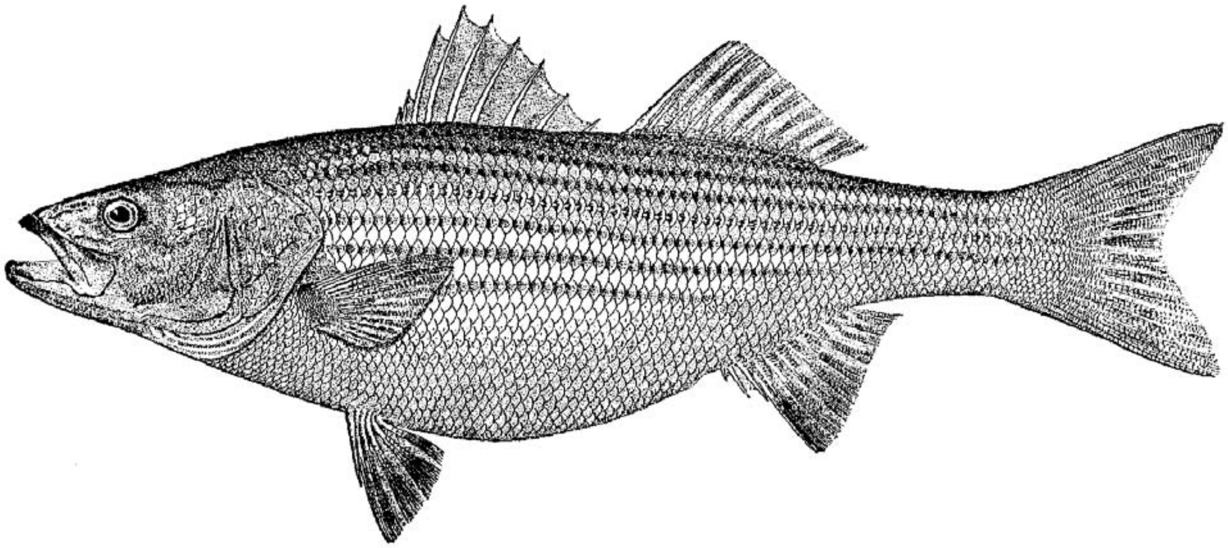
North Carolina
Fishery Management Plan

Estuarine Striped Bass



Albemarle Sound Area
Central/Southern Area

May 2004

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By
The North Carolina Division of Marine Fisheries
And
The North Carolina Wildlife Resources Commission

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3.0 EXECUTIVE SUMMARY

There are two geographic management units for the North Carolina Estuarine Striped Bass Fishery Management Plan (FMP). The northern management unit includes the **Albemarle Sound Management Area** (**ASMA**)- which includes Albemarle Sound and all its Joint and Inland water tributaries, (except for the Roanoke, Middle, Eastmost and Cashie rivers), Currituck, Roanoke and Croatan sounds and all their Joint and Inland water tributaries, including Oregon Inlet, north of a line from Roanoke Marshes Point across to the north point of Eagle Nest Bay and the **Roanoke River Management Area** (**RRMA**)- Roanoke River and its Joint and Inland water tributaries, including Middle, Eastmost and Cashie rivers, up to the Roanoke Rapids Dam. Management of striped bass within the ASMA is the responsibility of the North Carolina Marine Fisheries Commission (MFC) and within the RRMA, is the responsibility of the North Carolina Wildlife Resources Commission (WRC). The striped bass stock in these two harvest management areas is referred to as the Albemarle Sound/Roanoke River (A/R) stock.

The southern geographic management unit is the **Central/Southern Management Area** (**CSMA**) and includes all internal Coastal, Joint and contiguous Inland waters of North Carolina south of a line from Roanoke Marshes Point across to Eagle Nest Bay in Dare County, to the South Carolina state line. These stocks are referred to as the Central/Southern (C/S) stocks.

<u>Stock Status</u>

A/R Stock

In 1997, the A/R striped bass stock was declared by the Atlantic States Marine Fisheries Commission (ASMFC) to be restored. Annual population abundance has increased sharply from a low of 195,000 fish in 1988 to over 2 million fish in 1999. The population abundance is currently stabilizing at around 2 million fish. Recruitment of age 1 fish has been above the long-term average for 8 of the last 9 years. Since 1993 fishing mortality has varied between 0.13 and 0.60 and has averaged 0.30. The 2001 estimate of fishing mortality of F=0.13 on ages 3-7 is below the target for these ages (F target =0.28). Spawning stock biomass (total weight of sexually mature females in the population) was approximately 600,000 pounds in 1998, and has since increased to 1.6 million pounds in 2001. Population age structure is expanding. Age 8 and older fish were nearly absent from the population between 1990 and 1994; since 1997 conservation measures have resulted in a continuously increasing proportion of older fish in the population.

C/S Stocks

Available data are inadequate to estimate the population size for any of the C/S striped bass stocks. Rates of total and fishing mortality for the Neuse and Tar river stocks, estimated from fishery independent sampling indicate that fishing mortality rates for both stocks are excessive. For the Neuse River stock, the rate of fishing mortality was estimated to be 0.84 and for the Tar River, 1.02. These fishing mortality rates are substantially higher than those required for population recovery to occur, therefore over fishing is occurring. Fishing mortality must be reduced by approximately 60% to allow stock recovery in these waters. Virtually no data exists for the Cape Fear River striped bass stock but commercial landings and anecdotal observations suggest only a remnant population exists.

Commercial Fisheries

A/R Fishery

The Albemarle Sound area striped bass fishery dates back to the 1870s and historically supported the largest year-round commercial fishery in the state. Gill nets, anchor and drift, have historically been utilized in the fishery. Since the late 1960s gill nets have accounted for the majority of the harvest.

The ASMA commercial fishery from 1991 through 1997 operated on a 98,000 lbs. Total Allowable Catch (TAC) split between a spring and fall season. After stock restoration was declared in 1997, the 1998 TAC was increased to 125,440 lbs. and additional increases occurred in 1999 and 2000. From 2000 through 2002 the TAC remained at 225,000 lbs. In 2003, the commercial harvest TAC was increased to 275,000 lbs. The fishery operates with restrictions on seasons, net yardage, mesh size, size limits and daily landing limits to control harvest and bycatch. Striped bass harvest continues to be managed as a bycatch of the multi-species commercial fishery in the ASMA.

Commercial Discard/Bycatch Mortality

The discard/bycatch mortality of striped bass in the ASMA gill net fisheries has been a point of compliance with the ASMFC Striped Bass FMP since 1994. Annual estimates have been made since that time. As the striped bass population increased in size and the TAC remained static (1990-1997; 98,000 lb. TAC) the number of discards increased. Since 1997, the TAC has increased four times to the current harvest level of 275,000 lb. The increases in allowable harvest have lowered the number of discards in the large mesh gill net fisheries (flounder and shad) but has had very little effect in lowering the discard mortality in the small mesh fishery, since few fish captured in these nets are of legal size. Still, the number of estimated discards combined with commercial harvest has exceeded the TAC each year.

C/S Fishery

Commercial striped bass fisheries have historically occurred throughout the CSMA but are believed to have never been of the magnitude of the ASMA. The CSMA estuarine gill net fishery is a year round multi-species fishery but even with a 25,000 lb. TAC, daily landing limits and seasons in the CSMA, striped bass are targeted by commercial fishermen. Numerous management measures have been enacted in the CSMA that have reduced the take of striped bass and other species. Gill nets account for the highest percentage of the landings. The Pamlico Sound and Pamlico/Pungo river complex has accounted for 10.5% of the internal striped bass landings since 1994. The Neuse River landings since 1995 have been fairly consistent and averaged 5,950 lbs.; which are the highest commercial landings since 1976. The Cape Fear River season is only open to harvest during the spring (Jan – Apr) and striped bass landings primarily occur as bycatch of the American shad fishery. Since 1994, the average Cape Fear River landings were approximately 1,300 pounds.

Commercial Discard/Bycatch Mortality

The total striped bass discard estimate for Pamlico Sound and the adjacent rivers, using data from 2000 and 2001, is approximately 94,000 lbs. In Pamlico Sound small mesh gill nets accounted for 78.9% of the total striped bass discards for the area. Large mesh gill nets in the Pamlico and Neuse rivers accounted for 81.4% of the discards. This estimate is based on the best available data and will need to be refined through future studies.

<u>Recreational Fisheries</u>

Early in the 20th century interest in hook and line striped bass fishing began to increase. As recovery of the A/R stock continued into the late 1990s, a tremendous increase in recreational effort for striped bass occurred. Taking and possession of striped bass using hook and line in coastal North Carolina is regulated by the WRC in designated Inland Waters, jointly by the WRC and MFC in designated Joint Waters and by the MFC in designated Coastal Waters.

Roanoke River

In 1988, WRC began monitoring striped bass harvest in the Roanoke River with creel surveys during the spring months. Management of recreational striped bass harvest by TAC began in 1991, with an allocation of 29,400 lbs. From 1991-1997, the annual TAC remained static. Since 1998, four TAC increases have occurred with the 2003 allocation being 137,500 lbs. The WRC opened and closed the harvest season from 1991 through 2001 by proclamation authority of the Executive Director. In 2002, the WRC decreased the daily creel limit from three to two fish, but set a 46-day season in the lower river and a 46-day season in the upper river, and allowed possession seven days per week. WRC continues to monitor harvest, size, age and sex composition of striped bass caught in RRMA through an annual creel survey.

Albemarle Sound Area

In 1991, DMF began management of the 29,400 lb. striped bass TAC through a creel survey. The TAC was split between a spring and fall season. Season, harvest days, creel and size limits were established by proclamation authority of the Fisheries Director. The annual TAC remained static for 1991-1997. Since 1998, the TAC has increased four times, with the 2003 allocation being 137,500 lbs. The DMF continues to conduct creel surveys when the recreational season is open to determine harvest estimates.

C/S Area

Limited information exists on the recreational fisheries in the Tar-Pamlico, Neuse and Cape Fear rivers. Although estimates of recreational striped bass harvest from the Pamlico Sound are not available, WRC and DMF staffs believe it could be substantial, especially in northern Pamlico Sound.

Guided Fishing for Striped Bass

Since recovery of the A/R stock and the Atlantic Migratory Stock, striped bass has become one of the major species targeted in the guided recreational fishery. During early 2002, nearly 315 for-hire vessels were identified as operating in NC coastal waters, representing a 37% increase from the three prior years. Though many of these vessels pursue a variety of species, a growing number target striped bass. Annual sales of WRC Guide Licenses have increased steadily from 292 in 1987 to 970 in 2002. Due to the WRC guide's licenses being a combination hunting/fishing, it is not possible to determine the exact proportion of the increase sales that is attributable to fishing guides only.

Management Goals

The goal of the NC Estuarine Striped Bass FMP is to manage estuarine populations through science based decision-making processes that conserve adequate spawning stock and protect the integrity of critical habitats. The plan will consider biological, social, and economic factors in management of the fisheries. The plan will be adaptive, involving regular reviews and responding to new information regarding any aspect of the plan.

Management Objectives

1. Identify and describe population attributes necessary to sustain long-term stock viability.
2. Protect, restore and enhance spawning and nursery area habitat and environmental quality to increase growth, survival and reproduction.
3. Manage the fishery in a manner to sustain long-term stock viability, traditional harvest and prevent overfishing.
4. Initiate, enhance and/or continue programs to collect and analyze biological, social, economic, fishery, essential habitat and environmental data needed to effectively monitor and manage the fishery.
5. Develop an information program to educate the public and elevate awareness of the causes and nature of problems in the striped bass stocks, habitat and fisheries and explain the rationale for management efforts to solve these problems.
6. Develop regulations that provide adequate resource protection, optimize yield from the fishery, and consider the needs of all user groups.
7. Promote practices that minimize bycatch and discard mortality in recreational and commercial fisheries.

Optimum Yield (OY)

ASMA

Optimum yield is defined as that yield provided by exploiting the stock at the target exploitation rate as determined from the most recent stock assessment. The stock is currently managed with a TAC that is analogous to OY. The TAC for 2003 was conservatively established at 550,000 lbs. based on a target reference point of F=0.25. The target reference point recommended by the A/R Advisory Committee is F=0.22.

CSMA
OY is defined as the yield achieved by exploiting the stock at the target exploitation rate. OY as defined for the CSMA differs slightly from that for the ASMA in that a value for OY is not predetermined. The lack of data on the commercial and recreational fisheries prevents development of a quantitative assessment of stock abundance. Therefore, no projections of stock abundance and total catch rates are available for the CSMA and OY cannot be estimated numerically in advance. Until data for a complete assessment of these stocks are available, the only recourse is to manage based on exploitation rates.

Management Issues and Proposed Actions

The following striped bass management issues and options were developed through the FMP process, by DMF and WRC through cooperation and advice solicited from the A/R and C/S Advisory Committees, the public, MFC, Finfish and Regional Advisory committees, as well as the scientific community. In order to achieve the desired goals of the FMP, the MFC and WRC, after taking into account the advice and comments from the various participants on this plan, has selected the preferred management options on the management issues.

The management issues and proposed actions are divided as follows: (1) Issues relative to North Carolina coastal stocks in general, (2) Issues specific to the A/R stock and (3) Issues specific to the C/S stocks.

General NC Coastal Striped Bass Stock Issues

Water Flow

- Rivers with presently unregulated flows work with state water resource authorities to secure commitments for preservation of unaltered flow regimes.
- Rivers currently regulated to such a degree that flow patterns depart significantly from unregulated conditions, establish a recommended annual flow regime for striped bass spawning and nursery areas, and work with appropriate regulatory agencies to secure commitments for preservation of such regimes.
- Require Division of Water Resources (DWR) to include Division of Water Quality (DWQ), WRC, DMF and US Fish and Wildlife Service (FWS) in water supply planning process and future allocation negotiations.
- Neuse River- support removal of Milburnie Dam, to provide flexibility for flow management.
- Pee Dee River- participate (FWS and WRC, in cooperation with SC agencies) in re-licensing of hydropower dams, to obtain adequate flow releases for downstream habitats.

Critical Habitat

- Adopt into rules, measures to protect identified anadromous spawning and nursery areas for striped bass.
- Advocate stronger enforcement of regulations protecting critical habitat in the management areas.

- Purchase land adjacent to critical striped bass habitat areas to ensure protection.
- Continue to make recommendations on all state, federal and local permits where applicable to require avoidance of activities detrimental to critical striped bass habitats.
- Support implementation of habitat recommendations of Albemarle-Pamlico Estuarine Study (APES), Estuarine Shoreline Protection Stakeholders Report, and Coastal Habitat Protection Programs (CHPP).
- Maintain, restore and improve habitat to increase growth, survival and reproduction of striped bass. Monies from the Clean Water Trust Fund and others should be utilized for this.

Blockages of Historical Habitat

- Neuse River- support removal of Milburnie Dam in Raleigh. Removal would open approximately 15 miles of spawning habitat and allow better manipulation of flows.
- Cape Fear River- supports removal of Buckhorn Dam, Lock and Dam #2 and Lock and Dam #3. Support construction of the proposed “nature-like” fishway around Lock and Dam #1.

Entrainment and Impingement of Eggs and Larvae

- Continue to review and comment on state and federal permit requests in which water withdrawal structures are involved in coastal rivers.
- Monitor the progress of US EPA’s implementation of Section 316 (b) rules as these rules may apply to water withdrawal points in NC coastal rivers.
- In absence of effective technology, require water users to curtail withdrawal during periods in which striped bass eggs, fry and juveniles may be present.

Water Quality Concerns

- Work in coordination with DWQ, DWR, Division of Land Quality, and Natural Resource Conservation Service to maintain, restore and improve water quality to increase striped bass stocks.
- Support implementation of recommendations of DWQ basinwide water quality management plans, particularly measures that will reduce nutrient loading, sediment delivery and associated turbidity in all coastal watersheds.
- Support implementation of habitat and water quality recommendations of CHPPs, APES, and the Estuarine Shoreline Protection Stakeholders report.

Catch and Release Mortality in Hook and Line Fisheries

- Develop and implement creel surveys to estimate numbers of striped bass caught and released, as well as directed angling effort.
- Recreational harvest seasons should be limited to months (October – April) in which cool water temperatures (<70° F) occur, thus minimizing mortality from catch and release fishing.
- Implement an extensive angler education program on catch and release striped bass fishing. Components of the program would include presentations on the effects of water temperature, angling techniques, hook configuration, bait and lure use and

handling techniques. Continue research on identifying correct hook sizes and configuration of circle hooks.

Enforcement of Creel Limits in Vicinity of Inland/Joint or Coastal Boundaries

- WRC should implement a rule similar to MFC rule that requires compliance with season, size, and creel limits on the waterbody where fishing is taking place.

Albemarle Sound Management Area Boundary Line

- Maintain the current boundary line between the ASMA and the CSMA.

<u>Albemarle/Roanoke Stock Issues</u>

Biological Reference Points

- Support a fishing mortality rate no higher than 0.22 and a SSB no lower than 400,000 lbs. for the A/R stock.

Discard Mortality of Striped Bass in Multi-Species Gill Net Fishery

- Maintain status quo, existing gill net proclamation authority, with the requirement that small mesh nets be sunk after river herring gill net season closes. Small mesh gill nets (3 ¼ inch) would be restricted to no more than 25 – 30 meshes deep and set in no less than 7 feet of water unless attended. These requirements would remain in effect when attendance was not required. Also, consider area closures to gill netting. The following qualifications will also apply: 1. DMF will evaluate existing IGNS small mesh data to determine differences between striped bass catches in float and sink nets and 2. Observer data, current and future will be collected and analyzed to assess the benefits. Should the discard reductions not be within the estimated range of the other options in Table 10.14, then DMF may implement other options presented in the FMP, or other options that may be developed over time.

Management of Harvest Targets in the ASMA

- Supports no payback for overages in RRMA due to underage in 2003.
- Supports TAC allocation: 25% Roanoke River/WRC recreational, 25% Albemarle Sound/DMF recreational and 50% Albemarle Sound/DMF commercial.
- Penalties/Triggers for Overages: Short-term Overage: point harvest estimate exceeds the total TAC by 10% in a single year, overage deducted from the next year and restrictive measures implemented in the responsible fishery (ies). Long-term Overages: five year running average of point estimate exceeds the five year running average of the total TAC harvest by 2%, the responsible fishery exceeding the harvest limit will be reduced by the amount of the overage for the next five years. Should the target F be exceeded, then restrictive measures will be imposed to reduce F to the target level.

Management of Recreational Striped Bass Harvest in Atlantic Ocean

- Support remaining at Status Quo- year round recreational fishery.

Central/Southern Stock Issues

Biological Reference Points

- Manage the CSMA stocks under the same exploitation rate targets and thresholds as selected for the A/R stock (F= 0.22, SSB 400,000 lbs.). Improve data collection on these stocks so that biomass thresholds and targets can be developed for these stocks.

Striped Bass Stocking in Coastal River Systems

- Continue Phase II stocking program, with two systems in the CSMA (Tar-Pamlico, Neuse and Cape Fear rivers) being stocked annually, with a goal of 100,000 fish per drainage.
- Continue the Phase I striped bass stocking program, with a goal of 100,000 fish per year, per system in the CSMA.

Management Options for Recreational Striped Bass Harvest in CSMA

- Adequate information to evaluate specific recreational measures are lacking in the CSMS. Regulations should remain at status quo for 2004. A one year creel survey is being developed by DMF and WRC for the Tar-Pamlico and Neuse systems. This survey will collect data on recreational striped bass fisheries in these waters. The WRC will be conducting a creel survey in the Cape Fear system in 2004. After completion of the creel surveys and data analysis, appropriate regulations will be developed and implemented to distribute the reductions in fishing mortality necessary for stock recovery among the various recreational fisheries.

Discard Mortality of Striped Bass from Set Gill Nets in the CSMA
Management Options for Neuse River and Pamlico River Areas Gill Net Fishery

- Require "tie-downs" to reduce striped bass bycatch. DMF is currently evaluating the effectiveness of various tie- down configurations.
- <u>Rivers</u>- Increase the commercial possession limit to 10 fish per day per operation in the rivers during the open striped bass season. Require that gill nets in the shad and flounder fisheries operating in the Pamlico, Pungo and Neuse river areas (west of 76° 30'W long.) be tied down after the striped bass quota is reached and the season closed.
- <u>Pamlico Sound</u>- commercial possession limit would remain at 5 fish in the Pamlico Sound. Landings of striped bass will be limited to 50% by weight of the total catch, not to exceed 5 fish per day per fishing operation. Gill nets with a mesh length of 6 inches (stretched mesh) and greater would be prohibited during the striped bass season.
- <u>Other portions of the CSMA</u>- Maintain striped bass seasons, opening and closing through proclamation and operating under the 25,000 lb. TAC. This option is intended to allow the sale of striped bass bycatch resulting from gill net fisheries. As data are collected, more restrictive measures may be implemented as needed.

4.0 INTRODUCTION

4.1 Management Authority

4.1.1 Introduction

Fishery management includes all activities associated with maintenance, improvement, and use of the fisheries resources, including research and monitoring, development, regulation, enhancement and enforcement.

North Carolina's existing fisheries management system is powerful and flexible, with rule-making authority vested in the Marine Fisheries Commission (MFC) and the Wildlife Resources Commission (WRC) within their respective jurisdictions. The Division of Marine Fisheries (DMF) implements MFC rules and policies. The General Assembly retains for itself licensing and limited entry authorities. In the 1998 Amendment to the Fisheries Reform Act of 1997 (FRA), the General Assembly established a process for limiting entry for fisheries under the Fishery Management Plan (FMP) process. Federal authority under the Magnuson-Stevens Act applies to fisheries in the Exclusive Economic Zone (the area from 3 to 200 miles offshore); it also applies to a limited extent in areas within state jurisdiction deemed Essential Fish Habitat (EFH). The Atlantic coast states work together through the Atlantic States Marine Fisheries Commission (ASMFC) to prepare and implement interstate FMPs, but the regulatory responsibility and authority remain with the states. Passage of the Atlantic Coastal Fisheries Cooperative Management Act in 1993 gave the ASMFC oversight for species with ASMFC plans, but plan actions are implemented by each state. Thus, the MFC/WRC (rules) and DMF/WRC (research, enforcement, etc.) utilize their authorities to manage the fisheries. The MFC and WRC have the ability to establish seasons, authorize or restrict fishing methods and gear, limit quantities taken or possessed, and restrict fishing areas. Thus, all necessary authority needed for management of the striped bass fisheries is available through the existing state fishery management process. Protection, enhancement and development of sustainable fisheries will require appropriate use of this authority, along with the cooperation of stakeholders.

The MFC (August 2001) in their adoption of a priority schedule for FMP development included revisiting the Estuarine Striped Bass FMP that was approved in 1994. The 1994 plan was targeted at the recovery of the Albemarle Sound-Roanoke River (A/R) striped bass stock but also included some management measures for other striped bass stocks in the state. This 2003 Estuarine Striped Bass FMP document (developed under the criteria and standards of the 1997 FRA) replaces in total the 1994 FMP and addresses issues for the various estuarine striped bass stocks in North Carolina.

4.1.2 Legal Authority for Management

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 (DENR) is provided in G.S. 113-131. The DMF is the arm of the Department, which carries out this responsibility. The same statute also grants management authority to the WRC within its jurisdictional area. Enforcement authority for DMF enforcement officers (Marine Patrol) and WRC officers is provided by G.S. 113-116. Rule-making authority is granted to the MFC and WRC by G.S. 113-134. General Statute 113-181 authorizes DMF research and statistical programs. The 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 also allows the MFC to delegate authority to implement its regulations for fisheries “which may be affected by variable conditions” to the Director of DMF by issuing public notices called “proclamations.” General Statute 113-292 authorizes the WRC or the Executive Director to suspend or extend the hook and line season for striped bass in all of North Carolina’s coastal rivers through issuance of proclamations. The General Assembly has retained for itself the authority to establish commercial fishing licenses, but has delegated to the MFC authority to establish permits and permit fees for various commercial fishing activities. Thus North Carolina has a very powerful and flexible legal basis for coastal fisheries management.

The Fisheries Reform Act of 1997 (FRA) established a process for preparation of FMPs in North Carolina. The FRA states that “the goal of the plans will be to ensure that long-term viability of the State’s commercially and recreationally significant species or fisheries. Each plan will be designated 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 will:

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 (CHPP) 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 or fisheries.
c. Include conservation and management measures that prevent overfishing, while achieving, on a continuing basis, the optimal yield from each fishery.”

Optimal yield is defined in the FRA as “The amount of fish that:

a. Will provide that greatest overall benefit to the State, particularly with respect to food production and recreational opportunities, and taking into account the protection of marine ecosystems;
b. Is prescribed on the basis of the maximum sustainable yield from the fishery, as reduced by any relevant economic, social, or ecological factors; and
c. In the case of an overfished fishery, provides for rebuilding to a level consistent with producing the maximum sustainable yield in the fishery.” (FRA; G.S. 113-182.1).

4.2 General Problem Statement

Striped bass are distributed throughout the coastal waters of North Carolina and have been harvested historically (**Table** 4.1) from virtually all coastal systems. Over the last 40-50 years; however, the fisheries have been overwhelmingly concentrated in the Albemarle Sound area. In addition, historical landing data (Section 13, Appendix 1) indicate that the striped bass fisheries have always been concentrated in that area, with minor fisheries in other coastal systems. Data collection on the Albemarle/Roanoke (A/R) stock has been ongoing since the 1950s and was intensified in the 1980s when the stock nearly collapsed. Significant restrictions in harvest of A/R striped bass along with improvements in Roanoke River flow conditions since the late 1980s brought about remarkable improvements in spawning success. In 1997, the A/R stock was declared recovered by the ASMFC. The spawning stock biomass has increased and the age structure of the stock has expanded. The 2001 A/R stock assessment (Carmichael 2002) continues to indicate that the stock size is increasing. Now that recovery has been achieved, cautious increases in allowable striped bass harvest have been permitted. In order for the future management of the A/R striped bass stock, a reevaluation of current management regimes is warranted.

Outside the Albemarle Sound Management Area (ASMA), the DMF has conducted spawning and nursery area surveys, and commercial fish house sampling for size, age and sex composition data for most coastal streams, but this work ended 15-20 years ago, varying with area, as federal aid funds were decreased (**Table** 4.2). The DMF 2003 stock status report lists the status of striped bass in the Central/Southern (C/S) management unit as overfished. Commercial landing data for striped bass in these areas are available and the WRC has been monitoring spawning stock status of striped bass in the Neuse and Tar rivers since 1994 (**Table** 4.3). Otherwise, little data on these stocks exist; clearly indicating a need for the development of management strategies to enhance these stocks.

The 1994 Fisheries Management Plan for the Estuarine Stocks of Striped Bass in North Carolina was developed as a recovery plan for the A/R stock. Since the A/R stock has recovered and harvest parity has been reached between the commercial and recreational fisheries a revised FMP is warranted to explore management options for

Table 4.1. North Carolina striped bass commercial landings and dockside value, 1972 - 2002.

	ASMA	Pamlico Sound	Pamlico/ Pungo rivers	Neuse/Bay rivers	Cape Fear River	Confidential and Other Inside Waters	Atlantic Ocean	State total	
Year	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Value ($)
1972	304,809	64,978	49,294	500	3,033	11,399	827,047	1,261,060	358,312
1973	529,156	27,587	73,638	4,928	1,376	7,082	1,108,169	1,751,936	591,811
1974	427,940	19,618	41,986	456	729	32,267	493,316	1,016,312	393,187
1975	615,752	17,217	55,870	7,280	1,538	20,545	584,995	1,303,197	629,928
1976	668,903	7,117	11,904	8,625	1,814	7,498	332,293	1,038,154	522,637
1977	469,402	561	9,839	0	831	316	90,702	571,651	405,263
1978	524,999	3,920	2,754	0	1,326	287	164,578	697,864	623,250
1979	326,208	6,500	32,945	0	7,811	640	240,080	614,184	577,004
1980	372,482	5,282	50,655	*	17,418	4,832	21,834	472,503	435,479
1981	333,376	3,556	20,612	*	7,394	845	51,541	417,324	451,824
1982	227,626	4,345	11,045	228	1,815	378	92,873	338,310	531,470
1983	288,677	1,184	15,035	1,018	2,500	65	52,796	361,275	491,491
1984	475,607	690	16,539	3,445	2,081	33	14,501	512,896	452,002
1985	269,671	2,842	5,919	988	*	520	*	279,940	229,586
1986	172,683	6,104	8,766	687	*	752	*	188,992	189,859
1987	228,861	24,797	6,571	1,433	*	559	0	262,221	262,542
1988	108,791	3,609	2,538	*	*	977	*	115,915	116,776
1989	97,061	940	1,987	*	*	842	*	100,830	101,002
1990	103,757	373	235	*	*	904	8,670	113,939	159,630
1991	108,460	4,034	321	1,967	*	1,848	6,186	122,816	175,822
1992	100,549	6,019	774	9,053	*	16,912	27,702	161,009	204,434
1993	109,475	8,134	374	1,797	1,439	65,557	75,671	262,447	330,351
1994	102,367	9,974	866	8,289	481	247	139,672	261,896	353,559
1995	87,876	6,981	2,439	3,951	264	691	344,587	446,789	606,529
1996	90,100	17,321	4,230	6,965	4,140	593	58,217	181,566	220,903
1997	96,122	16,435	4,450	5,344	2,187	104	463,144	587,786	711,091
1998	123,927	11,520	7,515	5,537	501	900	272,969	422,869	520,039
1999	162,875	15,473	10,453	6,093	1,001	934	391,482	588,311	724,844
2000	214,029	9,652	16,749	4,808	566	64	161,638	407,506	471,916
2001	220,161	8,821	8,936	6,946	*	232	381,446	626,542	773,692
2002	220,834	8,616	8,207	4,133	*	16,627	441,046	699,462	853,195

* Denotes confidential data.

Table 4.2. Striped bass research and monitoring by the North Carolina Division of Marine Fisheries in the rivers and sounds of eastern North Carolina.

		Type of work					
System	Spawning areas	Juvenile abundance	Adult size, age and sex	Migration/ Tagging	Creel survey	Stock assessment	Commercial harvest*
Albemarle Sound area	1973, 1974, 1978, 1993	1972-present	1972-present	1974-present	1990-present **MRFSS	1994-2000	1978-present
Tar-Pamlico (includes Pamlico Sound)	1975-1976, 1980-1981	1974-1980	1974 - 1981 1998-present	1975-1976 1979-1981 1998-2001	**MRFSS		1978- present
Neuse	1977-1979	1976-1980	1976-1981 Sep 1998- Jan 2001	1977-1981 Sep 1998- Jan 2001	**MRFSS		1978- present
White Oak	1974-1975	1973-1975	1974-1975		**MRFSS		1978- present
New	1974-1975	1973-1975	1974-75 Sep 1998- Jan 2001		**MRFSS		1978- present
Cape Fear	1976-1981	1975-1981	1976-1981	1976-1981	**MRFSS		1978- present

* Commercial harvest available for earlier years by National Marine Fisheries Service (NMFS).

** Marine Recreational Fishery Statistics Survey (MRFSS) on going in the coastal waters of these systems but geographic coverage does not provide a complete estimate of harvest. Does provide size data on what is encountered the future. Insufficient information exists for the C/S stocks to quantitatively evaluate make sound, long term management decisions. The purpose of this plan is to examine and recommend management measures that will promote recovery of striped bass stocks in areas where long-term well being is in jeopardy, conserve adequate spawning stock in all of North Carolina's coastal striped bass stocks and protect the integrity of critical habitats required to maintain the health of the stocks. Areas to be addressed in the management of North Carolina's estuarine striped bass fishery are: (1) management strategies; (2) insufficient data and research needs; (3) protection of habitat, water quality and quantity; and (4) socioeconomic factors.

Table 4.3. Striped bass research and monitoring work by the North Carolina Wildlife Resources Commission in rivers of eastern North Carolina.

	Type of work			
System	Spawning stock survey	Egg and larvae	Adult size, age and sex	Creel survey
Chowan River				2001-2002
Roanoke River	1991- present	1981-1990	1991- present	1988- present
Albemarle Sound				1979-1980
Tar- Pamlico	1994-1995 1996- present	1970-1975 1988-1989, 1996	1970-1975	2004-2005
Neuse	1994- present	1970-1975 1988-1989	1970-1975	2002-2003
White Oak			1998, 2000	
Cape Fear		1999-2000	1992-1993	2003-2004
Northeast Cape Fear		2000	1998	
Inland waters of NC		1966-1968		1966-1968

4.3 Management Units

Striped bass are recorded from all of North Carolina's coastal river ecosystems (Menhinick 1991). Coastal basins with striped bass spawning, nursery and adult/subadult habitat, which are situated wholly or primarily in North Carolina are: Albemarle Sound and its tributaries; Pamlico Sound and its tributaries, including the Tar/Pamlico River, Pungo River, the Neuse River; the Newport River; the White Oak River; the New River; the Cape Fear and Northeast Cape Fear rivers and estuary; and the Shallotte River. Additional rivers, which enter the Atlantic Ocean in South Carolina also host striped bass and some spawning and nursery habitat for these populations may exist in North Carolina. These include the Waccamaw, Lumber, and Pee Dee river systems. The NC portions of these latter systems, whose striped bass populations are largely within South Carolina jurisdiction, will be regulated under this plan, but the biology of those populations will not be reviewed in the plan at this time.

There are two geographic management units for this estuarine striped bass FMP and the fisheries throughout the coastal systems of North Carolina. The management units are defined as follows:

Albemarle Sound Management Area (ASMA)- which includes Albemarle Sound and all its Joint and Inland Water tributaries, (except for the Roanoke, Middle, Eastmost and Cashie rivers), Currituck, Roanoke, and Croatan sounds and all their Joint and Inland Water tributaries, including Oregon Inlet, north of a line from Roanoke Marshes Point 35° 48'.3693' N - 75° 43'.7232' W across to the north point of Eagle Nest Bay 35° 44'.1710' N - 75° 31'.0520' W (**Figure** 4.1).

Roanoke River Management Area (RRMA)- Roanoke River and its Joint and Inland Water tributaries, including Middle, Eastmost and Cashie rivers, up to the Roanoke Rapids Dam (**Figure** 4.2**).**

Central/Southern Management Unit (CSMA) - All internal Coastal, Joint and contiguous Inland waters of North Carolina south of a line from Roanoke Marshes Point across to Eagle Nest Bay to the South Carolina State line (**Figure** 4.1).

4.4 Existing Agreements, Plans, Statutes and Rules

4.4.1 Agreements and Plans

In 1986, the North Carolina Department of Natural Resources and Community Development, WRC and United States Fish and Wildlife Service (FWS) entered into a cooperative agreement (Agreement No. 14-16-0004-87-904) for anadromous species restoration in North Carolina's coastal river basins. The cooperative program's intent is to restore self-sustaining stocks of anadromous fishes in coastal North Carolina waters through a combination of fishery techniques including stocking, regulations, and assessment. This cooperative program continues today and has resulted in numerous cooperative fishery management ventures between state and federal agencies.

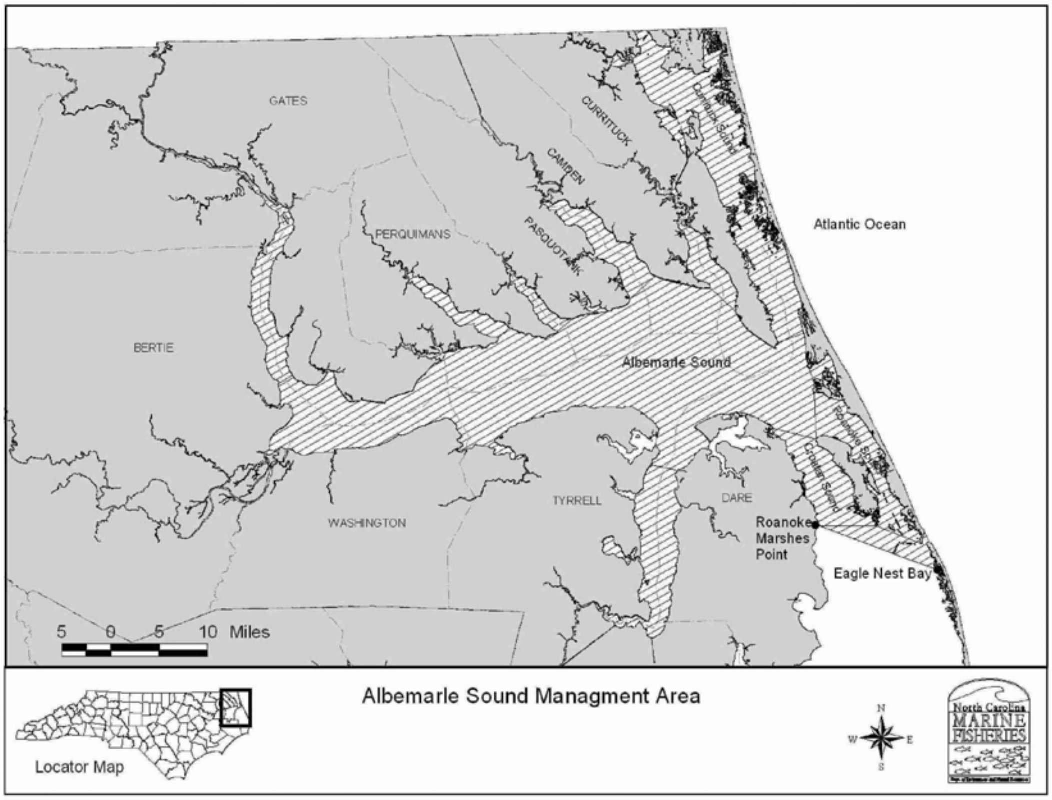


Figure 4.1. Boundary line between Albemarle Sound Management Area (ASMA) and Central Southern Management Area (CSMA).

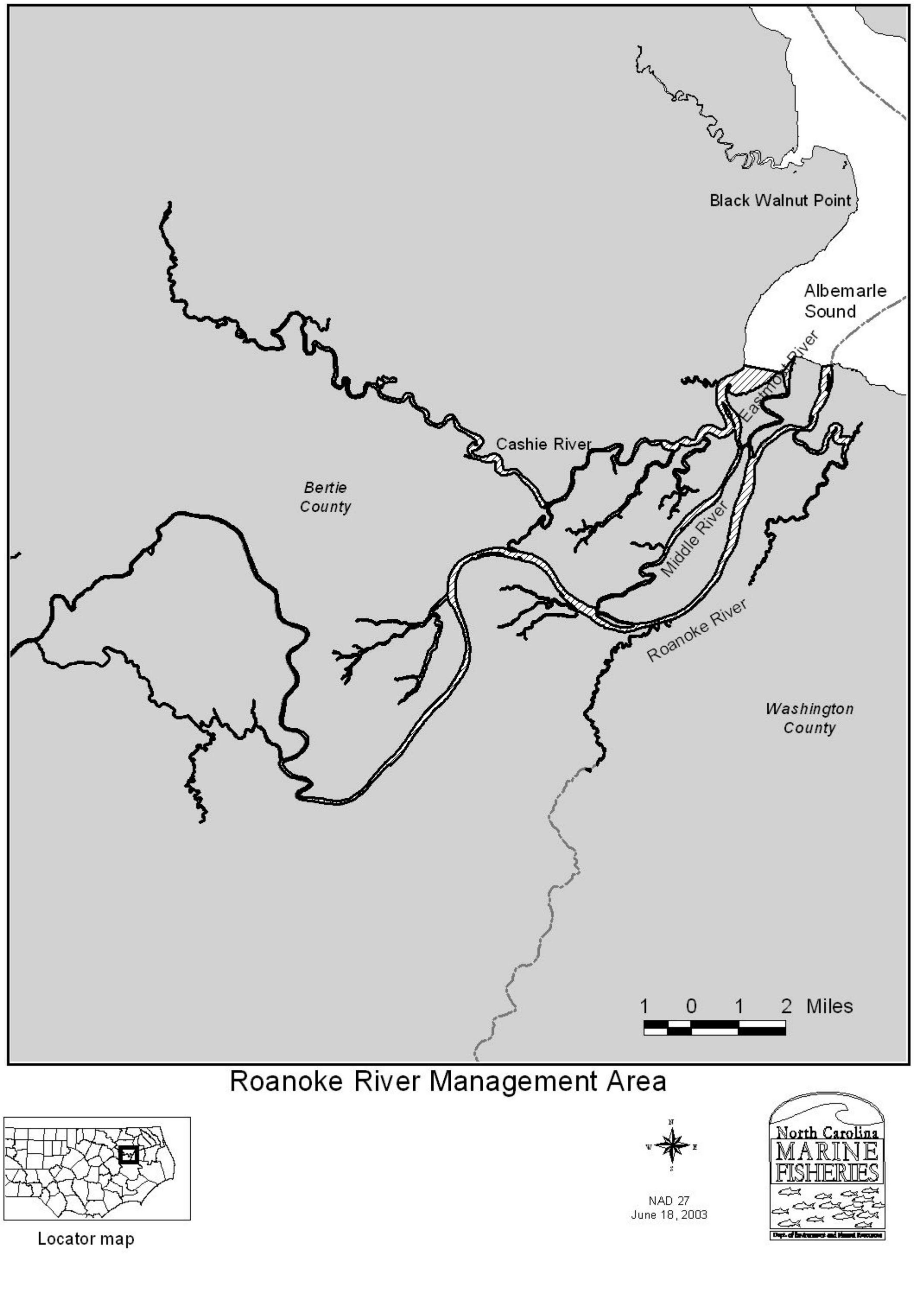


Figure 4.2. Boundary line between the ASMA and the Roanoke River Management Area (RRMA), under the management of the NC Wildlife Resources Commission.

In November 1990, a memorandum of agreement between the MFC and WRC was signed to provide stewardship and continuity of management for striped bass. Through this agreement, two distinct management zones were established: the Albemarle Sound and Roanoke River Management Areas. Under an additional agreement the MFC, WRC, and FWS established a cooperative for the purpose of restoring all inter-jurisdictional fishery stocks in North Carolina.

The ASMFC was directed, under the federal Striped Bass Conservation Act (1984) to develop a management plan, which would address all striped bass populations from South Carolina/North Carolina border northward. The Act, during reauthorization in 1988, was amended to include Section 5, which provided that the FWS, in consultation with the National Marine Fisheries Service (NMFS), would provide a report to Congress summarizing the findings of a study to be conducted on North Carolina striped bass. The Act specifically instructed the FWS to include: a description of the Albemarle Sound-Roanoke River Basin; an investigation and analysis of the effects of land and water use practices on the Albemarle Sound-Roanoke River striped bass stock (A/R stock); determination of the abundance, age, geographic distribution and amount and location of migration and spawning habitat; the extent and causes of mortality at successive life stages, including fishing; the effects of pollution and other alterations including water withdrawals, discharges and flows on A/R stock migration, spawning, viability and condition of eggs and larvae; the effectiveness of current fishery and reservoir management measures; an analysis of whether additional measures are needed to halt the decline of the A/R stock and initiate recovery; and a recommendation of whether conservation could be improved by managing the A/R stock under the ASMFC Interstate Fisheries Management Plan for Striped Bass and the Act.

The report of the FWS, Albemarle Sound and Roanoke River Basin North Carolina Striped Bass Study, was submitted to Congress in May 1992. The report contained recommendations for restoration of the A/R stock. One of the recommendations was that NC be allowed to continue management of its striped bass fishery, in the A/R system, under the ASMFC plan but with its own separate management provisions. The C/S management unit was not specifically addressed in the ASMFC plan.

Under the ASMFC Striped Bass Fishery Management Plan states are required to implement a variety of regulations and monitoring programs within their jurisdictions. These include a preferred minimum size of 20 inches in bays and estuaries and 28 inches in ocean waters. States can and do deviate from these preferred options, but any alternative measures must be reviewed by the Striped Bass Technical Committee and approved by the Striped Bass Management Board (ASMFC 1995).

The plan, implemented under ASMFC Amendment 5 of the Striped Bass FMP, requires annual submittal of a fishing plan, as well as a report on the previous year's fishery. Both the annual fishing plan and annual fishery report for the A/R stock must be accepted and approved by the ASMFC Striped Bass Technical Committee and also by the Striped Bass Management Board. Amendment 6 to the ASMFC Striped Bass FMP was adopted in February 2003 (ASMFC 2003).

The North Carolina Estuarine Striped Bass Fishery Management Plan was developed and approved by the MFC and WRC in 1994. This plan set forth measures necessary for continuing the recovery of the A/R stock, and advised the ASMFC of measures which North Carolina was taking in that regard. It also put in place a commercial quota and recreational size and bag limits for the CSMA. This coastwide plan also satisfied the recommendation, contained in the Report to Congress, that such a plan be prepared.

4.4.2 Statutes

All management authority for North Carolina's striped bass fishery is vested in the State of North Carolina. Since the stocks depend greatly on habitats found in both Coastal and Inland Waters, the MFC and the WRC will implement management actions in their respective jurisdictions.

General authorities noted in Section 4.1.2 provide the MFC and WRC with regulatory powers to manage the fisheries. There are some statutes (G.S. 113-268 (a), (b), and (c) and G.S. 113-282 c.1.) which promulgate specific rules to implement management objectives.

4.4.3 Rules

The following rules have been enacted to manage striped bass stocks in North Carolina through the authority vested in the MFC and WRC. (North Carolina Administrative Code- 15A NCAC)

4.4.3.1 Marine Fisheries Commission Rules

15A NCAC SUBCHAPTER 3J- NETS, POTS, DREDGES, AND OTHER FISHING DEVICES

SECTION .0100 – NETS RULES, GENERAL

.0101 FIXED OR STATIONARY NETS

It is unlawful to use or set fixed or stationary net:

(1) In the channel of the Intracoastal Waterway or in any other location where it may constitute a hazard to navigation;

(2) So as to block more than two-thirds of any natural or manmade waterway, sound, by, creek, inlet or any other body of water;

(3) In the middle third of any marked navigation channel;

(4) In the channel third of the following rivers: Roanoke, Cashie, Middle, Eastmost, Chowan, Little, Perquimans, Pasquotank, North, Alligator, Pungo, Pamlico, and Yeopim.

.0102 NETS OR NET STAKES

It is unlawful to use nets or net stakes:

(1) Within 150 yards of railroad or highway bridge crossing the Northeast Cape Fear River, New River, White Oak River, Trent River, Neuse River, Pamlico River, Roanoke River, and Alligator River;
(2) Within 300 yards of any highway bridge crossing Albemarle Sound,

.0103 GILL NETS, SEINES, IDENTIFICATION, RESTRICTIONS

(a) It is unlawful to use a gill net with a mesh length less than 2 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 coastal waters unless such 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 the 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 Paragraph (c) of this Rule, 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 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 with lead and 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 Quick Flasher No. 54 in Alligator River at the southern entrance of the Intracoastal Waterway to the South Carolina line, unless such net is used in accordance with the following conditions:
  (1) No more than two gill nets per boat may be used at any one time;

(2) Any net used must be attended by the fisherman from a boat 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 3J .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 following areas:

(1) Pamlico River, west of a line beginning at a point on Mauls Point 35° 26 .9176' N - 76° 55 .5253' W; to a point on Ragged Point at 35° 27 .5768' N - 76° 54 .3612 W;

(2) Within 200 yards of any shoreline in Pamlico River and its tributaries east of the line from Mauls Point at 35° 26 .9176' N - 76° 55 .5253' W; to Ragged Point at 35° 27. 5768' N - 76° 54 .3612' W and west of a line beginning at a point on Pamlico Point at 35° 18 .5906' N - 76° 28 .9530' W; through Marker #1 to a point on Roos Point at 35° 22 .3622' N - 76° 28. 2032' W;

(3) Pungo River, east of a line beginning at a point on Durants Point at 35° 30 .5312' N - 76° 35' 12. 1594' W; to the northern side of the breakwater at 35° 31 .7198' N - 76° 36 .9195' W;

(4) Within 200 yards of any shoreline in Pungo River and its tributaries west of a line from Durants Point at 35° 30 .5312' N - 76° 35 .1594'W; to the northern side of the breakwater at 35° 31 .7198' N - 76° 35 .1594' W, and west of a line beginning at a point on Pamlico Point at 35° 18 .5906' N - 76° 28 .9530' W; through Marker #1 to a point on Roos Point at 35° 22 .3622' N - 76° 28 .2032'W;

(5) Neuse River and its tributaries northwest of the Highway 17 high-rise bridge;

(6) Trent River and its tributaries;

(7) Within 200 yards of any shoreline in Neuse River and its tributaries east of Highway 17 high-rise bridge and west of a line beginning at a point on Wilkinson Point at 34° 57 .9166' N - 76° 48 .2240' W; to a point on Cherry Point at 34° 56 .3658' N - 76° 48 .7110' W.

(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 following internal coastal and joint waters of the state south of a line beginning at a point on Roanoke Marshes Point at 35° 48 .3693' N - 75° 43 .7232' W; to a point on Eagle Nest Bay at 35° 44 .1710' N - 75° 31 .0520' W to the South Carolina State Line:

(1) All primary nursery areas described in 15A NCAC 3R .0103, all permanent secondary nursery areas described in 15A NCAC 3R .0104, and no trawl areas described in 15A NCAC 3R .0106(3), (4), (6), and (7);

(2) In the area along the Outer Banks, beginning at a point on Core Banks at 34° 58 .7853' N - 76° 09 .8922' W; to a point on Wainwright Island at

34° 59 .4664' N - 76° 12 .4859' W; to a point at 35° 00 .2666' N - 76° 12 .2000' W; (M) to a point near Beacon "HL" at 35° 01. 5833' N - 76° 11 .4500' W; to a point near North Rock at 35° 06 .4000' N - 76° 04 .3333' W; to a point near Nine Foot Shoal Channel at 35° 08 .4333' N - 76° 02 .5000' W; to a point near the west end of Clark Reef at 35° 09 .3000' N - 75° 54 .8166' W; to a point south of Legged Lump at 35° 10 .9666' N - 75° 49 .7166' W; to a point on Legged Lump at 35° 11 .4833' N - 75° 51 .0833' W; to a point near No. 36 in Rollinson Channel at 35° 15 .5000' N - 75° 43 .4000' W; to a point near No. 2 in Cape Channel at 35° 19 .0333' N - 75° 36 .3166' W; to a point near No. 2 in Avon Channel at 35° 22 .3000' N - 75° 33 .2000' W; to a point on Gull Island at 35° 28 .4500' N - 75° 31 .3500' W; to a point west of Salvo at 35° 32 .6000' N - 75° 31 .8500'W; to a point west of Rodanthe Pier at 35° 35 .0000'N - 75° 29 .8833'W; to a point near No. 2 in Chicamacomico Channel, to a point west of Beach Slough at 35° 40 .0000'N - 75° 32 .8666'W; to a point west of Pea Island at 35° 45 .1833' N - 75° 34 .1000' W; to a point at 35° 44 .1710' N - 75° 31 .0520'W. Thence running south along the shoreline across the inlets to the point of beginning;

(3) In Back and Core sounds, beginning at a point on Shackleford Banks at 34° 39 .6601' N - 76° 34 .4078 W; to a point at Marker #3 at 34° 41 .3166' N - 76° 33 .8333' W; to a point at 34° 40 .4500' N - 76° 30 .6833' W; to a point near Marker "A37" at 34° 43 .5833' N - 76° 28 .5833' W; to a point at 34° 43 .7500' N - 76° 28 .6000' W; to a point at 34° 48 .1500' N - 76° 24 .7833' W; to a point near Drum Inlet at 34° 51 .0500' N - 76° 20 .3000' W; to a point at 34° 53 .4166' N - 76° 17 .3500' W; to a point at 34° 53 .9166' N - 76° 17 .1166' W; to a point at 34° 53 .5500' N - 76° 16 .4166' W; to a point at 34° 56 .5500' N - 76° 13 .6166' W; to a point at 34° 53 .5500' N - 76° 16 .4166' W; to a point at 34° 56 .4833' N - 76° 13 .2833 W; to a point at 34°58 .1833 N - 76° 12 .3000 W; to a point at 34° 58 .8000' N - 76° 12 .5166' W; to a point on Wainwright Island at 34° 59 .4664' N - 76° 12 .4859' W; to a point on Core Banks at 34° 58 .7832' N - 76° 09 .8922' W; thence following the shoreline south across Drum and Barden inlets to a 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 on Core Banks at 34° 58 .7853' N - 76° 09 .8922' W; to Camp Point at 34° 59 .7942' N - 76° 14 .6514' W to the South Carolina State Line.

15A NCAC SUBCHAPTER 3M- FINFISH

SECTION .0100 – FINFISH, GENERAL

.0101 MUTILATED FINFISH

It is unlawful to possess aboard a vessel or while engaged in fishing from the shore or a pier any species of finfish which is subject to a size or harvest restriction without having head and tail attached. Blueback herring, hickory shad and alewife shall be exempt from this Rule when used for bait provided that not more than two fish per boat or fishing operation may be cut for bait at any one time.

SECTION .0200- STRIPED BASS

.0201 GENERAL

(a) Striped bass is defined as striped bass (*Morone saxatilis*) and its hybrids taken in coastal and joint waters.
(b) Hook-and-line fishing equipment is not commercial fishing equipment in the striped bass fishery. It is unlawful to sell or purchase striped bass taken by hook-and-line. Striped bass taken legally with hook-and-line may be possessed and transported.
(c) It is unlawful to possess striped bass imported from other states less than 18 inches long (total length).
(d) It is unlawful to import, buy, sell, transport, offer to buy or sell, or possess striped bass except:
  (1) during the open season in internal coastal waters established in 15A NCAC 3M .0202;
  (2) during any open season established for the Atlantic Ocean in 15A NCAC 3M 0.204; or
  (3) during any open season of another state without possession of the following:
    (A) A bill of lading as described in 15A NCAC 3O .0114;
    (B) A numbered, state-issued tag from the State of origin affixed through the mouth and gill cover. This tag must remain affixed until processed for consumption by the consumer.

.0202 SEASON, SIZE AND HARVEST LIMIT: INTERNAL COASTAL WATERS

(a) The Fisheries Director may, by proclamation, impose any or all the following restrictions on the taking of striped bass in internal coastal waters:
  (1) Specify season or seasons:
    (A) for recreational purposes;
    (B) for commercial fishing operations from October 1 through April 30,
    (2) Specify areas,
    (3) Specify quantity,
    (4) Specify means/methods,
    (5) Specify size, but the minimum size specified shall not be less than 18 inches total length, and
    (6) Require submission of statistical and biological data. Fish that do not meet the minimum size limit specified by proclamation shall

immediately be returned to the waters from which taken regardless of condition.

(b) The Fisheries Director may, by proclamation, impose any or all the following restrictions on the taking of striped bass by hook-and-line or for recreational purposes in internal coastal waters in order to comply with the management requirements incorporated in the North Carolina Estuarine Striped Bass Plan:
  (1) Specify quantity, but shall not exceed possession of more than three fish in any one day, and
  (2) Specify size, but the minimum size specified shall not be less than 18 inches total length.

.0204 SEASON, SIZE AND HARVEST LIMIT: ATLANTIC OCEAN

(a) It is unlawful to possess striped bass taken from the Atlantic Ocean less than the size limit as determined by the Atlantic States Marine Fisheries Commission in their Interstate Fisheries Management Plan for striped bass. The Fisheries Director shall issue proclamations necessary to bring North Carolina's size limit in compliance with the Interstate Fisheries Management Plan.

(b) It is unlawful to buy, sell, transport, or possess striped bass from the Atlantic Ocean by any means except that the Fisheries Director may establish an open season at any time, and is further empowered to impose any or all of the following restrictions:
  (1)Specify number of days,
  (2)Specify areas,
  (3)Specify means and methods which may be employed in the taking,
  (4)Specify time period,
  (5)Limit the quantity, both commercially and recreationally, and
  (6)Provide for biological sampling of fish harvested.

.0205 PROHIBITED TRAWLING

(a) It is unlawful to possess striped bass on a vessel with a trawl net on that vessel in internal coastal waters except during transit from ocean fishing grounds to port during any open season in the Atlantic Ocean established by proclamation. Striped bass so possessed must meet the minimum size limit set by proclamation.

(b) It is unlawful to possess striped bass on a vessel in the Atlantic Ocean with a trawl net on that vessel except during any open season in the Atlantic Ocean established by proclamation.

.0206 HYBRID STRIPED BASS CULTURE

Culture and sale of hybrid striped bass conducted in accordance with Rule 15A NCAC 10H Section .0700 of the North Carolina Wildlife Resources Commission shall be exempt from rules of the North Carolina Marine Fisheries Commission concerning striped bass.

15A NCAC SUBCHAPTER 3O- LICENSES, LEASES AND FRANCHISES

SECTION .0300- RECREATIONAL COMMERCIAL GEAR LICENSES

.0301 ELIGIBILITY FOR RECREATIONAL COMMERCIAL GEAR LICENSES

(a) It is unlawful for any individual to hold more than on Recreational Commercial Gear License.

(b) Recreational Commercial Gear Licenses shall only be issued to individuals.

.0302 AUTHORIZED GEAR

(a) The following are the only commercial fishing gear authorized (including restrictions) for use under a valid Recreational Commercial Gear License:

- (1) One seine 30 feet or over in length but not greater than 100 feet with a mesh length less than 2 ½ inches when deployed or retrieved without the use of a vessel or any other mechanical methods. A vessel may only be used to transport the seine;
- (2) One shrimp trawl with a headrope not exceeding 26 feet in length per vessel. Mechanical methods for retrieving the trawl are not authorized for recreational purposes, including but not limited to, hand winches and block and tackle;
- (3) With or without a vessel, five eel, fish, shrimp, or crab pots in any combination, except only two pots of the five may be eel pots. Peeler pots are not authorized for recreational purposes;
- (4) One multiple hook or multiple bait trotline up to 100 feet in length;
- (5) Gill Nets:
  - (A) Not more than 100 yards of gill nets with a mesh length equal to or greater than 2 ½ inches except as provided in (5) (C) of this Rule. Attendance is required at all times;
  - (B) Not more than 100 yards of gill nets with a mesh length equal to or greater than 5 ½ inches except as provided in (5) (C) of this Rule. Attendance is required when used from one hour after sunrise through one hour before sunset in the Atlantic Ocean and north and west of a line beginning at a point at the Fort Macon rock jetty at 34° 41.8100' N - 76° 40.6244' W, running to a point at the east end of the Beaufort Highway 70 Drawbridge at 34° 43.3417' N - 76° 40.0992' W including Newport River. The northern boundary in Newport River is the Highway 101 Bridge. Attendance is required at all times south and west of that line in internal waters; and
  - (C) Not more than 100 yards of gill net may be used at any one time, except that when two or more Recreational Commercial Gear License holders are on board, a maximum of 200 yards may be used from a vessel;
  - (D) It is unlawful to possess aboard a vessel more than 100 yards of gill nets with a mesh length less than 5 ½ inches identified as recreational commercial fishing equipment when only one

recreational Commercial Gear License holder is on board. It is unlawful to possess aboard a vessel more than 200 yards of gill nets with a mesh length less than 5 ½ inches and more than 200 yards of gill nets with a mesh length equal to or greater than 5 ½ inches identified as recreational commercial fishing equipment when two or more Recreational Commercial Gear License holders are on board; and

(6) A hand-operated device generating pulsating electrical current for the taking of catfish in the area described in 15A NCAC 03J .0304.

(b) It is unlawful to use more than the quantity of authorized gear specified in Subparagraphs (a) (1) – (a) (6) of this Rule, regardless of the number of individuals aboard a vessel possessing a valid recreational Commercial Gear License.

(c) It is unlawful for a person to violate the restrictions of or use gear other than authorized by Paragraph (a) of this Rule.

(d) Unless otherwise provided, this Rule does not exempt Recreational Commercial Gear License holders from the provisions of other applicable rules of the Marine Fisheries Commission or provisions of proclamations issued by the Fisheries Director as authorized by the Marine Fisheries Commission.

.0303 RECREATIONAL COMMERCIAL GEAR LICENSE POSSESSION LIMITS

(a) It is unlawful to possess more than a single recreational possession limit when only one person aboard a vessel possesses a valid Recreational Commercial Gear License and recreational commercial fishing equipment as defined in 15A NCAC 03O.0302 (a) is used, regardless of the number of persons on board.

(b) It is unlawful to possess individual recreational possession limits in excess of the number of individuals aboard a vessel holding valid Recreational Commercial Gear Licenses.

(c) It is unlawful for any person who holds both a Recreational Commercial Gear License and a Standard or Retired Standard Commercial Fishing License and who is in possession of identified recreational commercial fishing equipment as defined in 15A NCAC 03O .0302 (a), to exceed the single recreational possession limit.

(d) It is unlawful for persons aboard a vessel collectively holding only one Recreational Commercial Gear License and any Standard Commercial Fishing License or Retired Standard Commercial fishing License and who are in possession of any identified recreational commercial fishing equipment as defined in 15A NCAC 03O .0302 (a), to exceed one recreational possession limit.

SECTION .0500 PERMITS

.0503 PERMIT CONDITIONS; SPECIFIC

(b) Dealers Permits for Monitoring Fisheries under a Quota/Allocation:

(1) During the commercial season opened by proclamation or rule for the fishery for which a Dealers Permit for Monitoring Fisheries under a Quota/Allocation permit is issued, it is unlawful for fish dealers issued such permit to fail to:

(A) Fax or send via electronic mail by noon daily, on forms provided by the Division, the previous day's landings for the permitted fishery to the dealer contact designated on the permit. Landings for Fridays or Saturdays may be submitted on the following Monday. If the dealer is unable to fax or electronic mail the required information, the permittee may call in the previous day's landings to the dealer contact designated on the permit but t must maintain a log furnished by the Division;

(B) Submit the required log to the Division upon request or no later than five days after the close of the season for the fishery permitted;

(C) Maintain faxes and other related documentation in accordance with 15A NCAC 3I .0114;

(D) Contact the dealer contact daily regardless of whether or not a transaction for the fishery for which a dealer is permitted occurred:

(E) Record the permanent dealer identification number on the bill of lading or receipt for each transaction or shipment from the permitted fishery.

(2) Striped Bass Dealer Permit:

(A) It is unlawful for a fish dealer to possess, buy, sell or offer for sale striped bass taken from the following areas without first obtaining a Striped Bass Dealer Permit validated for the applicable harvest area:

(i) Atlantic Ocean;

(ii) Albemarle Sound Management Area for Striped Bass, which is, defined as Albemarle Sound and all its joint water tributaries including Roanoke River, up to the Hwy. 258 bridge; Eastmost and Middle Rivers, and Cashie River below Sans Souci Ferry; Currituck Sound and all its joint water tributaries; Roanoke and Croatan Sounds and all their joint water tributaries, including Oregon Inlet, east of a line from Baum Point 34° 55 .1602' N - 75° 39 .5736' W; to Rhodoms Point 36° 00 .2146' N - 75° 43 .6399' W and east of a line from Eagleton Point 36° 01 .3178' N - 75° 43 .6585' W; to Long Point 36° 02 .4971' N - 75° 44 .2261' W at the mouth of Kitty Hawk Bay and north of a line from Roanoke Marshes Point 35° 48 .3693' N – 75° 43 .1710' W, to the north point of Eagle

Nest Bay 35° 44 .1710’ N - 75° 31 .0520’ W; Croatan Sound south of a line at the Highway 64/264 bridge at Manns Harbor and north of a line from Roanoke Marshes Point 35° 48 .3693’ N - 75° 43 .7232’ W; to the north point of Eagle Nest Bay 35° 44 .1710’ N - 75° 31 .0520’ W;

(iii) Central Area which is defined as all internal coastal waters of Carteret, Craven, Beaufort, and Pamlico counties; Pamlico and Pungo rivers; and Pamlico Sound south of line from Roanoke Marshes Point 35° 48 .3693’ N - 75° 43 .7232’ W, to the north point of Eagle Nest Bay 35° 44 .1710’ N - 75° 31 .0520’ W (southern boundary of Albemarle Sound Management Area for Striped Bass) to the county boundaries;

(iv) Southern Area, which is, defined as all internal coastal waters of Pender, Onslow, New Hanover and Brunswick counties.

(B) No permittee may possess, buy, sell or offer for sale striped bass taken from the harvest areas opened by proclamation without having a North Carolina Division of Marine Fisheries issued valid tag for the applicable area affixed through the mouth and gill cover or, in the case of striped bass imported from other states, a similar tag that is issued for striped bass in the state of origin. North Carolina Division of Marine Fisheries striped bass tags may not be bought, sold, offered for sale, or transferred. Tags shall be obtained at the North Carolina Division of Marine Fisheries Offices. The Division of Marine Fisheries shall specify the quantity of tags to be issued based on historical striped bass landings. It is unlawful for the permittee to fail to surrender unused tags to the Division upon request.

15A NCAC SUBCHAPTER 3Q- JURISDICTION OF AGENCIES: CLASSIFICATION OF WATERS

SECTION .0100- GENERAL REGULATIONS: JOINT

.0107 SPECIAL RULES, JOINT WATERS

In order to effectively manage all fisheries resources in joint waters and in order to confer enforcement powers on both fisheries enforcement officers and wildlife enforcement officers with respect to certain rules, the Marine Fisheries Commission and the Wildlife Resources Commission deem it necessary to adopt special rules for joint waters. Such rules supersede any inconsistent rules of the Marine Fisheries Commission or the Wildlife Resources Commission that would otherwise be applicable in joint waters under the provisions of 15A NCAC 3Q .0106:

(1) Striped bass:
   (a) It is unlawful to possess any striped bass or striped bass hybrid taken by any means which is less than 18 inches long (total length).
   (b) It is unlawful to possess more than three striped bass or striped bass by hook and line or with gear authorized by a Recreational Commercial Gear License in any one day from joint waters.
   (c) It is unlawful to engage in net fishing for striped bass or striped bass hybrids in joint waters except as authorized by duly adopted rules of the Marine Fisheries Commission.
   (d) It is unlawful to possess striped bass or striped bass hybrids in the joint waters of Albemarle, Currituck, Roanoke, and Croatan Sounds and their tributaries, excluding the Roanoke River, except during seasons as authorized by duly adopted rules of the Marine Fisheries Commission.
   (e) In the joint waters of the Roanoke River and its tributaries including Cashie, Middle and Eastmost Rivers, striped bass and hybrid striped bass fishing season, size limits and creel limits shall be the same as those established by duly adopted rules of the Wildlife Resources Commission for adjacent inland fishing waters.

.0108 MANAGEMENT PLANS FOR STRIPED BASS IN JOINT WATERS

In order to effectively manage the recreational hook and line harvest in joint waters of the Albemarle-Roanoke stock of striped bass, the Marine Fisheries Commission and the Wildlife resources Commission deem it necessary to establish two management areas for the joint waters of the Albemarle Sound and the Roanoke River, along with their defined tributaries. The Wildlife Resources Commission shall have principal management responsibility for the stock when it is in the joint and inland fishing waters of the Roanoke River and its tributaries including Cashie, Middle, and Eastmost Rivers. The Marine Fisheries Commission shall have principal management responsibility for the stock in the remaining waters of the Albemarle, Currituck, Roanoke and Croatan Sounds and their tributaries, including joint and inland waters. The annual quota for recreational harvest of the Albemarle-Roanoke striped bass shall be divided equally between the two management areas. The management plan shall:

(1) Be consistent with the guidelines established in the Atlantic States Marine Fisheries Commission Plan for Striped Bass.
(2) Limit harvest to a one fish per person per day creel limit in areas for which no data collection program is ongoing.

.0109 IMPLEMENTATION OF STRIPED BASS MANAGEMENT PLANS:

RECREATIONAL FISHING

The Marine Fisheries and Wildlife Resources Commissions shall implement their respective striped bass management plans for recreational fishing pursuant to their respective rule-making powers. To preserve jurisdictional authority of each Commission while establishing a means to implement their management plans, the Commissions find it necessary to create a means through which management measures can be implemented by a single instrument in each management area.

(1) In the Roanoke River and tributaries, the exclusive authority to open and close seasons and areas, whether inland or joint fishing waters shall be vested in the Wildlife Resources Commission. The Wildlife Resources Commission shall initiate action to close the management area when 90 percent of the assigned quota has been taken. An instrument closing any management area in joint waters shall operate as and shall be a jointly issued instrument opening or closing seasons or areas to harvest in the Roanoke River management area.

(2) In the Albemarle Sound management area, the exclusive authority to open and close seasons and areas, whether coastal or joint fishing waters shall be vested in the Marine Fisheries Commission. The Marine Fisheries Commission shall initiate action to close the management area when 90 percent of the assigned quota has been taken. In the Albemarle Sound management area administered by the Marine Fisheries Commission, an instrument or action by the Marine Fisheries Commission affecting the harvest in joint and coastal waters, excluding the Roanoke River management area, shall automatically be implemented and effective as a Wildlife Resources Commission action in the inland waters and tributaries to the waters affected.

4.4.3.2 Wildlife Resources Commission Rules

15A NCAC 10C .0107 SPECIAL REGULATIONS: JOINT WATERS

In order to effectively manage all fisheries resources in joint waters and in order to confer enforcement powers on both fisheries enforcement officers and wildlife enforcement officers with respect to certain rules; the Marine Fisheries Commission and the Wildlife Resources Commission deem it necessary to adopt special rules for joint waters. Such rules supercede any inconsistent rules of the Marine Fisheries Commission or the Wildlife Resources Commission that would otherwise be applicable in joint waters under the provisions of 15A NCAC 10C .0106:

(1) Striped Bass

- (a) It shall be unlawful to possess any striped bass or striped bass hybrid taken by any means which is less than 18 inches long (total length).
- (b) It shall be unlawful to possess more than three striped bass or their hybrids taken by hook and line in any one day from joint waters.
- (c) It shall be unlawful to engage in net fishing for striped bass or their hybrids in joint waters except as authorized by duly adopted rules of the Marine Fisheries Commission.
- (d) It is unlawful to possess striped bass or striped bass hybrids in the joint waters of Albemarle, Currituck, Roanoke and Croatan Sounds and their

tributaries, excluding the Roanoke River, except during seasons as authorized by duly adopted rules of the Marine Fisheries Commission.

(e) In the joint waters of the Roanoke River and its tributaries, including Cashie, Middle and Eastmost Rivers, striped bass and hybrid striped bass fishing season, size limits and creel limits shall be the same as those established and authorized by duly adopted rules of the Wildlife Resources Commission for adjacent inland fishing waters.

15A NCAC 10C .0110 MANAGEMENT PLANS FOR STRIPED BASS IN JOINT WATERS

In order to effectively manage the recreational hook and line harvest in joint waters of the Albemarle-Roanoke stock of striped bass, the Marine Fisheries Commission and the Wildlife Resources Commission deem it necessary to establish two management areas for the joint waters of the Albemarle Sound and Roanoke River, along with their defined tributaries. The Wildlife Resources Commission shall have principal management responsibility for the stock when it is in the joint and inland fishing waters of the Roanoke River and its tributaries, including Cashie, Middle and Eastmost Rivers. The Marine Fisheries Commission shall have principal management responsibility for the stock in the remaining waters of the Albemarle, Currituck, Roanoke and Croatan Sounds and their tributaries, including joint and inland waters. The annual quota for recreational harvest of the Albemarle-Roanoke striped bass stock shall be divided equally between the two management areas. The management plans shall:

(1) Be consistent with the guidelines established in the Atlantic States Marine Fisheries Commission Plan for Striped Bass.

(2) Limit harvest to a one fish per person per day creel limit in areas for which no data collection program is ongoing.

15A NCAC 10C .0111 IMPLEMENTATION/STRIPED BASS MANAGEMENT PLAN/RECREATIONAL FISHING

The Marine Fisheries and Wildlife Resources Commissions shall implement their respective striped bass management plans for recreational fishing pursuant to their respective rulemaking powers. To preserve jurisdictional authority of each Commission while establishing a means to implement their management plans, the Commissions find it necessary to create a means through which management measures can be implemented by a single instrument in each management area.

(1) In the Roanoke River and tributaries, the exclusive authority to open and close seasons and areas, whether inland or joint fishing waters shall be vested in the Wildlife Resources Commission. The Wildlife Resources Commission shall initiate action to close the management area when 90 percent of the assigned quota has been taken. An instrument closing any management area in joint waters shall operate as and shall be a jointly issued instrument opening or closing seasons or areas to harvest in the Roanoke River management area.

(2) In the Albemarle Sound management area, the exclusive authority to open and close seasons and areas, whether coastal or joint fishing waters shall be vested in the Marine Fisheries Commission. The Marine Fisheries Commission

shall initiate action to close the management area when 90 percent of the assigned quota has been taken. In the Albemarle Sound management area administered by the Marine Fisheries Commission, an instrument or action by the Marine Fisheries Commission affecting the harvest in joint and coastal waters, excluding the Roanoke River management area, shall automatically be implemented and effective as a Wildlife Resources Commission action in the inland waters and tributaries to the waters affected.

15A NCAC 10C .0215 REPLACEMENT COSTS OF WILDLIFE RESOURCES-FISH

(a) Replacement Costs Distinguished. As it applies to fishes the term "replacement costs" must be distinguished from the "value" of the fish concerned. Except in cases where fish may lawfully be sold on the open market, as with commercially reared species, the monetary value of the specimens cannot be determined easily. The degree of special interest or concern in a particular species by the public, including not only anglers, but also conservationists and those whom the value of fishes is primarily aesthetic, cannot be measured in dollar amounts. The average cost per fish legally taken by anglers including travel and lodging, fishing equipment and bait, excise taxes on equipment, licenses and other fees, may fairly be estimated. This too, however, is a reflection of the value of fish species should be considered only as they may bear on the necessity or desirability of actual replacement.

(b) Factors to be Considered. The factors which should be considered in determining the replacement costs of resident species of fishes that have been taken, injured, removed, harmfully, altered, damaged, or destroyed include the following:

(1) whether the species is classified as endangered or threatened;
(2) the relative frequency of occurrence of the species in the state;
(3) the extent of existing habitat suitable for the species within the state;
(4) the dependency of the species on unique habitat requirements;
(5) the cost of improving and maintaining suitable habitat for the species;
(6) the cost of capturing the species in areas of adequate populations and transplanting them to areas of suitable habitat with low populations;
(7) the cost of propagating and rearing the species in a hatchery and the cost of transporting them to areas of suitable habitat with low populations;
(8) the availability of the species and the cost of acquisition for restocking purposes;
(9) the cost of those species which, when released, have a probability of survival in the wild;
(10) the ratio between the natural life expectancy of the species and the period of its probable survival when, having been reared in a hatchery, it is released to the wild;
(11) the change in value of money as reflected by the consumer price index,

(c) Costs of Replacement. Based on the factors listed in Paragraph (b) of this Rule, including the June, 1980, consumer price index of 247.6 percent of the 1967 base, the following fishes are listed with the estimated replacement cost:

Species	Weight	Replacement Cost
Striped bass and	up to 5 lbs.	$ 25/fish
Bodie bass	5 lbs. to 10 lbs.	$ 20/lb.
	10 lbs. to 20 lbs.	$ 25/lb.
	Over 20 lbs.	$ 30/lb.

15A NCAC 10C .0301 INLAND GAME FISHES DESIGNATED

The following fishes are classified and designated as inland game fishes:

(10) striped bass and Morone hybrids (striped bass-white bass), when found in inland fishing waters;

15A NCAC 10C .0302 MANNER OF TAKING INLAND GAME FISHES

(d) In the inland waters of the Roanoke River upstream of U.S. 258 bridge, only a single barbless hook or a lure with a single barbless hook may be used from 1 April to 30 June. Barbless as used in this Rule, requires that the hook does not have a barb or the barb is bent down.

15A NCAC 10C .0304 TAKING AND POSSESSION OF INLAND GAME FISHES

(a) It is unlawful to take in one day more than the daily creel limit of those species of inland game fish having a specified creel limit; to possess more fish than the daily creel limit in effect on those waters being fished; to possess any fish outside of the size limit in effect on those waters being fished; to possess more fish than the daily creel limit while boating or afield; or to possess at any place more than three days creel limit. It is unlawful to destroy unnecessarily any inland game fish taken from public fishing waters.

(b) No person while fishing shall remove the head or tail or otherwise change the appearance of any game fish having a minimum size limit so as to render it impracticable to measure its total original length. No person while fishing shall change the appearance of any game fish having a daily creel limit so as to obscure its identification or render it impracticable to count the number of fish in possession.

15A NCAC 10C .0305 OPEN SEASONS: CREEL AND SIZE LIMITS

(a) Generally. Subject to the exceptions listed in Paragraph (b) of this Rule, the open seasons and creel and size limits are as indicated in the following table:

Game Fishes	Daily Creel Limits	Minimum Size Limits	Open Season
Striped Bass and their hybrids (Morone Hybrids)	8 aggregate (excs. 1, 5 & 12)	16 in. (excs. 1, 6, 5 & 10)	All Year (excs. 5, 12, & 14)

(b) Exceptions

(5) In the inland fishing waters of Cape Fear, Neuse, Pee Dee, Pungo and Tar Pamlico rivers and their tributaries extending upstream to the first impoundment, and Lake Mattamuskeet, the daily creel limit for striped bass and their hybrids is three fish in aggregate and the minimum length is 18 inches. In the Tar Pamlico River and its tributaries upstream of the NC 55 bridge in Lenior County, no striped bass or striped bass hybrids between the lengths of 22 inches and 27 inches shall be retained during the period April 1 through May 31.

(6) The open season for taking and possessing striped bass and their hybrids in the Roanoke River Striped Bass Management Area is March 1 through April 15 from the joint-coastal fishing waters boundary at Albemarle Sound upstream to the US 258 bridge and is March 15 through April 30 from the US 258 bridge upstream to Roanoke Rapids Lake dam. During the open season the daily creel limit for striped bass and their hybrids is two fish and no fish between 22 inches and 27 inches in length shall be retained.

(13) In designated inland fishing waters of Roanoke Sound, Croatan Sound, Albemarle Sound, Chowan River, Currituck Sound, Alligator River, Scuppernong River, and their tributaries (excluding the Roanoke River, and Cashie River and their tributaries), striped bass fishing season, size limits and creel limits shall be the same as those established by duly adopted rules or proclamations of the Marine Fisheries Commission in adjacent joint or coastal fishing waters.

(15) The Executive Director may, by proclamation, suspend or extend the hook-and-line season for striped bass in the inland and joint waters of coastal rivers and their tributaries. It is unlawful to violate the provisions of any proclamation issued under this authority.

SECTION .0500- PRIMARY NURSERY AREAS

15A NCAC 10C .0501 SCOPE AND PURPOSE

To establish and protect those fragile inland waters which support embryonic, larval or juvenile populations of marine or estuarine fish or crustacean species. These rules will set forth permanent nursery areas in inland fishing waters. Nursery areas are necessary for the early growth and development of virtually all of North Carolina's important marine or estuarine fish or crustacean species. Nursery areas need to be maintained, as much as possible, in their natural state, and the fish and crustacean populations within them must be permitted to develop in a normal manner with as little interference from man as possible.

15A NCAC 10C .0502 PRIMARY NURSERY AREAS DEFINED
Primary nursery areas are defined as those areas inhabited by the embryonic, larval or juvenile life stages of marine or estuarine fish or crustacean species due to favorable physical, chemical or biological factors.

15A NCAC 10C .0503 DESCRIPTIVE BOUNDARIES
The following waters have been designated as primary nursery areas:

(1) **North River**:
- (a) Broad Creek- Camden County- Entire stream;
- (b) Deep Creek- Currituck County- Entire stream;
- (c) Lutz Creek- Currituck County- Entire stream.

(2) **Alligator River**:
- (a) East Lake- Dare County- Inland waters portion;
- (b) Little Alligator River- Tyrrell County- Entire stream.

(3) **Currituck Sound**:
- (a) Martin Point Creek- Dare County- Entire stream (Jean Guite Creek);
- (b) Tull Creek and Bay- Currituck County- Tull Bay to mouth of Northwest River;
  Tull Creek from mouth upstream to SR 1222 bridge.

(4) **Pamlico River**:
- (a) Duck Creek- Beaufort County- Entire stream;
- (b) Bath Creek- Beaufort County- Entire stream;
- (c) Mixons Creek- Beaufort County- Entire stream;
- (d) Porter Creek- Beaufort County- Entire stream;
- (e) Tooleys Creek- Beaufort County- Entire stream;
- (f) Jacobs Creek- Beaufort County- Entire stream;
- (g) Jacks Creek- Beaufort County- Entire stream;
- (h) Bond Creek- Beaufort County- Entire stream;
- (i) Muddy Creek- Beaufort County- Entire stream;
- (j) Strawhorn Creek- Beaufort County- Entire stream;
- (k) South Prong Wright Creek- Beaufort County- Entire stream;
- (l) Jordan Creek- Beaufort County- Entire stream.

(5) **Neuse River**:
- (a) Slocum Creek- Craven County- Entire stream;
- (b) Hancock Creek- Craven County- entire stream.

(6) **New River**:
- (a) French Creek- Onslow County- Entire stream;
- (b) New River- Onslow County- US Highway 17 bridge to point 0.75 miles upstream.

(7) **Roanoke River**: Halifax and Northhampton counties- US Hwy 258 bridge to Roanoke Rapids dam

(8) **Tar-Pamlico River**: Nash, Edgecombe, Pitt and Beaufort counties- N&S railroad at Washington upstream to Rocky Mount Mills Dam.

(9) **Neuse River**: Wake, Johnson, Wayne, Lenior, Pitt and Craven counties- Pitchkettle Creek upstream to Millburnie Dam.

(10) **Cape Fear River**: Chatham, Lee, Harnett, Cumberland and Bladen counties- Lock and Dam No. 1 to Buckhorn dam.

5.0. GENERAL LIFE HISTORY

5.1 Description and Distribution

The accepted common and scientific names for the species are striped bass, *Morone saxatilis*, (Walbaum) (Robins et al. 1991). In North Carolina it is also known as striper, rockfish, or rock. The body of a striped bass is elongate and moderately compressed with a slightly arched back. The lower jaw protrudes and extends posteriorly to the middle of the orbit. Color dorsally ranges from shades of green to steel blue or almost black. The sides are silvery with 7 or 8 dark, more or less continuous stripes, one of which always follows the lateral line, with 3 or 4 others above it and 3 below. Ventrally, the fish are white to silver with brassy iridescence. They have one soft and one spiny dorsal fin separated at the base and about equal in length. Striped bass are relatively long-lived and capable of attaining moderately large size. Fish weighing 50 or 60 pounds are not exceptional. In general, females grow larger than males; reported maximum lengths are 1,524 mm FL (60.0 inches) and 1,156 mm FL (45.5 inches), respectively (Hill et al. 1989; ASMFC 1990). The largest striped bass on record are two females caught in Albemarle Sound, North Carolina weighing 125 pounds each (Smith 1907).

5.2 General Life History

Studies from 1938 through the 1990s indicate that only a small portion of striped bass spawned in the A/R system migrates out of the system to offshore waters (North Carolina Striped Bass Study Management Board 1992). Since the A/R stock has recovered and expanded however, an increasing number of tag returns indicate that larger A/R striped bass are migrating to the Atlantic Ocean and to northern coastal waters. This increase in distant tag returns likely reflects an increase in survival of larger individuals and the inability of these individuals to tolerate high summertime water temperatures of Albemarle Sound. In order to spawn successfully, striped bass require waters having suitable flows, salinities, temperatures, and other aspects of habitat quality, which make the species particularly vulnerable to river flow alterations (Rulifson et al. 1982b).

5.2.1 Spawning

Striped bass spawn in fresh water or nearly freshwater portions of North Carolina coastal rivers from late March to June depending upon water temperatures (Hill et al. 1989). Peak spawning activity occurs when water reaches 62°-67° F (16.7°-19.4° C) on the Roanoke River (Rulifson 1990 and 1991a), 66.2° F (19° C) on the Cape Fear (Sholar 1977; Fischer 1980), and 68°-70.7° F (20°- 21.5° C) on the Neuse (Hawkins 1979; Baker 1968), and 64°- 69°F (18°- 22° C) in Tar River (Kornegay and Humphries 1975). Spawning behavior is characterized by brief peaks of surface activity when a mature female is surrounded by up to 50 males as eggs are broadcast into the surrounding water, and males release sperm (Setzler et al. 1980). Spawning by a given female is probably completed within a few hours (Lewis and Bonner 1966).

5.2.2 Eggs
Mature eggs are .039 to 0.59 inch (1.0-1.5 mm) in diameter when spawned, and remain viable for about 1 hour (hr) before fertilization (Stevens 1966). Fertilized eggs are spherical, non-adhesive, semi-buoyant and nearly transparent. Water hardening occurs in a few hours, and eggs will range in diameter from .051 to .181 inch (1.3-4.6 mm) (Albrecht 1964; Murawski 1969). To keep eggs in suspension, minimum water velocities of .984 feet per second (ft/s) (30 cm/s) are generally required (Albrecht 1964). The incubation period at peak spawning temperatures ranges from 42 to 55 hours. At 68° F (20.0° C) (Hassler et al. 1981) found that eggs hatch in 38 hours. After hatching, larvae are carried by the current to the downstream nursery areas.

5.2.3 Larvae
The larval development of striped bass is dependent upon water temperature and is usually regarded as having three stages: 1) yolk-sac larvae are .20 to .31 inch (5-8 mm) in total length (TL) and depend on yolk material as an energy source for 7 to 14 days; 2) fin-fold larvae (.31-.47 inch; 8-12 mm TL) having fully developed mouth parts and persist about 10 to 13 days; and 3) post fin-fold larvae attain length up to 1.18 inches (30 mm) in 20 to 30 days (Hill et al. 1989). Researchers of North Carolina stocks of striped bass (primarily Albemarle-Roanoke) divide larval development into yolk-sac and post yolk-sac larvae. Growth occurs generally within the same rates described above depending upon temperature. At temperatures ≥ 68° F (20° C), larvae reach the juvenile stage in approximately 42 days (Hassler et al. 1981). Yolk-sac larvae can feed as early as 5 days post-hatch; the survival rate is reduced as time to first feeding increases. This can become critical, because the nursery grounds where primary food sources occur are considerable distances downstream (especially the Albemarle-Roanoke stock). Larvae are totally dependent upon river flows for transport and timing of arrival to the nursery grounds where feeding is initiated.

5.2.4 Juveniles
Most striped bass enter the juvenile stage at about 1.18 inches (30 mm) TL; the fins are then fully formed, and the external morphology of the young is similar to that of the adults. Juveniles are often found in schools and apparently prefer clean sandy bottoms (Hill et al. 1989). They may spend the first two years of life maturing in and around the nursery area (Hassler et al. 1981).

5.2.5 Maturation and Fecundity
Information on rates of maturation and fecundity are unavailable for coastal North Carolina stocks except the A/R stock. Recent research conducted on this stock indicates that females begin reaching sexual maturity in approximately 3 years, at sizes of 22-24 inches TL (Olsen and Rulifson 1991, Trent and Hassler 1968). Specifically, about 45% of the Roanoke females have reached sexual maturity by age 3; however, the viability of the eggs and resultant contribution of the progeny to the forming year class are unknown (Olsen and Rulifson 1991). Previous investigators determined the age at first maturity to be age 3 for male and age 4 for females (Trent and Hassler 1968; Harris and Burns 1983; Harris et al. 1984). In general, there is a strong positive correlation between the length, weight, and age of a female striped bass and the

number of eggs it produces. All Roanoke River females are mature by age 6, and a curvilinear relationship exists between the fish age and the number of eggs produced, with greatest increase between age 6 and age 10. Potential fecundity estimates range from approximately 181,000 eggs for age 3 to 5,000,000 eggs for age 16 (Olsen and Rulifson 1991). Lewis (1962) noted that some females in the Roanoke River, age seven and older, did not spawn annually.

5.2.6 Growth Pattern

5.2.6.1 Rates

Growth rates for the A/R stock are rapid during the first three years of life, and then decrease to a relatively slow rate as the fish reach sexual maturity. Striped bass grow approximately 270 mm during their 1st year, 150 mm during their 2nd year, 70 mm during their 3rd year, and 40-20 mm yearly thereafter (Olsen and Rulifson 1991). Mean lengths at age from large samples of Roanoke River striped bass sampled on the spawning grounds indicate female striped bass grow faster than males (**Table** 5.1). Growth rates for young-of-year striped bass ranged from 0.272 mm per day to 0.664 per day determined from a 20-year time series during 1955-1978 (Hassler et al. 1981). Statistically significant differences were found in these yearly growth rates. Additionally analyses indicated positive correlation with young-of-year growth rates and river discharge. Hassler speculated that increased river discharge transports greater amount of organic detritus to the estuary, which results in high productivity and faster growth rates for young-of-year striped bass.

5.2.6.2 Length-Weight Relationships

Length-weight relationships have been determined specifically for the A/R stock females from samples collected in 1989 and 1990. Regression analysis indicated a highly significant linear length-weight relationship (Olsen and Rulifson 1991);

$$\text{Total fish weight} = -.6381598 + 0.016316\,(FL)\quad (r = 0.94,\ p \leq 0.0001,\ n = 265).$$

Trent (1962) established the following relation for first-summer growth of striped bass in Albemarle Sound:

$$Y = 1.84615 + 2.91977X,$$

Where Y is log weight (mg) and X is log total length (cm). After maturity, the weight of male striped bass is generally less than that of females of the same length (Merriman 1941; Mansueti 1961).

5.3 Ecological Relationships

5.3.1 Food Habits

Major food items of larvae collected in Albemarle Sound were *Bosmina* sp. and copepodite stage copepods (Rulifson et al. 1991). Several food habit studies have been conducted on

Table 5.1. Mean lengths (mm) at age for striped bass sampled from the Roanoke River spawning grounds, year classes examined since 1991 (NCWRC data).

Sex and Year Class	Age 2	3	4	5	6	7
Males						
1988		465	510	545	573	581
1989	384	445	495	523	553	586
1990	383	452	494	525	560	597
1991	397	450	483	539	569	613
1992	397	450	474	543	579	610
1993	373	428	511	535	573	617
1994	311	462	488	537	569	608
1995	383	435	496	534	564	
1996	382	441	495	530		
1997	369	450	489			
1998	387	438				
1999	389					
Females						
1988		493	524	578	592	621
1989	399	473	518	549	580	626
1990	414	472	513	545	596	626
1991	376	478	503	553	597	631
1992	447	466	511	572	595	638
1993	375	441	536	551	602	664
1994	-	469	507	563	616	636
1995	381	462	513	573	584	
1996	423	476	531	541		
1997	429	472	512			
1998	439	462				
1999	-					

juvenile and adult striped bass since 1955 in the Roanoke River and Albemarle Sound. The most recent sampling on juvenile striped bass in Albemarle Sound found zooplankton and mysid shrimp as primary prey items for smaller juveniles in the summer, with small fish (most likely bay anchovies) entering the diet later in the season (Rulifson and Bass 1991, Cooper, Rulifson and Winslow 1998). Adults feed extensively on blueback herring and alewives in the river during the spawning migration (Trent and Hassler 1968). Manooch (1973) conducted a seasonal food habit study in Albemarle Sound. Fish primarily clupeids (Atlantic menhaden, blueback herring, alewife and gizzard shad) and engraulids (anchovies), dominated the diet in the summer and fall. Atlantic menhaden (54%) was the most frequently eaten species, which comprised a relatively large percentage of the volume (50.1%). In the winter and spring months, invertebrates occurred more frequently in the diet (primarily amphipods during the winter and blue crabs in the spring). Patrick and Moser (2001) found similar results from the Cape Fear River, with Atlantic menhaden and threadfin shad being the predominate species. Rulifson and Price (2001) collected striped bass stomachs (34) from the upper Currituck Sound during 2000 and determined that prey within the family *Alosinae* had the highest occurrence. The American shad was the most common species observed in the fall. DMF through the Fishery Independent Gill Net Survey (IGNS) has collected and analyzed stomach (1,167) contents from the Albemarle Sound area since 1995. River herring (51.8%) was the predominate species from the western sound samples, followed by Atlantic menhaden (25.7%). The dominance of river herring during the spawning migration supports that reported by Trent and Hassler (1968) and Manooch (1973). Blue crabs only accounted for 0.4% of the total from the western sound. Atlantic menhaden (47.8%), Atlantic croaker (18.3%) and anchovies (16.9%) dominated the eastern sound samples. Blue crabs comprised 3.2% of the stomach contents from the eastern sound.

5.3.2 Feeding Behavior

Striped bass are opportunistic feeders; specific food types depend upon the size of the fish, habitat, and the season (Rulifson et al. 1982a). They undergo an ontogenetic shift in diet with larvae feeding primarily on mobile planktonic invertebrates (Doroshev 1970; Markle and Grant 1970; Bason 1971). As they grow, their diet includes larger aquatic invertebrates and small fish (Shapovalov 1936; Ware 1971).

5.3.3 Predators

The only likely predators on adult striped bass would include some marine species that might ascend rivers and sounds or, in the case of the A/R stock, during a coastal migration. These predators might include sharks, bluefish, goose fish/monkfish (*Lophius sp.)*, tuna and tarpon. Any sympatric piscivorous fish may be a predator of larvae and juvenile striped bass. Examination of stomach contents of white and yellow perch, American eel, Atlantic croaker, white and channel catfish, and striped bass in Albemarle Sound showed that only white and channel catfish stomach contents contained *Morone* sp. (Rulifson 1984).

5.3.4 Competitors

Because striped bass share forage species with other piscivores, they are potential competitors (Setzler et al. 1980). Young striped bass may also compete with other fishes for food. Similar nursery areas and food habits show a potential for competition between young white perch and striped bass (Milhursky et al. 1976). The young may also compete with some species of clupeids (Hollis 1967).

Research in Cape Fear River suggests hybrid striped bass that have escaped from upstream reservoirs compete for food and spawning space with native striped bass (Patrick and Moser 2001).

5.4 Migration

5.4.1 Albemarle-Roanoke Adult Striped Bass

Numerous tagging or migration studies have been conducted on striped bass in North Carolina and along the Atlantic Coast since the 1930s. Several of these studies suggest that the A/R stock is migratory with primarily older adults migrating offshore. Tag recapture studies from previous investigators (Merriman 1941, Vladykov and Wallace 1952, Davis and Sykes 1960, Chapotan and Sykes 1961, Nichols and Cheek 1966, Holland and Yelverton 1973, Street et al. 1975, Hassler et al. 1981. Boreman and Lewis, 1987 and Benton 1992) indicate that a small amount of migration occurs (**Table**

5.2). However the studies conducted in the 1980s and 1991 were when the age structure of the stock was truncated and while the stock, in general was at low abundance. It was noted by several of these investigators that larger, older females were more migratory than males. Fish tagged and released at various locations in the Albemarle Sound have been recaptured on the spawning grounds in Roanoke River, in Albemarle, Pamlico, and Croatan sounds, and offshore from North Carolina to New England. These studies from 1937- 1985 showed a 0.7- 19.8% exchange rate (**Table** 5.2). Though the percent contribution in general has remained low, it is apparent that the Albemarle Sound and North Carolina territorial seas serve as a wintering ground for east coast stocks and to a lesser degree for the A/R stock.

In 1985, DMF reinstated adult striped bass tagging in the Albemarle and Croatan sound areas and this has continued to the present. Due to the population being at a low level, very few fish were tagged from 1985-1989 (n=16). Striped bass have been tagged and released from hook and line, DMF trawl surveys, gill nets, pound nets, DMF gill net surveys and electro-fishing efforts. A total of 14,260 striped bass was tagged and released in the ASMA from 1990 through the spring 2002 (**Table** 5.3). The percentage of fish tagged and released 18 inches (TL) and larger has ranged from 44.2 – 68.6% annually. Of the total number tagged, 23 striped bass captured and released through the DMF gill net surveys were 28 inches TL and larger (**Table** 5.4). A total of 1,087 tags (7.6%) have been returned, with 95.3% of the returns being from the ASMA. Nineteen of the returns were from the Atlantic Ocean off North Carolina or from areas north of the state (**Table** 5.3). The percentage of returns from outside the internal waters of the state has ranged from 1.4 – 33.3%. Most of these returns occurred within one year of release, while two were at large for over four years. The majority of the tag returns (n=14) from the northern areas were from April through July, from fish tagged during the fall and winter months (October – February) in the eastern Albemarle and Croatan sound areas. These returns further support the speculation by Street et al. (1975) that the eastern Albemarle and Croatan sounds serve as a wintering ground for a portion of the migratory stock. **Figure** 5.1 shows the returns by length from the DMF Gill Net Survey, Fall-Winter segments from outside the internal waters. A total of 11 tags have been returned. These fish have ranged in length from 14-24 inches TL. The returns from the Spring segments of the Gill Net Survey are presented in **Figure** 5.2. Only 2 returns (26 in TL and 31 in TL) have been from outside the internal waters of the state.

The Division in cooperation with the WRC has tagged and released 22,552 striped bass from the Roanoke River on the spawning grounds since 1991 (**Table** 5.3). Sixty-four percent of these fish were 18 inches TL or larger when tagged and released. The number of striped bass 28 inches TL and larger tagged and released has increased since the stock has been recovered (**Table** 5.5). A total of 2,460 (10.9%) tags have been returned, with 84.7 – 98.9% of the returns being from the ASMA or RRMA. Twenty-six of the returns (1%) have been from the ocean off NC or from waters to the north of the state (**Table** 5.3). The percentage of returns from the ocean and areas north has ranged from 0.3 – 3.0%. Generally, these returns occurred from May – September (n=12) and the fish have been at large up to eight years prior to capture.

Table 5.2. Summary of adult striped bass tagging efforts and returns.

Tagging period	Reference	Tagging location	Number tagged	Number recaptured	Percent return	Recapture location	Percent exchange (based on total returns)
Nov 1937	Vladykov and Wallace (1952)	Currituck Sound Croatan Sound Kitty Hawk	179 298 6 483	137	28.4	136 NC 1 NJ	0.7
Mar-Apr 1937	Merriman (1941)	Kitty Hawk (ocean)/ Albemarle Sound	600	45	7.5	24- Albemarle Sound 9- Ocean off VA Beach 8- Chesapeake Bay 2- NJ 1- NY 1- RI	19.6
Apr 1938	Merriman (1941)	Western Albemarle Sound	506	47	9.3	47- Albemarle Sound area	
Oct 1955-May 1957	Davis and Sykes (1960), Nichols and Cheek (1966)	Albemarle Sound	5,242	1,651	31.5	1,565- Albemarle Sound 79- Pamlico Sound 5- Chesapeake Bay 1- New England 1- Ocean off NC	0.4
1956-1983	Hassler et al. (1981)	Roanoke River	11,662	3,264	28.0	Albemarle Sound and Roanoke River	
Dec 1956-1958	Chapotan and Sykes (1961)	Atlantic Ocean off Oregon Inlet	81	19	23.5	5- Ocean 2- Albemarle Sound 8- Chesapeake Bay 2- NJ 1- RI 1- MA	10.5
		Albemarle Sound	34	14	41.2	12- Albemarle Sound 1- Roanoke River 1- MA	7.1
		Roanoke River	63	9	14.3	1- Roanoke River 8- Albemarle Sound	

Table 5.2 (Continued)

Tagging period	Reference	Tagging location	Number tagged	Number recaptured	Percent return	Recapture location	Percent exchange (based on total returns)
1968-1971	Holland and Yelverton (1973)	Ocean- Cape Lookout to NC/VA line	1,752	197	11.2	39- Albemarle/Pamlico S. 25- Ocean off NC 78- Chesapeake Bay 55- NJ-ME	19.8
Oct- Dec 1973	Street et al. (1975)	Croatan Sound	462	128	27.7	Croatan Sound Albemarle Sound	
1964-1985	Boreman and Lewis (1987)	Chesapeake Bay to Canada	27,674	1,959	7.1	18 Albemarle and Croatan Sound	0.9
1988-2002	Benton (1992), Laney (2002)	Cape Hatteras to mouth of Chesapeake Bay	30,618				
2002	Hewitt and Hightower (2002)	Roanoke River- near Scotland Neck	729	20	2.7	1 Pungo River 19 Albemarle Sound/ Roanoke River	

Table 5.3. Number of adult striped bass tagged and released throughout the ASMA and RRMA and recapture areas.

Year	Tagging location	Number tagged	Number returned	Percent return	Oregon Inlet Number/ Percent	Outside NC internal waters Number/ Percent	Internal waters outside ASMA Number/ Percent
Hook and line							
1990	Batchelor Bay	15	0				
1992	Albemarle Sound area	108	5	4.6			
1993	Albemarle Sound area	50	4	8.0			
1993	Pasquotank River	63	1	1.6			
1994	Pasquotank River	375	20	5.3			
1994	Albemarle Sound area	124	7	5.6			
1995	Albemarle Sound area	74	6	8.1		2 (33.3)	1 (16.6)
1996	Perquimans River	26	1	3.8	1 (100)		
1997	Albemarle Sound area	42	0				

Table 5.3 (Continued)

Year	Tagging location	Number tagged	Number returned	Percent return	Oregon Inlet Number/ Percent	Outside NC internal waters Number/ Percent	Internal waters outside ASMA Number/ Percent
1998	Albemarle Sound area	107	1	0.9			
1998	Perquimans River	30	2	6.7			
1999	Albemarle and Croatan sounds	244	5	2.0			
2000	Albemarle and Croatan sounds	194	18	9.3	1 (5.6)		
	Total	1,452	70				
Trawls							
1994	Albemarle Sound area	24	0				
Pound Nets							
1990	Batchelor Bay	275	34	12.4			
1990	Eastern Albemarle Sound	420	69	16.4			
1991	Eastern Albemarle Sound	183	30	16.3			
1992	Eastern Albemarle Sound	88	18	20.4			2 (11.1)
1993	Eastern Albemarle Sound	209	39	18.7			
1994	Eastern Albemarle Sound	77	5	6.5			
1995	Eastern Albemarle Sound	352	66	18.7	2 (3.1)	4 (6.2)	
1998	Chowan River	13	2	15.4			
	Total	**1,617**	**263**				
Gill Net Survey	**Fall-Winter**						
1990/91	Albemarle/Croatan sounds	245	55	22.4			
1991/92	Albemarle/Croatan sounds	329	69	21.0		1 (1.4)	
1992/93	Albemarle/Croatan sounds	267	36	13.5	2 (5.6)	1 (2.8)	2 (5.6)
1993/94	Albemarle/Croatan sounds	166	29	17.5			
1994/95	Albemarle/Croatan sounds	776	72	9.3	2 (2.8)	1 (1.4)	1 (1.4)
1995/96	Albemarle/Croatan sounds	464	41	8.8	1 (2.4)	4 (9.7)	2 (4.9)
1996/97	Albemarle/Croatan sounds	782	49	6.3	1 (2.0)	3 (6.1)	1 (2.0)
1997/98	Albemarle/Croatan sounds	695	55	7.9	3 (5.4)	1 (1.8)	
1998/99	Albemarle/Croatan sounds	1,054	83	7.8	2 (2.4)		1 (1.2)
1999/00	Albemarle/Croatan sounds	586	59	10.0	5 (8.5)		1 (1.6)
2000/01	Albemarle/Croatan sounds	382	23	6.0			2 (9.5)
2001/02	Albemarle/Croatan sounds	537	23	4.3			
2002/03	Albemarle/Croatan sounds	427					
	Total	**6,710**	**594**				

Table 5.3 (Continued)

Year	Tagging location	Number tagged	Number returned	Percent return	Oregon Inlet Number/ Percent	Outside NC internal waters Number/ Percent	Internal waters outside ASMA Number/ Percent
	Spring						
1993	Western Albemarle Sound	106	11	10.4			
1994	Western Albemarle Sound	64	4	6.2			
1995	Western Albemarle Sound	553	23	4.2			
1996	Western Albemarle Sound	406	20	4.9	2 (10.0)	1 (5.0)	
1997	Western Albemarle Sound	582	10	1.7			
1998	Western Albemarle Sound	582	8	1.4			
1999	Western Albemarle Sound	785	25	3.1	2 (8.0)		4 (16.0)
2000	Western Albemarle Sound	627	14	2.2	3 (21.4)	1 (7.1)	2 (14.2)
2001	Western Albemarle Sound	648	23	3.5	1 (4.3)		3 (13.0)
2002	Western Albemarle Sound	531	22	4.1			1 (4.8)
2003	Western Albemarle Sound	299					
	Total	**5,183**	**160**				
Electro-fishing							
1992	Albemarle Sound area	53	3	5.7			
1993	Albemarle/Roanoke	51	1	1.9			
1996	Albemarle/Roanoke	33	1	3.0			
1988	Roanoke River	37	9	24.3			
1989	Roanoke River	27	1	3.7			
1990	Roanoke River	335	33	9.8		1 (3.0)	
1991	Roanoke River	1,657	177	10.7		2 (1.1)	
1992	Roanoke River	2,453	355	14.5	1 (0.3)	2 (0.5)	4 (1.1)
1993	Roanoke River	2,338	283	12.1	1 (0.3)	1 (0.3)	2 (0.7)
1994	Roanoke River	9	3	33.3			
1995	Roanoke River	1,265	132	10.4	2 (1.5)	2 (1.5)	3 (2.3)
1996	Roanoke River	1,378	126	9.1	3 (2.4)	2 (1.6)	2 (1.6)
1997	Roanoke River	2,167	271	12.5	9 (3.3)	5 (1.8)	11 (4.1)
1998	Roanoke River	2,060	242	11.7	17 (7.0)	3 (1.2)	10 (4.1)
1999	Roanoke River	2,177	213	9.8	9 (4.3)	1 (0.4)	6 (2.8)
2000	Roanoke River	1,970	189	9.6	11 (5.9)	1 (0.5)	13 (7.0)
2001	Roanoke River	2,647	278	10.5	10 (3.7)	4 (1.5)	14 (5.2)
2002	Roanoke River	2,032	120	5.9	9 (9.3)	2 (2.1)`	2 (2.1)
2003	Roanoke River	3,146	36	1.1			
	Total	**25,835**	**5,642**				

Table 5.4. Total number of striped bass tagged and released, 28 inches (TL) and larger through DMF Gill Net Survey and returns by area.

Segment/Year	Total Number Tagged	Number Tagged 28 Inches and Larger	Percent of Total – Fish 28 Inches and Larger	Number and Percent of Returns Oregon Inlet Area	Number and Percent of Returns Outside NC Internal Waters
Fall/Winter 1992-1993	267	4	1.5	1 (25%)	
Fall/Winter 1993-1994	166	2	1.2		
Fall/Winter 1994-1995	776	1	0.1		
Spring 1995	553	3	0.5		
Spring 1996	406	1	0.2		1 (100%)
Fall/Winter 1997-1998	695	1	0.1		
Fall/Winter 1999-2000	586	2	0.3		
Spring 2000	627	1	0.1		
Fall/Winter 2000-2001	382	1	0.2		
Spring 2001	648	5	0.7		
Spring 2002	531	2	0.4		
Fall/Winter 2002-2003	427	2	0.4		
Spring 2003	299	6	2.0		

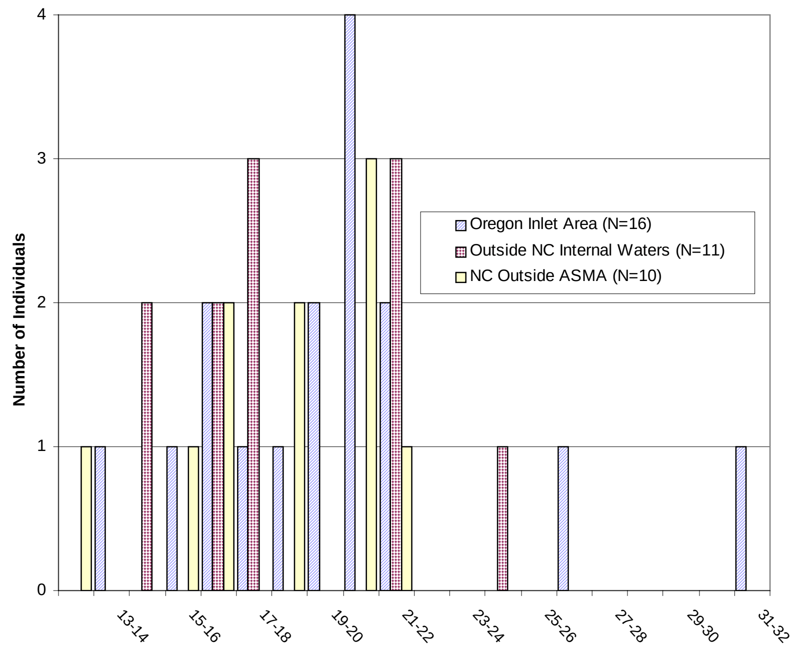


Figure 5.1. Length of tagged striped bass through DMF Independent Gill Net Survey, Fall-Winter segments by return areas outside the ASMA.

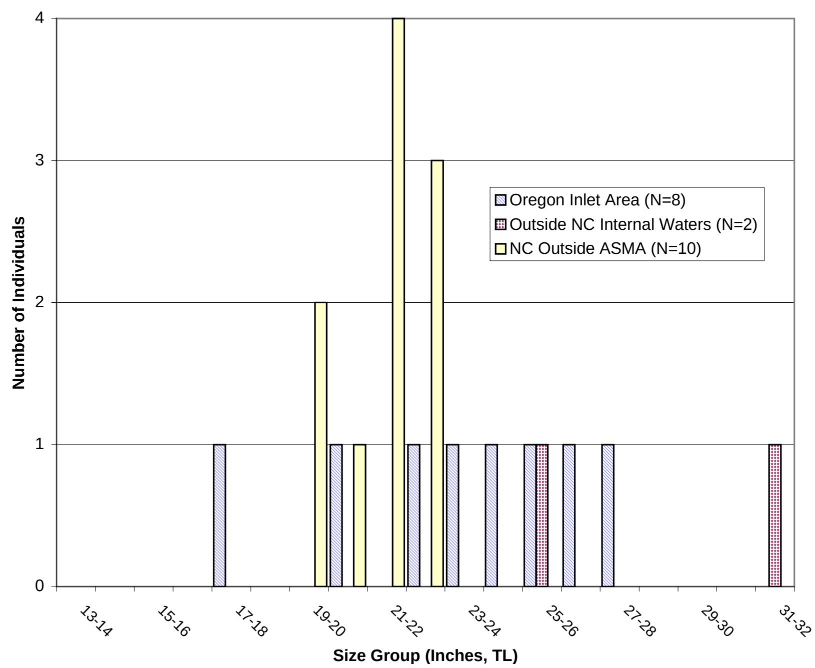


Figure 5.2. Length of tagged striped bass through DMF Independent Gill Net Survey, Spring segments, by return areas outside the ASMA.

Table 5.5. Total number of striped bass tagged and released, 28 inches and larger from the Roanoke River and returns by area. (Male, F-Female)

Year	Total Number Tagged	Number Tagged 28 Inches and Larger	Percent of Total – Fish 28 Inches and Larger	Number of Females	Number of Males	Number and Percent of Returns Inside RRMA	Number and Percent of Returns Oregon Inlet Area	Number and Percent of Returns Outside NC Internal Waters
1996	1,378	4	0.2	4	-		1 (F) (25%)	
1997	2,167	7	0.3	6	1	1 (M) (100%)		
1998	2,060	10	0.4	10	-		2 (F) (20%)	
1999	2,177	22	1.0	17	5		1 (F) (5.9%)	
2000	1,970	14	0.7	11	3	1 (F) (9 %)	2 (F) (18.1%)	1 (M) (33.3%)
2001	2,647	45	1.7	32	13		1 (F) (3.1%)	2 (F) (6.3%) 1 (M) (7.7%)
2002	2,032	72	3.5	48	24		2 (F) (4.2%) 4 (M) (16.7%)	2 (M) (8.3%)
2003	3,146	134	4.2	107	27			

Hewitt and Hightower (2002) tagged and released 729 striped bass from a fishwheel, located near Scotland Neck, NC during the spring 2002. Twenty tags have been returned with no returns from outside the internal waters of the state (**Table** 5.3). These returns continue to show very little contribution of the A/R stock to the migratory population. The returns from fish tagged on the Roanoke River, near Weldon and recaptured outside the internal waters are presented in **Figure** 5.3, by sex. A total of 17 males and 9 females returns have occurred. Males have ranged from 14-29 inches TL, with the 17-18 inch size group accounting for 23.5%. Females have ranged from 15-33 inches TL, with 22-23 inch size group contributing 33.3% of the returns.

Historical adult tag recovery databases (Street et al. 1975; Johnson et al. 1981; Hassler and Taylor 1986) suggested that the A/R striped bass stock was composed principally of a discrete resident population; however these conclusions were based upon tag returns from 3 through 5 year old fish that were not likely to migrate out of the system. Since the mid-1990s however, the age structure of the stock has broadened significantly and 35 (77.8%) of the 45 returns from outside the internal coastal waters of North Carolina have occurred during the period 1996 – 2002. Carmichael (1995)

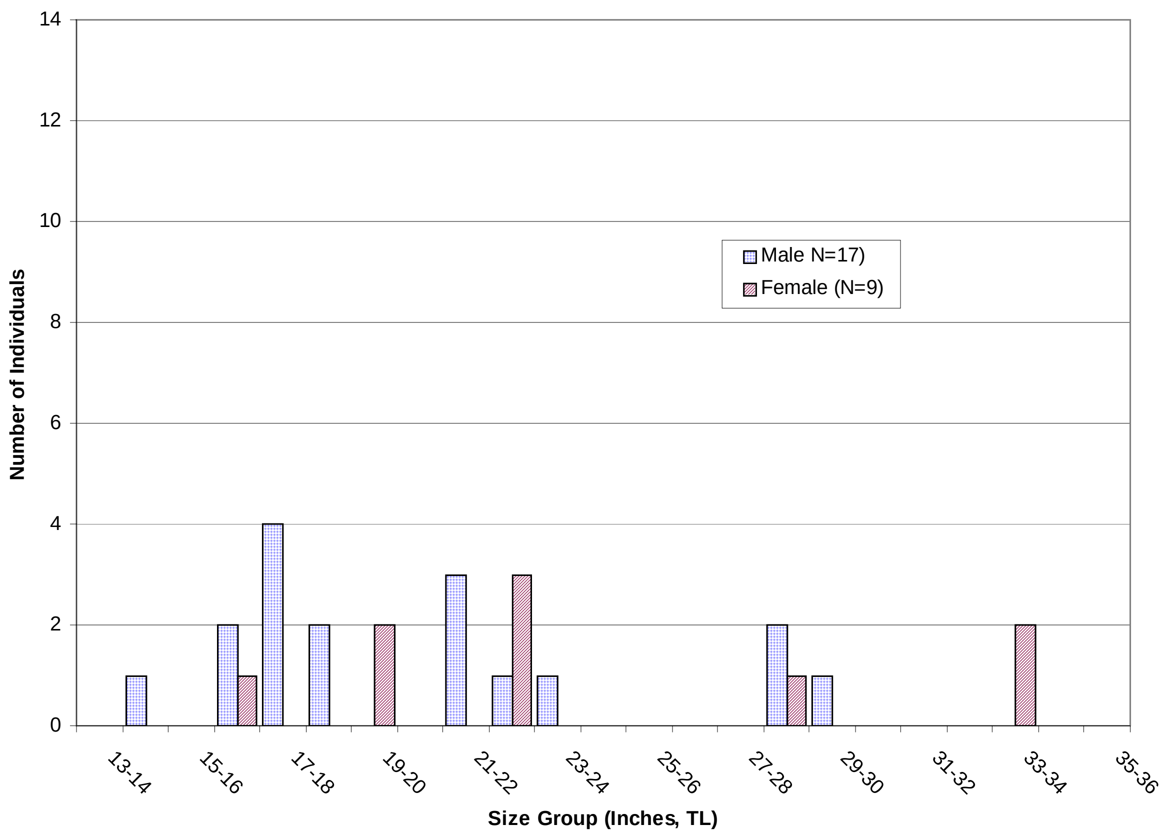


Figure 5.3. Length of tagged striped bass from the Roanoke River spawning grounds by return from outside North Carolina internal waters.

conducted telemetry studies on striped bass in the management area and the results supported the contention of Setzler et al. (1980) that there may be some mixing of the migratory and A/R populations within the Croatan Sound during the winter. Haeseker et al. (1996) through telemetry studies in the Albemarle Sound area during the summer found there was no evidence of migration to the Atlantic Ocean. Even though the number of returns from outside NC has increased over the last several years the data continues to indicate that the A/R stock contributes minimally to the Atlantic migratory stock.

Tag-recapture or tag recovery studies can be used to estimate rates of migration among different geographic regions, provided fish are released from several different regions simultaneously with tags that identify the region of release (Schaefer 1951; Darroch 1961; Dorazio et al. 1994). The number of tagged fish that are recaptured in each geographic region will depend on the frequency of migration to the region from all others and on the intensity of sampling or fishing effort in the area (Dorazio et al. 1994). Low returns from other areas could indicate less fishing in those areas or a low rate of migration. A high rate from internal waters may mean that few fish migrate, or that fish remaining within the sound are at a much higher risk of harvest than fish migrating to the ocean. A difference in tag return rates can also affect perceived migration rates. The size of tagged fish must be considered when examining return rates from different areas. Dorazio et al. (1994) reports relating total length to probability of migration to northern ocean waters, indicated that the probability of migration does not achieve 0.5 until fish are nearly 80 cm (31 inches TL). Considering the current size distribution for the A/R stock much observation of migration to the coastal stock would not be expected.

The recreational fishery around Oregon Inlet has grown significantly since the mid-1990s. One hundred tags have been returned from the Oregon Inlet area since 1996 (**Table** 5.3). Thirty-eight of these returns have occurred during October through December. The time period mid-April through August has accounted for 51 returns from this area. The majority of these returns (n=28) are from fish tagged on the spawning grounds that spring of capture, with a growing number exceeding 28 inches total length when released. The line of demarcation between the Atlantic Ocean and the ASMA is the centerline of the Bonner Bridge and east of the line is open year round. Some anglers during the summer months target striped bass in this area and due to the 28 in TL minimum size limit only large fish are retained.

Figure 5.1 shows the length frequency for the tag returns from the Fall-Winter DMF Gill Net Survey segments and **Figure** 5.2 for the Spring segments. Sixteen returns were from the Fall-Winter surveys, with 93.7% of the returns less than 28 inches TL (**Figure** 5.1). All returns (N=8) from fish tagged during the Spring segment were less than 28 in TL.

The Oregon Inlet area returns for striped bass tagged in the Roanoke River are shown in **Figure** 5.4, by sex. A total of 48 males have been recaptured ranging from 13-31 in TL. Ninety four percent of the males were less than 28 in TL and 6% were 28 in TL or

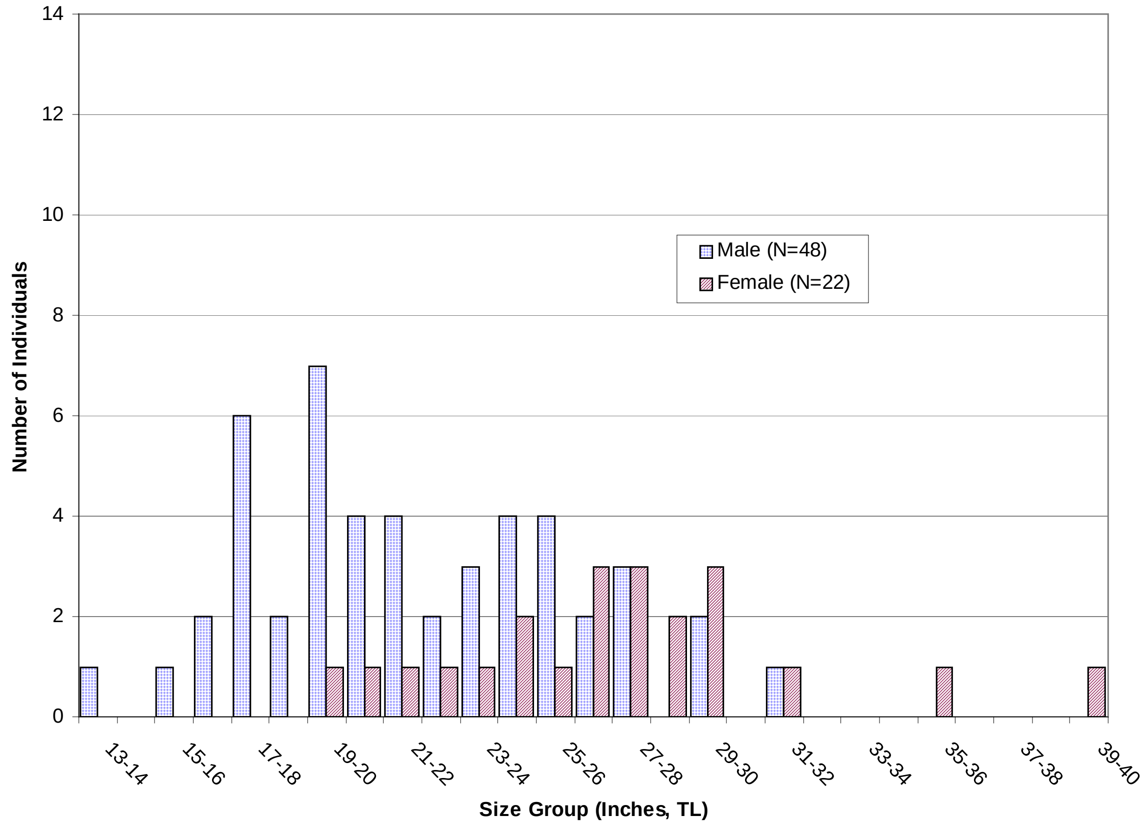


Figure 5.4. Length of tagged striped bass from the Roanoke River spawning grounds by return from the Oregon Inlet area.

ranging from 19-40 in TL. Of these returns, 63.6% of the females were less than 28 in TL and 36.4% were 28 in TL and larger.

There has been an increase over time of fish tagged in the ASMA and RRMA and the number of returns from waters that flow into the Chowan River and southern systems in NC

Three returns have occurred from the Blackwater and Nottoway rivers, VA from fish tagged during the Fall-Winter segments of the DMF Gill Net Survey in Albemarle Sound. Nine tag returns from the Nottoway and Meherrin rivers, VA have occurred from fish that were tagged on the spawning grounds in Roanoke River one to four years previously. All of these returns have occurred in the spring. The striped bass spawning areas have not been determined in these systems by Virginia but based on early sampling by Street et al. (1975) spawning does occur in these systems.

The number of returns (n=73) from the areas to the south (Pamlico Sound, Pamlico River, Pungo River, Tar River, Neuse River) of the ASMA have significantly increased during the period 1996-2002.

Though fish tagged in the ASMA and returned from these southern areas has increased somewhat, contributing 2.1% of the returns, the significance is the number of returns (n=54) from these areas of fish tagged on the spawning grounds in Roanoke River (**Table** 5.3). Hewitt and Hightower (2002) have had one return from the Pungo River; the fish was tagged and released on the spawning grounds in Roanoke River. The majority of these returns (n=36) have occurred within the last four years and during June through December. Record increases in juvenile production since the early 1990s coupled with a significantly expanding age structure have resulted in an expansion in range of the A/R origin striped bass.

Twenty tag returns have occurred from NC outside the ASMA from striped bass tagged through the DMF Gill Net Survey, Fall-Winter segments (N=10) and Spring segments (N=10), (**Figure**s 5.1 and **Figure** 5.2). Striped bass from the Fall-Winter segments ranged from 12-22 in TL and 19-23 in TL from the Spring segments.

A total of 49 males have been returned from internal waters outside the ASMA from fish tagged and released in the Roanoke River, near Weldon (**Figure** 5.5). Males ranged in length from 15-23 in TL and the 19-20 in size group accounted for 24.5%. Fifteen females were returned from outside the ASMA. The 23-24 in TL and 24-25 in TL size groups accounted for 53.5% of the female returns (**Figure** 5.5).

5.4.2 Phase II Striped Bass- Albemarle Area

The DMF in cooperation with the USFWS began a Phase II (5-8 inches TL) striped bass stocking program in the Albemarle Sound area in 1981. Annual stockings occurred through 1996 with a portion or all of the fish tagged prior to release. A total of 53,555 tagged Phase II fish was released and 4,711 tags (8.8%) returned. Over the sixteen year period a total of 17 returns was from the ocean off NC or waters to the north (**Table** 5.6). These percentages ranged from 0.3 – 3.2%. Fourteen of the 17 returns occurred within one year from release. These returns indicate very little contribution. However, these fish were considerably smaller (14 – 16 inches TL) than expected to be migratory.

Tags from Phase II fish were also returned from internal waters south of the ASMA. A total of 31 returns have occurred (**Table** 5.6). The percentage of returns from these areas has ranged from 0.6 – 50%. The Pungo River area has accounted for 90.3% of these returns. No tags from these stockings have been returned since 1997 from these areas.

5.4.3 Central/ Southern Area

5.4.3.1 Division of Marine Fisheries- Adults

Tagging studies conducted by Marshall (1977) and Hawkins (1980) indicate that Neuse River and Tar-Pamlico striped bass are riverine and endemic. These data also suggested that fish spend the winter in the Pamlico River between Washington and the mouth of the Pungo River and move up the Tar River during the spring spawning run (Pate 1975; Marshall 1976; Winslow et al. 1983). It should be noted that these fish were of a young age when tagged and recaptured. Historically, both the New and White Oak rivers were shown to support runs of striped bass (Baker 1968). Sholar (1975)

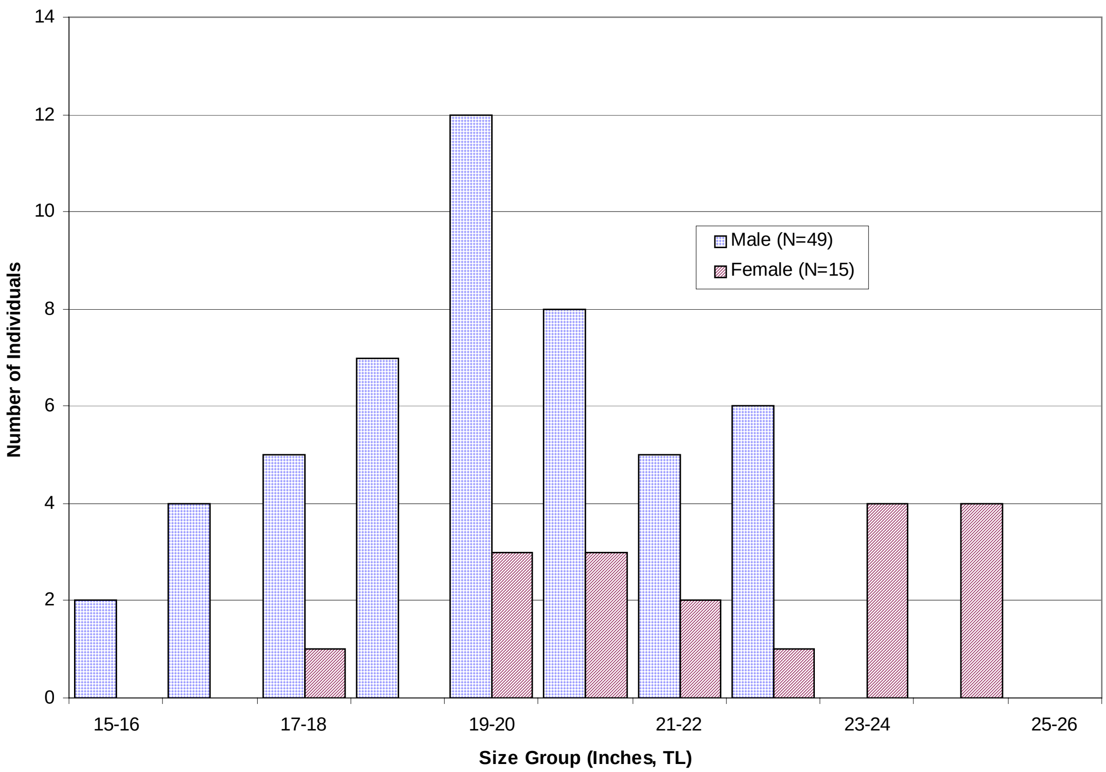


Figure 5.5. Length of tagged striped bass from the Roanoke River spawning grounds by return from North Carolina internal waters outside the ASMA/RRMA.

reported no striped bass found in the New River and only three in the White Oak River. Fischer (1980) and Winslow et al. (1983) reported that striped bass were abundant in the Cape Fear River below Wilmington, January through May. Tagging studies as reported by Winslow et al. (1983) suggest that this stock is riverine endemic with exchange between the Cape Fear and the Northeast Cape Fear rivers.

Since 1980, very little tagging effort has occurred on adult striped bass in the CSMA. The DMF since 1999, through various gill net surveys and minimal hook and line effort has tagged and released striped bass in the Pamlico (n=66) and Neuse (n=25) systems (**Table** 5.7). The percentage of returns from the Pamlico tagging has ranged from 7.1 – 10.5%, but only five tags have been returned. One of the returns (Apr 2002) was from the spawning grounds on the Roanoke River at Scotland Neck. The percentage of tag returns from fish tagged in the Neuse River has ranged from 25 – 33.3% (**Table** 5.7). All of these returns (n=8) were from the Neuse and Trent rivers.

Table 5.6. Phase II striped bass tag returns from outside the release areas in North Carolina and outside North Carolina internal waters.

System	Release date	Number tagged	Number recaptured	Total percent return	Recapture locations inside NC	Percent returns other NC systems	Recapture locations outside NC	Percent returns outside NC
Albemarle Sound area	Jan 26, 1981	10,000	1,817	18.2	22- Pungo R. 1- Long Shoal R. 1- Topsail Sound	1.3	9- Chesapeake Bay	0.5
	Jan 25, 1983	2,500	719	28.8	4- Pungo R.	0.6	2- Atlantic Ocean off Cape Lookout	0.3
	Dec 16, 1983	2,493	277	11.1			1- York River, VA 1- Indian River, DE	0.7
	Dec 10, 1984	6,445	575	8.9				
	Jan 10, 1986	1,110	38	3.4				
	Dec 9, 1986	4,999	453	9.1				
	Dec 9, 1987	2,500	214	8.6				
	Dec 9, 1988	5,000	94	1.9				
	Dec 7, 1989	1,400	22	1.6				
	Dec 19, 1990	2,000	62	3.1			1- Mystic River, MA 1- Newport River, RI	3.2
	Dec 11, 1991	2,994	320	10.7			1- Deep Creek, VA 1- Damariscotta River, ME	0.6
	Dec 15, 1992	2,465	84	3.4				
	Dec 9, 1993	2,180	20	0.9				
	Dec 8, 1994	2,481	2	0.08				
	Jan 10, 1996	2,498	12	0.4	2- Pungo Creek	16.7		
	Dec 12, 1996	2,490	2	0.08	1- Neuse River	50.0		
	Total	**53,555**	**4,711**					
Tar-Pamlico River	Jan 28, 1983	2,500	500	20.0	7- Alligator River 12- Albemarle S. 1- Chowan River 13- Neuse River 2- Off Cedar Is. 1- Trent River	7.2		
	Dec 20, 1984	1,000	28	2.8				
	Dec 11, 1987	2,500	39	1.6				
	Dec 12, 1991	1,993	78	3.9				
	Dec 8, 1993	2,204	39	1.8	1- Currituck Sound 1- Neuse River	5.1		
	Dec 9, 1994	2,320	27	1.2	1- Roanoke River 2- Croatan Sound	11.1		
	Jan 10, 1996	2,497	51	2.0	1- Neuse River	1.9	1- Cape Cod Canal, MA 1- Providencetown, MA	3.9
	Dec 11, 1997	4,865	104	2.1				

Table 5.6 (Continued)

System	Release date	Number tagged	Number recaptured	Total percent return	Recapture locations inside NC	Percent returns other NC systems	Recapture locations outside NC	Percent returns outside NC
	Dec 8, 1999	2,750	117	4.2	3- Neuse River 1- Trent River 1- Roanoke River	4.6		
	Dec 14, 2001	3,000	6	0.2				
	Total	**25,629**	**989**					
Neuse River	Feb 3, 1982	2,100	230	11.0	1- Pungo River 1- Trent River 1- Albemarle S.	1.3	1- Conowingo Dam, MD 1- Hudson River, NY	0.9
	Jan 13, 1986	2,119	60	2.8				
	Dec 8, 1988	2,500	22	0.9				
	Dec 11, 1990	2,992	84	2.8				
Neuse River	Dec 14, 1992	2,527	137	5.4				
	Dec 9, 1994	2,212	7	0.3	1- Albemarle S.	14.3		
	Dec 13, 1996	4,998	116	2.3	1- Pamlico River	0.9		
	Dec 11, 1998	2,500	70	2.8	1- Tar River 2- Croatan Sound 6- Roanoke River	13.0		
	Dec 6, 2000	2,900	26	0.8				
	Dec 6, 2002	2,960	0					
	Total	**24,848**	**752**					
Cape Fear River	Jan 24, 1980	2,900	17	0.6				
	Jan 17, 1984	1,395	6	0.4				
	Dec 8, 1989	1,300	23	1.8				
	Total	**5,595**	**46**					

Table 5.7. Number of adult striped bass tagged and released in the Pamlico Sound, Pamlico and Neuse river areas.

			Returns				
Year	Tagging location	Number tagged	2000	2001	2002	Number returned	Percent returned
1999	Pamlico, Pungo, Long Shoal river areas- Gill net survey	2				0	
2000	Pamlico, Pungo, Long Shoal river areas- Gill net survey	19	1	1		2	10.5
2001	Pamlico, Pungo, Long Shoal river areas- Gill net survey	28		1	1*	2	7.1
2002	Pamlico, Pungo, Long Shoal river areas- Gill net survey	13			1	1	7.7
2001	Pamlico and Pungo rivers- Hook and line	4				0	
1999	Neuse River area	12	1	2		3	25.0
2000	Neuse River area	13	1	1		1	33.3
	Total	91	3	4	1	8	8.8

* Recaptured in Roanoke River at Scotland Neck (Apr 25, 2002)

5.4.3.2 Wildlife Resources Commission- Adult Striped Bass

During the spring 2002, the WRC began tagging and releasing adult striped bass on the spawning grounds in Tar and Neuse rivers. A total of 298 striped bass was tagged and released in the Tar River. Ten tags have been returned, all from the Tar-Pamlico system (**Table** 5.8). Seventy-nine striped bass were tagged in the Neuse River and released and six tags have been returned from the New Bern area (**Table** 5.8).

Table 5.8. Number of adult striped tagged by the NCWRC on the spawning grounds, Tar River and Neuse River, spring 2002 and 2003. All returns from within system of release.

System	Number tagged	Number returned	Percent returns
Tar River- 2002	298	10	3.3
Neuse River- 2002	79	6	7.6
Tar River- 2003	211		
Neuse River- 2003	352		

5.4.4 CSMA Phase II Striped Bass

5.4.4.1 Pamlico River

The Pamlico River has been stocked with Phase II striped bass on a biannual rotating basis since 1983. A total of 25,629 tagged fish has been released and 989 tags (3.9%) returned (**Table** 5.6). The return rates have ranged from 0.1 – 20%. Only two tags have been returned from outside NC waters; both were released in January 1996. One return was from Cape Cod Canal, MA in June 1998 and the other from Providencetown, MA in June 2001.

The percentage of returns from the ASMA/RRMA and the Neuse River drainage has ranged from 1.9 – 11.1% (**Table** 5.6), showing exchange between the internal waters of the state. The largest number of returns from these areas was from fish stocked in 1983 and recaptured within one year of release (**Table** 5.6). The returns from areas outside the Pamlico system, from fish stocked since 1993, have been at large two to seven years. A tagged fish released in Pamlico River in 1996 was recaptured in Neuse River at Raleigh, in May 1998 an area where spawning occurred historically. In May 2001, a tagged fish released in December 1999 was recaptured in the Roanoke River on the spawning grounds at Weldon.

5.4.4.2 Neuse River

The Neuse River has also been stocked on a rotating basis since 1982. Tagged fish released in the system have totaled 24,848. Three percent (n=752) of these tags have been returned (**Table** 5.6). A tagged fish was recaptured at Conowingo Dam, MD and one in Hudson River, NY in July 1983. Both of these fish were released on February 3, 1982. These are the only returns from outside the state for the Neuse River stockings.

The number of returns (n=14) from other internal waters of NC have been north of the Neuse River and ranged from 0.9 – 14.3%. Six of the fourteen returns occurred from the Roanoke River during the spring 2002 and the ASMA accounted for two of the returns. All of these fish were four years old. Similar to the Pamlico River stockings, from 1986 through 1996 essentially all of the returns were from the system where the stockings occurred.

The tag returns from the Phase II stocking program in the Pamlico and Neuse rivers indicate there is insignificant exchange with the Atlantic Migratory Stock. The return data show there is exchange between the ASMA/RRMA and the CSMA and in recent years the rate of exchange has increased.

5.4.4.3 Cape Fear River

Phase II stockings only occurred in three years (1980, 1984, and 1989) in the Cape Fear River. A total of 5,595 tagged striped bass was released and 46 tags (0.8%) returned. Return rates ranged from 0.4 – 1.8%, with all returns from the system within a year of release. Stocking of this system was discontinued in 1989, due to the lack of a positive impact on the striped bass population and the high abundance of hybrids in the system.

6.0 STATUS OF THE STOCK

6.1 Albemarle-Roanoke Stock (ASMA)

6.1.1 Historical Condition

Dr. W. W. Hassler of NCSU conducted extensive research on striped bass fisheries and the striped bass stock of the Albemarle-Roanoke system from 1956 to 1983 (Hassler et al. 1981, Hassler 1984; Hassler and Taylor, 1984). Over most of those years Hassler estimated spawning population abundance through mark-recapture and regression of catch and effort, conducted juvenile abundance surveys, estimated exploitation, and estimated egg production. Landings and effort for the primary commercial and recreational fisheries for striped bass in the Roanoke River and Albemarle Sound are also tabulated, however, that information is addressed in the description of the fisheries. Except where noted, information used to develop the following assessment of historic stock condition is all excerpted from Hassler's final report (Hassler et al. 1981), and two additional reports covering the later years (Hassler 1984, Hassler and Taylor, 1984).

Hassler estimated the size of the spawning stock by estimating the size of the population in the Roanoke River during the spring spawning run. Two methods were used: 1) a Petersen mark-recapture method, based on annual estimates of exploitation from tag recoveries and total Roanoke River catch, for 1956-1981; and 2) Ricker's (Ricker 1940) regression of catch per unit effort for the commercial fishery, from 1956 - 1977. Hassler and Taylor (1984) noted a considerable decline in tag returns in 1981 following the imposition of considerable regulatory constraints. To avoid introducing a bias from the regulatory changes, they slightly modified the Petersen method and estimated spawning population abundance from annual Roanoke River harvest and average Roanoke River exploitation (tag derived), and provided updated estimates for the entire time series (1956-1983). All three estimates give similar pictures of spawner abundance over time (**Figure** 6.1). From 1956 – 1979 spawner abundance was variable, averaging around 300,000 fish and never falling below 100,000 fish. Estimated spawner abundance dropped nearly 70% between 1979 and 1980, and then declined even further in 1981 to only 12% of the 25 year average. Spawner abundance remained low in 1982 and 1983, although values for those years may be biased slightly low if regulatory changes imposed in 1981 reduced both harvest and exploitation.

Hassler developed an index of juvenile abundance based on trawl sampling in Albemarle Sound. These data provide a long time series based on consistent methodology from which trends can be evaluated. Juvenile abundance varied considerably during the 1960's and 1970's, averaging 6.5 and ranging from 0.2 in 1958 to nearly 24 in 1959. Between 1955 and 1977 only one observation fell below 2, while JAI values in 5 of the 6 years from 1978 – 1983 fell below 2 (**Figure** 6.2). Total mortality was estimated from tag recoveries over successive years, from 1956 to 1974. This estimate

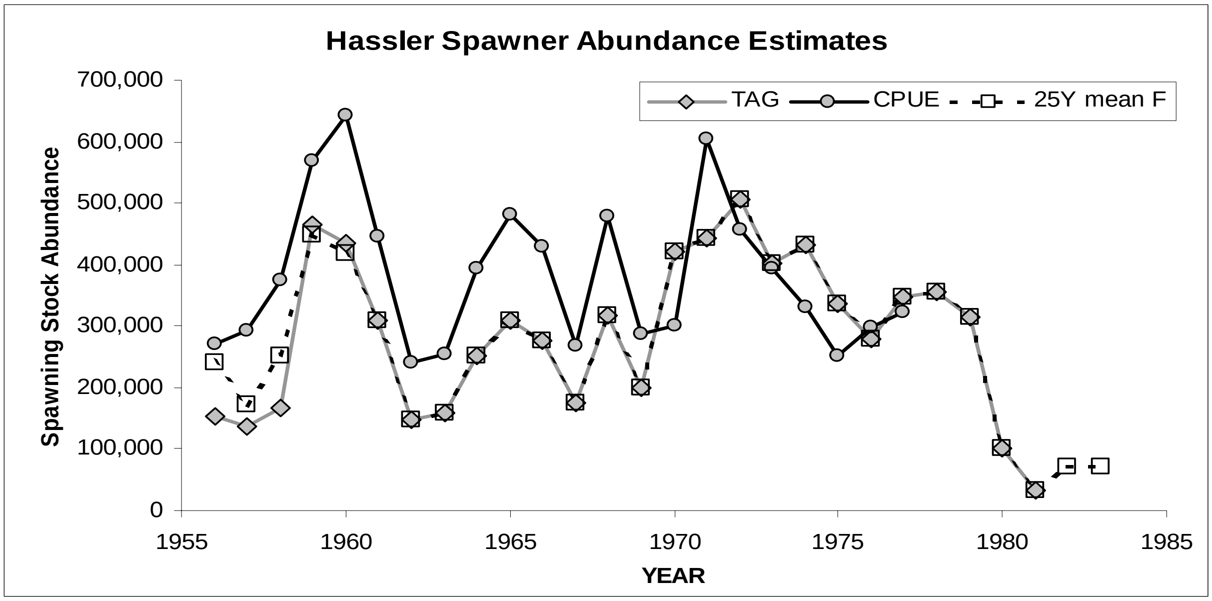


Figure 6.1. Roanoke River striped bass spawning stock abundance in numbers of fish, estimated from CPUE and mark-recapture methods.

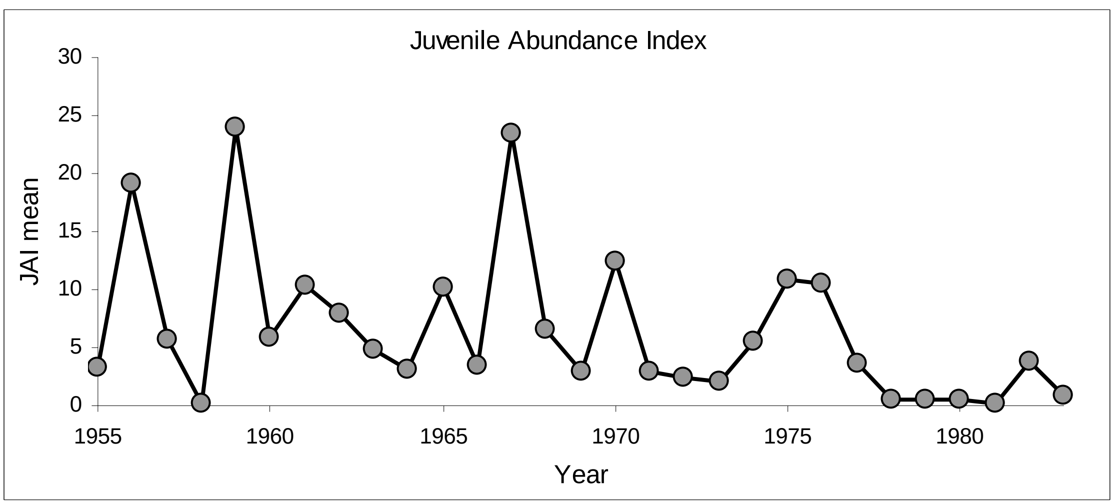


Figure 6.2. Juvenile abundance index values, 1955 – 1983.

would include both fishing and natural mortality, although the current estimate of natural mortality, M=0.15, is but a small fraction of the estimated total mortality over the period. Total mortality averaged around 1 from 1956 – 1964, then increased to over 2.5 by 1968 before declining to around 1.5 in the mid 1970's (**Figure** 6.3). These values are not adjusted for tag loss or tag induced mortality, and may therefore be biased high.

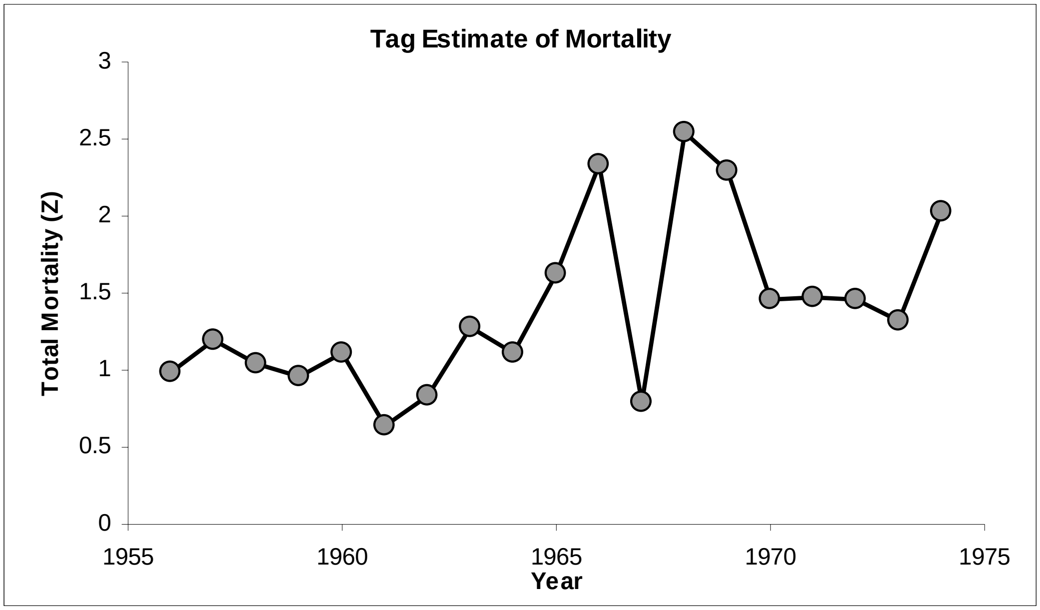


Figure 6.3. Total mortality estimated from multi-year tag return data, 1956-1974.

Relative exploitation was estimated annually from 1956-1983, based on the percentage annual releases returned in the same year. This method provides a relative measure of exploitation subsequent to the release events, but no information on exploitation prior to the release. Several other conditions can affect the validity of both the absolute values each year and the time series trend. First, the reporting rate (proportion of tags recovered that are actually reported) must be constant. Hassler notes that the apparent reporting rate dropped considerably following regulatory changes in 1981, and changed the estimation procedure for spawner abundance accordingly. Tag programs are also vulnerable to a decline in reporting rate over time, as anglers become saturated with the rewards and the novelty of capturing a tagged fish wanes. Second, tags must be retained for the annual values to be valid, and the retention rate must not change over time for the time series to be valid. Fish were tagged with three separate tags over the study: 1956-1964, streamer tag; 1965-1969, spaghetti tag; 1970-1980 Floy T-bar anchor tag. Hassler attributed the decline in the proportion of tags recovered after 1970 to tag retention problems stemming from inadequately anchoring the T-bar tags. Finally, tagged and untagged fish must be equally vulnerable to harvest. Most fish were tagged in the lower Roanoke River, and many were recaptured soon after and downstream of release. Striped bass have a tendency to 'fall back', or return downstream toward estuarine areas when handled during migration (Carmichael et al. 1998), and thus the vulnerability of tagged fish to capture by the significant upriver fisheries was likely reduced. Overall, annual estimates of mortality may be a reasonable, relative measure of exploitation from 1956-1969, but they are not a reliable indicator of the magnitude of exploitation and values for 1970-1983 are likely significantly biased.

Annual exploitation estimated multi-year recovery data is considerably less than that estimated for a single-year recovery (**Figure** 6.4). This can be attributed to exploitation

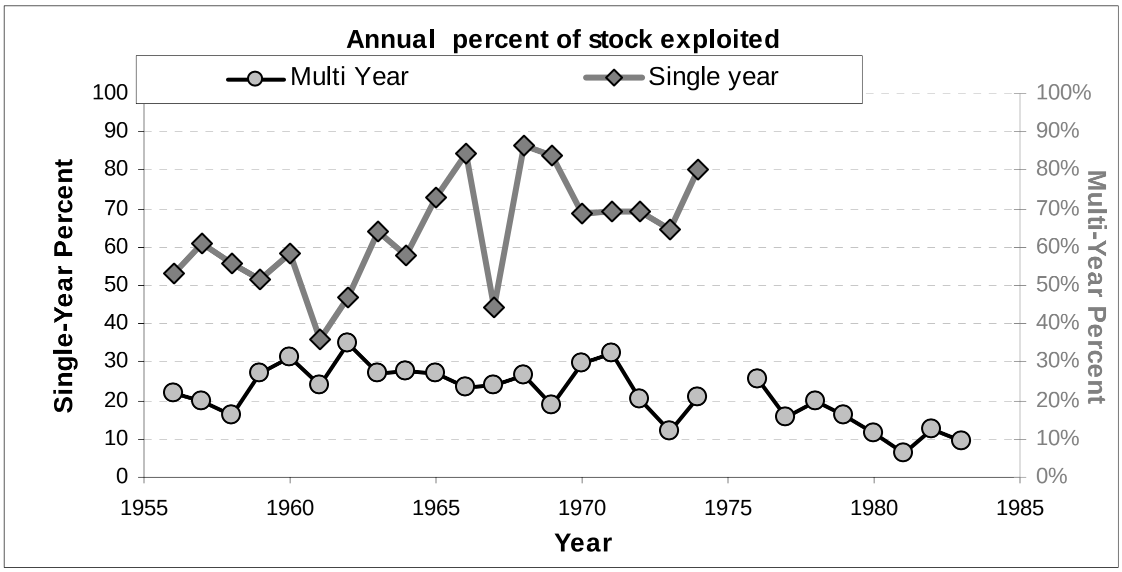


Figure 6.4. Relative annual exploitation estimated from single-year tag return data, 1956-1983.

before the tagging event, non-reporting of tags, unequal vulnerability of tagged fish and untagged fish to significant fishery components, and tag loss. Single-year recovery exploitation is relatively constant during the 1960's, whereas the multi-year recovery estimate increases, which may indicate a general decline in reporting rate over time. Moreover, the single year recovery estimates decline after 1970 when the program adopted the T-bar anchor tags (with known retention problems), while the multi-year recovery estimates remain high. All evidence suggests that the decline in relative exploitation after 1970 is related to survey changes and not reduced exploitation.

Hassler estimated both egg production and egg viability. Production provides a measure of the magnitude of annual spawning, and viability provides a measure of egg survival. The two measures together provide an indication of overall spawning success, with the product of eggs spawned and percent viability a measure of total viable egg production. Egg production increased during the 1960's, to a high of nearly 5 billion in 1972. Production dropped to around 2 million until 1979, then dropped sharply in 1980 and 1981 (**Figure** 6.5). Viability averaged nearly 90% until 1975 when it dropped to below 60%. There was some recovery in 1980 and 1981, but viability did not reach the pre-1975 average and dropped again in 1983. Although egg production did not vary appreciably from the long-term average until 1980, the decline in viability led to an overall decline in viable egg production after the 1972 peak, with viable egg production falling below 1 million by 1976 and remaining low for the next 8 years (**Figure** 6.6).

A number of factors contribute to the decline in Albemarle-Roanoke striped bass in the late 1970's and early 1980's. Exploitation rates were beyond any level now believed to be sustainable throughout the series, and were at their highest levels in the late 1960's and early 1970's when declining egg production and poor juvenile survival began to drive down recruitment success. Any stock experiencing even moderate exploitation and reduced recruitment will begin to decline in abundance and biomass, and a stock that has sustained high exploitation for several generations has less reserve capacity and will typically show signs of decline within a few years. Spawning success generally declines as the average age in the population declines, and spawning magnitude declines as overall mature biomass declines.

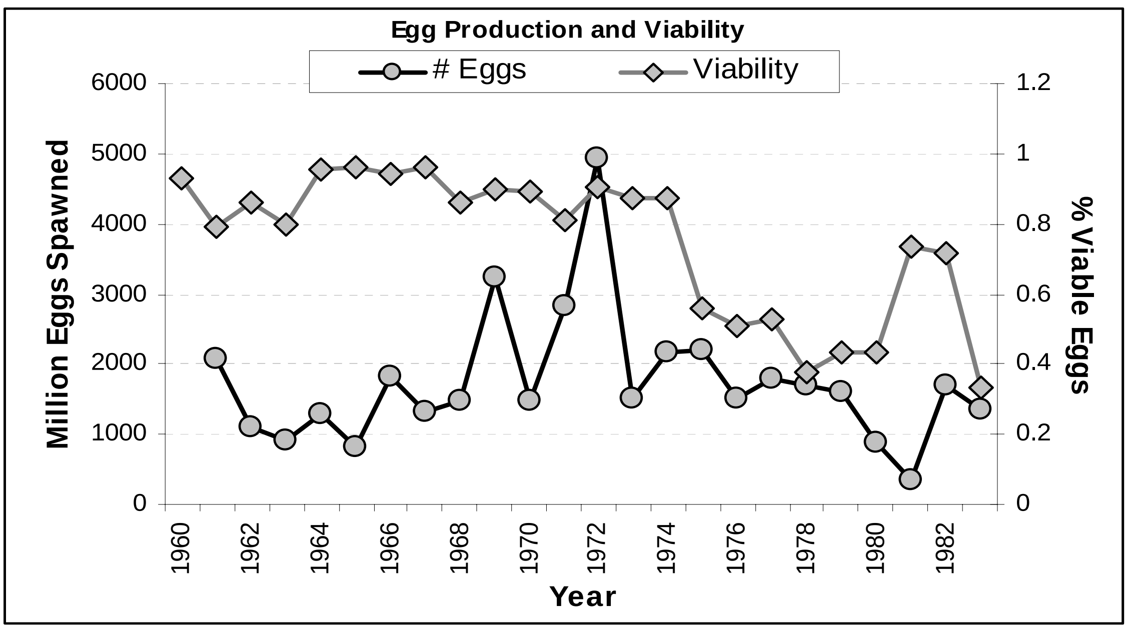


Figure 6.5. Total egg production and percentage viable eggs, 1960-1983.

Successful recruitment requires more than just spawning success and egg production; eggs must also hatch and juveniles must survive. Comparing juvenile abundance and total viable egg production, it is apparent that decreased juvenile survival may have been one of the earliest challenges to the stock (**Figure** 6.7). Egg production was

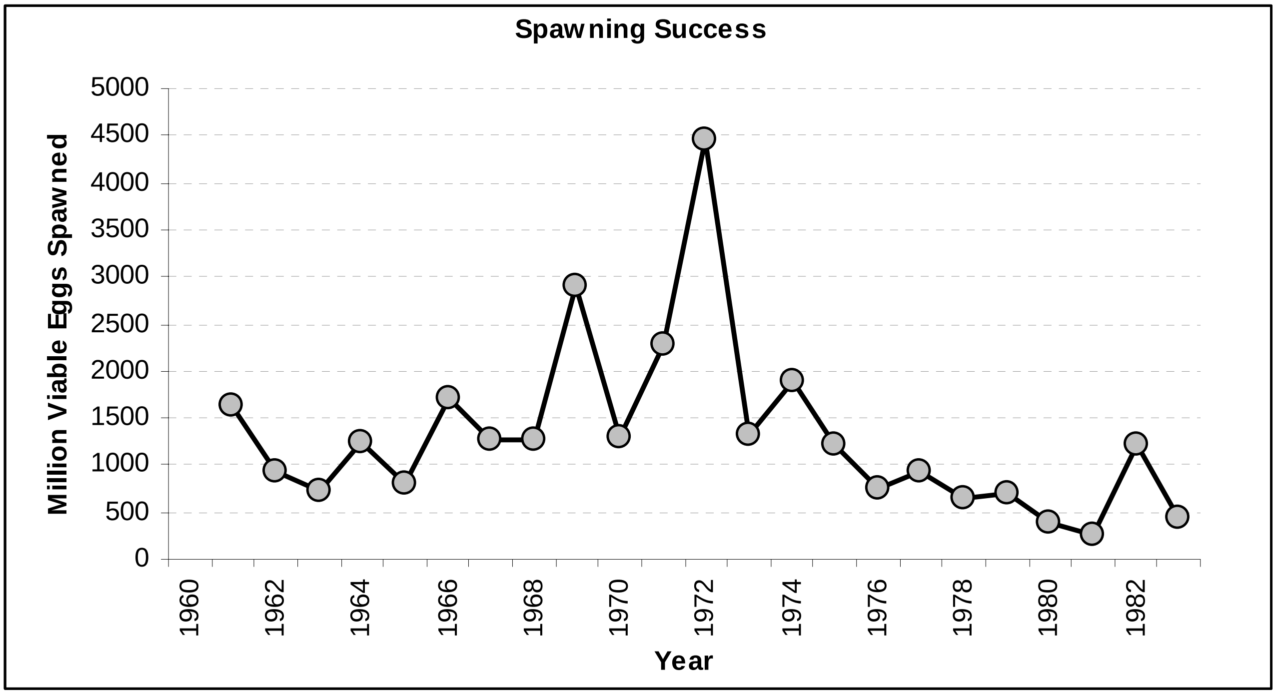


Figure 6.6. Total spawning success, 1961 – 1983.

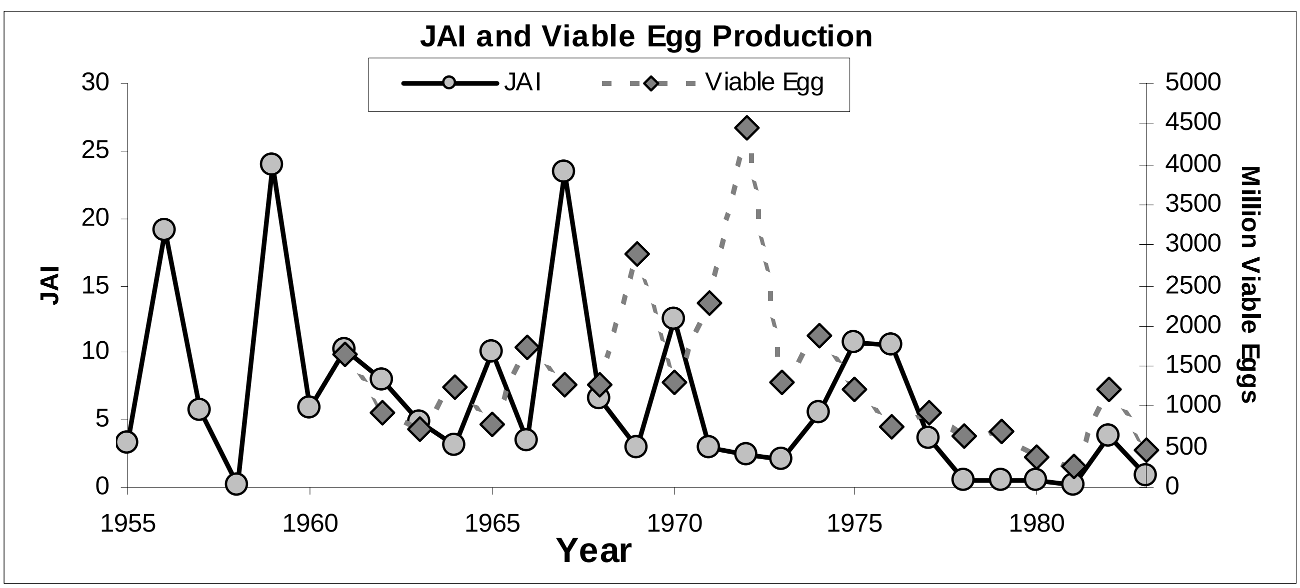


Figure 6.7 Juvenile abundance and total viable egg production, 1955 – 1983.

highest in 1969 and 1972, yet JAI values in those years are among the lower values of the series. From the JAI, the only good year class produced from 1969 to 1973 was in 1970, even though viable egg production over these years was better than average. This suggests that poor larval survival may have been the cause of the initial recruitment failures.

High fishing mortality likely harvested any surplus stock generated by the strong 1970 year class within a few years, and with no other strong cohorts coming into the population, spawning stock abundance declined sharply after 1979. Reduced egg viability combined with declining egg production resulted in a steady decline in viable egg production after the 1972 peak. There is little information available from which to judge the reliability of the estimated decline in egg viability; the trend may be real or it may be an artifact of sampling. The FWS Striped Bass Study Report to Congress (May 1992) suggests that the population age structure was truncated by the 1950s. Given that mortality estimates are high during the 1960s and 1970s, the age structure may have become severely truncated by the 1970s, with the spawning stock possibly composed of primarily first time spawners. First-time spawners are commonly considered to produce fewer eggs and to have a lower proportion of viable eggs than experienced spawners. Some combination of truncated age structure, the possibility for a majority of the spawners being inexperienced, and environmental degradation or variation is likely to blame for the decline in viable egg production reported by Hassler et al. (1980) in the mid-1970s. The moderate 1975 and 1976 year classes indicated by the JAI apparently sustained the fishery and the spawning stock biomass through 1979, but were largely 'fished out' by 1980, therefore spawner abundance dropped markedly. Support for this scenario is provided by DMF sampling of the age composition of the Albemarle Sound commercial fishery, which shows that in 1980 and 1981 nearly 80% of the harvest was composed of age 1 and 2 fish from the 1978-1980 cohorts.

Although additional management measures were imposed in 1981, the damage to the stock had already occurred. The few recruits produced by the stock in the early 1980's largely supported the fisheries and provided no improvement in spawner abundance. Commercial fishery harvest shifted from 3 – 5 year old fish in the 1970's to 1 and 2 year old fish in 1980 and 1981, then 2 and 3 year old fish under the increased minimum size after 1981. It is likely that recreational fisheries exhibited a similar shift, although no data are available on the recreational fishery age composition until the 1990's. The stock remained at low abundance and fishery yields remained low for over 10 years until the 1990's.

6.1.2 Comparison of current and historic stock condition

Since fish ascending the river to spawn are presumably mature, and there is no research indicating that mature striped bass do not spawn every year, Hassler's estimates of abundance should be useful as a measure of spawning stock abundance. Hassler used several methods to estimate abundance, and as noted above, the results are consistent for each. The comparison between historic and current spawner abundance is based on Hassler's mark-recapture method (Hassler and Taylor 1984), as this provides the longest time series and some overlap with the VPA estimates. Both

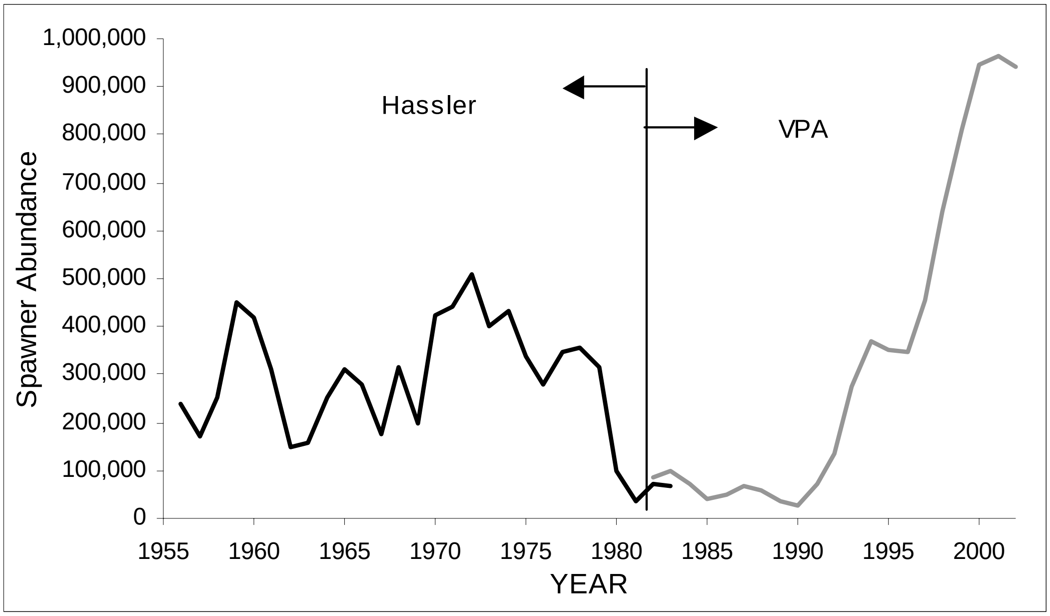


Figure 6.8. Estimated spawning stock abundance in numbers. 1956-1983 represents Hassler's estimates, 1982-2001 represents current VPA estimates.

series show that spawner abundance declined to very low levels in the early 1980's (**Figure** 6.8) Hassler initiated sampling of juvenile striped bass through trawling at fixed stations that are still in use for current juvenile sampling. This provides an unbroken time series of sampling based on consistent methods that can be used to compare relative juvenile abundance over the last 46 years. Recruitment estimated from the VPA and JAI values for 1982-1999 are modeled using a Ricker-type stock recruitment curve to predict recruitment from JAI values for 1956-1981 (**Figure** 6.9). Predicted recruitment values are then combined with VPA estimates for 1982-1999 to plot a time series of recruitment (**Figure** 6.10). Recruitment possibly averaged just under 700,000 fish during the 1960's and 1970's. A string of relatively poor year classes occurred from 1971-1973 and again from 1978-1980. Most of the high estimated recruitment values occurred when the JAI averaged around 10, by the mid 1970's the 5 year moving average drops to around 5, and then in the 1980's it drops even further to around 1 (**Figure** 6.11). Recent JAI values are very variable, with a notable lack of observations around 10 which would allow more robust evaluation of predicted historic recruitment values.

6.1.3 Current Condition

The DMF assesses the status of the Albemarle-Roanoke stock of striped bass annually, using the ADAPT program for solving a tuned Virtual Population Analysis (VPA). The following is a summary of current stock status as reported in Carmichael (2002).

The A/R stock of striped bass is at a high level of abundance and fishing mortality rates are within management targets. The stock is not overfished and overfishing is not occurring.

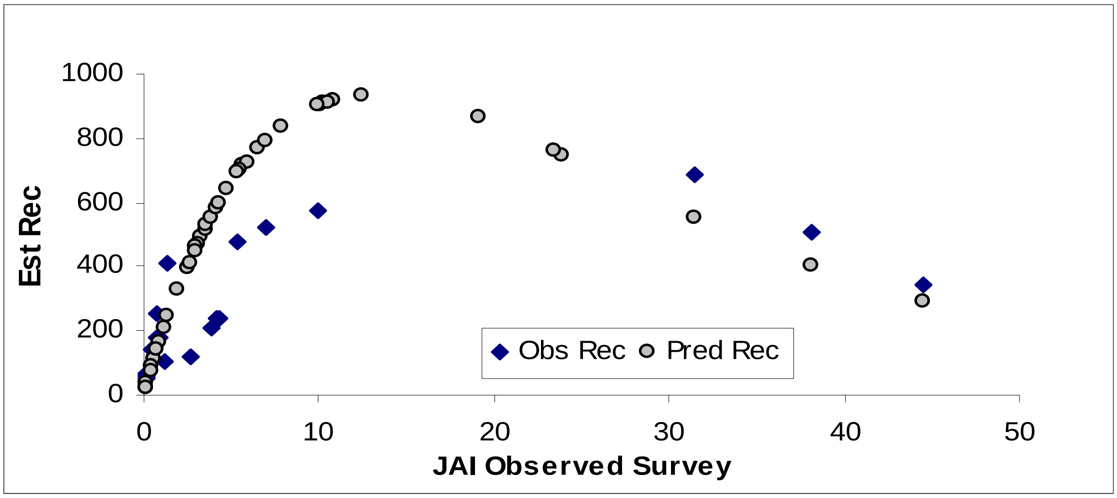


Figure 6.9. Relationship between juvenile survey values and estimated recruitment.

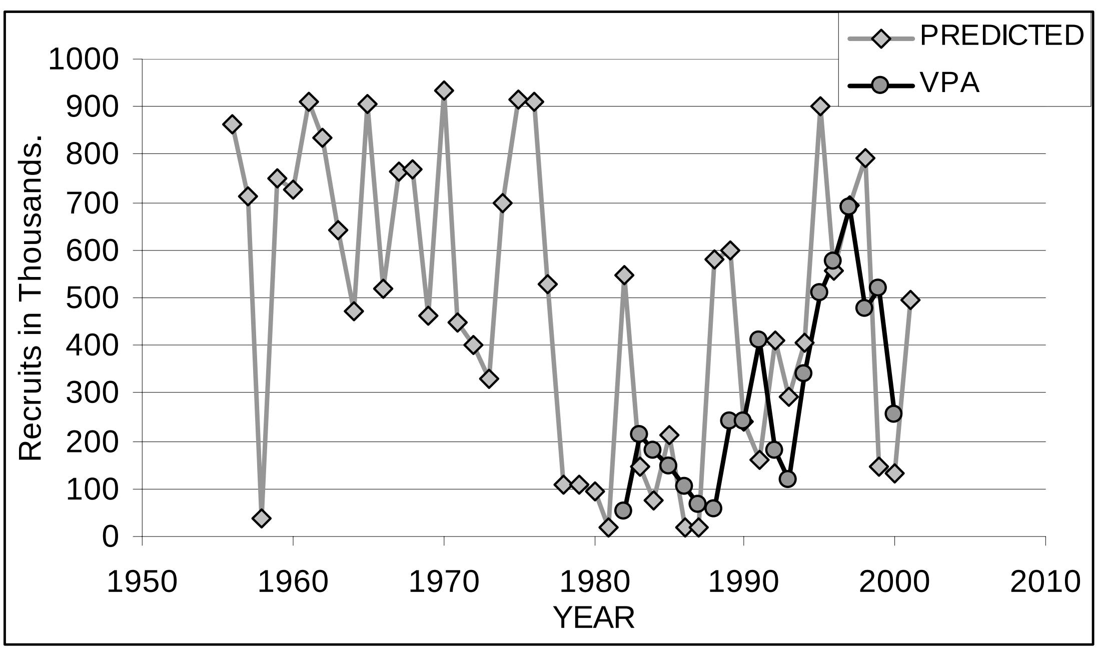


Figure 6.10. Time series of recruitment at age-1, estimated from the JAI and 'observed' values from VPA estimates.

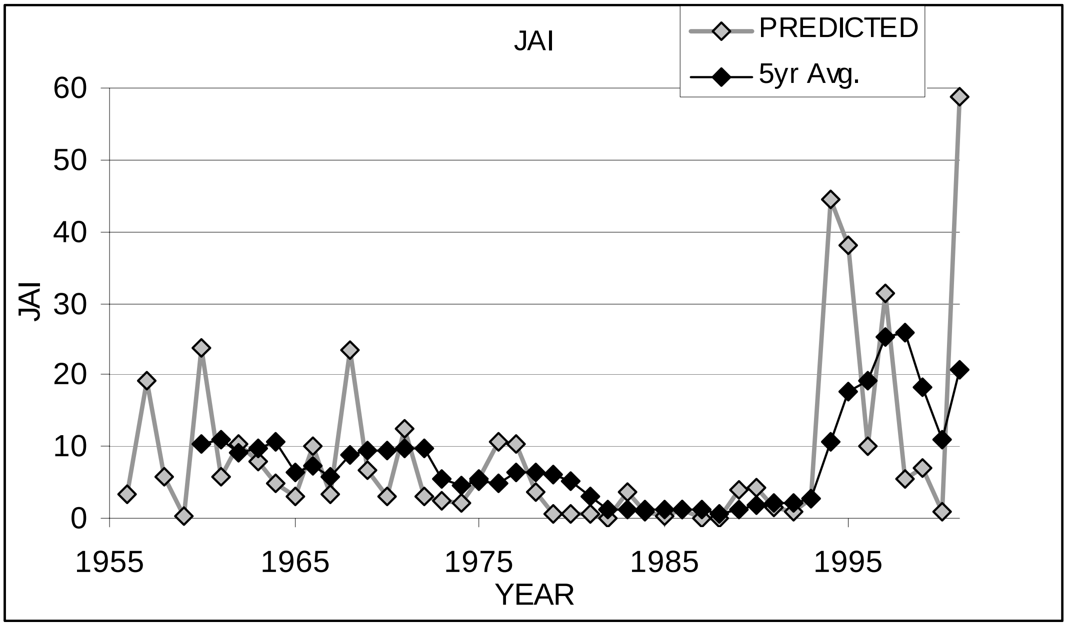


Figure 6.11. Juvenile Abundance Index, Hassler Trawl Stations 1956-2000 and 5 year moving average.

Annual population abundance increased sharply from a low of 195,000 fish in 1988 to over 2 million fish by 1999. Population abundance is currently stabilizing at around 2 million fish, although uncertain abundance estimates for recent cohorts over the last few years of the analysis leads to considerable variation in estimated abundance from year to year. To remove these effects, overall abundance is plotted for age 3 and older fish (**Figure** 6.12), which is stabilizing lower, at around 1.2 million fish. Recruitment at age 1 was below the 1982-2000 average of 284,000 fish from 1982-1983 with the exception of 1991, and has been above average since 1984 for every year except 2000. Although all indications are that the 2001 age 1 abundance will be well above average, the combination of low precision in the current estimate and a significant retrospective bias when young-of-the-year survey values are extremely high results in an estimate for 2001 that is unreasonable. This value will likely decline as more years are added to the series and this cohort recruits to the fishery.

Recruitment at age 1 was below the long term average (1982-2000, mean =282,000) from 1982 until 1993 with the exception of 1991. Recruitment has been above the long term average for 8 of the last 9 years (**Figure** 6.13).

Fishing mortality averaged over the exploited ages (3-7) was generally high from 1982 to 1991 (averaging F=.90), then declined to F=.31 in 1992. Since 1993 fishing mortality has varied between 0.13 and 0.60 and has averaged 0.30. The 2001 estimate of fishing mortality on ages 3-7 of F=0.13 is below the target for these ages (Ftarget = 0.28) (**Figure** 6.14).

Spawning stock biomass (SSB) based on females dropped from 200,000 pounds in 1982 to a low of 35,000 pounds in 1990. SSB then climbed gradually to nearly 600,000

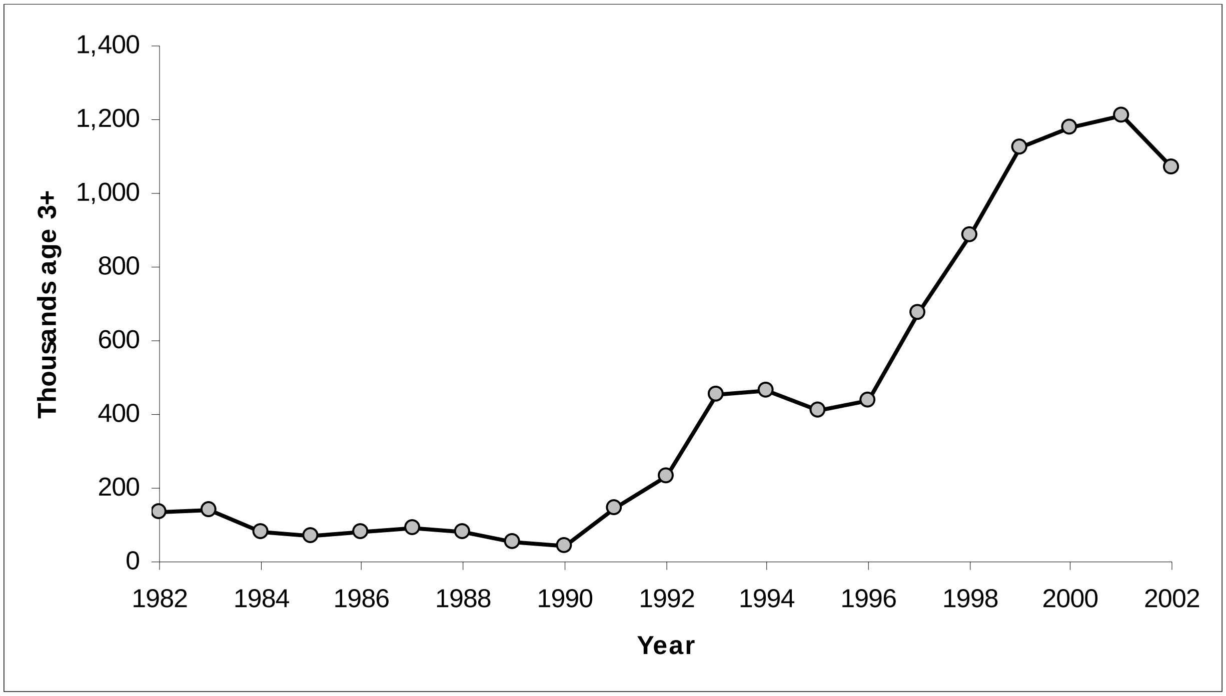


Figure 6.12. Abundance of Albemarle-Roanoke striped bass, age 3 and older.

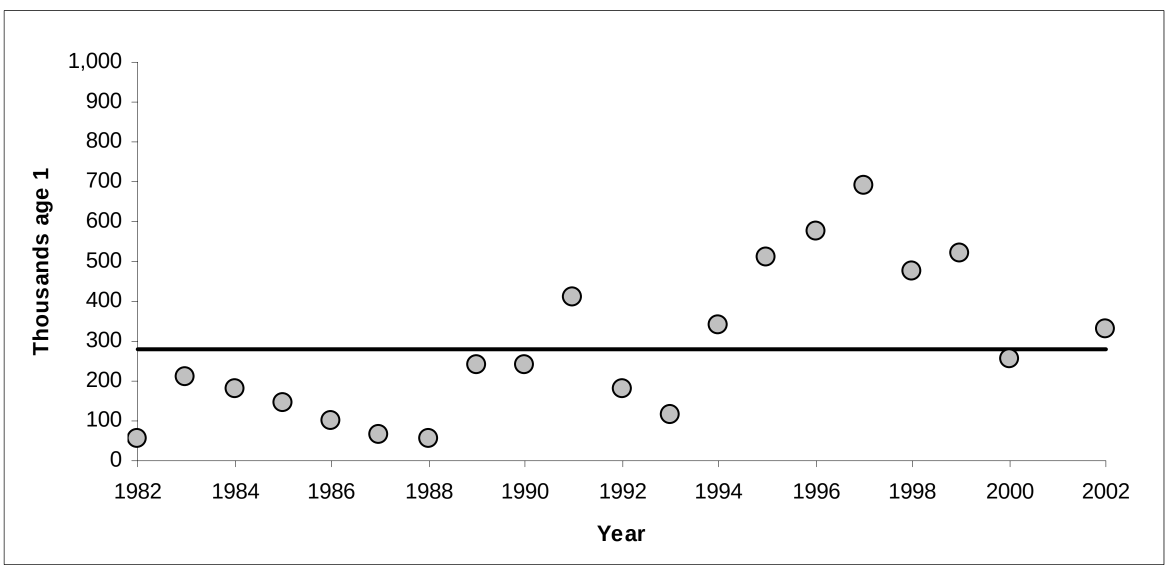


Figure 6.13. Recruitment in thousands of age-1 fish. (line represents mean; 2001 estimate omitted for scaling.

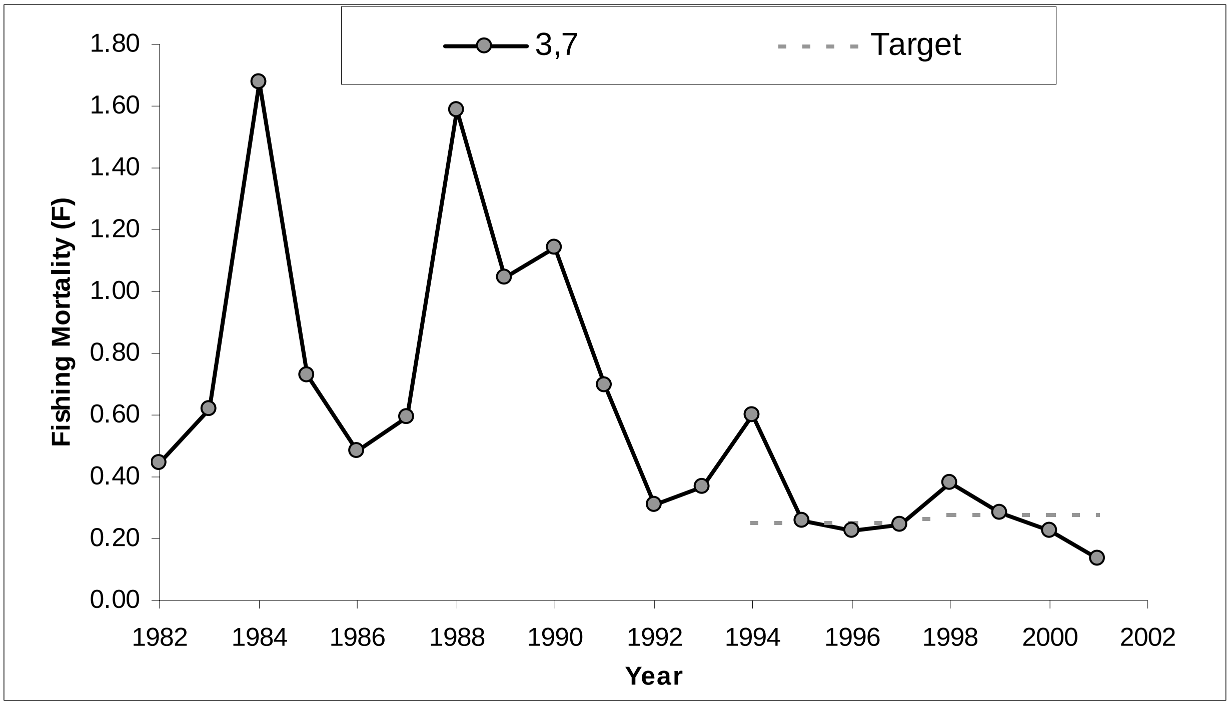


Figure 6.14. Estimated fishing mortality over ages 3-7 and fishing mortality target.

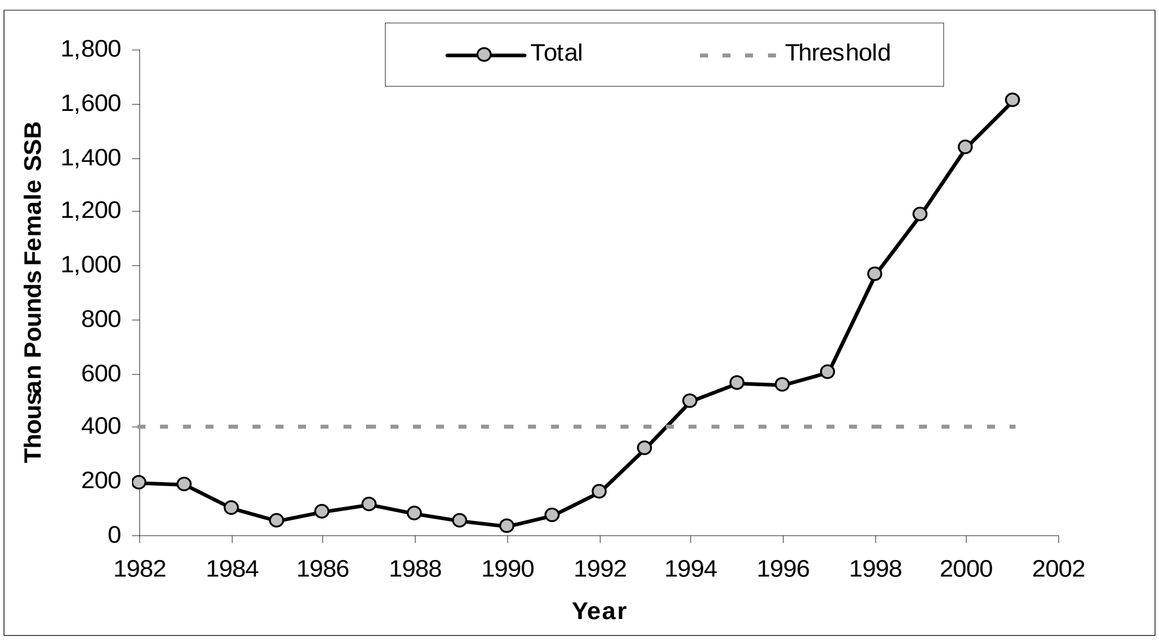


Figure 6.15. Female spawning stock biomass in thousands of pounds and threshold value.

pounds in 1998, and has since increased rapidly, reaching 1.6 million pounds in 2001 (**Figure** 6.15).

Population age structure shows signs of expansion over the last 10 years (**Figure** 6.16). In the early 1990's age 5 and older fish represented less than 1% of the population, although this ratio has increased to 10-20% since 1995. As expected, the recovery of age 8+ fish is somewhat behind that of age 5+. Age 8 and older fish were absent from the population between 1990 and 1994; since 1997 this component has averaged about 5% of the population.

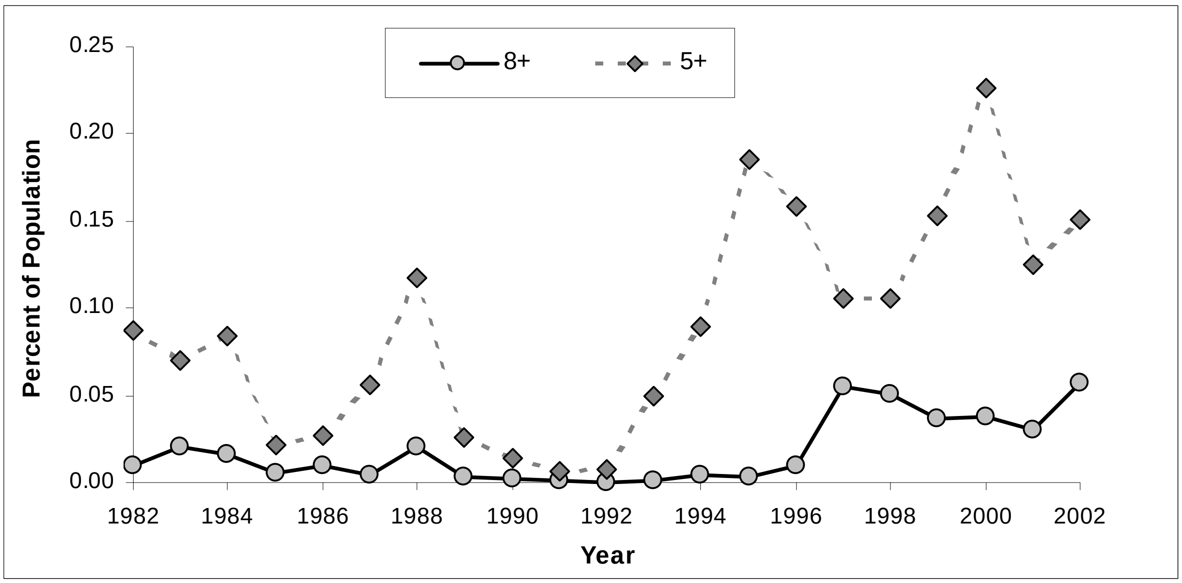


Figure 6.16. Percent composition of age 5+ and 8+ striped bass in the total

6.2 Central/Southern Management Area Stocks

Exploitation was estimated for the Tar and Neuse River stocks from survey catches per unit effort. No estimates of stock abundance are available at this time.

6.2.1 Neuse River Stock

Results of the catch curve analysis suggest that total mortality is excessive for the Neuse River stock of striped bass. Cohort catch curve estimates of total mortality average Z=0.99, resulting in an estimate of average fishing mortality of F=0.84. Annual catch curves indicate only slightly lower mortality levels (Z=0.86, F=0.71). Estimated mortality is significantly higher than the proposed threshold mortality rate (F10%SPR=0.40) based on life history characteristics of striped bass in general and the Roanoke River stock specifically, therefore overfishing is currently occurring. There is no apparent trend in mortality over time, suggesting that current management measures may be adequate to prevent stock collapse. However, current measures are not preventing overfishing and are not expected to provide any stock improvement. As only relative abundance estimates are available, it is not known whether the stock is

overfished. However, the prolonged overfishing indicated by the catch curve analysis and the truncated age structure of the stock suggest the Neuse River striped bass stock is also overfished.
Total mortality must be reduced substantially to stop overfishing of Neuse River striped bass. Current fishing mortality (average from cohort catch curves, F=0.84) is estimated at more than twice the overfishing threshold (F10% SPR = 0.40). Converting from instantaneous to annual exploitation rates, the current removal rate of 53% must be reduced by 42% to reach the threshold. Mortality will have to be reduced even further, by 61%, to reach target levels.

6.2.2 Tar River Stock

Estimates of total mortality for the Tar River striped bass stock indicate that mortality is excessive. Cohort catch curve estimates of total mortality average Z=1.17, resulting in an estimate of fishing mortality of F=1.02. Annual catch curve estimates are slightly higher, with total mortality averaging Z=1.30 and fishing mortality averaging F=1.15. These mortality estimates are significantly higher than the proposed threshold mortality rate (F10% SPR=0.40) based on life history characteristics striped bass in general and the Roanoke River stock specifically, therefore overfishing is currently occurring. As only relative abundance estimates are available, it is not known whether the stock is overfished. However, the prolonged overfishing indicated by the catch curve analysis and the truncated age structure of the stock suggest the Tar River striped bass stock is also overfished. Although the Tar River analysis is based on fewer years of survey data than the Neuse River analysis, the available data fit the catch curve models quite well, based on the strong linear trend in log transformed CPUE that is evident in both cohort and annual catches, consistency in the estimated slope parameters which can be considered evidence of consistent recruitment, and relatively small standard errors in both slope and intercept parameters for most years.

Total mortality must be reduced substantially to stop overfishing of Tar River striped bass. Current fishing mortality (average from cohort catch curves, F= 1.02) is estimated at more than two times the overfishing threshold (F10% = 0.40). Converting from instantaneous to annual exploitation rates, the current removal rate of 60% must be reduced by 49% to reach the threshold. Mortality will have to be reduced even further, by 66%, to reach target levels.

6.2.3. Cape Fear River Stock

No current information is available on the status of the Cape Fear stock at this time.

7.0 STATUS OF THE FISHERIES

7.1 Introduction

In North Carolina coastal sounds and tributary rivers, striped bass are harvested in both commercial and recreational fisheries. Commercial fisheries occur in Coastal and Joint waters and recreational fisheries occur in Coastal, Joint, and Inland waters. Striped bass harvest in the Atlantic Ocean; both commercial and recreational are managed consistent with coastwide specifications in the ASMFC Striped Bass Fishery Management Plan (2003).

7.2 A/R Stock
7.2.1 Commercial Fisheries
7.2.2 Historical
The Albemarle Sound area commercial striped bass fishery has been documented in numerous reports for over 100 years. In 1872, one of the most important striped bass fisheries began to develop through the haul seine fishery in Albemarle Sound. Striped bass were a bonanza to the haul seine fisheries in the Edenton area. Capehart's Avoca haul seine fishery in western Albemarle Sound was considered the best location to capture striped bass. Catches were phenomenal, on May 6, 1876 the first haul of the seine yielded 38,000 pounds and the second haul 13,000 pounds. Many of the fish weighing 80-90 pounds, with one reported at 105 pounds. Virtually all of the fish were iced and shipped to Norfolk, VA and sold to dealers in Washington, DC, Baltimore, MD, Philadelphia, PA and New York, NY (Taylor 1992).

During the early 1880s, a large fishery developed on Roanoke Island catching striped bass in the spring and fall. Gears included haul seines, drag nets, purse seines, fish traps and gill nets. The fish were small, averaging 1 – 2 pounds but the numbers were staggering. In 1886, a typical year, the 215 striped bass fishermen of Roanoke Island caught roughly 380,000 pounds. By the late 1880s, S.G. Worth reported that "The establishment and continuance of the pursuit accounts fully for the decrease or disappearance of the striped bass at the fisheries higher up on the Albemarle Sound" (Taylor 1992).

The huge haul seines, though very efficient, ultimately became victims of their own size. Harvest was high for a period of time and then dropped drastically. In 1869, two Ohio brothers, Captain John and William Hetterick, arrived in Edenton and began fishing with pound nets in Albemarle Sound (Earll 1887). The pound net, a simple device, is a long line of stakes draped with netting extended out into the channel which divert migrating fish into a small, heart-shaped funnel and then into the "pound". One or two men in a small boat used large dip nets to remove the fish from the pound. The use of the pound nets revolutionized fishing in North Carolina, especially in Albemarle Sound (Taylor 1992).

Pound nets had several advantages over the large haul seines: cost was just a few hundred dollars, were tended by only two or three men, and could be set any where. The number of pound nets increased from 117 in 1880 to 1,125 by 1896 in Albemarle Sound (Taylor 1992). Chestnut and Davis (1975) reported that 2,767 pound nets were set in North Carolina in 1927. Although the pound nets were set primarily for river herring and shad; striped bass were a considerable portion of the harvest. From the late 1880s through 1954 pound nets accounted for 26-62% of the total striped bass commercial harvest (Section 13, Appendix 1). The fish caught in the pound nets varied in size. Smith (1907) reported several striped bass captured in pound nets at Edenton in 1891 that weighed 125 pounds. By the late 1960's through the early 1970's, pound net contribution to the striped bass harvest had dropped to 4.8 – 7.3% of the total. Gill nets, anchor and drift, have historically been utilized in the striped bass fishery. Since the development of monofilament webbing, gill nets have been the dominant harvest gear. By the late 1960's to the early 1970's, gill nets were accounting for up to 77% of the striped bass harvest. Striped bass were harvested by purse seines, fish wheels, hoop and fyke nets and trotlines.

The Albemarle Sound area (ASMA) and Roanoke River historically supported the largest year-round commercial fishery for striped bass in North Carolina, accounting for up to 95% of the states striped bass harvest from 1930 through 1960. From 1972-1987, the Albemarle Sound area produced up to 87% of the striped bass landings from the state's internal waters. Chestnut and Davis (1975) presented a synopsis of striped bass landings by gear for the state (1887-1971), annual landings and value for some years, and landings by county (Section 13, Appendix 1). Annual landings by gear are shown in **Table** 7.1 for 1978 – 2002 and in **Table** 4.1 by waterbody for 1972 – 2002.

From 1915 through 1965, various regulations were promulgated for the Albemarle Sound fisheries, some specifically for striped bass, while others affected the harvest of the species though not developed directly for striped bass. The regulations included area closures, yardage restrictions, harvest limits and other restrictions (Section 13, Appendix 2). Appendix 3 summarizes rules and regulations enacted since 1979 for striped bass conservation and management.

The commercial fishery for striped bass has principally occurred from November through April in the Albemarle Sound, whereas, Roanoke River commercial effort was concentrated during the spring spawning run. During the summer months, all landings were much lower (Hassler et al. 1981). Anchor and drift gill nets were the most productive gear types in the spring spawning run portion of the Roanoke River fishery. In 1981, anchor gill nets were prohibited in the Roanoke River, and the mesh size of drift gill nets was restricted, resulting in sharply curtailed landings during the spawning run (Hassler 1984). Bow and dip netting was a productive method of harvesting spawning fish in Roanoke River until it was prohibited in 1981. Prior to this rule, fishermen using bow nets in the upper Roanoke River were allowed to retain 25 stripers per day when taken incidentally to shad and river herring fishing. A local law, allowing the commercial sale of striped bass in Halifax and Northhampton counties was enacted by the NC General Assembly and created a prominent commercial fishery for striped bass in its principal spawning area (Hassler et al. 1981). This law was repealed in 1981 and commercial fishing for striped bass was totally eliminated in the Roanoke River. Limited commercial fishing seasons were implemented in Albemarle Sound in 1984 (October-May) (Henry et al. 1992). State regulations enacted in 1985 prohibited the sale of hook and line caught striped bass.

7.2.3 Current

The ASMA commercial striped bass fishery from 1990 through 1997 operated on a 98,000 pound total allowable catch (TAC). The TAC was split in order to have a spring and fall fishery.

Table 7.1. North Carolina commercial striped bass landings from internal waters, by gear 1978-2002.

	Gill Net					**Haul/Beach**								
Year	Float	Sink	Run-around	Drift	Pound net	Seine	Swipe net	Trawl	Trolling	Rod-n-reel	Pots	Fyke nets	Unknown/ other	Internal State total
1978	492,269				36,314	1,164		102	1,924	1,513				533,286
1979	274,940			131	16,844	16,542		180	56,057	9,410				374,104
1980	410,236				13,826	7,276		*	1,589	17,332			410	450,669
1981	336,035				17,645	2,310		*	*	9,165			628	365,783
1982	195,847				32,048	7,859		*	*	9,093			590	245,437
1983	286,066		*		11,793	374		*	*	9,016			1,230	308,479
1984	487,600				7,618	846		*		2,329			2	498,395
1985	259,746				19,782	*		*	*				229	279,757
1986	182,853				5,596	*			*				532	188,981
1987	232,744				29,477									262,221
1988	108,622				7,254									115,876
1989	91,387				9,253			*					98	100,738
1990	95,214				10,055									105,269
1991	113,247				3,341	*		*					42	116,630
1992	128,592		*		4,626	79							10	133,307
1993	180,233		*		1,919	4,600		*					24	186,776
1994	48,465	56,368	303	253	12,800	2,290	500				341	905		122,225
1995	50,829	41,130	120	*	4,277	4,592	*	42		80	254	790	89	102,203
1996	64,681	50,541	429	197	4,990	1,820	*	*			137	513	40	123,348
1997	34,746	71,964	1,300	120	14,007	773	56	206		*	835	440	196	124,643
1998	33,776	96,430	1,493	80	14,735	1,890		118	*		749	517	112	149,900
1999	57,111	122,380	274	*	12,820	2,100	*			*	934	705	506	196,830
2000	42,547	181,093	476	*	17,590	*		*			1,227	1,343	1,592	245,868
2001	44,690	184,857	1,401		12,761	538	*			*	1,176	2,696	201	248,320
2002	33,480	192,117	5,644	3,640	18,862	1,621	*				196	1,485	1,376	258,416

The commercial fishery operated with net yardage restrictions, mesh size restrictions, size limit restrictions and daily landing limits. The A/R stock was declared recovered in 1997 by the ASMFC. In 1998, the commercial TAC was increased to 125,440 pounds and additional increases in poundage occurred in 1999 and 2000. From 2000 through 2002, the commercial TAC has remained at 225,000 pounds. The ASMFC Striped Bass Management Board approved a 50,000 pound TAC increase for the ASMA commercial harvest for 2003, for a total commercial harvest of 275,000 pounds. Since recovery, seasons, yardage and mesh size restrictions and daily landing limits have been used to control harvest and bycatch (Appendix 3). A summary of the ASMA commercial seasons, 1991-2003 is presented in **Table** 7.2.

From 1991 through 2002, the ASMA accounted for 85 – 93% of the internal striped bass landings in North Carolina (**Table** 4.1). The ASMA averaged approximately 407 fishermen reporting landings of striped bass for 1994 – 2002. Gill nets continue to contribute the highest percentage to the harvest, followed by pound nets (**Table** 7.1). The amount of fyke net effort has increased in the ASMA since 1994 and is reflected in the striped bass landings (**Table** 7.1).

Striped bass continue to be managed as a bycatch of the multi-species fishery in the ASMA. During 2002, when the striped bass season was open, commercial fishermen were allowed to land 5 fish per day, not to exceed 50% by weight of the total catch, with an 18 inch total length minimum size limit. Finfish dealers who purchase striped bass are required to obtain a striped bass dealer permit from DMF. The dealers are required to report their landings daily to DMF in order for the quota to be monitored. Dealers are also required to affix striped bass sale tags, provided by DMF, to the fish when purchased from the fishermen.

7.2.4 A/R Commercial Discard/Bycatch Mortality

The ASMA supports a substantial anchored gill net fishery for species such as flounder, striped mullet, white perch, river herring and shad. As a result of the recovery of the A/R stock, the incidental bycatch of striped bass has increased. Preventive measures have been implemented to address this issue, which has ranged from the prohibition of certain mesh sizes in gill nets, limiting the amount of yardage that can be fishes, area closures and required net attendance for small mesh gill nets during times of the year (Appendix 3). The MFC allows the multi-species gill net fishery to be pursued as indicated above. Since 1996, DMF has worked with commercial fishermen, to allow observers on their vessels, on a voluntary basis in the ASMA while gill net fishing. These observer trips have mainly focused on the flounder gill net fishery, during the summer and early fall, when personnel have been available. Some trips have been made in the shad and small mesh gill net fisheries, but insufficient data has been gathered to make an accurate estimate.

Table 7.2. Summary of striped bass commercial seasons in the Albemarle Sound Management Area, 1991 – 2003.

Year	Annual Quota (lbs.)	Spring Season	Bag Limit	Poundage Landed	Fall Season	Bag Limit	Poundage Landed	Total Pounds Landed
2003	275,000 (270,287)	Jan 6 – Mar 19 Mar 20 – Apr 14	5 fish/18" TL 10 fish/ 18" TL	193,554 (preliminary-Quota Monitoring)	?	?	?	?
2002	**225,000** (216,121)	Jan 7 – Apr 14 98 days	5 fish/18"TL	166,471	Nov 4 – Dec 20 47 days	5 fish/18"TL	54,363	220,834*
2001	**225,000** (211,348)	Jan 5 – Mar 25 Mar 26 – Apr 14 100 days	5 fish/18"TL 10 fish/ 18" TL	**185,585**	Nov 19 – Dec 21 33 days	5 fish/18"TL	34,642	220,227*
2000	**225,000** (200,109)	**Jan 7 – Mar 26** Mar 27 – Apr14 99 days	**5 fish/ 18"TL** 10 fish/ 18" TL	**162,467**	**Nov 13 – Dec 31** 49 days	5 fish/ 18"TL	51,294	**213,761***
1999	**137,984**	**Feb 9 – Mar 28** **Mar 29 – Apr 14** 65 days	**5 fish/ 18"TL** 10 fish/ 18" TL	**116,833**	**Dec 1 – Dec 12** Dec 13 – Dec 31 31 days	**10 fish/ 18"TL** 5 fish/ 18"TL	**38,343**	**162,875**
1998	**125,440**	**Feb 16 – Mar 6** Mar 7 – Apr 14 58 days	**5 fish/ 18"TL** 10 fish/ 18" TL	**101,093**	**Dec 1 – Dec 31** 31 days	**10 fish/ 18"TL**	**23,096**	**123,927**
1997	**98,000**	**Feb 15 – Mar 23** Mar24 – Apr14 59 days	**3 fish/ 18"TL** 7 fish/ 18"TL	**73,534**	**Nov 3 – Dec 5** 33 days	**5 fish/ 18"TL**	**22,116**	**96,122**
1996	**98,000**	Feb 16 – Apr 7 Apr 8 – Apr 14 59 days	5 fish/18"TL 3 fish/18"TL	**79,678**	Nov 30 – Dec 22 Dec 23 – Dec 31 32 days	5 fish/18"TL 10 fish/18"TL	9,946	90,100
1995	**98,000**	Mar 1– Apr 4 Apr 5– Apr 14 45 days	5 fish/18"TL 2 fish/ 18" TL	**85,302**	Nov 22 – Dec 31 40 days	2 fish/18"TL	4,200	87,876
1994	**98,000**	Feb 21 – Mar 13 21 days	**10 fish/ 18"TL**	**53,698**	**Nov 21 – Dec 23** 33 days	5 fish/ 18"TL	48,503	**102,367**
1993	**98,000**	**Feb 1 – Feb 28** **Mar 1 – Apr 5** 64 days	**5 fish/ 18"TL** 3 fish/ 18" TL	**109,475**	**No Season**			**109,475**

Table 7.2 (Continued)

Year	Annual Quota (lbs.)	Spring Season	Bag Limit	Poundage Landed	Fall Season	Bag Limit	Poundage Landed	Total Pounds Landed
1992	**98,000**	Jan 11 – Feb 2 Feb 3 – Mar 18 Mar 19 – Apr 16 97 days	**10 fish/ 18"TL** 5 fish/ 18" TL 3 fish/18"TL	**96,435**	**Nov 9 – Nov 20** **12 days**	**3 fish/ 18"TL**	**4,114**	**100,549**
1991	**98,000**	**Jan 7 – Jan 9** Jan 18 – Feb 12 Feb 13 – Feb 28 Mar 1 – Mar 24 Mar 25 – Apr 5 Apr 6 – Apr 13 86 days	**Monthly quota/14"TL Coastal/ 16"TL Joint** 3 fish/20"TL 5 fish/18"TL 10 fish/18"TL 20 fish/14"TL Coastal/16"TL Joint 5 fish/18"TL	**101,219**	**Nov 1 – Dec 20** 50 days	**3 fish/ 18"TL**	**7,241**	**108,460**

*Total allowable catch adjusted to compensate for overages in previous year.

The bycatch of striped bass in the ASMA gill net fisheries has been a point of compliance with the ASMFC Striped Bass Interstate Fishery Management Plan since 1994. An annual estimate of striped bass discards has occurred since 1994. The methods utilized and the estimates can be found in Section 10.3.2.1, **Discard Mortality of Striped Bass in the Multi-species Gill Net Fishery Issue Paper**.

7.3 Central/Southern Stocks

7.3.1 Pamlico and Tar Rivers and Pamlico Sound

7.3.1.1 Commercial

7.3.1.2 Historical

Commercial striped bass fisheries have historically occurred throughout Pamlico Sound and its tributaries. However, these fisheries were not of the magnitude of the Albemarle and ran second in total landings for the state. As with the Albemarle, the progression of various gears was the same over time from haul seines, pound nets to gill nets.
From the 1930s through the 1960's the Pamlico Sound, Pamlico and Tar rivers accounted for 3.4 – 5.5% of the total internal striped bass landings in North Carolina. During the 1970's and 1980's this area contributed 7 – 10% of the state's internal striped bass landings. Chestnut and Davis (1975) presented a synopsis of striped bass landings by gear for the state (1887 – 1971), annual landings and value for some years, and landings by county (Section 13, Appendix 1). Annual landings by gear are shown in **Table** 7.1 from 1978 – 2002 and in **Table** 4.1 by waterbody for 1972 – 2002.

From 1915 – 1965, various regulations were enacted on the fisheries of the Pamlico system. The regulations included net restrictions and area restrictions (Section 13, Appendix 2). Appendix 3 summarizes rules and regulations enacted since 1979 relative to striped bass management.

7.3.1.3 Current

Since 1994, when the North Carolina Striped Bass Management Plan was approved, the CSMA (all areas south of the ASMA line) has operated on a 25,000 pound TAC. The fishery has operated as a low harvest level fishery, using set seasons with size limit restrictions and daily landing limits. The various rules and regulations are shown in Appendix 3.

The Pamlico Sound and Pamlico/Pungo River complex has accounted for 10.5% of the state's internal striped bass landings since 1994. During 1999 and 2000, these areas exceeded the total 25,000 pound TAC for the entire Central/Southern area of the state (**Table** 4.1). In the Central/Southern region between 1994 – 2000, there was an average of 211 fishermen reporting landings in a given year. The majority of these fishermen were from the Pamlico Sound and Pamlico/Pungo river areas. Gill nets account for the highest percentage of the striped bass landings from this area.

The striped bass low harvest level fishery is divided into a spring and fall season. During the open season fishermen are restricted to daily landing limits and minimum size limits. Finfish dealers are required to obtain a striped bass permit, with a Central/Southern validation, report landings daily to DMF and affix a sale tag to the striped bass when purchased from the fishermen.

7.3.2 Neuse River

7.3.2.1 Commercial

7.3.2.2 Historical

Striped bass commercial fisheries have occurred in the Neuse River since colonial times. Worth (1903) reported that striped bass were numerous at New Bern and at other points along the Neuse River.

The progression of commercial gears was similar to the other areas of the state. Commercial fisheries on the Neuse River employed drift gill nets with a full range of mesh sizes upstream to Pitch Kettle Creek and stake gill nets and haul seines principally from New Bern downstream (Marshall 1977).

From the 1930s through the 1980's commercial landings of striped bass in the Neuse River were insignificant compared to the statewide landings. The commercial striped bass fishery may have been important at the turn of the century but has remained at very low levels for the last 50 years. Chestnut and Davis (1975) presented striped bass landings by county for the period 1930 – 1968 (Appendix 1), which shows the small amount of landings for the counties along the Neuse River. **Table** 4.1 shows the Neuse River landings from 1972 – 2002.

The fisheries of the Neuse were affected by various regulations enacted from 1915 – 1965 (Appendix 2). The rules and regulations enacted since 1979 relative to striped bass management are shown in Appendix 3.

7.3.2.3 Current

The harvest of striped bass is from bycatch of other fisheries and the landings are part of the 25,000 pound TAC. Since 1994, the Neuse River striped bass commercial landings have increased from that of the 1970's and 1980's (**Table** 4.1). The landings since 1995 have been fairly consistent and averaged 5,950 pounds, which are the highest commercial landings for the Neuse River since 1976 (**Table** 4.1). Gill nets account for the majority of the harvest.

7.3.3 Cape Fear River

7.3.3.1 Commercial

7.3.3.2 Historical
The striped bass fishery in the Cape Fear River system has typically been small compared to the other systems of the state. In 1923, a law was passed that made it unlawful to catch or take with nets or seines any striped bass (rock) in any waters of New Hanover County (NC Fishing Laws- 1923) (Section 13, Appendix 2). This law remained in effect through 1987. The majority of the striped bass landed were taken as incidental bycatch in the American shad fishery. Striped bass landings by county from 1930 – 1968 are presented in Appendix 1. Since 1979, various rules and regulations have been enacted by the state that have affected striped bass harvest (Appendix 3).

7.3.3.3 Current
The Cape Fear River system striped bass fishery has operated under the Central/Southern TAC since 1994. The fishery has been prosecuted as the other parts of the state with seasons, minimum size limits, daily landings limits and dealer permit requirements. The Cape Fear River season is only open to striped bass commercial harvest during the spring (Jan – Apr).

The striped bass landings primarily occur as bycatch of the American shad fishery. Since 1994, the average annual landings are approximately 1,300 pounds, which is less than it was in the 1970’s and early 1980’s (**Table** 4.1).

7.3.4 C/S Commercial Discard/Bycatch Mortality

The CSMA estuarine gill net fishery is a year round multi-species fishery where netting used and species targeted varies by area and season. Species commonly caught by the gill net fishery include American shad, Atlantic croaker, southern flounder, red drum, spot, spotted seatrout, striped bass, striped mullet and weakfish. Even though a 25,000 TAC, daily landing limits and seasons exist in the CSMA, striped bass is a targeted catch. Even with the 5 fish per operation daily landing limit, over 30% of the gill net trips during the open season were composed primarily of striped bass (defined as over 50% of the trip tickets).

An estimate of the discarded catch for a gear may be computed by estimating the “total catch” (quantity taken that reaches the deck of vessel) and subtracting from it the “landed catch” (that which is brought ashore). The discarded catch may then be multiplied by a mortality estimate (percent that are dead at the time of harvest) to give an estimate of the quantity of dead discard. Since the DMF does not have a comprehensive onboard observer program, the total catch must be estimated. The Division data and methods utilized to calculate a discard (dead) estimate for the set gill net fishery in Pamlico Sound and Pamlico, Pungo, Bay and Neuse rivers can be found in Section 10.4.3.2 Discard Mortality of Striped Bass From Set Gill Nets in the CSMA. Similar data for other areas in the CSMA is not available.

7.4 Recreational Fisheries

7.4.1 Introduction

The origins of recreational angling in North Carolina are poorly documented in existing literature. Most likely, Native Americans and early colonists first took striped bass with hook and line purely as a matter of subsistence. After the industrial revolution and with the advent of outboard motors, anglers began to seek striped bass with hook and line for both subsistence and recreation. Early in the 20th century, in the Croatan and Roanoke Sound areas of Dare County, charter boat fishing fleets developed, signaling a move towards angling for striped bass, purely as a recreational activity. An increase in disposable income and leisure time during the mid-1900s gave rise to a great interest in fishing for striped bass in North Carolina's sounds and rivers. As recovery of the A/R stock continued into the late 1990's, a tremendous increase in recreational effort for striped bass occurred.

Keeping striped bass for food has always been an important element of the recreational experience, but because striped bass caught recreationally were allowed to be sold in some areas the distinction between recreational and commercial fisheries has been unclear at times. For example, until the early 1980's, striped bass were caught with recreationally licensed bow nets in the upper reaches of Roanoke River and local legislation allowed these fish to be bought and sold. Striped bass caught on hook and line in the eastern Albemarle Sound charter boat fisheries were also bought and sold. After the near collapse of the A/R striped bass stock in the late 1970's, regulatory agencies recognized the need to remove economic incentives to sell striped bass taken with traditional recreational gear so that commercial harvest could be limited and quantified. Statutes allowing the sale of recreationally caught striped bass were repealed and rules of the MFC were changed to implement distinctions between the manner in which commercially saleable striped bass could be taken.

Taking and possession of striped bass using hook and line in coastal North Carolina is regulated by the WRC in designated Inland waters, jointly by the WRC and MFC in designated Joint waters and by MFC in designated Coastal waters. In designated Joint waters, rules governing harvest seasons, creel limits and size limits are jointly enacted by the WRC and the MFC and are jointly enforced by officers of both agencies.

Techniques for catching striped bass on hook and line include trolling, casting, and jigging with artificial lures and the use of live bait (eels, herring, shiners) and cut bait, primarily river herring. The North Carolina Fisheries Reform Act approved by the NC General Assembly in 1997 established the Recreational Commercial Gear License (RCGL). An individual holding a RCGL is allowed to use limited amounts of specified commercial gear to catch seafood for personal consumption or recreational purposes. The holder of this license cannot sell the catch and the catch must stay within the recreational size and creel limits. This license is not transferable and expires one year from the date of purchase. In 2002/2003, there were 6,213 RCGL holders. In certain designated joint and coastal waters, a daily creel limit of striped bass may be harvested with gill nets by persons holding a RCGL issued by DMF. Holders of the RCGL must adhere to the daily recreational creel limits and minimum size limits for striped bass. In the ASMA, RCGL holders are also restricted to harvest days during the open season.

During 2002, a total of 8,945 lbs. (1,925 fish) of striped bass was harvested by RCGL holders in the state. An estimated 3,188 striped bass were discarded by RCGL holders for the entire state. The Northern District accounted for 5,315 lbs. of the total landed and the Pamlico District the remaining poundage (NCDMF 2003).

7.4.2 Roanoke River

Using a combination of observer tallies and angler post card surveys, Hassler et al. (1981) estimated numbers of striped bass caught on hook and line in the Weldon area of Roanoke River from 1959 through 1980 and in the entire length of the river from 1970 through 1980. Catch (and presumably harvest) in the Weldon area survey ranged from 3,174 striped bass in 1963 to 37,446 in 1971. In the survey of the entire Roanoke River, estimates of striped bass catch were lowest in 1980 (15,239) and highest in 1971 (65,399). Based upon angler reports, Hassler et al. (1981) also estimated numbers of striped bass caught by drift bow nets and fight bow nets for the period 1961 through 1980. Striped bass catches by drift bow net fishermen ranged from 69 fish in 1968 to 8,655 in 1964. Fight bow net catches ranged from 1,051 striped bass in 1978 to 10,393 in 1969.

In 1988, WRC began monitoring striped bass harvest in the Roanoke River with creel surveys during spring months. The area surveyed, later to be designated the Roanoke River Striped Bass Management Area (RRMA) included Roanoke River from Roanoke Rapids Lake dam, downstream to Albemarle Sound, and the Middle, Eastmost, and Cashie rivers. As the agencies recognized that significant harvest restrictions would be necessary to rebuild the A/R stock, WRC first closed recreational springtime striped bass harvest in Roanoke River with emergency rules on May 10, 1990. Management of striped bass harvest by TAC began in both the RRMA and ASMA in 1991 and WRC closed the RRMA by emergency rules on May 1, 1991. From 1991 until 2002, WRC opened and closed the spring striped bass harvest season in the RRMA by proclamation authority of the Executive Director. Season closures were based upon weekly estimates of striped bass harvest as compared to the TAC of striped bass allocated to the RRMA. Because of high angling pressure, WRC, in 1994, began limiting striped bass harvest to three days per week during the spring season. After recovery of the stock in 1997, substantial increases in the TAC were implemented and WRC increased the number of days per week in which striped bass could be possessed from three to four. In 2002, after another increase in the TAC, WRC decreased the daily creel limit for striped bass from three to two, but set a 46 day season in the lower river (March 1 though April 15) and a 46 day season in the upper river (March 15 through April 30), and allowed striped bass to be possessed seven days per week. From the period of 1988 through 2002, estimates of striped bass harvest in the RRMA ranged from 7,471 fish in 1995 to 38,206 in 2000 (**Table** 7.3). The number of days open to harvest, angler effort, number and weight of striped bass harvested are directly related to the harvest management regime for that year.

7.4.3 Albemarle Sound

Recreational striped bass harvest in Albemarle Sound and tributaries as well as Croatan and Roanoke sounds was monitored by Hassler et al. (1981) from 1967 through 1973.

Table 7.3. Estimates of striped bass angling effort, harvest, and numbers caught and released from the Roanoke River Striped Bass Management Area, 1988-2002.

Year	Number of Days Open To Harvest	Harvest Season Effort (angler hours)	Number Harvested	Pounds Harvested	Pounds of Allowable Harvest	Pounds Over the Allowable Harvest*	Number Caught & Released During Harvest Season	Number Caught and Released After Harvest Season*
1988	-[a]	99,981	16,657	74,809	-		8,898	no estimate
1989	-[b]	46,566	8,753	32,180	-		8,666	no estimate
1990	-[c]	56,169	15,694	42,210	-		52,372	no estimate
1991	120	74,596	26,934	72,529	29,400		98,148	no estimate
1992	109	49,277	13,372	36,016	29,400		23,710	no estimate
1993	84	52,932	14,325	45,145	29,400		10566	46,225
1994	23	44,693	8,284	28,089	29,400		3,826	no estimate
1995	17	56,456	7,471	28,883	29,400		6,892	52,698
1996	11	46,164	8,367	28,178	29,400		15,230	148,222
1997	8	23,139	9,364	29,997	29,400	597	10,748	271,328
1998	21	72,410	23,109	73,541	62,700	10,841	87,679	102,299
1999	21	72,717	22,479	72,979	68,970	4,009	50,161	113,394
2000	28	95,622	38,206	120,113	112,500	7,613	93,148	no estimate
2001	61	100,119	35,231	112,823	112,500	323	71,003	no estimate
2002	61	122,584	36,422	112,698	112,500	198	55,775	no estimate

[a] no defined season opening or closure dates- estimates based on period surveyed: March 28-June 19, 1988
[b] no defined season opening or closure dates- estimates based on period surveyed: March 27-June 18, 1989
[c] no defined season opening date, first year with season closure date- estimates based on period surveyed: March 26-May 9, 1990
* NC Striped Bass FMP effective 1994, overages in TAC were to be adjusted from the next year's TAC.

Estimates of striped bass harvest were based upon records of marina or landing owners, angler interviews, and angler post card surveys. Striped bass catch was estimated to be 67,172 in 1967 with a peak catch of 96,170 in 1970, and a low catch of 30,783 fish in 1973. Mullis and Guier (1982) used a non-uniform probability, roving/access creel survey to estimate recreational striped bass harvest and effort in Albemarle, Roanoke, and Croatan sounds as well as tributary rivers (excluding Roanoke River) from 1977 through 1980. An average of 118,340 angler hours (54,914 party hours) was exerted each year of the study specifically for striped bass. Estimated striped bass harvest was 33,202 fish (71,871 lb.) in 1977, 16,599 fish (30,915 lb.) in 1978, and 5,235 fish (12,553 lb.) in 1979.

In 1991, DMF began monitoring the recreational harvest of striped bass in the Albemarle Sound and it's tributaries, excluding the Roanoke, Middle, Eastmost, and Cashie Rivers. In 1994, the survey was expanded to cover the Currituck, Croatan, and Roanoke Sounds to fully encompass the ASMA. Beginning on November 26, 1989, DMF opened and closed the spring and fall striped bass harvest seasons in the ASMA by proclamation authority of the Fisheries Director. Management of striped bass harvest through a TAC began in the ASMA on January 1, 1991. Season closures were based upon weekly estimates of striped bass harvest as compared to the TAC of striped bass allocated to the management area. Because of high angling pressure, DMF, in 1994, began limiting striped bass harvest to three days per week. In an effort to extend the number of fishing days, from 1995 through 1997, the daily creel limit for the fall season was reduced from three to two fish per person and the minimum size limit was increased to 21 inches. After 1997, the daily creel limit was reduced to two fish per person for both the spring and fall season, with a minimum size limit of 18 inches. In 2000, increases in the TAC allowed the number of fishing (possession) days to be increased from three to four per week. From the period of 1991 through 2002, estimates of striped bass harvest in the ASMA ranged from 6,901 in 1997 to 40,127 in 2001 (**Table** 7.4). The number of days open to harvest, angler effort, number and weight of striped bass harvested are directly related to the harvest management regime for that year.

7.4.4 Tar River

Recreational anglers in the upper reaches of Tar River pursue striped bass during spring months and in the lower reaches into Pamlico River year-round. Anecdotal observations indicate a year-round fishery for striped bass occurs around bridges near Washington, N.C. No surveys have been conducted to estimate striped bass angling effort or harvest, however, WRC will begin a 12-month creel survey on the Tar/Pamlico in July 2004.

7.4.5 Neuse River

Little information exists on the status of the recreational striped bass fisheries in Neuse River. Borawa (1983) surveyed a limited area (Pitch Kettle Creek downstream to the Highway 17 bridge at New Bern) of the Neuse River in 1981 and estimated only 163

Table 7.4. Estimates of striped bass angling effort, harvest, and numbers caught and released from the Albemarle Sound Striped Bass Management Area, 1991-2002.

Year	Number of Days Open To Harvest	Harvest Season Effort (angler hours)	Number Harvested	Pounds Harvested	Pounds of Allowable Harvest	Pounds over the Allowable Harvest*	Number Caught & Released During Harvest Season	Number Caught & Released After Harvest Season*
1991	143	337,830	14,395	35,344	29,400		23,540	17,997
1992	150	198,976	10,542	30,758	29,400		19,981	24,844
1993	77[a]	161,070	11,404	36,049	29,400		7,540	5,701
1994	19[b]	52,397	8,591	30,217	29,400	817	971	no estimate
1995	24	53,692	7,343	30,564	29,400 (28,583)	1,164	No data	no estimate
1996	22	35,809	7,433	29,186	29,400 (28,236)		11,865 (Fall only)	no estimate
1997	26	14,457	6,901	26,724	29,400		30,771	no estimate
1998	46	90,820	19,566	64,761	62,700	2,061	91,888	no estimate
1999	61	64,441	16,967	61,447	68,970 (66,909)		40,321	no estimate
2000	99	100,426	38,085	116,414	112,500	3,914	78,941	no estimate
2001	77	109,687	40,127	118,644	112,500 (108,586)	6,144	61,417	no estimate
2002	84	97,480	27,896	92,650	112,500 (106,356)		51,555	currently not available

[a] survey conducted from January – June 1993.
[b] 1994 and after- survey conducted only during the open harvest season.
* NC Striped Bass FMP effective 1994, overages in TAC were adjusted for the next year's TAC.

angler hours exerted for striped bass with a harvest of 29 fish. The WRC conducted a creel survey on Neuse River from July 2002 through June 2003. The survey was conducted from Smithfield downstream to New Bern on the Neuse River and from Trenton to New Bern on the Trent River. The total striped bass harvest (preliminary) for the year was estimated to be 9,677 fish and the total catch was 15,061 fish. The total effort for striped bass was 53,959 angler hours.

7.4.6 Pamlico Sound

Although estimates of striped bass harvest specifically from Pamlico Sound are not available, WRC and DMF personnel believe it to be substantial, especially in northern Pamlico Sound. DMF, in cooperation with National Marine Fisheries Service, estimates recreational harvest of fish in ocean and estuarine areas of North Carolina through the Marine Recreational Fisheries Statistics Survey (MRFSS). The MRFSS estimates categorize catch estimates as having come from offshore, nearshore, or from inside waters. In North Carolina, inside estuarine waters include all southern and central sounds and extreme lower portions of coastal rivers, extending up to and including Croatan and Roanoke sounds. Striped bass harvest in Croatan and Roanoke sounds is therefore included in both the ASMA creel survey and the MRFSS estimates, so there is no valid method to attribute harvest in this area to Pamlico Sound.

7.4.7 Cape Fear River

Striped bass are pursued by recreational anglers in the upper reaches of Cape Fear River during spring months and are caught incidentally in the lower reaches year-round. Anecdotal reports suggest that striped bass anglers commonly catch striped bass hybrids. These hybrids are likely escapees from those stocked in Jordan Lake by WRC. Stocking of hybrid striped bass in Jordan Lake was terminated by WRC in 2001 when managers began to plan for the recovery of the Cape Fear River striped bass stock. No surveys have been conducted to estimate striped bass angling effort or harvest however WRC began a 12-month creel survey on the Cape Fear River in July 2003.

7.5 Guided Fishing for Striped Bass

In 1984, a North Carolina license requirement for charter boats, headboats or guide boats (“for-hire” vessels) was initiated when North Carolina General Statute 113-152 (Licensing of vessels) was amended to include *“Commercial fishing operations also includes taking people fishing for hire”.* After much public debate and with the passage of the Fisheries Reform Act in 1997, “fishing for-hire” was eliminated from the definition of commercial fishing operations, and the license requirement for charter boats and headboats was eliminated, effective July 1, 1999 (NCDMF 2003). In designated joint and inland waters, fishing guides (persons receiving monetary compensation for taking others fishing) are required to purchase an annual guide’s license from WRC.

Since the recovery of the A/R stock and the Atlantic Migratory Stock, striped bass has become one of the major species in the guided recreational fishery. During early 2002, nearly 315 for-hire vessels were identified as operating in North Carolina’s coastal waters, representing a 37% increase from the three prior years. Though many of these vessels pursue a variety of species, a growing number target striped bass. In 2002, 96 new vessels entered the for-hire fishery with 48% of these occurring in the northern coastal area of North Carolina. This assessment of the coastal charter fleet size is most likely low given the difficulties in identifying these transient and mobile vessels, generally less than 25 feet in length (NCDMF 2003).

Annual sales of WRC guide licenses have increased steadily from 292 in 1987 to 970 in 2002. Because the WRC guide license is a combination hunting/fishing guide license, it is not possible to determine the exact proportion of the increase in license sales that is attributable to fishing guides only, but WRC wildlife management biologists believe the numbers of hunting guides, while increasing in recent years, have not increased at the rate of total guide license sales (D. Luszcz, S. Osborne, WRC, pers. comm.). It would be reasonable to conclude therefore, that perhaps a majority of the increase in WRC guide license sales since 1987 may be a result of an increase in fishing guides and observations by WRC field staff indicate many guides who have historically targeted other species, now include striped bass in their seasonal itineraries.

7.6 Catch and Release Fishing

Since the early 1990's, conservative striped bass creel limits have been in effect during open harvest seasons in the ASMA and RRMA. As this striped bass population has grown, an extensive catch and release fishery has developed both within and outside of the harvest seasons. During open harvest seasons, many anglers catch and retain their daily creel limit, then continue catching and releasing striped bass with individual catch rates sometimes exceeding 100 fish per day. Anglers often express the opinion that catching and releasing large numbers of striped bass after taking the daily creel limit offsets their desire to harvest more fish. Still, other anglers enjoy catching and releasing striped bass regardless of whether the harvest season is open, expressing no desire to keep any striped bass.

A proportion of striped bass caught and released in the hook and line fisheries die as a result of injuries or physiological stress. Hooking injuries that cause damage to the gills or puncture the esophagus are often fatal. Striped bass that are bleeding heavily upon capture generally die immediately (referred to as "initial mortality") but many striped bass that are apparently in good condition upon release die at a later time (referred to as "delayed mortality"). The physical exertion associated with being hooked, fought, dehooked, handled, and released causes the fish's metabolic rate to increase greatly above normal limits and as a result, large amounts of lactic acid are produced with the muscle tissues. Although this severe condition known as "lactic acidosis" is often fatal, death occurs slowly over a period of several days. Many anglers are under the false impression that if a striped bass caught and released swims away, then it will survive the encounter. Section 10.2.**3 Catch and Release Mortality in the Hook and Line Fisheries** provides a through discussion on this issue.

7.7 Hybrids

Hybrid striped bass (striped bass X white bass) have been identified in the Cape Fear River system and the Pamlico Sound area. These populations are the result of incidental introductions.

Hybrids have been introduced inadvertently into the Cape Fear River by stocking practices performed in Lake Jordan by the WRC, which escaped into the river (Patrick and Moser, 2001). Stocking of hybrids in Lake Jordan occurred from 1983 until 2001, and during this period hybrid striped bass abundance in the Cape Fear River increased from approximately a 25:75 (hybrid:native) ratio in 1990 to a 50:50 ratio in 2001 (Mallin et at. 2001, Patrick and Moser 2001).

The occurrence of hybrid striped bass in the Pamlico Sound area is a relatively recent observation made by DMF and commercial fishermen. The majority of the hybrids are captured in the Pungo River. Sources of these hybrids could be a result of escapement from aquaculture facilities during the floods that resulted from the hurricanes in the late 1990's.

Hybrid striped bass have been documented to reproduce under hatchery conditions (Forshage et al. 1986; Harrell and Webster, 1997) and in the wild (Ware 1975; Avise and Van Den Avyle 1984; Harrell et al. 1993). However, Smith and Jenkins (1984) reported only a 10% hatching rate in the wild for hybrids.

MFC regulations that apply to striped bass also apply to hybrids in coastal and joint waters of the state. Culture and sale of hybrid striped bass conducted through aquaculture facilities in accordance with WRC rules (15A NCAC 10H Section .0700) shall be exempt from rules of the MFC concerning striped bass.

7.8 Protected Species

The two predominate commercial fishing gears used for harvesting striped bass in North Carolina are gill nets and pound nets. In the Albemarle Sound Management Area (ASMA), striped bass are considered a "bycatch" species that cannot be targeted. Striped bass may be harvested in conjunction with other targeted species. Outside the ASMA, there is no "bycatch" provision for the harvest of striped bass. However, the daily landing limits are held to such a low level that limited targeting occurs for the species.

Most encounters with protected species have occurred in the gill net fisheries of the coastal North Carolina waters. Encounters with pound nets have occurred, but because of the configuration of the gear, mortality is very rare. Although there were no observed takes of marine mammals in the NC inshore gill net fisheries for the years 1997 – 2000, six strandings of bottlenose dolphins during the time period were attributed to Fishery Interactions- gear attached, net or line marks indicative of gill nets by the National marine Fisheries Service. None of the six strandings occurred in areas and/or during time periods when striped bass fisheries are normally prosecuted with gill nets. Three of the strandings occurred in Dare County in the months of July, August and December, two of the strandings occurred in Carteret County, one in September and one in October and one stranding occurred in Hyde County in November.

There have been interactions with sea turtles in the gill net fisheries of Pamlico Sound. On December 10, 1999, the National Marine Fisheries Service (NMFS) issued an emergency rule closing southeastern Pamlico Sound to the use of gillnets larger than five inch mesh to protect endangered and threatened sea turtles. From 2000 – 2002, NCDMF working with NMFS has continued to close portions of the Pamlico Sound in the fall to the use of large mesh gill nets. Fishing is allowed in these areas during the closed time only after acquiring a special permit. This permit allows the use of a relatively small amount of large mesh webbing to be fishing in the area. One of the stipulations of the permit is to allow observers on-board the vessel during fishing. Observers monitor the catch of these gillnets and when a certain number of sea turtle interactions occur (numbers differ per species) all gill nets are removed from the area.

Documented reports of the shortnose sturgeon in North Carolina are limited to two areas; western Albemarle Sound (1881 and 1998) and the Cape Fear River (1987). Interactions of shortnose and Atlantic sturgeons in the NCDMF Independent Gill Net Survey shows a very low mortality rate with fish captured in the survey gear.

PROTECTED SPECIES LIST:

BIRDS:
Bald eagle (Haliaeetus leucocephalus)
Roseate tern (Sterna dougallii dougallii)
Piping plover (Charadrius melodus)

MAMMALS:
West Indian manatee (Trichechus manatus)

FISH:
Shortnose sturgeon (Acipenser brevirostrum)
Carolina Madtom (Noturus furiosus)

REPTILES:
Kemp’s ridley sea turtle (Lepidochelys kempii),
Hawksbill sea turtle (Eretmochelys imbricata)
Leatherback sea turtle (Dermochelys coriacea)
Green sea turtle (Chelonia mydas)
Loggerhead sea turtle (Caretta caretta)

8.0 DESCRIPTION OF THE SOCIOECONOMIC CHARACTERISTICS OF THE FISHERY

8.1 Definitions

Commercial Fishing – Fishing in which fish harvested, either in whole or in part, are intended to enter commerce or enter commerce through sale, barter or trade. In North Carolina, a commercial fisherman is required to have a license issued by the North Carolina Division of Marine Fisheries (DMF) and is allowed only to sell to a licensed dealer. (Definition applies only after 1999.)

Confidential data - Direct or indirect identity of a fisherman and/or dealer (i.e., licensee) is considered confidential according to G.S. 113-170.3. Long-standing DMF policy (standard supported by all Atlantic coast fisheries agencies) identifies confidential data as data derived from fewer than three fishermen or dealers (termed the 'Rule of Three'). Confidential data can only be released in a summarized format that does not allow the user to track landings or purchases to any individual unless by direct court order.

Ex-vessel price and value - The total landed dollar amount of a given species (or species landing condition and market category). Example: 100 lbs. of striped bass at a PRICE of $1.50 per pound will have a VALUE of $150.

Fishing Trip – A period of time over which fishing occurs. The time spent fishing includes configuring, deploying, and retrieving gear, clearing animals from the gear, and storing, releasing or discarding catch. When watercraft are used, a fishing trip also includes the time spent traveling to and from fishing areas or locales and ends when the vessel offloads product at sea or returns to the shore. When fishing from shore or man-made structures, a fishing trip may include travel between different fishing sites within a 24-hour period.
Inflation-adjusted values – Inflation is overall 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 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.

Recreational Fishing - Any trip for the purpose of recreation from which none of the catch is sold or bartered. This includes trips with effort but no catch. A license is required for those who fish in waters controlled by the North Carolina Wildlife Resources Commission. Anglers who wish to use limited amounts of commercial fishing gear in coastal waters under the jurisdiction of the NC DMF are required to have a license.

8.2 Commercial Fishing

8.2.1 Ex-vessel Value and Price

In 1972, NCDMF began collecting commercial value statistics. The trip ticket program began in 1994 and it was mandated that all commercial landings be reported to DMF. Reporting the value of the landing continues to remain optional; however, the values of landings are reliable estimates. Considering that there is nearly thirty years of data to compare, it is useful not only to report the actual dollars paid for the seafood, but also to tie the value of annual landings back to an established baseline to control for the effects of inflation. In this way changes in landings values since 1972 can be more clearly understood.

Albemarle Sound Management Area (ASMA). From 1972 to 1978 there was a general trend for increased landings value from the ASMA as shown in **Figure** 8.1 that are associated with increases in landings. From 1978 on the overall trend is towards decreasing value. As is typical, the inflation adjusted figures show less volatility,

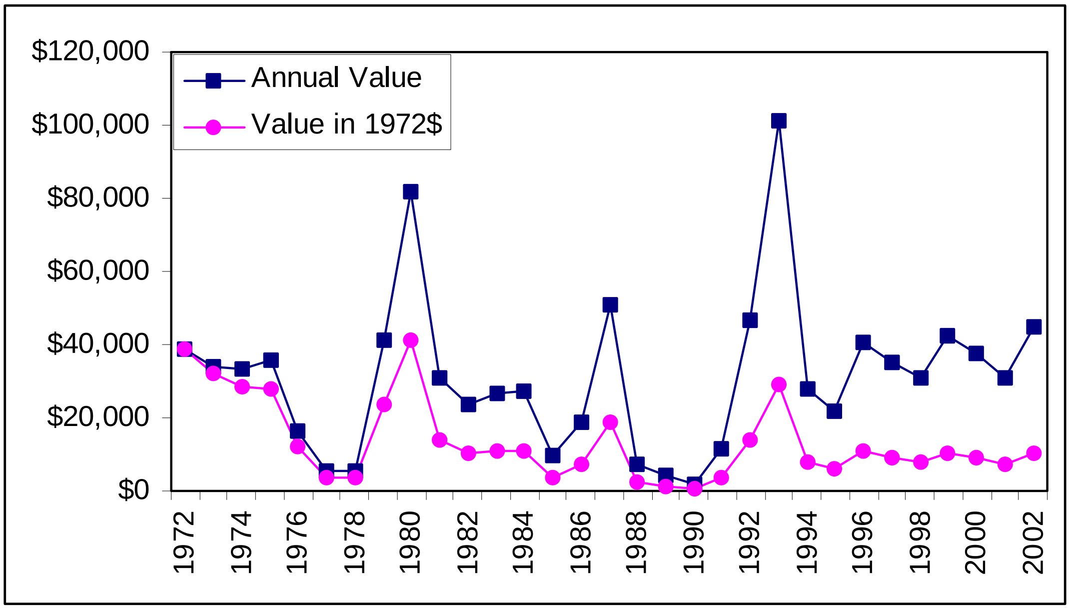


Figure 8.1. Value of ASMA striped bass landings, 1972 – 2002 (NCDMF Trip Ticket Program).

nonetheless, the 1978 high of $272,335 (inflation adjusted) is eight to nine times greater than the lows of approximately $30,000 - $40,000 from 1988 through 1998. In 1999 and 2002 the value of the landings increased, but were still lower than the pre-1988 values. Much of this reduction in value is due to the lower total allowable catch from these years.

Central/Southern Management Areas. Striped bass landings from the CSMA waters tend to be much lower than from the ASMA and more erratic. Consequently, the value of landings is also lower (**Figure** 8.2). Controlling for inflation, 1980 saw landings with the highest value ($41,358). Since then, in only two years (1987 and 1993) have annual landings from these waters been greater than $15,000.

Ocean. While some years were better than others, the overall trend in striped bass landings from the ocean decreased from a high of $367,671 (adjusted for inflation) in 1973 to a low of $17,529 in 1984 (**Figure** 8.3). From 1985 through 1989 the ocean was closed to harvesting of striped bass as mandated by the ASMFC Interstate FMP. Landings of striped bass from the ocean began to increase significantly in 1993, but dropped off sharply in 1996 due to changes in the total allowable catch. Landings values have increased somewhat in recent years, but they have not recovered to a level much higher than the 1976 inflation-adjusted values.

Figure 8.4 shows the 1972 inflation-adjusted values of the landings for all water bodies combined for each year from 1972 through 2002. As can be seen, the vast majority of landings for any given year can be accounted for in the landings from the ASMA or from

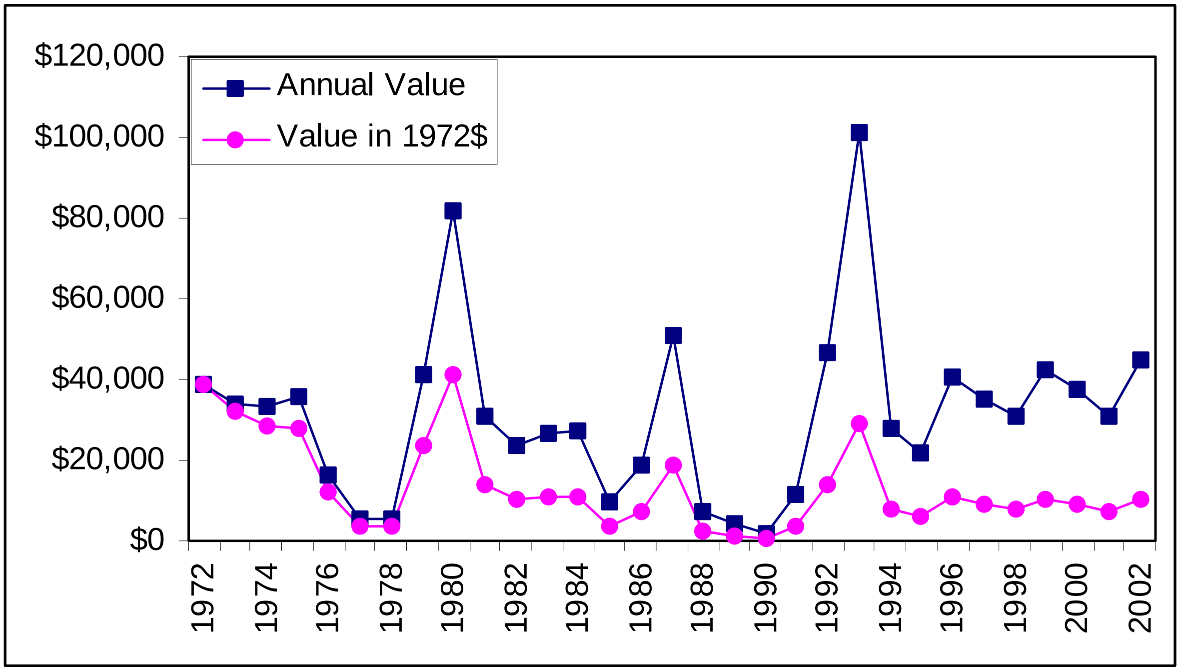


Figure 8.2. Value of Central/Southern waters striped bass landings, 1972 – 2002 (NCDMF Trip Ticket Program).

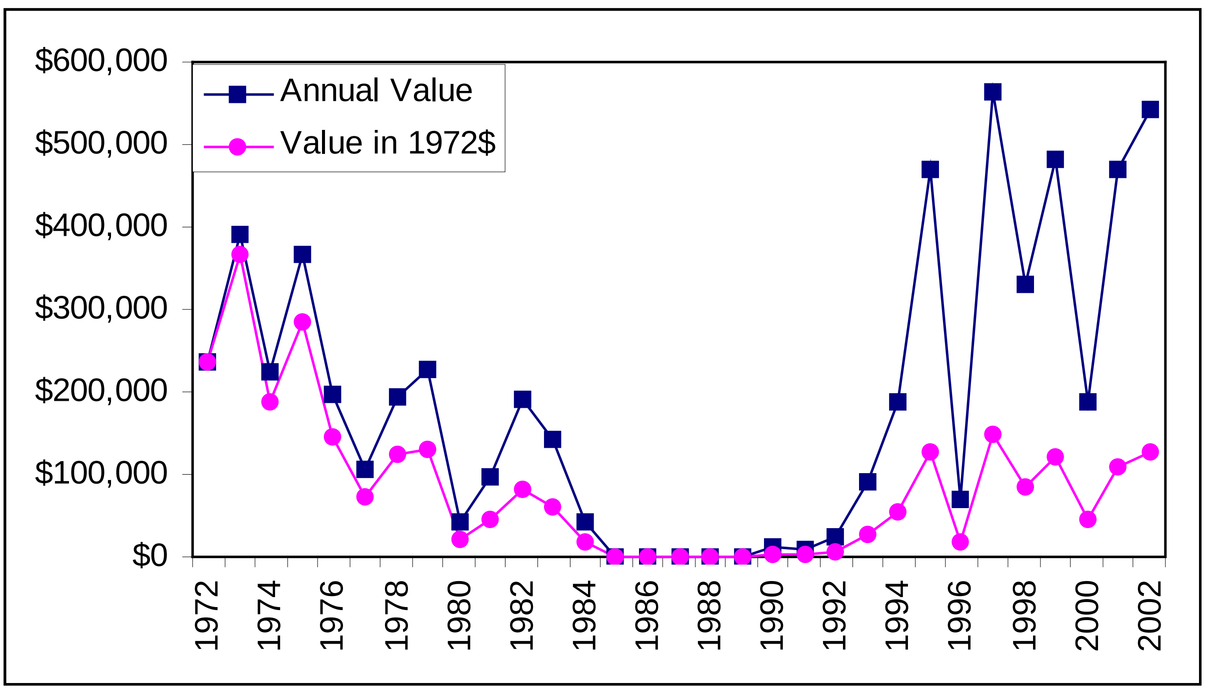


Figure 8.3. Value of ocean striped bass landings, 1972 – 2002 (NCDMF Trip Ticket Program).

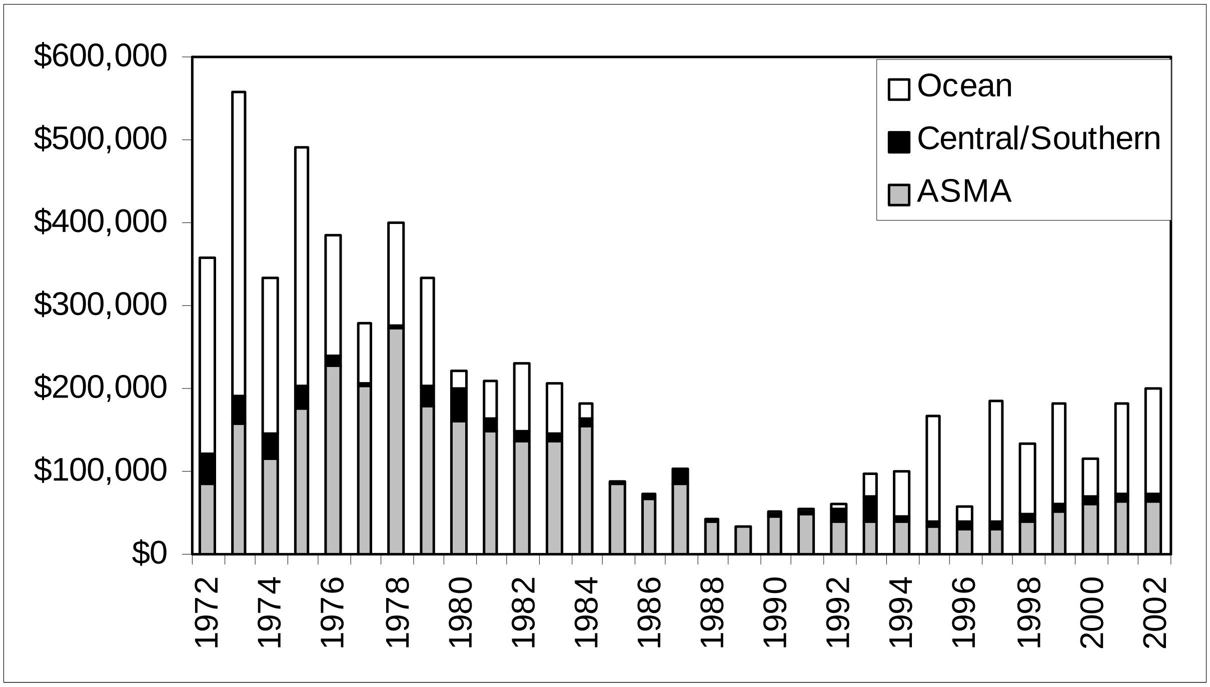


Figure 8.4. Total value of striped bass landed by water body (adjusted for inflation), 1972 – 2002 (NCDMF Trip Ticket Program).

the ocean, except for the years 1984 through 1992 when ocean harvesting was closed or extremely limited.

As shown in **Figure** 8.5, the total number of pounds landed diminished steadily from a high of 1.75 million pounds in 1973 to a low of just over 100,000 pounds in 1989. Much of the decrease in harvest can be attributed to moratoria and changes in the total allowable catch in the different water bodies during this period. The average number of pounds has been increasing since the early 1990's with 1997 and 1999 showing the largest annual landings of approximately 600,000 pounds each.

In the early 1970's the largest portion of striped bass were caught in the ocean. By the mid-1970's the majority of landings were coming from the ASMA. From the mid-1980's to the early 1990's landings from the ocean were extremely limited or nonexistent due to closures or limited fishing opportunities. From the mid-1990's on, with the exception of 1996 and 2000, ocean landings accounted for at least 50% of the total annual landings.

The average price per pound paid to the fisherman tends not to vary much at any given time period for fish caught in the ASMA or in the CSMA (**Figure**s 8.6 and 8.7). Price per pound in these waters increased steadily from $0.28 in 1972 to a high of $1.45 in 1992. The general trend has been towards decreasing price per pound since 1992. When controlling for inflation, the price per pound reached a high of about $.58 in 1983 and has been declining gradually since then. The price per pound of striped bass landed

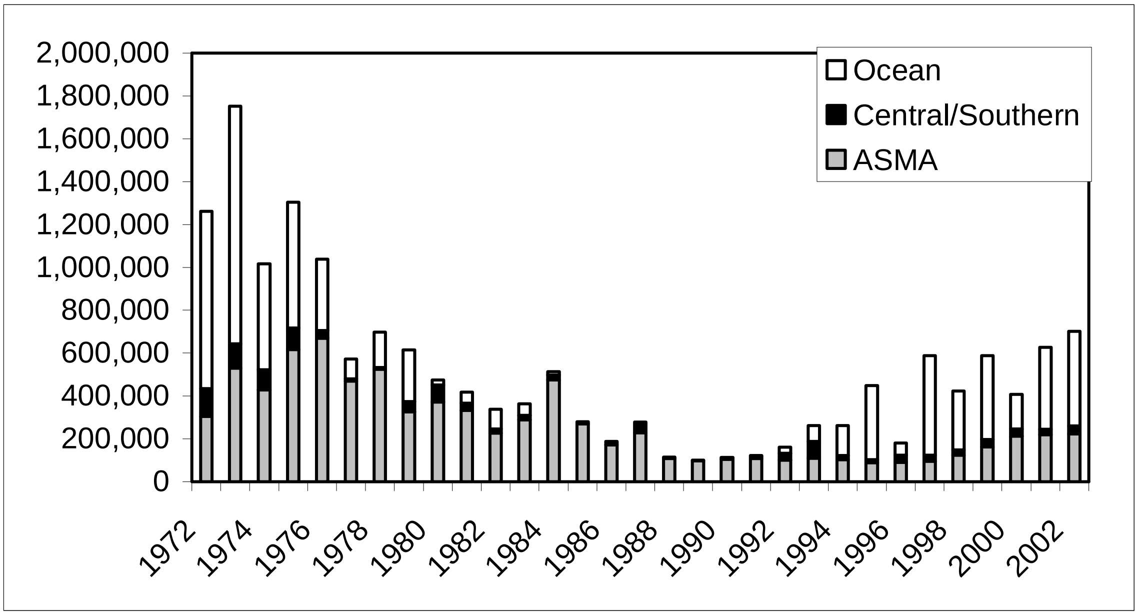


Figure 8.5. Number of pounds of striped bass landed by water body, 1972 – 2002 (NCDMF Trip Ticket Program).

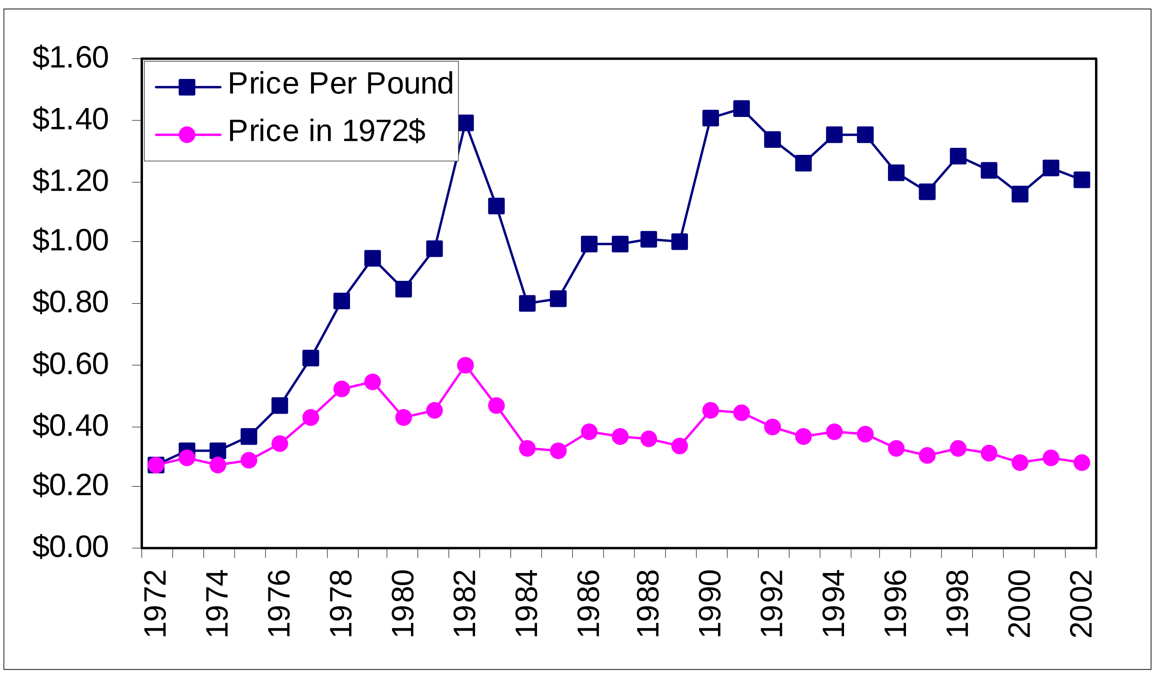


Figure 8.6. Price per pound by year for striped bass caught in ASMA, 1972 – 2002 (NCDMF Trip Ticket Program).

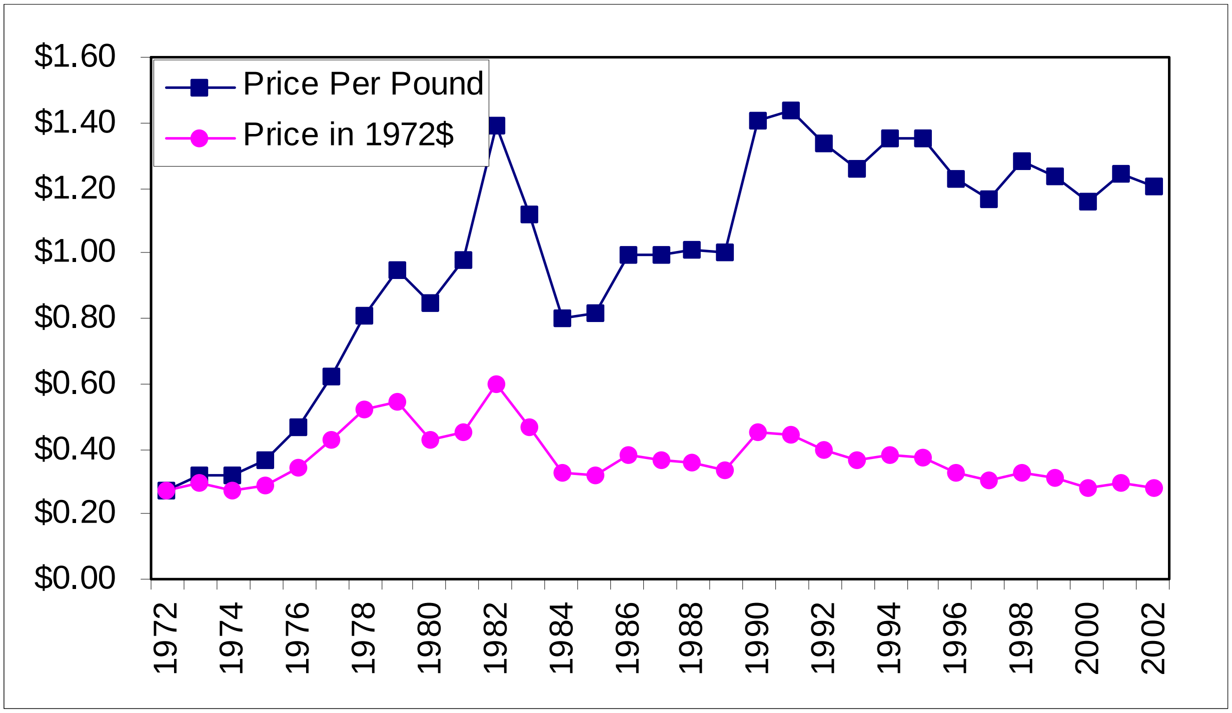


Figure 8.7. Price per pound by year for striped bass caught in Central/Southern waters, 1972 – 2002 (NCDMF Trip Ticket Program).

from the ocean was more volatile from 1972 to 1987 (**Figure** 8.8), from a low of $.28 per pound in 1972 to a high of $3 per pound in 1984. Since 1992, there has been a gradual decline in the price per pound of striped bass landed from the ocean where it currently is about $1.20 per pound.

Table 8.1 shows the number of participants in the fishery by year, major water body and the value of their annual landings from 1994 – 2002. In those years, the ASMA averaged approximately 407 fishermen reporting landings of striped bass. Of those, 52% had annual landings with values less than $200. In the Central/Southern regions, there is an average of 207 fishermen reporting landings in a given year. Seventy-five percent reported annual landings valued less than $200.

8.2.2 Gear and Price

From 1972 – 2002, 59% of all striped bass were caught using gill nets (84% floating gill nets, 15% sink gill nets, remaining 1% drift and runaround gill nets). An additional 22% were caught using beach seines and 4% in pound nets. The remaining 5% were caught as bycatch using other gears such as haul seines, other kinds of nets, pots, or trolling. **Table** 8.2 shows by year from 1994 – 2002 the number of trips made by each of the gears listed in **Figure** 8.9. The table also shows the number of pounds landed, the total value and the price per pound. In each case it can be seen that flounder trawls and beach seines have a much greater CPUE than do gill nets, yet 88% of all trips that

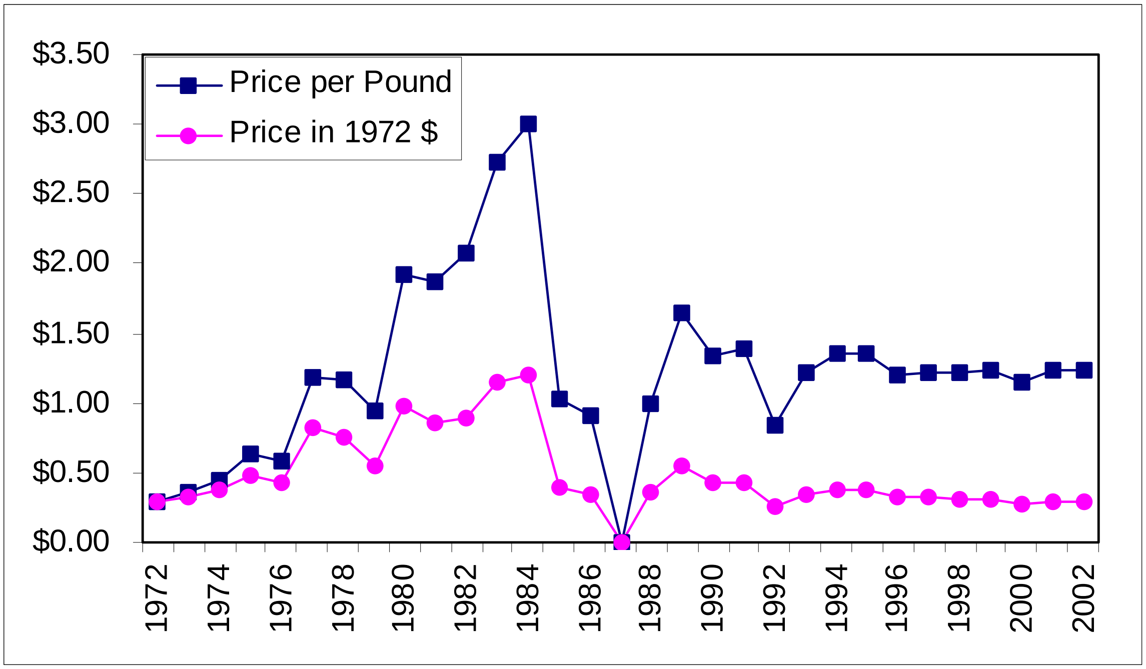


Figure 8.8. Price per pound by year for striped bass caught in the ocean, 1972 (courtesy of the NCDMF Trip Ticket Program)

Table 8.1 Number of participants in the Striped Bass Fishery by year, waterbody, and value of annual landings, 1994-2002 (NCDMF Trip Ticket Program). *Confidential data, included with the preceding category.

		Year									
Waterbody	Income Level	1994	1995	1996	1997	1998	1999	2000	2001	2002	Average
ASMA	<= $100.00	159	165	182	200	149	140	139	117	120	152
	$100.01 - $200.00	62	72	76	67	51	54	63	51	45	60
	$200.01 - $500.00	97	109	86	83	66	74	81	83	88	85
	$500.01 - $1,000.00	51	73	36	34	39	63	78	73	53	56
	$1,000.01 - $2,000.00	30	12	34	18	37	57	56	65	56	41
	> $2,000	4	0	4	3	13	13	21	25	34	13
	Total	403	431	418	405	355	401	438	414	396	407
Cent./So.	<= $100.00	61	117	105	202	173	123	146	108	94	125
	$100.01 - $200.00	23	25	28	26	38	35	37	35	30	31
	$200.01 - $500.00	24	17	35	31	37	50	34	42	39	34
	$500.01 - $1,000.00	9	7	19	13	10	13	18	12	23	14
		Year									
Waterbody	Income Level	1994	1995	1996	1997	1998	1999	2000	2001	2002	Average
	$1,000.01 - $2,000.00	6	*	7	*	*	5	*	*	7	6
	> $2,000	0	0	3	0	0	0	0	0	0	0

Table 8.1 (Continued)

Waterbody	Income Level		Year 1994	1995	1996	1997	1998	1999	2000	2001	2002	Average
		Total	123	166	197	272	258	226	235	197	193	207
Ocean	<= $100.00		23	46	23	21	24	13	11	20	10	21
	$100.01 - $200.00		6	21	6	30	11	3	9	28	21	15
	$200.01 - $500.00		10	39	5	34	28	18	11	57	89	32
	$500.01 - $1,000.00		10	38	16	54	44	34	18	47	51	35
	$1,000.01 - $2,000.00		8	33	7	33	57	70	23	48	107	43
	> $2,000		19	77	18	58	48	85	24	67	99	55
		Total	76	254	75	230	212	223	96	267	377	201

landed striped bass were using a gill net. Overall, there is very little difference in terms of the gear used on the average price per pound. **Table** 8.2 does not show inflation-adjusted amounts, but as can be seen in a comparison with **Figure**s 8.6 – 8.8, the average price per pound has followed a general downward trend.

Table**s** 8.3 to 8.5 show the gears that were used to land striped bass in the ASMA, CSMA, and ocean from 1996 – 2002. Gill nets accounted for the vast majority of landings in all water bodies for these years. The only other gear with significant landings was the use of beach seines in the ocean.

8.2.3 Marketing, Distribution, and Processing

Striped bass purchased by licensed dealers generally is sold fresh. By the time it gets to the consumer the vast majority of the fish have been processed into fillets. A few fish are sold whole, but as many of the individual fish are quite large, processing the fish into fillets is a matter of practicality as much as preference. A large percentage of the striped bass landed in North Carolina are destined for markets in the Northeast or Midwest US. In the past striped bass were frequently sold to consumers labeled as other kinds of fish. In recent years there has been a change towards selling striped bass under its own name, or simply as “rock fish”.

The price of striped bass is marked up about $.25 to $.35 per pound as it is handled by each of the middlemen prior to arriving on the consumer’s plate. Freight charges average $.10 per pound as the product moves from processor to processor. By the time it reaches a consumer in a large market such as New York or Chicago, the price per 8 ounce portion reaches approximately $6.00.

8.2.4 Economic Impact of Commercial Fishing

Historically, striped bass have provided a significant source of income for many fishermen, primarily for fishermen in the Albemarle Sound Management Area (refer to Section 8.1.1). Ocean landings through the mid 1970’s were also a significant source of income. Since the mid-1990’s landings from the ocean, once again are providing a significant source of income. Comparatively speaking, landings from Central/Southern internal waters have not provided more than about $125,000 total income in any given year.

Table 8.2. The average price per pound for striped bass (unadjusted for inflation) using different gears for the years 1994 – 2002 (NCDMF Trip Ticket Program).

		Beach Seine	Flounder Trawl	Gill Net	Haul Seine	Pound Net	All Other Gears	Total
1994	Trips	74	9	2,835	68	297	62	3,345
	Pounds	60,693	16,485	139,796	2,290	12,800	29,832	261,896
	Ave. pounds/trip	820	1,832	49	34	43	481	78
	Value	$81,936	$22,255	$188,725	$3,091	$17,279	$40,273	$353,559
	Price/pound	$1.35	$1.35	$1.35	$1.35	$1.35	$1.35	$1.35
1995	Trips	244	34	5,647	152	321	141	6,539
	Pounds	169,201	16,184	232,768	3,195	4,277	20,534	446,159
	Ave. pounds/trip	693	476	41	21	13	146	68
	Value	$229,943	$22,867	$315,741	$4,372	$5,706	$27,899	$606,528
	Price/pound	$1.36	$1.41	$1.36	$1.37	$1.33	$1.36	$1.36
1996	Trips	87	*	6,030	91	344	86	6,638
	Pounds	39,607	*	130,052	1,820	4,990	5,096	181,565
	Ave. pounds/trip	455	*	22	20	15	59	27
	Value	$47,243	*	$159,433	$2,199	$6,098	$6,211	$221,184
	Price/pound	$1.19	*	$1.23	$1.21	$1.22	$1.22	$1.22
1997	Trips	349	15	7,295	46	671	339	8,715
	Pounds	185,890	5,145	201,330	773	14,007	180,640	587,785
	Ave. pounds/trip	533	343	28	17	21	533	67
	Value	$224,619	$6,377	$242,605	$921	$15,654	$220,914	$711,090
	Price/pound	$1.21	$1.24	$1.21	$1.19	$1.12	$1.22	$1.21
1998	Trips	147	34	5,783	98	421	219	6,702
	Pounds	75,004	22,607	237,427	1,890	14,735	71,205	422,868
	Ave. pounds/trip	510	665	41	19	35	325	63
	Value	$93,980	$26,725	$293,087	$2,309	$18,829	$85,110	$520,040
	Price/pound	$1.25	$1.18	$1.23	$1.22	$1.28	$1.20	$1.23
1999	Trips	98	0	8,276	114	462	148	9,098
	Pounds	61,774	0	509,465	2,100	12,820	2,153	588,312
	Ave. pounds/trip	630	0	62	18	28	15	65
	Value	$76,394	$0	$627,337	$2,590	$15,866	$2,657	$724,844
	Price/pound	$1.24	$0.00	$1.23	$1.23	$1.24	$1.23	$1.23
2000	Trips	102	62	10,603	21	677	274	11,739
	Pounds	58,147	46,169	226,243	369	17,590	58,987	407,505
	Ave. pounds/trip	570	745	21	18	26	215	35
	Value	$67,177	$52,849	$261,363	$417	$20,627	$68,901	$471,334
	Price/pound	$1.16	$1.14	$1.16	$1.13	$1.17	$1.17	$1.16
2001	Trips	184	41	10,986	*	504	381	12,096
	Pounds	93,580	37,301	348,415	*	12,761	134,539	626,596
	Ave. pounds/trip	509	910	32	*	25	353	52
	Value	$120,037	$43,638	$429,355	*	$15,753	$163,121	$771,904
	Price/pound	$1.28	$1.17	$1.23	*	$1.23	$1.21	$1.23
2002	Trips	332	35	9,751	67	845	261	11,291
	Pounds	237,983	36,090	341,634	8,267	19,785	57,686	701,445
	Ave. pounds/trip	717	1031	35	123	23	221	62
	Value	$295,042	$43,308	$412,348	$9,896	$23,748	$70,707	$855,050
	Price/pound	$1.24	$1.20	$1.21	$1.20	$1.20	$1.23	$1.22

* Data are confidential

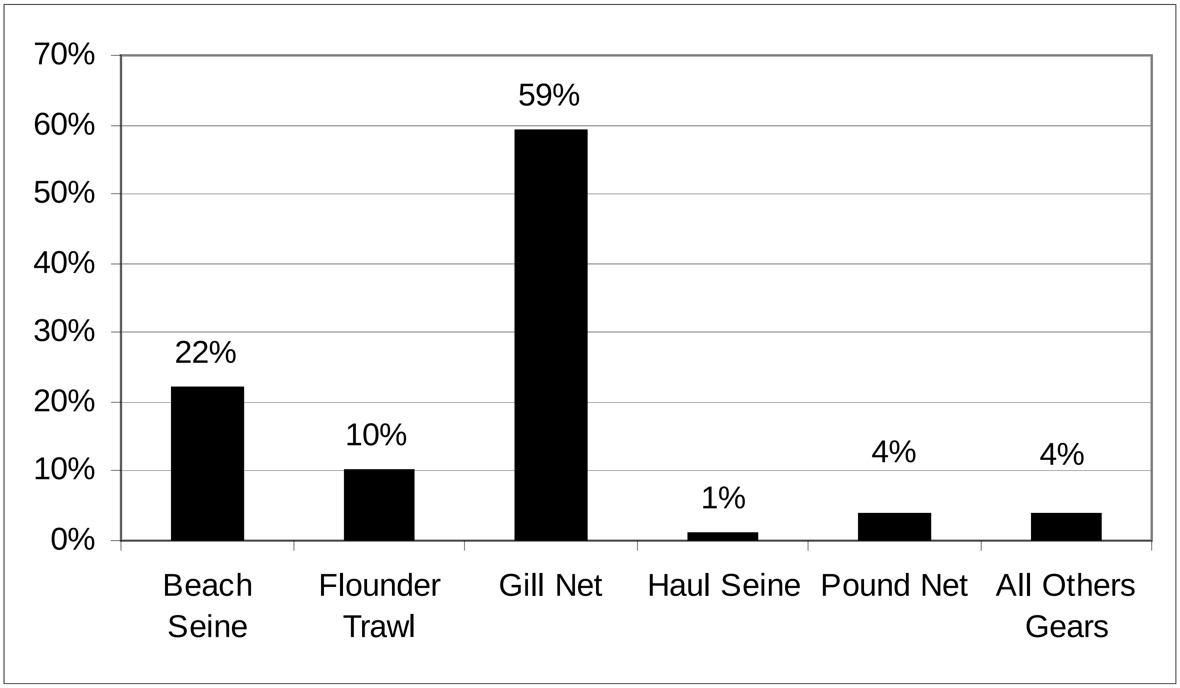


Figure 8.9. Percent of landings by gear used to harvest striped bass in all North Carolina waters, 1972 – 2002 (NCDMF Trip Ticket Program).

In 1999 a self-reported survey of ASMA commercial fishermen and seafood dealers was conducted by the DMF (Diaby, 2000). Except for those fishermen who operated vessels longer than 38 feet, the average ASMA finfish fisherman (includes those who target striped bass) reported an overall loss when subtracting annual costs from income. Striped bass accounted for approximately two percent of all seafood harvested from the ASMA sold by dealers.

8.3 Recreational Fishing

Annually, there are three survey programs in North Carolina that collect data from recreational striped bass anglers. **Figure** 8.10 shows the areas covered by these surveys. The Marine Recreational Fisheries Statistics Survey (MRFSS) collects data from the ocean landings of 0 – 3 mile from the coast and inside waters from part of the ASMA south to the SC border. Data are also collected up into the major river systems, but not far enough to cover the entire range where striped bass are caught. The DMF conducts the ASMA Creel survey during the spring and fall seasons. There is some overlap between the coverage areas of these two surveys. The WRC conducts surveys

Table 8.3 Striped bass landings and value by gears for the ASMA, 1997 – 2002 (NCDMF Trip Ticket Program).

	1997				
Gear	Value ($)	Pounds	Price/lb. ($)	Value in 1972 ($)	Price/lb. in 1972 ($)
Crab pot	660	549	1.20	171.94	0.31
Fyke net	495	440	1.12	128.85	0.29
Gill net (runaround)	249	201	1.24	64.76	0.32
Gill net set (float)	27,909	23,473	1.19	7,268.61	0.31
Gill net set (sink)	66,604	57,172	1.16	17,346.24	0.30
Haul seine	544	469	1.16	141.77	0.30
Pound net	14,851	13,359	1.11	3,867.78	0.29
Unknown & Conf.	535	459	1.17	139.46	0.30
Total or Average*	111,311	95,663	1.16	29,129.41	0.30

	1998				
Gear	Value ($)	Pounds	Price/lb. ($)	Value in 1972 ($)	Price/lb. in 1972 ($)
Crab pot	255.18	216	1.18	65.44	0.30
Fyke net	628.35	517	1.22	161.14	0.31
Gill net (runaround)	1,610.23	1,363	1.18	412.93	0.30
Gill net set (float)	27,121.50	21,928	1.24	6,955.04	0.32
Gill net set (sink)	107,858.35	83,502	1.29	27,659.20	0.33
Haul seine	2,309.26	1,890	1.22	592.19	0.31
Pound net	18,139.21	14,151	1.28	4,651.62	0.33
Unknown & Conf.	454.21	360	1.26	116.48	0.32
Total or Average*	157,922.07	123,567	1.28	40,614.01	0.33

	1999				
Gear	Value ($)	Pounds	Price/lb. ($)	Value in 1972 ($)	Price/lb. in 1972 ($)
Crab pot	180.85	147	1.23	45.37	0.31
Fyke net	873.07	705	1.24	219.05	0.31
Gill net set (float)	52,868.54	42,870	1.23	13,264.72	0.31
Gill net set (sink)	128,295.40	103,916	1.23	32,189.32	0.31
Haul seine	2,539.87	2,059	1.23	637.25	0.31
Pound net	15,857.75	12,813	1.24	3,978.71	0.31
Unknown & Conf.	452.23	365	1.24	113.46	0.31
Total or Average*	200,615.48	162,510	1.23	50,447.89	0.31

	2000				
Gear	Value ($)	Pounds	Price/lb. ($)	Value in 1972 ($)	Price/lb. in 1972 ($)
Crab pot	401.32	352	1.14	97.42	0.28
Fyke net	1,588.70	1,343	1.18	385.64	0.29
Gill net (runaround)	372.94	328	1.14	90.53	0.28
Gill net set (float)	29,816.18	25,929	1.15	7,237.58	0.28
Gill net set (sink)	194,531.58	167,758	1.16	47,220.60	0.28
Pound net	20,588.09	17,520	1.18	4,997.55	0.29
Unknown & Conf.	909.90	799	1.14	220.87	0.28
Total or Average*	247,298.80	213,230	1.16	60,250.18	0.28

	2001				
Gear	Value ($)	Pounds	Price/lb. ($)	Value in 1972 ($)	Price/lb. in 1972 ($)
Crab Pot	675	530	1.27	159.31	0.30
Fyke Net	3,258	2,648	1.23	768.84	0.29
Gill Net (Runaround)	1,289	1,107	1.16	304.15	0.27
Gill Net Set (Float)	39,504	31,179	1.27	9,322.98	0.30
Gill Net Set (Sink)	211,698	171,420	1.23	49,960.68	0.29
Pound Net	15,270	12,341	1.24	3,603.68	0.29
Unknown or Conf.	1,296	1,009	1.28	305.75	0.30
Total or Average	272,989	220,234	1.24	64,425.40	0.29

	2002				
Gear	Value ($)	Pounds	Price/lb. ($)	Value in 1972 ($)	Price/lb. in 1972 ($)
Crab Pot	139	127	1.09	32.26	0.25
Fyke Net	1,659	1,459	1.14	385.46	0.26
Gill Net (Runaround)	869	728	1.19	201.96	0.28
Gill Net Set (Float)	17,055	14,201	1.20	3,963.52	0.28
Gill Net Set (Sink)	222,172	184,101	1.21	51,632.69	0.28
Pound Net	22,993	19,156	1.20	5,343.67	0.28
Other	3,768	3,070	1.23	875.61	0.29
Total or Average	268,654	222,842	1.21	62,435.18	0.28

Table 8.4 Striped bass landings and value by gears for central/southern, 1997 – 2002 (NCDMF Trip Ticket Program.

	1997				
Gear	Value ($)	Pounds	Price/lb. ($)	Value in 1972 ($)	Price/lb. in 1972 ($)
Crab pot	303	245	1.24	78.93	0.32
Crab Trawl	58	47	1.24	15.17	0.32
Gill net (drift)	127	103	1.23	32.95	0.32
Gill net (runaround)	1,362	1,099	1.24	354.69	0.32
Gill net set (float)	13,855	11,273	1.23	3,608.41	0.32
Gill net set (sink)	17,824	14,792	1.20	4,642.16	0.31
Haul seine	377	304	1.24	98.14	0.32
Pound net	803	648	1.24	209.18	0.32
Rod-n-Reel	9	7	1.24	2.32	0.32
Swipe Net	3	3	1.24	0.81	0.32
Unknown & Conf.	389	314	1.24	101.27	0.32
Total or Average*	35,110	28,834	1.22	9,144.02	0.32

	1998				
Gear	Value ($)	Pounds	Price/lb. ($)	Value in 1972 ($)	Price/lb. in 1972 ($)
Crab pot	405	343	1.18	103.76	0.30
Crab Trawl	72	61	1.18	18.48	0.30
Gill net (drift)	94	80	1.18	24.08	0.30
Gill net (runaround)	153	130	1.18	39.23	0.30
Gill net set (float)	14,021	11,848	1.18	3,595.43	0.30
Gill net set (sink)	15,389	12,929	1.19	3,946.39	0.31
Pound net	690	584	1.18	176.93	0.30
Total or Average*	30,823	25,973	1.19	7,904.30	0.30

	1999				
Gear	Value ($)	Pounds	Price/lb. ($)	Value in 1972 ($)	Price/lb. in 1972 ($)
Crab pot	832	677	1.23	208.73	0.31
Gill net (drift)	18	15	1.23	4.63	0.31
Gill net (runaround)	267	217	1.23	66.98	0.31
Gill net set (float)	17,524	14,241	1.23	4,396.78	0.31
Gill net set (sink)	22,727	18,464	1.23	5,702.27	0.31
Haul seine	50	41	1.23	12.65	0.31
Pound net	9	7	1.23	2.16	0.31
Rod-n-Reel	310	252	1.23	77.87	0.31
Swipe Net	50	41	1.23	12.65	0.31
Unknown & Conf.	438	356	1.23	109.96	0.31
Total or Average*	42,227	34,311	1.23	10,594.68	0.31

	2000				
Gear	Value ($)	Pounds	Price/lb. ($)	Value in 1972 ($)	Price/lb. in 1972 ($)
Crab pot	974	854	1.14	236.38	0.28
Flynet	864	758	1.14	209.81	0.28
Gill net (drift)	64	56	1.14	15.59	0.28
Gill net (runaround)	176	148	1.20	42.80	0.29
Gill net set (float)	19,029	16,617	1.15	4,619.10	0.28
Gill net set (sink)	15,410	13,336	1.16	3,740.61	0.28
Pound net	79	70	1.13	19.26	0.28
Unknown & Conf.	1,008	884	1.14	244.66	0.28
Total or Average*	$37,605	32,723	1.15	9,128.22	0.28

Table 8.4 (Continued)

Gear	Value ($)	Pounds	Price/lb. ($)	Value in 1972 ($)	Price/lb. in 1972 ($)	Gear	Value ($)	Pounds	Price/lb. ($)	Value in 1972 ($)	Price/lb. in 1972 ($)
	2001						2002				
Crab Pot	484	389	1.25	114.30	0.29	Gill net (runaround)	5,884	4,904	1.20	1,367.54	0.28
Gill net (runaround)	309	269	1.15	73.01	0.27	Gill net set (float)	22,896	19,104	1.20	5,321.09	0.28
Gill net set (float)	16,138	13,509	1.19	3,808.55	0.28	Gill net set (sink)	11,123	9,289	1.20	2,584.94	0.28

Table 8.4 (Continued)

Gear	Value ($)	Pounds	Price/lb. ($)	Value in 1972 ($)	Price/lb. in 1972 ($)	Gear	Value ($)	Pounds	Price/lb. ($)	Value in 1972 ($)	Price/lb. in 1972 ($)
	1997						1998				
Gill net set (sink)	13,117	10,265	1.28	3,095.52	0.30	Pound net	755	629	1.20	175.42	0.28
Pound net	483	420	1.15	113.99	0.27	Other	4,388	3,660	1.20	1,019.75	0.28
Other	89	65	1.38	21.10	0.32	Total or Average*	45,046	37,586	1.20	10,468.73	0.28

Table 8.5. Striped bass landings and value by gears for the ocean, 1996-2002 (NCDMF Trip Ticket Program).

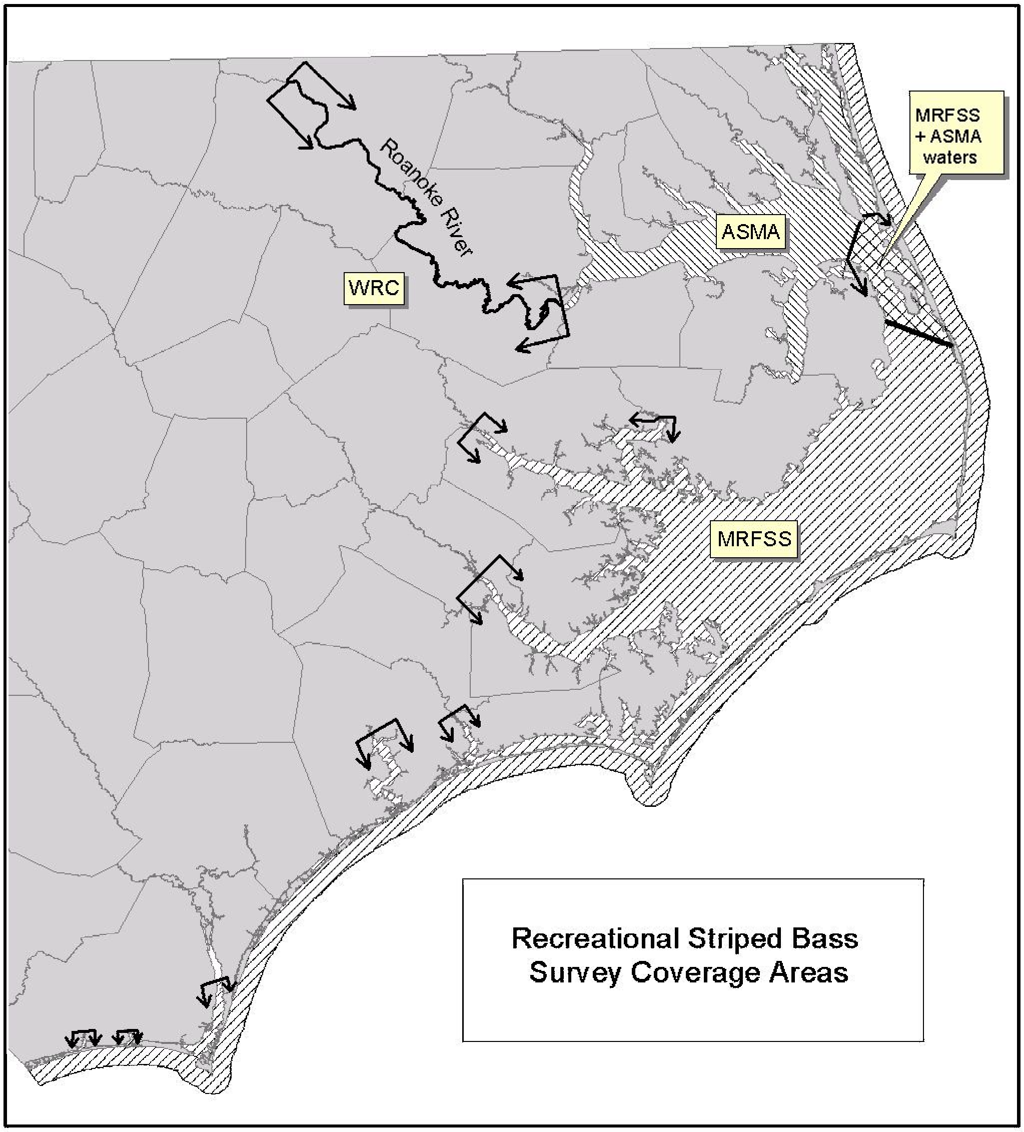
Gear	Value ($)	Pounds	Price/lb. $)	Value in 1972 ($)	Price/lb. in 1972 ($)	Gear	Value ($)	Pounds	Price/lb. ($)	Value in 1972 ($)	Price/lb. in 1972 ($)
	1997						1998				
Beach seine	224,619	185,890	1.21	58,499.73	0.31	Beach seine	93,980	75,004	1.25	24,100.21	0.32
Flounder trawl	6,377	5,145	1.24	1,660.88	0.32	Flounder trawl	26,725	22,607	1.18	6,853.30	0.30
Flynet	217,773	178,024	1.22	56,716.86	0.32	Flynet	83,210	69,637	1.19	21,338.39	0.31
Gill net set (sink)	114,344	92,948	1.23	29,779.83	0.32	Gill net set (sink)	126,540	105,395	1.20	32,449.91	0.31
Unknown & Conf.	1,409	1,137	$1.24	$367	$0.32	Unknown & Conf.	385	326	1.18	98.76	0.30
Total or Average*	564,523	463,144	$1.22	$147,024	$0.32	Total or Average*	330,840	272,969	1.21	84,840.58	0.31

Table 8.5. (Continued)

Gear	Value ($)	Pounds	Price/lb. $)	Value in 1972 ($)	Price/lb. in 1972 ($)	Gear	Value ($)	Pounds	Price/lb. ($)	Value in 1972 ($)	Price/lb. in 1972 ($)
			1999						2000		
Gear	Value ($)	Pounds	Price/lb. ($)	Value in 1972 ($)	Price/lb. in 1972 ($)	Gear	Value ($)	Pounds	Price/lb. ($)	Value in 1972 ($)	Price/lb. in 1972 ($)
Beach seine	76,394	61,774	1.24	19,167.15	0.31	Beach seine	67,218	58,147	1.16	16,316.49	0.28
Gill net set (sink)	405,566	329,685	1.23	101,756.55	0.31	Flounder trawl	52,867	46,169	1.15	12,832.96	0.28
Unknown & Conf.	28	23	1.23	7.10	0.31	Flynet	64,647	55,240	1.17	15,692.44	0.28
Total or Average*	481,988	391,482	1.23	120,930.79	0.31	Gill net set (sink)	2,366	2,072	1.14	574.38	0.28
						Unknown & Conf.	11	10	1.14	2.77	0.28
						Total or Average*	187,110	161,638	1.16	45,419.04	0.28
			2001						2002		
Gear	Value ($)	Pounds	Price/lb. ($)	Value in 1972 ($)	Price/lb. in 1972 ($)	Gear	Value ($)	Pounds	Price/lb. ($)	Value in 1972 ($)	Price/lb. in 1972 ($)
Beach Seine	120,037	93,580	1.28	28,328.73	0.30	Beach Seine	295,042	237,983	1.24	68,567.76	0.29
Flounder Trawl	43,638	37,301	1.17	10,298.61	0.28	Flounder Trawl	43,308	36,090	1.20	10,064.78	0.28
Flynet	157,319	129,898	1.21	37,127.19	0.29	Flynet	59,912	48,705	1.23	13,923.50	0.29

Table 8.5 (Continued)

			1997						1998		
Gear	Value ($)	Pounds	Price/lb. $)	Value in 1972 ($)	Price/lb. in 1972 ($)	Gear	Value ($)	Pounds	Price/lb. ($)	Value in 1972 ($)	Price/lb. in 1972 ($)
Gill Net Set (Sink)	144,193	117,965	1.22	34,029.48	0.29	Gill Net Set (Sink)	131,256	108,397	1.21	30,503.79	0.28
Unknown & Conf.	3,107	2,702	1.15	733.25	0.27	Unknown & Conf.	11,831	9,843	1.20	2,749.61	0.28
Total or Average*	468,293	381,446	1.23	110,517.26	0.29	Total or Average*	541,349	441,018	1.23	125,809.44	0.29



Lines and arrows define survey coverage areas.

Figure 8.10. Map of annual recreational fishing surveys conducted in North Carolina (NCDMF GIS Program.

landings in the Roanoke River both during their spring season, as
well as catch and release out of season for striped bass, during some years.

8.3.1 Historical Trends in Landings

Creel Survey. Since 1991 the DMF has conducted a recreational creel survey in the ASMA (see Table 8.6). The survey samples many fishermen throughout each season and then estimates the number of fish harvested, pounds harvested and the number of fish released.

In the earlier years of the survey (pre-1994), the season length was much longer with overall higher landings, but much smaller numbers of pounds harvested per day than in the years since 1994. There appears to be a statistically significant relationship ($r_{(18)} = -0.485$, $p < 0.05$) between the number of days in the season and the average weight of fish landed, with longer seasons resulting in a smaller average fish. For the years in which there are data, more fish were released than were harvested. It isn't clear whether fish were released because they were undersized, or because the fishermen had reached their bag limit.

MRFSS. The Marine Recreational Fisheries Statistics Survey (MRFSS) provides coverage of saltwater sport fishing (including estuarine and brackish water) from private/rental boats, charter and head boats, manmade structures, and the shore throughout North Carolina.

MRFSS data is collected by two independent, but complementary, surveys; 1) a telephone survey of households in coastal counties, and 2) an intercept (i.e. interview) survey of anglers at fishing access sites. Catch data are obtained from anglers intercepted by creel clerks stationed at fishing access sites. In North Carolina, access sites are recognized as any site where the likelihood of encountering marine species may exist. These sites do not extend much farther inland than the boundaries established for the coastal zone.

Only sites located in the eastern portion of the ASMA are covered through MRFSS sampling. These sites are located at Mann's Harbor, Manteo, Wanchese, Oregon Inlet, Kill Devil Hills, Kitty Hawk, and Southern Shores. Anglers intercepted at these sites fish primarily in Croatan, Roanoke, and Pamlico Sounds. Occasionally, anglers fishing in the most eastern section of Albemarle Sound near Mashoes Light are also intercepted. Additionally, MRFSS does not collect landings for striped bass in the Tar-Pamlico, Neuse, Trent, or Cape Fear rivers where there are known to be significant landings.

Table 8.7 shows landings estimates made by MRFSS for internal waters, and in the ocean. Furthermore, landings are displayed by mode of fishing, and year.

As might be expected, fish landed in the ocean tend to be heavier than those harvested from internal waters. MRFSS collection of striped bass landings began in 1988 when overall landings were low. Landings in these early years varied greatly from estimates of 264 fish in 1993 to 6,141 in 1988 and with no landings captured by MRFSS in 1990.

Table 8.6. Division of Marine Fisheries ASMA striped bass creel survey, 1991 – 2003 (NCDMF).

Season		Length in days	Fish harvested	Average number of fish harvested per day	Average weight of each fish harvested	Total pounds harvested	Average number of pounds harvested per day	Number of fish released	Average number of fish released per day
1991	Spring	120	9,978	83	2.5	24,561	205	11,701	98
	Fall	30	4,417	147	2.4	10,783	359	11,839	395
1992	Spring	120	8,034	67	2.9	23,582	197	13,167	110
	Fall	30	2,508	84	2.9	7,176	239	6,814	227
1993	Spring	77	11,404	148	3.2	36,049	468	13,241	172
	Fall	0	--	--	--	--	--	--	--
1994	Spring	12	4,005	334	3.5	14,087	1,174	no data	no data
	Fall	7	4,586	655	3.5	16,130	2,304	no data	no data
1995	Spring	9	4,240	471	4.1	17,355	1,928	no data	no data
	Fall	15	3,103	207	4.3	13,209	881	no data	no data
1996	Spring	8	4,374	547	3.4	14,851	1,856	no data	no data
	Fall	14	3,059	219	4.7	14,335	1,024	no data	no data
1997	Spring	5	4,941	988	3.5	17,315	3,463	6,111	1,222
	Fall	21	1,960	93	4.8	9,409	448	24,660	1,174
1998	Spring	18	9,310	517	3.3	30,709	1,706	25,060	1,392
	Fall	28	10,256	366	3.3	34,052	1,216	66,828	2,387
1999	Spring	37	10,137	274	3.6	36,970	999	32,742	885
	Fall	24	6,830	285	3.6	24,477	1,020	7,579	316
2000	Spring	67	13,993	209	3.7	51,428	768	23,205	346
	Fall	32	24,092	753	2.7	64,986	2,031	55,736	1,742
2001	Spring	53	17,582	332	2.7	47,448	895	16,737	316
	Fall	24	22,545	939	3.2	71,197	2,967	44,681	1,862
2002	Spring	52	17,989	346	3.3	59,297	1,140	20,502	394
	Fall	32	9,907	310	3.4	33,352	1,042	31,053	970
2003	Spring	61	8,937	147	3.4	30,141	494	14,283	234
Total		896	181,846	355	3.4	600,748	1,201	369,177	791

With the exceptions of 1998 and 2000, recreational landings of striped bass increased from the mid 1990’s through 2000.

Table 8.8 shows landings estimated by MRFSS for internal and ocean waters. MRFSS estimates show greater numbers of fish being harvested from internal waters than from the ocean. However, fish harvested from the ocean were much larger on average (~12.7 pounds) compared to fish from internal waters (~4.5 pounds). Part of this difference most certainly is due to the total size limit differences for fish from internal waters as opposed to those from the ocean. In years where there were no landings reported from a given location it is because the waters were closed to striped bass fishing.

WRC. The WRC estimates striped bass harvest from Roanoke River using an intensive creel survey when the springtime harvest season is open (usually mid-March through

Table 8.7. Recreational landings of striped bass, 1988 – 2002 (NC MRFSS).

Year	Mode of fishing	Area	Number landed	Pounds landed	Average weight/ fish
1988	Private/Rental	Ocean	367	972	2.6
		Internal	5,774	17,242	3.0
		Total	6,141	18,214	3.0
1989	Private/Rental	Internal	512	8,472	16.5
		Total	512	8,472	16.5
1990	No Landings				
1991	Beach/Bank	Ocean	391	3,882	9.9
		Total	391	3,882	9.9
1992	Beach/Bank	Ocean	967	16,197	16.7
	Private/Rental	Internal	350	586	1.7
		Total	1,317	16,783	12.7
1993	Beach/Bank	Ocean	264	3,029	11.5
		Total	264	3,029	11.5
1994	Beach/Bank	Ocean	3,758	53,739	14.3
	Private/Rental	Ocean	3,667	17,456	4.8
		Internal	504	857	1.7
		Total	7,929	72,052	9.1
1995	Manmade	Ocean	507	6,665	13.1
	Beach/Bank	Ocean	3,590	49,024	13.7
		Internal	1,255	5,441	4.3
	Charter	Ocean	654	9,183	14.0
		Internal	737	3,600	4.9
	Private/Rental	Ocean	6,699	93,226	13.9
		Internal	17,379	68,468	3.9
		Total	30,821	235,607	7.6
1996	Manmade	Ocean	1,908	17,630	9.2
	Beach/Bank	Ocean	6,970	84,258	12.1
		Internal	2,337	13,232	5.7
	Charter	Ocean	3,061	39,936	13.0
		Internal	465	1,556	3.3
	Private/Rental	Ocean	5,196	57,853	11.1
		Internal	14,456	70,609	4.9
		Total	34,393	285,074	8.3
1997	Manmade	Ocean	3,034	41,149	13.6
		Internal	1,450	5,329	3.7
	Beach/Bank	Ocean	11,451	133,261	11.6
	Charter	Ocean	5,385	84,412	15.7
		Internal	791	1,581	2.0
	Private/Rental	Ocean	27,282	349,156	12.8
		Internal	35,517	148,702	4.2
		Total	84,910	763,590	9.0
1998	Manmade	Ocean	1,105	16,076	14.5
		Internal	305	2,288	7.5
	Beach/Bank	Ocean	7,113	108,440	15.2
		Internal	1,006	6,237	6.2
	Charter	Ocean	5,364	90,678	16.9
		Internal	4,911	21,768	4.4
	Private/Rental	Ocean	17,098	200,392	11.7
		Internal	32,826	146,139	4.5
		Total	69,728	592,018	8.5
1999	Manmade	Ocean	302	3,272	10.8
	Beach/Bank	Ocean	4,623	54,996	11.9
	Charter	Ocean	5,201	60,968	11.7
		Internal	4,840	22,818	4.7
	Private/Rental	Ocean	36,672	437,686	11.9
		Internal	40,059	178,729	4.5
		Total	91,697	758,469	8.3
2000	Manmade	Ocean	933	6,378	6.8
	Beach/Bank	Ocean	1,768	23,627	13.4
	Charter	Ocean	4,418	89,654	20.3
		Internal	1,165	3,807	3.3
	Private/Rental	Ocean	5,074	69,475	13.7
		Internal	25,023	127,051	5.1
		Total	38,381	319,992	8.3
2001	Manmade	Ocean	4,404	10,276	2.3
		Internal	628	3,016	4.8
	Beach/Bank	Ocean	7,317	130,437	17.8
		Internal	3,215	11,076	3.4
	Charter	Ocean	2,671	47,077	17.6
		Internal	1,637	9,107	5.6
	Private/Rental	Ocean	25,623	420,827	16.4
		Internal	20,145	88,521	4.4
		Total	65,640	720,337	11.0
2002	Manmade	Ocean	1,493	24,447	16.4
	Beach/Bank	Ocean	3,820	62,697	16.4
	Charter	Ocean	2,900	54,363	18.7
		Internal	3,198	13,979	4.4
	Private/Rental	Ocean	25,397	461,079	18.2
		Internal	23,484	95,459	4.1
		Total	60,292	712,024	11.8
		Grand Total	492,416	4,509,543	9.2

April). The WRC uses all of its allowable harvest (112,500 lbs. in 2001) during the spring season whereas DMF allots half their allowable harvest in Albemarle Sound during the spring and the remainder during the fall. The WRC estimates the numbers of

Table 8.8. Recreational striped bass landings from wat4ers surveyed by MRFSS (courtesy NC MRFSS).

	Ocean		Internal	
Year	Number landed	Pounds landed	Number landed	Pounds landed
1988	367	972	5,774	17,242
1989	0	0	512	8,472
1990	0	0	0	0
1991	391	3,882	0	0
1992	967	16,197	350	586
1993	264	3,029	0	0
1994	7,425	71,195	504	857
1995	11,450	158,098	19,371	77,509
1996	17,135	199,677	17,258	85,397
1997	47,152	607,978	37,758	155,612
1998	30,680	415,586	39,048	176,432
1999	46,798	556,922	44,899	201,547
2000	12,193	189,134	26,188	130,858
2001	40,015	608,517	25,625	111,720
2002	33,610	602,586	26,682	109,438
Total	214,837	2,831,187	217,287	966,232

striped bass caught and released during the harvest season (**Table** 8.9). In addition, there are some data for a few years in which the WRC monitored the catch & release fishery after the harvest season closed.

Table 8.9. Recreational fishing trips landing striped bass from the Roanoke River (courtesy NC WRC).

		Open Harvest			Post Harvest Period			
Year	Number of fish	Weight	Number of hrs. fished	Number of trips	Number of fish	Weight	Number of hrs. fished	Number of trips
1989	153,185	32,034	46,566	9,803	*	*	*	*
1990	106,073	42,108	56,169	11,825	*	*	*	*
1991	26,934	72,365	74,596	15,704	*	*	*	*
1992	13,372	35,935	49,277	10,374	*	*	*	*
1993	14,325	45,043	52,932	11,144	*	*	*	*
1994	8,284	28,026	44,693	9,409	*	*	*	*
1995	7,471	28,818	56,456	11,885	52,698	*	20,639	4,345
1996	8,367	28,114	46,164	9,719	148,222	*	32,743	6,893
1997	9,364	29,929	23,139	4,871	271,328	*	47,001	9,895
1998	23,109	73,374	72,410	15,244	102,299	*	26,367	5,551
1999	22,479	72,813	72,717	15,309	113,394	*	30,633	6,449
2000	38,206	119,841	95,622	20,131	*	*	*	*
2001	35,231	112,567	100,119	21,078	*	*	*	*
2002	36,422	112,698	122,584	25,807	*	*	*	*

* no data

8.3.2 Recreational Fishing Activity

The DMF creel survey estimates anglers targeted striped bass for approximately 60,370 hours of in the fall of 2001 in the areas of the ASMA surveyed. This estimate is determined by analysis of the number of interviews completed, angler success rates and a trailer counting survey at ramps. The majority of fishermen interviewed lived in the county where they were fishing. Nearly all the other fishermen were from surrounding counties. Counties closer to the Virginia border were more likely to have fishermen who traveled from there to fish.

The MRFSS survey did not capture any fishermen who targeted striped bass in the years prior to 1991. In subsequent years, anglers who target striped bass in internal waters were more likely to use privately owned or rented boats. Anglers who target striped bass in the ocean were more likely to fish from a beach or a manmade structure such as a pier. Approximately 1.5-2.0% of trips in the areas where MRFSS data are collected target striped bass. It was estimated that 368,473 striped bass trips were taken in internal waters and 964,030 striped bass trips were taken in ocean waters between 1991 and 2002 (**Table** 8.10). Of significant interest is a trend towards an increased percent of internal charter trips that target striped bass. Prior to 1995,

MRFSS captured no internal waters charter trips that targeted striped bass. In 1995, almost 16% of these trips reported targeting striped bass. It increased each year until it peaked at 62% in 1999. MRFSS estimates there are over 1,000 of these trips a year.

The WRC collects data on the number of hours anglers fish for striped bass. It uses a conversion factor of 4.75 hours to determine the number of trips taken. **Table** 8.9 shows these data. In the years of 1989 to 1996, the number of trips taken by anglers to reach the quota of striped bass was between, 9,400, and 15,700. In 1997, there was a smaller quota and it was reached in fewer than,4,900 trips. From 1998 to 2001, the quota increased each year. Consequently the number of trips made before the quota was reached was from 15,200 in 1998 to a high of 21,000 in 2001.

8.3.3 Economic Value of the Recreational Fishery

There has been one study (Schuhmann, 1999) that measured the value of the recreational fishery and it only included the Roanoke River areas covered by the WRC creel survey. Economic value was determined using a willingness to pay analysis and a measurement of actual expenditures. Anglers were separated into two groups: catch and release vs. catch and keep. The economic value of the fishery was determined as "the benefits realized by the recreational anglers over and above the actual expenditures" (Schuhmann, 1999). Overall willingness to pay to catch a fish was determined to be in the range of $796,500 - $814,000 (in 1998 dollars), with 95% of that amount coming from the catch and release fishery. The reason for this difference is because catch and keep anglers are limited to the number of fish they can land and keep. Catch and release anglers do catch more fish and according to the survey, are willing to spend more money to catch each fish.

Anglers who participate in catch and release incurred approximately $70 in expenses per trip while the average catch and keep angler incurred $22 in additional expenses. Average additional expenses are shown in **Table** 8.11. When the data are aggregated across all fishermen, these expenditures amounted to approximately $918,000 in revenues that may have been realized by local businesses.

Table 8.10. Recreational fishing trips targeting striped bass (courtesy NC MRFSS).

		Internal			Ocean		
Year	Mode	Number of Angler Trips	Percent Targettting Striped Bass	Potential Striped Bass Trips	Number of Angler Trips	Percent Targettting Striped Bass	Potential Striped Bass Trips
1987	Beach/Bank	272,547	0.00%	0	1,282,990	0.00%	0
	Charter	1,118	0.00%	0	132,255	0.00%	0
	Manmade	189,328	0.00%	0	610,093	0.00%	0
	Private/Rental	584,997	0.00%	0	788,608	0.00%	0
	Total	1,047,990	0.00%	0	2,813,946	0.00%	0
1988	Beach/Bank	117,997	0.00%	0	1,594,380	0.00%	0
	Charter	801	0.00%	0	130,854	0.00%	0
	Manmade	128,097	0.00%	0	1,282,470	0.00%	0
	Private/Rental	598,248	0.00%	0	910,049	0.00%	0
	Total	845,143	0.00%	0	3,917,753	0.00%	0
1989	Beach/Bank	147,466	0.00%	0	1,510,930	0.00%	0
	Charter	2,234	0.00%	0	90,670	0.00%	0
	Manmade	114,228	0.00%	0	710,187	0.00%	0
	Private/Rental	625,060	0.00%	0	648,120	0.00%	0
	Total	888,988	0.00%	0	2,959,907	0.00%	0
1990	Beach/Bank	78,636	0.00%	0	1,394,330	0.00%	0
	Charter	925	0.00%	0	86,215	0.00%	0
	Manmade	99,665	0.00%	0	753,066	0.00%	0
	Private/Rental	713,295	0.00%	0	741,800	0.00%	0
	Total	892,521	0.00%	0	2,975,411	0.00%	0
1991	Beach/Bank	88,772	0.00%	0	1,408,510	1.32%	18,592
	Charter	665	0.00%	0	96,154	0.00%	0
	Manmade	84,849	0.00%	0	932,802	0.03%	280
	Private/Rental	495,460	0.04%	198	655,183	0.00%	0
	Total	669,746	0.03%	198	3,092,649	0.61%	18,872
1992	Beach/Bank	29,032	0.00%	0	1,743,990	0.42%	7,325
	Charter	2,017	0.00%	0	93,002	0.00%	0
	Manmade	188,409	0.00%	0	947,156	0.00%	0
	Private/Rental	638,441	0.39%	2,490	729,955	0.25%	1,825
	Total	857,899	0.29%	2,490	3,514,103	0.26%	9,150
1993	Beach/Bank	58,305	0.00%	0	1,774,230	1.03%	18,275
	Charter	1,249	0.00%	0	129,680	0.00%	0
	Manmade	188,336	0.00%	0	1,128,100	0.05%	564
	Private/Rental	726,294	0.13%	944	709,890	0.09%	639
	Total	974,184	0.10%	944	3,741,900	0.52%	19,478
1994	Beach/Bank	104,006	0.00%	0	1,800,290	2.07%	37,266
	Charter	4,834	0.00%	0	181,354	0.00%	0
	Manmade	248,038	0.86%	2,133	1,347,660	0.06%	809
	Private/Rental	743,197	0.42%	3,121	740,757	0.57%	4,222
	Total	1,100,075	0.48%	5,255	4,070,061	1.04%	42,297
1995	Beach/Bank	106,192	3.66%	3,887	2,038,150	3.27%	66,648
	Charter	4,617	15.79%	729	209,621	0.38%	797
	Manmade	277,908	0.63%	1,751	1,155,020	0.16%	1,848
	Private/Rental	587,485	3.94%	23,147	727,681	1.96%	14,263
	Total	976,202	3.02%	29,513	4,130,472	2.02%	83,555
1996	Beach/Bank	172,241	2.09%	3,600	1,693,000	4.18%	70,767
	Charter	2,102	16.67%	350	238,868	0.52%	1,242
	Manmade	207,610	2.45%	5,086	1,037,450	2.49%	25,833
	Private/Rental	829,994	2.51%	20,833	560,559	2.93%	16,424
	Total	1,211,947	2.46%	29,870	3,529,877	3.24%	114,266
1997	Beach/Bank	92,523	0.86%	796	1,680,360	6.58%	110,568
	Charter	4,381	22.58%	989	291,439	1.00%	2,914
	Manmade	243,311	2.48%	6,034	1,009,410	1.35%	13,627
	Private/Rental	869,823	4.35%	37,837	700,266	4.30%	30,111
	Total	1,210,038	3.77%	45,656	3,681,475	4.27%	157,221
1998	Beach/Bank	104,719	6.65%	6,964	1,341,900	4.58%	61,459
	Charter	10,344	39.15%	4,050	230,657	1.08%	2,491
	Manmade	274,912	6.50%	17,869	860,918	2.11%	18,165
	Private/Rental	1,030,340	4.96%	51,105	607,675	3.61%	21,937
	Total	1,420,315	5.63%	79,988	3,041,150	3.42%	104,053
1999	Beach/Bank	78,502	2.48%	1,947	1,381,070	2.23%	30,798
	Charter	4,242	62.16%	2,637	217,127	2.10%	4,560
	Manmade	166,592	0.79%	1,316	846,944	0.56%	4,743
	Private/Rental	971,833	4.03%	39,165	888,731	4.44%	39,460
	Total	1,221,169	3.69%	45,065	3,333,872	2.39%	79,560
2000	Beach/Bank	63,917	1.96%	1,253	2,072,370	3.44%	71,290
	Charter	2,715	35.62%	967	180,504	0.82%	1,480
	Manmade	318,728	3.16%	10,072	1,347,020	0.48%	6,466
	Private/Rental	1,105,420	2.62%	28,962	1,000,310	1.31%	13,104
	Total	1,490,780	2.77%	41,254	4,600,204	2.01%	92,339
2001	Beach/Bank	100,435	10.62%	10,666	1,813,766	4.50%	81,619
	Charter	4,755	31.46%	1,496	196,976	0.88%	1,733
	Manmade	321,056	4.24%	13,613	1,511,237	0.21%	3,174
	Private/Rental	1,287,829	1.97%	25,370	881,096	4.02%	35,420
	Total	1,714,075	2.98%	51,145	4,403,075	2.77%	121,947
2002	Beach/Bank	132,685	0.00%	0	702,515	2.77%	19,460
	Charter	6,910	13.54%	936	176,353	1.77%	3,121
	Manmade	156,305	0.00%	0	1,359,224	0.44%	5,981
	Private/Rental	1,238,365	2.92%	36,160	702,515	13.20%	92,732
	Total	1,534,265	2.42%	37,096	2,940,607	4.12%	121,294
	Location Total	18,055,337	2.04%	368,473	56,746,462	1.70%	964,030

Table 8.11. Expenditures by recreational striped bass anglers on the Roanoke River, 1998 (Schumann, 1999)

	Catch and release ($) (n=146)	Catch and keep ($) (n=213)
Lodging	8.83	1.08
Bait	7.37	5.65
Fuel	5.03	4.08
Guide	38.77	3.02
Other	9.55	7.00
Total	69.55	21.83

8.4 Demographic Characteristics

8.4.1 Commercial Fishermen

There is no source of sociodemographic data of commercial fishermen who specifically target striped bass. Johnson and Orbach (1996) provide a statewide summary of commercial fisherman characteristics. Their results are very similar to the findings of Diaby (2000) which states that in some ways such as income level, the demographic profile of ASMA fishermen is not unlike that of the typical North Carolina worker. As shown in **Table** 8.12, ASMA fishermen averaged about 43 years old. However, only about 6% of commercial fishermen were 65 or older compared to 12% of all workers in North Carolina. The average fisherman has been working commercially for 13 years. Eighty-seven percent of the fishermen have less than 20 years experience. Two thirds of them fish full-time.

Table 8.12. Socioeconomic profile of ASMA survey respondents, 1998 (Diaby, 2000).

Characteristics	**Fishermen (n=114)**	**State population**[1]
Fisherman status		N/A
Full-time	66.4%	
Part-time	33.6%	
Age		
Under 20		27.5%
20-34	27.7%	23.1%
35-44	29.4%	15.3%
45-54	24.4%	13.7%
55-64	12.6%	8.5%
65 and over	5.9%	12.0%
Years of experience in commercial fishing		N/A
Less than 1		
1-5	13.4%	
5-10	31.1%	
10-20	42.9%	
20-30	9.2%	
30-40	3.4%	
40 and over		
Gender		
Male	97.5%	49.7%
Female	2.5%	50.3%
Marital status (Married)	65.5%	45.0%

Table 8.12. (Continued)

Characteristics	Fishermen (n=114)	State population[1]
Ethnicity		
Caucasian	93.3%	73.4%
African-American		22.2%
Native American		1.6%
Asian or Asian-American	6.7%	1.2%
Latino or Hispanic-American		1.6%
Education		
Less than high school	0.8%	38.9%
High school graduate	52.1%	25.8%
Some college	30.3%	19.2%
College graduate	13.4%	11.8%
Graduate school or Professional degree	3.4%	4.4%
Characteristics	**Fishermen (n=114)**	**State population[1]**
Household income		
Under $15,000	10.2%	12.4%
$15,000-29,999	28.7%	23.0%
$30,000-49,999	34.3%	24.3%
$50,000-74,999	13.9%	20.5%
$75,000-99,999	12.0%	10.4%
$100,000 and over	1.9%	9.6%
Average percent of household income from commercial fishing	66.6%	N/A

[1] Current Population Survey 1998, March Supplement, Office of State Planning, Office of the Governor.

The vast majority of fishermen are men, with only 2.5% of respondents being female. Two thirds are married. The fishermen were also overwhelmingly Caucasian. Asian-Americans made up 6.7% of the respondents. No other racial or ethnic groups were interviewed.

The average ASMA fisherman interviewed was better educated than the average North Carolinian with over 50% being high school graduates and approximately 47% having had at least some college or one or more college degrees. Households with a commercial fisherman on average rely on fishing for two thirds of the total household income.

8.4.2 Recreational Fishermen

Of the three sources of data for recreational fishing activity, only the NC MRFSS routinely collects sociodemographic data on anglers (**Table** 8.13). Of those anglers who targeted striped bass in 1999 in the ASMA, only male anglers were intercepted. In addition, anglers in the ASMA tended to be older than anglers who fished in other areas. Anglers who fished in the ASMA or ocean, and targeted striped bass were more likely to be North Carolina residents. Those who targeted striped bass and fished in internal waters other than the ASMA and surveyed by MRFSS were more likely to be anglers who resided in other states.

Table 8.13. Sociodemographic characteristics of striped bass anglers, 1999 (courtesy of NC MRFSS).

Percent distribution by age, gender and area fished

	AREA								
	ASMA			INLAND OTHER			OCEAN		
Age	Male	Female	ALL	Male	Female	ALL	Male	Female	ALL
5 to 15				3.6	37.5	11.1	2.3		2.2
16 to 25				3.6		2.8			
26 to 35	17.9		17.9	21.4	12.5	19.4	25.3	20	25
36 to 45	14.3		14.3	32.1	25	30.6	31	40	31.5
46 to 55	25		25	32.1	12.5	27.8	18.4	40	19.6
56 to 65	32.1		32.1	3.6	12.5	5.6	19.5		18.5
65 and older	10.7		10.7	3.6		2.8	3.4		3.3

Percent distribution in-state/out of state residency by area fished

ASMA		INLAND OTHER		OCEAN	
In-State	Out State	In-State	Out State	In-State	Out State
82.1	17.9	35	65	63.9	36.1

9.0 ENVIRONMENTAL STATUS

9.1 Habitat

9.1.1 Essential Fish Habitat

Striped bass which inhabit coastal rivers and estuaries in North Carolina exhibit two differing life history strategies. Some portion of the Roanoke River stock is unquestionably migratory (based on tag returns), with mature adults residing in the Atlantic Ocean, returning to the river to spawn in the spring, and migrating back to the ocean for the summer and fall months. Based on the numbers of striped bass observed in the river in the aftermath of a late July, 1995 fish kill (Kornegay and Jones 1995), as well as anecdotal reports of large, mature striped bass captured in late summer in the Roanoke Rapids Dam tailrace (Ben Ricks, Roanoke Rapids, NC, personal communication, March 5, 2003), there may be some portion of the A/R stock which is resident in the river and Albemarle Sound estuary on a year-round basis. All other stocks which spawn in North Carolina waters apparently reside in their natal rivers and/or adjacent estuaries for their entire life cycle, using the lower river and estuarine waters as adult habitat (Raney 1957).

Both striped bass life history strategies (migratory or resident) evident in coastal North Carolina necessitate use of river segments with sufficiently flowing waters for spawning; riverine and estuarine nursery habitat for egg, larval and early juvenile stages; and estuarine, as well as oceanic, habitats for subadults and mature adult fish. For the purposes of this discussion, subadult striped bass are those which have grown beyond the early juvenile age (arbitrarily set for this discussion as age 1) but have not yet reached sexual maturity (which occurs at ages 2-3 for males and 4-5 for females). Adults are fish which have reached sexual maturity.

Striped bass habitats that occur within the jurisdiction of state fishery management agencies include the **water column** of riverine spawning areas; and **water column** of riverine and estuarine nursery areas and residence areas for subadult and adult fish in the rivers, sounds and nearshore Atlantic Ocean from the beach to three miles oceanward. Larval and juvenile striped bass also occasionally may use habitats such as **soft bottom**, **submerged aquatic vegetation, shell bottom, ocean hard bottom** and **wetlands**. Migratory adults also may use water column, **soft bottom** and ocean hard bottom habitat located in federal waters over three miles from shore (USFWS, unpublished data). Habitat terms in bold type in this text are defined in the Coastal Habitat Protection Plan (CHPP) (DMF, in preparation) as follows:

Water column
The water covering a submerged surface and its physical, chemical and biological characteristics.

Soft bottom
Areas of primarily unvegetated, unconsolidated sediment (particles smaller than rocks) beneath the water column not within other categories below.

Submerged aquatic vegetation
Habitat dominated by one of more species of submerged rooted vascular plants or macroalgae.

Shell bottom
Bottom composed of oyster shell, live oysters, and other estuarine shell-building organisms that are discrete, contiguous and clearly distinguishable from scattered shells in marshes and mudflats.

Ocean hard bottom
Exposed areas of rock or consolidated sediments that may or may not be characterized by a thin covering of live or dead animals, generally located in the ocean rather than an estuary.

Wetlands
Section 404 of the Federal Water Pollution Control Act defines wetlands as: “areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in wet soil conditions.” Fish habitat wetlands are adjacent to, or periodically flooded by riverine or coastal waters.

Successful restoration, recovery and maintenance of striped bass populations in all coastal river systems cannot occur unless the extent and quality of all the required habitats are maintained. Parameters which are important for defining the quality of habitats used by striped bass and their prey include dissolved oxygen (DO), temperature, salinity, current velocity, flow delivery pattern and timing (for spawning reaches), and prey abundance. In-stream oxygen concentrations greater than 5 milligrams per liter (mg/l) are recommended for all life stages of striped bass (Setzler-Hamilton and Hall 1991, Funderburk et al. 1991).

Striped bass are recorded from all of North Carolina's coastal river ecosystems (Menhinick 1991). Coastal basins with historical or potential striped bass spawning, nursery and adult/subadult habitats which are situated wholly or primarily in North Carolina are: Albemarle Sound, including its tributaries, the major ones being the Chowan and Roanoke Rivers; Pamlico Sound with its tributaries, with the Neuse and Tar/Pamlico Rivers the largest; the Newport River; the White Oak River; the New River; the Cape Fear and Northeast Cape Fear Rivers and estuary; and the Shallotte River. Additional rivers which enter the Atlantic Ocean in South Carolina also host striped bass and some spawning and nursery habitats for these populations are present in North Carolina. These include the Pee Dee River system and its Waccamaw and Lumber River tributaries.

Habitat requirements for all life stages of migratory and coastal resident striped bass are generally summarized in Hill et al. (1989) and Bain and Bain (1982). A general discussion of the habitat requirements of each striped bass life stage, which borrows liberally from those reports, is provided in the following sections. Localities and attributes of particular striped bass habitats in individual North Carolina river/estuary systems or portion thereof are documented in specific references for each system as indicated in the text following the general habitat descriptions.

9.1.1.1 Spawning Habitat

Striped bass spawn in inland reaches of Atlantic slope drainage North Carolina rivers where water temperatures, dissolved oxygen and flows are adequate for maintaining the semi-buoyant eggs in suspension and providing for proper development and hatching. Historically, in the absence of dams, striped bass migrated well into the Piedmont physiographic province. At present, dams on most of the major rivers [Meherrin (at Emporia, VA), Roanoke (Roanoke Rapids, Gaston and Kerr Dams), Tar-Pamlico (Rocky Mount Mills), Neuse (Milburnie and Falls Dams near Raleigh), Cape Fear (Lock and Dams Numbers 1-3) and Pee Dee (Blewett Falls near Rockingham, NC, and five other adjacent upstream dams)] (**Figure** 9.1 and 9.2) confine spawning to those reaches located at the lower end of the Fall Zone. Since 1998, the Quaker Neck Dam and other small dams in the Neuse River drainage have been removed, and passage is planned for other dams (Lock and Dam No. 1 on the Cape Fear). Dam removal or provision of passage will reestablish access to historic striped bass spawning areas.

Striped bass spawning in North Carolina rivers use the water column of fresh or nearly fresh portions of the rivers, with specific locations in individual rivers ranging as far inland as the Fall Zone (historically well above the Fall Zone, for example see Jenkins and Burkhead 1993) to portions much closer to the river mouth. Hill et al. (1989) report that preferred areas are shallow (0.3 to 6.1 m) and often turbid, extending from the tidal zone upstream as far as 320 km. Spawning sites in the southeastern Atlantic Coastal

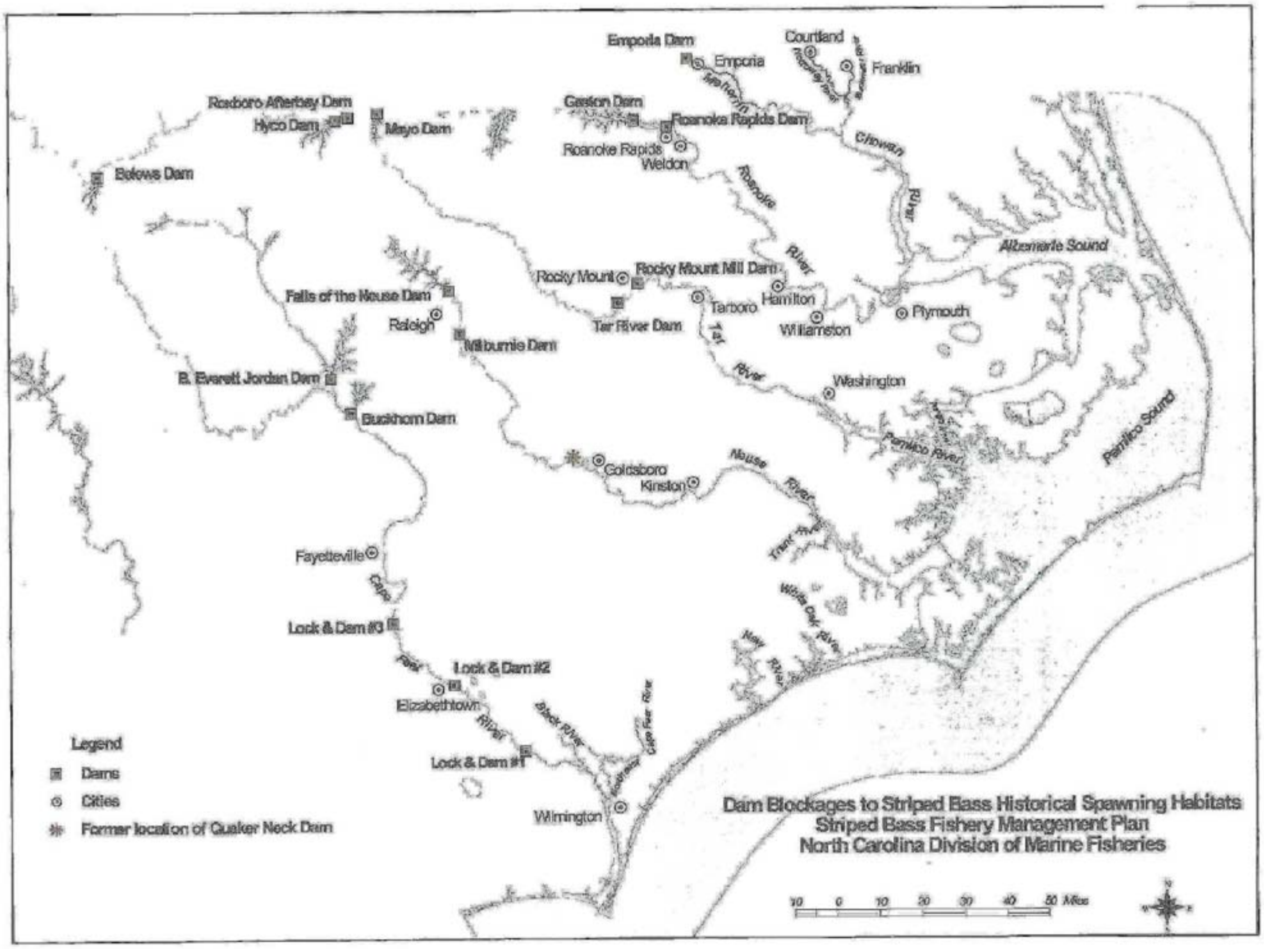


Figure 9.1. Dam blockages to striped bass historical spawning habitats in North Carolina.

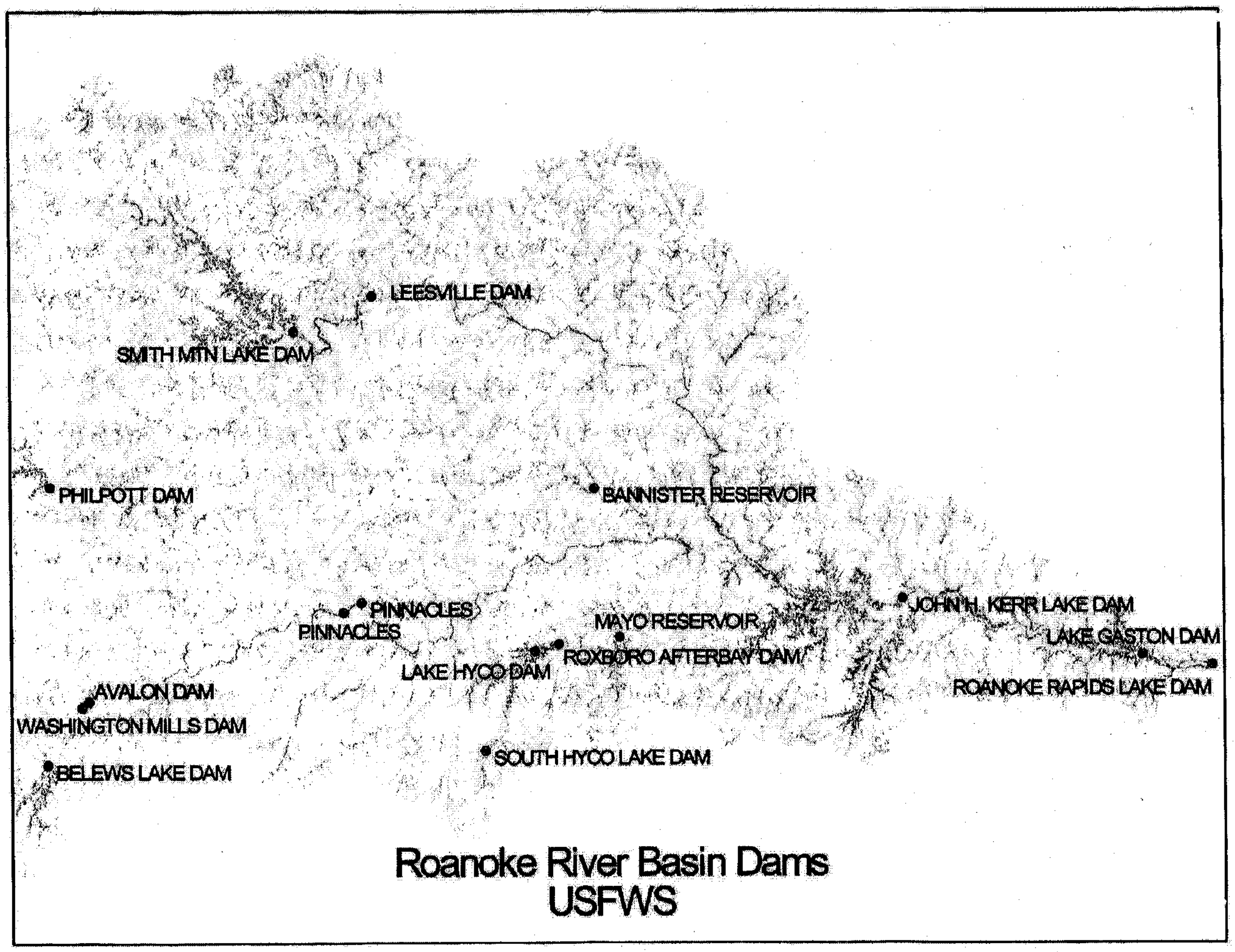


Figure 9.2. Dams within the Roanoke River basin, North Carolina and Virginia.

Plain were reported as often in the downstream portions of river systems, typically in reaches within 60 km of the coast.

Striped bass stocks which spawn in the inland portions of rivers requires water column habitat with appropriate patterns and volumes of freshwater discharge before and during spawning season (Bain and Bain 1982). The Habitat Suitability Index (HIS) model developed for coastal stocks of striped bass assumes that 100 percent of the natural river discharge will provide optimal spawning conditions (Bain and Bain 1982). River discharge above the average is believed to reduce habitat suitability; however it has been speculated that on the Roanoke and other NC rivers with broad floodplains located downstream of spawning grounds, eggs, larvae and early juveniles may be transported into adjacent wetlands where higher mortality may occur. Specific current velocities are required to suspend eggs in the water column during incubation. Minimum velocities of about 30 cm/sec are generally required (Albrecht 1964). Velocity required by different stocks may vary due to differences in egg buoyancy.

9.1.1.2 Nursery Habitats (eggs, larvae, early juveniles)

Nursery habitat for striped bass eggs, larvae and early juveniles (age less than a year) in North Carolina rivers consists of the water column habitat in river channels downstream from the spawning areas, and water column, soft bottom, submerged aquatic vegetation and wetlands of river deltas at the river moths, and in adjacent estuaries.

As noted above, eggs require minimum current velocities of about 30 cm/sec for suspension in the water column during incubation, but differences in egg buoyancy among spawning stocks may dictate different current velocity requirements (Albrecht 1964, Hill et al. 1989). Eggs which settle to the bottom may still hatch, provided substrates are relatively coarse (Bayless 1968).

Striped bass larvae pass through three development stages (yolk-sac 5-8 mm TL, fin fold 8-12 mm TL, and post fin fold 13-30 mm TL) all of which inhabit the water column of riverine systems downstream of the spawning reaches. Hill et al. (1989) report that little is known about microhabitat requirements of larvae in the wild. In natural waters, yolk-sac larvae apparently sink between efforts to swim, and turbulence may be required to keep them suspended in some waters (Pearson 1938, Mansueti 1958, Dickson 1958 and Barkuloo 1970 as cited in Hill et al. 1989). Density of yolk-sac larvae varied significantly with time of day and depth in the Potomac River (Boynton et al. 1977). Fin fold larvae have been reported to form schools and migrate inshore at 13-14 mm (Raney 1952, Texas Instruments, Inc. 1974). In Chesapeake Bay, fin fold and larger larvae were collected in mid-channel areas near the bottom (Kernehan et al. 1981). Several studies have demonstrated a downstream movement of early larval states, but it is unknown whether this is due to passive drift or a directed migration (Texas Instruments, Inc. 1974, Polgar et al. 1975, Mihursky et al. 1976). Other studies have indicated either little movement from the spawning area, an upstream migration (Setzler-Hamilton et al. 1981), or that larvae remain in the open surface waters of natal estuaries (Raney 1952). Inconsistencies in reported habitat use by larval life stages may be a reflection of continual upstream migration of spawning fish, prolonged spawning periods and different mortality rates of the life stages (Polgar et al. 1976).

Striped bass enter the early juvenile stage at about 30 mm, when fins are fully formed and the external morphology is similar to that of adults (Hill et al. 1989). Early juveniles tolerate a broader range of environmental conditions than eggs and larvae (Bain and Bain 1982). Movements, distribution and habitat use of early juveniles, especially in the water column of southeastern U.S. rivers, are little known (Hill et al. 1989). Setzler et al. (1980) indicated that the migration of early juveniles varies with locality. In Virginia, Markle and Grant (1970) reported a downstream migration to higher salinities during the first summer of life. In the Potomac River, early juveniles left spawning areas at about 70 mm TL (Mihursky et al. 1976). Bason (1971) reported largest concentrations of juveniles in protected areas of moderate salinity. Other authors (Sasaki 1966, Carlson and McCann 1968) reported that shoals were used as nursery areas. Rathjen and Miller (1957) reported the largest catches of juvenile striped bass were near clean sandy bottoms. Young-of-the-year from the Hudson River began to move offshore in the fall (Carlson and McCann 1969, Texas Instruments, Inc. 1974) but no similar movement was observed in the Patuxent River (Ritchie and Koo 1968).

An additional habitat consideration for larval and early juvenile striped bass is high food availability (Bain and Bain 1982). Some authors believe that striped bass year class strength is established, at least in part, by the availability of abundant zooplankton in the habitats required by the larval and early juvenile stages (i.e., in the downstream water column, soft bottoms, submerged aquatic vegetation and wetlands of rivers, river deltas and the landward portions of estuaries)(see Heinle et al. 1975, Eldridge et al. 1981 as cited in Bain and Bain 1982). Zooplankton abundance is in turn related to riverine and estuarine productivity, which are further linked to freshwater inflows and associated detrital inputs.

9.1.1.3 Subadult Habitat

These fish (age 1 though sexual maturity at ages 2-5) use the water column and soft bottom habitat present in North Carolina’s coastal rivers and estuaries, and migratory subadults may likely use the water column and ocean hard bottom of the nearshore Atlantic Ocean as well. It is generally believed that striped bass less than 2 years of age do not migrate (Boreman and Lewis 1987), therefore these fish would use only habitats in rivers and adjacent estuaries. Some subadult fish which appeared less than age 2 (based on TL), however, have been captured in Atlantic Ocean waters off Virginia and North Carolina (USFWS, South Atlantic Fisheries Coordination Office, unpublished data), so to the extent subadults may travel offshore, there is limited use at least of ocean water column, soft bottom and hard bottom habitats.

9.1.1.4 Adult Habitat

Migratory striped bass (presumed to be only some of the Albemarle/Roanoke stock in NC) use the water column of inland and coastal rivers for spawning, and migrate to and from the spawning grounds through the water column of rivers and adjacent estuaries and inlets to the Atlantic Ocean, where they spend much of the spring, summer and fall.

Migrating fish move north in the spring and summer and south in the fall and winter (Merriman 1941, Clark 1968, Boreman and Lewis 1987). All adults from rivers south of the Roanoke and Chowan remain in rivers or adjacent estuaries for their entire life cycle, as do most of the A/R stock. The water column of sandy beaches, rocky shores and shallow bays are inhabited in both marine and estuarine environments (Bigelow and Schroeder 1953). Striped bass adults are reported to remain relatively close (6-8 km; 4-5 mi) to shore when in the ocean (Bain and Bain 1982).

9.1.1.5 Striped Bass Habitats in NC River/Estuary Systems

The following sections contain as much information as is presently available regarding the use of specific habitats in North Carolina by coastal striped bass life stages (**Figure** 9.3). For the sake of completeness, all habitats used by a stock are included, even though in some cases, fish which use habitats in North Carolina may spawn offspring which use habitats up- or downstream in other states. North Carolina fishery management agencies and institutions, both state and federal, as well as anglers, need to be aware of the need to protect these habitats and enact compatible management measures for these stocks throughout their ranges.

9.1.1.5.1 Albemarle Sound Management Area

Chowan River and Tributaries (Blackwater, Meherrin and Nottoway Rivers)

Spawning Areas

Striped bass are known to have spawned in the Chowan River basin both historically (Mike Street, DMF, personal communication) and recently (1998) in the Meherrin River, based on the collection of eggs. Dr. Gilbert Tripp and students of Chowan College collected eggs in April, 1998, at Boone’s Bridge (SR 1311) in Northampton County (J.W. Kornegay, NC Division of Inland Fisheries, personnel communication and unpublished data). No recent surveys of spawning activity or habitats used for spawning have been conducted by the WRC or DMF. A spawning stock survey is currently being conducted in Virginia tributaries of the Chowan by the Virginia Department of Game and Inland Fisheries (J.W. Kornegay, NC Division of Inland Fisheries, personal communication).

Nursery Areas

Except for the aforementioned collection of striped bass eggs from the Meherrin River in Northampton County, no information was located on nursery areas which are used by striped bass eggs, larvae or early juveniles in the Chowan River or its tributaries.

Adult Movements, Summer Habitats, Migration

No information was located on habitats used by adult striped bass which occupy the Chowan River or its tributaries. Although Jenkins and Burkhead (1993) depict one capture site for striped bass in the Virginia portion of the Chowan River, they do not

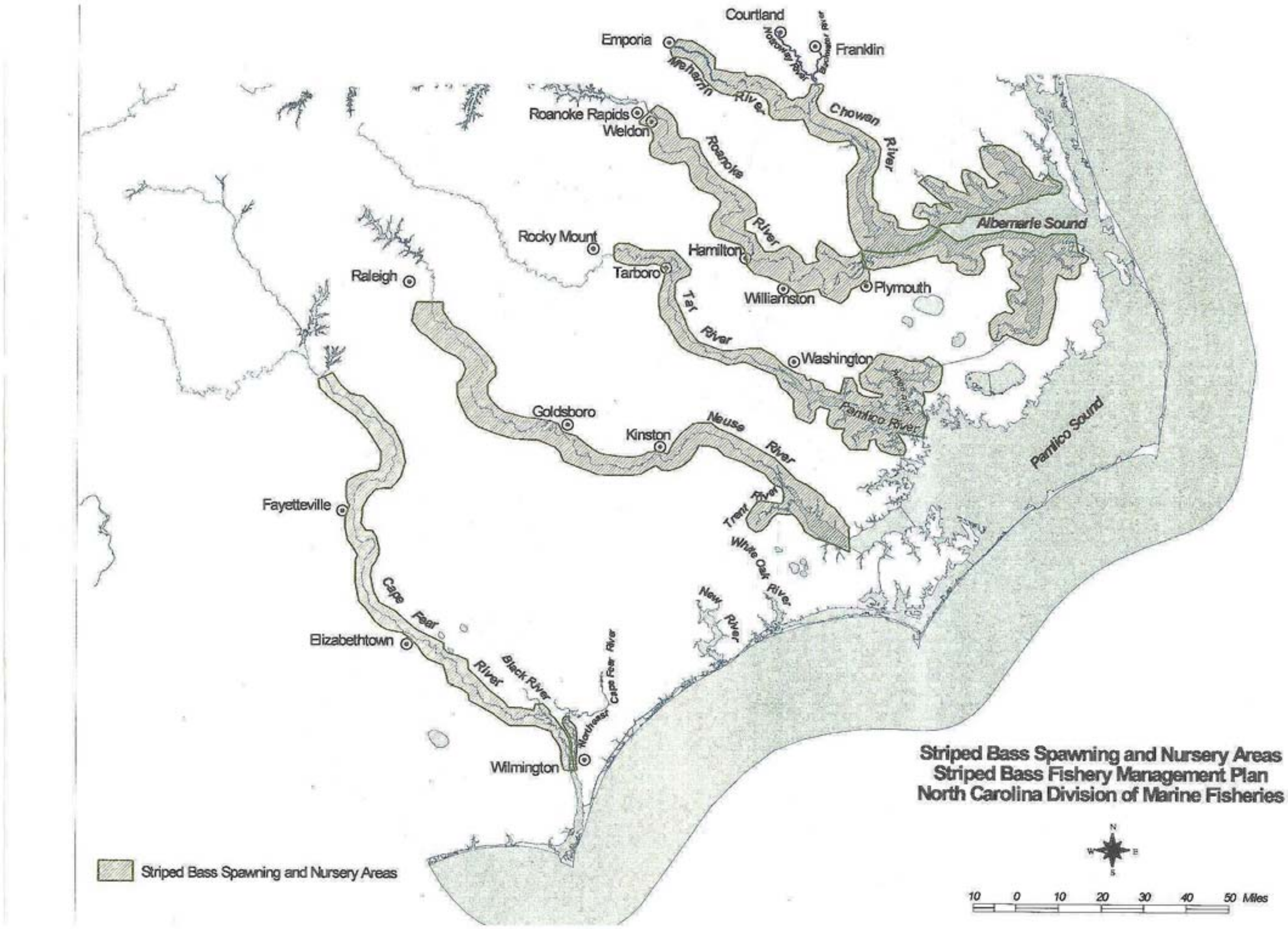


Figure 9.3. Striped bass spawning and nursery areas in North Carolina coastal rivers.

discuss the species in the text. Rulifson et al. (1982a) conducted an extensive review of striped bass literature, but also do not mention the Chowan River or its tributaries as hosting striped bass.

Roanoke River

Spawning Areas

Results of previous investigations (Fish 1959; McCoy 1959; Smith 1907; Hassler et al. 1981) were compared with a recent study (Rulifson 1991a) to determine the extent and location of spawning habitat. Construction of the Roanoke Rapids Dam in 1955 at River Mile (RM) 137.5 blocked access to any spawning grounds farther upstream; however, historical accounts indicate major spawning activity centered around Weldon (RM 130). Spawning grounds now range from RM 78 to RM 137.5 with most of the activity between RM 120 and RM 137, still centered around Weldon.

Nursery Areas
The primary nursery area for Roanoke-spawned fish is the low amplitude tidal, wind-influenced primarily fresh waters of western Albemarle Sound (**Figure** 9.3). Striped bass may spend the first two years of life maturing in and around this nursery area (Hassler et al. 1981). Dr. W. W. Hassler and the North Carolina State University staff conducted juvenile abundance surveys from 1955 to 1987. The DMF began sampling the seven stations established by Hassler in 1982 and has continued these surveys to present establishing a long-term relative index of abundance. In 1984 the DMF began sampling twelve stations in central Albemarle Sound to determine is a shift in the nursery area had occurred. Juveniles have also been collected in the central sound indicating dispersal throughout the Albemarle Sound and its tributaries (Henry et al. 1991).

Adult Movements, Summer Habitats, Migration
Tagging studies suggest that some portion of this stock is migratory with primarily older adults migrating offshore, and that the percent migration may be increasing as the age structure and population size rebuild. Tag-recapture studies from previous investigators (Fish 1959, Merriman 1941, Hassler and Taylor 1986, Davis and Sykes 1960, Chapoton and Sykes 1961, Street et al. 1975, Henry et al. 1992, Holland and Yelverton 1973, Benton 1992, Boreman and Lewis 1987, and ASMFC 1990), were examined to determine the amount and extent of migration from the spawning grounds to other seasonal habitats. It has been speculated that Croatan Sound and offshore waters serve as a wintering ground (Street et al.1975), and movement offshore and north occurs during the summer. Fish tagged and released at various locations in Albemarle Sound have been recaptured on the spawning grounds, in Albemarle, Pamlico and Croatan sounds, and offshore from North Carolina to New England. Studies from 1938 to present indicate a small amount of migration occurs. It was noted by several of these investigators that larger, older females were more migratory than males. However, it is apparent that the Albemarle Sound and North Carolina territorial seas serve as a wintering ground for not only the A/R stock, but for other east coast stocks as well. Limited tag returns suggest that some fish from other east coast systems also move into Albemarle Sound during winter.

9.1.1.5.2 Central Southern Management Area

Tar-Pamlico River

Spawning Areas
The Tar-Pamlico River system ranks second to the Roanoke River in production. The area of peak spawning activity was documented to occur upstream of Tarboro between RM 50 and RM 85 (**Figure** 9.3) (Humphries 1966). Eggs have been collected from

Rocky Mount to Grimesland (just upstream of Washington) (Marshall 1976). Upstream migration of anadromous fish is blocked by a dam at NC 43 (Collier and Odom 1989).

Nursery Areas
Larval striped bass, juveniles, and yearlings were collected in 1978 above Washington in the Tar River, and downstream in the Pamlico River to the Pungo River that were considered to originate from natural stock (Hawkins 1980).

Adult Movements, Summer Habitats, Migration
Tagging studies indicate that Tar-Pamlico and Neuse river striped bass are riverine and endemic (Marshall 1977; Hawkins 1980). These data also suggest that fish spend the winter in the Pamlico River between Washington and the mouth of the Pungo River and move up the Tar River during the spring spawning run (Marshall 1976; Pate 1975; Winslow et al. 1983).

Neuse River

Spawning Areas
Spawning in the Neuse River was documented in 1978 and 1979 to occur between RM 80 and RM 145 approximately between Kinston and Goldsboro, respectively (**Figure** 9.3). Spawning activity is concentrated between RM 80 and RM 120 in an area of high turbulence (Hawkins 1980). The Quaker Neck Dam at Goldsboro has been reported to block the upstream migration of striped bass (Baker 1968). However, a few eggs have been collected above the low-head dam indicating that some striped bass do migrate beyond the dam and spawn successfully. Distribution was greatly hindered by the dam (Hawkins 1980), until removal in 1998, opening up historical spawning reaches.

Nursery Areas
A few striped bass larvae and juveniles have been collected in the New Bern area in 1978 on the Neuse River that were thought to originate from natural stock (i.e. not stocked fish) (Hawkins 1980). The nursery area is considered to be downstream of New Bern (**Figure** 9.3).

Adult Movements, Summer Habitats, Migration
Tagging studies indicate that Neuse River striped bass are riverine and endemic (Marshall 1977; Hawkins 1980).

Newport, White Oak and New Rivers
Little information is available on these medium-sized streams in southern North Carolina. Historically, both the New and White Oak Rivers are shown as supporting runs of striped bass in Baker's (1968) Reconnaissance of Inland Fishing Waters. In 1973-1975, DMF conducted a fishery-independent anadromous fish survey for eggs, larvae, and adults.

No striped bass eggs, larvae, or adults were found in the New River. Habitat previously found above Jacksonville no longer exists because of channelization. Three adult striped bass were collected in the White Oak River. Two were three year old females and one was a seven year old female (Sholar 1975).

Cape Fear River

Distribution

Striped bass eggs, larvae and juveniles have been collected in the Cape Fear and Northeast Cape Fear rivers. Other major tributaries including the South and Black rivers do not seem to support spawning populations (Winslow et al. 1983). However, this may reflect a lack of sampling effort, since interviews with local recreational anglers in 1984 indicated that striped bass were caught in the spring well up the tributaries of the Black River (Laney 1984).

Spawning Areas

Spawning activity has been document on the Cape Fear River from RM 10 to RM 30 (upstream of Wilmington) where relatively high tidal currents keep eggs in suspension (**Figure** 9.3)(Fischer 1980; Winslow et al. 1983). Spawning activity has been documented on the Northeast Cape Fear from Ness Creek to Crooms Bridge. The South and Black Rivers apparently do not support spawning habitat for striped bass (Sholar 1977; Winslow et al. 1983).

Nursery Areas

Juveniles have been collected on the Cape Fear and Northeast Cape Fear rivers, though infrequently. The nursery area on the Cape Fear is centered around Wilmington (**Figure** 9.3)(Fischer 1980; Winslow et al. 1983). The nursery area on the Northeast Cape Fear ranges from Wilmington to Lanes Ferry (Sholar 1977; Winslow et al. 1983).

Adult Movements, Summer Habitats, Migration

Adults have been collected from Pikes Creek to the lower river in the Northeast Cape Fear. Some large striped bass (45 pounds) have been reported by recreational fishermen (Sholar 1977; Winslow et al. 1983). The distribution is more compressed in the Cape Fear River because of a series of locks and dams. The range extends from Reed Creek (below Lock and Dam No. 1) to the lower river. In the early 1980s, striped bass were abundant January-May below Wilmington (Fischer 1980; Winslow et al. 1983). Tagging studies suggest that this stock is riverine endemic with exchange between the Cape Fear and Northeast Cape Fear Rivers (Winslow et al. 1983).

Waccamaw River

Spawning Areas

No references were located which document spawning in the Waccamaw River drainage; however, striped bass weighing 20 pounds have been caught in the river above Conway, and smaller fish have been caught only 15-20 miles below the North Carolina state line (Craig Sasser, U.S. Fish and Wildlife Service, Waccamaw National Wildlife Refuge, personal communication). Investigation of the North Carolina portions of the Waccamaw River should be undertaken during the appropriate season.

Nursery Areas
No information on nursery areas used by striped bass eggs, larvae or early juveniles in the Waccamaw River drainage was located.

Adult Movements, Summer Habitats, Migration
No information has been located on habitats used by adult striped bass in the Waccamaw River system.

Lumber River
No information has been located on any habitats used by any striped bass life stages in the Lumber River system.

Pee Dee River

Spawning Areas
The only portion of the Pee Dee River presently available for spawning striped bass in North Carolina waters is the approximately 14-mile reach from Blewett Falls Dam, near Rockingham, NC, to the South Carolina state boundary. Areas reported as constituting striped bass spawning habitat include the Pee Dee River or Intercoastal Waterway in South Carolina (Crochet et al. 1976) and the Pee Dee River upstream from the US 301 bridge (White and Curtis 1969).

Nursery Areas
No information has been located on areas used as nursery habitats by striped bass life stages in the Pee Dee River system.

Adult Movements, Summer Habitats, Migration
No information has been located on areas used by striped bass adults in the Pee Dee River ecosystem. The Pee Dee River was listed by Burns (1887) as having a striped bass population. The population was still extant in 1980 (McIlwain 1980).

9.1.2 Habitat Protection Status
Protection of the quantity and quality of striped bass habitat, particularly areas designated as critical (i.e. spawning and nursery areas) is essential to the goal of this plan. Increasing human activity across North Carolina continues to have a significant influence on habitat quantity and quality as well as associated wildlife and fisheries resources.

The WRC has the authority to designate waters as Inland Primary Nursery Areas. Currently portions of the Roanoke, Tar, Neuse, and Cape Fear rivers are designated. However, the WRC has no additional regulatory authority and can only regulate fishing activities in these areas. Permitting agencies give these areas additional consideration relative to impacts prior to issuing development permits.

DMF has the authority to designate Critical Habitat Areas, Anadromous Spawning Areas, and Nursery Areas. Anadromous spawning and nursery area surveys have been conducted in the watersheds of Currituck Sound, Albemarle Sound, Tar-Pamlico River, Neuse River, White Oak River, New River, and Cape Fear River, but no directed surveys have occurred since the early 1980s outside of the Albemarle Sound area. Areas in each system that has been documented to function as spawning and/or nursery areas for striped bass. Although these areas have been identified by DMF, the areas have not been adopted into rule at this time. Furthermore, MFC has no additional regulatory authority in these areas and can only regulate fish size, creel, and method of fishing.

The 1997 Fisheries Reform Act mandates the Department of Environment and Natural Resources (DENR) shall coordinate the preparation of CHPP for critical fisheries habitats. The goal of the CHPP shall be the long-term enhancement of coastal fisheries associated with coastal habitat. The DMF, North Carolina Division of Water Quality (DWQ) and North Carolina Division of Coastal Management (DCM) shall prepare the CHPP, with assistance from other federal and state agencies. The plans shall: (1) describe and classify biological systems in the habitats, (2) evaluate the function, value to coastal fisheries, status, and trends of the habitats, (3) identify existing and potential threats to the habitats and the impact on coastal fishing and (4) recommend actions to protect and restore the habitats. The CHPP management units are: Coastal Ocean, Albemarle, Chowan, Roanoke, Tar-Pamlico, Pamlico, Neuse, Core/Bogue, New/White Oak, Cape Fear and Southern Estuaries. The MFC, the North Carolina Environmental Management Commission (EMC) and the North Carolina Coastal Resources Commission (CRC) will jointly approve these plans and all regulatory action must be consistent with approved CHPP. The CHPP must be completed by December 31, 2004 and must be reviewed every five years.

9.1.3 Habitat Concerns

9.1.3.1 River Flows

The flow pattern of a coastal river (the timing, rate, and delivery pattern of water in the channel of the waterway) is critical to maintaining proper oxygen, salinity, and temperature regimes and dissipating wastes throughout the watershed, including the receiving estuary. This pattern is also important to striped bass and other anadromous species. North Carolina rivers typically have exhibited higher flows during the spring of the year, providing an attractant flow for adult fish migrating toward the spawning grounds. Because striped bass have buoyant eggs, river discharge (the rate of flow per unit time) must be high enough to keep the eggs in suspension until they hatch and to transport the larval and postlarval stages to the appropriate nursery areas in the river. River flows must also be sufficient to maintain appropriate salinities in the estuarine nursery areas used by juvenile striped bass.

Disruptions to the historical patterns of flow, in volume and/or timing can render habitat unsuitable for use by fish and other aquatic organisms, or can significantly alter the extent of nursery or spawning habitats. Flow regimes can be altered by a number of human activities including dam operations, diversions, and water withdrawals. Some rivers in North Carolina have been dammed for hydropower generation, water supply, and flood control. Hydropower operations can vary discharge patterns in a highly unnatural manner, over a short time period causing rapid changes in depth and temperatures, and accumulation of water in adjacent back swamps. Reservoirs constructed for water supply and/or recreational purposes can alter downstream flow patterns when water is retained for those purposes and not released downstream. Flood control operations by the ACOE result in reduced maximum flows, but prolonged higher discharge levels, often for weeks at a time. Water diversions alter flows in river channel segments. Withdrawals of water from the river alter the flow temporarily below the intake, or permanently if the withdrawal is consumptive (not returned to the river) or is discharged into another distant basin (an interbasin transfer). Another potential source of impact to river flow patterns is groundwater withdrawal, which can affect subsurface flow to river ecosystems. Withdrawals from shallow wells which intersect groundwater supplies maintaining river base flows could be detrimental, especially during low-flow periods. All of these alterations may impact the cues which striped bass and other species require to successfully complete their life cycles.

Flow patterns in some North Carolina river systems exhibit significant deviations from historical patterns due to the regulation of flows within them or their major tributaries (Chowan, Roanoke, Tar-Pamlico, Neuse, Cape Fear, Yadkin-Pee Dee). Other rivers remain largely in an unregulated condition (White Oak, Northeast Cape Fear, Waccamaw). **A Water Flow Issue Paper can be found in Section 10.2.1.1.**

Preliminary evaluations of the flow patterns, as well as present and future predicted water demand, suggest that measures should be taken to provide for appropriate future flows to maintain striped bass populations and all other ecological functions. Such authority rests with the DWQ, the North Carolina Division of Water Resources (DWR), ACOE, and individual hydropower operators, subject to license under the Federal Energy Regulatory Commission. None of the federal or state fishery management agencies have the authority to regulate or specify flows. At present, the only river for which any sort of flow agreement is in effect, other than prescribed minimum flow releases for individual dams (mostly for water quality purposes), is the Roanoke.

9.1.3.2 Blockage of Historical Spawning Habitat

In North Carolina, dams are located along each of the major coastal rivers and/or their tributaries (**Figures** 9.1 and 9.2). The lowermost dam is often located near the fall line (transitional area between the piedmont and coastal plain) (Hightower 2001). Striped bass have historically migrated above the fall line to spawn, especially when river flows are above average. It is believed that by limiting access to spawning habitat, these blockages have contributed to the decline of striped bass populations. **Section 10. 2.1.3 describes Blockages to Historical Spawning Habitat in detail**.

9.1.3.3 Losses of Striped Bass Eggs and Fry to Water Intakes

Millions of gallons of water are pumped daily from coastal rivers by industrial, municipal, and agricultural water users. During the striped bass spawning season, striped bass eggs and larvae drifting downstream with river currents are subject to entrainment (drawing organisms into a system through water suction) or impingement (pinning organisms against a screen by water intake pressure) by these various water intakes. Juvenile striped bass that have not fully developed their swimming abilities are also susceptible to be removed. Once entrained, eggs, larvae, and juveniles can be considered completely lost from the river. Even if the withdrawn water is returned to the river (such as is the case with industrial cooling water), striped bass are killed by high water pressure, turbulence, abrasion, and exposure to excessive temperatures. Some intake structures are equipped with fine-mesh screens to exclude fish eggs and larvae; however, in many instances, fish eggs and larvae are impinged on these screens by water pressure. Furthermore, these screens require constant cleaning with air and water jets to remove debris. Little is known about the survival rates of eggs and larvae that are impinged and then released by cleaning operations. However, damage from pressure and abrasion seems likely. Removal of these eggs, larvae, and juveniles through water intakes represents a direct loss in striped bass reproductive success. Although the overall impact is currently unknown, these losses could theoretically be significant for those striped bass populations in which spawners are few**. Issues relative to Entrainment and Impingement of Eggs and Larvae is presented in Section 10.2.1.3**.

9.1.3.4 Loss of Wetlands

Wetlands form a unique interface between terrestrial and aquatic ecosystems, providing valuable water related functions and important habitat for a broad range of fish and wildlife species. Major conversions of coastal and freshwater wetlands have occurred due to agricultural and silvicultural expansion, industrial development, and urban encroachment. It is estimated that North Carolina has already lost 34% of its coastal wetlands (NCDCM 1999), which are critical fisheries habitat.

9.2 Water Quality

9.2.1 Water Quality Requirements

Temperatures required for spawning range from 12-24 degrees (°) C, with peaks usually between 18-21°C, although spawning has been observed between 14 and 24°C (Scruggs 1957, May and Fuller 1965, Smith 1973 and Barkuloo 1967). Spawning may terminate if temperatures decline as a function of weather (passage of cold fronts) or reservoir releases (see Calhoun et al. 1950, Mansueti and Hollis 1963, Boynton et al. 1977, as cited in Hill et al. 1989; Rulifson 1990 and 1991b). Although salinity and total dissolved solids (TDS) concentrations have been reported as important factors in some systems (Bain and Bain 1982), they have not been reported to influence spawning behavior in NC rivers.

Striped bass eggs develop optimally within a temperature range of 17-20°C (63-68°F, Bain and Bain 1982 citing Barkuloo 1970, Doroshev 1970, and Morgan et al. 1981).

Normal development and hatching require dissolved oxygen (DO) concentrations of at least 3-5 mg/l (Turner and Farley 1971, Harrell and Bayless 1982); however, “low” DO (2.0-3.5 mg/l) was determined responsible for the absence of eggs and larvae in the Delaware River (Murawski 1969, Chittenden 1971). Turner and Farley (1971) reported that moderate reductions in DO (from 5 to 4 mg/l) decreased egg survival. Larvae require 5-6 mg/l and the optimum range for juveniles is probably 6-12 mg/l (Bogdanov et al. 1967). Neither turbidity nor suspended sediments have been observed to significantly decrease hatching success (Talbot 1966, Schubel and Auld 1974 as cited in Bain and Bain 1982). Striped bass eggs in North Carolina spawning areas are unlikely to encounter significant salinities; however, levels typically encountered by eggs are not detrimental to survival and low salinity is considered optimal for water hardening (Albrecht 1964, Morgan et al. 1981).

Temperature, DO and salinity appear to play important roles in determining larval survival (Bain and Bain 1982). Larvae need a minimum of 3 mg/l to survive (Chittenden 1971). Moderate reductions in DO (from 5 to 4 mg/l) reduced the survival of larvae (Turner and Farley 1971). A temperature range of 18 to 21°C (64 to 70°F) is considered optimal for larvae (Rogers et al. 1977). Temperatures of 12 to 23°C (54 to 73°F) are tolerated (Doroshev 1970). The optimal salinity range is 3-7 parts per thousand (ppt) but 0-15 ppt are tolerated (Lal et al. 1977, Albrecht 1964).

For early juveniles, optimal growth was reported to occur at temperatures of 14 to 21°C (57-70°F), with tolerance of a range 10-27°C (50°-81°F). Dissolved oxygen levels required for high survival were 5 mg/l or above (Krouse 1968).

Adults appear to have similar water temperature and DO requirements as juveniles. Preferred temperatures vary depending on the ambient acclimation temperature (Meldrim and Gift 1971), with maximum upper avoidance temperature (for adults acclimated to 27°C, 81°F, in late August) of 34°C (93°F). Striped bass acclimated to 5°C (41°F) in December avoided 13°C (55°F) water. Merriman (1941) reported a preferred temperature range of 25-27°C (77-81°F) during the growing season. Areas with high temperatures and low DO may be unsuitable for use by adult striped bass (Coutant and Benson 1988, Kornegay 1988, Bales et al. 1991). Adult striped bass become restless at DO levels approaching 3 mg/l followed by inactivity, loss of equilibrium and death (Chittenden 1971). Striped bass of all ages are reported to avoid water with oxygen concentrations less than 3-4 mg/l (Cheek et al. 1985, Coutant 1985).

9.2.2 Water Quality Protection Status

Permit issuance to individuals and/or entities requesting permission to impact surface waters and wetlands is granted by state and federal regulatory agencies (DWQ, DCM, ACOE). Resource agencies (WRC, DMF, USFWS) are given the authority to request modification or denial of projects when the design is perceived as having adverse impacts to fisheries and aquatic resources. Basinwide water quality management plans prepared by the DWQ also identify specific water quality concerns within an individual watershed.

The EMC can classify areas with special water quality such as Outstanding Resource Waters (ORW), and these areas are given additional consideration of impacts prior to issuing development permits. In addition, the EMC can classify areas as Nutrient Sensitive Waters, and the Chowan River, Neuse River and Tar-Pamlico River basins have been designated as such. In conjunction with this designation, Nutrient Sensitive Waters Strategy (NSWS) is developed and includes a 30% reduction in nitrogen loading from agriculture, no net increase in phosphorous, protection for riparian areas, stormwater runoff control, and wastewater discharge standards.

The CRC regulations do not allow authorization of projects that can violate water quality standards or adversely affect the life cycle of estuarine resources. The CRC regulates development activities in Areas of Environmental Concern, which include coastal wetlands. Generally, no development is allowed in coastal wetlands except water dependent activities such as docks. The 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 (EAs), Coastal Area Management Act (CAMA) major permit applications, and ACOE permit applications to determine if the project will violate water quality standards.

Regulations enacted for water quality protection by the EMC and the CRC must be consistent with the authority of the CHPP.

9.2.3 Water Quality Concerns

An issue paper is presented in **Section 10.2.2** relative to water quality concerns in striped bass management areas.

10.0 PRINCIPAL ISSUES AND MANAGEMENT OPTIONS

10.1 Identification of Issues

Major issues and management options developed during the Striped Bass FMP process are summarized in this section. Management issues in the striped bass fishery have been solicited from the public, the Albemarle/Roanoke Advisory Committee, the Central/Southern Advisory Committee, the Marine Fisheries Commission, the Wildlife Resources Commission, Finfish, Habitat and Water Quality and Regional Advisory Committees, DMF, WRC, DENR, USFWS and the scientific community.

The issues are presented in a series of issue papers and each has the following format

Title
Issue
Background
Current Authority
Discussion
Management Options/Impacts
Research Needs

DMF/WRC Recommendation
Advisory Committee Recommendation

The issues and options are divided into three sections **10.2. Issues relative to all NC striped bass stocks**, **10.3. Issues relative to the A/R stock**, and **10.4. Issues relative to the C/S stocks**.

10.2 Issues Relative to the North Carolina Striped Bass Stocks

1. **Habitat (Section 10.2.1)**
   Water Flow (Section 10.2.1.1)
   Identify and Protect Critical Habitat- Spawning and Nursery Areas (Section 10.2.1.2)
   Blockages of Historical Spawning Habitat (Section 10.2.1.3)
   Entrainment and Impingement of Eggs/Larvae (Section 10.2.1.4)

2. **Water Quality (Section 10.2.2)**
   Point and Non-Point Source Discharge
   Hypoxia Events
   Bluegreen Algae Blooms
   Pfiesteria
   Summer Time Conditions
   Contaminants

3. **Catch and Release Mortality in the Hook and Line Fisheries (Section 10.2.3)**

4. **Enforcement of Creel Limits (Section 10.2.4)**

5. **ASMA Boundary Line (Section 10.2.5)**

10.3 Issues Relative to the A/R Striped Bass Stock

1. **Stock Structure (Section 10.3.1)**
   Biological Reference Points- F_{msy} and SSB Targets (Section 10.3.1.1)

2. **Fishing Mortality (Section 10.3.2)**
   Commercial Gill Net Discard Mortality and Bycatch (Section 10.3.2.1)

3. **Harvest Management (Section 10.3.3)**
   Management of Quota and Harvest Targets (Section 10.3.3.1)
   Recreational Harvest- Oregon Inlet Area (Section 10.3.3.2)

10.4 Issues Relative to the C/S Striped Bass Stocks

1. **Stock Structure (Section 10.4.1)**
   Biological Reference Points- F_{msy} and SSB Targets (Section 10.4.1.1)

2. **Striped bass stocking programs (Section 10.4.2)**

3. **Fishing Mortality (Section 10.4.3)**
Management Options-Recreational and Commercial Harvest /Catch Curve Exploitation Estimates (Section 10.4.3.1)
Commercial Gill Net Discard Mortality and Bycatch (Section 10.4.3.2)

10.2 Issues and Management Strategies Relative to North Carolina Striped Bass Stocks

10.2.1 Habitat Issues

10.2.1.1 Water Flow Issues

Issue
To identify impacts to riverine and estuarine aquatic habitats, in particular those used by striped bass, which occur as a consequence of flow modifications, and develop recommendations and accompanying strategies to eliminate or minimize impacts. It should be noted that this issue applies not only to striped bass, but also to all aquatic resources adapted to using North Carolina's coastal rivers and associated estuaries as resident, spawning and/or nursery habitats.

Background
It is intuitive that water is the lifeblood of aquatic habitats and the organisms, which reside in them. It is perhaps less intuitive that not only the water itself, but also the quality, amount and delivery pattern are critical as well, especially for rivers and their downstream estuaries. Many of the factors which affect river flow may also affect water quality. Water quality is addressed in another issue paper, but amount and delivery pattern to coastal rivers and estuaries are addressed here.

Each river system in North Carolina has a characteristic pattern of water flow, called discharge (measured in cubic feet per second, or cfs). The discharge is the amount of water flowing downstream past a given cross section. This amount varies seasonally as a function of inflows to the river. Inflows include rainfall or melting snow, as well as groundwater inputs. Flows in the coastal rivers in North Carolina generally exhibit highest levels in the winter and spring months, declining thereafter to lowest levels during summer and fall (see **Figures** 10.1-10.6). Discharge from North Carolina coastal rivers is in part a function of watershed extent, with the highest mean annual discharges emanating from the largest watersheds (**Table** 10.1). River discharge should not be confused with "point-source discharge," which refers to the flow coming from a single source, usually an outfall pipe, into the river (see the water quality issue paper). Of the 17 major river basins wholly or partially within North Carolina, 9 of them historically supported striped bass populations (Pasquotank, Chowan, Roanoke, Tar-Pamlico, Neuse, White Oak, Cape Fear (including the Northeast Cape Fear), Lumber and Yadkin-Pee Dee.

The aquatic organisms which reside in rivers and estuaries have co-evolved with the patterns of flow in North Carolina's coastal rivers. Resident species such as largemouth bass and other sunfishes which construct nests in shallow waters depend on warm temperatures and stable water levels for reproductive success. Anadromous species (those which spend most of their juvenile and adult life in the ocean, but are hatched and return to spawn in inland rivers) depend on higher attractant flows in late winter and early spring, and spawn across a range of seasonally increasing water temperatures. Those species which have buoyant (floating) eggs are dependent upon flowing waters to oxygenate the eggs and convey larvae and postlarvae to downstream nursery areas. The general sequence of anadromous spawning in North Carolina's coastal rivers, beginning in late January or early February and continuing through early July is shortnose sturgeon, hickory shad, alewife, blueback herring, American shad, striped bass and Atlantic sturgeon, with some temporal overlap, but different habitat use, among the latter four species. The catadromous American eel ascends coastal rivers and streams in the glass eel or elver stage in February and March, and along with the larval and post-larval stages of many other estuarine-dependent species, depends on tidal currents and the cues received from freshwater inflows to navigate to upstream nursery areas. All juvenile anadromous species use the river and/or downstream temperatures, and accumulation of water in adjacent back swamps. Reservoirs constructed for water supply and/or recreational purposes can alter downstream flow patterns when water is retained for those purposes and not released downstream. Finally, flood control operations by the ACOE result in reduced maximum flows, but prolonged higher discharge levels, often for weeks at a time (such "controlled flood" operations occur on the Roanoke, Neuse and Cape Fear Rivers which are regulated by Kerr, Falls and Jordan Reservoirs respectively). Water diversions alter flows in river channel segments (for example, the reach of the Roanoke River bypassed by the Roanoke Rapids Dam tailrace). Withdrawals of water from the river alter the flow estuary as their early nursery habitat. Most of them leave the system in the fall and move to the Atlantic Ocean to mature, although striped bass may remain in the system for years, and some may be resident, moving back and forth between the river and estuary.

Disruptions to the historical patterns of flow, in volume and/or timing can render habitat unsuitable for use by fish and other aquatic organisms, or can significantly alter the extent of nursery or spawning habitats. Flow regimes can be altered by a number of human activities. Rozengurt and Haydock (1993) characterized the "four insidious Ds" of watershed management as dams, diversions, dewatering and decertifications. Hydropower operations may vary discharge patterns in a highly unnatural manner, over a short time period (for example, flows on the Roanoke River increasing from 2,000 cfs to as much as 18,500 cfs within a matter of hours), causing rapid changes in depth and temporarily below the intake, or permanently if the withdrawal is consumptive (not returned to the river) or is discharged into another distant basin (an interbasin transfer,

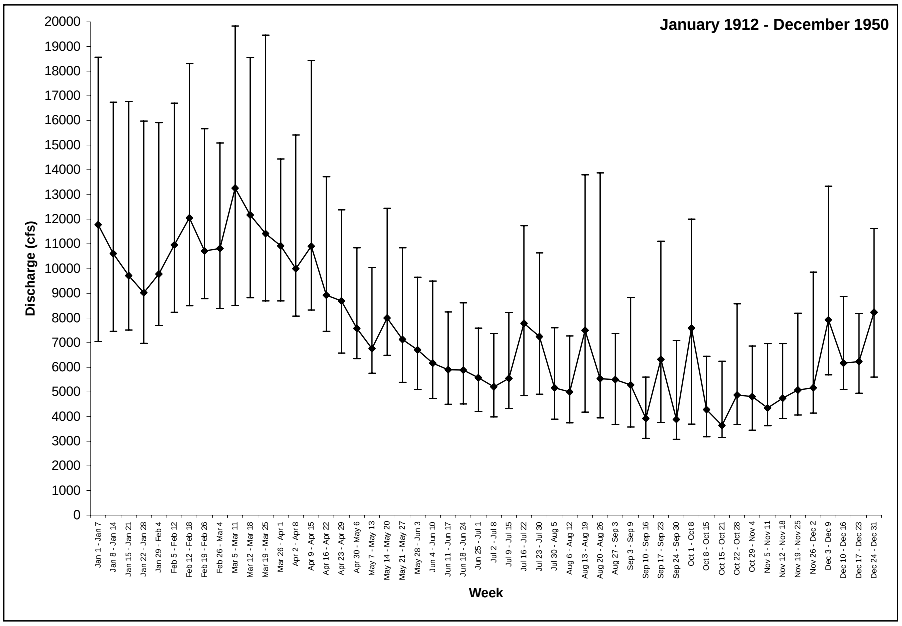


Figure 10.1. Weekly median discharges with corresponding 25th and 75th percentiles measured at the U.S. Geological Survey gaging station on the Roanoke River at Roanoke Rapids before and after construction of John H. Kerr Dam.

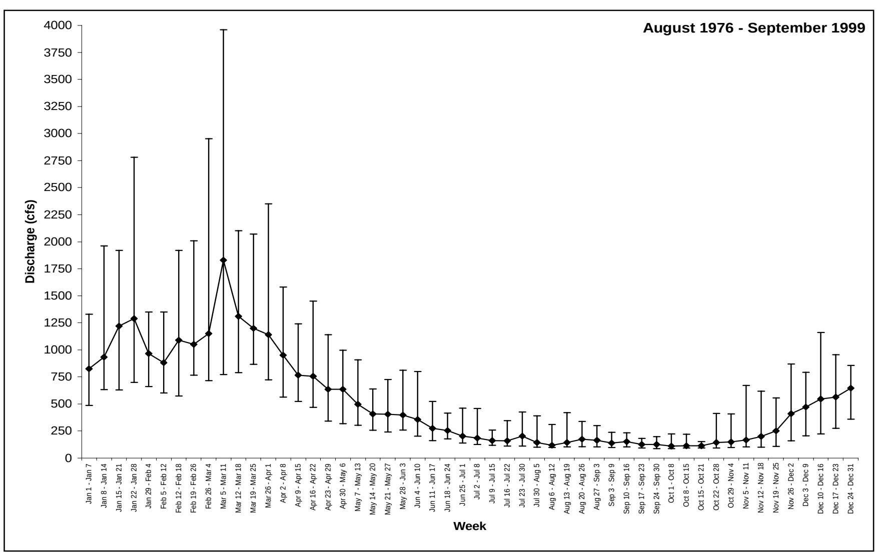


Figure 10.2. Weekly median discharges with corresponding 25th and 75th percentiles measured at the U.S. Geological Survey gaging station on the Tar River at Rocky

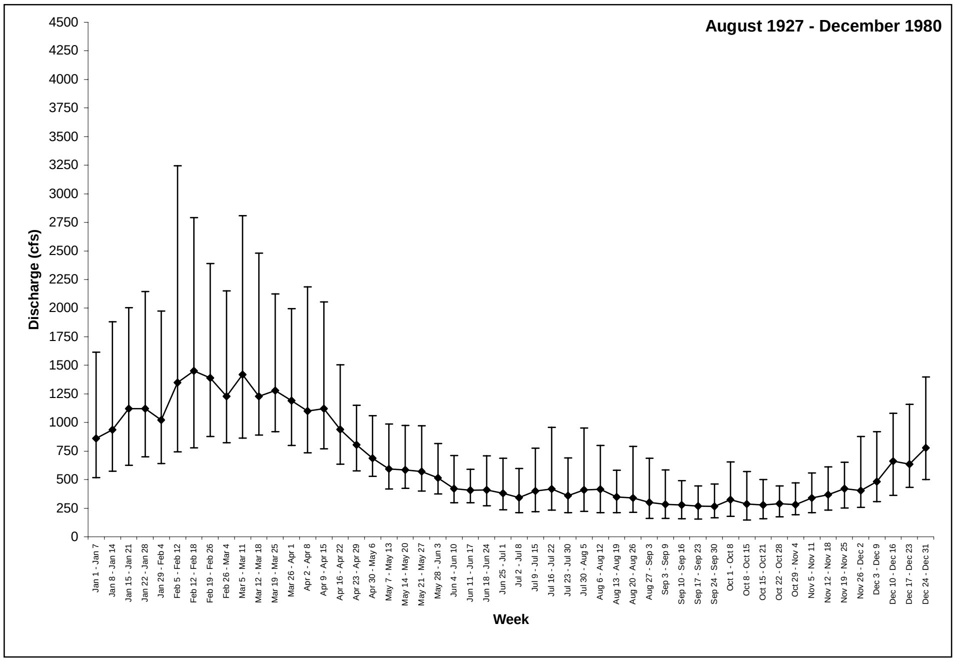


Figure 10.3. Weekly median discharges with corresponding 25th and 75th percentiles measured at the U.S. Geological Survey gaging station on the Neuse River near Clayton before and after the construction of Falls Lake Dam.

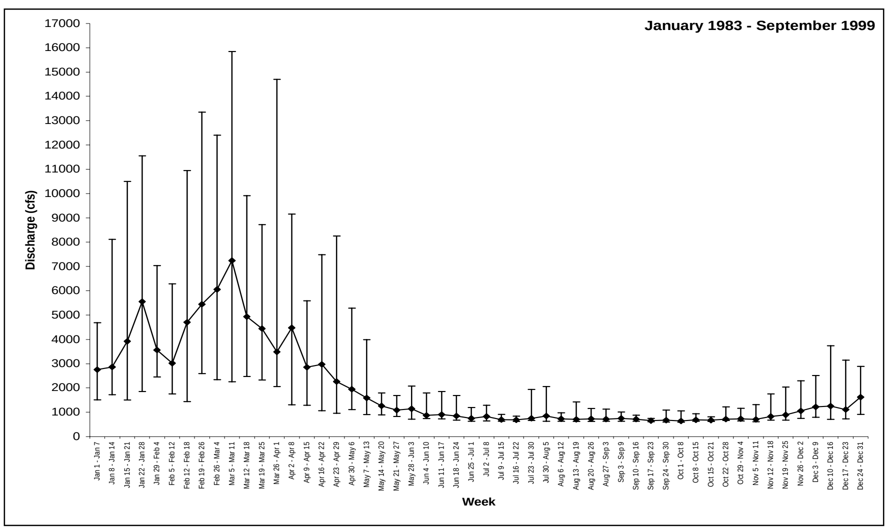


Figure 10.4. Weekly median discharges with corresponding 25th and 75th percentiles measured at the U.S. Geological Survey gaging station on the Cape Fear River near Lillington before and after the construction of B. Everett Jordan Dam.

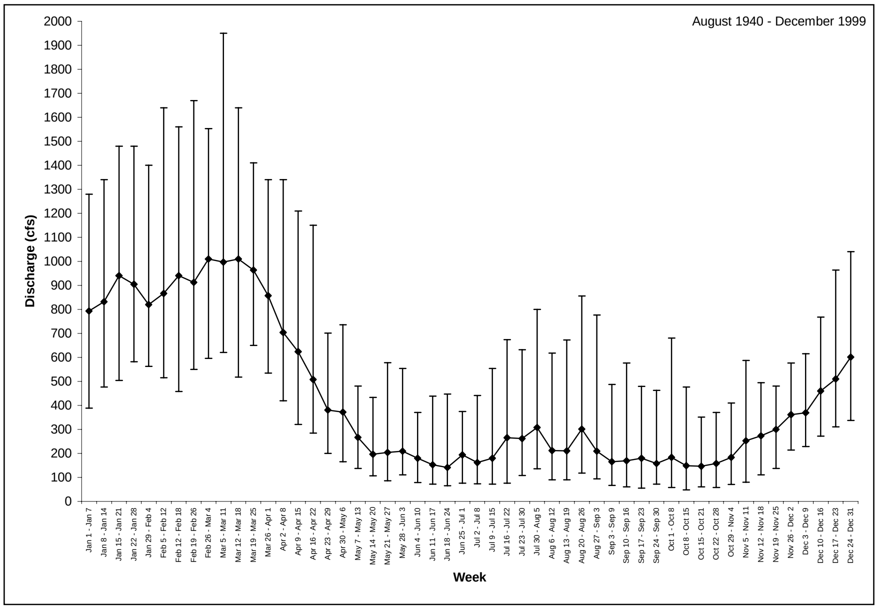


Figure 10.5. Weekly median discharges with corresponding 25th and 75th percentiles measured at the U.S. Geological Survey gaging station on the Northeast Cape Fear River near Chinquapin.

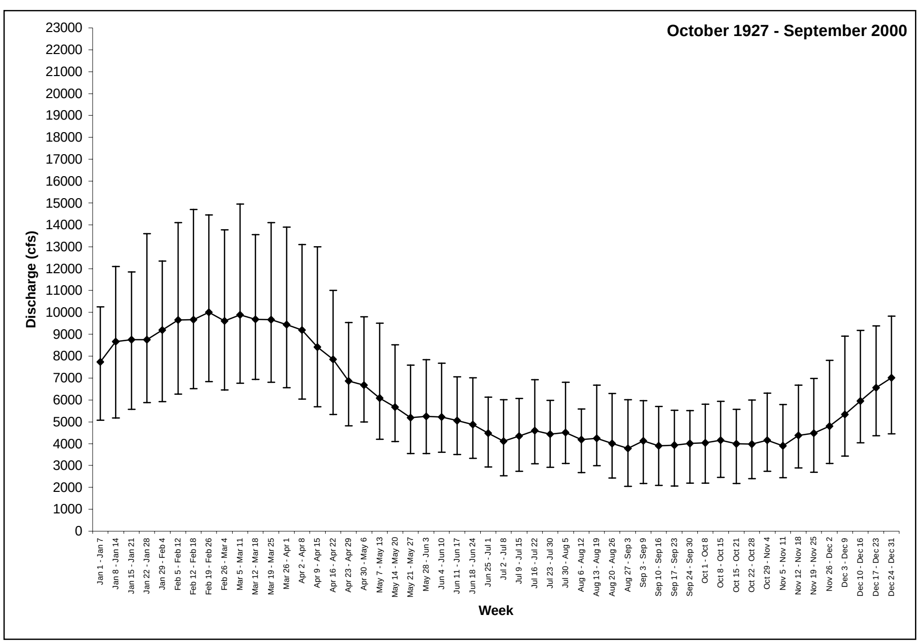


Figure 10.6. Weekly median discharges with corresponding 25th and 75th percentiles measured at the U.S. Geological Survey gaging station on the Pee Dee River near Rockingham before and after the dam construction.

Table 10.1. Characteristics of river basins supporting anadromous striped bass populations in North Carolina (and Virginia and South Carolina)(Burgess undated; NC Division of Water Quality 1999a-b, 2000, 2001a-c, 2002).

River Basin (north to south)	Area (sq. mi.)	Stream Miles	Mean Annual Flow (cfs)	September Median Flow (cfs)
Pasquotank	3,697 NC VA	478 NC		
Chowan	1,378 NC 4,061 VA 5,439 Tot.	788 NC		
Roanoke	3,503 NC 6,273 VA 9,776 Tot.	2,389 NC	8,500?	
Tar-Pamlico	5,440 NC	2,335		
Neuse	6,192 NC	3,440		
White Oak	1,233 NC	446		
Cape Fear (Northeast Cape Fear)	9,322 NC	6,049		
Lumber	3,336 NC SC	2,283 NC		
Yadkin-Pee Dee	7,213 NC 7,956 SC 15,169 Tot	5,989 NC 13,555 SC 19,544 Tot		

for example, the City of Virginia Beach's removal of up to 93 cfs from the Roanoke River at Gaston Reservoir). Another potential source of impact to river flow patterns is groundwater withdrawal, which can effect subsurface flow to river ecosystems. Withdrawals from shallow wells which intersect groundwater supplies maintaining river base flows could be detrimental, especially during low-flow periods. All of these alterations may impact the cues which striped bass and other species require to successfully complete their life cycles.

A number of studies have been undertaken to quantify the relationship between river flows and striped bass recruitment (Stevens 1977, Klauda et al. 1980, Mihursky et al. 1981, Uphoff 1989, Rulifson and Manooch 1990, Zincone and Rulifson 1991). Stevens (1977) reported that in the Sacramento-San Joaquin Estuary, high survival of striped bass coincides with moderately high river flows. He reported also that an unpublished study by the Maryland Department of Natural Resources determined that seine haul catch (for 1961-1971) of juvenile striped bass in the Potomac River was highly correlated with mean April-May river flow. However, similar relationships were not found for other parts of Chesapeake Bay. Klauda et al. (1980; reported in Versar 1990) concluded that striped bass year-class success in the Hudson River was directly or indirectly influenced by some combination of freshwater flow and water temperature just prior to and during spawning. Mihursky et al. (1981) determined that strong striped bass year classes in the Potomac River estuary were correlated with colder than average winters (December) which were followed by above average spring (April) freshwater runoff to the estuary. They concluded that "...any significant diminution of springtime freshwater discharge to the estuary would tend to decrease the probability of substantial recruitment success." Uphoff (1989) found that year-class success during 1980-1985 was significantly related to rainfall and river flow during the early larval stage; however, the correlations were between those variables and striped bass postlarval daily mortality. There was no significant correlation between those variables and abundance.

Over the period 1955 –1987, Rulifson and Manooch (1990) found striped bass recruitment to be best (juvenile abundance index, hereafter JAI, > 5.0) for years in which Roanoke River flows were low to moderate (5,000 to 11,000 cfs) and poor (JAI<5.0) when flows were very low (3,900-8,100 cfs) or very high (10,000 cfs or greater) during the spawning season (1 April-15 June). They found further that the average flow pattern for good recruitment years (JAI > 5.0) most closely resembled pre-impoundment flow conditions. When Roanoke River flow patterns were analyzed to assess the days within which a recommended flow regime (maintaining river discharge between the historical 25% low-flow and 75% high-flow values for the period March 1-June 30) had occurred, it was determined that the years of lowest JAI values were also those with the fewest days in which river flows were within the recommended bounds. Striped bass egg viability also was higher when discharges were within the bounds over 50% of spawning period days, but less when days within bounds averaged 27%. The authors noted also that river flow directly influenced 1) seasonal timing and location of spawning; 2) daily or hourly patterns in spawning activity; 3) egg transport downstream; 4) larval transport and feeding; 5) location of primary nursery grounds in Albemarle Sound; and 6) concentration and distribution of zooplankton (used as food by striped bass postlarvae and juveniles). Further analysis by Zincone and Rulifson (1991) confirmed the relationship of striped bass JAI from Albemarle Sound correlating with Roanoke River flows and contended that good JAI years corresponded with years in which flows were closest to pre-impoundment flows. Leahy (1992) maintained there were problems with the analysis which rendered the conclusions invalid; however, Zincone and Rulifson (1992) satisfactorily addressed his concerns.

A number of authors have addressed the issue of assessing the alteration of river flow, as well as defining approaches to maintaining appropriate flows for sustaining production of natural resources (Richter et al. 1996, Richter et al. 1997, Poff et al. 1997 and Silk et al. 2000). Poff et al. (1997) review the natural flow regime of unaltered rivers; human alteration of flow regimes; ecological functions of the natural flow regime; ecological responses to altered flow regimes; and recent approaches to streamflow management. They conclude that "…it is necessary to preserve the natural hydrologic cycle by safeguarding against upstream river development and damaging land uses that modify runoff and sediment supply in the watershed"(Poff et al. 1997, p. 780). New methods for assessing the degree to which river ecosystems have undergone hydrologic alteration attributable to human influence (Richter et al. 1996) and for setting streamflow-based river ecosystem management targets (Richter et al. 1997) also have been developed, and in fact are applied to the Roanoke River in both of these publications. Finally, Silk et al. (2000) considers the utility of reversing the traditional approach to instream flow water rights. Conventional instream flow approaches protect up to a specified level of flow to be left in a stream and indirectly allocate the remaining flows for water development. Silk et al. (2000) suggest that the reverse approach, directly specifying a level of water development and protecting the remaining flow in the stream, may be beneficial as an alternative approach or in combination with the traditional approach.

The remainder of this issue paper discusses the alterations to flow which have already occurred, or may potentially occur, in each North Carolina coastal river system which hosts striped bass, and provides recommendations for mitigating or eliminating their impacts.

Chowan River Basin

The Chowan River Basin lies in the northeastern coastal plain of North Carolina and southeastern Virginia. It is formed at the North Carolina-Virginia border by the confluence of the Blackwater and Nottoway Rivers, and joined by the Meherrin River in North Carolina. Approximately 75 percent of the watershed lies in Virginia (NCDWQ 2001a). The Chowan River empties into western Albemarle Sound. See **Table** 10.1 for characteristics of the basin.

Striped bass use the Chowan River and tributaries to an unknown extent. Based on the documented presence of striped bass eggs and/or larvae, spawning has occurred in the Meherrin River both historically (Street et al. 1975) and more recently (in April 1998,Gilbert Tripp, Chowan College, unpublished data; personal communication from J.W. Kornegay, NC Wildlife Resources Commission). However, no comprehensive study of the extent or magnitude of striped bass spawning migrations or nursery use of the Chowan River and its major tributaries (Blackwater, Meherrin and Nottoway) has ever been undertaken.

There are a number of dams in the Chowan River basin, including the Baskerville and Camp Pickett Dams on the Nottoway and a hydropower dam on the Meherrin River at Emporia, Virginia. The latter facility began operation around 1908 and does practice peak power generation. At present, the degree to which flows in the Chowan River and its major tributaries are regulated is unknown.

Local Water Supply Plans were submitted to the State of North Carolina by 21 water systems in the basin. All NC water supply systems (three countywide and one regional) in the basin currently rely exclusively on groundwater (NCDWQ 2001a,b). Surface water withdrawals from the Chowan River are primarily for agricultural purposes. There is one municipal surface water withdrawal, for the City of Norfolk water supply, which is withdrawn from the Blackwater River in the Virginia portion of the watershed.

Roanoke River Basin

The Roanoke River Basin in Virginia and North Carolina occupies an area of approximately 9,776 square miles. The Roanoke River historically transported more water than any other river in North Carolina, with an average annual flow of about 8,500 cfs (Manooch and Rulifson 1989; **Figure 10.1**).

Flow modifications which have altered discharge patterns on the Roanoke River have been discussed in detail in the reports of the Roanoke River Water Flow Committee (see Manooch and Rulifson 1989; Rulifson and Manooch 1990, 1991 and 1993). Flows in the river were altered by the construction and operation of six dams located upstream of Roanoke Rapids (RM 137) beginning in 1950 with John H. Kerr Dam. Water flow regulation by the ACOE, operator of Kerr Dam, prevents the magnitude of pre-impoundment floods; however, the unnatural, extended flooding during post-impoundment years adversely affected certain wildlife species, especially wild turkey, and likely reduced the survival of young striped bass and perhaps other anadromous species (Manooch and Rulifson 1989). Extremely low water releases are also thought to have negatively impacted the survival of young striped bass and other anadromous species.

Because of the dramatic declines in egg viability, juvenile abundance, estimated population size and adult striped bass landings which occurred during the late 1970's and early 1980's, fishery management agencies and Congress became concerned for the future of this nationally significant resource. While there were undoubtedly multiple contributing factors to the observed decline of striped bass on the Roanoke River, including deteriorating water quality and heavy fishing pressure (Manooch and Rulifson 1989), it was clear that "...one of the major forces influencing the aquatic environment and, therefore, striped bass stocks [was] water flow."

The Roanoke River Water Flow Committee (RRWFC) was established in 1988 specifically to address the issue of flows on the lower Roanoke River. The Committee examined pre- and post-impoundment water flows, and concluded that there had been significant changes in the river's flow regime since impoundment, and especially since 1977, as a consequence of hydropower peaking activities. Other investigations by the Committee indicated that there were significant relationships between striped bass egg viability and the percentage of days in which flows on the river were within the historic limits of flow variability. Flows for years in which the striped bass JAI was relatively high were also more similar to pre-impoundment flows (Manooch and Rulifson 1989). The work of the Committee ultimately resulted in the negotiation of a new flow regime for implementation during the striped bass spawning period (presently April 1-June 15). The new flow regime, coupled with harvest controls, has coincided with improved juvenile striped bass recruitment, with the JAI reaching record high levels.

Richter et al. (1996, 1997) used new approaches, the Indicators of Hydrologic Alteration (IHA) and Range of Variability Approach (RVA) respectively, to assess the degree to which flows on the Roanoke River have been altered, and for determining instream flow targets. The approaches rely on analysis of changes which occur in the five fundamental characteristics of hydrologic regimes (see Poff et al. 1997 for definitions) 1) magnitude, the amount of water moving past a fixed location per unit time; 2) frequency, how often a flow above a given magnitude recurs over some specified time interval; 3) duration, the period of time associated with a specific flow condition; 4) timing or predictability, the regularity with which flows of defined magnitude occur; and 5) rate of change or flashiness, how quickly flow changes from one magnitude to another.

The results of the IHA analysis for the Roanoke reflect the effects of Kerr Reservoir and Roanoke Rapids Dam on downstream flows, showing severe effects on pulsing behavior, elimination of high-magnitude flooding and prolonged multi-day maxima (Richter et al. 1996). The average duration of pulses was much shorter in the post-dam than pre-dam periods, which the authors attributed to hydropower operations. The effect on the hydrologic regime is to create a greater frequency of high and low pulses of lesser duration and also to increase the number of hydrograph rises and falls. The magnitude and timing of the annual minima have changed, with the post-dam period showing a shift to lower mid-winter annual lows. The authors attribute this change to the capturing of winter flows for later spring and summer use. The average rate of flow increase was reduced in comparison to the pre-dam period. This change is attributed to the fact that flow releases seldom exceed 20,000 cfs, which corresponds to the turbine capacity at Roanoke Rapids. In the pre-dam period, flows commonly rose more than 40,000 cfs in a single day, during rainstorms. Overall, variability of flows on the Roanoke has been reduced in summer and winter monthly means, in extremely low water conditions, in timing of the annual highs and lows, in high and low pulse durations, and in frequency and rate of hydrograph rises and falls. However, coefficients of variation increased for springtime monthly means and long duration (30 and 90-day), high flow magnitudes. The authors concluded that their IHA analysis should direct attention to assessing the effects of dam operations on fish populations, littoral-zone benthic fauna, and floodplain forest communities (Richter et al. 1996). They recommend that programs to monitor response to hydrologic restoration could follow two strategies 1) continue to characterize the hydrologic regime using the IHA method, in order to look for expected decreases in the before and after deviations in IHA groups; and 2) directly monitor the status of the targeted biota.

The results of the RVA are reported in detail in Richter et al. (1997). Based upon the RVA analysis conducted for the Roanoke River, they recommended that operations rules for Kerr Reservoir, including the “guide” curve, be modified to accomplish five primary objectives 1) restore high-magnitude flooding; 2) shift the timing of the largest annual floods back into the spring (February-April) and shift the timing of annual low flow extremes to early autumn (September-October); 3) decrease the frequencies of high and low pulses and increase their durations; 4) decrease the frequency of hydrograph reversals (shifts between rising and falling flow levels) attributable to hydropower operations; and 5) moderate the rate at which flow release rates rise or fall within or between days. They noted that some of the recommendations would entail more than merely changing the way Kerr Reservoir is operated. Downstream measures would be necessary to accomplish flood restoration on the Roanoke. The authors note that a monitoring regime should be established for both flows and resources which are dependent upon them, including striped bass.

Currently, a new group of agency, municipal and industry representatives are working to develop a new flow regime for the lower river which will in part be based on the results of instream flow incremental analysis (IFIM). The Fisheries Technical Work Group was formed as a part of the relicensing process for Dominion Generation's (formerly Virginia Electric and Power Company) Gaston and Roanoke Rapids Dams hydropower operations, and is currently negotiating a new regime which includes striped bass as an evaluation species.

Outside of the striped bass spawning period, flows on the river remain altered by ACOE controlled floods and hydropower peaking operations. Hydropower operations dewater the portion of the river bypassed by the tailrace and cause extreme hourly and daily fluctuations downstream of Roanoke Rapids Dam as a consequence of peaking operations. Flood control operations conducted by the ACOE eliminate historic high discharges, and cause prolonged flooding of adjacent floodplain areas, frequently during periods of the year which such flood events did not historically occur. All of these flow effects also impact the quality of habitat within the downstream nursery areas.

Water supply in the basin is addressed in DWQ (2001b). Surface water is currently used to meet most water needs in the NC portion of the basin (approximately 56 percent of estimated total water use). Water demand from public systems in the North Carolina portion of the basin is expected to increase 55 percent by 2020. Seven of the 43 systems reported that available water supply was not adequate to meet the projected 2020 demand, and seventeen other systems indicated that 2020 demand levels will exceed 80 percent of available supply.

Water supply systems in other basins are also viewing the Roanoke as a potential source for future water supply. The City of Virginia Beach successfully planned and implemented a withdrawal from the Roanoke at Lake Gaston. There has also been discussion on the part of municipalities located in the Piedmont portion of North Carolina regarding additional interbasin transfers from the Roanoke. Currently, there are 26 registered water withdrawals in the NC portion of the Roanoke River basin. Sixteen of these are surface water withdrawals. Excluding public water systems or power generating facilities, the cumulative permitted withdrawal capacity is 147.8 million gallons per day (mgd; NCDWQ 2001b).

Tar-Pamlico River Basin

In the Tar River, striped bass generally spawn from the City of Rocky Mount (RM 122) downstream to Bells Bridge (RM 94); however, their upstream migration is flow-dependent. Median weekly discharge for the Tar River at Rocky Mount ranges from 399 to 950 cfs during the months of April and May and generally declines over this time period (**Figure 10.2**).

Instream flow in the Tar River below Rocky Mount is determined in part by releases from Tar River Reservoir (RM 130). It is a 1,860-acre water supply reservoir for the City of Rocky Mount constructed in 1970. The minimum flow requirement for water quality augmentation is 80 cfs, except during drought conditions when it is reduced to 65 cfs. Although Tar River Reservoir impacts downstream flow, there is little opportunity for augmentation during the spring for anadromous fishes given the reservoir's limited storage capacity.

Flow downstream of Rocky Mount is further altered by Rocky Mount Mills Dam (RM 122). This is a small privately-owned hydropower facility, which is currently operated as a peaking operation, resulting in frequent changes in downstream flow. As a result, river depth downstream can fluctuate as much as 1 ft over a short period of time. The dam is required to maintain a minimum release of 85 cfs; however, this requirement is not enforced. Significantly higher flows are needed during the months of March, April, and May for striped bass spawning; however, it is unrealistic in most years due to the dam's limited storage capacity. Nevertheless, striped bass would benefit from the elimination of peaking operations during the spring, which would result in more natural flows downstream of the dam. Currently, a developer has proposed to convert Rocky Mount Mills into apartments, and as part of the negotiations the City of Rocky Mount, the city has requested that the dam be operated as a run-of-the-river facility.

Other factors impacting instream flow within the basin are the withdrawals of surface water for the purposes of municipal drinking water and agricultural use. The WRC personnel have observed numerous agricultural water intake pipes located in the river during the growing season. Unlike municipal withdrawals, such agricultural withdrawals are largely unregulated by the DWR. Municipalities currently withdrawing water include Enfield, Franklinton, Greenville, Louisburg, Rocky Mount and Tarboro. Each of these municipalities must submit a local water supply plan every five years to the DWR. Based upon 1997 local water supply plans, mean daily water demand from municipal water systems with existing surface water withdrawals in the Tar-Pamlico River basin is projected to increase 25 percent by 2010 and 37 percent by 2020 (**Table 10.2).** Although a portion of the municipal water withdrawn is returned to the river in the form of wastewater, there is an overall net loss. In addition, as the demand for water increases, not only are these systems expanding, new systems are being proposed. Furthermore, a portion of the basin (Beaufort, Edgecombe, Martin, Pitt, Washington and Wilson Counties) is within the Central Coastal Plain Capacity Use Area. The Central Coastal Plain Capacity Use Area rules, which become effective August 1, 2002, will require entities that withdraw water from aquifers within the use area to reduce groundwater withdrawals over a 16-year period. As a result, more municipalities will consider surface water as a supply source. Although each system withdrawing surface water must individually comply with the guidelines of the DWR, the cumulative impact of these withdrawals on the spawning habitat available to striped bass, and other species, must be considered.

Neuse River Basin

With the removal of the Quaker Neck Dam near Goldsboro (RM 140) in 1998, an additional 74 miles of historic spawning habitat upstream to Milburnie Dam near Raleigh (RM 214) became accessible to striped bass as well as other anadromous and resident species. However, this habitat is only accessible during years of moderate to high flows. During years with low flow, striped bass only migrate upstream as far as Smithfield (RM 188) (Herndon et al. 2000; Bowman and Hightower 2001). Bowman and Hightower (2001) concluded that adequate flow is most critical for striped bass when they migrate above the fall line (RM 184).

Milburnie Dam, a small hydropower facility, is a run-of-the-river operation, and instream flow downstream of Milburnie Dam is determined mainly by releases from Falls Dam (RM 230). Operated by the ACOE, Wilmington District, the dam impounds Falls of the Neuse Reservoir, which is managed for downstream flood control, municipal water supply, water quality enhancement downstream of the dam (under low-flow conditions), and recreation. Riverine fish habitat downstream of the dam is not a current consideration. Minimum flow guidelines for downstream water quality augmentation from April through October are 100 cfs measured at the base of the dam and 254 cfs measured at the U.S. Geological Survey gauging station near Clayton. These minimum releases are not sufficient to allow migration of striped bass upstream of Smithfield. It is estimated that a flow greater than 500 cfs at Clayton is needed to provide striped bass access to spawning habitat upstream of Smithfield (WRC, unpublished data). Prior to the construction of Falls Dam, weekly median discharge during May was greater than 570 cfs measured at Clayton (Figure 10.3). Since its construction, weekly median discharge in May has been generally less than 492 cfs at Clayton. Furthermore, discharge typically declines throughout the spring, but in late spring discharge can decrease by an order of magnitude over a few days. Some of this change may be due to natural variability; however, much of it is due to ACOE management practices. The current ACOE step-down guidelines range from approximately 500 to 1,000 cfs each hour for the transition from high flow releases to lower flow releases, resulting in large, abrupt changes in flow. This problem is exacerbated during low water years and can disrupt striped bass spawning activity, especially during the late spring. The impact of these fluctuations on striped bass spawning success and the subsequent survival of eggs and larvae is unknown.

The flexibility of the ACOE in releasing flows from Falls Dam is constrained by the backwater effect of Milburnie Dam. This backwater effect causes flows in excess of 4,000 cfs to flood a subdivision located between Falls Dam and Milburnie. If Milburnie Dam was not present, backwater effects would not occur and the ACOE would be able to release sustained higher flows for fishery management purposes.

Table 10.2. Current and projected water supply and demand data (mgd) for municipal water systems with surface water intakes within the Tar River Basin based upon 1997 Local Water Supply Plans submitted to the N.C. Division of Water Resources (http://dwr32.ehnr.state.nc.us:81/cgi-bin/foxweb.exe/c:/foxweb/lwsp971).

Municipal Water System	Surface Water Source	Surface Water Supply 1997	Total Water Supply 1997	Projected Total Water Supply 2010	Projected Total Water Supply 2020	Mean Daily Demand[a] 1997	Projected Mean Daily Demand[a] 2010	Projected Mean Daily Demand[a] 2020
Franklinton	New City Pond/Old City Pond	0.4[b]	0.4	0.4	0.4	0.6	0.7	0.7
Louisburg	Tar River	2.0	2.0	2.0	2.0	1.5	0.8	0.9
Rocky Mount	Tar River/Tar River Reservoir	29.1[c]	29.1	29.1	29.1	15.5	19.2	21.1
Tarboro	Tar River	12.0	12.0	12.0	12.0	3.2	3.7	3.9
Greenville	Tar River	22.5	22.9[d]	31.4	31.4	11.9	16.6	18.6
Enfield	Fishing Creek	7.3	7.3	7.3	7.3	0.5	0.6	0.6

[a] Includes service area demands and contract sales to other water systems.
[b] Includes 0.3 mgd from New City Pond and 0.1 mgd from Old City Pond.
[c] Includes 16.0 mgd from Tar River and 13.1 mgd from Tar River Reservoir.
[d] Includes 0.4 mgd of groundwater.

Also impacting instream flow downstream of Milburnie Dam are agricultural and municipal water supply withdrawals. The cumulative amount and/or impact of agricultural withdrawals are unknown. Based upon 1997 local water supply plans, mean daily water demand from municipal water systems with existing surface water withdrawals in the Neuse River basin is projected to increase 36 percent by 2010 and 58 percent by 2020 (Table 10.3). Municipal water withdrawals in the basin include Durham, Raleigh, Clayton, Smithfield, Goldsboro and Wilson. As the demand for water increases, these systems are expanding and new systems are being proposed. Further, the Central Coastal Plain Capacity Use Area rules (effective August 1, 2002) will require entities that withdraw water from aquifers within the use area to reduce groundwater withdrawals over a 16-year period. Within the Neuse River Basin, the area includes Carteret, Craven, Greene, Jones, Lenoir, Pamlico, Pitt, Wayne and Wilson Counties. As a result, more municipalities will consider surface water as a supply source. For example, Kinston-Lenoir County is already preparing to withdraw water from the Neuse in the near future. The cumulative impact of these withdrawals combined with inadequate releases from Falls Reservoir could limit the spawning habitat available to striped bass, especially during years with low flow.

White Oak River Basin

Several river systems are found within the White Oak River Basin including the New and White Oak rivers. These rivers are small coastal blackwater systems that discharge directly into the Atlantic Ocean (Table 10.1). The New River drains through the New River Inlet, whereas the White Oak River drains through Bogue Inlet. A large portion of each drainage is tidally influenced. Although discharge data for these systems are sparse, flow is unregulated. Striped bass are known to occur in these systems; however, the extent of spawning is unknown and believed to be limited. Given their unaltered flow regimes, negotiation of appropriate instream flow regimes is not an issue in the New or White Oak rivers. Nonetheless, every effort should be made to preserve the current unregulated flow regimes.

Cape Fear River Basin

Instream flow in the upper Cape Fear River is in part determined by releases from B. Everett Jordan Reservoir. Located on the Haw River (RM 4), it is 202 miles from the mouth of the Cape Fear River. This reservoir is operated by the ACOE for the purposes of water supply, downstream flood control, water quality augmentation downstream of the dam, recreation and fish and wildlife conservation. Minimum flow required for downstream water quality augmentation is 600 cfs measured at Lillington. Prior to the construction of B. Everett Jordan Dam, weekly median discharge during May ranged from 1,210 to 1,750 cfs, and since its construction, weekly median discharge in May has been comparable ranging from 1,090 to 1,950 cfs (Figure 10.4).

Downstream of Jordan Reservoir, there are four additional dams located on the Cape Fear River. Buckhorn Dam (RM 188) is a hydropower facility, owned by Progress Energy, which was originally constructed to provide supplement storage for a

Table 10.3. Current and projected water supply and demand data (mgd) for municipal water systems with surface water intakes within the Neuse River Basin based upon 1997 Local Water Supply Plans submitted to the N.C. Division of Water Resources (http://dwr32.ehnr.state.nc.us:81/cgi-bin/foxweb.exe/c:/foxweb/lwsp971).

Municipal	Surface	Surface Water Supply	Total Water Supply	Projected Total Water Supply		Mean Daily Demand[a]	Projected Mean Daily Demand[a]	
Water System	Water Source	1997	1997	2010	2020	1997	2010	2020
Orange-Alamance	Corporation Lake	0.4	0.5[b]	0.5	0.5	1.1	1.6	2.2
Hillsborough	Lake Ben Johnson	0.7	0.7	3.7	3.7	1.8	2.2	2.6
Durham	Flat River/Little River	37.0[c]	37.0	45.5	64.5	28.3	35.0	41.1
Creedmoor	Lake Rogers	0.8	0.8	0.8	0.8	0.3	0.3	0.3
Butner	J.D. Holt Reservoir	13.8	13.8	13.8	13.8	2.4	2.8	3.0
Raleigh	Falls Lake	72.0	72.0	89.0	89.0	55.2	69.6	80.1
Johnston Co.	Neuse River	12.0	12.0[d]	14.5	14.5	3.0	7.7	10.5
Smithfield	Neuse River	6.0	6.1[e]	6.0	6.0	2.1	4.6	4.8
Goldsboro	Neuse River	32.0	32.0	32.0	32.0	6.2	8.7	9.3
Zebulon	Little River	2.0	3.0[f]	4.0	4.0	0.7	0.9	1.2
Wilson	Toisnot Reservoir/Wiggins Mill Reservoir	7.0[g]	7.0	30.0	30.0	8.0	14.7	17.3

[a] Includes service area demands and contract sales to other water systems.
[b] Includes 0.1 mgd of groundwater.
[c] Includes 19.0 mgd from Flat River and 18.0 mgd from Little River.
[d] Includes <0.1 mgd purchased from Wendell.
[e] Includes 0.1 mgd purchased from Johnston Co.
[f] Includes 1.0 mgd purchased from Zebulon/Knightdale/Wendell/Raleigh.
[g] Includes 1.0 mgd from Toisnot Reservoir and 6.0 mgd from Lake Wiggins, but does not include regular withdrawals from Buckhorn Reservoir or Lake Wilson.

Table 10.4. Current and projected water supply and demand data (mgd) for municipal water systems with surface water intakes within the Cape Fear River Basin based upon 1997 Local Water Supply Plans submitted to the N.C. Division of Water Resources (http://dwr32.ehnr.state.nc.us:81/cgi-bin/foxweb.exe/c:/foxweb/lwsp971).

Municipal Water System	Surface Water Source	Surface Water Supply 1997	Total Water Supply 1997	Projected Total Water Supply 2010	Projected Total Water Supply 2020	Mean Daily Demand[a] 1997	Projected Mean Daily Demand[a] 2010	Projected Mean Daily Demand[a] 2020
Reidsville	Lake Reidsville	19.0	19.0	19.0	19.0	3.4	8.1	8.4
Burlington	Lake Mackintosh/Stoney Creek	48.0[b]	48.0	48.0	48.0	14.5	18.2	19.6
Graham	Graham-Mebane Lake	12.0	12.0	12.0	12.0	7.2	8.2	9.3
Pittsboro	Haw River	7.6	7.6	7.6	7.6	0.7	1.0	1.2
Orange Co. WSA	Cane Creek/University Lake	10.4[c]	10.4	20.4	20.4	9.0	11.7	13.8
Apex	B. Everett Jordan Reservoir	3.7	3.7	9.2	11.0	1.8	5.6	8.9
Cary	B. Everett Jordan Reservoir	12.3	15.8[d]	18.6	21.3	12.0	11.8	14.5
Chatham Co.	B. Everett Jordan Reservoir	6.0	6.0	12.0	12.0	0.8	3.2	4.2
High Point	City Lake/Oak Hollow Lake	21.4[e]	21.4	31.4	31.4	15.5	22.3	26.0
Greensboro	Lake Brandt	36.0[f]	36.0	71.0	71.0	40.3	50.5	58.0
Randleman	Polecat Creek	1.5	2.5[g]	3.5	3.5	1.2	1.5	1.6
Ramseur	Sandy Creek	6.6	6.6	6.6	6.6	0.6	0.9	1.0
Robbins	Bear Creek	1.5	1.5	1.5	1.5	0.8	0.8	0.9
Goldston-Gulf SD	Deep River	0.5	0.5	0.5	0.5	0.3	0.4	0.4
Siler City	Rocky River Lower Reservoir	3.8	3.8	5.8	5.8	2.8	3.4	3.7
Lee Co.	Deep River	1.5	1.5	1.5	1.5	0.8	0.9	0.9
Sanford	Cape Fear River	12.6	12.6	12.6	12.6	8.2	10.3	12.5
Erwin	Swift Textiles Reservoir	1.5	1.5	1.5	1.5	0.6	0.8	0.9
Dunn	Cape Fear River	8.0	8.0	8.0	8.0	4.6	5.6	5.7
Harnett Co.	Cape Fear River	12.0	13.3[h]	13.3	13.3	10.0	18.2	22.9
Carthage	Nick's Creek	0.5	0.5	0.5	0.5	0.3	0.5	0.5
Moore Co.	Little River	1.5	1.5	1.5	1.5	0.1	0.1	0.2
Fort Bragg	Little River Reservoirs	20.0	20.0	20.0	20.0	7.6	7.6	7.6
Fayetteville	Big Cross Creek/Cape Fear	92.0[i]	92.0	92.0	92.0	27.1	47.9	52.3
Riegelwood SD	Cape Fear River	1.0	1.0	1.0	1.0	0.6	0.6	0.6
Lower Cape Fear WSA	Cape Fear River	50.0	50.0	50.0	50.0	40.7	50.7	50.7
Wilmington	Cape Fear River	15.0	30.0[j]	35.4	35.4	12.3	19.9	22.1

[a] Includes service area demands and contract sales to other water systems.

[b] Includes 26.0 mgd from Lake Mackinstosh and 12.0 mgd from Stoney Creek.

[c] Includes 8.0 mgd from Cane Creek and 2.4 mgd from University Lake.

[d] Includes 3.5 mgd purchased from City of Raleigh.

[e] Includes 8.6 mgd from City Lake and 12.8 mgd from Oak Hollow Lake.

[f] Does not include regular withdrawals from Lake Townsend

[g] Includes 1.0 mgd purchased from City of Asheboro.

[h] Includes 1.0 mgd purchased from City of Dunn and 0.3 mgd purchased from Johnston County.

[i] Includes 2.- mgd from Big Cross Creek, 85.0 mgd from Cape Fear River, and 5.0 mgd from Glenville Lake.

[j] Includes 15.0 mgd purchased from Lower Cape Fear WSA.

downstream hydro facility. However, it is now used to ensure adequate water elevation ("head") for the cooling water intake of the Progress Energy Cape Fear Steam Plant upstream of the dam. Lock and Dam No. 1 (RM 67), Lock and Dam No. 2 (RM 100) and Lock and Dam No. 3 (RM 123) are operated by the ACOE for the purpose of navigation upstream to Fayetteville, with a navigable depth of 8 ft at low water. Although these dams are impediments to fish migration, they function as run-of-the-river dams and have little impact on instream flow.

Within the Cape Fear River Basin, instream flow is not currently considered a major limiting factor to either striped bass migration or spawning success (K.W. Ashley, WRC, personal communication). Weekly median discharge measured near Lillington ranges from 1,090 to 4,480 cfs during April and May (Figure 10.4).

Municipal water withdrawals are the largest threat to instream flow in the Cape Fear River. Based upon 1997 local water supply plans, mean daily water demand from municipal water systems with existing surface water withdrawals in the Cape Fear River Basin is project to increase 39 percent by 2010 and 56 percent by 2020 **(Table 10.4).** This does not account for any new surface water withdrawals that may be permitted. Current water allocations from Jordan Reservoir include Cary-Apex, Chatham County, Holly Springs, Morrisville, Orange County and Wake County-Research Triangle Park. Other municipalities including Fayetteville, Durham, and Greensboro have expressed an interest in future allocations from the reservoir. Downstream of Jordan Reservoir, major surface water withdrawals include Sanford, Harnett County, Fort Bragg, Fayetteville, the Lower Cape Fear Water and Sewer Authority, and Wilmington. The practice of interbasin transfer further complicates this issue. For example, the Town of Cary receives water from the Jordan Reservoir (Cape Fear Basin), yet its wastewater is currently discharged into Crabtree and Middle creeks (Neuse River Basin). In addition to municipal water withdrawals, industries including textile manufacturing, electrical power generation, paper production, and mining also use surface water. Within the Cape Fear River Basin these include Progress Energy (multiple facilities), International Paper, DuPont, and DAK Monomers, LLC. All surface water withdrawals, both municipal and industrial, have to individually comply with the guidelines of the DWR. However, the accumulative impact of these water withdrawals on instream fish habitat must be considered as local water supply plans are developed and revised within this regime**.**

Pee Dee River Basin

Currently, flows on the Pee Dee are highly regulated by a chain of reservoirs constructed primarily for hydropower operations by Progress Energy (Blewett Falls, Tillery) and Alcoa Corporation (four dams upstream of Tillery). All six projects are licensed by the Federal Energy Regulatory Commission (FERC) and their licenses expire in 2008. Both licensees recently convened Issue Advisory Groups (IAGs) to begin the scoping and study identification process. Representatives of the FWS and the WRC, in cooperation with South Carolina agencies, will be participating on the IAGs and will be identifying flow issues which need to be addressed by the licensees. At this time, the agencies have requested the two licensees to collaborate on the development of a flow model which will cover the river from the uppermost dam downstream to the

Winyah Bay estuary. Flow issues have not specifically been identified at this time; however based on personal observations, present patterns and quantities of water released from the system are likely unsuitable for optimal use of the striped bass habitats located downstream of the dams (Figure 10.6).

Current Authority

None of the federal or state fishery management agencies have the authority to regulate or specify flows. Such authority rests with the North Carolina DWQ and DWR, the ACOE, and individual hydropower operators, subject to license under the FERC. At present, the only river for which any sort of flow agreement is in effect, other than prescribed minimum flow releases for individual dams (mostly for water quality purposes), is the Roanoke River where a Memorandum of Understanding between Dominion Generation, the WRC and the ACOE specifies flow targets for release from Kerr Reservoir and Roanoke Rapids Dams during the period April 1 through June 15 of each year, for the maintenance of spawning flows for ecological purposes.

Discussion

The provision of appropriate quantity and seasonal delivery of freshwater flow from upstream to downstream in every North Carolina river basin is clearly necessary for maintaining their function as important spawning and nursery habitats for striped bass populations. Spawning adults require adequately high flows in the spring to reach spawning habitats and successfully reproduce; eggs require sufficient flows to remain suspended and develop; larvae and postlarvae require adequate flows for transport to downstream nursery areas; and flows are required to maintain proper conditions for estuarine nursery grounds. In some cases, river systems (White Oak, New, Northeast Cape Fear) are unregulated, and vigilance will be required to insure that they remain unregulated and that current flows are maintained. In other cases, rivers are regulated to varying degrees for other purposes (Chowan, Roanoke, Tar-Pamlico, Neuse, Cape Fear, Pee Dee), and negotiations must be undertaken to restore or secure appropriate flow regimes.

Management Options

Generic Management Options for River Basins

- No Action
- For rivers which are presently unregulated work with North Carolina and/or Virginia and South Carolina water resource authorities as appropriate, to secure commitments for preservation of the unaltered flow regimes.
- For rivers which are presently regulated to such a degree that flow patterns depart significantly from an unregulated condition, establish a recommended annual flow regime for striped bass spawning and nursery areas, and work with the appropriate regulatory agencies to secure commitments for preservation of such a regime.
- Require North Carolina Division of Water Resources to include Division of Water Quality, Wildlife Resources Commission, Division of Marine Fisheries and US Fish and Wildlife Service in the local water supply planning process and in future water

allocation negotiations. Where needed, water allocation for riverine fish habitat (in particular striped bass spawning and nursery habitat) should be obtained by these natural resource agencies.

Specific Management Options by River Basin

Neuse River

- Support removal of Milburnie Dam, to provide more flexibility for flow management
- Conduct IHA and RVA analysis of Neuse River flows, and submit the resultant flow regime to the ACOE for implementation.

Pee Dee River

- Participate (USFWS and WRC, in cooperation with SC agencies) in the re-licensing of dams, with a goal of obtaining adequate quantity and timing of flow releases for all downstream striped bass habitats.

Research Needs

- Conduct a new analysis of the relationship between Juvenile Abundance Index (JAI) in Albemarle Sound and Roanoke River flow to incorporate JAI values measured during the past decade, since previous analyses were conducted. Examine historical striped bass data sets from other North Carolina rivers to determine if sufficient information exists to evaluate relationships between striped bass life history stages and flows.
- Should there be insufficient data to evaluate relationships between striped bass life history stages and flows within a given river, such data should be collected for a sufficient length of time to allow determination of such relationships, if desirable.
- When implementing changes to flow regimes on any North Carolina river, conduct appropriate field monitoring of striped bass life stages to document any response.
- Conduct needed studies to further refine the relationship between striped bass life stages, flow and habitat quality (i.e., the relationship between flows and the location and extent of spawning and nursery habitat(s) in the Tar, Neuse, Cape Fear and Pee Dee rivers)

MFC, DMF, WRC and FWS Management Recommendation

Endorse the management options and research needs, excluding the No Action option.

A/R and C/S Advisory Committee Recommendation

Endorse in concept the management options and research needs, excluding the No Action management option.

10.2.1.2 Critical Habitat- Spawning and Nursery Area

Issue

Protection of critical habitat areas and identification of spawning and nursery area habitat.

Background
Protection of the quantity and quality of striped bass habitat, particularly areas designated as critical are essential to the goal of this plan. Increasing human activity across North Carolina continues to have a significant influence on habitat quantity and quality as well as associated wildlife and fisheries resources. Habitat alterations have already significantly impacted some resident wildlife populations either directly or indirectly. Wetlands form a unique interface between terrestrial and aquatic ecosystems, providing valuable water related functions and important habitat for a broad range of fish and wildlife species. Major conversions of coastal and freshwater wetlands have occurred due to agricultural and silvicultural expansion, industrial development, and urban encroachment, including resort communities. Development impacts in wetlands are magnified due to the loss or disruption of these unique characteristics through alternations of quantity or quality. It is estimated that North Carolina has already lost 34% of its coastal wetlands (DCM 1999), which are critical fisheries habitat. Habitat conservation and protection is directly related to environmental quality.

Current Authority

General Statutes of North Carolina
G.S. 143B-289.52 Marine Fisheries Commission- powers and duties
G.S. 143B-279.8 Coastal Habitat Protection Plans
G.S. 113-132 Management Jurisdiction
G.S. 113-129 North Carolina Wildlife Commission–powers and duties
Marine Fisheries Commission Rules

North Carolina Fisheries Rules for Coastal Waters (15A NCAC)
3I .0101 (20), (C), and (D)- Definitions

North Carolina Wildlife Resources Rules

North Carolina Fisheries Rules for Inland Waters (15A NCAC)
10C.0500 Primary Nursery Areas

Discussion
The WRC, DMF and USFWS have no direct authority to delineate and/or enforce regulatory actions except creel, size, and method of fishing taken in critical habitat areas, unless endangered species are present. The WRC can designate waters Inland Primary Nursery Areas (IPNA), however the WRC has no additional regulatory authority in these areas. Permits in these areas are given additional consideration of impacts by other agencies prior to issuing development permits.

The DMF has the authority to designate Critical Habitat Areas, Anadromous Spawning and Nursery Areas and regulate fishing activities in these areas. DMF has conducted anadromous spawning and nursery area surveys in the Albemarle Sound area, Tar-Pamlico, Neuse, White Oak, New and Cape Fear river systems. Except for the

Albemarle Sound area, no directed surveys have occurred since the early 1980s. Figure 9.3 shows the areas in each system that has been documented to function as spawning and/or nursery areas for striped bass. Although these areas have been identified by DMF, they have not been adopted into rule, making the designations only descriptions of the areas.

The 1997 Fisheries Reform Act mandates that DENR shall coordinate the preparation of Coastal Habitat Protection Plans (CHPP) for critical fisheries habitats. The goal of the CHPPs shall be the long-term enhancement of coastal fisheries associated with coastal habitat. The DMF, DWQ and DCM shall prepare the CHPPs, with assistance from other federal and State agencies. The plans shall (1) describe and classify biological systems in the habitats, (2) evaluate the function, value to coastal fisheries, status, and tends of the habitats, (3) identify existing and potential threats to the habitats and the impact on coastal fishing and (4) recommend actions to protect and restore habitats. The CHPPs management units are Coastal Ocean, Albemarle, Chowan, Roanoke, Tar-Pamlico, Pamlico, Neuse, Core/Bogue, New/White Oak, Cape Fear and Southern Estuaries. The MFC, EMC and the CRC will jointly approve these plans and all regulatory action must be consistent with approved CHPPs. All CHPPs must be completed by December 31, 2004 and must be reviewed every five years.

Waters classified as special water quality by the EMC such as Outstanding Resource Waters (ORW) are given additional consideration of impacts by DCM prior to issuing development permits. The EMC has designated the Chowan River, Neuse River and Tar-Pamlico River basins Nutrient Sensitive Waters and had developed Nutrient Sensitive Waters Strategy (NSWS) for both basins. The NSWS includes a 30% reduction in nitrogen loading from agriculture, no net increase in phosphorous, protection for riparian areas, stormwater runoff control, and wastewater discharge standards. Substantial reductions in nutrient loading have been achieved in the Chowan River Basin. Adherence to the rules already put in place and proposed by the EMC, as part of the NSWS should slow the eutrophication in the Neuse and Tar-Pamlico basins. Regulations by the CRC do not allow authorization of projects that can violate water quality standards or adversely affect the life cycle of estuarine resources. The CRC regulates development activities in Areas of Environmental Concern (AEC), which include coastal wetlands. Generally, no development is allowed in coastal wetlands except water dependent activities, such as docks. The 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 (EAS), Coastal Area Management Act (CAMA), and ACOE permit applications to determine if the project will violate water quality standards. Although both DWQ and DCM are authorized to protect wetlands and submerged lands, dredging, filling and other shoreline modifications are permitted. Over 55% of North Carolina’s original wetlands have been destroyed in the past 200 years. Estuarine shoreline continues to be armored at a rate of at least 25 mi/yr (NCCF 1997). Furthermore while these programs recognize the relatively greater biological value of nursery areas and outstanding resource waters, they fail to adequately address cumulative impacts from piecemeal development.

The DMF/MFC and WRC authority is provided through North Carolina General Statutes and regulations. The DMF and WRC do have policies and statutory authority to

- Provide comments and recommendation on proposals requiring State and Federal authorization in the form of permits, licenses, or funding, which have impacts on wildlife and fisheries resources.
- Participate in development of Federal plans, permits, and licenses, funding for activities impacting the State's wetlands and aquatic resources.
- Participate in development of State plans, permits, licenses, funding and policy and activities impacting the State's wetlands and aquatic resources.
- Provide technical guidance and assistance to government agencies, and provide information to the public emphasizing values of wetlands and aquatic ecosystems, and the need for their conservation.
- Encourage development and enactment of comprehensive, regional and statewide plans for conservation and management of wetlands and aquatic ecosystems.
- Cooperate with the USFWS in compliance with provisions of the Fish and Wildlife Coordination Act and other legislation.

Management Options

- Advocate the adoption of DMF already identified anadromous spawning and nursery areas for striped bass into rules.
- Advocate stronger enforcement of regulations protecting critical habitat in the management areas.
- Purchase land adjacent to critical habitat areas to ensure that these areas are protected. This should include the acquisition of approved refuge lands on the Roanoke River.
- Continue to make recommendations on all state, federal and local permits where applicable.
- Support implementation of habitat recommendations of the Albemarle-Pamlico Estuarine Study, the Estuarine Shoreline Protection Stakeholders Report, Coastal Habitat Protection Plans and Critical Habitat Protection Plans.
- Maintain, restore and improve habitat to increase growth, survival and reproduction of striped bass. Monies from the Clean Water Trust Fund and others should be utilized for this.

Research Needs

- Re-evaluate the spawning and nursery area surveys conducted previously. Identify potential incentives to landowners for protection of riparian buffers in the management area.
- Develop, identify and clarify what critical habitat needs are to protect, enhance and restore habitats and water quality utilized or required by striped bass.

MFC, DMF, WRC and FWS Management Recommendation

Support the management options/impacts and research needs.

A/R and C/S Advisory Committee Management Recommendation

Support the management options/impacts and the research needs.

10.2.1.3 Blockages of Historical Spawning Habitat

Issue
To identify blockages to historical spawning areas and develop strategies to minimize impacts from the blockages.

Background
A blockage is defined as any man made or natural obstruction that impedes striped bass trying to reach historical spawning areas. Mainstem dams occur in all coastal rivers in North Carolina. The lowermost dams are located around the fall line (transitional area between the piedmont and coastal plain) in the Meherrin, Roanoke, Nottoway, Tar and Neuse rivers (Hightower, 2001). Blockages are shown in Figure 9.1 and Figure 9.2.

Striped bass utilized the areas above the fall line for spawning, when flows were above average during the spawning run. This is evident by the fact that striped bass were trapped in Kerr Reservoir when the dams were closed. Kerr Reservoir lies several miles above the fall line on the Roanoke River. Striped bass routinely reach the base of dams blocking their migration when water flows are above average.

It is probable that these blockages have had detrimental impacts to striped bass populations in the Roanoke, Tar, Neuse, and Cape Fear rivers. Striped bass populations declined in the 1980's in these systems. Striped bass populations have made a dramatic come back in the Roanoke system where water releases from Kerr Dam were altered to provide flows more conducive to striped bass spawning. It is thought the flow releases negotiated with the ACOE and Dominion Power are one of the primary factors in restoring the Roanoke stocks.

Chowan River
The Blackwater and Nottoway rivers form the Chowan River just after entering North Carolina. There are three dams located on the Nottoway River. The lowermost dam (Baskerville Mill Dam) currently blocks migrating anadromous fish (Odom et al. 1986). The next dam upstream (Camp Pickett Dam) may be within the historical range of anadromous fish but the third dam in the series is above an impassable waterfall (Odom et al. 1986). One low water dam is present on the Blackwater River, approximately 8 miles above Franklin, VA. During normal spring flows this dam does not act as an impediment to anadromous fish (Mitchell Norman, VGIF, personal communication).

Emporia Dam is the first blockage in the Meherrin River, a major tributary to the Chowan. A fish lift was installed in 1990 to pass American Shad, but passage has been minimal to date, due in part to design problems (J. W. Kornegay, NCWRC, personal communication). A second dam further upriver (Whittles Mill Dam) is considered to be beyond the limit of migration for anadromous fish (Odom et al. 1986).

Roanoke River

Currently, numerous large and small dams are present in the upper reaches of the Roanoke River Basin. Roanoke Rapids Dam at river mile 137.5 is the lowermost dam on the main stem of the river. Roanoke Rapids Dam impounds the reach to Gaston Dam at river mile 145.5. Gaston Dam impounds the reach to river mile 170, below Kerr Dam at river mile 179.5. Kerr Dam impounds the river up the Dan River to river mile 206, and up the Staunton River to river mile 212 (Laney et. al. 2001).

Cape Fear

In the Cape Fear River, the lowermost obstructions to migration are the three locks and dams located within the coastal plain. Passage was attempted through a creek on the north side of the river during the 1960's but failed ostensibly from attractant flows being sufficient to draw fish into the creek channel. The first complete obstruction to migration is Buckhorn Dam, which is located near the fall line. Buckhorn Dam is considered to be an obstruction to migration for striped bass in the Cape Fear River.

Tar River

The lowermost dam on the Tar River (Rocky Mount Mill Dam) is an obstruction to migration of striped bass, American shad, hickory shad, and blueback herring (Collier and Odom 1989). Two other Tar River dams further upstream are considered to be within the range of anadromous fish migration, but are not currently accessible (Collier and Odom 1989).

Neuse

The first blockage in the Neuse River is currently Milburnie Dam at river mile 183. The next obstruction is Falls of Neuse Dam at river mile 195. A substantial amount of mainstem habitat was restored in 1998 with the removal of the Quaker Neck Dam near Goldsboro (Bowman and Hightower 2001).

Yadkin-Pee Dee

Although not a North Carolina river the Pee Dee does have an anadromous run of striped bass. The first dam blocking this run is Blewett Falls, followed by Tillery, Falls, Badin, Tuckertown and High Rock. Historically, striped bass were found above all these dams.

Current Authority

Neither DMF or WRC has authority covering existing dams unless a hydro-electric facility comes up for relicensing. At this point both agencies would have certain rights and privileges to comment on settlement agreements submitted to the Federal Energy Relicensing Commission (FERC). The Clean Water Trust Fund has monies available to buy existing dams or have them opened for fish passage, and receive input from both agencies on where fisheries priorities exist in the state.

Discussion

Chowan River

Little is known of striped bass movement, numbers, or spawning in the Chowan, Blackwater or Nottoway rivers. Anecdotal information from anglers suggests that striped bass are utilizing the Blackwater and Nottoway rivers. Spring electrofishing sampling has found few striped bass present in the Meherrin River below Emporia, Virginia (Chad Thomas, NCWRC, personal communication).

Roanoke River
The impacts of fish passage above Roanoke Rapids are difficult to predict. Landlocked populations of striped bass have been developed in many of the upstream impoundments, and are currently the focus of many anglers. Managers are currently trying to understand potential beneficial and/or negative impacts to reservoir fisheries associated with passage

Tar River
There is a small hydro-dam located at the first upstream dam (Rocky Mount Mills Dam) in the Tar River, which conducts peaking operations to produce electricity. Removal of the dam is unlikely due to the fact that the City of Rocky Mount has a water supply intake just above the dam and the dam is listed as a state historical site. Fish ladders would allow striped bass access to an additional 20 miles of riverine habitat before reaching the next dam. Utilization of this habitat would only be during periods of high flow, if then.

Neuse River
Removal of Milburnie dam would allow the ACOE some latitude to provide a stable flow regime for the Neuse and provide access to another 10-20 miles of riverine habitat for spawning. The owner of the dam has recently expressed an interest in selling the dam. The DWQ has expressed concern over removal of Milburnie Dam, due to possible loss of wetlands associated with the dam.

Cape Fear River
The Cape Fear River may provide the best opportunity for remediation of obstructions. The ACOE operates three locks and dams in the coastal plain of North Carolina. The Corps is willing to relinquish control of the upper two locks and dams if a suitable entity can be found to maintain the associated land surrounding the area. The Corps is also working on fish passage for the lower most lock and dam, and is studying the necessity for operating the structure in a manner that would not block spawning migration. The City of Wilmington does have a water intake structure above this facility, which would present some problems in opening the structure permanently.

Yadkin-Pee Dee
The Yadkin chain of dams will be coming up for renewal under the Federal Energy Regulatory Commission in the near future. The possibility exists that fish passage could be a part of the re-licensing process.

Research Needs

Chowan River
Nottoway, Blackwater and Meherrin rivers are tributaries to the Albemarle Sound Management Area. Investigations would determine if dams in this system were having an impact on striped bass spawning. Investigate abundance and spawning contribution of striped bass in the Blackwater, Nottoway and Meherrin rivers. Manpower and monies need to complete surveys are lacking at this time and work will require adding additional Virginia agencies to the management process.

Roanoke River
Investigate the potential for passage of striped bass above Roanoke Rapids Dam. Other anadromous species such as American shad and possibly sturgeon would benefit from fish passage. Passage of some undesirable species is a possibility and approximately one to five million dollars would be required for a passage facility.

Tar River
Investigate the feasibility of fish passage on Rocky Mount Mill Dam and Tar River Reservoir Dam. Passage would add an additional 20-40 miles of spawning habitat but it is not clear at this time if passage would be beneficial to striped bass or to resident reservoir species.

Yadkin-Pee Dee
Investigate the feasibility of fish passage above the Yadkin chain of dams in North Carolina. Passage would be costly but striped bass and other anadromous species could be restored to their historical range.

MFC, DMF, WRC and FWS Management Recommendation

Neuse River
Support the removal of Milburnie Dam in Raleigh. Removal of this dam would open another 20 miles of spawning habitat and allow better manipulation of flows from Falls of the Neuse Reservoir for spawning anadromous species. It would be advantageous to American shad and hickory shad spawning runs, in addition to striped bass.

Cape Fear River
Support the removal of Buckhorn Dam and Lock and Dam No.2 and No.3 and a new fish passage route around Lock and Dam No.1. Striped bass would be able to return to historical spawning grounds. A striped bass and other anadromous species fishery would be able to develop upstream.

A/R and C/S Advisory Committee Management Recommendation
Endorse the research needs and management recommendations regarding blockage of historical spawning habitats.

10.2.1.4 Entrainment and Impingement of Eggs and Larvae

Issue

Striped bass eggs, fry and juveniles are removed from coastal rivers through water withdrawals.

Background

Each day in North Carolina, millions of gallons of water are pumped from coastal rivers by industrial, municipal, and agricultural water users. During the striped bass spawning seasons, striped bass eggs and fry drifting downstream with river currents are subject to being suctioned out of the rivers through various water pumping systems. Juvenile striped bass that have not fully developed their swimming abilities are also susceptible to be removed via water intakes. Removal of these eggs, fry, and juveniles represents a direct loss in striped bass reproductive success.

Current Authority

Whenever an industrial or municipal water user proposes to install new withdrawal structures or modify existing structures, permits from the ACOE and/or the DCM are required. The WRC and the DMF review the permit proposals and generally request permit conditions to minimize “entrainment” (drawing organisms into a system through water suction) or “impingement” (pinning organisms against a screen by water intake pressure). Agricultural water withdrawal structures are generally exempt from permit requirements and the fisheries agencies therefore do not have an opportunity to seek modification of equipment or operations to minimize losses of eggs and fry. The DWR requires water users to register (no permit is required, just registration) with that agency if withdrawals are greater than 1 million gallons per day for agricultural users or 100,000 gallons per day for other users. New regulations enacted by the US Environmental Protection Agency (EPA) will eventually require new and existing major industrial water withdrawal facilities to use best available technology to reduce entrainment and impingement of aquatic organisms (USEPA Section 316(b) rules).

Discussion

Striped bass eggs are approximately 3.5 mm (about 1/8th of an inch) in diameter and drift downstream with river currents. Once hatched, striped bass fry are approximately 5 mm (about ¼ inch) in length and 2 mm in cross section width. Striped bass fry also drift downstream with river currents and until several days after hatching can swim only sporadically in an upward motion. Not until 10 days or so after hatching, at a length of 10 mm (about ½ inch), can the fry swim horizontally and then only in short distances. Once grown past the fry stage, juvenile striped bass do not develop strong swimming abilities for several weeks. In summary, striped bass eggs, fry, and juveniles are unable to avoid being entrained into most water withdrawal systems. Once entrained, eggs, fry, and juveniles may be considered completely lost from the river. Even if the withdrawn water is returned to the river (such as is the case with industrial cooling water), striped bass are killed by high water pressure, turbulence, abrasion, and exposure to excessive temperatures. Some intake structures are equipped with fine-mesh screens to exclude fish eggs and larvae however the screens require constant cleaning with air and water jets to remove debris. In many instances, fish eggs and fry may not be completely entrained into the system but might be impinged on screens by water pressure. Little is known about the survival rates of eggs and fry that are impinged, then released from screen cleaning operations, but damage from pressure and abrasion seems likely. The importance of egg, fry, and juvenile losses through water intakes is unknown however, for those striped bass populations in which spawners are few, these losses could be significant.

Although DWR requires registration of major water withdrawals, compliance with registration requirements is not monitored therefore the full extent of withdrawals is unknown. A partial listing of major water withdrawal points by DWR indicates withdrawals of approximately 50-100 million gallons per day (MGD) occur from Roanoke River below Roanoke Rapids Lake, 271 MGD from Tar River below Rocky Mount Mills dam, 40 MGD below Falls Lake dam on the Neuse River, and 1,655 MGD from Cape Fear River below Jordan Lake dam.

Management Options/Impacts

- Continue to give close attention to state and federal permit requests in which water withdrawal structures are involved in coastal rivers. Agency comments on proposed water intakes should, where data are available, provide estimates of striped bass eggs, fry, and juveniles that could potentially be lost.
- Monitor the progress of USEPA's implementation of Section 316(b) rules as these rules may apply to water withdrawal points in North Carolina's coastal rivers.
- In the absence of effective exclusion technology, require water users to curtail withdrawals during periods in which striped bass eggs, fry, and juveniles may be present.

Research Needs

- The magnitude and seasonal timing of agricultural water withdrawals from coastal rivers is unknown. Documentation of these withdrawals should be required by Division of Water Resources and Division of Water Quality, so that the extent of entrainment of striped bass eggs, fry, and juveniles can be estimated.
- Data on the density and distribution of striped bass eggs, fry, and juveniles in coastal rivers are needed so that potential losses can be estimated.
- Identify effective engineering solutions to prevent entrainment and impingement of striped bass eggs, fry, and juveniles.
- Research is needed to determine the fate of striped bass eggs, fry, and juveniles that are impinged, then released through screen cleaning operations.

MFC, DMF, WRC and FWS Management Recommendation

DMF and WRC have no direct authority to regulate facilities that withdraw water from North Carolina's coastal rivers. Our management recommendations are therefore limited to those stated in the Management Options/Impacts section of this issue paper.

A/R and C/S Advisory Committee Recommendation

Endorse the management options/impacts and research needs regarding loss of striped bass eggs, larvae and fry to water intakes.

10.2.2 Water Quality Concerns

Issue
Identification of water quality concerns in the striped bass management areas.

Background
General concerns exist about point and non-point source discharges in each of the basins relative to the striped bass populations. Issues specific to each watershed are indicated. Basinwide water quality management plans prepared by DWQ contain specific information on the individual watersheds.

Current Authority

General Statutes of North Carolina
143B – 279.8 Coastal Habitat Protection Plan
143B – 289.52 Marine Fisheries Commission – powers and duties
Coastal Area Management Act (G.S. 113A-100 through 113A-128), as amended, and the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.).

Discussion

Point Source Discharges
The DWQ has the responsibility of ensuring that the waste limits in the National Pollutant Discharge Elimination System (NPDES) permits are established to protect water quality standards in receiving waters. NPDES permits contain effluent limitations that establish the theoretical safe level of various pollutants that may be discharged into surface waters. Maintaining adequate levels of dissolved oxygen (DO) on a year-round basis is a major issue in all of coastal NC. For most of the State's waters the dissolved oxygen standard is 5.0 mg/L. Streams classified, as "swamp waters" by DWQ do not retain this level of protection, and are instead assigned acceptable DO levels on a case-by-case basis. Because many of the rivers and tributaries in coastal river basins receive drainage from swampland, low DO and low pH characteristics can be naturally occurring. This further reduces the ability of these waters to buffer negative impacts arising from seemingly low levels of point and non-point source pollution. The cumulative effects of multiple discharges in coastal North Carolina are of concern and DWQ has concluded that the past approach of assigning acceptable DO levels may have resulted in the over allocation of waste assimilative capacity of receiving waters. The DWQ has identified the need to develop a better method of assessing the ability of swamp waters to assimilate oxygen-consuming waste.

The largest permitted outfall (approximately 80 MGD) in the A/R management area is from the Weyerhaeuser Paper Company, which operates a paper mill near Plymouth. The outfall originally discharged into Welch Creek until 1988 when it was relocated to the mainstem Roanoke River. In the 1980s, dioxin, a carcinogen byproduct of the chlorine paper bleaching process and discharged in Weyerhaeuser's effluent was found to be accumulating in the tissues of fish living in the lower Roanoke River. It was not until 1994 that a complete modernization of the paper mill was instituted, rendering the use of chlorine in the bleaching process obsolete. Although dioxin levels in fish tissues are gradually decreasing, fish consumption advisories remain in effect in the A/R management area as a result, and Welch Creek and the lower Roanoke River will retain an *impaired-waters* listing until the advisory is removed. Other large paper mills discharge effluents into the upper reaches of Roanoke River near Roanoke Rapids and to the Blackwater River in Virginia, a major tributary to the Chowan River.

Point discharges are also a special concern in the CSMA systems, as the management area receives effluent from numerous municipal wastewater treatment plants. Some of the largest of these are permitted to the cities of Raleigh, Smithfield and Kinston on the Neuse River, Rocky Mount, Tarboro and Greenville on the Tar River and Fayetteville and Wilmington on the Cape Fear River. Major industrial discharges are also present near the mouths of the Neuse and Cape Fear rivers.

In an attempt to enhance their abilities to provided potable water to their constituents, several coastal municipalities are considering the use of membrane technologies (reverse osmosis). Membrane processes produce two streams, the permeate stream (product water) and the by-product stream (concentrated brine effluent). One of the more practiced forms of concentrate disposal is via discharge to surface waters. Problem constituents in this effluent include hydrogen sulfide, chloride, fluoride, pH, nutrients (TP and TN), ammonia, dissolved oxygen, metals (copper, iron), radionuclides (Radium 226/228), conductivity and total dissolved solids. Research conducted near reverse osmosis plant outfalls in Florida indicates concentrate discharges typically fail toxicity tests performed on invertebrate and vertebrate organisms indigenous to the receiving waters (Andrews 2001). There are no existing reverse osmosis plants in operation within the United States that function in aquatic systems similar to those found in the coastal ecoregion of North Carolina. Currently, reverse osmosis plants are proposed or have been constructed in the counties of Camden, Pasquotank, Hyde, Tyrrell, Dare and Beaufort.

Non-point discharges

Sedimentation resulting from erodible agricultural fields, construction and development sites, unstable shorelines, woody debris removal and road construction adjacent to waters in coastal North Carolina degrades water quality and threatens fisheries resources. In addition, increasing urbanization has intensified stormwater run-off pollution within each river basin. This is especially the case in Dare and Currituck counties in the A/R system which have experienced population growth in excess of 100% between 1970-1980, and again from 1980-1990. Similar increases have been observed in Brunswick (43%), Pender (42%) and New Hanover (33%) counties in the C/S systems between 1990-2000. The losses of wetlands and riparian buffer zones, which help to filter pollutants and settle out sediments, have an adverse impact on water quality and fisheries resources in adjacent water bodies.

Maintenance of good water quality in spawning and nursery habitats is essential to the well-being of striped bass stocks. High concentrations of suspended solids (500-1000 mg/L^{-1}) significantly reduce hatching of striped bass eggs and survival of striped bass larvae (Auld and Schubel, 1978). An increase in water turbidity can also adversely affect the ability of striped bass larvae to capture zooplankton prey, resulting in larval starvation or poor condition (Breitburg, 1988). When impacts on reproductive processes are severe, year-class strength, and ultimately recruitment of individuals to the fishery, is significantly reduced. Management strategies focused on the protection and maintenance of the water quality functions of wetlands, specifically for nonpoint source pollutant abatement, need to be strengthened and enforced in coastal North Carolina. DWQ has identified the need for more widespread monitoring data to better assess the impacts of nonpoint sources of pollution on water quality.

Hypoxia Events

Dissolved oxygen (DO) concentrations >5 mg/L are recommended for all life history stages of striped bass. As oxygen levels drop below this standard, potential population impacts include deformities and reduced hatch of striped bass eggs (Turner and Farley 1971), yolk-sac larvae mortality (Rogers et al., 1980), mortality of juvenile striped bass at or below 3.0-3.6 mg/L (Chittenden, 1971; Coutant, 1985), and avoidance of waters by all ages of striped bass when dissolved oxygen falls below 3-4 mg/L (Cheek et al., 1985; Coutant, 1985).

Numerous episodes of hypoxia (low dissolved oxygen) confirm that certain waterbodies in coastal North Carolina can become stressed to the point that striped bass growth and survival may be impacted. For instance, during the summer of 1998, and under currently permitted biochemical oxygen demand (BOD) loads, continuous water quality monitoring stations in Roanoke River indicated that the dissolved oxygen standard of 5 mg/L was contravened for 21 consecutive days. Proposals to bring further industrial development to the Roanoke River are of great concern because of the existing tenuous DO conditions. DWQ has stated that “The Roanoke River model has consistently predicted that the BOD capacity of the system is exhausted.”(Mulligan, et. al 1993, in Roanoke River Water Flow Committee Report). Given the absence of additional assimilative capacity, it is critical to the continued management of the A/R striped bass stock that no new BOD loads be permitted in the Roanoke River. Flood control and hydropower operations contribute to hypoxic conditions in Roanoke River. Prolonged and seasonal flooding of the extensive wetlands adjacent Roanoke River causes DO levels in the river to plummet when high BOD swamp waters suddenly enter the river at the end of a water control action. Recurrent hypoxic events are also well documented in Pamlico and Neuse rivers as well as Pamlico Sound and are linked to algae blooms resulting from nutrient over-enrichment.

Blue-green algae blooms

Nutrient loading in coastal North Carolina from both point and nonpoint sources has been problematic for decades as evidenced by the recurrence of blue-green algae blooms in the lower Chowan River and western Albemarle Sound and the Pamlico and Neuse rivers as well as Pamlico Sound. Sources of nutrients include animal operations, cropland, urban stormwater, fertilizer plants and wastewater treatment plants. Some waters, such as the Chowan and Neuse rivers, have been classified as Nutrient Sensitive Waters by the EMC and receive special nutrient loading protection. In previous analyses of nutrient over-enrichment problems in Albemarle Sound, DWQ identified Roanoke River as a significant contributing source for nitrogen and phosphorus. An overabundance of nutrients, primarily nitrogen and phosphorus, under certain conditions can stimulate the occurrence of nuisance algae blooms. Algae blooms, through the processes of respiration and decomposition, deplete dissolved oxygen in the water column often causing fish kills. Blue-green algae blooms are more severe (covering a wider area and of longer duration) during years with heavy winter and spring rains followed by a dry summer. One important concern associated with blue-green algae blooms appears to be disruption of the food chain for young striped bass. Evidence suggests that blue-green algae, which are not a suitable food source for small aquatic animals, can disrupt the food chain by displacing normal algae populations.

Pfiesteria

Coastal rivers and estuaries continue to experience eutrophication, summer stratification and associated hypoxia, especially in the shallow, poorly-flushed reaches of the Neuse and Pamlico Rivers (NCDWQ 1998). Although the relationship between hypoxia and pfiesteria is poorly understood, there is little argument that these two conditions (alone or in conjunction) are responsible for the majority of fish kills in coastal North Carolina. The presence of pfiesteria-like organisms was observed in conjunction with a number of fish kill events in the 1990s, with most of these events involving large schools of menhaden. The onset of a pfiesteria outbreak can kill fish in a matter of minutes. The sub-acute effects of pfiesteria include skin damage and ulceration, with documented chronic effects including decreased reproductive capacity, poor growth rates and an increased incidence of disease.

Summertime Conditions

The optimum temperature range for striped bass shifts to lower temperatures as the fish grow; for first year juveniles it approaches 26^{o}C (78.8^{o}F), whereas it is near 20-24^{o}C (68-75^{o}F) for age-2 fish (Coutant and Carroll, 1980; Coutant et al., 1984). As adults, optimum water temperatures drop to 20-22^{o}C (68-71.6^{o}F), with avoidance of temperatures above 25^{o}C (77^{o}F) when cooler water is available (Schaich and Coutant, 1980).

Periods of excessively high water temperatures have been observed in the coastal waters of North Carolina during the summer months. Although this condition is a function of natural environmental processes and is not considered a type of degradation, the impacts of hot water on striped bass can be significant. In August 1999, DWQ reported that approximately 21,000 adult striped bass died in Albemarle Sound and portions of Croatan Sound as a result of high water temperatures. An extended period (August 5-August 28) of hot weather resulted in water temperatures exceeding 29.4^{o}C (85^{o}F). In Albemarle and Pamlico sounds, persistent periods of hot weather, little wind, and low precipitation result in stratification of the estuarine water column. Saline water, which is denser than fresh water, layers the bottom and does not readily mix with upper freshwater layers. This results in a depletion of oxygen within the bottom layers of the water column and with little wind aeration, an eventual oxygen depletion of the entire column. Excessive nutrient inputs into all of North Carolina's estuaries with the accompanying overgrowth of microorganisms are known to exacerbate this summertime phenomenon.

Contaminants

The persistence of dioxins, mercury and other contaminants in our river basins can have significant and adverse impacts on aquatic and terrestrial organisms, and when absorbed or ingested by humans, pose serious and life threatening consequences. Dioxins are unintentionally produced in many manufacturing and incineration processes and are some of the most carcinogenic substances known to man. Burton et al. (1983) analyzed the impacts of treated bleached Kraft mill effluent on striped bass prolarvae, and concluded that at volumes approaching 8-20%, mortality after 72 hours of exposure was significant. In addition, because dioxins are chemically stable and bioaccumulate in animal tissues, organisms higher up in the food chain tend to have greater concentrations of the chemical. Dioxins do not mix with water, instead binding tightly with sediment, food particles and organic matter, leaving extremely low concentrations dissolved in the water. Due to the slow breakdown rate of dioxins, organisms (like large fish such as bass and bowfin) exposed to continuous sources of dioxins tend to have higher levels in their tissues than fish that are lower in the food chain. Bioaccumulation of these substances in certain sections of the A/R management area has resulted in fish consumption advisories being posted to warn the public of the health risks posed by eating fish. Research needs in the C/S systems include an assessment of the sediments in the lower Neuse and Pamlico rivers for the presence of contaminants resulting from Hurricane Floyd. The DWQ has monitored dioxin levels in fish tissues from the Roanoke River, Chowan River and Albemarle Sound since 1989. Fish consumption advisories for the Roanoke River and Welch Creek have been in place since 1990 and for Albemarle Sound since 1991. The current advisory, as of March 2001, covers Welch Creek; the Roanoke River from the U.S. Highway 17 bridge near Williamston to the mouth of the Albemarle Sound; and Albemarle Sound from Bull Bay to Harvey Point and west to mouth of the Roanoke River and the mouth of the Chowan River at the US Highway 17 Bridge. The advisory reads, "Catfish and carp from these waters may contain low levels of dioxins. Women of childbearing age and children should not eat any catfish or carp from this area until further notice. All other persons should eat no more than one meal per person per month of catfish and carp from this area."

Methylmercury has been identified as the most toxic and widespread contaminant affecting aquatic ecosystems in the United States (Wiener and Krabbenhoft, 1999). Atmospheric deposition of inorganic mercury (Hg) is the primary source of contamination. Certain water bodies can be classified as mercury sensitive, in that relatively small inputs of total mercury can seriously contaminate fish. Known mercury sensitive systems include wetlands, low-alkalinity lakes, and surface waters that border areas that are prone to flooding (Wiener and Krabbenhoft, 1999). In North Carolina, mercury contamination is problematic, leading to consumption advisories for largemouth bass, bowfin, and chain pickerel south and east of Interstate 85. Additionally, a statewide consumption advisory exists for bowfin due to elevated mercury levels.

Management Options/Impacts

The resource agencies (WRC, DMF, and FWS) do not issue permits to individuals and/or entities requesting permission to impact surface waters and wetlands. Permit issuance is instead granted by state and federal regulatory agencies (DWQ, DCM, ACOE). For this reason, the suggested solutions listed below cannot be implemented without the assistance and oversight of the regulatory agencies responsible. However, the resource agencies are given the authority to request modification or denial of projects when the design is perceived as having adverse impacts to fisheries and aquatic resources.

1. Eutrophication--Limit nutrient discharges which amplify algae blooms and stimulate growth of other aquatic vegetation that can negatively affect water quality, cause fish kills, and restrict fishing and boating activities. Develop nutrient discharge limits with DWQ and local soil and water conservation districts.
2. Sediment discharges--Control sediment discharges into the watershed which are detrimental to fish populations by affecting egg and larvae survival, health and condition of adults, and quality of spawning habitats. Sedimentation from erodible agricultural fields, urban development, unstable shorelines and road construction is exacerbated by the loss of wetlands and vegetated riparian zones. Develop sediment discharge limits with the NC Division of Land Quality and local soil and water conservation districts.
3. Oxygen demanding effluents--Encourage DWQ to develop an accurate oxygen budget for waters within each coastal river basin. Require existing and future dischargers to comply with BOD limitations such that dissolved oxygen levels in basin waters are not compromised.
4. Anthropogenic fish kills--Limit anthropogenic-caused fish kills, such as those caused by livestock lagoon failures and other sewage discharges which severely reduce fish abundance and eliminate or reduce spawning stock. This should also include assessment of effluents produced as a by-product of reverse osmosis facilities.
5. Impervious surface areas--Encourage the development and implementation of adequate stormwater management plans to minimize the use of impervious surfaces in urban and developed areas.
6. Riparian zones--Protect existing vegetated riparian zones and establish new buffers along coastal waterways.
7. Wetlands-- Protect existing wetland habitat from loss to development, encourage restoration of prior converted wetlands, and advocate creation of wetland habitat where appropriate.
8. Spawning/nursery areas--Protect spawning and nursery areas of resident and anadromous species from development practices, which degrade habitat quality.
9. Shoreline hardening--Encourage developers to maintain shoreline in its natural state. When shoreline stabilization cannot be avoided, promote the use of shoreline protection that provides the least impact to aquatic organisms.

Research conducted in coastal NC rivers by the WRC has determined that riprap (rock) shorelines support greater fish diversity and higher densities of fishes than bulkhead shorelines.

10. Interbasin transfer--Maintain status quo in coastal ecosystems by discouraging interbasin water transfers. This activity has the potential to exacerbate existing water quality conditions.

Research Needs

- Membrane Water Treatment Plants--Evaluate the impacts/effects of reverse osmosis plants on receiving waters and aquatic resources.
- Water quantity--Evaluate the effects of existing and future water withdrawals on water quality and quantity and fisheries habitat in coastal watersheds.
- Contaminants--Determine if contaminants are presence and identify those that are potentially detrimental to various life history stages of striped bass. Specific areas of concern include the lower Neuse, Pamlico and Roanoke rivers.

MFC, DMF, WRC and FWS Management Recommendation

- Work in coordination with agencies such as the Division of Water Quality (DWQ), Division of Water Resources, Division of Land Quality, and Natural Resource Conservation Service to maintain, restore and improve water quality to increase growth, survival and reproduction of striped bass. Priority activities identified include the establishment of buffer strips and conservation easements within each basin, and the continued refinement of best management practices on lands used primarily for agriculture, silviculture and industrial and residential development.
- Support implementation of recommendations of DWQ basinwide water quality management plans, particularly measures that will reduce nutrient loading, sediment delivery and associated turbidity in all coastal watersheds.
- Support implementation of habitat and water quality recommendations of Coastal Habitat Protection plans (CHPPs), the Estuarine Shoreline Protection Stakeholders report (1999), and the Albemarle-Pamlico Estuarine Study (1994) which includes the Comprehensive Conservation and Management Plan (CCMP).
- **A/R and C/S Advisory Committee Management Recommendation**

Support the recommendations and research needs.

10.2.3 Catch and Release Mortality in the Hook and Line Fisheries

Issue

A portion of striped bass caught and released in the hook and line fisheries die as a result of injuries or physiological stress.

Background

In order to categorize total annual mortality (or yearly removals) of striped bass, fishery managers must be able to assess and estimate the magnitude of significant sources of mortality. Observations, data collections, and review of scientific literature by WRC and DMF staff indicate that the practice of catch and release striped bass fishing may constitute a significant source of mortality. Resource managers and users need to consider what levels of catch and release losses are an acceptable component of the hook and line fishery.

Current Authority

North Carolina Marine Fisheries Commission Rules

North Carolina Fisheries Rules for Coastal Waters (15A NCAC)
3M .0100 FINFISH, GENERAL
3M .0101 Mutilated Finfish
3M .0200 Striped Bass
3Q .0107 Special Rules, Joint Waters
3Q .0108 Management Plans for Striped Bass in Joint Waters
3Q .0109 Implementation of Striped Bass Management Plans
Recreational Fishing
North Carolina Wildlife Resources Commission Rules
North Carolina Fisheries Rules for Inland Waters (15A NCAC)
10C .0301 Inland Game Fishes Designated
10C .0302 Manner of Taking Inland Game Fishes
10C .0305 Open Seasons Creel and Size Limits

Discussion
Since the early 1990s, conservative striped bass creel limits have been in effect during open harvest seasons in the Albemarle Sound and Roanoke River Striped Bass Management Areas. The 2002 recreational management measures are presented in Table 10.5. As this striped bass population has grown, an extensive catch and release fishery has developed both within and outside of the harvest seasons. During open harvest seasons, many anglers catch and retain their daily creel limit, then finish the day with catching and releasing, sometimes large numbers of striped bass. Anglers often express the opinion that catching and releasing large numbers of striped bass after taking the daily creel limit substitutes for their desire of higher creel limits or “it makes the trip worthwhile.” Still, other anglers enjoy catching and releasing striped bass regardless of whether the harvest season is open, expressing no desire to keep any striped bass.

A proportion of striped bass caught and released in the hook and line fisheries die as a result of injuries or physiological stress. Hooking injuries that cause damage to the gills or puncture the esophagus are often fatal. Striped bass that are bleeding heavily upon capture generally die immediately (referred to as “initial mortality”) but many striped bass that are apparently in good condition upon release die at a later time. The physical exertion associated with being hooked, fought, dehooked, handled, and released causes the fish’s metabolic rate to increase greatly above normal limits and as a result, large amounts of lactic acid are produced with the muscle tissues. This severe condition known as “lactic acidosis” often causes death but death occurs slowly over a period of

Table 10.5. Management measures for 2002 hook and line fisheries.

Unit	Agency	Creel	Size Limit	Season	Other
Roanoke River Management Area	WRC	2 fish per person per day	18 inch (TL) and no fish between 22 and 27 inches (TL)	During open season, may possess one daily creel limit of striped bass any day of the week	April – June Upstream of Hwy. 258 bridge- barbless hooks only
Albemarle Sound Management Area	DMF	2 fish per person per day	18 inch (TL)	Spring and Fall season opened by proclamation with 4 days of fishing per week	
Central/Southern Management Area (Inland)	WRC	3 fish per person per day	18 inch (TL), except April – May upstream of Grimesland Bridge on Tar River and upstream of Hwy. 55 Bridge Lenoir County on the Neuse River- No fish between 22 and 27 inches (TL)	Open year round	
Central/Southern Management Area (Coastal/Joint)	DMF	3 fish per person per day	18 inch (TL)	Open year round	

several days (referred to as “delayed mortality”). Many anglers are under the false impression that if a striped bass caught and released swims away, then it will survive the encounter.

Extensive research has been conducted upon catch and release mortality of striped bass and indicates that hooking location, bait type, and water temperature are the main factors influencing whether a caught and released striped bass will live or die. In an analysis of hooking mortality of 1,275 striped bass in freshwater based on published and unpublished data, Wilde et al. (2000) found that bait type and water temperature were both significant predictors of hooking mortality. Mortality was greater in fish captured on natural baits than artificial lures and increased rapidly for both bait types as water temperatures exceeded 25°C (77°F). The predictive model developed in this analysis, suggested that 50% of striped bass captured on natural bait die when water temperatures reach 27°C (80.6°F). In controlled tank studies of Roanoke River striped bass caught and released into large holding tanks, mean mortality rates were estimated to be 6.4%, however at water temperatures exceeding 70^{o}F, mortality rates ranged up to 26.7% (Nelson 1998). In Albemarle Sound studies, survival of striped bass caught and released was lowest when water temperatures were high and dissolved oxygen low (Gearhart, 2002). Similar results (less than 10% mortality in cooler waters and up to 40% mortality in warm waters) have been documented in studies in estuarine striped bass populations in Massachusetts, Maryland, and in reservoir striped bass in Texas.

Hooking location and its relation to bait type also play a role in catch and release mortality. In studies on Roanoke River, hooking in the esophagus (throat) and gut was much more likely using natural bait than with artificial lures. Striped bass hooked in the esophagus, gut or gills had significantly greater mortality rates than fish hooked in the jaw or mouth. In Albemarle Sound studies (Gearhart, 2002*)*, predictors of mortality included bleeding, fish length, water temperature, hook removal, and dissolved oxygen. Overall, 57.1% of deep hooked striped bass died compared to 16.7% that were hooked in the mouth or gill and 2.7% for jaw hooked fish. Fish hooks that penetrate the esophagus may penetrate the heart or liver, which lie under the esophagus, causing internal injury and bleeding. Gills damaged by hooks bleed profusely and may result in mortality because they contain major arteries directly from the heart supplying blood flow to the gills for re-oxygenation. Some studies have suggested that catch and release mortality of striped bass may be moderated by salinity; however, additional studies are needed to clarify this relationship (Wilde et al. 2000).

A significant catch and release fishery exists in Roanoke River near Weldon during the spring months. On a year-round basis, striped bass are caught and released in Albemarle, Currituck, Roanoke, and Croatan sounds and tributary rivers, nearly anywhere they tend to congregate (bridges, pilings, deep water, etc.). Hook and line harvest is allowed year-round in the C/S Management Area. The 2002 management measures are shown in Table 10.5. The extent of any catch and release fisheries that might exist in the Tar, Pamlico, Neuse, and Cape Fear river systems is currently believed to be low in intensity. Marine Recreational Fishery Statistics Survey (MRFSS) angler interviews from the C/S area from 1987 through 2001 identified few anglers targeting striped bass however the area of coverage of the MRFSS does not extend upstream to areas where concentrated striped bass catch and release fishing might occur. Because data on the extent of the catch and release fishery in the CSMA is either absent or incomplete, commitment of resources to implement creel surveys will be necessary to fully understand the magnitude of this issue.

Both WRC and DMF estimate the numbers of striped bass caught and released during the open harvest seasons in Roanoke River and Albemarle Sound. Whenever funding has been available, WRC has conducted creel surveys after closure of the striped bass harvest season on Roanoke River. In May 2002, DMF initiated a study to estimate angling effort and numbers of striped bass caught and released in the ASMA during periods closed to harvest. Considering the numbers of striped bass caught and released during the harvest seasons and during those instances in which post-harvest season numbers have been estimated (Tables 10.6 and 10.7), WRC and DMF staffs believe the losses from these fisheries may be substantial.

Table 10.6. Estimated numbers of striped bass harvested and caught and released from the Roanoke River Striped Bass Management Area, 1991-2002.

Roanoke River Striped Bass Management Area			
Year	Number Striped Bass Harvested	Number caught and released-harvest season	Number caught and released-post harvest season
1991	26,934	98,148	no data
1992	13,372	23,710	no data
1993	14,325	56,791	no data
1994	8,284	3,826	no data
1995	7,471	6,892	52,698
1996	8,367	15,230	148,222
1997	9,364	10,748	271,328
1998	23,109	87,679	102,299
1999	22,479	50,161	113,394
2000	38,206	93,148	no data
2001	35,231	71,003	no data
2002	36,422	55,775	no data

Management Options/Impacts

- To reduce catch and release mortality of striped bass, seasonal fishing restrictions could be implemented to prohibit recreational harvest during warm weather. These restrictions are already in place in the Roanoke River/Albemarle Sound fisheries that have spring (Roanoke River) and fall seasons (Albemarle Sound). New restrictions would have minimal effects in the Roanoke River/Albemarle Sound Management Areas, but would affect other systems that currently have a year-round fishery.

Table 10.7. Estimated numbers of striped bass harvested and caught and released from the Albemarle Sound Striped Bass Management Area, 1991-2002.

		Albemarle Sound Management Area	
Year	Number striped bass harvested	Number caught and released-harvest season	Number caught and released-post harvest season
1991	14,395	23,540	17,997
1992	10,562	19,981	24,844
1993[a]	11,404	7,540	5,701
1994[b]	8,591	971	no data
1995	7,343	no data	no data
1996	7,433	11,865 (Fall only)	no data
1997	6,901	30,771	no data
1998	19,566	91,888	no data
1999	16,967	40,321	no data
2000	38,085	78,841	no data
2001	40,127	61,417	no data
2002	27,896	51,555	Not available

[a] Survey conducted from January – June 1993.
[b] Survey conducted only during the open harvest season

- To reduce catch and release mortality of striped bass, the use of natural bait (live or cut herring, shad, crab, and eels) could be restricted in specific areas or during

specific seasons. This would be very unpopular with anglers accustomed to high striped bass catch rates using live or cut bait.
- In order to reduce handling time, the use of barbless hooks or circle hooks could be required in specific areas or during specific seasons. A public education program would be required to demonstrate the conservation benefits of using new hook configurations.

Research Needs
- Clarify relationship between salinity, dissolved oxygen, temperature and catch and release.
- Mortality rates of striped bass in the Albemarle Sound and Central/Southern rivers and sounds.
- Determine the seasonal magnitude of striped bass angling effort, catch, and harvest for North Carolina rivers and coastal waters outside the Roanoke River/ Albemarle Sound Management Areas.

DMF, WRC and FWS Management Recommendation
Support the management recommendations and research needs.
- The numbers of striped bass caught and released on a year-round basis may be substantial. Creel surveys will be necessary to estimate numbers of striped bass caught and released as well as directed angling effort for striped bass. Once numbers of striped bass caught and released are estimated, differential mortality rates from other studies can be applied to those numbers to estimate catch and release mortality. These estimates are necessary as a part of estimating total annual fishing mortality, the management of which is imperative to the long-term perpetuation of the stock. WRC and DMF agree that catch and release fishing for striped bass is an acceptable component of the recreational fishery however, until the magnitude of striped bass losses from this component is estimated, objective policy decisions concerning acceptable levels of striped bass losses cannot be made.
- Observations by WRC and DMF indicate that directed angling effort for striped bass diminishes significantly once harvest seasons are closed in both the Roanoke River and Albemarle Sound Striped Bass Management Areas. Therefore, as an interim measure to minimize striped bass mortality from catch and release fishing, WRC and DMF recommend that striped bass harvest seasons be considered in months (October – April) in which cool water temperatures (<70°F) occur and/or in portions of rivers and sounds deemed necessary.
- An extensive angler education program on catch and release striped bass fishing should be implemented. Components of the program would include understandable presentations of scientific research findings on the effects of water temperature, angling techniques, hook configurations, bait and lure use, and handling of striped bass. Continued research on identifying the correct sizes and configurations of circle hooks is needed to develop effective methods of reducing deep hooking of striped bass in the natural bait component of the fishery.

A/R and C/S Advisory Committee Management Recommendation
Concur and support the management recommendations and the research needs.

MFC Management Recommendation
Support the management recommendations, with the following modification, specific months (May – September) should be identified for closure, should not be based on water temperature (70° F).

10.2.4 Enforcement of Creel Limits in the Vicinity of Inland/Joint or Coastal Boundaries

Issue
Division of Marine Fisheries (DMF) and Wildlife Resources Commission (WRC) enforcement officers may be faced with problems with the enforcement of striped bass recreational creel limits at or near the jurisdictional boundaries between Inland and Joint or Coastal Waters or at the boundaries between different striped bass management areas due to different creel limits, size limits or legal possession limits.

Background
Solicitation of issues concerning law enforcement was largely unproductive. Issues brought up included "black-marketing" of striped bass, false documentation (paper trails) on hybrid bass, and a request to investigate the striped bass possession limits in the vicinity of the boundary lines between Inland and Joint or Coastal designated waters and the boundaries between striped bass management areas. The illegal marketing of striped bass and hybrids were discussed by the PDT and are addressed by existing rules. The different creel limits and legal possession days between the ASMA the RRMA and the regulatory size differences in the Neuse River at Pitch Kettle Creek are two examples where anglers could have in possession the two fish allowed by the WRC, in addition to the two or three fish allowed by the DMF. The fish conceivably were caught legally within a short distance of each other.

Current Authority

North Carolina Marine Fisheries Commission

North Carolina Fisheries Rules for Coastal Waters (15A NCAC)
3I .0120 Possession or Transportation Limits
3M .0200 Striped Bass
3Q .0107 Special Rules, Joint Waters
3Q .0108 Management Plans for Striped Bass in Joint Waters

Discussion
Recreational anglers may possess three striped bass per person per day in Joint (except the Eastmost, Middle and Cashie rivers) and Coastal Waters year round outside of the ASMA. In the Inland Waters of the RRMA during the open seasons, anglers may possess two striped bass per person seven days per week. Properly licensed anglers fishing near boundaries between Inland Waters and Joint or Coastal Waters may at

times possess legally-caught limits of striped bass from both Inland and Joint or Coastal Waters. Fishermen that launch their boats in Inland Waters, run downstream to Joint Waters and legally catch three fish, then return with their catch to the ramp can be checked and found in violation of the WRC's two fish possession limit.

The Atlantic Ocean has a two fish possession limit and a minimum size limit of 28 inches. The Pamlico Sound has the three fish limit and the Albemarle Sound Management has a two fish limit on days when the season is opened.

These situations cause problems with enforcement and especially with prosecution of such cases. Judges are usually sympathetic to the anglers when there is any measure of doubt involved and convictions would be difficult to obtain.

The MFC has two rules which dictate how Marine Patrol Officers enforce the creel limits. The first is 3M .0202 (b) (1) which sets forth the Director's proclamation authority to impose seasons and creel limits and states in part "Specify quantity, but shall not exceed possession of more than three fish in any one day". This is a possession limit and does not consider where the fish were caught. You are in violation if you possess more than three. The second rule is 3I .0120 (a) which states "It is unlawful to possess any species of fish which is subject to size or harvest restrictions, while actively engaged in a fishing, unless all fish are in compliance with the restrictions for the waterbody and area being fished". The MFC considered the question and decided that you needed to be in possession of the appropriate limit where you are checked.

The WRC enforcement officers follow the same policy, i.e. allow the daily possession limit for the body of water in which they are fishing. A legal limit could be caught in inland waters and a legal limit could be caught in Coastal Waters, however, you would have to take the first catch home before being caught in possession of the second one. So *possession* is the key word in WRC enforcement also.

Both agencies allow a limit to be transported by boat when running to ramp or dock. The violation occurs when the individuals in the boat are actively engaged in a fishing operation.

Management Options

1. *Status quo*. No change in present situation.
    - \- continued confusion in boundary areas
    - \+ no change in proclamation or rule

2. Allow possession of WRC and DMF limits
    - \- would require regulation change
    - \- encourage increased landings
    - \+ would eliminate confusion over limits

3. Standardize possession limits between jurisdictions
    - \+ would eliminate confusion over limits

- would still be confusion over whether the limits were additive

4. WRC adopt MFC rule that possession limits apply where you are checked.
    + would clarify how many fish you were allowed
    + would simplify prosecution of violations

MFC, DMF and WRC Management Recommendation
The simplest solution to this confusion, if it exists, is to publicize to anglers in the vicinity of these boundaries that when you are checked by an enforcement officer of either agency, you cannot have in possession more than the creel limit for the waterbody you are in while actively engaged in fishing.

In order to promote complete clarity, encourage the WRC to implement a rule similar to the MFC Rule that states you must be in compliance with the restrictions in place at the point you are checked. The MFC Rule reads, "It is unlawful to possess any species of fish which is subject to size or harvest restrictions, while actively engaged in a fishing, unless all fish are in compliance with the restrictions for the waterbody and area being fished".

A/R and C/S Advisory Committees Management Recommendation
Support the agencies recommendation.

10.2.5 Albemarle Sound Management Area Boundary Line

Issue
Review the Albemarle Sound Management Area southern boundary line.

Area Description
The Albemarle Sound Management Area includes
Albemarle Sound and all its inland and joint water tributaries, except for the Roanoke, Eastmost, Middle, and Cashie rivers. Currituck Sound and all its inland water tributaries. Roanoke and Croatan sounds and all their inland and joint water tributaries, including Oregon Inlet, north of a line from Roanoke Marshes Point 35° 48' .3693 N - 75° 43' .7232 W, running 122° (M) across to the north point of Eagle Nest Bay 34° 44' .1710 N - 75° 31' .0520 W (**Figure 4.1**).

Background
In November 1990, a memorandum of agreement between the MFC and the WRC was signed to provide stewardship and continuity of management for the striped bass resource (copy attached). Through this agreement, the formation of two distinct management zones was created the Roanoke River Management Area (RRMA) and the Albemarle Sound Management Area (ASMA). Jurisdiction for the RRMA was given to the WRC, which included the joint and inland portions of the Roanoke, Eastmost, Middle and Cashie rivers. The ASMA was to be managed by the MFC.

The North Carolina Striped Bass Cooperative (NCSBC) was formed in 1990, and was comprised of the DMF, WRC and the Unites States Fish and Wildlife Service (FWS) to begin developing the North Carolina Striped Bass Management Plan. The formation of the line from Eagle Nest Bay across to Roanoke Marshes Point, the southern boundary of the ASMA, came about as a mutual agreement between the NCSBC. Under much scrutiny and backed by scientific evidence, the cooperative deemed it necessary to protect the one point of ingress and egress to the Atlantic Ocean that would allow a migration corridor for the A/R stock. This boundary was established to insure the protection of striped bass in the historically important area of the Roanoke River and Albemarle Sound and to not interfere with a multitude of different fisheries in southern areas, where striped bass were not as prevalent. It was also necessary to effectively manage the 98,000-pound annual commercial quota, established by the ASMFC in 1990, for North Carolina. Recreational quotas for striped bass in the Albemarle Management Area did not occur until 1994, after the North Carolina Striped Bass Management Plan for the A/R stock was completed and approved by the MFC and the WRC. The 1994 recreational quota was set at 58,000 pounds to be split between the RRMA and the ASMA. Any increases that would occur after that point would come at a 62.5% increase to the recreational fishery and a 37.5% increase to the commercial fishery. This would continue until there was parity between the two groups. Any overages that occurred in the annual total allowable catch (TAC) would be subtracted from the next year's TAC. As of the year 2000, the TAC for the ASMA was 450,000 pounds, with an equitable split between the recreational and commercial fisheries of 225,000 pounds each. In 2003, the TAC for the ASMA was increased to 550,000 pounds, with an equitable split between the fisheries (commercial and recreational). The recreational quota is equally divided between the RRMA and the ASMA (137,500 pounds for each area).

In May 1992, The Report to Congress for the North Carolina Striped Bass Study Albemarle Sound and Roanoke River Basin was submitted by the FWS. In this report, it detailed the specifics as to how North Carolina could rebuild its depleted striped bass population in the A/R system. This plan looked at water flows on the Roanoke River, water quality problems throughout the system, fishing pressures, as well as other issues. As a result of this report, North Carolina was allowed to manage its striped bass fishery in the A/R system outside the Atlantic States Marine Fisheries Commission (ASMFC) provisions for the Atlantic Coastal Migratory Stock but under the overall guidance of the ASMFC Striped Bass Fishery Management Plan. Evidence at the time supported the opinion that the A/R stock of striped bass did not contribute significantly to the Atlantic Migratory Stock. However, North Carolina is not completely outside of the ASMFC control. Each year, a fishing plan for the upcoming calendar year must be submitted. The plan must include restrictions that maintain mortality within the specified limits for Producer Areas, and must be accepted and approved by the ASMFC Striped Bass Technical Committee and the ASMFC Striped Bass Management Board. Only after these two groups have approved North Carolina's plan, can any changes in regulations (recreational or commercial) occur.

Current Authority

North Carolina Marine Fisheries Commission Rules

North Carolina Fisheries Rules for Coastal Waters (15A NCAC)

3M .0200 Striped Bass
3Q .0107 Special Rules, Joint Waters
3Q .0108 Management Plans for Striped Bass in Joint Waters
3 Q .0109 Implementation of Striped Bass Management Plans Recreational Fishing

Discussion

The current southern boundary line of the ASMA provides a corridor for the ingress and egress of striped bass from the ASMA to the Atlantic Ocean via Oregon Inlet. Recently, some commercial and recreational fishermen have requested that the southern boundary line be moved northward to the Croatan Sound bridge (Hwy 64/264) at Manns Harbor and Roanoke Sound bridge (Hwy 64/264) at Manteo. Moving the line northward will expand the area regulated by CSMA restrictions, which include an 18" minimum size, commercial season and 25,000 pound TAL, and recreational 3 fish year-round possession limit.

Commercial quota allocations differ significantly between the ASMA and CSMA, with the ASMA quota (225,000 pounds in 2002) based on stock abundance and mortality targets, and the CSMA quota of 25,000 pounds based on a percentage of historical landings. Since commercial landings are allocated to management area quotas based on where the fish are harvested, moving the line will affect landing allocations by area and possibly the season length in each area. Impacts of shifting the line will likely vary between the various fishery components, commercial and recreational and harvest and discard. The degree to which relative season lengths and possession limits will be affected will depend on whether fishermen respond to the boundary line change by changing their fishing practices. Shifting the line will change the allocation of landings between management areas, and thus will also change the AR stock assessment. To maintain consistency and avoid bias, the assessment would have to be modified to reflect the altered landings allocation.

It is impossible to accurately determine how a change in a management boundary will affect fishing effort. Therefore, it is also impossible to evaluate how such a change will affect current regulations that have evolved over time in response to effort and stock abundance. Nonetheless, the following paragraphs are our best attempt to illustrate the directionality of regulatory changes resulting from shifting the line.

Moving the line North will result in commercial landings from Croatan and Roanoke sounds being counted against the 25,000 pound quota available for the rest of the state. Including harvest from this area would likely result in the CSMA TAL being reached much quicker, thus shortening the allowable harvest season. Shortening the allowable harvest season will likely result in increased discard losses. Further, applying the shortened season to areas such as Croatan and Roanoke Sounds where striped bass are abundant will increase discard losses even further. Removing the Croatan-Roanoke landings from the ASMA allocation results in the same TAL applying to a smaller area representing presumably less overall effort, which might at first translate into longer seasons and higher catch rates. However, if the A/R stock of fish in the Croatan-Roanoke Sound areas are exploited more heavily when subjected to CSMA regulations than when subjected to ASMA regulations, any liberalization of ASMA regulations could be temporary.

Shifting recreational harvest components could lead to even more severe changes in allocation, since the recreational fishery in the CSMA is regulated liberally and without an overall harvest limit. If striped bass in the Croatan-Roanoke Sound areas are abundant, allowing these fish to be recreationally exploited year-round under a 3 fish possession limit could lead to greatly increased harvest in the CSMA. However, since we lack adequate recreational survey coverage of the CSMA and thus cannot reliably estimate total harvest, the increased recreational harvest may not be detected.

Moving the boundary line southward was not requested, but should be considered among the possibilities if change is pursued. As long as recreational regulations in the ASMA are more restrictive than those in the CSMA, moving the line south will decrease recreational exploitation of all stocks. Shifting the line south would not likely increase commercial exploitation of A/R fish since the quota would remain in effect, and requiring ASMA gear restrictions over a larger area would likely decrease discarding.

Changing the boundary line and thus changing where catches are allocated will affect population assessments. Ideally the stock assessment of the A/R stock should account for all harvest of the stock, regardless of harvest location. If most of the catch from the Croatan-Roanoke Sound areas is composed of A/R stock fish, then tabulating those catches to CSMA stocks will produce a negative bias in estimates of A/R stock abundance. The net reduction in population abundance could lead to lower ASMA quotas, which would affect the allocation to both recreational and commercial fisheries. Furthermore, if effectively liberalizing recreational regulations in the Croatan-Roanoke Sound areas significantly increases recreational exploitation of the A/R stock, then overall exploitation for the stock will increase. The obvious response to increased exploitation will be more restrictive management, in effect restricting ASMA fisheries in an attempt to offset increased harvest of the A/R stock in the CSMA. Overall, it seems likely that moving the boundary line Northward will reduce the commercial exploitation of the A/R stock (A/R fish in Croatan-Roanoke Sounds would be subjected to the 25,000 pound quota) and increase the recreational exploitation (A/R fish in Croatan-Roanoke Sounds would be subjected to year-round 3 fish per day possession limit).

Tag returns (n=85) from fish tagged and released in Albemarle Sound or on the Roanoke River spawning grounds have increased from areas south of the ASMA boundary line from 1986-2002. These fish have been recaptured in Pamlico Sound behind Rodanthe, Buxton and Ocracoke; and in the Pungo, Pamlico, and Neuse Rivers. Similarly, tagged Phase II striped bass released in the Neuse and Pamlico rivers have been recaptured in the Albemarle Sound and Roanoke River (n=34) since at least 1996. These returns indicate that striped bass populations within North Carolina mix readily.

Since all anecdotal and assessment information indicates that the A/R stock is much larger than any of the other North Carolina stocks, in all likelihood far more A/R stock fish are being captured outside the ASMA than are Neuse or Tar stock being captured in the ASMA.

Any changes to the boundary line should be made with consideration to the stock composition of the population of fish available in the areas the change will affect. This is especially true if the boundary line is used to allocate catches to management units and thus to stocks. Allocating catches by some other, more direct method based on stock composition of the catch and not a geographic boundary is certainly preferable. An expanded tagging program covering all systems and including a component to estimate reporting rates by area is one possible approach.

The following conditions are required to redefine the ASMA.

1) Concurrence between the members of the North Carolina Striped Bass Cooperative that moving the boundaries for the ASMA is for the benefit of the stock.
2) Upon agreement that the ASMA boundaries should be moved, a fishing plan for the next calendar year would have to be developed and submitted to the ASMFC's Striped Bass Technical Committee.
3) Upon acceptance by the Technical Committee, the plan would go before the ASMFC's Striped Bass Management Board. Acceptance by the Management Board would then allow the proposed North Carolina fishing plan to be implemented, effectively moving the boundary lines.

Management Options

- Status quo – No change in boundary line
  - + No management or Fishing Plan change necessary
  - + Current assessment results based on landings under this allocation; no need to change assessment
  - + Believed to encompass primary areas inhabited by AR stock
  - - Some AR stock fish move outside the boundary, % may be increasing.
  - - The management boundary is not an impediment to stock movement
- Move the ASMA southern boundary line north to Croatan Sound and Roanoke Sound (Hwy 64/264) bridges.
  - + Fishermen desire this change
  - - Will require major change in stock assessment, with a retrospective allocation of catches to the newly defined management area.
  - - Commercial discard exploitation may increase
  - - AR fish may be tabulated as CSMA stocks fish.
  - - If more fishermen use the additional CSMA area, the season and possession limits will need to be more restrictive.
  - - Recreational exploitation of the AR stock would likely increase
  - - Increasing the area of the CSMA may result in increased commercial effort pursuing the 25,000 pound CSMA quota, thus quota would probably be reached faster .

- Move the ASMA southern boundary line south of the existing line from Roanoke Marshes Point/Eagle Nest Bay
  - \+ Smaller CSMA may result in fewer fishermen pursing the CSMA quota
  - \+ Reduced recreational exploitation
  - \+ May reduce commercial discard
  - \- Will require major change in stock assessment, with a retrospective allocation of catches to the newly defined management area.
  - \- May increase effort on ASMA commercial quota, potentially providing a shorter season.
  - \- May increase proportion of CSMA stock fish tabulated as AR fish.

Research Needs

- Accurate information on stock mixing in the Sounds and Rivers of North Carolina is required to enable unbiased evaluation of stock abundance. This may be achieved through a comprehensive tagging program.
- Accurate information on migratory patterns and movements of striped bass from CSMA stocks. This may be achieved through a tagging program.
- Accurate catch statistics, adequate biological sampling, and fishery-independent survey data for CSMA stocks is required to allow accurate stock assessment. This will require dedicated creel surveys, expanded MRFSS coverage, expanded commercial fish house sampling, and development of an independent survey.

MFC, DMF, WRC and FWS Management Recommendations
Support Status Quo, No shift in the Boundary Line and support the research needs.

The Boundary line was established to provide a migratory corridor for the Albemarle-Roanoke stock of striped bass. As currently established, the line accomplishes this goal. The line also provides a delineation point for allocating harvest to management areas, and is believed to encompass the primary areas inhabited by the Albemarle-Roanoke stock. Moving the line northward would likely exacerbate the problem of stock mixing, and contribute to a significant bias in assessment calculations for the Albemarle-Roanoke, Tar River, and Neuse River stocks. Furthermore, in all likelihood such a shift would lead to potential increases in commercial discard and recreational harvest losses.

A/R and C/S Advisory Committee Management Recommendation
Supports the Status Quo management option and the research needs.

10.3 Issues Relative to the A/R Striped Bass Stock

10.3.1 Stock Structure

10.3.1.1 Biological Reference Points

Issue
Estimation of biological reference points and management targets.

Background
North Carolina Fishery Management Plans are required to include management measures that prevent overfishing, while achieving, on a continual basis, the optimum yield for each fishery. OY is defined as the amount of fish the provides the greatest benefit to the State, is prescribed on the basis of the maximum sustainable yield (MSY), and in the case of an overfished fishery will provide for rebuilding to a level that will produce MSY.

Life history information from catch and survey sampling is the basic input of Yield per Recruit analysis (YPR) used to estimate yield or growth based reference points such as Fmax and F0.1 and evaluate growth overfishing. Expanding this method to include maturation at age information allows calculation of spawning potential and estimation of Spawning Potential Ratio (i.e., $F_{XX\%SPR}$) references and consideration of recruitment overfishing. Information on average recruitment provided by the VPA enables further scaling of 'per recruit' values from the YPR analysis to potential total population values.

MSY can be estimated only if estimating recruitment at various stock levels is possible. VPA estimates of recruitment and spawning stock biomass can be used to determine recruitment from spawner abundance, through either formal stock-recruitment relationship models (SRR) or more ad hoc approaches such as selecting future recruitment from observed values over various ranges of spawner abundance. Once a method to estimate recruitment is derived, population projection models are used evaluate stock performance over a range of exploitation rates and thus determine the rate (F_{msy}) that provides the maximum yield (MSY).

A range of potential biological reference points for North Carolina striped bass stocks was evaluated and presented to the North Carolina Striped Bass FMP Plan Development Team on January 8, 2002. The PDT reviewed the reference points and identified a range of options for biomass and mortality rate targets and thresholds. The analyses are based on biological and fishery data from the Albemarle Roanoke stock, as no data are available for the other stocks.

Current Authority

General Statutes of North Carolina
G.S. 113-182.1. Fishery Management Plans

Reference Point Evaluation

Yield per Recruit (YPR)

Yield per Recruit models have long been used to establish biological reference points and management benchmarks, largely due to their modest data requirements and ease of calculation. Data necessary for this analysis are weight at age, natural mortality, and selectivity at age. The reference point most often associated with this analysis is Fmax, defined as the fishing rate that provides the maximum yield per recruit. As further experience showed that fishing at Fmax could result in overfishing, a more conservative reference, $F_{0.1}$, was developed, defined as the point at which the slope of the YPR curve is $1/10^{th}$ the slope at the origin. YPR analysis assumes a population at equilibrium, i.e. that age at entry into the fishery, weight at age, maturation at age, natural mortality, and recruitment are all constant. Providing an estimate of average recruitment at equilibrium enables scaling of per-recruit values of yield and biomass to stock-level values.

Yield-per-recruit analysis used a dynamic pool model and input values from the recent assessment (Carmichael, 2001; Carmichael, 2002). Current stock conditions are summarized in Table 10.8 for comparison to predicted equilibrium conditions under the various reference points. The estimated value for Fmax is below the current mortality target, indicating that slight growth overfishing could occur at the current target (Table 10.9). F=0.1 is slightly below Fmax and approximately equal to the natural mortality rate, M, which is typical for most stocks. The point of stock collapse, based on the PDT recommendation of female spawner biomass declining below 400,000 pounds, is high at Fcollapse=0.90. This high Fcollapse suggests the stock has considerable resiliency and can endure significant exploitation before SSB declines enough to significantly degrade recruitment. Based on 1989-1999 average recruitment of 377,000 age 1 fish, yield at Fmax would be 1.0 million pounds, nearly double the 1998-2000 average catch (harvest+discard) of 505,286 pounds, and about 40% above the 2000 catch of 638,394 pounds. Although the actual exploitation rate at Fmax is lower than the current exploitation rate, the potential yield is higher due to increased stock biomass expected from an expanded age structure. Spawning stock biomass at Fmax is predicted to be over 3 times the 2000 value of about 1 million pounds.

Table 10.8. Current Albemarle-Roanoke striped bass stock conditions, from Carmichael, 2001.

Parameter	Value
Stock Abundance Numbers	1,567,000
Female Spawner Pounds	1,094,584
2000 Total Catch Pounds	638,394
1998-2000 Catch Pounds	505,286

Table 10.9. Biological reference points and associated yield parameters from YPR analysis

Reference Point	Estimated value
F0.1	0.12
Fmax	0.15
Fcoll	0.90
Yield@Fmax, mlb[1]	1.007
SSB@Fmax, mlb Female[1]	3.802
Catch, 1000's N[1]	134

[1] Yield, SSB, and catch are based on average recruitment of 377,000 age-1 fish.

Spawning Potential Ratio

Because the basic YPR analysis considers only the effect of fishing mortality on yield, associated reference points technically only address growth overfishing. Moreover, there is no feedback between stock abundance and yield and recruitment, thus the model cannot reflect density dependent factors that affect the population. The model can be extended by incorporating maturation or fecundity ogives as an attempt to address recruitment overfishing, but the previous limitation still applies. Reference points provided by this extension are based on the spawning potential ratio, calculated as the proportion of the maximum spawner biomass or egg production (i.e., that expected with no fishing exploitation) that will be produced at each exploitation rate, and are generally presented as $F_{xx\%SPR}$.

Although the specific %SPR necessary to prevent recruitment overfishing and sustain adequate spawner biomass is unknown unless a stock-recruitment relationship is available, SPR values between 20% and 40% are commonly considered, and some stocks have been sustained at considerably lower levels. Results of the SPR analysis can be combined with a stock-recruit plot to determine if a given level of SPR would have been adequate to sustain the stock given the observed recruitment history. Similarly, observed recruitment values can be used to determine the minimum SPR necessary on average to replace the stock over the observation period. Inverting the value of SSB per recruit provides a value for recruits/SSB that can be used as the slope of a line on the Stock-Recruitment plot. Recruitment values above a given line represent years when recruitment was adequate to replace the parent stock, while those values below a line represent years when recruitment was not adequate to replace the parent stock. The point where a given line intersects the predicted stock recruitment relationship represents where the stock would stabilize under average conditions.

Results of the SPR analysis based on a range of 10 - 40%SPR produced exploitation rates between F=0.14 and F=0.40 (**Table 10.10**). These values are safely below the point of collapse (F=0.9), and any value would likely produce adequate recruitment to at least sustain current stock abundance. The age structure of the population would vary

Table 10.10. Percent SPR based reference points with associated F values, % adequate recruitment from the observed history, % of the population age 8 and older, yield per recruit, and female spawner biomass.

Parameter	F	%SPR	% adequate R	%8+ pop.	Yield per Rec.	SSB[1]mpds
F40%SPR	0.10	40	100	24	.833	5.344
F30%SPR	0.16	30	100	18	.873	3.572
F20%SPR	0.22	20	95	13	.838	2.541
F10%SPR	0.40	10	95	6	.687	1.200
Fcoll	0.9	3.4	33	0.8	.505	0.402
Frep_95-99	0.75	4.3	83	1.4	.617	.532
Fmax	0.19	24	100	19	.874	3.802

1. Millions of pounds, based on average recruitment of 327,000 age 1 fish.

considerably over this range of exploitation rates, with the proportion of the population composed of older fish (8+) declining from 24% for F40%SPR to 6% for F10%SPR. Yield is close to the maximum for F40% to F20%SPR, drops about 20% for F10%SPR, and drops over 30% at Fcollapse. Spawner biomass would not increase over current levels for F10%SPR, but would increase considerably for the other references considered. The plot of recruitment and SSB overlain with %SPR reference lines shows that none of the %SPR values considered are likely to negatively impact recruitment (Figure 10.7). Therefore, even the apparently low 10%SPR could prevent recruitment overfishing.

Estimation of MSY

The reference points evaluated so far are largely based on ‘per recruit’ information, and are therefore useful even when future recruitment is unknown. Estimation of maximum sustainable yield, MSY, however, requires some determination of future recruitment. This is usually accomplished through a stock-recruitment relationship, such as that illustrated in Figure 10.7. Stock-recruitment relationships are among the hardest fisheries population characteristics to determine, often remaining inconclusive in spite of long data series and extensive evaluation. The true underlying relationship may be masked or even distorted by many factors, including, but certainly not limited to, environmental variation, an inability to adequately measure recruitment, and a lack of data over an adequate range of parent stock size. Even when a relationship can be determined with reasonable statistical accuracy, it is a record of past performance that may not be representative of future conditions, especially for a stock that undergoing rapid change. All of these factors affect the stock recruitment relationship for AR striped bass to some extent.

Estimates of F_{msy} and associated parameters were attempted, by iteratively fishing a simulated population to equilibrium over a range of exploitation rates. Stochasticity was incorporated by allowing recruitment to vary randomly from base values predicted by a Beverton-Holt Stock-Recruitment relationship; the magnitude of this variation was based on the variation in observed values. Input values for selectivity, maturity, and weight at age were identical to those used in the YPR analysis; starting population abundance was taken from the VPA (Carmichael, 2001).

The PDT reviewed and discussed the parameter estimates from the MSY analysis and determined that the results were not generally reliable. Much of the concern centered around the stock-recruitment relationship. Although a model can be fit with reasonable precision, the PDT did not feel it would adequately predict future conditions, largely due to current SSB being at an observed high and expected to further increase as recent strong year classes mature. Therefore, observations over the next few years will be at the rightmost extreme of the plot at high spawner abundance and will exert considerable influence over the asymptote predicted by the relationship (Figure 10.8).

Since the asymptote determines the average, long-term recruitment at high spawner abundance, it is expected that observations from the near future will greatly influence the estimated long term average recruitment, which will influence both MSY and

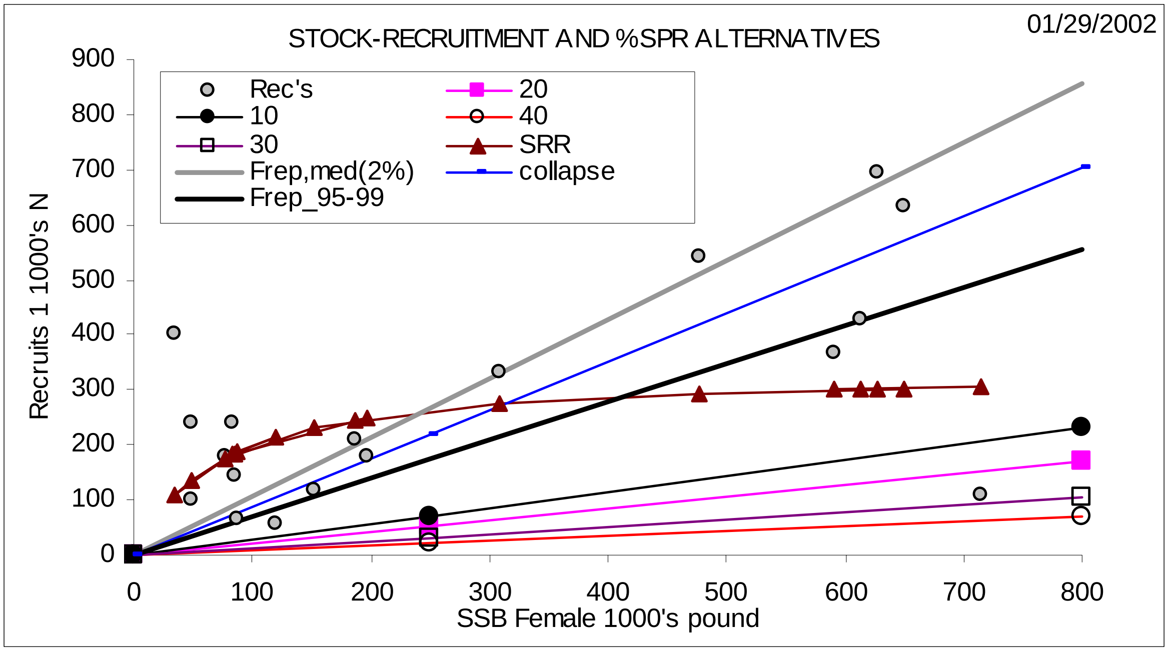


Figure 10.7. Stock-Recruitment plot with replacement (median of observed) %SPR and various %SPR levels.

equilibrium spawner biomass. This is shown in the plot by the difference in the two predicted relationships, one based on all years and the other based on all observations during the 1990's. The PDT feels strongly that the stock needs to achieve some stability, in terms of both recruitment and spawner abundance, before a reliable and predictive stock recruitment relationship can be developed. Although there was a period of stability during the mid-1990's, the combination of good recruitment and limited exploitation during those years resulted in high abundance of fish approaching maturity, exhibited by the 2000 point in the plot at the far right. Another concern expressed by the PDT is that observations at middle to low abundance predate flow control on the Roanoke River, and may reflect more the adverse environmental conditions at that time than the true stock-recruitment relationship. Given the uncertainty in the ability of the stock-recruitment relationship to predict recruitment, and concern that conditions in the near future may be considerably different from past years, the PDT did not endorse any estimate of MSY at this time.

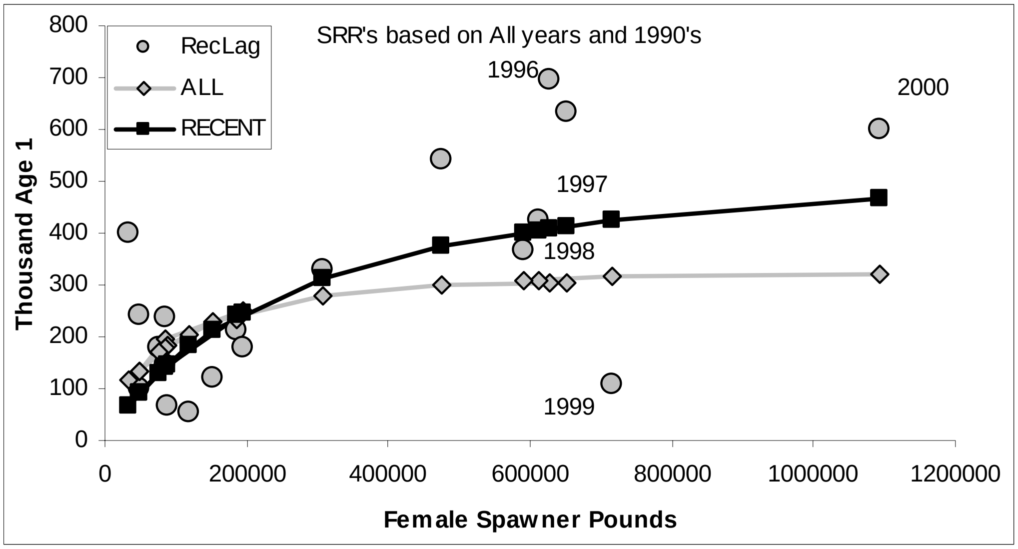


Figure 10.8. Stock-recruitment plot for striped bass and fitted Beverton-Holt stock-recruitment relationships, for all years and for the 1990's.

Spawner Biomass Threshold

The PDT did consider the plot of stock and recruitment valuable for identifying a threshold spawner biomass. From a graphical analysis, recruitment was generally poor when female spawner biomass was below 200,000 pounds, and strong when biomass was above 500,000 pounds. Since only one observation falls between these values, making it difficult to determine with precision the lower bound, and 200,000 pounds is clearly inadequate to ensure reasonable recruitment, the PDT decided to recommend a conservative threshold of 400,000 pounds.

Summary

The PDT advised that MSY could not be reliably determined for this stock at this time. They are concerned that developing an MSY estimate requires extrapolation of the stock beyond the observed record. Such an endeavor is particularly risky for a stock that is still recovering, at least in terms of age structure, from past over exploitation. Another concern is that the time series of stock and recruitment data is still heavily weighted toward periods of low abundance, overexploitation, and environmental degradation. Thus, the stock-recruitment relationship necessary to estimate MSY is especially uncertain, and may remain variable until the stock reaches some equilibrium. Recent regulatory changes, notably increased harvest allowances, further add uncertainty and instability to the stock at this time.

The PDT recommended that management benchmarks should be chosen based on a list of key criteria 1) Ability to evaluate a particular value or parameter, 2) Ability to effectively implement and manage under a particular strategy, 3) Past management experience, 4) consideration of uncertainty, and 5) management program goals. Using these criteria as a guide, the PDT recommends that the stock be managed through target and threshold exploitation rates, similar to the current strategy. This approach is proven through past experience, has been effectively implemented for many years, and has resulted in the current stock recovery. This approach is clearly measurable, as estimates of exploitation rates are proven more precise and reliable than estimates of absolute abundance. This approach provides significant flexibility; selection of proper target and threshold exploitation rates can ensure that management targets are met.

The PDT recommended that, where feasible, biomass thresholds be developed to support the exploitation rate targets. The past history of the stock, as reported in the recent assessment, provides reasonable guidance for selecting biomass thresholds. However, since the stock is expanding beyond the observed history, in both biomass and age structure, extrapolation to target biomass levels is risky at best. Setting target biomass levels in absolute values without knowledge of the stock's growth potential will result values for which neither the direction nor magnitude of potential bias and uncertainty can be determined.

Management Options/Impacts
Based on consideration by the PDT of the analyses summarized above and developed in Carmichael (2002), a range of management targets and thresholds were identified for consideration. Selection of threshold limits should be based on the biological characteristics and population dynamics of the stock. Within this limitation, target levels should be selected on the basis of specific management goals.

A. Options for the Albemarle Roanoke Stock

Mortality Rate Alternatives

1. **Fcollapse = 0.95**
   A stock collapse reference point was identified to delineate the upper bound of values that would be considered, based on the reference point evaluations and consideration of stock history. Exploiting the stock at this rate or higher is very likely to lead to collapse through recruitment failure.
   + Establishes an upper limit for threshold consideration
   - Adopting as threshold is not risk averse

2. **Fthreshold**
   Alternative1. Frep, 1995-1999 = 0.75
   An upper bound threshold exploitation was identified as a value that, if exceeded, would likely halt further stock growth given average observed recruitment. This value is based on the median observed recruitment/spawner biomass from 1995 to 1999, years selected to represent the current conditions of recruitment and spawner abundance. Fishing at this level results in considerable foregone future yield, declines in SSB toward the threshold, and a reduction in the abundance of older fish. Current yields could possibly be maintained, at the expense of stock abundance and biomass.
   + Based on observed recruitment and exploitation

+ Significantly distant from range of targets
- Approaching this level will lead to stock decline, especially SSB
- Approaching this level will not maximize yield

Alternative 2. F10%SPR = 0.40
A lower bound threshold exploitation rate, identified as the exploitation rate that will maintain the current spawner biomass given recent (1989-1999) average recruitment. Exploiting the stock at this level offers little opportunity for increased harvest over current levels.
+ Would determine overfishing before SSB impacted
+/- Possibly adequately distant from range of targets

3. **Ftarget.**
Alternative 1. Current Ftarget, F=0.28.
The ASMFC FMP currently mandates a producer area target F of 0.28, based on North Carolina's 18" minimum size. Because states may be more restrictive than mandated by the FMP, any Ftarget below this level is within the current FMP limitations. Exploiting the stock at this level could result in a slight and gradual increase in total pounds caught as the stock age structure expands, and SSB could also increase somewhat.
+ Stock continues to grow at this rate
+ Supported by current ASMFC FMP
- Only slight increase in SSB, age structure, and yield expected
- Allows some growth overfishing

Alternative 2. F20%SPR = 0.22.
This level of SPR is within the range of target values used for other stocks, although recent opinions are that F20% SPR should possibly be considered an upper limit of management targets. Exploiting the stock at this level could result in about a 30% increase in total catch, a doubling of SSB, and a considerable increase in the abundance of 8+ fish.
+ Within accepted range of target % SPR
+ Projected increase in yield, SSB, age structure
- Allows slight growth overfishing
- Below current target

Alternative 3. F30%SPR = 0.16
This level is also within the range of target values used for other stocks, and is rapidly replacing F20% as a preferred exploitation rate as experience is gained in using SPR as management targets. Exploiting the stock at this level could result in about a 50% increase in total catch and a considerable increase in both SSB and 8+ abundance.

+ Within accepted range of desirable % SPR
+ Conserves more SSB than F20% or F=0.28
+ Considerable increase in yield, SSB, and age structure

+ Not significantly different from Fmax
- Below current target

Alternative 4. Fmax = 0.15

This rate maximizes yield of individual fish, thus values above it result in some level of growth overfishing. However, whether or not it maximizes yield of the population depends on the stock-recruit relationship. Exploiting the stock at this level would maximize the yield at current average recruitment, providing a slight increase over that expected at F30%SPR. It is unlikely that the difference between F30%SPR and Fmax could be measured through a stock assessment.

+ Prevents growth overfishing – maximizes yield
+ Considerable increase in yield, SSB, age structure
- Below current target

Biomass Threshold Alternatives

Alternative 1. Female SSB Collapse = 200,000 pounds.

This alternative is considered excessively risky as a threshold, as it is likely that recruitment would suffer and the stock would decline rapidly if SSB declines to this level. The stock declined substantially, and drastic regulatory restrictions were required for recovery, when biomass fell to this level in the 1980's.

- Stock collapsed when SSB fell to this level
- Recruitment could be adversely impacted before stock declared overfished
- Recovery from this point could require drastic measures

Alternative 2. Female SSB Threshold = 400,000 pounds.

This alternative provides more protection to the stock than alternative 1, although considerable restrictions would still likely be required to rebuild if SSB falls to this level.

+ Declares stock overfished before recruitment is likely impacted
+ Somewhat removed from estimated point of collapse
- Recovery from this point might require significant restrictions

Maximum Sustained Yield

Maximum sustained yield cannot be reliably determined at this time.

Optimum Yield

Optimum yield is that yield projected from exploiting the stock at the target exploitation rate as determined from the most recent stock assessment. This is the approach currently used to manage this stock.

+ Consistent with current management approach
+ Allows yield to vary with stock conditions
- Not a predetermined, specific value
- Requires continued, potentially annual stock assessment

Overfishing and Overfished definitions

The PDT recommends that the overfishing definition be based on the threshold exploitation rate: *Overfishing will occur when the exploitation rate exceeds the threshold exploitation rate.*

The PDT recommends that the overfished definition be based on the biomass threshold: *The stock will be overfished if biomass falls below the threshold*.

Research Needs

- Additional stock monitoring at the current high abundance is necessary to define the stock-recruitment relationship.
- The emigration rate should be evaluated in the near future, as the proportion of the stock age 8 and older increases.

MFC, DMF, WRC and FWS Management Recommendation
Support the PDT management recommendations (F=0.22, SSB= 400,000 pounds) and the research needs.

A/R Advisory Committee Management Recommendation
Support an F rate of 0.22 and a threshold of 400,000 pounds of SSB for the A/R stock. The Committee also supports the research needs.

10.3.2 Fishing Mortality

10.3.2.1 Discard Mortality of Striped Bass in the Multi-species Gill Net Fishery ASMA

Issue
Investigation of bycatch and discards of striped bass (*Morone saxatilis)* in the multi-species, anchored gill net fishery in the Albemarle Sound Management Area (ASMA).

Definitions
Attended – Being in a vessel, in the water or on the shore immediately adjacent to the gear and immediately available to work the gear and within 100 yards of any gear in use by that person at all times. Attended does not include being in a building or structure.

Gill Net – A net set vertically in the water to capture fish by entanglement by the gills in its mesh as a result of net design, construction, mesh size, webbing diameter or method in which it is used.

Bycatch – That portion of a catch taken incidentally to the targeted catch because of non-selectivity of fishing gear to either species or size differences.

Discard – The portion of the catch that is not retained and includes incidental take of protected species.

Background
Striped bass have been an economically important fish species in the Albemarle Sound since colonial times. This species is utilized by commercial fishermen as well as being highly prized by recreational anglers. Striped bass stocks in the Albemarle Sound/ Roanoke River declined rapidly in the late 1970s into the 1980s. Factors believed to be responsible for the decline included overfishing, unfavorable water flow regimes on the

Roanoke River during spawning, and poor water quality (North Carolina Striped Bass Study Management Board 1992).

North Carolina's harvest of striped bass was severely reduced in response to drastic declines in coastal striped bass stocks. Flow regimes on the Roanoke River have been modified since 1988 to duplicate more natural conditions that occurred prior to the construction of the Lake Gaston and Roanoke Rapids dams. Also, the harvest of striped bass by commercial and recreational fishermen was limited severely. As a result, the A/R stock of striped bass has risen to levels that have not been seen in decades.

The ASMA supports a substantial anchored gill net fishery for species such as flounder, striped mullet, white perch, river herring and shad. As a result of the recovery of the A/R stock, the incidental bycatch of striped bass has increased. Preventive measures have been put into place to address this issue, which have ranged from the prohibition of the use of certain mesh sizes, limiting of the amount of yardage that can be fished and area closures. A list of regulations concerning the use of gill net can be found in Appendix 3. The MFC allows the multi-species gill net fishery to be pursued but striped bass can only be harvested as bycatch, meaning that it is not to be targeted. Fishermen must have a catch composition consisting of at least 50% other species by weight when harvesting striped bass. Since 1996, the DMF has worked with commercial fishermen, on a voluntary basis, to allow observers on their vessels in the ASMA while fishing gill nets. This work has been mostly focused on the flounder gill net fisheries during the summer and early fall, when personnel have been available. Some trips have been made during other fisheries, but insufficient data were gathered to make an accurate estimation. In 2002, as a requirement for the permittee to fish gill nets in the Pamlico Sound Gill Net Restricted Area (PSGNRA), observers were sent with fishermen to ascertain interactions with sea turtles. In part of the PSGNRA, some of the effort occurred north in the ASMA. Data was used from these trips and included in the estimates of discard for the ASMA.

Current Authority

General States of North Carolina
G.S. 113-170.4 Rules as to possession, transportation, and disposition of fisheries resources
G.S. 113-170.5 Violations with respect to coastal fisheries resources
G.S. 113-182 Regulation of fishing and fisheries
G.S. 113-221(e) Rules; proclamations; emergency Commission meetings
G.S. 143B-289.52 Marine Fisheries Commission – powers and authority

North Carolina Marine Fisheries Commission Rules

North Carolina Fisheries Rules for Coastal Waters (15A NCAC)
3H .0103 Proclamation Authority of Fisheries Director
3J .0103 Gill Nets, Seines, Identification, Restrictions
3Q .0107 Special Rules, Joint Waters

Methods

Unattended Gill Nets

The bycatch of striped bass in gill nets in the ASMA has been addressed as a point of compliance to the ASMFC since 1994 with an estimation of discards assessed for each year (NCDMF 1997, 1998, 1999, 2000, 2001). In order to calculate a gill net bycatch estimate for the ASMA, gill net effort was estimated as well as rates of bycatch and mortality. Estimates were stratified by month and season. Because observer coverage was limited, assumptions concerning gill net effort had to be substituted where observations could not be made. Total number of fishing trips needed to be established, then to allocate trips into major fishery categories, and finally a standard measure of gill net effort was developed. The total number of trips was obtained from the DMF Trip Ticket Program. Each time fish are sold to a licensed seafood dealer in North Carolina a trip ticket must be completed. Information included on each ticket includes the weight in pounds for each species sold, the gear types (i.e., trawl, gill net, pound net, etc), and the primary area fished. While the total number of gill net fishing trips was easily obtainable, assumptions were required to determine the mesh size used in each trip. First, three trip categories were established flounder, shad, and small mesh (Table 10.11). Next, predominate allowable mesh sizes were estimated for each category.

Table 10.11. Number of trips by category for the anchored gill net fisheries in the Albemarle Sound Management Area.

	CALENDER YEAR							
FISHERY	1994	1995	1996	1997	1998	1999	2000	2001
Flounder	10,059	10,356	8,338	12,866	10,311	8,425	9,326	10,099
Shad	832	1,430	1,836	1,527	2,252	2,288	2,546	2,573
Unattend Sm. Mesh	4,010	4,721	3,853	3,423	2,671	6,317	6,351	6,996
Attend Sm. Mesh	1,549	740	1,161	1,258	2,466	1,974	1,726	1,530

Based on observer and fishery research, the predominate mesh used in the perch, mullet and herring fisheries is 3.0 inch stretched mesh, while 5 ½ inch stretched mesh (ISM) are used in the flounder and shad fisheries. Third, assuming that size selectivity of small mesh nets would not result in substantial catches of flounder or shad, and that flounder and shad trips could be categorized based on catch characteristics each trip was examined for species composition and assigned to one of the three categories based on the primary species landed. A catch that consisted of 10% or greater of flounder, and flounder landings greater than shad, was considered a flounder trip. This procedure worked well when determining the number of flounder trips, largely because regulations require 'sinking' the nets during the flounder fishing. The 5 ½ ISM or larger sink gill net is more effective in the capture of flounder than any other species, and usually other gill net types are not fished simultaneously with the flounder net, so the trip would not be miscategorized to another type of fishery. The minimum mesh size allowed for flounder nets is 5 ¼ ISM, but the majority of participants sampled through observers used 5 ½ ISM. This is not the case when estimates of trips were made for the shad and the small mesh category in the spring. These fisheries occur simultaneously and fishermen typically employ both shad nets and small mesh nets in a single trip. Although several mesh sizes were likely used in any given trip, trips were either counted as shad or small mesh trips depending on the catch composition. Shad trips were defined as shad landings greater than flounder or greater than 30 pounds of shad. A trip that did not meet the criteria for the flounder or shad trip was considered small mesh trips.

Once the number of trips for each category year and month was estimated, trips were expanded into “trip days”, the yardage used per trip was estimated, and total effort standardized into ‘net yard days’. The amount of gear used per trip was estimated for the flounder nets by using the average yardage observed from “at-sea” observer data compiled by DMF staff (Table 10.12). Insufficient observer data was obtained for the

Table 10.12. Observed yardage through at-sea observer sampling with commercial fishermen in the Albemarle Sound Management Area.

	CALENDER YEAR					
FISHERY	1996	1997	1998	1999	2000	2001
Flounder		40,000	26,480	20,345	9,000	28,000
Shad	5,345		4,270		2,000	
Sm. Mesh *	6,120		1,360	1,200	800	

*Trips observed were during the unattended and attended seasons.

shad and small mesh trips, so maximum yardage allowed by regulation was used for the estimate. Although it is probably safe to assume that most fishermen are utilizing the maximum, it is not the case in every trip. Finally, effort data was further expanded into “yard days” by multiplying the number of “trip days” by the number of yards set per trip to come up with the final unit of effort, “net yard days”.

Catch per unit of effort (CPUE) was defined as the number of striped bass per yard per day, (i.e., one yard set for one day equals one unit of effort). CPUE estimates were developed for flounder nets, shad nets, and small mesh nets. The flounder net CPUE was calculated using observer samples and Fishery Resource Grant (FRG) data (Keefe 1995) for months when no observer data was available. Also, calculations of CPUEs for the flounder nets were stratified by season, based on the availability of observer or FRG data. The seasons were defined as November – May (FRG data) and June – October (observer data). CPUE was then calculated by dividing the number of striped bass captured by the total yards fished. CPUE for the small mesh (3.0, 3 ¼, 3 ¾, 4.0 ISM) and shad fisheries were calculated using NCDMF’s Fishery Independent Gill Net Survey (FIGNS) data. The survey employs a floating and sinking 5 ½ ISM gill net similar in function to gill nets used to target shad. The only significant differences are the monofilament twine size, which is slightly larger in diameter, and the depth that the nets are fished, which is somewhat shallower than those utilized by commercial shad fishermen. The survey also employs a 3.0, 3 ½ , and 4.0 ISM gill net, similar in function to those utilized by commercial fishermen. The 3 ½ ISM net is not allowed to be fished commercially in the ASMA, but this mesh size was used for the estimation process in lieu of the 3 ¼ and 3 ¾ ISM. CPUE values were calculated using the same methods described above. In 2000 and 2001, FRG data (Rose 2000,2001) utilizing shad nets was incorporated into the calculations for CPUE for the shad fishery. For the flounder fishery, mortality rates were calculated for the seasons mentioned above using observer and FRG data. For the remaining fisheries, mortality was calculated monthly using the FIGNS data. Mortality rates from the Rose FRGs were used in calculations for the shad fishery in 2000 and 2001.

Mortality rates were calculated by dividing the number of dead fish observed at the time the net was fished by the total number captured. Estimates of delayed mortality were made using 25%, 50%, and 75% of the encounters and combined with the initial mortality figures (Table 10.13).

Table 10.13. Estimates of initial and delayed discard mortality for the unattended gill net fishery in the Albemarle Sound Management Area 1994 - 2002.

1994

			Combined Initial and Delayed Mortality					
	Initial Mortality		25%		50%		75%	
Flounder	4,133	14,666	5,620	19,943	7,107	25,219	8,593	30,492
Shad	1,861	6,604	2,267	8,045	2,674	9,489	3,080	10,940
Un. Sm Mesh	33,142	82,457	43,255	107,618	53,368	132,779	63,481	157,940
Att.Sm Mesh	6,963	17,324	10,837	26,962	14,712	36,603	18,586	46,242
TOTAL	**46,099**	**121,051**	**61,979**	**162,568**	**77,861**	**204,090**	**93,740**	**245,614**

1995

			Combined Initial and Delayed Mortality					
	Initial Mortality		25%		50%		75%	
Net Type	Lb. of STB	Lb. of STB	No. of STB	Lb. of STB	No. of STB	Lb. of TB	No. of STB	Lb. of STB
Flounder	8,581	31,791	12,055	44,662	15,529	57,532	19,002	70,399
Shad	12,026	44,554	14,445	53,516	16,865	62,482	19,284	71,444
Un. Sm Mesh	124,694	143,273	170,233	195,597	215,772	247,921	261,311	300,246
Att.Sm Mesh	22,22	2,553	3,459	3,974	4,695	5,395	5,932	6,816
TOTAL	**147,523**	**222,171**	**200,192**	**297,749**	**252,861**	**373,330**	**305,529**	**448,905**

Table 10.13. (Continued)

1996

	Initial Mortality		Combined Initial and Delayed Mortality 25%		50%		75%	
NET TYPE	# OF STB	LB OF STB	# OF STB	LB OF STB	# OF STB	LB OF STB	# OF STB	LB OF STB
Flounder*	6575	28023	9421	40153	12268	52287	15114	64417
Shad	15199	64778	17533	74726	19866	84669	22200	94616
Un. Sm Mesh	18491	23502	23858	30323	29226	37146	34593	43968
Att.Sm Mesh	3636	4621	5659	7193	7682	9764	9705	12335
TOTAL	**43901**	**120924**	**56471**	**152395**	**69042**	**183866**	**81612**	**215336**

1997

	Initial Mortality		Combined Initial and Delayed Mortality 25%		50%		75%	
NET TYPE	# OF STB	LB OF STB	# OF STB	LB OF STB	# OF STB	LB OF STB	# OF STB	LB OF STB
Flounder*	10438	51585	13748	67943	17058	84301	20369	100664
Shad	11529	56976	16097	79551	20664	102121	25232	124696
Un. Sm Mesh	51908	110668	85610	182521	119311	254371	153013	326224
Att.Sm Mesh	4067	8671	6330	13496	8593	18320	10856	23145
TOTAL	**77942**	**227900**	**121785**	**343511**	**165626**	**459113**	**209470**	**574729**

1998

	Initial Mortality		Combined Initial and Delayed Mortality 25%		50%		75%	
NET TYPE	# OF STB	LB OF STB	# OF STB	LB OF STB	# OF STB	LB OF STB	# OF STB	LB OF STB
Flounder*	3875	15646	8003	32314	12190	49219	16348	66008
Shad	18519	74775	31874	128699	45230	182627	58585	236551
Un. Sm Mesh	29176	45436	43062	67061	56947	88684	70833	110309
Att.Sm Mesh	7350	11446	11440	17816	15530	24185	19620	30554
TOTAL	**58920**	**147303**	**94379**	**245890**	**129897**	**344715**	**165386**	**443422**

1999

	Initial Mortality		Combined Initial and Delayed Mortality 25%		50%		75%	
NET TYPE	# OF STB	LB OF STB	# OF STB	LB OF STB	# OF STB	LB OF STB	# OF STB	LB OF STB
Flounder*	5156	20111	6806	26547	8457	32987	10107	39422
Shad	9659	37675	18980	74032	28302	110392	37623	146749
Un. Sm Mesh	41118	81257	54322	107350	67526	133444	80730	159538
Att.Sm Mesh	7099	14029	11049	21835	14999	29641	18949	37447
TOTAL	**63032**	**153072**	**91157**	**229764**	**119284**	**306464**	**147409**	**383156**

Table 10.13. (Continued)

2000

			Combined Initial and Delayed Mortality					
	Initial Mortality		25%		50%		75%	
NET TYPE	# OF STB	LB OF STB	# OF STB	LB OF STB	# OF STB	LB OF STB	# OF STB	LB OF STB
Flounder*	4665	18328	5941	23341	7216	28350	8492	33364
Shad	7263	28535	9855	38719	12446	48898	15038	59082
Un. Sm Mesh	42545	91134	52321	112075	62098	133018	71874	153959
Att.Sm Mesh	6207	13296	9661	20695	13114	28091	16568	35490
TOTAL	**60680**	**151293**	**77778**	**194830**	**94874**	**238357**	**111972**	**281895**

2001

			Combined Initial and Delayed Mortality					
	Initial Mortality		25%		50%		75%	
NET TYPE	# OF STB	LB OF STB	# OF STB	LB OF STB	# OF STB	LB OF STB	# OF STB	LB OF STB
Flounder*	3416	15046	5070	22331	6723	29612	8377	36897
Shad	4295	18918	7141	31454	9987	43989	12833	56525
Un. Sm Mesh	27426	58083	35570	75330	43714	92578	51857	109823
Att.Sm Mesh	5502	11652	8564	18137	11625	24620	14687	31104
TOTAL	**40639**	**103699**	**56345**	**147252**	**72049**	**190799**	**87754**	**234349**

2002

			Combined Initial and Delayed Mortality					
	Initial Mortality		25%		50%		75%	
NET TYPE	# OF STB	LB OF STB	# OF STB	LB OF STB	# OF STB	LB OF STB	# OF STB	LB OF STB
Flounder*	4994	21992	14722	64831	20331	89531	25941	114236
Shad	4702	20873	8912	39562	13123	58255	17333	76944
Un. Sm Mesh	46928	85790	62913	115013	78899	144237	94884	173459
Att.Sm Mesh	7818	14292	12168	22245	16518	30197	20868	38149
TOTAL	**64442**	**145212**	**98715**	**241651**	**128871**	**322220**	**159136**	**402788**

Example of procedure for estimation of dead discards from shad gill nets.

2000	Encounters minus harvest						
Month	Trip days	STB/trip	No. STB	No. harvest	Adjusted number STB	Mortality percent	Number discard mortality
February	770	19.5	15,015	8,842	6,173	12.6	778
March	1336	7.5	10,020	9,612	408	27.6	113
April	440	50	22,000	6,457	15,543	41.0	6,373
					Total number		7,263

The total catch of striped bass in numbers was determined for each month by multiplying the number of striped bass per yard, per day, by the number of gill net yard days for each category. Fish captured in all categories when the striped bass commercial season was open accounted for harvest. Total numbers of striped bass harvested in a month were estimated by dividing the total pounds harvested in a month by the mean weight of the fish harvested as determined from commercial striped bass samples. The number of discard mortalities was the result of the total catch minus any commercial harvest multiplied by the mortality rate.

The number of discards at age was determined from FIGNS data. Numbers of discards by mesh size were proportioned into age groups based on the composition of age classes in the 3.0 and the 5 ½ ISM from the gill net survey. The numbers were then converted into pounds based on mean weight at age for a particular mesh size.

During the development of the fishery management plan (FMP) for southern flounder, the discards of striped bass was discussed as an issue during the process. The discards of striped bass were discussed only as it pertained to the flounder gill net fishery. A different criteria was used for the determination of a flounder trip. For this process, a trip that consisted of greater than fifty percent by weight flounder was considered a flounder trip. In previous estimations, a lower percentage was used to determine a flounder trip. The estimation of discards during the southern flounder FMP resulted in a lower number of trips in the flounder net category and thus lowered the number of discards. Trips that were lost from this category, due to the percentage of catch, would have fallen into one of the other two categories, increasing the number of discards for these fisheries.

Methods

Attended Gill Nets
During the late spring through early fall, an attended small mesh gill net fishery is allowed. This fishery is dominated by nets targeting striped mullet and perch. For an estimate, methods similar to those used for the unattended fishery were used. Two FRGs, targeting striped mullet, conducted between 1997 and 1999 were compared to establish the CPUEs for these fisheries (Dandar 1998, Williams 1997). The maximum yardage allowed was used to determine the number of striped bass per trip. One of these FRGs included initial mortality of striped bass in their project (Williams 1997). Estimates of delayed mortality were made using 25%, 50% and 75% mortality of the estimated encounters and combined with the initial mortality figures (Table 10.13).

Results

Unattended Gill Nets
Through data derived from the 1995 - 1997 FRG (Keefe 1995) and data collected from the at-sea observer program, CPUE values were calculated by month. It was estimated that during the time period of the 1995 FRG (November – May), utilizing flounder nets, the average number of striped bass encountered was approximately 3.7 fish per trip. This is using an average number of approximately 2,200 yards per operation. Data

collected through the southern flounder FMP puts the average number of yards per trip at approximately 1,900 yards per trip (3.2 fish per trip). CPUE of striped bass from the flounder observer trips (June – October) have ranged from 0.48 (1996) fish per trip to 0.98 (2000) fish per trip using the 2,200 yard average. Using an average yardage of 1,900 yards, it ranged from 0.41 (1996) to 0.88 (2000). The FIGNS data was used to estimate mortality for the period the nets were fished, the other month's mortality was derived from the observer samples. Initial mortality for the flounder net category ranged from approximately 28% in the winter months and as high as approximately 66% during the summer. Estimations of discards for flounder nets have ranged from 4,133 fish (14,666 lb.) in 1994 to 10,438 fish (51,585 lb.) in 1997. Discards have been on a decline for this fishery since 1997 with 3,416 fish (15,046 lb.) discarded in 2001 (Table 10.13).

The 5½ ISM gill net utilized by the FIGNS was used for estimations of striped bass discards for the shad fishery from 1994 – 1999. A FRG investigating the interactions of migratory waterfowl with shad nets was incorporated into the estimate for 2000 and 2001 (Rose 2000, 2001). Because of inadequate observer data, the maximum net yardage was used for calculating the CPUE. The average number of striped bass encountered has ranged from 6 fish per trip in 1994, with a maximum of 500 yards allowed, to a high of 50 fish per trip in April 1999 and 2000, near the end of shad season with an allowable 1,000 yards of gill net. From the FIGNS data, initial mortality has ranged from a low of 12.6% in February 2001 to a high of approximately 70% in April 1998. Estimates of discards have ranged from 1,861 fish (6,604 lb.) in 1994 to 18,519 fish (74,775 lb.) in 1998. The number of discards in the shad net fishery have been on the decline since 1996 with 4,295 fish (18,918 lb.) discarded in 2001 (Table 10.13).

For an estimation of discards in the small mesh fisheries, the 3.0 ISM gill net, utilized by the FIGNS was used. The numbers of observations of this fishery were insufficient to calculate a reliable estimate, so the maximum number of yards allowed was used to calculate CPUE. The average number of striped bass encountered has ranged from 0 striped bass per trip (April 1994) to 43 striped bass per trip (1995). Initial mortality has ranged from 41% in 1997 to a high of 88% in April of 1998. The number of discards in small mesh nets has ranged from 18,491 fish (23,502 lb.) in 1996 to 124,694 fish (143,273 lb.) in 1995. The number of discards in the small mesh fishery has fluctuated from year to year since 1996, but has been lower than the 1995 estimation (Table 10.13).

Attended Gill Nets

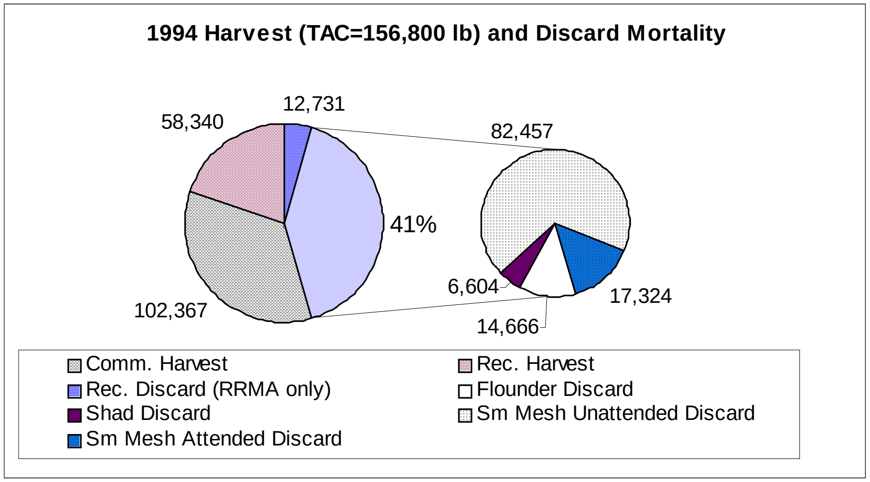
Using data derived from the two FRGs between 1997 and 1999 (Dandar 1998, Williams 1997), the average number of striped bass encountered during the attended fishery was approximated 11.6 fish per trip (av. trip 800 yards). In 1994, the number of striped bass encountered was slightly higher (14.5 fish/trip), due to the 1,000 yards per operation that was allowed. All other years since has been regulated to a maximum of 800 yards. Initial mortality from the Williams FRG was estimated to be approximately 31%. Estimates of discard ranged from a low of 2,222 fish (2,553 lb.) in 1995 to a high of 7,818 fish (14,292 lb.) in 2002.

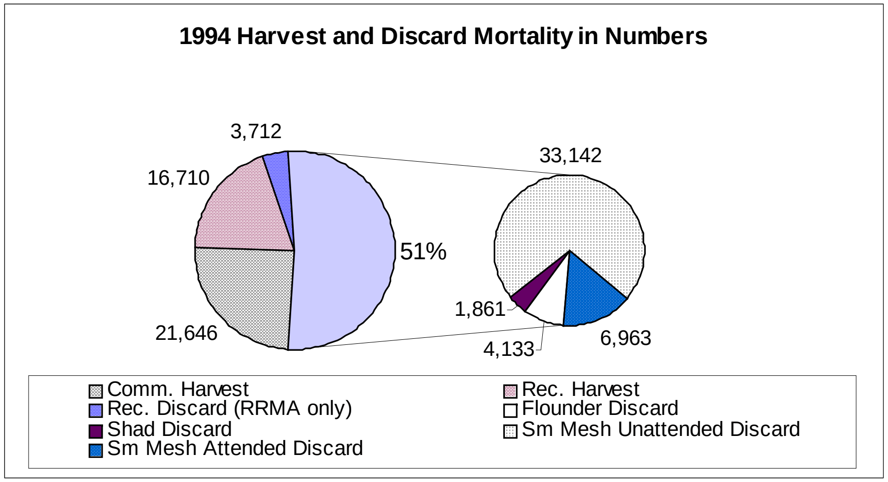
Discussion

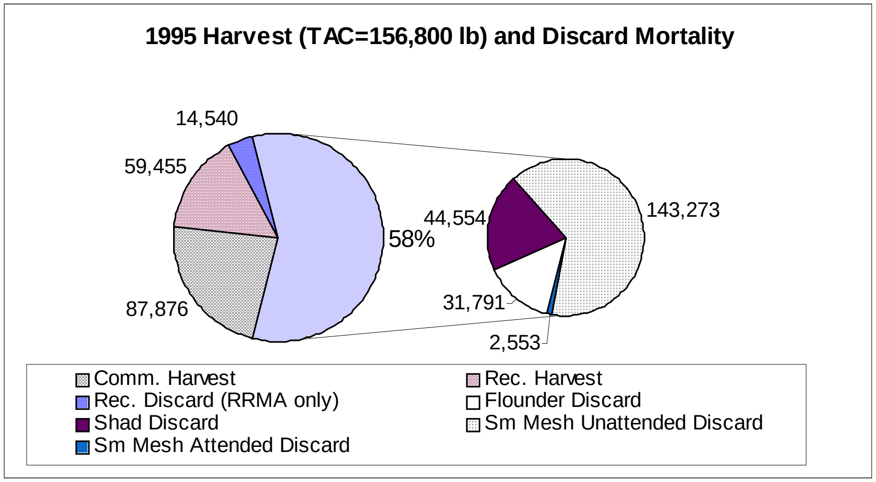
Through the 1990s and into 2002 the harvest of striped bass has been managed by a total allowable catch (TAC). Until 1998, the TAC for the commercial fishery of striped bass was held at 98,000 lb. With the growth of the population and the static TAC, discards of striped bass increased. In October 1997, the A/R stock was declared recovered by the ASMFC after showing substantial growth in the population. Since 1997, the TAC has increased four times to the current harvest level of 275,000 lb. for the commercial fishery. This increase in harvest has had the effect of lowering the number of discards in the large mesh fisheries (flounder and shad) (Figure 10.9). More of these fish that would have been discarded in previous years are now making it to market. Still, the number of estimated discards combined with commercial harvest has exceeded the TAC during each year. In years prior to the poundage increases, the poundage of discards have been equivalent to or as much as two times the allowed harvest for that year.

A majority of the discards in the gill net fishery in the ASMA have occurred in the small mesh gill nets (Figure 10.9). During the unattended season, the fishery is comprised primarily of 3.0 and 3 ¼ ISM gill nets that target perch, striped mullet, and river herring. Also, in areas of the Croatan and Roanoke sounds, 3 ¾ and 4 ISM gill nets are allowed for the targeting of trout, bluefish, hickory shad and croaker. During the attended fishery, 3 through 4 ISM are allowed. Examination of data from the FIGNS for gill nets of this size shows that approximately 18 to 22% of striped bass captured in the 3.0 and 3 ½ ISM are of legal harvestable size (18” TL). Approximately 65% of fish captured in the 4.0 ISM are of legal harvestable size. Most striped bass caught in the 3.0 and 3 ½ ISM are two to three years old and less than 18” in length. These fish tend to be caught along the gill plates where a greater chance of mortality occurs. Although the TAC for the commercial fishery has increased, it has had little affect in lowering the number of discard mortalities in the small mesh fishery, since few fish could be legally harvested.

Delayed mortality, as presented in Table 10.13, may have a significant effect on the total number of losses of striped bass. At this time there has been little work to quantify the impact of mortality on striped bass that were released alive from a gill net, but die at a later time. The use of the 25%, 50%, and 75% mortality is given as a possible range in which this mortality may occur. It is known that from tag recaptures in the FIGNS that fish do survive being caught in a gill net, but what percent is not known. A brief study was performed in 1999, by DMF that held fish for 72 hours after capture. This study, which is not yet published, showed an approximate 8.3% mortality for large mesh nets in the spring and summer. Results from small mesh nets showed a 100% mortality. The problem with this survey was sample size. There were only 35 fish captured for the large mesh portion of the study, which could influence the low mortality rate. Sample size was also a limiting factor for the small mesh portion, which only collected eight fish.







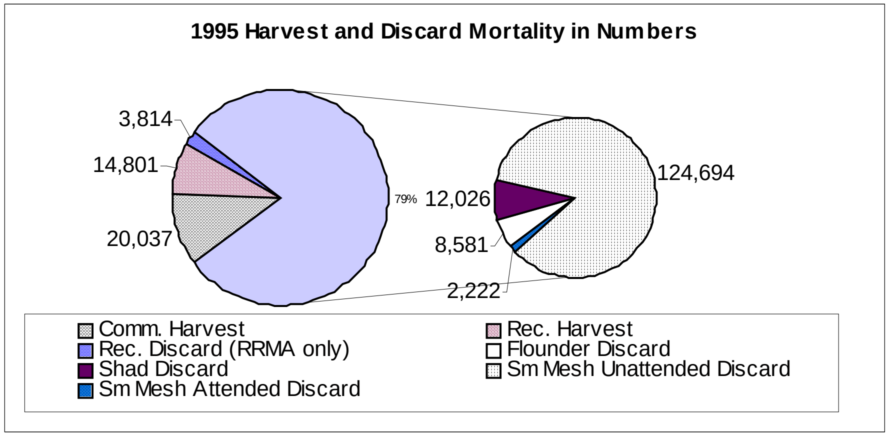
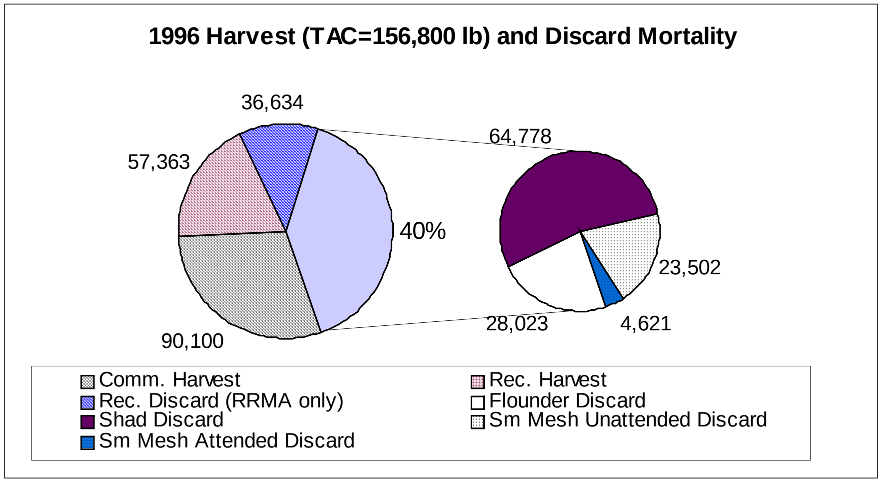
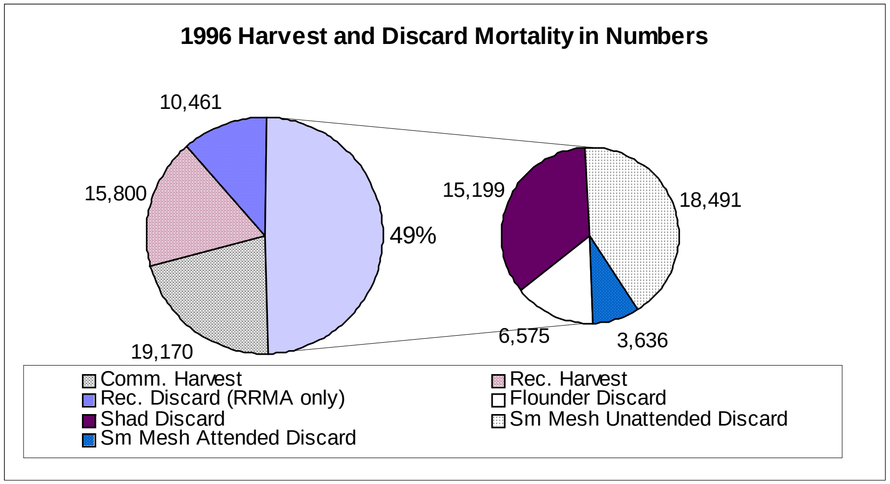
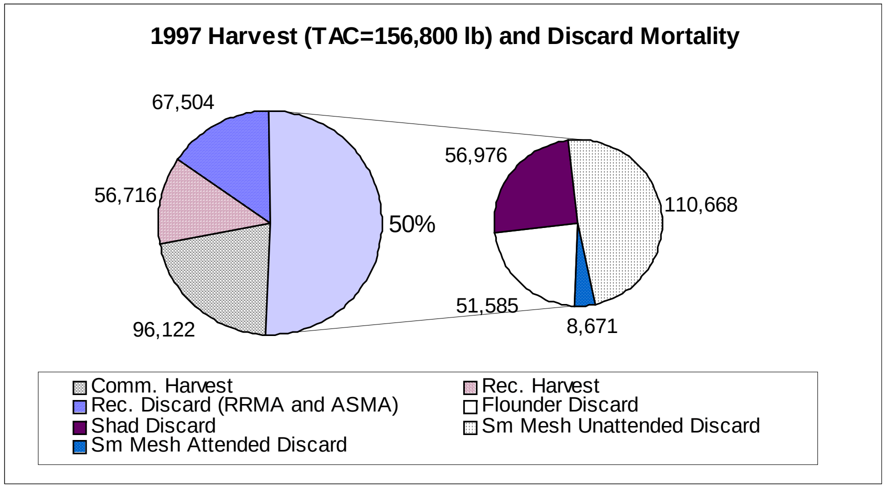


Figure 10.9. Percent contribution, in pounds and numbers of fish, to total removals of striped bass in the anchored gill net fisheries of the Albemarle Sound Management Area, 1994-2001.







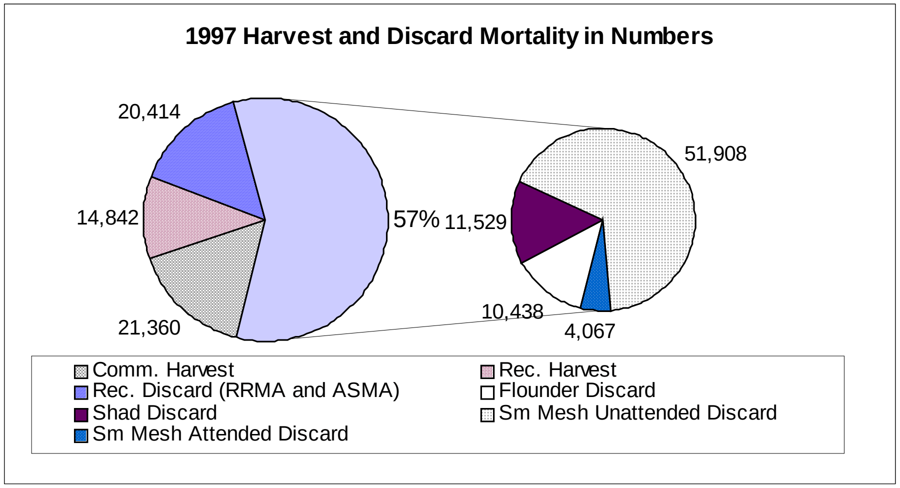
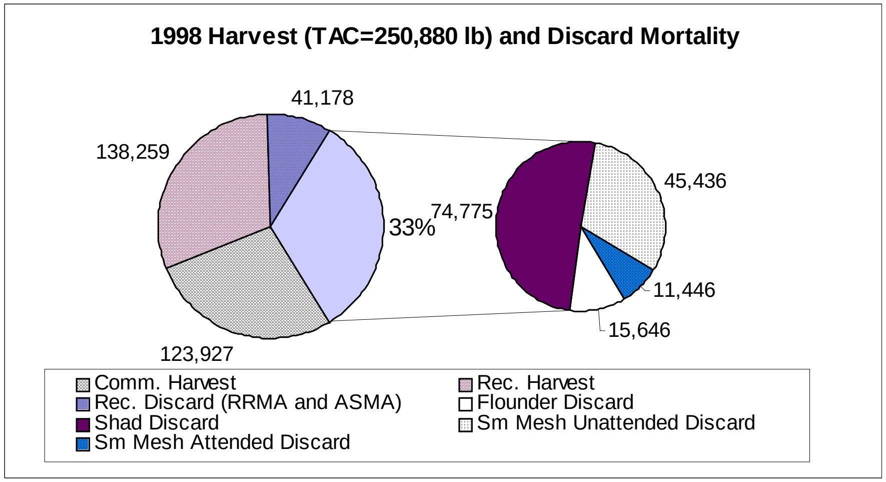
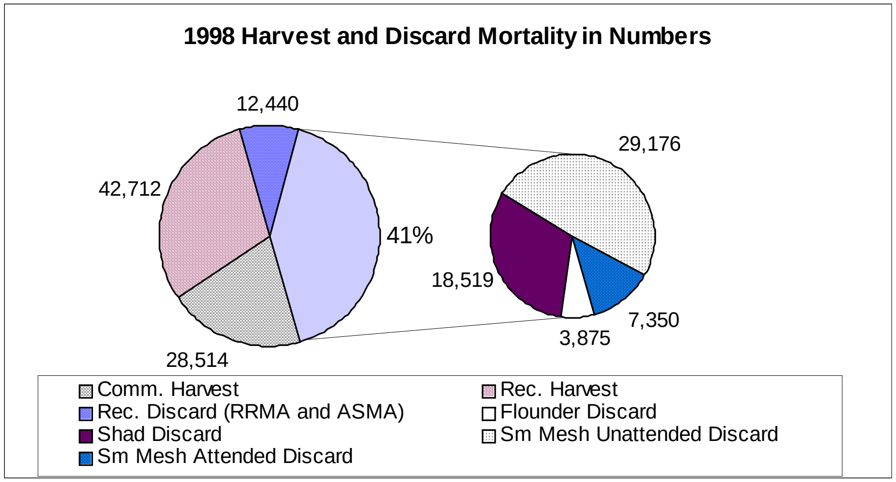
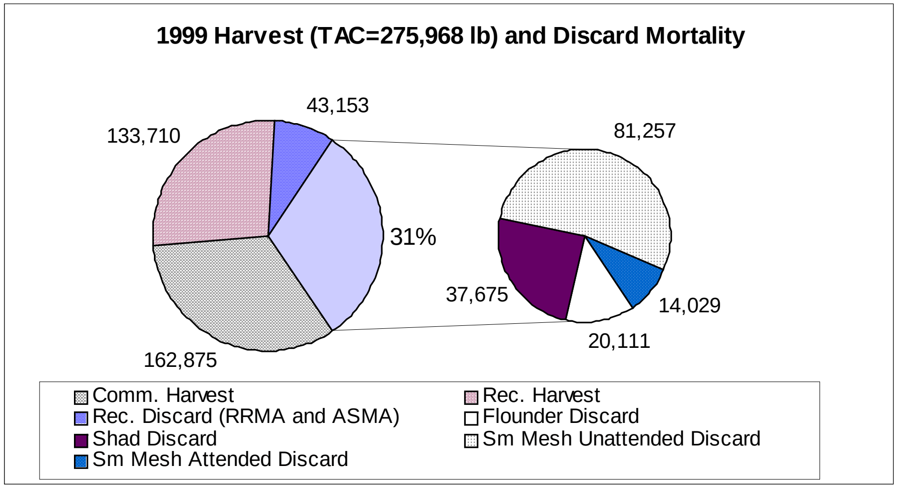


Figure 10.9. Continued







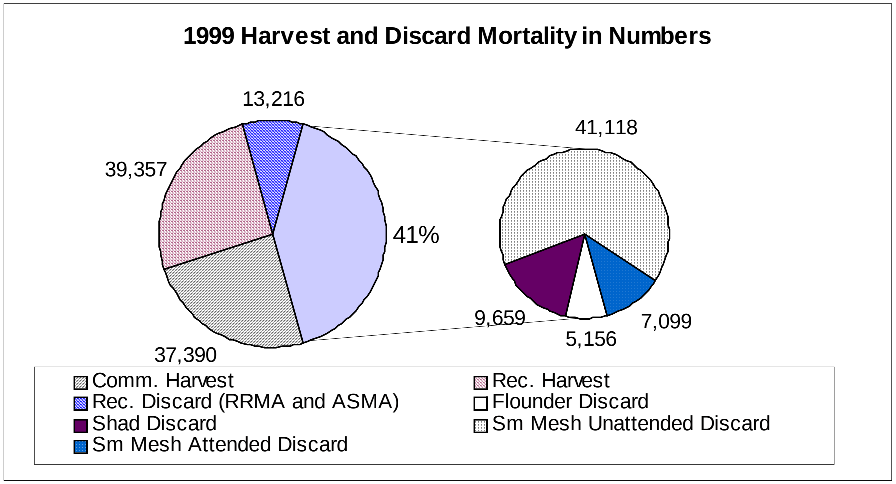


Figure 10.9. Continued

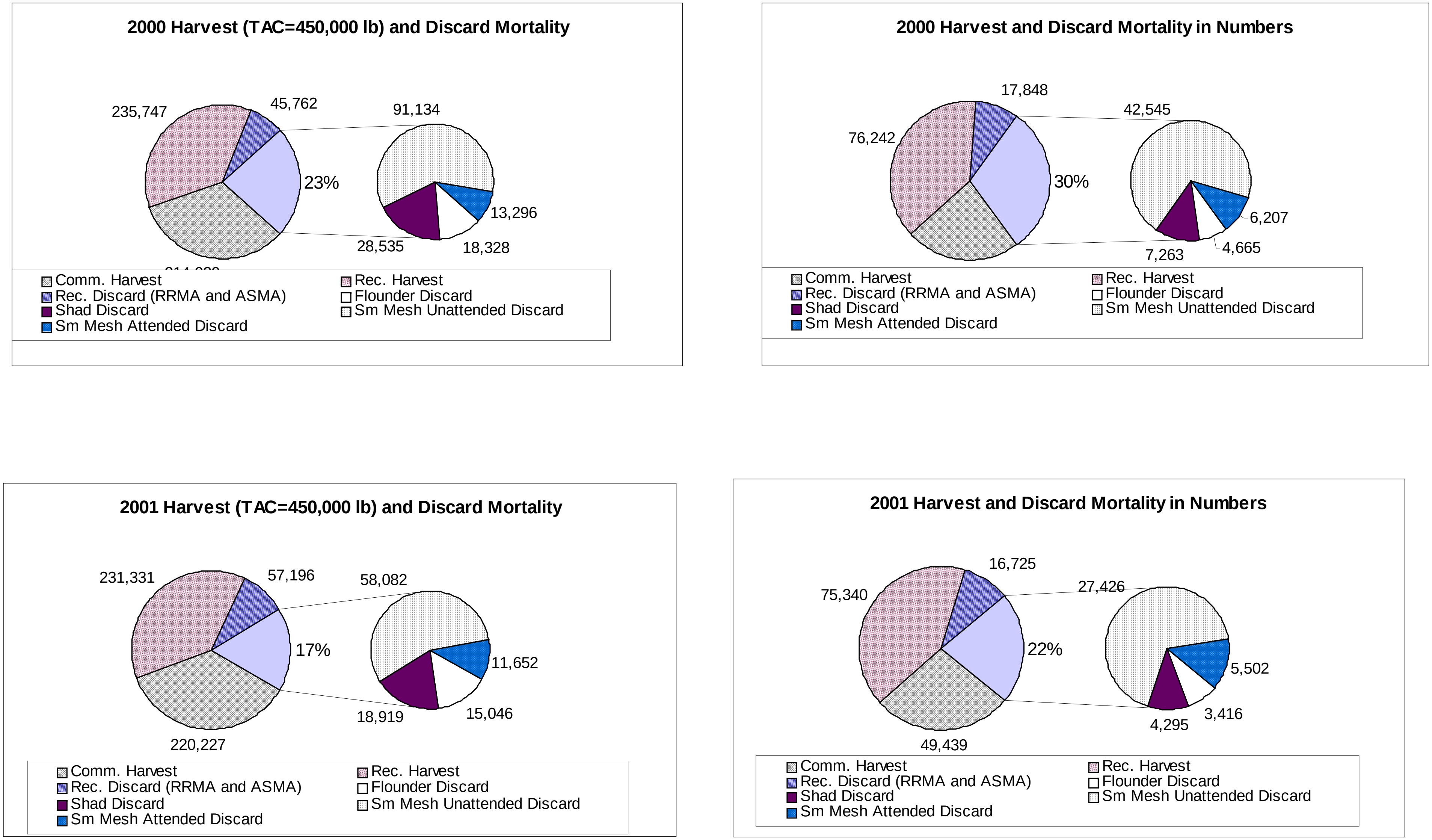


Figure 10.9. Continued

Limitations of Data

The use of various FRGs to estimate discard mortality of striped bass in the attended fishery has its limitations. First, most of these studies used for estimation were conducted in a very small area, which may not be representative of the entire ASMA. Catch rates that were experienced in one area may not be true for other areas. Another problem is that these studies were conducted during a limited time period. CPUE values from one period probably are not indicative of other years. For example, the estimated discards of striped bass in the unattended small mesh fishery for 1995 were excessively high, but estimates during the attended fishery for that year were lower than any other year.

Management Options

1) Status Quo

+ No further restrictions on gill net fishery due to interactions of target species striped bass.

- Current rate of discards would remain the same, unless harvest was increased.

2) Restrict the amount, size, area and time period in which gill nets can be fished.

+ Reduce the amount of gear in the water that could catch striped bass and reduce the bycatch mortality.

Since the early 1990s, various restrictions have been implemented in the small mesh gill net fishery in the ASMA. In the majority of the ASMA, only 3 and 3¼ inch small mesh gill nets are allowed. The small mesh unattended gill net fisheries have the highest discard rates, due to a large portion of the fish being of sub-legal size. The DMF data shows approximately 78-82% of the striped bass captured in the small mesh fishery are less than 18 inches total length. From 1998 to 2002, unattended small mesh gill nets have accounted for 50-73% of the total estimated discards from all gill net fisheries.

The attended small mesh gill net fishery requires that the fishermen be within 100 yards of the gear at all times and immediately available to work the gear. These gill nets also have an amount of discard mortality of striped bass; however, the estimates are 3 to 6 times less than the unattended nets, contributing 10-13% of the total discards. Even though the TAC in the ASMA has increased four times since 1997, it has had very little effect in lowering the discard mortality in the small mesh nets due to few fish being of legal size.

In 2000, the MFC approved the ASMA River Herring Fishery Management Plan, which established a 67,000 pound gill net TAC. Since 2000, when river herring gill net season closes 3 inch gill nets have been removed from the water. Gill nets of 3¼ inch are still allowed and limited to 800 yards. The attendance requirement for small mesh gill nets has been implemented between May 7-14 annually since 2000.

When river herring gill net season closes, remove all small mesh gill nets from the water until attendance is required. Removal of the nets would greatly reduce the amount of discards, but would eliminate the harvest of other marketable species during that time period (Table 10.14).

When river herring gill net season closes require all small mesh nets to be attended at all times. Attendance of small mesh gill nets is documented to reduce the number of striped bass discards significantly. Requiring attendance has also reduced the number of trips that occur. The attendance requirement would allow marketable species to be harvested and sold (Table 10.14).
Other fisheries include up to 31 species, top 7 species: catfishes, Atlantic menhaden, spot, striped mullet, weakfish, white peach and yellow perch.
- Would result in the loss of more marketable fish.

3) Remove gill nets as an allowable gear.
   + Would allow current bycatch mortality to be converted to harvest for other fisheries.
   - Would result in gill net fishermen having to seek alternative gears.
4) First Instance Mortality – The utilization for harvest all dead, marketable striped bass regardless of their size.
   + Would eliminate the majority of discard mortality from the gill net fishery.
   + Allow for a more accurate stock assessment by eliminating the uncertainty of discard mortality.
   + Poundage that is lost as discard mortality could be converted into harvest.
   - To insure that discard mortality does not occur after the TAC is achieved, all gill nets would have to be removed from the water.
5) Allow Hook-and-Line as a commercial gear.
   + Would allow the commercial harvest by hook and line since 1985.
   + Discard mortality would not be as significant as other types of gear.
   - Striped bass harvested by hook and line would not be available for other gear types.

Research Needs

1) More at-sea observations made for the gill net fishery to more accurately assess the discards from fishery.
   + Allows for a more accurate account of the unmarketable bycatch and a fuller assessment of what is being caught.
   - Increases burden on fishermen to have extra people on board their vessels.
   - High cost of running a survey.
2) Improvement in trip ticket data to collect gear parameters (yardage, mesh size, etc.).
   + Allow gathering of information that could be used for calculations of total yards fished in a fishery and CPUE for species.
   - Increases the amount of time for filling out trip tickets.
   - Increases work load for Trip Ticket staff.
3) Further investigate the impacts of delayed mortality on striped bass captured in gill nets.
   + Gives a more complete picture of the total losses to the striped bass population.
   - Number of delayed mortalities may impact the number of striped bass that could be harvested.

MFC, DMF, WRC and FWS Management Recommendation
Support the A/R AC option with the following qualifications: 1. DMF will evaluate existing IGNS small mesh data to determine differences between striped bass catches in float and sink nets. 2. Observer data, current and new studies will be used to assess the benefit of the A/R option. Should the discard reductions not be within the estimated range of the other options presented in Table 10.14, the DMF may implement either Option 2 or 3 of the table or other options that may be developed over time.

A/R Advisory Committee Management Recommendation
Stay at status Quo (existing gill net proclamation authority), with requirement that small mesh gill nets be sunk after river herring gill net season closes. Small mesh gill nets (3 ¼ inch) would be restricted to no more than 25 – 30 meshes deep and set in no less than 7 feet of water unless attended. These requirements would remain in effect when attendance was not required. Also, look at area closures to gill nets.

Option 2 Restrict the amount, size, area and time period in which gill nets can be fished

Amount

- Currently allowed
- 3,000 yards of flounder net (5 ¼" or greater sunken to fish no more than 4' from bottom)/ year round
- 1,000 yards of shad net (5 ¼" or greater)/ mid - February – mid-April

Table 10.14. Data utilized for Albemarle Sound Management Area, 2002.

	First Instance Mortality – No nets less that 5 ISM	Attended small mesh gill nets after river herring season	No small mesh nets after river herring season
Estimated reduction in discard mortality (%)	85[1]	43.8	50.4
Remaining mortality for all anchored gill nets (# of fish)	9,696[1]	36,191	32,444
Percent contribution of remaining discards to total population	0.29	1.09	0.99
Estimated number of fish saved from discard mortality	54,746	28,251	31,998
Percentage of fish saved to total population	1.67	0.86	0.97
Impact on other fisheries	-1,823,828 lb/$771,934[2]	1,823,828 lb/$771,934[3]	-1,504,698 lb/$662,164[4]
2002 population estimate used – 3.2 million fish			
Total gill net landings ASMA 3,136,m278 pounds/$2,352,838			

[1] This estimate could be up to 100%, but some mortality could remain from sub-legal fish. This is the 2002 estimate for large mesh gill nets.
[2] If striped bass allocation caught prior to end of year, the impact would be greater due to loss of other species caught in large mesh gill nets (Example, flounder and shad).
[3] Potential to maintain catch, but when attendance is required, the number of trips decreases, thus harvest also decreases.
[4] Gill net river herring season closing March 1.

- 800 yards of small mesh unattended (3 and 3 ¼”) January – early-May and December (3 ¾ and 4”) in parts of Croatan and Roanoke Sounds/ January – mid-April
- 800 yards of small mesh attended (3 – 4”) May – November
  Should the amount of webbing be reduced to minimize encounters with striped bass (all webbing, particular nets)?

Size

- Currently allowed
- Minimum 5 ¼” sunken year-round (flounder)
- Minimum 5 ¼” mid-February – mid-April (Shad)

- 3 and 3 ¼” December – early-May (Small mesh unattended)/3” removed after gill net herring quota is caught
- 3 ¾” and 4” in parts of Croatan and Roanoke Sounds /January – mid-April
- 3 – 4” May – November (Small mesh attended)

Is there a mesh size being used that is not necessary?

Can the minimum of 5 ¼” be raised to lower the encounters of striped bass and still allow the other fisheries to continue?
Is there enough difference between the 3 and 3 ¼” fisheries to warrant allowing both mesh sizes to be employed?

Should the 3 ¾” and 4” be allowed in the Croatan and Roanoke Sounds?

Area
- Currently allowed
- Gill netting allowed throughout the ASMA in joint and coastal waters with the exception of
  * Albemarle Sound west of a line from Black Walnut Point to mouth of Kendricks Creek (Mackey’s). (closed from February - November)
  * No set gill nets in Roanoke, Middle, Eastmost, and Cashie Rivers. Only drift gill nets with a mesh size of 3” can be used and cannot exceed 100 yards.

Are there areas in which certain gill nets should be restricted because of high encounter rates with striped bass?

Examples
- Use of shad nets in Northeastern portion of ASMA – high encounter rate with striped bass, few American shad captured
- Use of flounder nets in Croatan and Roanoke Sounds (late fall) particularly close to Hwy 64/264 bridge in Manns Harbor – high encounter rate with striped bass

Other areas?

Time Period
- Currently allowed
- 5 ¼” flounder nets – year round
- 5 ¼” shad nets – mid-February – mid-April
- 3” and 3 ¼” small mesh unattended January – early-May, December
- 3 ¾” and 4” small mesh unattended in parts of Croatan and Roanoke Sounds January – mid-April
- 3 –4” small mesh attended May – November

Should small mesh be attended for a longer period of time?

Should small mesh be attended all the time?

Should shad and flounder webbing be attended for part of the year or year round?

Gear Configurations
- Currently allowed
- 3,000 yards 5 ¼” or larger sunken, to fish no more than 4’ from bottom/ year round (flounder)
- 1,000 yards 5 ¼” or larger, float or sink/ mid-February – mid-April (shad)
- 800 yards small mesh unattended (3” and 3 ¼”), float or sink/ January- early May, December and 3 ¾” and 4”, float or sink/ January – mid April in parts of Croatan and Roanoke sounds
- 800 yards small mesh attended(3 – 4”), float or sink/ mid-April – November
- Gill nets of the above mentioned size can be hung in any manner a fishermen chooses. The standard hanging ratio is ½, but many fisherman hang nets on the ¼ or less to bag webbing between the ties. This is thought to increase the catchability of the net.

Float nets have a higher incidence of catching striped bass. Would it be feasible to fish only sink nets? Would a sink shad net reduce the occurrence of striped bass but still allow adequate harvest of other commercial fish?

Small mesh?
Does the hanging ratio of a gill net effect the number of striped bass that are captured? Should gill netters be made to hang nets on the ½?

Information Paper for Potential Buyout Scenario of Gill Net Fishery in the Albemarle Sound Management Area

Introduction
At the request of members of the Albemarle/Roanoke Striped Bass Advisory Committee, the Division of Marine Fisheries was asked to look at the potential for a

possible “buyout” of the use of gill nets by commercial fishermen for a certain portion of the year. It was suggested that during certain months gill nets could be removed from the water, while compensating the commercial fishermen for monies lost during the closed time. Compensation would be divided among the fishermen based on previous years’ income for that time period. It has not been determined where these monies would come from at this time.

Methods

Using the Division of Marine Fisheries Trip Ticket Program, the number of individuals were determined for each year from 1994 – 2001. These fishermen’s trips were then broken into three categories (flounder, shad, and small mesh) as done for estimating discard mortality of striped bass (see **Issue Paper Striped Bass Discard Mortality in the Unattended and Attended Multi-species Gill Net Fishery in the Albemarle Sound Management Area**). This allows examination of the potential income a fisherman may make for a certain time period, utilizing a particular gill net.

Ex-vessel value, the amount paid to the fisherman, was determined and fishermen were partitioned into categories by the amount of money made (ex. $1-500, $501-1,000, etc.) for a certain time frame. Inflation was not factored into any of the values that are presented.

It became apparent during analysis of the data that the criteria for assigning trips to the three categories may not truly represent the fisheries. The number of fishermen and value of the small mesh fishery was much lower than what was expected. Division staff looked at this problem and assigned new values to each fishery. The original criteria called all trips landing more than 10% flounder and shad < flounder in their catch as a flounder trip. The new criteria increased to 30%. Shad trips were defined as a greater catch of shad than flounder or greater than 30 pounds of shad. This was changed to a greater catch of shad than flounder and greater than 30 pounds of shad. All other trips that did not meet these criteria were called small mesh trips. The changing of the criteria moved trips from the flounder and shad fishery into the small mesh fishery. Trips were lost from the flounder fishery to the small mesh fishery, but the number of individuals participating remained fairly constant. Approximately 56.1% of the shad fishermen were reallocated to the small mesh fishery using the new criteria.

It is difficult to differentiate between the shad and small mesh fisheries, because in many cases they occur at the same time. In many instances, fishermen will employ both shad and small mesh nets at the same time, with only one trip ticket being completed at the time the catch is sold. So in doing these calculations, the trip will only be counted in one category.

Also, the trip tickets allow for more than one type of gear to be included. In some cases, fishermen will use gill nets and other forms of gear (pound nets, fyke nets, trotlines, etc.) and include them all on one trip ticket. This has the effect of inflating the actual value of the gill net fishery by including landings that originated from other gears.

Results

It has been determined that the gill net fishermen have averaged a total of $2,764,528 annually from 1994-2002 (Figure 10.10). The flounder gill net fishery has averaged $2,382,522 (86.2%) annually. The small mesh fishery has averaged $346,915 (12.5%) annually. The shad fishery has averaged $35,092 (1.3%) annually. These values were derived from the new criteria for the fisheries. Under the original criteria, the flounder fishery averaged $2,572,247 (93.1%), small mesh $97,373 (3.5%), and shad $94,907 (3.4%) annually.

There has been an average of 632 people involved in the gill net fishery annually (1994-2001), with a peak of 730 in 1995 to a low of 494 in 1999. Under the new criteria, an average of 630 (99.7%) people are involved in the flounder fishery, 571 (90.4%) in the small mesh fishery, and 83 (13.1%) in the shad fishery. Under the original criteria, 631 (99.8%) people were involved in the flounder fishery, 532 (84.2%) in the small mesh, and 186 (29.9%) in the shad fishery.

Under the original criteria, it was determined that approximately 63.4% of people fishing flounder nets made less than $2,000 annually (Figure 10.11). Approximately 90.8% of fishermen made less than $500 using small mesh nets, and 78.6% of fishermen made less than $500 with shad nets. Under the new criteria, 65.9% of flounder fishermen made less than $2,000, 72.1% of small mesh fishermen and 74.6% of shad fishermen made less than $500 (Figures 10.14 – 10.16).

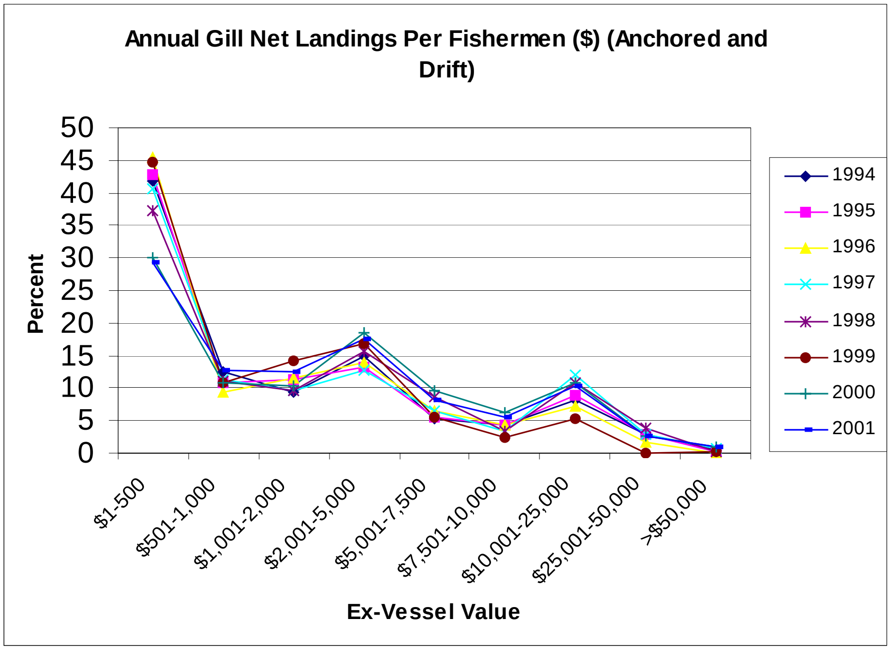


Figure 10.10. Annual gill net landings value per fisherman (Anchored and Drift nets)

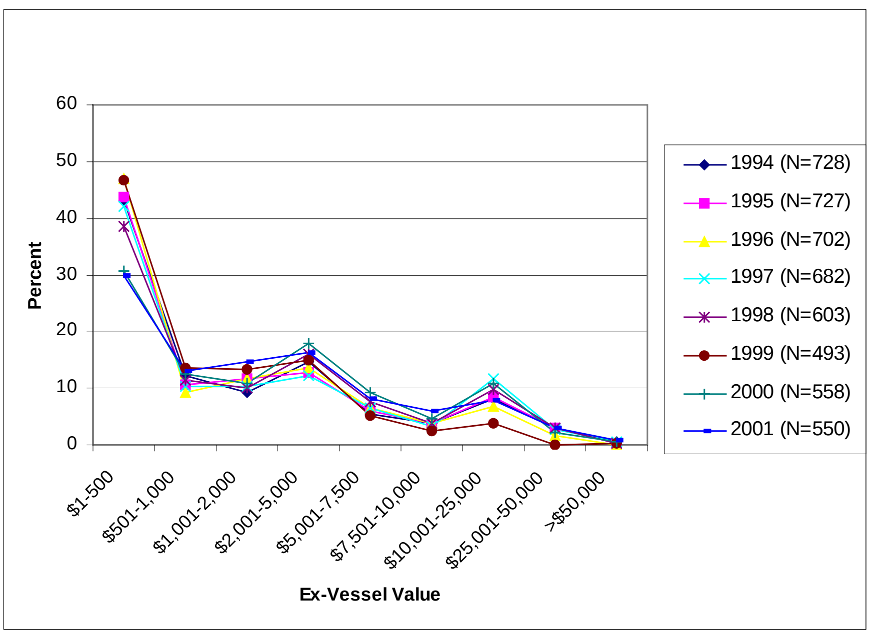


Figure 10.11. Percent of participants by average value of annual landings for flounder nets using original criteria.

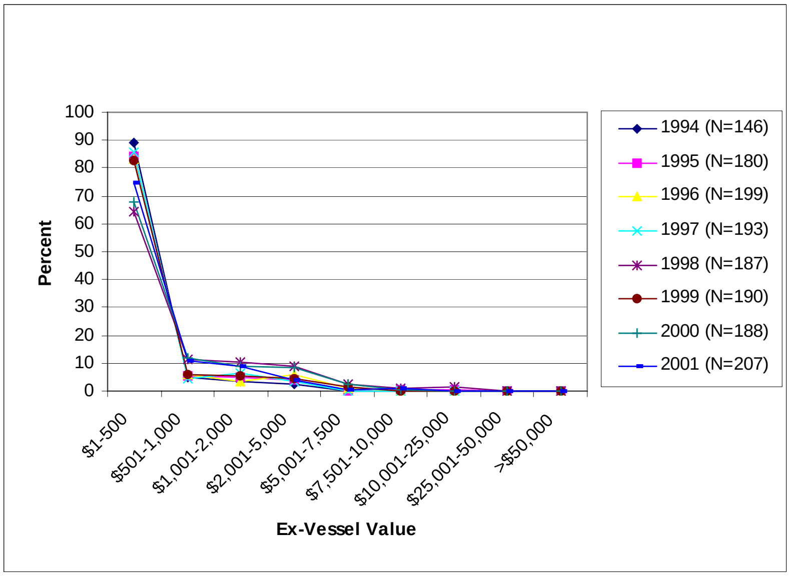


Figure 10.12. Percent of participants by average value of annual landings for shad nets using original criteria.

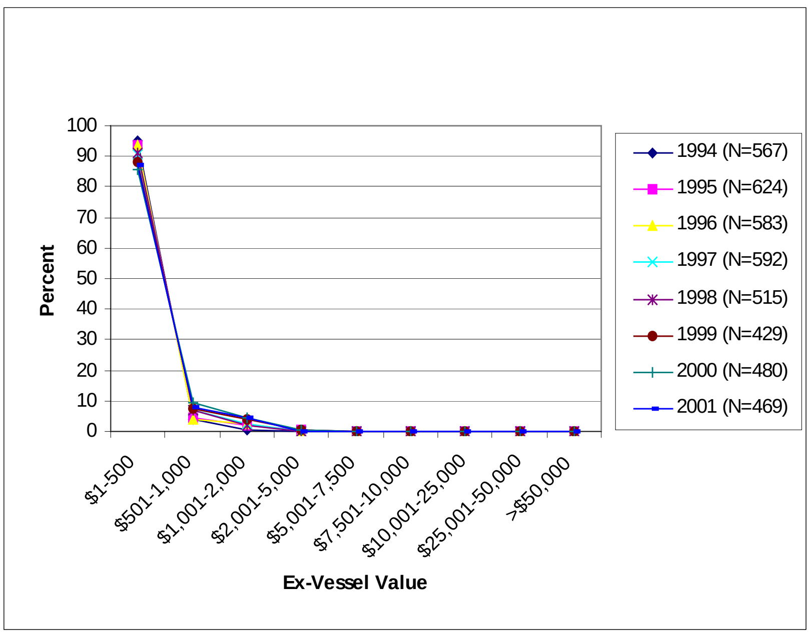


Figure 10.13. Percent of participants by average value of annual landings for small mesh nets using original criteria.

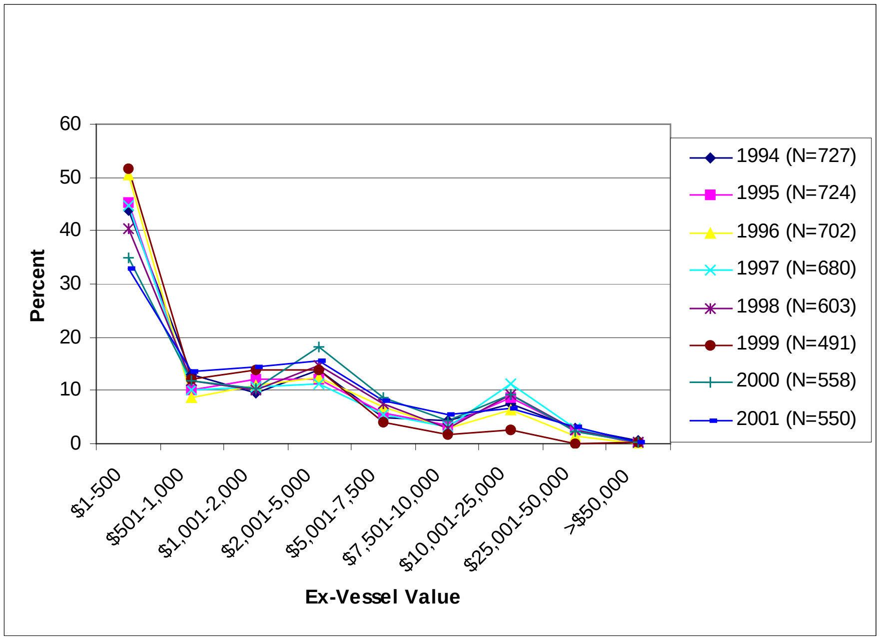


Figure 10.14. Percent of participants by average value of annual landings for flounder nets using new criteria.

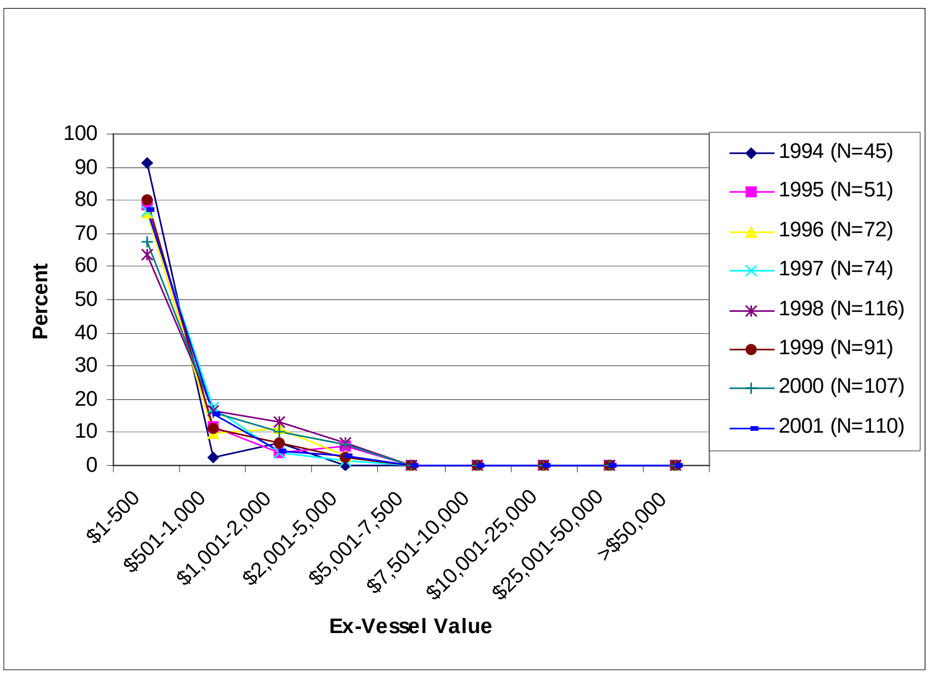


Figure 10.15. Percent of participants by average value of annual landings for shad nets using new criteria.

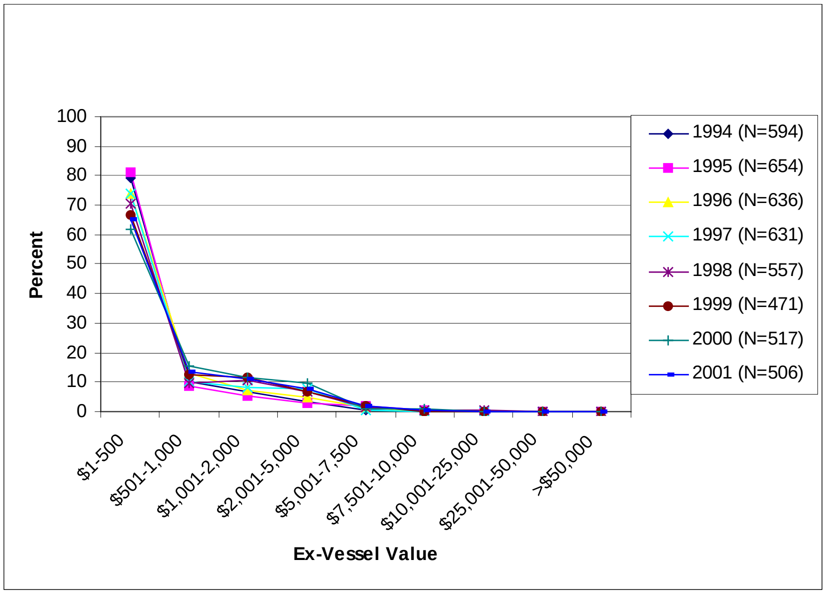


Figure 10.16. Percent of participants by average value of annual landings for small mesh nets using new criteria.

The closure of the use of gill nets for a certain length of time can have a differential impact depending on the time of year. The average value of the gill net fishery by month for the years 1994 – 2001 is presented in Table 10.15.

Table 10.15. Average value to fishermen of the gill net fishery in the Albemarle Sound

Month	Value	Number of Fishermen	Straight Average per Fisherman
January	$70,037	134	$523
February	$134,412	229	$586
March	$215,032	285	$755
April	$167,777	234	$718
May	$78,119	135	$580
June	$110,255	130	$851
July	$188,173	152	$1,238
August	$295,669	171	$1,732
September	$497,342	232	$2,140
October	$534,206	241	$2,215
November	$377,873	234	$1,612
December	$95,624	165	$578

10.3.3 Harvest Management

10.3.3.1 Management of Striped Bass Harvest Targets in the ASMA

Issue
Management of quotas and harvest targets for the ASMA and RRMA.

Background
Harvest of striped bass in the ASMA and RRMA has been managed by fishing mortality targets achieved through Total Allowable Catch (TAC) restrictions since 1991. TAC's are determined by applying target fishing mortality rates to abundance estimates from the annual stock assessment. Each fishery is allocated a specific portion of the TAC (Roanoke River 25%, Albemarle Sound Recreational 25%, Albemarle Sound Commercial 50%) and managed through fishery regulations such as seasons and creel limits. The ASMFC Striped Bass FMP and its Amendments, and the 1994 North Carolina Striped Bass FMP, specify that when fisheries are managed by TACs, overages are to be deducted from the TAC allocation for the following year. Such provisions are necessary to ensure that states adopt reasonable measures to prevent overages and strive to provide the most accurate and reliable point estimates of harvest possible.

Since 1994, striped bass harvest overages in the Albemarle Sound commercial and recreational fisheries have been deducted from the next year's TAC allocations. From 1994 through 2002, the estimates of striped bass harvest from the Roanoke River exceeded the cumulative TACs by approximately 23,000 lbs. (an average of approximately 2,600 lbs. per year) but were not repaid, because of a difference in opinion as to whether the Roanoke River harvest estimates were statistically different from the TAC. The WRC, argued that as long as the statistical confidence bounds of the harvest estimate encompassed the TAC, then the harvest estimate was not statistically different from the TAC and there was no overage to repay. The 1994 Striped Bass FMP specifically stated "subtract any harvest overages from the succeeding year's TAC."

Provisions for Repayment of Roanoke River Quota Overages, 1994-2002

Option 1. Payback through future underages or future increases
Since 1994, WRC has exceeded the harvest quota by approximately 23,000 pounds. It is anticipated that significant harvest underages in the spring 2003 will negate any payback obligation. Should it not, then the WRC will pay back these overages by utilizing the following options at its discretion

1. Harvest overages will be paid back over several years through future TAC underages.

2. Harvest overages will be paid back as allowable catches increase. The WRC proposes not to increase season length or creel limits until allowable catch has increased significantly. Because of potentially high catch rates and harvest in the RRMA, WRC recognizes that creel restrictions can only be relaxed if increases in TAC are great enough so that relaxation of regulations will not result in exceeding the TAC. Increases in allowable catch without adjustments in RRMA

regulations should minimize the probability the TAC will be exceeded and also serve to pay back overages.

Option 2. Direct Payback in 2004
Require that the harvest of the Roanoke River recreational fisheries in 2004 are reduced by the sum of the 1994 – 2002 quota overages, in addition to any appropriate adjustments incurred during 2003.

Option 3. No Payback
Quota overages of Roanoke River recreational fisheries from 1994 – 2002 will not require payback.

TAC Management Options Beginning in 2004

Option 1. Management through Strict TAC as in Current FMP
This option would continue the current system, which has been in place since 1994, with a TAC allocated to specific fisheries. Point estimates of the recreational harvest will be used as indicators of actual harvest and estimate of commercial harvest will come from trip ticket landings. DMF has managed the ASMA commercial and recreational fisheries by this means.

Harvest overages in each fishery will be deducted from that fishery's TAC for the next year. Harvest underages will not be carried over to the next year. Jurisdictions are obligated to close fisheries when it is projected that quota limits will be reached.

Option 2. Management of Albemarle Fisheries TAC by Proclamation, Roanoke Fishery by Fixed Regulations

WRC Management
This is the management system that has been in place for the RRMA since 2002.

In the spring 2002, WRC initiated a pre-set striped bass harvest season in the RRMA to address angler complaints about the uncertainty of the striped bass harvest season dates and their inability to plan fishing trips during the peak period. The pre-set harvest season (March 1 – April 15 in the lower Roanoke River and tributaries below US Hwy. 258 bridge and March 15 – April 30 in the upper river) was based on previous harvest records. Those records indicate that on average, the harvest will be within the established quota (112,500 lbs. in 2002). Because of annual differences in water temperatures, migration dates and fishing conditions, it was assumed that harvest would be less than the TAC in some years while harvest might exceed the TAC in other years. WRC's goal was to provide a predictable season for anglers while remaining at or under the TAC on a long-term basis.

To address potential overages, both chronic and acute, WRC will do the following:

1. Use a 3-year running average of the point estimates of harvest (pounds of striped bass) to evaluate performance of the pre-set season in the RRMA in relation to the total allowable catch. If the 3-year running average exceeds the annual point estimate by 10%, WRC will initiate rule changes to reduce harvest. Over the longer term, should the annual harvests during the 5-year period exceed the annual TAC (α=0.05), additional harvest reduction rules will be initiated.

2. In the event that a substantial over harvest of striped bass appears imminent while the harvest season is open, Inland Fisheries staff will recommend to the WRC Executive Director to close the season by proclamation.

DMF Management
Quotas will be established for those fisheries managed under the DMF based on allocation of the annual TAC. Harvest monitoring will occur on each fishery and the seasons would close by proclamation. Overages will be deducted.

Option 3. Management Through Harvest Targets for All Fisheries
The A/R stock of striped bass is considered recovered, and this FMP proposes managing for a specific fishing mortality target that is conservatively below the fishing mortality level that would result in overfishing. Such a management approach is based on the premise that it is acceptable, and even expected, for fishing mortality to vary around the target. Since the fishing mortality target is set reasonably below the threshold mortality level that would lead to stock damage, it follows that values for TAC that are based on the target fishing mortality will also be reasonably below harvest levels that would lead to stock damage. It also follows that observed harvest may fluctuate around the TAC without posing any risks to the stock. Therefore, a management strategy based upon fishery-specific harvest targets determined from a stock-specific TAC may be more appropriate than strict quotas, and may better address fluctuations in abundance and yield that are expected and acceptable for a recovered stock.

The primary difference between management by harvest targets and management by TACs is that TACs are hard limits expected to be achieved precisely and that typically require deduction of overages, whereas targets are soft limits expected to be approximately met and do not require deductions of overages. Harvest limits should be accompanied by bounding requirements to prevent excessive overages or changes in allocation schemes, and to ensure that jurisdictions adopt reasonable regulations. For example, it could be required that quota overages exceeding a percentage of the harvest limit (e.g., 10%) must be deducted, or it could be required that more restrictive measures be adopted if estimated harvest exceeds the harvest limit for a number of years (e.g., 3). So that there is no confusion, and in order to maintain a conservation buffer under this option, any harvest underage for a particular year would not increase the allowable catch for the following year nor allow relaxation of regulations. Harvest underages would be used to offset any overages occurring during the periods of the three and five year running harvest estimates.

Specific requirements:

TAC Allocation
Roanoke River/WRC -25% of total
Albemarle Sound/DMF- 75%, with
  Albemarle Sound recreational- 25% of total
  Albemarle Sound commercial- 50% of total

Penalties and Triggers for Chronic Overages
The management strategy proposed here is based on the assumption that observed landings will fluctuate at random around the harvest limit, and that observed landings will not significantly exceed the harvest limit. To prevent stock damage and the associated burden on all fisheries of reduced TAC stemming from overages in a specific fishery; both short-term and long-term triggers are needed. Short-term triggers will be invoked based on excessive overages in a single year, while long-term triggers will be invoked if a consistent bias is observed over a number of years.

Short - Term Excessive Overages
If the point estimates of harvest for any fishery component exceeds its allocated harvest target by more than 20% in a single year, then the overage must be deducted from the allocation for that fishery in the next year and more restrictive measures instituted for that fishery.

Long –Term Overages
If the point estimates of harvest for any fishery component exceed the allocated harvest targets by 5% for three years in a row, then more restrictive measures must be adopted for that fishery.

Long – Term Excessive Overages
If the five year running average of the point estimates of harvest for any fishery component exceeds the five year running average of that fishery's harvest limit by 10%, then the harvest limit for that fishery over the next five years will be reduced by the amount of the overage.

MFC, DMF, WRC, FWS and A/R Advisory Committee Management Recommendation
Supports Option 3- No payback for overages, due to the underage in 2003 harvest in the RRMA.

MFC, DMF, WRC, and FWS Management Recommendation
Manage through harvest targets with the following penalties and triggers for overages: Short-term Overages: point harvest estimate exceeds the total TAC by 10% in a single year, overage deducted from the next year and restrictive measures implemented in the responsible fishery (ies). Long-term Overages: Five-year running average of point estimate exceeds the five-year running average of the total TAC harvest by 2%, the

responsible fishery exceeding the harvest limit will be reduced by the amount of the overage for the next five years. Should the target F be exceeded, then restrictive measures will be imposed to reduce F to the target level.

A/R Advisory Committee Management Recommendation
Supports the agency's recommendation on harvest targets and penalties/triggers. In the future, recreational TAC increases should be allocated as follows: the ASMA should receive 35% of any increase and the RRMA receive 15%.

10.3.3.2 Recreational Striped Bass Harvest Closure- Atlantic Ocean

Issue
Increased harvest of striped bass 28 inches TL and larger during the late Spring through the summer.

Background
The recreational fishery around Oregon Inlet has grown significantly since the mid-1990s. This fishery not only targets the Atlantic Migratory Stock during the fall and winter but also the A/R stock during the late spring through the summer. This has resulted in a directed fishery essentially year round.
The line of demarcation between the Atlantic Ocean and the ASMA is the centerline of the Bonner Bridge and east of this line is open to harvest year round. The daily allowed harvest limit east of this line is 2 fish per person and a 28 inch TL minimum size limit.

Since 1996, one hundred tags have been returned from the Oregon Inlet area. These fish were tagged on the spawning grounds in Roanoke River or in the ASMA. The time period mid-April through September has accounted for 51 (51%) of the returns. The majority of these returns (n=28) are from fish tagged on the spawning grounds, with a growing number exceeding 28 inches TL when tagged and released. The DMF is not only concerned with the increased harvest of these large fish but also the mortality of sub-legal fish as a result of high water temperatures during the summer months. Data collected from the MRFSS survey in 2002 for the time period May-October for the ocean showed ~59,000 pounds of striped bass harvested.

Current Authority

North Carolina Marine Fisheries Commission Rules

North Carolina Fisheries Rules for Coastal Waters (15A NCAC)
3M.0204 Season, Size and Harvest Limit Atlantic Ocean

Discussion
As the A/R striped bass year classes have continued to increase, so has the availability of fish 28 inches TL and larger in the population. Since 1996, the percentage of striped

bass 28 inches and larger tagged on the spawning grounds has increased annually (**Table 5.5**). However, the percentage is still just over 1.2% of the total number tagged since 1996. Even though the number of fish 28 inches and larger have increased, they still only represent a small percentage of the total population. Fish of this size are considered prime spawners and should be provided protection.

Management Options

Option 1 Status Quo (allow the fishery to continue as is)

- Will provide no protection for these large fish
- Directed fishery will continue with hook and release mortality of sub-legal fish
+ Allow for economic gain to charter and guide services

Option 2 Close the Atlantic Ocean to the harvest of striped bass from the time the ASMA recreational season closes in the spring until October 1 of each year.

+ Will provide protection of 28 in. and larger striped bass
+ Reduce the hook and release mortality of sub-legal fish due to no directed fishery
+ Closure will coincide with adjacent waters (ASMA)
- Result in economic loss to charter and guide services

DMF, WRC, FWS and C/S Advisory Committee Management Recommendation

Support Option 2: Close the Atlantic Ocean to recreational striped bass harvest from when the ASMA closes in the spring until October 1.

MFC and A/R Advisory Committee Management Recommendation

Support remaining at Status Quo.

10.4 Issues Relative to the C/S Striped Bass Stocks

10.4.1 Stock Structure

10.4.1.1 Biological Reference Points

Issue

Estimation of biological reference points and management targets.

Background

North Carolina Fishery Management Plans are required to include management measures that prevent overfishing, while achieving, on a continual basis, the optimum yield for each fishery. The OY is defined as the amount of fish that provides the greatest benefit to the State, is prescribed on the basis of the maximum sustainable yield (MSY), and in the case of an overfished fishery will provide for rebuilding to a level that will produce MSY.

Life history information from catch and survey sampling is the basic input of Yield per Recruit analysis (YPR) used to estimate yield or growth based reference points such as F_{max} and $F_{0.1}$ and evaluate growth overfishing. Expanding this method to include maturation at age information allows calculation of spawning potential and estimation of Spawning Potential Ratio (i.e., $F_{XX\%SPR}$) references and consideration of recruitment overfishing. Information on average recruitment provided by the VPA enables further scaling of 'per recruit' values from the YPR analysis to potential total population values.

MSY can be estimated only if estimating recruitment at various stock levels is possible. VPA estimates of recruitment and spawning stock biomass can be used to determine recruitment from spawner abundance, through either formal stock-recruitment relationship models (SRR) or more ad hoc approaches such as selecting future recruitment from observed values over various ranges of spawner abundance. Once a method to estimate recruitment is derived, population projection models are used evaluate stock performance over a range of exploitation rates and thus determine the rate (F_{msy}) that provides the maximum yield (MSY).

A range of potential biological reference points for North Carolina striped bass stocks was evaluated and presented to the North Carolina Striped Bass FMP Plan Development Team on January 8, 2002. The PDT reviewed the reference points and identified a range of options for biomass and mortality rate targets and thresholds. The analyses are based on biological and fishery data from the Albemarle Roanoke stock, as no data are available for the other stocks.

Current Authority

General Statutes of North Carolina
G.S. 113-182.1. Fishery Management Plans

Reference Point Evaluation

Yield per Recruit (YPR)
Yield per Recruit models have long been used to establish biological reference points and management benchmarks, largely due to their modest data requirements and ease of calculation. Data necessary for this analysis are weight at age, natural mortality, and selectivity at age. The reference point most often associated with this analysis is Fmax, defined as the fishing rate that provides the maximum yield per recruit. As further experience showed that fishing at Fmax could result in overfishing, a more conservative reference, $F_{0.1}$, was developed, defined as the point at which the slope of the YPR curve is $1/10^{th}$ the slope at the origin. YPR analysis assumes a population at equilibrium, i.e. that age at entry into the fishery, weight at age, maturation at age, natural mortality, and recruitment are all constant. Providing an estimate of average recruitment at equilibrium enables scaling of per-recruit values of yield and biomass to stock-level values.

Yield-per-recruit analysis used a dynamic pool model and input values from the recent assessment (Carmichael, 2002). Current stock conditions are summarized in **Table**

10.16 for comparison to predicted equilibrium conditions under the various reference points. The estimated value for Fmax is below the current mortality target, indicating that slight growth overfishing could occur at the current target (**Table 10.17**). $F_{0.1}$ is slightly below F_{max} and approximately equal to the natural mortality rate, M, which is typical for most stocks. The point of stock collapse, based on the PDT recommendation of female spawner biomass declining below 400,000 pounds, is high at Fcollapse=0.90. This high Fcollapse suggests the stock has considerable resiliency and can endure significant exploitation before SSB declines enough to significantly degrade recruitment. Based on 1989-1999 average recruitment of 377,000 age 1 fish, yield at Fmax would be 1.0 million pounds, nearly double the 1998-2000 average catch (harvest+discard) of 505,286 pounds, and about 40% above the 2000 catch of 638,394 pounds. Although the actual exploitation rate at F_{max} is lower than the current exploitation rate, the potential yield is higher due to increased stock biomass expected from an expanded age structure. Spawning stock biomass at F_{max} is predicted to be over 3 times the 2000 value of about 1 million pounds.

Spawning Potential Ratio

Because the basic YPR analysis considers only the effect of fishing mortality on yield, associated reference points technically only address growth overfishing. Moreover, there is no feedback between stock abundance and yield and recruitment, thus the model cannot reflect density dependent factors that might affect the population. The model can be extended by incorporating maturation or fecundity ogives as an attempt to address recruitment overfishing, but the previous limitation still applies. Reference points provided by this extension are based on the spawning potential ratio, calculated as the proportion of the maximum spawner biomass or egg production (i.e., that expected with no fishing exploitation) that will be produced at each exploitation rate, and are generally presented as $F_{xx\%SPR}$.

Table 10.16. Current Albemarle-Roanoke striped bass stock conditions, from Carmichael, 2002.

Parameter	Value
Stock Abundance Numbers	1,567,000
Female Spawner Pounds	1,094,584
2000 Total Catch Pounds	638,394
1998-2000 Catch Pounds	505,286
1998-2000 Catch Numbers	161,089
catch, 1000's N[1]	134

Table 10.17. Biological reference points and associated yield parameters from YPR analysis.

Reference Point	Estimated value
F0.1	0.12
Fmax	0.15
Fcoll	0.90
Yield@Fmax, mlb[1]	1.007
SSB@Fmax, mlb Female[1]	3.802

[1] Yield, SSB, and catch are based on average recruitment of 377,000 age-1 fish.

Although the specific %SPR necessary to prevent recruitment overfishing and sustain adequate spawner biomass is unknown unless a stock-recruitment relationship is available, SPR values between 20% and 40% are commonly considered, and some stocks have been sustained at considerably lower levels. Results of the SPR analysis can be combined with a stock-recruit plot to determine if a given level of SPR would have been adequate to sustain the stock given the observed recruitment history. Similarly, observed recruitment values can be used to determine the minimum SPR necessary on average to replace the stock over the observation period. Inverting the value of SSB per recruit provides a value for recruits/SSB that can be used as the slope of a line on the Stock-Recruitment plot. Recruitment values above a given line represent years when recruitment was adequate to replace the parent stock, while those values below a line represent years when recruitment was not adequate to replace the parent stock. The point where a given line intersects the predicted stock recruitment relationship is represents where the stock would stabilize under average conditions.

Results of the SPR analysis based on a range of 10 - 40%SPR produced exploitation rates between F=0.14 and F=0.40 (**Table 10.18**). These values are safely below the point of collapse (F=0.9), and any value would likely produce adequate recruitment to at least sustain current stock abundance. The age structure of the population would vary considerably over this range of exploitation rates, with the proportion of the population composed of older fish (8+) declining from 24% for F40%SPR to 6% for F10%SPR. Yield is close to the maximum for F40% to F20%SPR, drops about 20% for F10%SPR, and drops over 30% at Fcollapse. Spawner biomass would not increase over current levels for F10% SPR, but would increase considerably for the other references considered. The plot of recruitment and SSB overlain with %SPR reference lines shows that none of the %SPR values considered are likely to negatively impact recruitment (Figure 10.17). Therefore, even the apparently low 10% SPR could prevent recruitment overfishing.

Table 10.18. Percent SPR based reference points with associated F values, % adequate recruitment from the observed history, % of the population age 8 and older, yield per recruit, and female spawner biomass.

Parameter	F	%SPR	% adequate R	%8+ pop.	Yield per Rec.	SSB[1]mpds
F40%SPR	0.10	40	100	24	.833	5.344
F30%SPR	0.16	30	100	18	.873	3.572
F20%SPR	0.22	20	95	13	.838	2.541
F10%SPR	0.40	10	95	6	.687	1.200
Fcoll	0.9	3.4	33	0.8	.505	0.402
Frep_95-99	0.75	4.3	83	1.4	.617	.532
Fmax	.19	24	100	19	.874	3.802

[1]Millions of pounds, based on average recruitment of 327,000 age 1 fish.

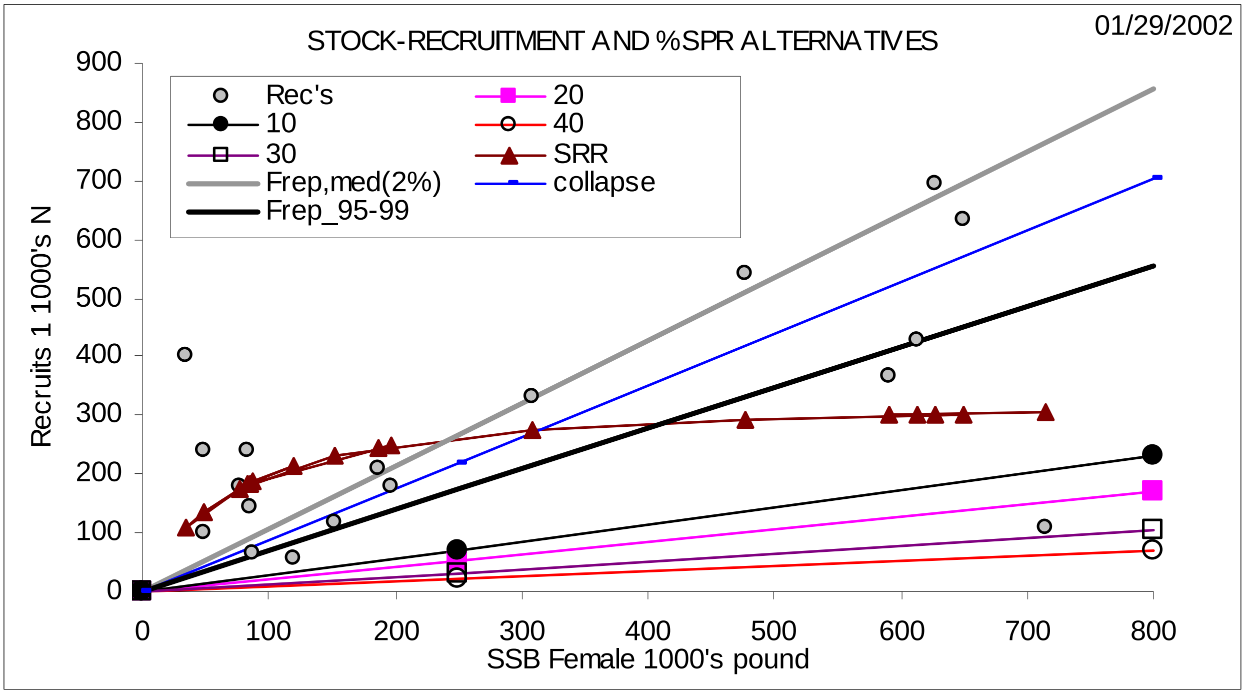


Figure 10.17. Stock-Recruitment plot with replacement (median of observed) %SPR and various %SPR levels.

Estimation of MSY

The reference points evaluated so far are largely based on 'per recruit' information, and are therefore useful even when future recruitment is unknown. Estimation of maximum sustainable yield, MSY, however, requires some determination of future recruitment. This is usually accomplished through a stock-recruitment relationship, such as that illustrated in Figure 10.18. Stock-recruitment relationships are among the hardest fisheries population characteristics to determine, often remaining inconclusive in spite of long data series and extensive evaluation. The true underlying relationship may be

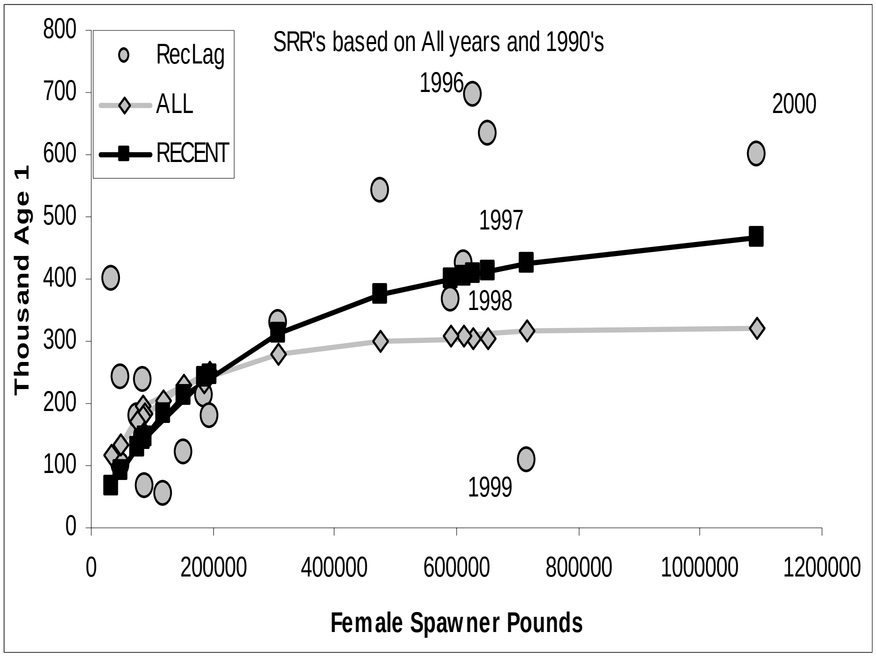


Figure 10.18. Stock-recruitment plot for striped bass and fitted Beverton-Holt stock-recruitment relationships, for all years and for the 1990's.

masked or even distorted by many factors, including, but certainly not limited to, environmental variation, an inability to adequately measure recruitment, and a lack of data over an adequate range of parent stock size. Even when a relationship can be determined with reasonable statistical accuracy, it is a record of past performance that may not be representative of future conditions, especially for a stock that undergoing rapid change. All of these factors affect the stock recruitment relationship for AR striped bass to some extent.

Estimates of F_{msy} and associated parameters were attempted, by iteratively fishing a simulated population to equilibrium over a range of exploitation rates. Stochasticity was incorporated by allowing recruitment to vary randomly from base values predicted by a Beverton-Holt Stock-Recruitment relationship; the magnitude of this variation was based on the variation in observed values. Input values for selectivity, maturity, and weight at age were identical to those used in the YPR analysis; starting population abundance was taken from the VPA (Carmichael, 2001).

The PDT reviewed and discussed the parameter estimates from the MSY analysis and determined that the results were not generally reliable. Much of the concern centered around the stock-recruitment relationship. Although a model can be fit with reasonable precision, the PDT did not feel it would adequately predict future conditions, largely due to current SSB being at an observed high and expected to further increase as recent strong year classes mature. Therefore, observations over the next few years will be at the rightmost extreme of the plot at high spawner abundance and will exert considerable influence over the asymptote predicted by the relationship (Figure 10.18). Since the asymptote determines the average, long-term recruitment at high spawner abundance, it is expected that observations from the near future will greatly influence the estimated long term average recruitment, which will influence both MSY and equilibrium spawner biomass. This is shown in the plot by the difference in the two predicted relationships, one based on all years and the other based on all observations during the 1990's. The PDT feels strongly that the stock needs to achieve some stability, in terms of both recruitment and spawner abundance, before a reliable and predictive stock recruitment relationship can be developed. Although there was a period of stability during the mid-1990's, the combination of good recruitment and limited exploitation during those years resulted in high abundance of fish approaching maturity, exhibited by the 2000 point in the plot at the far right. Another concern expressed by the PDT is that observations at middle to low abundance predate flow control on the Roanoke River, and may reflect more the adverse environmental conditions at that time than the true stock-recruitment relationship. Given the uncertainty in the ability of the stock-recruitment relationship to predict recruitment, and concern that conditions in the near future may be considerably different from past years, the PDT did not endorse any estimate of MSY at this time.

Spawner Biomass Threshold

The PDT did consider the plot of stock and recruitment valuable for identifying a threshold spawner biomass. From a graphical analysis, recruitment was generally poor when female spawner biomass was below 200,000 pounds, and strong when biomass was above 500,000 pounds. Since only one observation falls between these values, making it difficult to determine with precision the lower bound, and 200,000 pounds is clearly inadequate to ensure reasonable recruitment, the PDT decided to recommend a conservative threshold of 400,000 pounds.

Summary

The PDT advised that MSY could not be reliably determined for this stock at this time. They are concerned that developing an MSY estimate requires extrapolation of the stock beyond the observed record. Such an endeavor is particularly risky for a stock that is still recovering, at least in terms of age structure, from past over exploitation. Another concern is that the time series of stock and recruitment data is still heavily weighted toward periods of low abundance, overexploitation, and environmental degradation. Thus, the stock-recruitment relationship necessary to estimate MSY is especially uncertain, and may remain variable until the stock reaches some equilibrium. Recent regulatory changes, notably increased harvest allowances, further add uncertainty and instability to the stock at this time.

The PDT recommended that management benchmarks should be chosen based on a list of key criteria 1) Ability to evaluate a particular value or parameter, 2) Ability to effectively implement and manage under a particular strategy, 3) Past management experience, 4) consideration of uncertainty, and 5) management program goals. Using these criteria as a guide, the PDT recommends that the stock be managed through target and threshold exploitation rates, similar to the current strategy. This approach is proven through past experience, has been effectively implemented for many years, and has resulted in the current stock recovery. This approach is clearly measurable, as estimates of exploitation rates are proven more precise and reliable than estimates of absolute abundance. This approach provides significant flexibility; selection of proper target and threshold exploitation rates can ensure that management targets are met.

The PDT recommended that, where feasible, biomass thresholds be developed to support the exploitation rate targets. The past history of the stock, as reported in the recent assessment, provides reasonable guidance for selecting biomass thresholds. However, since the stock is expanding beyond the observed history, in both biomass and age structure, extrapolation to target biomass levels is risky at best. Setting target biomass levels in absolute values without knowledge of the stock's growth potential will result values for which neither the direction nor magnitude of potential bias and uncertainty can be determined.

CSMA

The PDT recommended that CSMA stocks be managed through the same exploitation rate target and threshold as selected for the Albemarle-Roanoke stock. Appropriate exploitation levels are largely the result of life history parameters that are fairly consistent for the species regardless of the individual stock. For example, natural mortality, inherent growth rates, and maturity are unlikely to significantly differ between fish from the various North Carolina systems. Furthermore, estimating exploitation rates is feasible from short-term datasets and non-catch based approaches such as tagging programs, whereas longer series and more complete data are necessary to estimate abundance and biomass.

Management Options/Impacts

Based on consideration by the PDT of the analyses summarized above and developed in Carmichael (2002), a range of management targets and thresholds were identified for consideration. Selection of threshold limits should be based on the biological characteristics and population dynamics of the stock. Within this limitation, target levels should be selected on the basis of specific management goals.

Maximum Sustained Yield

Maximum sustained yield cannot be reliably determined at this time.

Optimum Yield

Optimum yield is that yield projected from exploiting the stock at the target exploitation rate as determined from the most recent stock assessment. This is the approach currently used to manage this stock.

+Consistent with current management approach
+ Allows yield to vary with stock conditions
- Not a predetermined, specific value
- Requires continued, potentially annual stock assessment

Overfishing and Overfished definitions
The PDT recommends that the overfishing definition be based on the threshold exploitation rate: *Overfishing will occur when the exploitation rate exceeds the threshold exploitation rate.*

The PDT recommends that the overfished definition be based on the biomass threshold: *The stock will be overfished if biomass falls below the threshold*.

A. Options for the CSMA
The PDT recommends that the other North Carolina stocks be managed under the same exploitation rate targets and thresholds as selected for the Albemarle-Roanoke stock.
+ Establishes reference exploitation values for other stocks.
- Values not explicitly based on stock-specific information.
- Data are not available to evaluate exploitation for other stocks.

The PDT advises that no biomass thresholds or targets are available for the other stocks, due to a lack of data. The FMP should contain recommendations for collection of adequate data so that biomass thresholds and targets can be developed.

Research Needs
Data should be collected for the CSMA striped bass stocks that will enable determination of stock status and estimation of biomass thresholds and targets.

MFC, DMF, WRC and FWS Management Recommendation
Support the PDT recommendations, F=0.22 and 400,000 lb. SSB and the research needs.

C/S Advisory Committee Management Recommendation
The Committee recommends an F rate of 0.22 for the C/S region.

10.4.2 Striped Bass Stocking in Coastal River Systems

Issue
Stocking striped bass in NC coastal rivers.

Background

Historical
Enhancing striped bass resources in NC through stocking programs was initiated more than 120 years ago. North Carolina established the Department of Agriculture by an Act

of the General Assembly (March 12, 1877) and the Act required the Board of Agriculture, Immigration and Statistic “at once to provide for stocking all available waters of the State with the most approved breeds of fishes”. During the late 1870s, hatcheries were established in the vicinity of New Bern, primarily for American shad production and Avoca (confluence of Roanoke and Chowan rivers) for striped bass production (Rulifson and Laney 1999).

Because the striped bass was an important food source, the US Fish Commission was committed to “arresting its alarming decrease” (Worth 1884). In 1884, a striped bass hatchery was established on the Roanoke River (spawning grounds) at Weldon and was the only one in the nation until the 1960s and operated almost continuously, first by the Federal fisheries agencies and then by the North Carolina Wildlife Resources Commission (Harrell et al. 1990). The US Fish and Wildlife Service (FWS) Edenton Fish Hatchery was also involved in striped bass production using Roanoke River fish and served as a major source to other federal and state hatcheries, as well as overseas requests. The Roanoke River striped bass population served as the original strain for culture beginning in 1884, and for many years eggs, fry and fingerlings of Roanoke River origin were stocked in watersheds throughout the eastern seaboard, along the Gulf of Mexico and in Russia. These fish were used for stock enhancement and stock restoration programs. As a result of this 100+ year-old practice of cross-stocking (stocking of non-natal fish) introgression of non-endemic genetic strains to many striped bass populations has occurred. The effects of this long-standing practice remain undocumented and unquantified (Rulifson and Laney 1999).

Division of Marine Fisheries

The Division of Marine Fisheries (DMF) Phase II (5-8 inches total length) striped bass stocking and tagging program began in 1980, as a result of a co-operative agreement with the FWS. Striped bass were hatched and reared to Phase II sizes and stocked in the Albemarle Sound area, Pamlico River, Neuse River and Cape Fear River. This program was developed in an effort to augment striped bass populations during low population levels. The major objectives of the program were (1) to determine the effects of stocking on the striped bass fisheries in coastal North Carolina, and (2) to determine if stocked fish would contribute to the spawning populations. A portion of the Phase II fish stocked in each coastal system were tagged to estimate distribution, migration, utilization by the different fisheries, mortality and the contribution to the spawning stocks. DMF decided early in the program not to use Phase I (1-2 inches TL) fish because of the possibility of obscuring the results of the annual juvenile abundance index (JAI) surveys. Phase II fish were grown in the hatcheries tagged and stocked in December and January, well after the JAI surveys were completed.

Phase II fish were supplied by the FWS Edenton and McKinney Lake National Fish Hatcheries in NC, with supplemental fish produced in South Carolina, Georgia, Alabama and Texas. However, the Edenton Hatchery has been the primary producer. Brood fish from Roanoke River (Weldon and Dan River), Monks Corner, SC and Weldon/Monks Corner crosses were artificially spawned and larvae reared at the hatcheries. The Phase II fish are harvested from the hatchery ponds in the late fall to early winter, inventoried at the hatchery, a portion tagged and all released within approximately five days of harvest.

Phase II fish have been released in the Cape Fear, Neuse and Tar-Pamlico rivers on a rotating basis. The Albemarle Sound area was first stocked in 1981, then annually from 1983-1996. All of these stockings have occurred in the natural striped bass nursery areas (Street et al. 1975, Marshall 1976, Sholar 1977, Hawkins 1980, Dilday and Winslow 2002).

From 1981 through 1996, over 700,000 Phase II fish were stocked in the Albemarle Sound area, nearly 54,000 of these were tagged (**Table 10.19**). From 1990-1996, all striped bass released in the Albemarle Sound area were tagged, so that they would not be confused with naturally spawned fish captured in later surveys. During the early to mid 1990s, strict harvest restrictions and management of river flows on Roanoke River resulted in restoration of the Albemarle Sound stock and stocking in this system was discontinued in 1996. The Cape Fear River was stocked only during 1980, 1984 and 1989, due to the low number of prior tag returns and because of the complications posed by the large numbers of hybrids present in the system (escaped from Jordan Reservoir). Phase II stocking continues on a rotating basis in the Tar-Pamlico and Neuse systems. Portions of the stocked fish continue to be tagged (externally) and since 1998 all fish are oxytetracycline (OTC) marked prior to release.

This Phase II stocking program has likely helped sustain striped bass populations in the Tar-Pamlico and Neuse rivers during periods of low abundance, but cannot be used to restore populations to self-sustaining levels if heavy fishing pressure and, or degradation of habitat occurs.

Wildlife Resources Commission
In 1993, the North Carolina Wildlife Resources Commission (WRC) began stocking Phase I striped bass in coastal river systems (**Table 10.19**). During 1998-2000, the WRC also stocked some Phase II fish in the Cape Fear River and the Northeast Cape Fear River (**Table 10.19**). Phase I fish were reared at the WRC Fish Hatchery at Watha, NC and the FWS Edenton National Fish Hatchery. Prior to 1998, these stocked Phase I fish did not receive any type of tag or marking. Since 1998, all fish stocked by the WRC have been OTC marked.

The WRC and the DMF have been stocking Phase I and Phase II striped bass in the Tar and Neuse drainage's in an attempt to increase numbers of spawning adults. During most of these years, striped bass fingerlings of Roanoke River population parentage have been stocked. Patrick and Stellwag (2001) identified six distinct lineages or genotypes among striped bass from the Roanoke, Tar and Neuse rivers. Lineages I-III were abundant among all three populations, and represented 96% of the samples. Genotypic frequencies were similar between the Tar and Roanoke rivers populations, but were significantly different ($P< 0.05$) from the Neuse population. The researchers concluded that stocking practices could potentially affect the natural genotypic

Table 10.19. Phase I (1-2 inches total length) and Phase II (5-8 inches total length) striped bass stockings in coastal North Carolina. Phase I fish were released by the North Carolina Wildlife Resources Commission and Phase II by the North Carolina Division of Marine Fisheries. A portion of the Phase II fish was tagged with external tags prior to release. All fish stocked from 1998 to present were also OTC marked.

			Phase II			Phase I
System stocked	Year stocked	Total number stocked	Number tagged	Number of tag returns	Percent tag returns	Number stocked
Albemarle Sound area	1981	87,181	10,000	1,817	18.2	
	1983	106,675	2,500	719	28.8	
	1983	67,433	2,493	276	11.0	
	1984	236,242	6,445	575	8.9	
	1986	45,200	1,110	38	3.4	
	1986	118,345	4,999	453	9.1	
	1987	15,435	2,500	214	8.6	
	1988	5,000	5,000	94	1.9	
	1989	3,289	1,400	22	1.6	
	1990	2,000	2,000	62	3.1	
	1991	2,994	2,994	320	10.6	
	1992	2,465	2,465	84	3.3	
	1993	2,180	2,180	23	1.0	
	1994	2,481	2,481	2	0.1	
	1996	2,498	2,498	12	0.5	
	1996	2,490	2,490	2	0.08	
Total		**701,908**	**53,554**	**4,713**	**8.8**	
Pamlico-Tar River	1983	76,674	2,500	500	20.0	
	1984	26,000	1,000	28	2.8	
	1987	17,993	2,500	39	1.6	
	1991	30,801	1,993	78	3.9	
	1993	118,600	2,204	39	1.8	
	1994	183,254	2,320	22	0.9	127,635
	1995					100,000
	1996	140,972	2,497	50	2.0	39,450
	1997	24,031	4,865	110	2.3	28,022
	1998					230,606
Pamlico-Tar River	1999	17,954	2,750	117	4.2	100,000
	2000					188,839
	2001	37,000	3,000	7	0.2	171,000
	2002					39,110
	2003					242,631
Total		**676,279**	**25,629**	**997**	**3.9**	**1,267,293**

Table 10.19. (Continued)

System stocked	Year stocked	Phase II Total number stocked	Number tagged	Number of tag returns	Percent tag returns	Phase I Number stocked
Neuse River	1982	47,648	2,100	230	11.0	
	1986	39,769	2,199	60	2.8	
	1988	71,092	2,500	22	0.9	
	1990	61,877	2,992	84	2.8	
	1992	116,820	2,527	137	5.4	
	1993					48,000
	1994	79,933	2,212	6	0.3	103,057
	1995					99,176
	1996	100,760	4,998	120	2.4	100,000
	1997					100,000
	1998	83,195	2,500	69	2.8	207,730
	1999					100,000
	2000	108,000	2,900	29	1.0	121,993
	2001					103,000
	2002	147,654	2,960	0	--	
	2003					100,000
Total		**856,748**	**27,888**	**757**	**2.7**	**1,082,956**
Cape Fear River	1980	14,874	2,900	17	0.6	
	1984	56,437	1,395	6	0.4	
	1989	77,242	1,300	23	1.8	
	1994					100,733
	1995					100,000
	1998	30,479 (<14,098 OTC marked-WRC				
	2000	8,915 (OTC marked-WRC)				
	2001					90,149
Cape Fear River	2002					50,000
	2003					104,775
Total		**187,947**	**5,595**	**46**	**0.8**	**445,657**

Table 10.19. (Continued)

System stocked	Year stocked	Total number stocked	Phase II Number tagged	Number of tag returns	Percent tag returns	Phase I Number stocked
Northeast Cape Fear River	1999	10,327 (OTC marked-WRC)				
	2000	15,635 (OTC marked-WRC)				
	2001					94,083
	2002					50,000
	2003					105,015
Total		**25,962**				**249,098**

distribution in these populations, and suggested that broodstock sampling should be taken from each population for aquaculture production, rather than from Roanoke River strains, especially from stocking the Neuse River population. The WRC is now in the process of estimating the percent contribution of stocked fish to the striped bass spawning stocks in the Tar and Neuse rivers.

Discussion

Division of Marine Fisheries

The DMF Phase II stocking program is part of the NC Striped Bass Monitoring Project funded under a federal-aid grant from the USFWS. This type grant is 75% federal and 25% state match. Currently, the federal share is $9,000 and $3,000 state match for this portion of the project. A production goal of 100,000 Phase II fish is set annually for stocking. The grant funds received by DMF do not include the production costs that the hatcheries expend to produce and raise these fish to Phase I or Phase II size. Stock enhancement programs for striped bass cost approximately 20 cents each for Phase I fish and one dollar each for Phase II fish (Elliott Atstupenas, Edenton National Fish Hatchery, USFWS, personal communication).

Based on tag returns, these stocking programs have contributed to the recreational and commercial fisheries in the various systems, as well as to the spawning populations. Stocked fish have been captured on the spawning grounds in the Roanoke, Tar, and the Neuse rivers. Continued stocking may help sustain the striped bass populations in the Tar-Pamlico and Neuse rivers. When juvenile surveys start again in these river systems, stocking should cease or all stocked fish should be marked, so that natural production can be assessed.

The stocking program has been well received by the public. Due to budget problems several years ago, the stocking program was to be dropped. There was considerable outcry from citizens along the Pamlico River and even a petition submitted demanding that the striped bass stocking program continue.

Wildlife Resources Commission

The objective of WRC for stocking striped bass into coastal rivers is to increase spawning stock abundance and promote self-sustaining population levels appropriate for habitats and ecosystems. This objective will be pursued as long as management agencies take positive actions to reduce mortality rates so that stocking enhances population abundance. Stocking of striped bass in coastal rivers is prioritized in relation to stocking requests for inland reservoirs where no natural reproduction exists.

The WRC began collecting adult striped bass otolith samples from the Tar and Neuse rivers in 2002. These otoliths will be analyzed for OTC marks to determine the percentage of stocked fish in the sampled population for that year. Additional otoliths will be removed from striped bass in 2003 and 2004. Management decisions concerning the desirability of stocking Phase I striped bass in coastal rivers will be made based on the percentage of stocked striped bass in the population.

Currently, there is a Cooperative Agreement between the USFWS, DMF and WRC which schedules through and Annual Work Plan the production goals, number to be tagged and total number stocked.

Management Options

Status Quo

+ Continue the striped bass stocking program as is (all fish OTC marked, portion with external tags), with a production goal of 100,000 fish per year for Phase I and Phase II.
+ Stocked fish may contribute to the spawning stock.
+ Public visibility for improving the striped bass population.
- Numbers of fish will not be adequate to increase population size.

Increase the number of fish produced/released

+ Will increase the number of individuals in the striped bass population.
+ Stocked fish may contribute to the spawning population.
+ Public visibility for improving the striped bass population.
+ Increase number of tagged (external) fish- provides more data on migration, movement, growth, known age fish, time at large, etc.
- Cost of production/program would increase.
- Increase cost of reward program.

Decrease the number of fish produced/released

+ Reduce the overall cost of the program.
- Would provide no increase to the existing population size or spawning stock.
- Reduce/eliminate externally marked fish- lose data on migration, movement, growth, known age fish, time at large, etc.

Eliminate the stocking programs

+/- Maintain self-sustaining population through controlled harvest.
- Lose of data from tagged fish.

Research Needs

Survey stocked systems to determine percentage of wild versus stocked fish.

MFC and DMF Management Recommendation

Support continuing the Phase II striped bass stocking program (all fish OTC marked, portion marked with external tags), with two systems in the C/S Management Area (Tar-Pamlico, Neuse and Cape Fear rivers) being stocked annually, with a goal of 100,000 fish per system. DMF supports the research needs.

WRC Management Recommendation
Support continuing the Phase I striped bass stocking program (all fish OTC marked), with a goal of 100,000 fish per year, per system in the C/S Management Area (Tar, Neuse, and Cape Fear/Northeast Cape Fear rivers) annually. WRC supports the research needs.

A/R Advisory Committee Management Recommendation
Defer to the Central/Southern Committee

C/S Advisory Committee Management Recommendation
Support continuing the striped bass stocking program (all fish OTC marked, portion with external tags), with a production goal of 100,000 fish per year for Phase II and Phase I in the Pamlico, Neuse, and Cape Fear rivers annually. The Committee supports the research needs as presented.

10.4.3 Fishing Mortality

10.4.3.1 Catch Curve Exploitation Estimates and Management Options for Neuse River and Tar River Striped Bass Stocks

Issue
Estimation of survival and exploitation rates for the Central and Southern North Carolina stocks of striped bass through catch curve analysis.

Background
Surveys conducted by the WRC on the spawning grounds of the Tar and Neuse rivers are the only sources of quantifiable information on striped bass abundance in these systems. Age, length, and catch information collected through the surveys provide a time series of fishery independent abundance at age that can be used to estimate total mortality through catch curve analysis. Survey catch rates are also evaluated as an indicator of recruitment strength and compared with stocking rates to determine if observed cohort abundance is related to stocking rates.

Catch curve analysis is a simple analytical technique used since the early 1900s for estimating total mortality from catch or survey abundance at age data. Plots of catch versus age typically produce a convex curve, with the peak of the curve corresponding to the age of “full recruitment” -- all fish older than this age are fully vulnerable to the fishing gear. The increasing left limb, between the origin and the peak, represents increasing vulnerability with increasing size and age. The declining right limb, beyond the peak, represents declining abundance with increasing age and is due to mortality, both fishing (F) and natural (M). To estimate total mortality from a catch curve, observed catches at age are transformed using the natural logarithm and the slope and y-intercept of a line through the observed points of the declining limb are estimated through linear regression. Total mortality (F+M =Z), is estimated by the slope parameter of the fitted line.

Catch curves can be applied to annual data, catches across ages within a year, or to cohort data, catches across years of fish born in some year. Annual catch curves assume that recruitment is constant from year to year, fishing and natural mortality are constant, and vulnerability is constant above a given age. Cohort catch curves do not require that recruitment be constant, but the need to track a cohort over time can greatly reduce the amount of information available, especially when the time series of catch data is low or the life span of the species is long. Therefore, catch curves applied to cohorts may provide more robust estimates of mortality.

Current Authority

General Statutes of North Carolina
G.S. 113-182.1. Fishery Management Plans

Methods

Surveys
Adult striped bass were collected during the spawning season using boat-mounted electrofishing gear annually from the Tar River since 1996 and from the Neuse River since 1994. Weekly sampling was conducted from late March through mid-May. Electrofishing time was recorded, and striped bass abundance was indexed using catch per unit effort (CPUE), expressed as fish per hour. Total length (mm) was measured for each striped bass collected, and sex was determined by applying directional pressure on the fish’s abdomen and observing the release of eggs or milt. Scales were removed from the left side between the lateral line and the dorsal fins from at least 10 fish from each 25-mm length group for each sex. Annuli were counted at 33X magnification using a microfiche reader. The total number of fish collected in each age group by sex was estimated by expanding the sub-sample of fish aged to the entire sample of fish collected using an age-length key.

Neuse River Sample Design
Sampling in the Neuse River was conducted from Raleigh (Milburnie Dam) downstream to Kinston, approximately 128 river miles. Prior to the removal of Quaker Neck Dam near Goldsboro in 1998, sample stations were located near Goldsboro (upstream and downstream of Quaker Neck Dam), Seven Springs, and Kinston. Since 1998, stations downstream of Goldsboro have been abandoned, and sampling has expanded upstream to include stations at Goldsboro (upstream and downstream of the Quaker Neck Dam site), Richardson’s Bridge, Smithfield, Wilsons Mills, Clayton, Raleigh (Poole Road), and Raleigh (Milburnie Dam). A minimum of three 15-minute electrofishing samples was conducted within each station weekly depending on river flow (**Table 10.20**).

Tar River Sample Design

Sampling in the Tar River was conducted from Rocky Mount downstream to Tarboro, approximately 40 river miles. This area was divided into three stations, which were

Table 10.20. Total electrofishing time in hours with number of sample days in parenthesis for striped bass by sample station and year in the Neuse River, 1994-2002.

	Sample year								
Sample Station	1994	1995	1996	1997	1998	1999	2000	2001	2002
Raleigh (Milburnie Dam)					0.7 (1)	0.3 (1)	1.0 (2)		2.0 (2)
Raleigh (Poole Road)							1.0 (1)		
Clayton								0.8 (1)	
Wilsons Mills							2.3 (3)	2.3 (3)	2.0 (2)
Smithfield						2.8 (2)	4.5 (5)	3.3 (5)	4.0 (4)
Richardson's Bridge						2.3 (2)	1.3 (1)	1.5 (1)	1.0 (1)
Goldsboro (upstream Quaker Neck Dam)			4.5 (6)	5.3 (7)	4.3 (6)	3.7 (5)	5.3 (7)	5.3 (7)	6.0 (7)
Goldsboro (downstream Quaker Neck Dam)	7.3 (5)	4.9 (2)	5.8 (6)	7.0 (7)	6.0 (6)	4.8 (5)	5.0 (7)	4.5 (7)	4.8 (5)
Seven Springs		2.7 (1)	4.5 (6)	4.5 (6)	3.0 (4)				
Kinston		2.4 (3)	4.5 (6)	4.5 (6)	3.0 (4)				
Total[a]	7.3 (5)	10.0 (6)	19.3 (12)	21.3 (13)	17.0 (11)	13.9 (11)	20.4 (17)	17.7 (15)	19.8 (14)

[a] Because multiple stations were sampled in one day, the total number of sample days may not equal the sum of sample days by station.

Table 10.21. Total electrofishing time in hours with number of sample days in parenthesis for striped bass by sample station and year in the Tar River, 1996-2002.

	Sample year						
Sample Station	1996	1997	1998	1999	2000	2001	2002
Station 1 (Battle Park in Rocky Mount to Bourne Farms access area)	3.6 (4)	8 (5)	5.5 (3)	3.2 (3)	3 (2)	4 (3)	2.8 (2)
Station 2 (Bourne Farms access area to NCWRC access area at Tarboro)	5.9 (4)	10.3 (6)	13.2 (6)	6.7 (3)	4.6 (3)	0.9 (1)	4.5 (3)
Station 3 (NCWRC access area at Tarboro to City of Tarboro access area	12.6 (4)	10.5 (7)	8.6 (7)	1.6 (2)	3.9 (4)	2 (1)	4 (2)
Total[a]	22.1 (8)	28.8 (16)	27.3 (13)	11.5 (8)	11.5 (9)	6.9 (5)	11.3 (7)

[a] Because multiple stations were sampled in one day, the total number of sample days may not equal the sum of sample days by station.

each sampled weekly. Station 1 began at Battle Park in Rocky Mount and ended at the Bourne Farms access area off U.S. 64 Business. Station 2 began at the Bourne Farms access area and ended at the WRC access area on N.C. 33 in Tarboro. Station 3 began at the WRC access area at N.C. 33 and ended at the City of Tarboro access area off U.S. 64. Sampling consisted of 30-minute segments of electrofishing alternated with 30 minutes of drifting in each of the stations, with a minimum of 2 hours of electrofishing conducted in each station (**Table 10.21**). Electrofishing and drifting start points were alternated each trip to allow a systematic coverage of each station during the spawning season.

Catch Curve Analysis

Catch curves are constructed from survey catch at age for the Neuse River and Tar River spawning ground surveys (**Tables 10.22 and 10.23**). Age-length keys are not available from the Tar River survey, so annual Neuse River age-length keys are used to assign ages to Tar River survey data. The analysis is based on catch of males to reduce variability due to differential migration by sex that might distort the age of full recruitment. Both annual and cohort catch curves are analyzed. Since the Neuse and Tar rivers are stocked with striped bass in alternate years it is unlikely that recruitment is constant in these systems, and therefore cohort catch curves may be most appropriate. There are no significant regulatory changes expected to result in violation of the constant mortality over time assumption required of both annual and cohort catch curves.

Table 10.22. Neuse River spawning ground survey catch at age, total catch, effort in hours fished, and CPUE in catch per hour.

	YEAR							
Age	1994	1995	1996	1997	1998	1999	2000	2001
2	21	2	25	27	54	5	79	8
3	3	147	45	41	47	154	72	64
4	34	8	77	16	35	46	77	27
5	20	22	10	24	23	19	9	29
6	13	4	6	4	12	12	4	3
7			4	2	2	5	1	
8	1				2			
9						1		
Total	92	183	167	114	175	242	242	131
Effort (H)	7.35	10.98	19.30	21.26	16.98	13.77	20.24	17.52
CPUE	12.52	16.66	8.65	5.36	10.31	17.58	11.96	7.48

Table 12.23. Tar River spawning ground survey catch at age, total catch, effort in hours fished, and CPUE in catch per hour.

	YEAR					
Age	1996	1997	1998	1999	2000	2001
2		277	69	21	71	24
3		537	579	207	113	84
4		146	186	82	135	54
5		76	52	17	20	72
6		5	9	6	5	5
7		1	1	1	4	
Total		1042	896	334	348	239
Effort (H)	27.41	28.77	27.36	11.53	11.51	11.33
CPUE	0.00	36.21	32.74	28.96	30.24	21.09

Catches are divided by annual survey effort in hours fished to calculate catch-per-unit-effort (CPUE), thereby standardizing catch by annual effort to account for varying survey effort over time. Total mortality is calculated over a range of ages, from the age of full recruitment to the survey (determined for each year as the age having the greatest catch in that year, and typically occurring at age 3) through age 7. If catches at age do not extend to age 7, then the maximum age observed in the catch is used. Thus in most years 5 ages contribute to the estimate of mortality, but in some years as few as three ages contribute. Total mortality is estimated for each system by taking an average of the annual mortality estimates. Only years or cohorts having at least three observations contributing to the estimated morality for that year or cohort are included in the average. The first cohort included in the average for the cohort catch curves is that with observed catch at age 3.

A cohort catch curve analysis based on the Roanoke River survey is included to compare catch curve mortality estimates and catch-age assessment mortality estimates. The spawning ground survey conducted on the Roanoke River is similar to those conducted on the Tar and Neuse Rivers. A quantitative catch-age assessment of stock status is also available from the Albemarle-Roanoke stock, and serves as the primary measure of the stock for evaluating management and establishing harvest restrictions. To assess the overall reliability of catch curve analyses applied to spawning ground survey CPUE, an analysis similar to those used to evaluate the Neuse and Tar River stocks was applied to the Roanoke River CPUE data. Mortality estimates from the catch curve analysis are compared to the catch-age assessment mortality estimates by averaging cohort catch curve mortality estimates across ages 3 to 7 by year for 1991-1996 to generate average annual mortality rates. Annual catch curves are not developed for this comparison since available estimates indicate the constant recruitment assumption is violated.

Stocking - Recruitment Analysis

Catches are summed by cohort for total CPUE and CPUE for ages 2 and 3 to investigate relative recruitment trends and evaluate correlation with known stocking rates. The sum of total CPUE is likely biased because survey CPUE of fish > 18" (approximately age 3) is affected by fishery harvest, unlike the sum of ages 2 and 3 CPUE which largely represent fish that have not recruited to the fishery and may therefore be a reliable indicator of relative cohort strength. Recruitment is also evaluated from the estimated y-intercept from the catch curve analysis. This parameter represents the expected catch of a cohort at age-0, and may provide a relative measure of initial cohort abundance. The analysis is based on stocking rates for Phase-I fish only. Phase II stocking has only occurred in recent years; thus these fish have not recruited to the surveys. Relative recruitment parameters are compared to stocking rates to determine if there is any relation between apparent cohort strength and the number of fish stocked. If stocking contributes to a cohort, and the recruitment measures are representative of actual recruitment strength, then the stocking rate and recruitment measures should be positively correlated. Evaluating recruitment is important due to the annual catch curve assumption of constant recruitment. Further, detection of strong cohorts corresponding to stocking events may be considered evidence that the surveys do capture abundance information.

Results
Catch Curve Analysis
Neuse River

Five cohorts from 1991 to 1995 can be analyzed from the Neuse survey based on observed catches between age 3 and age 6 or older. Estimates are feasible for three others the 1991 cohort, although the youngest age observed in the catch is age 4 and thus the estimate may be biased; and the 1996 and 1997 cohorts, estimates for which are considered preliminary because catches for older ages are not yet observed (the 1996 cohort represents the age 5 catch in 2001 and the 1997 cohort represents the age 4 catch in 2001). Estimated slope parameters, the measure of total mortality (Z), range from 0.65 – 1.49 and average 0.99 for 1991-1995. The 1990 and 1996-1997 cohorts are not used in calculating the average since the observed catch record is incomplete for these cohorts. Subtracting natural mortality (M) from the average Z provides an estimate of average fishing mortality (F) of F=0.84 (**Table 10.24**). Confidence intervals in some years are quite broad, due to both high SE of the estimated slope and small numbers of observations. No confidence interval can be developed for the 1997 cohort estimates since only two observations are available for regression, leaving no degrees of freedom. Total mortality has averaged around 1, with a slight increase indicated in

Table 10.24. Estimated slope (total mortality, Z), y-intercept, F, SE of Z, and 90% confidence interval around Z for Neuse River cohort catch curves for 1990-1997 cohorts.

Year	Slope Z	Intercept	SE (Z)	Fishing mortality	90% Con. Int. lower	90% Con. Int. upper
1990	1.04	5.55	0.89	0.20	0.58	1.50
1991	0.65	2.37	0.50	0.09	0.39	0.91
1992	0.89	5.02	0.74	0.10	0.66	1.13
1993	0.76	3.32	0.61	0.33	-0.01	1.52
1994	1.17	5.67	1.02	0.45	-1.64	3.98
1995	1.49	6.97	1.34	0.31	-0.45	3.42
1996	0.96	5.24	0.81	0.07	0.51	1.40
1997	1.08	5.65	0.93	NA	NA	NA
Mean 91-95	0.99		0.84			

1994 and 1995 (**Figure 10.19**). A plot of estimated cohort decline over time for all cohorts shows that the lines for 1994 and 1995 have slightly steeper slopes than those for the other years, suggesting higher mortality for those cohorts (**Figure 10.20**). Plotting observed and predicted catch values as in **Figure 10.21** shows how well the linear catch curve model 'fits' the observed CPUE values. Deviations from a linear

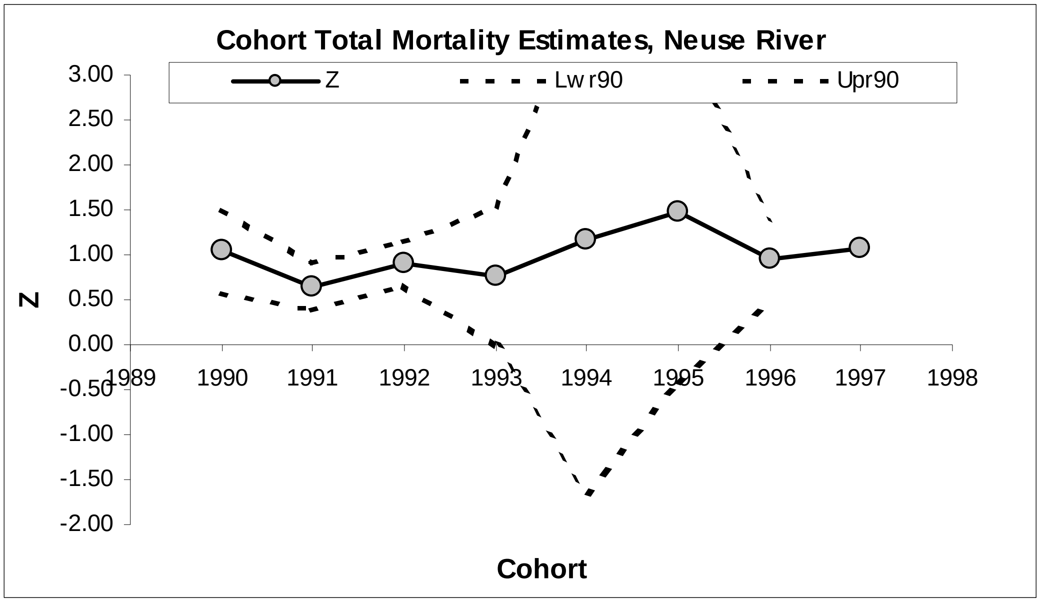


Figure 10.19. Total mortality (Z) estimated by cohort catch curve, 1990-1997 cohorts in Neuse River.

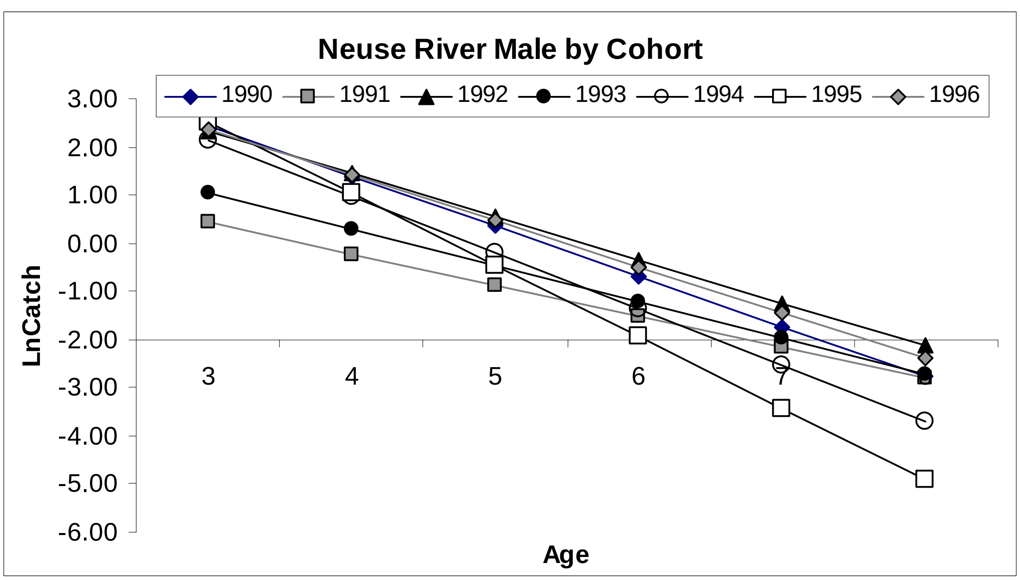


Figure 10.20. Comparison of mortality estimates for Neuse River Cohorts. Open symbols represent 1994 and 1995 cohorts, which appear to have slightly higher mortality.

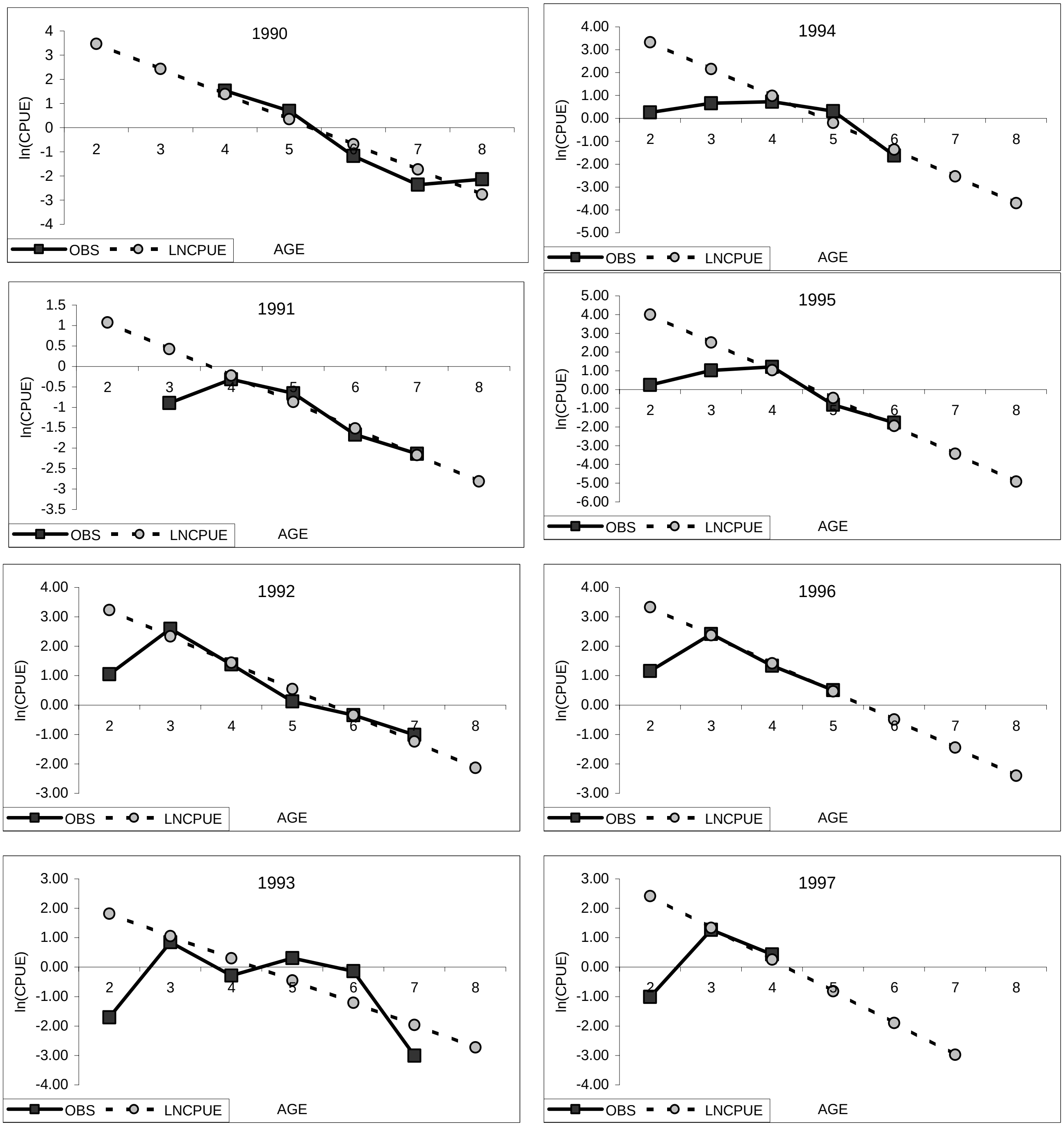


Figure 10.21. Observed and Estimated CPUE, Neuse River Cohort Catch Curves.

decline, which may indicate changes in exploitation over time, are apparent in several years with 1993 the most pronounced. The convex pattern emerging from the older ages of the 1993 and 1994 cohorts may indicate increased mortality in 2000 and later. Variability in the peak of observed catch shows how the age of recruitment varies between ages 3 and 4.

Annual catch curves give similar results, with Z averaging slightly lower at 0.88 for 1994-2001 (Table 10.25, Figure 10.22). There is some indication of increasing mortality in 2000 and 2001. Plots of natural logarithm transformed CPUE show only minor deviation from a linear decline in CPUE, which suggests that recruitment has been fairly constant over time (Figure 10.23). It is not readily apparent that the constant recruitment assumption required of annual catch curves is violated, even though fish were stocked in alternate years in the Neuse River.

Tar River Catch Curve Analysis

Three cohorts, 1993 to 1995, can be analyzed from the Tar River survey based on observed catches between the age 4 and age 6. Estimates are available for the 1992 and 1996 cohorts, although they are based on potentially incomplete information and are therefore less reliable. Nonetheless these estimates are included to expand the time series of mortality estimates for comparison, but are not included in the average. Estimated slope parameters for the 1993 to 1995 cohorts, the measure of total mortality (Z), range from 0.93 to 1.30, and average 1.17 for (Table 10.26). Subtracting natural mortality (M=0.15) from the average Z provides an estimate of average fishing mortality F) of F=1.02. Confidence intervals in some years are broad, due to both few observations (i.e., few ages between recruitment and maximum observed) and high standard errors. Estimates of total mortality do not exhibit much trend (Figure 10.24). Plots of observed and predicted values show virtually no deviation from linear trends, and therefore provide no indication that mortality has changed over time (Figure 10.25).

Annual catch curves give similar results, with Z averaging slightly higher for 1997- 2001 at 1.30 (Table 10.27, Figure 10.26). Mortality trends slightly downward over time, although the broad confidence intervals for the last few years indicate that the trend is not significant. Plots of observed and predicted CPUE show only slight deviations from linear trends (Figure 10.27), with the exception of 2001 which shows very little decline in abundance over ages 3 - 5. Based on the strong linear decline in abundance based on transformed CPUE, there is little indication of variation in recruitment for the Tar River and little evidence that either the constant recruitment assumption or the constant mortality assumption are violated.

Comparison of Catch Curve and VPA Mortality Estimates for the Roanoke River

Cohort catch curves are applied to both male and female CPUE from the Roanoke River. Estimates of fishing mortality by cohort were binned by year and age, then averaged across years to allow valid comparison with the annual estimates from the catch-age analysis. Catch curve estimates tend to smooth out some of the annual variation indicated by the VPA mortality estimates, especially in the early years of the time series (Figure 10.28). Since catch curve analyses assume constant mortality, such

Table 10.25. Estimated slope (Z), fishing mortality, SE, and 90% confidence interval for Neuse River Annual catch curve.

YEAR	Slope Z	Intercept	SE (Z)	Fishing mortality	90% Con. Int. Lower	90% Con. Int. Upper
1994	0.48	3.44	0.03	0.33	0.30	0.66
1995	0.98	4.90	0.51	0.83	-0.50	2.46
1996	0.94	4.66	0.28	0.79	0.13	1.75
1997	0.74	3.01	0.17	0.59	0.34	1.15
1998	0.60	2.82	0.14	0.45	0.31	0.89
1999	0.82	4.66	0.07	0.67	0.65	0.99
2000	1.38	6.59	0.18	1.23	0.86	1.91
2001	0.91	4.22	0.32	0.76	-0.03	1.85
mean	0.86	4.29		0.71		

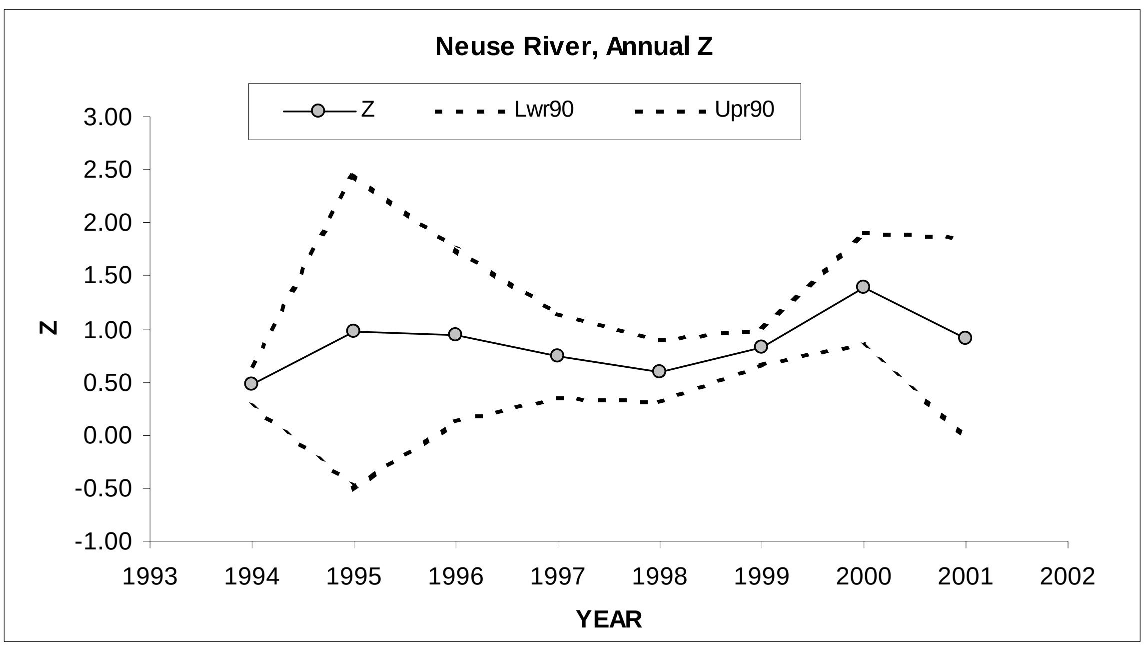


Figure 10.22. Estimated Z and 90% Confidence Interval, Neuse River Annual Catch Curve, 1994-2001.

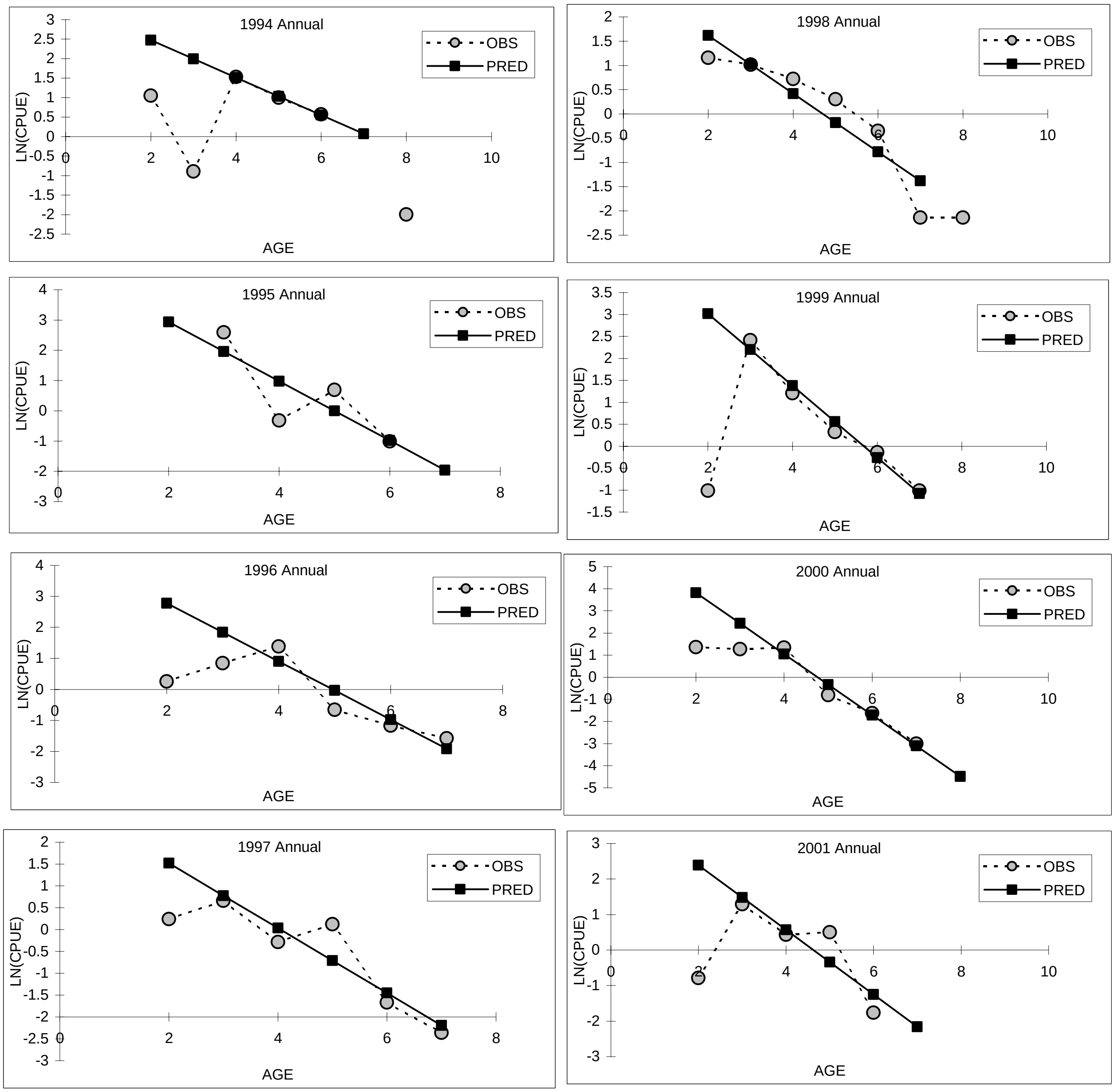


Figure 10.23. Observed and Estimated CPUE, Annual Neuse River catch curves.

Table 10.26. Estimated mortality and confidence intervals for Tar River striped bass from cohort catch curves.

Year	Slope Z	Intercept	SE (Z)	Fishing mortality	90% Con. Int. Lower	90% Con. Int. Upper
1992	1.70	9.36	0.02	1.55	1.61	1.80
1993	0.93	5.28	0.33	0.78	-1.12	2.99
1994	1.28	6.86	0.10	1.13	1.04	1.53
1995	1.30	7.05	0.10	1.15	1.02	1.58
1996	0.52	4.48	0.23	0.37	-0.93	1.97
Mean	1.17	6.40	0.18	1.02		

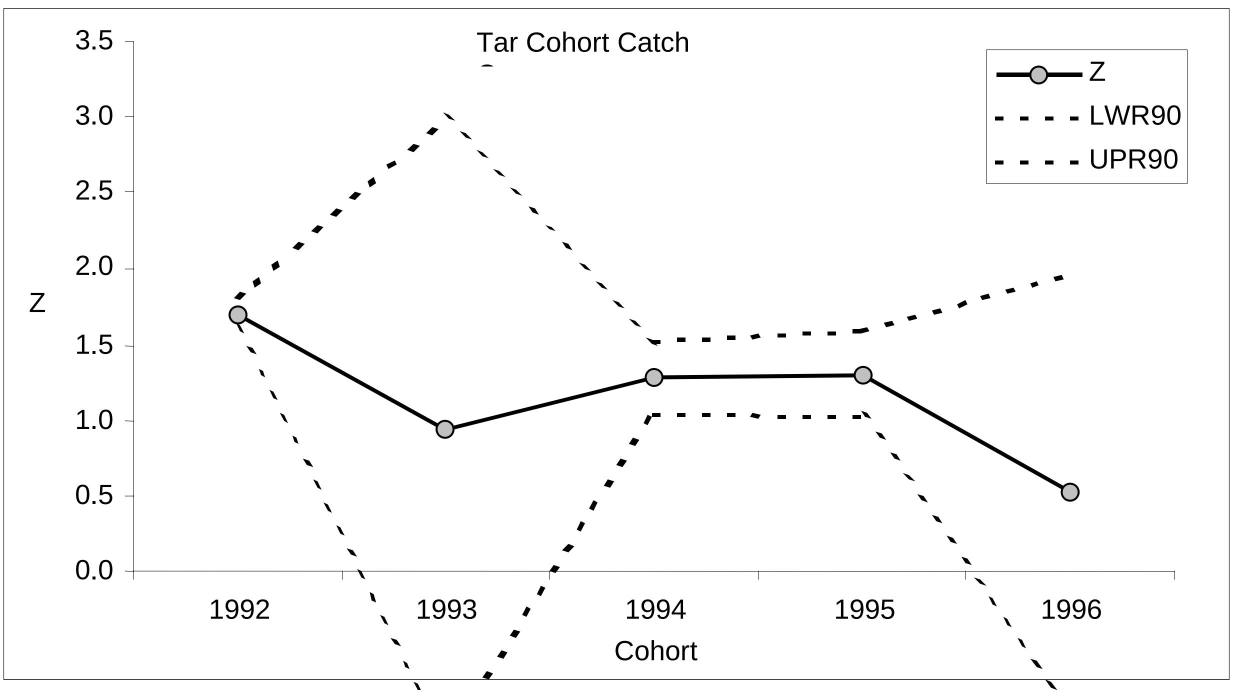


Figure 10.24. Tar River cohort catch curve estimated total mortality and confidence interval.

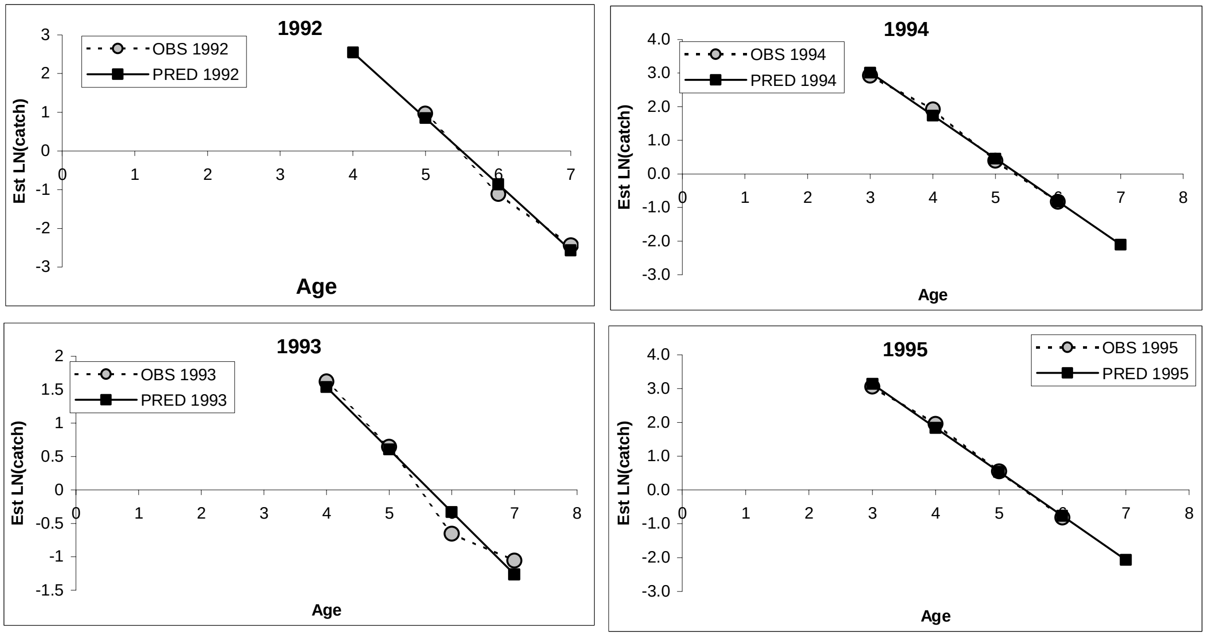


Figure 10.25. Observed and estimated In (catch), Tar River cohort catch curves.

Table 10.27. Estimated mortality and associated confidence intervals for Tar River striped bass from annual catch curves.

Year	lope Z	Intercept	E (Z)	Fishing mortality	90% Con. Int. Lower	90% Con. Int. Upper
1997	1.59	8.05	0.19	1.44	1.16	2.03
1998	1.57	8.11	0.13	1.42	1.27	1.87
1999	1.33	7.06	0.08	1.18	1.14	1.51
2000	1.19	6.85	0.27	1.04	0.40	1.98
2001	0.82	4.83	0.44	0.67	-0.46	2.10
Average	1.30	6.98	0.22	1.15		

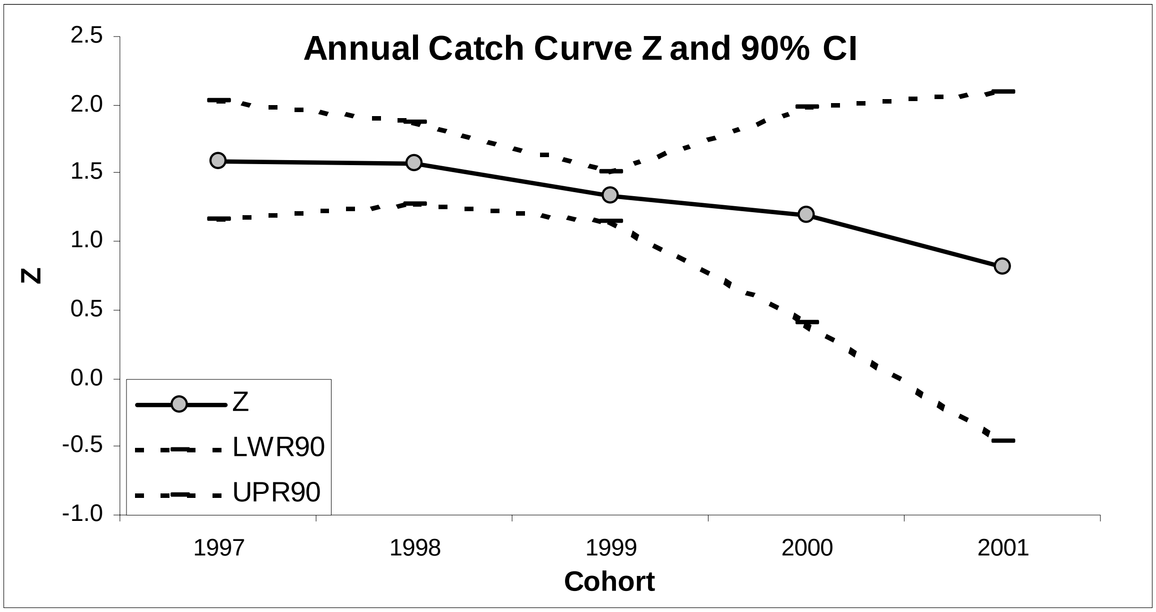


Figure 10.26. Tar River annual catch curve estimated total mortality and 90% confidence intervals.

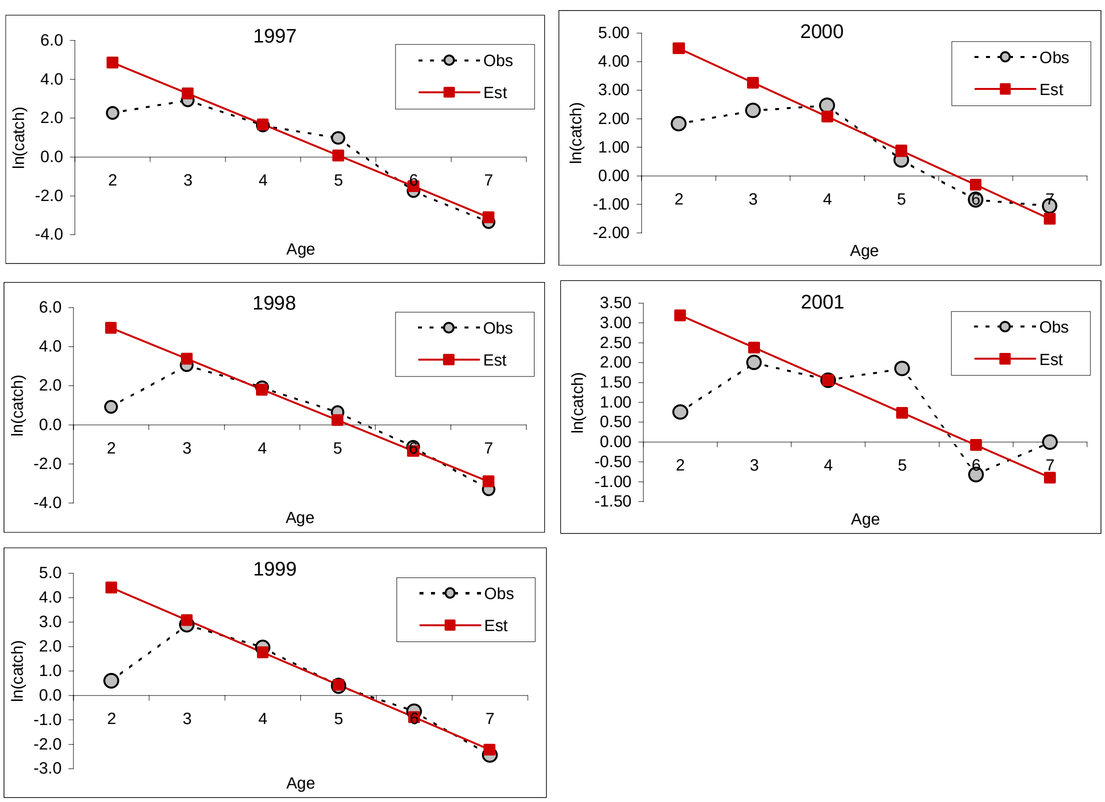


Figure 10.27. Observed and Estimated ln (catch) from Tar River annual catch curves.

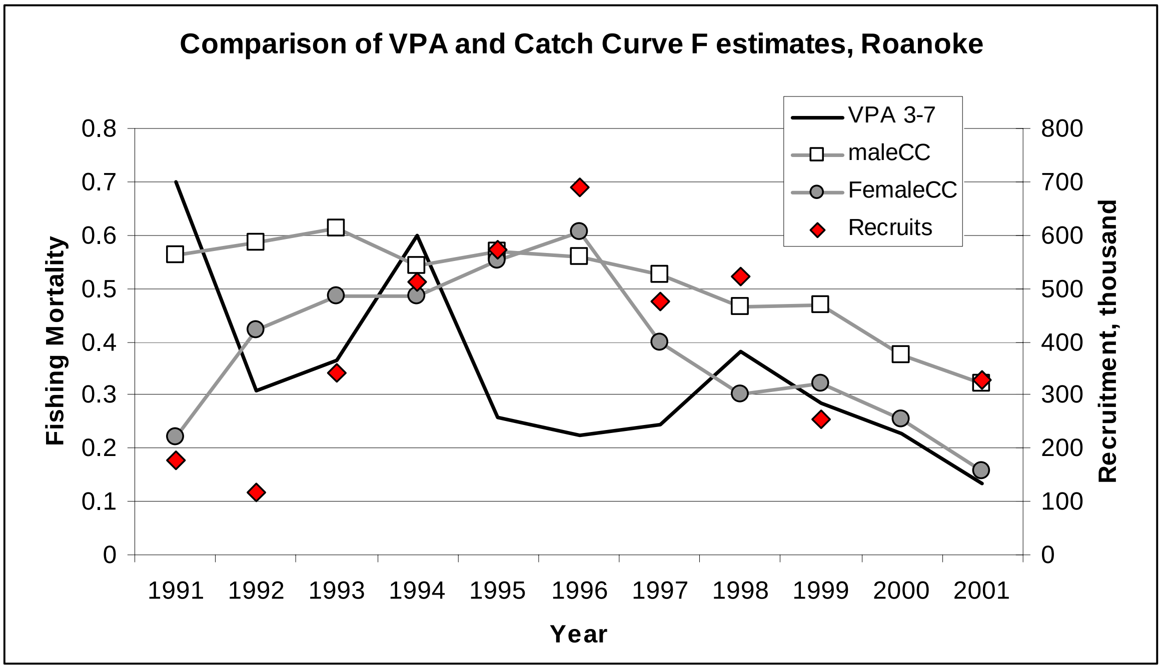


Figure 10.28. Annual recruitment and mortality estimates for male and female CPUE catch curves and VPA for the Roanoke River.

a pattern is expected during periods like the early 1990's when mortality was variable. According to the VPA, mortality dropped in the mid-1990's, but this change is not immediately apparent in the catch curve results. However, as mortality stabilizes in the late 1990's , catch curve estimates and VPA estimates start to converge.

Stocking-Recruitment Analysis

Neuse River

Several measures are explored for evaluating relative recruitment strength of Neuse River cohorts summed CPUE by cohort, summed CPUE of ages 2 and 3 by cohort, and the catch curve estimate of the y intercept (Table 10.28). Several recruitment measures are positively correlated with stocking rates (Table 10.29), with the exception of the Y-intercept value. The highest two values of summed CPUE for ages 2 and 3 occur in the two years when stocking exceeded 100,000 fish (Figure 10.29). The y-intercept estimated from the cohort catch curves is negatively correlated with the number of fish stocked, although much of this relationship is driven by the very high intercept in 1995 when no fish were stocked (Figure 10.30). However, the strong positive correlation between the y-intercept and total mortality may be an indication that the absolute value of the y-intercept is driven more by exploitation than relative abundance, and may not be a robust indicator of recruitment. The lack of correlation between total mortality (Z) and stocking rates indicates that stocking is not an effective tool for managing mortality.

Table 10.29. Correlation analysis of stocking rate and recruitment measures for the Neuse River.

	YEAR	Number Stocked	CPUE sum all ages	CPUE age 2-3	CPUE age 2	exp(int)	Z
YEAR	1.00						
Number Stocked	0.05	1.00					
CPUE sum all ages	-0.69	0.76	1.00				
CPUE age 2-3	0.29	0.82	0.93	1.00			
CPUE age 2	-0.17	0.80	1.00	0.73	1.00		
exp(int)	0.44	-0.24	-0.21	-0.13	-0.31	1.00	
Z	0.47	0.02	-0.26	-0.08	-0.34	0.93	1.00

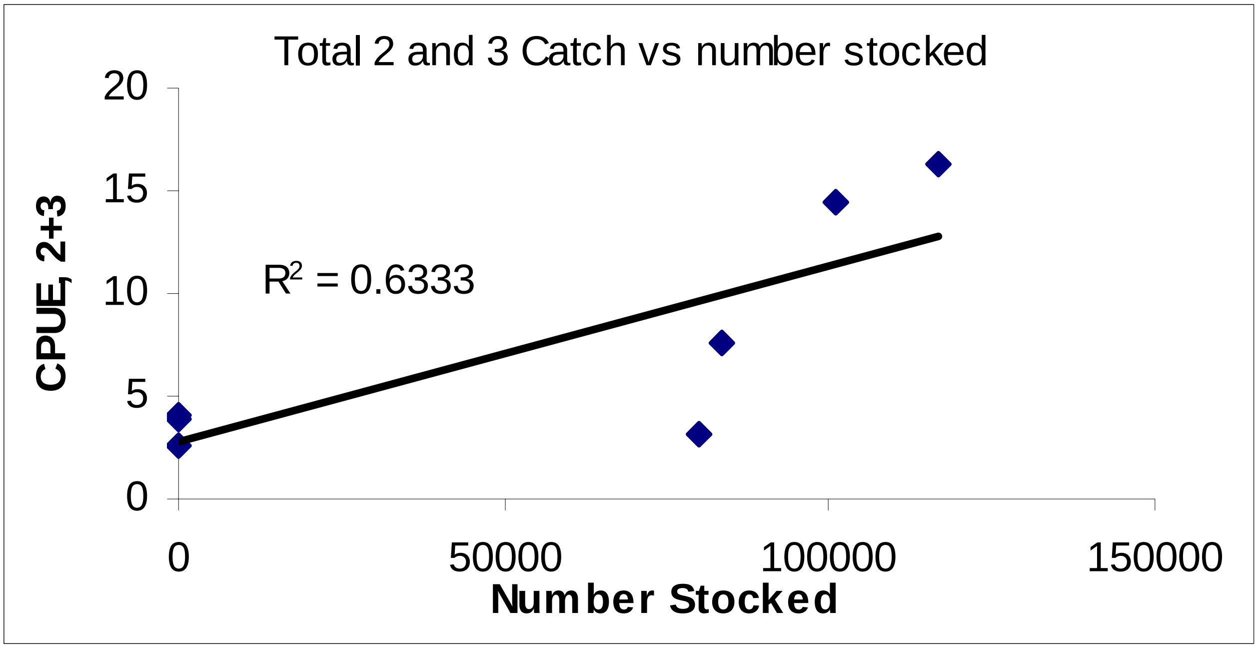


Figure 10.29. Neuse River number stocked vs sum of catch per unit effort at age 2 and 3.

Tar River

Several measures are explored for evaluating relative recruitment strength of Tar River cohorts summed CPUE by cohort, summed CPUE of ages 2 and 3 by cohort, and the catch curve estimate of the y intercept (Table 10.30). Stocking rates in the Tar River are correlated with measures of recruitment based on the catch per unit effort for age 2 and age 2 + age 3 fish (Table 10.31). Unlike the Neuse River, where correlation's were similar for the various CPUE sums investigated, in the Tar River the correlation between stocking intensity and the sum of total CPUE is actually negative. This most likely reflects an artifact of small sample size, as only three cohorts could be analyzed by total sum CPUE.

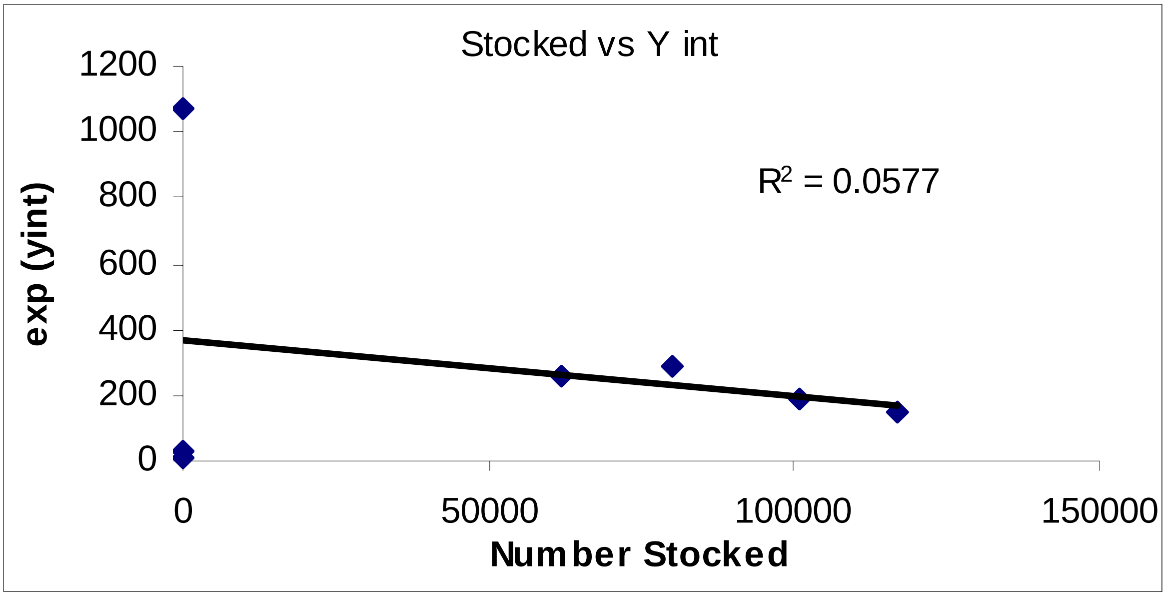


Figure 10.30. Neuse River number stocked vs estimated y-intercept

Table 10.30. Stocking rates of Phase II striped bass and measures of cohort abundance for the Tar River.

Year	Number Stocked	Total CPUE Sum	Age 2 CPUE sum	Ages 2-3 CPUE Sum	exp(int)	Total Mortality (Z)
1991	30,801					
1992	0.0				11,624	1.70
1993	118,600				195	0.93
1994	186,254	28.4			957	1.28
1995	140,972	40.1	9.6	30.8	1,148	1.30
1996	0	38.6	2.5	20.5	88	0.52
1997	24,031		1.8	11.6	86	0.72
1998	0		6.0	13.4		
1999	17,954		8.3			
2000	0					
2001	37,000					

Table 10.31. Correlation of stocking rates and recruitment measures for the Tar River.

	YEAR	Number Stocked	SUMCPUE	CPUE_2	CPUE 2+3	exp(int)	Z
YEAR	1.00						
Number Stocked	-0.42	1.00					
SUMCPUE	0.80	-0.60	1.00				
CPUE_2	0.04	0.63	1.00	1.00			
CPUE 2+3	-0.91	0.84	1.00	0.73	1.00		
exp(int)	-0.68	-0.40	-0.23	1.00	0.89	1.00	
Z	-0.75	0.25	-0.37	0.94	0.74	0.77	1.00

Although total mortality (Z) is more strongly correlated with stocking intensity in the Tar River than it was in the Neuse River, the relationship is weak and provides little evidence that stocking is an effective tool for controlling mortality. Similar to results from the Neuse River, it appears that CPUE is generally higher when stocking rates exceed 100,000 (Figure 10.31).

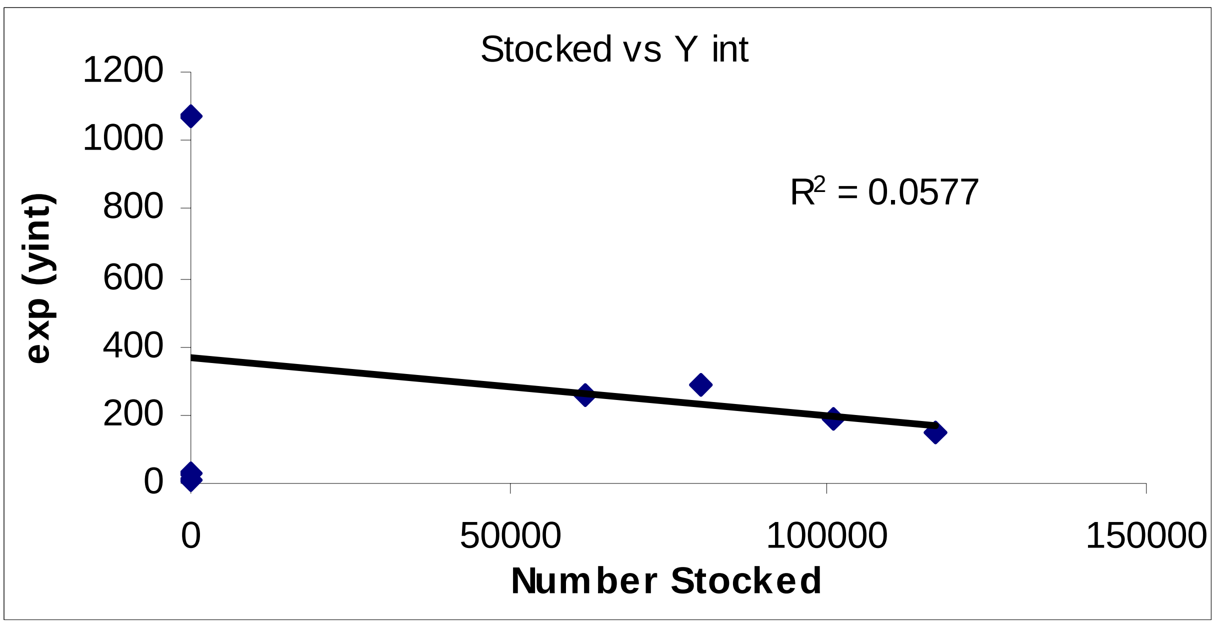


Figure 10.31. Neuse River number stocked vs estimated y-intercept

Discussion

The objective of this analysis is to evaluate mortality rates for the Neuse River and Tar River striped bass stocks, to provide guidance in developing management recommendations for the CSMA. Two aspects of a population are primarily considered when evaluating stock status 1) the rate of mortality, used to evaluate fishing intensity and determine whether or not “overfishing” is occurring or has occurred in the past, and 2) the abundance of the population, used to evaluate the impacts of past fishing intensity on the population and determine whether or not the stock is “overfished” or has been “overfished” in the past. The two terms are similar, but reference different stock aspects, with the present tense “overfishing” referring to the removal rate and the past tense “overfished” referring to stock abundance in either biomass or numbers. Overfishing is typically defined as occurring when the current rate of removals exceeds some threshold level that is determined from life history characteristics of the population and analysis of population dynamics. Overfished is typically defined as occurring when the abundance of the population falls below some threshold level that can only be determined through some knowledge of desirable abundance or biomass levels. Evaluating “overfished” is more difficult than evaluating “overfishing”, because it is considerably more difficult to determine stock abundance and develop threshold levels in terms of absolute abundance than to determine mortality rates and develop threshold exploitation levels.

Neuse River

Results of the catch curve analysis suggest that total mortality is excessive for the Neuse River stock of striped bass. Cohort catch curve estimates of total mortality average Z=0.99, resulting in an estimate of average fishing mortality of F=0.84. Annual catch curves indicate only slightly lower mortality levels (Z=0.86, F=0.71). Estimated mortality is significantly higher than the proposed threshold mortality rate (F10%SPR=0.40) based on life history characteristics of striped bass in general, therefore overfishing is currently occurring. There is no apparent trend in mortality over time, suggesting that current management measures may be adequate to prevent stock collapse. However, current measures are not preventing overfishing and are not expected to provide any stock improvement. As only relative abundance estimates are available, it is not known whether the stock is overfished. However, the prolonged overfishing indicated by the catch curve analysis and the truncated age structure of the stock suggest the Neuse River striped bass stock is also overfished.

Total mortality must be reduced substantially to stop overfishing of Neuse River striped bass. Current fishing mortality (average from cohort catch curves, F=0.84) is estimated at more than twice the overfishing threshold (F10% SPR = 0.40). Converting from instantaneous to annual exploitation rates, the current removal rate of 53% must be reduced by 42% to reach the threshold. Mortality will have to be reduced even further, by 61%, to reach target levels (Table 10.32).

Tar River

Estimates of total mortality for the Tar River striped bass stock indicate that mortality is excessive. Cohort catch curve estimates of total mortality average Z=1.17, resulting in an estimate of fishing mortality of F=1.02. Annual catch curve estimates are slightly higher, with total mortality averaging Z=1.30 and fishing mortality averaging F=1.15. These mortality estimates are significantly higher than the proposed threshold mortality

Table 10.32. Summary of current exploitation and the degree of exploitation relative to target and threshold values, as both instantaneous rates and annual percentage removals, and reductions in exploitation necessary to achieve threshold and target exploitation levels for the Neuse River and Tar River.

NEUSE	Reference	F	Relative F	Annual % Removal (A)	Relative A	Reduction % of (A)
	Faverage	0.84		53%		
	Fthreshold	0.4	2.10	31%	1.73	42%
	Ftarget	0.25	3.36	21%	2.59	61%
TAR	**REFERENCE**	**F**	**Relative F**	**Annual % Removal (A)**	**Relative A**	**Reduction % of (A)**
	Faverage	1.02		60%		
	Fthreshold	0.4	2.55	31%	1.95	49%
	Ftarget	0.25	4.08	21%	2.92	66%

Faverage is average of cohort based catch curve fishing mortality estimates.

Ftarget and Fthreshold based on Advisory Panel recommendations

rate (F10%SPR=0.40) based on life history characteristics striped bass in general, therefore overfishing is currently occurring. As only relative abundance estimates are available, it is not known whether the stock is overfished. However, the prolonged overfishing indicated by the catch curve analysis and the truncated age structure of the stock suggest the Tar River striped bass stock is also overfished. Although the Tar River analysis is only based fewer years of survey data than the Neuse River analysis, the available data fit the catch curve models quite well, based on the strong linear trend in log transformed CPUE that is evident in both cohort and annual catches, consistency in the estimated slope parameters which can be considered evidence of consistent recruitment, and relatively small standard errors in both slope and intercept parameters for most years.

Total mortality must be reduced substantially to stop overfishing of Tar River striped bass. Current fishing mortality (average from cohort catch curves, F= 1.02) is estimated at more than two times the overfishing threshold (F10% = 0.40). Converting from instantaneous to annual exploitation rates, the current removal rate of 60% must be reduced by 49% to reach the threshold. Mortality will have to be reduced even further, by 66%, to reach target levels (**Table** 10.32).

Roanoke River Catch Curve – VPA Comparison

Catch curves applied to survey CPUE compare favorably with catch-age assessment results for the Roanoke River. Deviations between mortality estimates provided by the two approaches are most apparent during times when the catch curve assumption of constant mortality is violated. When mortality is fluctuating without trend, as it did during the early 1990's for the AR stock, catch curve estimates tend to reflect the average mortality over time.

When mortality drops markedly, as it did in the mid-1990’s for the AR stock, cohort catch curves exhibit a lag and do not reflect the change for several more years. This is to be expected; cohorts which experienced the higher mortality, even if only for a few years, will continue to reflect the impact of that higher mortality over time. Only cohorts having a majority of ages that experience reduced mortality will tend to reflect lower mortality rates overall. Thus, it is not until mortality rates stabilize for a number of years, as in the late 1990’s, that the constant mortality assumption is met and catch curve analysis reflect reduced mortality. Overall, the catch curve mortality results do not appear biased, and do reflect the general magnitude of the mortality that each cohort experienced over its lifetime.

Stocking-Recruitment

Some measures of cohort abundance or recruitment are correlated with stocking rates. We initially postulated that CPUE for age 2 or ages 2 and 3 would show the strongest correlation with stocking and that any relationship with the total CPUE would be masked by mortality over time. For the Neuse River total CPUE was only slightly less correlated with stocking rates than the CPUE of younger ages, and in the Tar River the correlation was negative. In general, drawing a strong conclusion from the Tar River data is hampered by low sample size.

Years in which stocking rates exceed 100,000 Phase II fish result in cohorts having greater abundance than in those years when stocking rates are lower or stocking does not occur. Because no measures are available of the relative abundance of stocked and wild fish, there is no way to determine whether such relationships are simply due to chance, and no way to prove that stocking is actually enhancing natural recruitment. For example, stocking may have simply coincided with strong natural recruitment.

Cohort mortality rates are not correlated with stocking rates, thus there is no evidence that stocking is an effective management tool for controlling mortality for individual cohorts. Rather, stocking likely contributes to higher overall catches for stocked cohorts. Of course, this could in turn reduce the mortality of weak cohorts, so stocking may be preventing complete stock collapse during years of poor recruitment in these systems. If this is the case, stocking may be creating costly put-and-take fisheries.

Management Options

Mortality estimates for the Tar and Neuse Rivers are very similar, thus the PDT recommends continuing to manage these stocks under the same guidelines. The two stocks are currently treated as a single management unit in the FMP. Creating more management boundaries will increase confusion regarding regulations and add unnecessary complexity to the management program that will likely reduce the overall effectiveness of and support for any measures that are developed. Therefore, the management alternatives developed are considered applicable to the entire Central-Southern management unit. Regulations may vary between Inland and Marine jurisdictions.

Current regulations for the ASMA are given where applicable for comparison. Regulations in the ASMA are considerably less restrictive now as compared to the late 1980s and mid 1990s when the stock was depressed, and are consistent with maintaining a sustainable harvest from a recovered stock. Therefore, ASMA regulations may not be adequately restrictive to halt the overfishing that is occurring in the Tar River and Neuse River stocks. Commercial regulations in the ASMA are fairly specific, reflecting modifications over time intended to limit discard losses by reducing interactions between commercial gears and striped bass and to promote a non-directed fishery. Therefore, ASMA commercial regulations may not be compatible with the stock and fishery conditions in the CSMA.

Recreational Fishery

Moratorium

This measure would prohibit any harvest or possession of striped bass in the Central Southern Management Unit. Short-term harvest moratoriums were used to effectively recover striped bass along the Atlantic Coast. Because complete harvest and effort data are unavailable, there is no way to quantitatively evaluate the impacts of a moratorium and elimination of the fishery, even temporarily. Guidelines would be needed for re-opening the fishery, however the lack of any quantitative information on stock abundance will make any criteria purely subjective. Eliminating the fishery would remove the potential for collecting catch related stock information (catch rates, landings, age and length information).

+ Maximum recovery and rebuilding potential
+ Ease of enforcement
- Elimination of fishery
- Uncertainty in reopening criteria
- Uncertainty in stock status and need for such severe action
- Loss of potential data source

Possession Limit

Possession limits are used to restrict harvest of many fisheries. Hook and line recreational catch rate data for the CSMA are extremely limited; geographic coverage of the MRFSS does not extend beyond the lower reaches of the Tar and Neuse Rivers and few samples from the areas that are covered include observations of striped bass. Quantifying possession limits is not possible at this time and must therefore be judged subjectively. The current restriction for this management unit is 3 fish per day. Based on the limited MRFSS data for 1987-2002 (with 2002 not finalized through all waves), 63% of anglers harvest one fish or less, 27% land two fish, 2% land three fish, and 8% land four or more fish.

Striped bass may also be harvested by RCGL license holders in the CSMA. Preliminary 2002 RCGL survey data show a mean catch per trip of 1.2 striped bass for large mesh gill nets in the CSMA (the primary RCGL gear that harvests striped bass)

Options
1. No change (3 fish limit)
    + No management changes necessary.
    - No protection for the stocks, overfishing continues.
    - Over half of anglers catch one fish or less.
2. Reduce the possession limit to one or two fish.
    + May provide some stock protection. 10% of anglers land three or more, 37% land two or more.
    - Overall effectiveness is unknown since total removals are unknown.
    - Increased discard loss.
    - May reduce angler satisfaction.
3. Establish the same limits as used in the ASMA.
    + Ease of implementation and enforcement.
    + Reduced confusion by eliminating statewide variation.
    + Offers considerable stock protection.
        Regulations appropriate for a recovered stock may be inadequate for an overexploited stock.
        Impacts cannot be quantified due to a lack of effort and catch rate information.

Size Limit
Size limits can be effective tools for recovering stocks by limiting overall catch rates, and they can also be used to protect spawning fish if developed in accordance with size at maturity. The current size limit in coastal waters is 18". Inland waters have an 18" minimum, and a slot limit prohibiting possession of fish between 22" and 27" in the Tar and Neuse Rivers from April 1 – through May 31 (Similar to the Roanoke River). The combined effects of the slot limit, possession limits, and seasonal restrictions on the Roanoke River result in the majority of the harvest being composed of smaller, male fish. Age at maturity studies from the Roanoke River indicate 50% of females are mature at age 3 and 93% are mature at age 4. Size at age for female Neuse River striped bass is about 20" at age 3 and 22" at age 4. A 22" size limit would be necessary to let most female fish spawn once before vulnerable to harvest.

Options
1. No change
    + No management changes necessary
    + Consistency with other striped bass regulations
    - Allows harvest of females before they reach spawning age
    - Provides no additional stock protection
2. Increase restriction to 20"
    + Could provide some catch reduction
    + Allows approximately 50% of females to reach maturity before harvest
    - Inconsistency with ASMA regulations.
    - Results cannot be quantitatively analyzed
3. Increase restriction to 22"
    + Could provide catch reduction

+ Allows most (93%) of females to reach maturity before harvest
- Inconsistency with Albemarle-Roanoke regulations
- Results cannot be quantitatively analyzed

4. Establish same limits as in the ASMA
   + Consistency and ease of implementation
   + May provide some catch reduction
   - Actual impacts on Neuse and Tar stocks cannot be quantified
   - May not be adequate given that AR stock is declared recovered and CSMA stocks are experiencing overfishing
5. Establish a slot possession limit consistent with WRC regulations
   Prohibition of possession, 22”- 27”
   + Consistency in regulations
   + Protection of a portion of the spawning stock
   - Effects not reliably quantified
   - May increase pressure on 18-22” fish
6. Reduce the minimum size
   - Will reduce values of threshold and targets
   - Increased exploitation before maturity
   - Strong likelihood of increased harvest and exploitation

Quota

Quotas are used to manage the Albemarle-Roanoke striped bass stock and several other fisheries in the state. Quotas are effective when accurate and timely landings statistics are available, and should only be developed when accurate information on stock status, including overall abundance, is also available. Such information is not available for the C/S stocks. Moreover, quotas impose considerable demands on management and monitoring, require real-time catch tabulation for all fishery components and regular stock assessments for quota specification, and often lead to considerable discard and waste problems.

Options

1. No Change (Do not implement a quota)
   + Does not require costly, real-time monitoring
   + Does not require annual stock status estimates
   - No overall catch limitation imposed
2. Implement a Quota
   + Definite restriction on catch
   + Is a proven and effective management measure (if bycatch is controlled)
   + May be perceived as equitable in light of current commercial quota
   - Appropriate quota level cannot be determined
   - Catch rates are not available for quota monitoring

Season

Seasonal restrictions are an effective tool for limiting harvest and sometimes effort, and may allow lower size limits or higher possession limits during times when possession is allowed. Enforcement is often a concern during the initial closure, but compliance tends to increase over time if regulations are consistent. Differences in seasons between the AR stock and the rest of the state may now create some confusion and may be an enforcement burden. Analyzing appropriate seasons and evaluating catch reductions associated with seasons for the Neuse and Tar stocks are not possible at this time due to a lack of adequate catch statistics. Limited MRFSS and preliminary RCGL survey data, combined with anecdotal knowledge, may allow determination of appropriate seasonal closures.

Seasons can impose a discard mortality cost, although in theory closures could be developed to address seasonal differences in discard mortality rates. Application of the closure must consider not only seasonal discard mortality but also the relative popularity of the species being regulated. For example, a closure during periods of high water temperatures could reduce discard losses if effort declines as a result of the closure. Conversely, the closure could increase discard losses if the species being restricted is not a primary target and the closure has no effect on effort. Discard losses may be best minimized if seasonal closures for non-target species coincide with periods of greatest discard survival.

1. No change.
   + No management changes necessary
   + No enforcement burden
   - No catch limitation.
   - Other measures (size, bag limits) will need to be more strict
2. Impose a seasonal restriction equivalent to that in the ASMA
   + Consistency and ease of implementation
   + Reduced confusion
   + Likely to provide considerable catch reduction
   - Impacts on Neuse and Tar stocks and fisheries cannot be quantified
   - May not be adequate given that AR stock is considered recovered
3. Impose specific CSMA seasonal restriction
   + May provide stock protection if adequately determined
   + May provide CSMA specific management option
   + Could be developed to reduce discard losses during periods of high mortality (but only if fishing effort decreases during the closure)
   - Inadequate information available to determine specific timing and closure length
4. Enact a total closure – No open season.
   + Will reduce exploitation
   - Likely to increase discard losses

Harvest Targets
Recreational fisheries in the CSMA are managed by seasons, possession limits, and size limits. The lack of information on stock abundance precludes development of harvest limits from fishing mortality targets. The recreational regulations in the CSMA remain at status quo in 2004. A recreational creel survey will be conducted throughout the CSMA during 2004. Upon completion of the survey, data will be analyzed and restrictive measures implemented on the fishery as needed.

Commercial Fishery
The commercial fishery in the CSMA is managed through a 25,000 lb. quota. A season is imposed which is only opened when the AR management unit is open to commercial harvest and closes once the quota allocation is reached. During the harvest season possession is limited to five fish per vessel per day. In spite of the low quota and restrictive trip limits, over 30% of gill net trips land catches composed primarily (defined as over 50%) of striped bass. Most landings are taken by large mesh (>5") gillnet during winter. Discards of striped bass during fisheries for other species, such as flounder, shad, and mullet likely exceed the landed harvest.

Moratorium
A moratorium would prohibit possession of striped bass by commercial fishermen in the CSMA. Given the limited quota and low possession limit currently in effect, a moratorium will not likely change fishing practices, and since prohibiting possession will not prevent capture, this alternative will increase discarding and loss.

+ Will prevent harvest.
- Increased discard losses will consume much of the savings in catch.
- Disruption of the remaining market.
- Catch related data collection lost.
- Standards for reopening difficult to establish.

Quota
The current quota is 25,000 pounds.
Options
1. Status quo- monitor the harvest and close the fishery when quota reached, deduct overages from the next years quota allocation.
   + No changes necessary.
   + Discards not increased.
   - No additional protection to the stock.
2. Decrease the quota.
   + Harvest restricted.
   + Simplicity.
   - Discards will increase.
   - Disruption of remaining market.

Possession Limit
The current possession limit is five fish per day.
Options
1. Status quo.
   + No change necessary.
   + Extends the season.
   - Fishermen may desire a directed fishery.
   - No landings reduction since fishery is quota managed.
   - Creates discard if catch rates exceed five fish.

2. Decrease the possession limit
   + Further extend the season
   + Strengthens bycatch only fishery
   - Increased discarding
   - No landings reduction since fishery is quota managed
3. Increase the possession limit
   + Would allow greater harvest per trip (increased value)
   + Reduced discard losses during the open season.
   + Provides a shorter season, which may reduce discard losses if strict gear restrictions are imposed during closed season.
   - Provides a shorter season, which may increase discard losses during longer closed periods if no other changes (e.g. gear modifications) made.
   - Potential for increased targeting
   - No total landings reduction

Size Limit

The current size limit of 18” is the same as the ASMA size limit.

Options

1. No change
   + No management changes necessary
   + Consistency with other striped bass regulations
   - Allows harvest of females before they reach spawning age
   - Provides no additional stock protection
   - Increases discards
2. Increase minimum restriction to 20”

   + Could provide some catch reduction.(Fish house sampling indicates that 2% of landings are ≤ 20”)
   + Allows approximately 50% of females to reach maturity before harvest
   - Benefits to the population can only be qualitatively evaluated.
3. Increase minimum restriction to 22”
   + Could provide catch reduction (Fish house sampling indicates that 34% of landings are ≤ 22”)
   + Allows most (93%) of females to reach maturity before harvest
   - Benefits to the population can only be qualitatively evaluated.
4. Enact a protected slot similar to inland recreational areas

   Prohibition of possession, 22” – 27”
   + Increased protection of spawning stock
   - Could increase discard losses, depending on gear selectivity
5. Reduce the size limit
   - Will lower values of target and threshold
   - Possible increased exploitation of immature fish

Bycatch Only Specifications

Additional management measures could be imposed that restrict directed harvest. For example, striped bass could be limited to a specific fraction (e.g., 25%, 50%) of the total catch, typically by weight.

Options
1. Status Quo. Do not restrict the proportion of the catch that is striped bass
   + Ease of enforcement
   + Flexibility for fishermen
   - Potential for directed harvest
2. Enact catch proportion restriction
   + Prohibits directed harvest
   - Easy to 'work around' given the small possession limit (five fish; fishermen would easily possess enough "bait" or other species to cover the striped bass landings)
   - May not effectively stop directed harvest
   - Enforcement burden
   - Reduces flexibility
3. Specifically prohibit directed harvest of striped bass
   + Would prohibit directed fishery
   - Nearly impossible to effectively enforce
   - Nearly impossible to draft into a rule

Gear Restrictions
Many gear restrictions are used in the ASMA to manage the commercial quota and limit discard losses (e.g., see Table below). These measures have evolved over time in

ASMA Yardage Restrictions

		Typical ASMA Yardage Restrictions	
Category	Flounder	Large Mesh (SHAD)	Small mesh
Desc.	5 ¼" and above[1]	5 ¼" and above[2]	3 – 3 ¼ " [3]
Yardage Limit	3000	1,000	800

1. Flounder –must be tied down- not to exceed vertical height of 48 inches
2. Large mesh (Shad nets)- - seasonal only mid-February – 15 April
3. Small mesh Eastern sound seasonal allowance of 3 ¾ and 4 inch

response to the specific fisheries, conditions, and fishing practices of that area, and are not likely directly applicable to the CSMA, although some measures such as tie down restrictions may have more wide-spread applicability. Impacts of such measures, on either the fisheries or the population, are difficult to evaluate because there is little on-water sampling of gill net fisheries in the CSMA and DMF monitoring program nets are not fished or constructed identical to commercial fishery nets.

Central-Southern Management Area- Observed yardage

Area	Mesh Category	Description	Winter	Spring & Summer
Pamlico	Large	>30%Fldr, >5% shad/stb, >=5" mesh	1314	1423
Pamlico	Small	3 – 4 ½", shallow	1262	820
Rivers	Large	>30%Fldr, >5% shad/stb, >=5" mesh	952	1121
Rivers	Small	3 – 4 ½", shallow	440	540

Options

1. Status quo. No changes to gillnet restrictions
   + Ease of implementation
   + No disruption of existing fisheries
   + No disruption of fishing practices
   + No costs from gear modifications
   - Continued overharvest
   - Continued discard losses
2. Implement gillnet restrictions in accordance with ASMA requirements.
   + Ease of implementation
   + May provide some bycatch reductions
   + Reduces importance of boundary lines
   - Measures appropriate in ASMA may not be appropriate in CSMA
   - Enforcement burden
   - Increased regulatory confusion; ASMA rules change often
   - Sampling indicates yardage used does not differ much from ASMA requirements
3. Restrict allowable gillnet yardage.
   + Would reduce total effort in some cases
   + Would reduce harvest and discard losses
   - May disrupt other fisheries
   - Appropriate measures difficult to quantify due to lack of on-water observer data
4. Restrict use of 4 – 4 ½ " gill net mesh

   Mesh of this size is not allowed in the ASMA because it is very effective at catching striped bass. However, this mesh is widely used in the Pamlico Sound for a variety of fisheries. There is little information available to use in judging the impacts of restricting this size mesh in the CSMA.
   + Reduced interactions with striped bass
   - Overall impacts to Central-Southern fisheries is unknown.
   - Current net attendance rules may have already provide a discard reduction
   - Unforeseen circumstances (i.e., switching to other size mesh) could create discard problems in other fisheries or with protected and endangered species
5. Increase net attendance requirements.

   Currently gillnets with mesh less than 5" must be attended at all times in the upriver sections of the Tar (Pamlico) River and Neuse rivers, and when within 200 yards of the shoreline in the downriver sections. (15A NCAC 03J.0103.g).
   + Increasing the attendance requirements may reduce overall effort

- Additional burden on fishing operations
- Most of the areas in the Tar and Neuse Rivers already require attendance
- Difficult to evaluate discard reductions achieved from attendance requirements, especially without adequate information on current discard rates.

6. Require net 'tie-downs'

   Flounder nets in the ASMA must be 'tied down', i.e. held to within the bottom 48" of the water column, to reduce interactions with striped bass. Tie-down requirements could be developed for certain times of the year (e.g., when closed to striped bass harvest), and for certain areas of the CSMA (e.g., portions of the rivers)

   + May reduce striped bass interactions and thus reduce bycatch
   - Likely to increase sea turtle interactions and especially deaths if required in the Sound.
   - Likely to increase red drum interactions and bycatch losses
   - May be infeasible in some areas due to tide intensity

Research Needs

Quantitative assessment of Tar and Neuse River striped bass populations. Significant additional data are required to enable a thorough assessment of CSMA stocks. Information currently available includes commercial landings and associated biological characteristics, age structured surveys of Tar and Neuse spawning populations, limited migration and movement information from tag recoveries of stocked fish, and limited stock mixing from ASMA tagging programs and tagged stocked fish in the Tar and Neuse Rivers.

1. Data Needs And Potential Sources

1. Complete landings statistics for recreational fisheries (Creel Survey)
2. Biological characteristics of recreational fisheries (length, weight, age, sex (Creel Samples)
3. Discard estimates from recreational fisheries (Creel Survey)
4 Biological characteristics of recreational discard (Angler logs or Independent survey)
5. Biological characteristics of commercial catch , including length, age, weight, and sex (increased sampling, age structure collection)
6. Discard estimates from commercial fisheries (Trip level observer coverage)
7. Expanded survey coverage, including juvenile abundance and population abundance in the Sounds and lower Rivers (New or expanded surveys)
8. Increased external tagging of stocked fish (Additional tagging effort)
9. Comprehensive tagging of wild fish, including estimation of reporting rates (New Program)
10. Life history information maturity; fecundity; size and weight at age; egg and larval survival (Short term research projects; Federal aid/Universities)

2. **Thorough Analysis Of Stocking Programs**

To evaluate if stocked fish are contributing to the catch, establish percent contribution, and determine optimal stocking rates for both Phase I and II fish. This will become crucial if juvenile surveys are initiated.

3. **Comprehensive Tagging Program**
A tagging program provides a quick measure of exploitation, relative catch rates by fishery components, migration and movement information, and will expand knowledge of the stock composition of fisheries in both ASMA and CSMA. Also a source of samples for various biological studies and for catch characterization.

4. **Observer Coverage Of Commercial Fisheries**
Commercial discard is a potentially important but largely unobserved source of stock removals. Sampling and observation of commercial fishing trips on-the-water is the most reliable source of trip and gear characteristics, discard rates, and catch rate information.

MFC, DMF, WRC, FWS and C/S Advisory Committee Management Recommendation

Recreational Fishery Management Measures
Adequate information to evaluate specific recreational measures are lacking in the CSMA. Regulations should remain at status quo for 2004. A one year creel survey is being developed by DMF and WRC for the Tar-Pamlico and Neuse systems. This survey will collect data on the recreational striped bass fisheries in these waters. The WRC will be conducting a creel survey in the Cape Fear system in 2004. After completion of the creel surveys the data will be analyzed and appropriate regulations implemented as needed for the stocks.

Commercial Fishery Management Measures
Commercial fishery gill net restrictions have been enacted over the last several years, as a result of the Red Drum FMP and endangered species interactions. Large areas of Pamlico Sound are closed to gillnetting from August 15 – December 15, and other areas have strict permitting and gear restrictions. Attendance is required of gill nets within the upper rivers and within 200 yards of shore in lower river portions.

Comprehensive DMF gill net sampling within Pamlico Sound indicate extremely low catch rates of striped bass. Therefore, it is unlikely that gill net fisheries in the Sound are responsible for significant bycatch losses, and management efforts should instead focus on reducing striped bass interactions in the rivers. With the exception of the allowance of 4 –4 ½ inch mesh, many of the gill net restrictions imposed in Albemarle Sound are already required in the rivers of the CSMA.

Commercial Fishery Management Measures **see Section 10.4.3.2 Discard Mortality of Striped Bass from Set Gill Nets in the CSMA**.

10.4.3.2 Discard Mortality of Striped Bass from Set Gill Nets in the Central/Southern Management Area (CSMA)

Issue

Investigation of discards of striped bass in the multi-species, set gill net fishery in the Central Southern Management Area (CSMA).

Definitions

A variety of terms have been used in the literature related to wastage in fisheries. The term "bycatch" has been used in scientific and popular literature for more than half a century and has been subject to a variety of definitions, some of which are overlapping or contradictory. It can best be used as a generic term, applying to that part of the catch made up of non-target species or species assemblages (Alverson et al. 1994).

Target Catch-The catch of a species or species assemblage which is primarily sought in a fishery, such as shrimp, flounders, etc.

Incidental Catch-Retained catch of non-targeted species.

Discarded Catch-That portion of the catch returned to the sea as a result of economic, legal, or personal considerations.

Bycatch-Discarded catch plus incidental catch.

Attended-Being in a vessel, in the water or on the shore immediately adjacent to the gear and immediately available to work the gear and within 100 yards of any gear in use by that person at all times. Attended does not include being in a building or structure

Background

Gill Net Fisheries

The estuarine gill net fishery of North Carolina is a year round multi-species fishery where netting used and species targeted varies by area and season. Species commonly caught by the gill net fishery include American shad, Atlantic croaker, southern flounder, red drum, spot, spotted seatrout, striped bass, striped mullet and weakfish.

A gill net is defined as a net set vertically in the water to capture fish by entanglement by the gills in its mesh as a result of net design, construction, mesh size, webbing diameter or method in which it is used. Three primary types of gill net deployment exist in the North Carolina estuarine gill net fishery set, runaround, and drift nets. Runaround nets, also referred to as drop nets or strike nets, are often fished in one of two ways. For the first method, the net is attached to a point on shore and deployed parallel to shore with the terminal end of the net attached to the shore when the net is fully deployed. After the net has been set to block in a section of the shoreline, the boat is taken inside the blocked area, the fishermen rap on the boat with wooden poles or similar implements such that the resident fish leave the shallow shoreline and return to deeper waters. Fish encounter the net as they flee the shoreline. The net is retrieved after several passes have been made within the blocked area. For the second method, the net is set to encircle a school of fish (NCDMF 1997). The runaround gillnet fishery typically targets striped mullet and operates year round with most of the effort occurring during the fall from September through November. Vessels are usually open skiffs ranging from 15 to 25 feet in length with one or two-man crews. (NCDMF 2002). Drift nets are similar to the drop net but do not have enough weight attached to the lead line to remain stationary. The nets drift with the current. Drift nets are primarily used for shad and herring during spawning runs. Fishermen are actively tending their nets in both of these methods and bycatch may be readily returned to the water.

The last method, set nets, is the gill net fishery addressed in this issue paper. Set nets are deployed, anchored or staked, and left from a few hours up to a few days depending on severity of the weather and water temperature. Most sets are overnight. Set nets can be further divided into float and sink net categories. Float nets fish the entire height of the water column, while sink nets fish a fixed distance off the bottom and do not extend to the upper portion of the water column. Large mesh nets (5.0 inch and greater) are set primarily for flounder or shad, while small mesh (less than 5 inch) are directed toward sciaenids, striped mullet, bluefish, and a variety of other species.

A large mesh fishery operates from April (February in the rivers) through December in several areas shallow water next to the barrier islands in Pamlico and Core sounds, deep water Pamlico Sound, and the rivers of Pamlico, Pungo, Bay and Neuse both shallow and deep. Fishing depths are typically less than six feet for the shallow fishery and greater than ten feet for the deep water. Vessels are usually open skiffs ranging from 15 to 25 feet in length. Each fisherman sets 500 to 5000 yards of large mesh (5 1/4 to 7 inch) gillnet, which are soaked overnight and retrieved by hand or with the aid of net reels. Tie-downs may or may not be used, depending on the area and tidal conditions. The smaller operations generally occur in the shallow water fisheries and in the rivers.

A shallow water small mesh “set” gillnet fishery operates along the Outer Banks with most of the effort occurring from October through early December. Nets are anchored overnight, similar to the large mesh fishery for flounder that occurs in the same area. Vessels are usually open skiffs ranging from 15 to 25 feet in length with one or two-man crews. Each fishing operation sets 500 to 2000 yards of small mesh (3 to 4 1/2-inch stretched mesh) gillnets, which are retrieved by hand. Sets are composed of many short lengths of gillnet with most constructed of 0.5 mm twine or smaller. Tie-downs are not used in this fishery, but net depths range from 6 to 11 feet with sets occurring in depths less than three feet. This combination of water depth and net depth provides the same bag effect as the tie-down in the deep water large mesh fishery. Target species include striped mullet, spotted seatrout, weakfish, and bluefish. A similar small mesh fishery exists in the rivers and in the upper reaches of rivers the and targets white perch and catfish.

Using 2000 and 2001 as a basis, Tables 10.33 and 10.34 gives the average annual pounds and dollar value of landed target species, broken out by large and small mesh for the Sound and the river fisheries. For all species combined, the Pamlico Sound set gill net fishery averaged 1.4 million pounds with a dockside value of $1.9 million. The rivers set gill net fishery average 0.5 million pounds and $0.9 million. Table 10.35 gives the number of participants in these fisheries (defined as a unique individual who had at least 10 trips annually).

CSMA Striped Bass Management
Since 1994, when the North Carolina Striped Bass Management Plan was approved, the Central/Southern Management Area has operated on a 25,000 pound TAC. The fishery has operated as a low harvest level fishery, using set seasons with a 18 inch size limit restrictions and daily landing limits. The daily limit has ranged from 3 to 20 fish and at times could comprise no more than 25% of the trip harvest. The striped bass fishery is divided into a spring and fall season. During the open season fishermen are restricted to daily landing limits and minimum size limits. Finfish dealers are required to obtain a striped bass permit, with a Central/Southern validation, report landings daily to DMF, and affix a sale tag to the striped bass when purchased from the fishermen. The current measures (Table 10.36) have been in place since 1997. Striped bass is a targeted catch in the CSMA. Even with the five fish per operation daily limit, over 30% of the gill net trips during the open season were composed primarily of striped bass (defined as over 50% of the trip ticket)

Other management measures have also restricted the take of striped bass in the CSMA. The WRC initially (1996) allowed the use of a special device license for attended set gill nets in a number of inland waters. In 2000 this was no longer permitted in the northern and central coastal Districts (Districts 1 & 2) and was implemented in all the coastal areas in 2001 (Districts 3 & 4). Federal rule (50 CFR Part 223.206) states "No person may fish with gillnet fishing gear which has a stretched mesh size larger than 4 1/4 inches, annually from September1 through December 15, in the inshore waters of Pamlico Sound, North Carolina, and all contiguous tidal waters bounded on the north by 35°46.3' N. lat., on the south by 35°00' N. lat., and on the west by 76°30'W. long." This closed a major deep water flounder fishery. A Pamlico Sound Gillnet Restricted Area permit is issued to fishermen by DMF, under a federal Section 10 endangered species permit, that allows for the shallow water Outer Banks and mainland Hyde County bays flounder fisheries to continue with gear limits, weekly reporting and observer coverage Gill net attendance requirements for small mesh (<5 inch) gill nets

Table 10.33. Pamlico Sound set gill net landings, average for 2000 & 2001, by mesh size for main target species.

	Large Mesh						Small Mesh						Species Total	
	Summer		Winter		All		Summer		Winter		All			
Species	Pounds	Dollars	Pounds	Dollars	Pounds	Dollars	Pounds	Dollars	Pounds	Dollars	Pounds	Dollars	Pounds	Dollars
Bait, Menhaden	66	7	618	638	6,204	645	90,983	9,259	334,691	33,881	425,674	43,140	431,877	43,785
column %	0.0	0.0	5.2	0.4	1.2	0.1	11.5	2.2	49.5	13.9	29.0	6.6	21.9	3.2
Bluefish	11,804	3,234	504	138	12,308	3,371	223,766	57,697	20,120	5,633	243,886	63,330	256,193	66,701
column %	3.0	0.6	0.4	0.1	2.4	0.5	28.3	14.0	3.0	2.3	16.6	9.6	13.0	4.8
Croaker	4,406	1,174	76	21	4,482	1,194	13,283	3,519	31,214	9,228	44,497	12,747	48,978	13,942
column %	1.1	0.2	0.1	0.0	0.9	0.2	1.7	0.9	4.6	3.8	3.0	1.9	2.5	1.0
Drum, Red	13,532	15,087	4,944	5,505	18,475	20,592	40,981	45,156	26,168	29,040	67,149	74,197	85,624	94,788
column %	3.5	2.6	4.2	3.9	3.6	2.8	5.2	10.9	3.9	11.9	4.6	11.3	4.3	6.9
Flounders	317,327	540,208	61,409	106,027	378,736	646,234	39,537	67,110	6,032	10,240	45,569	77,350	424,305	723,584
column %	81.6	93.0	51.9	74.5	74.6	89.4	5.0	16.2	0.9	4.2	3.1	11.8	21.5	52.4
Hickory Shad	7	2	7,043	1,749	7,049	1,751	982	252	39,253	9,846	40,235	10,098	47,284	11,849
column %	0.0	0.0	5.9	1.2	1.4	0.2	0.1	0.1	5.8	4.0	2.7	1.5	2.4	0.9
Mackerel, Spanish	415	313	10	8	425	321	119,736	92,250	396	311	120,132	92,561	120,557	92,882
column %	0.1	0.1	0.0	0.0	0.1	0.0	15.1	22.3	0.1	0.1	8.2	14.1	6.1	6.7
Mullet, Jumping	1,679	788	1,299	604	2,978	1,392	70,816	32,629	46,059	25,539	116,875	58,167	119,852	59,560
column %	0.4	0.1	1.1	0.4	0.6	0.2	9.0	7.9	6.8	10.5	8.0	8.9	6.1	4.3
Perch, White	124	81	429	242	553	323	947	511	3,419	2,109	4,365	2,620	4,918	2,943
column %	0.0	0.0	0.4	0.2	0.1	0.0	0.1	0.1	0.5	0.9	0.3	0.4	0.2	0.2
Perch, Yellow	1	1	.	.	1	1	5	5	181	176	186	181	187	182
column %	0.0	0.0	.	.	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Shad, American	474	311	10,447	6,852	10,921	7,163	46	29	765	487	810	516	11,731	7,679
column %	0.1	0.1	8.8	4.8	2.2	1.0	0.0	0.0	0.1	0.2	0.1	0.1	0.6	0.6
Trout, Grey	4,388	2,528	3,080	1,752	7,468	4,280	35,707	20,699	65,474	38,190	101,181	58,889	108,649	63,169
column %	1.1	0.4	2.6	1.2	1.5	0.6	4.5	5.0	9.7	15.7	6.9	9.0	5.5	4.6
Trout, Spotted	2,354	2,954	3,765	4,778	6,120	7,732	7,544	9,584	37,873	48,302	45,416	57,886	51,536	65,618
column %	0.6	0.5	3.2	3.4	1.2	1.1	1.0	2.3	5.6	19.9	3.1	8.8	2.6	4.8
Spot	3,568	1,478	271	112	3,839	1,590	37,271	15,437	7,250	3,005	44,521	18,442	48,360	20,032
column %	0.9	0.3	0.2	0.1	0.8	0.2	4.7	3.7	1.1	1.2	3.0	2.8	2.4	1.5
Striped Bass	95	118	8,216	10,065	8,310	10,183	15	17	138	159	153	175	8,463	10,358
column %	0.0	0.0	6.9	7.1	1.6	1.4	0.0	0.0	0.0	0.1	0.0	0.0	0.4	0.8
Striped Bass, Discard	1,263		6,157		7,420		14,083		13,589		27,672		35,092	
55 Additional Sp.	28,691	12,406	16,310	3,803	39,482	16,212	109,412	59,269	57,175	27,141	166,590	86,411	206,076	102,623
column %	7.4	2.1	13.8	2.7	7.8	2.2	13.8	14.3	8.5	11.2	11.4	13.2	10.4	7.4
Area Total	388,931	580,690	118,421	142,294	507,351	722,984	791,031	413,423	676,208	243,287	1,467,239	656,710	1,974,590	1,379,695

Table 10.34. Rivers (Pamlico, Pungo, Bay and Neuse) set gill net landings, average for 2000 & 2001, by mesh size for main target species.

	Large Mesh						Small Mesh							
	Summer		Winter		All		Summer		Winter		All		Species Total	
Species	Pounds	Dollars	Pounds	Dollars	Pounds	Dollars	Pounds	Dollars	Pounds	Dollars	Pounds	Dollars	Pounds	Dollars
Bait, Menhaden	1,035	114	2,162	220	3,197	333	13,998	1,414	59,426	6,030	73,424	7,444	76,620	7,777
column %	0.4	0.0	2.0	0.2	0.9	0.1	5.7	1.1	19.8	3.8	13.4	2.6	8.6	1.0
Bluefish	1,055	281	53	14	1,108	295	6,273	1,585	78	19	6,351	1,604	7,459	1,899
column %	0.4	0.1	0.0	0.0	0.3	0.1	2.6	1.2	0.0	0.0	1.2	0.6	0.8	0.2
Croaker	3,898	982	115	33	4,013	1,015	2,802	699	35	10	2,837	708	6,850	1,723
column %	1.6	0.3	0.1	0.0	1.2	0.2	1.1	0.5	0.0	0.0	0.5	0.2	0.8	0.2
Drum, Red	6,630	7,398	3,132	3,450	9,762	10,848	2,409	2,669	3,841	4,250	6,250	6,919	16,012	17,767
column %	2.8	2.0	2.9	3.1	2.8	2.3	1.0	2.0	1.3	2.7	1.1	2.4	1.8	2.3
Flounders	208,421	344,778	36,024	59,062	244,445	403,841	11,161	18,408	3,937	6,442	15,099	24,850	259,543	428,691
column %	87.9	95.1	33.1	53.8	70.6	85.5	4.5	13.9	1.3	4.1	2.8	8.5	29.1	56.2
Hickory Shad	8	2	7,760	2,044	7,768	2,045	300	73	21,588	5,979	21,888	6,053	29,656	8,098
column %	0.0	0.0	7.1	1.9	2.2	0.4	0.1	0.1	7.2	3.8	4.0	2.1	3.3	1.1
Mackerel, Spanish	439	335	4	3	443	337	34,896	27,085	4	3	34,900	27,088	35,343	27,425
column %	0.2	0.1	0.0	0.0	0.1	0.1	14.2	20.4	0.0	0.0	6.4	9.3	4.0	3.6
Mullet, Jumping	1,554	625	4,330	1,749	5,884	2,374	145,803	65,756	132,025	56,131	277,828	121,887	283,712	124,261
column %	0.7	0.2	4.0	1.6	1.7	0.5	59.4	49.5	44.0	35.5	50.9	41.9	31.8	16.3
Perch, White	68	37	1,458	817	1,526	854	2,400	1,374	9,578	5,807	11,979	7,181	13,504	8,034
column %	0.0	0.0	1.3	0.7	0.4	0.2	0.1	1.0	3.2	3.7	2.2	2.5	1.5	1.1
Perch, Yellow	25	26	390	393	414	419	597	616	1,152	1,169	1,748	1,785	2,163	2,204
column %	0.0	0.0	0.4	0.4	0.1	0.1	0.2	0.5	0.4	0.7	0.3	0.6	0.2	0.3
Shad, American	623	421	22,665	15,519	23,288	15,940	32	22	433	268	465	290	23,753	16,230
column %	0.3	0.1	20.8	14.1	6.7	3.4	0.0	0.0	0.1	0.2	0.1	0.1	2.7	2.1
Trout, Grey	2,220	1,199	1,047	548	3,267	1,748	1,687	928	2,747	1,453	4,434	2,380	7,702	4,128
column %	0.9	0.3	1.0	0.5	0.9	0.4	0.7	0.7	0.9	0.9	0.8	0.8	0.9	0.5
Trout, Spotted	2,269	2,904	1,905	2,337	4,174	5,241	3,430	4,344	54,590	66,854	58,020	71,198	62,194	76,439
column %	1.0	0.8	1.7	2.1	1.2	1.1	1.4	3.3	18.2	42.3	10.6	24.5	7.0	10.0
Spot	1,046	436	170	70	1,215	505	10,992	4,554	751	314	11,743	4,868	12,959	5,373
column %	0.4	0.1	0.2	0.1	0.4	0.1	4.5	3.4	0.3	0.2	2.2	1.7	1.5	0.7
Striped Bass	9	10	17,702	20,662	17,711	20,672	.	.	327	385	327	385	18,038	21,058
column %	0.0	0.0	16.2	18.8	5.1	4.4	.	.	0.1	0.2	0.1	0.1	2.0	2.8
Striped Bass, Discard	41,871		6,387		48,258		7,734		3,286		11,020		59,278	
22 Additional Sp.	7,822	2,873	10,076	2,859	17,900	5,734	8,834	3,295	9,857	2,783	18,690	6,079	36,590	11,813
column %	3.3	0.8	9.2	2.6	5.2	1.2	3.6	2.5	3.3	1.8	3.4	2.1	4.1	1.5
Area Total	237,122	362,421	108,993	109,780	346,115	472,201	245,614	132,822	300,369	157,897	545,983	290,719	892,098	762,920

Table 10.35. Number of set gill net fishermen who had at least 10 trips annually, average years 2000 & 2001.

Fishery	Season	Number of Fishermen
Pam Sd Large	Winter	49
	Spring /Summer.	146
	Non-duplicative Total	182
Pam Sd Small	Winter	101
	Spring /Summer	151
	Non-duplicative Total	188
Pamlico Sound All	Non-duplicative Total	274
Rivers Large	Winter	70
	Spring /Summer	112
	Non-duplicative Total	151
Rivers Small	Winter	54
	Spring /Summer	48
	Non-duplicative Total	92
Rivers All	Non-duplicative Total	203

were first instituted in Pamlico and Neuse rivers by proclamation in 1995. Expanded attendance requirements are now in rule from the red drum FMP for the state (15A NCAC 03J.0103). Year round attendance is required in the upper portions of the rivers and within 200 yards of shore in the lower rivers. From May 1 through October 31 small mesh nets must be attended in all primary and permanent secondary nursery areas, no trawl areas, and in a large
area along Outer and Core Banks. This measure has reduced the amount of small mesh effort in these areas.

Current Authority

General Statutes of North Carolina

G.S. 113-170.4 Rules as to possession, transportation, and disposition of fisheries resources
G.S. 113-170.5 Violations with respect to coastal fisheries resources

G.S. 113-182 Regulation of fishing and fisheries
G.S. 113-221(e) Rules; proclamations; emergency Commission meetings
G.S. 143B-289.52 Marine Fisheries Commission – powers and authority

North Carolina Marine Fisheries Commission Rules

North Carolina Fisheries Rules for Coastal Waters (15A NCAC)
3H .0103 Proclamation Authority of Fisheries Director
3J .0103 Gill Nets, Seines, Identification, Restrictions
3Q .0107 Special Rules, Joint Waters
3M .0202 Striped Bass Season, Size and Harvest Limit Internal Coastal Waters

Table 10.36. Striped bass commercial season in CSMA, 2001 & 2002.

Year/ Season	Proclamation	Areas Opened	Date Opened	Date Closed	Total Days	Creel Limit	Other Restriction	Landings from Permit Quota Monitoring: Pamlico Sound	Western Pamlico Sound Tributaries	Carteret County	Cape Fear	Total
2001												
Spring	FF-01-01	Cape Fear River	01-08-01	04-30-01	113	10/day	Dealer permit and tags required					
	FF-23-01	Carteret, Craven, Bft, Pamlico counties; Pamlico, Pungo and White Oak rivers, Jones and West bays, Pamlico Sound	02-12-01	03-02-01 (FF-27-01) 03-14-01 (FF-29-01)	19 31	5/day	Dealer permit and tags required	8,637	11,966	7	129	20,739
Fall	FF-56-01	Carteret, Craven, Beauft, Pamlico counties; Pamlico, Pungo and White Oak rivers	12-04-01	12-14-01 (FF-71-01)	11	5/day	Dealer permit and tags required	(184)	3,911	83	-	3,994
							2001 TOTAL	(8,821)	15,877	90	129	24,733

Table 10.36. (Continued)

Year/ Season	Proclamation	Areas Opened	Date Opened	Date Closed	Total Days	Creel Limit	Other Restriction	Pamlico Sound	Western Pamlico Sound Tributaries	Carteret County	Cape Fear	Total
2002												
Spring	FF-76-01	Cape Fear River	01-07-01	04-30-01	114	10/day	Dealer permit and tags required					
	FF-16-02	Carteret, Craven, Bft, Pamlico counties; Pamlico, Pungo and White Oak rivers, Jones and West bays, Pamlico Sound	02-25-02	03-16-02 (FF-23-02)	20	5/day	Dealer Permit and Tags Required	8,301	9,295	1,937	156	19,689
Fall	FF-49-02	Carteret, Craven, Beauft, Pamlico counties; Pamlico, Pungo and White Oak rivers	12-02-02	12-13-02 (FF-60-02)	12	5/day	Dealer permit and tags required	(60)	1,998	7,452 (Ocean fish)	-	9,510
							2002 TOTAL	8,361	11,293	9,389	156	29,199

Methods

Discard (dead) Estimate for CSMA

An estimate of the discarded catch for a gear may be computed by estimating the "total catch" (quantity taken that reaches the deck of the fishing vessel) and subtracting from it the “landed catch” (that which is brought ashore). The discarded catch may then be multiplied by a mortality estimate (percent that are dead at the time of harvest) to give an estimate of the quantity of dead discard. Since the DMF does not have a comprehensive onboard observer program, the total catch must be estimated. The following table shows the matrix of Division data that were used to calculate a discard (dead) estimate for the set net gill net fishery in Pamlico Sound and the Pamlico, Pungo, Bay, and Neuse rivers Similar data for other areas in the CSMA are not available.

Data sources used for the discard estimate of striped bass in set gill nets.

Var	Trips	Harvest of striped bass	Yards fished average	Soak time (hours) average	Catch of striped bass (per yard/hour) in number	Catch of striped bass (per yard/hour) in weight	Mortality estimate (percent dead at time fished)
Source	Trip Ticket	Trip Ticket	Fish House Samples	Fish House Samples	DMF Independent gill net (IGN) samples	DMF Independent gill net (IGN) samples	DMF Surveys
Area	Pamlico Sound (code 34), Rivers (29,3,33,52)’		0500 to 052799=Sound, 0528 to 053530=Rivers		0500 to 052799=Sound, 0528 to 053530=Rivers		
Mesh	Large based on >30% fldr, or >5% shad or rock on the ticket, else mesh=small		From interview with fishermen, large >=5 inch and small <5 inch		Large CPUE based on net mesh sets >= 5 in. in the deep strata (gt 6 feet) set parallel to shore, and also shallow sets in months 10 & 11. Small CPUE based on net mesh sets 3.0 to 4.5 in. in the shallow strata		Same as <<←==
Caveat			If a computational cell was missing any of these values then an estimate was used, based on other applicable cells, to complete the calculations				

The discard (dead) estimate = [(number of trips * yards fished *soak hours *IGN cpue) minus the commercial landings] * mortality. A single estimate is produced which is based on the average for the years 2000 and 2001. These years were selected because DMF only had an Independent Gill Net survey ongoing in either the rivers or the Sound during these years.

Calculations were done by month and the results are summarized and presented by the two mesh sizes (small and large) for the two areas (Pamlico Sound and the rivers-Pamlico, Pungo, Bay, and Neuse), and by two seasons Spring/Summer (month 4-10) and winter (month 11,12,1-3) (Tables 10.33 and 10.34).

Results

A summary of the average gill net yardage, soak time and number of trips is given in **Table 10.37. For the four different fishery components the small mesh nets ranged in** yardage from 440 to 820, in number of trips from 858 to 3,489, and in soak time from 12.0 to 23.7 hours. The large mesh nets ranged in yardage from 952 to 1,423, in number of trips from 886 to 3,632, and in soak time from 17.1 to 24.2 hours. The discard (dead) estimate was 94,370 pounds (Table 10.33). While this estimate is based on the best available data, it is only intended to provide a starting point for discussion. The estimate should not be taken as absolute due to a number of limitations in the fishing techniques between the Division IGN survey and the commercial fishery. The most appropriate subset of IGN data was used to mirror commercial practices but these nets are float nets and fish more of the water column than the tied-down commercial nets. Thus, the IGN catch rate of striped bass will be higher. Better estimates will only be possible with observer coverage for all components of the fishery.

Table 10.37. Set gill net parameters and number of commercial trips, average years 2000 & 2001.

Fishery	Season	Mean Yards	Mean Soak Hours	Trips
Pam Sd Large	Winter	1,314	24.4	886
	Spring/Summer	1,423	20.8	3,632
Pam Sd Small	Winter	1,262	23.7	2,315
	Spring/Summer	820	15.4	3,489
Rivers Large	Winter	952	17.1	1,492
	Spring/Summer	1,121	24.1	2,951
Rivers Small	Winter	440	12.0	959
	Spring/Summer	540	12.0	858
Total or Overall Mean		984	18.7	16,582

The size distribution of the striped bass taken in the IGN survey are shown in Figures 10.32 and 10.33. The distribution indicates the size range that is available for harvest. Also shown is the landed catch size distribution for comparison. The commercial fishery is harvesting striped bass mainly in the 18” to 25” total length range.

Discussion

In November 1991 the North Carolina Marine Fisheries Commission adopted a policy directing the DMF to establish the goal of reducing bycatch to the absolute minimum and incorporate that goal into its actions. The general reasons for a species to be discarded can be categorized as follows (1) physical-biological interaction, (2) economic, (3) legal, and (4) personal value considerations. In the case for North Carolina striped bass, the commercial discard is due primarily to the current management measures in place (legal). In looking at ways to reduce discard there are

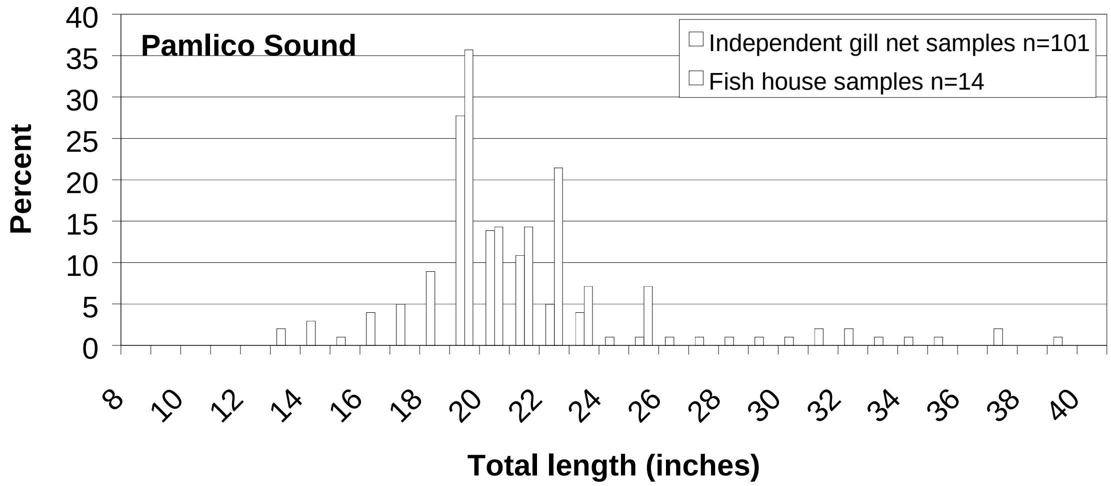


Figure 10.32. Pamlico Sound striped bass length distribution from independent gill net sampling and from samples of the commercial harvest.

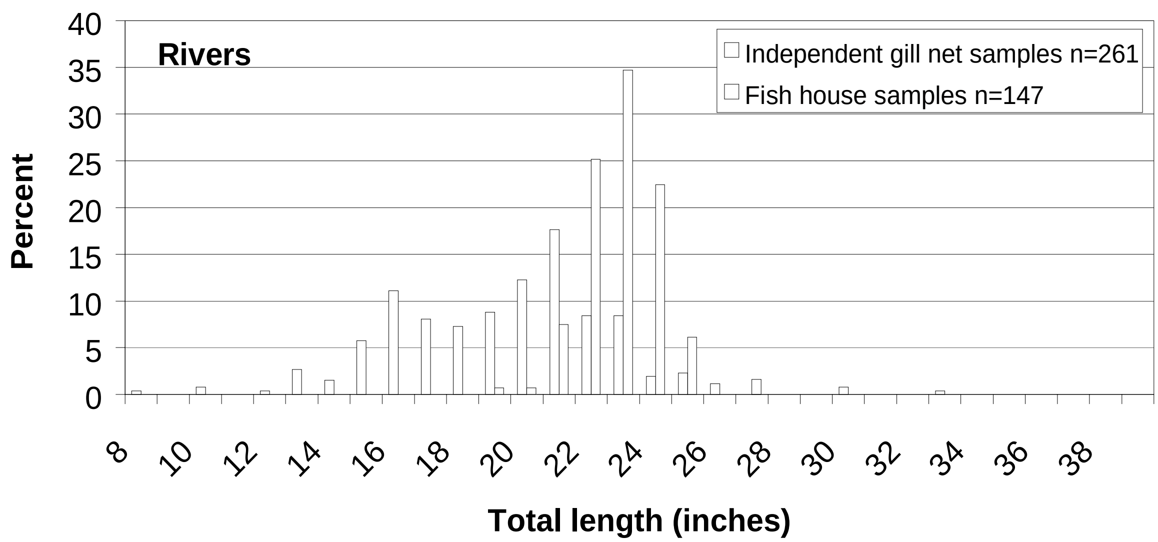


Figure 10.33. Striped bass length distribution from independent gill net sampling and from sampling of the commercial harvest in the rivers.

just three basic ways to accomplish it (Alverson et al. 1994)

- Catch fewer number of the individuals/species.
- Reduce the mortality of the individuals/species being discarded.
- Use a greater spectrum of the species or sizes of species normally caught and discarded.

Gear restrictions (mesh sizes, yardage limits, and attendance) and area (including distance set from shore) and season closures have been used to limit discard losses in a number of North Carolina fisheries. Other regulation based solutions such as effort reduction and incentive/disincentive programs have not been initiated.

Management Options

1. Status quo. No changes to gillnet restrictions

+Ease of implementation
+No disruption of existing fisheries
+No disruption of fishing practices
+No costs from gear modifications
- Continued overharvest
- Continued discard losses

2. Restrict allowable gillnet yardage.

+ Would reduce total effort in some cases
+ Would reduce harvest and discard losses
- \ May disrupt other fisheries
- Appropriate measures difficult to quantify due to lack of on-water observer data

3. Restrict use of 4 – 4 ½" gill net mesh

This mesh is widely used in the Pamlico Sound for a variety of fisheries. There is little information available to use in judging the impacts of restricting this size mesh in the CSMA.
+ Reduced interactions with striped bass
- Overall impacts to Central-Southern fisheries is unknown.
- Current net attendance rules already provides a discard reduction
- Unforeseen circumstances (i.e., switching to other size mesh) could create discard problems in other fisheries or with protected and endangered species

4. Increase net attendance requirements.

Currently gillnets with mesh less than 5" must be attended at all times in the upriver sections of the Pamlico, Pungo, Neuse, and Trent rivers, and when within 200 yards of the shoreline in the down river sections. (15A NCAC 03J.0103.g).
+ Increasing the attendance requirements may reduce overall effort
- Additional burden on fishing operations
- Most of the areas in the Tar and Neuse Rivers already require attendance
- Difficult to evaluate discard reductions achieved from attendance requirements, especially without adequate information on current discard rates.

5. Require net 'tie-downs'

Tie-down requirements could be developed for certain times of the year (e.g., when closed to striped bass harvest), and for certain areas of the CSMA (e.g., portions of the rivers)

+ May reduce striped bass interactions and thus reduce bycatch
- Likely to increase sea turtle interactions and especially deaths if required in the Sound.
- May be infeasible in some areas due to tide intensity

6. Remove gill nets as an allowable gear

+ Would allow current bycatch mortality to be converted to harvest for other fisheries
- Would result in gill net fishermen having to seek alternative gears

Research Needs

1. More at-sea observations made for the gill net fishery to more accurately assess the discards from fishery.
   + Allows for a more accurate account of the unmarketable bycatch and a fuller assessment of what is being caught
   - Increases burden on fishermen to have extra people on board their vessels
   - High cost of running a survey
2. Improvement of trip ticket data to collect gear parameters (yardage, mesh size, etc.).
   + Allow gathering of information that could be used for calculations of total yards fished in a fishery and CPUE for species
   - Increases the amount of time for filling out trip tickets
   - Increases work load for Trip Ticket staff
3. Further investigate the impacts of delayed mortality on striped bass captured in gill nets.
   + Gives a more complete picture of the total losses to the striped bass population
   - Number of delayed mortalities may impact the number of striped bass that could be harvested

DMF, WRC, and FWS Management Recommendation

The only preferred additional management measure is to require 'tie downs' to reduce striped bass bycatch. The DMF is currently evaluating the effectiveness of various tie down configurations at reducing striped bass bycatch. Proposed action

1. <u>Rivers</u> Increase the commercial possession limit to 10 fish per day per commercial fishing operation holder in the rivers during the open striped bass season. Require that gill nets in the shad and flounder fisheries operating in the Pamlico, Pungo and Neuse river areas (west of 76° 30' W long.) be tied down after the striped bass quota is reached and the season closed.

   <u>Pamlico Sound</u> The commercial possession limit would remain at five fish in the Pamlico Sound. Striped bass will be limited to 50% by weight of the total catch, not to exceed five fish per day per fishing operation. Gill nets with a mesh length

of 6 inches (stretched mesh) and greater would be prohibited during the striped bass season.

This option is intended to shorten the “directed” striped bass harvest season and impose the tie down provisions to reduce striped bass bycatch after the season closes. This option will be most effective if the tie down provisions essentially eliminate striped bass interactions. Requiring the 50% weight provisions and prohibiting large mesh gill nets in Pamlico Sound will eliminate the directed fishery.

2. In the remaining portions of the CSMA continue the commercial striped bass seasons, opening and closing through proclamation and operating under the TAC. This option is intended to allow bycatch of striped bass from gill net fisheries. As data are collected, more restrictive measures will be implemented as needed.

MFC Management Recommendation
Support the agencies recommendation with the following modification to 2. As data are collected, measures may be implemented as needed,

C/S Advisory Committee Management Recommendation
The following motions were approved for the CSMA commercial fishery:

Pamlico Sound, Pamlico and Neuse Systems
January 1 to April 15 (shad season) allow a 10 fish striped bass commercial possession limit until the quota is reached, once the quota is reached then require large mesh set nets to be tied down till 15 April. (Passed 5 to 4)

Require large mesh set nets to be tied down from April 15 to December 31 (for areas that will not conflict with sea turtles). (Passed 5 to 4). Prohibit the use of gill nets with a mesh 6 ISM and larger in Pamlico Sound during the open striped bass season.
Support management of remaining portions of the CSMA at Status Quo.
Endorsed the three research needs stated in regards to commercial discards.

EVALUATION OF CSMA STRIPED BASS DISCARD REDUCTION OPTIONS
MAY 12, 2003

Optimum Yield (OY)
As noted in the stock status section of the draft FMP, “Optimum yield is defined as that yield provided by exploiting the stock at the target exploitation rate.” In the CSMA, OY can not be estimated numerically as an annual poundage figure (e.g.Total Allowable Catch = 550,00 pounds) as is done in the ASMA. A quantitative stock assessment for the CSMA was not possible due “to the lack of accurate data on landings and discarding from the recreational fishery, discarding from the commercial fishery, and length and

age composition of the catch." Instead a simple catch curve analysis was used to estimate fishing mortality rates (F) for the Tar/Pamlico and Neuse rivers (a 53% annual removal rate in the Neuse and a 60% rate in the Tar/Pamlico). By comparing these estimated annual rates to the designated target and threshold exploitation levels, it was determined that fishing mortality should be reduced by 61% in the Neuse and 66% in the Tar/Pamlico to prevent overfishing.

Since accurate data on the various fishery components (recreational harvest, recreational discard, and commercial discard) are not known, then the contribution of these components to the overfishing problem is also unknown and subject to speculation. In the same manner, the potential reduction in F from the various management options is not quantifiable because in most cases there is not a quantifiable value to use as a starting point. For example the amount the 4 to 4.5 inch mesh gill nets contribute to the striped bass discard quantity is not known, much less what portion the commercial discard makes up of the overall take of striped bass (another unknown quantity).

Data Needs

As stated many times to the Advisory Committee and as noted in the CSMA Catch Curve Analysis Issue Paper quantitative assessments of Tar and Neuse River striped bass populations are needed. However, "significant additional data are required to enable a thorough assessment of CSMA stocks. Information currently available includes commercial landings and associated biological characteristics, age structured surveys of Tar and Neuse spawning populations, limited migration and movement information from tag recoveries of stocked fish, and limited stock mixing from ASMA tagging programs and tagged stocked fish in the Tar and Neuse Rivers.

DATA NEEDS and POTENTIAL SOURCES

1. Complete landings statistics for recreational fisheries (Creel Survey)
2. Biological characteristics of recreational fisheries (length, weight, age, sex) (Creel Samples)
3. Discard estimates for recreational fisheries harvest and catch (Creel Survey)
4. Biological characteristics of recreational discard (Angler logs or Independent survey)
5. Biological characteristics of commercial catch, including length, age, weight, sex (increased sampling, age structure collection)
6. Discard estimates from commercial fisheries (Trip level observer coverage)
7. Expanded survey coverage, including juvenile abundance and population abundance in the Sounds and lower Rivers (New or expanded surveys)
8. Increased external tagging of stocked fish (Additional tagging effort)
9. Comprehensive tagging of wild fish, including estimation of reporting rates (New Program)
10. Life history information maturity; fecundity; size and weight at age; egg and larval survival (Short term research projects; Federal aid/Universities)".

Consensus Management
While data are lacking and DMF is not able to provide quantitative evaluations of many of the management options, this does not negate the use of a management approach which is based on instituting first hand experience and common sense measures that most individuals would agree would produce reductions in F. These "consensus based" measures would be put in place and data collection programs implemented that in time would be able to produce the data needed to measure the anticipated improvement in F. A starting point may be provided based on the information at hand and using some of the simplifying assumptions for relating exploitations, current landings, and current regulations. The example given in the stock status section helps to illustrate this "If a fishery is regulated with a 10 fish possession limit and it is assumed that most trips land at that limit, the possession limit would need to be reduced to 5 fish to achieve a 50% reduction. If instead it is assumed that most trips only land 6 fish, then achieving the 50% reduction would require reducing the possession limit to 3 fish."

Table 10.38 gives a qualitative evaluation of the discard management options and provides the rationale used for the evaluation.

The goal of the FMP process is to develop plans that ensure the long-term viability of the State's commercially and recreationally significant species or fisheries. The FMP management measures should prevent overfishing, while achieving, on a continuing basis, the optimal yield from each fishery. The degree to which the Commission approved CSMA measures for striped bass will achieve this, will only be determined upon the successful implementation of new data collection programs.

Table 10.38. Striped Bass Discard from Set Gill Nets Management Options Evaluation

	Gear Yardage	Gear Mesh	Gear Attendance	Gear Tie Down	Gear Areas/ Seasons
Measure	Establish a yardage limit on large mesh nets -In the Southern Flounder FMP DMF recommends 3000 yds per person (closed season partial November and December). -CSMA AC suggested 2500 yds	CSMA suggest prohibit use of nets of stretch mesh size 4 to 5.5 in the rivers. This should not include drop or drift nets.	Status Quo	Require large mesh nets to be tied down in the Rivers Year round, when quota met or selected months. See **Figure**s 1-3 If increase possession to 10 fish, quota reached faster and tie downs in effect sooner than at 5 fish level	-Prohibit large mesh nets in the Rivers during January through March or -Prohibit the use of large mesh nets within 200 yards of shore during January through March in the Rivers.
Fishing Mortality Reduction Potential	None	Minimal	None	Substantial	Substantial
	Gear Yardage	Gear Mesh	Gear Attendance	Gear Tie Down	Gear Areas/ Seasons

Table 10.38. (Cotinued)					
	Gear Yardage	Gear Mesh	Gear Attendance	Gear Tie Down	Gear Areas/ Seasons
Rational	-Places a cap on what could be fished in the rivers, even though the suggested limits are greater than the average yardage now set (See **Table** 4 in Commercial Discard Issue Paper,)	-Current net attendance measures address the 3 to 5" mesh discard in the rivers where it is most prevalent, and thus has already provided a significant reduction in discard. Fishermen no longer set so effort and thus striped bass interaction reduced.	Current net attendance measures are in the most appropriate areas and seasons to address the bulk of the small mesh discards.	-DMF conducting a study to quantify possible reduction, ASMA has shown this measure to be effective. -Can only be done in the Rivers because of potential interaction with sea turtles in the Sound	-With no nets eliminates discard from large mesh nets during this time frame -With a shore restriction, lessens interaction with striped bass.
Other Pros (or Cons)	-Might benefit other stocks like flounder -if increase number of possession fish then caps setting more net to target striped bass	Would significantly reduce the hickory shad fishery, which would reduce F for that fishery.	No additional burden on fishermen	-Some upper river fishermen already use tie downs	Spring fishery would become more of a "bycatch" fishery
Limitations	-Does not reduce effort or harvest to any extent -May disrupt other fisheries	Rivers only because a number of economically important sound fisheries use this size webbing (Spanish, bluefish, and speckled trout). If similar fisheries in rivers then they will be impacted. These mesh sizes do take some legal sized striped bass -see **Table** 2.		-If year round will eliminate the shad fishery, See table 3. -May increase gear interaction with other species -May be a problem if implemented in tidal areas or problems with grasses -Causes changes to existing gear; extra time and effort on fishermen	-Would eliminate the spring shad fishery in the Rivers See **Table** 3 -Does not address flounder net discards during the remainder of the year

Table 10.39. Striped bass average total length (TL) by stretch mesh size, Albemarle Sound Independent Gill Net program, 2000 and 2001 combined.

Stretch Mesh	Mean TL (Inches)	Minimum (Inches)	Maximum (Inches)
2.5 inch	11.9	07	21
3.0 inch	14.7	10	22
3.5 inch	16.5	10	23
4.0 inch	17.3	12	23
4.5 inch	18.3	10	22
5.0 inch	19.5	15	24
5.5 inch	20.8	15	29
6.0 inch	22.6	17	27
6.5 inch	23.5	17	27

Table 10.40. Commercial landings and value of American shad in North Carolina, 1972-2002.

	Landings							State Total	
Year	Atlantic Ocean	Albemarle Sound Area	Cape Fear River	Neuse River	Pamlico River	Pamlico Sound	Other Areas	Lb.	$
1972	--	130,399	66,968	81,715	92,799	92,069	4,534	468,484	111,609
1973	--	80,770	32,120	69,526	30,300	105,237	3,047	321,000	85,491
1974	--	116,502	20,219	61,091	32,167	132,926	5,928	368,833	105,668
1975	--	87,063	22,949	27,764	34,157	69,307	0	241,240	82,815
1976	1,547	78,301	7,288	34,161	32,150	13,743	0	167,190	65,227
1977	--	79,594	16,106	6,144	13,432	3,171	2,575	121,022	54,764
1978	5,000	158,908	32,999	31,726	40,908	124,243	8,233	402,017	144,986
1979	25,064	85,158	52,104	31,611	10,971	69,486	3,676	278,070	121,662
1980	3,943	68,695	45,486	11,615	6,430	44,564	18,473	199,206	88,112
1981	107,415	66,732	52,911	15,549	9,761	97,106	2,026	351,500	189,793
1982	63,979	118,794	78,184	18,129	5,080	122,898	4,788	411,852	183,483
1983	3,788	216,058	65,728	45,378	53,794	58,324	2,809	445,879	187,360
1984	13,511	227,308	69,040	70,305	108,410	85,177	10,552	584,843	241,009
1985	3,159	148,555	17,788	56,620	40,675	52,607	10,235	329,639	152,547
1986	63,085	120,367	37,048	70,880	18,138	49,357	14,919	373,794	228,819
1987	41,162	149,923	14,003	47,117	22,640	50,168	2,633	327,646	215,115
1988	50,088	128,061	5,266	15,110	46,607	33,485	4,433	283,050	171,962
1989	38,548	208,807	12,719	13,452	17,012	27,158	5,700	323,396	214,896
1990	37,064	214,954	26,519	11,543	6,520	14,803	2,147	313,550	170,161
1991	19,217	209,900	30,040	2,860	2,568	9,827	2,095	276,507	221,880
1992	23,956	131,499	44,250	13,808	14,231	8,546	2,872	239,162	194,629
1993	28,122	73,631	62,278	8,538	3,033	3,102	86	278,790	149,739
1994	33,895	49,713	10,871	7,216	4,039	4,944	297	110,975	95,703
1995**	102,984	60,953	11,180	15,311	9,573	5,232	634	205,867	188,541
1996**	58,167	65,953	26,818	24,439	8,672	9,115	5,969	199,133	171,625
1997**	98,312	63,736	15,584	17,154	8,985	12,126	3,633	219,530	149,203
1998**	118,017	168,444	11,144	11,715	11,698	5,008	1,533	327,559	233,761
1999**	32,970	70,071	6,804	7,719	6,920	6,054	1,083	131,621	108,142
2000**	110,907	129,584	11,098	9,220	14,671	15,814	6,593	297,887	212,929
2001**	11,839	95,005	12,583	10,674	6,417	9,788	4,779	151,085	108,536
2002**	8,377	175,103	19,185	40,176	14,973	13,902	2,942	274,658	

**Closed season April 15-January 1

Information paper on the gill net tie down study in the Central/Southern Management Area
May 12, 2003

Issue
Comparison of striped bass captured in gill nets with tie downs and without tie downs.

Project Objectives
(1) To determine differences in catch rates of project target species between gill nets with and without tie downs
(2) To determine the difference in catch rates of project target species between nets with different tie down heights

Background
The gill net fishery of North Carolina is a multi-species fishery that operates year around according to the seasonality of commercially marketable species. This fishery varies considerably by area regarding the type of netting used and species targeted. In the river systems a large mesh float gill net fishery occurs in the early spring (February and March) for American shad (Alosa sapidissima). This coincides with other anadromous runs for species such as striped bass.

Striped bass in the Central/Southern Management Area (CSMA) are managed by a size limit, a commercial quota (25,000 pounds), and recreational creel limits. The draft NC Estuarine Striped Bass FMP has determined that the CSMA stocks are overfished. A management measure employed in the Albemarle Sound Management Area (ASMA) is the requirement for 4-foot tie downs in certain gill net fisheries. The impact of a tie down requirement in the rivers of the CSMA need to be quantified, as well as to determine the most effective tie down height.

Study Site
The study started on February 14, 2003 and is ongoing with nets set at locations in the Pamlico, Pungo, and Neuse rivers (Figure 10.34). Sampling areas are selected where the project target species, shad and striped bass, are commonly caught by gill nets. Sampling locations are changed as needed to reflect seasonal/area fishing practices and to capture both project target species. Selections of fishing days were based on fish abundance and sampling conditions. Samples are obtained in a manner to closely resemble commercial fishing practices.

Description of Tie Down & Float Gill Nets
Target species of the study are commonly caught by gill nets set parallel to the shore. Four control and four test nets of varying tie down heights were set (Table 10.41). Tie down heights of 2’, 2.5’, 3’, and 4’ were tested on each sampling day. Each float net without a tie down is 100 yds. long by 12 ft deep. Each sink net with a tie down is 100

Pamlico River

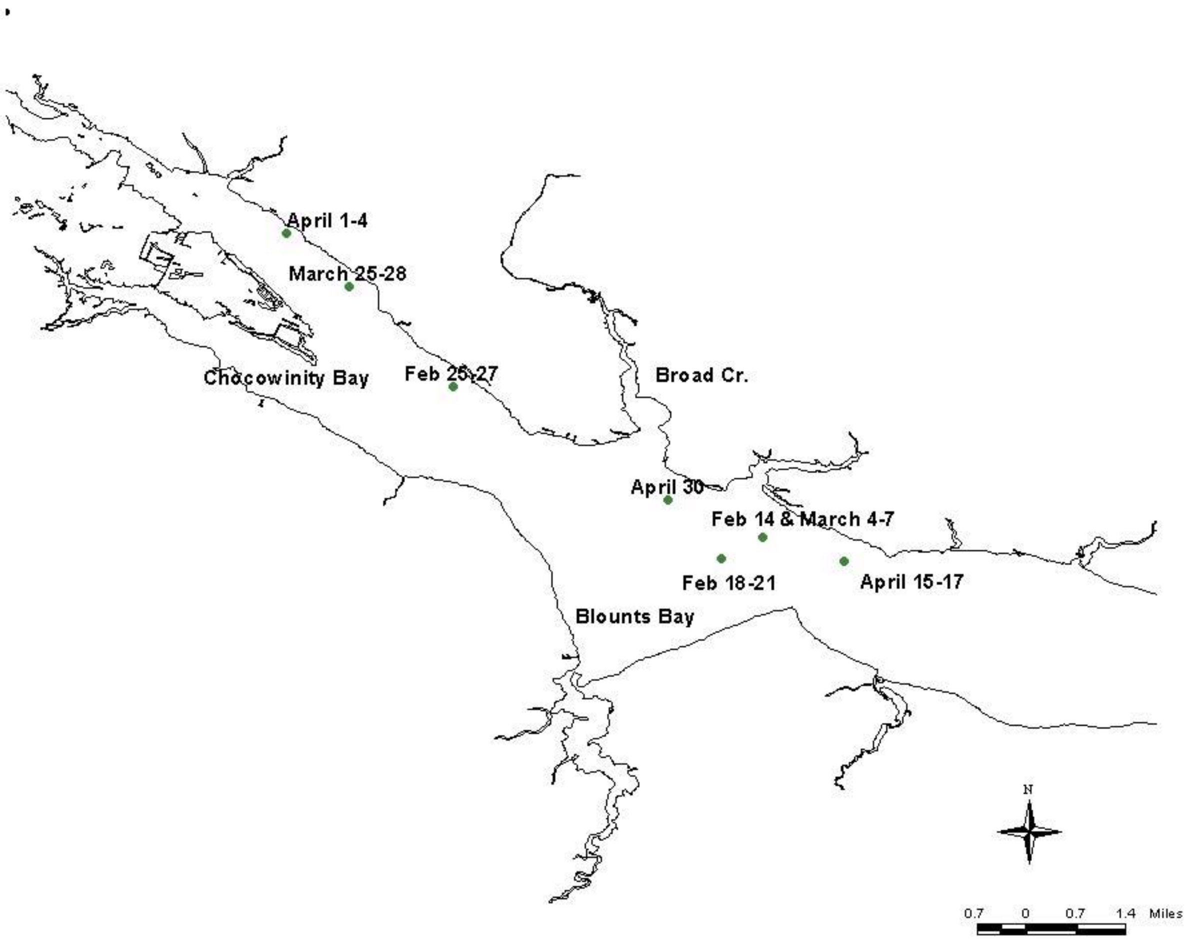


Figure 10.34. Sampling locations for the tie down gill net study from February 14 – April 30, 2003.

Neuse River

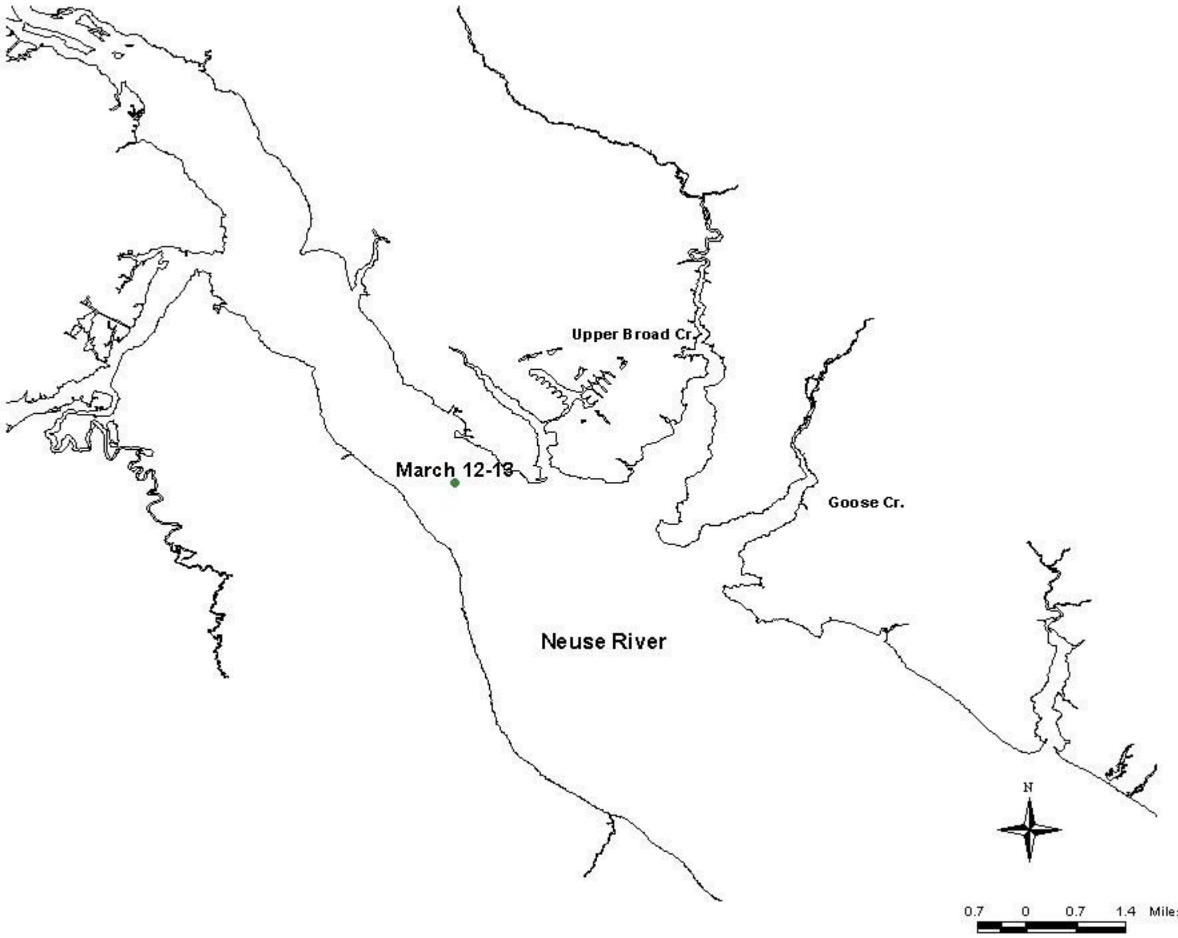


Figure 10.34. (Continued)

Pungo River

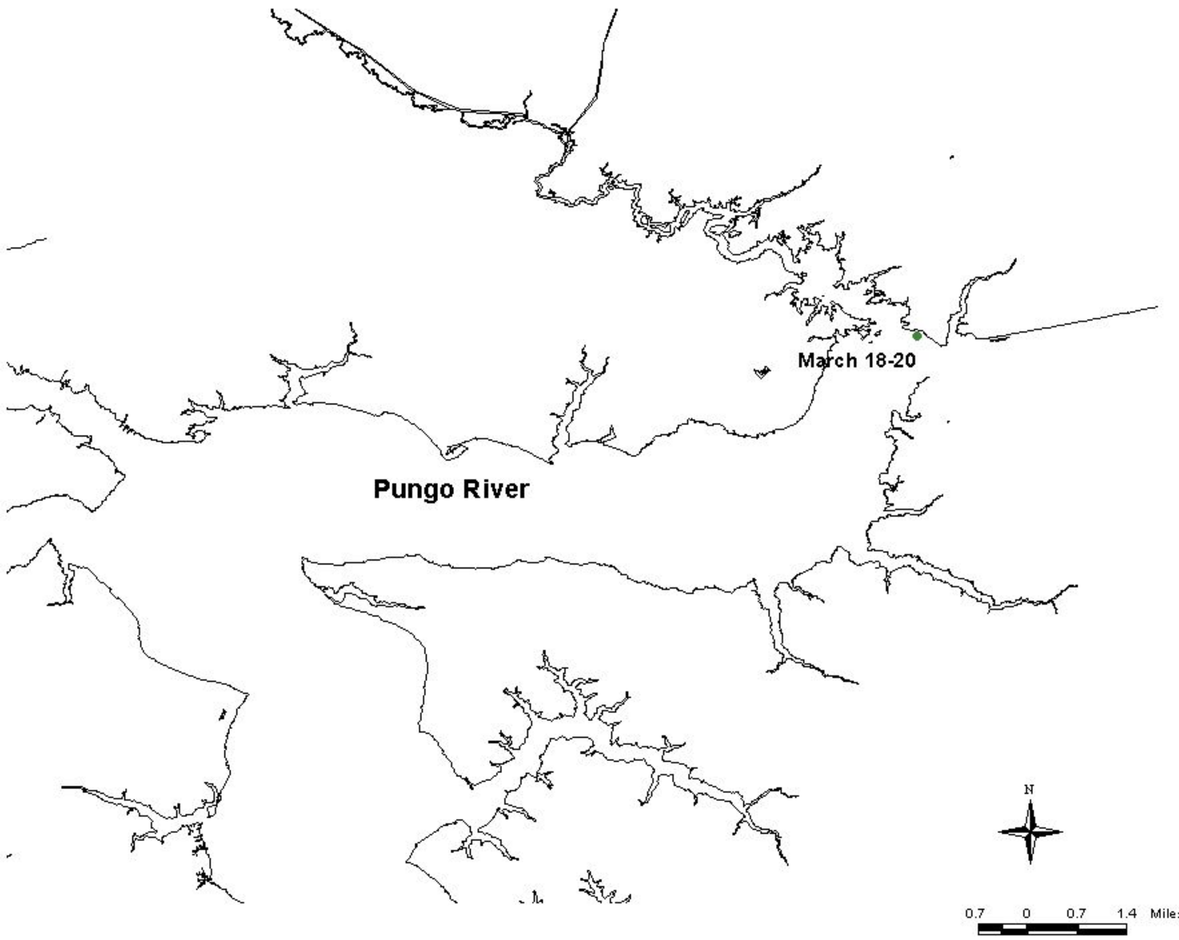


Figure 10.34. (Continued)

Table 10.41. Gill net configurations for the tie down study.

Net #	Net type	Stretch mesh size(in)	Net length (yds)	Net height (ft)	Mesh depth	Twine diameter (mm)
1	Control-float	5 1/2	100	12.0	30	0.33
2	Control-float	5 1/2	100	12.0	30	0.33
3	Control-float	5 1/2	100	12.0	30	0.33
4	Control-float	5 1/2	100	12.0	30	0.33
5	Tie down-sink	5 1/2	100	2.0	20	0.33
6	Tie down-sink	5 1/2	100	2.5	20	0.33
7	Tie down-sink	5 1/2	100	3.0	20	0.33
8	Tie down-sink	5 1/2	100	4.0	20	0.33

yds by 8 ft deep. All nets were constructed of number 104 (0.33 mm) diameter monofilament webbing hung on a 1 to 2 ratio and are a 5 1/2-inch stretched mesh. Each net is inspected for damage upon retrieval. Damage to each net is maintained below 10% of the total surface area. On each set, nets are placed to minimize differences in physical influences such as bottom contours, distance from channels, etc. Nets are set in the afternoon and checked in the morning with a target soak time of 18 to 24 hours which is consistent with commercial practices.

Processing of Field Samples

The total number of each target species, including damaged individuals, was counted. Lengths of undamaged specimens were measured to the nearest millimeter (FL) and (alive and dead) were recorded. A group weight was recorded to the nearest 0.1 kg for each target species. All other marketable species were sorted to species, counted, measured to the nearest mm (FL or TL), weighed as a species group, and alive versus dead condition of fish are recorded. Species such as menhaden, carp, suckers were counted and a grouped weight recorded. Environmental conditions such as temperature (°C), salinity (ppt), dissolved oxygen (mg/L), wind direction, and wind velocity were recorded upon retrieval of the nets on each sampling trip.

Preliminary results

Hybrid striped bass are considered striped bass according to the North Carolina Fisheries Rules for Coastal Waters (15A NCAC 3M .0201) and for analysis purposes combined in the total striped bass catches from this study (**Table 10.42**). From February 14, 2003, 29 trips were completed and sampling is still ongoing. The gill nets were set from 20-1,500 yards from shore in the three river systems, with the majority of the trips in the Pamlico River (n=24). Other finfish species besides striped bass captured included American shad, hickory shad, white catfish, menhaden, southern flounder, speckled trout, longnose gar, bowfin, carp, white catfish, brown bullhead catfish, gizzard shad, silver redhorse, and creek chubsucker.

Table 10.42. Total catch (kgs) and total number of striped bass captured in each trip of the gill net tie down study from Feb. 14-Apr. 30, 2003.

	Tie downs			Controls					
River system/ Date	# striped bass	# A. shad	Total catch in tie downs (lbs.)	# striped bass	# A. shad	Total catch in controls (lbs.)	Distance from shore (yds.)	Latitude	Longitude
14-Feb-Pamlico	0	3	51.46	0	5	180.21	780	3527.77	7655.88
18-Feb-Pamlico	2	9	121.80	0	14	382.92	1,500	3527.51	7656.38
19-Feb-Pamlico	1	18	141.45	0	21	439.85	1,500	3527.51	7656.38
20-Feb-Pamlico	0	1	79.95	0	8	300.01	1,500	3527.51	7656.38
21-Feb-Pamlico	0	2	66.24	0	13	368.92	1,500	3527.51	7656.38
25-Feb-Pamlico	0	0	48.18	0	8	158.58	400	3529.60	7659.64
26-Feb-Pamlico	6	0	44.36	3	15	245.35	400	3529.60	7659.64
27-Feb-Pamlico	1	5	33.49	1	8	157.44	400	3529.60	7659.64
04-Mar- Pamlico	2	1	59.38	0	11	208.00	780	3527.77	7655.88
05-Mar-Pamlico	0	3	38.64	2	13	184.14	780	3527.77	7655.88
06-Mar-Pamlico	0	0	24.39	1	26	210.45	780	3527.77	7655.88
07-Mar-Pamlico	0	3	42.60	4	18	240.17	780	3527.77	7655.88
12-Mar-Neuse	0	0	36.87	0	11	126.50	600	3503.38	7659.28
13-Mar-Neuse	0	0	30.21	0	2	75.41	600	3503.38	7659.28
18-Mar-Pungo	4	0	74.31	13	0	427.70	20	3533.25	7627.75
19-Mar-Pungo	0	0	93.21	2	0	391.72	20	3533.25	7627.75
20-Mar-Pungo	0	0	188.24	0	0	647.23	20	3533.25	7627.75
25-Mar-Pamlico	0	0	31.22	1	13	187.60	400	3530.81	7700.90
26-Mar-Pamlico	0	5	33.78	0	16	154.75	400	3530.81	7700.90
27-Mar-Pamlico	1	0	34.51	0	13	150.65	400	3530.81	7700.90
28-Mar-Pamlico	0	0	21.72	1	7	120.44	400	3530.81	7700.90
01-Apr-Pamlico	0	0	73.71	1	11	243.43	150	3531.46	7701.65
02-Apr-Pamlico	0	0	64.61	1	12	183.30	150	3531.46	7701.65
03-Apr-Pamlico	0	0	56.82	0	13	208.31	150	3531.46	7701.65
04-Apr-Pamlico	0	0	54.97	0	13	183.39	-	3531.46	7701.65
15-Apr-Pamlico	0	0	6.59	0	10	99.14	600	3527.48	7654.90
16-Apr-Pamlico	0	0	20.24	0	6	90.01	600	3527.48	7654.90
17-Apr-Pamlico	0	0	8.03	0	2	65.95	-	3527.48	7654.90
30-Apr-Pamlico	0	0	56.49	0	4	267.16	700	3528.22	7657.03
Total	17	50	1,637.49	30	287	6,698.72			

Total catches of all species combined were four times higher in the control nets with the catch per trip ranging from 65.95-647.23 lbs./trip and average 230.99 lbs./trip The tie down nets caught between 6.59-188.24 lbs./trip with an average of 56.45 lbs./trip.

A total of 17 striped bass was captured in tie down gill nets and 30 in the control gill nets. Although almost half the number of striped bass were captured in the tie down nets as compared to the control gill nets, the numbers are still too low to quantify a reduction in capture of striped bass from gear modifications using tie downs. Differences between the catch rate and tie down height cannot be estimated at this time due to the low numbers captured overall. The number of American shad were greatly reduced in the tie down nets (Table 10.42). A total of 50 American shad was captured in all trips in the tie down nets while 287 were captured in the control gill nets. Preliminarily, these findings suggest tie down gill nets could negatively impact the shad fishery in the river systems.

11.0 RECOMMENDED MANAGEMENT PROGRAM AND RESEARCH NEEDS

11.1 Goals and Objectives

The goal of the North Carolina Estuarine Striped Bass Fishery Management Plan (FMP) is to manage estuarine striped bass populations through science based decision-making processes that conserve adequate spawning stock and protect the integrity of critical habitats. The plan will consider biological, social, and economic factors in management of the fisheries. The plan will be adaptive, involving regular reviews and responding to new information regarding any aspect of the plan.

To achieve these goals the following objectives must be met:

1. Identify and describe population attributes necessary to sustain long-term stock viability.
2. Protect, restore and enhance spawning and nursery area habitat and environmental quality to increase growth, survival and reproduction of striped bass.
3. Manage the fishery in a manner to sustain long-term stock viability, traditional harvest and prevent overfishing.
4. Initiate, enhance and/or continue programs to collect and analyze biological, social, economic, fishery, essential habitat and environmental data needed to effectively monitor and manage the striped bass fishery.
5. Develop an information program to educate the public and elevate awareness of the causes and nature of problems in the striped bass stocks, habitat and fisheries, and explain the rationale for management efforts to solve these problems.
6. Develop regulations that provide adequate resource protection, optimize yield from the fishery, and consider the needs of all user groups.
7. Promote practices that minimize bycatch and discard mortality in recreational and commercial fisheries.

11.2 Optimum Yield

The FRA mandates that fishery stocks be managed to produce Optimum Yield (OY). The following information is presented to illustrate how the available information on the two management units can be used to define OY. Specific values are subject to change pending review and final approval of the FMP.

11.2.1 Optimum Yield for the Albemarle-Roanoke Stock (Albemarle Sound Management Area, ASMA)

Optimum yield is defined as that yield provided by exploiting the stock at the target exploitation rate as determined from the most recent stock assessment.

This definition of OY is in accordance with current management procedures. The stock is currently managed with a Total Allowable Catch (TAC) that is analogous to OY. The TAC for 2003 was conservatively established at 550,000 pounds based on a target reference point of F= 0.25. The target reference point recommended by the Albemarle-Roanoke Advisory Committee is F= 0.22.

Establishing OY as a static value rather than a specific fixed value allows yield to vary with stock conditions. If growth and recruitment are favorable and the stock is highly productive, OY may increase over time. Conversely, if growth and recruitment decline, OY may decrease over time. Such an approach is often desirable when considering a stock such as this for which reliable and acceptable estimates of absolute stock abundance at maximum productivity are not available. The A/R stock has recovered from past overfishing, in that it is not overfished and overfishing is not occurring. However, although stock abundance appears near optimal levels, much of the population remains at relatively low ages, while spawning stock biomass continues to increase and the age structure of the population continues to expand.

Because OY is defined relative to stock abundance, stock status must be routinely evaluated. The stock is currently assessed and quotas established annually, although assessment frequency could be decreased to every 2nd and 3rd year without undue risk now that the stock is considered recovered. . Reducing the frequency of assessments and quota evaluations could provide several benefits: (1) reduced time demands on analytical personnel and quota evaluations could enable additional work on other striped bass stocks, (2) increasing the time between assessments allows for better evaluation of management changes, (3) establishing quotas for several years at a time reduces year to year variability in management actions.

11.2.2 Optimum Yield for the Pamlico-Tar River and Neuse River Stocks (Central-Southern Management Area, CSMA)

Optimum yield (OY) is defined as the yield achieved by exploiting the stock at the target exploitation rate.

The OY as defined for the CSMA differs slightly from OY for the ASMA in that a value for OY is not predetermined. The lack of accurate data on landings and discarding from the recreational fishery, discarding from the commercial fishery and length and age composition of the catch prevents development of a quantitative assessment of stock abundance. Therefore, no projections of stock abundance and total catch rates are available for the CSMA and OY cannot be estimated numerically in advance.

Until data for a complete assessment of these stocks are available, the only recourse is to manage based on exploitation rates. Such a restriction is not a major impediment, as many stocks are managed successfully by controlling exploitation rates. One obvious example is striped bass in the ASMA, but others include striped bass of the Atlantic migratory stock, summer flounder, weakfish, king and Spanish mackerels and red drum. When managing by exploitation rate, regulatory changes are developed by making a simplifying assumption that landings are proportional to exploitation (This is true to the extent that population abundance and availability to the fisheries do not vary from year to year). For example, if a 50% reduction in exploitation is necessary, regulations are adopted that will provide a 50% reduction in landings. If no information on landings is available, further assumptions must be made as to the relationship between current landings and current regulations. Continuing the same example for a 50% reduction in exploitation, if a fishery is regulated with a 10 fish possession limit and it is assumed that most trips land at that limit, the possession limit would need to be reduced to five fish. If instead it is assumed that most trips only land six fish, then achieving that 50% reduction would require reducing the possession limit to three fish.

11.3 Strategies

The strategies listed below outline the need for additional data in order to improve the ability to assess the status of the striped bass stocks. These actions have to be accomplished in order to meet the goals and objectives of the FMP. All new work and expansion of programs will require additional personnel, equipment and operating funds.

11.3.1 North Carolina Coastal Stocks

11.3.1.1 Water Flow Issues (Section 10.2.1.1)

Issue

To identify impacts to aquatic habitats, which occur as a consequence of flow modifications, and develop strategies to eliminate or minimize impacts.

Management Recommendations/Proposed Action

For rivers which are presently unregulated work with North Carolina and/or Virginia and South Carolina water resource authorities as appropriate, to secure commitments for preservation of the unaltered flow regimes.

For rivers which are presently regulated to such a degree that flow patterns depart significantly from an unregulated condition, establish a recommended annual flow regime for striped bass spawning and nursery areas, and work with the appropriate regulatory agencies to secure commitments for preservation of such a regime.

Require North Carolina Division of Water Resources to include Division of Water Quality, Wildlife Resources Commission, Division of Marine Fisheries and US Fish and Wildlife Service in the local water supply planning process and in future water allocation negotiations. Where needed, water allocation for riverine fish habitat (in particular striped bass spawning and nursery habitat) should be obtained by these natural resource agencies.

Specific Management Recommendations by River Basin

Neuse River
Support removal of Milburnie Dam, to provide more flexibility for flow management.

Conduct IHA and RVA analysis of Neuse River flows, and submit the resultant flow regime to the USACOE for implementation.

Pee Dee River
Participate (USFWS and NCWRC, in cooperation with SC agencies) in the relicensing of dams, with a goal of obtaining adequate quantity and timing of flow releases for all downstream striped bass habitats.

11.3.1.2 Critical Habitat- Spawning and Nursery Areas (Section 10.2.1.2)

Issue
Protection of critical habitat areas and identification of spawning and nursery area habitat.

Management Recommendations/Proposed Action
Advocate the adoption of DMF already identified anadromous spawning and nursery areas for striped bass into rules.

Advocate stronger enforcement of regulations protecting critical habitat in the management areas.

Purchase land adjacent to critical habitat areas to ensure that these areas are protected. This should include the acquisition of approved refuge lands on the Roanoke River.

Continue to make recommendations on all state, federal and local permits where applicable.

Support implementation of habitat recommendations of the Albemarle-Pamlico Estuarine Study, the Estuarine Shoreline Protection Stakeholders Report, Coastal Habitat Protection Plans and Critical Habitat Protection Plans.

Maintain, restore and improve habitat to increase growth, survival and reproduction of striped bass. Monies from the Clean Water Trust Fund and others should be utilized for this.

11.3.1.3 Blockages of Historical Habitat (Section 10.2.1.3)

Issue
To identify blockages to historical spawning areas and develop strategies to minimize impacts from the blockages.

Management Recommendations/Proposed Action

Neuse River
Support the removal of Milburnie Dam in Raleigh. Removal of this dam would open another 20 miles of spawning habitat and allow better manipulation of flows from Falls of the Neuse Reservoir for spawning anadromous species. It would be advantageous to American shad and hickory shad spawning runs, in addition to striped bass.

Cape Fear River
Support the removal of Buckhorn Dam and Lock and Dam #2 and #3 and a new fish passage route around Lock and Dam #1. Striped bass would be able to return to historical spawning grounds. A striped bass and other anadromous species fishery would be able to develop upstream.

11.3.1.4 Entrainment and Impingement of Eggs and Larvae (Section 10.2.1.4)

Issue
Striped bass eggs, fry and juveniles are removed from coastal rivers through water withdrawals.

Management Recommendations/Proposed Action
DMF and WRC have no direct authority to regulate facilities that withdraw water from coastal rivers.

Continue to give close attention to state and federal permit requests in which water withdrawal structures are involved in coastal rivers. Agency comments on proposed water intakes should, where data are available, provide estimates of striped bass eggs, fry, and juveniles that could potentially be lost.

Monitor the progress of USEPA's implementation of Section 316(b) rules as these rules may apply to water withdrawal points in North Carolina's coastal rivers.

In the absence of effective exclusion technology, require water users to curtail withdrawals during periods in which striped bass eggs, fry, and juveniles may be present.

11.3.1.5 Water Quality Concerns (Section 10.2.2)

Issue
Identification of water quality concerns in the striped bass management areas.

Management Recommendations/Proposed Action
Work in coordination with agencies such as the Division of Water Quality, Division of Water Resources, Division of Land Quality, and Natural Resource Conservation Service to maintain, restore and improve water quality to increase growth, survival and

reproduction of striped bass. Priority activities identified include the establishment of buffer strips and conservation easements within each basin, and the continued refinement of best management practices on lands used primarily for agriculture, silviculture and industrial and residential development.
Support implementation of recommendations of DWQ basinwide water quality management plans, particularly measures that will reduce nutrient loading, sediment delivery and associated turbidity in all coastal watersheds.
Support implementation of habitat and water quality recommendations of Coastal Habitat Protection plans (CHPPs), the Estuarine Shoreline Protection Stakeholders report (1999), and the Albemarle-Pamlico Estuarine Study (1994) which includes the Comprehensive Conservation and Management Plan (CCMP).

11.3.2 Management Strategies

11.3.2.1 Catch and Release Mortality in Hook and Line Fisheries (Section 10.2.3)

Issue

A portion of striped bass caught and released in the hook and line fisheries die as a result of injuries or physiological stress.

Management Recommendations/Proposed Action

Agencies and C/S AC support status quo until the creel surveys are complete in the CSMA.)

1. The numbers of striped bass caught and released on a year-round basis may be substantial. Creel surveys will be necessary to estimate numbers of striped bass caught and released as well as directed angling effort for striped bass. Once numbers of striped bass caught and released are estimated, differential mortality rates from other studies can be applied to those numbers to estimate catch and release mortality. These estimates are necessary as a part of estimating total annual fishing mortality, the management of which is imperative to the long-term perpetuation of the stock. WRC and DMF agree that catch and release fishing for striped bass is an acceptable component of the recreational fishery however, until the magnitude of striped bass losses from this component is estimated, objective policy decisions concerning acceptable levels of striped bass losses cannot be made.

2. Observations by WRC and DMF indicate that directed angling effort for striped bass diminishes significantly once harvest seasons are closed in both the Roanoke River and Albemarle Sound Striped Bass Management Areas. Therefore, as an interim measure to minimize striped bass mortality from catch and release fishing, WRC and DMF recommend that striped bass harvest seasons be considered in months (October – April) in which cool water temperatures (<70°F) occur and/or only in certain portions if rivers and sounds deemed necessary.

3. An extensive angler education program on catch and release striped bass fishing should be implemented. Components of the program would include understandable presentations of scientific research findings on the effects of water temperature, angling

techniques, hook configurations, bait and lure use, and handling of striped bass. Continued research on identifying the correct sizes and configurations of circle hooks is needed to develop effective methods of reducing deep hooking of striped bass in the natural bait component of the fishery.

11.3.2.2 Enforcement of Creel Limits in the Vicinity of Inland/Joint or Coastal Boundaries (Section 10.2.4)

Issue

Division of Marine Fisheries (DMF) and Wildlife Resources Commission (WRC) enforcement officers may be faced with problems with the enforcement of striped bass recreational creel limits at or near the jurisdictional boundaries between Inland and Joint or Coastal Waters or at the boundaries between different striped bass management areas due to different creel limits, size limits or legal possession limits.

Management Recommendations/Proposed Action

The simplest solution to this confusion, if it exists, is to publicize to anglers in the vicinity of these boundaries that when you are checked by an enforcement officer of either agency, you cannot have in possession more than the creel limit for the waterbody you are in while actively engaged in fishing.

In order to promote complete clarity; encourage the WRC to implement a rule similar to the MFC Rule that states you must be in compliance with the restrictions in place at the point you are checked. The MFC Rule reads, “It is unlawful to possess any species of fish which is subject to size or harvest restrictions, while actively engaged in a fishing operation, unless all fish are in compliance with the restrictions for the waterbody and area being fished”.

11.3.2.3 Albemarle Sound Management Area Boundary Line (Section 10.2.5)

Issue

Review the Albemarle Sound Management Area southern boundary line.

Management Recommendations/Proposed Action

Support Status Quo, No shift in the Boundary Line and support the research needs. The Boundary line was established to provide a migratory corridor for the Albemarle-Roanoke stock of striped bass. As currently established, the line accomplishes this goal. The line also provides a delineation point for allocating harvest to management areas, and is believed to encompass the primary areas inhabited by the Albemarle-Roanoke stock. Moving the line northward would likely exacerbate the problem of stock mixing, and contribute to a significant bias in assessment calculations for the Albemarle-Roanoke, Tar River, and Neuse River stocks. Furthermore, in all likelihood such a shift would lead to potential increases in commercial discard and recreational harvest losses.

11.3.3 Albemarle/Roanoke Striped Bass Stock

11.3.3.1 Biological Reference Points (Section 10.3.1.1)

Issue
Estimation of biological reference points and management targets.

Management Recommendations/Proposed Action

Overfishing and Overfished definitions
The DMF and WRC recommend that the overfishing definition be based on the threshold exploitation rate: *Overfishing will occur when the exploitation rate exceeds the threshold exploitation rate.*

The DMF and WRC recommend that the overfished definition be based on the biomass threshold: *The stock will be overfished if biomass falls below the threshold*.

Management Recommendation
Support a F rate of 0.22 and a threshold of 400,000 pounds of SSB for the A/R stock.

11.3.3.2 Discard Mortality of Striped Bass in the Multi-species Gill Net Fishery-ASMA Section 10.3.2.1)

Issue
Investigation of bycatch and discards of striped bass in the multi-species, anchored gill net fishery in the Albemarle Sound Management Area (ASMA).

Management Recommendations/Proposed Action

Maintain status quo, existing gill net proclamation authority, with requirement that small mesh gill nets be sunk after river herring gill net season closes. Small mesh gill nets (3 ¼ inch) would be restricted to no more than 25 – 30 meshes deep and set in no less than 7 feet of water unless attended. These requirements would remain in effect when attendance was not required. Also, consider area closures to gill netting.
The following qualifications will also apply: 1. DMF will evaluate existing IGNS small mesh data to determine differences between striped bass catches in float and sink gill nets. 2. Observer data, current and new will be collected and analyzed to assess the benefits. Should the discard reductions not be within the estimated range of the other options in Table 10.14, then DMF may implement other options of the FMP, or options that may be developed over time.

11.3.3.3 Management of Quotas and Harvest Targets in the ASMA (Section 10.3.3.1)

Issue
Management of quotas and harvest targets for the ASMA and RRMA.

Management Recommendations/Proposed Action
Supports no payback for overages in RRMA due to underage in 2003.

Supports TAC allocation: 25% Roanoke River/WRC recreational, 25% Albemarle Sound/DMF recreational and 50% Albemarle Sound/DMF commercial.

Penalties/Triggers for Overages: Short-term Overage: point harvest estimate exceeds the total TAC by 10% in a single year, overage deducted from the next year and restrictive measures implemented in the responsible fishery (ies). Long-term Overages: five year running average of point estimate exceeds the five year running average of the total TAC harvest by 2%, the responsible fishery exceeding the harvest limit will be reduced by the amount of the overage for the next five years. Should the target F be exceeded, then restrictive measures will be imposed to reduce F to the target level.

11.3.3.4 Recreational Striped Bass Harvest Closure Atlantic Ocean (Section 10.3.3.2)

Issue
Increased harvest of striped bass 28 inches TL and larger during the late spring through the summer.

Management Recommendation
Support Status Quo- continue to allow harvest year round.

11.3.4 Central/Southern Striped Bass

11.3.4.1 Biological Reference Points (Section 10.4.1.1)

Issue
Estimation of biological reference points and management targets.

Management Recommendations/Proposed Action
The DMF, WRC and FWS recommends that the CSMA stocks be managed under the same exploitation rate targets and thresholds (F=0.22, SSB= 400,000 pounds) as selected for the Albemarle-Roanoke stock. The DMF and WRC advises that no biomass thresholds or targets are available for the other stocks, due to a lack of data. Data collection needs for biomass targets and threshold levels can be developed as listed in the research needs.

11.3.4.2 Striped Bass Stocking in Coastal River Systems (Section 10.4.2)

Issue
Stocking striped bass in NC coastal rivers.

Management Recommendations/Proposed Action
Support continuing the Phase II striped bass stocking program (all fish OTC marked, portion marked with external tags), with two systems in the C/S Management Area (Tar-Pamlico, Neuse and Cape Fear rivers) being stocked annually, with a goal of 100,000 fish per system. DMF supports the research needs.

Support continuing the Phase I striped bass stocking program (all fish OTC marked), with a goal of 100,000 fish per year, per system in the C/S Management Area (Tar, Neuse, and Cape Fear/Northeast Cape Fear rivers) annually. WRC supports the research needs.

11.3.4.3 Catch Curve Estimates/Management Options for Neuse River and Tar-Pamlico River Striped Bass Stocks (Section 10.4.3.1)

Issue
Estimation of survival and exploitation rates for the Central and Southern North Carolina stocks of striped bass through catch curve analysis.

Management Recommendations/Proposed Action
Recreational Fishery Management Measures
Adequate information to evaluate specific recreational measures is lacking in the CSMA. Regulations should remain at status quo for 2004. A one year creel survey is being developed by DMF and WRC for the Tar-Pamlico and Neuse systems. The WRC in 2004 will be conducting a creel survey in the Cape Fear system. These surveys will collect data on the recreational striped bass fisheries in these waters. After completion of the creel survey the data will be analyzed and appropriate regulations implemented as needed for the stocks.

Commercial Fishery Management Measures
Commercial fishery gill net restrictions have been enacted over the last several years, as a result of the Red Drum FMP and endangered species interactions. Large areas of Pamlico Sound are closed to gill netting from August 15 – December 15, and other areas have strict permitting and gear restrictions. Attendance is required of gill nets within the upper rivers and within 200 yards of shore in lower river portions.

Comprehensive DMF gill net sampling within Pamlico Sound indicates extremely low catch rates of striped bass. Therefore, it is unlikely that gill net fisheries in the Sound are responsible for significant bycatch losses, and management efforts should instead focus on reducing striped bass interactions in the rivers. With the exception of the allowance of 4 –4 ½ inch mesh, many of the gill net restrictions imposed in Albemarle Sound are already required in the rivers of the CSMA.

Commercial Fishery Management Measures- see Section 11.3.4.4

11.3.4.4 Discard Mortality of Striped Bass from Set Gill Nets in the Central/Southern Management Area (CSMA) (Section 10.4.3.2)

Issue

Investigation of discards of striped bass in the multi-species, set gill net fishery in the Central Southern Management Area (CSMA).

Management Recommendations/Proposed Action

The only preferred additional management measure is to require 'tie downs' to reduce striped bass bycatch. The DMF is currently evaluating the effectiveness of various tie down configurations at reducing striped bass bycatch. Two alternatives were developed:

Rivers: Increase the commercial possession limit to 10 fish per day per commercial fishing operation in the rivers during the open striped bass season. Require that gill nets in the shad and flounder fisheries operating in the Pamlico, Pungo and Neuse river areas (west of 76° 30'W long.) be tied down after the striped bass quota is reached and the season closed.

Pamlico Sound: The commercial possession limit would remain at five fish in the Pamlico Sound. Striped bass will be limited to 50% by weight of the total catch, not to exceed five fish per day per commercial fishing operation. Gill nets with a mesh length of 6 inches (stretched mesh) and greater would be prohibited during the striped bass season.

This option is intended to shorten the "directed" striped bass harvest season and impose the tie down provisions to reduce striped bass bycatch after the season closes. This option will be most effective if the tie down provisions essentially eliminate striped bass interactions. Requiring the 50% weight provisions and prohibiting large mesh gill nets in Pamlico Sound will eliminate the directed fishery.

In the remaining portions of the CSMA continue the commercial striped bass seasons, opening and closing through proclamation and operating under the TAC. This option is intended to allow bycatch of striped bass from gill net fisheries. As data are collected, more restrictive measures may be implemented as needed.

11.4 Research Needs Summary

The following research needs were compiled from those listed in the issue papers in Section 10. Proper management of the striped bass resources is dependent upon most of these research needs being met. The MFC, DMF, WRC and both AC's support all of the research needs.

11.4.1 NC Coastal Striped Bass Stocks

Water Flow
Examine historical striped bass data sets from NC rivers to determine if sufficient information exists to evaluate relationships between striped bass life history stages and water flows.

Should there be insufficient data to evaluate relationships between striped bass life history stages and flow within a given river, such data should be collected for a sufficient length of time to allow determination of such relationships.

When implementing changes to flow regimes on any NC river, agencies must conduct appropriate field monitoring of striped bass life stages to document any response.

Critical Habitat
Re-evaluate the spawning and nursery area surveys conducted previously (Tar-Pamlico, Neuse, Cape Fear, etc.).

Identify potential incentives to landowners for protection of riparian buffers in the management areas.

Develop, identify and clarify what critical habitat needs are to protect, enhance and restore habitats and water quality utilized or required by striped bass.

Entrainment and Impingement
The magnitude and seasonal timing of agricultural water withdrawals from coastal rivers is unknown. The Division of Water Resources and the Division of Water Quality should require documentation of all withdrawals, so that the extent of entrainment of striped bass eggs, fry and juveniles can be estimated.

Data on the density and distribution of striped bass eggs, fry and juveniles in coastal rivers are needed so that potential losses can be estimated.

Identify effective engineering solutions to prevent entrainment and impingement of striped bass eggs, fry and juveniles.

Research is needed to determine the fate of striped bass eggs, fry and juveniles that are impinged, then released through screen cleaning operations.

Water Quality
Membrane Water Treatment Plants: Evaluate the impacts/effects of reverse osmosis

plants on receiving waters and aquatic resources.

Water Quantity: Evaluate the effects of existing and future water withdrawals on water quality and quantity and fisheries habitat in coastal watersheds.

Contaminants: Determine if contaminants are presence and identify those that are potentially detrimental to various life history stages of striped bass. Specific areas of concern include the lower Neuse, Pamlico and Roanoke rivers.

Catch and Release Mortality- Hook and Line Fisheries
Clarify relationships between salinity, dissolved oxygen, temperature and catch and release mortality rates of striped bass in the Albemarle Sound Management Area (ASMA) and the Central/Southern Management Area.

Determine the seasonal magnitude of striped bass angling effort, catch and harvest for NC rivers and coastal waters outside the Roanoke River/ASMA.

Socioeconomic
Collect comprehensive socioeconomic data in the commercial fishery that will allow for estimates by species based on gear usage and water body.

Collect data on recreational fishermen who use commercial gear and target striped bass.

Collect comprehensive socioeconomic data, including catch statistics and angler demographics in a single data collection effort of recreational fishermen who target striped bass in all water bodies where striped bass are routinely harvest.

Collect landings data from recreational fishermen who target striped bass in the areas of the Tar-Pamlico, Neuse, Trent and Cape Fear rivers not already covered by MRFSS.

Conduct a socioeconomic survey of “for hire” guides, particularly in the ASMA, as they account for an increasingly significant number of recreational trips for striped bass.

Tagging Program
Comprehensive tagging program.

Increased external tagging of stocked Phase II striped bass (additional tagging effort).

Comprehensive tagging program of wild fish, including estimation of reporting rates. Thorough evaluation and analysis of stocking programs.

Albemarle Sound Management Area Boundary Line
Accurate information on stock mixing in the sounds and rivers of NC is required to enable unbiased evaluation of stock abundance. This may be achieved through a

comprehensive tagging program.

Accurate information on migratory patterns and movements of striped bass from the CSMA stocks needs to be determined. This may be achieved through a tagging program.

Accurate catch statistics, adequate biological sampling, and fishery-independent survey data for CSMA stock are required to allow accurate stock assessment. This will require dedicated creel surveys, expanded MRFSS coverage, expanded commercial fish house sampling and development of an independent survey.

11.4.2 A/R Striped Bass Stock

Water Flow
Conduct a new analysis of the relationship between the Juvenile Abundance Index (JAI) in Albemarle Sound and Roanoke River flow to incorporate JAI values measured during the past decade, since previous analyses were conducted.

Blockages
Chowan River system: Nottoway, Blackwater and Meherrin rivers are tributaries to the ASMA. Investigations would determine if dams in this system are having an impact on striped bass spawning. Investigate abundance and spawning contribution of striped bass in the Blackwater, Nottoway and Meherrin rivers. Manpower and monies needed to complete surveys are lacking at this time and work will require adding additional Virginia agencies to the management process.

Roanoke River: Investigate the potential for passage of striped bass above Roanoke Rapids Dam. Other anadromous species such as American shad and possibly sturgeon would benefit from fish passage. Passage of some undesirable species is a possibility and approximately 1 to 5 million dollars would be required for a passage facility.

Discard Mortality in the Multi-Species Gill Net Fishery
More at seas observations for the gill net fishery are needed to more accurately assess discards from the fishery.

Improvements should be made in the trip ticket data to collect gear parameters (yardage, mesh size, etc.).

Need to further investigate the impacts of delayed mortality on striped bass captured in gill nets.

Biological Reference Points
Additional stock monitoring at the current high abundance is necessary to define the stock-recruitment relationship.

The emigration rate should be evaluated in the near future, as the proportion of the stock age 8 and older increases.
Data should be collected for striped bass stocks outside the Albemarle /Roanoke system that will enable determination of stock status and estimation of biomass thresholds and targets.

11.4.2 C/S Striped Bass Stocks

Water Flow

1. Conduct needed studies to further refine the relationship between life stages, flow and habitat quality (i.e., the relationship between flows and the location and extent of spawning and nursery habitat(s) in the Tar, Neuse, Cape Fear and Pee Dee rivers).

2. Conduct sediment contamination study as a result of Hurricane Floyd.

Blockages

Tar River: Investigate the feasibility of fish passage on Rocky Mount Mill Dam and Tar River Reservoir Dam. Passage would add an additional 20 – 40 miles of spawning habitats, but it is not clear at this time if passage would be beneficial to striped bass or to resident reservoir species.

Yadkin-Pee Dee Rivers: Investigate the feasibility of fish passage above the Yadkin chain of dams in NC. Passage would be costly but striped bass and other anadromous species could be restored to their historical range.

Biological Reference Points

Data should be collected for striped bass stocks in the CSMA that will enable determination of stock status and estimation of biomass thresholds and targets.

Striped Bass Stocking in Coastal River Systems

Survey stocked systems to determine percentage of wild versus stocked fish.

Life History Information

Determine maturity, fecundity, size and weight at age. Determine egg and larval survival rates.

Expanded survey coverage, including juvenile abundance and population abundance in the sounds and lower rivers.

Predator prey relationship

Recreational Data

Quantitative assessment of Tar and Neuse River striped bass populations.

Complete landings statistics for recreational fisheries (creel survey).

Biological characteristics of recreational fisheries (length, weight, age and sex) (creel samples).

Discard estimates from recreational fisheries (Creel Survey).

Biological characteristics of recreational discard (Angler's log or independent survey).

Improve accuracy of striped bass discard estimates.

Commercial Data
Biological characteristics of commercial catch. Including length, age, weight and sex (increased sampling, age structure collection).

Discard Mortality from Set Gill Nets in the CSMA
More at-sea observations made for the gill net fishery are needed to more accurately assess the discards from the fishery.

Improvements should be made in trip ticket data to collect gear parameters (yardage, mesh size, etc.).

Need to further investigate the impacts of delayed mortality on striped bass captured in gill nets.

Improve the accuracy of striped bass discard estimates.

11.5 Review Cycle
As provided in the Fisheries Reform Act of 1997, the Striped Bass Fishery Management Plan will be reviewed and revised at least every five years with the support of advisors.

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13.0 Appendices

Appendix 1. North Carolina striped bass landings (Chestnut and Davis, 1975).

Year	Pounds ('000)	Value ($) ('000)	Year	Pounds ('000)	Value ($) ('000)
1887	500	25	1951	702	134
1888	560	28	1952	647	121
1889	531	31	1953	757	137
1890	568	32	1954	1,122	188
1897	845	58	1955	736	120
1902	1,175	114	1956	764	119
1908	510	36	1957	597	90
1918	287	46	1958	1,097	197
1923	477	76	1959	872	158
1927	738	119	1960	782	125
1928	507	72	1961	550	88
1929	246	41	1962	747	120
1930	457	61	1963	736	115
1931	327	35	1964	714	117
1932	507	55	1965	484	77
1934	362	36	1966	653	100
1936	768	61	1967	1,817	253
1937	713	69	1968	1,912	385
1938	523	49	1969	1,568	326
1939	339	34	1970	2,318	479
1940	540	59	1971	1,449	314
1945	609	121	1972	1,261	358
1950	797	165	1973	1,752	592

North Carolina striped bass landings by gear (Chestnut and Davis 1975).

	Haul seines		Purse seines		Pound nets		Gill Nets		Fyke nets		Trawls		Lines		Dip nets/ Bow nets		Fish wheels		Other	
Year	Pounds	Value ($)	Pounds	Value ($)	Pounds	Value ($)	Pounds	Value ($)	Pounds	Value ($)	Pounds	Value ($)	Pounds	Value ($)	Pounds	Value ($)	Pounds	Value ($)	Pounds	Value ($)
	149,422	6,831			203,335	11,553	53,279	3,706	1,250	75										
1888	161,300	6,438			270,487	15,288	57,557	3,879	1,250	75										
1889	220,766	11,912			240,221	13,732	69,112	4,892	1,250	75										
1890	288,587	11,798			260,464	14,874	77,980	5,387	1,310	79										
1897	250,918	16,875			430,620	29,824	145,635	10,033	400	20			8,300	615			6,800	496	2,400	172
1902	297,027	27,920			677,135	67,380	160,616	14,613	500	50			3,800	380			6,222	600	30,100	2,688
1908	177,000	12,000			215,000	15,000	38,000	2,700	2,400	200			6,200	500					71,000	5,700
1918	31,673	3,235	18,000	4,500	210,284	31,785	17,993	3,487	1,943	253										
1923	189,147	28,368	15,523	2,252	110,607	16,748	158,124	27,865	3,600	720										
1927	188,496	27,267	16,700	2,505	233,499	37,291	288,910	50,420	10,100	1,978										
1928	221,547	28,344	4,985	614	156,352	24,116	117,827	17,700	5,870	986					200	50				
1929	80,652	11,701			95,397	16,424	64,703	11,909	5,605	1,190										
1930	203,526	20,863	10,000	1,500	106,350	15,569	118,650	18,475	16,350	3,643					1,000	150			1,000	250
1931	185,560	16,871	5,000	750	57,550	7,198	63,900	6,862	14,500	1,845										
1932	236,600	20,848	75,000	11,250	75,200	9,115	95,675	10,007	21,000	2,125										
1934	139,300	13,405	20,000	2,000	92,400	9,240	87,300	8,730	3,000	300			11,760	1,171						
1936	138,100	11,932	100,000	5,000	319,800	25,001	194,000	17,769	11,300	960			20,000	2,000						
1937	198,300	19,372	55,000	5,500	288,700	27,826	153,500	15,006	17,400	1,720			4,600	595						
1938	212,400	19,879			205,900	19,777	84,700	7,111	19,700	1,861										
1939	47,900	4,635			158,500	15,805	126,700	12,665	6,500	650										
1940	49,300	5,423			248,600	27,346	231,000	25,410	11,000	1,210										
1945	41,700	8,284			238,200	47,576	267,300	53,036	61,300	12,260										
1950	191,700	32,090	112,800	22,560	310,000	73,216	137,200	28,311	45,000	9,000	100	30								
1951	143,200	31,535	155,000	27,250	233,600	40,115	127,300	27,345	23,800	4,950			11,300	1,715	8,000	1,200				
1952	118,600	24,692	138,100	23,670	206,200	36,026	161,700	32,690	3,700	750					8,500	1,530				
1953	189,100	32,533	112,500	21,270	274,700	47,598	150,900	29,962	5,500	1,060					16,500	3,300				
1954	74,800	14,440	101,600	20,320	696,500	104,636	242,700	47,598	6,100	1,198										
1955	54,300	8,301	36,000	6,105	334,800	51,469	307,600	53,729	3,300	495										
1956	64,900	9,735	22,500	3,375	362,600	54,390	312,700	51,635	800	120										
1957	27,800	4,170	22,700	3,405	208,700	31,305	337,800	50,670												
1958	193,100	34,758	82,800	14,904	211,500	38,070	601,800	108,324	6,800	1,224										
1959	201,400	36,320	65,000	11,700	121,800	22,090	483,300	87,346												
1960	196,700	31,472	89,800	14,368	195,300	31,248	300,500	48,080												
1961	123,300	19,728	47,700	7,632	133,600	21,376	245,100	39,216												
1962	182,400	29,184	70,000	11,200	163,100	26,096	331,800	53,088												
1963	100,600	14,416	10,000	1,600	180,400	28,864	444,800	69,028												
1964	131,600	21,581			154,400	24,878	427,300	70,095												
1965	96,900	15,081			131,400	20,809	257,200	41,111												
1966	66,800	10,275			47,700	7,166	528,800	81,310	4,800	743			9,000	1,372						
1967	285,600	37,654	50,100	9,398	52,700	9,262	1,368,500	191,412	2,100	346	56,700	4,886	300	55						
1968			24,600	5,408	92,600	15,311	1,302,500	296,649	800	156	30,200	6,028	100	18						
1969	367,900	87,769	166,700	33,018	54,200	8,119			1,700	318	117,900	27,789								
1970	588,600	135,031	246,200	46,885	198,600	38,972	617,700	127,979	600	126	665,500	130,302								
1971	306,700	69,749	59,000	11,797	92,100	19,680	541,200	119,123	6,400	1,300	443,600	92,151								

Appendix 1. Striped bass landings and value by county, 1930-1968 (Chestnut and Davis, 1975).

Year	Bertie		Camden		Chowan		Currituck		Dare		Gates	
	Pounds	Value ($)	Pounds	Value ($)	Pounds	Value ($)	Pounds	Value ($)	Pounds	Value ($)	Pounds	Value ($)
1930	3,500	425	3,000	600	19,800	3,910	61,822	11,999	136,200	19,705	400	74
1931	1,800	180	3,000	450	14,500	1,450	56,760	6,621	107,300	10,947	200	20
1934	20,900	2,090	3,000	300	18,700	1,870	47,500	4,750	116,000	11,600	No data	
1936	13,700	1,255	7,300	660	15,000	1,257	34,900	3,435	474,800	34,392	3,500	350
1937	11,500	1,150	8,800	714	9,800	980	83,500	8,532	367,100	36,697	2,000	200
1938	10,600	954	4,700	470	8,600	774	96,600	9,660	278,400	26,568	2,200	198
1945	27,000	5,400	2,500	500	No data		64,500	12,900	160,000	32,000	5,000	1,000
1950	5,600	1,120	5,000	1,000	22,700	4,540	162,100	26,120	335,300	77,145	1,000	200
1951	5,600	1,400	3,200	800	9,800	2,450	100,400	25,100	310,700	46,610	5,000	1,000
1952	4,300	860	3,500	770	16,400	3,280	94,800	20,856	238,100	35,715	1,700	428
1953	16,000	3,200	4,900	1,078	20,900	4,180	77,300	15,460	269,400	41,145	1,400	280
1954	9,900	2,772	7,300	1,825	No data		24,700	4,446	98,200	19,640	4,900	980
1955	16,200	2,430	8,500	1,530	158,500	23,775	62,500	9,375	130,900	19,635	4,900	980
1956	7,300	1,095	2,500	375	199,000	29,850	23,400	3,510	266,200	39,930	No data	
1957	10,600	1,590	1,500	225	247,000	37,050	16,900	2,535	112,100	16,815	No data	
1958	7,900	1,422	10,000	1,800	311,000	55,980	22,400	4,032	348,100	62,658	No data	
1959	4,700	940	9,500	1,900	280,000	50,400	19,900	3,582	225,100	40,518	No data	
1960	8,800	1,408	15,000	2,400	72,500	11,600	31,900	5,104	356,200	56,992	No data	
1961	4,400	704	13,500	2,160	64,500	10,320	6,500	1,040	116,600	26,656	No data	
1962	3,800	608	22,300	3,568	87,400	13,984	86,000	13,760	236,100	37,776	No data	
1963	7,400	1,184	30,600	4,896	141,800	22,688	81,000	12,960	132,800	19,568	No data	
1964	7,000	1,120	55,000	8,993	82,100	13,406	58,000	9,280	181,200	29,566	No data	
1965	2,600	416	23,600	3,776	51,400	8,224	61,000	9,760	110,600	17,133	No data	
1966	3,500	534	No data		247,500	38,143	24,400	3,700	74,200	11,269	No data	
1967	4,900	896	No data		436,500	73,348	9,800	1,685	886,000	96,601	No data	
1968	4,300	663	No data		224,300	47,216	79,800	15,040	600,000	111,519	No data	

	Hertford		Martin		Pasquotank		Perquimans		Tyrrell		Washington	
	Pounds	**Value ($)**	**Pounds**	**Value ($)**	**Pounds**	**Value ($)**	**Pounds**	**Value ($)**	**Pounds**	**Value ($)**	**Pounds**	**Value ($)**
1930	No data		6,000	825	25,000	4,800	60,000	9,000	12,100	1,855	80,814	1,397
1931	No data		1,500	150	11,600	2,212	30,000	3,000	6,000	600	50,800	5,080
1934	200	20	20,000	2,000	5,000	500	12,000	1,200	37,000	3,700	47,000	4,700
1936	3,000	300	6,400	770	29,800	2,640	27,200	2,448	119,200	10,750	20,100	1,809
1937	3,500	350	1,000	80	28,800	2,592	29,100	2,549	82,300	8,230	23,400	2,340
1938	3,000	270	800	64	30,500	2,440	29,000	2,320	22,000	1,925	17,600	1,179
1945	1,500	180	2,000	400	107,300	21,460	73,700	14,740	100,000	20,000	9,000	1,800
1950	1,300	260	25,000	5,000	42,600	8,520	22,500	4,500	134,000	26,800	12,500	2,500
1951	1,300	260	12,500	3,125	42,400	10,600	43,200	10,790	120,000	24,000	2,000	500
1952	1,300	286	2,400	432	58,400	11,680	36,100	7,942	82,000	14,760	13,400	2,412
1953	1,100	242	2,600	468	83,700	16,740	30,400	6,688	100,500	18,090	16,100	2,898
1954	3,000	600	3,000	600	54,500	10,900	26,200	5,240	250,000	50,000	10,500	1,680
1955	2,000	400	1,500	375	96,800	17,424	22,500	4,050	175,000	31,500	26,500	3,975
1956	No data		3,000	450	74,900	15,965	9,900	1,485	108,200	16,230	52,000	7,800
1957	600	90	1,000	150	61,400	9,210	6,900	1,035	111,600	16,740	16,300	2,445
1958	No data		500	90	159,700	28,746	10,000	1,800	195,500	35,190	9,100	1,638
1959	No data		500	90	103,000	18,540	15,000	2,700	184,500	33,210	12,800	2,304
1960	No data		600	96	93,500	14,960	25,000	4,000	130,800	20,928	7,700	1,232
1961	300	48	300	48	69,000	11,040	20,000	3,200	132,000	21,120	4,200	672
1962	200	32	100	16	80,000	12,800	30,000	4,800	124,500	19,920	7,900	1,264
1963	500	80	500	80	91,000	14,560	35,000	5,600	154,000	23,500	5,300	848
1964	1,000	160	1,900	304	147,500	24,337	20,000	3,285	113,400	18,711	6,500	1,040
1965	No data		No data		100,000	16,000	13,000	2,080	81,100	12,895	1,200	192
1966	No data		No data		99,200	15,288	No data		132,300	20,109	11,000	1,714
1967	No data		No data		100,300	16,408	No data		105,200	18,892	151,700	24,514
1968	No data		No data		769,000	15,485	No data		177,800	34,958	575,400	124,640

	Halifax		Beaufort		Pamlico		Carteret		Craven		**Hyde**	
	Pounds	**Value ($)**	**Pounds**	**Value ($)**	**Pounds**	**Value ($)**	**Pounds**	**Value ($)**	**Pounds**	**Value ($)**	**Pounds**	**Value ($)**
1930	No data		7,300	755	1,100	43	17,290	1,644	16,350	2,438	2,200	80
1931	No data		23,500	1,950	2,100	210	200	6	15,400	1,540	350	35
1934	No data		24,900	1,965	No data		800	80	6,500	650	No data	
1936	No data		8,700	783	1,000	100	500	50	1,100	108	1,600	149
1937	No data		59,500	4,780	No data		0	0	1,100	110	1,500	120

	Halifax		Beaufort		Pamlic		Carteret		Craven		Hyde	
	Halifax		Beaufort		Pamlico		Carteret		Craven		**Hyde**	
	Pounds	**Value ($)**	**Pounds**	**Value ($)**	**Pounds**	**Value ($)**	**Pounds**	**Value ($)**	**Pounds**	**Value ($)**	**Pounds**	**Value ($)**
1938	No data		12,300	1,206	3,500	350	800	40	700	70	900	90
1945	No data		6,000	1,200	3,500	700	500	100	39,800	7,960	No data	
1950	No data		22,400	6,272	1,100	330	100	25	1,800	450	500	100
1951	35,000	5,250	12,000	2,400	700	140	0		2,000	300	No data	
1952	35,500	6,390	45,200	11,300	1,000	250	0		5,500	1,650	No data	
1953	34,500	6,900	86,100	17,220	2,000	400	0		7,000	1,400	No data	
1954	No data		19,200	3,840	300	60	0		3,200	640	No data	
1955	No data		27,800	4,170	700	140	0		1,300	260	No data	
1956	No data		15,400	2,310	No data		0		600	90	No data	
1957	No data		8,400	1,260	No data		0		200	30	1,100	165
1958	No data		14,700	2,646	100	18	0		2,300	414	3,700	666
1959	No data		15,100	3,020	100	18	200	36	No Data		600	108
1960	No data		34,300	5,488	800	128	2,500	400	2,100	336	No data	
1961	No data		27,700	4,432	1,900	304	33,800	5,408	2,900	464	100	16
1962	No data		38,400	6,144	12,600	2,016	11,900	1,904	3,800	608	700	112
1963	No data		35,600	5,696	1,100	176	14,600	2,336	3,500	560	100	16
1964	No data		29,300	4,688	2,800	448	5,700	912	2,400	384	200	32
1965	No data		34,600	5,501	900	144	1,300	208	1,600	256	600	96
1966	No data		57,300	8,830	500	69	800	123	300	38	100	23
1967	No data		117,200	20,132	1,700	83	600	102	No Data		200	31
1968	No data		170,600	35,009	100	12	600	103	No Data		500	109

	Lenior		**New Hanover**	
	Pounds	**Value ($)**	**Pounds**	**Value ($)**
1930	4,000	1,000	No data	
1931	1,500	75	No data	
1934	2,500	250	No data	
1936	No data		No data	
1937	No data		No data	
1938	No data		500	50
1945	No data		5,300	636
1950	No data		1,300	325
1951	No data		1,400	385
1952	No data		7,400	2,220
1953	No data		3,100	930

	Lenior		New Hanover	
	Pounds	Value ($)	Pounds	Value ($)
1954	No data		800	240
1955	No data		No data	
1956	No data		1,100	165
1957	No data		1,400	210
1958	No data		1,000	180
1959	No data		500	90
1960	No data		600	96
1961	No data		2,000	320
1962	No data		1,600	256
1963	No data		1,000	160
1964	No data		400	64
1965	No data		800	128
1966	No data		1,400	211
1967	No data		2,900	501
1968	No data		1,500	278

Appendix 2
Historical Regulations

These regulations are just a few of those in place overtime.
The following rules are quoted from the referenced rule books:

North Carolina Fishing Laws- Consolidated Statutes 1923- Fisheries Commission Board

If any person fishes on Sunday with a seine, drag-net, or other kind of net, except such as is fastened to stakes, he shall be guilty of a misdemeanor, and fines not less than two hundred nor more than five hundred dollars, or imprisoned not more than twelve months.

Albemarle Sound Area
No person shall set or fish any dutch net or pound net in Roanoke River, Cashie or Middle and Eastmost rivers, or within two miles of the mouth of said rivers, or within one mile of the mouth of any other river emptying into Albemarle Sound, or less than two miles in width at its mouth, any such net set within one mile of the mouth of any other river emptying into said sound shall not extend into the main channel at its mouth.

It is unlawful to set, fish or use any gill nets of any description, either stake, anchor or drift, for commercial purposes in the Albemarle Sound west of a line drawn straight from Batt's Island on northern side of Albemarle Sound to mouth of Scuppernong River on south side of said sound, except between the hours of four o'clock and eleven o'clock p.m., and then said nets or combinations of such nets shall not be more than six hundred yards in length, and there shall not be allowed to any boat more than six hundred yards of such gill nets.

Cape Fear River
It is unlawful to fish with dutch, pod, fyke or other pound nets, or stake or stationary nets, or nets of like kind, in the waters of the Cape Fear River below the mouth of Black River, twelve miles above Wilmington, or in the waters of Northeast River below the Castle Hayne Bridge. Drift nets shall be permitted in the waters of the Cape Fear River within the territory as above described in this section, and its tributaries, between February first and May first of each year. Any person violating the provisions of this section shall be guilty of a misdemeanor and fined not less than fifty dollars or imprisoned not less than thirty days.

Pamlico and Tar River
If any person, from the fifteenth day of February to the tenth day of May of every year, from twelve o'clock meridian of Saturday until sunrise Monday morning of each week, shall fish any seine, set net, drift net, or any other net of any name or kind whatever, in the waters of Pamlico or Tar rivers and tributaries, except bow or skim nets, he shall be guilty of a misdemeanor.

Neuse River
If any person shall set or fish any dutch or pound nets in the waters of Pamlico County, or shall use any seine or drag net in the waters of said county, including the north side of Neuse River from the mouth of the river to the mouth of Upper Broad Creek, from the first day of May to the first day of January next ensuing, or shall ant any time catch fish

with a seine or drag net along the shores of said county on any day of the week except Monday, Wednesday and Friday, he shall be guilty of a misdemeanor and be fined not more than fifty dollars or imprisoned not more than thirty days.

Rules and Regulations of the Department of Conservation and Development Relative to the Commercial Fisheries of North Carolina 1947
It shall be unlawful for any person, firm or corporation to take, buy, sell, offer for sale, have in his or their possession, or unnecessarily destroy, anywhere in the State of North Carolina, any fish of less size than the length specified for the several kinds of fish or for any express company, railroad company or any common carrier to accept them for shipment. Rockfish or striped bass 12 inches. Provided, that this provision shall not be construed to prevent catches of smaller fish with hook and line for sport or personal use.

Albemarle Sound Area
It shall be lawful to use purse seines not exceeding two hundred yards in length for taking rock in Albemarle Sound east of a line drawn from Laurel Point Light House to Batt's Island from October 1 to December 20 of each year.

It shall be unlawful at any time to take female (roe) striped bass (rock) with nets, seines, or by any means whatsoever in that portion of the Roanoke River between the Hart Bridge near Scotland Neck and the New Highway Bridge at Weldon. Any female or roe striped bass taken within said territory shall be released immediately at the place caught and with as little damage as possible to the fish.

It shall be unlawful for any person, firm or corporation to fish nets of any kind in Albemarle Sound and its tributaries above a line drawn from Laurel's Point Lighthouse to Batt's Island between sunset and sunrise during the shad and herring fishing seasons.

Neuse or Pamlico Rivers
It shall be unlawful to set anchor gill nets in any of the waters of Neuse or Pamlico Rivers at any season of the year.

Cape Fear River
It shall be unlawful to catch or take with nets or seines any striped bass or rock in any waters of New Hanover County.

Appendix 3

Regulations (rules or proclamations) resulting in conservation and /or reduction of striped bass harvest for coastal North Carolina. (ASMA-Albemarle Sound Management Area, RRMA- Roanoke River Management Area, Central/Southern- all coastal, joint and contiguous inland waters below ASMA line, DMF- NC Division of Marine Fisheries, WRC- NC Wildlife Resources Commission, TL- Total length, ISM- inch stretched mesh, TAC- Total Allowable Catch)

Year	Statewide	ASMA/RRMA	Central/Southern
Prior to 1979	Minimum size limit 12 in TL, daily creel limit 25 fish (DMF/WRC)		
1979	Internal Coastal and Joint Waters- gill nets with a mesh length less than 2 ½ ISM are illegal (except area specifics)	No trawling in Albemarle and Croatan Sounds between Dec 1 and Mar 31	
		Roanoke River drift gill nets must be attended at all times (DMF)	
		Gill net mesh size changed from 3 ¼ ISM to 3 ½ ISM- western Albemarle Sound and Chowan River- summer/fall (DMF/Jul)	
		Defined small mesh nets (mullet nets to be used only in eastern Albemarle Sound) (DMF/Jul)	
1980	Creel limit reduced to 8 fish per day in Inland Waters (WRC)	Eliminated set gill nets in Roanoke River- Apr-May and restricted mesh size of drift gill nets (DMF/Oct)	
	Field possession limit reduced to one day's creel limit- Inland Waters (WRC)		
1981		Roanoke River bow netting eliminated (WRC) Possession of large dip nets prohibited in Inland Waters of the Roanoke River (WRC)	
		Extended drift gill net regulations to mouth of Roanoke, Middle, Eastmost and Cashie rivers proper (DMF/Oct)	

Year	Statewide	ASMA/RRMA	Central/Southern
1982	Minimum size limit increased to 16 in TL in Inland Waters (WRC)		
1983		Eliminated small mesh gill nets in Currituck Sound, minimum size increased to 3 ½ ISM (Jun-Dec) (DMF/Jan)	
		Roanoke River- re-instituted use of set gill nets Apr-May of 3 ISM and less, no more than one drift gill net per boat (DMF Jan and Oct)	
		Eliminated 3 ¼ ISM gill nets (Jun-Dec) in all of Albemarle Sound and tributaries, increased minimum mesh size to 3 ½ ISM (DMF/Oct)	
	Prohibited possession of striped bass on vessels using trawl in Internal Coastal Waters (DMF/Jan)		
1984		First limited commercial season Oct-May (DMF/Aug)	
		Minimum gill net mesh size 3 ½ ISM Oct-Dec (DMF/Aug)	
		Eliminated gill nets in Albemarle Sound and tributaries Jun-Sep, except defined “mullet nets” (2 ½-3 ISM), floating and within 300 yd of shore (DMF/Aug)	
	Reduction in hook and line creel limit to 8 fish/day and increase minimum size limit to 16 in TL for Joint and Internal Coastal Waters (Jun-Sep) (DMF/Aug)		
	Unlawful to sell or offer for sale striped bass from Jun-Sep (DMF/Aug)		
	First size limit for Atlantic Ocean- 24 in TL		

Year	Statewide	ASMA/RRMA	Central/Southern
	commercial and recreational (DMF/Aug)		
	Closure of Atlantic Ocean, commercial and recreational, to possession by proclamation (DMF/Aug)		
1985	Reduction in creel limit to 3 fish in Inland Waters (WRC)	Prohibit sale of striped bass taken from Inland Waters of the Roanoke River (NC General Assembly)	
	Reduction in commercial season (Nov-Mar), unlawful to sell or possess striped bass from commercial gear except during the open season (DMF/Aug)	Revision of summer gill net use (Jun-Sep), which allowed 5 ISM and greater "flounder nets" and attendance at all times provisions for "mullet nets" in Albemarle Sound and tributaries (DMF/Aug)	
	Hook and line creel limit reduced to 3 fish/day Internal Coastal and Joint Waters year round. No sale of hook and line caught striped bass (DMF/Aug)		
	Commercial minimum size limit increased to 16 in TL in Joint Waters (DMF/Aug)		
	Commercial minimum size limit increased to 14 in TL in Internal Coastal Waters (DMF/Oct)		
1986	Minimum size limit increased to 16 in TL Internal Coastal waters (DMF/Oct)	Revisions to depth of water and net size for the fall gill net regulations (Oct-Dec)- increased striped bass conservation without severely impacting the harvest of white perch and catfish (DMF/Nov)	
	Repealed 16 in TL size limit, revert back to 14 in TL minimum size limit Internal Coastal Waters (DMF/Nov)	Established proclamation authority to open and close a portion of the striped bass season (Oct and Apr) (MFC/Nov)	

Year	Statewide	ASMA/RRMA	Central/Southern
		Aligned Currituck Sound net regulations with the Albemarle Sound regulations relative to conservation measures (DMF/Nov)	
		Eliminated the possession and sale of striped bass from the spring Albemarle Sound gill net fishery and Roanoke River delta pound net fishery (DMF-effected by Aug 1985 regulations)	
1987		Eliminated all trawling in Albemarle Sound and tributaries year round (DMF/Dec)	
		Closed a portion of western Albemarle Sound to gill netting (Batchelor Bay area) and restricted the spring pound net fishery in the Roanoke River delta by proclamation (DMF/Aug) (remains in effect 2002)	
1988	Size limit in Atlantic Ocean will correspond to ASMFC Interstate Striped Bass FMP		
		Allow use of "mullet gill nets" in Currituck Sound between 2 ½ - 3 ¼ ISM, maximum 400 yds, attended at all times (Jun-Dec) (DMF/Sep)	
1989	Established proclamation authority to specify season or seasons: (a) hook and line and (b) commercial fishing equipment between 1 Oct and 30 Apr. Proclamations may specify areas, quantity, size and means/methods employed in harvest and require submission of statistical and biological data	Closed Batchelor Bay area to anchor gill netting and restricted the possession of striped bass taken in pound nets to fish not less than 18 in TL or greater than 24 in TL.	

Year	Statewide	ASMA/RRMA	Central/Southern
	(MFC/Sep)		
		Restricted use of small mesh “mullet gill nets” in Albemarle Sound and tributaries (DMF/Jun and Sep)	Commercial season in Internal Coastal waters closed 20 Apr (DMF/Apr)
		Delayed use of commercial gill nets of between 3-5 ISM in Albemarle Sound and tributaries from 1 Oct until 15 Nov, when commercial striped bass season opened statewide. Mullet nets required attendance at all times (DMF/Oct)	Commercial season opened 15 Nov in Internal Coastal Waters (DMF/Nov)
		Gill net mesh sizes restricted in Albemarle Sound area (DMF/Nov)	Commercial season closed in Internal Coastal Waters 22 Nov (DMF/Nov)
	Hook and line season closed in Internal Coastal Waters 26 Nov (DMF/Nov)		
1990		Albemarle Sound area- 98,000 lb. (TAC) commercial harvest allocation to be managed on a monthly basis (DMF/Jan)	Commercial season opened 1 Jan in Internal Coastal Waters (DMF/Jan)
		Gill net size restrictions in Albemarle Sound area (DMF/Jan, Feb and Apr)	Commercial season closed 11 Jan in Internal Coastal Waters (DMF/Jan)
		Batchelor Bay area closed 1 Apr to anchor gill nets and prohibited the possession between 24 and 28 in TL and less than 18 in TL from pound nets (DMF/Mar)	Commercial season opened 21 Feb in Internal Coastal Waters (DMF/Feb)
		Delayed use of commercial gill nets of between 3-5 ISM from 3 Oct until 7 Jan 1991, when season opened statewide, required mullet gill nets be attended at all times (DMF/Oct)	Commercial season closed 20 Apr in Internal Coastal Waters (DMF/Apr)

Year	Statewide	ASMA/RRMA	Central/Southern
	Hook and line season opened 1 Jan in Internal Coastal Waters (DMF/Jan)	By collateral action through proclamation (DMF) and emergency rule (WRC), striped bass season closed 10 May for hook and line possession in Joint Waters of Albemarle Sound area (DMF and WRC/May)	
	Hook and line season closed 24 Apr in Internal Coastal Waters (excluding Joint Waters) (DMF/Apr)	By emergency rule season closed 10 May for hook and line possession in Inland Waters of Roanoke River (WRC/May)	
	By collateral action DMF and WRC, closed hook and line possession in Internal Coastal, Joint and Inland Waters 21 May (DMF and WRC/May)		
1991		ASMA commercial season opened 7 Jan and closed 9 Jan	Commercial season opened 7 Jan in all Internal Coastal Waters outside the ASMA (DMF/Jan)
		ASMA commercial TAC of 98,000 lbs. and managed on a monthly basis. Individual harvest permits required for fishermen or operations, 14 in TL minimum size in Internal Coastal Waters and 16 in TL in Joint Waters. Extensive gill net restrictions with specific amount or yardage of gill nets less than 5 ISM for all 1991 (DMF/Jan)	Commercial season closed by rule 30 Apr, all waters outside ASMA (DMF)
		ASMA opened 18 Jan with gear restrictions, harvest permittee limited to landing 3 fish/day, minimum size 20 In TL	1 Nov commercial season opened statewide, 18 in TL minimum size limit (DMF/Nov)
	Effective 1 Jan -16 in TL size limit established and a daily creel limit not to exceed 3 fish per person per day for all Internal Coastal, Joint and Inland Waters (DMF/WRC)	ASMA – 13 Feb harvest permittee limited to landing 5 fish/day, minimum size 18 in TL	
		ASMA- 1 Mar harvest permittee limited to landing 10 fish/day, minimum size	1 Jan- hook and line season opened in all Internal Coastal waters statewide, excluding

Year	Statewide	ASMA/RRMA	Central/Southern
		limit 18 in TL	ASMA (DMF/Jan)
		ASMA- 25 Mar harvest permittee limited to landing 20 fish/day, minimum size 14 in TL in Internal Coastal Waters and 16 in TL in Joint Waters. Batchelor Bay area closed to anchor gill nets. Drift gill nets allowed in Roanoke, Eastmost, Middle and Cashie rivers, stationary gill nets prohibited (DMF/Mar)	1 Nov- hook and line season opened in all Internal Coastal and Joint Waters of the state, except for ASMA and RRMA
		ASMA- 6 Apr harvest permittee limited to landing 5 fish/day, minimum size limit 18 in TL (DMF/Apr)	By rule effective 1 Jul- 3 fish daily creel, 18 in TL minimum size, established year round for Inland Waters of the Tar, Neuse and Cape Fear rivers (WRC/Jul)
	By joint rule effective 1 Nov, minimum size limit for Joint Waters increased to 18 in TL (WRC and DMF/Nov)	ASMA- 13 Apr commercial season closed (DMF/Apr)	
	By rule effective 1 Nov, minimum size limit in Internal Coastal Waters increased to 18 in TL (DMF)	ASMA- 21 Jun- 3 ISM gill nets allowed, attended at all times (DMF/Jun)	
		ASMA- 3 Sep- 3-3 ½ ISM gill nets allowed with area restrictions and attendance at all times (DMF/Sep)	
		ASMA- 1 Oct- 2 ½ ISM and larger gill nets allowed in southern portions of Roanoke and Croatan sounds (DMF/Oct)	
		ASMA- 1 Nov commercial season opened, harvest permittee limited to landing 3 fish/day, 18 in TL minimum size limit, small mesh gill nets attended at all times, with area	

Year	Statewide	ASMA/RRMA	Central/Southern
		restrictions (DMF/Nov)	
		ASMA- 8 Nov allowed 5 ¼ ISM and larger gill nets, consistent with 18 in TL minimum size limit (DMF/Nov)	
		ASMA- 22 Nov allowed 3-3 ½ ISM gill nets unattended in waters less than 6 ft deep with restrictions (DMF/Nov)	
		ASMA- 20 Dec commercial season closed	
		1 Jan- MFC and WRC adopted joint rules establishing the Albemarle Sound Management Area (ASMA) and the Roanoke River Management Area (RRMA). Harvest management in the two areas based upon an allocation of 29,400 lb. (TAC) per year for each area (corresponds to an 80% reduction in historical hook and line harvest) WRC management authority for hook and line harvest- Joint and Inland Waters of RRMA (Roanoke, Middle, Eastmost and Cashie rivers and their tributaries) MFC management authority for hook and line harvest in the remaining Internal Coastal, Joint and Inland Waters of the ASMA (Albemarle, Currituck, Roanoke and Croatan sounds and their tributaries) (Defined areas only apply to striped bass hook and line harvest management)	
		1 Jan- hook and line	

Year	Statewide	ASMA/RRMA	Central/Southern
		season opened in ASMA	
		By emergency rule hook and line season opened 1 Jan in RRMA (WRC/Jan)	
		31 Jan- hook and line season closed in ASMA (DMF/Jan)	
		7 Feb- hook and line season opened in ASMA (DMF/Feb)	
		1 May- hook and line season closed in ASMA (DMF/May)	
		By emergency rule the WRC closed the hook and line season 1 May in RRMA (WRC/May)	
	By NC General Statute 113-292 (effective May 23, 1991) the WRC was granted proclamation authority to open and close hook and line striped bass seasons in the inland and joint waters of coastal rivers		
		1 Nov- hook and line season opened in ASMA, 18 in TL minimum size limit and daily creel limit of 3 fish (DMF/Nov)	
		30 Nov- hook and line season closed in the ASMA (DMF/Nov)	
		By rule effective 1 Jul, in RRMA the following were established during the open season: 1 Jan- 31 Mar- Inland Waters- 1 fish daily creel, 18 in TL minimum size limit, Joint Waters- 3 fish daily creel, 18 in TL minimum size limit 1 Apr- 31 May- Inland Waters 3 fish daily creel, 18 in TL minimum size limit and NO fish between	

Year	Statewide	ASMA/RRMA	Central/Southern
		22- 27 in TL maybe retained from US Hwy 258 to Roanoke Rapids Dam; Joint Waters- 3 fish daily creel, 18 in TL minimum size limit 1 Jun- 31 Dec- Inland Waters- 1 fish daily creel, 18 in TL minimum size limit, Joint Waters- 3 fish daily creel, 18 in TL minimum size limit	
1992		Throughout 1992 in the ASMA (excluding Croatan and Roanoke sounds) harvest permittee was limited to specific yardage of gill nets with stretched mesh less than 5 ¼ in. Gear and area restrictions varied seasonally. Stationary gill nets were prohibited in the RRMA.	21 Apr- commercial season closed in all Internal Coastal and Joint waters, outside the ASMA (DMF/Apr)
		ASMA- 11 Jan commercial season opened, harvest permittee limited to landing 10 fish per day (DMF/Jan)	23 Oct- commercial season opened in all Internal Coastal and Joint Waters, outside the ASMA
		ASMA- 3 Feb commercial harvest permittee limited to landing 5 fish per day (DMF/Feb)	
		ASMA- 19 Mar commercial harvest permittee limited to landing 3 fish per day. Drift gill nets allowed in Roanoke, Middle, Eastmost and Cashie rivers.	
		ASMA- 16 Apr commercial season closed	
		ASMA- 3 Jul- small mesh gill nets must be attended at all times (DMF/Jun)	
		ASMA- 21 Oct- small mesh gill nets must be attended between sunrise and sunset (DMF/Oct)	
		ASMA- 9 Nov- commercial season opened with a closure date 20 Nov, harvest permittee limited	

Year	Statewide	ASMA/RRMA	Central/Southern
		to landing 3 fish per day (DMF/Oct)	
		ASMA- 23 Nov- allowed unattended small mesh gill nets (DMF/Nov)	
		RRMA- 1 Jan- hook and line season opened (WRC/Jan)	
		ASMA- 1 Jan- hook and line season opened (DMF/Dec)	
		RRMA- 20 Apr- hook and line season closed (WRC/Apr)	
		ASMA- 1 May- hook and line season closed (DMF/Apr)	
		ASMA- 1 Nov- hook and line season opened (DMF/Oct)	
		ASMA- 30 Nov- hook and line season closed (DMF/Nov)	
1993		Throughout 1993, ASMA (excluding Croatan and Roanoke sounds) harvest permittee were limited to specific yardage of gill nets with a stretched mesh less than 5 ¼ in. Gear and area restrictions varied seasonally. Stationary gill nets were prohibited in RRMA.	17 Jan commercial season closed in Internal Coastal and Joint Waters
		RRMA- 18 Jan drift gill nets allowed	1 Feb commercial season opened in all Internal Coastal and Joint Waters, outside ASMA
		ASMA- 1 Feb commercial season opened, harvest permittee limited to landing 5 fish per day, prohibited harvest from commercial gear in RRMA	5 Apr commercial season closed in Internal Coastal and Joint Waters outside the ASMA
		ASMA- 1 Mar commercial harvest permittee limited to landing 3 fish per day	
		ASMA- 5 Apr commercial season closed	
		ASMA- 17 May gill nets	

Year	Statewide	ASMA/RRMA	Central/Southern
		prohibited in Batchelor Bay-western Albemarle Sound and RRMA, excluding the prohibited area, gill nets in the western sound from Chowan River to the NC Power Transfer Line must be attended	
		ASMA- 2 Aug small mesh gill nets must be attended at all times, excluding Croatan and Roanoke sounds	
		ASMA- 6 Oct small mesh gill nets prohibited in water depth greater than 6 ft, excluding Croatan and Roanoke sounds	
		RRMA- 1 Feb hook and line season opened	
		ASMA- 1 Feb hook and line season opened	
		ASMA- 18 Apr hook and line season closed	
		RRMA- 25 Apr hook and line season closed	
1994		ASMA- 19 Feb recreational season open- harvest days Wed, Sat and Sun- 3 fish per person, 18 in TL minimum size limit and 15,000 pounds spring allocation	Commercial 25,000 lb. TAC for joint and internal coastal waters, outside the ASMA with the approval of the FMP by the MFC and WRC (Annual 1994-2002)
		ASMA- 21 February commercial season open- permittee limited to landing 10 fish per day and 18 in TL minimum size limit	Upper portions of Pamlico, Pungo, Bay and Neuse Rivers- 1 Sep gill nets less than 5 ISM must be attended at all times
		ASMA- 16 Mar recreational season closed	Upper portions of Pamlico, Pungo, Bay and Neuse Rivers- 12 Oct attendance lifted on all areas except upper Pamlico River
		RRMA- 19 Feb, hook an line season opened, possession limited to Wed, Sat and Sun, 2 Apr, lower river closed, 21 Apr, upper river closed	13 Mar commercial season closed in all Internal Coastal and Joint Waters
		RRMA- effective 1 Jul, protective 22 to 27 in TL slot limit extended to entire	

Year	Statewide	ASMA/RRMA	Central/Southern
		Roanoke River, 1 Apr- 31 May (WRC)	
		ASMA- 21 Nov commercial season open- permittee limited to landing 5 fish per day and 18 in TL minimum size limit	
		ASMA- 23 Nov recreational season open- harvest days Wed, Sat and Sun- 3 fish per person, 18 in TL minimum size limit	
		ASMA- 7 Dec recreational season closed	
		ASMA- 21 Feb no gill nets set from 4:00 p.m. Friday until sunrise Monday	
		ASMA- 14 Mar- 15 Apr no gill nets set from 4:00 p.m. on Friday until sunrise Monday, 16 Apr – 31 May all gill nets attended 7 days per week, except flounder nets Batchelor Bay/ Western Albemarle Sound closed	
		ASMA- 1 Jun- 28 Oct small mesh gill nets 1,000 yd limit attended unless set in water less than 7 ft	
		ASMA- 17 Oct- 18 Nov small mesh gill nets 1,000 yd limit- attended Batchelor Bay/ Western Albemarle Sound closed	
		ASMA- 18 Nov no gill nets set from 4:00 p.m. Friday until sunrise Monday, small mesh gill nets attended, 3,000 yd limit- flounder nets	
1995		ASMA- 16 Jan small mesh gill nets (3 and 3 ¼) limit 800 yds, drift gill net 2 ½- 3 ISM, no flounder nets	Portions (upper and 200 yds. off shore) of Pamlico and Pungo Rivers- 20 Mar gill nets less than 5 ISM attended at all times

Year	Statewide	ASMA/RRMA	Central/Southern
		ASMA- 1 Mar recreational season open	Portions (upper and 200 yds. off shore) of Pamlico and Pungo rivers- 8 Dec attendance lifted for gill nets less than or equal to 3 ½ ISM in nets nearshore in lower rivers
		ASMA- 1 Mar commercial season open- permittee limited to landing 5 fish per day, 18 in TL minimum size limit	Pamlico Sound, Pamlico, Bay and Neuse rivers- 22 Nov commercial season open, 18 in TL minimum size limit, limited to landing 10 fish per day, permit required/ sale tags
		ASMA- 19 Mar recreational season closed	
		ASMA- 4 Apr commercial harvest- permittee limited to landing 2 fish per day (striped bass not to exceed 5% of total weight of catch), 18 in TL minimum size limit, commercial season close 14 Apr; Mesh size and yardage restrictions on gill nets, area closure	
		ASMA- 22 Nov commercial season open, 18 in TL minimum size limit, limited to landing 2 fish per day, harvest permit required and sale tags	
		ASMA- 22 Nov recreational season open, harvest days Wed, Sat and Sun, 21 in TL minimum size limit, 2 fish per day	
		ASMA- 24 Dec recreational season closed	
		ASMA- 26 Dec commercial season closed	
		RRMA- 1 Mar, hook and line season opened, possession limited to Wed, Sat, and Sun, 9 Apr, lower river closed, 14 Apr, upper river closed	
1996		ASMA- 16 Feb commercial	Cape Fear River- 29 Jan

Year	Statewide	ASMA/RRMA	Central/Southern
		season open, 18 in TL minimum size limit, limited to landing 5 fish per day (not to exceed 25% by weight of total catch), permit required and sale tags, season close 15 Apr	commercial season open, 18 in TL minimum size limit, limited to landing 10 fish per day, permit required and sale tags, season close 30 Apr
		ASMA- 16 Mar recreational season open- harvest days Wed, Sat and Sun, 18 in TL minimum size limit, 3 fish per person per day	Upper portions of Pamlico, Pungo, Bay, Neuse and Trent Rivers- gill nets less than 5 ISM must be attended at all times
		ASMA- 31 Mar recreational season closed	Pamlico Sound, Pamlico, Pungo, Bay and Neuse rivers- 29 Feb commercial season open, 18 in TL minimum size limit, limited to landing 5 fish per day, permit required and sale tags
		ASMA- 8 Apr commercial season, 18 in TL minimum size limit, limited to landing 3 fish per day (not to exceed 15% by weight of the total catch)	Pamlico Sound, Pamlico , Pungo, Bay and Neuse rivers- 12 Dec commercial season open, 18 in TL size limit, limited to landing 5 fish per day (not to exceed 25% by weight of total catch), harvest permits , season close 31 Dec
		ASMA- 30 Nov commercial season open, 18 in TL minimum size limit, limited to landing 5 fish per day (not to exceed 25% by weight of total catch, permit required and sale tags	
		ASMA- 22 Dec recreational season closed	
		ASMA- 23 Dec commercial 18 in TL minimum size limit, limited to landing 10 fish per day (not to exceed 25% by weight of total catch), close 31 Dec	
		RRMA- 16 Mar, hook and line season opened, possession limited to Wed, Sat, and Sun, 10 Apr, lower river closed	
		RRMA- effective 1 Jul, single barbless hook rule	

Year	Statewide	ASMA/RRMA	Central/Southern
		enacted for Roanoke River, 1 Apr- 30 Jun, Roanoke River, 1 Apr- 30 June, Roanoke Rapids Lake Dam down stream to US Hwy 258 bridge (WRC)	
1997		ASMA- 15 Feb commercial season open, 18 in TL minimum size limit, limited to landing 3 fish per day (not to exceed 25% by weight of total catch	Cape Fear River- 13 Jan commercial season open, 18 in TL minimum size limit, limited to landing 10 fish per day, season close 30 Apr
		ASMA- 15 Mar recreational season open, 18 in TL minimum size limit, 3 fish per day, harvest days- Wed, Sat and Sun	Pamlico Sound, Pamlico, Pungo, Bay and Neuse rivers and Carteret County- 15 Feb commercial season open, 18 in TL minimum size limit, limited to landing 3 fish per day (not to exceed 25% by weight of total catch)
		ASMA- 23 Mar recreational season closed	Pamlico Sound, Pamlico, Pungo, Bay and Neuse rivers and Carteret County- 22 Mar commercial season closed
		ASMA- 24 Mar commercial, 18 in TL minimum size limit, limited to landing 7 fish per day (not to exceed 40% by weight of total catch), permit and sale tags required, season closed 15 Apr	Pamlico Sound, Pamlico, Pungo, Bay, Neuse, White Oak and all Internal Waters of Carteret County- 3 Nov commercial season open, 18 in TL minimum size limit, limited to landing 5 fish per day, permit and sale tags required
		ASMA- 15 Nov recreational season open, 21 in TL minimum size limit, 2 fish per day, harvest days- Wed, Sat and Sun, season close 31 Dec	Pamlico Sound, Pamlico, Pungo, Bay, Neuse, White Oak and all Internal Waters of Carteret County- 19 Nov commercial season closed
		ASMA- 3 Nov commercial season open, 18 in TL minimum size limit, limited to landing 5 fish per day (not to exceed 50% by weight of total catch), permit required and sale tags	Portions of Pamlico, Pungo, Neuse and Trent Rivers- 24 Jan attendance required for gill nets less than or equal to 5 ISM, except gill nets less than or equal to 3 ½ ISM in nearshore (less than 200 yds from shore) in lower rivers
		ASMA- 5 Dec commercial	

Year	Statewide	ASMA/RRMA	Central/Southern
		season closed	
		RRMA- 15 Mar, hook and line season opened, possession limited to Wed, Sat, and Sun, 23 Mar, lower river closed, 2 Apr, upper river closed, upper river reopened 19 Apr for a 6 hour season to use remaining allowable harvest	
1998		ASMA- TAC commercial 125,440 lb., recreational 62,720 lb., RRMA- TAC recreational 62,720 lb.	Cape Fear River- 8 Jan commercial season open, 18 in TL minimum size limit, limited to landing 10 fish per day, permit and sale tags required, season close 30 Apr
		ASMA- 16 Feb commercial season open, 18 in TL minimum size limit, limited to landing 5 fish per day, dealer permit and sale tags required	Pamlico Sound, Coastal Rivers, Bays and Tributaries and Internal Waters of Carteret County- 16 Feb commercial season open, 18 in TL minimum size limit, limited to landing 5 fish per day, dealer permit and sale tags required
		ASMA- 14 Mar recreational season open, 18 in TL minimum size limit, 3 fish per day, harvest days- Wed, Sat and Sun	All Internal Coastal Waters- Carteret, Craven, Beaufort and Pamlico Counties and Pamlico and Pungo rivers- 1 Dec commercial season open, 18 in TL minimum size limit, limited to landing 5 fish per day, dealer permit and sale tags required, close 31 Dec
		ASMA- 8 Apr commercial season closed	Portions of upper Pamlico, Pungo, Neuse and Trent Rivers- 1 Dec through 30 Apr attendance requires for gill nets less than 5 ISM and within 200 yds. of shore
		ASMA- 22 Apr recreational season closed	
		ASMA- 28 Oct recreational season open, 18 in TL minimum size limit, 2 fish per day, harvest days- Wed, Sat and Sun, season close 30 Dec	

Year	Statewide	ASMA/RRMA	Central/Southern
		ASMA- 1 Dec commercial season open, 18 in TL minimum size limit, limited to landing 10 fish per day, dealer permit and sale tags required, season close 31 Dec	
		RRMA- 14 Mar, hook and line season opened, possession limited to Wed, Sat, and Sun, 12 Apr, lower river closed, 29 Apr, upper river closed	
1999	Internal Coastal and Joint Waters- 6 Nov recreational season open, 18 in TL minimum size limit, 3 fish per person per day	ASMA- TAC commercial 137,984 lbs., recreational 68,992 lbs., RRMA- TAC recreational 68,992 lbs.	Cape Fear River- Internal, Joint and Coastal Waters- 8 Jan commercial season open, minimum size limit 18 in TL, limited to landing 10 fish per day, dealer permit and sale tags required, season close 30 Apr
	All Primary Nursery Areas (PNAs) and Secondary Nursery Area (SNAs), no trawl areas (Outer Banks areas modified) and within 200 yds. of shore- 1 May through 31 Oct gill nets less than 5 ISM must be attended each year	ASMA- 1 Jan recreational season open, 18 in TL minimum size limit, 2 fish per person per day, harvest days- Wed, Sat and Sun, season close 16 Mar	All Internal Coastal Waters of Carteret, Craven, Beaufort, and Pamlico Counties, Pamlico and Pungo Rivers and Pamlico Sound- 9 Feb commercial season open, 18 in TL minimum size limit, limited to landing 5 fish per day, dealer permit and sale tags required
		ASMA- 9 Feb commercial season open, 18 in TL minimum size limit, limited to landing 5 fish per day, dealer permit required and sale tags, season close 28 Mar	All Internal Coastal Waters of Carteret, Craven, Beaufort and Pamlico Counties, Pamlico and Pungo rivers and Pamlico Sound- 5 Apr commercial season closed
		ASMA-29 Mar commercial 18 in TL minimum size limit, limited to landing 10 fish per day, dealer permit and sale tags required, season closed 15 Apr	Upper Pamlico, Pungo and Neuse Rivers- 1 May gill nets less than 5 ISM must be attended at all times (year round)
		ASMA- 2 Apr recreational season open, 18 in TL minimum size limit, 2 fish per person per day, harvest days- Fri, Sat, Sun and Mon, season close 5 Apr	All Internal Coastal Waters Carteret, Craven, Beaufort and Pamlico Counties, Pamlico, Pungo and White Oak rivers- 1 Dec commercial season open, 18 in TL minimum size limit, limited to

Year	Statewide	ASMA/RRMA	Central/Southern
			landing 5 fish per day, dealer permit and sale tags required, season close 31 Dec
		ASMA- 6 Nov recreational season open, 18 in TL minimum size limit, 2 fish per person per day, harvest days- Wed, Sat and Sun, season close 29 Dec	
		ASMA- 1 Dec commercial season open, 18 in TL minimum size limit, limited to landing 10 fish per day, dealer permit and sale tags required, season close 12 Dec	
		ASMA- 13 Dec commercial season open, 18 in TL minimum size limit, limited to landing 5 fish per day, dealer permit and sale tags required, season close 31 Dec	
		RRMA- 13 Mar, hook and line season opened, possession limited to Wed, Sat and Sun, 7 Apr, lower river closed, 28 Apr, upper river closed	
2000	Effective 1 Jul, no striped bass 22 to 27 in TL may be possessed in the Inland Waters of Tar and Neuse river, 1 Apr- 31 May	ASMA- TAC commercial 225,000 lbs., recreational 112,500 lbs., RRMA- TAC recreational 112,500 lbs.	
		ASMA- 1 Jan recreational season open, 18 in TL minimum size limit, 2 fish per person per day, harvest days- Wed, Fri, Sat and Sun, season close 26 Apr	Cape Fear River- 8 Jan commercial season open, 18 in TL minimum size limit, 1imited to landing 10 fish per day, dealer permit and sale tags required, season close 30 Apr
		ASMA- 7 Jan commercial season open, 18 in TL minimum size limit, limited to landing 5 fish per day, dealer permit and sale tags required, season close 26 Mar	Internal Coastal Waters Carteret, Craven, Beaufort and Pamlico Counties, Pungo and White Oak Rivers and Pamlico Sound- 11 Feb commercial season open, 18 in TL minimum size limit, limited to landing 5 fish per

Year	Statewide	ASMA/RRMA	Central/Southern
			day, dealer permit and sale tags required
		ASMA- 27 Mar commercial, 18 in TL minimum size limit, limited to landing 10 fish per day, dealer permit and sale tags required, season close 15 Apr	Pamlico Sound- Internal Coastal Waters- 9 Mar commercial season closed
		ASMA- 11 Oct recreational season open, 18 in TL minimum size limit, 2 fish per person per day, harvest days- Wed, Fri, Sat and Sun, season close 12 Nov	Internal Coastal Waters Carteret, Craven, Beaufort, and Pamlico Counties, Pungo and White Oak Rivers- 24 Mar commercial season closed
		ASMA- 13 Nov commercial season open, 18 in TL minimum size limit, limited to landing 5 fish per day, dealer permit and sale tags required, season close 31 Dec	Internal Coastal Waters Carteret, Craven, Beaufort, and Pamlico Counties, Pungo and White Oak Rivers- 13 Nov commercial season open, 18 in TL minimum size limit, limited to landing 5 fish per day, dealer permit and sale tags required
		ASMA- 15 Nov recreational season open, 18 in TL minimum size limit, 1 fish per person per day, harvest days- Wed, Fri, Sat and Sun, season close 3 Dec	Internal Coastal Waters Carteret, Craven, Beaufort, and Pamlico Counties, Pungo and White Oak Rivers- 28 Nov commercial season closed
		RRMA- 15 Mar, hook and line season opened, possession limited to Tue, Wed, Sat and Sun, 12 Apr lower river closed, 30 Apr upper river closed	
2001		ASMA- 5 Jan commercial season open, 18 in TL minimum size limit, limited to landing 5 fish per day, dealer permit and sale tags required, season closed 25 Mar	Cape Fear River- 8 Jan commercial season open, 18in TL minimum size limit, limited to landing 10 fish per day, dealer permit and sale tags required, season close 30 Apr
		ASMA- 17 Jan recreational season open, 18 in TL minimum size limit, 2 fish per person per day, harvest days- Wed, Fri, Sat and Sun, season close 18 Apr	Internal Coastal Waters Carteret, Craven, Beaufort and Pamlico Counties, Pungo and White Oak Rivers and Pamlico Sound- 12 Feb commercial season open, 18 in TL minimum size limit,

Year	Statewide	ASMA/RRMA	Central/Southern
			limited to landing 5 fish per day, dealer permit and sale tags required
		ASMA- 26 Mar commercial season open, 18 in TL minimum size limit, limited to landing 10 fish per day, dealer permit and sale tags required, season close 15 Apr	Pamlico Sound- Internal Coastal Waters- 2 Mar commercial season closed
		ASMA- 17 Oct recreational season open, 18 in TL minimum size limit, 2 fish per person per day, harvest days- Wed, Fri, Sat and Sun, season closed 25 Nov	Internal Coastal Waters Carteret, Craven, Beaufort, and Pamlico Counties, Pungo and White Oak Rivers- 14 Mar commercial season closed
		ASMA- 19 Nov commercial season open, 18 in TL minimum size limit, limited to landing 5 fish per day, dealer permit and sale tags required, season closed 21 Dec	Internal Coastal Waters Carteret, Craven, Beaufort, and Pamlico Counties, Pungo and White Oak Rivers- 3 Dec commercial season open, 18 in TL minimum size e limit, limited to landing 5 fish per day, dealer permit and sale tags required
		RRMA- 13 Mar hook and line season opened, possession limited to Tue, Wed, Sat and Sun, 22 Apr lower river closed, 29 Apr upper river closed	Internal Coastal Waters Carteret, Craven, Beaufort, and Pamlico Counties, Pungo and White Oak Rivers- 14 Dec commercial season closed
2002		ASMA- 7 Jan commercial season open, 18 in TL minimum size limit, limited to landing 5 fish per day (not to exceed 50% by weight of the total catch), dealer permit and sale tags required, season closed 15 Apr	Cape Fear River- 7 Jan commercial season open, 18 in TL minimum size limit, limited to landing 10 fish per day, dealer permit and sale tags required, season close 30 Apr
		ASMA- 7 Jan small mesh gill nets not to exceed 800 yds, 5 ¼ ISM and larger flounder nets limited to 3,000 yds, 5 ¼ ISM and larger shad (float) nets limited to 1,000 yds (18 Feb- 14 Apr), western Albemarle Sound area closed to gill nets	Internal Coastal Waters Carteret, Craven, Beaufort and Pamlico Counties, Pungo and White Oak Rivers and Pamlico Sound- 25 Feb commercial season open, 18 in TL minimum size limit, limited to landing 5 fish per day, dealer permit and sale tags required, season closed 16 Mar

Year	Statewide	ASMA/RRMA	Central/Southern
		ASMA- 16 Jan recreational season open, 18 in TL minimum size limit, 2 fish per person per day, harvest days- Wed, Fri, Sat and Sun, season closed 14 Apr	Internal Coastal Waters Carteret, Craven, Beaufort and Pamlico Counties, Pungo and White Oak Rivers- 2 Dec commercial season open, 18 in TL minimum size limit, limited to landing 5 fish per day, dealer permit and sale tags required, season closed 13 Dec
		RRMA- hook and line season set by WRC regulations, lower river open 1 Mar- 15 Apr, upper river open 15 Mar- 30 Apr, creel limit reduced to 2 fish/day, possession allowed 7 days/week, protective 22- 27 in TL slot limit extended to include the entire open harvest season	
		ASMA- 4 Nov commercial season open, 18 in TL minimum size limit, limited to landing 5 fish per day, dealer permit and sale tags required, season closed 20 Dec	
		ASMA- 6 Nov recreational season open, 18 in TL minimum size limit, 2 fish per person per day, harvest days- Wed, Fri, Sat and Sun, season closed 29 Dec	
2003		ASMA- 6 Jan commercial season open, 18 in TL minimum size limit, limited to landing 5 fish per day, dealer permit and sale tags required, season to close15 Apr, unless closed earlier by proclamation	Cape Fear River- 9 Jan commercial season open, 18 in TL minimum size limit, limited to landing 10 fish per day, dealer permit and sale tags required, season closes 30 Apr
		ASMA- 15 Jan recreational season open, 18 in TL minimum size limit, 2 fish per person per day, harvest days- Wed, Fri, Sat and Sun, season will closed 23 Apr, re-open 25 Apr and closed 30 Apr, 18	Internal Coastal Waters Carteret, Craven, Beaufort and Pamlico Counties, Pungo and White Oak Rivers and Pamlico Sound- 3 Mar commercial season open, 18 in TL minimum size limit, limited to landing 5 fish per

Year	Statewide	ASMA/RRMA	Central/Southern
		in TL minimum size limit, 2 fish per person, harvest days- Wed, Fri, Sat and Sun	day, dealer permit and sale tags required, season closed 31 Mar
		RRMA- hook and line season set by WRC regulations, lower river open 1 Mar- 15 Apr, upper river open 15 Mar- 30 Apr, creel limit reduced to 2 fish/day, possession allowed 7 days/week, protective 22- 27 in TL slot limit extended to include the entire open harvest season, only 1 of the 2 fish daily creel limit may be greater than 27 in TL	

RULE CHANGES ASSOCIATED WITH THE STRIPED BASS FMP
November, 2003

The Estuarine Striped Bass Fishery Management Plan (FMP) in its present form defines an additional management area (Central/Southern), which necessitates several changes in the rules of the Marine Fisheries Commission and the Wildlife Resources Commission where descriptions of those management units appear. Below are the proposed changes that pertain to the North Carolina Rules for Coastal Fisheries and the Joint Rules (MFC Rules):

(1) The "new" descriptions of the management areas would be placed in the MFC Rulebook under 15A NCAC 3R, where all of our descriptive boundaries are found. This would be an appropriate place to add any other management areas that may evolve in the future, such as a Cape Fear Management Area.

SECTION .0200 – FISHERY MANAGEMENT AREAS
15A NCAC 03R .0201
STRIPED BASS MANAGEMENT AREAS

The Albemarle Sound Management Area is ~~defined~~ designated as Albemarle Sound and all its joint and inland water tributaries, (except for the Roanoke, Middle, Eastmost and Cashie rivers), Currituck, Roanoke and Croatan sounds and all their joint and inland water tributaries, including Oregon Inlet, north of a line beginning at a point 35° 48 .3693'N - 75° 43 .7232'W on Roanoke Marshes Point, running southeasterly to a point 35° 44 .1710'N - 75° 31 .0520'W on the north point of Eagle Nest Bay.

The Roanoke River Management Area is ~~defined~~ designated as Roanoke River and its joint and inland tributaries, including Middle, Eastmost and Cashie rivers, up to the Roanoke Rapids dam.

The Central/Southern Management Area is ~~defined~~ designated as all internal coastal, and joint and contiguous inland waters south of a line beginning at a point 35° 48 .3693'N - 75° 43 .7232'W on Roanoke Marshes Point, running southeasterly to a point 35° 44 .1710'N - 75° 31 .0520'W on the north point of Eagle Nest Bay, to the South Carolina line.

(2) The description of the management areas appear in the dealer permit rule in a more detailed version that delineates the boundaries of the Croatan, Roanoke and Currituck sounds. It is not known why this longer version exists as it has no quota monitoring or management use. It is proposed that the longer version be stricken and the ASMA and the CSMA descriptions in 3R be referred to in 3O.
15A NCAC 03O .0503
(2) Striped Bass Dealer Permit:

(A) It is unlawful for a fish dealer to possess, buy, sell or offer for sale striped bass taken from the following areas without first obtaining a Striped Bass Dealer Permit validated for the applicable harvest area:

(i) Atlantic Ocean;

(ii) Albemarle Sound Management Area as designated in 15A NCAC 3R .0201. ~~for Striped Bass which is defined as Albemarle Sound and all its joint water tributaries including Roanoke River, up to the Hwy. 258 bridge; Eastmost and Middle Rivers, and Cashie River below Sans Souci Ferry; Currituck Sound and all its joint water tributaries; Roanoke and Croatan Sounds and all their joint water tributaries, including Oregon Inlet, east of a line from Baum Point 35° 55.1602' N – 75° 39.5736'W to Rhodoms Point 36° 00.2146' N – 75° 43.6399' W and east of a line from Eagleton Point 36° 01.3178' N – 75° 43.6585' W; to Long Point 36° 02.4971' N – 75° 44.2261' W at the mouth of Kitty Hawk Bay and north of a line from Roanoke Marshes Point 35° 48.3693' N – 75° 43.7232' W to the north point of Eagle Nest Bay 35° 44.1710' N – 75° 31.0520' W; Croatan Sound south of a line at the Highway 64/264 bridge Point at Manns Harbor and north of a line from Roanoke Marshes 35° 48.3693' N – 75° 43.7232' W across to the north point of Eagle Nest Bay 35° 44.1710' N – 75° 31.0520' W;~~

~~(iii) Central Area which is defined as all internal coastal waters of Carteret, Craven, Beaufort, and Pamlico counties; White Oak and Pungo rivers; and Pamlico Sound south of a line from Roanoke Marshes Point 35° 48.3693' N – 75° 43.7232' W to the north point of Eagle Nest Bay 35° 44.1710' N – 75° 31.0520' W (southern boundary of the Albemarle Sound Management Area for Striped Bass) to the county boundaries;~~

~~(iv) Southern Area which is defined as all internal coastal waters of Pender, Onslow, New Hanover, and Brunswick counties.~~

(iii) The joint and coastal waters of the Central/Southern Management Area as designated in 15A NCAC 3R .0201.

***Note that this will necessitate the changing of the areas described on the Striped Bass Dealer Permit**

(3) The management areas need to be referenced in the 15A NCAC 3M .0200 Section, which are general striped bass rules. The following language is proposed for an (e) at the end of the Rule:

15A NCAC 03M .0201

.0207 ESTUARINE STRIPED BASS MANAGEMENT AREAS

(e) The management units and recreational fishery management areas for estuarine striped bass fisheries in coastal North Carolina are designated in 15 A NCAC 03R .0201.

(4) The following are Joint Rules that are shared by the MFC and WRC. They must be adopted by both commissions and be worded the same. The administrative procedures of both commissions should be coordinated so that the effective date of this adoption occurs simultaneously.

15A NCAC 03Q .0108 (WRC Rule 15A NCAC 10C .0110)

MANAGEMENT ~~PLANS~~ RESPONSIBILITY FOR ESTUARINE STRIPED BASS IN JOINT WATERS

(a) The management ~~units~~ areas for estuarine striped bass fisheries in coastal North Carolina are designated in 15A NCAC 3R .0201.

(b) In order to effectively manage the recreational hook and line harvest in joint waters of the Albemarle Sound-Roanoke River stock of striped bass, the Marine Fisheries Commission and the Wildlife Resources Commission deem it necessary to establish two management areas; the Albemarle Sound Management Area and the Roanoke River Management Area as designated in 15A NCAC 3R .0201. ~~for the joint waters of the Albemarle Sound and the Roanoke River, along with their defined tributaries~~. The Wildlife Resources Commission shall have principal management responsibility for the stock when it is in the joint and inland fishing waters of the Roanoke River Management Area. ~~and its tributaries including Cashie, Middle and Eastmost rivers.~~ The Marine Fisheries Commission shall have principal management responsibility for the stock in the coastal, joint and inland ~~remaining~~ waters of the Albemarle Sound Management Area. ~~Currictuck, Roanoke and Croatan Sounds and their tributaries, including joint and inland waters.~~ The annual quota for recreational harvest of the Albemarle-Roanoke striped bass stock shall be divided equally between the two management areas. Each commission shall ~~develop~~ implement ~~a~~ management ~~plans~~ actions for recreational harvest within their respective management areas~~.~~ ~~The management plans shall:~~

~~(1) Be consistent with the guidelines established in the Atlantic States Marine Fisheries Commission Plan for Striped Bass.~~

~~(2) Limit harvest to a one fish per person per day creel limit in areas for which no data collection program is ongoing~~.

that will be consistent with the North Carolina Estuarine Striped Bass Fishery Management Plan.

(5) The WRC has not conformed to the second sentence of (1) below for several years. They have a set creel limit and a set season, which is codified in WRC Rule 15A NCAC 10C .0305. It is proposed that that language be removed from the joint rule to reflect what is actually being done.

15A NCAC 03Q .0109 (WRC Rule 15A NCAC 10C .0111)
IMPLEMENTATION OF ESTUARINE STRIPED BASS MANAGEMENT PLAN: RECREATIONAL FISHING

The Marine Fisheries and Wildlife Resources Commissions shall implement their respective striped bass management ~~plans~~ actions for recreational fishing pursuant to their respective rule-making powers. To preserve jurisdictional authority of each Commission, the following means are established through which management measures can be implemented by a single instrument in ~~each~~ the following management area:

(1) In the Roanoke River Management Area ~~and tributaries~~, the exclusive authority to open and close seasons and areas~~,~~ and establish size and creel limits whether inland or joint fishing waters shall be vested in the Wildlife Resources Commission. ~~The Wildlife Resources Commission shall initiate action to close the management area when 90 percent of the assigned quota has been taken.~~ An instrument closing any management area in joint waters shall operate as and shall be a jointly issued instrument opening or closing seasons or areas to harvest in the Roanoke River management area.

(2) In the Albemarle Sound M~~m~~anagement A~~a~~rea, the exclusive authority to open and close seasons and areas~~,~~ and establish size and creel limits, whether coastal or joint fishing waters shall be vested in the Marine Fisheries Commission. ~~The Marine Fisheries Commission~~ The season will close ~~the season~~ by proclamation if the quota is about to be exceeded. In the Albemarle Sound ~~m~~Management ~~a~~Area administered by the Marine Fisheries Commission, a proclamation affecting the harvest in joint and coastal waters, excluding the Roanoke River ~~m~~Management ~~a~~Area, shall automatically be implemented and effective as a Wildlife Resources Commission action in the inland waters and tributaries to the waters affected.

(6) Following are changes proposed by the WRC to make the Joint Rules conform to their current management actions and to clarify two points. The WRC does not allow a creel limit of three fish, so they proposed the wording in (1) (b) below. It is also proposed to delete (d) and (e) because they are redundant. The previous rule above handles jurisdiction of the agencies.

15A NCAC 10C .0107 (MFC Rule 15A NCAC 3Q .0107)

SPECIAL REGULATIONS: JOINT WATERS

I In order to effectively manage all fisheries resources in joint waters and in order to confer enforcement powers on both fisheries enforcement officers and wildlife enforcement officers with respect to certain rules; the Marine Fisheries Commission and the Wildlife Resources Commission deem it necessary to adopt special rules for joint waters. Such rules supersede any inconsistent rules of the Marine Fisheries Commission or the Wildlife Resources Commission that would otherwise be applicable in joint waters under the provisions of 15A NCAC 10C .0106:

(1) Striped Bass

(a) It is unlawful to possess any striped bass or striped bass hybrid taken by any means which is less than 18 inches long (total length).

(b) It is unlawful to possess more than ~~three striped bass or their hybrids taken by hook and line in any one day from joint waters~~ one daily creel limit of striped bass or their hybrids, in the aggregate, per person per day, regardless of the number of management areas fished, and fish possessed by the individual must be in compliance with the size and creel limits for the management area being fished.

(c) It is unlawful to engage in net fishing for striped bass or their hybrids in joint waters except as authorized by ~~duly adopted~~ rules of the Marine Fisheries Commission.

~~(d) It is unlawful to possess striped bass or striped bass hybrids in the joint waters of Albemarle, Currituck, Roanoke and Croatan Sounds and their tributaries, excluding the Roanoke River, except during seasons as authorized by duly adopted rules of the Marine Fisheries Commission.~~

~~(e) In the joint waters of the Roanoke River and its tributaries, including Cashie, Middle and Eastmost Rivers, striped bass and hybrid striped bass fishing season, size limits and creel limits shall be the same as those established and authorized by duly adopted rules of the Wildlife Resources Commission for adjacent inland fishing waters.~~

(2) Lake Mattamuskeet:

(a) It is unlawful to set or attempt to set any gill net in Lake Mattamuskeet canals designated as joint waters.

(b) It is unlawful to use or attempt to use any trawl net or seines in Lake Mattamuskeet canals designated as joint waters.

(3) Cape Fear River. It is unlawful to use or attempt to use any net or net stakes within 800 feet of the dam at Lock No.1 on the Cape Fear River.

(4) Shad: It is unlawful to possess more than 10 American shad or hickory shad, in the aggregate, per person per day taken by hook-and-line.