NORTH CAROLINA RED DRUM

FISHERY MANAGEMENT PLAN

AMENDMENT I

PREPARED BY THE

RED DRUM FISHERY MANAGEMENT PLAN ADVISORY COMMITTEE

AND THE

NORTH CAROLINA DIVISION OF MARINE FISHERIES DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES MOREHEAD CITY, NORTH CAROLINA

November, 2008

NC red drum stock assessment completed	April	2007
MFC approves FMP for public comment	January	2008
Finalize RDAC and DMF recommendations	March/April	2008
MFC selects preferred management options	April	2008
Submitted to DENR for review	May	2008
Submitted to JLCSA	May	2008
Draft rules approved for notice to text	June	2008
Public hearings on draft rules	October	2008
MFC selects rules and adopts plan	November	2008

1. ACKNOWLEDGEMENTS

Amendment 1 to the North Carolina Red Drum Fishery Management Plan (FMP) was developed by the North Carolina Department of Environment and Natural Resources' Division of Marine Fisheries (DMF) under the direction of the North Carolina Marine Fisheries Commission (MFC) with the advice of the Red Drum Public Advisory Committee. Deserving special recognition are the members of the Red Drum Public Advisory Committee and the Plan Development Team who contributed their time and knowledge to this effort.

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3. EXECUTIVE SUMMARY

Goals and Objectives

The goal of Amendment 1 to the North Carolina Red Drum Fishery Management Plan (FMP) is to prevent overfishing in the red drum (*Sciaenops ocellatus*) stocks by allowing the long-term sustainable harvest in the red drum fishery. To achieve these goals, it is recommended that the following objectives be met:

1. Achieve and maintain a minimum overfishing threshold where the rate of juvenile escapement to the adult stock is sufficient to maintain the long-term sustainable harvest in the fishery.
2. Establish a target SPR to provide the Optimum Yield (OY) from the fishery in order to maintain a state FMP that is in compliance with the requirements of the Atlantic States Marine Fisheries Commission (ASMFC) Red Drum FMP.
3. Continue to develop an information program to educate the public and elevate their awareness of the causes and nature of problems in the red drum stock, its habitat and fisheries, and explain the rationale for management efforts to solve these problems.
4. Develop regulations that while maintaining sustainable harvest from the fishery, considers the needs of all user groups and provides adequate resource protection.
5. Promote harvest practices that minimize the mortality associated with regulatory discards of red drum.
6. In a manner consistent with Coastal Habitat Protection Plan (CHPP), restore, improve and protect essential red drum habitat and environmental quality to increase growth, survival, and reproduction of red drum.
7. Improve our understanding of red drum population dynamics and ecology through the continuation of current studies and the development of better data collection methods, as well as, through the identification and encouragement of new research.
8. Initiate, enhance, and continue studies to collect and analyze the socio-economic data needed to properly monitor and manage the red drum fishery.

Stock Status

The current stock status of red drum in North Carolina waters indicates that the stock is currently not undergoing overfishing. More restrictive management measures in place as a result of the 2001 North Carolina Red Drum FMP have effectively reduced fishing mortality. The primary benchmarks in determining the stock status, spawning potential ratio (SPR) and escapement are currently at or near target levels. It is critical to note that reaching the target is only the first step in maintaining this fishery. In order for the red drum stock to be considered healthy and viable, the 40% SPR target must be maintained continuously over time. Increases in

the harvest rates (relaxation of current regulations) of red drum should only be allowed if those increases are not anticipated to lower the SPR values below the overfishing definition.

Commercial and Recreational Fisheries

While landings typically peak in the fall, red drum are harvested commercially and recreationally on a year round basis throughout North Carolina's estuarine and nearshore coastal waters. Commercially, red drum are harvested using a variety of gears and have traditionally been harvested as bycatch in fisheries targeting other species. A directed fishery using run-around gillnets did develop in the mid-1990's. Regulations implemented through the 2001 Red Drum FMP prohibit the targeting of red drum and restrict commercial harvest to a daily trip limit. As a bycatch fishery, anchored gill nets account for the vast majority of the commercial landings. The commercial dockside value of the red drum fishery is seasonally variable but has shown an upward trend since the 1970's. The average price paid per pound has steadily increased from $0.12 per pound in 1972 to $1.34 per pound in 2005.

Recreational anglers account for about 60% of the annual harvest of red drum. Red drum are consistently rated as one of the top target species by shore based recreational anglers. Over time, the practice of catch and release fishing has become an increasingly larger component of the recreational fishery due both to angler preference and further bag and size limit restrictions. Economic data on the recreational red drum fishery are occasionally collected through add-on surveys through the Marine Recreational Fisheries Statistics Survey. The most recent data estimates that total expenditures of red drum related recreational fishing trips totaled approximately $50 million in 2004.

Habitat and Water Quality

Red drum utilize a variety of estuarine and oceanic habitats throughout their life cycle. Each habitat type provides ecological services that aid in maintaining and enhancing the red drum population, and also influences the functioning of the ecosystem overall. The South Atlantic Fishery Management Council has recognized areas of Essential Fish Habitat (EFH) and Habitat Areas of Particular Concern (HAPC) for red drum. In North Carolina the primary EFH areas include flooded salt marsh, fresh and brackish marsh, tidal creeks, submerged rooted vascular plants (sea grass), oyster reefs and shell banks, soft sediment bottom, ocean high salinity surf zones and artificial reefs. HAPC are those areas that are known to be critical to a particular life history stage for red drum, including spawning areas and nursery grounds. These areas include all coastal inlets, state-designated nursery habitats known to be important to red drum, currently known spawning sites and any future designated sites of spawning activity and areas supporting submerged aquatic vegetation (SAV).

At the state level, North Carolina has developed a strategy to protect and restore habitats critical to North Carolina's coastal fishery resources through the implementation of the Coastal Habitat Protection Plan (CHPP). This plan recognizes those habitats that have been identified to provide critical habitat functions or that are particularly at risk due to imminent threats, vulnerability or rarity. Areas meeting these criteria are to be designated as "Strategic Habitat

Areas" (SHAs) and given the highest priority for protection. In addition to its overall goals, the CHPP has specific recommendations that will benefit habitat used by red drum. Additional red drum habitat research needs identified in the Red Drum FMP are:

- Determine juvenile habitat preference and examine if recruitment is habitat limited.
- Examine ecological use and importance of shell bottom to red drum.
- Identify coastal wetlands and other habitats utilized by juvenile red drum and assess relationship between changes in recruitment success and changes in habitat conditions.
- Assess cumulative impact of large-scale beach nourishment and inlet dredging on red drum and other demersal fish that use the surf zone.
- Determine location and significance of spawning aggregation sites throughout the coast.
- Determine if navigational dredging between August and October significantly impacts spawning activity.
- Determine if designation of spawning areas by MFC is needed, and if specific protective measures should be developed.

Management Issues and Proposed Actions

In the development of Amendment 1 to the Red Drum FMP, management options were developed for identified key issues through the FMP process. These issues and options were developed by the NCDMF through the cooperation and advice solicited from the Red Drum Advisory Committee (RDAC), MFC, Finfish and Regional Advisory committees, public, as well as the scientific community. The MFC selected preferred management strategies for each of the key issues at their November 6-7, 2008 business meeting. A summary of the key issues along with the selected MFC management strategies are listed in the following table (*Any changes/additions to current rules or proclamations are underlined and italicized in the table)*:

ISSUE	MFC SELECTED MANAGEMENT STRATEGY	OBJECTIVES ADDRESSED	REGULATORY ACTION
Adult Harvest Limits	Status quo (no harvest over 27 inches TL)	1 & 2	No action required
Recreational Targeting of Adult Red Drum	*It is unlawful to use any hook larger than 4/0 from July 1 through September 30 in the internal coastal fishing waters of Pamlico Sound and its tributaries south of the Albemarle Sound Management Area as defined in 15A NCAC 03R .0201 and north of a line beginning at a point 34° 59.7942' N - 76° 14.6514' W on Camp Point; running easterly to a point at 34° 58.7853' N - 76° 09.8922' W on Core Banks while using natural bait from 7:00 p.m. to 7:00 a.m. unless the terminal tackle consists of: (1) A circle hook defined as a hook with the point of the hook directed perpendicularly back toward the shank, and with the barb*	1, 2 & 5	Rule change 3J .0306

	either compressed or removed. *(2) A fixed sinker not less than two ounces in weight, secured not more than six inches from the fixed weight to the circle hook.* *(also continued education on fishing methods that minimize risk to fish)During July through September, unlawful to use J-hooks larger than 4/0 while fishing natural bait in Pamlico Sound and its tributraries, excluding the ASMA and Core Sound, south* (also continued education on fishing methods that minimize risk to fish)		
Recreational Bag and Size Limits	Status quo (one fish per day between 18 and 27 inches TL)	1, 2 & 4	No action required
Commercial Limits	**Trip Limit and Bycatch Provision** Status quo (7 fish trip limit with 50% bycatch provision). Director retains authority to modify trip limit and bycatch provision as needed. *Allow the possession of up to 3 fish while engaged in fishing without requiring that they be subject to the bycatch provision. Upon landing/sale all red drum possessed would be subject to bycatch provision.* **Commercial Cap** Continue 250,000 lb annual cap monitored from September 1 to August 31. *Implement a split season on the annual commercial cap, capping the period of September 1 to April 30 at 150,000 lb and conserving the remaining portion of the cap for the period of May 1 to August 31. Unused cap in period one would be available for period two. Any annual commercial harvest limit that is exceeded one year will result in the poundage overage being deducted from the subsequent year's commercial harvest limit.*	1, 2, 4 & 5	New proclamation Rule Change 3M .0501

Estuarine Gill Net Discarded Bycatch of Red Drum	**Small Mesh Attendance (<5" stretch mesh)** **Year-round Attendance** *Expand year-round attendance within 200 yards of shore to include the area of the lower Neuse out to the mouth of the river.* **Seasonal Attendance** 1) Modify the seasonal attendance requirements for small mesh gill nets (currently May 1 to October 31) to include the period of May 1 through *November 30* in the following locations: a) All primary and permanent secondary nursery areas and modified no-trawl areas *b) Within 200 yards of any shoreline for the areas of Pamlico, Pungo, Neuse and Bay Rivers and bays* *c) Within 50 yards of any shoreline in the areas of Pamlico and Core Sound south to the NC/SC line* *d) Area Core Sound and south is excluded from 50 yard shoreline attendance requirement during October and November* **Modification to current small mesh seasonal attendance area along the Outer Banks (i.e. modified no-trawl area)** *Modify attendance area between Rodanthe and Gull Island to straighten out line and allow for non-attended nets in area of deeper water* *Modify the current attendance line in the area of Oliver Reef, near Hatteras to allow for non-attended nets in area of deeper water.*	1, 2, & 5	Rule change 3R .0112 Rule change 3J .0103 & 3R .0112 Rule change 3R .0112

Estuarine Gill Net Discarded Bycatch of Red Drum	**Large Mesh (>5" stretch mesh)** *Require all unattended large mesh gill nets to be set a minimum of 10 feet from any shoreline from June through October*	1, 2, & 5	Rule change 3J .0103
The use of gigs, gaffs or spears to take red drum.	Continue to prohibit and *move Proclamation FF-40-2001 into rule*	1 & 2	Rule change 3M .0501

Rules in place during the development of the Red Drum FMP Amendment 1 are listed in Section 4.7.3. Rules necessary to implement the MFC selected management strategies as outlined in the this table are provided in Appendix 1.

4. INTRODUCTION

4.1 Legal Authority for Management

Fisheries management includes all activities associated with maintenance, improvement, and utilization of the fisheries resources of the coastal area, including research, development, regulation, enhancement, and enforcement.

Many different state laws (General Statutes - G.S.) provide the necessary authority for fishery management in North Carolina. General authority for stewardship of the marine and estuarine resources by the North Carolina Department of Environment and Natural Resources (NCDENR) is provided in G.S. 113-131. The North Carolina Division of Marine Fisheries (DMF) is the arm of the Department which carries out this responsibility. General Statute 113-163 authorizes research and statistical programs. The North Carolina Marine Fisheries Commission (MFC) is charged to "manage, restore, develop, cultivate, conserve, protect, and regulate the marine and estuarine resources of the State of North Carolina" (G.S. 143B-289.51). The MFC can regulate fishing times, areas, fishing gear, seasons, size limits, and quantities of fish harvested and possessed (G.S. 113-182 and 143B-289.52). General Statute 143B-289.52 allows the MFC to delegate the authority to implement its regulations for fisheries "which may be affected by variable conditions" to the Director of DMF who may then issue public notices called "proclamations." Thus, North Carolina has a very powerful and flexible legal basis governing coastal fisheries management. The General Assembly has retained the authority to establish commercial fishing licenses, but has delegated to the MFC authority to establish free permits for various commercial fishing gears and activities.

The Fisheries Reform Act of 1997 (FRA 1997) and as ratified in 2004 establishes a process for preparation of coastal fisheries management plans for North Carolina. The FRA states: "the goal of the plans shall be to ensure the long-term viability of the State's commercially and recreationally significant species or fisheries. Each plan shall be designed to reflect fishing practices so that one plan may apply to a specific fishery, while other plans may be based on gear or geographic areas. Each plan shall:

a. Contain necessary information pertaining to the fishery or fisheries, including management goals and objectives, status of the relevant fish stocks, stock assessments for multi-year species, fishery habitat and water quality considerations consistent with Coastal Habitat Protection Plans adopted pursuant to G.S. 143B-279.8, social and economic impact of the fishery to the State, and user conflicts.

b. Recommend management actions pertaining to the fishery and fisheries.

c. Include conservation and management measures that will provide the greatest overall benefit to the State, particularly with respect to food production, recreational opportunities, and the protection of marine ecosystems, and that will produce a

sustainable harvest.

d. Specify a time period, not to exceed 10 years from the date of adoption of the plan, for ending over fishing and achieving a sustainable harvest. This subdivision shall only apply to a plan for a fishery that is over fished. This subdivision shall not apply to a plan for a fishery where the biology of the fish or environmental conditions make ending overfishing and achieving a sustainable harvest within 10 years impracticable."

Sustainable harvest is defined in the FRA as "The amount of fish that can be taken from a fishery on a continuing basis without reducing the stock biomass of the fishery or causing the fishery to become overfished."

Overfished is defined as "The condition of a fishery that occurs when the spawning stock biomass of the fishery is below the level that is adequate for the recruitment class of a fishery to replace the spawning class of the fishery.

Overfishing is defined as "Fishing that causes a level of mortality that prevents a fishery from producing a sustainable harvest."

4.2 Goals and Objectives

The goal Amendment 1 to the North Carolina Red Drum Fishery Management Plan (FMP) is to prevent overfishing in the red drum (*Sciaenops ocellatus*) stocks by allowing the long-term sustainable harvest in the red drum fishery. To achieve these goals, it is recommended that the following objectives be met:

1. Achieve and maintain a minimum overfishing threshold where the rate of juvenile escapement to the adult stock is sufficient to maintain the long-term sustainable harvest in the fishery.
2. Establish a target SPR to provide the Optimum Yield (OY) from the fishery in order to maintain a state FMP that is in compliance with the requirements of the Atlantic States Marine Fisheries Commission (ASMFC) Red Drum FMP.*
3. Continue to develop an information program to educate the public and elevate their awareness of the causes and nature of problems in the red drum stock, its habitat and fisheries, and explain the rationale for management efforts to solve these problems.
4. Develop regulations that while maintaining sustainable harvest from the fishery, considers the needs of all user groups and provides adequate resource protection.
5. Promote harvest practices that minimize the mortality associated with regulatory discards of red drum.
6. In a manner consistent with Coastal Habitat Protection Plan (CHPP), restore, improve and protect essential red drum habitat and environmental quality to increase growth, survival, and reproduction of red drum.

7. Improve our understanding of red drum population dynamics and ecology through the continuation of current studies and the development of better data collection methods, as well as, through the identification and encouragement of new research.
8. Initiate, enhance, and continue studies to collect and analyze the socio-economic data needed to properly monitor and manage the red drum fishery.

*See ASMFC Red Drum FMP compliance requirements in Section 4.7.1 Existing Plans.

4.3 Sustainable Harvest

The FRA mandates that fishery stocks be managed to allow for sustainable harvest and prevent overfishing. Sustainable harvest for the North Carolina red drum fishery will be defined as the amount of harvest, including release and discard mortality, that can be taken while maintaining a SPR at or above 30% the level that would result if fishing mortality did not exist (F=0). The red drum fishery in North Carolina will be considered to be undergoing overfishing when the SPR is below 30%.

4.4 Management Unit

The management unit for this FMP includes red drum and the various fisheries that encounter red drum in all joint and coastal waters throughout North Carolina.

4.5 General Problem Statement

The 2007 stock assessment report indicates that the red drum stock in North Carolina is currently not experiencing overfishing. The red drum stock was previously experiencing overfishing from at least 1986 through 1998. No assessment data is available for years prior to 1986. Current management measures are the direct result of the 2001 NC Red Drum FMP and were implemented at the beginning of FMP development as interim measures to divert overfishing. The purpose of this plan is to recommend or maintain management measures that prevent overfishing and provide the long-term sustainable harvest for the fishery. Areas to be addressed in the management of North Carolina's red drum fishery are: 1) management strategies; 2) insufficient data and research needs; 3) habitat and water quality; and 4) socioeconomic factors.

4.6 Interim Measures

The DMF is required, under the MFC guidelines, to recommend to the appropriate standing committee(s) any preservation management measures necessary and appropriate to maintain the well-being of the stock. These measures are intended to prevent further declines for a stock that is overfished or for a stock that is experiencing overfishing at a level that may jeopardize the long-term sustainable harvest for the fishery. Currently the red drum stock in North Carolina is not experiencing overfishing and no interim measures are necessary.

4.7 Existing Plans, Statutes, and Rules

4.7.1 Existing Plans

Red drum along the Atlantic coast are managed jointly by the Atlantic States Marine Fisheries Commission (ASMFC) and the South Atlantic Fishery Management Council (SAFMC). The ASMFC adopted an FMP for red drum along the Atlantic coast from Maryland through Florida in 1984 (ASMFC, 1984), then revised the FMP in 1988 when the Interstate Fisheries Management Program (ISFMP) Policy Board requested that all states from Maine through Florida implement plan requirements to prevent development of northern markets for southern fish. The SAFMC Red Drum FMP (SAFMC, 1990) was developed and passed in 1990 and was subsequently adopted as Amendment 1 to the ASMFC Red Drum FMP (ASMFC, 1991). This joint FMP, or Amendment 1, stated that intense fishing mortality on juvenile red drum in state waters was resulting in reduced recruitment to the adult spawning stock; this statement was supported by the 1990 stock assessment report which indicated that the red drum stock was undergoing overfishing with extremely low SPR values ranging from 2-3 percent (Vaughan, 1990). The plan recommended closing the Exclusive Economic Zone (EEZ) to all harvest and possession of red drum to protect the adult stock and thereby placed further regulatory responsibility with the states. Amendment 1 also required that states adopt measures to prevent overfishing and rebuild the stock to a target of 30% SPR. Rebuilding was scheduled to occur in steps, starting with an initial goal of 10% SPR. This initial step required states to adopt one of two options: 1) 18-inch TL minimum, 27-inch TL maximum, and a five fish bag limit with the option of one fish exceeding 27-inch TL; or 2) 14-inch minimum, 27-inch TL maximum, and a 5 fish bag limit, with no fish exceeding 27-inches TL. North Carolina adopted option 1 in 1992.

In 1998, the Council adopted new definitions of OY and overfishing for red drum. OY was defined as 40% SPR and overfishing was defined as 30% SPR. The 2000 stock assessment (Vaughan and Carmichael, 2000) showed that SPR increased to 18% in the Northern region for the period of 1992-1997, indicating that the management measures imposed under Amendment 1 were successful in improving sub-adult recruitment to the adult stock. The initial step of 10% SPR called for in Amendment 1 was achieved by all states although red drum stocks in both the Northern and Southern region of the Atlantic coast were still experiencing overfishing. In 1998 North Carolina began the development of a state red drum FMP as a result of the 1997 FRA which required the management of all recreationally and commercially important species in North Carolina to be managed for Optimum Yield. North Carolina adopted the definition of 40% SPR to obtain OY as the goal of the state red drum FMP. As a result, North Carolina took pro-active management measures for a federally managed species with the implementation of the 2001 North Carolina Red Drum FMP. Rules implemented by the state FMP were enacted as early as October of 1998 as interim measures to prevent further overfishing while the state red drum FMP was being developed. Harvest restrictions included: restricting all harvest of red drum to fish between 18 and 27 inches total length, implementing a one fish recreational bag limit; limiting the commercial fishery with a daily trip limit set by the Director; and maintaining the previous 250,000 pound commercial cap. In addition, the commercial fishery for red drum

was designated as a bycatch fishery. The North Carolina Red Drum FMP was approved in March of 2001 and maintained all the interim measures.

Amendment 2 of the ASMFC FMP was adopted in 2002 and required that all states implement management measures projected to result in a 40% SPR by at least January of 2003. Individual states must maintain these management strategies in order to ensure that overfishing is not occurring and that OY in the red drum fishery can be obtained. Amendment 2 compliance requirements to the states include:

- Implementing bag and size limits projected by bag and size limit analysis to achieve the minimum 40% SPR.
- Establishing a maximum size limit of 27 inches or less in all red drum fisheries.
- Maintaining current or more restrictive commercial fishery regulations.
- Requires any commercial cap overages from one fishing year to be subtracted from the subsequent years commercial cap.

As a result of the management measures enacted through the state Red Drum FMP of 2001, no new management measures were required for North Carolina in order to comply with Amendment 2. Amendment 2 did, however, disallow the "sliding scale" commercial trip limit implemented in the state FMP. In 2003, the NCDMF requested and received approval from the ASMFC South Atlantic State-Federal Fisheries Management Board (ASMFC-SAB) to restore the flexibility of the NCDMF Director to raise or lower the daily commercial trip limit provided that those changes were done in response to preventing excessive discards. Any other future regulatory changes by individual states require prior approval of the ASMFC-SAB or that state will be deemed out of compliance. A state can request to implement alternative measures to the compliance requirements only if that state can show to the Board's satisfaction that its alternative will have the same conservation value as the measure contained in Amendment 2. A more detailed description of mandatory compliance requirements can be found in the ASMFC Amendment 2 Red Drum FMP (ASMFC 2002).

4.7.2 Statutes

All management authority for North Carolina's red drum fishery is vested in the State of North Carolina. General authorities that are noted in Section 4.1 provide the MFC with the regulatory powers to manage red drum. Although most red drum harvest is taken from coastal waters, the limited harvest from inland waters falls under the jurisdiction of the North Carolina Wildlife Resources Commission (WRC).

4.7.3 Rules

The following rules have been enacted to manage red drum stocks in North Carolina through the authority vested in the MFC. These rules were in place at the beginning of the Red Drum FMP Amendment 1 development. Rules necessary to implement the selected management strategies for this plan and selected by the NC MFC are listed in Appendix 1.

SUBCHAPTER 3M-FINFISH

SECTION .0500 - OTHER FINFISH

.0501 RED DRUM

(a) The Fisheries Director, may by proclamation, impose any or all of the following restrictions on the taking of red drum:

(1) Specify areas.
(2) Specify seasons.
(3) Specify quantity.
(4) Specify means/methods.
(5) Specify size.

(b) It is unlawful to remove red drum from any type of net with the aid of any boat hook, gaff, spear, gig, or similar device.

(c) It is unlawful to possess red drum less than 18 inches total length or greater than 27 inches total length.

(d) It is unlawful to possess more than one red drum per person per day taken-by hook-and-line or for recreational purposes.

(e) The annual commercial harvest limit (September 1 through August 31) for red drum is 250,000 pounds. If the harvest limit is projected to be taken, the Fisheries Director shall, by proclamation, prohibit possession of red drum taken in a commercial fishing operation.

History Note: *Authority G.S. 113-134; 113-182; 113-221; 143B-289.52;*
Eff. January 1, 1991;
Amended Eff. March 1, 1996; October 1, 1992; September 1, 1991;
Temporary Amendment Eff. May 1, 2000; July 1, 1999; October 22, 1998;
Amended Eff. April 1, 2001;
Temporary Amendment Eff. May 1, 2001;
Amended Eff. August 1, 2002.

SUBCHAPTER 3J - NETS, POTS, DREDGES, AND OTHER FISHING DEVICES

SECTION .0100 - NET RULES, GENERAL

SECTION .0103 GILL NETS, SEINES, IDENTIFICATION, RESTRICTIONS

.0103 GILL NETS, SEINES, IDENTIFICATION, RESTRICTIONS

(a) It is unlawful to use gill nets:

(1) With a mesh length less than 2 ½ inches.
(2) In internal waters from April 15 through December 15, with a mesh length 5 inches or greater and less than 5 ½ inches.

(b) The Fisheries Director may, by proclamation, limit or prohibit the use of gill nets or seines in coastal waters, or any portion thereof, or impose any or all of the following restrictions on the use of gill nets or seines:

(1) Specify area.
(2) Specify season.

(3) Specify gill net mesh length.
(4) Specify means/methods.
(5) Specify net number and length.

(c) It is unlawful to use fixed or stationary gill nets in the Atlantic Ocean, drift gill nets in the Atlantic Ocean for recreational purposes, or any gill nets in internal waters unless nets are marked by attaching to them at each end two separate yellow buoys which shall be of solid foam or other solid buoyant material no less than five inches in diameter and no less than five inches in length. Gill nets, which are not connected together at the top line, shall be considered as individual nets, requiring two buoys at each end of each individual net. Gill nets connected together at the top line shall be considered as a continuous net requiring two buoys at each end of the continuous net. Any other marking buoys on gill nets used for recreational purposes shall be yellow except one additional buoy, any shade of hot pink in color, constructed as specified in this Paragraph, shall be added at each end of each individual net. Any other marking buoys on gill nets used in commercial fishing operations shall be yellow except that one additional identification buoy of any color or any combination of colors, except any shade of hot pink, may be used at either or both ends. The owner shall always be identified on a buoy on each end either by using engraved buoys or by attaching engraved metal or plastic tags to the buoys. Such identification shall include owner's last name and initials and if a vessel is used, one of the following:

(1) Owner's N.C. motor boat registration number, or
(2) Owner's U.S. vessel documentation name.

(d) It is unlawful to use gill nets:

(1) Within 200 yards of any pound net set with lead and either pound or heart in use, except from August 15 through December 31 in Albemarle Sound, excluding tributaries, west of a line beginning at a point 36° 04.5184' N - 75° 47.9095' W on Powell Point; running southerly to a point 35° 57.2681' N - 75° 48.3999' W on Caroon Point, it is unlawful to use gill nets within 500 yards of any pound net set with lead and either pound or heart in use;
(2) From March 1 through October 31 in the Intracoastal Waterway within 150 yards of any railroad or highway bridge.

(e) It is unlawful to use gill nets within 100 feet either side of the center line of the Intracoastal Waterway Channel south of the entrance to the Alligator-Pungo River Canal near Beacon "54" in Alligator River to the South Carolina line, unless such net is used in accordance with the following conditions:

(1) No more than two gill nets per vessel may be used at any one time;
(2) Any net used must be attended by the fisherman from a vessel who shall at no time be more than 100 yards from either net; and
(3) Any individual setting such nets shall remove them, when necessary, in sufficient time to permit unrestricted boat navigation.

(f) It is unlawful to use drift gill nets in violation of 15A NCAC 03J .0101(2) and Paragraph (e) of this Rule.

(g) It is unlawful to use unattended gill nets with a mesh length less than five inches in a commercial fishing operation in the gill net attended areas designated in 15A NCAC 03R .0112(a).

(h) It is unlawful to use unattended gill nets with a mesh length less than five inches in a commercial fishing operation from May 1 through October 31 in the internal coastal and joint waters of the state designated in 15A NCAC 03R .0112(b).

(i) It is unlawful to use more than 3,000 yards of gill net with a mesh length 5 1/2 inches or greater per vessel in internal waters regardless of the number of individuals involved.

History Note: *Authority G.S. 113-134; 113-173; 113-182; 113-221; 143B-289.52;*
Eff. January 1, 1991;
Amended Eff. August 1, 1998; March 1, 1996; March 1, 1994; July 1, 1993; September 1, 1991;
Temporary Amendment Eff. October 2, 1999; July 1, 1999; October 22, 1998;
Amended Eff. April 1, 2001;
Temporary Amendment Eff. May 1, 2001;
Amended Eff. September 1, 2005; August 1, 2004; August 1, 2002.

SUBCHAPTER 3R - DESCRIPTIVE BOUNDARIES

.0100 - DESCRIPTIVE BOUNDARIES

.0112 ATTENDED GILL NET AREAS

(a) The attended gill net areas referenced in 15A NCAC 03J .0103 (g) are delineated in the following areas:

(1) Pamlico River, west of a line beginning at a point 35° 27.5768' N - 76° 54.3612' W on Ragged Point; running southwesterly to a point 35° 26.9176' N - 76° 55.5253' W on Mauls Point;

(2) Within 200 yards of any shoreline in Pamlico River and its tributaries east of the line beginning at a point 35° 27.5768' N - 76° 54.3612' W on Ragged Point; running southwesterly to a point 35° 26.9176' N - 76° 55.5253' W on Mauls Point; and west of a line beginning at a point 35° 22.3622' N - 76° 28.2032' W on Roos Point; running southerly to a point at 35° 18.5906' N - 76° 28.9530' W on Pamlico Point;

(3) Pungo River, east of the northern portion of the Pantego Creek breakwater and a line beginning at a point 35° 31.7198' N - 76° 36.9195' W on the northern side of the breakwater near Tooleys Point; running southeasterly to a point 35° 30.5312' N - 76°35.1594' W on Durants Point;

(4) Within 200 yards of any shoreline in Pungo River and its tributaries west of the northern portion of the Pantego Creek breakwater and a line beginning at a point 35° 31.7198' N - 76° 36.9195' W on the northern side of the breakwater near Tooleys Point; running southeasterly to a point 35° 30.5312' N - 76° 35.1594' W on Durants Point; and west of a line beginning at a point 35° 22.3622' N - 76° 28.2032' W on Roos Point; running southerly to a point at 35° 18.5906' N - 76° 28.9530' W on Pamlico Point;

(5) Neuse River and its tributaries northwest of the Highway 17 highrise bridge;

(6) Trent River and its tributaries;

(7) Within 200 yards of any shoreline in Neuse River and its tributaries east of the Highway 17 highrise bridge and west of a line beginning at a point 34° 57.9116' N - 76° 48.2240' W on Wilkinson Point; running southerly to a point 34° 56.3658' N - 76° 48.7110' W on Cherry Point.

(b) The attended gill net areas referenced in 15A NCAC 03J .0103 (h) are delineated in the following coastal and joint waters of the state south of a line beginning on Roanoke Marshes Point at a point 35° 48.3693' N - 75° 43.7232' W; running southeasterly to a point 35° 44.1710' N - 75° 31.0520' W on Eagles Nest Bay to the South Carolina State line:

(1) All primary nursery areas described in 15A NCAC 03R .0103, all permanent secondary nursery areas described in 15A NCAC 03R .0104, and no trawl areas described in 15A NCAC 03R .0106 (2),(4),(5), and (6);

(2) In the area along the Outer Banks, beginning at a point 35° 44.1710' N - 75° 31.0520' W on Eagles Nest Bay; running northwesterly to a point 35° 45.1833' N - 75° 34.1000' W west of Pea Island; running southerly to a point 35° 40.0000' N - 75° 32.8666' W west of Beach Slough; running southeasterly and passing near Beacon "2" in Chicamicomico Channel to a point 35° 35.0000' N - 75° 29.8833' W west of the Rodanthe Pier; running southwesterly to a point 35° 32.6000' N - 75° 31.8500' W west of Salvo; running southerly to a point 35° 28.4500' N - 75° 31.3500' W on Gull Island; running southerly to a point 35° 22.3000' N - 75° 33.2000' W near Beacon "2" in Avon Channel ; running southwesterly to a point 35° 19.0333' N - 75° 36.3166' W near Beacon "2" in Cape Channel; running southwesterly to a point 35° 15.5000' N - 75° 43.4000' W near Beacon "36" in Rollinson Channel; running southwesterly to a point 35° 11.4833' N - 75° 51.0833' W on Legged Lump; running southeasterly to a point 35° 10.9666' N - 75° 49.7166' W south of Legged Lump; running southwesterly to a point 35° 09.3000' N - 75° 54.8166' W near the west end of Clarks Reef; running westerly to a point 35° 08.4333' N - 76° 02.5000' W near Nine Foot Shoal Channel; running southerly to a point 35° 06.4000' N - 76° 04.3333' W near North Rock; running southwesterly to a point 35°01.5833' N – 76° 11.4500' W near Beacon "HL"; running southerly to a point 35° 00.2666' N - 76° 12.2000' W; running southerly to a point 34° 59.4664' N - 76° 12.4859' W on Wainwright Island; running easterly to a point 34° 58.7853' N - 76° 09.8922' W on Core Banks; running northerly along the shoreline and across the inlets following the Colregs Demarcation line to the point of beginning.

(3) In Core and Back sounds, beginning at a point 34° 58.7853' N - 76° 09.8922' W on Core Banks; running northwesterly to a point 34° 59.4664' N - 76° 12.4859' W on Wainwright Island; running southerly to a point 34° 58.8000' N - 76° 12.5166' W; running southeasterly to a point 34° 58.1833' N - 76° 12.3000' W; running southwesterly to a point 34° 56.4833' N - 76° 13.2833' W; running westerly to a point 34° 56.5500' N - 76°13.6166' W; running southwesterly to a point 34° 53.5500' N - 76° 16.4166' W; running northwesterly to a point 34° 53.9166' N - 76° 17.1166' W; running southerly to a point 34° 53.4166' N - 76° 17.3500' W; running southwesterly to a point 34° 51.0617' N – 76° 21.0449' W; running southwesterly to a point 34° 48.3137' N - 76° 24.3717' W; running southwesterly to a point 34° 46.3739' N – 76° 26.1526' W; running southwesterly to a point 34° 44.5795' N – 76° 27.5136' W; running southwesterly to a point 34° 43.4895' N – 76° 28.9411' W near Beacon "37A"; running southwesterly to a point 34° 40.4500' N – 76° 30.6833' W; running westerly to a point 34° 40.7061' N – 76° 31.5893' W near Beacon "35" in Back Sound; running westerly to a point 34° 41.3178' N -76° 33.8092' W near Buoy "3"; running southwesterly to a point 34° 39.6601' N – 76° 34.4078' W on Shackleford Banks; running easterly and northeasterly along the shoreline and across the inlets following the COLREGS Demarcation lines to the point of beginning;

(4) Within 200 yards of any shoreline, except from October 1 through October 31, south and east of Highway 12 in Carteret County and south of a line from a point 34° 59.7942' N - 76° 14.6514' W on Camp Point; running easterly to a point at 34° 58.7853' N - 76° 09.8922' W on Core Banks; to the South Carolina State Line.

History Note: *Authority G.S. 113-134; 113-173; 113-182; 113-221; 143B-289.52;*
Eff. August 1, 2004.

5. GENERAL LIFE HISTORY

5.1 Description and Distribution

The red drum is one of twenty-two members of the drum family (Sciaenidae) that includes many of North Carolina's most important inshore commercial and recreational species. Species in this family are typically known as the drums, and other common drum species landed in North Carolina include weakfish, Atlantic croaker, spot, spotted seatrout, kingfishes (sea mullet), and black drum. Red drum and many others in this family produce drumming sounds by vibrating their swim bladders with special muscles. Other common names for red drum include channel bass, redfish, spottail bass, and puppy drum. Red drum are common along the Atlantic coast over a wide range of habitats from Chesapeake Bay to Key West, Florida. Historically, landings reached as far north as Massachusetts and there was a moderate commercial fishery off the coast of New Jersey in the 1930's. There are few reports of landings from areas north of Chesapeake Bay since the 1950's suggesting a decline in red drum distribution along the Atlantic coast.

5.2 Reproduction and Development

Red drum spawning has long been accepted to occur at night in high salinity areas in or around the major estuarine passes and inlets (Pearson, 1929; Johnson, 1978). There is now evidence that substantial spawning activity may take place inside the estuaries. Red drum have been collected in spawning condition inside Hatteras and Ocracoke Inlets and near the mouths of bays and rivers on the western side of Pamlico Sound (Ross et al., 1995). Researchers using hydrophones to detect spawning sounds documented spawning activity of red drum near Ocracoke Inlet and on the western side of Pamlico Sound near Bay River (Figure 1). Eggs captured during this survey were identified as red drum eggs and provide further evidence of spawning activity within the estuary (Luczkovich et al., 1999). In 2003 and 2004, additional hydrophone surveys were conducted in the lower Neuse River estuary. Results for these years found spawning aggregations of red drum occurring in the lower Neuse River in an area ranging from Oriental to the river mouth (Barrios 2004).

Laboratory tests show optimal conditions for spawning are salinities ranging from 25-35 ppt and temperatures between 22-30 °C (Holt et al., 1981). Documented spawning activity in Pamlico Sound during 2003 and 2004 occurred in salinities ranging from 20 to 25 ppt (Barrios 2004). The buoyant eggs are small (approximately 1 mm in diameter) and hatch within 24 to 36 hours of fertilization. Larvae, while found over a wide range of salinities (0-33 ppt) in North Carolina (Ross and Stevens, 1992), have been shown in laboratory experiments to have optimum growth and survival at salinity levels between 5-10 ppt (Neill, 1987). Larvae are distributed throughout the estuary by tidal and wind driven currents. The majority are transported to the upper reaches of the estuary where they settle out in shallow, low-salinity nursery areas with

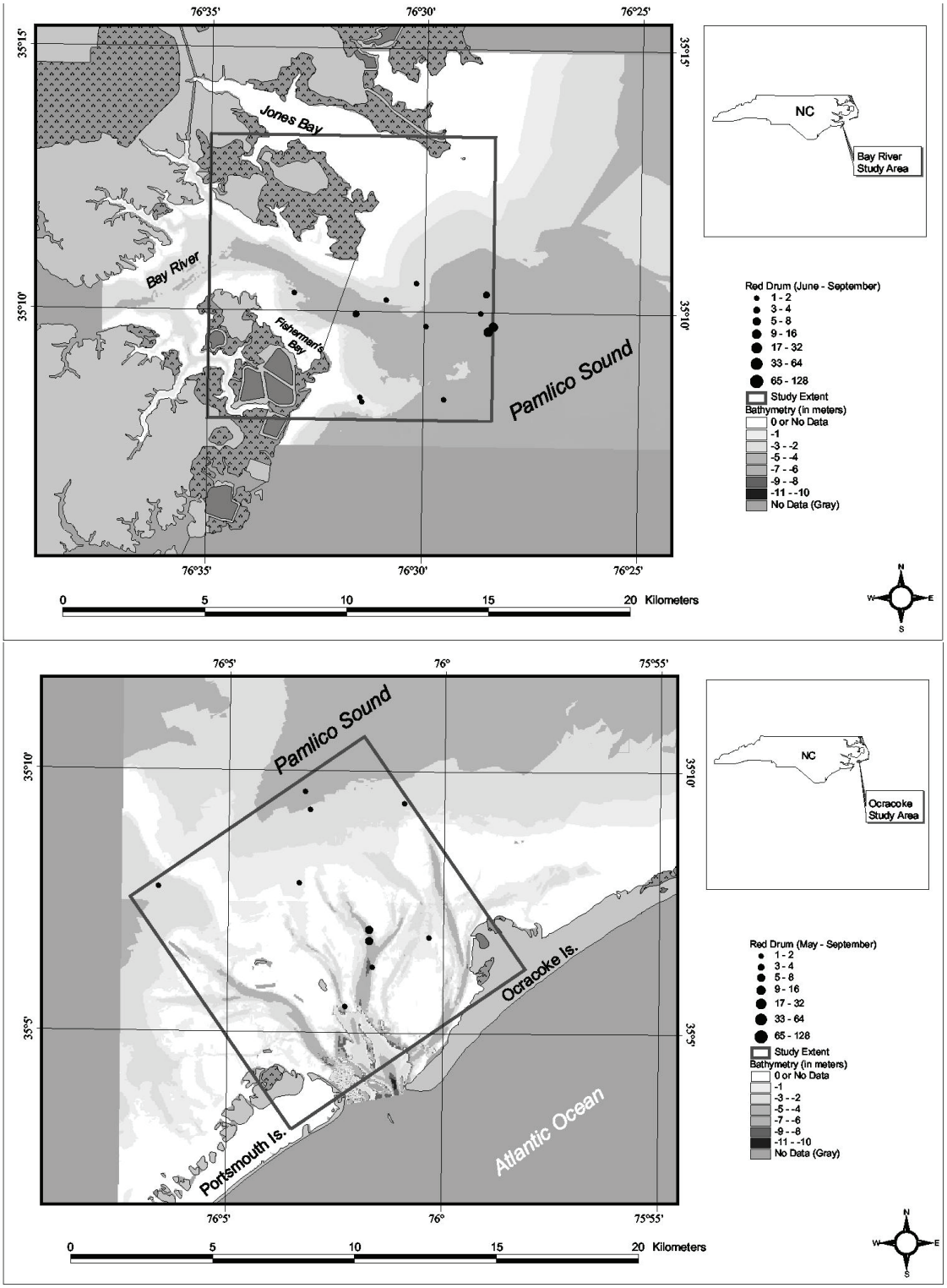

Figure 1. Red drum spawning sites identified in the Bay River and Ocracoke Inlet areas through acoustic sampling (Luczkovich et al., 1999).

abundant food supplies, such as coastal creeks, protected bays with sandy or muddy bottoms, and grass beds (Mercer, 1984; Daniel; 1988; Wenner et al., 1990; Ross et al., 1992).

Red drum are eurythermal and have been collected over a wide range of temperatures ranging from 2° C to 33° C (Simmons and Breuer, 1962). During extreme cold conditions in the winter, small juvenile red drum leave the shallow water habitats for channels and other deep water areas and then return to shallow water areas the following spring as water temperatures rise (Wenner et al., 1990). The distribution of larvae and juveniles in the estuary varies seasonally as the fish grow and disperse. In North Carolina, juvenile red drum are found year-round over a wide range of salinity and habitats, although they generally prefer the shallow shorelines of the various bays and rivers, and the shallow grass flats behind the barrier islands (Ross and Stevens, 1992).

Red drum grow rapidly during their first year, reaching 9-10 inches TL by early summer when they leave the shallow nursery grounds, and 12 to 14 inches TL by their first birthday in September. The legal size limit of 18 inches TL is reached when they are around 20 months old during the late fall and early spring (Daniel, 1988; Wenner et al., 1990; Ross et al., 1995), and most grow beyond the maximum size limit of 27 inches TL during their second full year of life. Red drum mature 1-2 years later at 3 to 4 years old and 30 to 36 inches TL (Ross et al., 1995). Once mature, red drum tend to spend more time in the ocean but are still estuarine dependent as they come inshore to feed, develop, and spawn. The oldest red drum aged was captured in North Carolina waters and was 62 years of age (Ross et al., 1995).

5.3 Diet and Food Habits

The diet of red drum during various stages of development has been studied by Daniel (1988), Music and Pafford (1984), and reported in SAFMC (1990). Stomach content analysis shows that dominant food sources coincide with habitat changes. Early juveniles 0.2-0.6 inches TL preyed on copepods, while mysids, small benthic shrimp common in salt marsh, were the dominant food source for juveniles 0.6-1.2 inches TL. The diet preference shifts to fish for red drum between 3.0-6.0 inches TL, coinciding with movement out of shallow marshes and into deeper creeks in the winter. Decapod crustaceans, predominantly mud crabs and fiddler crabs, comprise 96% of the diet of red drum between 7.9-11.8 inches TL. Red drum over 11.8 inches TL depend on a more diverse food base, although they remain a predominately benthic feeder. Overall, crustaceans comprised 72% of their prey, fish comprised 17% and plant matter comprised 11%. Fiddler crab and mud crab were the overall predominant prey. Diet work specific to red drum in North Carolina is currently lacking and any future life history studies should attempt to fill this void.

5.4 Migration Patterns

The movements of juvenile and adult red drum were summarized by Mercer (1984) and described from tagging studies conducted by NCDMF from 1986 through 1995 (Ross and Stevens, 1992; Marks and DiDomenico, 1996; Burdick et al., 2007). Tagging studies in North Carolina, consist of two segments: tagging of one-year old sub-adult red drum by Division staff, and tagging of adult red drum by anglers participating in a state-sponsored volunteer tagging program. More than 45,000 red drum have been tagged since the mid-1980's with an overall recapture rate of 11%. Recapture rates decrease with increasing fish size and are 18% for sub-legal size fish (<18 inches), 13% for legal size (18-27 inches) and 2% for red drum over the slot limit of 27 inches (Burdick et al. 2007).

Most of the DMF tagging effort has been concentrated from June through October in the Pamlico and Neuse rivers and over grass flats behind the barrier islands of Pamlico Sound, while tagging efforts by the volunteer participants have occurred year round throughout state coastal waters. Late age 0 and age 1 red drum show limited movement for most of the year although movement tends to increase in the fall. During 1991-1995, over 65% of tagged red drum under 18 inches were recaptured within 10 km of the release site. Late age 0 and age 1 red drum are common throughout the shallow portions of North Carolina's estuaries and are particularly abundant along the shorelines of rivers and bays, in creeks, and over grass flats and shoals common in many of the sounds. Tag returns indicate that in the fall a portion of the sub-adult fish residing in the rivers move toward higher salinity areas such as the grass flats and shoals of the barrier islands and inlets and the surf. Sub-adults residing near coastal inlets and barrier islands during the summer likely enter the surf in the fall. Tag return rates are low during winter, with most returns coming from sub-adults recaptured in the estuaries and a few taken in the surf and inlets. During spring and summer, recaptures are common along the barrier islands, near coastal inlets, and in the surf zone, with a large number of the sub-adults continuing to be recaptured in the rivers. Red drum of age 2 to 3 have generally left the coastal rivers and are recaptured along the barrier islands, the shallow water areas around the outer bars and shoals of the surf, and in coastal inlets, over inshore grass flats, creeks or bays.

Movements of adult red drum have been documented through recreational and commercial landings records and through the state-sponsored volunteer tagging program. During the spring adult red drum occur along the beaches and inlets for one to two months as they move from offshore wintering grounds and appear in recreational catches of surf fishermen primarily from Cape Lookout to Cape Hatteras. Large aggregations have been observed around Ocracoke, Hatteras, and Oregon inlets. A large portion of the population moves inside Pamlico Sound during the summer months, while other schools of fish are reported to continue moving north to the Chesapeake Bay and the Virginia barrier islands. Schools of adult fish are common in coastal inlets and in Pamlico Sound, particularly in the mouth of the Pamlico and Neuse rivers, during the spawning season in August and September. By late September most adult drum are found around the coastal inlets and along the beaches where they remain through November before moving offshore for winter. Mercer (1984) documented schools of large red drum moving south from Virginia waters and along the coastal beaches of the Outer Banks during the fall. Anglers have reported catches of large red drum during December around the shoals and outer bars of the barrier islands and around submerged structures up to a couple of

kilometers offshore. By late December, most large red drum have moved offshore where they are no longer available to near-shore fishing activity.

6. STATUS OF STOCKS

The most recent stock assessment indicates that the red drum stock in North Carolina is no longer experiencing overfishing and that the current escapement level of juvenile fish to the adult stock is near the target of 40% (Takade and Paramore 2007; see Appendix 2). Information necessary to estimate abundance at age for adult red drum and calculate spawning stock biomass (SSB) are lacking because slot limits restrict the age classes that may be harvested and fishery-independent survey data are not available for the adult fish. Therefore, the primary benchmarks used in determining the status of red drum are spawning potential ratio (SPR) and escapement or survivability to age 4. It is important to note that due to the lack of information on the adult fish, SPR values reported are not a reflection of the current spawning stock, but an estimate of the SPR that would result if all sources of mortality (fishing and natural) present during the assessment period continue to be static.

Although early assessments evaluated the Atlantic Coastal red drum population as a single stock, recent assessments are divided into Northern (NC to MD) and Southern (SC to FL) components to better account for the limited migration of the species (Vaughan 1996). Northern region assessment results are largely representative of the North Carolina stock, since North Carolina accounts for virtually all the commercial landings, the majority of the recreational landings, and the only fishery-independent data that are available for the region.

The northern red drum stock was assessed using commercial, recreational, and independent data from 1986 to 2005. Results were broken into three regulatory periods with relatively uniform regulations [early: 1986-1991, mid: 1992-1998, and late: 1999-2005 (Table 1)]. A major assumption in this assessment was assigning an accurate length distribution to released fish from the recreational fishery. While several assumptions on the length distribution of recreational releases were calculated, the preferred matrix (Tagging) used length frequencies estimated from modeling of North Carolina Division of Marine Fisheries (NCDMF) tag returns. Late period age-3 selectivity was estimated to be 0.48 of fully selected fish (age-2), and was estimated from modeling of NCDMF tag returns (Burdick et al. 2007). Two models were used: a backward calculating virtual population analysis (VPA) and a forward calculating spreadsheet catch-at-age model. Both models were updated from the Vaughan and Carmichael (2000) assessment. Fishing mortality (F) estimated from FADAPT ranged from 0.50 to 0.49, with escapement ranging from 40.6% to 41.0% and static spawning potential ratio (SPR) ranging from 40.4% to 40.8%. The spreadsheet catch-at-age model F estimates ranged from 0.66 to 0.63, with escapement estimated at 32.8% and static SPR estimated at 32.3%. All estimated runs using the TAGGING matrix from both models were above the threshold of 30% static SPR and the FADAPT estimates were above the target of 40% static SPR. All runs showed improvements in escapement and SPR from the previous regulation period (1992-1998).

Table 1. Primary harvest limits for recreational and commercial fisheries within each of the regulation periods

Regulation period	Recreational regulations	Commercial regulations
1987-1991	14 in TL minimum size limit Only 2 fish over 32 in TL	14 in TL minimum size limit
1992-1998	18-27 in TL window limit 5 fish bag limit 1 fish >27 in TL allowed	250,000 lb commercial cap 18-27 in TL window limit 1 fish >27 in TL allowed (no sale)
1999-2005	18-27 in TL window limit 1 fish bag limit	18-27 in TL window limit daily trip limit (7 fish since 2001)

The red drum stock in North Carolina has responded to increased regulations since the early 1990's (Figure 2). The current red drum assessment indicates that F has decreased and escapement and static SPR have increased for the red drum northern stocks since the current (1999 - 2005) management was implemented. Current estimates are all above 30% static SPR and therefore, indicate that overfishing is not occurring. In contrast, during the earliest assessment period of 1987 to 1991, SPR was estimated at only 1.2%. This low estimate was primarily attributed to excessive fishing mortality on age-1 red drum. During the mid-period (1992 – 1998) SPR estimates were 18%, an improvement, although, still well below the overfishing definition of 30% SPR.

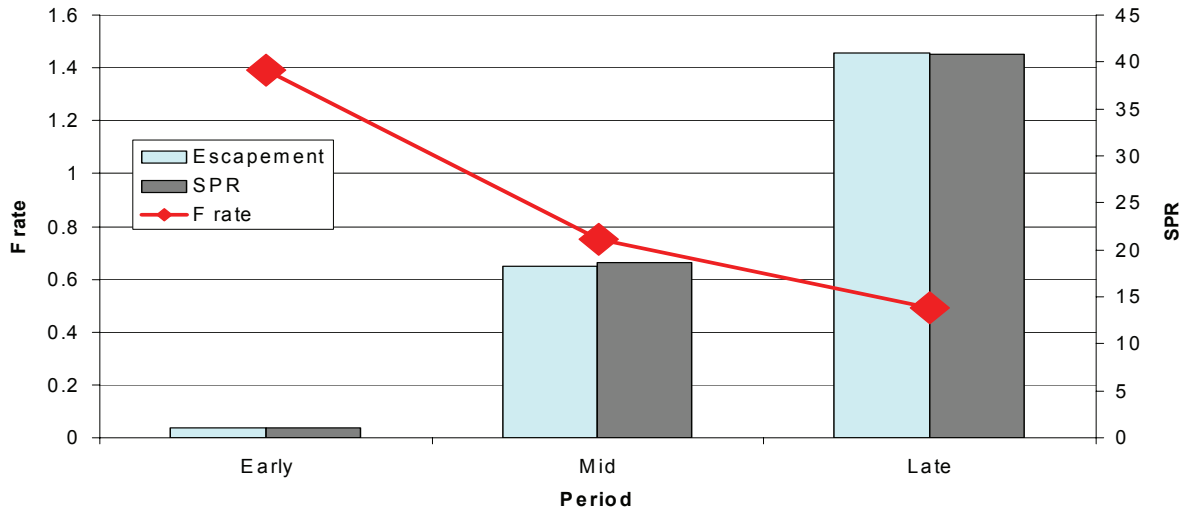

Figure 2. Summary of the stock status for the northern region red drum stocks during the early (1987 – 1991), mid (1992 – 1998) and late (1999 – 2005) regulatory periods.

In addition to traditional stock assessment techniques, the DMF has tagged red drum in estuarine waters since 1983 to determine both migration patterns and estimate mortality of the exploited age classes. Recent analysis and modeling by Bacheler et al. (2008) was conducted to determine both the selectivity and fishing mortality at age from tagging data for red drum in each of the regulatory periods. Results indicate that the increase in minimum size and reduction in the recreational bag limit put into place after 1991 acted to lower the selectivity and substantially reduce the fishing mortality rate on age-1 fish. Further harvest restrictions in 1998 acted to further decrease selectivity and fishing mortality on age-1 fish. A significant drop in fully recruited age-2 fish was not evident in this analysis. However, there was a reduction in the overall fishing mortality for fish moving through the slot limit. Results of the tagging data were consistent with the results of the 2007 North Carolina red drum stock assessment, indicating an increase in escapement and spawning potential ratio from the mid to late regulation period.

It appears that the condition of the northern red drum stock has improved and that the more restrictive management measures implemented during the late period (1999-2005) have aided in that improvement. Quantitative assessment results, tag-based survival estimates, and survey data all indicate that the conditions that led to overfishing during the prior management periods of 1987 to 1998 are no longer occurring. The current stock status indicates that SPR and escapement estimates have responded to regulatory changes and that the current level of fishing mortality is sufficiently low to sustain the fishery. It is critical to note however, that reaching the target is only the first step in maintaining this fishery. In order for the red drum stock to be considered healthy and viable, the 40% SPR target must be maintained continuously over time. Increases in the harvest rates (relaxation of current regulations) of red drum should only be allowed if those increases are not anticipated to lower the SPR values below the overfishing definition.

7. DESCRIPTION OF FISHERIES

7.1 Commercial Fishery

A directed red drum fishery does not exist in North Carolina today and historically red drum made up only a small portion of North Carolina's total commercial landings. Along the Atlantic coast however, North Carolina's red drum landings are highest for all states accounting for 96% of red drum commercially harvested from 1999 to 2005 (Table 2). Commercial landings of red drum in North Carolina fluctuated annually from 1972 to 2005, averaging 161,433 pounds (lb) and ranging from 19,637 lb in 1977 to 372,942 lb in 1999 (Figure 3).

The first commercial fishery regulations were implemented in 1976 and included a minimum size limit of 14 inches (in) total length (TL) and imposed a possession limit of two fish greater than 32 in TL. Prior to this limit on adult fish, Outer Banks fishermen occasionally targeted large red drum with long haul seines in Pamlico Sound (SAFMC 1990). Management remained unchanged until the 1990's. In 1990, a 300,000 lb commercial cap was established and no more than one fish greater than 32 in TL could be harvested. The commercial cap was originally implemented to prevent North Carolina's commercial red drum fishery from

expanding beyond historical harvest levels. At the time, southern red drum markets (i.e. Florida) were prohibiting the sale of red drum, increasing the demand from other areas. A stock assessment conducted for the period of 1987-1991 indicated that overfishing was occurring. As a result, North Carolina implemented an 18 – 27 in TL slot limit, with an allowance for possession but no sale of one fish over 27 in TL and further reduced the annual commercial cap to 250,000 lb. An updated assessment evaluated these changes and used data for the period of 1992-1998. Results indicated that, while showing marked improvement, the red drum fishery continued to be overfished. In the fall of 1998 North Carolina began development of a state FMP. The first action taken in the plan was to reduce harvest and divert overfishing. In October of 1998 new management measures were put into place by the NCMFC. Daily trip limits were established and possession of red drum over 27 in TL was prohibited. Daily trip limits originally set at 100 pounds per day were later reduced due to annual cap overages and the current seven fish per day limit has been in place since 2001. Additionally, targeting of red drum was prohibited by requiring that the total weight of red drum make up no more than 50% of the total marketable catch (excluding menhaden) for each trip. As a result of these regulatory changes, North Carolina's regulatory history can easily be summarized into three distinct management periods from which data are available for assessments: 1987-1991, 1992-1998, and 1999-2005 (see Table 1 in Section 6).

With the changes in regulations over the years, the size structure of the commercial harvest has also shifted towards larger fish (Figure 4). During the initial management period of 1987-1991 most red drum harvested were ~14 in TL and one year in age. Very few fish were harvested at the upper end of the slot limit. When the size restrictions changed (18 – 27 in TL) in 1992, the modal length for red drum harvested shifted to 19 in TL and two years in age. As a result of decreasing the available sizes that can be retained within the slot limit, landings were now primarily from a single year class of fish and dependent upon year class strength from a single cohort. While the regulatory changes in 1999 did not change the legal size limits, the reductions in harvest resulting from the daily trip limit did correspond with a shift in the modal length of harvested fish from 19 to 23 in TL. In addition, fish at the upper end of the slot limit that were once rare in the landings are now commonly encountered.

Table 2. Annual commercial landings (lb) of red drum by state along the mid-Atlantic coast.

Year	RI	NY	NJ	DE	MD	VA	NC	SC	GA	FL*	Total
1972	-	-	-	-	-	5,900	42,919	1,200	3,400	128,400	181,819
1973	-	-	-	900	-	6,200	70,264	600	3,700	166,500	248,164
1974	-	-	-	-	-	15,700	142,437	2,300	3,100	137,300	300,837
1975	-	-	-	200	-	19,600	214,236	12,400	10,000	83,300	339,736
1976	-	-	-	-	-	18,600	168,259	2,600	7,300	106,000	302,759
1977	-	-	-	200	-	300	19,637	800	5,000	103,500	129,437
1978	-	-	-	300	-	2,100	21,774	4,325	328	104,696	133,523
1979	-	-	-	-	100	1,900	126,517	1,767	935	92,684	223,903
1980	-	-	-	-	-	400	243,223	4,107	1,493	191,222	440,445
1981	-	-	-	-	-	200	93,420	-	261	258,374	352,255
1982	-	-	-	-	-	1,700	52,561	2,228	251	139,170	195,910
1983	-	-	-	-	100	41,700	219,871	2,274	1,126	105,164	370,235
1984	-	-	-	-	-	2,600	283,020	3,950	1,961	130,885	422,416
1985	-	-	-	-	-	1,100	152,676	3,512	3,541	88,929	249,758
1986	-	-	-	-	1,000	5,400	249,076	12,429	2,939	77,070	347,914
1987	-	-	-	-	-	2,600	249,657	14,689	4,565	42,993	314,504
1988	-	-	-	-	8,100	4,000	220,271	-	3,281	284	235,936
1989	-	-	-	-	1,000	8,200	274,356	165	3,963		287,684
1990	-	-	-	-	29	1,481	183,216	-	2,763		187,489
1991	-	-	-	-	7,533	24,771	96,045	-	1,637		129,986
1992	-	-	-	-	1,087	2,352	128,497	-	1,759		133,695
1993	-	-	-	-	55	8,637	238,099	-	2,533		249,324
1994	5,094	-	-	-	859	4,080	142,119	-	2,141		154,293
1995	-	668	-	-	6	2,992	248,122	-	2,578		254,366
1996	-	8	-	-	215	2,073	113,338	-	2,271		117,905
1997	43	-	-	-	22	4,049	52,502	-	1,395		58,011
1998	165	57	311	-	336	6,436	294,366	-	672		302,343
1999	-	47	241	6	504	12,368	372,942	-	1,115		387,223
2000	-	1,215	-	-	843	11,457	270,953	-	707		285,175
2001	-	58	14	-	727	5,318	149,616	-	-		155,733
2002	-	116	-	-	1,161	7,752	81,364	-	-		90,393
2003	-	43	-	-	631	2,716	90,525	-	-		93,915
2004	-	-	-	-	12	638	54,086	-	-		54,736
2005	-	-	-	-	37	656	128,770	-	-		129,463
Total	5,302	2,212	566	1,606	24,357	235,976	5,488,734	69,346	76,715	1,956,471	7,861,285

*Florida landings are for the East coast of Florida only.

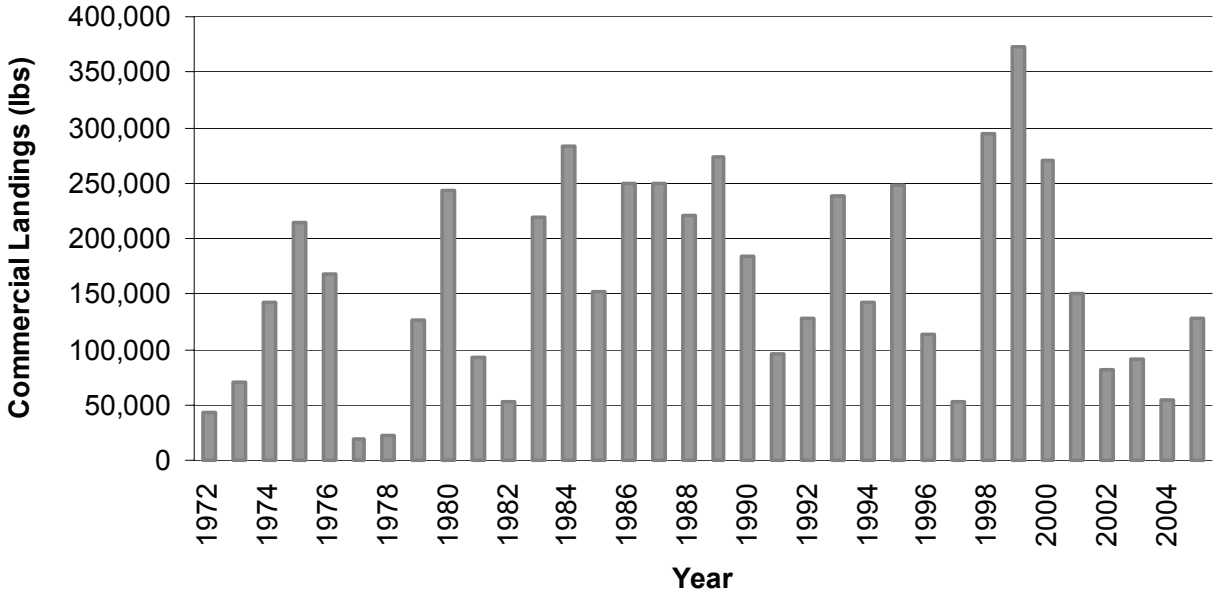

Figure 3. Annual commercial landings of red drum in North Carolina.

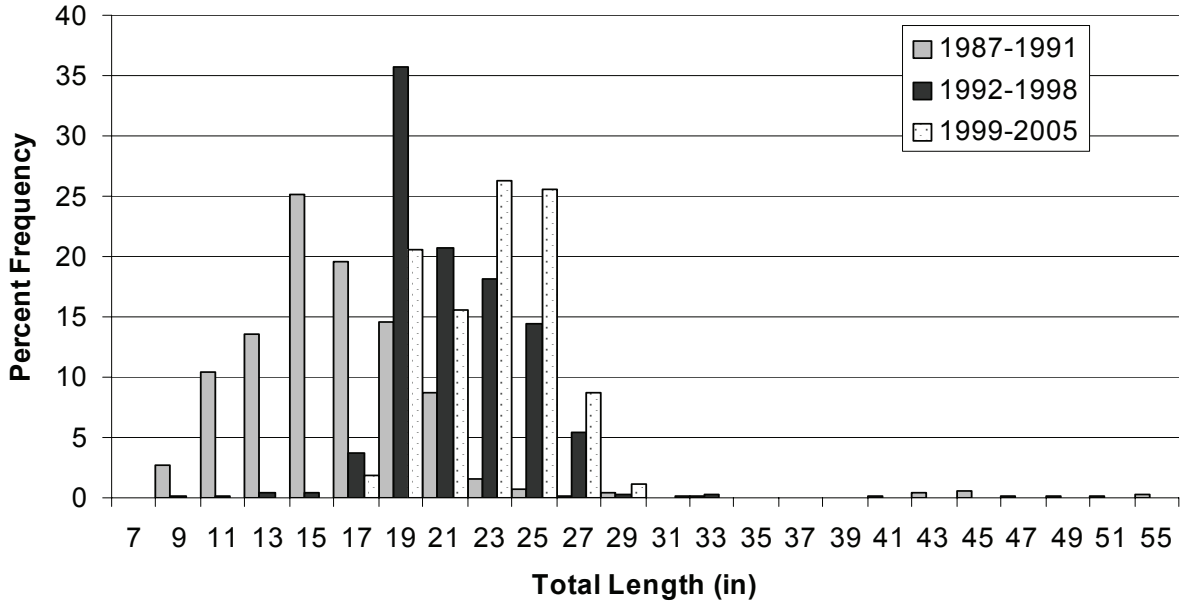

Figure 4. Length frequency of red drum sampled from the North Carolina commercial harvest (all gears combined) for the periods 1987-1991, 1992-1998, and 1999-2005.

Red drum have been harvested over the years using a variety of commercial gears. Throughout the 1970's long haul seines and common haul seines were generally the most productive gears, while gill nets, pound nets and trawls were also commonly used (ASMFC

2002). Since the 1980's, gill nets have become the dominant gear. In the years leading up to the implementation of daily trip limits in 1999, nearly one-half of the total annual commercial harvest of red drum was harvested by a small number of trips with high landings. Nearly half of all red drum landings (48.5%) from 1994 to 1998 occurred in only 1.1% of the total number of trips that harvested red drum. Runaround gill nets became a significant contributor to the red drum commercial harvest during this time (Figure 5). The runaround gill net and long haul seine fisheries typically had the largest individual trips of red drum landings during this time because of their effectiveness in encircling large schools of red drum. Participation in the runaround gill net fishery increased in the mid-1990's as fishermen actively pursued schools of red drum. The largest landings occurred in the estuarine waters from Oregon Inlet to Ocracoke (Table 3). During this time there were a few exceptional long haul seine catches of up to 10,000 lb. A typical catch for a runaround gill net trip ranged from 100 to 1,000 lb per trip with several catches up to 5,000 lb. Now that regulations prohibit targeting, red drum are most commonly encountered as bycatch in the southern flounder estuarine gill net fishery but are also still common bycatch in many of the gears in which they were traditionally captured.

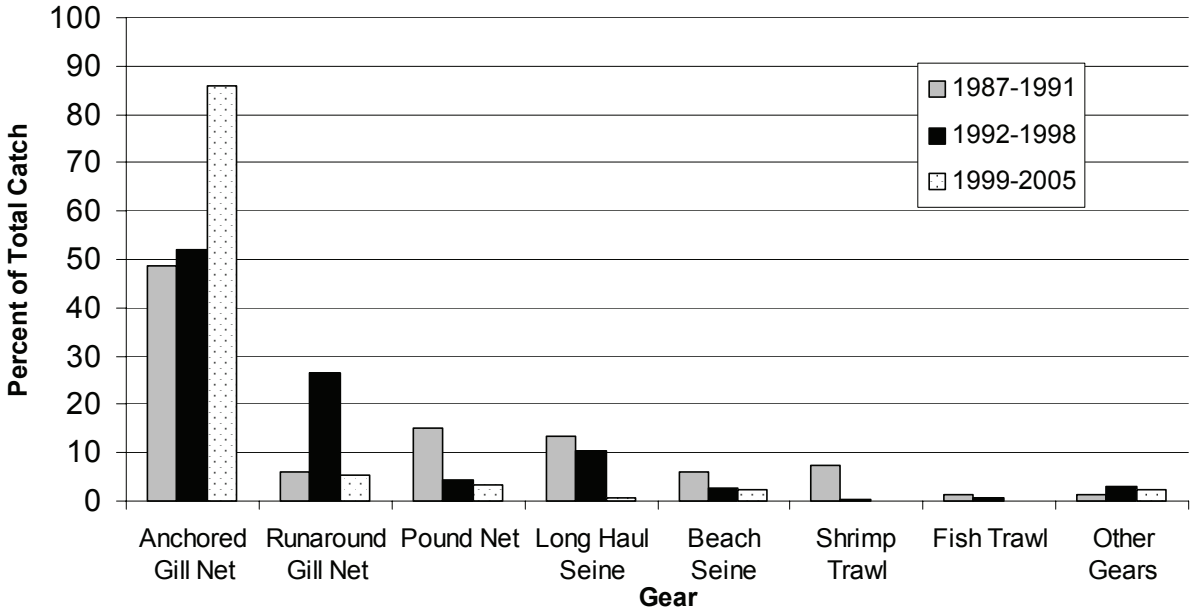

Figure 5. Percent landings of red drum by gear type for each harvest period.

Table 3. Percentage of commercial landings of red drum in North Carolina by major water bodies.

Year	Albermarle Sound	Atlantic Ocean	Core Sound	Croatan and Roanoke Sounds	Pamlico Sound	Pamlico/ Neuse River	Bogue Sound south	Unknown	Total
1972	0.70	40.39	20.07	0.23	34.32	4.04	0.24	-	100
1973	0.24	46.69	31.79	0.31	19.41	1.21	0.35	-	100
1974	0.65	24.87	29.06	5.61	36.57	2.22	1.02	-	100
1975	6.17	50.97	10.58	2.54	25.12	4.23	0.39	-	100
1976	18.22	16.56	3.01	2.46	32.57	26.28	0.89	-	100
1977	-	31.84	20.81	0.96	33.13	12.54	0.72	-	100
1978	-	71.69	8.97	-	14.97	4.37	-	-	100
1979	0.08	21.06	39.47	0.40	27.86	10.87	0.27	-	100
1980	-	29.26	27.12	0.06	36.44	6.78	0.34	-	100
1981	-	29.85	12.97	-	53.39	3.41	0.39	-	100
1982	0.33	58.57	17.32	0.21	14.43	5.61	3.54	-	100
1983	0.82	31.54	26.87	0.53	24.27	3.33	12.65	-	100
1984	0.25	58.39	19.68	0.85	7.16	2.60	11.08	-	100
1985	0.03	47.78	21.47	0.02	9.45	0.76	20.48	-	100
1986	1.68	27.81	20.78	0.23	24.65	11.19	13.66	-	100
1987	13.03	16.78	19.51	2.17	28.85	8.26	11.41	-	100
1988	5.02	23.19	26.03	0.60	24.96	9.12	11.08	-	100
1989	3.57	19.31	23.02	1.50	35.68	7.14	9.77	-	100
1990	0.43	26.04	21.79	1.16	35.34	1.88	13.37	-	100
1991	5.56	13.95	22.44	1.03	36.94	1.57	18.51	-	100
1992	9.37	10.75	13.32	3.19	47.02	1.99	14.34	-	100
1993	19.07	15.08	6.65	5.75	41.23	2.54	9.68	-	100
1994	6.74	24.39	4.76	0.71	51.75	4.02	7.63	-	100
1995	1.75	10.73	8.51	1.33	63.39	6.73	7.56	-	100
1996	1.26	15.20	12.71	0.46	42.75	7.33	20.28	<0.01	100
1997	0.70	13.39	22.77	2.73	40.02	6.83	13.56	-	100
1998	6.94	2.27	3.39	5.29	76.40	2.84	2.87	-	100
1999	19.64	1.90	6.17	11.42	50.06	7.16	3.66	-	100
2000	9.38	10.40	5.92	15.73	46.14	7.65	4.77	-	100
2001	7.82	4.83	9.01	20.65	43.00	9.53	5.15	-	100
2002	9.68	2.68	10.28	14.09	32.02	20.01	11.24	-	100
2003	6.31	3.62	8.88	16.63	33.86	15.13	15.55	-	100
2004	3.09	5.73	10.48	12.71	47.16	6.35	14.47	-	100
2005	6.11	2.37	14.71	5.33	40.05	18.55	12.87	-	100

7.2 Recreational Fishery

Red drum are targeted by recreational anglers year-round throughout the sounds, rivers, and beaches of North Carolina. Angling methods used to catch red drum, include conventional, spinning, and fly tackle; using live, dead, and artificial bait. Red drum are consistently reported as one of the top target species by shore-based recreational anglers, and were the number one or two target species in 1993, 1995, 1996 and every year from 1999 to 2003 (National Marine Fisheries Service, Fisheries Statistics Division, personal communication).

Recreational fishermen must adhere to the same slot limit (18 to 27 in TL) as commercial fishermen and are allowed to harvest one fish per person per day. From 1992 to 1998 when there was a five fish creel limit, recreational landings averaged 286,548 lb and accounted for approximately 60% of the total red drum harvested in North Carolina. After the creel limit was reduced to one fish per day, annual landings dropped to an average of 204,725 lb for the period of 1999 to 2005, accounting for 56% of total red drum landed in North Carolina.

Similar to the commercial fishery, recreational landings vary annually in response to changes in year-class abundance. For example, landings increased from 39,077 lb in 1997 to 591,428 lb in 1998 (Table 4). Unlike the commercial landings, North Carolina does not dominate harvest of red drum in the recreational fishery along the Atlantic coast (Table 5). North Carolina landings only accounted for 14% of the recreational harvest by weight for the Atlantic Coast from 1999 to 2005. South Carolina (16%) and Georgia (14%) had a similar average, while the east coast of Florida dominated with 50% of the catch, averaging 718,498 lb per year.

Compliance with the 18 in minimum size limit varies by year, but has improved on average in recent years. Undersized red drum accounted for 19% of the recreational harvest from 1994 to 1998, ranging from 1% in 1998 to 35% in 1997. Undersized red drum accounted for only 3.4% of the harvest from 1999 to 2005, ranging from a low of 0% in both 2003 and 2005 to a high of 5.5% in 1999.

Prior to the prohibition of red drum greater than 27 inches TL in 1999, North Carolina offered award citations for red drum captured weighing 45 lb or greater. A citation could also be received for the release of a captured red drum greater than 40 in TL. As of 1999, all award citations are for the releases only. The NCDMF citation data show an increasing trend in the number of release citations issued prior to 1999 indicating an increasing tendency by anglers to practice catch and release ethics (Table 6). In addition, release citations have increased substantially in 1999 and appear to be trending upward. While this trend appears encouraging, it is difficult to ascertain if this trend is due to increases in availability of large fish, increases in fishing effort or due to increased popularity of the citation program.

Table 4. Red drum catches for recreational anglers (MRFSS), for 1989 - 2005. All weights are in pounds. Commercial weights are included as a reference with combined weights reported.

	Recreational				
	Numbers		Weight (lb)		
	A + B1*	B2*	A + B1	Commercial	Total
Year	# Landed	# Released		Weight (lb)	Weight (lb)
1989	62,359	7,566	214,849	274,356	489,205
1990	33,149	12,452	302,994	183,216	486,210
1991	38,658	121,178	108,268	96,045	204,313
1992	23,593	60,230	109,134	128,497	237,631
1993	49,493	182,301	266,459	238,099	504,558
1994	28,953	107,662	192,060	142,119	334,179
1995	88,593	164,520	405,620	248,122	653,742
1996	36,746	35,752	204,556	113,338	317,894
1997	8,749	259,570	39,077	52,502	91,579
1998	114,638	199,701	591,428	294,366	885,794
1999	64,739	247,146	326,303	372,942	699,245
2000	61,618	203,967	316,029	270,953	586,982
2001	23,142	238,552	132,578	149,616	282,194
2002	42,541	640,857	182,226	81,364	263,590
2003	25,481	75,561	118,808	90,525	209,333
2004	30,165	191,593	114,434	54,086	168,520
2005	53,268	319,322	242,078	128,770	370,848

Definitions of recreational catch type:
*A = fish brought ashore in whole form which can be identified, enumerated, weighed, and measured by interviewers.
*B = fish not brought ashore that can be separated into: B1 = fish caught used as bait, filleted, or discarded & B2 = those released alive.

Table 5. Recreational harvest (pounds of A + B1 fish) of red drum along the Atlantic coast, 1981-2005 (NMFS, Office of Science & Technology).

Year	DE	MD	VA	NC	SC	GA	FLEC	Total
1981		4,370	347,939	31,519	50,230	9,442	317,963	761,463
1982				37,511	340,686	52,150	480,676	911,023
1983		3,018	51,299	109,540	222,691	67,298	675,924	1,129,770
1984			1,285	1,160,539	183,282	294,583	976,971	2,616,660
1985				70,677	1,532,316	185,887	414,176	2,203,056
1986		754,161	145,517	31,594	498,586	173,837	360,725	1,964,420
1987			44,332	200,729	913,639	250,795	227,222	1,636,717
1988			9,030	451,974	1,050,049	385,860	12,507	1,909,420
1989		2,348	27,236	214,849	396,771	127,245	146,064	914,513
1990		2,679		302,994	631,819	161,712	258,569	1,357,773
1991		5,635	30,582	108,268	284,290	337,207	516,999	1,282,981
1992			55,324	109,134	411,484	198,751	396,555	1,171,248
1993			45,505	266,459	282,614	328,245	290,930	1,213,753
1994			3,684	192,060	314,632	353,616	578,412	1,442,404
1995			66,270	405,620	417,595	300,337	525,231	1,715,053
1996			1,512	204,556	396,394	164,756	596,483	1,363,701
1997			1,810	39,077	296,155	129,836	345,390	812,268
1998			34,861	591,428	129,619	84,348	487,091	1,327,347
1999			92,794	326,303	103,777	166,630	540,310	1,229,814
2000			95,596	316,029	93,043	228,965	885,447	1,619,080
2001	860		51,890	132,578	188,198	155,854	853,714	1,382,234
2002	* 860	15,154	155,213	182,226	103,830	170,572	551,128	1,178,983
2003			57,214	118,808	449,399	234,865	729,445	1,589,731
2004			31,748	114,434	402,789	286,486	668,179	1,503,636
2005			7,463	242,078	310,586	190,411	754,756	1,505,294
Total	1,720	787,365	1,358,104	5,960,984	10,004,474	5,039,688	12,590,867	

* Weight estimated from same number of fish (275) caught in 2001

Table 6. The number of award citations issued on an annual basis for catches of red drum. Citations are awarded for releases ≥ 40 in and weigh-ins* ≥ 45 lb.

Year	# Citations	# Released	% Released
1987	215	150	70
1988	324	266	82
1989	335	275	82
1990	419	374	89
1991	335	308	92
1992	451	427	95
1993	644	627	97
1994	876	868	99
1995	622	607	98
1996	685	655	96
1997	737	704	96
1998	515	483	94
1999	1073	1073	100
2000	1200	1200	100
2001	1156	1156	100
2002	1330	1330	100
2003	1030	1030	100
2004	1337	1337	100
2005	1520	1520	100

*Due to regulations all citations since 1999 are for release only.

8. DESCRIPTION OF THE SOCIOECONOMIC CHARACTERISTICS OF THE FISHERY

8.1 Economic Aspects of the Fishery

8.1.1 Ex-Vessel Value and Price

Red drum is currently a commercial bycatch fishery in North Carolina; as such, its overall value is low relative to other species, though the price of red drum is higher than many targeted species. In terms of value, the fishery clearly had a high point in the late-nineties, with landings sometimes nearing or exceeding $400,000. Landings for 2005 were less than half of that, and recent years have been even smaller (Figure 6).

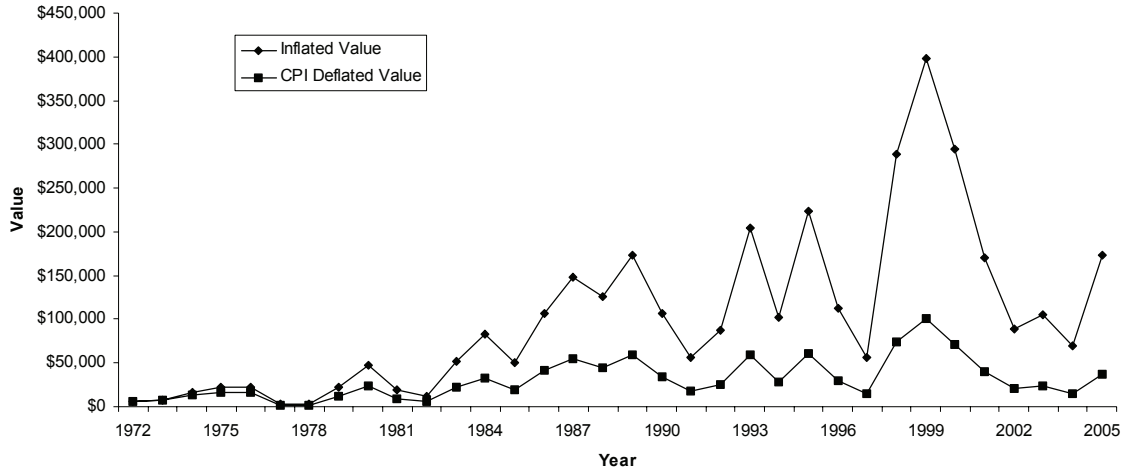

Figure 6. Value of red drum landings in North Carolina, 1972 – 2005. DMF Trip Ticket Program.

The price fetched for red drum has steadily increased in recent years, even accounting for inflation. Fishermen are now receiving the highest price on record ($1.34 per pound in 2005), probably because of the constricted supply of commercially available red drum due to the ban on the sale of red drum in South Carolina, Florida, Louisiana, Alabama, and Texas (Figure 7). The states of Mississippi, Georgia, Virginia, and North Carolina are the only sources of marketable red drum along the entire Atlantic and Gulf coasts. Rising prices have restored some of the value of the red drum fishery, though it is still smaller than its all-time highs (see Table 7, Figure 7).[1] As a bycatch fishery with a strict trip limit, the steadily rising price of red drum should have a minimal impact on fishermen's behavior.

1 The consumer prices index (CPI) is a standard tool of adjusting value to account for inflation over time. Ex-vessel value of landings are inflation-adjusted to 1972 because that is the first year that DMF began to have data for all state-managed species.

Table 7. Detail values of red drum landed, total value, deflated value, price per pound, and percent change from year to year for red drum landed in North Carolina, 1972—2005. DMF Trip Ticket Program.

Year	Inflated Value	Conversion	CPI Deflated Value	% Change Value	Inflated Price per Pound	CPI Price per Pound	% Change per Pound
1972	$5,228	1.0000	$5,228	---	$0.12	$0.12	---
1973	$7,775	0.9414	$7,320	40%	$0.11	$0.10	-14%
1974	$15,781	0.8479	$13,380	83%	$0.11	$0.09	-10%
1975	$21,537	0.7770	$16,733	25%	$0.10	$0.08	-17%
1976	$21,700	0.7346	$15,941	-5%	$0.13	$0.09	21%
1977	$2,673	0.6898	$1,844	-88%	$0.14	$0.09	-1%
1978	$2,480	0.6411	$1,590	-14%	$0.11	$0.07	-22%
1979	$21,728	0.5758	$12,510	687%	$0.17	$0.10	35%
1980	$47,133	0.5073	$23,910	91%	$0.19	$0.10	-1%
1981	$18,817	0.4598	$8,653	-64%	$0.20	$0.09	-6%
1982	$12,273	0.4332	$5,316	-39%	$0.23	$0.10	9%
1983	$51,958	0.4197	$21,806	310%	$0.24	$0.10	-2%
1984	$82,458	0.4023	$33,174	52%	$0.29	$0.12	18%
1985	$50,384	0.3885	$19,573	-41%	$0.33	$0.13	9%
1986	$106,808	0.3814	$40,735	108%	$0.43	$0.16	28%
1987	$148,205	0.3680	$54,533	34%	$0.59	$0.22	34%
1988	$125,289	0.3533	$44,269	-19%	$0.57	$0.20	-8%
1989	$173,755	0.3371	$58,572	32%	$0.63	$0.21	6%
1990	$106,450	0.3198	$34,044	-42%	$0.58	$0.19	-13%
1991	$56,989	0.3069	$17,490	-49%	$0.59	$0.18	-2%
1992	$86,859	0.2979	$25,878	48%	$0.68	$0.20	11%
1993	$203,955	0.2893	$58,999	128%	$0.86	$0.25	23%
1994	$102,326	0.2821	$28,861	-51%	$0.72	$0.20	-18%
1995	$223,310	0.2743	$61,249	112%	$0.90	$0.25	22%
1996	$112,881	0.2664	$30,073	-51%	$1.00	$0.27	7%
1997	$56,939	0.2604	$14,829	-51%	$1.08	$0.28	6%
1998	$288,397	0.2564	$73,957	399%	$0.98	$0.25	-11%
1999	$398,282	0.2509	$99,929	35%	$1.07	$0.27	7%
2000	$294,871	0.2427	$71,577	-28%	$1.09	$0.26	-1%
2001	$170,548	0.2360	$40,253	-44%	$1.14	$0.27	2%
2002	$89,192	0.2324	$20,724	-49%	$1.10	$0.25	-5%
2003	$105,671	0.2272	$24,006	16%	$1.17	$0.27	4%
2004	$69,753	0.2213	$15,435	-36%	$1.29	$0.29	8%
2005	$173,040	0.2140	$37,036	140%	$1.34	$0.29	1%

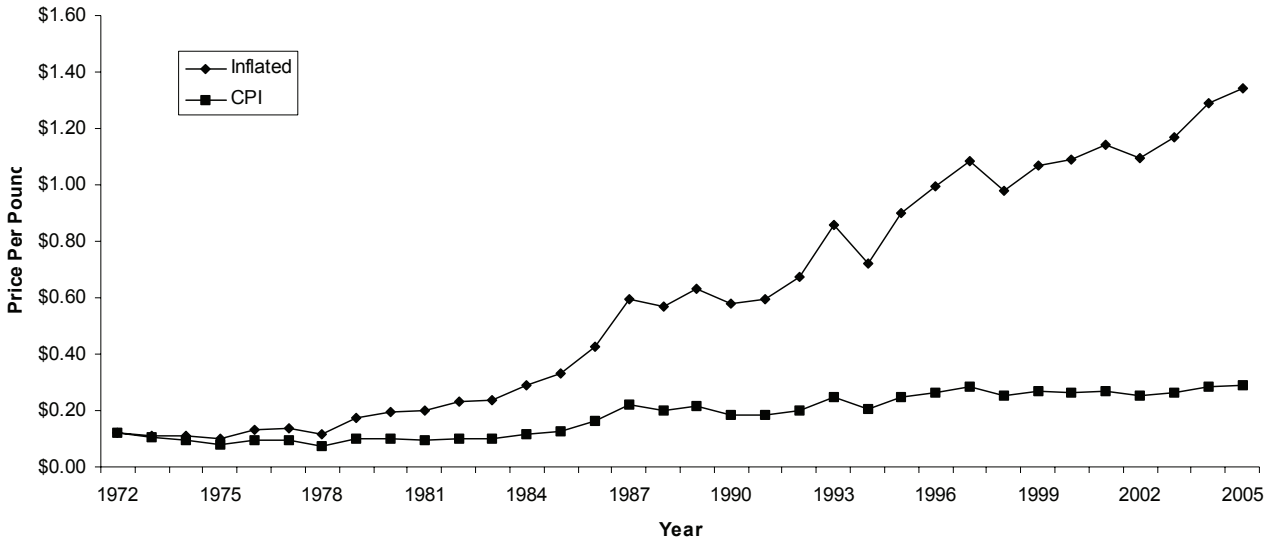

Figure 7. Average price per pound of red drum landings in North Carolina, 1972 - 2005. DMF Trip Ticket Program.

8.1.2 Participants and Trips

The Division of Marine Fisheries keeps rigorous track of the commercial catch levels of all fishermen in the state. Information is captured at the point at which catch is sold to the commercial dealer for every trip. This information can be broken down and categorized for a closer look at the patterns of behavior of fishermen in any particular fishery.

Table 8 shows the number of fishermen involved with the fishery since 1999, broken down by the number of individual trips that resulted in catching red drum in each year. Notice that these trips are still relatively rare - less than a third of the fishermen landed drum more than ten times in recent years. Red drum are generally landed as a bycatch of the flounder and striped mullet estuarine gill net fisheries.

Table 9 breaks down participants in this fishery by annual income from drum. The numbers are relatively small, reflecting the bycatch nature of the fishery. From 2001-2005, an average of 6,881 trips per year included a red drum landing, with an average value of $17.63 per landings. Those same trips averaged $148 in flounder landings.

Table 8. Number of participants and the number of trips taken that landed red drum in North Carolina, 1999 - 2005 (DMF Trip Ticket Program).

	Year						
	1999	2000	2001	2002	2003	2004	2005
1 Trip	247	274	205	190	183	165	157
% within Year	27%	28%	26%	26%	27%	32%	23%
2 - 10 Trips	425	452	360	357	315	262	304
% within Year	47%	46%	46%	49%	46%	51%	44%
11 - 20 Trips	105	107	90	104	90	46	117
% within Year	12%	11%	12%	14%	13%	9%	17%
21 - 50 Trips	94	114	86	62	68	30	83
% within Year	10%	12%	11%	8%	10%	6%	12%
51 - 100 Trips	33	24	31	22	24	9	29
% within Year	4%	2%	4%	3%	4%	2%	4%
More than 100 Trips	5	5	7	1	2	0	5
% within Year	1%	1%	1%	0%	0%	0%	1%
Total	909	976	779	736	682	512	691

Table 9. Number of participants in the red drum fishery by value of landings and year in North Carolina, 1999—2005. DMF Trip Ticket Program.

	Year						
	1999	2000	2001	2002	2003	2004	2005
$1 - $50	398	455	363	405	348	301	286
% within YEAR	44%	46%	47%	55%	51%	59%	41%
$51 - $100	110	131	113	125	108	75	102
% within Year	12%	13%	14%	17%	16%	15%	15%
$101 - $200	116	101	105	85	100	58	92
% within YEAR	13%	10%	13%	12%	15%	11%	13%
> $200	286	292	199	122	126	78	216
% within YEAR	31%	30%	26%	17%	18%	15%	31%
Total	910	979	780	737	682	512	696

As with any commercial fishery in the state, fishermen who land red drum may only sell their catch to licensed dealers. The number of dealers who handled red drum has remained stable for the past decade, fluctuating between 134 and 168 dealers in any single year (Figure 8.4). The dealers with the highest volume are in the areas that define Pamlico Sound.

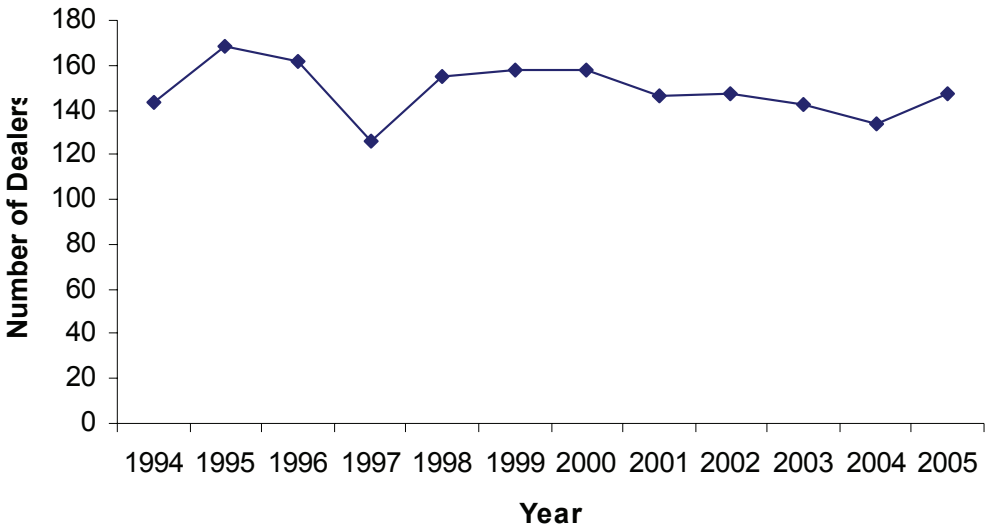

Figure 8. Number of dealers who purchased red drum from 1994—2005. DMF Trip Ticket Program.

8.1.3 Economic Impact of Commercial Fishery

Table 10 shows the economic impact of the red drum harvest to North Carolina's economy over the past six years. These impacts were calculated using IMPLAN, an economic modeling software. Trip ticket data includes crew sizes (on average between 1.2 and 1.4 for drum-landing trips), so the number of fishermen actually involved is slightly larger than the "participants" number the DMF uses to indicate the licensed commercial fishermen who sell fish to dealers. As the fishermen spend their earnings, these models project that additional economic impact until it leaves the state's borders, although the full impact is underestimated since there is no specific data available to track the flow of dollars between different commercial fishing business, nor a way to track the economic impact of business taxes for a particular species harvested. Since trips than land red drum are mostly comprised of other fish, the red drum harvest is essentially a "bump" that increases the value of other fisheries, and not a larger generator of money by itself.

In 2005, sales of red drum accounted for roughly one quarter of one percent of the total value of seafood landed commercially in North Carolina, which is not out of line with historical landings; red drum sales have never exceeded .4% of the state's total seafood production.

Table 10. Economic impact of the commercial red drum fishery in North Carolina, 2000—2005. DMF Trip Ticket Program, IMPLAN.

Year	Ex-Vessel Value	Fishermen (w/crew)	Total Statewide Impact	Additional Jobs Created
2000	$294,871	1234	$491,728	2.5
2001	$170,548	965	$284,333	1.5
2002	$89,192	964	$148,857	0.8
2003	$105,671	875	$175,617	0.9
2004	$69,753	664	$122,583	0.5
2005	$173,040	904	$307,347	1.3

8.1.4 Recreational Fishery Economics

The DMF collects data about recreational fishing in conjunction with the federal government's Marine Recreational Fisheries Statistics Survey (MRFSS). MRFSS estimates for red drum-targeting and red drum-landing recreational trips are in Table 11.

Table 11. Estimated number of red drum-related recreational fishing trips. MRFSS Program.

Year	Trips
2000	322,873
2001	190,192
2002	361,688
2003	170,633
2004	251,184
2005	289,773
2006	495,430

MRFSS occasionally includes a socioeconomic add-on to generate spending estimates. The most recent data available is from 2004. The average and total estimated expenditures per red drum-targeting and red drum-landing recreational trips in 2006 are shown in Table 12. It should be noted that expenditures in the recreational fishery are not comparable to the unexpanded ex-vessel value reported for the commercial fishery. Data necessary to determine the total economic impact of the red drum landings in the commercial fishery are currently not available.

Table 12. Estimated expenditures of drum-related recreational fishing trips. MRFSS Program.

Trip Type	Total Trips	Mean expenditures		Total Expenditures
Charter	17,908	$	577.94	$ 10,349,709.06
Shore	132,445	$	89.82	$ 11,895,856.52
Private	345,077	$	80.45	$ 27,763,011.17
	TOTAL EXPENDITURES			$ 50,008,576.75

Drum are also occasionally caught by holders of the Recreational Commercial Gear License (RCGL). RCGL fishermen use commercial gear (primarily gill nets and trawls) to catch fish and shrimp, but cannot sell their catch. A 2004 survey revealed the average expenditure for a drum-landing (but not necessarily drum-directed) RCGL trip to be $87.35. There were 5,003 RCGL trips that year that caught red drum, which would indicate $437,012.05 was spent overall, though most of that would have to be attributed to other species (primarily flounder) caught in those same nets.

8.2 Social Aspects of the Fishery

8.2.1 Commercial Fishermen

The socioeconomic program at the DMF has been conducting a series of in-depth interview-style surveys with commercial fishermen along the coast since 2001. Data from these interviews is added to a growing database and used for fishery management plans, among other uses. A total of 432 of the fishermen in the database have had commercial landings of red drum according to the trip ticket program. That group is used to provide a snapshot of North Carolina fishermen who catch red drum.

8.2.1.1 Demographic Characteristics of Commercial Fishermen

Table 13 shows the demographic characteristics of the red drum-reporting fishermen surveyed by the Socioeconomic Program over the past five years. Nearly all were white males, with an average age of 50 and over 27 years of commercial fishing experience. Two thirds of them had a high school diploma and 23% had at least some college education. Half had $30,000 or less in household income when surveyed, with 24% bringing in $50,000 or more. Only 9% had less than $15,000 in annual household income (Table 13).[2]

Fishing accounted for 70% of the household income from these fishermen, and 48% reported that fishing was their sole source of income. They are least likely to fish December through April, which is the slowest time of the year for most fishermen. They own an average of 1.7 registered commercial fishing vessels.

8.2.1.2 Historical Importance of the Commercial Fishery

A historical overview of the red drum fishery can be found in Section 7.0, Description of the Fisheries. The socioeconomic interviewers asked fishermen how important commercial fishing has historically been in their communities. Almost all of them felt it had been vital, giving it a 9.4 on a 10-point scale. Perceptions of current community support were lower, at 7.1. The statement "fishing is important economically in my community" drew an 8.5.

2 The refusal rate on the household income question was 4%.

Table 13. Demographic characteristics of red drum commercial fishermen. DMF Socioeconomic Program.

Variable	n = 432	Average or %
Years Fishing		27.3
Age		50.2
Gender	Male	97%
	Female	3%
Race	White	98%
	Black	1%
	other	1%
Education Level	Less than HS	32%
	HS Grad	45%
	Some College	17%
	College Graduate	6%
Marital Status	Married	78%
	Divorced	10%
	Widowed	3%
	Never Married	1%
	Separated	8%
Total Household Income	Less than $15,000	9%
	$15,001 - $30,000	41%
	$30,001 - $50,000	24%
	$50,001 - $75,000	17%
	More than $75,000	7%

8.2.1.3 Community Reliance on the Commercial Fishery

Given its status as a bycatch fishery, no commercial fishermen in North Carolina rely primarily on red drum to make a living; drum fishermen are instead mostly flounder and striped mullet fishermen who land the occasional red drum in their nets, and target other species as well such as blue crabs, clams, and shrimp (Table 14)

Table 14. Prevalent species targeted by red drum commercial fishermen. DMF Socioeconomic Program.

Species	% who land
Flounder	59.5%
Blue crabs	36.8%
Clams	25.2%
Shrimp	24.3%
Striped Mullet	23.1%
Perch	22.0%
Spot	18.9%
Sea Mullet	15.1%
Striped Bass	14.8%
Shad	14.8%

8.2.1.4 Perceived Conflicts

Fishermen were asked about conflicts in the previous year with recreational users and with other commercial fishermen. Conflicts with other users of a public resource are to be expected, and part of the job of the DMF is to balance the needs of different user groups. Less than a third of fishermen reported conflicts with other commercial fishermen. A slightly larger percentage reported having had conflicts with recreational fishermen, with two-thirds reporting no conflict in the previous year (see Figure 9).

Perceptions of conflicts with federal regulations were stronger, with a quarter mentioning 20+ conflicts over the previous year, though the overall numbers were still relatively low. Reported conflicts with state regulations are quite different: more than a third reported "daily" conflicts with the state, and more than half had 20+ conflicts.

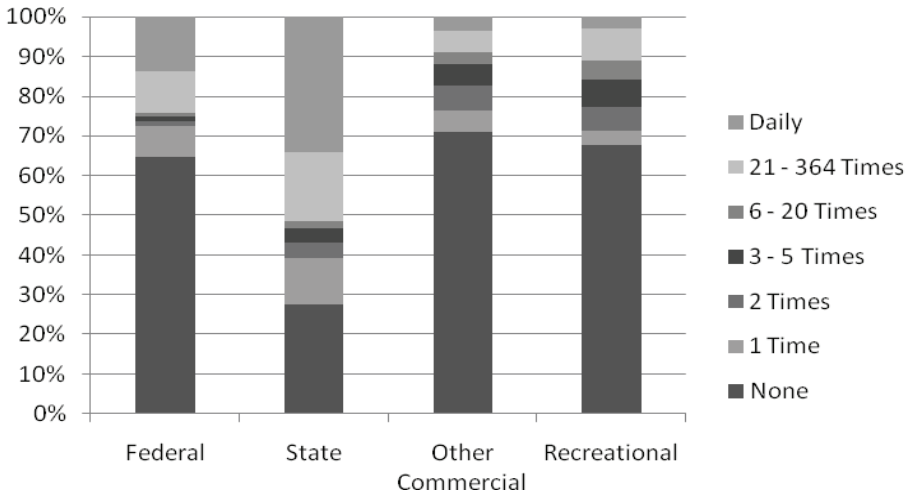

Figure 9. Reported conflicts of Commercial Fishermen (DMF Socioeconomic Progam).

8.2.1.5 Perception of Important Issues

The fishermen were also asked to rate the seriousness of a number of issues facing themselves and their businesses. State regulations were the most important issue, followed by the related issues of imported seafood and low prices (Table 15).

Table 15. Fishing related issues considered most important to fishermen who landed drum. DMF Socioeconomic Program.

Ranking	Issue
1	State Regulations
2	Imported seafood
3	Low prices for seafood
4	Keeping up with regulations
5	Size limits
6	Federal regulations
7	Costs of doing business
8	Gear restrictions

8.3.1 Recreational Fishery

The DMF has no information about hook-and-line red drum fishermen, or the issues that they find most important, though presumably regulations would be important to them as well. The survey of RCGL holders did reveal some demographic and attitudinal statistics comparable to those of the commercial fishermen; in age and sex, the RCGL holders are nearly identical to SCFL holders, but the RCGL holders have generally higher education and household incomes (see Table 16).

Table 16. Demographic characteristics of red drum RCGL fishermen. DMF RCGL Program.

Variable	n = 91	Average or %
Age		75% over 40
Gender		
	Male	96%
	Female	4%
Race		
	White	96%
	Black	4%
Education Level		
	Less than HS	8%
	HS Grad	27%
	Some College	30%
	College Graduate	35%
Marital Status		
	Married	78%
	Divorced	9%
	Widowed	2%
	Never Married	10%
	Separated	1%
Total Household Income		
	Less than $15,000	12%
	$15,001 - $30,000	11%
	$30,001 - $50,000	22%
	$50,001 - $75,000	22%
	More than $75,000	33%

RCGL holders were also surveyed on conflicts with other fishermen and asked their opinions about the amount of gear in the water. Those results are shown below in Figure 10.

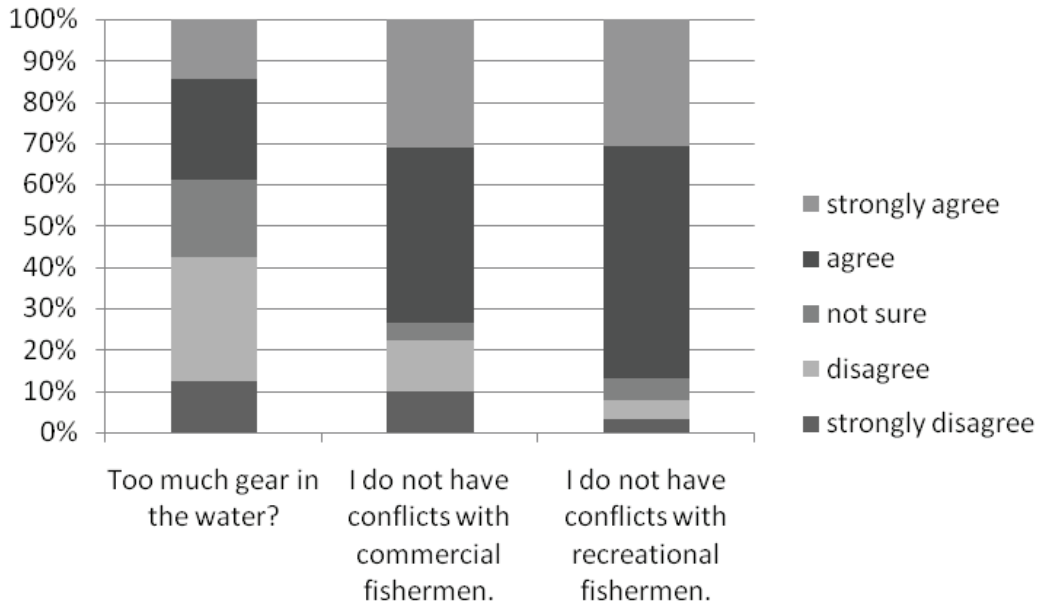

Figure 10. Perceptions of Recreational Commercial Gear License Holders. (DMF RCGL Program).

8.4 Research Recommendations

The most pressing socioeconomic research issue is for data about the hook-and-line recreational red drum fishery. Unlike commercial fishermen, recreational anglers can and do target red drum, and it is a popular fish for catch-and-release fishermen. Annual surveys of recreational anglers, modeled on the already-proven commercial fishermen survey, would be the best approach for gathering the necessary social and economic data.

8.5 Definitions and Acronyms

CPI (Consumer Price Index) – The CPI measures the price paid by consumers for a fixed group of goods and services. Changes in the CPI over time constitute a common measure of inflation.

Deflated (Inflation-adjusted) price and value – Inflation is a general upward price movement of goods and services in an economy, usually as measured by the Consumer Price Index (CPI). Ex-vessel prices and values can be adjusted (deflated) according to the CPI to remove the effects of inflation so that the value of a dollar remains the same across years. Inflation adjusted values allow for easier understanding and analysis of changes in values. Some products allow for a Producer Price Index (PPI). The PPI measures inflation in wholesale goods. It is considered a more reliable indicator than CPI because it is related to a specific product or group of products. The PPI is related to the CPI in that PPI is considered a precursor to CPI because fluctuations in production costs are usually associated with general measures of inflation.

9. ENVIRONMENTAL FACTORS

9.1 Habitat

As described in the life history section of the plan, red drum utilize a variety of estuarine and oceanic habitats throughout their life cycle. Each habitat provides ecological services that aid in maintaining and enhancing the red drum population, and also influences the functioning of the ecosystem overall. Protecting the integrity of the entire system is therefore necessary to manage this species. The South Atlantic Fishery Management Council recognizes several habitats as Essential Fish Habitat (EFH) for red drum from Virginia to Florida. In North Carolina, these natural communities include tidal freshwater, estuarine emergent vegetated wetlands (flooded salt marsh, brackish marsh, and tidal creeks), submerged rooted vascular plants (sea grass), oyster reefs and shell banks, unconsolidated bottom (soft sediment), ocean high salinity surf zones, and artificial reefs (SAFMC, 1998).

Of the designated EFH, Habitat Areas of Particular Concern (HAPC) have been recognized for red drum by the SAFMC. Areas which meet the criteria for HAPC in North Carolina include all coastal inlets, all state-designated nursery habitats of particular importance to red drum, documented sites of spawning aggregations, other spawning areas identified in the future, and areas supporting submerged aquatic vegetation (SAV) (SAFMC, 1998). These HAPC include the most important habitats required during the life cycle of the species, including spawning areas and nursery grounds. Other areas of concern are barrier islands, since these geological formations are vital to maintain estuarine conditions needed for larval and juvenile stages. Information on the ecological value of each of these habitats to red drum and their current condition is provided below.

9.1.1. Water column

Red drum depend on the water column throughout their life history for spawning, larval transport, feeding, and migration. In North Carolina, large concentrations of red drum occur around Ocracoke, Hatteras, and Oregon Inlets and along adjacent beaches and shoals in the spring prior to entering Pamlico Sound for the summer (Ross and Stevens 1992; Luczkovich et al. 1999). In August adult drum will concentrate around inlets and the mouths of some rivers to spawn and remain in the vicinity through October. Gravid and spent adults have been documented by DMF in the vicinity of Hatteras, Ocracoke, and Drum inlets, as well as in the mouth of the Pamlico, Neuse, and Bay rivers, and other bays in that vicinity, indicating spawning activity in those areas (Ross and Stevens, 1992). Luczkovich et al. (1999) confirmed that spawning occurred in these areas using hydrophone surveys to detect characteristic spawning knocks and ichthyoplankton surveys to locate sciaenid eggs. Red drum spawning was detected on the east (Ocracoke and Hatteras Inlet areas) and west (Bay River) sides of Pamlico Sound in August, September, and October, with the greatest amount of activity occurring in September. Luczkovich et al. (1999) concluded that areas near the mouth of Bay River appear the most critical for spawning red drum within their study area.

In 2003 and 2004, hydrophone surveys were conducted in the lower Neuse River estuary, to locate and assess the significance of spawning aggregations in that area (Barrios 2004). The surveys found that red drum spawning aggregations occurred in the lower Neuse River estuary from approximately Oriental to the mouth of the river, and were most concentrated in August and September. The location of spawning activity was positively related to water depth (> 4.5 m), oxygen levels (> 2.5 mg/l) and proximity to river mouth (salinity approx. 20-25 ppt). Spawning occurred over mud bottom and subtidal shell bottom. By spawning closer to the nursery grounds, the probability of successfully reaching the nursery grounds and surviving could be greater than for eggs spawned at ocean inlets.

Currently, a large hook and line recreational fishery exists at some of these known spawning aggregations in Pamlico Sound. There is concern that the act of capturing and releasing these large gravid fish could potentially have a negative impact on spawning success due to stress or post-release mortality. Catch and release mortality studies in this fishery have found that J-hooks result in significantly greater incidence of deep hooking and as a result, have release mortality rates that are higher than for fish captured using circle hooks. Requiring the use of circle hooks in Pamlico Sound during the spawning season could alleviate some of the impacts of this fishery. This issue is further addressed in Section 10.2.2 Recreational Targeting of Adult Red Drum.

In areas south of Pamlico Sound, collection of gravid adults, larvae, and early post-settlement juveniles has indicated localized spawning activity. Red drum larvae have been documented in low numbers in the vicinity of Beaufort and Barden inlets (Hettler and Chester 1990; Powell and Robbins 1998). Aggregations of ripe adult females near New River and Cape Fear River inlets and the presence of larvae and post settlement juveniles in adjacent estuaries indicated spawning in those areas. (DMF unpub. data; Stewart 2006). The extent that other inlets in North Carolina are utilized for spawning has not been documented.

Fertilized eggs and larvae are transported through the water column from the spawning sites to shallow bays and estuaries (Weinstein 1980; Holt et al. 1989; Peters et al. 1995). Larval transport studies in North Carolina have found that ocean and inlet spawned larvae are dependent on the appropriate wind and current conditions to occur so that larvae can pass into and be retained in the estuary (Hare et al.1999). Because of this, recruitment success of red drum in North Carolina, Texas, and Florida appears to be highly influenced by local nearshore wind-driven currents, tidal flow patterns, as well as estuarine flush rates (Peters and McMichael 1987; Scharf 2000; Brown et al. 2005; Stewart 2006). In the Neuse River estuary and other western Pamlico Sound tributaries, northeast winds will enhance recruitment into adjacent shallow tributaries (Barrios 2004). In a study conducted in estuaries further south, the greater relative abundance of juvenile red drum in the New River estuary compared to the Cape Fear River system was attributed to hydrologic differences that result in greater retention of larvae in the New River system (Stewart 2006). While the New River is shallow, broad, and has reduced tidal exchange, the Cape Fear River is deep, connects directly to the ocean, and has a shorter flush time.

In addition to its role in spawning and larval transport, the water column provides food and oxygen critical for survival and growth of red drum populations. Inlets are also very important for their role in mixing of sea water and fresh water, which is critical for

maintaining salinity and current regimes, dispersing nutrients and pollutants, and providing migratory corridors for juvenile and adult fish and invertebrates. There are currently 20 inlets in North Carolina that connect estuarine waters to the sea. Unnatural or human-induced changes that reduce or increase flow into estuaries may result in environmental stress in organisms (SAFMC, 1998).

Red drum populations are affected by water quality conditions wherever they occur in the system. In North Carolina and other areas, year class strength of red drum is variable and highly dependent on large-scale processes and environmental conditions that effect recruitment success, such as temperature, salinity, currents, predation, and growth rates (Scharf 2000). Predation and growth rates are affected by habitat as well as water column conditions. More information on water quality is in Section 9.2. The use of various habitats by red drum and their status are described below.

9.1.2. Wetlands

Wetlands are one of several important nursery habitats for red drum. Tidal marsh wetlands generally occur along the edge of estuaries and sounds in polyhaline and mesohaline waters. The combination of shallow water and thick vegetation provides excellent nursery and foraging habitat for red drum and many other fish species (Graff and Middleton 2003). Shallow wetlands also provide refuge from large fish predators and provide a safe corridor for migration to other habitats within the system (Mitsch and Gosselink 1993; Rozas and Odum 1997). It is estimated that over 95% of commercially harvested finfish and invertebrates in the United States are wetland dependent, a strong indication of their high habitat value (Feierabend and Zelanzy 1987). Riparian wetlands are also highly effective and well recognized for their ability to trap and filter pollutants from upland runoff, and store, spread, and slow stormwater runoff prior to entering surface waters (Mitsch and Gosselink 1993).

Juvenile red drum have been primarily collected in tidal creeks and embayments adjacent to tidal marsh wetlands in both high and low salinity waters. Studies have shown that juvenile red drum in vegetated areas suffer significantly less predation mortality than those in unvegetated areas (Rooker et al., 1998). Also, laboratory experiments found that red drum grew significantly faster in marsh and seagrass habitats compared to shell and nonvegetated bottom (Stunz et al 2002). However field experiments comparing growth rates of red drum from the same habitats did not find significant differences in growth, perhaps a reflection of movement among and use of multiple habitats within the estuary.

Coastal wetlands were mapped by NC Division of Coastal Management (DCM) in 1994 and are shown in Figure 11. There are estimated to be approximately 254,000 acres of fresh, brackish, and salt marsh in North Carolina (Sutter, 1999). Pamlico, Core, and Bogue sounds, and estuaries south of Bogue Sound, have the highest percentages of estuarine wetlands. The largest acreage of salt/brackish marsh is in the Pamlico Sound region (Street et al. 2005).

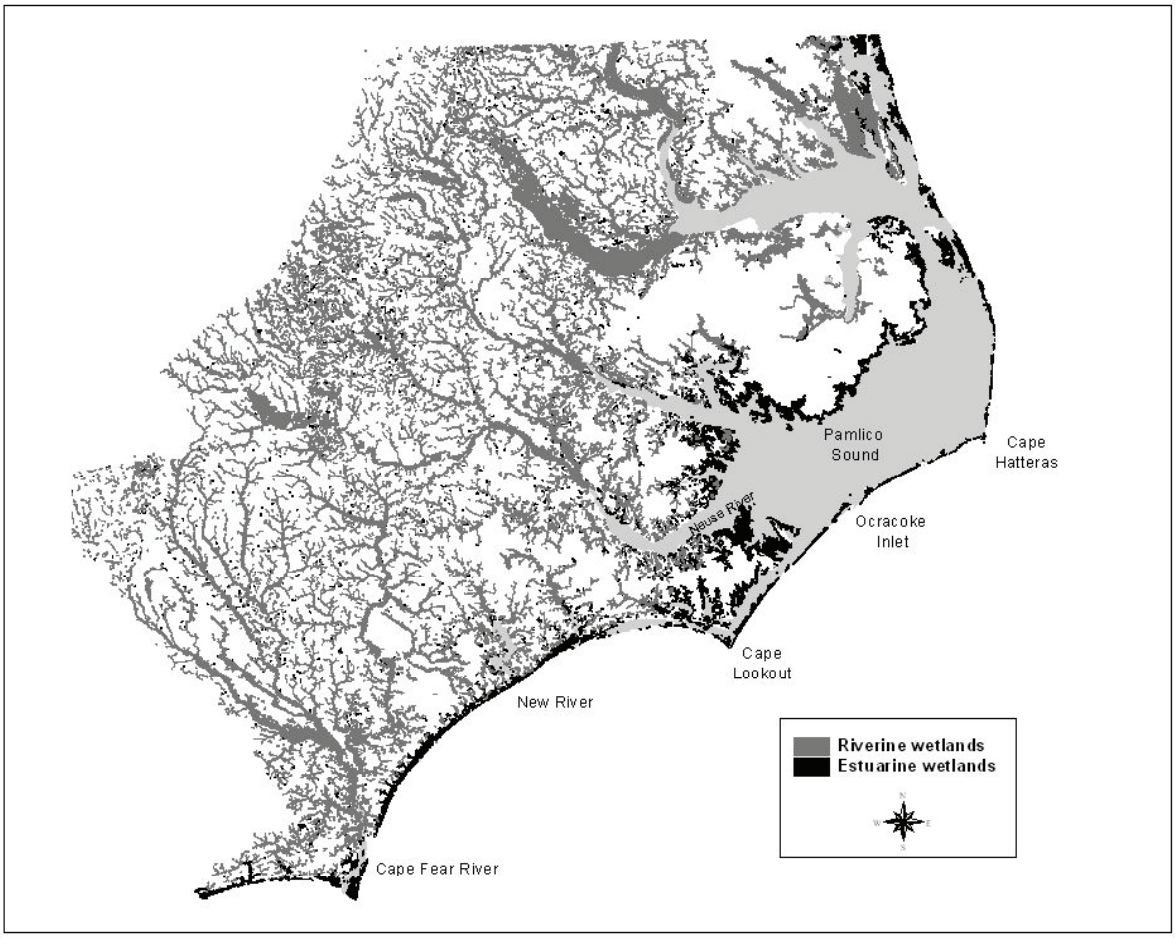

Figure 11. Location of esturarine and riverine wetlands in coastal North Carolina, based on 1994 DCM mapping data (Street et al. 2005).

9.1.3. Submerged Aquatic Vegetation

Submerged aquatic vegetation is another habitat utilized by red drum as a nursery area. SAV habitat is defined in the Coastal Habitat Protection Plan (CHPP) as "bottom recurrently vegetated by living structures of submerged, rooted vascular plants (roots, rhizomes, leaves, stems, or propagules), as well as temporarily unvegetated areas between vegetated patches" (Street et al. 2005). Submerged aquatic vegetation occurs in both subtidal and intertidal zones and may be colonized by estuarine species, such as eelgrass (*Zostera marina*), shoalgrass (*Halodule wrightii*), or widgeon grass (*Ruppia maritima*) or freshwater species, such as wild celery (*Vallisneria americana*) and sago pondweed (*Potamogeton pectinatus*).

Over 150 species of fish and invertebrates have been documented by DMF in seagrass beds in eastern Pamlico and Core sounds, including red drum (DMF 1990). The three-dimensional structure provides a surface for small plants and animals to attach to and provides a safe refuge and foraging area for a large number of juvenile fish and invertebrates (SAFMC 1998). The structure of SAV grass blades provides an excellent

nursery area and enhances a safe corridor between habitats, reducing predation (Micheli and Peterson 1999).

Eggs, larvae, postlarvae, young-of-year and sub-adult red drum have been documented in mesohaline and polyhaline SAV beds (Mercer 1984; Thayer et al. 1984; Reagan 1985). In North Carolina, SAV is utilized as a nursery area where it is available, and also as a foraging area for subadult red drum. Data collected by DMF through the seine survey and tagging studies indicate high abundance of late age-0 red drum in shallow, high-salinity grass beds behind the Outer Banks. SAV is also particularly important as foraging grounds for one and two-year-old fish (Ross and Stevens, 1992; DMF unpub. data). Juveniles appear to be more abundant in ecotonal areas with patchy grass coverage than in homogeneously vegetated sites (Mercer 1984; Reagan 1985; Ross and Stevens 1992).

SAV also enhances the entire ecosystem by stabilizing and trapping sediment, reducing wave energy and cycling nutrients within the system (Thayer et al. 1984). Beds of SAV also produce large quantities of organic matter, which supports a complex food base for numerous fish and other organisms (Thayer et al. 1984).

The amount of SAV in North Carolina was estimated to be between 134,000 and 200,000 acres around 1990 (Ferguson and Wood 1994; Carraway and Priddy 1983). The majority of SAV occurred in eastern Pamlico Sound and Core Sound in high salinity waters (Figure 12). SAV was also documented to occur in a narrow band along a portion of the western Pamlico Sound shoreline and the Pamlico and Neuse rivers and tributaries, although its distribution and abundance in this area was underestimated due to reduced water clarity. However, Davis and Brinson (1990) qualitatively described the location of SAV in this area. Areas south of Bogue Sound have not been mapped. Because light is the primary limiting factor affecting its distribution, SAV is restricted to relatively shallow waters, usually less than two meters in depth. The amount of SAV fluctuates seasonally and inter-annually, depending on the species and salinity regime.

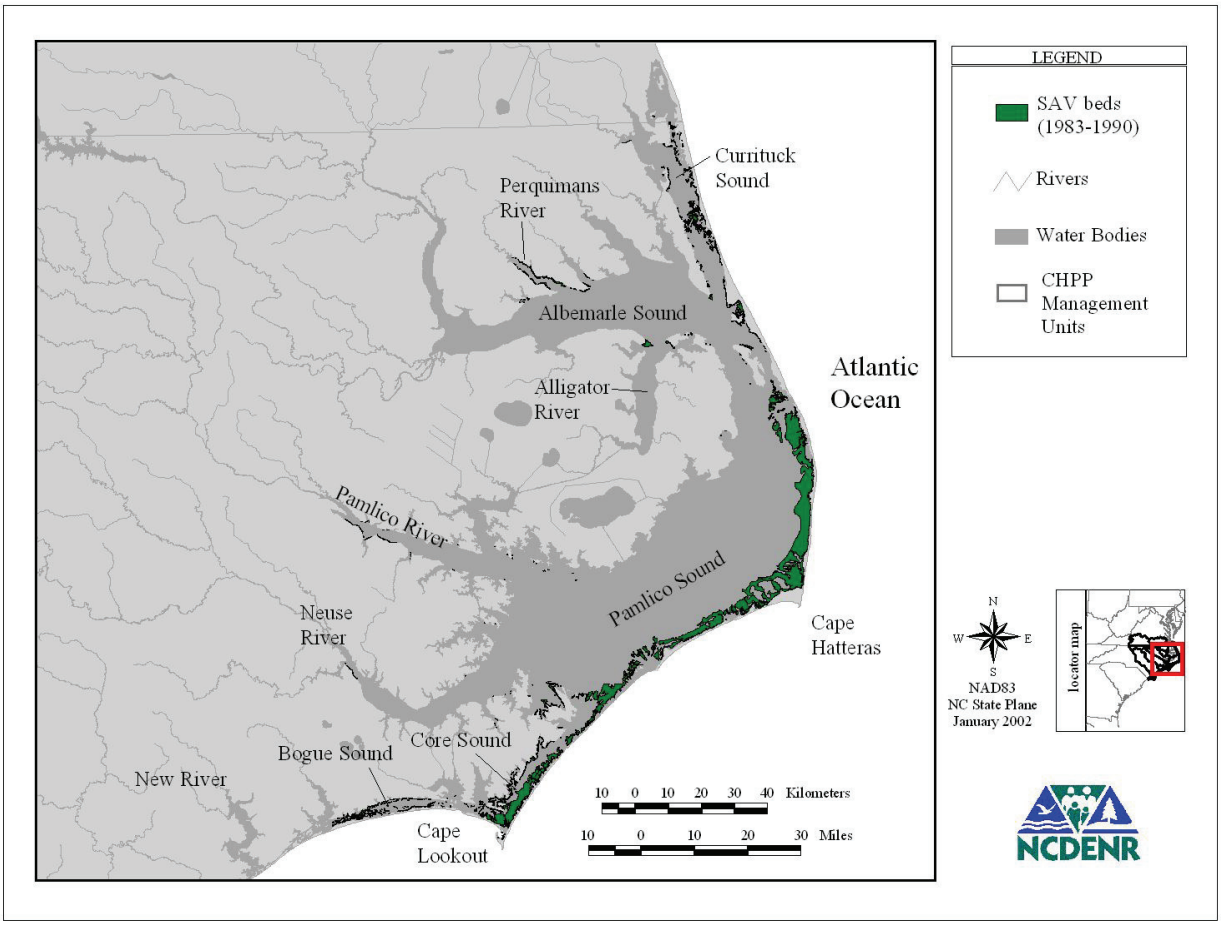

Figure 12. Distribution of known submerged aquatic vegetation habitat in North Carolina (Street et al. 2005).

9.1.4. Soft bottom

Red drum also utilize shallow estuarine soft bottom as a nursery and foraging area. This habitat consists of unconsolidated, unvegetated sediment that occurs in freshwater, estuarine, and marine systems. Wetlands, SAV and shell bottom often occur adjacent to shallow soft bottom. Sediment composition varies from sand to fine muds due to geomorphology and location within the system and may be a factor in juvenile red drum distribution. Courser sandy sediments are concentrated along eroding or high energy shorelines and shallower perimeter of waterbodies, while finer mud sediments are located along low energy shorelines or deeper water (Riggs 1996). Soft bottom is valuable as a foraging area for demersal fish and shallow portions are utilized as nursery areas. The sediment type and energy regime will affect the primary and secondary productivity of the bottom, and therefore the food available to red drum. Benthic mircoalgae growing on the surface of the sediment provide a food base for the invertebrates on which red drum forage (Peterson and Peterson 1979). The dominant diet of juvenile red drum (16-30 mm in length) consists of benthic invertebrates typically found in soft bottom, such as copepods, mysid shrimp, amphipods, and polychaetes

(Daniel 1988; Llanso et al 1998). As red drum grow, the dominant prey shifts to grass shrimp (when approx. 60-90 mm in length). At around 100 mm, dominant diet consists of crabs, penaeid shrimp, and juvenile fish (Mercer 1984). Red drum larger than 300 mm, feed on a mix of blue crab and other portunid crabs, penaeid shrimp, small pelagic fish (anchovy, menhaden, silversides) and some demersal fish (flounder, pinfish) (Scharf and Schlicht 2000). Although there is little benthic structure associated with soft bottom, shallow bottom can provide refuge and a migratory corridor that large predators cannot access (Peterson and Peterson 1979).

Subadult and adult red drum forage in the surf zone and shoals in the nearshore ocean and inlet systems. In addition to providing fishery functions for juvenile and adult red drum, soft bottom plays a very important role in the ecology of estuarine ecosystems by storing and cycling nutrients, chemicals and microbes. Intense biogeochemical processing and recycling establishes a means to trap and reprocess natural and human-induced nutrients and toxic substances.

9.1.5. Shell bottom

Red drum use shell bottom as nursery and foraging areas to some extent. Shell bottom habitat is estuarine intertidal or subtidal bottom having concentrations of shell, including living or dead oysters (*Crassostrea virginica*), hard clams (*Mercenaria mercenaria*), and other shellfish. Common terms used to describe shell bottom habitats in North Carolina are "oyster beds," "oyster rocks," "oyster reefs," "oyster bars," and "shell hash." Shell hash is a mixture of sand or mud with gravel and/or unconsolidated broken shell (clam, oyster, scallop, and/or other shellfish). Intertidal oyster reefs in the central and southern estuarine systems are usually only a few oysters thick. However, subtidal oyster mounds in Pamlico Sound can be several meters tall (DMF 2001). In North Carolina, oysters attach to and accumulate on existing oyster beds, other shell, hard structures and exposed *Spartina* roots (DMF 2001). Intertidal oyster reefs in North Carolina may occur along the adjacent to salt marsh and SAV, or as isolated reef features, away from other structure (Grabowski et al. 2000). Oyster distribution and abundance are limited by salinity, high temperature (Funderburk et al. 1991) and predators like oyster drills and boring sponges (Bahr and Lanier 1981). In North Carolina, intertidal oyster beds occur extensively throughout the central and southern coast where salinity ranges from 14 to 30 ppt. Subtidal oyster reefs also occur in the New, Newport and White Oak rivers. In the Albemarle-Pamlico system, oysters are concentrated in the lower portion of Pamlico Sound tributaries, along the western shore of Pamlico Sounds and to a lesser extent behind the Outer Banks (Street et al. 2005).

The complex three-dimensional structure provides protective cover for juvenile and sub-adult red drum, while the small invertebrates living on and among oyster shells provide a food source (Meyer et al. 1996; ASMFC 2007). Fringing shell bottom or shell hash may serve as a nearshore corridor between habitats such as salt marsh and SAV, which red drum utilize (ASMFC 2007; Micheli and Peterson 1999). Juvenile red drum have been documented in shell bottom habitat in South Carolina (Daniel 1988; Coen et al. 1999), Virginia (Luckenbach and Ross 2003), Texas (Stunz et al. 2001), and North Carolina (Grabowski et al. 2002). Barrios (2004) documented spawning aggregations of red drum over subtidal shell bottom (3-5 m water depth) in the lower Neuse River

estuary. The bathymetric relief provided by the shell structure was thought to attract adults and enhance foraging during the spawning season. Peterson et al. (2003), in reviewing studies examining fish use of shell bottom habitat, found that red drum were documented utilizing shell bottom in two out of five past studies. However it was inconclusive whether the presence of oyster beds enhanced red drum abundance.

Shell bottom also provides many important functions that enhance the health of the entire ecosystem for fishery and non-fishery species. Oysters filter sediment and pollutants from the water column, enhancing water quality and improving conditions for SAV growth. The hard multi-faceted shell structure aids in reducing wave energy, stabilizing sediment, and reducing shoreline erosion. Oysters, like SAV and benthic microalgae, facilitate storage and cycling of nutrients (ASMFC 2007).

9.1.6. Nursery habitat preference

Habitat preference by juvenile red drum varies somewhat regionally. In Gulf coast estuaries, studies indicated that SAV was the preferred nursery habitat for red drum, (Stunz et al. 2002; Rooker et al. 1999). However, where SAV was sparse or not present, the highest densities of newly recruited red drum were found at the *Spartina* marsh edge interface and within 1 m inside of the marsh edge. Red drum were not found at 5 or 10 m inside of the marsh edge or at 30 m waterward of the marsh edge. Relatively low densities of red drum were found on soft bottom and no red drum occurred in shell bottom. In contrast, in South Carolina, post-larvae and juveniles settle out in meso-euryhaline estuaries (10-25 ppt) on mud and sand bottom with oysters and shell hash as well as shallow tidal marsh creeks (Daniel 1988).

In North Carolina, juvenile red drum habitat includes detritus or mud bottom wetland creeks in western Pamlico Sound and Pamlico and Neuse rivers, grass beds behind the Outer Banks, and mud or sand bottom in shallow water in other areas (Ross and Stevens, 1992). The most common habitat characteristics among DMF sampling sites is shallow water depth (<5 feet) and relatively wind-protected water bodies. Results from directed red drum seine surveys and fishery independent sampling have documented juveniles from the Cape Fear River, north through Buzzard Bay in Dare County (Ross and Stevens, 1992). Juveniles were most consistently abundant at the stations located near the mouths of the Pamlico and Neuse rivers and the bays and rivers between these two large rivers. In the Cape Fear and New rivers, juvenile red drum utilize the shallow upper reaches of polyhaline and mesohaline tidal creeks and tidal marsh fringe along the rivers (Weinstein 1979; Stewart 2006). Shell hash is found on the bottom of some of the tidal creeks where red drum occur. More information is needed on red drum utilization of shell hash and oyster reefs.

Powers and Gaskill (2004) conducted seine surveys in low (10-20 ppt) and high (28-35 ppt) salinity estuaries in North Carolina to assess recruitment and abundance in various habitats. They found juvenile red drum were more common in the lower salinity estuaries (Adams Creek, Slocum Creek, and other upper Neuse tributaries) then in the higher salinity areas, such as Core, Bogue and Back sounds and the mouth of the Neuse River, regardless of habitat type. Powers and Gaskill (2004) concluded that higher abundance of mid-level predators in the lower estuary (higher salinity sites) in the fall

might be limiting recruitment success of red drum in those areas. Habitat use in the low salinity areas included tidal creeks, marsh edge, and sandy beach habitat, although drum were most abundant along sandy beaches. In higher salinity estuaries, red drum occured in the same habitats, as well as seagrass beds, but at lower overall abundance levels than habitats in upstream sites. When habitat use by juvenile red drum was assessed in mesocosm experiments, results indicated that juvenile red drum occupied sand bottom the most, followed by oysters and then artificial SAV (Powers and Gaskill 2004). More field research along North Carolina's coast is needed to determine juvenile habitat preference and examine if recruitment is habitat limited.

9.1.7. Habitat condition

Because red drum utilize multiple habitats, protecting the integrity of the entire system is necessary to manage this species. Protection and enhancement of spawning and nursery areas may be particularly important to enhance growth and survival of juvenile red drum. In North Carolina, there have been reported losses of wetlands, SAV, and shell bottom habitat. Since studies indicate that use of SAV and marsh edge by juvenile red drum reduce predation rates and increase growth rates (Rooker et al. 1998; Stunz and Minello 2001; Stunz et al. 2002), an increase in habitat coverage could potentially improve recruitment success. Levin and Stunz (2005), assuming red drum populations were not recruitment limited, estimated through modeling of a hypothetical red drum population, that restoring marsh edge and SAV habitat in Galveston Bay to their near original amounts could increase average post-settlement survival in Galveston Bay by 24%, sufficiently abating the rate of population decline.

Wetlands

It is estimated that as much as 34-50% of North Carolina's original wetland coverage was lost, primarily due to ditching, channelization, and filling for agriculture and development (Dahl 1990; DWQ 2000a). According to the Division of Water Quality (DWQ 2000a), approximately 88% of salt/brackish marsh, 81-88% of riverine forested wetlands, and 48% of pocosins remain. According to DCM, 29,560 acres (11.6%) of existing salt, brackish, and freshwater marsh appear to be physically altered. From the early 1800s to the early 1900s, ditching and draining for agriculture accounted for the majority of wetland losses (Heath 1975). From about 1950 to the 1990s, conversion to managed forest and agriculture accounted for 53% and 42%, respectively, with development associated activities responsible for the remaining 5% (Bales and Newcomb 1996). Since 1990, there have been greatly reduced losses from agriculture and forestry and increasing losses from development. However, between 1998 and 2000, due to a change in federal wetland regulations (repeal of Tulloch Rule), approximately 12,000 acres of wetlands were ditched and drained, primarily in the southern portion of the coast. Changes in state regulations are now in place to prevent such activity. Except for this period, there have been no new large-scale wetland drainage projects since the mid-1970s.

The primary threats to wetland habitat today are filling, dredging, and hydrological alterations associated with residential and commercial development. The Coastal Resource Commission (CRC) regulates development activities in Areas of

Environmental Concern, which include coastal wetlands (15A NCAC 7H .0205). Generally, no development is allowed in coastal wetlands except water dependent activities, such as docks. The Environmental Management Commission (EMC) manages wetlands through the 401/404 Certification Program, under the federal Clean Water Act. This program focuses on avoiding and minimizing filling of wetlands and streams through review of all Environmental Assessments, Coastal Area Management Act (CAMA) Major, and US Army Corps of Engineers (COE) permit applications.

Although the rate of wetland loss from dredging and filling activities has slowed, smaller losses continue to occur, which may still result in cumulative impacts. From 2001 to 2006, in the five river basins where red drum occur, a total of 904 acres of wetlands were permitted by DWQ, to allow impacts from dredging or filling (Table 17). The greatest wetland impacts occurred in the Cape Fear, followed by the Neuse. The total acres impacted by year ranged from 80 in FY 2003/2004 to 228 in FY 2005/2006. Compensatory mitigation for permitted losses and voluntary restoration efforts have partially offset some of these losses. However, the type of wetland gained is often not equivalent to what was lost. In addition, not all impacts require mitigation.

Table 17. DWQ 401 permitted wetland impacts (acres) in coastal river basins inhabited by red drum, 2001-2006 (DWQ, unpubl. data, R. Ridings, 2007).

River Basin	2001/2002	2002/2003	2003/2004	2004/2005	2005/2006	Total
Cape Fear	152.04	52.98	38.93	32.90	138.36	415.21
Neuse	30.22	91.55	15.25	88.38	40.72	266.12
Pasquotank	16.53	25.66	9.28	22.71	9.33	83.51
White Oak	7.22	12.79	7.84	37.45	5.97	71.27
Tar-Pamlico	7.39	5.07	9.36	13.16	33.72	68.70
Total	213.40	188.05	80.66	194.60	228.10	904.81

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In 2003 the Ecosystem Enhancement Program (EEP) was established through a cooperative agreement with the Department of Transportation (DOT), Department of Environment and Natural Resources (DENR), and COE. The program was developed to provide environmental mitigation to offset unavoidable impacts associated with transportation and other development, with the goal of restoring, enhancing, preserving, and protecting wetlands, streams, and riparian area functions (EEP 2006). EEP oversees mitigation programs for wetland impacts related to 1) transportation, 2) statewide stream and wetland 401 permits, 3) removal of riparian buffers, and 4) nutrient offset impacts. The program has been increasing the amount of wetland and stream mitigation completed annually. In FY 2005-2006, wetland and stream credits for state wetland in-lieu fee impacts exceeded the wetland mitigation requirements (generally at least a 2:1 ratio with acres impacted). The riparian buffer and nutrient offset programs have also resulted in a net positive gain. Since 2003, more than $2 billion in approved and pending transportation projects are moving forward because required compensatory mitigation was met. In FY 2005-2006, 310,000 ft of stream and 589 acres of wetland mitigation

projects were begun. Work involves a mix of restoration, enhancement, and high quality preservation (EEP 2006).

Shoreline stabilization results in direct and gradual loss of wetlands but is not accounted for through the 401 permit process. Hard stabilization along estuarine shorelines can result in a cumulative loss of wetlands since a hardened structure 1) prevents landward migration of wetlands over time, 2) results in loss of marsh vegetation waterward of the structure, which can not reestablish due to increased wave energy and scour against the vertical structure (Garbisch et al. 1973; Knutson 1977), and 3) reduces or eliminates the intertidal habitat due to shoreline deepening. Several studies have found that abundance of juvenile fish adjacent to bulkheaded shorelines was much less than what occurred adjacent to unaltered naturally vegetated shorelines (80-300% less) (Mock 1966; Peterson et al. 2000; Waters and Thomas 2001). The difference was attributed to lower abundance of organic detritus and small benthic invertebrates, deeper water, and less intertidal vegetation. Ocean shoreline stabilization and prevention of barrier island processes, such as overwash and inlet migration, suppresses development of new tidal marsh behind barrier islands and is another deterrent to wetland expansion.

According to permit records, DCM issued permits between 1984 and 2000 to stabilize approximately 457 miles of shoreline (11.7% of the estimated 3,900 miles of estuarine shoreline). During this time period, the amount of shoreline stabilization permitted annually along the coast has ranged from eight to 91 miles. These numbers must be considered with caution since the numbers include CAMA permits include repairs, replacements, or projects that may not have been done or completed, and there could be data entry errors. Beaufort, Dare, Carteret, and Currituck counties have the greatest total lengths of permitted bulkheads. In these counties, the percent of hardened shoreline along major waterbodies ranges from roughly 8% to 32%. Because shoreline stabilization contributes to wetland loss which would impact nursery habitat, there is a need to more accurately assess where and how much of the estuarine shoreline is hardened. As part of CHPP implementation actions, the CRC is currently in the process of revising estuarine shoreline management rules using recommendations from the Estuarine Shoreline Biological and Physical Processes Work Group to minimize impacts to natural shoreline and nearshore fish habitat functions. These rule changes will try to encourage use of the most environmentally sensitive stabilization structure that is also effective for each specific location.

Ongoing initiatives such as wetland restoration, land acquisition and preservation, and agricultural cost-share BMPs need to be enhanced to offset continued losses. There should also be additional initiatives implemented to protect and enhance wetland habitat. The many fishery and water quality functions provided by wetlands make their preservation and restoration along North Carolina's coast a high priority for protection of all coastal fish habitats.

SAV

The current spatial distribution and acreage of SAV is unknown since some areas that historically supported SAV were not mapped, western Pamlico sound tributaries were not accurately quantified, and changes may have occurred since the original mapping. While there are reports of large-scale losses of SAV in North Carolina's low salinity tributaries on the mainland side of Pamlico Sound, (North Carolina Sea Grant 1997; J. Hawkins, DMF, pers. com, 2003), the high salinity grass beds behind the barrier islands appear relatively stable (Ferguson and Wood 1994). Efforts are currently underway to quantitatively map high and low salinity SAV habitat in 2007 through an interagency effort coordinated by Albemarle Pamlico National Estuary Program. The Division is a partner in this effort. This will provide baseline information on distribution of SAV in some areas, and allow trend analysis in distribution and abundance of SAV in eastern Pamlico, Core and Bogue sounds. Additional field monitoring of existing SAV beds is needed to identify environmental conditions necessary to support SAV, and model where SAV could potentially occur in shallow water.

The greatest threat to SAV is large-scale nutrient enrichment and sediment loading, which increases turbidity, reduces light penetration, and subsequently impacts SAV growth, survival, and productivity (Goldsborough and Kemp 1988; Kenworthy and Haunert 1991; Funderburk et al. 1991; Stevenson et al. 1993). Catastrophic losses of seagrass beds have been correlated with these water quality problems in other states in the past (Twilley et al. 1985; Orth et al. 1986; Durako 1994). Nutrient enrichment and/or increased sediment loads impact SAV growth, survival, and productivity by increasing chronic turbidity in the water column from suspended sediment or phytoplankton associated with algal blooms. In North Carolina, most of the low salinity areas that have experienced large reductions in SAV coverage (Tar-Pamlico River and Neuse River basins) have nutrient loading issues and are designated Nutrient Sensitive Waters. Once SAV is lost, increased turbidity and sediment destabilization can result in accelerated shoreline erosion and make recolonization more difficult (Durako 1994; Fonseca 1996). Therefore, prevention of any additional SAV loss through water quality maintenance and improvement is a high priority for red drum management.

Increased sediment and nutrient loading in the water column can enter coastal waters from point source discharges, nonpoint source stormwater runoff, or resuspension of bottom sediments. Specific sources that contribute to increased sediment loading include construction activities, unpaved roads, road construction, golf courses, uncontrolled urban runoff, mining, silviculture, row crop agriculture, and livestock operations (DWQ 2000b). Specific sources that contribute to increased nutrient loading include agricultural and urban runoff, wastewater treatment plants, forestry activities, and atmospheric deposition. Nutrients in point source discharges are from human waste, food residues, cleaning agents, and industrial processes. The primary contributors of nutrients from nonpoint sources are fertilizer and animal wastes (DWQ 2000b).

In North Carolina, there are water quality standards for light associated parameters including turbidity, total suspended solids (TSS), and chlorophyll *a*. Modifications to regulatory water quality standards may be needed to improve their effectiveness for SAV protection. A review of current chlorophyll, TSS, and turbidity

standards should be conducted to determine if they are appropriate for the protection of SAV in North Carolina waters or if a new standard for protecting water clarity for SAV is needed.

Dredging for navigational channels, marinas, or other infrastructure can physically damage or remove SAV, while shading from docks over grass beds can lead to gradual loss of SAV beneath the structures (Loflin 1995; Shafer 1999). As additional docks and marinas are constructed along the coast, the potential for boating-related impacts increases. Results from Connell and Murphey (2004) indicate that current dock designs over SAV beds in North Carolina result in a reduction in SAV coverage and density. Regulations by CRC state that activities which will directly impact SAV, such as dredging or construction of docking facilities, should be avoided (15A NCAC 7H .0208(a)(5). Dock criteria are currently being evaluated by CRC, with support from DMF, to determine how existing dock siting requirements could be modified to reduce impacts to SAV and other fish habitats.

Use of bottom disturbing gear can damage SAV beds, but MFC regulations restrict gears that cause the most damage over SAV habitat, including oyster dredges, crab dredges, and hydraulic clam dredges. Bay scallop dredges, which are smaller and have no teeth, cause less severe damage to SAV than oyster and crab dredges, and are allowed over SAV habitat. Hand gear, such as bull rakes and large oyster tongs, can uproot and damage SAV, but to much smaller areas than mechanical gears (Thayer et al. 1984). Current MFC rules prohibit use of rakes more than twelve inches wide or weighing more than six pounds in SAV. Clam kicking can also severely impact SAV habitat since substrate is displaced by propeller backwash (Guthrie and Lewis 1982; Peterson and Howarth 1987). Because of the severe disturbance to the bottom, clam kicking is restricted to sandy bottom, in waters more than 10 ft deep, in Core and Pamlico sounds, and Newport, North, New, and White Oak rivers. The fishery is managed intensively, with strong enforcement to prevent clam kicking in the restricted areas.

Shrimp and crab trawls can shear or cut the blades of SAV, or uproot plants without major disruption of the sediment (ASMFC 2000). While shearing of grass blades does not kill a seagrass plant, shoot density is reduced, decreasing productivity and structural complexity. Where the trawl doors dig into the sediment, SAV plants can be uprooted and killed. The impact of the doors depends on gear configuration, vessel speed and other factors. High turbidity and sedimentation from use of bottom-disturbing fishing gear can reduce water clarity, affecting SAV growth, productivity, and in some cases, survival (ASMFC 2000). The boundaries of No Trawl Areas in Core Sound were modified in the Peneaid Shrimp Fishery Management Plan (DMF 2006) to avoid additional grass beds. Additional law enforcement may be needed to enforce buffers around closed areas supporting SAV, such as No Trawl Areas and Mechanical Clam Harvest Areas. If other areas are identified where bottom disturbing gears are impacting SAV, boundary changes should be evaluated.

Shell bottom

The current distribution of shell bottom is much less than what historically occurred (Newell 1988). Mechanical harvesting of oysters was the primary and initial cause of habitat loss (DMF 2001). Most shell bottom losses have been to subtidal beds in Pamlico Sound, where DMF has also found declines in oyster recruitment. Although

mechanical harvesting of oysters has been greatly restricted, reefs have not recovered, possibly due to stress from water quality degradation and increased occurrence of disease (Dermo, MSX) (DMF 2001). Oyster dredging removes oysters and reduces the vertical profile of oyster rocks, increasing the susceptibility of remaining shell bottom at that location to low dissolved oxygen (DO) and possible mortality (Lenihan and Peterson 1998). Other causes of shell bottom losses include dredging for navigation channels or marinas. These activities can physically remove or damage existing shell bottom or result in turbidity that clogs oyster gills or covers sediment completely. Hydrologic modifications also impact oyster habitat by altering salinity regimes. While drainage for agriculture has changed little in recent years, drainage for urban/suburban development is increasing steadily.

In designated oyster management areas and other designated habitat areas, trawling and mechanical harvest of oysters is prohibited, including portions of Core and Pamlico sounds. Through the DMF Oyster Fishery Management Plan (2001), oyster dredging was restricted from additional shallow areas in western Pamlico Sound tributaries. Hand harvest methods for oysters and clams can also be destructive, but on a much smaller scale. Completion of mapping of North Carolina shellfish beds by DMF would enhance the ability to enforce existing regulations and make it possible to quantify changes to this habitat relative to changes in land use, water quality, and regulatory measures. Restoration of subtidal oyster reefs in the lower Neuse River and other western Pamlico Sound estuaries could enhance spawning conditions for red drum.

Soft bottom

Activities that lead to the deepening, loss, or chemical contamination of shallow and intertidal habitat are the greatest threat to this habitat. Dredging associated with construction of marina and dock facilities alters the shoreline configuration, circulation patterns, and changes in bottom sediment characteristics (Wendt et al. 1990). Light availability on the bottom of dredged marinas is lowered, reducing productivity from benthic algae (Ianuzzi et al. 1996). Operation of a marina can also affect productivity of the soft bottom community due to introduction of heavy metals, hydrocarbons, and bacteria (Chmura and Ross 1978; Marcus and Stokes 1985; Voudrias and Smith 1986). Heavy metals and hydrocarbons are toxic to many soft bottom dwelling invertebrates and benthic feeding fish (Weis and Weis 1989). Additionally, DO may become depleted or below biotic thresholds in dredged marina basins and channels. A North Carolina marina study found significantly lower DO concentrations (less than 5.0 mg/l) inside some marinas compared to outside marinas (DEHNR 1990). Estuarine shoreline stabilization can also degrade soft bottom habitat utilized by red drum by reducing or eliminating the intertidal zone, deepening shallow soft bottom habitat, or contaminating sediment from leaching of toxic preservatives from wood structures (Weis et al. 1998).

The extent of sediment contamination in North Carolina coastal waters is not well known. Sediment sampling is not routinely conducted by the DWQ since there are no sediment standards in the state. Studies examining sediment contamination at sites in North Carolina soft bottom have found various levels of contamination (Riggs et al. 1989; 1991; Hackney et al. 1998). Highest contamination levels tended to occur in low salinity areas with low flushing and high river discharge. In the Neuse River, surface sediments were found to contain elevated levels of several heavy metals, including zinc, copper, lead, and arsenic, primarily between New Bern and the mouth of the river. The

contaminated sites were primarily attributed to permitted municipal and industrial treatment plant discharges. Marinas were also found to contribute substantial amounts of copper and variable amounts of zinc and lead. Nonpoint sources were more difficult to evaluate. In the Pamlico River, heavy metal contamination was less severe, although arsenic, cobalt, and titanium exceeded the levels found in the Neuse River. These studies suggest that sediment contamination in some estuarine areas, especially those where both organic rich mud and waste water discharges are present, may be significant and could affect fish populations and the base of their food chain. To better determine if contaminated sediment is a significant threat to coastal fish habitat, the distribution and concentration of heavy metals and other toxic contaminants in freshwater and estuarine sediments needs to be adequately assessed and areas of greatest concern need to be identified.

Bottom disturbing gear can potentially impact soft bottom habitat, but because of the limited structure and dynamic nature of this habitat, has historically been considered the most appropriate location for such gear. Of the bottom disturbing gears, trawling is more commonly used than dredges on soft bottom habitat in both estuarine and coastal ocean waters. Trawling can potentially impact soft bottom habitat by removing or damaging epifauna, and burrow-forming infauna, reducing diversity and abundance of benthic community, smoothing sediment features, and increasing exposure to predators (Auster and Langton 1999; Collie et al. 1997). Sediment resuspension can increase turbidity, reducing light dependent benthic productivity, which in turn affects the benthic food web. While several studies have shown negative effects of trawling, other studies have found no negative impacts (Van Dolah et al 1991; Currie and Parry 1996; Cahoon et al. 2002). No studies have specifically looked at the effect of trawling on the bottom habitat of Pamlico or other large sounds in North Carolina.

Use of trawl nets, long haul seines, swipe nets, dredges, and mechanical harvest of shellfish is prohibited over productive shallow soft bottom habitat designated as a Primary and Secondary Nursery Area by the MFC (15A NCAC 3N .0104). There are approximately 147,000 acres of designated Primary Nursery Areas (PNA) and Secondary Nursery Areas (SNA) (15A NCAC 3N .0101 - .0105) in North Carolina (Figure 13). They are generally located in the upper portions of tidal creeks and rivers and usually include wetlands, soft bottom, and in some areas shell bottom. These nursery areas include some but not all of red drum nursery areas. Dredging for navigational purposes is also not allowed in PNAs by CRC regulations.

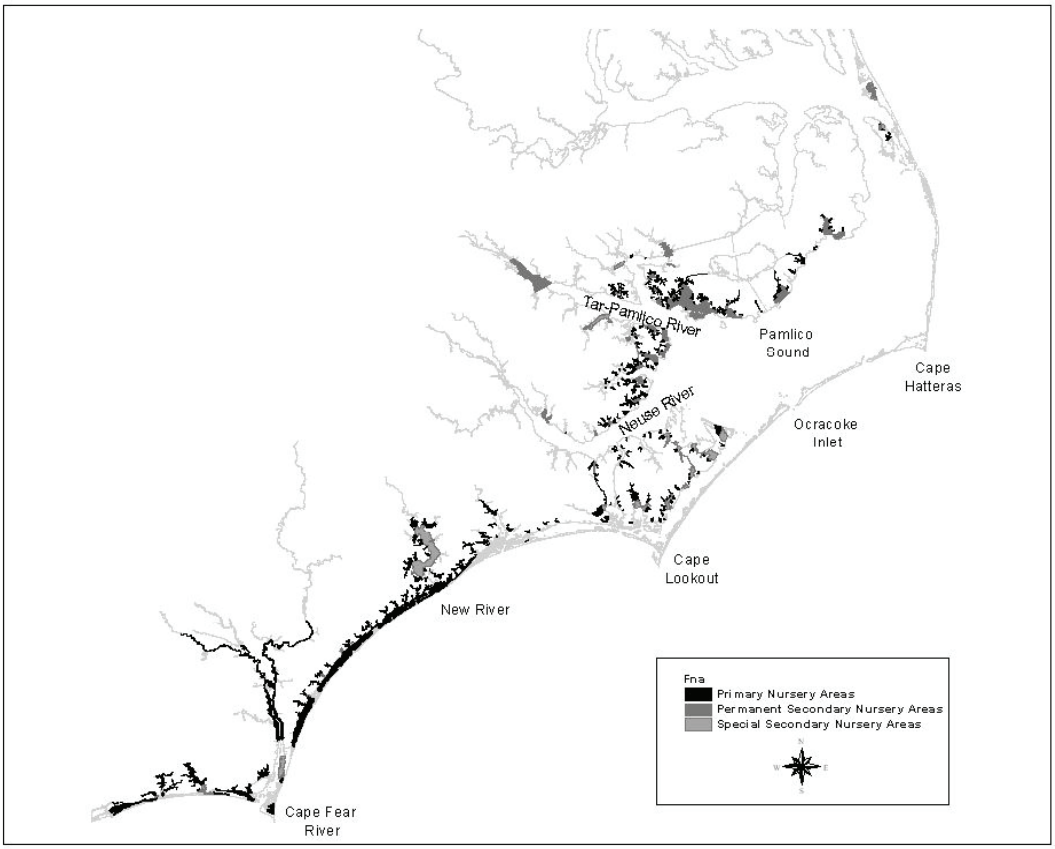


Figure 13. MFC designated fishery nursery areas.

Beach nourishment can threaten the quality of intertidal and shallow subtidal ocean bottom habitat, which is important nursery and foraging grounds for subadult and adult red drum. When sand is put on the intertidal beach, the existing benthos is buried, killing the prey available for red drum and other benthic feeding fish (Hackney et al. 1996). Because red drum are mobile, they can move to another area. However there may be cumulative impacts if multiple beaches within a region are nourished at the same time. The reported recovery time of the benthic community generally ranges from one month to one year, although longer in some cases (Reilly and Bellis 1983; Rackocinski et al. 1993; Donoghue 1999; Jutte et al. 1999; Lindquist and Manning 2001). Factors that affect the recovery time include compatibility of deposited material with native sand, volume, depth, and length of filled area, time of year of project, frequency of renourishment events, and specific site conditions. In addition to reduction in available food, beach renourishment can affect red drum and other fish species by altering preferred topographic features such as ebb tide deltas and nearshore muddy sloughs or reducing visibility (Street et al. 2005).

Studies examining the effect of beach nourishment on fish abundance found that large inter-annual fluctuations in surf zone fish populations made detection of change very difficult (COE 2001; COE 2003). More detailed studies are needed to assess the effect of large-scale beach nourishment on red drum diet and behavior**.** As of 2005, the miles of beach authorized for storm damage reduction projects increased from 16 to 35

mi with an additional 104 mi at some stage of requesting authorization. As the number of beach nourishment projects increase, adequate monitoring of the effects of beach nourishment on the soft bottom community and associated surf fish populations is increasingly important and should be required for all large-scale or long-term nourishment projects. The MFC adopted a beach nourishment policy in 2000 to guide the permitting process to more fully consider fish habitat impacts. All beach nourishment projects should adhere to the guidelines provided in that policy. The policy is a tool for the MFC to use, should they decide to comment on a project. As part of CHPP implementation, DCM has begun preparing a coastwide comprehensive beach management plan to provide guidelines to minimize long-term impacts, benefiting red drum and other surf zone species.

9.2 Water Quality

Good water quality is essential for maintaining the chemical properties of the water column needed to support the various life stages of red drum, as well as sustain other habitats which red drum utilize, such as SAV, shell bottom and soft bottom. Although red drum have a wide tolerance range for environmental conditions, there are optimal temperature, salinity, and pH thresholds which enhance survival and growth for different life stages of the species. Optimum temperatures for spawning are between 22 and 30^{o}C and at lunar spring tides (SAFMC, 1998). Eggs and larvae require salinity of 25 – 35 ppt for proper buoyancy while planktonic. Elevated pH levels and low water temperatures can reduce survival of red drum larvae (Lyon and Fisher, 1998). Several studies indicate that mortality during early post-settlement is substantial and that survival through this stage is critical to recruitment success (Rooker et al., 1998; Baltz et al., 1998). In mesocosm experiments, Rooker et al. (1998) found a 3–9% decrease in mortality per millimeter increase in length of fish. Consequently, faster growth rates associated with high water temperatures increase recruitment success. Because red drum remain within one estuarine system for several years, they can be vulnerable to water quality problems within a watershed.

Human activities that alter the preferred salinity or temperature conditions of the species, elevate toxins, nutrients, or turbidity, or lower DO levels can degrade water quality and impact growth and survival of red drum. These pollutants may be derived from both point and nonpoint sources. Point sources include direct discharges of treated domestic or industrial wastewater or untreated stormwater. Point source discharges are regulated by DWQ and the US Environmental Protection Agency (EPA). In estuarine waters, there are numerous wastewater discharges. EMC requires a NPDES permit for point source discharges, which specifies limits of various pollutants in treated discharge waters, based on the water quality classification of the receiving stream. Areas classified as Nutrient Sensitive Waters have more stringent limits on nutrients. Leaks or ruptures of sewage pipes and failing lift stations can also lead to untreated sewage entering into coastal waters. In ocean waters, wastewater discharges are not permitted, because this activity has been found to cause significant beach pollution in other states (Moore 1992). Dumping of sewage sludge and industrial wastes has also caused adverse impacts to the fishing industry (Cross et al. 1985). Ocean outfalls should continue to be prohibited in North Carolina to minimize water quality degradation to the water column.

Nonpoint stormwater runoff can originate from numerous activities, including urban development, roadways, marinas, concentrated animal operations, and land disturbance from agriculture and forestry. Stormwater runoff can carry nutrients, sediment, bacteria, and toxic chemicals into coastal waters. In some instances, stormwater is directly discharged into ocean or estuarine waters. Beach communities appear to be increasingly using "temporary" pumping of storm water to the beach as a solution to stormwater runoff. The runoff during heavy rain events flood the streets, in part due to improper siting of structures in flood zones, excessive impervious surface, and lack of upland stormwater retention areas. Precautionary swimming advisories at Hanby Beach, Carolina Beach, Emerald Isle, and Kill Devil Hills have been posted because of potential contamination from stormwater discharge onto the beach or water (JD Potts, DEH, pers. comm.). As coastal areas continue to develop and flooding problems increase, managing stormwater should be a high priority for protecting habitat and water quality. Because red drum are demersal bottom feeders and relatively long-lived, they could be particularly susceptible to low DO and toxins that accumulate in bottom sediment.

9.2.1 Water quality status

Red drum in North Carolina occur in several coastal river basins, including the Tar-Pamlico, Neuse, Pasquotank, White Oak, Cape Fear and Lumber river basins (Figure 14). DWQ evaluates water quality in river basins on 5-year cycles, for six different Use Support categories. Aquatic life and shellfish harvest are the most ecologically pertinent categories. The aquatic life use support category is an indicator of whether aquatic invertebrates and fish can adequately live in the waters. Benthic invertebrate and fish community data, ambient water quality, and NPDES data are considered in the assessment. The shellfish harvest use support category is determined by elevated fecal coliform bacteria levels and is a general indication that stormwater runoff is entering surface waters.

Table 18 summarizes the most recent Aquatic Life and Shellfish Harvest Use Support for the coastal river basins where red drum occur. From the Use Support data, the Pasquotank river basin, that includes the Albemarle region and northern Pamlico Sound, has relatively low amounts of impaired fresh and estuarine waters and a low amount of shellfish closures. In the Tar-Pamlico, which includes many of the estuarine tributaries of western Pamlico Sound and the southern portion of Pamlico Sound from Hatteras to Ocracoke inlets, aquatic life impairment of freshwater streams is relatively high (7.9%). However in the lower portion of the river basin, impairment of aquatic life use support in estuarine waters and impairment of shellfish harvest use support is low. All of the impaired estuarine waters for the aquatic life use support category were located in the lower Pamlico River and tributaries (subbasin 03-03-07, between Washington and Roos Point). The Neuse river basin has the highest amount of impaired freshwater streams. The Cape Fear, followed by the Neuse river basin, has the most impaired estuarine waters for aquatic life use support. Estuarine waters are those that are most likely used by juvenile red drum. In the Cape Fear river basin, impaired estuarine waters for aquatic life were primarily located in subbasin 03-06-17 in the main stem of the river, between Toomer's Creek (north of Wilmington) and Snow's Cut. In the Neuse river basin, impaired estuarine waters for aquatic life were primarily located in subbasin 03-04-10, between New Bern and Tonney Hill Point (mouth of Neuse River, northern shore). Impaired waters for shellfish harvest is greatest in the southern river basins -

Lumber, Cape Fear, and White Oak. This coincides with population density, development, and increased impervious surfaces. Water quality stressors attributed to aquatic life use support impairment in fresh water streams and estuaries include habitat degradation (reduced biodiversity due to sedimentation and channelization), low dissolved oxygen, fecal coliform contamination, and elevated turbidity (DWQ 2005). The specific source of the stressors is in most cases unknown.

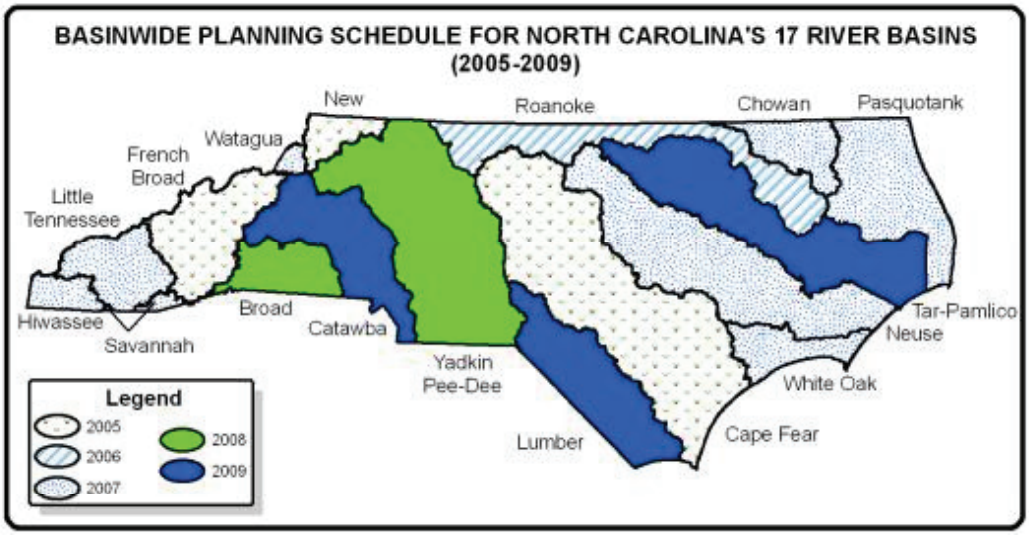


Figure 14. Location of North Carolina river basins (http://h2o.enr.state.nc.us/basinwide)

Table 18. Impaired water ratings for Aquatic Life and Shellfish Harvest Use Support categories in six coastal river basins (DWQ 2002a,b, 2003, 2004, 2005, 2007)

	Aquatic life - streams			Aquatic life - estuarine			Shellfish harvest		
River Basin (year[1])	Impaired stream miles	% impaired of monitored streams	Total % monitored	Impaired estuarine acres	% impaired of monitored waters	Total % monitored	Impaired (acres)	% impaired	Total % monitored
Pasquotank (2002)	0.0	0.0	29	0	0	69	5,033	1.3	100
Tar-Pamlico (2004)	64.1	7.6	33	6,071	1	92	7,516	1.3	100
Neuse (2002)	278.0	22.3	36	31,763	9.1	91	3,710	1.1	100
White Oak (2007)	0.0	n/a	n/a	7,942	n/a	n/a	37,582	31.8	n/a
Cape Fear (2005)	425.4	6.9	n/a	6,527.40	20.6	n/a	6,500.70	41.0	n/a
Lumber (2003)	0.0	0.0	32	0	0	50	3,606.90	84.0	100

[1] Year of most recent DWQ River Basin plan, from which data was derived

There is sparse data available on nearshore ocean water quality trends since DWQ does not monitor ambient water quality in nearshore ocean waters. The Shellfish Sanitation Office, Division of Environmental Health, has been recording *Enterococcus* bacteria levels for safe swimming along ocean beaches and some estuarine areas since 1997. Since 2002, a public advisory or alert has been issued for the ocean for 288 days in 38 sampling areas (0 in 2002, 12 in 2003, 19 in 2004, 7 in 2005), with advisories most

frequently occurring in Dare and Carteret counties. Although these bacteria will not hurt red drum, it is an indicator that other pollutants associated with upland activity, such as nutrients or toxins, are present.

An additonal source of water quality data in North Carolina is the National Coastal Assessment Program conducted by the EPA. Approximately 33 stations have been sampled in the summer since 2002. Information is collected to determine sediment, benthic, and habitat indices, as well as fish tissue condition, in areas where red drum occur and where DWQ data is sparse (Pamlico, Core, and Bogue sounds). The assessment rated the Carolinian province as being in fair to good condition.

9.2.2 Water quality stressors

Water quality stressors attributed to water quality impairment in coastal waters are often associated with increased development. There has been a significant increase in population over the past 20 years in coastal river basins. Increased population has been directly correlated with increased impervious surfaces and hydrological alterations, which in turn results in increased stormwater runoff (Mallin et al. 2000). Increased population results in the need for additional septic tanks, increased wastewater treatment capacity, road infrastructure, and marinas, which can increase pollutant loading into coastal waters. Hydromodifications due to ditching and drainage of uplands and wetlands accelerates the quantity and rate at which pollutants enter estuarine waters, decreases the amount of filtering that occurs prior to pollutants entering the waters, and may alter the salinity regime in the upper estuary (DWQ 2000b). Loading and movement of sediment, nutrients, and toxins are often greater in channelized sections than natural streams, and can negatively impact the fish community and benthic habitats (White 1996; EPA 2001). Several studies have found that the size, number, and species diversity of fish in channelized streams are reduced and the fisheries associated with them are less productive than those associated with unchannelized reaches of streams (Tarplee et al. 1971; Hawkins 1980; Schoof 1980). Pate and Jones (1981) found that productivity of several species of juvenile fish was significantly less in PNAs that received moderate to high levels of drainage from ditched uplands. They attributed this to the unstable salinity conditions that occurred in areas adjacent to channelized systems following moderate to heavy rainfall (>1 inch/24 hr). Therefore, hydromodification of the system can be the driver of other subsequent water quality stressors, such as hypoxia, eutrophication, and toxic contamination.

Hypoxia and eutrophication

Adequate supply of DO is critical to survival of benthic invertebrates and fish. Most demersal fishes experience mortality in waters having 1-2 mg/l O_2, impaired larval growth where oxygen levels are < 4.7 mg/l, and altered metabolism where oxygen levels are < 4 mg/l (Miller et al. 1995; Gray et al 2002). Some estuarine species are capable of detecting and avoiding low oxygen waters and will generally move to shallower oxygenated waters, but there are species-specific differences in tolerance thresholds (Wannamaker and Rice 2000). There are no reported oxygen tolerances for red drum.

Low-oxygen conditions can occur naturally in a system from flushing of swamp waters, which characteristically have low DO, or from stratification of the water column due to wind, temperature, and salinity conditions. However, low-oxygen conditions can also be fueled by increased stormwater runoff carrying nutrients and oxygen-consuming

wastes, which result in excessive oxygen demand in the water column or sediment. Algal blooms deplete the water column of DO due to respiration and organic decomposition (DWQ 2000b). Dissolved oxygen depletion in the water column occurs most often in summer. Warm surface waters, calm winds, and reduced freshwater inflow reduce mixing of water. The stratified bottom layer of water is prevented from receiving oxygenated surface waters and rapidly becomes depleted of oxygen. Shallow water estuaries with less frequent flushing often develop persistent stratification and bottom-water hypoxia that can last for weeks to months (Tenore 1972). Several studies have indicated that the frequency, duration, and spatial extent of low oxygen events have increased over the years due to increasing eutrophication of coastal waters from human and animal waste discharges, greater fertilizer use, loss of wetlands, and increased atmospheric nitrogen deposition (Cooper and Brush 1991; Dyer and Orth 1994; Paerl et al. 1995; Buzelli et al. 2002).

In the Neuse River, past estimates suggest that up to 30-50% of the estuary during summer is unsuitable bottom habitat due to hypoxia (Eby et al. 2000). Since relatively deeper oxygenated waters of the Neuse River estuary are important spawning areas for red drum (Barrios 2004), stratification and hypoxia in the Neuse River estuary could reduce the suitable habitat available for spawning and lower survival rates of eggs and larvae. Lower salinity, which may co-occur under summer stratification conditions, decreases egg buoyancy, causing eggs to sink and be more susceptible to hypoxic conditions, rather than being carried in surface waters to suitable nursery grounds (Barrios 2004).

Fish kills are often attributed to low oxygen events. Over the past ten years in coastal river basins supporting red drum, the number of reported fish kills peaked in 2001 and has decreased and remained relatively low in the past three years (Table 19, Figure 15). Approximately 10 estuarine species were reported in fish kills over the years. Atlantic menhaden, flounder, and spot were the most frequently reported estuarine species. Only one red drum in 2001 and one red drum in 2004, have been reported in fish kill events, indicating that red drum are not directly impacted by low DO and fish kills. However fish kills are an indicator of poor water quality conditions that may affect red drum indirectly. Overall, fish kills were most frequent in the Neuse river basin, followed by the Cape Fear, and Tar-Pamlico (DWQ 2006). Kill activity in the Neuse and Tar-Pamlico rivers was most frequent in the lower estuary, below New Bern and Washington, respectively. In this mixing zone, low DO, high temperatures, and fluctuating salinity are stressful to fish life. In 2006, low DO was cited as a factor in 30% of the fish kills, followed by toxic spills and algal blooms. Both of the latter can also deplete oxygen from the water column. Real-time monitoring sensors in the Neuse and Tar-Pamlico rivers located close to fish kill events verified that fish kills occurred following significant decreases in oxygen levels to hypoxic conditions (< 1.0 mg/l) the previous evening or early morning for several hours. Overall, DO depletion, coupled with unfavorable environmental conditions, is the most common cause of fish kills in estuarine waters. It is unknown if the apparent decline in fish kills in the past few years was due to favorable natural weather conditions or improved water quality conditions.

Table 19. Reported fish kills in coastal river basins supporting red drum, 1996-2006 (DWQ 2006).

River Basin	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Cape Fear	21	16	23	14	12	5	8	3	1	2	5
Neuse	14	12	8	16	23	37	9	21	8	9	10
Lumber	4	3	5	0	2	0	0	2	1	1	2
Pasquotank	10	2	8	2	0	1	6	2	0	2	0
Tar/Pamlico	3	6	5	11	14	23	8	6	2	1	2
White Oak	3	3	1	3	3	3	3	0	0	1	0
Yearly total	55	42	50	46	54	69	34	34	12	16	19

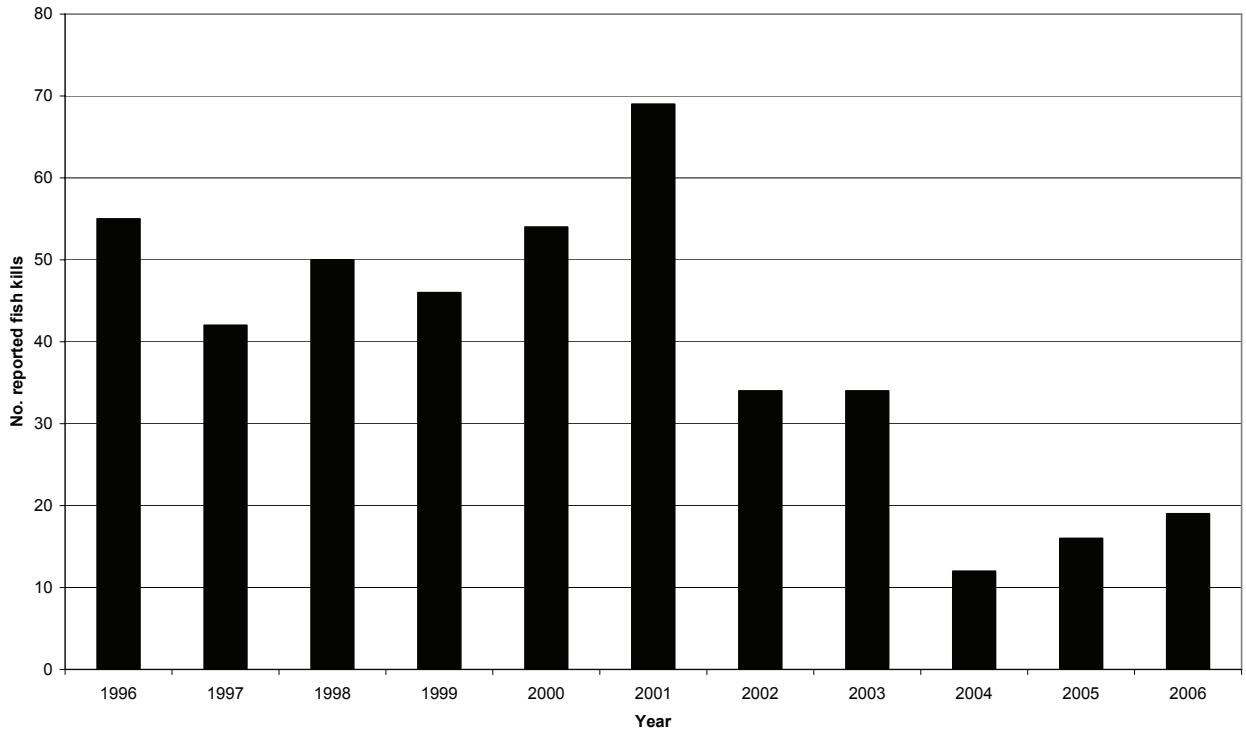


Figure 15. Reported annual fish kill events in coastal river basins supporting red drum, 1996-2006. Includes Pasquotank, Tar-Pamlico, Neuse, White Oak, Cape Fear, and Lumber river basins.

Low oxygen events can also impact red drum by altering the benthic community upon which it feeds (Luettich et al. 1999). Following a period of anoxia, initial food available to red drum could be greatly reduced. As the benthos recolonizes, small organisms typical of early successional communities provide a source of food for small juvenile benthic feeders, but larger organisms needed to support older red drum and other benthic feeding adult fish are lacking or inadequate (Luettich et al. 1999). More information is needed to understand the consequences on the estuarine food web and to what extent anoxia is impacting the soft bottom community. Efforts are needed to reduce

anthropogenic nutrient loading, particularly in systems that have a history of hypoxia and anoxia.

Toxins

Toxins in sediments or the water column can inhibit or alter reproduction or growth of aquatic organisms, or cause mortality in some situations (Weis and Weis 1989). Early life stages are most vulnerable to toxins (Funderburk et al. 1991). Toxicity testing indicated that juvenile red drum were significantly more sensitive to organophosphorus pesticides than mummichogs (Van Dolah et al., 1997). While the survival of some aquatic organisms is affected by toxins, other organisms survive and bioaccumulate the chemicals to toxic levels, passing them along in the food chain. Multiple studies have shown clear connections between concentrations of toxins in sediments and those in benthic feeding fish and invertebrates (Kirby et al. 2001; Marburger et al. 2002).

Toxic chemicals tend to accumulate in fine-grained sediments to several orders of greater magnitude than overlying waters, but can be resuspended in the water column by storm events or human activities such as dredging and trawling. Sediment toxicity can reduce the abundance of benthic prey available to red drum, reducing the quality of the habitat. Because macroinvertebrate diversity declines with increasing sediment contamination, food resources for benthic feeders, like red drum, may be limited in highly contaminated areas (Weis et al. 1998; Brown et al. 2000; Dauer et al. 2000).

Toxic chemicals come from localized point sources as well as diffuse nonpoint sources. Point sources include industrial and municipal waste discharges. Nonpoint sources of toxins include household and yard chemicals from urban runoff, petroleum and other chemicals from roads, parking lots, marinas, docks, and boating activity, runoff from agriculture and forestry, industrial emissions, and chemical spills (Wilbur and Pentony 1999).

Because low concentrations of heavy metals in the water column can be easily incorporated into fine-grained sediment, chemicals can accumulate in the sediment to toxic levels and be resuspended into the water column (Riggs et al. 1991). Studies have shown that fine-grained sediments are the primary reservoir for heavy metals, particularly organic rich muds (Riggs et al. 1991). Since organic rich muds occur extensively in North Carolina's estuaries and primary nursery areas, resuspension of contaminated organic rich muds is of particular concern. Refer to the section on soft bottom condition for more information on the known extent of sediment contamination in North Carolina.

Weather events

Hurricanes and other weather events can have a large influence on water quality in Pamlico Sound and other areas of North Carolina's coast. Hurricanes are considered an important natural perturbation that is necessary for the long-term maintenance of estuarine systems (Meeder and Meeder, 1989). With increasing loss of wetlands and hydrological modifications, however, the effect of flooding and storm damage is intensified, and the resulting runoff is more severely contaminated. In 1996, Hurricanes Bertha and Fran resulted in severe flooding of coastal waters, anoxia, and multiple fish kills in both Neuse and Pamlico rivers and Pamlico Sound. Shortly after the passage of Hurricane Floyd in September 1999, some anoxic conditions were documented in

Pamlico Sound (DWQ, DMF, unpub. data). However, subsequent storms and strong winds prevented prolonged stratification of the water column and increased oxygen concentrations, minimizing fish kills in the sound. Large inputs of nutrients and toxic chemicals were introduced into the system from flooded and failing hog lagoons and wastewater treatment plants, and from organic matter displaced from swamps and upland sources. The high number of fish kills in the Neuse and Tar-Pamlico river basins in 2001 may be a delayed ecological response to these nutrient inputs. In 2003, Hurricane Isabel breached a new inlet through Hatteras Island, which could have enhanced flushing in Pamlico Sound. However, DOT refilled the inlet to restore traditional transportation. Prevention of natural barrier island processes will have a long-term effect on water quality in adjacent estuarine waters.

Global warming and sea level rise could have a significant impact on future estuarine conditions and consequently red drum. As sea level continues rising, portions of barrier islands are expected to be inundated, increasing ocean influence and salinity in Pamlico Sound and tributaries (Pearsall and Poulter, in press). On a global scale, 30% of global wetlands are expected to be lost due to the combination of sea level rise and development along the shoreline, which deters landward migration of wetlands (IPPC 2002). In the Albemarle-Pamlico system, where elevations are low and landscape slope is minimal, there is concern that the rate of vertical accretion of marsh peat (currently estimated at 2.4-3.6 mm/yr - Craft et al. 1993) will not be able to keep up with sea level rise and prevent submergence of wetlands (Moore et al. 2006; Pearsall and Poulter, in press). While the current rate of sea level rise in the Albemarle region is 4.3 mm/yr (Pearsall and Poulter, in press), the rate of sea level rise is expected to double or triple over the next 50-100 years (IPCC 2002). The effect of these changes to red drum is unknown, but will most likely influence spawning aggregation patterns, and suitability of nursery habitats. Wetland loss will result in less filtering of stormwater runoff and less available nursery areas. Efforts are needed to plan for and attempt to offset the impacts of sea level rise on North Carolina's estuarine system. Restoration strategies include selectively plugging some ditches and installing tide gates on others to reduce impacts of salt intrusion and peat soil erosion, and planting flood and brackish tolerant plants on cleared lands.

9.3 Habitat and Water Quality Protection

MFC Authority

Presently, the MFC has authority for managing, restoring, developing, cultivating, conserving, protecting, and regulating marine and estuarine resources. Marine and estuarine resources are defined as "All fish [including marine mammals, shellfish, and crustaceans], except inland game fish, found in the Atlantic Ocean and in coastal fishing waters; all fisheries based upon such fish; all uncultivated or undomesticated plant and animal life, other than wildlife resources, inhabiting or dependent upon coastal fishing waters; and the entire ecology supporting such fish, fisheries, and plant and animal life." (G.S. 113-129)

Although the MFC's primary responsibilities are management of fisheries (season, size and bag limits, licensing, etc.), the MFC has the authority to comment on

State permit applications that may have an effect on marine and estuarine resources or water quality, regulate the placement of fishing gear, develop and improve mariculture, and regulate location and utilization of artificial reefs. Authority for the MFC is found at G.S. 143B-289.51 and 52.

Authority of Other Agencies

The North Carolina Department of Environment and Natural Resources have several divisions responsible for providing technical and financial assistance, planning, permitting, certification, monitoring, and regulatory activities, which impact the coastal water quality or habitat. The DCM is responsible for development permits along the estuarine shoreline in 20 coastal counties. Wetland development activity throughout North Carolina is permitted through the United States Army Corps of Engineers (COE) and DWQ (DWQ; 401-certification program). The DWQ has established a water quality classification and standards program for "best usage" to promote protection of unique and special pristine waters with outstanding resource values. The High Quality Waters (HQW), Outstanding Resource Waters (ORW), Nutrient Sensitive Waters (NSW), and Water Supply (WS) classifications have outlined management strategies to control point and nonpoint source pollution. The Neuse River Basin and Tar-Pamlico River Basin were designated as Nutrient Sensitive Waters by EMC in 1988 and 1989, respectively, due to increases in algal blooms and fish kills in the upper estuary. The blooms were linked to excessive nutrient levels. Regulations and water quality standards were developed to reduce loading of non-point sources of nutrient runoff. These changes in effluent and development standards are intended to reduce eutrophication of waters. Phase II stormwater regulations will be effective beginning July 2007 in designated areas. In coastal waters, this includes Brunswick, New Hanover, and Onslow counties, as well as the municipalities of Wilmington, Jacksonville, and Greenville. These new regulations will require more stringent control of stormwater runoff, identification and correction of point source discharges of stormwater, and lower amounts of maximum built upon area, when using the low-density development option.

Various federal and state environmental and resource agencies, including DMF, evaluate projects proposed for permitting and provide comments and recommendations to the DCM, DWQ, and COE on potential habitat and resource impacts. Waters that have been designated as PNAs by MFC or have a special EMC water quality classification, such as HWQ and ORW, are given additional consideration of impacts by DCM and DWQ prior to issuing a permit. Habitat protection relies on enforcement, the efforts of commenting agencies to evaluate impacts, and the incorporation of recommendations into permitting decisions. Habitats are also protected through the acquisition and management of natural areas as parks, refuges, reserves, or protected lands by public agencies and/or private groups.

Coastal Habitat Protection Plan (CHPP)

The Fisheries Reform Act (FRA) of 1997 mandated the DENR to prepare Coastal Habitat Protection Plan (CHPP -- G. S. 143B-279.8). The legislative goal for the CHPP is long-term enhancement of the coastal fisheries associated with coastal habitats. The CHPP provides a framework for management actions to protect and restore habitats

critical to North Carolina's coastal fishery resources and involves mandatory participation by the three commissions that have regulatory jurisdiction over the coastal resources (Coastal Resource Commission), water (Environmental Management Commission), and marine fishery resources (Marine Fisheries Commission), as well as the Department. The CHPP was completed in December 2004 and implementation plans for each Division and the Department were approved in July 2005. The plan is to be reviewed every five years. Actions taken by all three commissions pertaining to the coastal area, including rule making, are to comply, "to the maximum extent practicable" with the plans. The CHPP helps to ensure consistent actions among these three commissions as well as their supporting DENR agencies.

The CHPP describes and documents the use of habitats by species supporting coastal fisheries, status of these habitats, and the impacts of human activities and natural events on those habitats. Fish habitat is defined as freshwater, estuarine, and marine areas that support juvenile and adult populations of economically important fish, shellfish, and crustacean species (commercial and recreational), as well as forage species important in the food chain (Street et al. 2005). Habitats are categorized as wetlands, submerged aquatic vegetation (SAV), soft bottom, shell bottom, ocean hard bottom, and water column. The plan explains the environmental requirements, ecological value, status, and threats of the six fish habitats and includes management recommendations to protect and enhance the entire coastal ecosystem.

The CHPP recommends that some areas of fish habitat be designated as "Strategic Habitat Areas" (SHAs). SHAs are defined as specific locations of individual fish habitat or systems of habitat that have been identified to provide critical habitat functions or that are particularly at risk due to imminent threats, vulnerability, or rarity. While all fish habitats are necessary for sustaining viable fish populations, some areas may be especially important to fish viability and productivity. Protection of these areas would therefore be a high priority (Street et al. 2005). The process of identifying and designating SHAs began in 2005.

This fishery management plan describes habitat conditions or needs for the various life stages of the red drum. The FRA gives precedent to the CHPP and stipulates that habitat and water quality considerations in the fishery management plan be consistent with CHPP. Management actions recommended in this plan that are under MFC authority will be acted upon directly, while those management actions under other DENR authorities will be considered and acted upon through the CHPP implementation process and the appropriate agencies.

Since the original red drum fishery management plan was completed in 2001, habitat and water quality conditions appear to be the same or in some cases, somewhat better. SAV appears to be increasing in estuaries south of New River and in the lower salinity estuaries of the Neuse and Tar-Pamlico. The latter increase could be related to nutrient reduction efforts in those river basins. However, additional loading from increasing urbanization of the watersheds, as well as airborne deposition may offset net reductions in nutrient loading from the Tar-Pam and Neuse Nutrient Sensitive Waters Management Program. Wetland acreage continues to decline from permitted losses, although mitigation efforts by EEP may be preventing a net loss. Efforts have increased to restore more shell bottom habitat through additional funding and positions to the oyster restoration and recycling programs, and partnerships with other non-profit

organizations. Water quality, in terms of aquatic life use support impairment, is greatest in streams in the Neuse river basin and estuaries in the Cape Fear river basin. Fish kill events have declined but can be locally problematic.

Status of 2001 red drum habitat recommendations

In reviewing the past habitat and water quality management recommendations, many have been implemented or are underway. The following management actions are underway or completed. Many of these are components of the CHPP implementation plan.

- Coastwide mapping of SAV habitat has been funded and is underway, through an APNEP interagency cooperative mapping project.
- Critical SAV areas will be designated for additional protection through the SHA process, which is underway.
- Dredging of SAV habitat is avoided through DMF's permit review process.
- CRC is in the process of revising dock siting rules, which will consider minimum water depths, to avoid boating related impacts to SAV.
- Additional bottom disturbing gear restrictions have been implemented through the bay scallop, shrimp, and oyster fishery management plans to avoid damage to SAV and oysters.
- Research has been conducted examining red drum spawning activity in the Neuse River estuary.
- DMF continues to comment on beach nourishment projects to minimize impacts to spawning activities and larval transport.
- Additional funding of positions and equipment has been obtained to accelerate completion of shell bottom mapping and restoration of this habitat.
- DMF staff continues to comment on projects to prevent dredging through oyster reefs and prevent habitat degradation.
- The CRC is in the process of revising shoreline stabilization rules to discourage and reduce the use of bulkheads. However, there have been no efforts to require removal of bulkheads, as was recommended in the 2001 fishery management plan.
- EEP is in the process of evaluating mitigation requirements for wetland, oyster, and SAV impacts, and improving the mitigation process.
- Neuse and Tar-Pamlico NSW nutrient reduction measures have successfully reduced nutrient loading by more than their 30% reduction goals.
- Phase II regulations will also help reduce nutrient, sediment, and toxin inputs from stormwater runoff. EMC is currently developing coastal stormwater rules to provide stormwater protection to all coastal counties. However, additional efforts will continue to be needed as population increases.

Several of the approved CHPP recommendations will benefit habitat utilized by red drum. Implementation plans have been developed by the responsible agencies to address the recommendations. CHPP recommendations or actions that will benefit red drum and should continue to be implemented include:

- Identify and designate Strategic Habitat Areas (SHAs) using ecologically based criteria, analyze existing rules and enact measures needed to protect SHAs, and improve programs for conservation and acquisition of areas supporting SHAs.
- Complete and continue mapping of SAV to assess distribution and change over time.
- Conduct cooperative DMF/NOAA research to assess environmental conditions needed to support SAV, and model potential SAV habitat.
- Work with CRC and EMC to enhance enforcement and compliance with CRC, EMC, and MFC rules and permit conditions, particularly regarding dredging, dock construction, and wetland filling).
- Work with CRC to develop and implement a comprehensive coastal marina and dock management plan and adequate dock siting criteria for the protection of SAV, shell bottom, and shellfish harvesting.
- Work with CRC and EMC to implement measures to adequately reduce nutrient and sediment loading by:

  - Reducing point source pollution from wastewater by increasing inspections of facilities and infrastructure and providing incentives for upgrading all types of wastewater treatment systems.

  -Improving land-based strategies throughout riverbasins to reduce non-point pollution and minimize cumulative losses to wetlands and streams through voluntary actions and rule making.
- Complete shell bottom mapping throughout the coast.
- Continue to restore oyster reef no-take sanctuaries.
- Work with CRC to revise shoreline stabilization rules to adequately protect riparian wetlands and shallow water habitat and significantly reduce the rate of shoreline hardening.
- Initiate DO and other continuous water quality monitoring in the Pamlico Sound system to track water quality changes over time and effect on fishery species.
- Work with EMC to develop and implement a mandatory coastal stormwater management program that is equally or more protective than the Phase II stormwater program.
- Assess the distribution and concentration of heavy metals and other toxins in estuarine waters and sediments, assess benthic condition, and identify the areas of greatest concern.

<u>Red drum habitat research needs</u>

- Determine juvenile habitat preference and examine if recruitment is habitat limited.
- Examine ecological use and importance of shell bottom to red drum.

- Identify coastal wetlands and other habitats utilized by juvenile red drum and assess relationship between changes in recruitment success and changes in habitat conditions.
- Assess cumulative impact of large-scale beach nourishment and inlet dredging on red drum and other demersal fish that use the surf zone.
- Determine location and significance of spawning aggregation sites throughout the coast.
- Determine if navigational dredging between August and October significantly impacts spawning activity.
- Determine if designation of spawning areas by MFC is needed, and if specific protective measures should be developed.

9.4 Recommended Management Actions

Suitable and adequate habitat is a critical element in the ecology and productivity of estuarine systems. Degradation or improvement in one aspect of habitat may have a corresponding impact on water quality. Maintenance and improvement of suitable estuarine habitat and water quality is critical to successfully managing red drum stocks.

9.4.1 Environmental Factors

Habitat and water quality protection, conservation, and restoration are essential to accomplish the goal and objectives of this plan. The MFC, CRC, and EMC should adopt rules to protect critical habitats for red drum as outlined in the Coastal Habitat Protection Plans (CHPP), The N.C. General Assembly and/or divisions of the DENR should develop a strategy to fully support CHPP implementation with additional staff and funding. The involvement of federal agencies and increased funding (state and federal) may be necessary to accomplish these actions. The MFC and DMF should continue to comment on activities that may impact aquatic habitats and work with permitting agencies to minimize impacts and promote restoration and research.

Research is needed before any new management actions can be taken. The recommended research items in this FMP should be conducted and the results used to better manage red drum. To accomplish the research needs listed in the Environmental Factors section, CRFL funds or other funding sources should be sought. If possibly, additional sampling by the Division throughout the coast should be conducted, targeting summer spawning estuarine juvenile fish at the appropriate time of year and in appropriate locations. This information would aid in determining habitat preferences, and the relationship between red drum, coastal fish habitats, and activities that alter those habitats.

10. PRINCIPAL ISSUES AND MANAGEMENT OPTIONS

10.1 Identification of Issues

Major issues and management options developed during the FMP process are summarized in this section. Management issues in the North Carolina red drum fishery have been solicited from the public, Red Drum Advisory Committee, Marine Fisheries Commission, Finfish and Regional Advisory committees, DMF, DENR, and the scientific community.

10.1.1 Issues Addressed in this Plan

1. Adult Harvest Limits
2. Recreational Targeting of Adult Red Drum
3. Recreational Bag and Size Limits
4. Commercial Harvest Limits
5. Bycatch in the Estuarine Gill Net Fishery

10.2 Issues and Management Strategies

10.2.1 Adult Harvest Limits

Issue

The potential modification of the rule prohibiting the harvest and possession of red drum greater than 27 in total length.

Background

Regulations on the harvest of juvenile and adult red drum have changed significantly over the past 31 years. Restrictions on the harvest of adult red drum were first put into place in 1976 with the allowance of two fish greater than 32 in total length (TL). In 1990, a five fish bag limit was put into place on juvenile red drum with an allowance of one adult fish 32 in TL or greater. In 1992 the maximum size limit was reduced to 27 in TL with no sale of fish greater than 27 in TL. The harvest of one large, adult red drum was allowed until October 1998. As an interim measure to the North Carolina Red Drum FMP, required in the guidelines for FMP development, the MFC prohibited the harvest and possession of red drum greater than 27 in TL in October 1998 (NCAC 15A 3M .0501 (c)). Amendment 2 to the ASMFC Red Drum FMP requires states from New Jersey to Florida to achieve and maintain the necessary size and creel limit combinations to attain a spawning potential ratio (SPR) of 40% and it required all states to maintain or implement more restrictive commercial fishery regulations (ASMFC 2002).

Discussion

The rule prohibiting the possession and harvest of red drum greater than 27 in TL was implemented to reduce mortality on the spawning stock because overfishing was occurring (NCDMF 2001). The average SPR from 1986 to 1991 was estimated at only 1.3% (Vaughan and Carmichael 2000). The estimated SPR of the North Carolina red drum stock increased to 18% from 1992 to 1997 but was still below the overfishing threshold of 30% (Vaughan and Carmichael 2000). Results from the latest stock assessment indicate that the average SPR for the northern stock of red drum (North Carolina and Virginia) is above the 30% threshold but below the 40% target from 1999 to 2005 (Takade and Paramore 2007). The SPR estimates from the latest stock assessment correspond with increased escapement rates into the adult population during this time.

An indication of increased escapement into the adult population is evident from length frequency data from the NCDMF Red Drum Volunteer Tagging Program. The percentage of red drum tagged by volunteer tagger Norman Miller between 28 and 36 in TL (young adult red drum) was examined over three time periods (1984-92, 1992-99, 2000-06) from Ocracoke Inlet to see how the proportion of this size class has changed over time (Figure 16). The time periods were lagged one year because fish within the slot limit on the last year of the management period would be the first cohort to recruit to the adult tagging program in the new management period, but they would have been subject to fishing mortality at ages 1 and 2 in the old management period. Norman tagged virtually every adult red drum he and his customers caught, which minimized bias and provided the most comprehensive length frequency data for the time series. The proportion of red drum in the 28-36 in TL size class increased from 17.8% to 18.1% in the early and middle periods, respectively, to 34.4% in the late period. A further indication of increased escapement into the adult population can be found in the commercial estuarine gill net length frequency data (Figure 17). The length frequency distributions were examined over three time periods (1986-91, 1992-98, 1999-04), which covered different size and trip limit regulations (see Section 6, Status of the Commercial Fisheries). The length frequency distribution during the early period was mostly comprised of fish in the lower end of the slot limit (14 in TL, 1986-1990, 18 in TL 1991), with very few fish in the upper end of the slot limit. The middle period had more fish in the upper end of the slot limit, but the modal size (19 in TL) was at the lower end of the slot limit. The length frequency was distributed throughout the slot limit in the late period with the modal size (22-24 in TL) in the middle of the slot limit. The increased escapement into the adult population and size limit regulations have resulted in red drum throughout the slot limit available to the commercial and recreational fisheries and an increase in the size class comprising young adult fish.

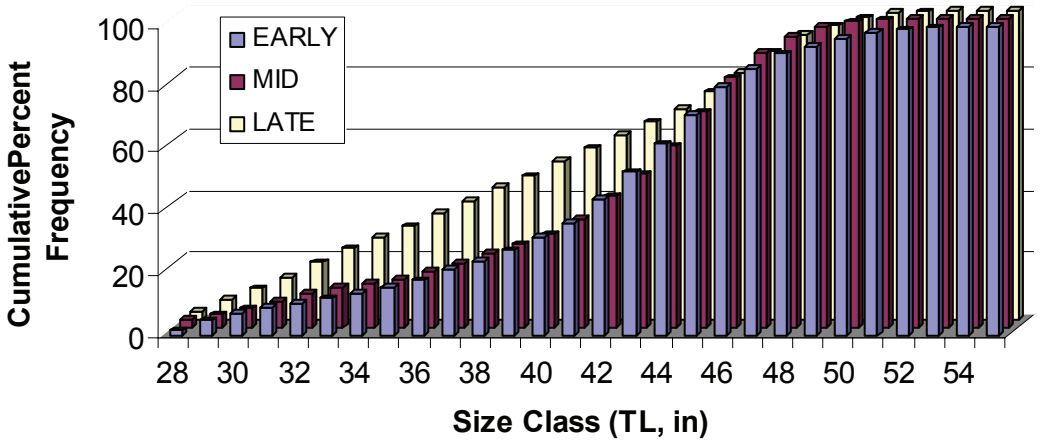


Figure 16. Cumulative percent frequency at size for adult red drum tagged in Ocracoke Inlet from the NCDMF Red Drum Volunteer Tagging Program during the early (1986-1991), mid (1992-1997) and late (1999-2005) management periods.

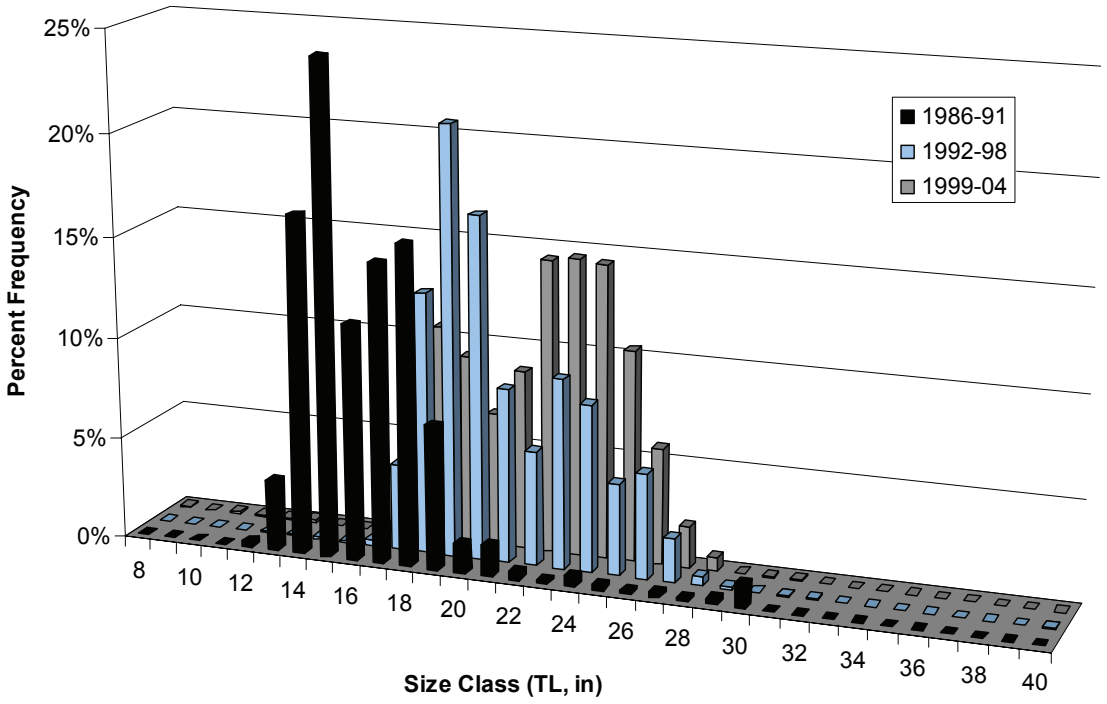


Figure 17. Length frequency distributions of red drum from the commercial estuarine gill net fishery during the early (1986-91), middle (1992-98) and late (1999-04) management periods.

The prohibition on harvesting red drum greater than 27 in TL prevents anglers from applying for a potential International Game Fish Association (IGFA) all tackle

world record. Allowing a trophy fishery where an angler can keep one red drum over 55 in TL during the year if the angler obtains a "trophy tag" is a possible solution. The State of Florida has a tarpon tag for anglers who possess or harvest a tarpon (http://www.myfwc.com). A trophy tag would be available to all anglers who purchase a coastal recreational fishing license (CRFL) at no additional cost. The NCDMF is unable to charge a fee for a trophy tag or permit. The number of adult red drum harvested in a year could be limited by restricting each license holder to one trophy tag per year. Length frequency data from the NCDMF Volunteer Tagging Program indicate that not many adult red drum caught by anglers exceed 55 in TL, so the number of adult red drum harvested under this management option would likely be low (Figure 18). The trophy tag would give the NCDMF information on the number of adult fish harvested but would provide very limited biological data on the adult population. If red drum over 55 in TL was only comprised of old adults and senescence commonly occurred in older red drum, then the impact on the spawning stock could be minimal. An age, growth and maturity study by Ross and Stevens (1992) only found two fish (ages 49 and 51) that were senescent but also sampled an age 51 fish that recently spawned. Age and growth data for adult red drum show that red drum 55 in TL and greater were age 40 and older (Figure 19). However, the sample size was very low (n=2), which precludes making any conclusions about the age structure of red drum 55 in TL and greater. Although the average age generally increases with the length of the fish, the range of ages for any given adult size class is very large, making length a poor indicator of age. Further complicating a trophy tag system is Amendment 2 to the ASMFC Red Drum FMP, which requires states from New Jersey to Florida to achieve and maintain the necessary size and creel limit combinations to attain an SPR of 40% and it required all states to maintain or implement more restrictive commercial fishery regulations (ASMFC 2002). These states currently prohibit the harvest and possession of adult red drum (ASMFC 2006). Therefore, any state that allows the adult harvest of red drum would be found out of compliance with the ASMFC FMP.

A similar option is to make special permits available to anglers who wish to harvest adult red drum greater than 27 in TL. Like the trophy tag option, these permits would be available to all anglers at no cost. This would likely result in more adult red drum harvested per year than the trophy tag management option because of the broader size range of adult fish that could be harvested. The entire age range of adult red drum could be harvested, which would increase the impact on the spawning stock. More age and growth data could be collected by the NCDMF under this management option, but a very large number of adult red drum would be needed on an annual basis for an age and growth study of the adult population because the maximum age of red drum is greater than age 60 and because of the overlapping sizes at age. The number of adults that must be harvested in order to get reliable age and growth information for the entire adult population is contrary to the current management strategies for red drum and could compromise the sustainability of the spawning stock. And this option would also be out of compliance with Amendment 2 to the ASMFC Red Drum FMP.

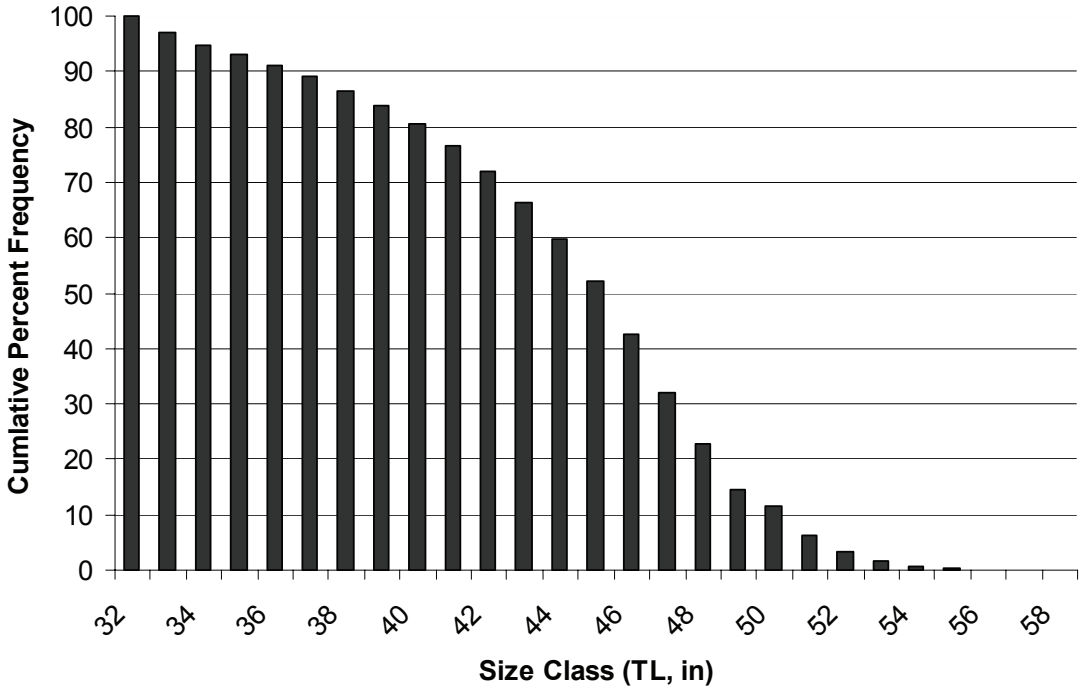


Figure 18. Length frequency distribution of adult red drum from the NCDMF Volunteer Tagging Program, 1984-2006.

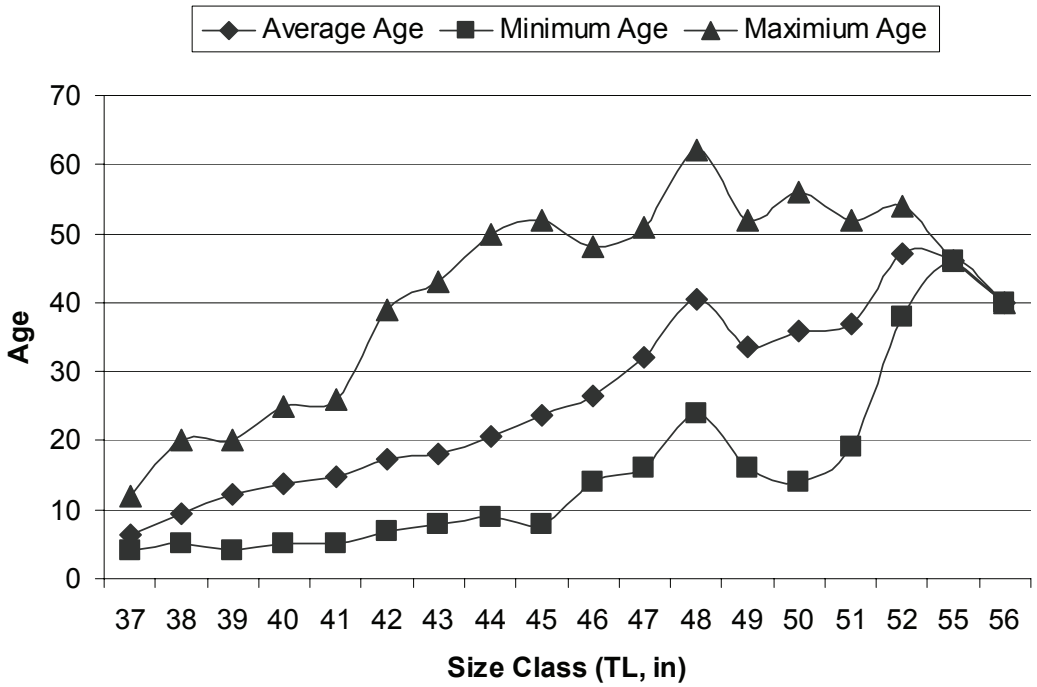


Figure 19. Average, minimum and maximum ages for adult red drum per one inch size class, 37-56 in TL.

Another option would be to allow the harvest of adult red drum while maintaining the SPR above the 30% threshold. This would provide some benefits to the commercial and recreational fisheries in the form of some adult red drum could be harvested and the angling all tackle world record could be broken. There is also the potential for the NCDMF to collect age and growth data on the adult fish. Unlike the trophy tag and special permit options, the number of adult red drum harvested per year would be difficult to obtain, and the NCDMF would not have a reliable way to monitor the number of adult red drum harvested. And this option would also be out of compliance with Amendment 2 to the ASMFC Red Drum FMP.

Waiting until the SPR target of 40% is reached before allowing the harvest of adult red drum would be more risk averse and could avoid compliance issues with the ASMFC FMP. The next coastwide stock assessment for red drum is scheduled for 2009, so no new SPR information will likely be available before then. It is also uncertain whether the next amendment to the ASMFC FMP will allow the harvest of adult red drum if the SPR target is reached. Vaughan and Carmichael (2000) indicated that it would likely take 15-20 years for the spawning stock of red drum to rebuild based on the age at maturity and longevity of the species. North Carolina would be found out of compliance if adult harvest is allowed and the next amendment to the ASMFC Red Drum FMP does not allow adult harvest.

The Red Drum Plan Development Team (PDT) discussed the issue of the "tradeoff" between the harvest of adult red drum and the subsequent reduction in juvenile red drum harvest in order to avoid overfishing. The creel and size limit analysis used to calculate the required harvest reductions in 1998 were examined to determine if it is possible to calculate a tradeoff between juvenile and adult fish. This is an appropriate method to use for calculating harvest reductions but does not work well for calculating harvest increases because the length frequency of the released fish is unknown. Using the length frequency distribution when adult harvest was permitted (1992-98) is problematic because the length frequency distribution has significantly changed since then. And any reduction in juvenile harvest to offset adult harvest would result in increased release and discard mortality of juvenile red drum.

The lack of data for the adult population continues to prevent assessing the red drum spawning stock. Management measures that allow the harvest of adult red drum could provide NCDMF with data on this portion of the population, but the data would likely be inadequate to assess the adult population. This summer the NCDMF will begin a fisheries independent longline study in Pamlico Sound and near shore ocean waters to develop an abundance index for adult red drum. The study will sample adult red drum to develop information on catch per unit effort (CPUE) and length frequencies, to collect migratory and stock identification information on adult red drum, and to evaluate the age composition and reproductive status of red drum less than 90 cm TL (35.4 in TL). Available age and growth data indicates that red drum less than 90 cm TL are primarily ages 10 and less. Examination of this portion of the population can provide an indication of whether adequate escapement is occurring in the sample area. This study will provide North Carolina with the resources necessary to develop a fishery independent index of abundance for adult red drum occurring in state waters that will be used in future stock assessment work.

Current Authority

North Carolina Fisheries Rules for Coastal Waters (15A NCAC)
03M.0501 Red Drum (Director's proclamation authority for red drum)

Management Options/Impacts

(+ potential positive impact of action)
(- potential negative impact of action)

1) Status quo (prohibit all possession and sale of red drum >27 in TL)

+ Protects adult spawning stock
+ Increase likelihood of good year classes (recruitment)
+ Increase stock diversity
+ Increase likelihood of reaching management targets
+ No changes for juvenile harvest regulations required
- Continued potential economic impact on recreational and commercial fisheries
- Impact on historical use as food fish
- Limits availability of data for assessment of stock diversity

2) Trophy fishery (1 fish 55 in TL or greater) through the use of a trophy tag

+ Controlled harvest of adults with mandatory reporting
+ Potential positive impact on recreational fishery
+ Allows retention of potential state or world record red drum
+ Collect harvest data on recreational fishery
+ Provide some use as food
+ Relatively small number of adult red drum likely harvested
- Selectively harvest larger, more productive fish
- Added cost to purchase a trophy tag
- Increased administrative burden on the NCDMF
- Provide limited biological data to NCDMF
- Limits protection of adult stock
- Delays stock recovery
- Reduction in juvenile harvest to offset adult harvest
- Increased enforcement required
- Out of compliance with ASMFC Red Drum FMP

3) Special Permit to retain 1 fish > 27 in TL

+ Controlled harvest of adults with mandatory reporting
+ Potential positive impact on recreational fishery
+ Collect harvest data on recreational fishery
+ Provide some use as food fish
- Limits protection of adult stock

- Increased administrative burden on the NCDMF
- Provide limited biological data to NCDMF
- Delays stock recovery
- Reduction in juvenile harvest to offset adult harvest
- Increased enforcement required
- Out of compliance with ASMFC Red Drum FMP

4) Harvest of adults (>27 in TL) while maintaining a 30% SPR threshold

+ Adult harvest at threshold levels
+ Potential positive impact on recreational and commercial fisheries
+ Increases likelihood of a sustained fishery
+ Potential for some use as food fish
+ No permit required, no administrative burden on the NCDMF
- Provide limited harvest and biological data to NCDMF
- Limits protection of adult stock
- Delays stock recovery
- Allows harvest of adults before SPR target is met
- Reduction in juvenile harvest to offset adult harvest
- Out of compliance with ASMFC Red Drum FMP

5) No harvest of adults (>27 in TL) while maintaining a 40% SPR target

+ Adult harvest at target levels
+ Potential positive impact on recreational and commercial fisheries
+ Increases likelihood of a sustained fishery
+ Potential for some use as food fish
+ No permit required, no administrative burden on the NCDMF
- Provide limited harvest and biological data to NCDMF
- Limits protection of adult stock
- Requires reduction in mortality on juvenile fish to increase escapement/SPR rates
- Reduction in juvenile harvest to offset adult harvest
- Out of compliance with ASMFC Red Drum FMP unless FMP is amended to allow adult harvest

Management Recommendations

DMF and RDAC - Status quo (no harvest over 27 inches TL)

MFC Selected Management Option

Endorses DMF and RDAC

Research Recommendations

- Design an appropriate state fishery-independent survey of adult red drum to be implemented (NCDMF Red Drum Longline study, begun summer 2007).
- Improved catch and effort data for the adult red drum fishery, particularly the fishery that occurs at night.
- Improved length frequency data for adult red drum in the commercial and recreational fisheries.
- Continue tagging efforts of adult red drum through the NCDMF Volunteer Tagging Program.
- Age, growth and maturity data for the adult red drum.

10.2.2 Recreational Targeting of Adult Red Drum

Issue

The directed recreational catch and release fishery for adult red drum and the concerns and potential risks of this fishery.

Background

Recreational fishing for adult red drum continues to grow in popularity despite the prohibition of possessing or harvesting red drum greater than 27 inches total length (TL) (NCAC 15A 3M .0501 (c)). Catch and effort data for the adult red drum fishery are lacking, but the number of release citations awarded for red drum 40 inches TL and greater has greatly increased since the late 1990s. However, it is difficult to ascertain how much of this trend is due to increases in availability of large fish, increases in fishing effort or to increased popularity of the citation program.

Most of the adult red drum caught by anglers in North Carolina occurs from the spring through the fall (Burdick et al. 2007). The most common angling practice is to use cut bait fished on the bottom, and fishing takes place during the day and at night. Anglers generally catch adult red drum in the surf and inlets of the Outer Banks in the spring and fall and in the western Pamlico Sound estuary in the summer (Ross et al. 1995, Beckwith and Rand 2004a, Beckwith and Rand 2004b). Red drum spawn in the late summer and fall around the inlets and western Pamlico Sound (Ross et al. 1995,

Luczkovich et al. 1999, Barrios Beckwith et al. 2006). Anglers often catch red drum in spawning condition in the western Pamlico Sound estuary (Beckwith and Rand 2004a). A number of guide services participate in this fishery and there are tournaments targeting adult red drum. In addition, a number of guides and anglers participate in a volunteer tagging program of adult red drum for the NCDMF.

There have been concerns raised regarding the targeting of adult red drum by recreational anglers. Some members of the public believe that adult red drum should not be targeted because of the prohibition on possessing or harvesting adult red drum. The harvest of adult red drum is prohibited because the juveniles are harvested and the spawning stock is the component of the population that requires the most protection in order to achieve and maintain sustainable harvest. The improper handling of the fish before they are released and the deep hooking of adult red drum can lead to release mortality. The results from the latest stock assessment indicate the spawning potential ratio (SPR) is above the threshold of 30% and near the target of 40% (Takade and Paramore 2007). Under the current management strategy, SPR must be maintained at a minimum of 40% to meet the target of both the state and ASMFC red drum FMP's.

The 2001 North Carolina Red Drum FMP addressed the issue of recreational gear restrictions—specifically, the use of circle hooks and the attendance of fishing rods while fishing for red drum to reduce the chance of deep hooking (NCDMF 2001). The management action for this issue was to develop educational information on conservative angling practices for red drum. This paper will revisit the issue based on research conducted since the 2001 FMP.

Discussion

Researchers have conducted studies to estimate the release mortality of adult red drum, the factors leading to mortality and the differences in deep hooking events between circle hooks and J-style hooks (Aguilar 2003, Beckwith and Rand 2004a, Beckwith and Rand 2004b). Studies by Aguilar (2003) and Beckwith and Rand (2004a) had overall mortality rates ranging from 3.8% to 6.7% for adult red drum that were held for up to three days after being caught using either circle hooks or J-style hooks. All mortalities showed evidence of internal bleeding from being deep hooked (Aguilar 2003, Beckwith and Rand 2004a). Beckwith and Rand (2004b) found that circle hooks had a much lower incidence of deep hooking than J-style hooks. The researchers found that a large or intermediate sized circle hook (8/0-16/0) combined with a short leader and a fixed weight resulted in the lowest incidence of deep hooking (4%) in the study. The investigators also recommended using fishing tackle that shortens the time it takes to land the fish and to minimize handling while unhooking and releasing red drum (Beckwith and Rand 2004a).

No research has been conducted on the effects of catch and release fishing on the reproductive biology of red drum, but it has been studied for snook in Florida (Lowerre-Barbieri et al. 2003). A catch and release fishery exists for spawning aggregations of snook during the summer months (June through August) at inlets and passes of the Gulf and Atlantic coasts of the State. Histological examination of ovaries of recaptured snook

showed that the stress of being caught and released by anglers did not cause females to interrupt or terminate spawning (Lowerre-Barbieri et al. 2003). The snook were caught during the warm summer months, and fishing for adult red drum on the spawning grounds occurs during a similar time of year (late summer and early fall) in North Carolina. However, the results from this research cannot be assumed to be the case for red drum and are included as a comparison to a similar fishery under similar conditions.

Educational information provided by the NCDMF and North Carolina Sea Grant, educational seminars to recreational fishing clubs, video productions, magazine articles and hook and line mortality studies have been successful in getting anglers to adopt conservative angling practices for adult red drum (Barrios Beckwith et al. 2006). The NCDMF and North Carolina Sea Grant conducted a survey of anglers who target adult red drum to characterize this fishery (unpublished data, NCDMF). Overall (Atlantic Ocean and Pamlico Sound), 56% of the respondents always use circle hooks and another 27% occasionally use circle hooks for adult red drum. The results were similar for anglers in Pamlico Sound, with 52% of the respondents using circle hooks and 16% using circle and J-style hooks for adult red drum. Many other State fisheries agencies also provide educational information on the proper release of fish and on hooks and other gear to reduce release mortality of fish. Much information on conservative angling practices is available to anglers, and survey results show that anglers targeting adult red drum utilize many of these practices. However, anglers are not required to use circle hooks or other types of gear that improve the chance of survival for released red drum.

Large circle hooks, short leaders and fixed sinkers are proven to minimize the chance of deep hooking red drum in the western Pamlico Sound estuary (Beckwith and Rand 2004b). This fishery is usually prosecuted by setting fishing rods in rod holders, which results in slack line. The fixed sinker attached close to the hook prevents the fish from ingesting the hook past the pharyngeal teeth (Beckwith and Rand 2004b). Anglers targeting adult red drum in the surf on the Outer Banks use either circle hooks or J-style hooks with sliding sinkers. Both long and short leader lengths are used with short leaders gaining popularity due to the ability to cast the rig a greater distance. Although no studies of deep hooking red drum in the surf exist, anecdotal evidence indicates a low incidence of deep hooking due to anglers tending their fishing rods and the fishing line remaining tight so the anglers can feel the red drum eat the bait.

Fishing gear regulations such as requiring the use of circle hooks and other gear types to fish for adult red drum would decrease the release mortality. Fishing gear regulations are used for other recreational fisheries. The State of Florida limits the number of fishing rods that can be used and prohibits certain gear types for tarpon fishing in Boca Grande Pass on the west coast of Florida from April to June (http://www.MyFWC.com). And the North Carolina Wildlife Resources Commission (NCWRC) requires all anglers on the Roanoke River to use single barbless hooks from April 1 to June 30 to reduce the release mortality of striped bass on the spawning grounds (http://www.ncwildlife.org). However, gear restrictions would be difficult to enforce in the adult red drum fishery. Much of the fishing effort occurs at night and many anglers fish from boats. Fishing for adult red drum in North Carolina covers an extensive area whereas the tarpon fishery at Boca Grande Pass and the striped bass fishery on the Roanoke River take place in relatively discrete locations. Anglers also fish for other species at the same time and locations where adult red drum fishing takes place. In

addition, some anglers will fish for other species while they are fishing for adult red drum. Therefore, enforcement officers could have difficulty determining whether certain anglers are targeting adult red drum. And requiring all anglers to use certain gear types regardless of whether they are fishing for adult red drum could significantly limit, if not eliminate, fishing for other species.

The survey conducted by the NCDMF and North Carolina Sea Grant showed anglers targeting adult red drum in Pamlico Sound used J-style hooks no smaller than size 5/0 and circle hooks no smaller than size 7/0 (unpublished data, NCDMF). Anglers targeting fish such as southern flounder, spotted sea trout, juvenile red drum and bluefish use hooks much smaller than the hooks used to target adult red drum. Implementing a maximum hook size for J-style hooks that is much smaller than what is used in the adult red drum fishery would allow for the targeting of other species, and would require anglers who target adult red drum in Pamlico Sound to use circle hooks. Adult red drum are incidentally caught on small J-style hooks, but anglers targeting adult red drum are not likely to use small J-style hooks because these hooks do not hold up to the pressure of landing large fish. However, a maximum hook size regulation would be difficult to enforce due to the variations in hook styles and inconsistent hook measurements among hook manufacturers. And any fishing gear regulations for adult red drum fishing in Pamlico Sound would likely cover a very large area due to their widespread distribution.

This regulation would require tarpon anglers in Pamlico Sound fishing with natural bait to use circle hooks. Circle hooks are commonly used in the Florida recreational tarpon fisheries, but they are not widely used in the Pamlico Sound tarpon fishery (Captain George Beckwith, Downeast Guide Service, Personal Communication). However, this regulation implemented to reduce the release mortality of adult red drum could also reduce the release mortality of tarpon, as well.

Closing water bodies or areas where and when adult red drum are known to congregate would increase the protection of these fish. For adult red drum, this could include ocean inlets, the surf along the Outer Banks and the western Pamlico Sound estuary. The National Marine Fisheries Service (NMFS) prohibits fishing and possession of striped bass in the Exclusive Economic Zone (EEZ) of the Atlantic Ocean to limit the harvest and fishing effort. Similarly, Maryland prohibits the fishing for striped bass on the spawning grounds in the Chesapeake Bay tributaries from March 1 through May 31 (http://www.dnr.state.md.us). However, every Atlantic coast state from Maryland to Florida has a recreational catch and release fishery for adult red drum without any closed areas. Closed areas would require much enforcement and would involve the same enforcement difficulties as requiring specific gear types. The closed areas could be large and cover multiple water bodies. Adult red drum are found in many different locations along the coast throughout the year (Burdick et al. 2007), and it may not be possible to designate each one as a seasonal closed area or water body. Closed areas could be limited only to known red drum spawning locations. Barrios Beckwith et al. (2006) found that spawning activity was related to day of the year, year, depth and salinity in the lower Neuse River. Factors such as salinity and dissolved oxygen can vary annually and daily, which results in different distributions of red drum spawning aggregations. And spawning locations in the rest of the State that are not as well documented would remain open to fishing.

A number of guide services in North Carolina specialize in fishing for adult red drum; closed seasonal areas or water bodies would have a negative impact on their businesses. These closed seasonal areas or water bodies would also impact some fishing tournaments that take place in these locations. In addition, this would have a significant impact for anglers participating in the NCDMF Red Drum Volunteer Tagging Program. Closing water bodies or areas to adult red drum fishing would severely decrease the number of red drum tagged and minimize the use of this data source by the NCDMF. The incidental catch of adult red drum would still occur in these areas by anglers targeting other species. Anglers fishing for tarpon in western Pamlico Sound employ similar bait and tackle as anglers targeting adult red drum. The same situation occurs for anglers fishing for striped bass, cobia and bluefish along the surf and inlets of the Outer Banks. Fishing for a variety of others species also takes place in these areas and the gear employed and the specific locations fished by these anglers rarely results in the incidental catch of adult red drum. Closing areas or water bodies to all recreational fishing would further prevent the incidental catch of adult red drum but would negatively impact anglers who do not target and who are unlikely to catch adult red drum.

Current Authority

North Carolina Fisheries Rules for Coastal Waters (15A NCAC)
03M.0501 Red Drum (Director's proclamation authority for red drum)

Management Options/Impacts

(+ potential positive impact of action)
(- potential negative impact of action)

1) Status quo (continued educational information on conservative angling practices for red drum).

+ Anglers informed about best practices to minimize release mortality of adult red drum
+ Could improve stock recover due to reduced release mortality through anglers adopting conservative angling practices
+ Coastal Recreational Fishing License (CRFL) identifies a known user group to provide information
+ No negative impact on the NCDMF adult red drum volunteer tagging program
+ No additional enforcement responsibilities
+ No additional regulations or rule changes
- The use of hooks and gear that increase release mortality still allowed
- No reduction in effort
- Fishing still occurring on spawning grounds

2) Require the use of circle hooks and other gear types to reduce release mortality of adult red drum.

+ Reduce release mortality of adult red drum
+ Provides additional protection to spawning stock
+ Could improve stock recovery due to reduced release mortality
- Difficult to enforce
- Regulations could apply to much of the State's coastal waters
- Additional rules and regulations required
- Could affect fishing for other species

3) Implement a maximum hook size for J-style hooks that is much smaller than what is used in the adult red drum fishery in Pamlico Sound

+ Require the use of circle hooks in the adult red drum fishery, which would reduce the release mortality
+ Provides additional protection to spawning stock
+ Could improve stock recovery due to reduced release mortality
+ Would allow fishing for other species to take place
+/- Would require the use of circle hooks in the tarpon fishery
- Difficult to enforce
- Additional rules and regulations required
- Regulated area could be very large

4) Seasonal closures of water bodies or areas to adult red drum fishing where adult red drum are known to congregate.

+ Provides additional protection to spawning stock
+ Could improve stock recovery due to reduced release mortality
+/- Incidental catch of adult red drum could still occur
- Additional enforcement required
- Difficult to enforce
- Additional rules and regulations required
- Affects the NCDMF Red Drum Volunteer Tagging Program
- Economic impact to guide services and tournaments that target adult red drum
- Prohibits a popular recreational fishery

5) Seasonal closures of water bodies or areas to all recreational fishing where adult red drum are known to congregate.

+ Provides additional protection to spawning stock
+ Could improve stock recovery due to reduced release mortality
- Additional enforcement required
- Additional rules and regulations required
- Difficult to enforce
- Eliminates all recreational fishing in these areas or water bodies
- Affects the NCDMF Red Drum Volunteer Tagging Program

- Economic impact to guide services, tournaments and local communities in these areas or water bodies
- Prohibits a popular recreational fishery

Management Recommendation

DMF and RDAC – During July through September, unlawful to use J-hooks larger than 4/0 while fishing natural bait in Pamlico Sound and its tributaries, excluding the Albemarle Sound Management Area (ASMA) and the are from Core Sound south to the NC/SC state line. Recommendation would also include status quo (continued educational information on conservative angling practices for red drum)

MFC Selected Management Option:

It is unlawful to use any hook larger than 4/0 from July 1 through September 30 in the internal coastal fishing waters of Pamlico Sound and its tributaries south of the Albemarle Sound Management Area and north of Core Sound while using natural bait from 7:00 p.m. to 7:00 a.m. unless the terminal tackle consists of:
(1) A circle hook defined as a hook with the point of the hook directed perpendicularly back toward the shank, and with the barb either compressed or removed.
(2) A fixed sinker not less than two ounces in weight, secured not more than six inches from the fixed weight to the circle hook. (also continued education on fishing methods that minimize risk to fish)

Research Recommendations

- Improved catch and effort data for the adult red drum fishery, particularly the fishery that occurs at night.
- Identify the spawning areas for adult red drum in North Carolina.
- Economic analysis of the adult red drum fishery.
- Conduct further studies/surveys on hooks and tackle currently used in adult red drum fishery.
- Incorporate information on conservative angling practices for red drum into the upcoming Angler's Guide and make the information available on the NCDMF website.

10.2.3 Recreational Bag and Size Limits

Issue

The recreational bag limit for red drum is currently 1 fish per person per day from 18 to 27 inches TL. The North Carolina fishery management plan for red drum may consider options to modify the current bag limit and other recreational management measures.

Background

The recreational fishery for red drum in North Carolina occurs year round with peaks in the spring and fall. Similar to the commercial fishery, the recreational red drum fishery varies annually and is dependent on year class strength. Available data from the MRFSS from 1989 to 2006 indicate that:

1. Recreational landings of red drum have averaged 227,461 pounds.
2. Landings of red drum vary annually. Recreational landings increased from 39,077 pounds in 1997 to 591,428 pounds in 1998 (Table 20).

When reductions in harvest were needed to reduce fishing mortality, major consideration was given to making reductions equitable for both the commercial and recreational sectors. Estimated reductions, based on the one fish recreational bag limit and the seven fish commercial trip limit, were intended to reduce annual harvest in each fishery by approximately 40%. Because landings vary annually dependent upon the year class strength of fish available in the slot limit it is difficult to ascertain if the reductions were successful over a short period of time. Comparing across each management period should reduce annual variability allowing for some comparison. The prior management period (1992 to 1998) was compared to the current management period (1999 to 2006). However, the 1999 and 2000 harvest years were excluded from the analysis because during this time a 100-pound trip limit was in place for the commercial fishery as opposed to the current 7 fish bycatch allowance. For both periods, the recreational fishery landed approximately 60% of the overall catch (Table 21). In addition, compared to the prior period, average annual landings in current management period were reduced by 35% for the recreational fishery and by 36% for the commercial fishery. Based on this information, the current management was successful at both maintaining equitability among the sectors and at reducing harvest.

Table 20. North Carolina red drum catches for recreational anglers (MRFSS), for 1989 – 2005 with PSE. All weights are in pounds. Commercial weights are included as a reference, and combined weights are reported.

	Recreational							
	Numbers							
	A + B1*		B2*		A + B1		Commercial	Total
Year	# Landed	PSE	# Released	PSE	Weight (lb)	PSE	Weight (lb)	Weight (lb)
1989	62,359	16	7,566	34	214,849	20	274,356	489,205
1990	33,149	28	12,452	38	302,994	64	183,216	486,210
1991	38,658	15	121,178	14	108,268	16	96,045	204,313
1992	23,593	19	60,230	18	109,134	20	128,497	237,631
1993	49,493	12	182,301	20	266,459	14	238,099	504,558
1994	28,953	16	107,662	14	192,060	21	142,119	334,179
1995	88,593	12	164,520	11	405,620	13	248,122	653,742
1996	36,746	15	35,752	18	204,556	16	113,338	317,894
1997	8,749	26	259,570	11	39,077	28	52,502	91,579
1998	114,638	12	199,701	11	591,428	13	294,366	885,794
1999	64,739	15	247,146	10	326,303	15	372,942	699,245
2000	61,618	13	203,967	14	316,029	13	270,953	586,982
2001	23,142	16	238,552	14	132,578	17	149,616	282,194
2002	42,541	15	640,857	11	182,226	17	81,364	263,590
2003	25,481	17	75,561	15	118,808	18	90,525	209,333
2004	30,165	19	191,593	10	114,434	19	54,086	168,520
2005	53,154	21	327,859	15	242,019	21	128,770	370,789
2006	52,383	14	463565	10	219362	15	168,489	387,851

Definitions of recreational catch type:

*A = fish brought ashore in whole form which can be identified, enumerated, weighed, and measured by interviewers.

*B = fish not brought ashore that can be separated into: B1 = fish caught used as bait, filleted, or discarded & B2 = those released alive.

Table 21. Average annual landings of red drum by fishing sector and management period.

	Average Annual Landings (percent of combined)				
Period	Recreational		Commercial		Combined
1992 to 1998	258,333	(59.8%)	173,863	(40.2%)	432,197
2001 to 2006	168,238	(60.0%)	112,142	(40.0%)	280,380

Discussion

The reduction in the recreational bag limit from 5 to 1 was intended to reduce the recreational harvest while still allowing recreational anglers to possess a fish for personal consumption. The reduction in overall harvest is intended to allow for the continued use of the resource by the public, while diverting the overfishing that had been occurring in the previous management period.

The most recent stock assessment for red drum in North Carolina indicates a marked improvement in the escapement of juveniles to the adult stocks and is reflective of the current recreational and commercial harvest controls. With a target Spawning

Potential Ratio (SPR) of 40%, and a sustainable harvest SPR threshold definition of 30% escapement, the current level of SPR is above the overfishing threshold and appears to be near the target, although these estimates may be considered optimistic given the lack of information on commercial discards.

Amendment 2 to the ASMFC Red Drum Fishery Management Plan does not mandate specific bag and size limits. The Amendment specifies that all states must implement an appropriate bag and size limit which will attain the management goal of 40% SPR. For states in the northern region which still have a commercial harvest of red drum, the overall harvest restrictions for commercial and recreational harvest combined must be sufficient to attain a 40% SPR.

The following combinations of bag and size limits were conducted on data for the period of 1992 to 1998 (Table 22)(Vaughan and Carmichael 2001). They are based on necessary reductions in fishing mortality through both recreational bag and size limits and commercial trip limits. Each combination of bag and size limit is considered to provide conservation equivalencies that meet or exceed the 40% SPR. All combinations assume a 40% reduction in commercial harvest over the prior management period (1992 to 1998), which was achieved by the trip limit currently in place.

Table 22. Potential bag and size limit combinations that are projected by the bag and size limit analysis to achieve the 40% SPR.

Bag Limit	Slot Limit (total length)
1	18-27”
2	19-27”
3	18-26”

The bag and size limit analysis assumes that the conditions prevalent during the 1992 to 1998 period will remain constant into the future. Changes in angler behavior, angler success or increased effort and participation over time could offset any predicted gains. For the period of 1999 to 2005, reducing the possession limit to one fish and limiting all harvest to fish between 18 and 27 inches was effective at increasing SPR values above the overfishing definition as predicted. Changes to this management strategy should be carefully considered as each bag and size limit combination has potential risks. For instance, increasing the minimum size limit has less potential positive effect as does decreasing the maximum size. This is because harvest loss due to increases in the minimum size can potentially be offset through delayed harvest as the fish grow above the minimum legal size. This is particularly true for a fast growing fish such as red drum whose growth from 18 to 19 inches will take approximately one month. Conversely, decreasing the maximum size carries no risk of delayed harvest. Protecting the larger fish maximizes the benefit to the SPR estimates because these fish have already been exposed to most of the fishery effort and have an increased chance of survival to maturity.

A bag limit of one fish was effective at reducing harvest as intended. While the reduction from five fish to one fish was a drastic reduction in the potential harvest for a given angler, it was not a tremendous reduction in actual overall harvest. For the period of 1992 to 1998, very few trips landed more than two red drum. A one fish bag limit was necessary to achieve ample reductions without a severely reducing the slot limit. Increasing the bag limit above one, in combination with adjusting the slot limit may lead to reduced SPR estimates due to recoupment in the fishery. Recoupment occurs when anglers either increase effort or change their behavior to increase or maintain harvest in response to regulatory changes. Projected gains from decreasing the slot limit can easily be offset if the resulting increased bag limit leads to increases in effort or targeting. In addition, angler success rates and/or fish availability can also contribute to recoupment under more liberal bag limits. This tends to be particularly true when abundant year classes enter the slot. Current trends in angler success rate for red drum indicate a positive trend (Figure 20). It is well accepted that recreational effort has and will continue to increase over time (Figure 21 and Figure 22). In addition, technology continues to improve, enhancing anglers potential for success. The current 1 fish bag limit at 18 to 27 inches has less potential for recoupment in the red drum fishery and has proven effective at increasing SPR levels. Increased bag limits with corresponding slot limits do offer viable alternatives based on the bag and size limit analysis, but also have risks for which the analysis cannot quantify. It should be noted that all options, including the current regulations, could result in lower SPR values, albeit to varying degrees, if fishing effort or participation increases.

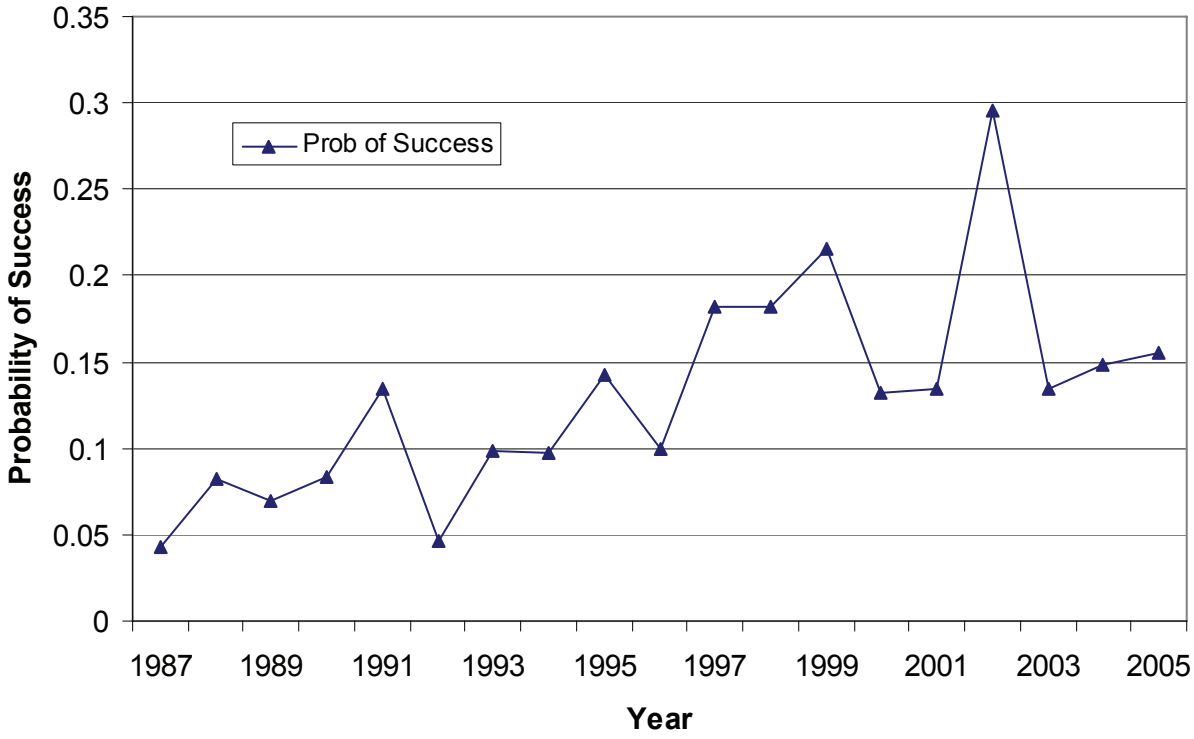


Figure 20. Probability of success for anglers targeting red drum recreationally. Successful trip defined as a trip that targeted and landed red drum.

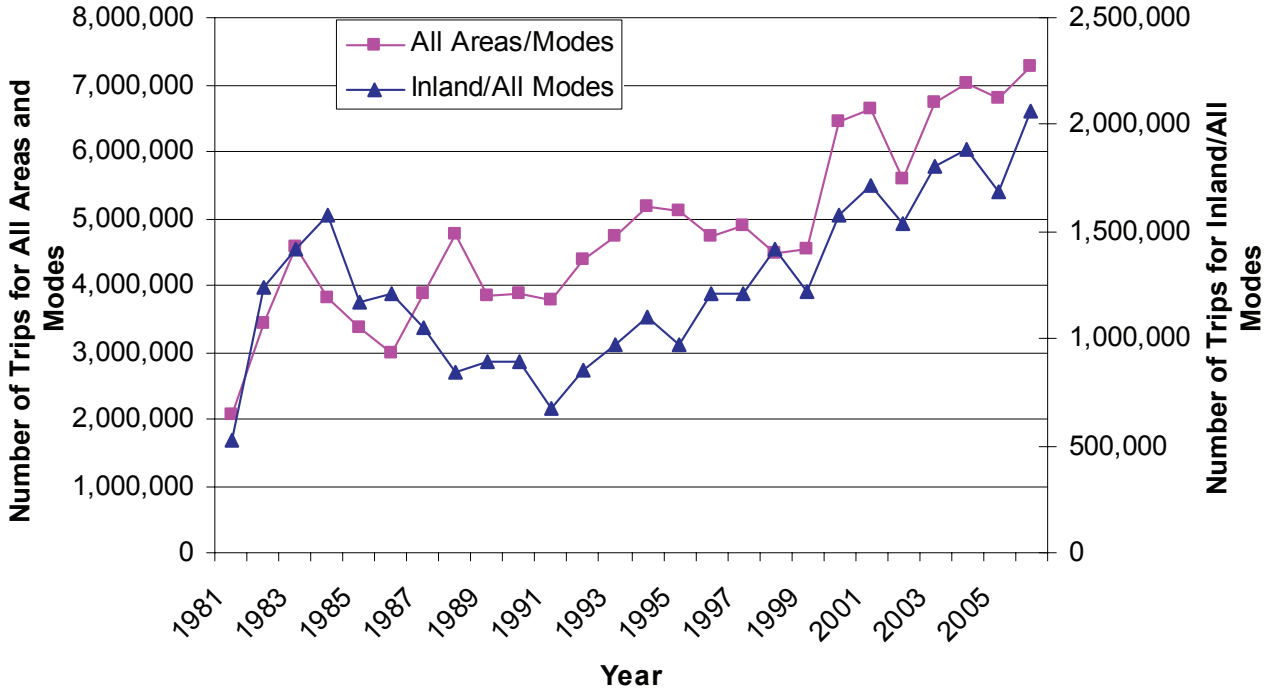


Figure 21. Recreational fishing effort (number of trips) from 1981 to 2006. Source MRFSS.

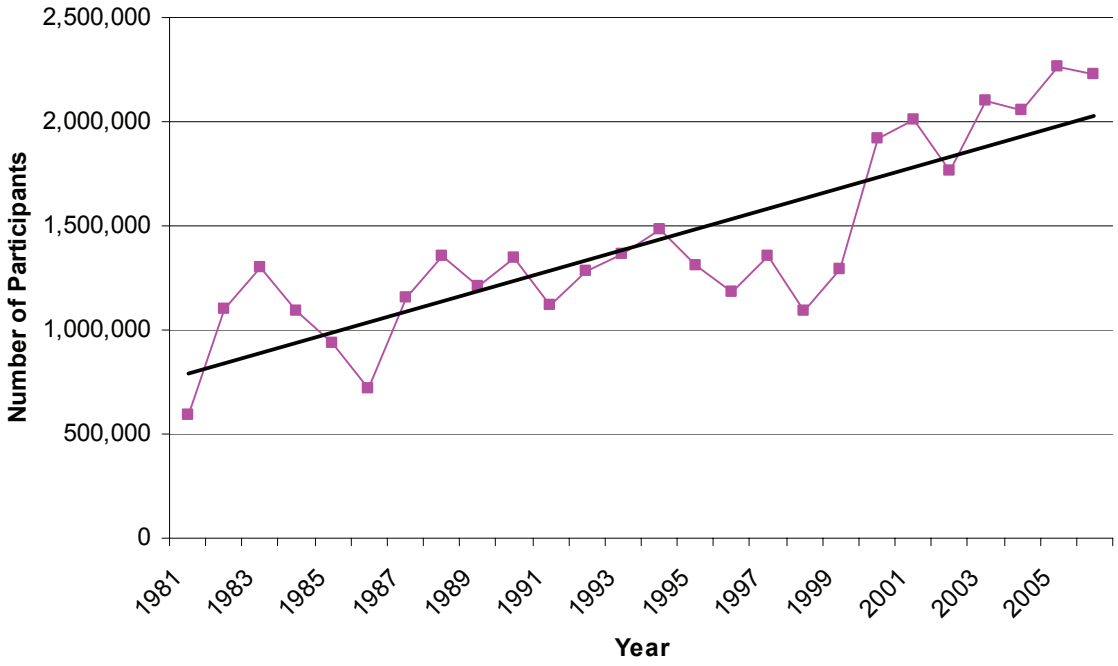


Figure 22. Number of participants in North Carolina recreational fishery (coastal, non-coastal and non-resident).

Another consideration to choosing an appropriate bag and size limit option should be to account for regional discrepancies in the availability of red drum at a given size. Red drum recruit throughout the estuaries as juveniles but tend to be particularly

abundant in the upper reaches of the estuary at smaller sizes. As they become larger, they tend to have a net movement to higher salinity areas, such as coastal inlets. Increasing the minimum size could reduce the availability of fish available for harvest along the western sounds. Investigation of MRFSS length frequencies by region indicates that areas along the western Pamlico Sound would be most adversely impacted by the increases in the minimum size limit, while decreasing the maximum size limit would have the largest impact on the eastern Pamlico (Figure 23; Table 23). Either increasing or decreasing the size limit had a similar impact on the southern region. Harvest of illegal size fish (non-compliance) was significant for all regions.

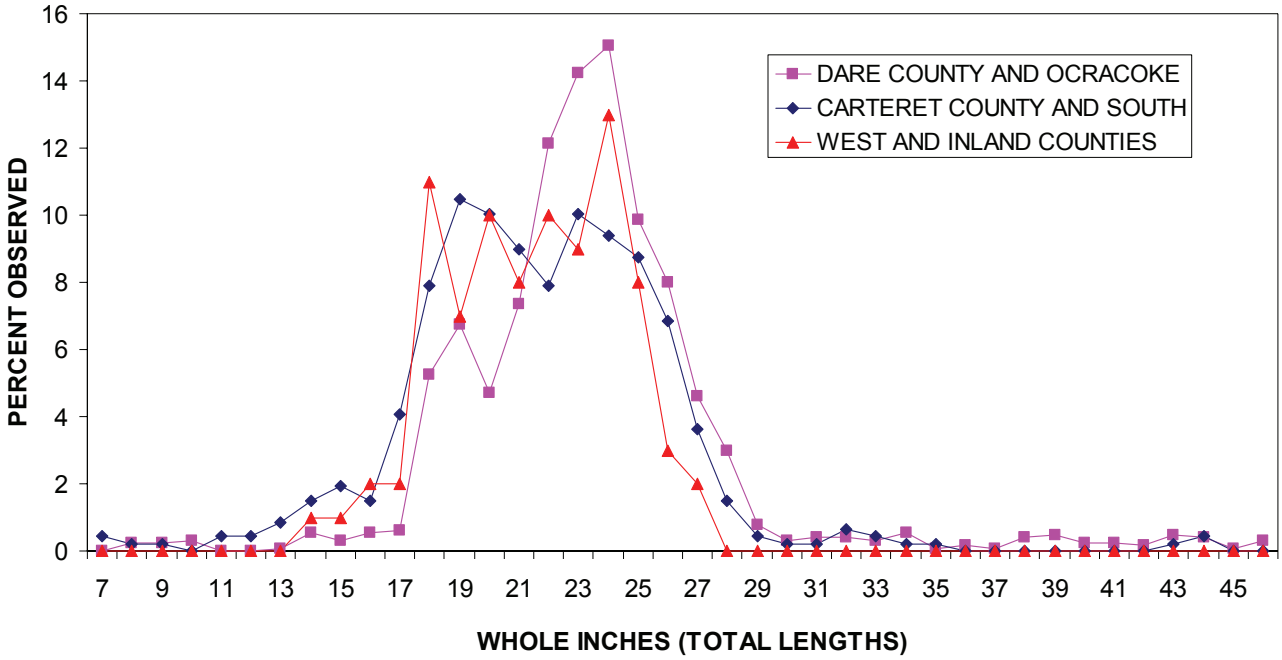


Figure 23. Length frequency distribution of red drum observed in MRFSS survey by region from 1993 to 2006.

Table 23. Percent non-compliance (red drum harvested that were <18 or >27 inches total length) and the percent of fish measured that would be illegal if either a 19 inch minimum or a 26 inch maximum size limit were put into place. Samples from MRFSS 1993 to 2006.

	Dare County and Ocracoke	Carteret County and south	West and Inland Counties
% non-compliance	16.7	19.7	9.2
19 inch minimum size*	6.3	9.8	13.9
26 inch maximum size*	9.6	8.5	3.8

* non-compliant fish were not included in this analysis.

If increasing the bag limit is a desirable option for the public then a conservative alternative may be to decrease the maximum size limit to 26 inches and implement a bag limit of two fish. Reducing the maximum size (as opposed to increasing the minimum size) will be more beneficial to future SPR values and the bag limit is the most conservative step in lieu of status quo. Additionally, there would be minimal discrepancies in regional distribution of fish, where an increase in the minimum size would create a negative impact on the lower salinity areas where larger slot size red drum are less common.

Current Authority

North Carolina Fisheries Rules for Coastal Waters (15A NCAC)
03M.0501 Red Drum (Director's proclamation authority for red drum)

Management Options/Impacts

(+ potential positive impact of action)
(- potential negative impact of action)

1) Status quo (1 fish 18-27 inches TL)

+ Same size limit as commercial sector - enforcement
+ Increase likelihood of reaching management goals (SPR rates)
+ Familiarity and acceptance by fishermen
+ Greatest size range – greater opportunity to keep a fish
+ No changes before next assessment
- Limits harvest for individuals
- Potential for increased release mortality

2) Increase the bag limit and change size range

+ Increase number of fish for personal consumption
+ Potential for less discards (based on increased bag limit)
- Reduced range of sizes over which to keep a fish
- Discrepancy in recreational and commercial size limits
- Potential for recoupment and/or delayed harvest in fishery which may negatively impact SPR
- Changes before next assessment (2008)
- Regional discrepancies in availability of fish by size

Management Recommendations

DMF and RDAC - Status quo (1 fish 18-27 inches TL)

MFC Selected Management Option

Endorses DMF and RDAC recommendation

Research Recommendations

- Assess the size distribution of recreational discards
- Increase recreational sampling coverage
- Expand recreational sampling to include night-time intercepts

10.2.4 Commerical Harvest Limits

10.2.4.1 Commercial Trip Limit

Issue

Can the current bycatch allowance in the Red Drum FMP of 7 fish be increased?

Background

Historically, annual landings of red drum have been highly variable from year to year. Annual landings during the 1970's averaged 83,009 lbs per year and ranged from 7,500 to 214,000 lbs (Figure 24). Annual landings from the 1980's were greater than those from the 1970's, averaging 203,813 lbs per year and ranging from 52,561 to 283,020 lbs. Landings during the 1990's averaged 186,932 lbs per year and ranged from 52,548 to 372,749 lbs. The majority of the landings have historically originated from Pamlico and Core sounds and the Atlantic Ocean. During the 1970's, no commercial gear dominated landings although long haul seines and common haul seines were generally the most productive gears with gill nets, pound nets, and fish trawls occasionally contributing larger catches. Anchored and run-around gill nets were the dominant gear during the 1980's and 1990's, accounting for greater than 70% percent of annual commercial landings. Most of these gill net fisheries are seasonal, targeting flounder, spotted seatrout, and striped mullet along the barrier islands and mainland shorelines. Although they catch red drum incidentally, red drum can make an important contribution to the overall catch.

A directed fishery that developed in the mid-1990's used run-around gill nets to encircle schools of red drum and accounted for 31% of all red drum commercially harvested from 1994 to1998. Prior to the implementation of trip limits in 1998, nearly one-half of the total annual commercial harvest of red drum was accounted for by only a

few trips landing large amounts of red drum. From 1994 to 1998, a total of 1.1% of the trips that reported landings of red drum accounted for 48.5% of the total harvest. For this period, the largest landings of red drum primarily occured behind the 'Outer Banks' from Oregon Inlet to Ocracoke during the spring and fall. Gears that typically had large landings of red drum were runaround gill nets and long haul nets and these gears made up a larger proportion of the landings by gear during this period (Figure 25). These gears have proven to be effective in circling large schools of red drum. Participation in the run-around gill net fishery increased during this period as many of these fishers actively pursued schools of red drum. While there have been a few exceptional long haul catches of up to 10,000 pounds, a typical catch for a run-around gill net trip would range from 100 to 1000 pounds.

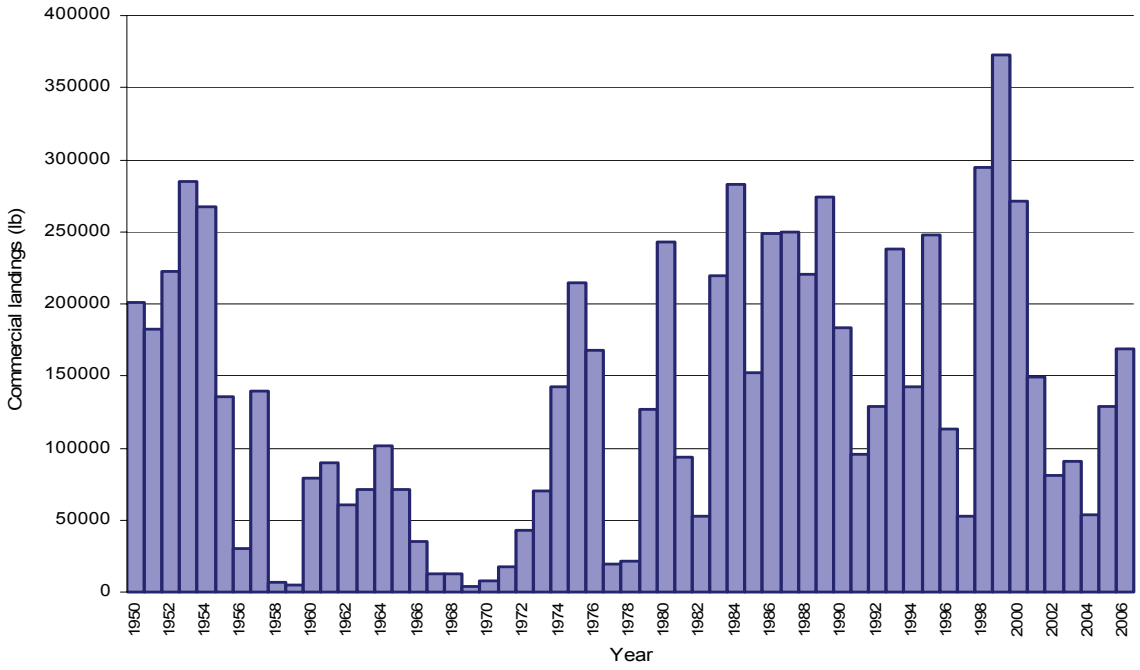


Figure 24. Annual commercial landings of red drum from 1950 to 2006.

The 7 fish bycatch provision was developed by DMF in an effort to control the commercial harvest by eliminating the targeting of red drum while still allowing a reasonable bycatch allowance when taken incidental to other fisheries. The trip limit was effective at shifting landings back towards gears that take red drum incidentally to other species (Figure 25). Preparation of the red drum FMP began in 1998. Interim rules were developed in October 1998 to reduce harvest by both recreational and commercial fishermen and protect a strong year class that was entering the fishery. The bag limit for the recreational fishery was reduced from 5 fish to 1 fish and a commercial trip limit was established at 100 pounds while the annual harvest cap of 250,000 pounds was maintained.

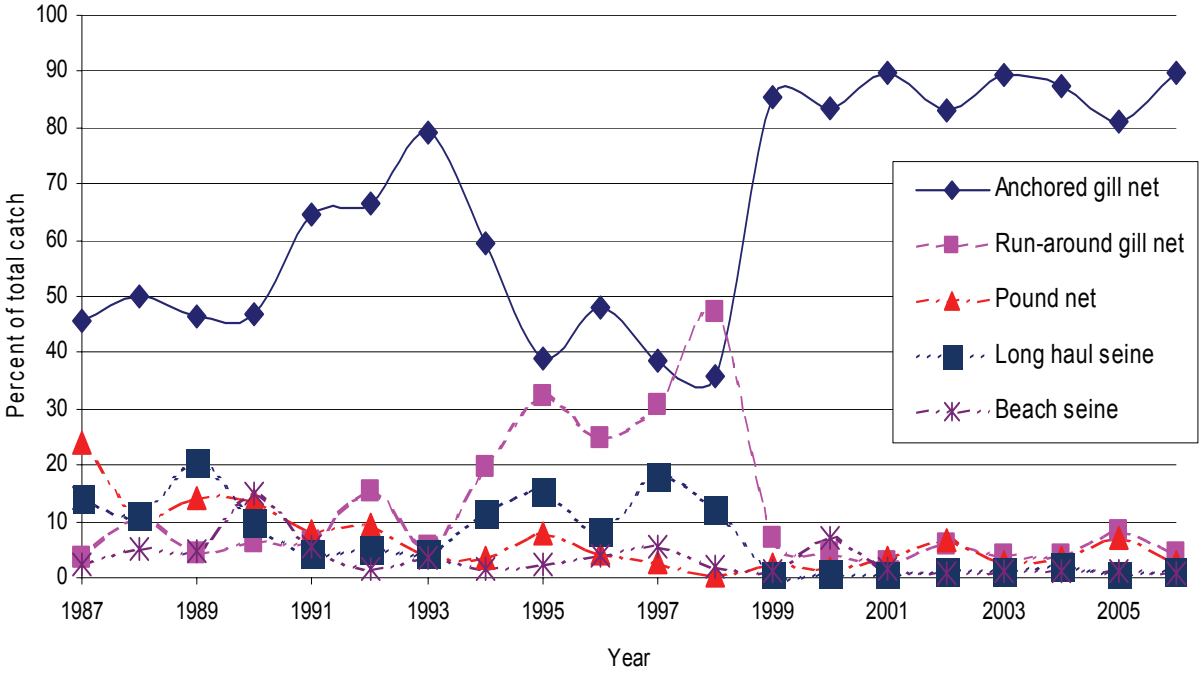


Figure 25. Proportion of commercial red drum ladings by gear type from 1987 to 2006.

In 1999, the fishery was closed by proclamation on November 5, 1999 because the cap had been exceeded. The final harvest for 1999 was 372,942 pounds, well over the 250,00 pound cap.

The 100 pound trip limit was suspended on July 22, 2000 and replaced by a 5 fish per day limit for commercial operations to ensure that the harvest limit was not exceeded. The fishery was closed on August 19, 2000.

During 1999 and 2000, the early closures prevented the southern flounder gill net fishery, the fishery with the greatest bycatch of red drum, from landing any red drum. The MFC decided in October 2000 to move forward with the provision in the FMP to change the start of the fishing year from January 1 to September 1 to ensure that the unavoidable bycatch of red drum occurring in the flounder fishery could be landed. As a result, a proclamation was issued on October 11, 2000 that reinstated the 5 fish bycatch allowance as a transition into the new commercial harvest season (September 1 - August 31). The final commercial harvest figure for 2000 was 270,953 pounds.

Proclamation FF-47-2001 was issued on September 6, 2001 to implement the approved red drum FMP setting the bycatch allowance at seven (7) and requiring that red drum make up less than 50% of the total catch of all finfish (excluding menhaden) landed daily for a commercial fishing operation. The intent was to ensure that annual harvest remains below the cap and to allow red drum harvest only as bycatch taken incidental to other fisheries. The annual landings of red drum have remained below the cap since this proclamation was issued.

Fishermen and members of the MFC have requested a re-examination of the current trip limit, as a result of annual landings being below the cap, in hopes of increasing the bycatch allowance. The commercial cap was originally set as a harvest level that would prevent a directed fishery back in 1990 when the blackened redfish craze developed in the Gulf of Mexico. **The commercial cap was set at 300,000 pounds and subsequently reduced to 250,000 pounds in 1991, but is not based on any population assessment and should not be viewed as the amount of harvest that can be allowed in a given year. If an assessment based annual commercial harvest limit were put into place for the commercial red drum fishery in North Carolina, it would be considerably less than 250,000 pounds.** For example, from 1992 to 1998 North Carolina's commercial landings averaged approximately 174,000 pounds for a period when the escapement rate was estimated to be 18%, well below the current target of 40%. For a quota managed fishery, any reduction in harvest necessary to increase escapement would be taken from these average landings and not from the 250,000 pound cap, a level of landings that historically have rarely been achieved. North Carolina opted not to reduce the commercial cap, but chose instead to reduce harvest through a daily bycatch allowance. The current commercial trip limit has two advantages for the commercial fishery over a quota managed fishery: 1) it allows more harvest to occur in years where a strong year class is present than would be possible with a quota, and 2) it does not require the commercial season to close resulting in discards after the allowable harvest is taken.

When Amendment 2 to the ASMFC Red Drum FMP was approved in 2002, it included analysis that calculated a reduction in landings necessary to achieve a target 40% escapement rate. A compliance requirement of Amendment 2 is that each state must implement management measures in order to achieve 40% escapement. No new regulations were necessary in North Carolina to achieve this reduction because of the 7 fish commercial bycatch allowance and the 1 fish recreational bag limit in place as a result of the NC Red Drum FMP. Projections based on these regulations estimated North Carolina's escapement rate to be slightly above 40%. Results of the most recent assessment indicate that the regulations were largely successful in achieving this goal. An additional compliance criterion of Amendment 2 is that states must maintain current or more restrictive commercial fishery regulations for red drum, i.e. no relaxation of current fisheries management measures. This stipulation removed the NC Fisheries Director's ability to modify the commercial trip limit. The sliding trip limit set by the Director was originally approved as part of the 2001 NC Red Drum FMP. In August 2003, North Carolina requested that the ASMFC South Atlantic Board approve a motion to include this authority in the framework of Amendment 2 also. If approved the NC Fisheries Director would once again be able to raise or lower the current 7 fish commercial bycatch allowance without going out of compliance with the ASMFC plan. The intent of the motion was to maintain a bycatch only fishery and only to allow increases when necessary to account for unavoidable bycatch. The motion was approved. To date, the 7 fish commercial trip limit has remained unchanged.

Discussion

The DMF has monitored the red drum commercial harvest and conducted fishery-dependent gill net sampling that allows an analysis of the red drum catch per trip. Based on fishery-dependent, estuarine sampling of large and small mesh gill nets from 2004-2006 (Trips sampled = 1,404), 80% of the trips sampled contained no red drum. The majority of trips (67%) that did land red drum (n = 279) contained 3 red drum or less.

The data indicate that there were not many trips that caught their bycatch limit of 7 fish (Figure 26). Very few trips (3% for all trips and 13% for trips that landed red drum) had 7 or more red drum, indicating that most trips do not encounter 7 legal size red drum and that waste is not a large problem.

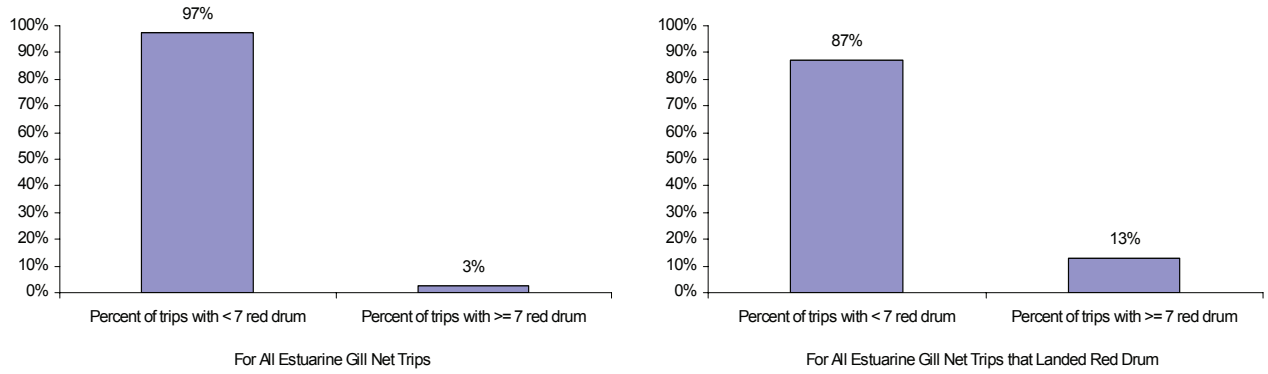


Figure 26. Percentage of estuarine gill net trips that did or did not capture the seven fish bycatch allowance. Given for all trips sampled and for all trips sampled where red drum were present.

In addition to fishery dependent sampling where commercial trips are intercepted at the fish house, NCDMF also has observer coverage for the estuarine gill net fishery since 2001. During this period, 1,470 large mesh (≥5" stretch mesh) estuarine gill net trips have been observed. The majority of the trips occurred in eastern Pamlico Sound with southern flounder being the most abundant species captured. Similar to the dependent fish house data, most trips did not exceed the current 7 fish bycatch allowance. Of all trips observed, 98% had less than the allowable limit. For trips that landed red drum, 8% had the 7 fish bycatch allowance.

For all trips observed, 1,246 legal size red drum were captured (Table 24). Of these, the vast majority (83%) were either marketed or released alive. Unmarketable discards accounted for 7% of legal size red drum encountered, while dead regulatory discards accounted for 8%.

Further analysis was conducted to determine the fate of red drum when the 7 fish bycatch allowance was encountered. This occurred on 1.8% of the 1,470 observed trips. These 27 trips encountered 334 legal size red drum. The fates of these fish included harvested (59%), released alive (17%), unmarketable discards (4%) and dead regulatory discards (19%).

Table 24. Fate of legal size red drum (n=1,246) in the large mesh estuarine gill net fishery. NCDMF observer data from 2001 to 2006 (n=1,470 trips sampled)

Disposition	Number	Percent
Marketed	866	70%
Released Alive	166	13%
Dead Discard	98	8%
Unmarketable	89	7%
Unknown	30	2%
Total	1,246	100%

In addition to the large mesh trips that were observed, 405 small mesh gill net trips were also observed. No more than six legal size red drum were encountered on any of these trips.

One FRG study of incidental catch and discard of red drum in large mesh gillnets was conducted in 2002 in the Newport River and specifically addressed the issue of the 7 fish bycatch allowance (Buckel et al. 2006). Fishing 10 nets (100 yards each) a day from June through November, the catch of red drum exceeded the daily bag limit on 23% of the days. Of the 326 red drum retrieved from the gill nets, 32.5% were dead, but only 15 of the 106 dead red drum had to be discarded due to size limits and 6 were discarded dead based on harvest limits. The majority of discards were released alive. The author notes that the findings support the current regulations (7 fish limit) but also acknowledges that the study took place during a year when red drum available in the slot limit were at a low abundance.

An additional concern raised by fishermen has been over the requirement that red drum be landed as bycatch to other finfish. Both the state and ASMFC plans for red drum allow for only the non-directed (bycatch) landings of red drum, where they are taken incidental to other target species. Since 2001, it has been required that red drum make up less than 50% by weight of all finfish (excluding menhaden) landed by a commercial fishing operation. Requiring red drum to be landed as bycatch presents a problem when red drum are encountered in a fishery prior to other 'target' species being encountered. NC Marine Patrol could interpret possession of red drum on board a vessel while the commercial operation is engaged in fishing activity as a violation if the red drum possessed exceeds the weight of other finfish in possession at the time of inspection. Available data from the observer program indicates that the percent of fish discarded due to this is not significant. Options could be considered to either 1) allow red drum to be possessed up to the daily bycatch allowance while actively fishing gear but require adequate poundage of other finfish at time of landing, or 2) allow fishing operations to possess some red drum outside of the bycatch provision.

Increasing the commercial trip limit has been the topic of debate among commercial fishers and several MFC members for some time. An increase could allow for some red drum in the slot limit to be harvested as opposed to being discarded dead.

However, all available data to date suggests that discard levels have been low to moderate and that most legal size red drum encountered are either harvested or released alive. Increasing the bycatch allowance may also entice purposeful setting of gill nets in areas where red drum are known to occur. The current stock assessment indicates that SPR and escapement rates are currently above the overfishing definition and approaching the target. It must be noted that the assessment fails to account for the size and magnitude of discards in the commercial fishery, a factor that in all likelihood makes the current SPR and escapement rates optimistic. **A criterion for increasing harvest outside of an excessive bycatch issue would be if the escapement rate of 40% were being exceeded. This is not currently the case.**

If bycatch levels justify an increase in the trip limit, the NCDMF Director has the authority to increase the trip limit. Recently it was proposed at a MFC meeting to consider allowing the first three red drum captured to be landed without the requirement that other edible finfish be present (not as bycatch) and then to continue the current 7 fish bycatch allowance. This would create a 10 fish daily limit provided other species were captured to allow for red drum bycatch of 7 fish. The additional 3 fish would allow for any red drum captured prior to other targeted species to be taken without the possibility of being found out of compliance with the current 50% bycatch provision.

10.2.4.2 Commercial Fishing Year

Issue

Avoiding closures in the commercial red drum bycatch fishery.

Background

A September 1 to October 31 commercial fishing year was implemented as part of the 2001 NC Red Drum FMP. This shift in the commercial fishing year was made to ensure that there would be no closure during peak landings that typically occur in the fall (see discussion in 12.2.4.1). Additionally, because red drum are a somewhat unavoidable bycatch component to the southern flounder estuarine gill net fishery, it is imperative to keep the red drum fishery open during the flounder season to avoid excessive discards and waste.

Discussion

After exceeding the cap in 1999 and 2000, a 7 fish daily trip limit has kept commercial landings well below the commercial cap since 2001. However, during the current fishing year (2007/2008), atypically high winter landings have caused an early closure for commercially harvested red drum due to the 250,000 lb cap being met and exceeded before April. A concern in the current fishing year is that excessive discards are now likely to occur primarily as a bycatch in the southern flounder estuarine gill net fishery. In an effort to address the discard issue in the future, the RDAC recommended implementing a spit in the commercial fishing year. Under the proposal, 150,000 lb of red drum would be allotted to the period of September 1 to April 30, with the remaining cap of 100,000 lb conserved for the second period (May 1 to August 31). Any remaining cap from period one would be available for landing in period two. Reserving at least

100,000 lb of landings for period tow, during the warmer summer months, will reduce waste when discard mortality is at its highest. Any potential closure under this scenario would most likely occur during the winter when discard mortality is low.

As a result of the 2007/2008 commercial closure, the MFC took action suspending the rule 3M .0501 which sets the commercial year and cap and allowed the DMF Director to reopen the commercial season with a limited harvest of 4 fish per day per commercial fishing operation. This action was taken due to the concern over the potential for dead discards during the closed portion of the season that coincided with the peak of the southern flounder estuarine gill net fishery. To ensure harvest of red drum during this time is legitimate bycatch, red drum harvest is currently limited to commercial fishers who are capturing southern flounder, striped mullet or spotted seatrout. Red drum are considered a common bycatch in gill net fisheries targeting these species. Overages during the current fishing year will be subtracted from the 2008/2009 fishing year and any closures if necessary will likely occur during the winter.

It should also be noted that any overages in the commercial cap during any fishing year require that the amount of that overage (exceeding 250,000 lb) be subtracted from the subsequent years commercial cap. This is a requirement of Amendment 2 to the ASMFC Red Drum FMP.

Current Authority

North Carolina Fisheries Rules for Coastal Waters (15A NCAC)
03M.0501 Red Drum (Director's proclamation authority for red drum)

Management Options/Impacts

(+ potential positive impact of action)
(- potential negative impact of action)

1) Status quo (7 fish limit with 50% bycatch provision, DMF Director maintains proclamation authority to increase trip limit and adjust the bycatch provision as needed)

+ Keeps harvest at a level to meet 40% escapement requirement
+ Increase likelihood of reaching management goals (SPR rates)
+ No regulatory changes before next assessment
+ Discards of legal size fish appear to currently be insignificant
+ NCDMF Director still has authority to increase bycatch allowance if discards increase
- Limits harvest for individuals
- Potential for increased discards if a strong year class enters the slot limit

2) Increase the bycatch allowance

+ Potential for reduced discards
+ Increased harvest
- Potential for increased pressure in areas where red drum occur
- Potential negative impact on SPR
- Reduces likelihood of reaching management goals
- Data suggests discards are not currently a major issue
- NCDMF Director already has this authority to increase bycatch allowance if discards increase

3) Allow for possession of some red drum while actively fishing gear even if adequate finfish (excluding menhaden) have not yet been obtained.

+ Less discards
+ Increased harvest
- More difficult to enforce
- Potential for dead release of red drum that could have been released alive

4) Allow for the possession of some red drum without requiring that they be bycatch
(Example would be to allow three red drum to be landed without requiring other finfish to be present; additional landed red drum would be subject to bycatch provision)

+ Less discards
+ Increased landings
- Potential for targeting
- Less incentive for netters to avoid areas where red drum typically occur

5) Implement a split season on the commercial fishing year, capping the period of September 1 to April 30 at 150,000 lb and conserving the remaining portion of the cap (100,000 lb) for the period of May 1 to August 31. Unused cap in Period 1 can be carried forward to Period 2.

+ Avoid closure during the summer when discard mortality is highest
+ Less likely to have Cap overages
- May result in reduced landings if fish availability changes

Management Recommendations

DMF and RDAC –

1) **Status quo (7 fish trip limit with 50% bycatch provision). Director retains authority to modify the trip limit and bycatch provisions as needed.**
2) **Allow for the possession of up to 3 fish while engaged in red drum without requiring that they be subject to the 50% bycatch provision. Upon landing/sale all red drum possessed would be subject to any bycatch requirements.**
3) **Implement a split season on the commercial fishing year, capping the period**

of September 1 to April 30 at 150,000 lb and conserving the remaining portion of the cap (100,000 lb) for the period of May 1 to August 31. Unused cap in period 1 can be carried forward to period 2. Any annual commercial harvest limit that is exceeded one year will result in the poundage overage being deducted from the subsequent year's commercial harvest limit.

MFC Selected Management Option

Endorses DMF and RDAC recommendations.

Research Recommendations

- Continued and expanded observer coverage in the commercial fishery.
- Expand independent gill net survey to other parts of the state.

10.2.5 Red Drum Discarded Bycatch in the Estuarine Gill Net Fishery

10.2.5.1 Statewide Estuarine Gill Net Bycatch Estimates

Issue

The occurrence and magnitude of regulatory and unmarketable red drum discards in the estuarine gill net fishery.

Background

Non-harvest loss of red drum occurring from the use of commercial fishing gear is currently not fully known. This lack of information continues to be a major source of bias in accurately assessing the current stock status of red drum in North Carolina. Current fishing mortality rates for red drum stocks in North Carolina appear to allow for adequate escapement of juvenile red drum to the adult stock. These escapement rates, however, carry the caveat that non-harvest losses in the commercial fishery are not known. This lack of information on discards likely results in an overly optimistic estimate of escapement and spawning potential ratio (SPR). Assessing the magnitude of discards in the commercial fishery is listed as high research priority in both the 2007 red drum stock assessment update (Takade and Paramore 2007) and Amendment 2 to the Atlantic States Marine Fisheries Commission (ASMFC) Red Drum Fishery Management Plan (FMP) (ASMFC 2002).

Bycatch is an important issue facing the North Carolina Division of Marine Fisheries (NCDMF) and the North Carolina Marine Fisheries Commission (NCMFC). The Guidelines for the North Carolina Fishery Management Plans as adopted by the NCMFC, set a standard for FMP's to design management measures which minimize waste of fishery resources, including both target and bycatch species. In addition, an objective of this fishery management plan is to promote harvest practices that minimize bycatch of unmarketable red drum. While non-harvest losses likely occur to some extent from various commercial gears, it has been well accepted that the primary loss is likely due to the

bycatch of red drum in the estuarine gill net fishery. As a result, the 2001 NC Red Drum FMP took measures to reduce red drum bycatch in the estuarine gill net fishery by requiring the seasonal attendance of small mesh gill nets (<5" stretch mesh). Gill nets of this mesh size select for red drum less than 18" TL and are a significant source of the bycatch mortality, particularly in months when water temperatures are high. Current North Carolina regulations require the attendance of small mesh gill nets from May 1 through October 31 in areas known to be critical for juvenile red drum. These include all primary and secondary nursery areas, areas within 200 yards of any shoreline, and the extensive area of shallow grass flats located behind the Outer Banks. An exemption to this rule lifts the attendance requirement for the region from Core Sound to the South Carolina border in October to allow for the fall spot fishery. A study conducted in Core Sound during 1999 indicated that catches of red drum during the October fall spot fishery were relatively low. All observed trips conducted during the study occurred while gill netters were fishing nets set approximately 100 yards from shore. This practice of setting nets well off the shoreline appeared to be effective at reducing the incidence of juvenile red drum bycatch in this fishery. During the same study, Division gill nets set less than 100 yards from shore had substantially more red drum bycatch than did sets made at $\geq$100 yards from shore.

During the development of the 2001 NC Red Drum FMP, several issues were tabled by the red drum AC and DMF due to inadequate information. To address this data deficiency, four research recommendations from the 2001 FMP were: 1) Collect information on gill net effort by area/season; 2) Conduct at sea samples to estimate red drum discards from gill nets; 3) Estimate the release mortality from gill nets; 4) Collect data on the harvest and releases of red drum captured in gill nets under the Recreational Commercial Gear License. New data has been collected to some extent for all four of these research recommendations. This issue paper will provide a summary of all data collected to date and will provide management options based on this new information.

All results reported are based on anchored estuarine gill nets unless noted otherwise. Drift and run-around gill nets were not included in the analysis. Bycatch from other fisheries/gears are not currently available.

1) Collect information on estuarine gill net effort by area and season.

Information specific to North Carolina's estuarine gill net fishery can be drawn from three DMF sampling programs briefly described below:

NC Trip Ticket Program

Commercial red drum landings and the red drum commercial cap are monitored through the North Carolina trip ticket program. Under this program licensed fishermen can only sell commercial catches to licensed NCDMF fish dealers. The dealer is required to complete a trip ticket every time a licensed fishermen lands fish. Trip tickets capture data on gears used to harvest fish, area fished, species harvested, and total weights of each individual species. The trip ticket program began in 1994.

Commercial Fish House Sampling

Commercial fishing activity is monitored through fishery dependent (fish house) sampling. Sampling occurs dockside as fish are landed. Commercial fishers are interviewed and the catch is sampled. Data collected includes information on location, effort and gear characteristics, as well as information used to determine the size and age distribution of species landed. Over the past decade gill nets have been the dominant gear used for red drum accounting for >70% of the overall harvest. In 2006, 93.5% of the red drum harvest was taken in gill nets, followed by pound nets with 4%.

Commercial Observer Program

Starting in October of 2000, the Pamlico Sound flounder gill net fishery has been restricted, operating under an Incidental Take Permit (ITP) issued by NMFS to reduce interactions with endangered and threatened sea turtles. The restrictions on this fishery are effective from September 15 through December 31. Stipulations of the permit include permitted entry, restricted areas, limited yardage of gill net and mandatory scientific observer coverage. This ITP began the available observer data available for the estuarine gill net fishery in North Carolina. From 2001 to 2003, coverage was limited to the fall Pamlico Sound flounder gill net fishery. From 2004 to 2006, coverage was expanded by DMF to include other regions and estuarine gill net fisheries. Participation in this expanded coverage by commercial gill netters was voluntary. Information gathered during observer trips includes data on effort and mesh sizes used, as well as, data on the size and ultimate fate of captured species.

Information gathered from these three programs was used to characterize North Carolina's estuarine gill net fishery. North Carolina has a large number of commercially valuable species that are targeted by gill nets throughout the year with no single size gill net (i.e. mesh size) being ideal for all species. The result is gill netters utilize specific mesh size nets depending on the species they intend to target. While multiple species are most often landed for a single trip, a target (key) species most often represents the majority of the catch.

In order to characterize a specific estuarine gill net fishery the species being targeted must first be identified. This information is not readily available and must be inferred from the catch composition. Data collected from 2001 to 2006 was analyzed to determine the target species for each individual trip made. As noted earlier, drift and run-around gill nets were not included in the analysis. Using trip ticket data, the species of highest abundance in landings was considered the target species and was used to define the trip. After initial analysis, 95% of all gill net trips fell into one of sixteen key species. These sixteen species were then each identified as a separate fishery. For those remaining undefined trips, a hierarchy was used where the species of second and then third highest abundance was used to define the trip if it was represented by one of these sixteen species. This defined an additional 4% of the remaining trips. Of the remaining trips (1%) the non-key species of highest abundance in the catch was used to define the trip. Overall, flounder was the primary species targeted by gill netters in estuarine waters of North Carolina (Table 25). Overall landings across all trips for each of the key species are summarized in Table 26.

Table 25. Anchored estuarine gill net trips with the species of highest abundance landed (target species) being used to define a trip.

Species	2001	2002	2003	2004	2005	2006	Combined	(%)	cum%
Flounder	19,390	17,779	16,255	16,208	14,402	16,884	100,918	(47)	47
Striped Bass	5,198	5,041	4,965	4,404	4,377	3,363	27,348	(13)	59
Spot	2,105	2,793	2,861	2,847	2,930	1,686	15,222	(7)	66
Striped Mullet	3,149	3,041	2,720	2,035	1,853	1,659	14,457	(7)	73
American Shad	1,327	1,746	1,865	1,556	1,447	1,325	9,266	(4)	77
Menhaden	1,579	1,512	1,647	1,192	1,226	1,725	8,881	(4)	81
Bluefish	1,895	991	1,484	915	1,240	1,063	7,588	(4)	85
White Perch	882	1,111	1,827	968	879	858	6,525	(3)	88
Catfish	1,040	916	831	743	776	1,112	5,418	(3)	90
Red Drum	2,347	356	556	331	599	883	5,072	(2)	93
Speckled Trout	413	820	621	486	411	948	3,699	(2)	94
Spanish Mackerel	685	668	279	308	553	396	2,889	(1)	96
Hickory Shad	801	219	199	619	550	306	2,694	(1)	97
River Herring	341	488	377	314	413	281	2,214	(1)	98
Weakfish	458	330	218	406	321	275	2,008	(1)	99
Sea Mullet	129	92	99	74	67	147	608	(0)	99
Others (37 species)	463	357	279	220	137	199	1,655	(1)	100
Combined	42,202	38,260	37,083	33,626	32,181	33,110	216,462	(100)	

Table 26. Annual landings of major species in North Carolina's anchored estuarine gill net fishery.

Species	2001	2002	2003	2004	2005	2006	Combined
Flounder	1,905,276	1,807,364	1,469,218	1,587,289	1,283,917	1,539,360	9,592,425
Menhaden	1,134,509	791,479	980,822	561,149	865,364	602,951	4,936,272
Striped Mullet	778,261	891,357	709,182	512,018	449,901	377,231	3,717,950
Spot	536,123	675,204	652,932	685,989	728,509	325,141	3,603,898
Bluefish	445,555	256,451	488,170	278,599	368,342	231,817	2,068,932
Striped Bass	226,372	226,705	339,056	295,172	235,708	184,266	1,507,279
American Shad	119,925	238,923	356,303	241,001	179,411	161,248	1,296,812
White Perch	175,525	219,077	404,865	176,027	138,723	106,859	1,221,077
Catfish	155,373	157,399	170,153	125,599	118,345	134,689	861,557
Spanish Mackerel	183,834	199,166	74,470	88,931	178,606	97,679	822,686
Hickory Shad	161,234	44,195	63,388	173,352	169,441	48,963	660,573
Red Drum	129,509	66,335	78,805	44,917	103,648	145,833	569,047
Weakfish	106,464	95,321	69,863	89,238	101,191	74,261	536,339
Speckled Trout	55,038	101,934	96,928	67,850	50,757	114,347	486,854
River Herring	86,164	71,636	82,119	75,920	74,727	36,849	427,414
Sea Mullet	45,656	40,184	38,423	28,907	25,755	54,951	233,877

Once trips were defined, each fishery was then further characterized from available fish house sampling and observer data from 2001 to 2006. For each of the sixteen fisheries defined, information specific to mesh sizes used, yards of net fished, soak times and depths fished are included (Table 27 and Table 28). Species with similar gear parameters for mesh size are grouped together into large ($\geq$ 5 inch) or small (<5 inch) stretch mesh gill net fisheries. Available information is also separated by region. Regions include: Albemarle Sound, Core Sound to the South Carolina border, Pamlico and Neuse River, and Pamlico Sound.

The availability of various species in North Carolina's estuarine gill net fishery varies by season. Monthly landings by region for each of the sixteen key species are provided in Figure 27 and Figure 28.

Table 27. Large mesh (≥ 5 inch) gill net fishery parameters commonly associated with the targeting of various species, 2001-2006.

FLOUNDERS		Gill Net Stretch Mesh Size						Effort Data (yards fished)			Soak Time (hours)			Depth (ft)		
Region	Source (Program)	N	mode	common range	mean	min	max	mean	min	max	mean	min	max	mean	min	max
All	Dependent	1,686	5.50	5.25 - 6.5	5.66	2.88	7.00	1,534	50	6,000	20	4	96	5	1	20
Albemarle Sound	Dependent (pgm 461)	293	5.75	5.5 - 6	5.74	3.13	6.50	1,737	200	3,700	26	12	72	9	1	20
	Observer (pgm 466)	66	5.50	5.25 - 6	5.59	3.25	6.50	2,109	600	3,000	22	10	48	7	1	20
Core Sound South	Dependent (pgm 461)	349	5.50	5.5 - 6	5.63	3.25	7.00	1,949	200	6,000	17	7	48	3	1	12
	Observer (pgm 466)	101	5.50	5.5 - 6	5.66	5.25	6.50	1,519	500	3,400	18	11	48	3	1	6
Pamlico/Neuse River	Dependent (pgm 461)	543	5.50	5.25 - 5.5	5.46	3.00	7.00	1,176	50	5,333	17	4	72	4	1	18
	Observer (pgm 466)	202	5.50	5.25 - 5.5	5.45	3.00	6.00	935	100	3,200	21	4	144	4	1	18
Pamlico Sound	Dependent (pgm 461)	501	6.00	5.25 - 6.5	5.83	2.88	7.00	1,411	100	6,000	22	8	96	3	1	10
	Observer (pgm 466)	881	6.00	5.5 - 7	5.99	3.00	8.75	1,179	100	3,000	24	2	144	3	<1	13

STRIPED BASS		Gill Net Stretch Mesh Size (inches)						Effort Data (yards fished)			Soak Time (hours)			Depth (ft)		
Region	Source (Program)	N	mode	common range	mean	min	max	mean	min	max	mean	min	max	mean	min	max
All	Dependent	150	5.50	5.5 - 8	5.70	2.50	10.00	657	50	3,000	17	1	36	6	2	15
Albemarle Sound	Dependent (pgm 461)	24	5.75 & 8	5.5 - 8	5.90	2.50	10.00	1,009	100	3,000	20	1	24	8	3	15
	Observer (pgm 466)	7	5.50	5.50	5.50	5.50	5.50	950	400	2,000	31	24	48	11	6	18
Core Sound South	Dependent (pgm 461)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Observer (pgm 466)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pamlico/Neuse River	Dependent (pgm 461)	111	5.50	5.5 - 7	5.70	5.50	7.00	555	50	1,800	16	12	36	6	2	12
	Observer (pgm 466)	6	5.50	5.25 - 6	5.45	5.25	6.00	1,033	600	1,600	22	12	24	6	4	12
Pamlico Sound	Dependent (pgm 461)	15	5.75	5.75 - 6	5.30	3.00	6.00	986	400	1,500	21	12	24	6	3	12
	Observer (pgm 466)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

RED DRUM		Gill Net Stretch Mesh Size (inches)						Effort Data (yards fished)			Soak Time (hours)			Depth (ft)		
Region	Source (Program)	N	mode	common range	mean	min	max	mean	min	max	mean	min	max	mean	min	max
All	Dependent	51	5.50	5.5 - 6	5.30	3.00	6.50	838	100	3,200	17	8	48	3	1	7
Albemarle Sound	Dependent (pgm 461)	7	6.00	4.5 - 6	5.63	4.50	6.00	700	100	2,000	16	12	24	3	1	5
	Observer (pgm 466)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Core Sound South	Dependent (pgm 461)	9	5.50	4.5 - 5.75	5.06	3.00	5.75	738	200	3,200	16	12	24	3	2	5
	Observer (pgm 466)	3	5.50	5.5 - 5.75	5.56	5.50	5.75	1,033	600	1,600	16	12	24	2	2	4
Pamlico/Neuse River	Dependent (pgm 461)	12	5.50	5.25 - 6	5.25	3.25	6.00	750	100	1,400	15	12	24	4	2	4
	Observer (pgm 466)	1	5.50	4.5 - 5.5	5.00	4.50	5.50	800	800	800	16	16	16	4	2	7
Pamlico Sound	Dependent (pgm 461)	23	6.00	5.5 - 6.25	5.43	3.25	6.50	968	300	3,000	19	8	48	3	1	7
	Observer (pgm 466)	14	6.00	4.75 - 6.5	5.76	4.75	6.50	1,016	300	1,700	23	12	48	2	1	4

AM SHAD		Gill Net Stretch Mesh Size (inches)						Effort Data (yards fished)			Soak Time (hours)			Depth (ft)		
Region	Source (Program)	N	mode	common range	mean	min	max	mean	min	max	mean	min	max	mean	min	max
All	Dependent	208	5.50	5 - 5.5	5.50	3.00	7.00	759	100	2,500	24	12	96	9	1	14
Albemarle Sound	Dependent (pgm 461)	18	5.50	5.25 - 5.5	5.37	3.00	7.00	892	300	1,400	49	12	96	9	8	10
	Observer (pgm 466)	33	5.50	5.25 - 5.5	5.25	3.00	6.00	786	231	2,400	28	12	96	10	2	21
Core Sound South	Dependent (pgm 461)	2	5.25	5.25	5.25	5.25	5.25	300	300	300	18	12	24	4	4	4
	Observer (pgm 466)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pamlico/Neuse River	Dependent (pgm 461)	179	5.50	5.25 - 5.5	5.56	3.75	7.00	731	100	2,500	22	12	72	9	1	14
	Observer (pgm 466)	54	5.50	5 - 6	5.55	5.00	7.00	835	198	3,000	26	12	73	6	2	14
Pamlico Sound	Dependent (pgm 461)	9	5.50	5.50	5.29	3.13	6.00	1,217	200	2,000	26	12	48	5	2	6
	Observer (pgm 466)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 27. Continued.

HICKORY SHAD*		Gill Net Stretch Mesh Size (inches)						Effort Data (yards fished)			Soak Time (hours)			Depth (ft)		
Region	Source (Program)	N	mode	common range	mean	min	max	mean	min	max	mean	min	max	mean	min	max
All	Dependent	55	5.50	3 - 5.5	4.20	3.00	6.00	1,073	231	3,000	23	12	48	7	1	13
Albemarle Sound	Dependent (pgm 461)	1	5.50	2.5 - 5.5	3.67	2.50	5.50	1,150	1,150	1,150	12	12	12	5	5	5
	Observer (pgm 466)	8	5.25	3 - 5.5	4.98	3.00	5.50	963	400	1,760	22	12	48	11	8	21
Core Sound South	Dependent (pgm 461)	13	3.75	3.25 - 4.0	3.58	3.00	4.00	939	400	1,900	20	12	24	4	2	6
	Observer (pgm 466)	2	3.50	3.25 - 3.75	3.60	3.25	5.50	1,000	500	1,500	36	24	48	5	3	6
Pamlico/Neuse River	Dependent (pgm 461)	19	5.50	3.75 - 5.5	4.70	3.75	5.50	878	231	1,900	26	12	24	10	5	13
	Observer (pgm 466)	9	5.50	4 - 5.5	4.93	4.00	5.50	836	231	1,770	24	12	48	7	3	15
Pamlico Sound	Dependent (pgm 461)	22	4.00	3.0 - 4.0	3.96	2.88	6.00	1,365	400	3,000	23	12	48	5	1	10
	Observer (pgm 466)	4	3.50	3 - 5.75	4.17	3.00	5.75	763	560	1,150	24	24	24	3	1	5

CATFISH		Gill Net Stretch Mesh Size (inches)						Effort Data (yards fished)			Soak Time (hours)			Depth (ft)		
Region	Source (Program)	N	mode	common range	mean	min	max	mean	min	max	mean	min	max	mean	min	max
Albemarle Sound	Observer (pgm 466)	12	5.50	3.25 - 5.5	4.68	3.00	5.75	1,338	400	3,000	20	1	48	8	2	18
Core Sound South	Observer (pgm 466)	2	5.50	3.25 - 5.5	4.30	3.25	5.50	1,100	900	1,300	36	24	48	3	2	6
Pamlico/Neuse River	Observer (pgm 466)	15	5.50	3.25 - 5.5	5.50	5.00	6.00	713	132	2,400	21	10	24	6	3	11
Pamlico Sound	Observer (pgm 466)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 28. Small mesh (< 5 inch) gill net fishery parameters commonly associated with the targeting of various species, 2001-2006.

SPOT		Gill Net Stretch Mesh Size (inches)						Effort Data (yards fished)			Soak Time (hours)			Depth (ft)		
Region	Source (Program)	N	mode	common range	mean	min	max	mean	min	max	mean	min	max	mean	min	max
All	Dependent	160	3 - 3.25	3 - 3.5	3.46	2.75	8.00	780	100	3,000	17	1	48	6	2	20
Albemarle Sound	Dependent (pgm 461)	46	3.25	3.13 - 3.25	3.50	3.00	8.00	715	133	1,600	16	2	24	6	3	10
	Observer (pgm 466)	13	3.25	3.0 - 3.25	3.22	3.00	3.75	815	200	1,700	11	1	24	7	2	16
Core Sound South	Dependent (pgm 461)	42	3.00	3 - 3.13	3.32	2.75	5.75	544	100	2,500	12	1	24	5	3	20
	Observer (pgm 466)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pamlico/Neuse River	Dependent (pgm 461)	12	3.00	3 - 3.25	3.57	3.00	5.50	544	200	800	10	2	24	4	3	4
	Observer (pgm 466)	6	3.00	2.75 - 3.25	3.50	2.75	5.50	791	400	1,025	18	12	24	4	2	6
Pamlico Sound	Dependent (pgm 461)	60	3.00	3 - 3.5	3.54	2.88	6.00	1,091	200	3,000	22	7	48	6	2	13
	Observer (pgm 466)	26	3.50	3 - 3.75	4.25	2.87	7.00	1,020	140	2,630	24	2	72	4	1	12

STRIPED MULLET		Gill Net Stretch Mesh Size (inches)						Effort Data (yards fished)			Soak Time (hours)			Depth (ft)		
Region	Source (Program)	N	mode	common range	mean	min	max	mean	min	max	mean	min	max	mean	min	max
All	Dependent	89	3.75 - 4	3 - 4	4.10	2.88	5.75	818	200	2,600	16	1	48	5	1	17
Albemarle Sound	Dependent (pgm 461)	9	3.25	3.25	4.60	3.00	5.75	1,371	500	2,600	27	10	48	8	3	17
	Observer (pgm 466)	18	3.25	3 - 3.5	3.71	3.00	5.50	537	100	1,200	10	1	24	5	1	11
Core Sound South	Dependent (pgm 461)	10	3.75	3.75 - 4	4.00	3.25	5.50	833	400	1,600	17	12	36	4	3	5
	Observer (pgm 466)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pamlico/Neuse River	Dependent (pgm 461)	60	4.00	3 - 4	3.70	2.88	6.50	638	200	1,800	11	1	24	4	3	7
	Observer (pgm 466)	1	4.00	4	4.75	4.00	5.50	800	800	800	12	12	12	5	4	6
Pamlico Sound	Dependent (pgm 461)	10	4.00	3.25 - 4	4.60	3.25	6.50	889	400	1,500	19	12	24	3	1	7
	Observer (pgm 466)	44	4.00	3.50 - 4.0	4.02	3.00	6.00	901	55	1,500	26	1	72	3	1	24

Table 28. Continued.

SPOTTED SEATROUT		Gill Net Stretch Mesh Size (inches)						Effort Data (yards fished)			Soak Time (hours)			Depth (ft)		
Region	Source (Program)	N	mode	common range	mean	min	max	mean	min	max	mean	min	max	mean	min	max
All	Dependent	70	4.00	3.5 - 4(+5.5)	4.20	3.00	5.75	1,055	100	2,300	19	3	72	4	3	8
Albemarle Sound	Dependent (pgm 461)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Observer (pgm 466)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Core Sound South	Dependent (pgm 461)	6	4.00	3.5 - 4	3.90	3.50	4.00	1,180	400	1,600	17	3	24	4	2	5
	Observer (pgm 466)	4	3.75	3.25-3.75(+5.5)	4.00	3.25	5.50	1,175	800	1,500	42	24	48	4	2	6
Pamlico/Neuse River	Dependent (pgm 461)	40	4.00	3.5 - 4(+5.5)	4.20	3.00	5.50	988	400	2,000	13	12	24	4	2	7
	Observer (pgm 466)	3	5.50	3 - 5.5	4.28	3.00	5.50	840	331	1,400	15	1	24	3	1	5
Pamlico Sound	Dependent (pgm 461)	24	4.00	3.75 - 4.75	4.30	3.25	5.76	1,083	100	2,300	27	12	72	4	2	8
	Observer (pgm 466)	14	4.00	3.75 - 4.5	4.21	3.50	6.00	1,030	400	1,700	24	16	48	4	2	8

BLUEFISH		Gill Net Stretch Mesh Size (inches)						Effort Data (yards fished)			Soak Time (hours)			Depth (ft)		
Region	Source (Program)	N	mode	common range	mean	min	max	mean	min	max	mean	min	max	mean	min	max
All	Dependent	161	3.25	2.88 - 3.5	3.70	2.88	6.50	1,036	100	3,900	23	2	48	6	2	17
Albemarle Sound	Dependent (pgm 461)	11	3.25	3.13 - 3.25	3.23	3.12	3.25	950	500	1,200	24	12	48	5	3	10
	Observer (pgm 466)	1	3.00	3.00	3.00	3.00	3.00	2,000	2,000	2,000	2	1	4	4	2	7
Core Sound South	Dependent (pgm 461)	16	3.00	3 - 3.25	3.43	2.88	6.00	1,103	150	2,000	18	12	24	5	3	8
	Observer (pgm 466)	1	5.50	5.50	5.50	5.50	5.50	900	900	900	24	24	24	3	3	4
Pamlico/Neuse River	Dependent (pgm 461)	2	3.25	3.25	4.38	3.25	5.50	1,700	1,700	1,700	12	12	12	3	3	3
	Observer (pgm 466)	3	3.25	3.25	4.25	3.25	6.00	867	200	1,400	11	4	18	5	4	6
Pamlico Sound	Dependent (pgm 461)	132	3.25	2.88 - 3.5	3.76	2.88	6.50	1,026	100	3,900	23	2	48	6	2	17
	Observer (pgm 466)	37	3.50	3.25 - 4	4.89	3.00	7.00	885	200	2,775	24	12	48	4	1	11

WEAKFISH		Gill Net Stretch Mesh Size (inches)						Effort Data (yards fished)			Soak Time (hours)			Depth (ft)		
Region	Source (Program)	N	mode	common range	mean	min	max	mean	min	max	mean	min	max	mean	min	max
All	Dependent	36	3.00	2.88 - 3.25	3.30	2.50	6.25	1,307	200	4,000	21	1	48	8	3	14
Albemarle Sound	Dependent (pgm 461)	2	3.25	3.25	3.25	2.50	3.25	800	800	800	14	14	14	7	7	7
	Observer (pgm 466)	1	3.13	3.13	3.13	3.13	3.13	270	270	270	18	12	24	4	3	5
Core Sound South	Dependent (pgm 461)	2	3.00	3 - 4	3.31	3.00	4.00	650	500	800	18	12	24	4	4	5
	Observer (pgm 466)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pamlico/Neuse River	Dependent (pgm 461)	1	3.00	3.00	3.00	3.00	3.00	200	200	200	12	12	12	7	7	7
	Observer (pgm 466)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pamlico Sound	Dependent (pgm 461)	31	3.00	2.88 - 3.25	3.34	2.88	6.25	1,408	250	4,000	22	1	48	8	3	14
	Observer (pgm 466)	18	3.00	2.88 - 3.75	3.37	2.88	5.75	999	300	2,440	22	3	48	7	2	15

MENHADEN		Gill Net Stretch Mesh Size (inches)						Effort Data (yards fished)			Soak Time (hours)			Depth (ft)		
Region	Source (Program)	N	mode	common range	mean	min	max	mean	min	max	mean	min	max	mean	min	max
All	Dependent	37	3.00	3 - 3.25	3.60	2.88	4.00	985	200	2,000	22	9	48	7	3	15
Albemarle Sound	Dependent (pgm 461)	13	3.25	3.13 - 3.75	3.43	3.00	4.00	844	300	1,500	24	12	48	9	6	12
	Observer (pgm 466)	37	5.25	3 - 5.5	4.68	3.00	5.50	829	210	1,965	29	12	72	10	4	22
Core Sound South	Dependent (pgm 461)	2	3.13	3 - 3.13	3.06	3.00	3.12	850	200	1,500	18	12	24	5	3	6
	Observer (pgm 466)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pamlico/Neuse River	Dependent (pgm 461)	6	3.00	3 - 4	3.50	3.00	4.00	567	200	1,000	12	12	12	6	6	6
	Observer (pgm 466)	28	5.50	3.25 - 5.5	4.65	3.25	8.00	758	248	1,700	20	2	48	6	2	16
Pamlico Sound	Dependent (pgm 461)	16	3.00	3 - 3.25	3.75	2.88	4.00	1,170	200	2,000	23	9	48	7	3	15
	Observer (pgm 466)	41	3.50	2.88 - 3.5	3.72	2.87	7.00	721	200	1,955	24	1	72	6	1	15

Table 28. Continued.

SP MACKEREL		Gill Net Stretch Mesh Size (inches)						Effort Data (yards fished)			Soak Time (hours)			Depth (ft)		
Region	Source (Program)	N	mode	common range	mean	min	max	mean	min	max	mean	min	max	mean	min	max
All	Dependent	48	3.50	3.38 - 3.75	3.55	3.00	4.00	1,291	500	2,700	7	2	12	13	6	17
Albemarle Sound	Dependent (pgm 461)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Observer (pgm 466)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Core Sound South	Dependent (pgm 461)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Observer (pgm 466)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pamlico/Neuse River	Dependent (pgm 461)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Observer (pgm 466)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pamlico Sound	Dependent (pgm 461)	48	3.50	3.38 - 3.75	3.55	3.00	4.00	1,291	500	2,700	7	2	12	13	6	17
	Observer (pgm 466)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

WHITE PERCH		Gill Net Stretch Mesh Size (inches)						Effort Data (yards fished)			Soak Time (hours)			Depth (ft)		
Region	Source (Program)	N	mode	common range	mean	min	max	mean	min	max	mean	min	max	mean	min	max
Albemarle Sound	Observer (pgm 466)	17	3.25	3 - 3.25	3.77	2.33	5.50	709	100	1,400	28	2	96	10	2	2
Core Sound South	Observer (pgm 466)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pamlico/Neuse River	Observer (pgm 466)	7	3.25	3.25 - 3.5	3.29	3.25	3.50	667	300	1,050	18	12	24	4	3	6
Pamlico Sound	Observer (pgm 466)	6	3.50	3 - 3.5	4.00	3.00	5.75	1,012	450	1,650	28	24	48	4	3	7

RIVER HERRING		Gill Net Stretch Mesh Size (inches)						Effort Data (yards fished)			Soak Time (hours)			Depth (ft)		
Region	Source (Program)	N	mode	common range	mean	min	max	mean	min	max	mean	min	max	mean	min	max
Albemarle Sound	Observer (pgm 466)	28	3.00	3 - 3.25	3.59	3.00	5.50	694	280	1,590	32	12	72	9	2	17
Core Sound South	Observer (pgm 466)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pamlico/Neuse River	Observer (pgm 466)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pamlico Sound	Observer (pgm 466)	5		3 - 3.5	4.04	3.00	5.50	1,390	750	1,700	24	24	24	4	1	8

SEA MULLET		Gill Net Stretch Mesh Size (inches)						Effort Data (yards fished)			Soak Time (hours)			Depth (ft)		
Region	Source (Program)	N	mode	common range	mean	min	max	mean	min	max	mean	min	max	mean	min	max
All	Dependent	5	2.88	2.88 - 3.5	2.82	3.50	3.50	1,280	200	2,000	13	3	24	11	7	14
Albemarle Sound	Dependent (pgm 461)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Core Sound South	Dependent (pgm 461)	1	3.50	3.50	3.50	3.50	3.50	200	200	200	3	3	3	7	7	7
Pamlico/Neuse River	Dependent (pgm 461)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pamlico Sound	Dependent (pgm 461)	4		2.62 - 3.5	3.00	2.62	3.50	1,550	1,000	2,000	15	12	24	13	12	14

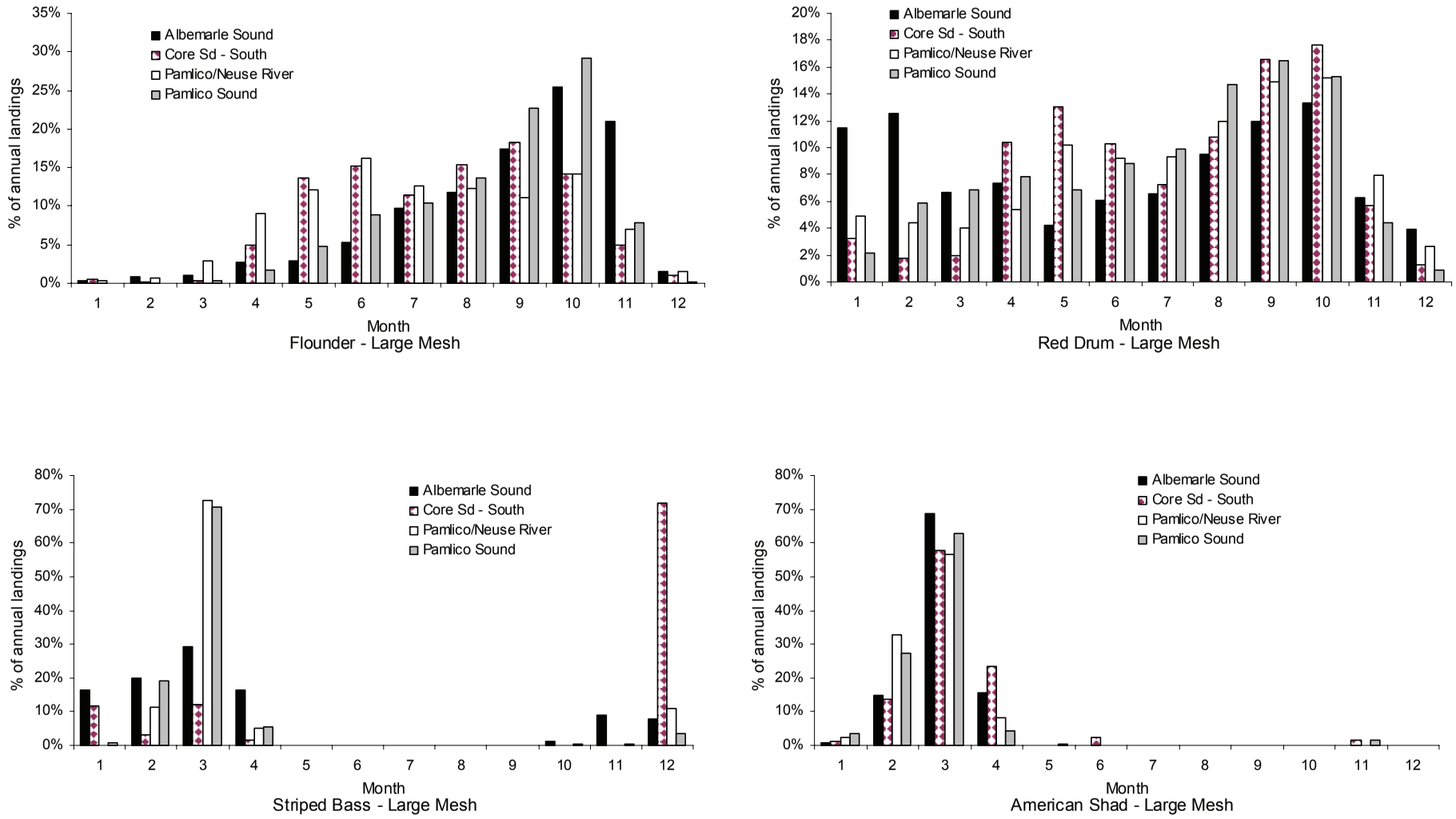
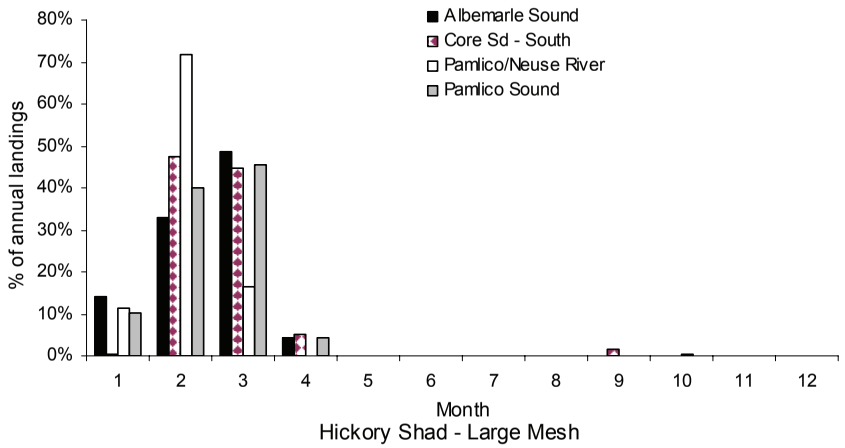


Figure 27. Monthly landings by region for common species targeted in the large mesh estuarine gill net fishery.



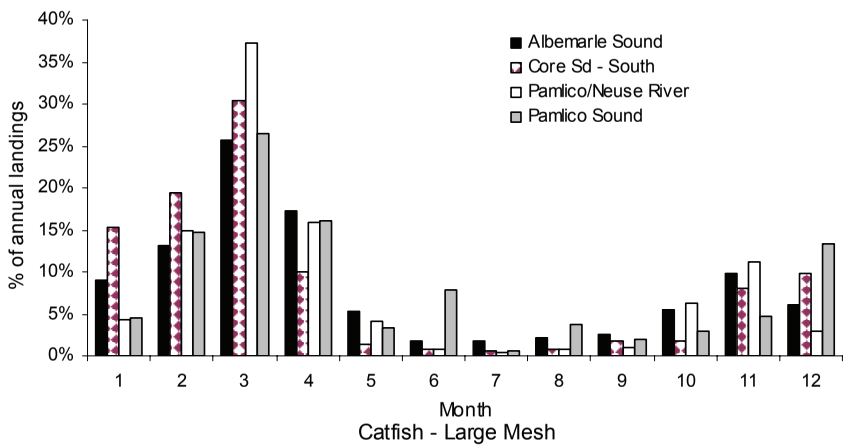
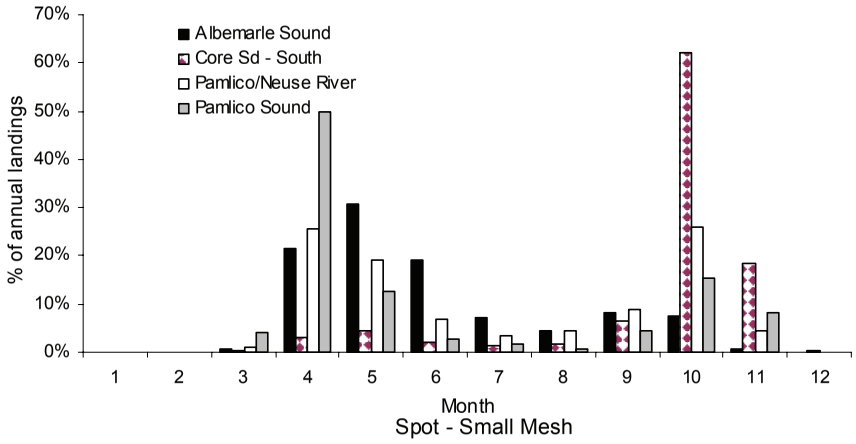


Figure 27. Continued.



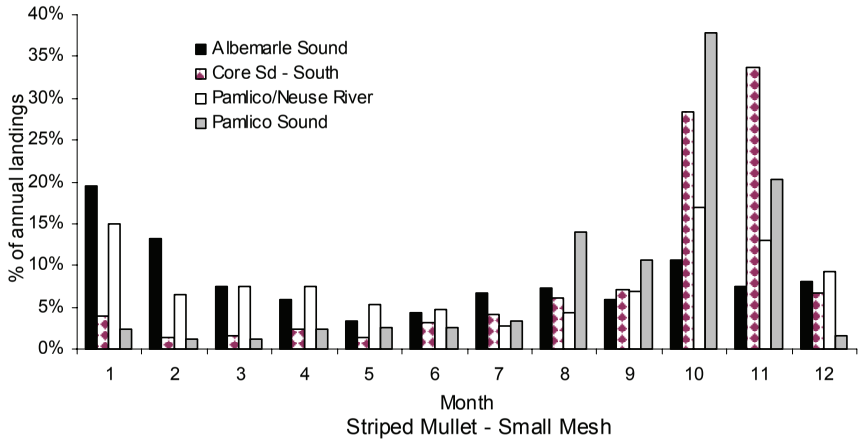
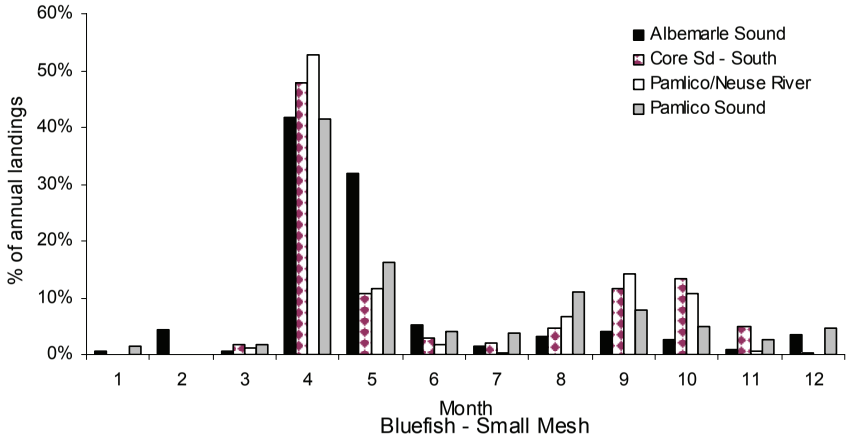
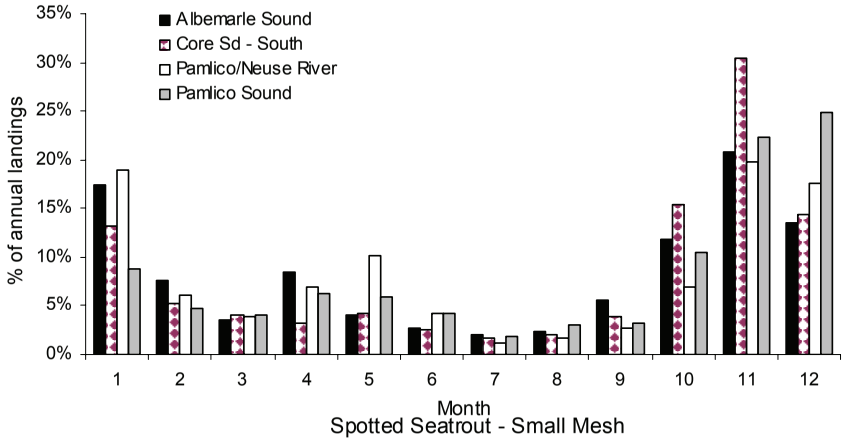
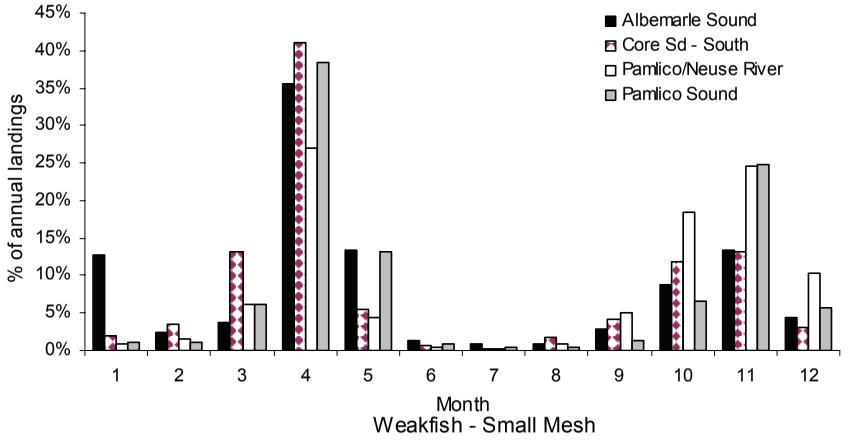


Figure 28. Monthly landings by region for common species targeted in the small mesh estuarine gill net fishery.







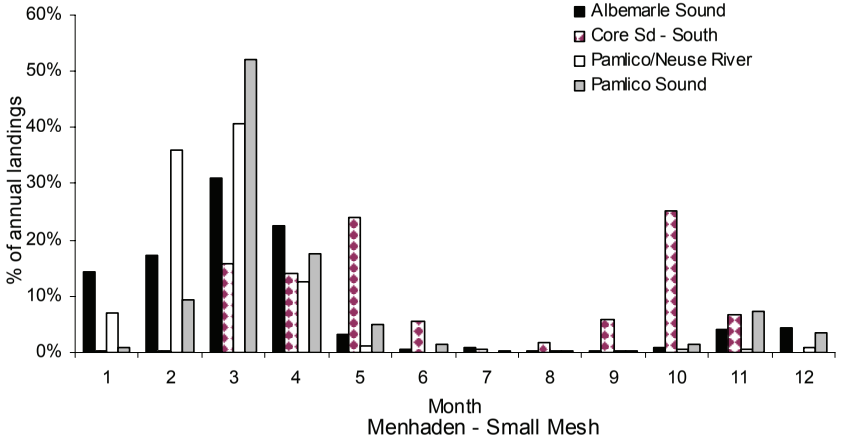
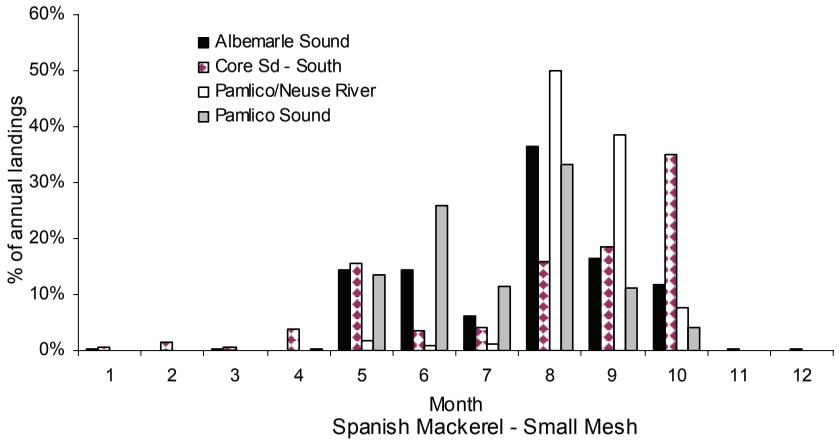
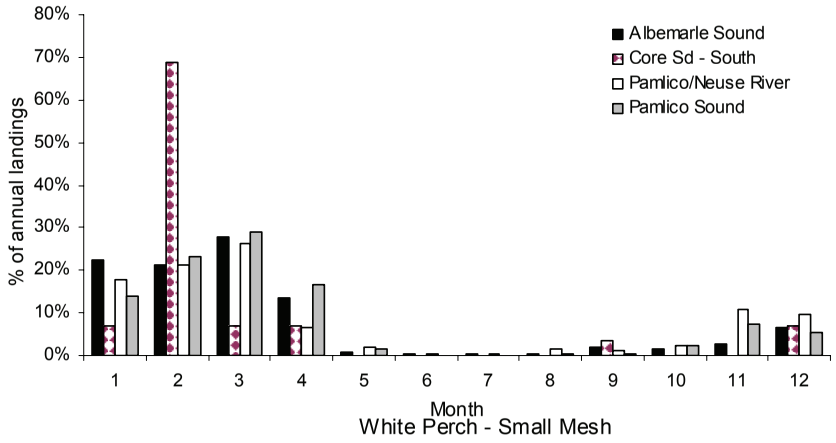
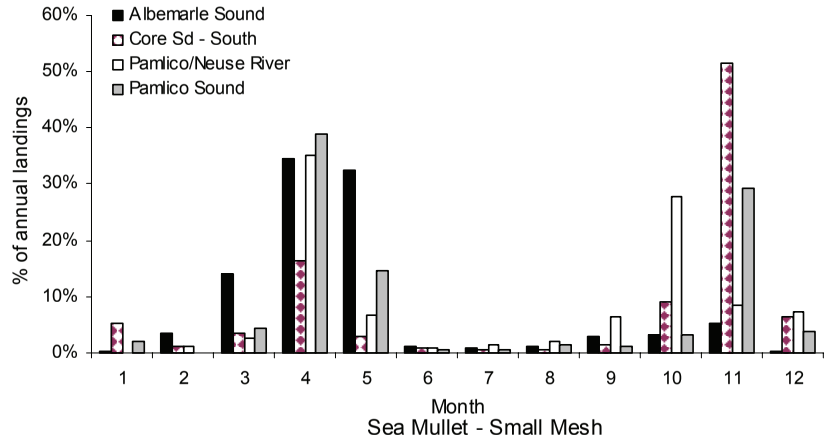


Figure 28. Continued







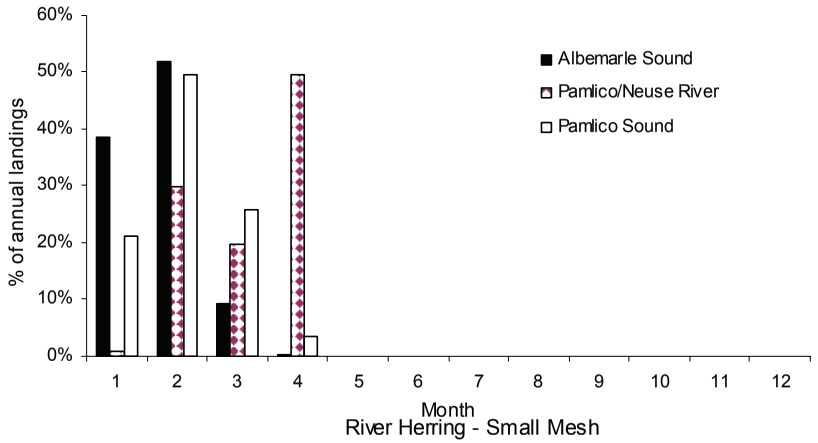


Figure 28. Continued.

2) Conduct at sea samples to estimate dead red drum discards from gill nets

North Carolina observer data were used to estimate discards of dead red drum from the estuarine gill net fishery. Available observer coverage was for the period of 2001 to 2006 (Table 29). Data from 2001 to 2003 were exclusively from the Pamlico Sound gill net fishery in the fall. Due to this limited coverage, annual coast wide estimates for these years were not attempted.

Table 29. Observed estuarine gill net trips by month and year from the North Carolina observer program.

Month	2001	2002	2003	2004	2005	2006
January	0	0	0	5	7	22
February	0	0	0	14	34	40
March	0	0	0	36	45	45
April	0	0	0	28	35	34
May	0	0	0	48	31	26
June	0	0	0	51	27	26
July	0	0	0	30	22	14
August	0	0	0	25	38	12
September	29	69	34	91	56	61
October	70	73	52	96	77	92
November	66	32	25	58	63	30
December	14	5	7	21	6	0
Total	179	179	118	503	441	402

Available data from 2004 to 2006 were separated by region as described in the previous section and included: Albemarle Sound, Pamlico Sound, Pamlico/Neuse River, and Core Sound to the South Carolina border. In addition, available data were further partitioned into seasons. Seasons were selected based on several criteria that included: months with similar mean water temperatures, peak landings for major fisheries, and periods where small mesh gill net attendance was required. The seasons selected were: January through April; May through August; September through October; and November through December.

Observed trips, in the same manner as was done for the trip ticket data, used the species of highest abundance in the catch to define the trip. A catch per unit effort (CPUE) was then generated for discarded dead red drum. The CPUE was defined as the number (or weight) of dead red drum discarded per trip. Estimates of discards were then calculated by multiplying the number of trips taken in a particular fishery by the corresponding CPUE from the observer data. Initial analysis attempted to generate CPUE's by fishery, season and region; however data were not sufficient at this level. Observed trips were then collapsed into large ($\geq$5 inch stretch mesh) or small (<5 inch stretch mesh) mesh gill net fishery groupings in an attempt to fill data gaps. CPUE was generated by year, region and season where at least 10 trips were observed. Collapsing across regions by season then filled remaining data gaps for each year. For the small mesh estimates, low sample sizes required additional collapsing across region and season by year.

Estimates of dead red drum discards from 2004 to 2006 in the large mesh estuarine gill net fishery ranged from 12,393 lbs in 2004 to 54,143 lbs in 2005 (Table 30). Dead discards from small mesh gill nets ranged from 3,042 lbs in 2004 to 5,570 lbs in 2006 (Table 31). Results of this analysis should be viewed with caution as bycatch associated with various fisheries can vary drastically. The number of observed trips for each of the key fisheries was inadequate to allow for estimates by a single fishery. After collapsing across key fisheries, samples in the large mesh fishery were much better represented by region and season than were the samples for the small mesh fishery. Small mesh observer trips were not adequate for analysis by region and season. Most of the data was collapsed across both regions and seasons to provide a single CPUE by year. For this reason, small mesh estimates in particular should be viewed with caution.

Combined estimates from the small and large mesh fishery were as follows: 15,435 lb in 2004; 58,950 lb in 2005; and 32,676 lb in 2006. These values represent 29%, 46% and 19% of the annual commercial harvest in 2004, 2005 and 2006.

3) Estimate the dead red drum discards resulting from the release mortality associated with gill nets

Estimated red drum discards from the commercial estuarine gill net fishery are based on red drum observed to be dead at the time the gear is fished and do not account for any mortality associated with red drum released alive at the net. In the red drum stock assessment a 10 percent mortality is assumed for all red drum released in the recreational fishery. This estimate is based on hook and line studies where red drum have been captured using techniques common to the recreational fishery and then held for a short period to determine the short-term mortality associated with catch and release. From 1999 to 2000, the NCDMF conducted studies to determine the short-term mortality associated with the release of red drum from estuarine gill nets. During this study, delayed mortality estimates were conducted separately for small ($\leq$ 4 ½ inch) and large ($\geq$ 5 inch) stretch mesh gill nets (Price and Gearhart 2002a; Price and Gearhart 2002b). Red drum were held (72 hours) in pens to determine the short-term mortality. Results varied by mesh size. For small mesh nets the overall delayed mortality averaged 3% while large mesh mortality was significantly higher averaging 33%. Discrepancies in these values were attributed to the low sample size of red drum captured in the large mesh nets (n = 18) relative to the small mesh nets (n = 1,236). Additional work should be conducted in this area to provide more reliable estimates.

The magnitude of mortality associated with release from estuarine gill nets was estimated using an intermediate release mortality of 10%. Estimates were calculated in the same manner as previously used to estimate dead red drum discards occurring at the net. The one exception being that the CPUE was defined as the number (or weight) of red drum released per trip. This number was then multiplied by 10% to determine the total release mortality. CPUE was generated by year, region and season where at least 10 trips were observed. Collapsing across regions for each season then filled remaining data gaps for each year. For the small mesh estimates low sample sizes required additional collapsing across region and season by year.

Estimated release mortalities from 2004 to 2006 in the large mesh estuarine gill net fishery ranged from 2,613 lb in 2004 to 6,229 lb in 2005 (Table 32). For the small mesh gill net fishery, estimates were lower ranging from 1,005 lb in 2004 to 2,222 lb in 2005 (Table 33).

Table 30. Estimated dead discards (number and weight) of red drum from the large mesh estuarine gill net fishery.

2004	Season	# trips	# trips observed	% coverage	CPUE (#)	CPUE (lbs)	exp_num	exp_wt
Albemarle Sound	Jan-Apr	5,755	30	0.5%	0.00	0.00	-	-
	May-Aug	2,371	41	1.7%	0.00	0.00	-	-
	Sep-Oct	1,838	5	0.3%	0.78	1.30	1,434	2,389
	Nov-Dec	1,037	4	0.4%	0.25	0.28	259	290
Core Sound South	Jan-Apr	504	0	0.0%	0.02	0.04	10	20
	May-Aug	2,273	1	0.0%	0.26	0.38	591	864
	Sep-Oct	1,098	27	2.5%	1.96	3.26	2,152	3,579
	Nov-Dec	230	2	0.9%	0.25	0.28	58	64
Pamlico/Neuse River	Jan-Apr	1,422	21	1.5%	0.05	0.10	68	142
	May-Aug	1,477	67	4.5%	0.27	0.24	399	354
	Sep-Oct	930	22	2.4%	0.00	0.00	-	-
	Nov-Dec	330	17	5.2%	0.00	0.00	-	-
Pamlico Sound	Jan-Apr	503	0	0.0%	0.02	0.04	10	20
	May-Aug	2,220	36	1.6%	0.39	1.15	866	2,553
	Sep-Oct	1,646	110	6.7%	0.69	1.18	1,136	1,942
	Nov-Dec	354	27	7.6%	0.44	0.49	156	173
Combined		23,988	410	1.7%			**7,138**	**12,393**

2005	Season	# trips	# trips observed	% coverage	CPUE (#)	CPUE (lbs)	exp_num	exp_wt
Albemarle Sound	Jan-Apr	4,640	11	0.2%	0.00	0.00	-	-
	May-Aug	1,654	7	0.4%	0.48	1.06	794	1,753
	Sep-Oct	2,216	0	0.0%	1.82	6.53	4,033	14,470
	Nov-Dec	1,458	0	0.0%	0.54	1.46	787	2,129
Core Sound South	Jan-Apr	458	0	0.0%	0.44	0.72	202	330
	May-Aug	2,008	14	0.7%	1.50	2.50	3,012	5,020
	Sep-Oct	1,225	2	0.2%	1.82	6.53	2,230	7,999
	Nov-Dec	226	2	0.9%	0.54	1.46	122	330
Pamlico/Neuse River	Jan-Apr	1,410	41	2.9%	0.22	0.61	310	860
	May-Aug	1,671	57	3.4%	0.25	0.63	418	1,053
	Sep-Oct	810	2	0.2%	1.82	6.53	1,474	5,289
	Nov-Dec	172	3	1.7%	0.54	1.46	93	251
Pamlico Sound	Jan-Apr	483	3	0.6%	0.44	0.72	213	348
	May-Aug	1,771	18	1.0%	0.61	1.73	1,080	3,064
	Sep-Oct	1,721	125	7.3%	1.74	6.29	2,995	10,825
	Nov-Dec	327	46	14.1%	0.50	1.29	164	422
Combined		22,250	331	1.5%			**17,925**	**54,143**

2006	Season	# trips	# trips observed	% coverage	CPUE (#)	CPUE (lbs)	exp_num	exp_wt
Albemarle Sound	Jan-Apr	4,631	26	0.6%	0.23	0.22	1,065	1,019
	May-Aug	2,582	0	0.0%	0.30	0.76	775	1,962
	Sep-Oct	2,625	0	0.0%	0.72	2.42	1,890	6,353
	Nov-Dec	1,100	0	0.0%	0.19	0.56	209	616
Core Sound South	Jan-Apr	396	0	0.0%	0.12	0.12	48	48
	May-Aug	2,466	27	1.1%	0.33	0.99	814	2,441
	Sep-Oct	1,390	1	0.1%	0.72	2.42	1,001	3,364
	Nov-Dec	156	0	0.0%	0.19	0.56	30	87
Pamlico/Neuse River	Jan-Apr	1,214	24	2.0%	0.00	0.00	-	-
	May-Aug	1,574	23	1.5%	0.00	0.00	-	-
	Sep-Oct	904	0	0.0%	0.72	2.42	651	2,188
	Nov-Dec	160	0	0.0%	0.19	0.56	30	90
Pamlico Sound	Jan-Apr	588	2	0.3%	0.12	0.12	71	71
	May-Aug	2,065	13	0.6%	0.92	1.98	1,900	4,089
	Sep-Oct	1,915	144	7.5%	0.73	2.43	1,396	4,653
	Nov-Dec	217	25	11.5%	0.20	0.58	43	126
Combined		23,983	285	1.2%			**9,922**	**27,106**

Collapsed across region by season where n<10

Table 31. Estimated dead discards (number and weight) of red drum from the small mesh estuarine gill net fishery.

2004	Season	# trips	# trips observed	% coverage	CPUE (#)	CPUE (lbs)	exp_num	exp_wt
Albemarle Sound	Jan-Apr	2,175	19	0.9%	0.00	0.00	-	-
	May-Aug	647	5	0.8%	**0.09**	**0.23**	**58**	**149**
	Sep-Oct	288	3	1.0%	0.26	0.86	75	248
	Nov-Dec	187	2	1.1%	0.13	0.18	23	34
Core Sound South	Jan-Apr	418	0	0.0%	**0.09**	**0.23**	**38**	**96**
	May-Aug	454	0	0.0%	**0.09**	**0.23**	**41**	**104**
	Sep-Oct	962	0	0.0%	0.26	0.86	250	827
	Nov-Dec	427	0	0.0%	0.13	0.18	53	77
Pamlico/Neuse River	Jan-Apr	475	5	1.1%	**0.09**	**0.23**	**43**	**109**
	May-Aug	185	1	0.5%	**0.09**	**0.23**	**17**	**43**
	Sep-Oct	72	1	1.4%	0.26	0.86	19	62
	Nov-Dec	164	2	1.2%	0.13	0.18	21	30
Pamlico Sound	Jan-Apr	1,199	5	0.4%	**0.09**	**0.23**	**108**	**276**
	May-Aug	797	2	0.3%	**0.09**	**0.23**	**72**	**183**
	Sep-Oct	584	12	2.1%	0.35	1.15	204	672
	Nov-Dec	604	20	3.3%	0.15	0.22	91	133
Combined	All	9,638	77	0.8%			**1,112**	**3,042**

2005	Season	# trips	# trips observed	% coverage	CPUE (#)	CPUE (lbs)	exp_num	exp_wt
Albemarle Sound	Jan-Apr	2,068	31	1.5%	0.10	0.11	207	227
	May-Aug	1,013	9	0.9%	0.32	0.55	324	557
	Sep-Oct	240	0	0.0%	**0.22**	**0.32**	**53**	**77**
	Nov-Dec	193	1	0.5%	0.40	0.53	77	102
Core Sound South	Jan-Apr	224	0	0.0%	0.14	0.20	31	44
	May-Aug	306	0	0.0%	0.32	0.55	98	168
	Sep-Oct	607	0	0.0%	**0.22**	**0.32**	**134**	**194**
	Nov-Dec	423	1	0.2%	0.40	0.53	169	224
Pamlico/Neuse River	Jan-Apr	609	18	3.0%	0.06	0.05	37	30
	May-Aug	172	3	1.7%	0.32	0.55	55	95
	Sep-Oct	108	0	0.0%	**0.22**	**0.32**	**24**	**35**
	Nov-Dec	171	0	0.0%	0.40	0.53	68	91
Pamlico Sound	Jan-Apr	1,421	16	1.1%	0.31	0.52	441	739
	May-Aug	1,444	10	0.7%	0.70	1.22	1,011	1,762
	Sep-Oct	327	4	1.2%	**0.22**	**0.32**	**72**	**105**
	Nov-Dec	605	18	3.0%	0.44	0.59	266	357
Combined	All	9,931	111	1.1%			**3,066**	**4,807**

2006	Season	# trips	# trips observed	% coverage	CPUE (#)	CPUE (lbs)	exp_num	exp_wt
Albemarle Sound	Jan-Apr	1,325	44	3.3%	0.18	0.21	239	278
	May-Aug	638	2	0.3%	**0.20**	**0.33**	**126**	**211**
	Sep-Oct	292	0	0.0%	0.57	1.69	166	493
	Nov-Dec	256	0	0.0%	0.25	0.28	64	72
Core Sound South	Jan-Apr	169	2	1.2%	0.18	0.24	30	41
	May-Aug	196	2	1.0%	**0.20**	**0.33**	**39**	**65**
	Sep-Oct	950	0	0.0%	0.57	1.69	542	1,606
	Nov-Dec	508	0	0.0%	0.25	0.28	127	142
Pamlico/Neuse River	Jan-Apr	691	15	2.2%	0.00	0.00	-	-
	May-Aug	221	1	0.5%	**0.20**	**0.33**	**44**	**73**
	Sep-Oct	222	1	0.5%	0.57	1.69	127	375
	Nov-Dec	288	0	0.0%	0.25	0.28	72	81
Pamlico Sound	Jan-Apr	1,200	16	1.3%	0.38	0.59	456	708
	May-Aug	1,053	1	0.1%	**0.20**	**0.33**	**211**	**347**
	Sep-Oct	543	6	1.1%	0.57	1.69	310	918
	Nov-Dec	575	4	0.7%	0.25	0.28	144	161
Combined	All	9,127	94	1.0%			**2,694**	**5,570**

Collapsed across region by season where n<10
Collapsed across region and season by year

Table 32. Estimated release mortalities (number and weight) of red drum from the large mesh estuarine gill net fishery.

2004	Season	# trips	# trips observed	% coverage	CPUE (#)	CPUE (lbs)	(10%) exp_num	(10%) exp_wt
Albemarle Sound	Jan-Apr	5,755	30	0.5%	0.00	0.00	-	-
	May-Aug	2,371	41	1.7%	0.00	0.00	-	-
	Sep-Oct	1,838	5	0.3%	1.64	2.93	301	539
	Nov-Dec	1,037	4	0.4%	1.59	3.04	165	315
Core Sound South	Jan-Apr	504	0	0.0%	0.99	1.66	50	84
	May-Aug	2,273	1	0.0%	0.37	0.28	84	64
	Sep-Oct	1,098	27	2.5%	2.85	4.49	313	493
	Nov-Dec	230	2	0.9%	1.59	3.04	37	70
Pamlico/Neuse River	Jan-Apr	1,422	21	1.5%	0.00	0.00	-	-
	May-Aug	1,477	67	4.5%	0.46	0.32	68	47
	Sep-Oct	930	22	2.4%	0.64	0.96	60	89
	Nov-Dec	330	17	5.2%	0.47	0.70	16	23
Pamlico Sound	Jan-Apr	503	0	0.0%	0.99	1.66	50	83
	May-Aug	2,220	36	1.6%	0.56	0.48	124	107
	Sep-Oct	1,646	110	6.7%	1.68	3.20	277	526
	Nov-Dec	354	27	7.6%	2.44	4.89	86	173
Combined		23,988	410	1.7%			1,630	2,613

2005	Season	# trips	# trips observed	% coverage	CPUE (#)	CPUE (lbs)	(10%) exp_num	(10%) exp_wt
Albemarle Sound	Jan-Apr	4,640	11	0.2%	0.14	0.40	65	185
	May-Aug	1,654	7	0.4%	0.73	1.22	121	202
	Sep-Oct	2,216	0	0.0%	2.15	5.55	476	1,230
	Nov-Dec	1,458	0	0.0%	1.65	4.01	241	585
Core Sound South	Jan-Apr	458	0	0.0%	1.69	2.20	77	101
	May-Aug	2,008	14	0.7%	3.14	5.49	631	1,102
	Sep-Oct	1,225	2	0.2%	2.15	5.55	263	680
	Nov-Dec	226	2	0.9%	1.65	4.02	37	91
Pamlico/Neuse River	Jan-Apr	1,410	41	2.9%	0.80	1.39	113	196
	May-Aug	1,671	57	3.4%	0.32	0.44	53	74
	Sep-Oct	810	2	0.2%	2.15	5.55	174	450
	Nov-Dec	172	3	1.7%	1.65	4.02	28	69
Pamlico Sound	Jan-Apr	483	3	0.6%	1.69	2.20	82	106
	May-Aug	1,771	18	1.0%	0.39	0.72	69	128
	Sep-Oct	1,721	125	7.3%	2.18	5.68	375	978
	Nov-Dec	327	46	14.1%	1.15	1.66	38	54
Combined		22,250	331	1.5%			2,844	6,229

2006	Season	# trips	# trips observed	% coverage	CPUE (#)	CPUE (lbs)	(10%) exp_num	(10%) exp_wt
Albemarle Sound	Jan-Apr	4,631	26	0.6%	0.23	0.27	107	125
	May-Aug	2,582	0	0.0%	0.38	0.52	98	134
	Sep-Oct	2,625	0	0.0%	1.43	2.76	375	725
	Nov-Dec	1,100	0	0.0%	1.23	1.83	135	201
Core Sound South	Jan-Apr	396	0	0.0%	0.20	0.32	8	13
	May-Aug	2,466	27	1.1%	0.19	0.28	47	69
	Sep-Oct	1,390	1	0.1%	1.43	2.76	199	384
	Nov-Dec	156	0	0.0%	1.23	1.83	19	29
Pamlico/Neuse River	Jan-Apr	1,214	24	2.0%	0.17	0.40	21	49
	May-Aug	1,574	23	1.5%	0.26	0.23	41	36
	Sep-Oct	904	0	0.0%	1.43	2.76	129	250
	Nov-Dec	160	0	0.0%	1.23	1.83	20	29
Pamlico Sound	Jan-Apr	588	2	0.3%	0.20	0.32	12	19
	May-Aug	2,065	13	0.6%	1.15	1.78	237	368
	Sep-Oct	1,915	144	7.5%	1.42	2.77	272	530
	Nov-Dec	217	25	11.5%	1.28	1.90	28	41
Combined		23,983	285	1.2%			1,747	3,001

Collapsed across region by season where n<10

Table 33. Estimated release mortalities (number and weight) of red drum from the small mesh estuarine gill net fishery.

2004	Season	# trips	# trips observed	% coverage	CPUE (#)	CPUE (lbs)	(10%) exp_num	(10%) exp_wt
Albemarle Sound	Jan-Apr	2,175	19	0.9%	0.00	0.00	-	-
	May-Aug	647	5	0.8%	0.25	0.19	16	12
	Sep-Oct	288	3	1.0%	1.72	2.12	50	61
	Nov-Dec	187	2	1.1%	2.08	3.05	39	57
Core Sound South	Jan-Apr	418	0	0.0%	0.03	0.31	1	13
	May-Aug	454	0	0.0%	0.25	0.19	11	9
	Sep-Oct	962	0	0.0%	1.72	2.12	165	204
	Nov-Dec	427	0	0.0%	2.08	3.05	89	130
Pamlico/Neuse River	Jan-Apr	475	5	1.1%	0.03	0.31	1	15
	May-Aug	185	1	0.5%	0.25	0.19	5	4
	Sep-Oct	72	1	1.4%	1.72	2.12	12	15
	Nov-Dec	164	2	1.2%	2.08	3.05	34	50
Pamlico Sound	Jan-Apr	1,199	5	0.4%	0.03	0.31	4	37
	May-Aug	797	2	0.3%	0.25	0.19	20	15
	Sep-Oct	584	12	2.1%	2.29	2.83	134	165
	Nov-Dec	604	20	3.3%	2.45	3.61	148	218
Combined		9,638	77	0.8%			729	1,005

2005	Season	# trips	# trips observed	% coverage	CPUE (#)	CPUE (lbs)	(10%) exp_num	(10%) exp_wt
Albemarle Sound	Jan-Apr	2,068	31	1.5%	0.16	0.11	33	23
	May-Aug	1,013	9	0.9%	0.41	0.72	42	73
	Sep-Oct	240	0	0.0%	0.25	0.25	6	6
	Nov-Dec	193	1	0.5%	1.10	1.71	21	33
Core Sound South	Jan-Apr	224	0	0.0%	0.82	1.01	18	23
	May-Aug	306	0	0.0%	0.41	0.72	13	22
	Sep-Oct	607	0	0.0%	0.25	0.25	15	15
	Nov-Dec	423	1	0.2%	1.10	1.71	47	72
Pamlico/Neuse River	Jan-Apr	609	18	3.0%	0.22	0.28	13	17
	May-Aug	172	3	1.7%	0.41	0.72	7	12
	Sep-Oct	108	0	0.0%	0.25	0.25	3	3
	Nov-Dec	171	0	0.0%	1.10	1.71	19	29
Pamlico Sound	Jan-Apr	1,421	16	1.1%	2.75	3.58	391	509
	May-Aug	1,444	10	0.7%	0.90	1.59	130	230
	Sep-Oct	327	4	1.2%	0.25	0.25	8	8
	Nov-Dec	605	18	3.0%	1.22	1.90	738	1,147
Combined		9,931	111	1.1%			1,503	2,222

2006	Season	# trips	# trips observed	% coverage	CPUE (#)	CPUE (lbs)	(10%) exp_num	(10%) exp_wt
Albemarle Sound	Jan-Apr	1,325	44	3.3%	0.59	0.80	78	106
	May-Aug	638	2	0.3%	0.73	1.05	47	67
	Sep-Oct	292	0	0.0%	0.71	0.69	21	20
	Nov-Dec	256	0	0.0%	1.25	2.59	32	66
Core Sound South	Jan-Apr	169	2	1.2%	0.76	1.09	13	18
	May-Aug	196	2	1.0%	0.73	1.05	14	21
	Sep-Oct	950	0	0.0%	0.71	0.69	67	66
	Nov-Dec	508	0	0.0%	1.25	2.59	64	132
Pamlico/Neuse River	Jan-Apr	691	15	2.2%	0.40	0.49	28	34
	May-Aug	221	1	0.5%	0.73	1.05	16	23
	Sep-Oct	222	1	0.5%	0.71	0.69	16	15
	Nov-Dec	288	0	0.0%	1.25	2.59	36	75
Pamlico Sound	Jan-Apr	1,200	16	1.3%	1.75	2.74	210	329
	May-Aug	1,053	1	0.1%	0.73	1.05	77	111
	Sep-Oct	543	6	1.1%	0.71	0.69	39	37
	Nov-Dec	575	4	0.7%	1.25	2.59	72	149
Combined		9,127	94	1.0%			828	1,268

Collapsed across region by season where n<10

4) Collect data on the harvest and releases of red drum captured in gill nets under the Recreational Commercial Gear License.

Commercial fishing gears such as gill nets, crab pots and shrimp trawls have been used for recreational purposes in the coastal waters of North Carolina for many years. To participate in these activities the user must possess a Recreational Commercial Gear License (RCGL) that entitles the individual to use limited amounts of commercial gear to catch fish for personal consumption but does not allow for the sale of the catch.

The North Carolina Division of Marine Fisheries License and Statistics Section initiated a survey project in March 2002 to collect catch and effort data from RCGL holders. Questionnaires are mailed to 30% of all RCGL holders each month requesting that they indicate waterbodies commonly fished, types and amounts of gear used, number and weight of individual species kept, and number of individual species discarded at sea.

Survey Design

The monthly and bimonthly survey questionnaires were designed to determine the number of trips taken and quantities of gear used. Participants are also requested to provide estimates for the numbers and pounds of each species caught and retained as well as the number of each species discarded.

The sampling universe of RCGL holders for the monthly surveys includes all individuals who purchased a license within a year prior of each month sampled. SAS® PROC SURVEYSELECT is used to randomly select a sample of the population at a 30.0% coverage rate by county of residence, resulting in a mailing of 1,200 to 2,000 questionnaires, depending on the number of active licenses during each sample period.

Effort and Catch Extrapolation Methods

To estimate the total number of trips taken by all RCGL holders, the monthly survey data are extrapolated for each sample period and gear combination by:

1) Calculating the level of participation by dividing the total number of participants actively using a specific gear by the total number of returned questionnaires,
2) Calculating the mean number of trips taken by the participants indicating actively using a specific gear and
3) Estimating the effort using the mean number of trips, level of participation, and the total number of RCGL holders for the given sample period.

Determination of the estimated catch for each species is also calculated for each sample period and gear level by:

1. Summing the total catch by species, sample period and gear combination,
2. Summing the total number of trips taken by sample period and gear combination,

3. Dividing total catch by the total number of trips to determine the mean catch for each species for every sample period and gear combination and
4. Calculating the catch estimate using the product of the mean catch and the estimated effort.

Red drum discards from RCGL gill nets were estimated for both small and large mesh gill nets separately from 2002 to 2006. Information on the disposition of the red drum released from RCGL gill nets was not available. Small mesh gill nets used under the RCGL require full time attendance. Large mesh gill nets used under the RCGL can be left unattended from one hour before sunset to one hour after sunrise north of the Emerald Isle Bridge (HWY 58) in Carteret County but must be attended at all times south of this bridge to the South Carolina line. A maximum of 100 yards of gill net per license holder up to 200 yards of gill net per vessel can be fished. Although the mortality associated with the use of this gear is unknown, the limited yardage and attendance requirements should reduce the potential for excessive mortality.

Estimated red drum landings and discards from RCGL gill nets are summarized in Table 34.

Table 34. Estimated number and pounds of red drum harvested and the number of red drum discarded using the Recreational Commercial Gear License in North Carolina.

Year	Gear	Expanded Trips	Actual Number Observations	Kept (number)	Kept (pound)	Discard* (number)
2002	Large Mesh Gill Nets	4,599	98	2,598	8,413	2,791
	Small Mesh Gill Nets	789	26	441	1,480	1,252
	All	5,388	124	3,039	9,893	4,043
2003	Large Mesh Gill Nets	1,645	47	738	2,746	818
	Small Mesh Gill Nets	976	28	386	1,499	777
	All	2,621	75	1,124	4,245	1,595
2004	Large Mesh Gill Nets	2,389	47	538	1,927	1,897
	Small Mesh Gill Nets	1,304	40	791	2,605	1,735
	All	3,693	87	1,329	4,532	3,632
2005	Large Mesh Gill Nets	2,647	85	1,166	4,879	1,601
	Small Mesh Gill Nets	1,572	54	672	2,748	1,777
	All	4,219	139	1,838	7,627	3,378
2006	Large Mesh Gill Nets	1,783	70	843	3,619	979
	Small Mesh Gill Nets	1,719	72	1,000	3,941	6,655
	All	3,502	142	1,843	7,560	7,634

*discard estimates include both live and dead red drum

In order to estimate the potential dead discards from the RCGL large mesh gill net fishery, the ratio of dead to live releases was calculated from the commercial observer data from 2004 to 2006. Only trips with a soak time of less than 12 hours were used to correspond with the attendance requirement during the day. Of all red drum discarded, 33% were discarded dead. The mean weight

of individual red drum discarded dead was also calculated from the commercial observer data to allow for annual discard estimates by weight to be calculated. The mean weight of an individual discarded dead red drum by year was 1.74 lb in 2004; 3.02 lb in 2005; and 2.73 lb in 2006. Based on this analysis, dead discards from the large mesh RCGL gill nets accounted for between 882 lb and 1,596 lb of red drum discards per year (Table 35).

Table 35. Estimated dead discards from large mesh RCGL gill nets.

Year	Dead Discards (number)	Dead Discards (weight)
2004	626	1,089
2005	528	1,596
2006	323	882

Estimates of dead red drum discards from attended small mesh RCGL gill nets were not calculated due to the lack of information on the fate of discarded red drum in this fishery. Commercial observer data had zero mortalities from small mesh trips where the soak time was less than two hours. Low gillnet mortality in attended nets is consistent with the findings of Thorpe et al. (2001). This study characterized the mortality associated with various types of estuarine gill net fisheries in southeastern North Carolina. They reported a 0% acute mortality for red drum discarded in the run-around spotted seatrout fishery, as well as in the small mesh RCGL gill net fishery and a 2.2% acute mortality for red drum taken in the run-around gill net striped mullet fishery. Short soak times, actively fishing gear, and limited yardage appear to be an effective way of minimizing discard mortality.

Summary of Discard Estimates

Available data on red drum discard mortality are summarized below in both pounds and numbers. The summary includes estimates from anchored estuarine gill nets for both commercial and RCGL users. Estimated pounds of dead discards from the anchored estuarine gill net fishery represented between 20% and 39% of the total removals from the population by this gear between the years 2004 and 2006 (Table 36). Expressed as the number of fish removed from the population, dead discards represented between 50% and 55% of all removals by anchored estuarine gill nets during 2004 and 2005 (Table 37). Total harvest numbers were derived from the catch at age in the stock assessment so no values were available for 2006. Discard (release) mortality represents a large portion of the overall annual removals from the red drum population in both the recreational and commercial fishery. In 2004 and 2005, dead discards from the recreational fishery represented between 38% and 39% of the total recreational removals (harvest + dead discards) by number (Table 38). Currently, the assessment only accounts for the recreational removals and no estimates have been available in the commercial fishery. Based on this analysis, the stock assessment failed to account for between 14% and 18% of all annual removals from the population in 2004 and 2005.

Table 36. Summary of all estimated discard mortalities in pounds associated with the anchored estuarine gill net fishery.

	Anchored Estuarine Gill Net Dead Discards (lbs)		Anchored Estuarine Gill Net Mortality from Releases (lbs)		Recreational Large Mesh Gill Net Dead Discards (lbs)*	Total Discard Mortalities (lbs)	Harvest from Anchored Estuarine Gill Nets (lbs)**	Proportion of Total Removals (lbs)	
Year	Small Mesh	Large Mesh	Small Mesh	Large Mesh	Large Mesh	All		% Dead Discard	% Harvested
2004	3,042	12,393	1,005	2,613	1,089	20,142	46,844	30%	70%
2005	4,807	54,143	2,222	6,229	1,596	68,997	108,527	39%	61%
2006	5,570	27,106	1,268	3,001	882	37,827	149,452	20%	80%

*no estimates for releases recreational small mesh gill nets

**includes commercial and recreational harvest by anchored estuarine gill nets

Table 37. Summary of all estimated discard mortalities in numbers associated with the anchored estuarine gill net fishery.

	Anchored Estuarine Gill Net Dead Discards (#'s)		Anchored Estuarine Gill Net Mortality from Releases (#'s)		Recreational Large Mesh Gill Net Mortalities (#'s)*	Total Discard Mortalities (#'s)	Harvest from Anchored Estuarine Gill Nets (#'s)**	Proportion of Total Removals (#'s)	
Year	Small Mesh	Large Mesh	Small Mesh	Large Mesh	Large Mesh	All		% Dead Discard	% Harvested
2004	1,112	7,138	729	1,630	626	11,235	9,159	55%	45%
2005	3,066	17,925	1,503	2,844	528	25,866	25,727	50%	50%

*no estimates for releases recreational small mesh gill nets

**includes commercial and recreational harvest by anchored estuarine gill nets

Table 38. Estimated total takes from the red drum population by year from the recreational hook and line fishery.

			Proportion of Total Removals	
Year	Discard Mortality (10% of Releases)	Harvest	% Dead Discard	% Harvested
2004	19,159	30,165	39%	61%
2005	32,786	53,154	38%	62%

Note: all values reported are in numbers of fish.

Is it possible to eliminate or reduce the bycatch of unmarketable red drum in the estuarine gill net fishery?

Understanding the habitat use of sub-legal red drum is a key factor in the successful management of red drum and is critical if management options can be developed to effectively reduce bycatch. The NCDMF began an independent gill net survey (IGNS) in Pamlico Sound in 2001. The program was expanded to include the Pamlico, Pungo, and Neuse Rivers in 2003. A major objective of this study was to provide a relative index of abundance for key species, including red drum. A secondary objective was to look at habitat usage and associated catch rates of various species. Information gathered from this program should provide insight on habitat use of red drum, as well as ways to avoid red drum bycatch in the estuarine gill net fishery.

The IGNS utilized a stratified random sampling design where locations were selected based on strata and depth (Figure 29). Sampling was divided into four regions: eastern Pamlico Sound [Dare County (includes Outer Banks Dare and Hyde)], western Pamlico Sound [Hyde County (includes mainland Hyde County)], Neuse River, and Pamlico/Pungo River. Each of these sampling regions was further divided into four evenly sized strata. A one-minute by one-minute (one square nautical mile) grid system was laid over each stratum. Each stratum was sampled twice monthly. A sample consisted of two shots of gill net and shots were made up of an array of panels, with each panel being 30 yards in length. Panels varied in mesh size ranging from 3 to 6 ½ inches stretch mesh by ½ inch intervals. For each sample, one shot was placed in deep ($\geq$ 6 ft) and one shot was placed in shallow (<6 ft) water for a total of 480 yards of gill net fished. Gill nets were set at dusk and fished the following morning with a target soak time of 12 hours. Nets set close to shore were either set perpendicular or parallel based on conditions and common fishing practice in the area.

Individual species captured were enumerated, measured and condition of fish at capture was recorded (alive, dead or spoiled). Pertinent environmental data such as: salinity, temperature, dissolved oxygen, bottom type, attached grass species, depth, and distance from shore were also noted.

When and where are sub-legal red drum typically captured in estuarine gill nets?

The abundance of sub-legal red drum by season and habitat was explored using data from the IGNS for each of the major regions sampled. Key predictors examined included depth and distance from shore. Catch per unit effort (# of red drum captured per set) was calculated by month for all red drum captured less than 18 inches total length. Results were pooled across years. Comparison of CPUE values between shallow and deep sets clearly reveals a strong preference to shallow water by sub-legal red drum (Table 39). Across regions and months, shallow sets generally captured >90% the number of red drum as did deep sets with only a few exceptions having lower values. In all instances, CPUE's from shallow sets exceeded those of deep sets. Monthly CPUE values for sub-legal red drum in shallow sets increased in all regions beginning in August as fish recruited to the gear (Figure 30). Peak monthly CPUE values occurred in September for the Neuse River, October for the Pamlico River and Dare County, and in November for the Pungo River and Hyde County. The highest combined CPUE across all regions occurred in November.

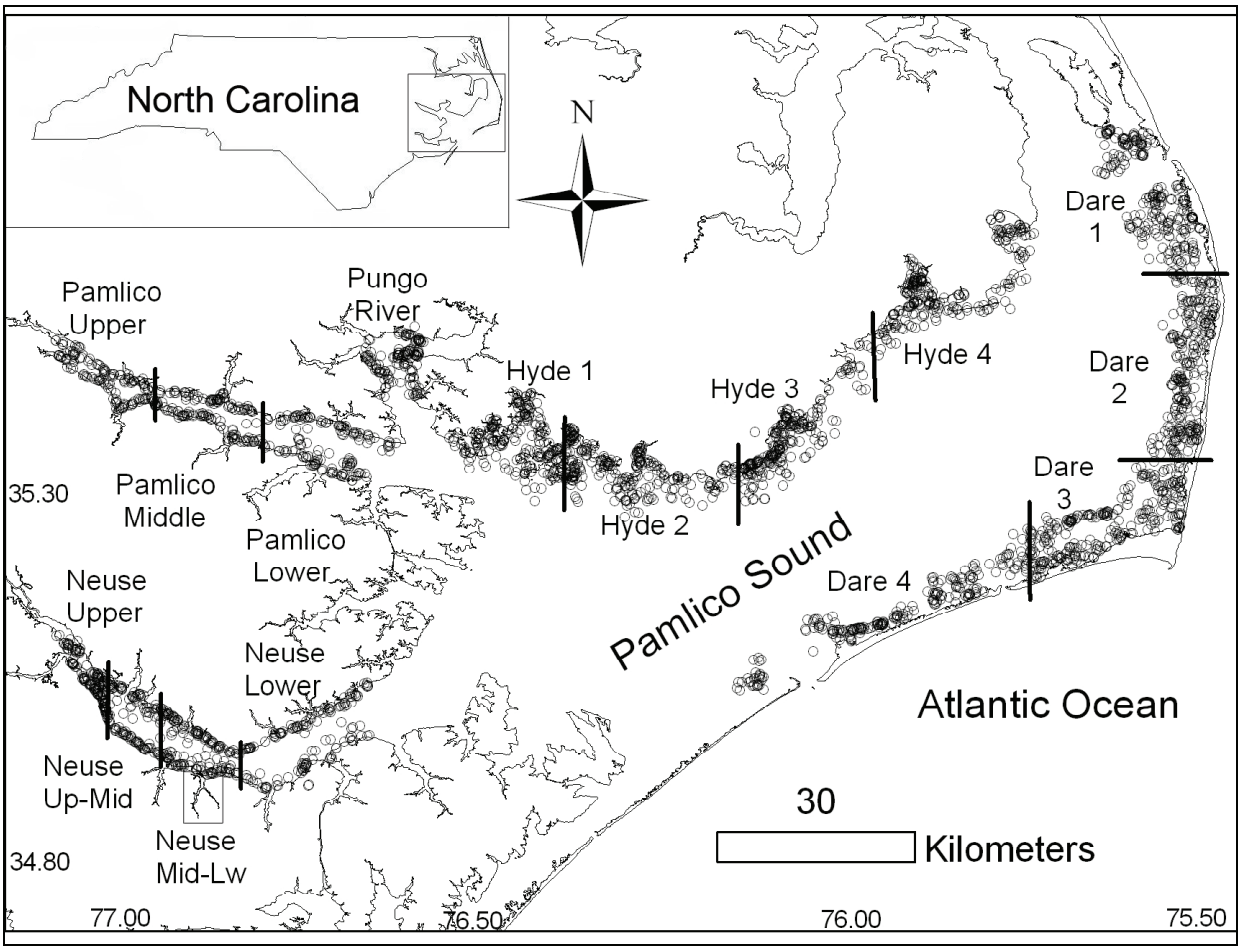


Figure 29. Map of Pamlico Sound and associated rivers showing the sample strata and locations of individual samples taken in the NCDMF independent gill net survey from 2001 to 2006.

Table 39. Independent gill net survey CPUE for sub-legal red drum (<18 inches TL) captured in shallow (<6 ft) versus deep (>6 ft) sets from 2001 to 2005.

		CPUE by Month										
Location		February	March	April	May	June	July	August	September	October	November	December
Neuse River	shallow sets	1.33	1.29	1.17	1.27	0.63	2.14	5.08	11.87	6.02	7.19	2.75
	deep sets	0.13	0.04	0	0	0.5	0	0.13	0.07	0.83	0.22	0.24
	% reduced in deep	90%	97%	100%	100%	21%	100%	97%	99%	86%	97%	91%
Pamlico River	shallow sets	0	0	0.91	0.13	0.375	0.94	2.02	3.56	7.88	4.15	1.96
	deep sets	0	0	0	0.11	0	0	0.1	0.51	0.13	0.29	0.13
	% reduced in deep	-	-	100%	15%	100%	100%	95%	86%	98%	93%	93%
Pungo River	shallow sets	0	4	1.1	0.63	3.5	1.83	1.57	4.04	3.63	8.63	4.75
	deep sets	0	0.25	0	0.4	0	0	0	0.17	0.1	0.17	0.25
	% reduced in deep	-	94%	100%	37%	100%	100%	100%	96%	97%	98%	95%
Hyde County	shallow sets	0.85	0.58	1.21	0.77	0.15	0.44	1.44	4.57	6.77	9.21	5.52
(Pamlico Sound)	deep sets	0	0	0.1	0.02	0.06	0	0	0.02	0.02	0.29	0.25
	% reduced in deep	-	100%	92%	97%	60%	100%	100%	100%	100%	97%	95%
Dare County	shallow sets	0.25	1.03	2.28	1	1.29	0.33	1.25	3.7	6.15	3.73	2
(Pamlico Sound)	deep sets	0.1	0.03	0.13	0.06	0.02	0.04	0.02	0.86	0.94	0.48	1
	% reduced in deep	60%	97%	94%	94%	98%	88%	98%	77%	85%	87%	50%

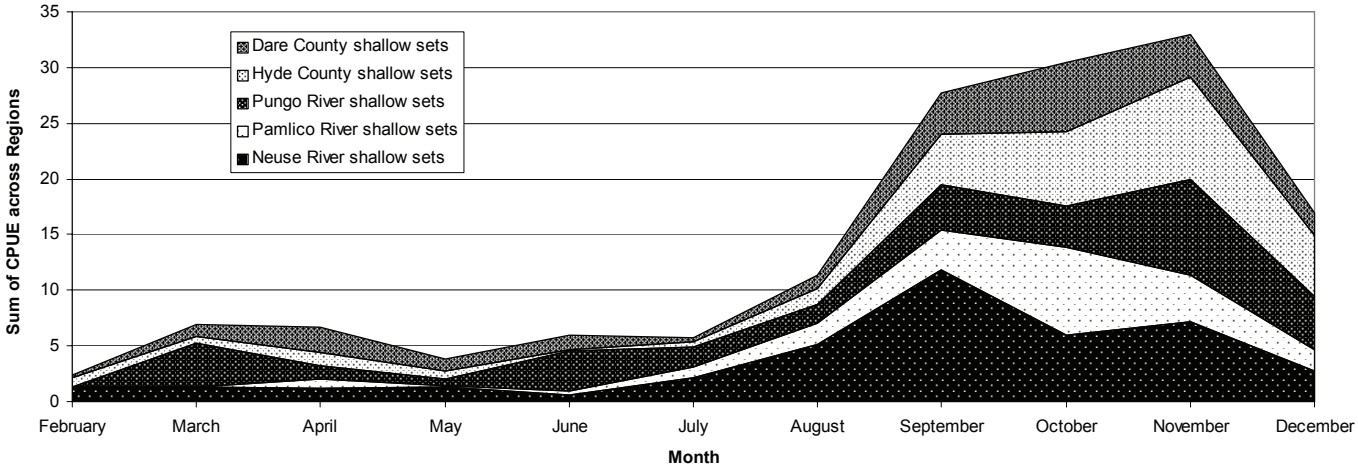


Figure 30. Sub-legal red drum (<18 inches TL) CPUE by month and region from the Pamlico Sound independent gill net survey from 2001 to 2005.

In addition to depth, distance from shore was also analyzed to determine how sub-legal red drum catches may be impacted based on gill nets set at varying distances from shore. For this analysis, sets made less than or greater than 50, 100 and 200 yards were compared using both deep and shallow sets combined. In all regions, CPUE values typically decreased as distance from shore increased (Table 40). Hyde County had the greatest overall reduction with a 96% decrease in sub-legal red drum catch resulting from gill nets being set at least 50 yards from shore. Dare County saw the lowest reduction but still had a 35% decrease in sub-legal red drum catch at 50 yards from shore. Because depth typically increases with distance from shore, and red drum CPUE decreased with increasing depth, the data were also analyzed using only shallow sets. Results using only shallow water sets had higher overall CPUE values than did the deep and shallow sets combined, but the percent reduction with distance from shore was similar. At 50 yards, the reduction in sub-legal red drum catch ranged from 32% for Dare County to 95% for Hyde County.

Table 40. Sub-legal red drum CPUE from the NCDMF independent gill net survey with percent reductions in CPUE based on establishing 50, 100, and 200 yard buffers from shorelines for gill nets.

	CPUE reduction at 50 yds			CPUE reduction at 100 yds			CPUE reduction at 200 yds		
All Sets (Deep and Shallow)	≤50 yds	>50 yds	% reduction	≤ 100 yds	> 100 yds	% reduction	≤ 200 yds	> 200 yds	% reduction
Pamlico/Pungo/Neuse Rivers	1.87	0.88	53%	1.65	0.91	45%	1.51	0.18	88%
Pamlico Sound (Hyde County)	2.25	0.08	96%	2.01	0.01	100%	1.81	0.01	99%
Pamlico Sound (Dare County)	1.77	1.15	35%	1.72	1.13	34%	1.74	1.13	35%
Shallow Sets Only									
Pamlico/Pungo/Neuse Rivers	3.23	2.02	37%	3.2	1.92	40%	3.16	0.41	87%
Pamlico Sound (Hyde County)	2.96	0.14	95%	2.94	0	100%	2.94	0	100%
Pamlico Sound (Dare County)	2.96	2.01	32%	2.92	1.96	33%	2.87	1.97	31%

What factors determine the fate of a red drum captured in a gill net?

Data from the NCDMF IGNS was analyzed to determine the fate of sub-legal red drum captured with regard to month (water temperature) and mesh size (Table 41). Mortality was highest for both small and large mesh gill nets during the summer months from June through September. Mortality in small mesh gill nets was higher than that for large mesh gill nets in every month except September. Mortality rates showed a positive correlation with water temperature (Figure 31).

Table 41. Sub-legal red drum acute mortality from capture in small and large mesh gill nets from the NCDMF independent gill net survey, 2001 to 2006. Based on 12-hour soak time.

	Small Mesh		Large Mesh		Average Water
Month	N	% dead	N	% dead	Temperature (°F)
February	34	29%	7	0%	48
March	115	30%	9	0%	53
April	169	38%	30	33%	64
May	115	50%	11	27%	71
June	99	72%	27	67%	80
July	116	72%	17	65%	84
August	306	74%	30	57%	83
September	729	67%	67	69%	78
October	953	51%	80	24%	68
November	962	40%	74	4%	59
December	274	23%	24	4%	51

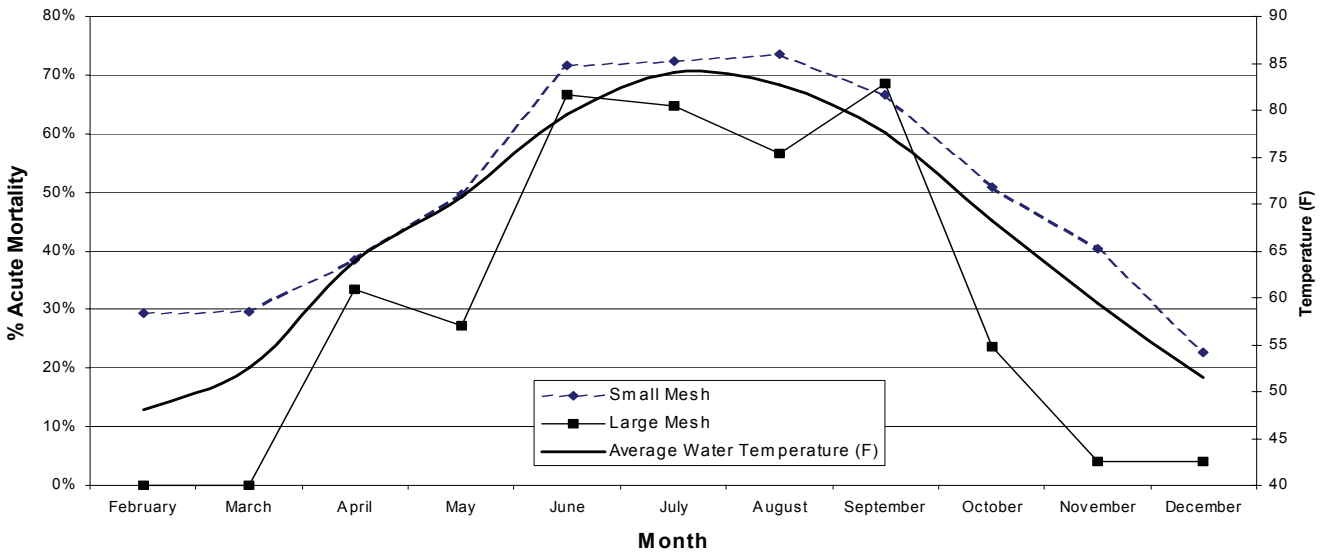


Figure 31. Mean water temperature (°F) and percent acute mortality (at the net) for sub-legal red drum captured in small and large mesh gill nets by month.

Discussion

A goal of the North Carolina Red Drum FMP is to promote fishing practices that minimize bycatch. Bycatch in the estuarine gill net fishery appears to be a substantial source of mortality in the red drum fishery. Estimates from the available observer data indicate that dead red drum discards from the estuarine gill net fishery are approximately equal to the number of red drum harvest commercially on an annual basis. This loss due to discard mortality accounted for about 14% to 18% of all red drum removals in 2004 and 2005. The majority of these mortalities are sub-legal fish.

Sub-legal red drum have been described as being ubiquitous with shoreline habitat (Ross and Stevens 1992). Data gathered from the IGNS indicated that red drum catch rates increase with decreasing water depth and decreasing distance to shore. Bacheler et al. (2007) recently analyzed data from the IGNS to determine what factors contribute to the distribution of red drum in Pamlico Sound. The study used a generalized additive model (GAM) to relate water quality, microhabitat, geographic, and temporal factors to red drum catches in the IGNS. The model utilized these variables to predict what factors were significant in determining the habitat usage of various life stages of red drum in North Carolina. Results indicated that age 1 (primarily sub-legal) red drum had a strong preference to shallow, nearshore habitat. In addition, red drum along the 'Outer Banks' (Dare County), tended to also commonly be associated with seagrass habitat. Findings of the study are consistent with the descriptive data presented in this paper, and indicate that limiting gill nets in shallow water habitats and near shorelines could substantially reduce red drum discard mortality. The undesirable effect of this action is that landings of other legal species could potentially be negatively impacted.

The difficult question moving forward is to weigh the cost and benefits of various actions. Can catches of other species (i.e. spot, striped mullet, speckled trout, bluefish and flounder) be retained or recouped if gill nets are prohibited in particular areas or if they are required to be set at a particular distance from shore?

Large Mesh Gill Net Fishery

Data collected by NCDMF in the fall of 2004 found no significant difference in the catch rates of flounder taken in gill nets set on the shoreline versus those set 50 yards offshore. Sets were made in the Pamlico, Pungo and Neuse Rivers. A Fishery Resource Grant (FRG) conducted in 2002 was designed to address the catch rates of red drum and flounder in large mesh gill nets set close to and off the shoreline (Montgomery 2003). The results of the study found that more red drum were captured in gill nets set close to and perpendicular to the shoreline while flounder catches were highest in nets set slightly off (10 to 25 ft) and parallel to the shore. The conclusion of the study was that the data tended to support the hypothesis that nets set farther from the marsh line would decrease red drum bycatch without decreasing the number of flounder taken. It was also noted however, that the study was limited in spatial coverage and that the overall number of red drum captured was relatively low. In 2005, a FRG was conducted in southeastern North Carolina to determine the effect of gill net tie-downs on fish and bycatch rates in the flounder and American shad fisheries (Thorpe et al. 2005). While the study did not find a significant difference in the catch rates of red drum using tie-downs, the study did report that distance from shore (<80 ft) and net

orientation (perpendicular to shore) were significant factors in increasing the incidence of red drum capture in the shad fishery from January through April. It was not apparent from the study if shad or flounder species were impacted by these variables. A third FRG conducted in 2005 and 2006 was designed to characterize the flounder gill net fishing techniques and bycatch in the Pamlico River (Hassell 2007). Unlike the previous studies, results of this study showed some decrease in flounder catches with increasing distance from shore. At a minimum distance from shore of 50 yards flounder catches were reduced by 22% while red drum bycatch was reduced by 76%. The author suggests an alternative option should be to explore a 25 yard buffer where the results indicated that flounder catches would be reduced by 11% with red drum catches reduced by 48%.

To address this question more thoroughly, IGNS data was analyzed for legal size southern flounder with catch rates reported for sets made at less than or greater than 50 yards from shore (Table 42). Results for the rivers from the IGNS support the findings of Hassell (2007) and show that catches of flounder outside 50 yards were reduced. Reductions in the IGNS rivers region were much more significant (61%) than those of Hassell (22%). Fishing methods in the IGNS may not be typical for flounder fishermen in this area. For instance, the average depth fished in the Hassell study was approximately 5 ft where sets made in the IGNS are typically either less than 3 ft or greater than 6 ft. These differences may explain why the IGNS saw such a drastic decline in catch rates in the rivers for sets made outside 50 yards where sets were typically made in water >6 ft. Catch rates in Pamlico Sound (Hyde County) showed no differences in CPUE values for southern flounder from sets made less than or greater than 50 yards while red drum bycatch was reduced by 96% in the offshore sets in this area (Table 40). The Pamlico Sound (Dare County) saw a 22% reduction in legal size flounder catches in gill net sets made outside of 50 yards with a corresponding reduction in sub-legal red drum bycatch of 35%.

Table 42. CPUE of southern flounder captured in IGNS from 2001 to 2006 in gill net sets made either less than or greater than 50 yards from shore.

	CPUE		
Region	≤50 yds	>50 yds	% reduction
Pamlico/Pungo/Neuse Rivers	0.67	0.26	61%
Pamlico Sound (Hyde County)	1.1	1.1	0%
Pamlico Sound (Dare County)	1.4	1.09	22%

note: corresponding reductions of red drum are given in Table 16

An important criterion in deciding if and when regulations are needed should be to determine when the potential impacts are the greatest. The number of trips made in the gill net fishery fluctuates with season, but red drum discard mortality for a given unit of gill net effort will primarily be determined by two factors: 1) the mortality associated with being captured and 2) the availability or catch rate of red drum to the gear being fished. In order to investigate how the cumulative effect of these two factors has the potential to impact sub-legal red drum discard mortality throughout the year, the relative index of abundance by month from the IGNS was multiplied by the mean monthly acute mortality rate associated with gill net capture. Results indicate that the greatest potential impact in the large mesh gill net fishery increases in June through August with a large peak in

September (Figure 32). Impacts are minimal in February, March, November and December. Considering these impacts, the third factor to consider is fishing effort. Based on trip ticket information, large mesh gill net trips are relatively high throughout the year but peak in October and March. Based on this analysis the greatest potential impact for bycatch mortality of sub-legal red drum in the large mesh gill net fishery would be for the period of June through October with the month of September having by far the largest potential impact (Figure 32).

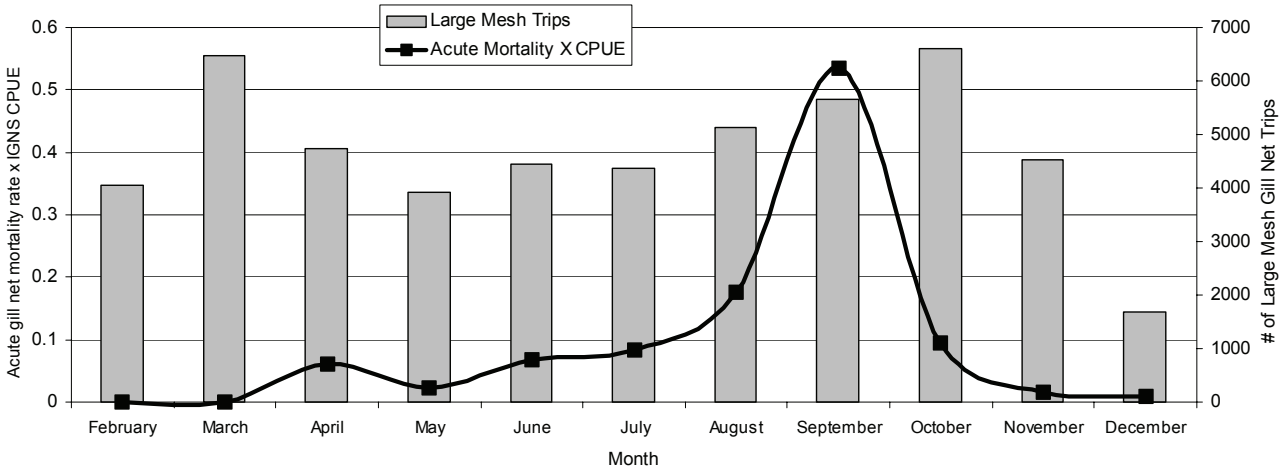


Figure 32. Potential impact of large mesh gill nets per unit of effort based on the availability of sub-legal red drum (CPUE from IGNS) and the % acute mortality associated with capture in a gill net by month. Based on samples collected from 2001 to 2006.

Small Mesh Gill Net Fishery

As stated in the background of this report, North Carolina took action as part of the 2001 NC red drum FMP to reduce red drum bycatch in the estuarine gill net fishery. The restrictions require the seasonal attendance of small mesh gill nets (<5" stretch mesh) and have been in place since October of 1998. Small mesh gill nets select for red drum less than 18" TL and can be a significant source of the bycatch mortality, particularly in months when water temperatures are high. Current North Carolina regulations require the attendance of small mesh gill nets from May 1 through October 31 in areas known to be critical for juvenile red drum. These include all primary and secondary nursery areas, areas within 200 yards of any shoreline, and the extensive area of shallow grass flats located behind the Outer Banks. An exemption to this rule lifts the attendance requirement for the region from Core Sound to the South Carolina border in October to allow for the fall spot fishery. In this fishery, observed trips by NCDMF noted that gill netters tended to set nets at least 100 yards from shore and were able to avoid red drum bycatch.

When attendance rules were debated during the development of the 2001 Red Drum FMP, much discussion centered on the potential need for attendance to extend into November. At the time, data were unavailable on the incidence of red drum bycatch during this period. Data collected since that time indicates that sub-legal red drum have their highest catch rates during November and although the acute mortality rate associated with this month is lower, it is still >40% (Figure 31;

Table 41).

Analysis was done for small mesh gill nets, as with large mesh gill nets, to determine the months when the greatest potential impact per unit of gill net effort occurred for sub-legal red drum. The results indicate that the months of August through November have the greatest potential impact with a peak in September (Figure 33). Mortality is likely already greatly reduced due to attendance regulations currently in place from May 1 through October 31. Of the remaining months, November and December have the greatest potential for dead sub-legal discards.

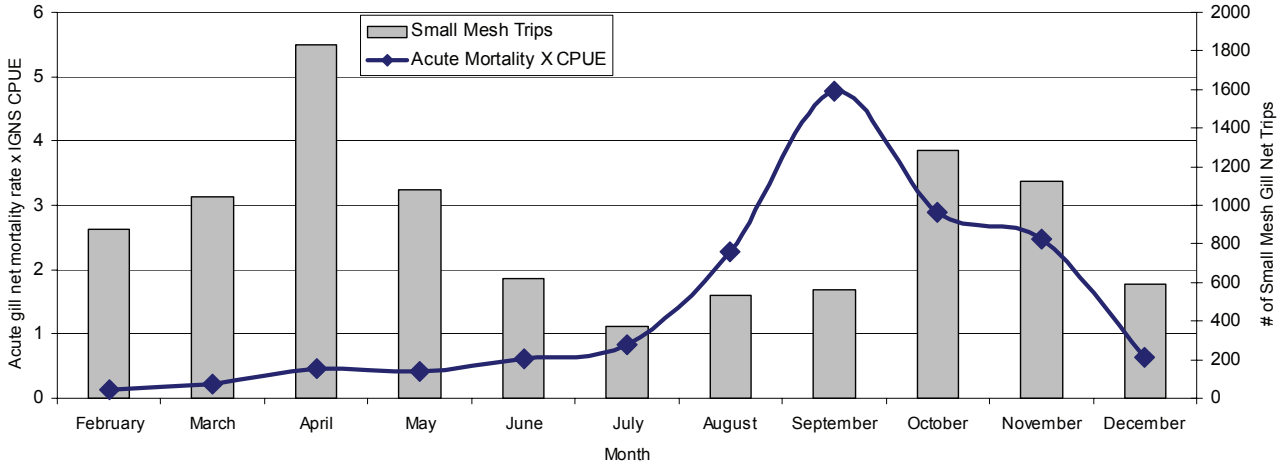


Figure 33. Potential impact of small mesh gill nets per unit of effort based on the availability of sub-legal red drum (CPUE from IGNS) and the % acute mortality associated with capture in a gill net by month. Based on samples collected from 2001 to 2006.

It is extremely difficult to predict how commercial gill net landings will be impacted by any regulations. Reductions based on minimum distance from shore cannot account for the potential adaptability of commercial users. Some landings, particularly for small mesh fisheries, may shift to other gears such as run-around gill nets. The simplest exercise to understand potential impacts may be to look at how landings shifted in the periods before and after the current attendance rule went into place in October of 1998. Key species that were likely to be impacted by past attendance regulations include those typically taken in small mesh gill nets: bluefish, Spanish mackerel, menhaden, striped mullet, sea mullet, spot, weakfish, spotted seatrout and white perch (Table 43). Landings after the attendance requirements were implemented in late 1998 show an overall 15% increase over the pre-attendance period. By species, bluefish, Spanish mackerel, menhaden, spot and white perch increased in landings, while striped (jumping) mullet, sea mullet, weakfish and spotted seatrout landings decreased. Overall landings increased despite a 14% decrease in the number of trips made and a 6% decrease in the ex-vessel value. Additional analysis indicates that overall, there was no major shift to run-around gill nets and away from anchored gill nets since attendance rules were implemented (Table 44). It appears that for those fisheries impacted by the attendance requirements, gill netters were able to locate suitable fishing grounds outside the attendance areas or were willing to attend their gillnets without major reductions in landings.

Table 43. Average annual landings, trips and value of key species captured in the estuarine gill net fishery before (1994-1998) and after (1999-2006) the small mesh gill net rules were implemented. Species included are those typically taken in the small mesh gill net fishery. These data include both anchored and run-around gill net landings.

	Average Landings (lbs)			Average Trips			Average Value		
	1994-1998	1999-2006		1994-1998	1999-2006		1994-1998	1999-2006	
Species	Pre-attendance	Attendance	% change	Pre-attendance	Attendance	% change	Pre-attendance	Attendance	% change
Bluefish	277,235	335,646	21%	7,170	6,236	-13%	$ 73,658	$ 83,351	13%
Mackerel, Spanish	128,006	138,230	8%	1,625	1,200	-26%	$ 72,036	$ 130,154	81%
Menhaden	198,216	738,872	273%	668	3,433	414%	$ 18,754	$ 80,602	330%
Mullets, Jumping	1,772,629	1,700,232	-4%	11,748	8,477	-28%	$ 1,153,276	$ 867,614	-25%
Sea Mullet	47,651	37,089	-22%	2,973	2,290	-23%	$ 41,289	$ 36,060	-13%
Spot	493,543	647,588	31%	6,596	7,593	15%	$ 179,944	$ 305,350	70%
Weakfish	342,333	123,736	-64%	9,813	6,488	-34%	$ 198,686	$ 80,335	-60%
Trout, Speckled	198,945	172,753	-13%	9,853	7,214	-27%	$ 231,783	$ 219,384	-5%
White Perch	122,086	209,871	72%	5,316	4,902	-8%	$ 93,631	$ 136,966	46%
Total	3,580,644	4,104,018	15%	55,764	47,834	-14%	$ 2,063,056	$ 1,939,817	-6%

Table 44. Average annual landings for key species captured in the small mesh estuarine gill net fishery before (1994-1998) and after (1999-2006) the small mesh gill net rules were implemented. Results are broken down into either anchored or run-around/drift gill nets. Species included are those typically taken in the small mesh gill net fishery.

		Average Landings (lbs)		
		1994-1998	1999-2006	
Gear	Species	Pre-attendance	Attendance	% change
Anchored Gill Nets	Bluefish	265172	324815	22%
	Mackerel, Spanish	123981	135048	9%
	Menhaden	196119	715089	265%
	Mullets, Jumping	851131	714349	-16%
	Sea Mullet	46963	36526	-22%
	Spot	443381	603629	36%
	Weakfish	339261	122123	-64%
	Trout, Speckled	169378	127865	-25%
	White Perch	120958	205755	70%
	Total	2556344	2985197	17%
Run-around/Drift Gill Nets	Bluefish	12063	10832	-10%
	Mackerel, Spanish	4025	3182	-21%
	Menhaden	2097	23783	1034%
	Mullets, Jumping	921498	985884	7%
	Sea Mullet	688	563	-18%
	Spot	50162	43959	-12%
	Weakfish	3072	1613	-47%
	Trout, Speckled	29567	44889	52%
	White Perch	1129	4116	265%
	Total	1024300	1118821	9%

Current Authority

North Carolina Fisheries Rules for Coastal Waters (15A NCAC)
03J.0103 Gill Nets, Seines, Identification, Restrictions
03R.0112 Attended Gill Net Areas

Management Options/Impacts

(+ potential positive impact of action)
(- potential negative impact of action)

Set small mesh (<5 inches stretch) estuarine gill net management options:

1) Status quo
+ No additional rules or burden for commercial fishery
- Continued bycatch and discards of sub-legal red drum
- Potentially reduced SPR and escapement rates

2) Extend attendance duration
+ Reduce red drum bycatch mortality
+ Decreased bias in stock assessment
+ Reduce bycatch of other unmarketable species
- Additional rules with increased burden for commercial fishery
- Potential for some reduced landings of target species

3) Extend attendance areas
+ Reduce bycatch and discard mortality in habitats where sub-legal red drum are abundant
+ Reduced mortality of juvenile red drum and decreased bias in stock assessment
+ Reduce bycatch of other unmarketable species
+ Continued use of gears/methods that have less impact (run-around gill nets, attended nets)
- Additional rules with increased burden for commercial fishery
- Potential for some reduced landings of target species

4) Require minimum depth for the use of set small mesh gill nets
+ Reduce red drum bycatch mortality in areas where sub-legal red drum are abundant
+ Decreased bias in stock assessment
+ Reduce bycatch of other unmarketable species
+ Continued use of gears/methods that have less impact (run-around gill nets, attended nets)
- Additional rules with increased burden for commercial fishery
- Increased potential for reduced landings of target species

5) Require minimum distance from shore for the use of set small mesh gill nets
+ Reduce red drum bycatch mortality in areas where sub-legal red drum are abundant
+ Decreased bias in stock assessment

+ Reduce bycatch of other unmarketable species
+ Continued use of gears/methods that have less impact (run-around gill nets, attended nets)
- Additional rules with increased burden for commercial fishery
- Potential for some reduced landings of target species

Set large mesh (≥5 inches stretch) estuarine gill net management options:

1) Status quo
+ No new rules or additional burden for commercial fishery
- Continued bycatch and discards of sub-legal red drum
- Potentially reduced SPR and escapement rates

2) Require attendance seasons
+ Reduce red drum bycatch mortality during periods when discard mortality is high
+ Decreased bias in stock assessment
+ Reduce bycatch of other unmarketable species
- Additional rules with increased burden for commercial fishery
- Potential for some reduced landings of target species

3) Require nets to be set at a minimum distance from shore
+ Reduce red drum bycatch bycatch mortality in areas where sub-legal red drum are abundant
+ Decreased bias in stock assessment
+ Reduce bycatch of other unmarketable species
+ Continued use of gears/methods that have less impact (run-around gill nets, attended nets)
- Additional rules with increased burden for commercial fishery
- Potential for some reduced landings of target species

4) Require nets to be set at a minimum depth of water
+ Reduce bycatch and discard mortality in areas where sub-legal red drum are abundant
+ Reduced mortality of juvenile red drum and decreased bias in stock assessment
+ Reduce bycatch of other unmarketable species
+ Continued use of gears/methods that have less impact (run-around gill nets, attended nets)
- Additional rules with increased burden for commercial fishery
- Difficult to enforce
- Increased potential for some reduced landings of target species

Management Recommendations

DMF Recommendation

Small Mesh (<5" stretch mesh)

Year-round attendance requirements:

Extend attendance within 200 yards of shore to include the area of the lower Neuse out to the mouth of the river.

Seaasonal attendance requirements:

Modify the seasonal attendance requirements for small mesh gill nets (currently May 1 to October 31) to include the period of May 1 through November 30 in:

1) all primary and permanent secondary nursery areas and all modified no-trawl areas (shallow grass beds in eastern Pamlico and Core Sound)
2) Within 200 yards of any shoreline for the areas of Pamlico, Pungo, Neuse, and Bay Rivers
3) Within 50 yards of any shoreline in areas of Pamlico and Core Sound and in all coastal waters south to NC/SC line
4) Area from HWY 58 bridge south is excluded from shoreline requirement during October and November

Large Mesh (>5" stretch mesh)

Require all unattended large mesh gill nets to be set a minimum of 10 yards from any shoreline from June through October

RDAC Recommendation

Small Mesh (<5" stretch mesh)

Year-round attendance requirements:

Extend attendance within 200 yards of shore to include the area of the lower Neuse out to the mouth of the river (and)

Require year-round attendance of small mesh nets in Primary and Permanent Secondary Nursery Areas north of the Wainwrights in Carteret County and exempting the Albemarle Sound Management Area

Seaasonal attendance requirements:

Modify the seasonal attendance requirements for small mesh gill nets (currently May 1 to October 31) to include the period of May 1 through November 30 in:

a) all primary and permanent secondary nursery areas
b) all modified no-trawl areas (shallow grass beds in eastern Pamlico and Core Sound)
c) all areas within 200 yards of any shoreline, exempting the areas of Core Sound and south from the 200 yards of any shoreline requirement during the months of October and November

Large Mesh (>5" stretch mesh)

Require all unattended large mesh gill nets to be set a minimum of 10 yards from any shoreline

MFC Selected Management Option:

Small Mesh (<5" stretch mesh)

Year-round attendance requirements:

Extend attendance within 200 yards of shore to include the area of the lower Neuse out to the mouth of the river.

Seaasonal attendance requirements:

Modify the seasonal attendance requirements for small mesh gill nets (currently May 1 to October 31) to include the period of May 1 through November 30 in:

5) **all primary and permanent secondary nursery areas and all modified no-trawl areas (shallow grass beds in eastern Pamlico and Core Sound)**
6) **Within 200 yards of any shoreline for the areas of Pamlico, Pungo, Neuse, and Bay Rivers**
7) **Within 50 yards of any shoreline in areas of Pamlico and Core Sound and in all coastal waters south to NC/SC line**
8) **Area from Core Sound and south is excluded from shoreline requirement during October and November**

Large Mesh (>5" stretch mesh)

Require all unattended large mesh gill nets to be set a minimum of 10 yards from any shoreline from June through October

Research Recommendations

- Conduct research to determine the extent of red drum interactions with the small mesh gill net fishery in the areas of Core Sound and south during the months of October and November.
- Continue and expand estuarine gill net observer program to collect data across various key fisheries by season and area.
- Collect data from observer program or through other sources on the catch rates of red drum and targeted species with regard to distance from shore.
- Conduct a comprehensive survey of gill net fishers including information on species targeted, gear characteristics, areas fished.
- Conduct studies that explore ways to reduce red drum interactions while allowing for retention of targeted species.
- Conduct additional research to determine the release mortality of red drum captured in gill nets.
- Continue and enhance collection of fishery dependent data.

10.2.5.2 Red Drum Discard Byctatch in the Pamlico, Pungo and Neuse Rivers

Issue

Red drum discarded bycatch in the small mesh gill net fishery of the Pamlico, Pungo, and Neuse rivers, N.C.

Background

Bycatch is defined as the " the portion of a catch taken incidentally to the targeted catch because of non-selectivity of the fishing gear to either species or size differences" (ASMFC 1994). The 2001 Red Drum FMP stipulates that the take of red drum is allowed solely as bycatch, one may not target or direct fishing effort toward red drum. Therefore any take of red drum meets the definition of bycatch. Bycatch can be further divided into two components: incidental catch (retained or marketable non-targeted species), and discard (portion of catch returned to the waters as a result of regulatory, economic or personal considerations). Current management allows the commercial harvest of up to 7 red drum, provided an equal weight of other commercially marketable species is also taken. This harvest would be considered incidental catch, and any other take would be "discard". The distinction between these two categories is often overlooked in the public discussion of "bycatch issues".

The Neuse River small mesh gill net fisheries have become a focal point for these discussions. During the development of the initial 2001 Red Drum FMP the issue of red drum discards in large and small mesh gill net fisheries was debated and the following management measures were enacted to reduce the discard and minimize impacts to other ongoing targeted fisheries (striped mullet, speckled trout, etc.):

Rule NCAC 03J .0103 (Gill net, seines, identification, restrictions) sets up small mesh (< 5 inches stretched mesh) net attendance requirements for referenced areas either year round or seasonally from May 1 through 31 October. This rule also grants the Director broad proclamation authority for gill nets and seines.

Rule NCAC 03R. 0112 (Attended gill net areas) specifies the year round locations (upper Neuse, Pamlico and Pungo rivers and within 200 yards of shore within portions of these systems) and the seasonal areas (primary nursery, permanent secondary nursery, no trawl, Outer Banks Mechanical Methods prohibited, within 200 yards of any shoreline).

The existing Rule NCAC 03O .0302 (Authorized gear for Recreational Commercial Gear License) limits RCGL small mesh (defined as less than 5 ½ inch stretch mesh) to 100 yards per person and not more than 200 yards when two or more RCGL holders are onboard a vessel. All RCGL small mesh must be attended (within 100 yards) at all times. In inland water under the Wildlife Resources Commission (WRC) no gill nets are allowed. During the development of the 2001 FMP whether to include the month of November as part of the seasonal attendance period was debated but tabled due to a lack of adequate data. This issue paper will summarize independent survey information that is now available.

The public concern about red drum discard in this system has intensified. The Division (DMF) and the Marine Fisheries Commission (MFC) have received numerous complaints about red drum discard in the tributaries and requests to eliminate small mesh gill nets. The recreational print media have also highlighted this concern with several articles. This issue paper will summarize for the Neuse and Pamlico river systems red drum discard rates, mortality rates, commercial effort and harvest trends, and other relevant information in order to provide a sound basis for discussing potential management actions.

Data Sources

Data for this issue paper were obtained from two fishery-independent programs (462, and 915), and two fishery-dependent programs (estuarine gill net sampling and the trip ticket program), which are briefly described below. All analysis and discussion are based on seasons (October–December) area (Pamlico, Pungo, and Neuse rivers) and anchored set gill nets with mesh size (3.5", 4", 4.5"). These mesh sizes are commonly used in the small mesh fisheries of Pamlico, Pungo and Neuse rivers.

Trip Ticket Data

In 1994, NCDMF implemented a mandatory Trip Ticket Program, which is a landings information record keeping system for each commercial harvest trip. Under this program licensed fishermen can only sell commercial catches to licensed NCDMF fish dealers. The dealer is required to complete a trip ticket every time a licensed fishermen lands fish. Trip tickets capture data on gears used to harvest fish, area fished, species harvested, and total weights of each individual species. Gear codes to distinguish large and small mesh gill nets were initiated in 2004. Care must be used in the interpretation of landings assigned to a specific gear and waterbody. Up to three gears and one waterbody may be reported on an individual trip ticket. On tickets with more than one gear, assignment of landings to a specific gear is a judgment call. The method described in the "Bycatch and Discards of Red Drum in the North Carolina Estuarine Gill Net Fishery" issue paper was used to determine small mesh catches. The landings for the complex of targeted small mesh species identified in the referenced Issue paper were used to represent this fishery in the Trends Section of this paper.

Program 462 Independent Estuarine Gill Net Selectivity Study

Due to the aforementioned concerns the DMF initiated a study to quantify catch rates and mortality of red drum, spotted sea trout, southern flounder, and striped bass during months in which small mesh gill net attendance is not required. A total of 288 small mesh gill net samples were collected in creeks off the Neuse and Bay rivers during the months of October - December 2005 & 2006 (Figure 34). This study utilized three separate gangs of nets with each gang consisting of three nets (3½, 4, and 4½" stretched mesh, each 30 yards long by 8 feet deep). Each individual 30 yard set composed a sample. Nets were set perpendicular and as close to shore as possible, left unattended and then fished each following day with a target soak time of 24 hours in a manner that closely mirrored commercial fishing practices.

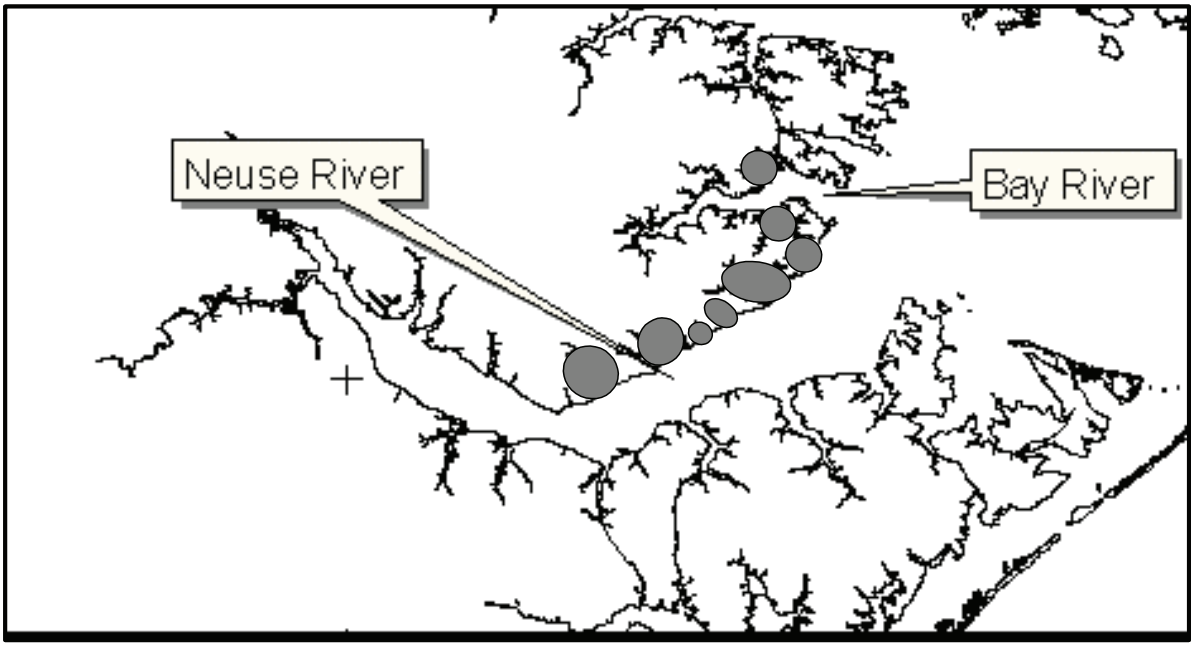


Figure 34. Program 462 gill net sampling areas.

Data collected included: water depth; temperature, salinity, dissolved oxygen; time gear set and retrieved, GPS coordinates of set, species captured, length (FL or TL), and condition (alive, dead, spoiled). Individual weights were calculated based on length/weight relationships obtained from DMF age sampling. Upon retrieval of the nets, fish were enumerated by mesh size, measured to the nearest mm and a total group weight obtained (kg). This program provided information on red drum mortality, CPUE, and size and species composition, of small mesh gill nets.

Program 915 Pamlico Sound Independent Gill Net Survey

The DMF began an independent gill net survey (IGNS) in Pamlico Sound in 2001. The program was expanded to include the Pamlico, Pungo, and Neuse rivers in 2003. One objective of this study was to provide a relative index of abundance for key species, including red drum.

The IGNS utilizes a stratified random sampling design where locations are selected based on strata and depth. Sampling is divided into four regions: eastern Pamlico Sound (Dare County), western Pamlico Sound (Hyde County), Neuse River, and Pamlico/Pungo River. Each of these sampling regions is further divided into four evenly sized strata (Figure 35). A one-minute by one-minute (one square nautical mile) grid system is laid over each stratum. Each stratum is sampled twice monthly. A sample consisted of two shots of gill net and shots are made up of an array of panels, with each panel being 30 yards in length. Panels vary in mesh size ranging from 3 to 6 ½ inches stretch mesh by ½ inch intervals. For each sample, one shot was placed in deep ($\geq$ 6 ft) and one shot was placed in shallow (<6 ft) water. Gill nets were set at dusk and fished the following morning with a target soak time of 12 hours. Nets set close to shore are either set perpendicular or parallel based on conditions and common fishing practice in the area.

Individual species captured are enumerated, measured and condition of fish at capture is recorded (alive, dead or spoiled). Pertinent environmental data such as: salinity, temperature, dissolved oxygen, bottom type, attached grass species, depth, and distance from shore are also noted. Data from this program was used to obtain species composition, size data, and CPUE estimates for small mesh gill nets.

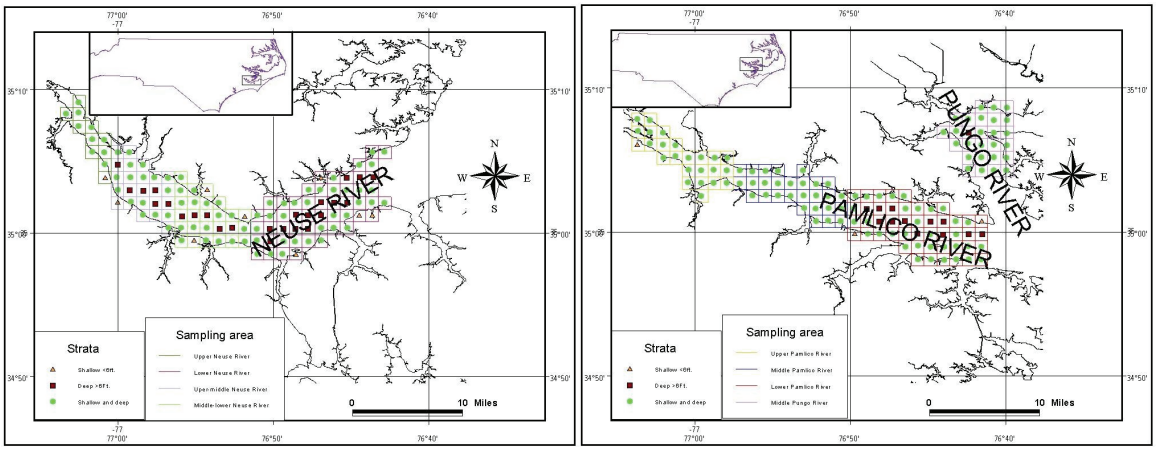


Figure 35. Independent gill net (Program 915) sampling grids for the Neuse, Pamlico, and Pungo, rivers.

Program 461 Dependent Estuarine Gill Net Sampling

Sampling of the estuarine gill net fishery was initiated by the DMF in April 1991 to determine age, size, and composition of species taken in the gill net fishery. Trip information is gathered on waterbody fished, total length of nets (feet), soak time (minutes), specific net type (i.e. float, sink, etc.), mesh size (bar mesh, inches), net depth (float nets, recorded in feet), vertical fishing depth (sink nets, recorded in feet), twine size, average water depth (meters) and incidental species. Information from this program was used to estimate average yardage by mesh size of small mesh nets fished in the river system, which was then used to obtain estimates of red drum CPUE in the commercial fishery.

Trend Analysis

Landings for the targeted small mesh gill net fishery in the rivers have averaged 663,591 pounds since 1994, while other estuarine water small mesh landings have averaged 3.3 million pounds during the same time frame. Landings for both areas have shown an upward trend since 1994 (Figure 36). The number of trips in the rivers has remained relatively stable and had averaged 4, 074 since 1994 (Figure 37). Although landings for other waters have shown an upward trend the number of trips is declining (Figure 38) and have averaged 24,184 trips per year. Both areas have shown a declining trend in the number of participants, with 282 fishermen on average working the rivers and, 1,362 in other areas of the state (Figure 39). The small mesh fishery in the rivers accounts for 17% of the poundage and participation, and 14% of the trip of the statewide estuarine small mesh fishery.

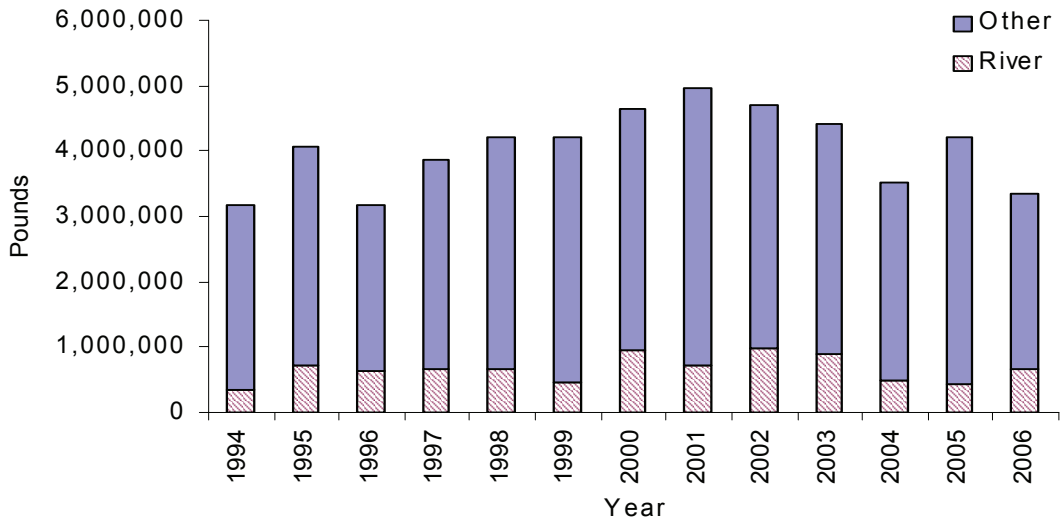


Figure 36. Reported landings for targeted small mesh gill net species. River includes Pamlico, Pungo, and Neuse rivers; other includes all other estuarine waters of the state. Targeted species are bluefish, red drum, kingfish, Spanish mackerel, Atlantic Menhaden (bait), striped mullet, white perch, spotted seatrout, spot, and weakfish.

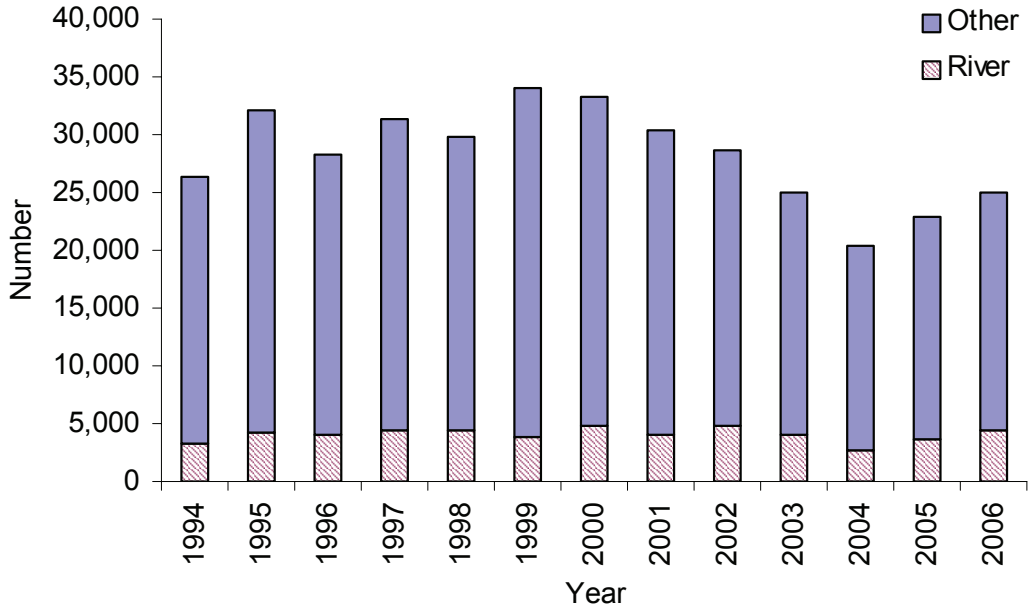


Figure 37. Numbers of trips for targeted small mesh gill net species. River includes Pamlico, Pungo, and Neuse rivers; other includes all other estuarine waters of the state.

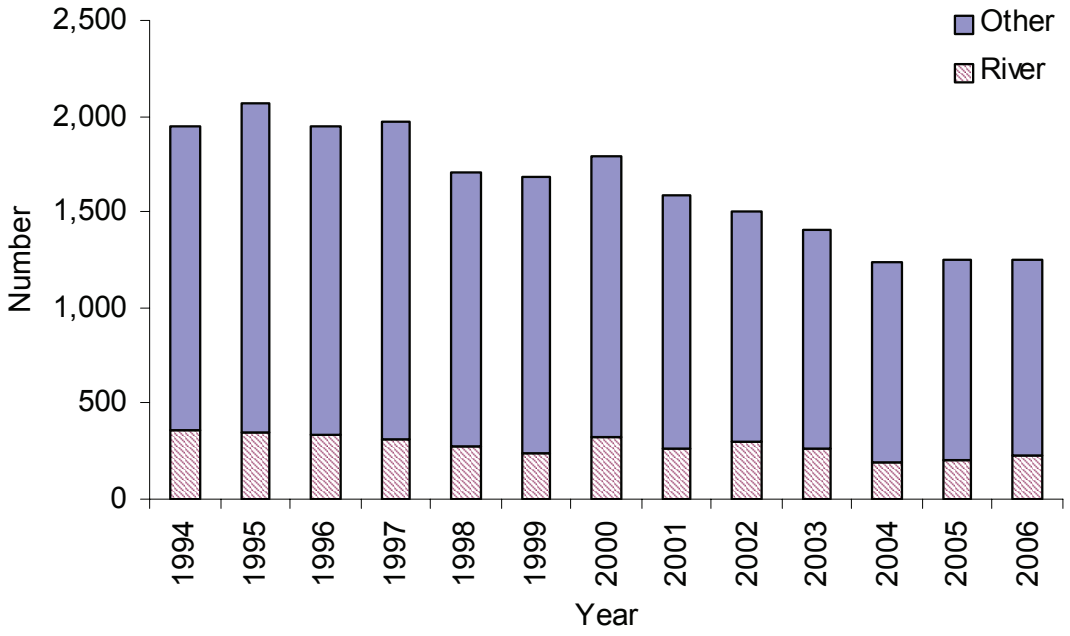


Figure 38. Numbers of participants targeting small mesh gill net species. River includes Pamlico, Pungo, and Neuse rivers; other includes all other estuarine waters of the state.

Species Composition

Species composition by river system is shown for October and November/December in order to contrast catch composition between attendance and non-attendance periods.

Trip Ticket Species Composition

Based on annual landings the seasonal percentage by species using small mesh gill nets in the Neuse River, October through December, were spotted seatrout (41.9%), spot (40.9%), striped mullet (32.8%), red drum (22%) and bluefish (15.2%). October accounts for 8% of all gill net landings in the Neuse River, while November accounts for 5%, and December 3% (Table 45). For the Pamlico/Pungo complex, 66% of the weakfish were landed from October through November (Table 46). Other species with significant landings during this three month period are; Sea mullet (65%), striped mullet (39%), red drum (33%), and spotted sea trout (32%). October landings for this system are 10% of the total, followed by November (8%), and December (7%).

Program 462 Species Composition

Percent species composition for Program 462 sampling includes all species captured. Looking at all species, striped mullet were the primary species captured in October accounting for 41% of the total collection weight (Table 47). Other commercially important species captured during this month included, red drum (10.1%), spotted seatrout (6.8%), southern flounder (3.9%) and weakfish (0.9%).

When only the top five marketable species for October are included, percentages shifted to for striped mullet (67.4%), red drum (19.8%), spotted seatrout (7.5%), bluefish (4.3%) and spot (1%). For November and December, red drum (49.7%) were more abundant than striped mullet (35%).

For all species during November and December red drum were the most abundant species captured in this study accounting for 49.7% of the total weight (Table 48). Striped mullet accounted for 35.1% of the catch, followed by spotted seatrout (14.2 %), spot (1.0 %) and no bluefish.

Program 915 Species Composition

Data from the shallow water sets (< 6') were used in this analysis because the vast majority of commercial effort is prosecuted within shallow waters. Furthermore, 94 % of the red drum were caught in shallow sets (Table 49), and these sets are similar to those made in Program 462. Red drum were the primary species captured in October and accounted for 34.4% of the total collection weight for the Neuse River (Table 50). When only the top five marketable species for October are included, percentages shifted to for red drum (64.3%), striped mullet (19.0 %), spotted seatrout (9.6 %), bluefish (4.7 %) and spot (2.3 %). November and December show similar species compostion.

For the Pamlico and Pungo rivers red drum were the most abundant species accounting for 26.8% of the total catch (Table 51). Other economically important species captured were striped mullet (18.4%), striped bass (6.2%), and southern flounder (3.7%).

When looking only at the top five marketable species for October, percentages shifted for red drum (52.5%), striped mullet (45.1 %), spotted seatrout (0.5 %), bluefish (0 %) and spot (1.9 %). Again, November and December also have similar species composition.

During November and December red drum accounted for 30.6% of the catch in the Neuse River (Table 52). Striped bass accounted for 13.6% of the catch, followed by striped mullet (13.1%), spotted sea trout (3.3%), and southern flounder (1.1%). Catches from the Pamlico and Pungo rivers for this time frame were dominated by gizzard shad [35.9% (Table 53)]. Red drum was the second most abundant species and accounted for 14.1% of the catch. This was followed by striped bass (11.9%), and striped mullet (11.2%).

Table 45. Average monthly landings (pounds) for targeted small mesh gill net species in the Neuse River, NC 2001 – 06, set nets only.

	Month												
Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Bluefish	.	1	76	2,854	579	59	16	434	872	819	53	2	5,764
Red drum	465	395	412	601	1,190	899	716	838	1,330	1,179	577	178	8,780
Sea mullet	.	0	6	74	9	0	2	3	5	48	10	1	159
Spanish mackerel	.	8	.	1	30	4	65	7,724	4,813	1,011	18	.	13,673
Atlantic menhaden	3,341	35,380	30,923	15,109	1,406	3	36	247	269	674	595	825	88,807
Mullets	5,987	3,649	2,224	4,063	2,406	1,999	1,846	2,338	3,791	6,589	5,045	2,167	42,103
White perch	63	202	275	92	5	3	4	8	7	8	84	112	864
Spotted sea trout	1,458	898	669	1,212	1,129	491	160	277	375	818	2,183	1,822	11,491
Spot	11	1	94	2,672	1,633	551	506	398	1,049	4,003	761	13	11,691
Weakfish	40	75	179	801	130	17	10	26	105	364	284	190	2,221
All	11,365	40,608	34,860	27,479	8,518	4,026	3,360	12,292	12,614	15,512	9,610	5,310	185,554

Table 46. Average monthly landings (pounds) for targeted small mesh gill net species in the Pamlico, Pungo rivers, NC 2001 – 06, set nets only.

	Month												
Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Bluefish	.	.	1	968	326	81	2	97	220	34	2	.	1,731
Red drum	184	144	119	131	163	259	486	689	618	778	437	168	4,175
Sea mullet	.	3	0	6	6	1	0	1	4	14	9	16	60
Spanish mackerel	.	.	.	2	289	144	147	1,303	2,199	393	1	.	4,477
Atlantic menhaden	2,717	13,520	24,530	2,603	58	114	31	28	11	7	47	35	43,702
Mullets	12,594	4,517	7,395	5,488	4,226	4,005	1,760	3,179	5,107	13,009	8,701	9,026	79,007
White perch	2,328	2,528	3,162	767	234	60	25	185	156	290	1,338	1,078	12,150
Spotted sea trout	2,430	251	254	464	1,297	571	111	128	253	543	1,281	898	8,480
Spot	.	3	48	1,893	1,505	702	142	436	640	866	44	2	6,282
Weakfish	3	8	112	508	63	6	2	17	142	578	851	258	2,546
All	20,255	20,973	35,620	12,829	8,165	5,941	2,706	6,064	9,351	16,514	12,709	11,481	162,609

Table 47. Species composition from Program 462, Estuarine Gill Net Selectivity Study, Neuse River NC, October, 2005 - 06.

Species	Number of nets	Mean catch weight (kg)	Percent total weight	Mean catch number	Percent total number	Mean fish weight (kg)	Total number	Total weight (kg)
Striped mullet	54	1.8	41.0	2.3	22.4	0.8	126	96.6
Gizzard shad	54	1.0	23.5	2.4	23.1	0.4	130	55.5
Red drum	54	0.4	10.1	0.7	6.6	0.6	37	23.9
Spotted seatrout	54	0.3	6.8	0.3	2.5	1.1	14	16.0
Atlantic menhaden	54	0.3	6.0	2.1	19.8	0.1	111	14.0
Southern flounder	54	0.2	3.9	0.5	4.6	0.4	26	9.3
Blue crab	54	0.1	2.2	0.6	5.7	0.2	32	5.1
Black drum	54	0.1	1.8	0.1	0.9	0.8	5	4.2
Pinfish	54	0.1	1.7	1.0	9.3	0.1	52	3.9
Weakfish	54	0.0	0.9	0.2	1.6	0.2	9	2.1
Spot	54	0.0	0.8	0.1	1.4	0.2	8	1.8
Striped bass x white	54	0.0	0.5	0.0	0.2	1.2	1	1.2
Bluefish	54	0.0	0.3	0.0	0.4	0.4	2	0.8
Atlantic croaker	54	0.0	0.2	0.0	0.4	0.2	2	0.4
White perch	54	0.0	0.1	0.0	0.2	0.4	1	0.4
Silver perch	54	0.0	0.1	0.1	0.5	0.1	3	0.3
Southern kingfish	54	0.0	0.1	0.0	0.2	0.3	1	0.3
Ladyfish	54	0.0	0.1	0.0	0.2	0.2	1	0.2
White shrimp	54	0.0	0.0	0.0	0.2	0.0	1	0.0

Table 48. Species composition from Program 462, Estuarine Gill Net Selectivity Study, Neuse River NC, November - December, 2005 - 06.

Species	Number of nets	Mean catch weight (kg)	Percent total weight	Mean catch number	Percent total number	Mean fish weight (kg)	Total number	Total weight (kg)
Red drum	234	1.2	30.2	1.7	24.1	0.7	388	273.1
Striped mullet	234	1.0	25.6	1.2	17.0	0.8	274	230.9
Spotted seatrout	234	0.6	14.3	0.5	6.9	1.2	112	129.2
Gizzard shad	234	0.5	13.4	1.1	15.6	0.5	251	121.2
Atlantic menhaden	234	0.2	5.2	1.4	20.5	0.1	330	47.1
Southern flounder	234	0.1	3.4	0.3	4.9	0.4	79	30.7
White perch	234	0.1	1.9	0.2	3.2	0.3	51	17.3
Longnose gar	234	0.0	1.2	0.0	0.4	1.8	6	10.5
Striped bass x white	234	0.0	1.0	0.0	0.5	1.1	8	9.0
Bowfin	234	0.0	0.8	0.0	0.3	1.4	5	7.2
Black drum	234	0.0	0.7	0.1	1.4	0.3	22	6.6
Blue crab	234	0.0	0.7	0.2	3.3	0.1	53	6.5
Striped bass	234	0.0	0.6	0.0	0.5	0.7	8	5.5
Spot	234	0.0	0.3	0.0	0.4	0.4	6	2.5
White catfish	234	0.0	0.3	0.0	0.2	0.8	3	2.4
Pinfish	234	0.0	0.1	0.0	0.6	0.1	9	0.6
Sheepshead	234	0.0	0.0	0.0	0.1	0.2	2	0.4
Tarpon	234	0.0	0.0	0.0	0.1	0.2	1	0.2
Hogchoker	234	0.0	0.0	0.0	0.1	0.1	1	0.1
Ladyfish	234	0.0	0.0	0.0	0.1	0.1	1	0.1

Table 49. Program 915 sampling effort and number of red drum by month in shallow (<6ft) and deep (>6ft) water gill net sets. Data is combined for all river systems sampled, Pamlico, Pungo and Neuse rivers. Set is defined as each 30 yard net (3 ½, 4, and 4 ½").

	Total sets made		Red drum captured in sets	
Month/year	Shallow	Deep	Shallow	Deep
Sep-05	12	18	12	1
Oct-05	33	33	107	0
Nov-05	31	31	40	7
Dec-05	15	15	0	0
Feb-06	14	15	0	0
Mar-06	30	30	1	0
Apr-06	30	30	13	0
May-06	30	30	21	0
Jun-06	29	30	23	0
Jul-06	30	30	8	0
Aug-06	29	31	5	5
Sep-06	24	30	19	4
Oct-06	30	30	5	3
Nov-06	29	30	75	0
Dec-06	15	15	7	0
Total	381	398	336	20
Percent of total	49%	51%	94%	6%

Table 50. Neuse River species composition data from Program 915, Pamlico Sound Independent Gill Net Survey, October, 2005 - 06.

Species	Number of nets	Mean catch weight (kg)	Percent total weight	Mean catch number	Percent total number	Mean fish weight (kg)	Total number	Total weight (kg)
Red drum	24	3.9	34.4	3.4	11.5	1.2	27	31.4
Gizzard shad	24	3.0	25.9	6.8	23.0	0.4	54	23.7
Atlantic menhaden	24	1.8	15.7	13.9	47.2	0.1	111	14.4
Striped mullet	24	0.9	7.6	1.0	3.4	0.9	8	6.9
Spotted seatrout	24	0.5	4.4	0.5	1.7	1.0	4	4.1
Southern flounder	24	0.2	2.2	0.6	2.1	0.4	5	2.0
Striped bass	24	0.2	2.0	0.1	0.4	1.8	1	1.8
Bluefish	24	0.2	1.6	0.3	0.9	0.7	2	1.4
Black drum	24	0.2	1.4	0.1	0.4	1.3	1	1.3
Atlantic sturgeon	24	0.2	1.4	0.3	0.9	0.7	2	1.3
Atlantic croaker	24	0.1	0.9	0.4	1.3	0.3	3	0.8
Pinfish	24	0.1	0.6	0.5	1.7	0.1	4	0.6
Blue crab	24	0.1	0.6	0.5	1.7	0.1	4	0.6
Sheepshead	24	0.1	0.5	0.1	0.4	0.5	1	0.5
Ladyfish	24	0.0	0.2	0.1	0.4	0.2	1	0.2
Weakfish	24	0.0	0.2	0.1	0.4	0.2	1	0.2
Spot	24	0.0	0.2	0.1	0.4	0.2	1	0.2
Cownose ray	24	.	.	0.6	2.1	.	5	.

Table 51. Pamlico and Pungo rivers species composition data from Program 915, Pamlico Sound Independent Gill Net Survey, October, 2005 - 06

Species	Number of nets	Mean catch weight (kg)	Percent total weight	Mean catch number	Percent total number	Mean fish weight (kg)	Total number	Total weight (kg)
Red drum	39	6.3	26.8	6.5	13.9	1.0	85	82.5
Gizzard shad	39	5.7	24.1	14.2	30.2	0.4	184	74.1
Striped mullet	39	4.4	18.4	5.6	12.0	0.8	73	56.7
Striped bass	39	1.5	6.2	1.6	3.4	0.9	21	19.1
Atlantic menhaden	39	1.1	4.5	7.5	16.1	0.1	98	14.0
Southern flounder	39	0.9	3.7	2.2	4.8	0.4	29	11.4
Carp	39	0.9	3.7	0.8	1.6	1.1	10	11.4
Moxostoma suckers	39	0.8	3.5	0.9	2.0	0.9	12	10.7
Bowfin	39	0.6	2.4	0.4	0.8	1.5	5	7.3
Blue crab	39	0.6	2.3	4.6	9.8	0.1	60	7.2
White perch	39	0.2	1.0	0.8	1.6	0.3	10	3.1
Largemouth bass	39	0.2	0.9	0.3	0.7	0.7	4	2.9
White catfish	39	0.2	0.7	0.2	0.5	0.7	3	2.2
Atlantic croaker	39	0.1	0.4	0.2	0.5	0.4	3	1.3
Spot	39	0.1	0.4	0.2	0.5	0.4	3	1.1
Spotted seatrout	39	0.1	0.3	0.1	0.2	1.0	1	1.0
Yellow bullhead	39	0.0	0.2	0.1	0.2	0.6	1	0.6
Pinfish	39	0.0	0.2	0.5	1.0	0.1	6	0.5
Black drum	39	0.0	0.2	0.1	0.2	0.5	1	0.5
Black crappie	39	0.0	0.1	0.1	0.2	0.4	1	0.4

Table 52. Neuse River species composition data from Program 915, Pamlico Sound Independent Gill Net Survey, November - December 2005 - 06.

Species	Number of nets	Mean catch weight (kg)	Percent total weight	Mean catch number	Percent total number	Mean fish weight (kg)	Total number	Total weight (kg)
Red drum	36	3.7	30.6	4.5	15.8	0.8	54	44.3
Gizzard shad	36	2.0	16.2	4.7	16.4	0.4	56	23.5
Atlantic menhaden	36	1.7	14.5	13.9	48.8	0.1	167	21.0
Striped bass	36	1.6	13.6	0.8	2.9	2.0	10	19.7
Striped mullet	36	1.6	13.1	2.0	7.0	0.8	24	19.0
Spotted seatrout	36	0.4	3.3	0.3	0.9	1.6	3	4.8
Black drum	36	0.3	2.4	1.2	4.1	0.2	14	3.5
Bowfin	36	0.2	1.5	0.1	0.3	2.2	1	2.2
Southern flounder	36	0.1	1.1	0.2	0.6	0.8	2	1.6
White catfish	36	0.1	1.1	0.2	0.6	0.8	2	1.5
White perch	36	0.1	0.7	0.2	0.6	0.5	2	1.0
Spot	36	0.1	0.5	0.2	0.6	0.4	2	0.7
Atlantic sturgeon	36	0.1	0.4	0.1	0.3	0.6	1	0.6
Largemouth bass	36	0.1	0.4	0.1	0.3	0.6	1	0.6
Bluefish	36	0.0	0.4	0.1	0.3	0.6	1	0.6
Hickory shad	36	0.0	0.3	0.1	0.3	0.5	1	0.5

Table 53. Pamlico and Pungo rivers species composition data from Program 915, Pamlico Sound Independent Gill Net Survey, November - December 2005 - 06.

Species	Number of samples	Mean catch weight (kg)	Percent total weight	Mean catch number	Percent total number	Mean fish weight (kg)	Total number	Total weight (kg)
Gizzard shad	57	6.4	35.9	14.0	39.1	0.5	266	121.6
Red drum	57	2.5	14.1	3.6	10.0	0.7	68	47.8
Striped bass	57	2.1	11.9	1.7	4.9	1.2	33	40.3
Striped mullet	57	2.0	11.2	3.1	8.5	0.7	58	37.8
Bowfin	57	1.8	9.8	0.9	2.5	2.0	17	33.3
Atlantic menhaden	57	1.0	5.5	8.8	24.7	0.1	168	18.7
White perch	57	0.5	2.8	1.5	4.1	0.3	28	9.6
Moxostoma suckers	57	0.3	1.9	0.3	0.9	1.1	6	6.4
Carp	57	0.3	1.5	0.3	0.9	0.8	6	4.9
Largemouth bass	57	0.2	1.2	0.3	0.7	0.8	5	3.9
Silver redhorse	57	0.2	1.1	0.2	0.4	1.3	3	3.8
White catfish	57	0.1	0.7	0.2	0.6	0.6	4	2.3
Southern flounder	57	0.1	0.7	0.3	0.7	0.4	5	2.2
Black crappie	57	0.1	0.4	0.2	0.4	0.5	3	1.5
Spotted seatrout	57	0.1	0.4	0.1	0.1	1.3	1	1.3
Chain pickerel	57	0.1	0.4	0.1	0.1	1.3	1	1.3
Suckers	57	0.1	0.3	0.1	0.1	1.0	1	1.0
Yellow bullhead	57	0.0	0.3	0.1	0.1	0.9	1	0.9
Blue crab	57	0.0	0.2	0.3	0.9	0.1	6	0.7

Discussion

Length Frequency

Independent gill net survey data indicates that small mesh gill nets used from October - December in the Neuse River predominately take red drum under 18 inches (Figure 39, Figure 40, and Figure 41). Ninety-nine percent of red drum captured in program 462 were sublegal (<18") and none were above the upper slot limit (>27"). Eighty-nine percent of red drum captured in program 915 were sublegal (<18") and none were above the upper slot limit (>27").

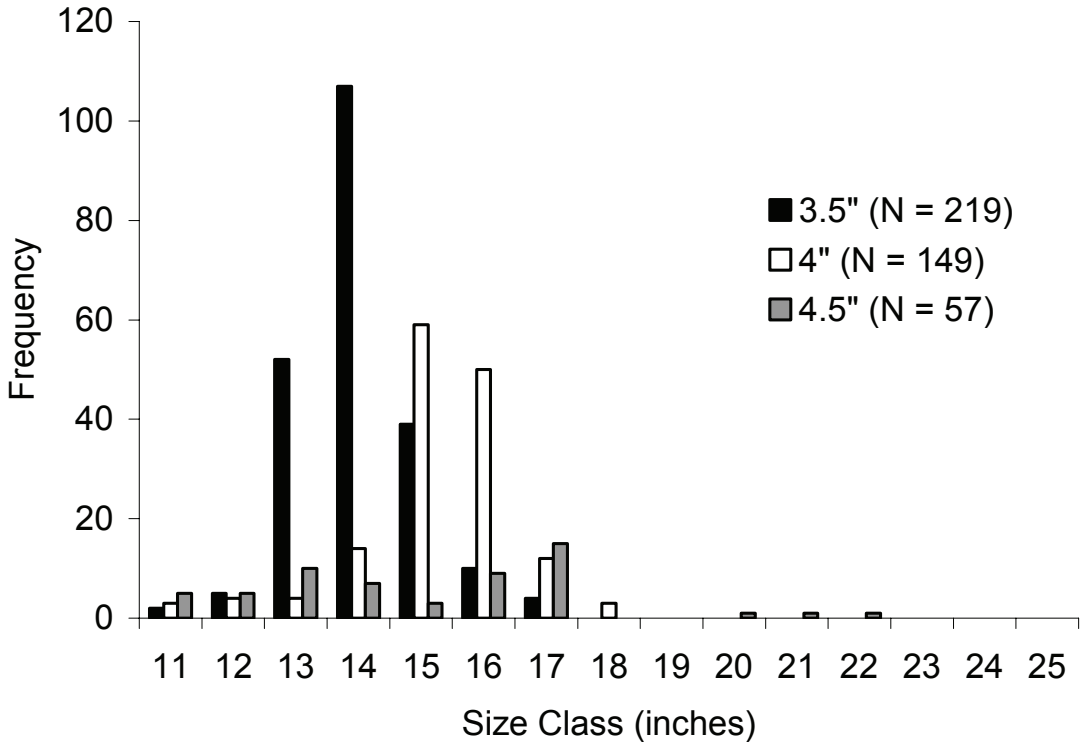


Figure 39. Red drum length frequency from October - December 2005 and 2006 from Neuse River, NC. Samples taken from NCDMF Program 462 independent Estuarine Gill Net Sampling.

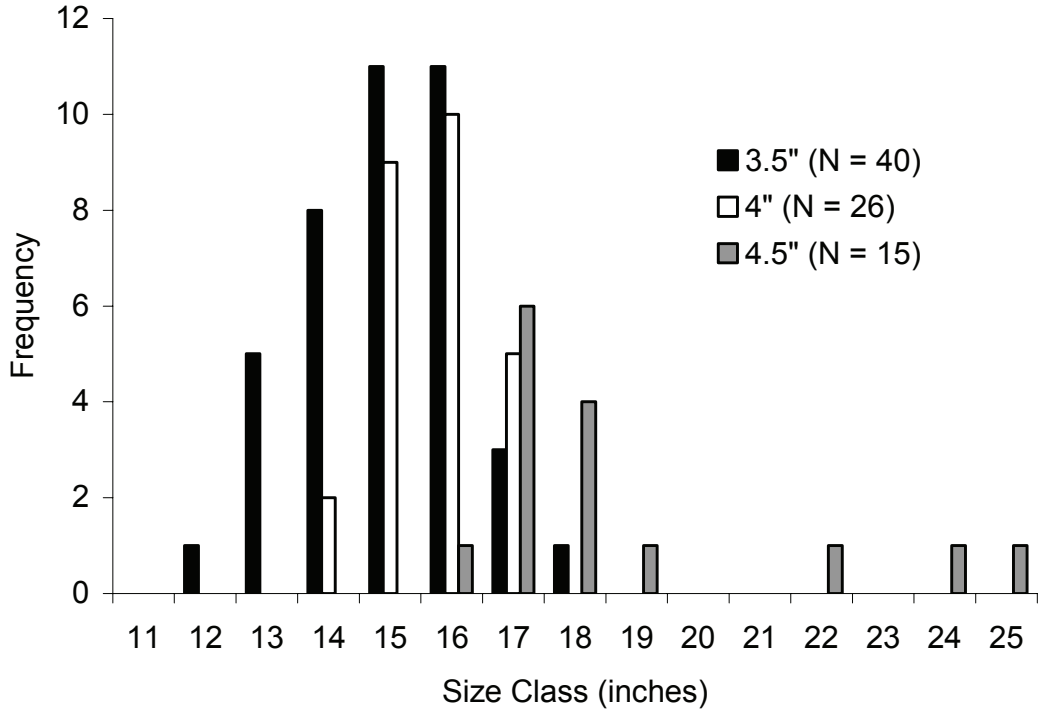


Figure 40. Red drum length frequency from October-December 2005 and 2006 from Neuse River, NC. Samples taken from NCDMF Program 915 Pamlico Sound Independent Gill Net Survey.

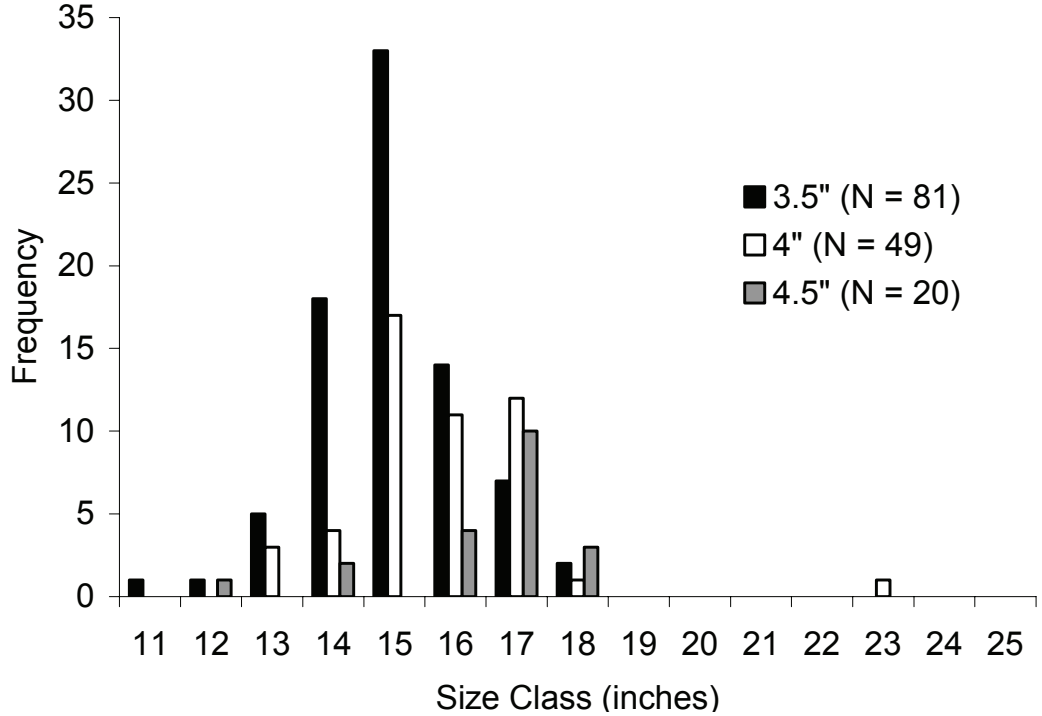


Figure 41. Red drum length frequency from October-December 2005 and 2006 from Pamlico, Pungo rivers, NC. Samples taken from NCDMF Program 915 Pamlico Sound Independent Gill Net Survey.

Mortality

Overall, mortality rates estimated from sampling indicate October having the highest rate (46.0-58.6%), while November (28.3-40.0%) and December (0-14.5%) were lower (Table 54, Table 55, and Table 56). Mortality varied by mesh size and month for both Program 915 and 462 but showed the same overall trend (Table 54, Table 55, and Table 56), generally declining with increasing mesh size.

Table 54. Program 462 mortality estimates for red drum by mesh and month for Neuse River, NC, 2005 and 2006 (N = Number captured).

	3.5"		4"		4.5"		Total	
Month	N	% Mortality	N	% Mortality	N	% Mortality	N	% Mortality
October	22	40.9	8	75.0	7	28.6	37	46.0
November	162	38.3	132	25.0	41	19.5	335	30.8
December	35	14.3	9	33.3	9	.0	53	15.1
Total	219	34.7	149	28.2	57	17.5	425	30.1

Table 55. Program 915 mortality estimates for red drum by mesh and month for Neuse River, NC, 2005 and 2006 (N = Number captured).

	3.5"		4"		4.5"		Total	
Month	N	% Mortality	N	% Mortality	N	% Mortality	N	% Mortality
October	9	66.7	11	54.6	7	42.9	27	55.6
November	29	41.4	15	20.0	8	0	52	28.9
December	2	0	0	0	0	0	2	0
Total	40	45.0	26	34.6	15	20.0	81	37.0

Table 56. Program 915 mortality estimates for red drum by mesh and month for Pamlico Pungo rivers NC, 2005 and 2006 (N = Number captured).

	3.5"		4"		4.5"		Total	
Month	N	% Mortality	N	% Mortality	N	% Mortality	N	% Mortality
October	27	51.9	39	59.0	16	31.3	82	51.2
November	52	51.9	8	50.0	3	0	63	49.2
December	2	50.0	2	0.0	1	0	5	20.0
Total	81	51.9	49	55.1	20	25.0	150	49.3

CPUE

A total of 8,640 yards of small mesh gill net was set for Program 462 yielding a CPUE of one red drum captured for every 20.3 yards of small mesh net fished. A total of 3,600 yards of small mesh gill net was set for Program 915 yielding a CPUE of one red drum captured for every 44.4 yards of small mesh net fished. Catch rates from Program 915 and 462 were used to estimate the number of red drum captured per trip by commercial fisherman on the Neuse River, NC (Table 57). The November estimates of red drum CPUE per trip (37.5) for the two programs (462, and 915) were the same; however, the estimate from Program 915 was double the amount estimated for

Program 462 in October and half of what was estimated for December (Table 57). The average number of small mesh trips taken in the Neuse River from October through December was used to expand the estimated red drum captured per trip shown in the last column in Table 57. The estimated number of red drum captured by month (October through December) for the Neuse River is shown in Table 58. Using this information, an estimated number of red drum taken in the Neuse River small mesh gill net fishery was generated (Table 58). Table 59 and Table 60 give the same information for the Pamlico/Pungo river complex, however only data from Program 915 was used for the expansions. When comparing just the trip estimates based on the Program 915 data, the estimates for the Pamlico/Pungo rivers were slightly higher in October than those for the Neuse River (36.6 fish per trip versus 28.2). The reverse was true in November with the Neuse River rate being 49.3,as opposed to 31.4 for the Pamlico/Pungo rivers. Trip estimates were similar in December (Neuse 7.0, Pamlico/Pungo 5.2) (Table 57 and Table 59). The estimated take of red drum for these systems was ~3,400 to 3,700 fish in the Neuse River and ~1,200 fish for the Pamlico/Pungo rivers.

It is important to note that fishery independent gill net samples for Program 915 were randomly selected and no attempt was made to avoid areas that may or may not have a high density of red drum, or commercial fishing activity. Additionally, the estimated red drum captured per trip during October represent the worst-case scenario for this month. During this month commercial fisherman are required to attend their nets and the soak times used for extrapolation were 12 hours (Program 915) and 24 hours (Program 462).

For the Neuse River it does appear that there was a small shift (~10%) from set nets to runaround/drift nets during the attendance period [May through October (Table 61)]. However, there is no apparent difference in net use before the net attendance rule was put in place and after, during the November through April time period (Table 61). The overall trend for small mesh gill net trips in this system is down, but there is a rebound in the number of trips beginning in 2004 (Figure 42). Changes in the Pamlico/Pungo river complex are shown in Table 62. For this system there appears to be an 8 to 10% shift from set nets to run around/drift nets. The number of small mesh trips in this system is stable with no apparent upward or downward trend (Figure 43). While the change in effort is not substantially large, there has been a shift in the percent contribution of target species that set and run around small mesh nets capture (Table 63). Overall there has been a 34% decline in the percent contribution that set nets made to the total small mesh gill net landings for the ten listed target species. While the set net contribution declined, the run around gill net contribution increased by 49% (Table 63).

Table 57. Neuse River estimated red drum CPUE for commercial small mesh fishery from October – December (2005-06 combined). Data from Program 915- Pamlico Sound Independent Gill Net Survey, Program 462-Estuarine Gill Net Selectivity Study and Program 461 – Estuarine Gill Net Sampling were used to estimate commercial discards.

			3.5"		4"		4.5"		Total	
Program	Month	Mean yards fished [2]	Red drum CPUE per yard[1]	Est. red drum per trip	Red drum CPUE per yard[1]	Est. red drum per trip	Red drum CPUE per yard[1]	Est. red drum per trip	Red drum CPUE per yard[1]	Est. red drum per trip
462	October	704.0	0.04	28.2	0.01	7.0	0.01	7.0	0.02	14.1
	November	704.0	0.11	77.4	0.08	56.3	0.02	14.1	0.07	49.3
	December	704.0	0.05	35.2	0.01	7.0	0.01	7.0	0.02	14.1
915	October	704.0	0.04	28.2	0.04	28.2	0.03	21.1	0.04	28.2
	November	704.0	0.12	84.5	0.06	42.2	0.03	21.1	0.07	49.3
	December	704.0	0.02	14.1	0	0.0	0	0.0	0.01	7.0

[1] - CPUE was estimated from two Independent Gill Net Surveys.

[2] - This value represents the average yards fished by a commercial fisherman in the Neuse River, source program 461.

Table 58. Neuse River estimated number of red drum captured in commercial small mesh gill nets based on mortality and month from October – December (2005-06 combined). Data from Program 915- Pamlico Sound Independent Gill Net Survey, Program 462-Estuarine Gill Net Selectivity Study, and Trip Ticket Program were used to estimate commercial mortality.

					Discarded				Incidental harvest	
Program	Month	Estimated red drum per trip	Trip Ticket estimated number of trips[1]	Estimated number of red drum captured	Percent sublegal dead	Sublegal dead	Percent sublegal alive	Sublegal alive	Percent legal	Number legal
462	October	14.1	58	817.8	41.0%	331.2	51.0%	420.3	8.0%	66.2
	November	49.3	63	3105.9	30.0%	934.9	69.0%	2143.1	1.0%	28.0
	December	14.1	44	620.4	15.0%	93.7	85.0%	526.7	0	0
Total (Nov-Dec)				3726.3		**1028.6**		2669.8		28.0
915	October	28.2	58	1635.6	48.0%	790.0	35.0%	564.3	17.0%	281.3
	November	49.3	63	3105.9	28.0%	879.0	64.0%	1994.0	8.0%	232.9
	December	7.0	44	308.0	0	0	100%	308.0	0	0
Total (Nov-Dec)				3413.9		**879.0**		2302.0		232.9

[1] – Average for 2005 – 2006.

Table 59. Pamlico - Pungo river estimated red drum CPUE for commercial small mesh fishery from October – December (2005-06 combined). Data from Program 915- Pamlico Sound Independent Gill Net Survey, Program 462-Estuarine Gill Net Selectivity Study, and Program 461 – Estuarine Gill Net Sampling were used to estimate commercial discards.

			3.5"		4"		4.5"		Total	
Program	Month	Mean yards fished [2]	Red drum CPUE per yard[1]	Est. red drum per trip	Red drum CPUE per yard[1]	Est. red drum per trip	Red drum CPUE per yard[1]	Est. red drum per trip	Red drum CPUE per yard[1]	Est. red drum per trip
915	October	523.5	0.07	36.6	0.11	57.6	0.04	20.9	0.07	36.6
	November	523.5	0.14	73.3	0.02	10.5	0.01	5.2	0.06	31.4
	December	523.5	0.01	5.2	0.01	5.2	0.01	5.2	0.01	5.2

[1] - CPUE was estimated from 915 Pamlico Sound Independent Gill Net Survey.
[2] - This value represents the average yards fished by a commercial fisherman in the Pamlico-Pungo rivers, source data Program 461.
[3] – No samples for 4.5" mesh. Estimated based on 4.5" from Neuse River information.

Table 60. Pamlico - Pungo estimated number of red drum captured in commercial small mesh gill nets based on mortality and month from October – December (2005-06 combined). Data from Program 915- Pamlico Sound Independent Gill Net Survey and Trip Ticket Program were used to estimate commercial mortality.

					Discarded				Incidental harvest	
Program	Month	Estimated red drum per trip	Trip Ticket estimated number of trips[1]	Estimated number of red drum captured	Percent sublegal dead	Sublegal dead	Percent sublegal alive	Sublegal alive	Percent legal	Number legal
462	October	36.6	34	1244.4	40.5%	504.0	45.1%	561.5	7.3%	91.1
	November	31.4	33	1036.2	30.1%	311.9	49.2%	509.9	1.5%	16.5
	December	5.2	21	109.2	15.1%	16.5	80.0%	87.4	0%	0
Total (Nov-Dec)				1145.4		**328.4**		597.3		16.5

[1] Average for 2005 and 2006.

Table 61. Percentage of reported trips in the Neuse River using various types of gill nets before the attendance rule was implemented (1994 - 1998), and after it was implemented.

	Post attendance Nov - April		Pre attendance Nov - April		Post attendance May - Oct		Pre attendance May - Oct	
Year	run&drift	setnet	run&drift	setnet	run&drift	setnet	run&drift	setnet
1994			10%	90%			11%	89%
1995			11%	89%			33%	67%
1996			31%	69%			46%	54%
1997			38%	62%			51%	49%
1998			28%	72%			47%	53%
1999	28%	72%			46%	54%		
2000	20%	80%			42%	58%		
2001	27%	73%			43%	57%		
2002	30%	70%			37%	63%		
2003	25%	75%			65%	35%		
2004	31%	69%			55%	45%		
2005	39%	61%			60%	40%		
2006	33%	67%			63%	37%		
Total	28%	72%	25%	75%	49%	51%	39%	61%
Total trips	1,708	4,312	1,070	3,163	2,140	2,196	1,633	2,520
Avg trips	214	539	214	633	268	275	327	504

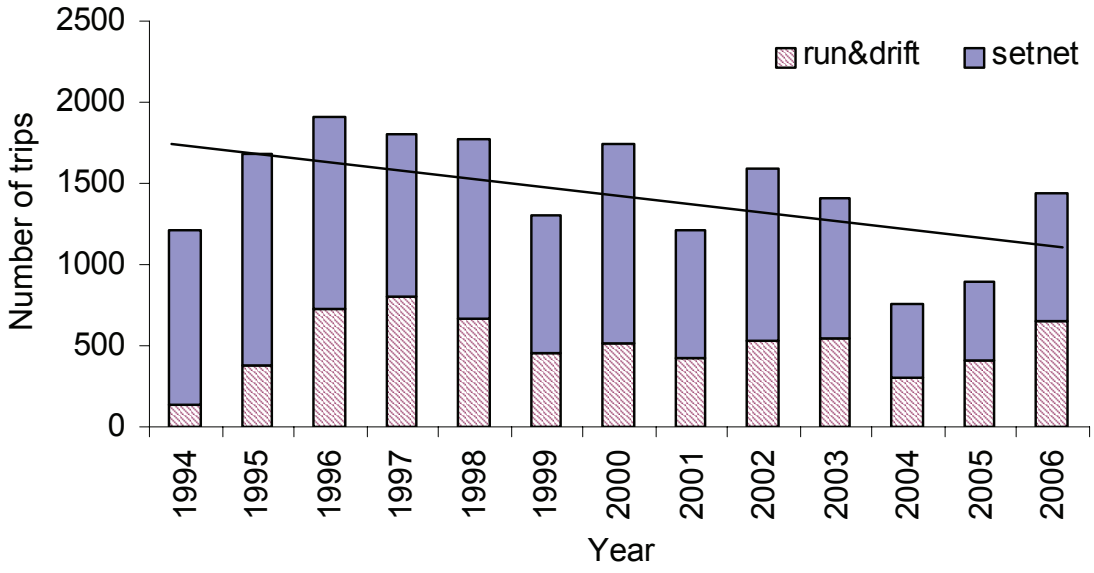


Figure 42. Neuse River small mesh gill net trips (all gears combined), and overall trend for gill net trips in this river, 1994 – 2006.

Table 62. Percentage of reported trips in the Pamlico/Pungo river complex using various types of gill nets before the attendance rule was implemented (1994 -1998), and after it was implemented.

	Post attendance Nov - April		Pre attendance Nov - April		Post attendance May - Oct		Pre attendance May - Oct	
Year	run&drift	setnet	run&drift	setnet	run&drift	setnet	run&drift	setnet
1994			2%	98%			2%	98%
1995			1%	99%			21%	79%
1996			5%	95%			20%	80%
1997			6%	94%			19%	81%
1998			9%	91%			19%	81%
1999	5%	95%			25%	75%		
2000	8%	92%			24%	76%		
2001	19%	81%			36%	64%		
2002	14%	86%			22%	78%		
2003	17%	83%			36%	64%		
2004	20%	80%			27%	73%		
2005	8%	92%			27%	73%		
2006	10%	90%			22%	78%		
Total	12%	88%	5%	95%	27%	73%	17%	83%
Total trips	481	3421	108	2074	694	1850	284	1386
Avg trips	60	428	22	415	87	231	57	277

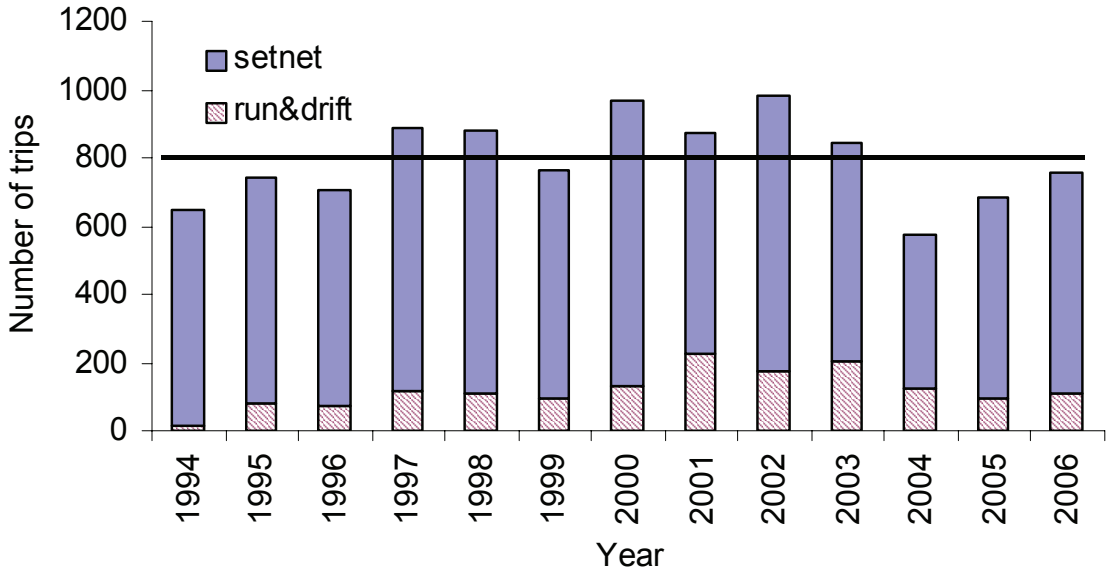


Figure 43. Pamlico, Pungo rivers small mesh gill net trips (all gears combined), and overall trend for gill net trips in this system, 1994 – 2006.

Table 63. Percent contribution (landings) of targeted species for small mesh gill net fisheries by gear type (set nets, and run around), pre and post small mesh attendance rules, Pamlico, Pungo, and Neuse rivers landings data combined. 1994 – 2006, trip ticket data.

	Set nets			Run around/drift		
Species	Pre attendance	Post attendance	Percent change	Pre attendance	Post attendance	Percent change
Bluefish	92.7	71.7	-22.7	7.3	28.3	288.1
Red drum	88.4	84.3	-4.6	11.7	15.7	34.7
Sea mullet	99.8	63.5	-36.3	0.2	36.5	15212.5
Spanish Mackerel	93.8	83.0	-11.5	6.2	17.0	174.4
Atlantic menhaden	100.0	82.7	-17.3	0.0	17.3	
Mullets	55.0	31.3	-43.0	45.0	68.7	52.5
White perch	95.9	86.5	-9.7	4.1	13.5	226.4
Spotted seatrout	75.1	54.5	-27.4	25.0	45.5	82.3
Spot	93.9	71.3	-24.1	6.1	28.8	369.5
Weakfish	96.8	90.5	-6.5	3.2	9.5	195.8
All (weighted avg)	58.6	38.5	-34.3	41.4	61.5	48.5

Current Authority

The MFC has granted proclamation authority to the Director to specify the means/methods to take red drum, in addition to other parameters (NCAC 15A 3M .0501). The MFC also has granted proclamation authority to the Director to impose a variety of restrictions on gill nets (3J. 0103(b)) and passed rules related to gill net attendance (3J. 0103 (g)(h)). A listing of the current rules as they apply to red drum can be found in Section 4.7.

Management Options/Impacts (See section 10.2.5.1 Statewide Estuarine Gill Net Bycatch Estimates)

Research Recommendations (See section 10.2.5.1 Statewide Estuarine Gill Net Bycatch Estimates)

10.2.5.3 Other Gill Net Issues

Issue

Consider possible alterations to the current gill net attendance (modified no-trawl) area along the eastern Pamlico Sound based on public comments received during FMP process.

Background

During the public comment period for Amendment 1 to the North Carolina Red Drum FMP gill net fishers expressed concerns over the need for possible changes to the small mesh gill net attendance line along the eastern Pamlico Sound. Three separate issues were raised: 1) modifications to the current small mesh gill net attendance line along the Outer Banks and 2) small mesh gill net attendance requirements under the Pamlico Sound Gill Net Restricted Area and 3) consideration for exemptions to small mesh attendance for deepwater areas within the attendance line where red drum discards are minimal.

Gill netters fishing water bodies in eastern Pamlico Sound between Rodanthe and Gull Island requested a slight modification to the current gill net attendance line to allow for additional areas to be fished with small mesh gill nets without requiring that they be attended. Gill netters fishing in the area of Hatteras requested consideration for allowing unattended small mesh gill nets in a region near Olivers Reef if attendance was extended into November. The Northeast Advisory Committee voted unanimously to request that NCDMF review these requests as part of the FMP process. Additionally, at the April 2008 MFC meeting, the fishermen from the areas of Hatteras and Ocracoke requested the DMF and the MFC consider allowing some deep water small mesh gill netting with unattended nets in areas within the attendance line.

The current small mesh gill net attendance line (modified "No Trawl") along the Outer Banks region is designed to protect the shallow grass beds to the east while allowing fishers to set nets in deep water areas to the west (Figure 44). The protected area to the east of the line includes shallow shoals and flats often characterized by dense SAV (submerged aquatic vegetation, i.e. eelgrass, widgeon grass, etc.), and is the primary habitat for sub-legal red drum along the Outer Banks. The current small mesh gill net attendance line in this area was developed and modified by the NCDMF from the "No Trawl" line as listed in the current rules. Later modifications were made, based on public comment, in areas where the "No Trawl" line extended further out into the sound than necessary, possibly putting commercial fishers in the direct path of working trawlers and outside of productive deep water fishing grounds. The DMF considered the recommendations of local fishers in developing the gill net attendance line and then made some additional modifications in order to straighten the line to relieve some of the difficulty in enforcement.

Discussion

1) Modifications to the current small mesh gill net attendance line along the Outer Banks

During the 2001 Red Drum FMP process, modifications were made in response to concerns raised by commercial fishers along the 'Outer Banks' during the development of the current small mesh gill net attendance line,. The contention among these fishers was that the original attendance area along the 'Outer Banks' extended to far offshore outside shallow areas, unnecessarily forcing gill net fishers into less productive and potentially hazardous conditions created by the deeper water. Modifications made addressed the majority of the concerns raised and were considered a successful compromise in the approved plan. During the process of developing Amendment 1 to the NC Red Drum FMP, additional concerns were raised in the

areas of Rodanthe to Gull Island and in the area of Hatteras, near Oliver Reef. NCDMF investigated the proposed changes and is recommending to the NCMFC that the following changes can be made without any substantive increase in red drum discards.

Area 1: Rodanthe to Gull Island

Gill netters fishing the area from Rodanthe to Gull Island have requested the straightening of the attendance line along the area from just south of Rodanthe channel to Gull Island (Figure 44; Area 1). This rule change would require the removal of a single point along the current gill net attendance line. Changing the line in this manner affords additional access to productive fishing ground to the west of the line during the attendance period. The change also makes it easier for gill netters in this area to know they are in compliance with the rule by making it straight and therefore more easily discerned on the water. The area to the west of this modified change consists primarily of habitat that is deeper than where sub-legal red drum are typically captured and is not likely to result in any substantive increase in discards.

Area 2: Hatteras, near Oliver Reef

Gill netters fishing in this region requested that the attendance line be moved inshore from its current location to allow for additional access to deep water fishing grounds where attendance would not be required. NCDMF investigated the area and is recommending that an additional area of deep water along Oliver Reef be excluded from the attendance line (Figure 44; Area 2). The modification to the rule would extend the current attendance line inshore from Beacon "36" to Beacon "35" along Rollinson Channel where it would then run southwesterly to a "Danger" Beacon offshore of Austin Reef before merging back with the current line. These changes would only exclude deep water habitat and it has the added advantage of being clearly marked by visible beacons on the water.

2) Small Mesh Gill Net Attendance Requirements under the Pamlico Sound Gill Net Restricted Area

During 2000, the Pamlico Sound Gill Net Restricted Area (PSGNRA) was established by National Marine Fisheries Service (NMFS) and created a permanent closure of Pamlico Sound to large mesh gillnets (> 4 ¼ in. stretch mesh, FR Vol. 67, No 173 56931) from September 1 to December 15 each year. The PSGNRA was established due to increased observations of sea turtle strandings, and subsequent observed gillnet interactions in 1999 along the Outer Banks (Gearhart 2001). NCDMF pursued and received a Section 10 Incidental Take Permit along the mainland side and Outer Banks of Pamlico Sound to allow a limited, shallow water gillnet fishery to continue to operate. The permit establishes conditions (e.g., restricted fishing areas, reporting requirements, observer coverage) that must be met in order for the fishery to continue.

Habitat Conservation Plans (HCPs) within Section 10 Incidental Take Permit (ITP) requires an extensive monitoring program in permitted area which has been in place since 2000.

The primary goal each year in the management of the PSGNRA is to monitor and reduce sea turtle interactions in commercial gillnets with the assumption that these will result in decreased sea turtle strandings in Pamlico Sound from September through December of each year. Fishery management measures within HCPs restrict areas, seasons, gear, mandate observer coverage, and require weekly reporting. These actions protect sea turtles, allow a limited shallow water gillnet fishery, and characterize catch, effort, and bycatch along the Outer Banks and mainland side of Pamlico Sound from September through December of each year.

One of the conditions of the current Section 10 ITP is that all small mesh gill nets fished within the permitted area must be attended from September 15 through October 31 of each year. This condition increases the attendance areas beyond those established by the 2001 NC Red Drum FMP along the Outer Banks and forces fishermen out into deeper water during this period. NCDMF has requested and the NMFS has agreed to allow NCDMF to manage small mesh gill nets in this area through the current rule passed as part of the 2001 NC Red Drum FMP.

3) Consideration for exemptions to small mesh attendance for deepwater areas within the attendance line.

The current attendance line, as previously stated, was designed to minimize the mortality associated with sub-legal red drum discards in the small mesh gill net fishery during the months when discard rates and mortality are the highest. Several changes have been made to the existing attendance line at the request of the public. Modifications, when made, have been allowed in the past because the areas being excluded were not deemed as areas where red drum interactions typically occur with gill nets. DMF has documented habitat types that are commonly associated with red drum abundance along the Outer Banks region. The primary factor associated with the presence of sub-legal red drum is shallow depth, although submerged aquatic vegetation and close proximity to a shoreline tend to also be important. DMF data indicate that red drum bycatch is highest in gill nets set in shallow water (<3 ft) and can be significantly reduced by >90% when compared to nets set at depths of 6 feet or greater.

Gill netters asked DMF and MFC to consider allowing unattended gill nets to be set in existing deep water habitats within the current attendance line. Based on comments received, the majority of the small mesh effort in these areas would be directed at menhaden, bluefish, trout and sea mullet in depths of 6 to 12 feet of water. Criteria for opening these areas would be an average minimum depth of at least 6 feet in an area that is easily distinguished. Small deep sloughs surrounded by shallow habitat would not be suitable candidates due to the difficulty in enforcing and the increased potential for red drum interactions.

The primary area of concern expressed during public comment was for the deep water habitat located between Rollinson Channel and Cape Channel. These areas of deep water fall within the current attendance line. NCDMF staff investigated this area to determine if significant deep water areas existed that could be delineated without the inclusion of significant shallow water habitat. The conclusion of this investigation was that while significant areas of deep water are present, there are also significant areas of shoals and submerged aquatic vegetation. There was no apparent way to delineate an area of deep water habitat without the

inclusion of considerable shallow water habitat. A second consideration, allowing unattended gill nets to be set at a minimum depth (i.e. 7 ft), was not considered enforceable.

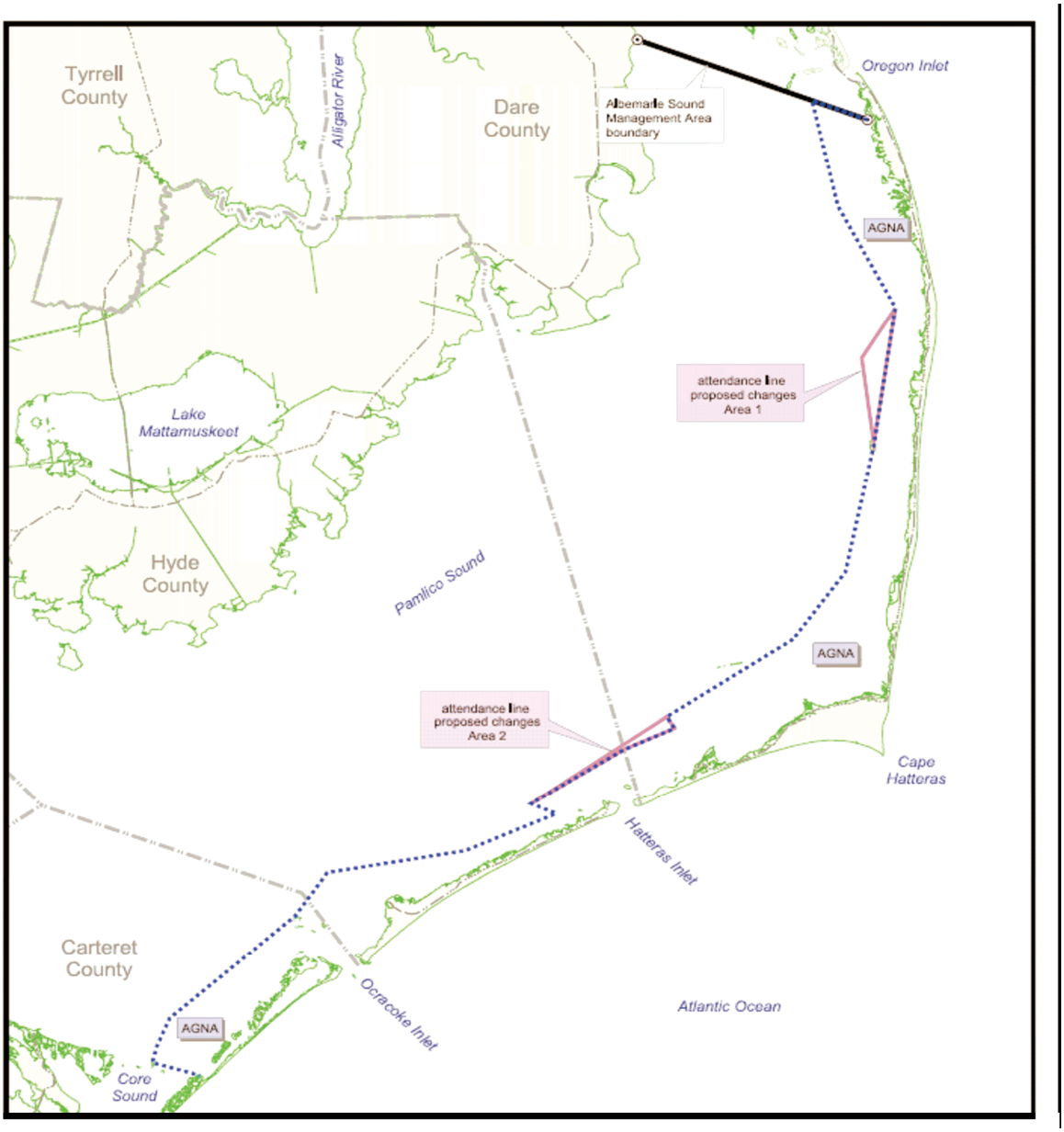


Figure 44. Map of the current gill net attendance area along the Outer Banks. The black-dashed line denotes the modified attended gill net area (AGNA) along the Outer Banks of Pamlico Sound. Proposed changes to "Area 1" near Rodanthe and "Area 2" behind Hatteras would allow for additional deep water areas to be fished outside the attendance area.

Current Authority

North Carolina Fisheries Rules for Coastal Waters (15A NCAC)
03J.0103 Gill Nets, Seines, Identification, Restrictions
03R.0112 Attended Gill Net Areas

Management Options/Impacts

(+ potential positive impact of action)
(- potential negative impact of action)

1) No Action/Maintain current small mesh attendance line
- \+ Reduced bycatch of undersized red drum
- \+ Maintain established areas for attendance
- \- Potential economic burden for fishers
- \- More difficult to enforce/more difficult for gill netters to comply

2) Modify current attendance line in 15A NCAC 03R0.112 (b)(2) between Rodanthe and Gull Island striking the point along the attendance line at the location described as 'west of Salvo' and located at 35° 32.6000' N - 75° 31.8500' W.
- \+ Increased area for small mesh gill nets to be set unattended
- \+ More protected from elements of open waters
- \+ Deeper area with less likelihood of red drum bycatch
- \+ Straight line easier to discern and enforce
- \- Potential that some additional red drum discards may occur

3) Modify current attendance line in 15A NCAC 03R0.112 (b)(2) in the area of Oliver Reef, near Hatteras.
- \+ Increased area for small mesh gill nets to be set unattended
- \+ More protected from elements of open waters
- \+ Deeper area with less likelihood of red drum bycatch
- \+ Line easier to discern and enforce due to use of existing beacons
- \- Potential that some additional red drum discards may occur

4) Consider exempting large deepwater areas within the current attendance area along the Outer Banks.
- \+ Increased area for small mesh gill nets to be set unattended
- \+ More protected from elements of open waters
- \- Very difficult to enforce
- \- Potential for some increased red drum discards

Management Recommendations

RDAC - Modify current attendance line in 15A NCAC 03R0.112 (b)(2) between Rodanthe and Gull Island striking the point along the attendance line at the location described as 'west of Salvo' and located at 35° 32.6000' N - 75° 31.8500' W.

DMF - Modify current attendance line between Rodanthe and Gull Island striking the point along the attendance line at the location described as 'west of Salvo' and located at 35° 32.6000' N - 75° 31.8500' W and modify current attendance line in 15A NCAC 03R0.112 (b)(2) in the area of Oliver Reef, near Hatteras.

MFC Selected Management Option

Modify current attendance line between Rodanthe and Gull Island striking the point along the attendance line at the location described as 'west of Salvo' and located at 35° 32.6000' N - 75° 31.8500' W and modify current attendance line in 15A NCAC 03R0.112 (b)(2) in the area of Oliver Reef, near Hatteras.

Other actions being taken by NCDMF:
For the period of September 1 to October 31, NCDMF asked NMFS to consider allowing the gill net attendance line established in 15A NCAC 03R0.112 (b)(2) to be the area where small mesh gill net attendance is required as opposed to the PSGNRA that has been used (see part (2) of discussion above). NMFS had no objection to this request and DMF was allowed to make this change without violating the current Section 10 ITP issued by NMFS. The changes were made effective with the 2008 fishing year through proclamation authority.

11. MANAGEMENT PROGRAM

A management program has been developed in an effort to meet the goals and objectives of this FMP as listed in Section 4.2. This section outlines the need for additional data in order to improve our ability to assess the status of the red drum stocks, details the selected management strategy as approved by the NC MFC, and summarizes the research needs covered in this plan.

11.1 Data Needs

Additional data are needed to improve red drum stock assessments, to better evaluate the effects of current management actions, and to identify additional management actions that will allow for the long-term sustainability of the North Carolina red drum stock. A listing of data needs, based on reviews by Vaughan and Carmichael (2000) and Takade and Paramore (2007) is provided below.

1. Improved Fishery-Dependent Sampling.

Currently available catch statistics may not be complete for a number of reasons that are described in detail below. Failure to account for all removals from the population, and to properly allocate harvest and discard losses into size and age categories, contributes to uncertainty and bias in stock assessment results. In addition, adequate monitoring of non-harvest losses is necessary to develop management measures that prevent waste.

There is limited sampling of at-sea discarding in commercial fisheries which should be continued and expanded. Although red drum are considered a bycatch species, as noted in the description of commercial fisheries (Section 7.1), they are encountered by many different fisheries throughout the state. Given the restrictive allowable harvest of red drum, the mortality associated with discarding by these fisheries represents a potentially significant, but largely unknown, removal from the population. In addition to estimates of total removals, data are also needed on the size and age distribution of bycatch losses.

Sampling of the recreational fishery should be improved. Recreational harvest accounts for greater than half of the total North Carolina harvest each year, so reliable and precise estimates of total harvest and adequate characterization of the length, weight, and age composition of the harvest are crucial. The number of MRFSS intercepts should be increased, collection of biological samples from the recreational harvest should be improved, and additional sampling, especially at night when many directed recreational trips occur, should be pursued. Data on the length distribution of recreational discards is severely needed. Although important for many species, this is especially critical for red drum because of both the steadily increasing proportion of red drum that are released and the nature of the management program. Since red drum are managed through a possession limit and a slot size limit, red drum may be discarded that are below the minimum size, above the maximum size, or in excess of the possession limit. Methods for determining size distribution on an annual basis should be investigated.

2. Improved Fishery-Independent Sampling

Surveys at age are needed to better monitor the abundance of red drum. Prior assessments on red drum in North Carolina have utilized the red drum juvenile abundance index generated from the NCDMF Red Drum Seine Program. More recently, NCDMF initiated an independent gill net survey in estuarine waters designed to provide an index of abundance for sub-adult red drum in North Carolina. Sampling of sub-adults should improve estimates of recruitment and better warn of recruitment failure and could provide more accurate data for estimates of SPR and escapement. The index generated from this survey was used in the most recent stock assessment. Sampling of the adult population is needed to provide data on the age structure of the population and long-term sampling could possibly provide an index of the spawning stock that could potentially be used to estimate spawning stock abundance and biomass. During 2007, NCDMF initiated a Red Drum Longline Survey designed to provide an index of abundance of adult red drum over time. As with all monitoring studies, the strength of the data is dependent upon maintaining a long-term database to track changes over time.

3. Improved Estimates of Vital Rates

Assessment and population model results are sensitive to input parameters such as natural mortality, fecundity, and growth rates. Research should be directed at estimating these important vital rates for red drum in North Carolina.

4. Improved Tagging Programs

Red drum tagging programs have been conducted by DMF for many years. Recent improvements in modeling techniques have made this data useful in providing estimates of both the selectivity and fishing mortality rates of red drum at age (Bacheler et al. 2007). Selectivity patterns estimated from North Carolina's tagging data were used in the most recent assessment to provide critical information on the length frequency of red drum released in the recreational fishery (Burdick et al. 2007). Estimates of mortality rates calculated from well designed tagging studies could provide a useful complement to traditional assessment techniques, particularly for red drum, where results are complicated by the lack of an adult index, a high proportion of captured and released fish, and an atypical dome shaped selectivity curve centered around juvenile fish. In the future, tagging studies conducted by North Carolina should be better designed to limit potential biases and improve mortality estimates. In particular, studies should include methods to estimate the non-reporting rate of tag recaptures, tag loss rates over time and the mortality associated with the tagging event. Additionally, effort should be made to ensure proper mixing of tagged individuals into the population.

11.2 Management Strategies and Proposed Actions

Listed below are the management strategies as selected from each of the management issues in Section 10.2. Each numbered strategy is followed by a reference to the Principal Issue and Management Option section that supports it, e.q. (10.1.1) and the Objectives from Section 4.2 that it addresses, e.q. [2,3]. Changes to the current rules required to implement these actions are found in Appendix 1.

11.2.1 Adult Harvest Limits

Issue: The potential modification of the rule prohibiting the harvest and possession of red drum greater than 27 inches in total length.

Management Options:

1) Status quo (prohibit all possession and sale of red drum >27 in TL)
2) Trophy fishery (1 fish 55 in TL or greater) through the use of a trophy tag
3) Special Permit to retain 1 fish > 27 in TL
4) Harvest of adults (>27 in TL) while maintaining a 30% SPR threshold
5) No harvest of adults (>27 in TL) while maintaining a 40% SPR target

Management Recommendations
DMF and RDAC

- Status quo (no harvest over 27 inches TL)

MFC Selected Management Strategy

Selects DMF and RDAC recommendation.

(Section 10.2.1), [Objectives 1,2]

11.2.2 Recreational Targeting of Adult Red Drum

Issue: The directed recreational catch and release fishery for adult red drum and the concerns and potential risks of this fishery.

Management Options:

1) Status quo (prohibit all possession and sale of red drum >27 in TL)
2) Trophy fishery (1 fish 55 in TL or greater) through the use of a trophy tag
3) Special Permit to retain 1 fish > 27 in TL

4) Harvest of adults (>27 in TL) while maintaining a 30% SPR threshold

5) No harvest of adults (>27 in TL) while maintaining a 40% SPR target

Management Recommendations
DMF and RDAC
- Status quo (no harvest over 27 inches TL)

MFC Selected Management Strategy
Selects DMF and RDAC recommendation.
(Section 10.2.2), [Objectives 1, 2 and 5]

11.2.3 Recreational Bag and Size Limits

Issue: The recreational bag limit for red drum is currently 1 fish per person per day from 18 to 27 inches TL. The North Carolina fishery management plan for red drum may consider options to modify the current bag limit and other recreational management measures.

Management Options:
1) Status quo (1 fish 18-27 inches TL)

2) Increase the bag limit and change size range

Management Recommendations
DMF and RDAC
- Status quo (1 fish 18-27 inches TL)

MFC Selected Management Strategy
Selects DMF and RDAC recommendation.
(Section 10.2.3), [Objectives 1, 2 and 4]

11.2.4 Commercial Harvest Limits

Issues: Can the current bycatch allowance in the Red Drum FMP of 7 fish be increased?

Avoiding closures in the commercial red drum bycatch fishery.

Management Options:
1) Status quo (7 fish limit with 50% bycatch provision, DMF Director maintains proclamation

authority to increase trip limit and adjust the bycatch provision as needed)

2) Increase the bycatch allowance

3) Allow for possession of some red drum while actively fishing gear even if adequate finfish (excluding menhaden) have not yet been obtained.

4) Allow for the possession of some red drum without requiring that they be bycatch (Example would be to allow three red drum to be landed without requiring other finfish to be present; additional landed red drum would be subject to bycatch provision)

5) Implement a split season on the commercial fishing year, capping the period of September 1 to April 30 at 150,000 lb and conserving the remaining portion of the cap (100,000 lb) for the period of May 1 to August 31. Unused cap in Period 1 can be carried forward to Period 2.

Management Recommendations:
DMF and RDAC –

1) **Status quo (7 fish trip limit with 50% bycatch provision). Director retains authority to modify the trip limit and bycatch provisions as needed.**
2) **Allow for the possession of up to 3 fish while engaged in red drum without requiring that they be subject to the 50% bycatch provision. Upon landing/sale all red drum possessed would be subject to any bycatch requirements.**
3) **Implement a split season on the commercial fishing year, capping the period of September 1 to April 30 at 150,000 lb and conserving the remaining portion of the cap (100,000 lb) for the period of May 1 to August 31. Unused cap in period 1 can be carried forward to period 2. Any annual commercial harvest limit that is exceeded one year will result in the poundage overage being deducted from the subsequent year's commercial harvest limit.**

MFC Selected Management Strategy

Selects DMF and RDAC recommendations.

(Section 10.2.4), [Objectives 1, 2, 4 and 5]

11.2.5 Bycatch in the Estuarine Gill Net Fishery

Issue: The occurrence and magnitude of regulatory and unmarketable red drum discards in the estuarine gill net fishery.

Management Options:

Set small mesh (<5 inches stretch) estuarine gill net management options:

1) Status quo
2) Extend attendance duration
3) Extend attendance areas
4) Require minimum depth for the use of set small mesh gill nets
5) Require minimum distance from shore for the use of set small mesh gill nets

Set large mesh (≥5 inches stretch) estuarine gill net management options:

1) Status quo
2) Require attendance seasons
3) Require nets to be set at a minimum distance from shore
4) Require nets to be set at a minimum depth of water

Management Recommendations:

DMF Recommendation

Small Mesh (<5" stretch mesh)

Year-round attendance requirements:

Extend attendance within 200 yards of shore to include the area of the lower Neuse out to the mouth of the river.

Seaasonal attendance requirements:

Modify the seasonal attendance requirements for small mesh gill nets (currently May 1 to October 31) to include the period of May 1 through November 30 in:

1) all primary and permanent secondary nursery areas and all modified no-trawl areas (shallow grass beds in eastern Pamlico and Core Sound)
2) Within 200 yards of any shoreline for the areas of Pamlico, Pungo, Neuse, and Bay Rivers
3) Within 50 yards of any shoreline in areas of Pamlico and Core Sound and in all coastal waters south to NC/SC line
4) Area from HWY 58 bridge south is excluded from shoreline requirement during October and November

Large Mesh (>5" stretch mesh)

Require all unattended large mesh gill nets to be set a minimum of 10 yards from any shoreline from

June through October

RDAC Recommendation

Small Mesh (<5" stretch mesh)

Year-round attendance requirements:

Extend attendance within 200 yards of shore to include the area of the lower Neuse out to the mouth of the river (and)

Require year-round attendance of small mesh nets in Primary and Permanent Secondary Nursery Areas north of the Wainwrights in Carteret County and exempting the Albemarle Sound Management Area

Seaasonal attendance requirements:

Modify the seasonal attendance requirements for small mesh gill nets (currently May 1 to October 31) to include the period of May 1 through November 30 in:

1) all primary and permanent secondary nursery areas
2) all modified no-trawl areas (shallow grass beds in eastern Pamlico and Core Sound)
3) all areas within 200 yards of any shoreline, exempting the areas of Core Sound and south from the 200 yards of any shoreline requirement during the months of October and November

Large Mesh (>5" stretch mesh)

Require all unattended large mesh gill nets to be set a minimum of 10 yards from any shoreline

MFC Selected Management Strategy

Small Mesh (<5" stretch mesh)

Year-round attendance requirements:

Extend attendance within 200 yards of shore to include the area of the lower Neuse out to the mouth of the river.

Seaasonal attendance requirements:

Modify the seasonal attendance requirements for small mesh gill nets (currently May 1 to October 31) to include the period of May 1 through November 30 in:

5) **all primary and permanent secondary nursery areas and all modified no-trawl areas (shallow grass beds in eastern Pamlico and Core Sound)**
6) **Within 200 yards of any shoreline for the areas of Pamlico, Pungo, Neuse, and Bay Rivers**
7) **Within 50 yards of any shoreline in areas of Pamlico and Core Sound and in all coastal waters south to NC/SC line**
8) **Area from Core Sound and south is excluded from shoreline requirement during October and November**

Large Mesh (>5" stretch mesh)

Require all unattended large mesh gill nets to be set a minimum of 10 yards from any shoreline from June through October

(Section 10.2.5), [Objectives 1, 2 and 5]

11.3 Habitat and Water Quality Management Recommendations

At the state level, North Carolina has developed a strategy to protect and restore habitats critical to North Carolina's coastal fishery resources through the implementation of the Coastal Habitat Protection Plan (CHPP). This plan recognizes those habitats that have been identified to provide critical habitat functions or that are particularly at risk due to imminent threats, vulnerability or rarity. Areas meeting these criteria are to be designated as "Strategic Habitat Areas" (SHAs) and given the highest priority for protection. In addition to its overall goals, the CHPP has specific recommendations that will benefit habitat used by red drum. Additional red drum habitat research needs identified in this Red Drum FMP Amendment are:

- Determine juvenile habitat preference and examine if recruitment is habitat limited.
- Examine ecological use and importance of shell bottom to red drum.
- Identify coastal wetlands and other habitats utilized by juvenile red drum and assess relationship between changes in recruitment success and changes in habitat conditions.
- Assess cumulative impact of large-scale beach nourishment and inlet dredging on red drum and other demersal fish that use the surf zone.
- Determine location and significance of spawning aggregation sites throughout the coast.
- Determine if navigational dredging between August and October significantly impacts spawning activity.
- Determine if designation of spawning areas by MFC is needed, and if specific protective measures should be developed.

(Section 9.0), [Objective 6]

11.4 Research Needs Summary

The following research needs were compiled from those listed in the issue papers in Section 10.0 as well as those outlined in Section 11.1 Data Needs. Improved management of red drum is dependent upon research needs being met. Research needs are not listed in order of priority.

- Assess the size distribution of recreational discards.
- Improved catch and effort data for the red drum recreational fishery, particularly for the fishery that occurs at night.
- Development of independent surveys to monitor both the sub-adult and adult red drum populations. (Underway).
- Improved length frequency data for adult red drum in the recreational and commercial fisheries.

- Conduct studies to determine the magnitude of red drum interactions and discards in the small mesh gill net fishery from Core Sound and south during November and December.
- Continue tagging efforts of adult red drum through the NCDMF Volunteer Tagging Program.
- Update and/or continue to monitor age, growth and maturity data for the red drum.
- Conduct studies on the diet of red drum in North Carolina.
- Further identification of the spawning areas for adult red drum in North Carolina.
- Economic analysis of the adult red drum fishery.
- Improved social and economic data collection on the recreational and commercial fishery, including information on current conflicts and the potential for future conflicts in this fishery.
- Characterize the trophy recreational fishery (tackle, geographic location, bait, water temperature, seasonality, hook types, etc.).
- Incorporate information on conservative angling practices for red drum into future fishing guides and make the information available on the NCDMF website.
- Expand independent gill net survey to other parts of the state.
- Continue and expand estuarine gill net observer program to collect data across various key fisheries by season and area.
- Collect data from the observer program or through other sources on the catch rates of red drum and targeted species with regard to distance from shore in estuarine gill nets.
- Conduct a comprehensive survey of gill net fishers including information on species targeted, gear characteristics, areas fished.
- Conduct studies that explore ways to reduce red drum interactions with commercial gear while allowing for retention of targeted species.
- Conduct additional research to determine the release mortality of red drum captured in gill nets.
- Continue and enhance collection of fishery dependent data.
- Continue and improve tagging studies to estimate mortality rates in the red drum fishery.

11.5 Review Cycle

As provided in the Fisheries Reform Act of 1997, the Red Drum Fishery Management Plan will be reviewed and revised at least every five years with the support of advisors.

12. LITERATURE CITED

Aguilar, R. 2003. Short-term post-hooking mortality and movement of adult red drum in the Neuse River, North Carolina. MS, North Carolina State University, Raleigh, NC. 138 p.

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

Atlantic States Marine Fisheries Commission (ASMFC). 1994. Fishery Management Plan for Red Drum – Amendment # 1. Fisheries Management Report No. 19. ASFMC, Washington, DC, 123 p.

Atlantic States Marine Fisheries Commission (ASMFC). 1999. ASMFC guidelines for evaluating fishing gear impacts to submerged aquatic vegetation and determining mitigation strategies. ASMFC, Washington, DC. 34p.

Atlantic States Marine Fisheries Commission (ASMFC). 2000. Evaluating fishing gear impacts to submerged aquatic vegetation and determining mitigation strategies. ASFMC Habitat Management Series 5, 38p.

Atlantic States Marine Fisheries Commission (ASMFC). 2002. Amendment 2 to the Interstate fishery management plan for red drum. Fisheries Management Report No. 38. Atlantic States Marine Fisheries Commission, Washington, DC. 142 p.

Atlantic States Marine Fisheries Commission (ASMFC). 2006. 2006 Review of the ASMFC fishery management plan for red drum (*Sciaenops ocellatus*). Atlantic States Marine Fisheries Commission, Washington, DC. 16 p.

Atlantic States Marine Fisheries Commission (ASMFC). 2007. The importance of habitat created by molluscan shellfish to managed species along the Atlantic coast of the United States. ASMFC, Washington, DC, ASMFC Habitat Management Series #8, 128p.

Auster, P. J. and R.W. Langton. 1999. The effects of fishing on fish habitat. p. 150-187 *in* L. Benaka (ed.). Fish habitat: essential fish habitat and rehabilitation. American Fisheries Society, Bethesda, Md. Symp. 22, 459p.

Bacheler, N. M. , J. E. Hightower, L. M. Paramore, J. A. Buckel, and K. H. Pollock. 2008. An age-dependent tag return model for estimating mortality and selectivity of an estuarine-dependent fish with high rates of catch and release. Transactions of the American Fisheries Society 137:1422-1432.

Bacheler, N.M., L.M. Paramore, J.A. Buckel. In Press. Abiotic and biotic factors influence the habitat use of an estuarine fish. Marine Ecology Progress Series.

Bahr, L. M. and W. P. Lanier. 1981. The ecology of intertidal oyster reefs of the south Atlantic coast: a community profile. US Fish and Wildlife Service, Washington, DC, FWS/OBS/81.15. 105 p.

Bales, J. D. and D.J. Newcomb. 1996. North Carolina wetland resources. p. 297-302 *in* R.M. Hirsch (dir). National Water Summary on Wetland Resources. U.S. Geological Survey, Atlanta, GA, USGS Water-Supply Paper 2425.

Baltz, D. M., J. W. Fleeger, C. R. Rakocinski, and J. N. McCall. 1998. Food, density, and microhabitat: factors affecting growth and recruitment potential of juvenile saltmarsh fishes. Environmental Biological Fisheries 53(1): 89-103.

Barrios, A. T. 2004. Use of passive acoustic monitoring to resolve spatial and temporal patterns of spanwing activity for red drum, *Sciaenops ocellatus,* in the Neuse River Estuary, North Carolina. MS, NCSU, Raleigh, NC, 97p.

Barrios Beckwith, A.T., G.H. Beckwith, Jr., and P.S. Rand. 2006. Identification of critical spawning habitat and male courtship vocalization characteristics of red drum, *Sciaenops ocellatus*, in the lower Neuse River estuary of North Carolina. North Carolina Sea Grant Fishery Research Grant Program, Final Report 05-EP-05. 39 p.

Beckwith, Jr., G.H. and P.S. Rand. 2004a. Investigating post-hooking recovery and mortality of red drum in the Neuse River. North Carolina Sea Grant Fishery Research Grant Program, Final Report 02-FEG-03. 31 p.

Beckwith, Jr., G.H. and P.S. Rand. 2004b. Large circle hooks and short leaders with fixed weights reduce incidence of deep hooking in angled adult red drum. Fisheries Research. 71(2005) 115-120.

Brown, C. A., G.A. Jackson, S.A. Holt, and G.J. Holt. 2005. Spatial and temporal patterns in modeled particle transport to estuarine habitat with comparisons to larval fish settlement patterns. Estuarine, coastal, and shelf science 64(1): 33-46.

Brown, S. S., G.R. Gaston, C.F. Rakocinski, and R.W. Heard. 2000. Effects of sediment contaminants and environmental gradients on macrobenthic community trophic structure in Gulf of Mexico estuaries. Estuaries 23(3): 411-424.

Buckel, J.A., R.J. Hines, and T.C. McArthur, Jr. 2006. Incidental catch and discard of red drum, *Sciaenops ocellatus*, in a large mesh Paralichthyidae gillnet fishery: experimental evaluation of a fisher's experience at limiting bycatch. Fisheries Management and Ecology 13: 1-7.

Burdick, S.M., J.E. Hightower, J.A. Buckel, L.M. Paramore and K.H. Pollock. 2007. Movement and selectivity of red drum and survival of adult red drum: an analysis of 20 years of tagging data. Completion Report. North Carolina Division of Marine Fisheries, Morehead City, NC. 85 p.

Buzzelli, C. P., R.A. Luettich Jr., S.P. Powers, C.H. Peterson, J.E. McNinch, J.L. Pinckney, and H.W. Paerl. 2002. Estimating the spatial extent of bottom water hypoxia and habitat degradation in a shallow estuary. Marine ecology progress series 230: 103-112.

Cahoon, L. B., M.H. Posey, T.D. Alphin, D. Wells, S. Kissling, W. H. Daniels, and J. Hales. 2002. Shrimp and crab trawling impacts on estuarine soft-bottom organisms. UNC-Wilmington, Wilmington, NC, 17p.

Carraway, R. J. and L.J. Priddy. 1983. Mapping of submerged grass beds in Core and Bogue Sounds, Carteret County, North Carolina, by conventional aerial photography. CEIP Report No. 20, 88p.

Chmura, G. L. and N.W. Ross. 1978. Environmental impacts of marinas and their boats. Rhode Island Sea Grant, Narragansett, RI, P675; RIU-T-78-005.

COE (US Army Corps of Engineers). 2001. The New York District's biological monitoring program for the Atlantic coast of New Jersey, Asbury Park to Manasquan section beach erosion control project. USACOE, Vicksburg, MS, Final report , 103p.

COE (US Army Corps of Engineers). 2003. Effects of dredged material beach disposal on surf zone and nearshore fish and benthic resources on Bald Head Island, Caswell Beach, Oak Island, and Holden Beach, North Carolina: Interim study findings. Versar, Inc., Columbia, Md.

Coen, L. D., M.W. Luckenbach, and D.L. Breitburg. 1999. The role of oyster reefs as essential fish habitat: a review of current knowledge and some new perspectives. p. 438-454 *in* L.R. Benaka (ed). Fish habitat: Essential fish habitat and rehabilitation. American Fisheries Societs, Bethesda, Md, Symposium 22, 459 p.

Collie, J. S., G.A. Escanero, and P.C. Valentine. 1997. Effects of bottom fishing on the benthic megafauna of Georges Bank. Marine Ecology Progress Series 155: 159-182.

Connell, B. and T. Murphey. 2004. A preliminary evaluation on the effects of dock shading on density and coverage of shoal grass (*Halodule wrightii*). DENR, DMF, Morehead City, NC, 13p.

Cooper, S. R. and G.S. Brush. 1991. A 2500 year history of anoxia and eutrophication in the Chesapeake Bay. Science 254: 992-1001.

Cross, F. A., D.S. Peters, and W.E. Schaaf. 1985. Implications of waste disposal in coastal waters on fish populations. Aquatic Toxicology and Hazard Assessment: Seventh Symposium, American Society for Testing and Materials, Philadelphia, PA. 383-399.

Currie, D. R. and G.D. Parry. 1996. Effects of scallop dredging on a soft sediment community: a large-scale experimental study. Marine Ecological Progress Series. 134: 131-150.

Dahl, T. E. 1990. Wetlands - losses in the United States, 1780's to 1980's. U.S. Fish and Wildlife Service, Washington, D.C., Report to Congress, 13p.

Daniel, L. B. III. 1988. Aspects of the biology of juvenile red drum, *Sciaenops ocellatus* and spotted seatrout, *Cynoscion nebulosus* (Pisces: Sciaenidae) in South Carolina. M. S. Thesis, College of Charleston, 58 p.

Dauer, D. M., J.A. Ranasinghe, and S.B. Weisberg. 2000. Relationships between benthic community condition, water quality, sediment quality, nutrient loads, and land use patterns in Chesapeake Bay. Estuaries 23(1): 80-96.

Davis, G. J. and M.M. Brinson. 1990. A survey of submersed aquatic vegetation of the Currituck Sound and the Western Albemarle-Pamlico estuarine system. DNRCD, Albermarle-Pamlico Estuarine Study Project No. 89-10, 135p.

DEHNR (NC Dept. of Environment Health and Natural Resources). 1990. North Carolina coastal marinas: water quality assessment. DEHNR, Raleigh, NC, 90-01, 69p.

DMF (North Carolina Division of Marine Fisheries). 1990. Justification for submerged aquatic vegetation critical habitat designation. DMF , Unpub. rep. 15p.

DMF (North Carolina Division of Marine Fisheries). 2001a. North Carolina oyster fishery management plan. N.C. Department of Environment and Natural Resources, Division of Marine Fisheries, 225 p.

DMF (North Carolina Division of Marine Fisheries). 2006. North Carolina shrimp fishery management plan. NC DMF, Morehead City, NC.

Donoghue, C. R. 1999. The influence of swash processes on *Donax variabilis* and *Emerita talpoida*. PhD Dissertation, University of Virginia, Charlottesville, Va, 197 p.

Durako, M. J. 1994. Seagrass die-off in Florida Bay (USA): changes in shoot demographic characteristics and population dynamics in *Thalassia testudinum*. Marine Ecology Progress Series 110: 59-66.

DWQ (North Carolina Division of Water Quality). 2000a. Water quality progress in North Carolina in 1998-1999, 305(b) report. DENR, Division of Water Quality, Raleigh, NC, 34p.

DWQ (North Carolina Division of Water Quality). 2000b. A citizen's guide to water quality management in North Carolina. DENR, Div. Water Quality, Planning Branch, Raleigh, NC, 156p.

DWQ (North Carolina Division of Water Quality). 2002a. Neuse River Basinwide Water Quality Plan. N.C. Department of Environment and Natural Resources, Raleigh, NC, http://h20.enr.state.nc.us/nepp.

DWQ (North Carolina Division of Water Quality). 2002b. Pasquotank River Basinwide Water Quality Plan. N.C. Department of Environment and Natural Resources, Raleigh, NC, http://h20.enr.state.nc.us/nepp.

DWQ (North Carolina Division of Water Quality). 2003. Lumber River Basinwide Water Quality Plan. N.C. Department of Environment and Natural Resources, Raleigh, NC, http://h20.enr.state.nc.us/nepp.

DWQ (North Carolina Division of Water Quality). 2004. Tar-Pamlico River Basinwide Water Quality Plan. N.C. Department of Environment and Natural Resources, Raleigh, NC, http://h20.enr.state.nc.us/nepp.

DWQ (North Carolina Division of Water Quality). 2005. Cape Fear River Basinwide Water Quality Plan. N.C. Department of Environment and Natural Resources, Raleigh, NC, http://h20.enr.state.nc.us/nepp.

DWQ (North Carolina Division of Water Quality). 2006. Annual report of fish kill events, 2006. Division of Water Quality, Raleigh, NC.

DWQ (North Carolina Division of Water Quality). 2007. White Oak River basinwide water quality plan. N.C. Department of Environment and Natural Resources, Raleigh, NC.

Dyer, K. R. and R.J. Orth. 1994. Changes in fluxes in estuaries: implications from science to management. Olsen and Olsen, Fredenburg, Denmark.

Eby, L., L. Crowder, and C. McClellan. 2000. Neuse River estuary modeling and monitoring project Stage 1: effects of water quality on distribution and composition of the fish community. Water Resources Research Institute, Raleigh, NC, Report N. 325-C, 2p.

EEP (Ecosystem Enhancement Program). 2006. 2005-2006 Annual report. EEP, Raleigh, NC, 17p.

EPA (U.S. Environmental Protection Agency). 2001. Hydromodification chapter factsheet. http://www.epa.gov/OWOW/NPS/MMGI/hydro.html, 12/2001.

Feierabend, S. J. and J.M. Zelazny. 1987. Status report on our nation's wetlands. National Wildlife Federation, Washington, D.C., 50p.

Ferguson, R. L. and L.L. Wood. 1994. Rooted vascular aquatic beds in the Albemarle-Pamlico estuarine system. NMFS, NOAA, Beaufort, NC, Project No. 94-02, 103 p.

Fonseca, M. S. 1996a. The role of seagrasses in nearshore sedimentary processes: a review. p. 261-286 *in* C. Roman and K. Nordstrom (eds). Estuarine Shores: Hydrological, Geomorphological and Ecological Interactions. Blackwell, Boston, MA.

Funderburk, S. L., J.A. Mihursky, S.J. Jordan, and D. Riley. 1991. Habitat requirements for Chesapeake Bay living resources. Habitat Objectives Workgroup, Living Resources Subcommittee and Chesapeake Research Consortium with assistance from Maryland Department of Natural Resources, Solomons, MD.

Garbisch, E. W., P.B. Woller, W.J. Bostian, and R.J. McCallum. 1973. Biotic techniques for shore stabilization. p. 405-407 *in* L.E. Cronin (ed.). Estuarine Research. Academic Press Inc., New York, NY, II.

Gearhart J. 2001. Sea turtle bycatch monitoring of the 2000 fall flounder gillnet fishery of southeastern Pamlico Sound, North Carolina. Completion Report for ITP 1259. North Carolina Department of Environment and Natural Resources, Division of Marine Fisheries. 26pp.

Goldsborough, W. J. and W.M. Kemp. 1988. Light responses of submersed macrophytes: implication for survival in turbid waters. Ecology 69: 1775-1786.

Grabowski, J. H., D. Pettipas, M.A. Dolan, A.R. Hughes, and D.L. Kimbro. 2000. The economic and biological value of restored oyster reef habitat to the nursery function of the estuary. NC Sea Grant, Morehead City, NC, FRG # 97-EP-6, 29p.

Graff, L. and J. Middleton. 2003. Wetlands and fish: catch the link. NOAA, National Marine Fisheries Service, Silver Springs, MD, 48p.

Gray, J. S., R. S. Wu, and Y.Y. Or. 2002. Effects of hypoxia and organic enrichment on the coastal marine environment. Marine Ecology Progress Series 238: 249-279.

Guthrie, J. F. and C. W. Lewis. 1982. The clam-kicking fishery of North Carolina. Marine Fisheries Review 44(1): 16-21.

Haab, T. , J. Whitehead, and Ted McConnell. The Economic Value of Marine Recreational Fishing in the Southeast United States: 1997 Southeast Economic Data Analysis., National Marine Fisheries Service, Southeast Regional Office, St. Petersburg, FL. 2000.

Hackney, C. T., J. Grimley, M. Posey, T. Alphin, and J. Hyland. 1998. Sediment contamination in North Carolina's estuaries. Center for Marine Science Research, UNC-W, Wilmington, NC, Publication #198, 59p.

Hackney, C. T., M.H. Posey, S.W. Ross, and A.R. Norris. 1996. A review and synthesis of data on surf zone fishes and invertebrates in the South Atlantic Bight and the potential impacts from beach renourishment. Prepared for Wilmington District, US Army Corps of Engineers. UNC-Wilmington, Wilmington, NC, 111 p.

Hare, J. O., J.A. Quinlan, F.E. Werner, B.O. Blanton, J.J. Govini, R.B. Forward, L.R. Settle, and D.E. Hoss. 1999. Larval transport during winter in the SABRE study area: results of a coupled vertical larval behavior-three-dimensional circulation model. Fisheries Oceanography. 8(2): 57-76.

Hassell, J. 2007. Characterization of flounder gill net fishing techniques and bycatch in the Pamlico river. North Carolina Sea Grant Fishery Research Grant Program, Final Report 06-FRG-04. 52 p.

Hawkins, J. H. 1980. Investigations of anadromous fishes of the Neuse River, North Carolina. DMF, Morehead City, NC, Special Science Report No. 34, 111p.

Heath, R. C. 1975. Hydrology of the Albemarle-Pamlico region, North Carolina: a preliminary report on the impact of agricultural developments. US Geological Survey Water Resources Investigations 80(44): 1-85.

Hettler, W. F. and A.J. Chester. 1990. Temporal distribution of ichthyoplankton near Beaufort Inlet, North Carolina. Marine Ecology Progress Series 68: 157-168.

Holt, S. A., G.J. Holt, and C.R. Arnold. 1989. Tidal stream transport of larval fishes into non-stratified estuaries. p. 100-104 *in* J.H.S. Blaxter, J. C. Gamble J. Westernhagen. The early life history of fish. The third ICES Symposium, Bergen, 3-5 October 1988. International Council for the Exploration of the Sea, Bergen.

Iannuzzi, T. J., M.P. Weinstein, K.G. Sellner, and J.C. Barrett. 1996. Habitat disturbance and marina development: An assessment of ecological effects. I. Changes in primary production due to dredging and marina construction. Estuaries 19(2A): 257-271.

IMPLAN PRO version 2.0 (2000). Stillwater, MN: Minnesota IMPLAN Group.

IPPC (Intergovenrmental Panel on Climate Change). 2002. Climate Change 2001: Synthesis report. Cambridge University Press, Cambridge, England.

Johnson, J. C., and M. K. Orbach. 1996. Effort management in North Carolina fisheries: a total systems approach. Fisheries Research Reports to the Fisheries Moratorium steering

Committee, North Carolina Sea Grant College Program, UNC-SG-96-08, Institute for Coastal and Marine Resources East Carolina University, Technical Report 96-07.

Jutte, P. C., R.F.Van Dolah, and M.V.Levison . 1999. An environmental monitoring study of the Myrtle Beach renourishing project: intertidal benthic community assessment. Phase II-Myrtle Beach. Final Report, prepared by Marine Resources Division; submitted to US Army Corps of Engineers. SC Department of Natural Resources, Charleston, SC, 34p.

Kenworthy, W. J. and D.E. Haunert. 1991. The light requirements of seagrasses: proceedings of a workshop to examine the capability of water quality criteria, standards and monitoring progress to protect seagrasses. National Oceanic and Atmospheric Administration, Beaufort, NC, Tech. Memo. NMFS-SEFC-287, 181p.

Kirby, J., W. Maher, and F. Krikowa. 2001. Selenium, cadmium, copper, and zinc concentrations in sediments and mullet (*Mugil cephalus*) from the southern basin of Lake Macquarie, NSW Australia. Archives of environmental contamination and toxicology 40(2): 246-256.

Knutson, P. L. 1977. Planting guidelines for marsh development and bank stabilization. US Army Corps of Engineering Research Center, Fort Belvoir, Va.

Laney, R. W. 1997. The relationship of submerged aquatic vegetation (SAV) ecological value to species managed by the Atlantic States Marine Fisheries Commission (ASFMC): Summary for the ASMFC SAV Subcommittee. In Atlantic coastal submerged aquatic vegetation: a review of its ecological role, anthropogenic impacts, state regulation, and value to Atlantic coastal fisheries (C.D. Stephan and T.E. Bigford, editors). ASFMC Habitat Management Series #1, 78 p.

Lenihan, H. S., and C. H. Peterson. 1998. How habitat degradation through fishery disturbance enhances impacts of hypoxia on oyster reefs. Ecological Applications 8(1): 128-140.

Levin. P.S. and G.W. Stunz. 2005. Habitat triage for exploited fishes: Can we identify essential "Essential Fish Habitat?". Estuarine, Coastal and Shelf Science 64: 70-78.

Lindquist, N. and L. Manning. 2001. Impacts of beach nourishment and beach scraping on critical habitat and productivity of surf fishes. NC Division of Marine Fisheries, Fisheries Resource Grant 98-EP-05: 41 .

Llanso, R. J., S.S. Bell, and F.E. Vose. 1998. Food habits of red drum and spotted seatrout in a restored mangrove impoundment. Estuaries 21(2): 294-306.

Loflin, R. K. 1995. The effects of docks on seagrass beds in the Charlotte Harbor estuary. Florida Scientist 58(2): 198-205.

Lowerre-Barbieri, S.K., F.E. Vose and J.A. Whittington. 2003. Catch-and-release fishing on a spawning aggregation of common snook: does it affect reproductive output? Transactions of the American Fisheries Society. 139: 940-952.

Luckenbach, M. W. and P.G. Ross. 2003. An experimental evaluation of the effects of scale on oyster restoration. A final report to VA Sea Grant Consortium. 120p.

Luczkovich, J. J., H. J. Daniel, III, and M. W. Sprague. 1999. Characterization of critical spawning habitats of weakfish, spotted seatrout and red drum in Pamlico Sound using hydroplane surveys. Completion Report, F-62, NC Division of Marine Fisheries, Morehead City, NC. 128 p.

Luettich, R. A., J.E. McNinch, J.L. Pinckney, M.J. Alperin, C.S. Martens, H.W. Paerl, C.H. Peterson, and J.T. Wells. 1999. Neuse River estuary modeling and monitoring project, final report: Monitoring phase. Water Resources Research Institute, Raleigh, NC, 190p.

Lyon, D. D. and M. R. Fisher. 1998. Temperature and pH-related mortality of red drum larvae in fertilized culture ponds. Progressive Fish-Culturist 60(3): 227-230.

Mallin, M. A., K.E. Williams, E.C. Esham, and R.P. Lowe. 2000b. Effect of human development on bacteriological water quality in coastal watersheds. Ecological Applications 10(4): 1047-1056.

Marburger, J. E., W.E. Johnson, T.S. Gross, D.R. Douglas, and J. Di. 2002. Residual organochlorine pesticides in soils and fish from wetland restoration areas in central Florida. Wetlands 22(4): 705-711.

Marcus, J. M. and T.P. Stokes. 1985. Polynuclear aromatic hydrocarbons in oyster tissue around three coastal marinas. Bulletin of Environmental Contamination and Toxicology 35: 835-844.

Marks, R. E., and G. DiDominico, 1996. Life History Aspects of Selected Marine Recreational Fishes in North Carolina. Tagging Studies, Maturity, and Spawning of Red Drum (*Sciaenops ocellatus*) in North Carolina. Completion Report F-43, Segment 1, NC Division of Marine Fisheries, Marine Fisheries, Morehead City, NC 38 p.

Meeder, J. F. and L.B. Meeder. 1989. Hurricanes in Florida: a dominant physical process. Bulletin of Marine Science 44(1).

MFC (North Carolina Fisheries Commission) 1997. North Carlina fisheries rules for coastal waters 1999-2000. NC Division of Marine Fisheries, Morehead City, NC. 206 p.

Mercer, L. P. 1984. A biological and fisheries profile of red drum, *Sciaenops ocellatus*. North Carolina Division of Marine Fisheries. Special Scientific Report 41. Morehead City, NC.

Meyer, D. L., E.C. Townsend, and P.L. Murphey. 1996. Final report for the project evaluation of restored wetlands and enhancement methods for existing restorations. National Oceanic and Atmospheric Administration, Office of Habitat Conservation Restoration Center, Silver Springs, MD.

Micheli, F. M. and C. H. Peterson. 1999. Estuarine vegetated habitats as corridors for predator movement. Conservation Biology 13(4): 869-881.

Miller, J. M., L.B. Crowder, and M.L. Moser. 1985. Migration and utilization of estuarine nurseries by juvenile fishes: an evolutionary perspective. p. 338-352 *in* M.A. Rankin (ed.). Migration: mechanisms and adaptive significance. Contributions to Marine Science (Supplement). 27.

Mitsch, W. J. and J.G. Gosselink. 1993. Wetlands, Second Edition. Van Nostrand Reinhold, New York, NY, Second Edition, 772p.

Mock, C. R. 1966. Natural and altered estuarine habitats of penaeid shrimp. Proceedings Gulf Caribbean Fish Institute 19th Annual Session. 86-98.

Montgomery, J. 2003. What effect does setting a flounder net close to the marsh have on the incidental by catch of red drum? North Carolina Sea Grant Fishery Research Grant Program, Final Report, Final Report 02-FEG-18. 13 p.

Moore, J. W. 1991. Inorganic contaminants of surface water, research and monitoring priorities. Springer-Verlag, New York, NY, Springer series on environmental management. 334p.

Moore, L. J., J.H. List, D. Stolper, and S.J. Williams. 2006. Modeling the large-scale morphodynamics of barrier island coasts under conditions of rising sea level. EOS Transactions, American Geophysical Union 87 (36 supp).

Music, J. L., Jr., and J. M. Pafford. 1984. Population dynamics and life history aspects of major marine sportfishes in Georgia's coastal waters. Georgia Dept. of Natural Resources, Coastal Resources Division, Coastal Fisheries Section, Final Report Study VI F-31, 382 p.

Neill, W. H. 1987. Environmental requirements of red drum. In G.W. Chamberlain, R. J. Miget and M. G. Haby (eds.), Manual on Red Drum Aquaculture. Preliminary draft of invited papers presented at the Production Short course of the 1987 Red Drum aquaculture Conference on 22-24 June, 1987 in Corpus Christi, Texas A&M University, College Station.

North Carolina Coastal Federation (NCCF). 1997. State of the Coast Report 15(4). 19p.

North Carolina Division of Marine Fisheries (NCDMF). 1998. Blue Crab Public Information Document. Morehead City, NC.

North Carolina Division of Marine Fisheries (NCDMF). 2001. Red Drum Fishery Management Plan. North Carolina Division of Marine Fisheries, Morehead City, NC. 110 p. + appendices.

North Carolina Sea Grant. 1997. Coastal water quality. NC State University, Raleigh, NC, UNC-SG-97-04 , 72 p.

Orth, R. J., J. Simons, J. Capelli, V. Carter, L. Hindman, S. Hodges, K. Moore, and N. Rybicki. 1986. Distribution of submerged aquatic vegetation in the Chesapeake Bay and tributaries - 1985. US EPA, Washington, DC, Final report.

Paerl, H., M. M. Mallin, C. A. Donahue, M. Go, and B. L. Peierls. 1995. Nitrogen loading sources and eutrophication of the Neuse River, NC: direct and indirect roles of atmospheric deposition. Publication 291. Water Resources Research Institute, UNC, Chapel Hill, NC.

Pate, P. P., Jr., and R. Jones. 1981. Effects of upland drainage on estuarine nursery areas of Pamlico Sound, North Carolina. UNC Sea Grant Pub. No. UNC-SG-WP-10. 24 p.

Pearsall, S. and B. Poulter. In press. Adapting coastal lowlands to rising seas. *in* M. Groom, ed. Principles of Conservation Biology . Sinauer Press.

Pearson, J. C. 1929. Natural history and conservation of the redfish and other commercial sciaenids on the Texas coast. Bulletin of the U.S. Bureau of Fisheries. 44:129-214.

Peters, D. S., L.R. Settle, and J.D. Fuss. 1995. Larval fish abundance in the vicinity of Beaufort Inlet prior to berm construction. NMFS, Beaufort, NC, NMFS Progress Report , 20 p.

Peters, K. M. and J. R.H. McMichael. 1987. Early life history of the red drum, *Sciaenops ocellatus* (Pisces: Sciaenidae) in Tampa Bay, Florida. Estuaries 10(2): 92-107.

Peterson, B. J. and R.W. Howarth. 1987. Sulfur, carbon, and nitrogen isotopes used to trace organic matter flow in the salt-marsh estuaries of Sapelo Island, Georgia. Limnology and Oceanography 32(6): 1195-1213.

Peterson, C. H., J.H. Grabowski, and S.P. Powers. 2003. Quantitative enhancement of fish production by oyster reef habitat: restoration valuation. Marine Ecology Progress Series 264: 249-264.

Peterson, C. H. and N.M. Peterson. 1979. The ecology of intertidal flats of North Carolina: A community profile. U.S. Fish and Wildlife Service, OBS-79/39, 73 p.

Peterson, M. S., B.H. Comyns, J.R. Hendon, P.J. Bond, and G.A. Duff. 2000c. Habitat use by early life-stages of fishes and crustaceans along a changing estuarine landscape: difference between natural and altered shoreline sites. Wetland, Ecology, and Management 8(2-3): 209-219.

Powell, A. B. and R.E. Robbins. 1998. Ichthyoplankton adjacent to live-bottom habitats in Onslow Bay, North Carolina. NOAA , Seattle, Washington, Tech. Rep. NMFS 133, 32p.

Powers, M. J. and D. Gaskill. 2004. Recruitment, growth, and habitat utilization of red drum *Sciaenops ocellatus*, in North Carolina estuaries. North Carolina Sea Grant Extension Program, FRG project #00-EP-04 , 40p.

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

Price, A. B. and J.L. Gearhart. 2002b. Large Mesh (≥ 5-inch) Gillnet Discard Mortality of Spotted Seatrout (*Cynoscion nebulosus*), Weakfish (*Cynoscion regalis*), Southern Flounder (*Paralichthys lethostigma*), and Red Drum (*Sciaenops ocellata*) in Roanoke Sound, Core Sound, and the Neuse River, North Carolina. North Carolina Division of Marine Fisheries, Morehead City, North Carolina.

Rakocinski, C., S.E. LeCroy, J.A. McLelland, and R.W. Heard. 1993. Responses by macroinvertebrate communities to beach renourishment at Perdido Key, Florida: benthic recovery. US Dept. of the Interior, National Park Service.

Reagan, R. E. 1985. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Gulf of Mexico) – red drum. US Fish and Wildlife Service, Washington, DC. Biological Report 82 (11.36). 16 p.

Reilly, F. J. Jr. and B.J. Bellis. 1983. The ecological impact of beach nourishment with dredged materials on the intertidal zone at Bogue Banks, North Carolina. U.S. Army Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, VA.

Riggs, S. R. 1996. Sediment evolution and habitat function of organic-rich muds within the Albemarle estuarine system, North Carolina. Estuaries 19(2A): 169-185.

Riggs, S. R., E.R. Powers, J. T. Bray, P.M. Stout, C. Hamilton, D. Ames, R. Moore, J. Watson , S. Lucas, and M. Williamson. 1989. Heavy metal pollutants in organic rich muds of the Pamlico River estuarine system: their concentration, distribution, and effects upon benthic environments and water quality: Albemarle-Pamlico Estuarine Study. Project No. 89-06. US EPA and NC DNRCD, Raleigh, NC, 108p.

Riggs, S. R., J.T. Bray, E.R. Powers, C. Hamilton, D. Ames, D. Yeates, K. Owens, S. Lucas, J. Watson, and M. Williamson. 1991. Heavy metal pollutants in organic-rich muds of the Neuse River Estuary: their concentration and distribution. Albemarle-Pamlico Estuarine Study Report. Project no. 90-07. DENR, Raleigh, 168p.

Rooker, J. R., G. J. Holt, S. A. Holt. 1998. Vulnerability of newly settled red drum (*Sciaenops ocellatus*) to predatory fish: Is early-life survival enhanced by seagrass meadows? Marine Biology 131(1): 145-151.

Rooker, J. R., S.A. Holt, G.J. Holt, and L.A. Fuiman. 1999. Spatial and temporal variability in growth, mortality, and recruitment potential of postsettlement red drum, *Sciaenops ocellatus*, in a subtropical estuary. Fisheries Bulletin 97(3): 581-590.

Ross, J. L., and T. M. Stevens. 1992. Life history and population dynamics of red drum (*Sciaenops ocellatus*) in North Carolina waters. NC Division of Marine Fisheries, Marine Fisheries Research Completion Report Project F-29, , 130 p.

Ross, J. L., T. M. Stevens, and D. S. Vaughan. 1995. Age, growth, mortality, and reproductive biology of red drums in North Carolina waters. Trans. Am. Fish. Soc. 124:37-54.

Rozas, L. P. and W.E. Odum. 1987. The role of submerged aquatic vegetation in influencing the abundance of nekton on contiguous tidal freshwater marshes. Journal of Experimental Marine biology and Ecology 114(2-3): 289-300.

Scharf, F. S. 2000. Patterns in abundance, growth, and mortality of juvenile red drum across estuaries on the Texas coast with implications for recruitment and stock enhnacement. Transactions of the American Fisheries Society 129: 1207-1222.

Schoof, R. 1980. Environmental impact of channel modification. Water Resources Bulletin 16(4): 697-701.

Shafer, D. J. 1999. The effects of dock shading on the seagrass *Halodule wrightii* in Perdido Bay, Alabama. Estuaries 22(4): 936-943.

Simmons and Breuer, 1962. A study of redfish (*Sciaenops ocellatus* Linnaeus) and black drum (*Pogonias cromis* Linnaeus). Publications of the Institute of Marine Science, University of Texas 8:184-211.

South Atlantic Fishery Management Council (SAFMC). 1990. The Atlantic coast red drum fishery management plan, including an environmental impact statement and regulatory impact review. SAFMC, Charleston, SC in cooperation with MAFMC, Dover, Delaware, 106 p.

South Atlantic Fishery Management Council (SAFMC). 1998. Final habitat plan for the south Atlantic region: essential fish habitat requirements for fishery management plans of the South Atlantic Fishery Management Council. SAFMC, Charleston, SC, 457 p.

Stevenson, J. C., L.W. Staver, and K.W. Staver. 1993. Water quality associated with survival of submerged aquatic vegetation along an estuarine gradient. Estuaries 16(346-361).

Stewart, C. B. 2006. Spatial and temporal variability in recruitment timing, relative abundance, and mortality of juvenile red drum (*Sciaenops ocellatus*) in southeastern North Carolina. MS, UNC-W, University of North Carolina Wilmington, 69 p.

Street, M. W., A.S. Deaton, W.S. Chappell, and P.D. Mooreside. 2005. North Carolina Coastal Habitat Protection Plan. DENR, DMF, Morehead City, 607p.

Stunz, G. W., P. S. Levin, and T.J. Minello. 2001. Selection of estuarine nursery habitats by wild-caught and hatchery-reared juvenile red drum in laboratory mesocosms. Environmental Biology of Fishes 61(3): 305-313.

Stunz, G. W. and T.J. Minello. 2001. Habitat-related predation on juvenile wild-caught and hatchery-reared red drum *Sciaenops ocellatus*. Journal of Experimental Marine Biology and Ecology 260(1): 13-25.

Stunz, G. W., T.J. Minello, and P.S. Levin. 2002. A comparison of early juvenile red drum densities among various habitat types in Galveston Bay, Texas. Estuaries 25(1): 76-85.

Sutter, L. 1. 1999. DCM wetland mapping in coastal North Carolina. DENR, Raleigh NC, 33p.

Takade, H. and L.M. Paramore. 2007. Stock status of the northern red drum stock. North Carolina Division of Marine Fisheries, Morehead City, NC. 47 p. + appendices.

Tarplee, W. H. Jr., D.E. Louder, and A.J. Weber . 1971. Evaluation of the effects of channelization on fish populations in North Carolina's coastal plain streams. North Carolina Wildlife Resources Commission, Raleigh, NC.

Tenore, K. R. 1972. Macrobenthos of the Pamlico River estuary, North Carolina. Ecological Monographs 42: 51-69.

Thayer, G. W., W. Kenworthy, and M. Fonseca. 1984. The ecology of eelgrass meadows of the Atlantic Coast: a community profile. FWS/OBS-84/02. 147 p.

Thorpe, T., D. Beresoff, and K. Cannady. 2001. Gillnet bycatch potential, discard mortality, and condition of red drum (*Sciaenops ocellatus*) in southeastern North Carolina. Final Report to the Marine Fisheries Commission, Fishery Resource Grant Program. 00-FEG-14. 72 p.

Thorpe, T., D. Beresoff. 2005. Effects of gillnet tie-downs on fish and bycatch rates associated with American shad (*Alosa sapidissima*) and flounder (*Paralichthys spp*.) fisheries in southeastern North Carolina. Final Report to Marine Fisheries Commission, North Carolina Sea Grant 04-FEG-03. 111 p.

Twilley, R. R., W.M. Kemp, K.W. Staver, J.C. Stevenson, and W.R. Boynton. 1985. Nutrient enrichment of estuarine submersed vascular plant communities. 1. Algal growth and effects on production of plants and associated communities. Marine Ecology Progress Series 23: 179-191.

Van Dolah, R. F., P. H. Wendt, and M. V. Levisen. 1991. A study of the effects of shrimp trawling on benthic communities in two South Carolina sounds. Fisheries Research 12: 139-156.

Van Dolah, R. F., P. P. Maier, M. H. Fulton, and G. I. Scott. 1997. Comparison of azinphosmethyl toxicity to juvenile red drum (*Sciaenops ocellatus*) and the mummichog (*Fundulus heteroclitus*). Environmental Toxicology and Chemistry 16(7): 1488-1493.

Vaughan, D. S., and T. E. Helser. 1990. Status of the red drum stock of the Atlantic coast: Stock assessment report for 1989. NOAA Tech. Memo. NMFS-SEFC-263. 117 p.

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

Vaughan, D.S., and J. T. Carmichael. 2000. Assessment of Atlantic Red Drum for 1999: Northern and Southern Regions. NOAA Tech. Mem. NMFS-SEFSC-447.

Vaughan, D.S. and J.T. Carmichael. 2001. Bag and size limit analyses for red drum in northern and southern regions of the U. S. Atlantic. NOAA Technical Memorandum NMFS-SEFSC-454, 37 p.

Voudrias, E. A. and C.L. Smith. 1986. Hydrocarbon pollution from marinas in estuarine sediments. Estuarine Coastal Shelf Sciences 22: 271-284.

Wannamaker, C. M. and J.A. Rice . 2000. Effects of hypoxia on movements and behavior of selected estuarine organisms from the southeastern United States. Journal of Experimental Marine Biology and Ecology 249: 145-163.

Waters, C. T. and C.D. Thomas. 2001. Shoreline hardening effects on associated fish assemblages in five North Carolina coastal rivers. North Carolina Wildlife Resources Commission, Raleigh, NC, 20p.

Weinstein, M. P. 1979. Shallow marsh habitats as primary nurseries for fishes and shellfish, Cape Fear River, NC. Fisheries Bulletin 2: 339-357 .

Weinstein, M. P., S.L. Weiss, R.G. Hodson, and L.R. Gerry. 1980. Retention of three taxa of postlarval fishes in an intensively flushed tidal estuary, Cape Fear River, North Carolina. fishery Bulletin 78(2): 419-436.

Weis, J. S. and P. Weis. 1989. Effects of environmental pollutants on early fish development. Aquatic Sciences 1(1): 45-55.

Weis, J. S., P. Weis, and T. Proctor . 1998. The extent of benthic impacts of CCA-treated wood structures in Atlantic coast estuaries. Archives of Environmental Contamination and Toxicology 34(4): 313-322.

Wendt, P. H., R.F. Van Dolah, M.Y. Bobo, and J.J. Manzi. 1990. Effects of marina proximity on certain aspects of the biology of oysters and other benthic macrofauna in a South Carolina estuary. South Carolina Wildlife and Marine Resources Department, Charleston, SC, South Carolina Marine Resources Center Tech. Rep. No. 74, 49p.

Wenner, C. A., W. A. Roumillat, J. E. Moran, Jr., M. B. Maddox, L. B. Daniel, III, and J. W. Smith. 1990. Investigations on the life history and population dynamics of marine recreational fishes in South Carolina: Part 1. Final Rep., Proj. F-37, SC Wildl. Mar. Resour. Dept., Mar. Resour. Res. Inst., 180p.

White, K. 1996. Restoration of channelized streams to enhance fish habitat. http://www.ies.wisc.edu/research/ies900/kimchannelization.htm, Dec. 2003.

Yokel, B. 1966. A contribution to the biology and distribution of red drum, *Sciaenops ocellata.* MS Thesis. University of Miami, Miami.

Zieman, J. C. 1982. The ecology of seagrasses of south Florida: a community profile. US Fish and Wildlife Service, Washington, DC. FWS/OBS-82/25. 123 p.

Appendix 1 – Rule Changes Necessary to Implement Red Drum FMP Amendment One.

RULES NECESSARY TO IMPLEMENT RED DRUM FMP AMENDMENT MANAGEMENT STRATEGIES SELECTED BY THE MFC

Changes to implement Red Drum FMP Amendment are underlined and highlighted.

Issue: **Recreational Targeting of Adult Red Drum**

SUBCHAPTER 03J - NETS, POTS, DREDGES, AND OTHER FISHING DEVICES
SECTION .0300 – POTS, DREDGES, AND OTHER FISHING DEVICES

NEW RULE PROPOSED
15A NCAC 03J .0306 HOOK-AND-LINE
It is unlawful to use any hook larger than 4/0 from July 1 through September 30 in the internal coastal fishing waters of Pamlico Sound and its tributaries south of the Albemarle Sound Management Area as defined in 15A NCAC 03R .0201 and north of a line beginning at a point 34° 59.7942' N - 76° 14.6514'
W on Camp Point; running easterly to a point at 34° 58.7853' N - 76° 09.8922' W on Core Banks while using natural bait from 7:00 p.m. to 7:00 a.m. unless the terminal tackle consists of:

(1) A circle hook defined as a hook with the point of the hook directed perpendicularly back toward the shank, and with the barb either compressed or removed.
(2) A fixed sinker not less than two ounces in weight, secured not more than six inches from the fixed weight to the circle hook.

History Note: Authority G.S. 113-182; 113-182.1; 143B-289.52.
Eff.???

Issues: **Recreational Bag and Size Limit**
Commercial Cap and Fishing Year
The Use of Gigs, Gaffs or Spears to take Red Drum

SUBCHAPTER 03M - FINFISH
Section .0500 – other finfish

15A NCAC 03M .0501 RED DRUM
~~(a) The Fisheries Director, may by proclamation, impose any or all of the following restrictions on the taking of red drum:~~

~~(1) Specify areas.~~
~~(2) Specify seasons.~~
~~(3) Specify quantity.~~
~~(4) Specify means/methods.~~
~~(5) Specify size.~~

~~(b)~~(a) It is unlawful to remove red drum from any type of net with the aid of any boat hook, gaff, spear, gig, or similar device.
(b) It is unlawful to take or possess red drum taken by gigs, gaffs ,spears, or similar device.
~~(c)~~(b)(c) It is unlawful to possess red drum less than 18 inches total length or greater than 27 inches total length.

~~(d)~~(c)(d) It is unlawful to possess more than one red drum per person per day taken-by hook-and-line or for recreational purposes.
~~(e)~~(d)(e) The annual commercial harvest limit (September 1 through August 31) for red drum is 250,000 pounds. The annual commercial harvest limit will be allotted in two periods: September 1 through April 30 at 150,000 pounds, and May 1 through August 31 at 100,000 pounds plus any remainder from the first period allotment. Any annual commercial harvest limit that is exceeded one year will result in the poundage overage being deducted from the subsequent year's commercial harvest limit and the Fisheries Director shall adjust the period allotments accordingly. If the harvest limit is projected to be ~~taken,~~ taken in any period, the Fisheries Director shall, by proclamation, prohibit possession of red drum taken in a commercial fishing ~~operation.~~ operation for the remainder of that period.

History Note: *Authority G.S. 113-134; 113-182; 113-221; 143B-289.52;*
Eff. January 1, 1991;

Issues: **Estuarine Gill Net Discarded Bycatch of Red Drum**

SUBCHAPTER 03J - NETS, POTS, DREDGES, AND OTHER FISHING DEVICES
SECTION .0100 - NET RULES, GENERAL
15A NCAC 03J .0103 GILL NETS, SEINES, IDENTIFICATION, RESTRICTIONS

(a) It is unlawful to use gill nets:
- (1) With a mesh length less than 2 ½ inches.
- (2) In internal waters from April 15 through December 15, with a mesh length 5 inches or greater and less than 5 ½ inches.

(b) The Fisheries Director may, by proclamation, limit or prohibit the use of gill nets or seines in coastal waters, or any portion thereof, or impose any or all of the following restrictions on the use of gill nets or seines:
- (1) Specify area.
- (2) Specify season.
- (3) Specify gill net mesh length.
- (4) Specify means/methods.
- (5) Specify net number and length.

(c) It is unlawful to use fixed or stationary gill nets in the Atlantic Ocean, drift gill nets in the Atlantic Ocean for recreational purposes, or any gill nets in internal waters unless nets are marked by attaching to them at each end two separate yellow buoys which shall be of solid foam or other solid buoyant material no less than five inches in diameter and no less than five inches in length. Gill nets, which are not connected together at the top line, are considered as individual nets, requiring two buoys at each end of each individual net. Gill nets connected together at the top line are considered as a continuous net requiring two buoys at each end of the continuous net. Any other marking buoys on gill nets used for recreational purposes shall be yellow except one additional buoy, any shade of hot pink in color, constructed as specified in this Paragraph, shall be added at each end of each individual net. Any other marking buoys on gill nets used in commercial fishing operations shall be yellow except that one additional identification buoy of any color or any combination of colors, except any shade of hot pink, may be used at either or both ends. The owner shall be identified on a buoy on each end either by using engraved buoys or by attaching engraved metal or plastic tags to the buoys. Such identification shall include owner's last name and initials and if a vessel is used, one of the following:
- (1) Owner's N.C. motor boat registration number, or
- (2) Owner's U.S. vessel documentation name.

(d) It is unlawful to use gill nets:
- (1) Within 200 yards of any pound net set with lead and either pound or heart in use, except from August 15 through December 31 in all coastal fishing waters of the Albemarle Sound, including its tributaries to the boundaries between coastal and joint fishing waters, west of a line beginning at a point 36° 04.5184' N - 75° 47.9095' W on Powell Point; running southerly to a point 35° 57.2681' N - 75° 48.3999' W on Caroon Point, it is unlawful to use gill nets within 500 yards of any pound net set with lead and either pound or heart in use;

(2) From March 1 through October 31 in the Intracoastal Waterway within 150 yards of any railroad or highway bridge.

(e) It is unlawful to use gill nets within 100 feet either side of the center line of the Intracoastal Waterway Channel south of the entrance to the Alligator-Pungo River Canal near Beacon "54" in Alligator River to the South Carolina line, unless such net is used in accordance with the following conditions:

(1) No more than two gill nets per vessel may be used at any one time;

(2) Any net used must be attended by the fisherman from a vessel who shall at no time be more than 100 yards from either net; and

(3) Any individual setting such nets shall remove them, when necessary, in sufficient time to permit unrestricted boat navigation.

(f) It is unlawful to use drift gill nets in violation of 15A NCAC 03J .0101(2) and Paragraph (e) of this Rule.

(g) It is unlawful to use unattended gill nets with a mesh length less than five inches in a commercial fishing operation in the gill net attended areas designated in 15A NCAC 03R .0112(a).

(h) It is unlawful to use unattended gill nets with a mesh length less than five inches in a commercial fishing operation from May 1 through ~~October 31~~ November 30 in the internal coastal and joint waters of the state designated in 15A NCAC 03R .0112(b).

(i) ~~It is unlawful to use more than 3,000 yards of gill net with a mesh length 5 1/2 inches or greater per vessel in internal waters regardless of the number of individuals involved.~~ For gill nets with a mesh length five inches or greater, it is unlawful:

(1) To use more than 3,000 yards of gill net per vessel in internal waters regardless of the number of individuals involved.

(2) From June through October, for any portion of the net to be within 10 feet of any point on the shoreline while set or deployed, unless the net is attended.

(j) For the purpose of this Rule and 15A NCAC 03R .0112, shoreline is defined as the mean high water line or marsh line, whichever is most seaward.

History Note: *Authority G.S. 113-134; 113-173; 113-182; 113-221; 143B-289.52;*
Eff. January 1, 1991;
Amended Eff. August 1, 1998; March 1, 1996; March 1, 1994; July 1, 1993; September 1, 1991;
Temporary Amendment Eff. October 2, 1999; July 1, 1999; October 22, 1998;
Amended Eff. April 1, 2001;
Temporary Amendment Eff. May 1, 2001;
Amended Eff. December 1, 2007; *September 1, 2005; August 1, 2004; August 1, 2002.*

SUBCHAPTER 03R - DESCRIPTIVE BOUNDARIES
SECTION .0100 - DESCRIPTIVE BOUNDARIES

03R .0112 ATTENDED GILL NET AREAS

(a) The attended gill net areas referenced in 15A NCAC 03J .0103 (g) are delineated in the following areas:

(1) Pamlico River, west of a line beginning at a point 35° 27.5768' N - 76° 54.3612' W on Ragged Point; running southwesterly to a point 35° 26.9176' N - 76° 55.5253' W on Mauls Point;

(2) Within 200 yards of any shoreline in Pamlico River and its tributaries east of the line beginning at a point 35° 27.5768' N - 76° 54.3612' W on Ragged Point; running southwesterly to a point 35° 26.9176' N - 76° 55.5253' W on Mauls Point; and west of a line beginning at a point 35° 22.3622' N - 76° 28.2032' W on Roos Point; running southerly to a point at 35° 18.5906' N - 76° 28.9530' W on Pamlico Point;

(3) Pungo River, east of the northern portion of the Pantego Creek breakwater and a line beginning at a point 35° 31.7198' N - 76° 36.9195' W on the northern side of the breakwater near Tooleys Point; running southeasterly to a point 35° 30.5312' N - 76°35.1594' W on Durants Point;

(4) Within 200 yards of any shoreline in Pungo River and its tributaries west of the northern portion of the Pantego Creek breakwater and a line beginning at a point 35° 31.7198' N - 76° 36.9195' W on the northern side of the breakwater near Tooleys Point; running southeasterly to a point 35° 30.5312' N - 76° 35.1594' W on Durants Point; and west of a line beginning at a point 35° 22.3622' N - 76°

28.2032' W on Roos Point; running southerly to a point at 35° 18.5906' N - 76° 28.9530' W on Pamlico Point;

(5) Neuse River and its tributaries northwest of the Highway 17 highrise bridge;

(6) Trent River and its tributaries;

(7) Within 200 yards of any shoreline in Neuse River and its tributaries east of the Highway 17 highrise bridge and ~~west of a line beginning at a point 34° 57.9116' N - 76° 48.2240' W on Wilkinson Point; running southerly to a point 34° 56.3658' N - 76° 48.7110' W on Cherry Point~~. south and west of a line beginning on Maw Point at a point 35° 09.0407' N – 76° 32.2348' W; running southeasterly near the Maw Point Shoal Marker "2" to a point 35° 08.1250' N - 76° 30.8532' W; running southeasterly near the Neuse River Entrance Marker "NR" to a point 35° 06.6212' N – 76° 28.5383' W; running southerly to a point 35° 04.4833' N - 76° 28.0000' W near Point of Marsh in Neuse River. In Core and Clubfoot creeks, the Highway 101 Bridge constitutes the attendance boundary.

(b) The attended gill net areas referenced in 15A NCAC 03J .0103 (h) are delineated in the following internal coastal and joint waters of the state south of a line beginning on Roanoke Marshes Point at a point 35° 48.3693' N - 75° 43.7232' W; running southeasterly to a point 35° 44.1710' N - 75° 31.0520' W on Eagles Nest Bay to the South Carolina State line:

(1) All primary nursery areas described in 15A NCAC 03R .0103, all permanent secondary nursery areas described in 15A NCAC 03R .0104, and no trawl areas described in 15A NCAC 03R .0106 (2),(4),(5), and (6);

(2) In the area along the Outer Banks, beginning at a point 35° 44.1710' N - 75° 31.0520' W on Eagles Nest Bay; running northwesterly to a point 35° 45.1833' N - 75° 34.1000' W west of Pea Island; running southerly to a point 35° 40.0000' N - 75° 32.8666' W west of Beach Slough; running southeasterly and passing near Beacon "2" in Chicamicomico Channel to a point 35° 35.0000' N - 75° 29.8833' W west of the Rodanthe Pier; running southwesterly ~~to a point 35° 32.6000' N - 75° 31.8500' W west of Salvo; running southerly~~ to a point 35° 28.4500' N - 75° 31.3500' W on Gull Island; running southerly to a point 35° 22.3000' N - 75° 33.2000' W near Beacon "2" in Avon Channel ; running southwesterly to a point 35° 19.0333' N - 75° 36.3166' W near Beacon "2" in Cape Channel; running southwesterly to a point 35° 15.5000' N - 75° 43.4000' W near Beacon "36" in Rollinson Channel; running southeasterly to a point 35° 14.9386' N - 75° 42.9968' W near Beacon "35" in Rollinson Channel; running southwesterly to a point 35° 14.0377' N - 75° 45.9644' W near a "Danger" Beacon northwest of Austin Reef; running southwesterly to a point 35° 11.4833' N - 75° 51.0833' W on Legged Lump; running southeasterly to a point 35° 10.9666' N - 75° 49.7166' W south of Legged Lump; running southwesterly to a point 35° 09.3000' N - 75° 54.8166' W near the west end of Clarks Reef; running westerly to a point 35° 08.4333' N - 76° 02.5000' W near Nine Foot Shoal Channel; running southerly to a point 35° 06.4000' N - 76° 04.3333' W near North Rock; running southwesterly to a point 35°01.5833' N – 76° 11.4500' W near Beacon "HL"; running southerly to a point 35° 00.2666' N - 76° 12.2000' W; running southerly to a point 34° 59.4664' N - 76° 12.4859' W on Wainwright Island; running easterly to a point 34° 58.7853' N - 76° 09.8922' W on Core Banks; running northerly along the shoreline and across the inlets following the Colregs Demarcation line to the point of beginning.

(3) In Core and Back sounds, beginning at a point 34° 58.7853' N - 76° 09.8922' W on Core Banks; running northwesterly to a point 34° 59.4664' N - 76° 12.4859' W on Wainwright Island; running southerly to a point 34° 58.8000' N - 76° 12.5166' W; running southeasterly to a point 34° 58.1833' N - 76° 12.3000' W; running southwesterly to a point 34° 56.4833' N - 76° 13.2833' W; running westerly to a point 34° 56.5500' N - 76°13.6166' W; running southwesterly to a point 34° 53.5500' N - 76° 16.4166' W; running northwesterly to a point 34° 53.9166' N - 76° 17.1166' W; running southerly to a point 34° 53.4166' N - 76° 17.3500' W; running southwesterly to a point 34° 51.0617' N – 76° 21.0449' W; running southwesterly to a point 34° 48.3137' N - 76° 24.3717' W; running southwesterly to a point 34° 46.3739' N – 76° 26.1526' W; running southwesterly to a point 34° 44.5795' N – 76° 27.5136' W; running southwesterly to a point 34° 43.4895' N – 76° 28.9411' W near Beacon "37A"; running southwesterly to a point 34° 40.4500' N – 76° 30.6833' W; running westerly to a point 34° 40.7061' N – 76° 31.5893' W near Beacon "35" in Back Sound; running westerly to a point 34° 41.3178' N -76° 33.8092' W near Buoy "3"; running southwesterly

to a point 34° 39.6601' N – 76° 34.4078' W on Shackleford Banks; running easterly and northeasterly along the shoreline and across the inlets following the COLREGS Demarcation lines to the point of beginning;

(4) ~~Within 200 yards of any shoreline, except from October 1 through October 31, south and east of Highway 12 in Carteret County and south of a line from a point 34° 59.7942' N - 76° 14.6514' W on Camp Point; running easterly to a point at 34° 58.7853' N - 76° 09.8922' W on Core Banks; to the South Carolina State Line.~~ Within 200 yards of any shoreline in the area upstream of the 76° 28.0000'W longitude line beginning at a point 35° 22.3752' N - 76° 28.0000' W near Roos Point in Pamlico River; running southeasterly to a point 35° 04.4833' N - 76° 28.0000' W near Point of Marsh in Neuse River.

(5) Within 50 yards of any shoreline east of the 76° 28.0000'W longitude line beginning at a point 35° 22.3752' N - 76° 28.0000' W near Roos Point in Pamlico River; running southeasterly to a point 35° 04.4833' N - 76° 28.0000' W near Point of Marsh in Neuse River, except in internal coastal fishing waters south and east of Highway 12 in Carteret County and south of a line from a point 34° 59.7942' N - 76° 14.6514' W on Camp Point; running easterly to a point at 34° 58.7853' N - 76° 09.8922' W on Core Banks; to the South Carolina State Line during October 1 through November 30.

History Note: *Authority G.S. 113-134; 113-173; 113-182; 113-221; 143B-289.52; Eff. August 1, 2004.*

Appendix 2. Active and Complete NC Red Drum FMP Management Issues.

	Management Issue	Initial FMP	Amend I	Amend I Status
1	Recreational Bag and Size Limit	2001		Active; status quo (1 fish 18–27 inches)
2	Adult Harvest Limits	2001		Active, status quo (prohibit all harvest >27 inches)
3	Recreational Targeting of Adult Red Drum	2001		Active; Education on ethical fishing practices.
			2008	New; Seasonal circle hook requirements in Pamlico Sd.
4	Commercial Harvest Limits Commercial Trip Limits	2001		Active; status quo (Director has authority to set trip limits and bycatch requirements)
			2008	New: Allow for possession of up to three red drum without requiring that they be subject to any bycatch provision while actively fishing gear. Upon sale/landing bycatch provisions would apply to all drum possessed.
	Commercial Fishing Year	2001		Active; (September 1 to August 31 with 250,000 lb cap)
			2008	New; Split fishing year with 150,000 lb for period of September 1 through April 30 and conserving the remaining portion for period of May 1 to August 31.
5	Gill Net Attendance Rules Small Mesh Gill Nets	2001		Active; May 1 to October 31 attendance requirement in all primary and permanent secondary nursery areas, shallow grass beds along 'Outer Banks', and within 200 yards of any shoreline. Area from Core Sound and south excluded from 200 yard from shore attendance requirement in October.
			2008	Modify; Extend current attendance through November. Require year round attendance in Neuse River for all nets set within 200 yards of shore. Reduce seasonal distance from shore requirement for Pamlico Sound and south to 50 yards. Area from Core Sound and south excluded from 50 yard from shore attendance requirement in October and November. Modify attendance line along 'Outer Banks' in areas of Rodanthe and Hatteras.
	Large Mesh Gill Nets			
			2008	New; Require attendance of nets set within 10 feet of shore from June through October.

Appendix 3

Stock Status of the Northern Red Drum Stock

April 2007

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Appendix 3

Executive Summary

The current red drum assessment indicates that F has decreased and escapement and static SPR have increased for the red drum northern stocks during the current (late) management period. The results from the 2000 stock assessment indicated that overfishing was occurring, with static SPR values well below the threshold SPR. The current model estimates are all above 30% static SPR and, therefore, indicate that overfishing is not occurring. It appears that the condition of the northern red drum stock has improved and that the more restrictive management measures implemented during the late period (1999-2005) have aided in that improvement.

The northern red drum stock was assessed using commercial, recreational, and independent data from 1986 to 2005. Results were broken into three regulatory periods with relatively uniform regulations (early: 1986-1991, mid: 1992-1998, and late: 1999-2005). A major assumption in this assessment was assigning an accurate length distribution to released fish from the recreational fishery. While several assumptions on the length distribution of recreational releases were calculated, the preferred matrix (Tagging) used length frequencies estimated from modeling of North Carolina Division of Marine Fisheries (NCDMF) tag returns. Late period age-3 selectivity was estimated to be 0.48 of fully selected fish (age-2), and was estimated from modeling of NCDMF tag returns. Two models were used: a backward calculating virtual population analysis (VPA) and a forward calculating spreadsheet catch-at-age model. Both models were updated from the Vaughan and Carmichael (2000) assessment. Fishing mortality (F) estimated from FADAPT ranged from 0.50 to 0.49, with escapement ranging from 40.6% to 41.0% and static spawning potential ratio (SPR) ranging from 40.4% to 40.8%. The spreadsheet catch-at-age model F estimates ranged from 0.66 to 0.63, with escapement estimated at 32.8% and static SPR estimated at 32.3%. All estimated runs using the TAGGING matrix from both models were above the threshold of 30% static SPR and the FADAPT estimates were above the target of 40% static SPR. All runs showed improvements in escapement and SPR from the previous regulation period (1992-1998).

Appendix 3

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Appendix 3

Introduction

Atlantic red drum (*Sciaenops ocellatus*) are an important marine species with the most recent stock assessment conducted in 2000. The first assessments were conducted using catch curves and separable virtual population analysis (SVPA) and treated the Atlantic red drum as a single stock (Vaughan and Hesler 1990; Vaughan 1992; Vaughan 1993). More recent assessments (Vaughan 1996; Vaughan and Carmichael 2000) divided the Atlantic coast into two stock regions: the northern region from North Carolina and north and the southern region from South Carolina through the east coast of Florida.

This assessment is an update of the northern region stock assessment that was conducted in 2000. The 2000 assessment is the approved assessment for Amendment 2 to the Atlantic States Marine Fisheries Commission (ASMFC) Red Drum Fishery Management Plan (FMP). The North Carolina Division of Marine Fisheries (NCDMF) Red Drum Plan Development Team (PDT) consensus in the development of this stock assessment was to maintain a methodology consistent with that used in the previous assessment. Exceptions to the previous methodology occurred as a result of regulation changes since the last assessment. These included assumptions about estimates of the length composition from recreational releases and the relative selectivity at age. Assumptions for these estimates were no longer valid primarily due to reductions in the bag limit and the prohibition of red drum greater than 27 in from harvest and new methods were developed to estimate these parameters. The North Carolina Marine Fisheries Commission (NCMFC) and Red Drum Advisory Committee will use this assessment to update the North Carolina Red Drum FMP.

Commercial Fishery Description

A directed commercial red drum fishery does not currently exist in North Carolina and historically red drum have made up only a small portion of North Carolina's total commercial landings. However, North Carolina's red drum landings are highest for all states along the Atlantic coast (Table 1). From 1999 to 2005, 96% of all red drum harvested commercially were landed in North Carolina. From 1972 to 2005, commercial landings of red drum in North Carolina fluctuated annually, averaging 161,433 pounds (lb) and ranging from 19,637 lb in 1977 to 372,942 lb in 1999 (Figure 1).

Red drum have been commercially harvested over the years using a variety of commercial gears, with Outer Banks fishermen occasionally targeting large red drum in Pamlico Sound (SAFMC 1990). Throughout the 1970's long haul seines and common haul seines were generally the most productive gears, while gill nets, pound nets and trawls were also commonly used (Mercer 1984). Since the 1980's, gill nets have become the dominant gear. In the years leading

up to the implementation of daily trip limits in 1999, nearly one-half of the total annual commercial harvest of red drum was harvested by a small number of trips with high landings. From 1994 to 1998, nearly half of all red drum landed (48.5%) was taken by only 1.1% of the total number of trips that harvested red drum. During this time, runaround gill nets became a significant contributor to the red drum commercial harvest (Figure 2). The runaround gill net and long haul seine fisheries typically had the largest individual red drum landings per individual trip during this time because of their effectiveness in encircling large schools of red drum. Pamlico Sound had the highest annual red drum landings in the state (Table 2). Much of the harvest and the largest individual catches occurred from Oregon Inlet to Ocracoke Inlet. Although there were a few exceptional long haul seine catches of up to 10,000 lb, a typical catch for a runaround gill net ranged from 100 to 1,000 lb per trip. Now that regulations prohibit a directed fishery, red drum are most commonly encountered as bycatch in the southern flounder estuarine gill net fishery but are also still common bycatch in many of the gears in which they were traditionally captured.

With the changes in regulations over the years, the size structure of the commercial harvest has also shifted towards larger fish (Figure 3). During the initial management period of 1987 to 1991 most red drum harvested were ~14 in total length (TL) and age-1. In 1992, when the size restrictions changed (18 – 27 in TL), the modal length for red drum harvested shifted to 19 in TL and age-2. As a result of decreasing the available sizes that can be retained within the slot limit, landings are now primarily from a single year class of fish and dependent on year class strength. While the regulatory changes in 1999 removed the ability to retain one fish over 27 in, the reductions in harvest resulting from the daily trip limit did correspond with a shift in the modal length of harvested fish from 19 in TL to 23 in TL. In addition, fish at the upper end of the slot limit that were once rare in the landings are now commonly encountered.

Recreational Fishery Description

North Carolina accounts for most of the recreational landings in the northern region (Table 3 and Table 4). Landings in Virginia can be substantial for some years. Landings are minor North of Virginia. Angling methods used to catch red drum include conventional, spinning, and fly tackle; using live, dead, and artificial bait. Red drum are targeted by recreational anglers year-round throughout the sounds, rivers and beaches of North Carolina. Red drum are consistently reported as one of the top target species by shore-based recreational anglers, and were the number one or two target species in 1993, 1995, 1996 and every year from 1999 to 2003.

Recreational fishermen must adhere to the same slot limit (18 – 27 in TL) as commercial fishermen and are allowed to harvest one fish per person per day. Similar to the commercial fishery, recreational landings vary annually in response to changes in year-class abundance. For example, landings increased from

38,286 lb in 1997 to 591,435 lb in 1998 (Table 3). When there was a five fish creel limit, recreational landings averaged 286,548 lb and accounted for approximately 60% of the total red drum harvested in North Carolina from 1992 to 1998. After the creel limit was reduced to one fish per day, annual landings dropped to an average of 204,628 lb from 1999 to 2005 and accounted for approximately 56% of all red drum harvested.

Undersized red drum accounted for 19% of the recreational harvest from 1994 to 1998, with a range of 1% in 1998 to 35% in 1997. Undersized red drum only accounted for 3.4% of the harvest from 1999 to 2005, with a range of 0% in 2003 and 2005 to 5.5% in 1999. Prior to the prohibition of red drum greater than 27 in TL in 1999, North Carolina offered award citations for red drum captured weighing 45 lb or greater. A citation could also be received for the release of a captured red drum greater than 40 in TL. All award citations issued since 1999 are for releases only. Trends in the NCDMF citation data show an increasing trend in the percentage of citations that were awarded for releases prior to 1999, indicating an increasing tendency by anglers to practice catch and release ethics (Table 5). In addition, release citations increased substantially in 1999 and appear to be trending upward. While this appears encouraging, it is difficult to ascertain if this is due to increases in availability of large fish, increases in fishing effort or due to increased popularity of the citation program.

General Life History

Red drum is an estuarine-dependent species, common along the Atlantic coast over a wide range of habitats from Chesapeake Bay to Key West, Florida. Historically, red drum have ranged as far north as Massachusetts and there was a moderate commercial fishery off the New Jersey coast in the 1930's (Lux and Mahoney 1969, Mercer 1984). There are few landings reported from areas north of Chesapeake Bay since the 1950's, suggesting a decline in red drum distribution along the Atlantic coast.

Red drum spawning has been observed occurring at night in high salinity areas in or around the major estuarine passes and inlets (Pearson 1929, Johnson 1978). Evidence now suggests that substantial spawning activity may take place inside the estuaries. Red drum have been collected in spawning condition inside Hatteras and Ocracoke Inlets and near the mouths of bays and rivers on the western side of the Pamlico Sound (Ross et al. 1995). More recent work used passive acoustic techniques to document suspected spawning activity. Using the drumming sounds produced by males during courtship, Luzkovich et al. (1999) documented spawning activity along Ocracoke Inlet and in the mouth of the Bay River in western Pamlico Sound. Barrios (2004) further documented spawning red drum with this technique in western Pamlico Sound near the mouth of the Neuse River.

Subsequent to spawning, larvae are distributed throughout the estuary by wind and tidal currents. The majority of larvae will settle out in shallow, low

salinity areas with abundant food supplies. These habitats include coastal creeks, protected bays with sandy or mud bottoms, and grass beds (Mercer 1984, Daniel 1988, Wenner et al. 1990, Ross et al. 1992). Juvenile distribution in the estuary varies seasonally as the fish grow and disperse. In North Carolina, juvenile red drum are found year-round over a wide range of salinity and habitats, although they generally prefer the shallow shorelines of various bays and rivers and the shallow grass flats behind barrier islands (Ross and Stevens 1992). Red drum grow rapidly during the first few years and most will reach the legal size limit of 18 in TL by 20 months of age. Most red drum have grown beyond the current maximum size limit of 27 in TL before they reach age-3. The earliest mature females occur at age-3 and all are mature at age-4 (30-35 in TL). Males mature sooner with 100% maturity occurring by age-3 around 27-32 in TL (Ross et al. 1995).

Movement and migration of red drum in North Carolina and along the Atlantic coast have been documented using tagging studies. Studies in North Carolina and South Carolina indicate high site fidelity. For subadult and adult red drum tagged in North Carolina estuaries, 99% of the red drum tag recaptures occur in North Carolina coastal waters (Ross and Stevens 1992, Marks and DiDomenico 1996). South Carolina tagged fish were mainly caught within nine nautical miles of their release site (ASMFC 2002). Less than 5% of subadult recaptures occurred outside of South Carolina coastal waters and no adults were recovered outside coastal waters (ASMFC 2002). Further north, large red drum schools have been reported to move from Virginia south along the beaches of the Outer Banks during the fall as water temperatures decline. These schools then return north in the spring (Mercer 1984). Tagging data provides evidence for separate stocks that should be considered as separate management units. Therefore, beginning with the 1995 assessment, red drum have been assessed as northern and southern stocks, with the stock split occurring at the North Carolina/South Carolina border (Vaughan 1996, Vaughan and Carmichael 2000).

Regulations and Management History

When assessing the northern stock of red drum the assessment results can easily be segregated into three distinct management periods which will be referred to throughout this document: early (1986-1991), mid (1992-1998), and late (1999-2005). A regulatory summary for each period is summarized in Table 6.

Red drum regulations in North Carolina began in 1976, with a 14 in TL minimum size limit and a limit of two fish per day exceeding 32 in TL. In December of 1987, proclamation authority for the NCDMF director was established for areas, seasons, quantity, means/methods and size. Management of red drum at the federal level began in the 1980's with red drum being managed by multiple management entities. The first plan was developed by the ASMFC in 1984, although this plan had no regulatory requirements. The South

Atlantic Fishery Management Council (SAFMC) FMP was subsequently adopted in 1990 and closed federal waters to the harvest of red drum. This plan was then adopted as Amendment 1 to the ASMFC FMP in 1991. The goal of Amendment 1 was to obtain optimum yield from the fishery over time. Optimum yield (OY) was defined as the amount of harvest that could be taken while maintaining a 30% spawning stock biomass per recruit (SSBPR). This goal however, was not attainable due to a lack of information on the adult population. This led to a 30% spawning potential ratio (SPR) being used as a proxy to SSBPR. Because the SPR at this time was estimated to be 2 to 3%, Amendment 1 recommended that all states implement harvest controls to attain at least a 10% SPR as a phase-in approach to rebuilding the stocks. The result was a significant increase in management of red drum in North Carolina during the 1990's. In 1990, the recreational creel limit was set at five fish per day, harvest of red drum over 32 in TL was limited to one fish per day, and a 300,000 lb commercial cap was established. A commercial cap was enacted to prevent North Carolina's commercial red drum fishery from expanding beyond historical harvest levels at a time when other markets (i.e. Florida) were prohibiting the sale of red drum. The commercial cap was further reduced to 250,000 lb in 1991 and the size limit was changed to a slot limit of 18 to 32 in TL with one fish greater than 32 in. All of these regulations constitute the 'early' period as defined above. By 1992, North Carolina had in place the current 18 to 27 in TL slot limit, a five fish creel limit, and allowed the harvest of one fish over 27 in TL. The regulations from 1992-1998 remained unchanged and referred to as the 'mid' period in this report.

In 1998 the SAFMC adopted new definitions of overfishing and OY for red drum, setting the levels at 30% SPR and 40% SPR, respectively. Later in 1998, North Carolina, through the development of a state FMP, implemented management measures designed to eliminate overfishing and achieve OY. As a result, the recreational bag limit was reduced to one fish per day and a 100 lb daily commercial trip limit (set at the Director's discretion) was imposed, while the previous 250,000 lb commercial cap remained in place. Harvest of any fish outside of the slot was prohibited. After exceeding the commercial cap in 1999 and 2000, a commercial trip limit of seven fish per day was established in 2001. In addition to the daily commercial trip limit, targeting of red drum was prohibited by requiring that the total weight of red drum make up no more than 50% of the total marketable catch (excluding menhaden) for each trip. The North Carolina FMP with these regulatory changes was approved by the NCMFC in 2001. Amendment 2 of the ASMFC FMP was adopted in 2002 and required that all states implement management measures necessary to obtain a 40% SPR. As a result of the North Carolina Red Drum FMP of 2001, no additional management measures were required by North Carolina. With the exception of changing the trip limit in the commercial fishery, regulations in North Carolina have remained unchanged since 1999 and comprise the 'late' period. This assessment will determine if the management action taken in the 'late' period was adequate to obtain OY as defined in the NCFMP and Amendment 2 to the ASMFC FMP.

Virginia's regulatory history is similar to North Carolina's regulations. In 1986, a 14 in TL minimum size limit was established with a possession limit of no more than two fish greater than 32 in TL. In late 1992, the slot limit was established at 18 - 27 in TL with a five fish bag limit, allowing only one fish greater than 27 in TL to be harvested. In 2003, the slot limit was changed to 18 - 26 in TL with a three fish bag limit and no allowance for red drum harvest outside of the slot limit. Virginia's regulations apply to both commercial and recreational fisheries.

Previous Assessment Results

Atlantic red drum have been previously assessed on five occasions, with the most recent coastwide assessment occurring in 2000. The first assessment was conducted using catch curve analysis and VPA. The best estimates indicated that SPR and escapement (relative survival from age at entry into fishery to age four) were low (Vaughan and Helser 1990). All of the estimates were well below the SAFMC threshold of 30% SPR. Assessment updates occurred in 1992 and 1993. For assessment purposes, the stock was split into northern (North Carolina and north) and southern (South Carolina, Georgia, and the east coast of Florida) regions beginning in 1995. Estimates of escapement from 1992 to 1994 for the northern region were 10.4%, which was an increase from the estimate of 0.6% for the early period (Vaughan 1996). The SPR estimate increased from 0.2% for the early period to 9.0% in the 1992-1994 period, putting it just below the 10% SPR level for first phase recovery. Results of the 2000 stock assessment used data through 1998 and indicated that escapement had improved for the entire period of 1992 to 1998 to around 18% (Vaughan and Carmichael 2000). This estimate however, falls short of the 30% overfishing definition. This assessment is intended to evaluate the effectiveness of the most recent regulatory changes in improving the red drum stocks. This iteration of the red drum stock assessment was conducted as part of the North Carolina Red Drum FMP update. The next coastwide assessment is scheduled for 2009 by the ASMFC.

Assessment Data

Commercial

North Carolina commercial landings data have been collected through the North Carolina Trip Ticket Program (NCTTP) since 1994. Between 1978 and 1993, landings information was gathered through the National Marine Fisheries Service (NMFS)/North Carolina Cooperative Statistics program. Reporting was voluntary during this period, with North Carolina and NMFS port agents sampling the state's major dealers (Lupton and Phalen 1996). Since 1994, commercial landings reporting has been mandatory. For further information on the sampling methodology for the NCTTP, see Lupton and Phalen (1996). Virginia has also had mandatory commercial reporting since 1993. Like North Carolina, Virginia's

landings information prior to 1993 was collected on a voluntary basis through a cooperative program with the NMFS.

Commercial length frequency data were obtained by the NCDMF commercial 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. Sample sizes obtained for Virginia commercial length frequencies were inadequate to describe the length distribution of red drum taken by gear type and year. As a result, North Carolina length frequency distributions from the same or similar gears were used to describe Virginia's commercial harvest (Table 7). Commercial length sampling intensity was determined by number of fish sampled per thousand pounds of catch for four major gears: gill nets, long haul seines, pound nets and winter trawls (Table 8). A rough reference for sampling adequacy used in the 2000 assessment was a minimum of 100 fish sampled per 200 metric tons. This converts to the current standard of greater than 0.23 fish sampled per 1,000 lb. By this standard, the major gears of gill net, long haul seine, and pounds nets were sampled adequately during the late time period. It is important to note that the nature of this fishery (small landings, large variability) likely requires larger sampling proportions. Gill nets and long haul seines had previously been determined to be adequately sampled for all years but 1986 and gill nets in 1987 and 1988 (Vaughan and Carmichael 2000). Commercial samples were taken throughout the year and from all areas where red drum are landed. Combined, gill nets, long haul seines and pound nets made up over 98% of all commercial landings for the northern region for the period of 1999-2005. Of these, gill net landings dominated, accounting for between 88% and 94% of all commercial harvest annually.

Recreational

The Marine Recreational Fishery Statistics Survey (MRFSS) collected the recreational landings data. The survey has two parts: a coastal county household telephone survey and an angler intercept survey at access sites. The survey data were combined to estimate numbers of fish caught, released, and harvested, harvest biomass, total trips and numbers of people fishing recreationally. Beginning in 1987, North Carolina has supplemented the MRFSS sampling targets for the state, increasing the sample size by nearly six times. The supplemental sampling has greatly improved catch estimate precision. Proportional standard error (PSE) is used to examine the precision of MRFSS estimates. For further information on MRFSS and the recreational sampling

methodology see
http://www.st.nmfs.gov/st1/recreational/pubs/data_users/index.html.

Trip effort estimates for 1986-2005 were generated using programs developed by Holiman (1996). Trips where red drum were identified as a species of interest were defined as target trips. Both successful and unsuccessful trips were included. From this data set, two indices were generated including a catch-per-unit effort index that used targeted trips and corresponding catch data and a probability of success index that used the proportion of successful targeted trips to the total number of targeted trips (Figure 4).

Ageing

Red drum sagittal otoliths were collected from the commercial and recreational fishery, with supplemental samples collected from fishery independent surveys. Age samples were collected monthly with sampling targets set for specified length bins. When possible, fork and total length to the nearest millimeter, weight to the nearest 0.1 kg, date, gear and water location were recorded for each sample. 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 Hillquist 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. Otolith sections were read independently by two readers. 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. Validation of this technique is presented in Ross and Stevens (1992). Age-length data for this updated assessment were provided by the NCDMF (2,917 fish from 1999-2005) and Old Dominion University (via Virginia Marine Resources Commission (VMRC); 289 fish from 1999-2005). Old Dominion University has been ageing red drum since 1998 from Virginia catches. Samples from North Carolina and Virginia were combined to generate age-length keys for the red drum catch-at-age.

Fishery Independent Data

<u>North Carolina Seine Survey</u>

A juvenile abundance index (JAI) was developed using data from the NCDMF red drum beach seine survey. The program was established to determine a red drum JAI and to evaluate habitat requirements for juvenile red drum. The survey was first conducted in 1987 as a pilot study. Through 1990, between 20 and 24 stations were randomly selected for sampling. Since 1991, set stations in internal waters have been sampled twice monthly from September to November. Seining is conducted using a bag seine measuring 18 m (60 ft) by

1.8 m (6 ft) with 6.4 mm (1/4 in) bar mesh in the body and 3.2 mm (1/8 in) bar mesh in the bag. A standard tow has one net end at the water's edge while the other end is pulled perpendicular to the shore. The end in the water is pulled a quarter sweep in the direction of tide or flow, and then fished to shore. The CPUE was defined as the average number of juvenile red drum captured per tow.

The assessment included the time period from 1991 to 2005, excluding only 1996 because of known environmental causes that decreased availability of fish (Figure 5). The trends prior to 1999 were highly variable. It appears that juvenile abundance was generally low from 1999 to 2001. Since 2001, the JAI has steadily increased to present.

Pamlico Sound Independent Gill Net Survey (IGNS)

Age-1 and age-2 indices were calculated using data from the Pamlico Sound independent gill net survey. The program began in 2001 with four objectives: to calculate annual abundance indices for key species in Pamlico Sound (including red drum), to provide supplemental samples for age, growth, and reproduction studies, to evaluate catch rates and species distribution in relation to bycatch, and to characterize habitat utilization. The survey used a stratified-random survey design with depth (greater or less than 6 ft) and region as strata. Regions were overlaid with a one-minute by one-minute grid system, with sampling sites selected randomly using PROC PLAN in SAS (SAS 2006). Each grid selected was sampled with a net array of 30-yard segments of 3, 3 ½, 4, 4 ½, 5, 5 ½, 6, and 6 ½ in stretch mesh webbing for 240 total yd of gill net fished in each regional deep and shallow strata. For each month, random samples were obtained from 16 shallow and 16 deep water sites. Gear was deployed within an hour of sunset and soaked for approximately 12 hours before retrieval. The sampling season occurred from February 15 to December 15 annually. The CPUE was defined as the number of red drum captured at age per sample.

The short time period limits the ability to determine trends for the age-1 and age-2 indices independently, although they appear highly variable from year to year (Figure 6). There are indications that the IGNS can follow cohorts as they progress through time. An example is the large age-1 value in 2002, which does appear as a high value in the age-2 index in 2003. The 2003 age-1 value is low, which corresponds with a low age-2 index value in 2004.

Life History Parameters

Natural Mortality

The natural mortality (M) rates previously used by Vaughan and Carmichael (2000) for the northern region were 0.20 for subadults (ages 1-5) and

0.12 for adults (ages 6 and older) and were based on a size at age relationship (Boudreau and Dickie 1989). These values are used in this assessment.

Age and Growth

Age and growth data were used both to estimate the von Bertalanffy-type growth equations and to develop annual age-length keys for converting catch at length data to catch at age. In order for the for the results to be based on a calendar year it was necessary to adjust the ages so that the age assigned to an individual red drum would coincide with a calendar year. Because September 1 is the theoretical birthdate for red drum in the northern region, all ages were adjusted so an age-1 fish (based on a January-December calendar year) would range in actual age from 5 to 16 months (Vaughan and Carmichael 2000). All age-length keys were annual and used two-inch length bins with bin designation using the midpoint (Table 9).

Previous red drum assessments have fitted growth data to both standard and linear versions of the von Bertalanffy (1938) growth equations (Vaughan 1996; Vaughan and Carmichael 2000). The linear von Bertalanffy equation assumes that L_{∞} is a linear function of age rather than a constant, which is the assumption in the standard von Bertalanffy equation. The equations were fitted using the PROC NLIN function in SAS (SAS 2006). The preferred parameters for the previous assessment were estimated from the linear growth equation as opposed to the standard equation. The linear growth equation includes an extra parameter that is significantly different from zero. The linear model is capable of better fitting the higher growth rates at earlier ages and the slower growth rates at later ages. For this assessment linear and standard von Bertalanffy parameter estimates are shown in Table 10 and equations can be found in Appendix 2.

Maturity at Age

The maturity schedule used in this assessment is based on Ross et al. (1995) and is consistent with that used in the previous update. The maturity schedule was used to determine the percent SPR and used only the female maturity schedule. The maturity schedule at age was as follows: age-2 was 0.01, age-3 was 0.58, age-4 was 0.99, and age-5 was 1.00. All fish collected during the maturity study were collected between September 1 and the end of the calendar year and for this reason no adjustments were necessary to align the adjusted calendar based ages with the age at maturity data.

Catch at Age Matrices

Annual catch-at-age (CAA) matrices were calculated for the period from 1999 to 2005 and followed the assumptions used by Vaughan and Carmichael (2000). The period from 1986 to 1998 used the existing CAA calculated for the 2000 assessment. For the current period, a CAA matrix was generated for four

major commercial gears including gill nets, long haul seines, pound nets and winter trawl. The remaining commercial gears were not sampled and accounted for less than 1% of the annual commercial harvest in any year. These gears were combined with gill nets in the CAA workup. The recreational CAA matrices were generated based on information derived from MRFSS. The age-length keys used to in calculating the CAA are based on 12-month periods rather than 6-month periods.

Five different CAA matrices were calculated for different assumptions about the length frequency distribution of the recreational releases (Tables 11-13). The first, BASE0, assumed that there was no recreational discard mortality. The BASE1 matrix assumed 10% discard mortality and that the length frequency distribution was the same as the observed recreational harvest length frequency. The DELTA matrix assumed a 10% discard mortality rate and assumed that the length frequency distribution equaled the positive difference between the observed recreational harvest length frequencies of the early period (1986-1991) and the late period (1999-2005). The PROP catch matrix assumed a 10% discard mortality rate and used a weighted average of the MRFSS length frequencies from the BASE1 and DELTA catch matrices. The weights were 40% BASE1 and 60% DELTA, based on the 40% reduction that was required by Amendment 2. The last, TAGGING matrix, assumed a 10% discard mortality rate and based the length frequency distribution on the estimated selectivity at length for the B2 catch from an analysis of the North Carolina tagging data described below (Figure 7).

Length-based selectivity patterns were estimated for recreationally released red drum using NCDMF mark-recapture data (Burdick et al. 2006). The differences in selectivity were examined by time periods established for fisheries regulation changes. The selectivity of discards (fish released alive) and harvested fish could be estimated separately for recreational tag returns. Selectivity patterns were estimated using a generalized linear model that fitted an expected tag return rate using the rate of tag recovery by gear (Myers and Hoenig 1997). In this method, length-based selectivity of red drum for recreationally released fish is estimated by fitting a model for the expected tag return rate of tagged fish through multiplying four factors: the number of fish tagged by tag type and length bin, the tag recovery rate for recreationally released fish and tag type, the exploitation rate by gear type and tag type, and the selectivity of gear type in each length bin, with the equation in Appendix 2. The tag recovery rate is the product of the proportion of fish that survive tagging, the proportion of tags that are not lost (shed), and the proportion of recovered tags that are reported. This method assumes that tag loss, tagging mortality, M, and tag reporting are independent of length and age for recapture. It also assumes exploitation and recovery did not change and that fish did not grow out of their assigned length bin before recapture. For length-based analysis, the maximum allowed time at-large and length bin designations were adjusted to achieve the optimum combination given available data. If fish grew out of

assigned length bins before recapture, the resultant selectivity curves could be biased and the optimal combination was 100-mm length bins and 90-day time periods (Burdick et al. 2006). The GENMOD procedure in SAS was use to perform the analysis (SAS 2006) and data were log transformed with an assumed binomial error distribution. The GENMOD procedure was modified to scale to the length bin with the maximum selectivity.

Commercial discard estimates were not available for this assessment and have not been available for previous assessments. Research is currently being conducted to determine commercial discard estimates for the 2009 coastwide assessment.

Methods

Separable Virtual Population Analysis (SVPA)

Previous red drum assessments used SVPA to estimate fishing mortality (F) and population numbers. For this assessment, an SVPA was employed solely to estimate the terminal year selectivity vectors for the FADAPT analyses. For the SVPA, catch-at-age data (ages 1-5 and years 1986-2005) were divided into the three previously defined management time periods. The catch-at-ages were analyzed separately for each management period and B2 calculation.

The SVPA computer program requires specification of a fully recruited reference age and relative selectivity for a second age (Clay 1990). Typically, the selectivities of the first fully recruited age and the oldest age are equal; within the model both would be equal to 1.0. This is not appropriate for this assessment because of the decreased availability of older fish from harvest. In the previous assessment, as well as this assessment, the age at full recruitment was age-2 and the second age to be determined was age-3. How this selectivity was determined varies by time period. For the early period, selectivity for age-2 and age-3 was considered equal. The selectivity of age-3 fish during the mid period was initially estimated to be 0.43. This estimation was based on an investigation of the size distribution of age-3 fish relative to age-2 fish that fell within the 18 to 27 in TL slot limit for the northern region. This value was considered inappropriate because the selectivity of 0.43 assumes no harvest of red drum outside the slot limit and during the mid period harvest of one red drum greater than 27 in TL was allowed. As a result an age-3 selectivity assumption of 0.7 was used in the 2000 stock assessment. This assumption is no longer appropriate for the late period, as fish can no longer be harvested above the slot limit.

For the late period, two selectivities were initially investigated. Because the slot limit remained unchanged from the mid to late periods and harvest of red drum greater than 27 in TL was prohibited, the 0.43 selectivity estimated for age-3 red drum during the last assessment was considered for this assessment. A second selectivity was estimated for age-3 red drum based on tag return

analyses conducted on the NCDMF tagging data for red drum (Nathan Bacheler, NCSU, unpublished data). A total of 22 years of tagging data from the NCDMF were used to assess the effect of two previous regulation changes, occurring in 1991 and 1998, on F and selectivity patterns of red drum in North Carolina. The model chosen was an age-dependent tag return model (Brownie et al. 1985; Hoenig et al. 1998a; Hoenig et al. 1998b) that accounted for both harvest and catch-and-release fishing by separating mortality of the tags (where the fish are released alive but the tags are removed and reported) from mortality experienced by the fish (Jiang et al. 2006). This model was very similar to the Jiang et al. (2006) model, but age-dependent M values were input, and the model estimated the tag reporting rate. Related equations can be found in Appendix 2. Tag retention of less than 100% was accounted for the two different tag types. Red drum were placed into four age groupings (age-1, age-2, age-3, and age-4+) at tagging based on a 6-month age-length key provided by NCDMF, which provided very good separation of length groupings. Hooking mortality was accounted for using Jiang et al.'s (2006) method of adjusting F upwards given a previously reported hooking mortality rate for red drum (10%; Jordan 1990) and an estimate of F', the tag mortality defined above. Burdick et al.'s (2006) estimate of annual tag retention of dart tags (0.74) was used based on double tagging analyses and annual tag retention of internal anchor tags (0.91). Age-dependent natural mortality rates (0.30 for age-1, 0.22 for age-2, 0.16 for age-3, and 0.10 for age-4+ fish) were fixed based on a life history estimator that related M to body size (Boudreau and Dickie 1989). The selectivity was allowed to vary by age and regulation period in our model, and model parameters were estimated using maximum likelihood estimators. Fish recovered within 7 days of tagging were excluded to allow time for mixing to occur. Assumptions were: (1) no deaths occurred from the tagging process, (2) tagged fish are independent, (3) equal reporting rates whether harvested or released, (4) no ageing errors, (5) selectivity of harvested and caught-and-released fish are equal, and (6) 7 days was enough time to allowed fish to mix adequately. Overall, the model produced robust estimates of age- and regulation period-specific selectivity that were usable in the North Carolina red drum stock assessment. The age-3 specific selectivity produced by this model for the late period was 0.48.

Spreadsheet Model

A forward projecting catch-age analysis was performed using Microsoft Excel and iteratively solved using the Solver function to produce estimates of F (Carmichael et al. 1999). This formulation allows for the inclusion of auxiliary information. The data included in this model were the catch-at-age matrix for 1986-2005, the JAI for the NCDMF from 1991 to 2005, which was used to tune recruitment estimates, and two MRFSS target indices, a CPUE and a probability of success, which was used to tune total annual abundance from 1987 to 2005. A second data configuration added the Pamlico Sound IGNS CPUE that was used to tune ages 1 and 2 from 2001 to 2005. Three selectivity periods were used to correspond to regulatory changes in the fishery. Each model run was

restarted from several points to determine if the model had reached a global solution and uses a lognormal error structure. Basic equations can be found in Appendix 2.

FADAPT VPA

The FADAPT program is a modification of Gavaris (1988) by Restrepo (1996) and was the preferred assessment model from the 2000 assessment. This program does not assume separability and does allow for tuning by abundance indices at age. The model requires that a terminal year selectivity be input, which was determined by the SVPA runs (Table 14). Basic equations can be found in Appendix 2.

Data inputs include the catch-at-age matrix from 1986 to 2005, the NCDMF JAI from 1991 to 2005 and two MRFSS indices: a target CPUE from 1987 to 2005; and a probability of targeted trip successes from 1987 to 2005. This configuration was an update of the 2000 assessment. Additional runs were made including the Pamlico Sound IGNS CPUE for ages 1 and 2.

Escapement and SPR

The spawning stock biomass (SSB) for red drum cannot be directly estimated because data on adult fish are lacking. Overfishing thresholds and targets are determined through percent escapement and spawning potential ratio (SPR). The SPR benchmarks set by the ASMFC Amendment 2 were a 30% SPR threshold and a 40% SPR target. Escapement is determined as the percentage of fish recruiting to the adult population at age-4.

SPR is calculated using the %Maximum Spawning Potential (%MSP) method from Gabriel et al. (1989). Additional data required to calculate static SPR are a female maturity schedule and the growth estimates from the von Bertalanffy equation. Both escapement and SPR use the average F at age for each time period, recreational B2 discard assumption, and selectivity assumption. Basic equations can be found in Appendix 2.

Model Assumptions

The VPA models assume that the catch is aged without error. The forward projecting spreadsheet model does not have that assumption. Both the spreadsheet and FADAPT models tune to the catch-at-age matrix and the incorporated indices. Indices are assumed to reflect the actual population abundance and influences on abundance measurements (i.e. regulation changes in a dependent index) must be kept in mind when including the indices and analyzing the results. VPA models tend to exhibit some degree of retrospective bias, where the estimates are initially either over or underestimated. As the terminal year is replaced by subsequent terminal years, the estimates converge

to a 'true' value. Concern about retrospective bias has resulted in the previous assessments omitting the terminal year estimates from the average F at age results, which was continued for this assessment. A limited retrospective analysis was also conducted to determine the extent and possible effects of the bias.

Data Limitations

Data limitations impact the assessment. There are no commercial discards included in the catch estimates. Available data are inadequate to estimate commercial discard levels. Therefore it is likely that model results are optimistic, though to what extent is unknown. The length characteristics of the B2 catch were estimated, as the MRFSS does not sample the fish that are caught and released. The MRFSS sampling can be limited in particular areas. A particular deficiency is the absence of intercepts for fisheries prosecuted at night. There is a notable catch-and-release fishery for over the slot limit red drum that occurs at night, though no extra red drum lengths would be observed, as fish greater than 27 in should be released. The adult spawning population cannot be estimated, therefore SSB is unknown and condition of the adult stock is inferred through the escapement estimates. There is also limited independent data on relative abundance of exploited ages (1-5).

Preferred Runs

The model configurations differed due to various assumptions and the inclusion or exclusion of various indices. The major assumptions were for selectivity and the assumed length frequencies of recreational discards. The red drum PDT met and determined the preferred runs that would be considered for the stock status determination. The decision was made to include runs with selectivity vectors of 0.48 for the late period. Sensitivity runs using the 0.43 selectivity vectors were conducted and are detailed in Appendix 1. These runs do indicate that lower selectivity vectors result in lower F estimates and higher estimates of escapement and SPR and that the FADAPT model is more sensitive to different selectivity vectors. While there are differences, 0.48 was selected as the appropriate value because it was estimated quantitatively through the tagging data and is more conservative than 0.43. The mid period used runs with a selectivity vector of 0.7, which was used in the previous assessment to determine stock status. The second major decision was selecting a preferred method to estimate the size distribution of recreational discards. A decision was made to solely use the TAGGING catch matrix in the late period as the preferred run. The PDT selected the TAGGING catch matrix because the results are based on analysis of observed recreational releases from the red drum fishery. In addition, because the data are based on observed lengths, the TAGGING matrix includes fish lengths not typically obtained by the MRFSS (the large fish released above slot limit fish during a predominantly night time fishery). The remaining other model runs for the late period using the various B2 discard assumptions can be

found in Appendix 1. The mid period used the DELTA assumption for the preferred run for both this and the previous assessments.

Results

Fishing Mortality (F)

FADAPT VPA

The inclusion or exclusion of the IGNS showed little difference in the estimated F. Estimates of F for the late period ranged from 0.50 to 0.49 at age-2 for the TAGGING run (Table 15). Estimates of F at age-3 ranged from 0.24 to 0.23 and decreased dramatically for ages 4 and 5. The late period F vectors were lower than the mid period F Delta vectors.

Spreadsheet Model

When compared to the FADAPT results, the spreadsheet model had slightly greater variability in estimated F. Estimates of F for the late period were higher in the spreadsheet VPA than were exhibited by the FADAPT estimates. The TAGGING F ranged between 0.66 and 0.63 at age-2 (Table 16). Age-3 estimated F ranged from 0.32 to 0.30 then decreased dramatically at ages 4 and 5.

Escapement and SPR

FADAPT VPA

The escapement estimates for the TAGGING configurations ranged from 40.6% to 41.0% and the static SPR estimates were 40.4% to 40.8% (Table 15). All of the TAGGING configurations were just above the 40% static SPR target. Runs that included the IGNS indices were slightly lower than those runs that were strict updates of the 2000 assessment.

Spreadsheet Model

The escapement estimates for the TAGGING configurations were 32.8% and the static SPR estimates were 32.3% (Table 16). All the TAGGING configurations were above the 30% static SPR threshold and below the 40% static SPR target. Runs that included the IGNS indices were identical to those runs that were strict updates of the 2000 assessment.

Model Fit and Configuration

The residual sum of squares (RSS) was examined to determine the goodness of fit. The FADAPT runs including the IGNS indices fit slightly better

than those that were strict updates of the 2000 assessment. When compared to PROP runs (see Appendix 1), TAGGING runs had consistently smaller RSS, indicating that TAGGING runs were better fits.

Residual plots for the tuning indices were examined (Figures 8-11). Plotted values are the difference between the observed survey value and the survey value predicted from the estimated catchability (q) and abundance. A 'good' residual plot shows a random scattering of points with no trends over time. For TAGGING run, regardless of inclusion or exclusion of the IGNS index, the MRFSS (CPUE and proportional) indices showed increasing trends through time for the late period (Figures 8 and 9). This could indicate changes in catchability over time. The residuals are only slightly different in magnitude between the IGNS included and excluded runs. For the JAI indices, the scatter of points appeared to be random (Figure 10). The IGNS indices also appear to be randomly distributed (Figure 11). For all of these analyses, the time period is fairly short as they have been constrained to the late period only and long-term trends cannot be determined.

The spreadsheet analysis goodness of fit was determined using a minimized sum of squares error for the catch and indices. The strict updates of the 2000 assessment had lower values than did those runs with the IGNS index included. Generally, the MRFSS CPUE and probability index estimates fit fairly well with a few notable departures in 1990, 1998, and 2002 (Figure 12). While the JAI estimates prior to 1996 were consistently over estimates and the IGNS index fit fairly well, except for 2002, which was much higher than the population estimate (Figure 13). Between IGNS included and excluded runs, predicted values were quite similar (Figure 14).

FADAPT Retrospective Analysis

A retrospective analysis was conducted to examine the uncertainty in the data for the assessment and the performance of the model configuration. The preferred runs did exhibit some degree of retrospective pattern. However, while the direction was relatively consistent, the magnitude and the duration did not exhibit clear consistency. Generally, F is overestimated and, as time passes, the estimates decrease (Figures 15 and 16). This is particularly true in 2002. The F overestimation in the 2002 terminal year was the highest of any years examined in the retrospective analysis. Typically, the bias is resolved within two to four years. The convergence is not perfect and there are some years in some configurations (2005 in the TAGGING configuration) that remain lower throughout the converged time series (Figures 15 and 16). The variation between runs was largely without pattern, except that 2002 consistently had the highest F values at ages two and three.

Discussion

The current red drum assessment indicates that F has decreased and escapement and static SPR have increased for the red drum northern stocks during the current (late) management period. The results from the 2000 stock assessment indicated that overfishing was occurring; with static SPR values were well below the threshold SPR. The current model estimates are all above 30% static SPR and, therefore, indicate that overfishing is not occurring. In general, it appears that the condition of the northern red drum stock has improved and that the more restrictive management measures implemented during the late period have aided in that improvement.

Results for both models, including and excluding the IGNS indices, over the entire assessment time period are summarized below:

Period	Model/Run	F	Escapement	SPR
Early	FADAPT/BASE1	1.39	1.0	1.1
	Spreadsheet/TAGGING IGNS	1.31	2.3	2.4
	Spreadsheet/TAGGING	1.32	2.2	2.3
Mid	FADAPT/DELTA	0.75	18.3	18.7
	Spreadsheet/TAGGING IGNS	0.59	30.3	30.4
	Spreadsheet/TAGGING	0.60	30.1	30.3
Late	FADAPT/TAGGING IGNS	0.50	40.6	40.4
	FADAPT/TAGGING	0.49	41.0	40.8
	Spreadsheet/TAGGING IGNS	0.66	32.8	32.3
	Spreadsheet/TAGGING	0.63	32.8	32.3

Assumptions of table runs (above): The B2 assumptions in the early and mid periods were the same across both models (early used BASE1 and mid used DELTA). The notation of TAGGING in the early and mid periods denotes the B2 assumption made in the late period only. Highlighted rows in early and mid periods denote preferred model runs. The early period age-2 to age-3 selectivity was 1.0 and 1.0. The mid period age-2 to age-3 selectivity was 1.0 to 0.7 and the late period age-2 to age-3 selectivity was 1.0 to 0.48. The external review also recommended using the TAGGING as the preferred run.

When compared with the 2000 stock assessment results, the average F values in the current assessment do not appear to be greatly different than those in the previous assessment, yet the estimates of SPR were improved (Tables 15-16). This may be the result of changes in selectivity between the two periods. During the mid period, the harvest of a single red drum over the slot limit was allowed. During the late period, possession of red drum over the slot was prohibited. This prohibition likely decreased F on the older fish and thus would have resulted in higher SPR estimates. Other possible reasons are the overall

decrease in harvest, which occurred at basically all ages and may have had a more considerable cumulative effect.

The spreadsheet model indicated few differences in terms of F, escapement, and static SPR between the mid and late regulation periods. It should be noted that during the previous assessment, the red drum TC considered the results of the spreadsheet model to be optimistic and that may continue to be true for the period. This was not true of the late period, as both models gave more similar results with the spreadsheet estimating static SPR values that were less optimistic than the FADAPT. The mid period has remained highly divergent between the two models. It may be the result of the significant change in regulation that occurred between the early and mid periods, as the FADAPT estimates were determined in discrete periods while the spreadsheet estimated the entire time period with the selectivity fixed by period. It is not clear why the differences still exist but the spreadsheet mid period estimates may still be considered high.

The retrospective analysis indicated that the model configurations or data exhibit some uncertainty. The 2000 assessment did not include the terminal year in the average F at age calculation from the FADAPT because of retrospective bias concerns. The bias tendency is to overestimate F and to converge within two to four years. Therefore, estimates for the late management period may be conservative in nature. However, while there appears to be direction in the bias, it is important to note that the estimates are clearly uncertain in the most recent years.

The other source of uncertainty is discard characterization for, both the commercial and recreational fisheries. Commercial discards are not included in the assessment because reliable estimates are not available. The length frequencies could be inferred in a similar manner as the DELTA method, but the magnitude, unlike the B2 estimates, is unknown. While the quantity of loss due to discards in the gill net fisheries continues to be unknown, the NCDMF has taken steps to minimize the loss of undersized red drum. In October of 1998, as part of the North Carolina Red Drum FMP, measures were taken requiring the attendance of small mesh gill nets (<5” stretch mesh). Gill nets of this mesh size select for red drum less than 18” TL and are a significant source of the bycatch mortality, particularly in months when water temperatures are high. Current North Carolina regulations require the attendance of small mesh gill nets from May 1 through October 31 in areas known to be critical for juvenile red drum. These include all primary and secondary nursery areas, areas within 200 yd of any shoreline, and the extensive area of shallow grass flats located behind the Outer Banks. Because commercial discard mortalities were not included, the overall fishing mortality is likely underestimated and the escapement and SPR are likely overestimated to an unknown degree. Recreational discards are estimated, but the length and age characterization must be inferred, as it cannot be directly measured. The red drum PDT believed that the assumed TAGGING discard

length frequency distributions most accurately reflected the current recreational fishery releases.

Current and ongoing research using tagging data from North Carolina fish was explored in this assessment. The age-3 selectivity for the current regulation period estimated from the tagging model was 0.48, which was similar to 0.43, the estimate from the length frequency analysis done for the 2000 assessment. The analysis of the NCDMF tagging data that was incorporated into the TAGGING run was capable of examining fish that were captured and released for regulatory reasons. It found that the late regulatory period had the highest estimate of older fish in the CAA of any of the discard assumptions (Table 13). This may be a reflection of a catch-and-release fishery that exists for red drum over the slot limit. The sizes and ages of fish captured in the over the slot limit fishery could not be captured in MRFSS and therefore could not be appropriately factored into the CAA. The tagging studies had returns from the over the limit fishery, which were the basis for the TAGGING CAA.

Research Recommendations

The previous assessment listed the following as the three primary needs for future assessments: 1) Catch statistics (sampling of at-sea discards in particular), 2) Length frequency distributions by gear, and 3) age-length keys. Of these, commercial at-sea discards and discard size frequencies remain data gaps for this update.

The lack of at-sea commercial discard sampling continues to be a data limitation in the northern region. The needed data include the amount of fish discarded, the discard mortality by gear type, and the size distribution of those discarded fish. The data on recreational discards continue to be limited in terms of characterizing the fish size distribution. The tagging model estimates may be a step in the direction of observed size distributions. All the methods for recreational B2 size distribution continue to be limited because a common size distribution is used throughout a regulation period. Methods for determining size distribution on an annual basis should be investigated. Also, as recreational landings represent the majority of landings coastwide, the MRFSS intercepts should be increased to accurately characterize this large segment of the total fishery.

The VPA models that were used for this update can be sensitive to M. Better estimates of both subadult M and adult M should be investigated. The model was also demonstrated to be sensitive to changes in the selectivity vector. Research should continue to determine vectors that most closely represent the fishery selectivity and the migration pattern of the fish. Maturity at age was last investigated in 1995 and that data should be updated to reflect the current population conditions as much as possible.

Appendix 3

The current TAGGING configuration is based analysis of tagging data that allowed for the combined selectivity of harvest and released fish to be estimated. Updated tagging models conducted during the completion of the assessment allow for separate selectivity estimates for harvested and released fish (Bacheler et al., In progress). Altering the models to accommodate two selectivities based on the fate of the fish was beyond the scope of this update, but should be investigated for future assessments.

The previous assessment called for continued standardized sampling of the subadults. The northern region had a single fishery-independent index at the time of the last assessment (the North Carolina JAI). Currently, there is also the North Carolina IGNS, which was included as a tuning index for this assessment. Though the time series is short (2001-2005), the IGNS index could track the large 2001 cohort and may be a good indicator of recruitment to the fishery. Future assessment should thoroughly examine the index for its use in those assessments.

There is still a need for the monitoring of adult red drum to provide a fishery-independent spawning stock index. As was discussed in the previous assessment, applying a VPA to the entire age structure, which would extend through ages 50 to 55, is functionally impractical. There are currently very few adult fish age samples and because of the extremely slow adult growth there are too many ages that could be applied to a given length. However, information on the adult population abundance, length, and age structure could provide some indication of the condition of the spawning red drum stock.

Literature Cited

Atlantic States Marine Fisheries Commission (ASMFC). 2002. Amendment 2 to the Interstate Fishery Management Plan for Red Drum. Fisheries Management Report No. 38. ASFMC, Washington, DC, 142 pp.

Bacheler, N.M., J.E. Hightower, L.M. Paramore, J.A. Buckel, and K.H. Pollock. In progress. Changes in fishing mortality and selectivity of North Carolina red drum due to fishery regulations: estimates from an age-dependent tag return model. North American Journal of Fisheries Management.

Barrios, A.T. 2004. Use of passive acoustic monitoring to resolve spatial and temporal patterns of spawning activity for red drum, *Sciaenops ocellatus*, in the Neuse River Estuary, North Carolina. M.S. Thesis, North Carolina State University, 97 pp.

Boudreau, P.R. and L.M. Dickie. 1989. Biological model of fisheries production based on physiological and ecological scalings of body size. Can. J. Fish. Aquat. Sci. 46: 614-623.

Brownie, C., D.R. Anderson, K.P. Burnham, and D.S. Robson. 1985. Statistical inference from band-recovery data – a handbook, 2nd edition. United States Department of the Interior Fish and Wildlife Service, Resource Publication 156.

Burdick, S.M., J.E. Hightower, J.A. Buckel, L. Paramore and K.H. Pollock. 2006. Movement and selectivity of red drum and survival of adult red drum: an analysis of 20 years of tagging data. NCDMF, Final Report, Morehead City, North Carolina.

Carmichael, J.T., J.E. Hightower, and S.E. Winslow. 1999. Spreadsheet based catch at age assessment of blueback herring in the Chowan River, North Carolina. Abstracts for American Fisheries Society, 129th Annual Meeting, Charlotte, NC.

Clark, W.G. 1991. Groundfish exploitation rates based on life history parameters. Can. J. Fish. Aquat. Sci. 38: 297-307.

Clark, W.G. 1993. The effect of recruitment variability on the choice of a target level of spawning biomass per recruit. Univ. Alaska Sea Grant College Program, Rep. No. 93-02: 233-246.

Clay, D. 1990. TUNE: a series of fish stock assessment computer programs written in FORTRAN for microcomputers (MS DOS). International

commission for the conservation of Atlantic Tunas, Coll. Vol. Sci. Pap. 32: 443-460.

Cowan, J.H., Jr., R.L. Shipp, H.K. Bailey, IV, and D.W. Haywick. 1995. Procedure for rapid processing of large otoliths. Trans. Am. Fish. 124(2): 280-282.

Daniel, L.B. III. 1988. Aspects of the biology of juvenile red drum, *Sciaenops ocellatus* and spotted seatrout, *Cynoscion nebulosus* (Pisces: Sciaenidae) in South Carolina. M.S. Thesis, College of Charleston, 58 pp.

Gabriel, W.L., M.P. Sissenwine, and W.J. Overholtz. 1989. Analysis of spawning stock biomass per recruit: an example for Georges Bank haddock. N. Am. J. Fish. Manage. 9: 383-391.

Gavaris, S. 1988. An adaptive framework for the estimation of population size. Can. Atl. Fish. Sci. Adv. Comm. (CAFSAC) Res. Doc. 88/29, 12 pp.

Hoenig, J., N. Barrowman, W. Hearn, and K. Pollock. 1998a. Multiyear tagging studies incorporating fishing effort data. Canadian Journal of Fisheries and Aquatic Sciences 55:1466-1476.

Hoenig, J., N. Barrowman, K. Pollock, E. Brooks, W. Hearn, and T. Polacheck. 1998b. Models for tagging data that allow for incomplete mixing of newly tagged animals. Canadian Journal of Fisheries and Aquatic Sciences 55:1477-1483.

Holiman, S.G. 1996. Estimating recreational effort using the Marine Recreational Fisheries Statistics Survey Data. NOAA Tech. Mem. NMFS-SEFSC-389, 53 pp.

Jiang, H. 2005. Age-dependent tag return models for estimating fishing mortality natural mortality and selectivity. Doctoral dissertation. North Carolina State University, Raleigh, North Carolina.

Jiang, H., K.H. Pollock, C. Brownie, J.M. Hoenig, R.J. Latour, B.K. Wells, and J.E. Hightower. 2006. Tag return models for catch-and release fisheries: Striped bass natural mortality estimates change with age and calendar year. North American Journal of Fisheries Management, In Press.

Johnson, G.D. 1978. Development of fishes of the mid-Atlantic Bight. An atlas of egg, larval and juvenile stages. Vol IV. U.S. Fish and Wildlife Service, Biological Services Program. FSW/OBS-78/12: 190-197.

Jordan, S.R. 1990. Mortality of hook-caught red drum and spotted seatrout in Georgia. Georgia Department of Natural Resources, Brunswick, Georgia.

Lupton, B.Y. and P.S. Phalen. 1996. Designing and Implementing a Trip Ticket Program. North Carolina Division of Marine Fisheries, Morehead City, NC. 32 pp + appendices.

Luczkovich, J.J., L.B. Daniel, III, and M.W. Sprague. 1999. Characterization of critical spawning habitats of weakfish, spotted seatrout and red drum in Pamlico Sound using hydrophone surveys. Completion Report F-62, 1-128. NCDMF, Morehead City, NC.

Lux, F. F. and J. V. Mahoney. 1969. First record of the channel bass *Scianops ocelltaus* (Linnaeus), in the Gulf of Maine. Copeia 3: 632-633

Marks, R.E. and G. DiDomenico. 1996. Life history aspects of selected marine recreational fishes in North Carolina. Tagging studies, maturity, and spawning of red drum (*Sciaenops ocellatus*) in North Carolina. Completion report F-43, Segment 1, North Carolina Division of Marine Fisheries, Morehead City, NC. 38 pp.

Mercer, L.P. 1984. A biological and fisheries profile of red drum, *Sciaenops ocellatus*. North Carolina Division of Marine Fisheries. Special Scientific Report 41. Morehead City, NC.

Murphy, M.D. 2005. A stock assessment of red drum, *Sciaenops ocellatus*, in Florida: status of the stocks through 2003. In-House Report 2005-XXX, Florida Fish and Wildlife Commission Fish and Wildlife Research Institute, St. Petersburg, 31 p. see: http://www.floridamarine.org/features/view_article.asp?id=14056

Myers, R.A. and J.M. Hoenig. 1997. Direct estimates of gear selectivity from multiple tagging experiments. Canadian Journal of Fisheries and Aquatic Science 54:1-9.

Pearson, J.C. 1929. Natural history and conservation of the redfish and other commercial sciaenids on the Texas coast. Bull. U.S. Bureau of Fish. 44: 129-214.

Restrepo, V.R. 1996. FADAPT Version 3.0, A guide. University of Miami, RSMAS, 4600 Rickenbacker Causeway, Miami, FL. 21 pp.

Ross, J.L. and T.M. Stevens. 1992. Life history and population dynamics of red drum (*Sciaenops ocellatus*) in North Carolina waters. Marine fisheries Research completion Report, Project F-29. North Carolina DMF, Morehead City, NC.

Ross, J.L., T.M. Stevens, and D.S. Vaughan. 1995. Age, growth, and reproductive biology of red drums in North Carolina waters. Trans. Am. Fish. Soc. 124: 37-54.

SAS. 2006. SAS System fro Windows V9.1. Cary, North Carolina.

South Atlantic Fishery Management Council (SAFMC). 1990. Profile of the Atlantic Coast Red Drum Fishery and Source Document for the Atlantic Coast Red Drum Fishery Management Plan. Charleston, SC: 144 pp.

Vaughan, D.S. 1992. Status of the red drum stock of the Atlantic coast: Stock assessment report for 1991. NOAA Tech. Mem NMFS-SEFC-297. 58 pp.

Vaughan, D.S. 1993. Status of the red drum stock of the Atlantic coast: Stock assessment report for 1992. NOAA Tech. Mem. NMFS-SEFC-313. 60 pp.

Vaughan, D.S. 1996. Status of the red drum stock of the Atlantic coast: Stock assessment report for 1995. NOAA Tech. Mem. NMFS-SEFC-380. 50 pp.

Vaughan, D.S. and J.T. Carmichael. 2000. Assessment of Atlantic Red Drum for 1999: Northern and Southern Regions. NOAA Tech. Mem. NMFS-SEFSC-447.

Vaughan, D.S. and T.E. Helser. 1990. Status of the red drum stock of the Atlantic coast: Stock assessment report for 1989. NOAA Tech. Mem. NMFS-SEFC-263. 50 pp.

von Bertalanffy, L. 1938. A quatitative theory of organic growth. Human Biol. 10: 181-213.

Wenner, C.A., W.A. Roumillat, J.E. Moran, Jr., M.B. Maddox, L.B. Daniel, III, and J.W. Smith. 1990. Investigations of the life history and population dynamics of marine recreational fishes in South Carolina: Part 1. Final Rep., Proj. F-37, SC Wildl. Mar. Resour. Dept., Mar. Resour. Res. Inst., 180 pp.

Appendix 3

Table 1. Annual commercial landings (lb) of red drum by state along the mid-Atlantic coast.

Year	RI	NY	NJ	DE	MD	VA	NC	SC	GA	FL*	Total
1972	-	-	-	-	-	5,900	42,919	1,200	3,400	128,400	181,819
1973	-	-	-	900	-	6,200	70,264	600	3,700	166,500	248,164
1974	-	-	-	-	-	15,700	142,437	2,300	3,100	137,300	300,837
1975	-	-	-	200	-	19,600	214,236	12,400	10,000	83,300	339,736
1976	-	-	-	-	-	18,600	168,259	2,600	7,300	106,000	302,759
1977	-	-	-	200	-	300	19,637	800	5,000	103,500	129,437
1978	-	-	-	300	-	2,100	21,774	4,325	328	104,696	133,523
1979	-	-	-	-	100	1,900	126,517	1,767	935	92,684	223,903
1980	-	-	-	-	-	400	243,223	4,107	1,493	191,222	440,445
1981	-	-	-	-	-	200	93,420	-	261	258,374	352,255
1982	-	-	-	-	-	1,700	52,561	2,228	251	139,170	195,910
1983	-	-	-	-	100	41,700	219,871	2,274	1,126	105,164	370,235
1984	-	-	-	-	-	2,600	283,020	3,950	1,961	130,885	422,416
1985	-	-	-	-	-	1,100	152,676	3,512	3,541	88,929	249,758
1986	-	-	-	-	1,000	5,400	249,076	12,429	2,939	77,070	347,914
1987	-	-	-	-	-	2,600	249,657	14,689	4,565	42,993	314,504
1988	-	-	-	-	8,100	4,000	220,271	-	3,281	284	235,936
1989	-	-	-	-	1,000	8,200	274,356	165	3,963	-	287,684
1990	-	-	-	-	29	1,481	183,216	-	2,763	-	187,489
1991	-	-	-	-	7,533	24,771	96,045	-	1,637	-	129,986
1992	-	-	-	-	1,087	2,352	128,497	-	1,759	-	133,695
1993	-	-	-	-	55	8,637	238,099	-	2,533	-	249,324
1994	5,094	-	-	-	859	4,080	142,119	-	2,141	-	154,293
1995	-	668	-	-	6	2,992	248,122	-	2,578	-	254,366
1996	-	8	-	-	215	2,073	113,338	-	2,271	-	117,905
1997	43	-	-	-	22	4,049	52,502	-	1,395	-	58,011
1998	165	57	311	-	336	6,436	294,366	-	672	-	302,343
1999	-	47	241	6	504	12,368	372,942	-	1,115	-	387,223
2000	-	1,215	-	-	843	11,457	270,953	-	707	-	285,175
2001	-	58	14	-	727	5,318	149,616	-	-	-	155,733
2002	-	116	-	-	1,161	7,752	81,364	-	-	-	90,393
2003	-	43	-	-	631	2,716	90,525	-	-	-	93,915
2004	-	-	-	-	12	638	54,086	-	-	-	54,736
2005	-	-	-	-	37	656	128,770	-	-	-	129,463
Total	5,302	2,212	566	1,606	24,357	235,976	5,488,734	69,346	76,715	1,956,471	7,861,285

*Florida landings are for the East coast of Florida only.

Appendix 3

Table 2. Percentage of commercial landings of red drum in North Carolina by water area.

Year	Albermarle Sound	Atlantic Ocean	Core Sound	Croatan and Roanoke Sounds	Pamlico Sound	Pamlico/ Neuse River	Bogue Sound south	Unknown	Total
1972	0.70	40.39	20.07	0.23	34.32	4.04	0.24	-	100
1973	0.24	46.69	31.79	0.31	19.41	1.21	0.35	-	100
1974	0.65	24.87	29.06	5.61	36.57	2.22	1.02	-	100
1975	6.17	50.97	10.58	2.54	25.12	4.23	0.39	-	100
1976	18.22	16.56	3.01	2.46	32.57	26.28	0.89	-	100
1977	-	31.84	20.81	0.96	33.13	12.54	0.72	-	100
1978	-	71.69	8.97	-	14.97	4.37	-	-	100
1979	0.08	21.06	39.47	0.40	27.86	10.87	0.27	-	100
1980	-	29.26	27.12	0.06	36.44	6.78	0.34	-	100
1981	-	29.85	12.97	-	53.39	3.41	0.39	-	100
1982	0.33	58.57	17.32	0.21	14.43	5.61	3.54	-	100
1983	0.82	31.54	26.87	0.53	24.27	3.33	12.65	-	100
1984	0.25	58.39	19.68	0.85	7.16	2.60	11.08	-	100
1985	0.03	47.78	21.47	0.02	9.45	0.76	20.48	-	100
1986	1.68	27.81	20.78	0.23	24.65	11.19	13.66	-	100
1987	13.03	16.78	19.51	2.17	28.85	8.26	11.41	-	100
1988	5.02	23.19	26.03	0.60	24.96	9.12	11.08	-	100
1989	3.57	19.31	23.02	1.50	35.68	7.14	9.77	-	100
1990	0.43	26.04	21.79	1.16	35.34	1.88	13.37	-	100
1991	5.56	13.95	22.44	1.03	36.94	1.57	18.51	-	100
1992	9.37	10.75	13.32	3.19	47.02	1.99	14.34	-	100
1993	19.07	15.08	6.65	5.75	41.23	2.54	9.68	-	100
1994	6.74	24.39	4.76	0.71	51.75	4.02	7.63	-	100
1995	1.75	10.73	8.51	1.33	63.39	6.73	7.56	-	100
1996	1.26	15.20	12.71	0.46	42.75	7.33	20.28	<0.01	100
1997	0.70	13.39	22.77	2.73	40.02	6.83	13.56	-	100
1998	6.94	2.27	3.39	5.29	76.40	2.84	2.87	-	100
1999	19.64	1.90	6.17	11.42	50.06	7.16	3.66	-	100
2000	9.38	10.40	5.92	15.73	46.14	7.65	4.77	-	100
2001	7.82	4.83	9.01	20.65	43.00	9.53	5.15	-	100
2002	9.68	2.68	10.28	14.09	32.02	20.01	11.24	-	100
2003	6.31	3.62	8.88	16.63	33.86	15.13	15.55	-	100
2004	3.09	5.73	10.48	12.71	47.16	6.35	14.47	-	100
2005	6.11	2.37	14.71	5.33	40.05	18.55	12.87	-	100

Appendix 3

Table 3. North Carolina red drum catches for recreational anglers (MRFSS), for 1989 – 2005 with PSE. All weights are in pounds. Commercial weights are included as a reference with combined weights reported.

	Recreational							
	Numbers							
Year	A + B1* # Landed	PSE	B2* # Released	PSE	A + B1 Weight (lb)	PSE	Commercial Weight (lb)	Total Weight (lb)
1986	17,501	66	-	.	31,594	67	249,076	280,670
1987	61,100	20	18,499	37	166,031	28	249,657	415,688
1988	142,626	18	24,874	58	451,979	29	220,271	672,250
1989	62,359	16	7,566	34	214,851	20	274,356	489,207
1990	33,149	28	12,452	38	302,996	64	183,216	486,212
1991	38,658	15	121,178	14	108,269	16	96,045	204,314
1992	23,593	19	60,230	18	109,136	20	128,497	237,633
1993	49,493	12	182,301	20	266,461	14	238,099	504,560
1994	28,953	16	107,662	14	192,062	21	142,119	334,181
1995	83,686	11	155,421	10	382,431	11	248,122	630,553
1996	35,061	13	34,286	18	194,136	14	113,338	307,474
1997	8,580	26	254,219	11	38,286	28	52,502	90,788
1998	114,638	12	199,701	11	591,435	13	294,366	885,801
1999	64,739	14	247,146	10	326,307	15	372,942	699,249
2000	61,618	13	203,967	14	316,032	12	270,953	586,985
2001	23,142	16	238,552	14	132,580	17	149,616	282,196
2002	42,541	15	640,857	11	182,227	17	81,364	263,591
2003	25,481	16	75,561	15	118,809	18	90,525	209,334
2004	30,165	19	191,593	10	114,435	19	54,086	168,521
2005	53,154	21	327,859	15	242,021	21	128,770	370,791

Definitions of recreational catch type:
*A = fish brought ashore in whole form which can be identified, enumerated, weighed, and measured by interviewers.
*B = fish not brought ashore that can be separated into: B1 = fish caught used as bait, filleted, or discarded & B2 = those released alive.

Table 4. Northern region red drum catches for recreational anglers (MRFSS), for 1989 – 2005 with PSE. All weights are in pounds. Commercial weights are included as a reference with combined weights reported.

	Recreational							
	Numbers							
Year	A + B1* # Landed	PSE	B2* # Released	PSE	A + B1 Weight (lb)	PSE	Commercial Weight (lb)	Total Weight (lb)
1986	58,444	27	7,595	68	931,280	55	255,476	1,186,756
1987	63,286	19	18,499	37	191,830	24	252,257	444,087
1988	146,938	18	28,832	51	461,009	29	232,371	693,380
1989	75,381	14	17,521	30	244,434	18	283,556	527,990
1990	34,427	27	13,386	36	305,674	64	184,726	490,400
1991	58,522	16	140,071	15	144,486	14	128,349	272,835
1992	36,867	19	75,914	17	164,462	20	131,936	296,398
1993	63,498	14	232,736	18	311,967	12	246,791	558,758
1994	30,331	16	118,346	13	195,746	20	152,152	347,898
1995	87,350	10	187,699	11	448,449	10	251,788	700,237
1996	35,631	13	36,712	17	195,643	14	115,634	311,277
1997	10,495	24	366,469	13	40,081	27	56,616	96,698
1998	127,709	11	296,129	10	626,296	12	301,671	927,967
1999	77,164	14	482,187	16	419,102	15	386,108	805,210
2000	84,222	12	401,966	19	411,628	12	284,468	696,096
2001	30,384	15	268,917	13	184,471	13	155,733	340,204
2002	98,131	14	1,461,896	9	353,455	15	90,393	443,848
2003	39,088	17	122,606	17	176,023	17	93,915	269,938
2004	35,140	19	224,809	10	146,183	19	54,736	200,919
2005	55,827	20	359,005	14	249,387	21	129,463	378,850

Definitions of recreational catch type:
*A = fish brought ashore in whole form which can be identified, enumerated, weighed, and measured by interviewers.
*B = fish not brought ashore that can be separated into: B1 = fish caught used as bait, filleted, or discarded & B2 = those released alive.

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Table 5. The number of NCDMF award citations issued on an annual basis for catches of red drum. Citations are awarded for releases ≥ 40 in and weigh-ins* ≥ 45 lb.

Year	# Citations	# Released	% Released
1987	215	150	70
1988	324	266	82
1989	335	275	82
1990	419	374	89
1991	335	308	92
1992	451	427	95
1993	644	627	97
1994	876	868	99
1995	622	607	98
1996	685	655	96
1997	737	704	96
1998	515	483	94
1999	1,073	1,073	100
2000	1,200	1,200	100
2001	1,156	1,156	100
2002	1,330	1,330	100
2003	1,030	1,030	100
2004	1,337	1,337	100
2005	1,520	1,520	100

*Due to regulations all citations since 1999 are for release only.

Table 6. Primary size and bag limits for recreational and commercial fisheries within each of the regulatory periods for North Carolina.

Regulation period	Recreational regulations	Commercial regulations
1987-1991	14 in TL minimum size limit Only 2 fish over 32 in TL	14 in TL minimum size limit
1992-1998	18-27 in TL slot limit 5 fish bag limit 1 fish >27 in TL allowed	250,000 lb commercial cap 18-27 in TL slot limit 1 fish >27 in TL allowed (no sale)
1999-2004	18-27 in TL slot limit 1 fish bag limit	18-27 in TL slot limit 7 fish daily trip limit

Table 7. Commercial length frequencies by regulation period sampled from major North Carolina fisheries. TL measured in inches.

Total	Early				Mid				Late			
Length	Gill	Haul	Pound	Trawl	Gill	Haul	Pound	Trawl	Gill	Haul	Pound	Trawl
7	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	5.34	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	8.68	0.00	0.00	0.00	0.38	0.00	1.24	0.00	0.00	0.00	0.00
11	0.13	12.24	0.00	0.00	0.03	0.02	0.00	1.24	0.00	0.00	0.00	0.00
12	0.13	14.57	27.83	0.00	0.07	0.27	0.51	2.48	0.00	0.00	0.44	0.00
13	2.96	6.34	1.74	0.00	0.08	0.59	0.00	1.24	0.05	0.00	0.00	0.00
14	17.37	4.67	5.22	0.00	0.12	0.51	0.51	1.24	0.05	0.00	0.00	0.00
15	24.58	7.23	12.17	9.52	0.10	0.15	0.51	0.00	0.00	0.00	0.00	0.00
16	11.58	3.56	9.57	0.00	0.32	0.10	1.02	0.00	0.05	0.00	0.00	0.00
17	14.41	10.68	9.57	9.52	4.15	2.34	2.54	0.00	1.81	2.86	0.89	0.00
18	15.32	5.90	14.78	0.00	12.79	25.01	3.55	0.00	12.16	10.71	7.11	0.00
19	7.21	1.11	6.96	9.52	20.03	16.56	2.03	0.00	8.81	17.14	6.67	0.00
20	1.42	0.67	1.74	4.76	17.85	7.06	1.52	0.00	7.12	14.29	0.44	0.00
21	1.67	13.90	0.87	0.00	8.56	5.72	0.51	3.73	8.54	9.29	3.11	44.44
22	0.39	0.22	0.00	0.00	4.96	14.17	5.08	0.00	12.71	9.29	6.67	0.00
23	0.13	2.56	0.00	0.00	9.93	9.38	11.68	11.18	14.55	7.86	11.11	6.67
24	0.51	0.11	0.87	0.00	7.59	11.57	14.72	18.63	14.76	5.71	23.11	8.89
25	0.26	0.33	1.74	0.00	5.10	4.41	25.38	22.36	10.42	7.14	18.22	6.67
26	0.00	0.22	0.87	0.00	5.53	0.89	20.30	16.77	6.08	3.57	14.22	22.22
27	0.00	0.22	0.00	0.00	2.08	0.06	6.60	14.91	1.95	3.57	5.78	0.00
28	0.13	0.00	2.61	0.00	0.37	0.00	0.51	0.00	0.55	5	1.78	4.44
29	0.26	0.00	0.87	0.00	0.13	0.00	0.51	0.00	0.29	2.14	0.44	4.44
30	0.13	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.02	0.71	0.00	0.00
31	0.00	0.00	0.00	0.00	0.06	0.00	0.51	0.00	0.07	0.71	0.00	0.00
32	0.00	0.00	0.00	0.00	0.06	0.51	1.02	0.62	0.00	0.00	0.00	2.22
33	0.26	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
34	0.00	0.00	0.00	4.76	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.62	0.00	0.00	0.00	0.00
37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.62	0.00	0.00	0.00	0.00
38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.48	0.00	0.00	0.00	0.00
39	0.00	0.11	0.00	0.00	0.00	0.00	0.51	0.00	0.00	0.00	0.00	0.00
40	0.13	0.11	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
41	1.03	1.22	2.61	61.90	0.03	0.00	0.51	0.62	0.00	0.00	0.00	0.00

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Table 8. Commercial sampling intensity of major gears, determined by numbers of fish sampled per thousand lb of catch, 1999-2005. Gill net includes estuarine gill nets, sink nets, beach seines, and others.

	1999	2000	2001	2002	2003	2004	2005
Gill net	2.6	2.6	2.7	5.6	4.3	6.2	6.2
Pound net	6.0	2.6	6.1	6.9	0.8	3.2	7.8
Long haul seine	8.7	13.2	4.0	31.5	16.9	6.0	3.4
Ocean Trawl	0	21.2	16.8	0	0	0	0

Table 9. Age-length key for the northern red drum stock, 1999-2005.

	Length Bin																	
Age by period	7	9	11	13	15	17	19	21	23	25	27	29	31	33	35	37	39	41	Total
1999																			
1		100	100	56.6	49.17	33.64	25	10.2	2.53	0	0	0	0		0		0	0	173
2		0	0	43.4	50.83	66.36	75	75.51	77.22	83.78	50	22.22	33.33		0		0	0	391
3		0	0	0	0	0	0	14.29	20.25	16.22	50	77.78	66.67		0		0	0	51
6		0	0	0	0	0	0	0	0	0	0	0	0		100		100	100	14
2000																			
1	100	100	100	63	43.93	43.53	12.9	0	0	0	0	0	0	0	0	0		0	133
2	0	0	0	37	56.07	56.47	85.7	90.63	73.68	48.94	6.9	7.14	0	0	0	0		0	289
3	0	0	0	0	0	0	1.43	9.38	26.32	51.06	90	85.71	78.57	50	0	0		0	98
4	0	0	0	0	0	0	0	0	0	0	3.5	7.14	21.43	50	100	100		0	10
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		100	7
2001																			
1		100	94	40.4	33.77	27.78	15.2	0	0	0	0	0	0	0	0	0		0	91
2		0	5.9	59.6	66.23	72.22	84.9	71.74	44.44	14.52	8.3	0	0	0	0	0		0	247
3		0	0	0	0	0	0	28.26	55.56	85.48	83	53.85	0	25	0	0		0	129
4		0	0	0	0	0	0	0	0	0	8.3	46.15	100	75	50	0		0	20
5		0	0	0	0	0	0	0	0	0	0	0	0	0	50	100		0	3
6		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		100	5
2002																			
1			94	60	63.29	44.23	30.9	4.76	0	0	0	0	0	0	0		0	0	150
2			6.3	40	36.71	55.77	69.1	95.24	92.86	92.31	70	0	0	0	0		0	0	243
3			0	0	0	0	0	0	7.14	7.69	20	16.67	0	100	33		0	0	9
4			0	0	0	0	0	0	0	0	10	83.33	100	0	0		0	0	11
5			0	0	0	0	0	0	0	0	0	0	0	0	67		100	0	3
6			0	0	0	0	0	0	0	0	0	0	0	0	0		0	100	9
2003																			
1				0	24	17.54	5.17	0	0	0	0	0						0	19
2				100	76	82.46	94.8	100	88.71	67.74	0	0						0	237
3				0	0	0	0	0	11.29	32.26	88	60						0	27
4				0	0	0	0	0	0	0	13	40						0	3
6				0	0	0	0	0	0	0	0	0						100	1
2004																			
1		100	100	100	100	98.15	65.5	0	0	0	0	0	0					0	245
2		0	0	0	0	1.85	34.5	83.33	50	3.03	21	12.5	0					0	33
3		0	0	0	0	0	0	16.67	50	96.97	79	75	50					0	65
4		0	0	0	0	0	0	0	0	0	0	12.5	50					0	2
6		0	0	0	0	0	0	0	0	0	0	0	0					100	3
2005																			
1			100	93.3	74.32	37.84	7.89	0	0	0	0	0				0	0	0	151
2			0	6.67	25.68	62.16	92.1	100	98.11	98.25	85	0				0	0	0	318
3			0	0	0	0	0	0	1.89	1.75	15	100				0	0	0	6
5			0	0	0	0	0	0	0	0	0	0				100	0	0	1
6			0	0	0	0	0	0	0	0	0	0				0	100	100	7

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Table 10. Estimated von Bertalanffy parameters for the northern red drum stock, standard and linear.

Standard		Linear	
L_{max}	47.1615	b_0	40.8008
k	0.1539	b_1	0.1541
t_0	-1.7434	k	0.3161
		t_0	0.1095

Table 11. Catch-at-age matrices in numbers of fish with the recreational B2 length frequency assumptions included for the early period, 1986-1991.

	Early (1986-1991)					
	Base0					
	1	2	3	4	5	6+
1986	101,938	24,874	2,452	74	91	21,382
1987	116,635	28,332	3,578	2,174	149	2,264
1988	141,765	60,424	25,013	146	94	3,031
1989	126,086	44,436	7,492	66	53	3,648
1990	85,935	15,926	4,621	182	27	1,974
1991	80,141	20,584	1,211	824	28	394
	Base1					
	1	2	3	4	5	6+
1986	102,376	24,951	2,452	74	92	21,627
1987	118,127	28,617	3,584	2,233	153	2,267
1988	143,310	61,301	25,453	148	96	3,046
1989	127,161	44,977	7,601	66	54	3,673
1990	87,017	16,079	4,694	187	28	2,001
1991	91,236	23,176	1,369	973	31	407

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Table 12. Catch-at-age matrices in numbers of fish with the recreational B2 length frequency assumptions included for the mid period, 1992-1998.

	Mid (1992-1998)					
	Base0					
	1	2	3	4	5	6+
1992	4,064	64,480	4,746	306	51	266
1993	4,837	76,259	31,366	47	20	419
1994	7,401	29,995	20,006	3,416	45	1,327
1995	11,718	114,051	11,038	1,135	520	294
1996	18,487	30,534	10,983	985	37	399
1997	18,516	8,043	4,116	371	77	75
1998	12,056	209,647	5,076	388	350	1,156
	Base1					
	1	2	3	4	5	6+
1992	4,594	70,976	5,301	306	53	271
1993	6,241	92,744	36,644	51	24	514
1994	8,960	34,862	23,977	4,373	60	1,787
1995	13,822	128,965	12,407	1,366	629	336
1996	19,853	31,921	11,774	1,071	40	435
1997	37,768	15,700	12,359	1,426	331	262
1998	12,436	237,416	6,125	471	430	1,405
	Delta					
	1	2	3	4	5	6+
1992	6,725	68,879	4,773	338	58	729
1993	14,459	88,284	31,452	143	42	1,836
1994	15,160	33,230	20,061	3,466	56	2,046
1995	25,789	117,440	11,118	1,194	547	1,436
1996	21,411	31,024	10,995	1,002	40	622
1997	49,485	10,933	4,469	536	112	2,308
1998	25,918	223,329	5,174	514	421	2,926
	Prop					
	1	2	3	4	5	6+
1992	6,150	69,445	4,915	329	57	605
1993	12,240	89,488	32,854	118	37	1,479
1994	13,486	33,671	21,118	3,711	57	1,976
1995	22,558	120,552	11,466	1,241	569	1,139
1996	20,990	31,266	11,206	1,021	40	572
1997	46,322	12,220	6,599	776	171	1,756
1998	22,278	227,132	5,431	502	423	2,515

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Table 13. Catch-at-age matrices in numbers of fish with the recreational B2 length frequency assumptions included for the late period, 1999-2005.

	Late (1999-2005)					
	Base0					
	1	2	3	4	5	6+
1999	12,233	117,782	30,517	1,747	0	0
2000	3,776	74,179	62,195	1,372	0	0
2001	1,518	20,709	34,263	4,129	40	234
2002	24,625	88,979	3,104	1,943	797	0
2003	915	48,706	10,621	641	0	0
2004	9,214	17,783	18,675	323	0	0
2005	1,377	82,195	2,097	43	0	0
	Base1					
	1	2	3	4	5	6+
1999	15,990	150,989	40,858	2,667	0	0
2000	4,860	93,698	81,298	1,867	0	0
2001	2,288	28,486	49,120	7,375	76	439
2002	57,431	195,351	6,310	4,575	1,982	0
2003	1,092	58,337	12,909	806	0	0
2004	13,958	27,335	26,721	463	0	0
2005	1,576	116,967	3,025	43	0	0
	Delta					
	1	2	3	4	5	6+
1999	32,348	141,615	30,679	2,077	372	3,403
2000	21,236	93,304	62,383	1,647	310	2,837
2001	10,348	36,387	34,353	4,313	248	2,132
2002	97,967	148,884	3,596	2,943	1,926	10,319
2003	4,336	56,459	10,662	725	95	865
2004	28,832	18,654	18,751	477	174	1,587
2005	19,891	96,401	2,217	289	277	2,534
	Prop					
	1	2	3	4	5	6+
1999	25,805	145,365	34,751	2,313	223	2,042
2000	14,685	93,462	69,949	1,735	186	1,702
2001	7,124	33,226	40,260	5,538	179	1,455
2002	81,753	167,471	4,682	3,596	1,948	6,191
2003	3,038	57,210	11,561	757	57	519
2004	22,882	22,126	21,939	471	104	952
2005	12,565	104,627	2,540	191	166	1,520
	Tagging					
	1	2	3	4	5	6+
1999	31,221	136,541	33,049	2,637	1,138	5,919
2000	19,013	89,540	65,028	2,249	949	4,935
2001	10,424	31,317	36,734	5,104	675	3,534
2002	86,809	143,062	5,139	8,446	4,248	17,946
2003	4,592	54,673	11,103	981	289	1,505
2004	23,235	20,741	20,385	828	531	2,759
2005	17,753	94,683	2,907	1,016	847	4,407

Table 14. SVPA estimated selectivity vectors for the FADAPT modeling runs.

Period/Configuration	1	2	3	4	5	6+
Early	0.781	1.000	1.000	0.184	0.074	0.074
Mid/Delta	0.173	1.000	0.701	0.080	0.015	0.015
Late/Prop	0.134	1.000	0.481	0.038	0.005	0.005
Late/Tagging	0.184	1.000	0.481	0.070	0.030	0.030

Table 15. FADAPT estimates of average F, escapement, and static SPR by regulation period for TAGGING runs.

	Early (1986-1991)	
	TAGGING without IGNS	TAGGING with IGNS
Age-1	1.05	1.05
Age-2	1.39	1.39
Age-3	1.72	1.72
Age-4	0.41	0.41
Age-5	0.21	0.21
escapement	1.0	1.0
SPR	1.1	1.1

	Mid (1992-1998)	
	TAGGING without IGNS	TAGGING with IGNS
Age-1	0.21	0.21
Age-2	0.75	0.75
Age-3	0.39	0.39
Age-4	0.03	0.03
Age-5	0.005	0.005
escapement	18.3	18.3
SPR	18.7	18.7

	Late (1999-2004)	
	TAGGING without IGNS	TAGGING with IGNS
Age-1	0.13	0.13
Age-2	0.49	0.50
Age-3	0.23	0.24
Age-4	0.03	0.03
Age-5	0.015	0.016
escapement	41.0	40.6
SPR	40.8	40.4

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Table 16. Spreadsheet model estimates of average F, escapement, and static SPR by regulation period for TAGGING runs.

	Early (1986-1991)	
	TAGGING without IGNS	TAGGING with IGNS
Age-1	0.97	0.97
Age-2	1.32	1.31
Age-3	1.32	1.31
Age-4	0.20	0.20
Age-5	0.07	0.07
escapement	2.2	2.3
SPR	2.3	2.4

	Mid (1992-1998)	
	TAGGING without IGNS	TAGGING with IGNS
Age-1	0.13	0.13
Age-2	0.60	0.59
Age-3	0.42	0.41
Age-4	0.05	0.05
Age-5	0.014	0.014
escapement	30.1	30.3
SPR	30.3	30.4

	Late (1999-2004)	
	TAGGING without IGNS	TAGGING with IGNS
Age-1	0.13	0.13
Age-2	0.63	0.66
Age-3	0.30	0.32
Age-4	0.05	0.05
Age-5	0.032	0.032
escapement	32.8	32.8
SPR	32.3	32.3

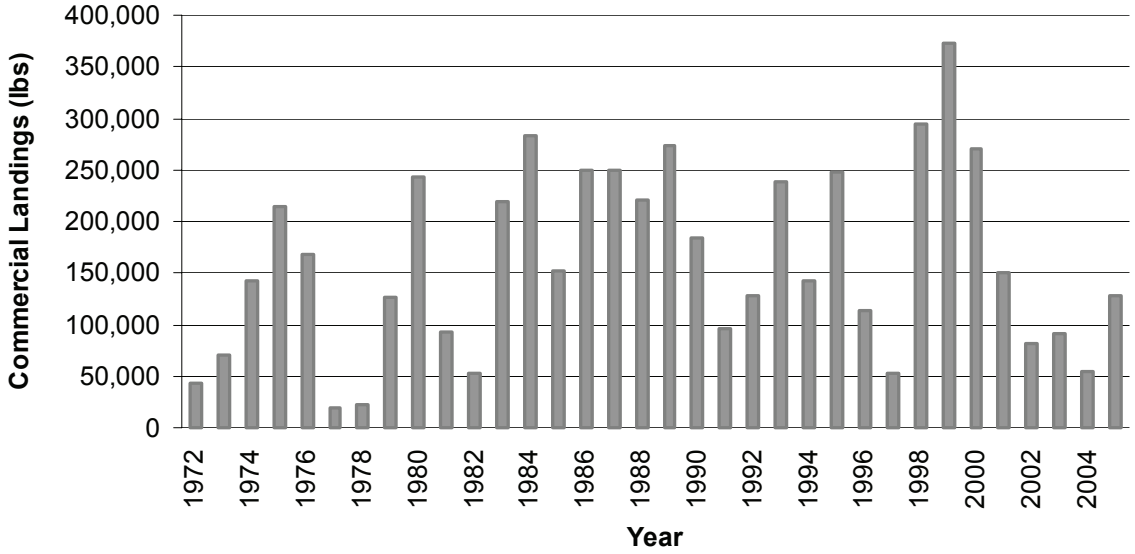

Figure 1. Annual commercial landings of red drum in North Carolina.

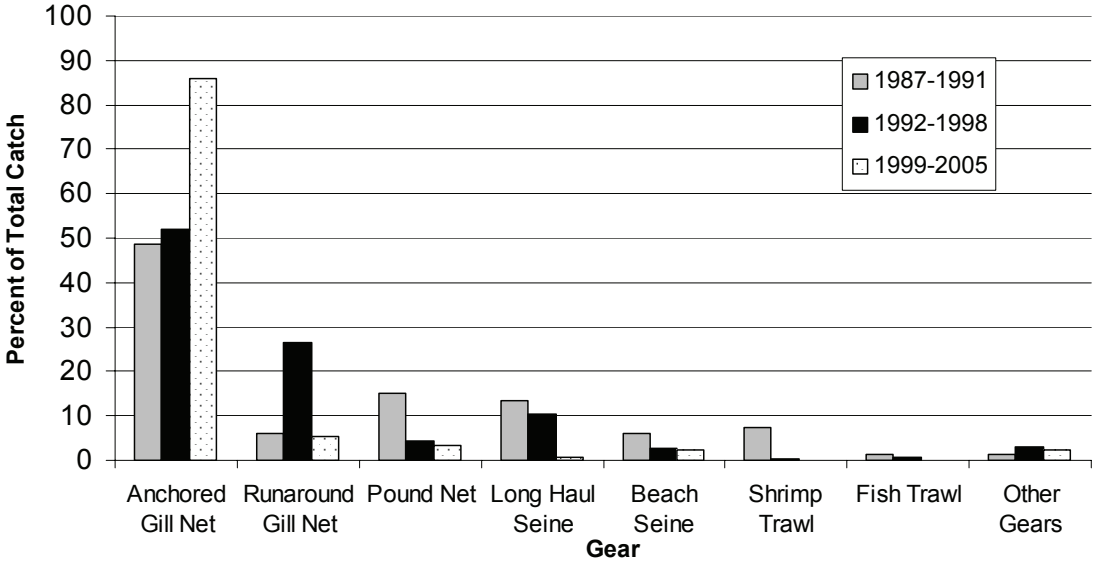

Figure 2. Percent landings of red drum by gear type for each harvest period.

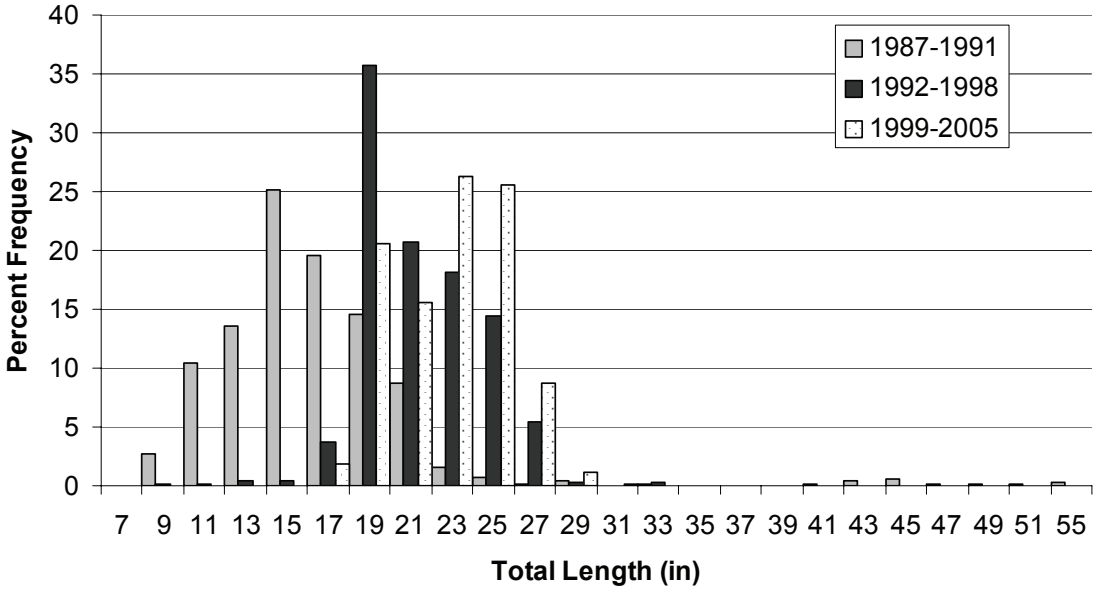

Figure 3. Length frequency of red drum sampled from the North Carolina commercial harvest (all gears combined) for the periods 1987-1991 (n=462), 1992-1998 (n=1,216), and 1999-2005 (n=4,174).

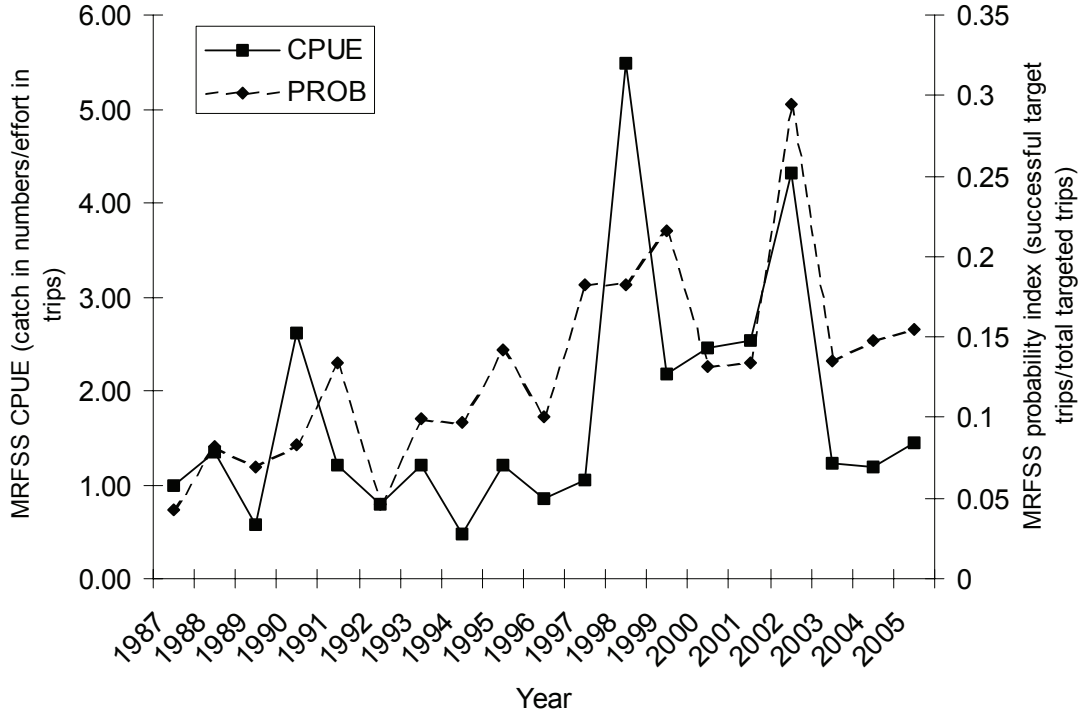

Figure 4. Target MRFSS catch per unit effort (CPUE) and MRFSS probability (PROB) indices for the northern red drum stock, 1987-2005.

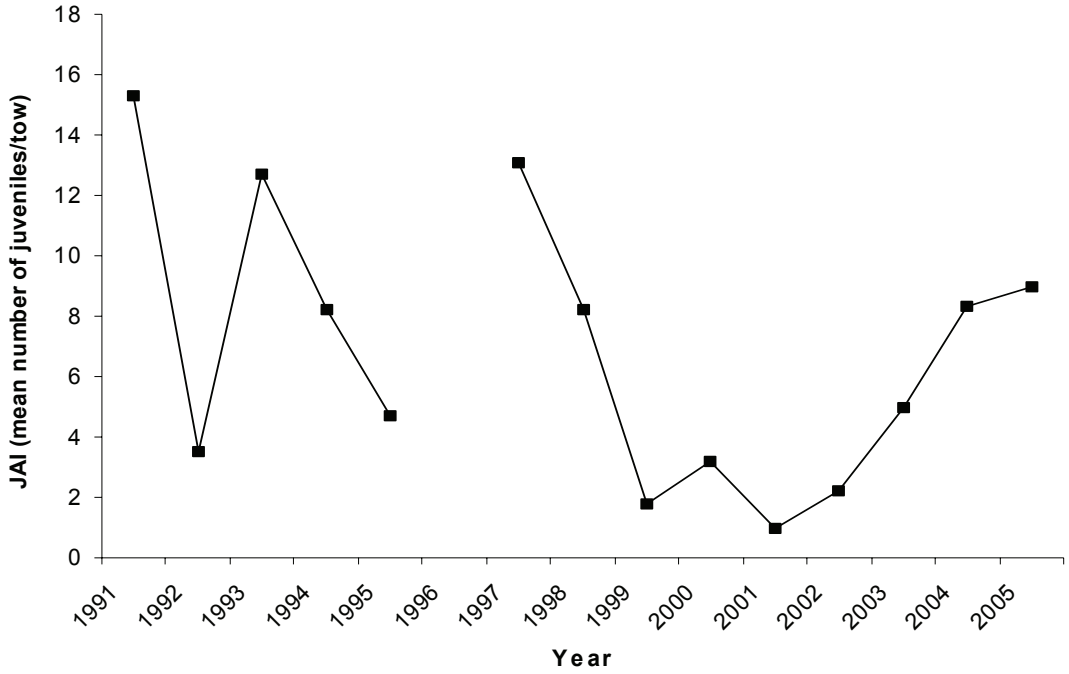

Figure 5. North Carolina JAI calculated from a state seine survey, 1992-2005. The 1996 value is excluded because of environmental conditions.

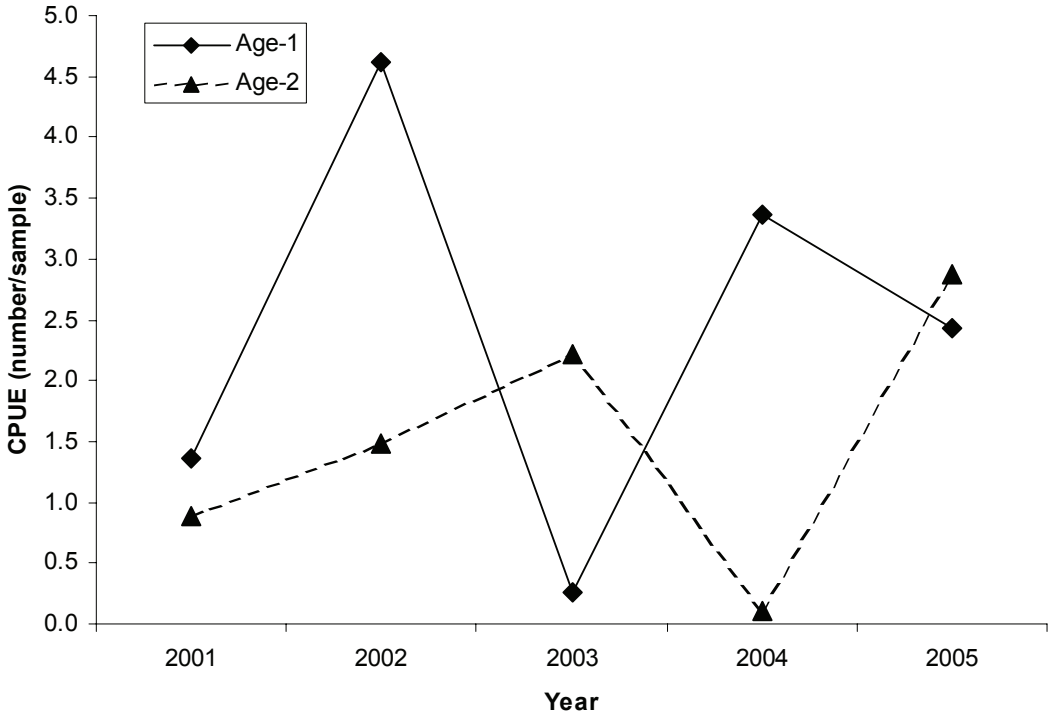

Figure 6. North Carolina IGNS age-1 and age-2 indices of abundance, 2001-2005.

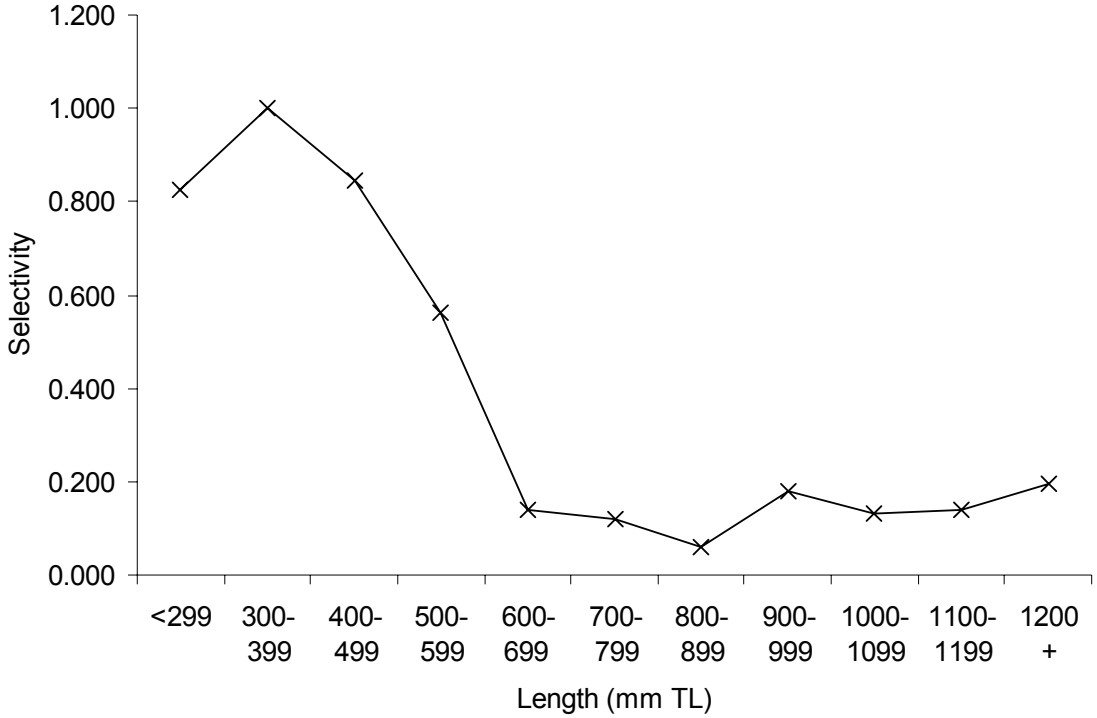

Figure 7. Recreational release length selectivity curve from tag analysis, from Burdick et al. 2006.

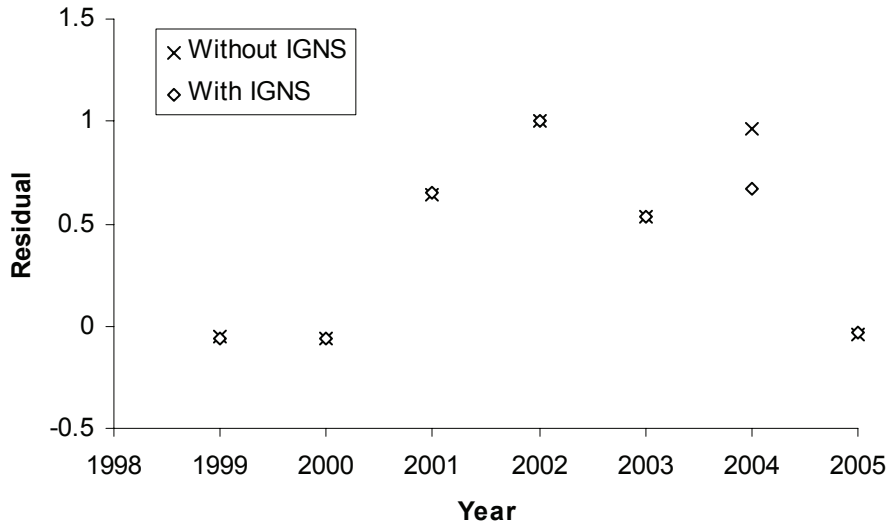

Figure 8. Residual plots of the MRFSS CPUE index for TAGGING FADAPT model runs including the IGNS indices and excluding the indices for the late period (1999-2005).

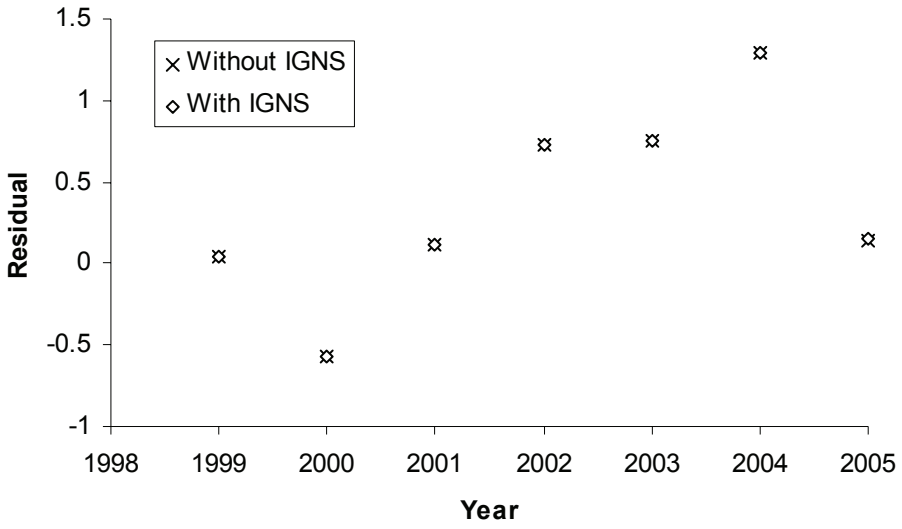

Figure 9. Residual plots of the MRFSS probability index for TAGGING FADAPT model runs including the IGNS indices and excluding the indices for the late period (1999-2005).

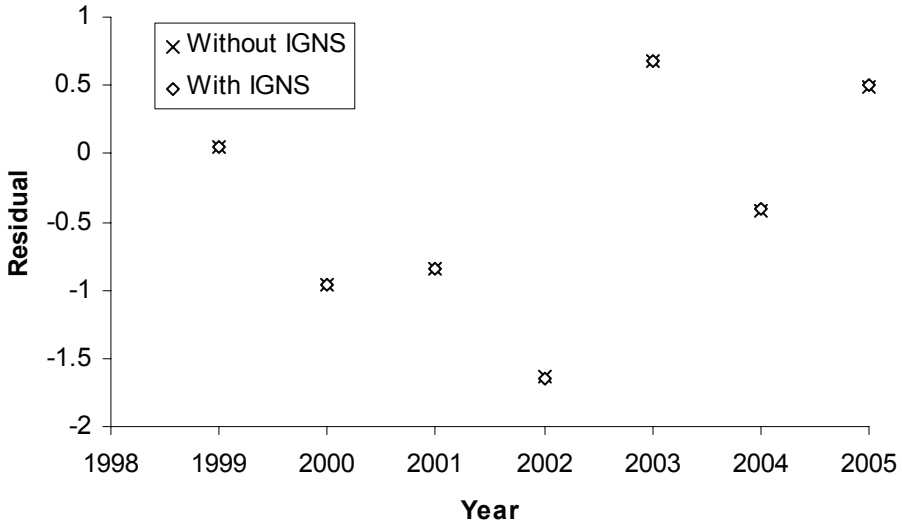

Figure 10. Residual plots of the JAI for TAGGING FADAPT model runs including the IGNS indices and excluding the indices for the late period (1999-2005).

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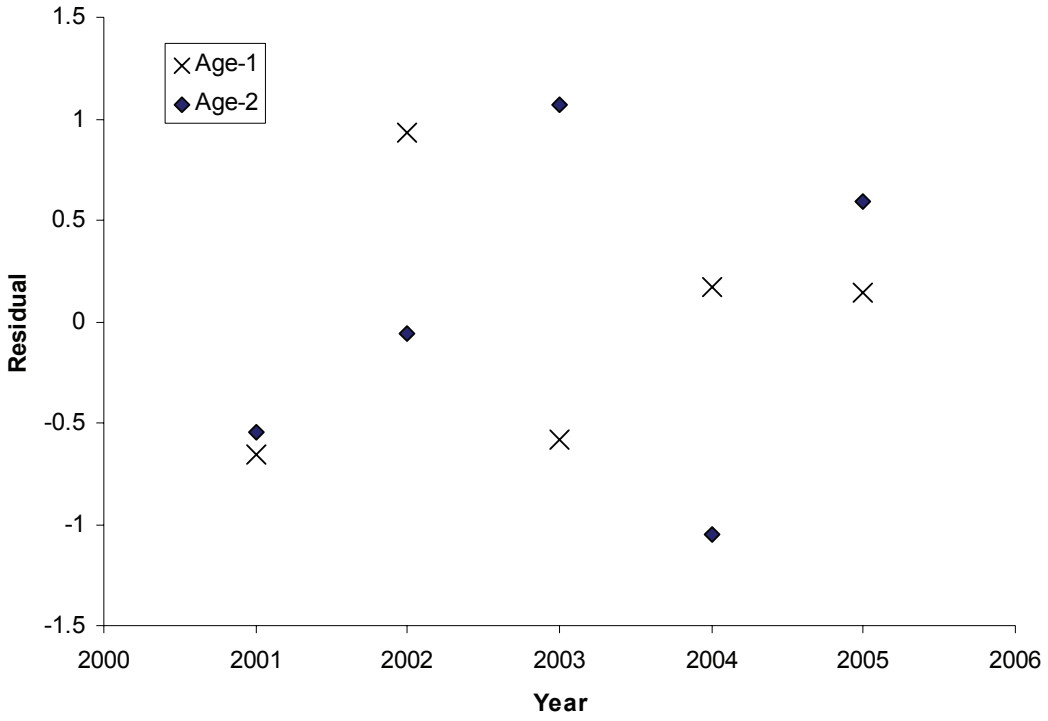

Figure 11. Residual plots of the IGNS age-1 and age-2 indices for TAGGING FADAPT model runs.

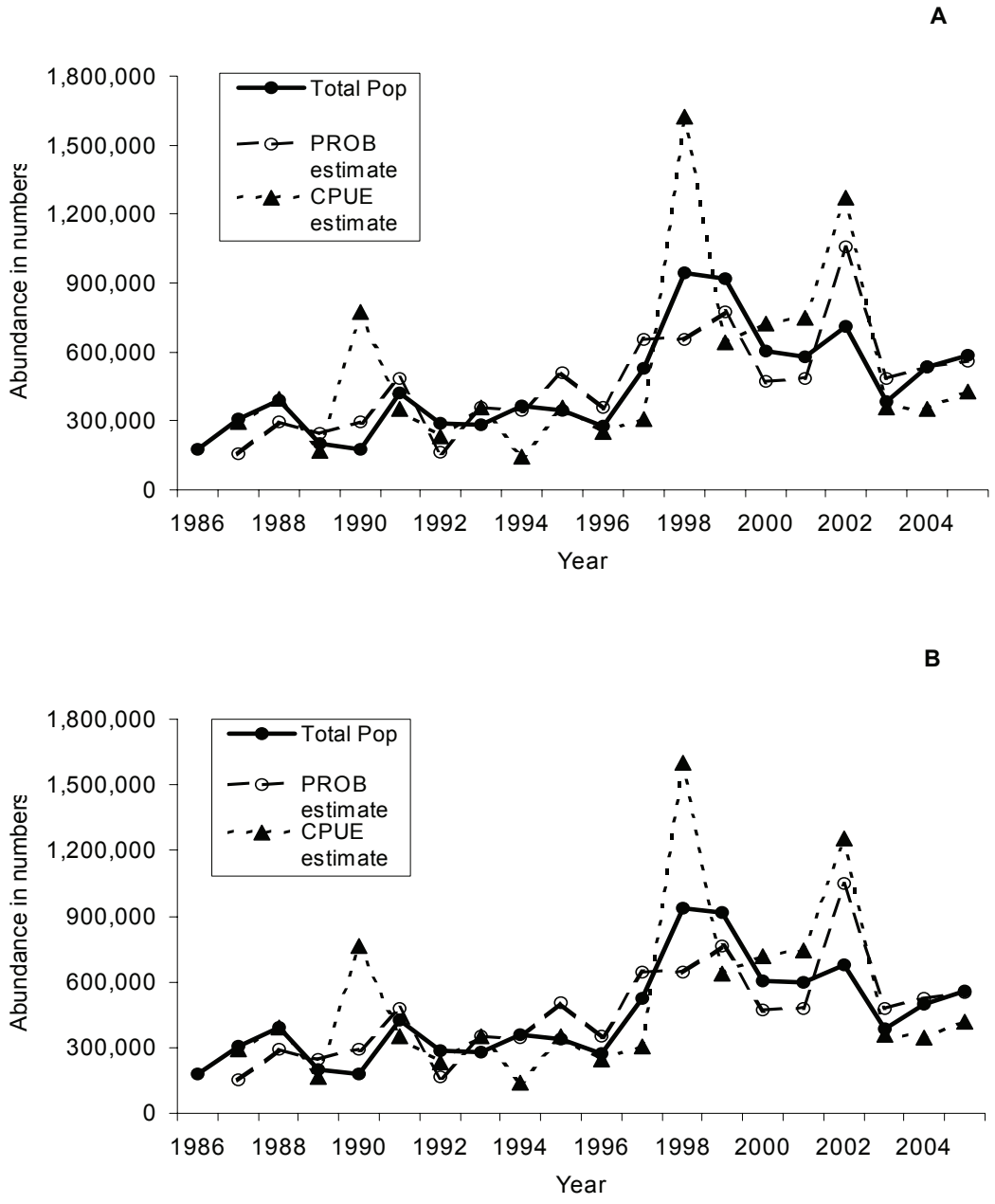

Figure 12. Estimated fits of the MRFSS CPUE and PROB indices for TAGGING spreadsheet model runs including the IGNS indices (A) and excluding the indices (B).

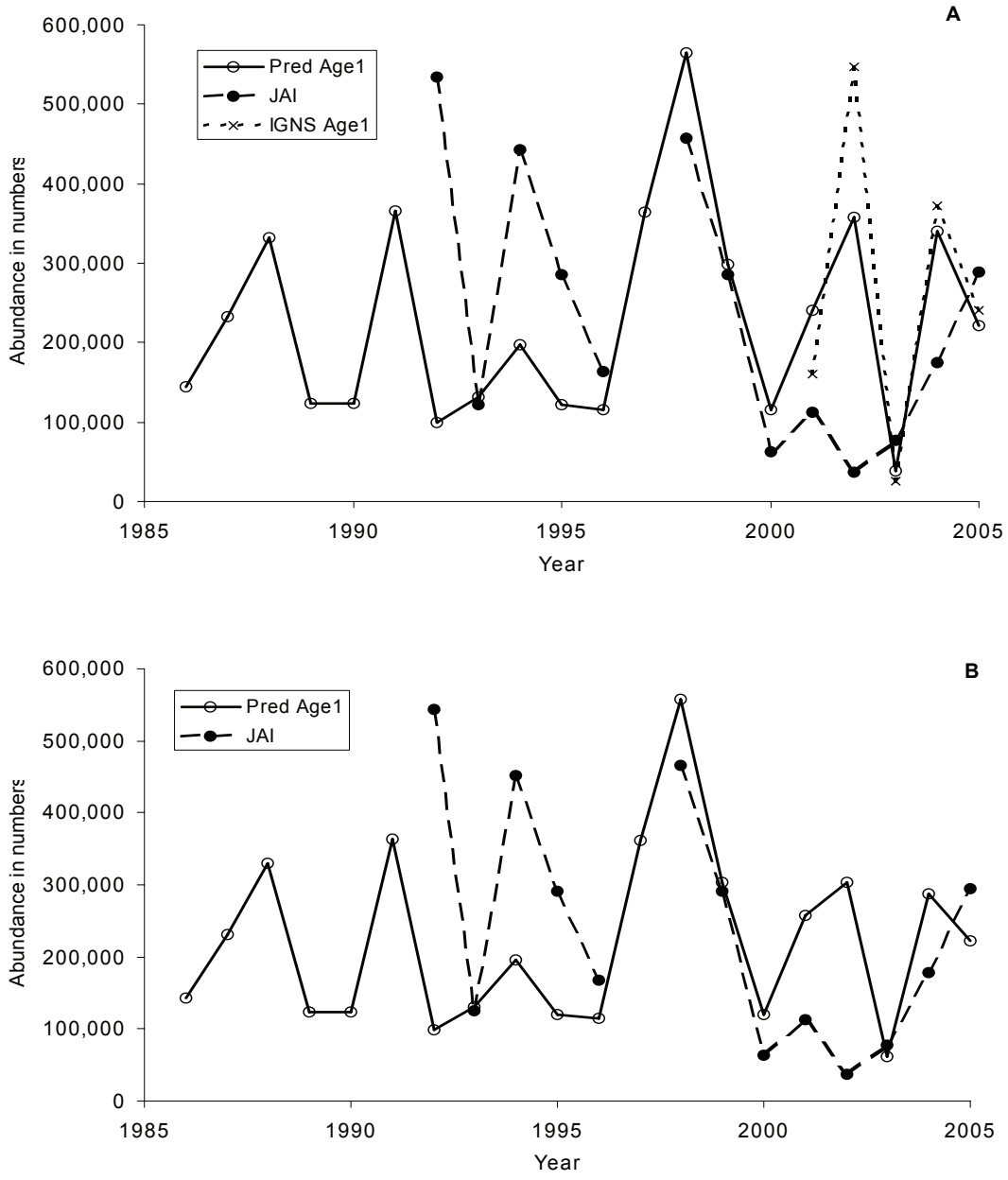

Figure 13. Estimated fits of the JAI and IGNS age-1 index for TAGGING spreadsheet model including (A) and excluding the IGNS indices (B).

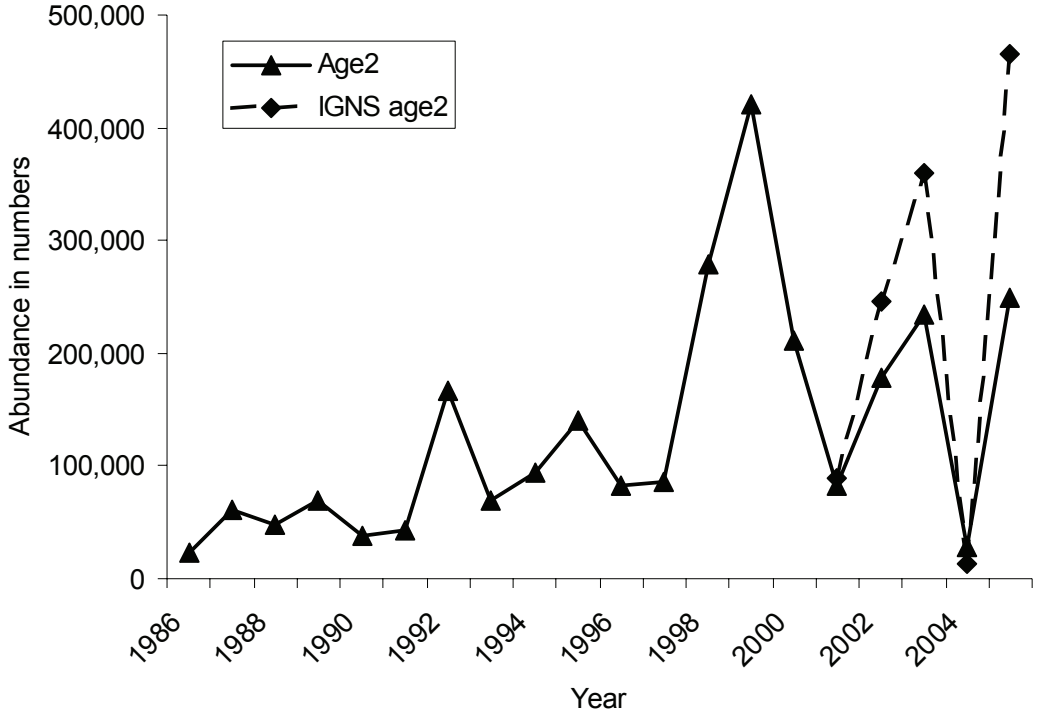

Figure 14. Estimated fits of the IGNS age-2 index for TAGGING spreadsheet model runs.

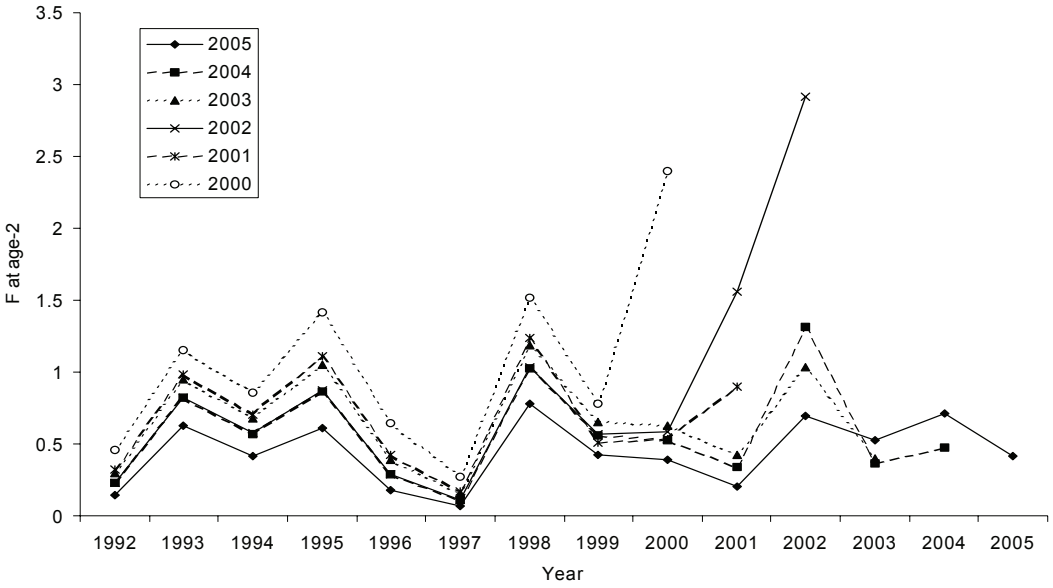

Figure 15. FADAPT retrospective analysis for the TAGGING configuration without the IGNS indices, 1992-2005.

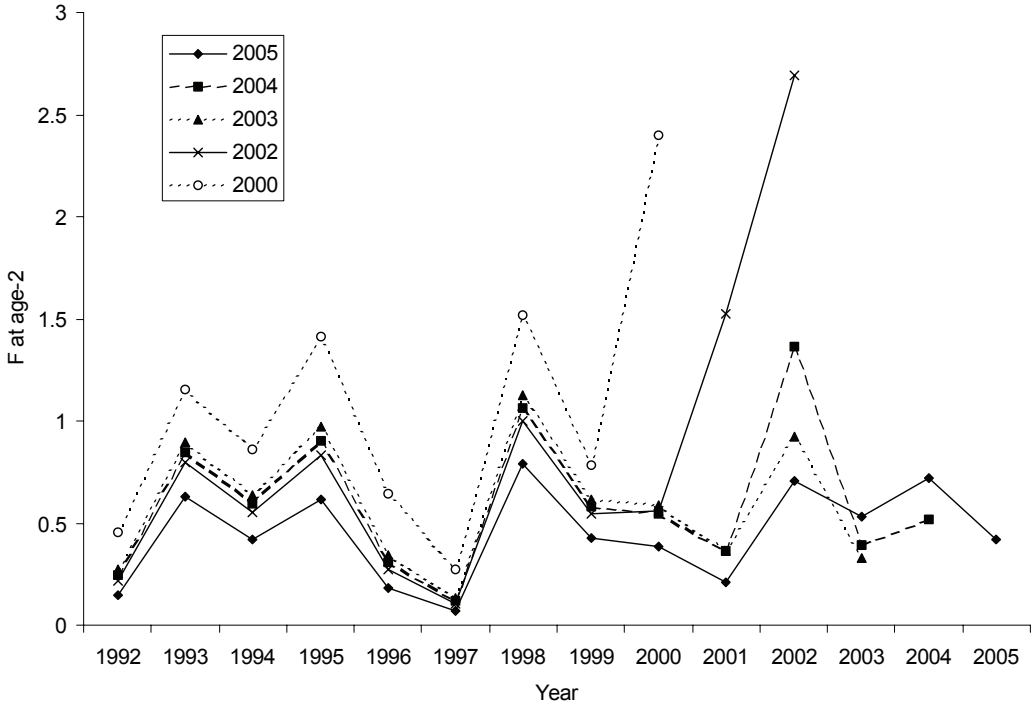

Figure 16. FADAPT retrospective analysis for the TAGGING configuration with the IGNS indices, 1992-2005. The 2001 run could not be completed due to model errors.

Appendix 1. Alternative discard and selectivity assumption sensitivity runs

Introduction

The previous assessment (2000) investigated four different discard assumptions. For this assessment, the same assumptions were examined and were not considered as preferred runs. The Base0, Base1, Delta, and Prop assumptions were all considered unlikely to represent the red drum fishery for the most recent regulation period. Also, the 2000 assessment used a slightly lower relative age-3 selectivity, 0.43 as well as the 0.7 selectivity vectors. These values were not used in favor of the 0.48 age-3 selectivity vectors that were estimated from tag returns.

This appendix contains the results and discussion of the assumptions that were not considered preferred runs. These results should be considered sensitivity runs to further understand model output in light of extreme model configurations compared to the preferred runs.

The methods used were the same as those described in the methods section of the assessment. These results were also conducted using the 0.48 selectivity assumption unless otherwise noted.

Results

FADAPT VPA

Base0 FADAPT runs had a fully recruited F ranging from 0.90 to 0.92 (Table A1). Full recruitment occurred at age-3, which differed from the results of the preferred runs. Escapement values ranged from 3.2% to 3.4% and static SPR values ranged from 3.2% to 3.3% (Table A1). Runs that included the IGNS indices had lower F values and higher percent escapement and static SPR.

Base1 FADAPT runs had a fully recruited F ranging from 0.99 to 1.02 (Table A1). Full recruitment occurred at age-3, which was different from the results of the preferred runs. Escapement values ranged from 2.5% to 2.8% and static SPR values ranged from 2.3% to 2.5% (Table A1). Runs that included the IGNS indices had lower F values and higher percent escapement and static SPR.

Delta FADAPT runs had a fully recruited F ranging from 0.67 to 0.71 (Table A1). Full recruitment occurred at age-2. Escapement values ranged from 26.4% to 30.1% and static SPR values ranged from 26.6% to 30.3% (Table A1). Runs that excluded the IGNS indices had lower F values and higher percent escapement and static SPR.

Prop FADAPT runs had a fully recruited F ranging from 0.69 to 0.70 (Table A1). Full recruitment occurred at age-2. Escapement values ranged from 27.6% to 28.4% and static SPR values ranged from 27.9% to 28.7% (Table A1). Runs that excluded the IGNS indices had lower F values and higher percent escapement and static SPR.

The 0.43 selectivity vector FADAPT runs had a fully recruited F of 0.44 (Table A2). Full recruitment occurred at age-2. Escapement values ranged from 45.4% to 45.6% and static SPR values ranged from 45.3% to 45.5% (Table A2). The runs that included the IGNS indices had slightly higher estimates of F, escapement, and SPR when compared to those without the indices. All of the estimates of fully recruited F were lower and the escapement and SPR estimates were higher than the comparable estimates with the higher 0.48 selectivity vector (see Table 13).

Spreadsheet VPA

Base0 spreadsheet runs had a fully recruited F ranging from 0.55 to 0.65 (Table A3). Escapement values ranged from 35.8% to 42.0% and static SPR values ranged from 36.2% to 42.3% (Table A3). Runs that excluded the IGNS indices and used the 0.48 selectivity vector had lower F values and higher percent escapement and static SPR.

Base1 spreadsheet runs had a fully recruited F ranging from 0.67 to 0.75 (Table A3). Escapement values ranged from 30.3% to 34.3% and static SPR values ranged from 30.7% to 34.7% (Table A3). Runs that excluded the IGNS indices and used the 0.48 selectivity vector had lower F values and higher percent escapement and static SPR.

Delta spreadsheet runs had a fully recruited F ranging from 0.68 to 0.75 (Table A3). Escapement values ranged from 27.3% to 34.3% and static SPR values ranged from 27.4% to 34.7% (Table A3). Runs that excluded the IGNS indices and used the 0.48 selectivity vector had lower F values and higher percent escapement and static SPR.

Prop spreadsheet runs had a fully recruited F ranging from 0.68 to 0.72 (Table A3). Escapement values ranged from 29.8% to 32.6% and static SPR values ranged from 30.0% to 32.8% (Table A3). Runs that included the IGNS indices and used the 0.48 selectivity vector had lower F values and higher percent escapement and static SPR.

The 0.43 selectivity vector spreadsheet runs had a fully recruited F ranging from 0.62 to 0.65 (Table A4). Full recruitment occurred at age-2. Escapement values ranged from 33.2% to 34.7% and static SPR values ranged from 32.8% to 34.2% (Table A4). The runs that included the IGNS indices had lower estimates of escapement and SPR and higher estimates of F than those

that did not include those indices. All of the estimates of fully recruited F were lower and the escapement and SPR estimates were higher than the comparable estimates with the higher 0.48 selectivity vector (see Table 14).

Discussion

The Base0, Base1, Delta, and Prop runs were not retained as preferred runs because the red drum PDT determined that they were unlikely to be reflections of the existing recreational fishery. Base0 assumed that there was no discard mortality in the recreational fishery, which seemed to be extremely unlikely. The Base1 discards are assumed to have a length frequency that is the same as those fish that are caught and retained. Given the slot limit that has been in place since 1992, it was believed to be unlikely that anglers would only catch fish within the slot. The pre-slot limit period regularly caught fish both above and below the limits. The Delta assumption had many more smaller and younger fish than occurred in the Base1 length frequencies and did allow for regulatory releases. However, Delta essentially assumed that all fish released were regulatory releases due to fish captured outside the slot limit and with the current bag limit set at one, it is likely that some releases are occurring within the slot limit. The PROP catch matrix assumed a 10% discard mortality rate and used a weighted average of the MRFSS length frequencies from the BASE1 and DELTA catch matrices, with the weights 40% BASE1 and 60% DELTA. The Tagging assumption does contain observed lengths of released fish. Generally, the Base0 and Base1 catch-at-age has a very high peak at age-2 and few fish at ages one, three, and four. Both catch-at-ages only rarely had fish ages 5 and 6+. The Delta catch-at-age had fish at ages five and 6+ and higher proportions of fish at ages one and four. The PROP run distribution falls between the Base1 and Delta runs. The Tagging catch-at-age distribution falls between Base1 and Delta up through age-3. At age-4 and greater, there are more fish than any of the other assumptions.

Both models estimated more optimistic results with the 0.43 selectivity vector. The spreadsheet model consistently estimated a level of SPR that meet or exceed the SPR threshold of 30%. For the spreadsheet model, these estimates may be related to the lower levels of F at ages greater than three, which would allow for more fish to escape to reproduce (Table A4). The FADAPT estimates of F were generally lower through all ages, which likely resulted in the higher estimates of escapement and SPR.

The FADAPT model was much more sensitive to the B2 assumptions than was the spreadsheet model. It appears that the extremely small numbers of fish at the oldest ages had a significant impact on the assessment results. Zeros that occur between non-zero values in a cohort cannot be handled in the model calculations. In fact, where there were zeros in catch-at-ages, the zeros were replaced with ones to prevent the model from failing to solve. The FADAPT model interpretation of the low catch numbers assumes that the population

numbers were low. The Delta and Prop runs were similar to each other, though still estimating lower levels of escapement and SPR than the Tagging runs.

The spreadsheet model was much less sensitive to differences in the B2 discards. The highest escapement and static SPR percentages consistently occurred for the Base0 assumption of no discards. Spreadsheet model runs only showed slight improvements in escapement and SPR from the mid to late periods, except for the Delta assumption. The full Delta and Prop runs including the IGNS indices estimated higher levels of escapement and static SPR in the mid period than in the late period. It is important to note that the previous assessment indicated that escapement and SPR in that time period was much higher than the estimates from the FADAPT model. The spreadsheet model results were similar to those results from the preferred runs.

Appendix 3

Table A1. FADAPT estimates for the late regulatory period for the Base0, Base1, Delta, and Prop discard assumptions using 0.48 selectivity vectors.

	Late (1999-2004)							
	Without IGNS				With IGNS			
	Base0	Base1	Delta	Prop	Base0	Base1	Delta	Prop
Age-1	0.08	0.11	0.24	0.15	0.08	0.10	0.18	0.15
Age-2	0.92	1.02	0.71	0.70	0.90	0.99	0.67	0.69
Age-3	1.37	1.49	0.36	0.41	1.35	1.45	0.32	0.40
Age-4	1.06	1.06	0.03	0.03	1.06	1.05	0.03	0.03
Age-5	0.55	0.79	0.007	0.004	0.54	0.77	0.007	0.004
escapement	3.2	2.5	26.4	27.6	3.4	2.8	30.1	28.4
SPR	3.2	2.3	26.6	27.9	3.3	2.5	30.3	28.7

Table A2. FADAPT estimates for the late regulatory period for the TAGGING discard assumptions using the 0.43 selectivity vectors.

	Late (1999-2004)	
	TAGGING with IGNS	TAGGING without IGNS
Age-1	0.12	0.12
Age-2	0.44	0.44
Age-3	0.20	0.20
Age-4	0.03	0.03
Age-5	0.012	0.012
escapement	45.6	45.4
SPR	45.5	45.3

Appendix 3

Table A3. Spreadsheet catch-age model estimates for the late regulatory period for the Base0, Base1, and Delta discard assumptions using 0.48 selectivity vectors.

	Early (1986-1991)							
	Without IGNS				With IGNS			
	Base0	Base1	Delta	Prop	Base0	Base1	Delta	Prop
Age-1	1.00	1.01	0.97	0.97	1.00	1.01	0.97	0.98
Age-2	1.41	1.41	1.34	1.33	1.42	1.42	1.34	1.33
Age-3	1.41	1.41	1.34	1.33	1.42	1.42	1.34	1.33
Age-4	0.22	0.23	0.21	0.21	0.23	0.23	0.21	0.21
Age-5	0.08	0.08	0.07	0.074	0.08	0.08	0.08	0.074
escapement	1.7	1.7	2.1	2.2	1.7	1.7	2.1	2.1
SPR	1.8	1.8	2.2	2.2	1.8	1.8	2.2	2.2

	Mid (1992-1998)							
	Without IGNS				With IGNS			
	Base0	Base1	Delta	Prop	Base0	Base1	Delta	Prop
Age-1	0.06	0.11	0.13	0.12	0.06	0.11	0.13	0.12
Age-2	0.62	0.64	0.61	0.57	0.64	0.65	0.62	0.57
Age-3	0.43	0.45	0.43	0.40	0.45	0.45	0.43	0.40
Age-4	0.05	0.06	0.06	0.05	0.05	0.06	0.06	0.05
Age-5	0.014	0.017	0.015	0.014	0.014	0.017	0.015	0.014
escapement	31.3	28.5	29.3	32.0	30.2	27.9	29.2	31.9
SPR	31.5	28.7	29.5	32.1	30.4	28.1	29.3	31.9

	Late (1999-2004)							
	Without IGNS				With IGNS			
	Base0	Base1	Delta	Prop	Base0	Base1	Delta	Prop
Age-1	0.04	0.05	0.15	0.11	0.04	0.05	0.16	0.11
Age-2	0.55	0.67	0.68	0.66	0.65	0.75	0.75	0.72
Age-3	0.26	0.32	0.33	0.32	0.31	0.36	0.36	0.35
Age-4	0.02	0.03	0.03	0.03	0.02	0.03	0.04	0.03
Age-5	0.0002	0.0002	0.012	0.007	0.0002	0.0002	0.012	0.007
escapement	42.0	34.3	30.3	32.6	35.8	30.3	27.3	29.8
SPR	42.3	34.7	30.4	32.8	36.2	30.7	27.4	30.0

Table A4. Spreadsheet catch-age model estimates for the late regulatory period for the PROP and TAGGING discard assumptions using the 0.43 selectivity vectors.

	Early (1986-1991)	
	TAGGING with IGNS	TAGGING without IGNS
Age-1	0.97	0.97
Age-2	1.30	1.31
Age-3	1.30	1.31
Age-4	0.20	0.20
Age-5	0.07	0.07
escapement	2.3	2.3
SPR	2.4	2.4

	Mid (1992-1998)	
	TAGGING with IGNS	TAGGING without IGNS
Age-1	0.12	0.13
Age-2	0.56	0.57
Age-3	0.39	0.40
Age-4	0.05	0.05
Age-5	0.013	0.013
escapement	32.4	31.8
SPR	32.5	32.0

	Late (1999-2004)	
	TAGGING with IGNS	TAGGING without IGNS
Age-1	0.13	0.13
Age-2	0.65	0.62
Age-3	0.28	0.27
Age-4	0.05	0.05
Age-5	0.029	0.029
escapement	33.2	34.7
SPR	32.8	34.2

Appendix 2. Relevant Equations

von Bertalanffy (1938):

Standard:

$$L_t = L_\infty \left(1 - \exp\left(-k * \left(t - t_0\right)\right)\right)$$

Where L_t is the length at time t and L_∞, k, and t_0 are estimated parameters.

Linear:

$$L_\infty = b_0 + b * t$$

Burdick et al. (2006):

$$E\left[C_{i,g,l}\right] = N_{i,l} R_{i,g} U_{i,g} S_{g,l}$$

Where $E\left[C_{i,g,l}\right]$ is the expected tag return rate, $N_{i,l}$ is the number of fish tagged, $R_{i,g}$ is rate of tag recovery for gear type g for fish tagged in experiment i, $U_{i,g}$ is the exploitation rate of fish tagged in experiment i and recaptured by gear type g, and $S_{g,l}$ is the selectivity of gear type g in length (or age) bin l.

Bacheler et al. (in review):

$$E\left[R_{ijk}\right] = N_{ik} P_{ijk}$$

$$P_{ijk} = \begin{cases} \left(\prod_{v=i}^{j-1} S_{ivk}\right)\left(1 - S_{ijk}\right)\dfrac{F_j Sel_{k+j-i}}{\left(F_j' + F_j\right)Sel_{k+j-i} + M}\lambda & \text{(when } j > i\text{)} \\ \left(1 - S_{ijk}\right)\dfrac{F_j Sel_k}{\left(F_j' + F_j\right)Sel_k + M}\lambda & \text{(when } j = i\text{)} \end{cases}$$

$$S_{ijk} = \exp\left[-\left(F_j + F_j'\right)Sel_{k+j-i} - M\right]$$

Where $E[R_{ijk}]$ is the expected number of tag returns from fish tagged at age k, released in year i, and harvested in year j. N_{ik} is the number of fish tagged at age k and released in year i, P_{ijk} is the probability a fish tagged at age k and released in year i is harvested in year j, S_{ijk} is the annual survival rate of fish tagged at age k and released in year i then harvested in year j, F_j is the instantaneous fishing mortality in year j, F_j' is the instantaneous fishing mortality

on tags taken from caught and released fish in year *j*, *M* is natural mortality, Sel_k is the selectivity of age *k*, and λ is the tag-reporting rate of harvested fish.

$$E\left[R_{ijk}'\right] = N_{ik}P_{ijk}'$$

$$P_{ijk}' = \begin{cases} \left(\prod_{v=i}^{j-1} S_{ivk}\right)\left(1-S_{ijk}\right)\dfrac{F_j' Sel_{k+j-i}}{\left(F_j'+F_j\right)Sel_{k+j-i}+M}\lambda' & \text{(when j > i)} \\ \left(1-S_{ijk}\right)\dfrac{F_j' Sel_k}{\left(F_j'+F_j\right)Sel_k+M}\lambda' & \text{(when j = i)} \end{cases}$$

Where $E[R_{ijk}']$ is the expected number of tag returns from fish tagged at age *k*, released in year *i*, and caught and released in year *j*. P_{ijk} is the probability a fish tagged at age *k* and released in year *i* is caught and released in year *j* and λ' is the tag-reporting rate of caught and released fish.

Spreadsheet catch-at-age model:

$$F_{a,y} = s_a \hat{F}_y$$

$$N_{a+1,y+1} = N_{a,y}\exp\left(-\left(M + s_a\hat{F}_y\right)\right)$$

$$\hat{C}_{a,y} = \frac{F_{a,y}}{M+F_{a,y}}N_{a,y}\left(1-\exp\left(-\left(M+F_{a,y}\right)\right)\right)$$

Where $F_{a,y}$ is the fishing mortality at age *a* in year *y*, s_a is the selectivity at age *a*, $\hat{F}_y$ is the fitted fishing mortality in year *y*, $N_{a+1,y+1}$ is the population abundance at age *a+1* and year *y+1*, $N_{a,y}$ is the population abundance at age *a* and year *y*, *M* is natural mortality, and $\hat{C}_{a,y}$ is the predicted catch at age *a* and year *y*.

FADAPT model:

$$\frac{N_{a+1,t+1}}{C_{a,t}} = \frac{Z_{a,t}}{F_{a,t}} * \frac{\exp\left(-Z_{a,t}\right)}{1-\exp\left(-Z_{a,t}\right)}$$

$$Z_{a,t} = F_{a,t} + M$$

$$N_{a,t} = \frac{Z_{a,t}}{F_{a,t}} * \frac{C_{a,t}}{1-\exp\left(-Z_{a,t}\right)}$$

$$N_{a,t} = N_{a+1,t+1} \exp(M) + C_{a,t} \exp\left(M/2\right)$$

Where $N_{a+1,t+1}$ is the population abundance at age *a+1* and time *t+1*, $C_{a,t}$ is the catch at age *a* and time *t*, $Z_{a,t}$ is the total mortality at age *a* and time *t*, $F_{a,t}$ is the fishing mortality at age *a* and time *t*, $N_{a,t}$ is the population abundance at age *a* and time *t*, and *M* is natural mortality.

% SPR from Gabriel et al. (1989):

$$B = \sum N_a S_a W_a P_a$$

Where B is female biomass, N_a is the cohort numbers at age a, S_a is the proportion of females, W_a is the mean weight of females at age a, and P_a is the proportion of mature females at age a.