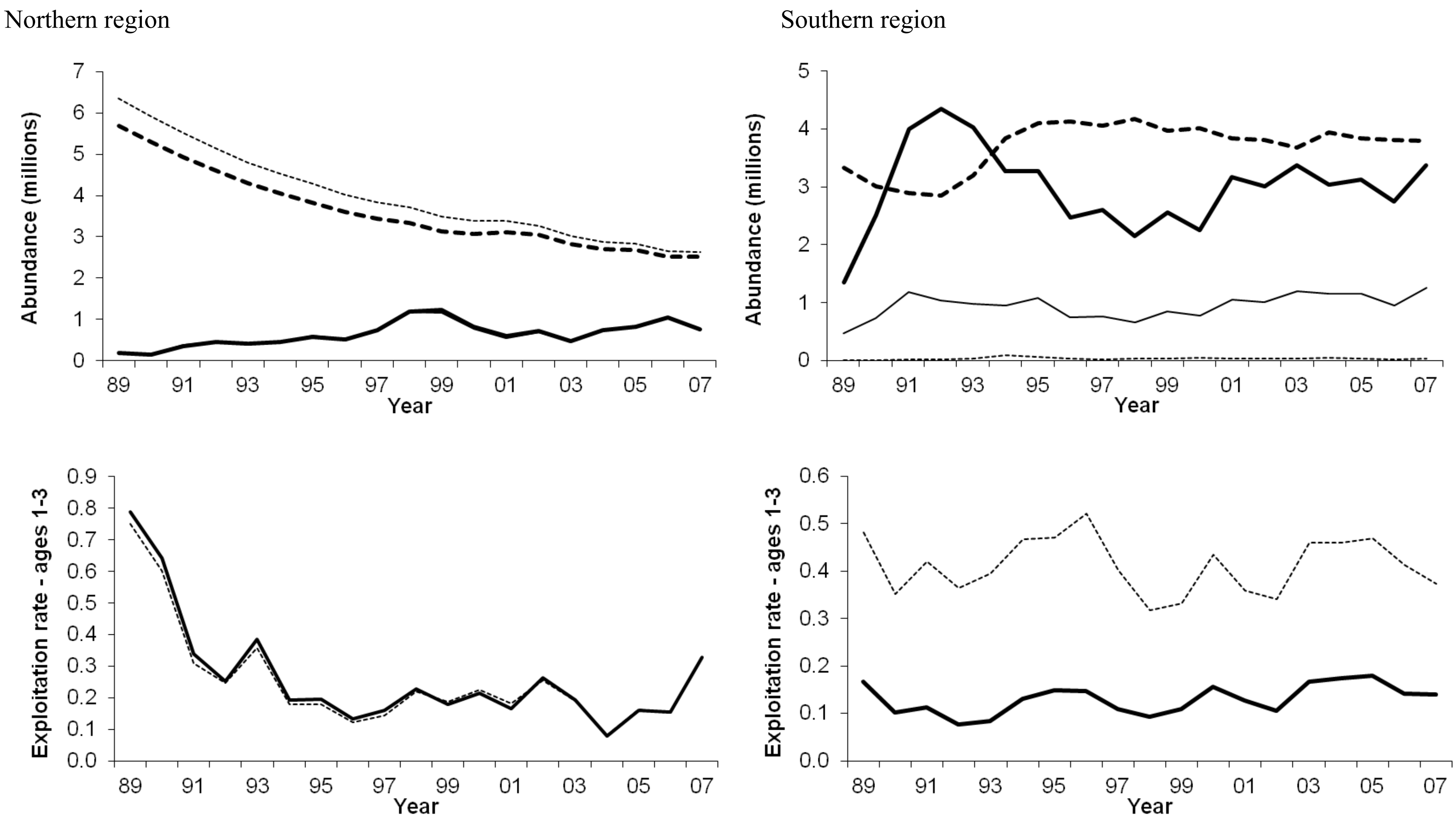


Figure A3.2.5.16. Estimates of abundance and age 1-3 exploitation when the selectivities of ages 1-5 were estimated (lighter lines) in the models instead of the restricted configuration used in the base model runs (heavy lines). The abundance panels show the estimates for the pooled ages 1-3 (solid lines)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

Northern region

Southern region

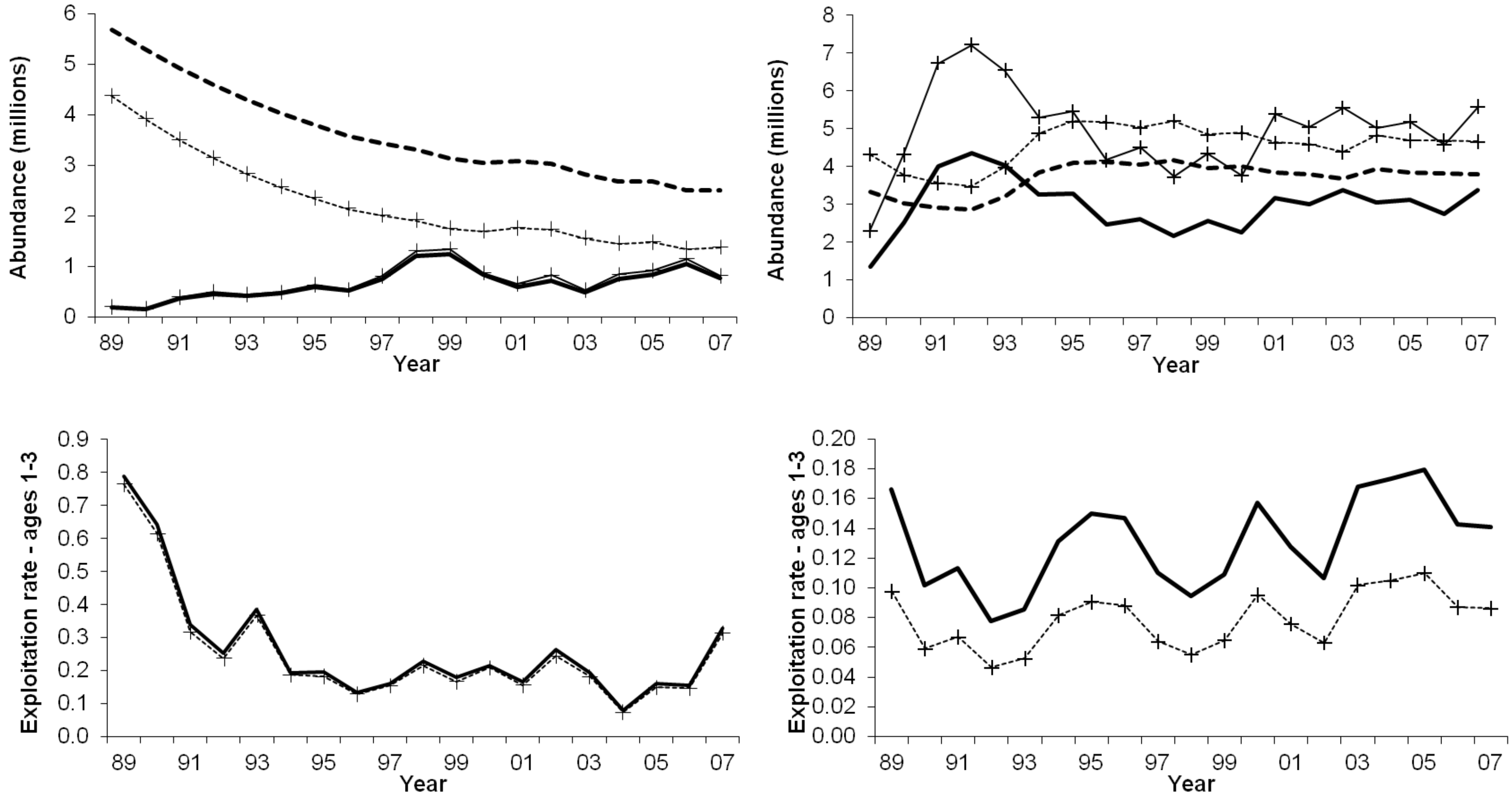


Figure A3.2.5.17. Estimates of abundance and age 1-3 exploitation using the **high** M (+'s) and base model M's (lines without symbols). The abundance panels show the estimates for the pooled ages 1-3 (heavier solid lines) and for ages 4^+ (heavy dashed lines)

Northern region

Southern region

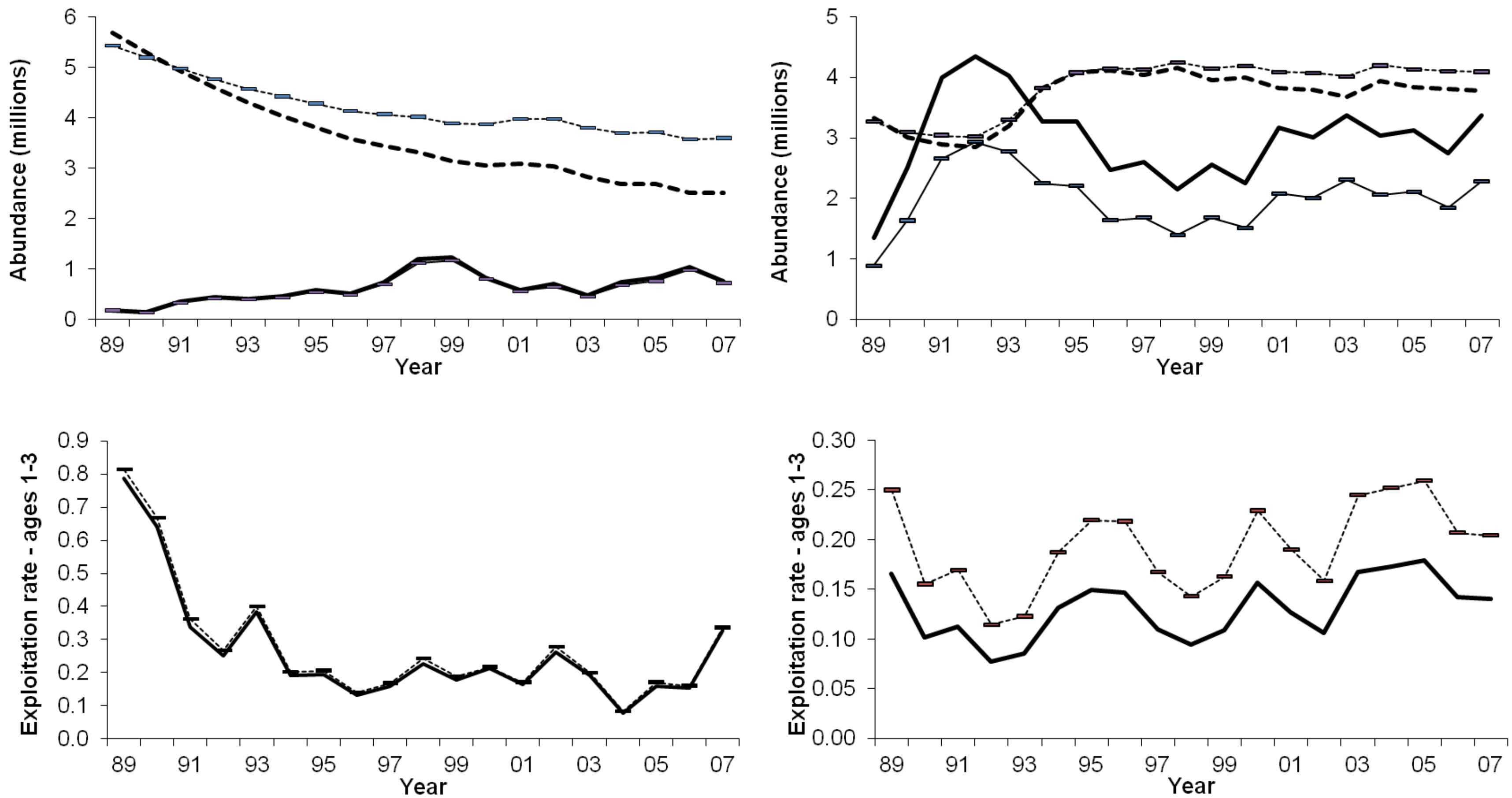


Figure A3.2.5.18. Estimates of abundance and age 1-3 exploitation using the **low** M (-'s) and base model M's (lines without symbols). The abundance panels show the estimates for the pooled ages 1-3 (heavier solid lines) and for ages 4^+ (heavier dashed lines)

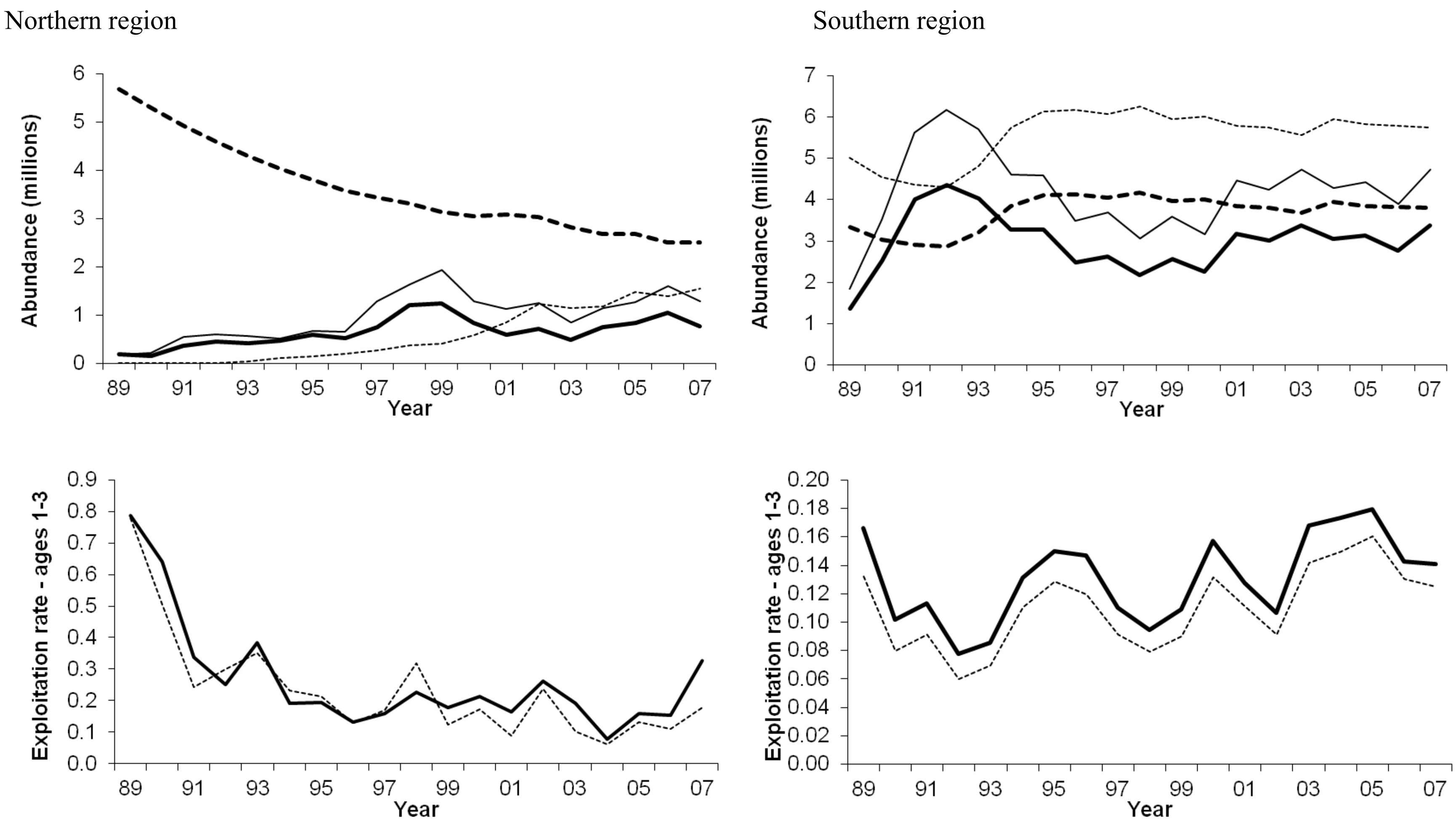


Figure A3.2.5.19. Estimates of abundance and age 1-3 exploitation when the hooking mortality was 0.16 (lighter lines), double the base level of 0.08 (heavier lines). The abundance panels show the estimates for the pooled ages 1-3 (heavier solid lines) and for ages 4^+ (heavier dashed lines).

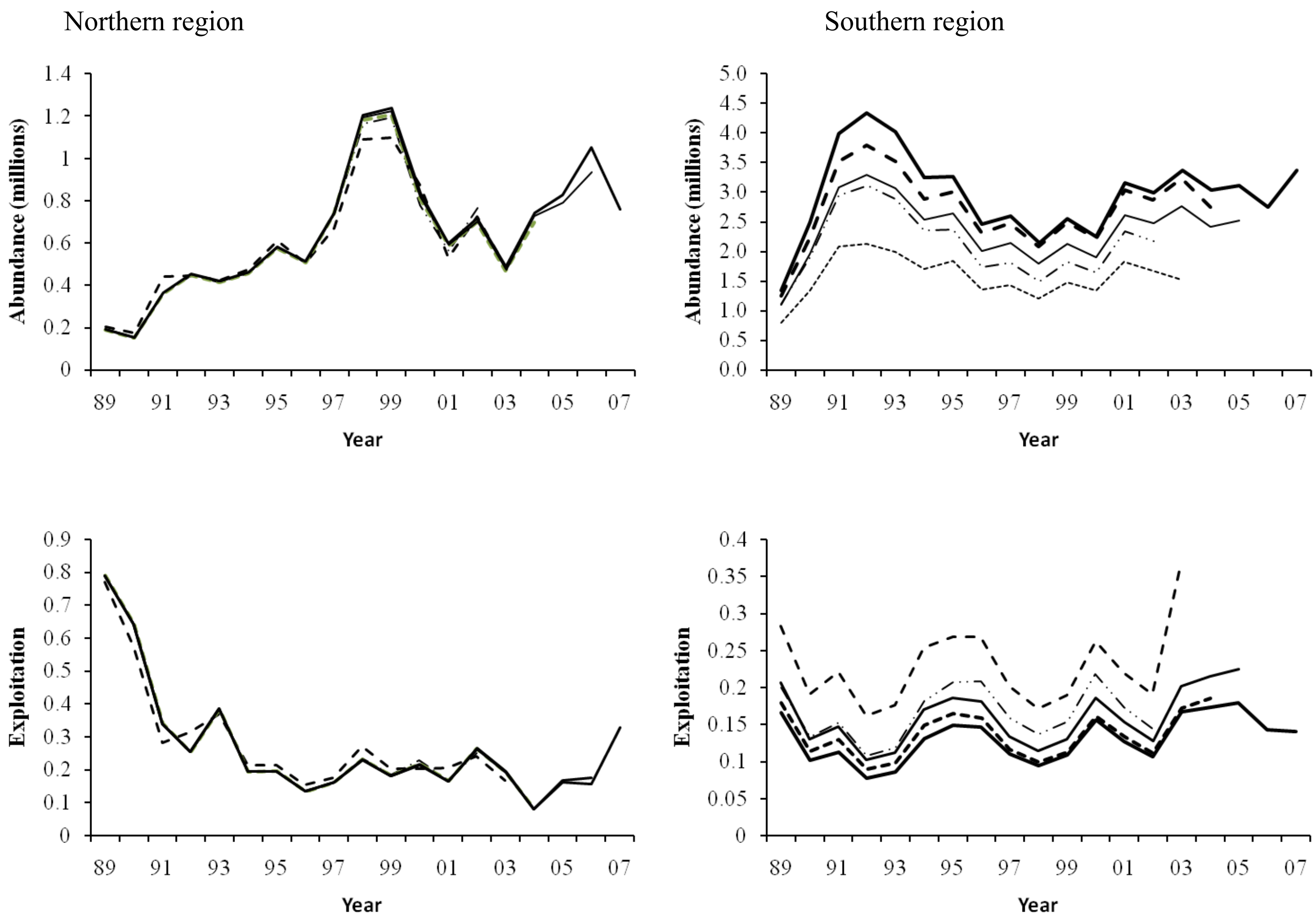


Figure A3.2.5.20. Estimates of age 1-3 abundance (top) and exploitation rate (bottom) using sequentially fewer years in the analysis, with the ending year changing from 2007 to 2006, to 2005, to 2004, to 2003, and to 2002. The 2003 and 2005 northern and the 2006 southern runs were not shown because their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

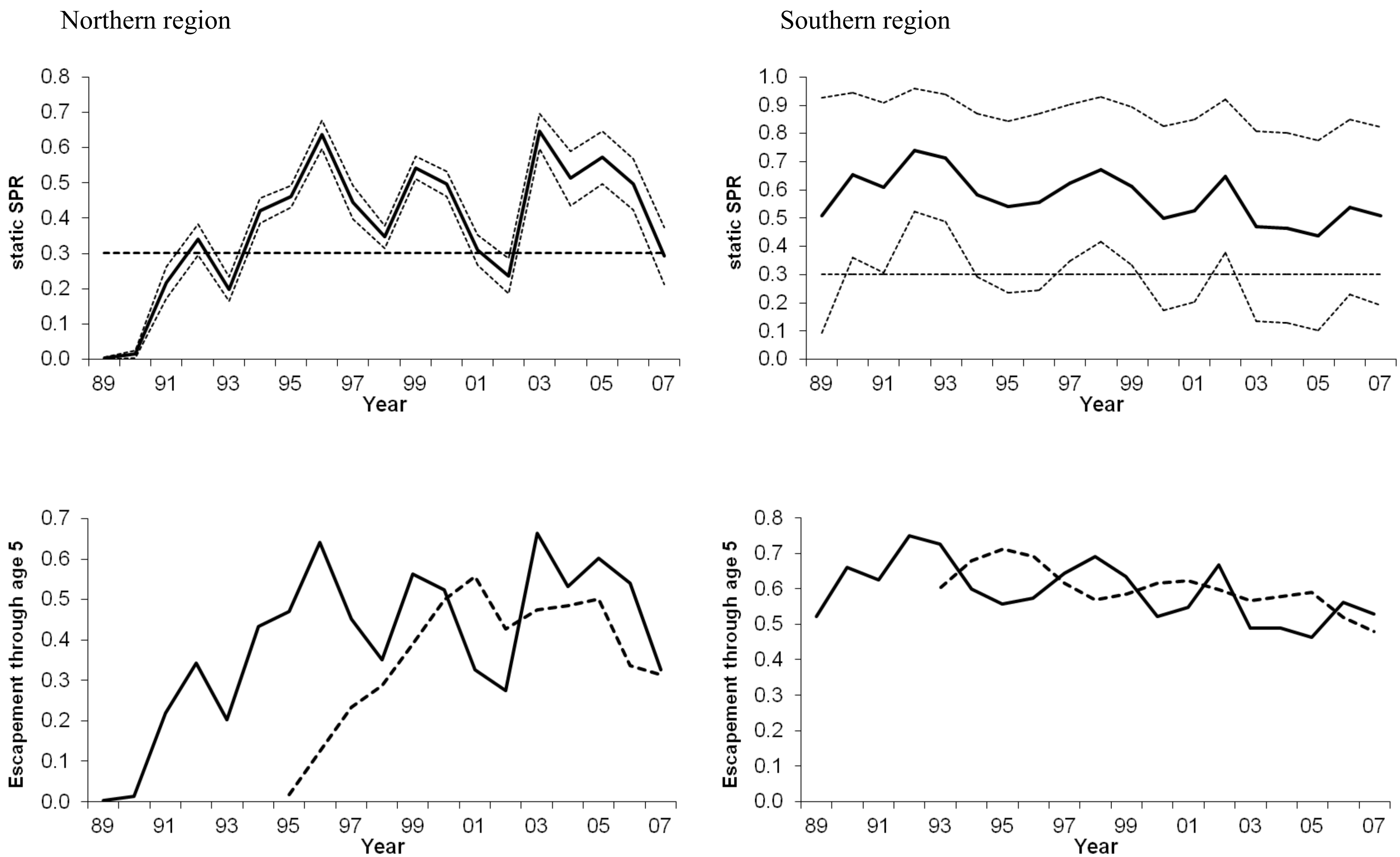
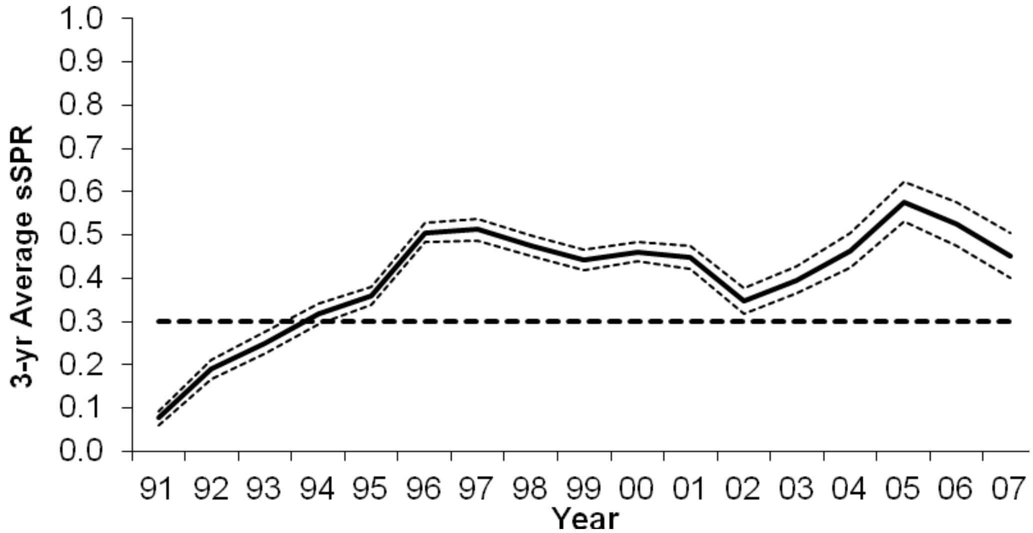


Figure A3.2.5.21. Northern and **southern** region estimates of static spawning potential ratio with ± 1.96 standard errors (dashed lines) during 1989-2007 (top) and escapement rates (bottom) showing year-specific (heavy line) and year class-specific (dashed line) estimates.

Northern region



Southern region

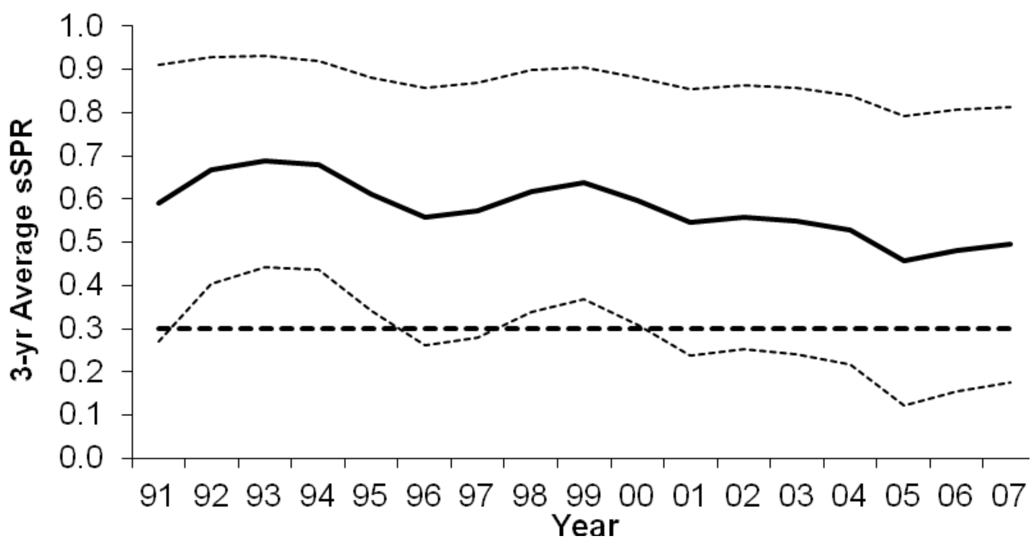
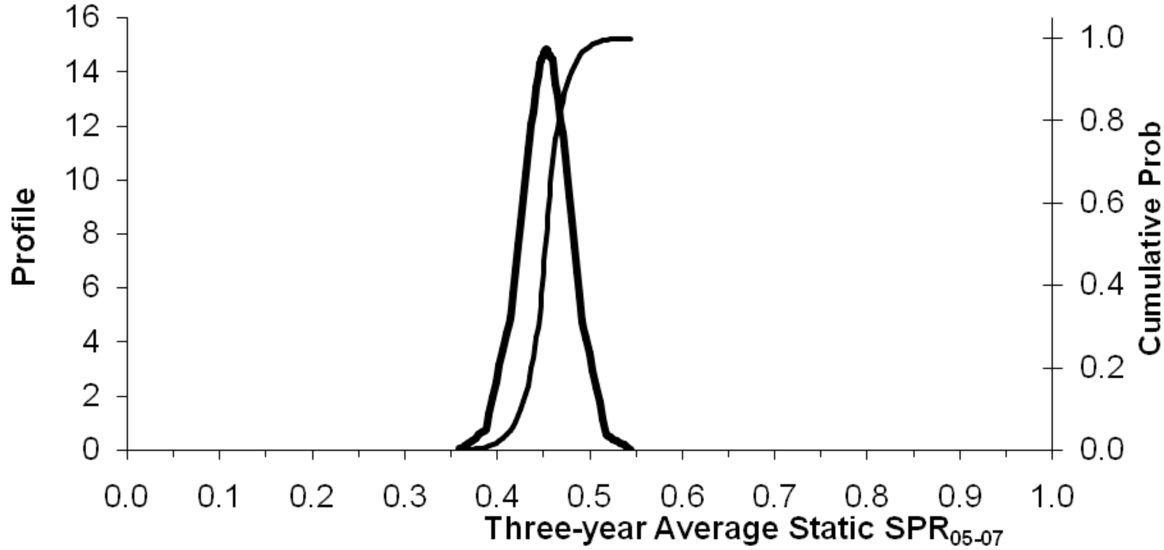


Figure A3.2.5.22. **Northern** and **southern** region estimates of three-year average static spawning potential ratio with ± 1.96 standard errors (dashed lines) during 1991-2007. Three-year averages include current and previous two year's sSPR estimates. The heavy dashed line shows the 30% overfishing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

Northern region



Southern region

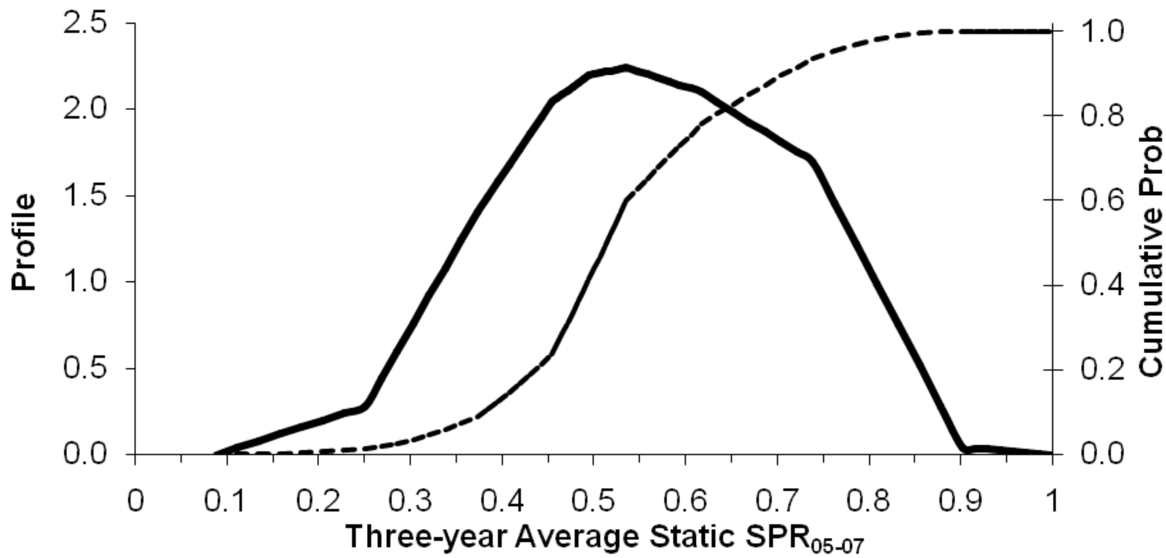
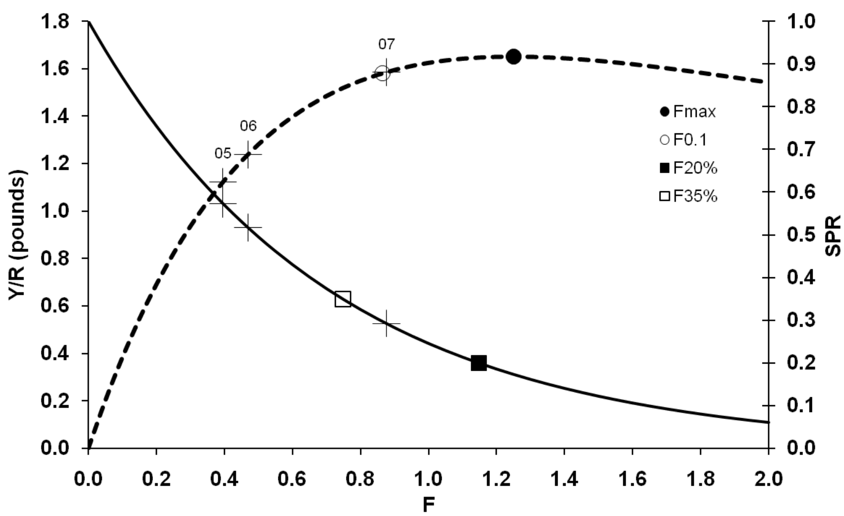


Figure A3.2.5.23. Northern and **southern** region likelihood profiles (solid line) and cumulative probability distribution (dashed lines) for the base model estimates of three-year-average static spawning potential ratio in 2007 (2005-2007 average).

Northern region



Southern Region

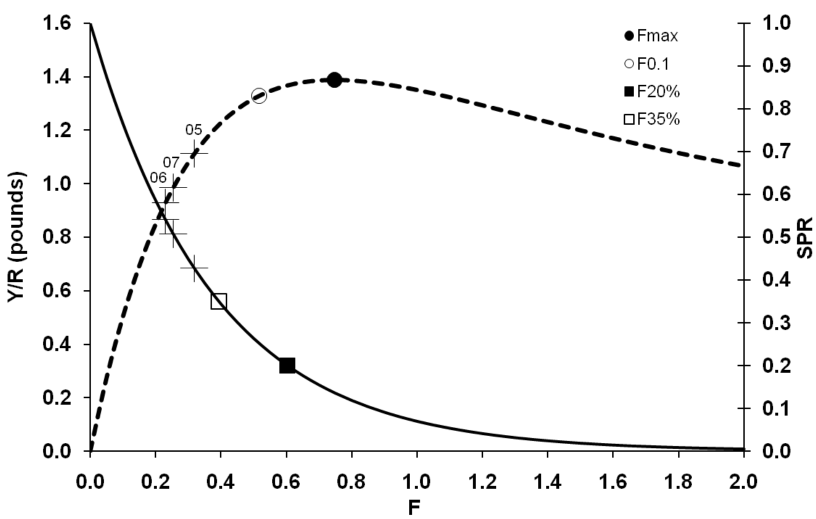


Figure A3.2.5.24. Equilibrium yield-per-recruit (dashed line) and spawning-stock-biomass-per-recruit (of spawning potential ratio, SPR, solid line) expected for red drum across a range of instantaneous fishing mortalities in the northern and southern. As indicated in legend, the YPR benchmarks F_{max}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

3.2.6 References

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

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

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

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

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

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

Description

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

Model code

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

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

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

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

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

 // last age that selectivity is estimated
 init_int last_sel_age

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

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

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

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

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

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

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

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

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

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

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

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

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



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

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

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

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

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

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

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

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

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

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

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



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

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

   // Fully recruited Frelease

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


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

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


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


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

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

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

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

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



      matrix log_N(firstyr,lastyr,firstage,lastage)

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

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

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

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

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

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

    objective_function_value f

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

      likeprof_number three_yrSPR2007



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

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

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

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

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

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

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

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

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

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

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

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

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

             // standardize relative to this maximum
```

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

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

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


FUNCTION get_mortality_rates

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

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

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

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

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


FUNCTION get_numbers_at_age

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

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

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

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




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

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


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

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


FUNCTION calculate_catch

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


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

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

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

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

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

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

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


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


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


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


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

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


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


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


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

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

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

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

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

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

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

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

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

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



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

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

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



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



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

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


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

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

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

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


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

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

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

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

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

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

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

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

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

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

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

Input data

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

```
  1  1  1  2  2  2  2  2  2  2  3  3  3  3  3  3  3  3  3

  1  1  1  2  2  2  2  2  2  2  3  3  3  3  3  3  3  3  3

#

# total kill by fleet in numbers, except only A+B1 for fleet3 (rec) (1=VAMDNCcomGNBS, 2=VAMDNCcomSE, 3=NCVAMDrecAB1, 4=NCVAMDrecB2)

#1989    1990    1991    1992    1993    1994    1995    1996    1997    1998    1999    2000    2001    2002    2003    2004    2005    2006
2007

60989   49914   35102   31823   37551   20723   34082   19195   9299    78437   137880  86069   51500   32678   33681   21790   55287   50590
84072

17901   15866   20887   4736    5655    4568    12315   3505    3430    15034   4441    3025    1634    2422    1457    701     2455    3332
4571

75381   34497   58678   36869   63923   30603   92921   37470   10714   132765  78764   84262   30400   100481  41360   35340   55892   74598
136178

0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0
0

# CV's for total kill by fleet in numbers (assumed for commercial fleets, from MRFSS AB1 north region for fleet 3 and B2 for fleet 4))

#1989    1990    1991    1992    1993    1994    1995    1996    1997    1998    1999    2000    2001    2002    2003    2004    2005    2006
2007

0.01    0.01    0.01    0.01    0.01    0.01    0.01    0.01    0.01    0.01    0.01    0.01    0.01    0.01    0.01    0.01    0.01    0.01
0.01

0.01    0.01    0.01    0.01    0.01    0.01    0.01    0.01    0.01    0.01    0.01    0.01    0.01    0.01    0.01    0.01    0.01    0.01
0.01

0.1448  0.2741  0.1552  0.1851  0.1446  0.1590  0.1200  0.1485  0.2387  0.1129  0.1367  0.1203  0.1519  0.1394  0.1708  0.1884  0.2009
0.1737  0.1109

0.3003  0.3621  0.1488  0.1672  0.1841  0.1338  0.1109  0.1702  0.1298  0.1041  0.1605  0.1891  0.1265  0.0935  0.1704  0.0973  0.1300
0.1058  0.0982

#

#input B2 selectivity for rec northern region by age (columns through last_sel_age) and select period (rows)

1.000   0.221   0.012   0.012   0.012   0.012   0.012

1.000   0.467   0.031   0.023   0.023   0.023   0.023

0.6840  1.0000  0.2070  0.0890  0.089   0.089   0.089

# total release by fleet

#1989    1990    1991    1992    1993    1994    1995    1996    1997    1998    1999    2000    2001    2002    2003    2004    2005    2006
2007

0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0
0

0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0
0

0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0
0

17522   13385   140347  75915   232761  118372  198152  38175   371869  298735  482682  402443  268973  1464952 137762  223283  350290
633277  610962

#release mortality

 0.08

#

#proportion catch at age (age columns, year rows) by fleet -- corrected both coms LP 6/15 email; fleet 1 with discard -8/25

#Age      1               2               3               4               5               6               7+

# VAMDNCcomGNBS

0.53532641      0.25506212      0.19125250      0.01174369      0.00105295      0.00000658      0.00001273

0.54997111      0.27865103      0.15184156      0.01232150      0.00103996      0.00004544      0.00000468

0.53784406      0.29116599      0.15630788      0.01212885      0.00225448      0.00012662      0.00000516

0.53346258      0.11710446      0.32076407      0.02500651      0.00230494      0.00000702      0.00000786

0.53634137      0.10894496      0.23925858      0.11382647      0.00113475      0.00002393      0.00001488

0.53386572      0.11729449      0.22677101      0.11199137      0.00924675      0.00001067      0.00001353

0.53572492      0.10890644      0.29441983      0.05949493      0.00140140      0.00000525      0.00000525

0.53656341      0.14708777      0.26285039      0.05212642      0.00115173      0.00003075      0.00001273

0.53978786      0.16026654      0.23778351      0.05938571      0.00248020      0.00004542      0.00001734
```

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

VAMDNCcomSE

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

#NCVAMDrec (just A+B1 proportions)

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

```
0.018908000     0.648792000     0.328451000     0.003848000     0.000000000     0.000000000     0.000001000

#NCVAMD B2 only -- calculated within program this is just initializing matrix

0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000

0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000

0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000

0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000

0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000

0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000

0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000

0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000

0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000

0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000

0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000

0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000

0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000

0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000

0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000

0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000

0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000

0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000

0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000     0.000000000

#

#number of ages that went into catch at age calcs by fleet and year (1=VAMDNCcomGNBS, 2=VAMDNCcomSE, 3=NCVAMDrecAB1, 4=NCVAMDrecB2) sqrt alkN
with 2 minimum

#1989   1990    1991    1992    1993    1994    1995    1996    1997    1998    1999    2000    2001    2002    2003    2004    2005    2006
2007

18      19      16      21      21      17      22      20      22      25      25      23      22      21      17      19      22      26
24

18      19      16      21      21      17      22      20      22      25      25      23      22      21      17      19      22      26
24

18      19      16      21      21      17      22      20      22      25      25      23      22      21      17      19      22      26
24

2       2       2       2       2       2       2       2       2       2       2       2       2       2       2       2       2       2
2

# North region information on F at age for age 1-4+, 1989-2004 total harvest)

#estimates

2.564   3.873   1.418   0.119

1.987   3.002   1.099   0.092

0.499   0.755   0.276   0.023

0.177   0.653   0.192   0.030

0.259   0.952   0.280   0.044

0.121   0.446   0.131   0.021

0.087   0.320   0.094   0.015

0.070   0.257   0.076   0.012

0.126   0.463   0.136   0.022

0.165   0.606   0.178   0.028

0.026   0.437   0.104   0.001

0.034   0.558   0.133   0.001

0.065   1.080   0.257   0.003

0.071   1.168   0.278   0.003

0.026   0.422   0.101   0.001

0.015   0.256   0.061   0.001
```

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

```
0.1287

0.1696

0.2000

0.2887

# number of indices

# 1)NCIGNS1 2)NCIGNS2 3)NC JAI 4) MRFSS

  4

# first year of surveys forllowed by last year of surveys

  2001 2001 1992 1991

  2007 2007 2007 2007

# indices ages (indices in order by row showing begin, end ages)

 1 2 1 1

 1 2 1 3

#

# middle of survey (months)

 9  6  0  6

#

#observed index values across years (columns)

# 1)NCIGNS1 2)NCIGNS2 3)NC JAI 4) MRFSS

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


1.03    2.63    0.27    1.85    1.37    1.64    0.53


0.44    0.55    0.97    0.06    1.36    1.21    2.54

                                                                                14.848  3.716   12.650  8.290   4.613   -999    13.127  8.234
1.878   3.179   0.975   2.258   5.008   8.375   9.017   3.592

                                                                        0.105   0.058   0.066   0.064   0.115   0.068   0.222   0.147   0.182
0.096   0.109   0.294   0.084   0.131   0.138   0.159   0.147


# estimated CV's for the index values

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


0.2816  0.1597  0.2593  0.1568  0.2117  0.1524  0.1698


0.2273  0.2182  0.2062  0.3333  0.1765  0.1818  0.3898

                                                                                0.1468  0.3054  0.1753  0.2909  0.1570  -999    0.2342
0.1361  0.2213  0.1809  0.1922  0.2334  0.2458  0.1349  0.1558  0.2038

                                                                        0.139   0.146   0.131   0.131   0.108   0.123   0.138   0.104   0.114
0.11    0.126   0.117   0.149   0.154   0.145   0.11    0.102

#Fbrake level

 20.

# choice of weighting scheme

# TC, PAA, Ndx, tagF

   1.  2.   1.   1.

#

# weight, maturity, and natural mortality at age through age 62

0.864973405     0.00    0.1954623

3.349192056     0.00    0.1293428

8.374519205     0.01    0.09780164

12.87254557     0.58    0.085783

16.23206009     0.99    0.07992542

19.10192225     1.00    0.0760537
```

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

```
43.08459987     1.00    0.05934452

43.21591391     1.00    0.05928947

43.32235499     1.00    0.059245

43.40706135     1.00    0.05920971

43.47341589     1.00    0.05918213

43.52483293     1.00    0.05916081

43.564341       1.00    0.05914441
```

Weight options files

```
#File: n0_TC.wts

#weights

#total catch by fleet

# Ha:default

#fleet1 fleet2 fleet3 fleet4

   1.     1.     1.     1.

# Ha:B2 rec total catch estimates are suspect

#fleet1 fleet2 fleet3 fleet4

   1.   1.     1.     0.1

# Ha:B2 rec total catch estimates are really suspect

#fleet1 fleet2 fleet3 fleet4 fleet5 fleet6

1.     1.     1.     0.01


#File: n0_PAA.wts

#PAA weights

#Ha:default

#catch at age by fleet and year (excluding the B2 release fleet4)

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

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

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

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

#Ha:the AB1 age compostion data is less uncertain than commercial age comp

#catch at age by fleet and year

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

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

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

0.01    0.01    0.01    0.01    0.01    0.01    0.01    0.01    0.01    0.01    0.01    0.01    0.01    0.01    0.01    0.01    0.01    0.01
0.01    0.01    0.01    0.01    0.01    0.01    0.01    0.01


#File: n0_Ndx.wts

#weights

#Ha:default

# index weight

 1. 1. 1. 1.

#Ha:the MRFSS index is best due to areal coverage
```

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

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

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

Description

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

Model code

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

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

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

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


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

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

 // last age that selectivity is estimated
 init_int last_sel_age

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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


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

    int PAA_n
    int PAA_n2
    int tC_n
    int ndx_n


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

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


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

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

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



      matrix log_N(firstyr,lastyr,firstage,lastage)

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

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

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

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

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

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

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

    objective_function_value f

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

      likeprof_number three_yrSPR2007

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


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

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

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

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

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

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

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

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

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

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


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

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

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

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

             // standardize relative to this maximum
```

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

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


FUNCTION get_mortality_rates

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

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

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

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

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

FUNCTION get_numbers_at_age

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

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

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

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

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


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

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

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

```
FUNCTION calculate_catch

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



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



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

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

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

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

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

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

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


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


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


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

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


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


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


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



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

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

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

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

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

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


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

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

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

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

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

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

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

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

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

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

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

Input data

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

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

0.17953596	0.31587891	0.30031710	0.17939555	0.01256366	0.00505562	0.00725322
0.11702704	0.30777011	0.33983358	0.18920826	0.02241453	0.00637073	0.01737576
0.22010868	0.33805670	0.26139372	0.15497726	0.01788476	0.00373733	0.00384154
0.18653179	0.29320276	0.24769939	0.20553831	0.02714874	0.02077304	0.01910598
0.10784524	0.36313031	0.35031347	0.14930099	0.01825740	0.00779767	0.00335492
0.03845467	0.53227078	0.35115582	0.05616096	0.02195777	0.00000000	0.00000000
0.02401761	0.51088664	0.36026963	0.07174471	0.03308141	0.00000000	0.00000000
0.02482402	0.47662003	0.36615689	0.08837673	0.04389968	0.00000000	0.00012265
0.01007436	0.47685025	0.37480700	0.09497156	0.04329683	0.00000000	0.00000000
0.01981715	0.52036051	0.36055582	0.06363114	0.03563539	0.00000000	0.00000000
0.01555853	0.44304880	0.34944481	0.18347572	0.00847214	0.00000000	0.00000000
0.02869365	0.43988907	0.36660982	0.15375091	0.01105655	0.00000000	0.00000000
0.01693788	0.37794664	0.44798483	0.14113257	0.01589195	0.00003032	0.00007581
0.02978489	0.39047265	0.42949546	0.13710285	0.01314415	0.00000000	0.00000000

#GArec/com (AB1 prop at age)

0.58807613	0.35680267	0.05231875	0.00275960	0.00002142	0.00000000	0.00002142
0.59379797	0.26131516	0.08816583	0.01466469	0.00034733	0.00372683	0.03798219
0.73753163	0.23628607	0.01865553	0.00752677	0.00000000	0.00000000	0.00000000
0.70990141	0.24566672	0.03121396	0.00398124	0.00101811	0.00110938	0.00710918
0.62853250	0.27307518	0.07494238	0.01852342	0.00236331	0.00040910	0.00215410
0.69157626	0.27337695	0.03307431	0.00197248	0.00000000	0.00000000	0.00000000
0.71064814	0.25169231	0.03613704	0.00149097	0.00001578	0.00000000	0.00001578
0.68907944	0.28339394	0.02392936	0.00348294	0.00006533	0.00001633	0.00003266
0.52709418	0.38161973	0.07491347	0.01349308	0.00287954	0.00000000	0.00000000
0.50857638	0.42506809	0.05537142	0.01098411	0.00000000	0.00000000	0.00000000
0.60780851	0.34030628	0.05188521	0.00000000	0.00000000	0.00000000	0.00000000
0.56457193	0.31181173	0.10821051	0.01540583	0.00000000	0.00000000	0.00000000
0.74783700	0.23056974	0.01778527	0.00379655	0.00000000	0.00000000	0.00001144
0.62638628	0.34851337	0.02221689	0.00288346	0.00000000	0.00000000	0.00000000
0.65512016	0.30180315	0.04307670	0.00000000	0.00000000	0.00000000	0.00000000
0.30019432	0.61402208	0.08271649	0.00306711	0.00000000	0.00000000	0.00000000
0.63523497	0.33689193	0.02780420	0.00006890	0.00000000	0.00000000	0.00000000
0.45014750	0.53095416	0.01629958	0.00254976	0.00000000	0.00000109	0.00004792
0.55402776	0.43192821	0.01220683	0.00183720	0.00000000	0.00000000	0.00000000

#SCrec/com (AB1 prop at age)

0.46673155	0.40522280	0.10678364	0.02026848	0.00073466	0.00001726	0.00024161
0.41886135	0.50722428	0.06177473	0.01162317	0.00047980	0.00000000	0.00003667
0.69379537	0.28492226	0.01899512	0.00093946	0.00038801	0.00009213	0.00086765
0.48001112	0.45784774	0.04723312	0.00424613	0.00406233	0.00000000	0.00659956
0.39646715	0.49961103	0.08372224	0.01840634	0.00140248	0.00000381	0.00038695
0.34777466	0.54623850	0.09285186	0.01274663	0.00036686	0.00002148	0.00000000
0.62140162	0.31418236	0.04777840	0.01450957	0.00207994	0.00000039	0.00004773
0.30077812	0.64126531	0.04650402	0.01041973	0.00100249	0.00003033	0.00000000
0.85118386	0.09215811	0.03184139	0.02319292	0.00115356	0.00040086	0.00006930
0.32008089	0.53968954	0.09455215	0.04164577	0.00396179	0.00006884	0.00000103
0.48523039	0.42423492	0.07823522	0.01156125	0.00073562	0.00000260	0.00000000
0.47343670	0.41549695	0.09345039	0.01632059	0.00129537	0.00000000	0.00000000
0.63593933	0.27528619	0.07257250	0.01561033	0.00057439	0.00000036	0.00001690
0.30850326	0.65687384	0.03138038	0.00313999	0.00009259	0.00000995	0.00000000

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

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

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

Weight options files

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

```
#fleet1 fleet2 fleet3 fleet4 fleet5 fleet6

   1.     1.     1.     1.     0.1    0.1

# Ha:B2 rec total catch estimates are really suspect

#fleet1 fleet2 fleet3 fleet4 fleet5 fleet6

   1.     1.     1.     1.     0.01    0.01


#File: s0_PAA.wts

#weights

#Ha:default

#catch at age by fleet and year

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

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

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

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

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

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

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

#Ha:the B2 age compostion data is very uncertain

#catch at age by fleet and year

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

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

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

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

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

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

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

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

#catch at age by fleet and year

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

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

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

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

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

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

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


#File: s0_Ndx.wts

#weights
```

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

S E D A R

Southeast Data, Assessment, and Review

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SEDAR 18

Addenda and Post-Review Updates

Atlantic Red Drum

October 16, 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

1 Addenda and Post-Review Updates

1.1 Significant Assessment Modifications

The reader's attention is directed to Appendix A of the Review Workshop Report (SAR Section V). Appendix A presents responses by the Assessment Team to requests from the Review Panel formulated during the review process, both before and during the Review Workshop. Significant revisions were involved. These revisions affected data, data use, analytic approaches, assessment outputs, and interpretation of results. While there were essential differences between the analyses and accompanying discussion reported in the initial Assessment Workshop Report and those presented in the Review Workshop Report, Appendix A, the Review Panel determined that the replacement model run and analyses did not constitute a new assessment. To gain a full understanding of the assessment and its review up to publication of the Stock Assessment Report (October 16, 2009), the reader should read the original Assessment Workshop Report (SAR Section III), the Review Workshop Report (SAR Section V), and Appendix A of the Review Workshop Report.